Central Community Unit District #301

Mission Statement

To provide quality education within a nurturing environment which enables all students to become life-long learners who strive for excellence and who are responsible contributors to our ever changing global society.

Science Mission Statement

Students completing the Central Community Unit School District #301 Science curriculum will analyze and evaluate the interconnections of the life, physical, and earth/space sciences while applying the processes of scientific inquiry and technological design. The students will be able to assess the connections and relationships among the sciences, technology, and society. As a result they will be able to make responsible decisions in our every changing global environment.

Recommendations

The Science SAC has carefully looked at such things as biome study, special activities, and overlaps and has spread some topics out across the grade levels. In addition, some grades will need Foss kits in order to more effectively utilize the inquiry model for some topics.

Science SAC Purpose Statements

Kindergarten

Life - Students will differentiate living and non-living things through observation and interpretation of data.

Physical - Students will categorize matter as solid or liquid.

Earth - Students will interpret weather patterns using observations and data from sensory information.

1st Grade

Life - Students will identify, describe and compare how living things function, adapt, change and interact with each other and their environments.

Physical - Students will identify and compare concepts relating to matter, energy, force and motion.

Earth - Students will identify and describe the features and processes of the Earth and its resources and describe the composition and structure of the solar system and Earth's place in it.

2nd Grade

Life - Students will classify animals according to lifestyle, function, structure, and habitat through investigation.

Physical - Students will examine various forces and properties of matter to evaluate a variable.

Earth - Students will identify component features of earth's history and the solar system through modeled exploration.

3rd Grade

Life - Students will analyze the interrelatedness of living things within ecosystems.

Physical - Students will apply knowledge of forces and motion.

Earth - Students will examine the Earth's features.

4th Grade

Life - Students will examine the structural and functional features of animals and plants as found on the prairie.

Earth - Students will analyze atmospheric changes to predict the effects on weather and climate.

Physical - Students will apply knowledge of electricity to practical problem solving situations and students will demonstrate an understanding of the chemical and physical characteristics of matter.

5th Grade

Life - Students will classify plants by structures and functions and they will examine the structures and functions of animals.

Physical - Students will apply the scientific method while investigating variables through models, design and invention.

Earth - Students will differentiate between the bodies in outer space and examine the inner earth.

6th Grade

Life - Students will classify animals based on the differences and level of complexity of their organ systems and will appraise the competitive advantages associated with various organ systems.

Physical - Students will compare and categorize ways that thermal energy is transferred beneath the Earth, in water, and in the atmosphere.

Earth - Students will combine their understandings of movements in the atmosphere (weather) and bodies of water (ocean/lake currents) to examine their similarities.

7th Grade

Life - Students will discriminate between living and non-living entities and how they are classified. Students will construct knowledge of human genetics and cellular structures.

Physical - Students will understand and apply the principals of electronics.

Earth - Students will appraise the importance of the effects of organisms on our environment.

8th Grade

Physical - Students will apply the scientific method to further explore concepts in force and motion and sound and light.

Chemistry - Students will examine the interactions of matter and develop an understanding of the periodic table.

Astronomy - Students will integrate physics into the study of astronomy and assess the importance of the space exploration program to society.

Grades 9-12

APPLIED BIOLOGY

Students will build an understanding and appreciation of biology via a general overview while integrating the basic principles of biology and connecting biology to the everyday world.

BIOLOGY Required

Students will build and understanding and appreciation of biology at the molecular and cellular level while integrating the principles of biology and connecting biology to the everyday world.

FRESHMAN HONORS BIOLOGY

Students will appraise the connections and relationships between biochemistry, and the structure and function of living organisms.

AP BIOLOGY

Students will build a comprehensive understanding of biology from the molecular to the macroscopic levels of biological organization; including biochemistry, cellular biology, molecular genetics and heredity, biotechnology, diversity, structure and function of organisms, and ecology and evolution; comparable to a college biology course. Students will also perform appropriate level laboratory work.

EARTH SCIENCE I Required

Students will integrate an understanding of the earth's dynamic systems and the impact of human activities on the earth's environment.

EARTH SCIENCE II

Students will integrate an understanding of the earth's dynamic forces and their impact on the earth over time.

ASTRONOMY

Students will investigate the history of Astronomy, the four fundamental forces, and relate their usefulness to the study of the night sky. The emphasis of this course will be on stellar evolution, origins, and the make-up of the universe.

PHYSICS

Students will examine our physical world and the relationship of energy to matter. Students will apply the rigors of mathematics to mechanics, heat, and waves, and modern physics topics.

AP PHYSICS

Students will acquire and apply knowledge of mechanics, heat, electricity and magnetism, waves (including optics and sound), and modern physics topics comparable to a college physics course.
Students will develop the ability to ask physical questions and to obtain solutions by the use of qualitative and quantitative reasoning by experimental investigation.

CHEMISTRY

Students will acquire and apply the knowledge of the atomic theory, atomic structure, chemical bonding, gases, liquids and solids, solutions, reaction types, stoichiometry, equilibrium and kinetics. Students will also apply chemistry lab processes and techniques.

ACCELERATED CHEMISTRY

Students will analyze atomic theory and atomic structure, chemical bonding, gases, liquids and solids, solutions, reaction types, stoichiometry, equilibrium and kinetics, at an accelerated pace. Students will also apply chemistry lab processes and techniques.

AP CHEMISTRY

Students will analyze the atomic theory and structure, chemical bonding, states of matter, solutions, reaction types, stoichiometry, equilibrium, kinetics, and thermodynamics comparable to an introductory college level chemistry course. Students will perform appropriate level laboratory work.

INTRODUCTORY PHYSICAL SCIENCE Required

Students will implement the process of the scientific method and demonstrate proficiency in lab techniques.

CURRENT SCIENCE TOPICS

Students will investigate and discuss current technology, research, and topics in science today.

Science Curriculum

Kindergarten

Focus: ***Life Science***

Purpose: Students will differentiate living and nonliving things through observation and interpretation of data.

Outcome: **S.K.1** Students will observe, categorize, and describe basic needs and life cycles of living things.

Component: **S.K.1.1** – Identify basic needs of living things. (**observation**) 12.A.K, **12.A.1b**

S.K.1.2 – Categorize living/nonliving things. (**observation**) 12.A.Ka, **12.A.1b**

S.K.1.3 – Identify and describe the characteristics of living things (move, breathe, grow and change). (**observation**) 12.A.Ka, 12.B.K., **12.A.1b**

S.K.1.4 – Predict and identify basic needs of a butterfly. (**observation**)

S.K.1.5 – Observe and illustrate life cycle of a butterfly. (**observation**) 12.A.Ka, **12.A.1b**

S.K.1.6 – Identify parts of a plant. (**observation**) 12.A.Ka, **12.A.1b**

S.K.1.7 – Predict and identify basic needs of a plant. (**observation**) 12.A.Ka, 12.B.K, **12.A.1b**

S.K.1.8 – Identify and classify animals into groups (birds, fish, mammals, insects). (**observation**) 12.A.Ka, **12.A.1b**

S.K.1.9 – Observe and illustrate where plants and animals live (water, land, etc.).

Focus: ***Physical Science***

Purpose: Students will categorize matter as solid, liquid or gas.

Outcome: **S.K.2** Students will categorize matter as solid, liquid or gas.

Component: **S.K.2.1** – Observe examples of solids, liquids, and gases. (**observation**) 12.C.K, **12.C.1b**

S.K.2.2 – Compare solids, liquids, and gases. (**observation**) 12.C.K, **12.C.1b**

S.K.2.3 – Categorize matter as a solid, liquid or gas. (**observation, data interpretation**) 12.C.K, **12.C.1b**

Focus: ***Earth Science***

Purpose: Student will interpret weather patterns using observation and data from sensory information, and students will observe and demonstrate ways to reduce, reuse, and recycle.

Outcome: **S.K.3** Students will identify and describe patterns of weather and seasonal change.

Component: **S.K.3.1** – Observe and predict weather patterns. (**inference/predictions, data collecting**) 11.B.Ka, **12.E.1b**

S.K.3.2 – Observe and predict seasonal change. (**data display and communication**) 11.B.Ka, **12.F.1b**

S.K.3.3 – Observe daily patterns related to day and night. (**observation**) 12.D.K, **12.F.1b**

S.K.3.4 – Observe the night sky. (**observation**) **12.F.1b**

Outcome: **S.K.4** Students will identify their five senses and use senses to explore and observe materials.

Component: **S.K.4.1** – Identify fives senses and the body part that each is associated with. (**observation**) 11.A.Ka, **12.C.1b**

S.K.4.2 – Use five senses to observe materials. (**observation, using tools – hand lens**) 11.A.Ka, 11.B.Ka, **12.C.1b**

S.K.4.3 – Use five senses to explore materials. (**observation, using tools – magnifying glass**) 11.A.Ka, 11.B.Ka, **12.C.1b**

**Skills used within these components: Observation and using tools.*

Outcome: **S.K.5** Students will observe and demonstrate ways to reduce, reuse, and recycle.

Component: **S.K.5.1** – Observe ways to reduce, reuse, and recycle. (**observation**) **13.B.1e**

S.K.5.2 – Demonstrate ways to reduce, reuse, and recycle. (**inferences/predictions, data collecting, data display and communication**) **13.B.1e**

Science Curriculum
1st Grade

Focus: ***Life Science***

Purpose: Students will identify, describe and compare how living things function, adapt, change and interact with each other and their environment.

Outcome: **S.1.1** Students will observe and compare plants and animals from fresh water pond and desert habitats.

Components: **S.1.1.1** – Identify non-living parts of a fresh water pond habitat. **(observation, using tools – hand lens)** 12.B.1a

S.1.1.2 – Identify plants and animals in a fresh water pond habitat. **(observation, classifying, data collection, interpretation)** 12.A.1a

S.1.1.3 – Identify non-living parts of a desert habitat. **(observation)** 12.B.1a

S.1.1.4 – Identify plants and animals in a desert habitat. **(observation, data collection, interpretation, using tools – hand lens)** 12.B.1a

S.1.1.5 – Describe basic needs of plants and animals in a fresh water pond habitat. **(data interpretation, concluding)** 12.A.1a

S.1.1.6 – Describe basic needs of plants and animals in a desert habitat. **(data interpretation, concluding)** 12.A.1a

S.1.1.7 – Examine one animal from a fresh water pond habitat (tadpole) with regards to size, color, family unit and shape and life cycle. **(observation, measure, classify, using tools – hand lens, data gathering, data display)** 12.A.1b

S.1.1.8 – Compare the characteristics of plants and animals in fresh water pond and desert habitats with regard to how they function, adapt, change, interact with each other and their environment. **(data interpretation)** 12.B.1a

Focus: ***Physical Science***

Purpose: Students will identify and compare concepts relating to:

Energy – Heat, light, sound
Force – Magnets push and pull
Motion

Outcome: **S.1.2** Students will examine and compare examples of the types of energy, forces and motion that make up our world.

Components: **S.1.2.1** – Identify three types of energy – heat, light, sound. **(observation)** 12.C.1a

S.1.2.2 – Identify observable forces in nature – push, pull. **(observation)** 12.D.1b

S.1.2.3 – Classify materials by their magnetic attraction or repulsion. **(classification, using tools – magnets)** 12.D.1b

S.1.2.4 – Explain examples of simple inertia and momentum in the real world (classroom, playground, home). **(observation, data collection, interpretation)** 12.D.1a

Focus: ***Earth Science***

Purpose: Students will identify and describe the features and processes of the Earth and its resources. They will describe the composition and structure of the solar system and the Earth's place in it.

Outcome: **S.1.3** Students will identify and compare the Earth's land, water and atmospheric components. They will describe and compare the easily visible objects in the Solar System and what happens as a result of the Earth moving through space.

Components: **S.1.3.1** – Identify and classify land features (valleys, mountains, rivers, oceans, plains, ponds). **(observation, classification)** 12.E.1a

S.1.3.2 – Identify and classify sources and uses of water; salt vs. fresh (rivers, oceans, ponds, lakes). **(observation, classification)** 12.E.1a

S.1.3.3 – Sketch atmospheric features (clouds – water cycle). **(diagramming, observation)** 12.E.1a

S.1.3.4 – Classify renewable and non-renewable resources. (Include discussion of: Wind power, Earth Day, ecology, recycling) **(classification)** 12.E.1c

S.1.3.5 – Describe familiar objects of the solar system (sun, earth, moon, stars). **(diagramming)** 12.F.1a

S.1.3.6 – Describe patterns of Earth's movement (day/night, year). **(observation)** 12.F.1b

S.1.3.7 – Observe day and night sky (Star Lab). **(observation, related)** 12.F.1b

Science Curriculum
2nd Grade

Focus: ***Life Science***

Outcome: **S.2.1** Students will investigate and compare the characteristics of habitats within the rainforest and polar/tundra biomes.

Component: **S.2.1.1** – Identify characteristics of fish, amphibians, reptiles, birds, mammals, and invertebrates. (**observation, classification**) 12.A.1a, 12.A.1b

S.2.1.2 – Compare and contrast the life cycles of oviparous animals. Examine one animal with a focus on embryology (chicks) and its life cycle. **(using tools, gathering data, classification)** 12.A.1a

S.2.1.3 – Identify the characteristics of the rainforest and the polar/tundra biomes as a collection of interdependent habitats for plants and animals. **(classification, diagramming)** 12.B.1a, 12.B.1b

S.2.1.4 – Identify the characteristics of the plants and animals that live within each of these biomes. **(observation, classification, research)** 12.A.1a, 12.A.1b

S.2.1.5 – Describe the relationship among living things in these environments and how they depend upon one another for survival (predator: prey and food chains). **(concluding, make a model)** 12.B.1a, 12.B.1b

Focus: ***Physical Science***

Outcome: **S.2.2** Students will analyze matter and energy to determine their properties and forms.

Component: **S.2.2.1** – Define and describe the phases of matter (solid, liquid, gas). **(observation, classification)** 12.C.1b

S.2.2.2 – Define the properties of matter (mass, volume, temperature, texture, and buoyancy). **(using tools – pan balance, thermometer, graduated volume container, classification)** 12.C.1b

S.2.2.3 – Define and describe the different forms of energy (light, heat, sound). **(observation)** 12.C.1a

S.2.2.4 – Identify how types of energy travel (waves, refraction or "bending", reflection). **(using tools)** 12.C.1a

S.2.2.5 – Identify the sources of energy (fossil fuels, solar power, wind, hydroelectricity, etc.) and differentiate between renewable and nonrenewable sources of energy. **(classification)** 12.C.1a

Focus: ***Earth Science***

Outcome: **S.2.3** Students will analyze earth's place in space in respect to the solar system and its major components.

Component: **S.2.3.1** – Illustrate how the rotation of Earth causes day/night. 12.E.1b

S.2.3.2 – Identify how the Earth's tilt causes the seasons. 12.F.1b

S.2.3.3 – Identify how the Earth's orbit is equivalent to one calendar year. 12.F.1b

S.2.3.4 – Explain the phases of the moon.

S.2.3.5 – Identify, characterize, and order the planets in our solar system in relation to the sun. **(classification, research)** 12.F.1a, 12.F.2a

S.2.3.6 – Describe how technology has shaped our understanding of astronomy.

S.2.3.7 – Model the solar system and its components. **(make a model)**

Outcome: **S.2.4** Students will identify characteristics of prehistoric earth to exemplify its changes over time.

Component: **S.2.4.1** – Describe how living things have changed over time (adaptations, endangered species, and extinction). **(classification)** 12.B.1a, 12.B.1b

S.2.4.2 – Identify the characteristics of prehistoric animals according to the fossil record. **(classification, research)**

S.2.4.3 – Describe how earth's changes through time have supplied mankind with nonrenewable resources (fossil fuels: oil, gas, coal).

S.2.4.4 – Describe how technology has shaped our understanding of paleontology.

Science Curriculum
3rd Grade

Focus: ***Life Science***

Purpose: Students will analyze the interrelatedness of living things within Biomes. 12.B.1a, 12.B.2a, 12.B.2b, 12.B.1b, 12.E.2c, 13.B.2d

Outcome: **S.3.1** Students will analyze ecosystems within the Ocean and Deciduous Forest biomes to determine interrelatedness of the living things and the energy flow within the system.

Components: **S.3.1.1** – Identify organization within the ecosystem (population, community, food chains, food webs, etc.). 12.B.1a, 12.B.1b

S.3.1.2 – Identify abiotic and biotic within the ecosystem. **(observing, classifying, using tools – hand lens)** 12.B.1a

S.3.1.3 – Determine relationships between producers, consumers (herbivores, carnivores, omnivores) and decomposers. **(classifying, research)** 12.B.2a

S.3.1.4 – Determine relationships among biotic components (including predator/prey, scavengers, symbiotic, parasite, host). **(research)** 12.B.2a

S.3.1.5 – Examine the competition among living things (food, space). 12.B.1b

S.3.1.6 – Apply scientific inquiry by using proper lab safety and equipment to hypothesize, observe, and collect data, while dissecting an owl pellet. Draw conclusions about the predator/prey relationship. **(classification)** 12.B.2b, 11.A.2b, 11.A.2d, 11.A.1f, 13.A.1a, 13.A.1c, 13.A.2b

S.3.1.7 – Hypothesize the effects of societal causes on endangered animals and their habitats (air/water pollution, housing, developments, road construction, etc.). **(analyze data, concluding)** 13.B.2d, 12.E.2c

S.3.1.8 – Examine how plants and animals survive together in their ecosystems, describing the food chains and webs in various ecosystems. Compose a viable food chain. 12.B.2a

Focus: ***Physical Science***

Purpose: Students will apply knowledge of force and motion. 12.D.2b, 12.D.2a, 11.B.1a, 11.B.1b, 11.B.1c, 11.B.1d, 11.B.1e, 13.A.2b

Outcome: **S.3.2** Students will analyze force and motion, differentiate between the seven types of simple machines (wheel and axel, screw, pulley, lever, inclined plane, wedge) and the work each can do.

Components: **S.3.2.1** – Define work. 12.D.2b, 12.D.2a

S.3.2.2 – Explain how a simple machine makes work easier. **(concluding)** 11.B.2a, 12.D.2b, 13.B.1d

S.3.2.3 – Identify and differentiate among the six types of simple machines. **(classification, using tools – spring scale)** 12.D.2b

S.3.2.4 – Conduct an experiment to demonstrate effectiveness of a simple machine. (Does it work?) **(using tools – spring scale)** 11.B.1b, 11.B.1c, 11.B.1d, 11.B.1e, 13.A.2b

S.3.2.5 – Identify and describe a compound machine. 12.D.2b

S.3.2.6 – Define and identify causes of friction and its effect on motion. **(using tools – measuring, data collecting)** 12.B.2b

S.3.2.7 – Identify the force exerted on a variable (push/pull, friction, gravity, magnetism) and its effect on motion. 12.D.1b, 12.D.2b

S.3.2.8 – Design and construct a simple or compound machine. **(make a model, concluding)** 11.B.1a, 11.B.1b

Focus: ***Earth Science***

Purpose: Students will examine the Earth's features. 12.E.2a, 12.E.2b, 12.E.1a, 12.E.1b, 12.E.1c, 11.A.2a, 11.A.2b, 11.A.2c, 11.A.2d, 13.B.1f, 13.B.2f

Outcome: **S.3.3** Students will explain the Earth's features including: Earth's layers, layers of soil, landforms, rocks, natural resources, and natural disasters.

Components: **S.3.3.1** – Describe the three different rock classifications (metamorphic, igneous, sedimentary). **(classification)** 12.E.1a

S.3.3.2 – Categorize rocks by applying the streak and scratch tests. 11.A.2a, 11.A.2b, 11.A.2d

S.3.3.3 – Identify different uses for minerals. **(observation)** 12.E.1a

S.3.3.4 – Identify the three layers of soil (top soil, sub-soil, solid rock). **(observation)** 12.E.1a

S.3.3.5 – Identify and label the four layers of the Earth (inner core, outer core, mantle and crust). 12.E.1a, 11.A.2c

S.3.3.6 – Define renewable and nonrenewable resources; identify two kinds of each.

S.3.3.7 – Compare the effects of society on natural resources. 17.C.1a, 17.C.1b, 13.B.2e

S.3.3.8 – Identify Earth's landforms including caves, mountains, hills, plateau, mesa, valley, canyon and shorelines. 12.E.1a, 12.E.2a

S.3.3.9 – Identify Earth's natural disasters such as volcanoes (model making), earthquakes, hurricanes, floods, Tsunami, tornados and explain the possible impact of the disaster including the effects of erosion. 12.E.2b, 12.E.1b

S.3.3.10 – Describe water cycle.

1/19/11

Science Curriculum
4th Grade

Focus: ***Life Science***

Purpose: Students will examine the structural and functional features of animals and plants as found throughout the United States, with an emphasis on the Illinois prairie.

Outcome: **S.4.1** Students will identify the common needs of animals and conclude how the behaviors and adaptations of animals aid them in meeting these needs.

Components: **S.4.1.1** – Identify common animal needs (food, shelter, water, body temperature) and describe examples of how these needs are met. **(observation, inferring)** 12.B.2a, 12.B.2b

S.4.1.2 – Describe how structural adaptations (teeth, beaks, claws) help animals meet their needs. (Voles, hawks, coyotes, bison, raccoons, prairie dogs) **(questioning, predicting)** 12.B.2a, 12.B.2b

S.4.1.3 – Describe how behavior adaptations by an individual or by a group help animals meet their needs. 12.B.2a, 17.B.2b

S.4.1.4 – Differentiate between learned and instinctive behaviors of animals. **(inferring)** 12.A.2b

Outcome: **S.4.2** Students will explain how structures and adaptations of plants allow for their survival.

Components: **S.4.2.1** – Describe a prairie ecosystem (including the soil). 12.B.2a, 13.B.2e, 13.B.2f, 17.B.2b

S.4.2.2 – Examine various prairie grasses and forbs present during different seasons. (See notebook) **(observation)** 12.B.2a, 12.B.2b, 13.B.2b, 13.B.2c

S.4.2.3 – Identify the parts of a plant and describe each parts function. 12.B.2a, 12.B.2b

S.4.2.4 – Observe the adaptations (i.e., root system) of prairie plants (or other plants) and point out the importance of said adaptations. **(observation)** 12.B.2a, 12.B.2b

Focus: ***Physical Science***

Purpose: Students will apply knowledge of electricity to practical problem solving situations and students will demonstrate understanding of the chemical and physical characteristics of matter.

Outcome: **S.4.3** Students will build a variety of circuits and consider how the same principles apply to household circuitry.

Components: **S.4.3.1** – Compare and contrast static and current electricity. 12.C.2a, 13.B.2b, 13.B.2c

S.4.3.2 – Identify the components of a complete circuit. 12.C.2a, 13.B.2b, 13.B.2c

S.4.3.3 – Build and compare series and parallel circuits and their implications in the home. (i.e., Christmas lights, circuit breakers, fuses, blowdryers). **(model making, tools, lab safety)** 12.C.2a, 13.B.2b, 13.B.2c

S.4.3.4 – Utilize a switch and explain its implication within a variety of circuits. **(observation, inferring)** 12.C.2a, 13.B.2b, 13.B.2c

S.4.3.5 – Test a variety of materials to determine whether each is a conductor or insulator and explain the difference. **(predicting, data collection, data interpretation, concluding, lab safety)** 12.C.2a, 13.B.2b, 13.B.2c

S.4.3.6 – Investigate electromagnets and verify variables which affect their strength. **(experiment design)** 12.D.2b, 12.C.2a, 13.B.2b, 13.B.2c

Outcome: **S.4.4** Students will discriminate between various sources of energy and will investigate the process from generation to usable electricity, including conservation.

Components: **S.4.4.1** – Identify types and sources of electricity: generators, electric cells, and solar cells. **(classify)** 12.C.2a, 13.B.2b, 13.B.2c, 13.B.2e, 13.B.2f

S.4.4.2 – Describe the process from power plant to usable energy in the home with an emphasis on conversion to heat, light and sound. **(concluding)** 12.C.2a, 12.E.2c, 13.B.2b, 13.B.2c, 13.B.2e, 13.B.2f

S.4.4.3 – Identify methods of energy conservation.

Focus Skills:

Inferring, predicting, concluding.

Outcome: **S.4.5** Students will discriminate between chemical and physical properties and identify usefulness of such properties.

Components: **S.4.5.1** – Identify uses of matter based on its properties. 12.C.2b, 13.B.2c

S.4.5.2 – Measure mass and volume and density and calculate density of solids and liquids. **(calculate density, using tools – measurement, calculators, balance scale, grad. cylinders)** 12.C.2b, 13.B.2c, 11.A2b, 13.A.2.d

S.4.5.3 – Define atoms, elements, molecules, compounds and mixtures. **(classify)** 12.C.2b, 13.B.2c

S.4.5.4 – Explain the role of energy and the cause and molecular implications of changes in states of matter (solids, liquids, gases). **(inferring, predicting)** 12.C.2b, 13.B.2c

S.4.5.5 – Explore the periodic table of elements**. (observation)** 12.C.2b, 13.B.2c

S.4.5.6 – Distinguish between physical and chemical changes. 12.C.2b, 13.B.2c

Focus: ***Earth Science***

Purpose: Students will analyze atmospheric changes to predict the effects on weather and climate.

Outcome: **S.4.6** Students will measure atmospheric changes and consider the Earth's natural landforms to predict and prepare for changes in weather conditions.

Components: **S.4.6.1** – Describe the atmosphere and its layers (stratosphere, mesosphere, thermosphere, exosphere, troposphere). 12.E.2a

S.4.6.2 – Determine the changes in the condition of air (temperature, water vapor, pressure) that results in different forms of weather. **(evaluate data)** 12.E.2a

S.4.6.3 – Measure and evaluate changes in the condition of air to predict local weather. **(predicting, data collecting, model making, using tools – measuring, thermometer, barometer, rain gauge, anemometer, wind vane)** 12.E.2a, 13.B.2a, 13.B.2c

S.4.6.4 – Discriminate among varying cloud types (including: cumulus, nimbus, stratus, cirrus, etc.) and identify how each signifies different weather patterns. **(observations, classifying, concluding, inference)** 12.E.2a

S.4.6.5 – Evaluate weather maps (air masses and fronts) to identify patterns which lead to weather prediction. **(predicting, data analysis, concluding)** 12.E.2a, 13.AB.2a, 13.B.2c, 17.A.2.b

S.4.6.6 – Describe safety procedures for various severe weather situations. (i.e., tornado, thunderstorm, blizzard) 12.E.2a, 12.E.2b, 17.C.2.a

S.4.6.7 – Explain the interrelationships between weather and landforms (lake effect, mountains). 12.E.2a

Focus Skills:

Measuring, model making, tools, questioning, observation, inferring, predicting, concluding, data collection, data interpretation, lab performance, lab safety.

Outcome: **S.4.7** Students will interpret climate changes over time.

Components: **S.4.7.1** – Distinguish between weather and climate. **(classify)** 12.E.2b

S.4.7.2 – Identify and describe climate zones. **(classify)** 12.E.2a, 12.E.2b

S.4.7.3 – Describe the Earth's climate changes within a historical context with an emphasis on Illinois' climate and landforms (glacier action). (**inferring)** 12.E.2a, 12.E.2b

S.4.7.4 – Evaluate human effect on climate, including global warming. (**predicting, questioning)** 13.B.2c, 13.B.2d, 13.B.2e, 13.B.2f

Science Curriculum
5th Grade

Focus: ***Life Science – Classification of plants and animals and the organization of their systems.***

Purpose: Students will classify plants and animals by structures and functions and they will examine the structures and functions of the systems.

Outcome: **S.5.1** Students will examine the properties of all living things, how they interact with each other and how they are classified.

Components: **S.5.1.1** – Gather information on how animals and plants are classified. (Animals – vertebrates and invertebrates) (Plants – how leaves carryout photosynthesis/structures and functions of roots, stems and leaves.) **(classify, observation, making diagrams)** 12.B.2a., 12.A.3c

S.5.1.2 – Define what an organism is, how we classify them, and explain that all organisms are made up of cells. (multicellular organisms) (**classify)** 12.A.3a

S.5.1.3 – Distinguish how cells are organized. (Cells form tissues, tissues form organs, and organs work together in organ systems.) **(classify)** 12.A.3c

S.5.1.4 – Identify the parts and functions of a plant cell and an animal cell. (Cell membrane, nucleus, cell wall and chloroplast.) **(diagramming)** 12.A.3c

S.5.1.5 – Examine how organisms interact. (The flow of energy in ecosystems, biomes, animals depend on plants, reasons why organisms are in different places.) 12.b.3B

Focus: ***Earth Science – Inner Earth***

Purpose: Students will differentiate between the bodies in outer space and examine the inner earth.

Outcome: **S.5.2** Students will analyze the forces that form and change the rocks and landforms of the Earth's surface and determine the properties and composition of the Earth's materials.

Components: **S.5.2.1** – Illustrate the layers of the Earth and describe the properties of each. **(diagramming)** 12.E.3b

S.5.2.2 – Investigate the composition of the Earth's crust (soil, rocks, and minerals), how the Earth's surface changes (erosion, weathering, volcanoes, earthquakes), and how we know that change has occurred (fossils). **(observation)** 12.E.3b, 12.E.3a

S.5.2.3 – Compare the three types of rocks describing the differences between the three classifications of rocks, analyze how the rocks are formed (rock cycle) and show characteristics of each. **(classification)** 12.E.2a

S.5.2.4 – Examine the major landforms on Earth and describe how they are created and changed (Plate Tectonics). 12.E.3a, 12.E.2b

S.5.2.5 – Distinguish between the ecosystem cycles (water, oxygen, carbon, nitrogen) and how each substance is circulated through the Earth. **(diagramming)** 12.E.2a

Focus: ***Earth Science – Outer Space***

Purpose: Students will differentiate between the bodies in outer space and examine the inner earth.

Outcome: **S.5.3** Students will discriminate the similarities and differences among objects in our solar system and the tools we use to investigate them.

Components: **S.5.3.1** – Identify the relative position of the eight planets and the distance from the sun, compare and contrast the sizes, compositions, surface features, moons and movement. **(classification, diagramming)** 12.F.3b

S.5.3.2 – Establish the relative position and motion of the Earth, moon and sun by evaluating revolution and rotation and how the axis tilt affects the amount of sunlight. (Day, night, solar eclipses, seasons, lunar eclipses) **(observation)** 12.F.2a

S.5.3.3 – Discriminate between compositions of asteroids, meteors, comets, and any manmade objects (satellites) in space. 12.F.3c, 12.F.2c, 12.F.3c

S.5.3.4 – Examine that we are one of many galaxies; identify and locate the Milky Way and discuss that there are many theories on the birth of the solar system. 12.F.3c, 12.F.2c, 12.F.3c

S.5.3.5 – Trace the discoveries and theories of Ancient and Early Astronomers. 13.B.1c, 13.B.2b, 13.B.3b

S.5.3.6 – Name commonly observed constellations (Big Dipper, Little Dipper, Orion, etc.) and explain why we only see them during certain seasons. 12.F.3c

S.5.3.7 – Describe manmade technological tools used for investigation and observation in space (space probes, satellites, shuttles, telescopes). 13.B.2a

S.5.3.8 – Evaluate space missions and how they affected space theories. (Challenger, Voyager, Apollo) 13.B.3b

Focus: ***Physical Science – Scientific model design and use of variables.***

Outcome: **S.5.4** Students will apply the skills of investigation in order to build explanations based on prior knowledge and gathered evidence through the inquiry model.

Components: **S.5.4.1 –** Identify relationships between structure and function of materials and systems. 11.A.2a, 11.B.2a

S.5.4.2 – Design and construct conceptual and physical models. 11.A.2a, 11.B.2a, 11.B.2b

S.5.4.3 – Implement a proposed design. 11.B.2b, 11.B.2d

S.5.4.4 – Utilize appropriate tools and techniques to organize and analyze data from investigations. 11.B.2d

S.5.4.5 – Identify many solutions to one problem. 11.B.2e

S.5.4.6 – Develop descriptions, explanations, predictions and models using evidence. 11.A.2d, 11.A.2e

S.5.4.7 – Apply mathematics in the context of science. 11.B.2d

S.5.4.8 – Evaluate and critique completed designs or products. 11.B.2e, 11.A.2e, 11.B.2f

Science Curriculum
6th Grade

Focus: ***Life Science***

Purpose: Students will classify animals based on the differences and level of complexity of their organ systems and will appraise the competitive advantages associated with various organ systems.
Standards: 12.A.3a, 12.A.3c, 12.A.4c, 12.B.3b, 12.B.4a

Outcome: **S.6.1** Students will classify animals into phyla based on physical characteristics and design an accurate model.

Components: **S.6.1.1** – Define what it means to be an animal (multicellular, heterotrophic, most move at some point, most reproduce sexually). **(classification)** 12.A.3a

S.6.1.2 – Distinguish between animals that are bilateral, radial, or asymmetrical. 12.A.3c

S.6.1.3 – Classify an animal into phylum, class, order, family, genus, and species. 12.A.3c

S.6.1.4 – Examine (the diversity of) and make observations about animals in each of the following phyla: Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Mollusca, Arthropoda, Echinodermata, and Chordata. **(classification)** 12.A.3c

S.6.1.5 – Identify the defining characteristics of each phyla. **(classification)** 12.B.3b

S.6.1.6 – Compare the physical characteristics of animals within each phylum as well as across phyla. **(classification)** 12.B.3b

S.6.1.7 – Design and build an accurate 3-D model of an animal. **(model making)** 11.A.3c

Outcome: **S.6.2** Students will sequence developing complexity of organ systems from simple through complex organisms. 12.A.3c

Components: **S.6.2.1** – Identify the things that all animals need (food, water, oxygen), are (multicellular, heterotrophic), and do (move, reproduce).

S.6.2.2 – Examine how the members of each of the phyla studied accomplish the above.

S.6.2.3 – Describe diffusion. 12.A.3a

S.6.2.4 – Track the development and evolution of the following body systems as the animal phyla studied become more complex: circulatory system, digestive system, musculature system, excretory system, nervous system, respiratory system, skeletal system. 12.A.3c

S.6.2.5 – Describe the ways in which animals can communicate. 12.B.3b

S.6.2.6 – Evaluate the advantages and/or disadvantages to the animal as their organ systems and behavior become more complex.

Outcome: **S.6.3** Students will evaluate how animals have adapted and evolved to meet their needs under changing conditions. 12.A.4c

Components: **S.6.3.1** – Identify adaptations possessed by animals in each phyla that help the animals obtain and consume food, move, escape danger, reproduce. 12.B.3b

S.6.3.2 – Provide examples of adaptations that enabled animals to live on land. 12.A.4c

S.6.3.3 – Explain how a particular animal has evolved/adapted to meet its needs in its environment. **(research)** 12.A.4c

S.6.3.4 – Identify interdependent relationships between animals. 12.A.3c

S.6.3.5 – Evaluate the effects current environmental changes have on a particular animal. 12.B.3a

Focus: ***Physical Science***

Purpose: Students will compare and categorize ways in which thermal energy is transferred beneath the Earth, in water, and in the atmosphere.
Standards:

Outcome: **S.6.4** Students will diagram, describe and explain molecular motion as it relates to temperature, change of state, and pressure.
12.C.3a, 12.C.3b, 13.A.3c, 13.B.3c

Components: **S.6.4.1** – Measure mass and volume using pan balances, graduated cylinders, beakers, rulers, water (for irregular solids), etc.
12.C.3b, 11.A.3c, 13.A.3c

S.6.4.2 – Use the Metric system to calculate and explore the concept of density. 12.C.3a

S.6.4.3 – Use the Metric system to calculate the density of water and salt (ocean) water. 12.C.3a

S.6.4.4 – Define and explain the relationship between energy, heat, and temperature. 12.C.3a

S.6.4.5 – Determine and diagram the effect of temperature change on molecules (rate of motion, state). 13.A.3c

S.6.4.6 – Define pressure.

S.6.4.7 – Describe how high pressure moves toward low pressure (diffusion, weather, lift), and explain why this happens. 12.E.3b

Outcome: **S.6.5** Students will differentiate between radiation, conduction, and convection as methods of heat transfer on Earth. 12.C.3a

Components: **S.6.5.1** – Define radiation, conduction, and convection. 12.C.3a

S.6.5.2 – Identify applications of each method of heat transfer on the Earth, in the ocean, and the atmosphere. 12.C.3a

S.6.5.3 – Compare how heat/energy is transferred by each method. 12.C.3a

Focus: ***Earth Science***

Purpose: Students will combine their understanding of movements in the Earth (plate tectonics), atmosphere (weather) and bodies of water (ocean/lake currents) to examine their similarities. 12.E.3a, 12.E.3b, 13.B.3c, 13.B.3f

Outcome: **S.6.6** Students will analyze the reasons and effects of heat transfer and movement in the Earth. 12.E.3a, 12.E.3b

Components: **S.6.6.1** – Describe the heating within the layers of the Earth. 12.E.3b

S.6.6.2 – Explain how convection currents form beneath the Earth. 12.E.3b

S.6.6.3 – Explain plate tectonics and support the explanation with evidence. 13.B.3f

Outcome: **S.6.7** Students will analyze the reasons and effects of heat transfer and movement in the ocean. 12.C.3a

Components: **S.6.7.1** – Identify layers and regions of the ocean. 12.E.3b

S.6.7.2 – Identify layers and regions of the ocean. 12.C.3b

S.6.7.3 – Compare the characteristics of fresh water and salt water. 12.C.3b

S.6.7.4 – Identify the warm and cool surface currents of the ocean. 12.C.3a

S.6.7.5 – Evaluate how one of these currents has affected history.

13.A.3b

S.6.7.6 – Evaluate how one of these currents affects climate. 12.E.3a

S.6.7.7 – Connect knowledge of density and temperature to explain deep ocean currents. 12.E.3b

S.6.7.8 – Compare and contrast surface currents and deep ocean currents. 12.D.3a

S.6.7.9 – Propose the possible effects if these currents were disrupted. 12.E.3b, 13.B.3f, 11.A.3a

Outcome: **S.6.8** Students will analyze the reasons for and effects of heat transfer and movement in the atmosphere. 12.C.3a

Components: **S.6.8.1** – Identify the layers of the atmosphere. 12.E.3a

S.6.8.2 – Explain the relationship between axis and the North Star. 12.F.3b

S.6.8.3 – Define and explain solstices and equinoxes. **(make a model)** 12.F.3b

S.6.8.4 – Define differential heating and give examples. 12.C.3a

S.6.8.5 – Connect the effect of solar angle, day length, and beam spreading to the seasons. **(make a model)** 12.F.3b

S.6.8.6 – Explain how weather fronts form and move. 12.D.3a

S.6.8.7 – Predict weather and support prediction. 11.A.3a

Outcome: **S.6.9** Students will diagram how water moves around the Earth and atmosphere and the effects of pollution. 12.D.3a

Components: **S.6.9.1** – Evaluate the effects of water (or lack of water) in the atmosphere (dew point, fog, rain and snowstorms, desertification). 12.B.3a

S.6.9.2 – Describe and graph how water is distributed: oceans, ice, rivers and lakes, ground water, water vapor. **(data analysis)** 12.E.3a

S.6.9.3 – Define watershed and explain how local water moves. 12.E.3b

S.6.9.4 – Identify sources of water, soil and air pollution and explain their connection. 12.E.3c

S.6.9.5 – Propose ways that pollution can be reduced today. 13.B.3e, 13.B.3f

Science Curriculum
7th Grade

Focus: ***Earth Science***

Outcome: **S.7.1** Students will evaluate the role of organisms in the environment and defend the importance of their roles as producers, consumers, and decomposers in our environment.

Components: **S.7.1.1** – Explain that energy entering the ecosystem as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food webs. 12.B.3a, 12.B.3b

S.7.1.2 – Correlate that matter is transferred over time from one organism to others in the food web and between organisms and the physical environment. 12.C.3a

S.7.1.3 – Use a variety of print and electronic resources (including the World Wide Web) to collect information and evidence on a specific organism in a food web as part of a research project. (Gather information) 1.C.3a, 3.C.3a, 12.B.3a

S.7.1.4 – Conduct a well-designed experiment to determine the effect of light or water on plant leaves. (Variables analyzing data, observation) 11.A.3a, 11.A.3b, 11.A.3c

S.7.1.5 – Analyze evidence that within an ecosystem organisms have different functions (niches) that enable them to survive. 12.B.3b

S.7.1.6 – Study one native organism to find out what function it serves in the ecosystem, and compare organisms with others to determine how they are interrelated. 12.B.3a

S.7.1.7 – Organize class information and hypothesize what might happen if organism is removed or added to an ecosystem, and justify ones thinking. (Alt.: Or if an organism is added to foreign ecosystem and survives.) 11.A.3a, 11.A.3c, 11.A.3d, 11.B.3e

Focus ***Life Science***

Outcome: **S.7.2** Students will differentiate between living and non-living organisms and how they are classified.

Components: **S.7.2.1** – Discriminate the characteristics of life at cellular level and beyond. 12.A.3a

S.7.2.2 – Differentiate between unicellular and multicellular organisms and name common examples of each. 12.A.4b

S.7.2.3 – Compare and contrast how unicellular and multicellular organisms perform various life functions. 12.A.4b

S.7.2.4 – Know that cells function similarly in all living organisms. 12.A.4b

S.7.2.5 – Categorize organisms using a taxonomic key. 12.A.4b

Outcome: **S.7.3** Students will defend and perform investigations relevant to microorganisms.

Components: **S.7.3.1** – Differentiate between bacterial cells and viruses. 12.A.3b

S.7.3.2 – Interpret and publish findings from an investigation about the effects of disinfectants or antibiotics on the growth of microorganisms. 12.A.3c, 12.B.3a

S.7.3.3 – Provide adequate supporting evidence to draw conclusions from an investigation. (Virus Day, Science Sleuth) 11.A.3f, 11.A.3g

S.7.3.4 – Explain from a historical example how a scientist modifies ideas based on new information. (Van Leeuwenhoek – cell theory) 13.A.3b

S.7.3.5 – Explain how the science and technology of microorganism strongly influence life both positively and negatively under different technological circumstances in the past and today. 13.A.3b, 13.B.3a

S.7.3.6 – Examine current and historical viral, bacteriological infectious diseases.

Outcome: **S.7.4** Students will communicate scientific knowledge related to miotic cell division and knowledge of cellular structure and organization.

Components: **S.7.4.1** – Analyze the structure and function of cells, tissues, and interactions in living organisms. 12.A.3c

S.7.4.2 – Distinguish animal cell organelles and their functions and compare to those of plant cells. (Include nucleus, mitochondria, cell membrane, vacuole, lysosome, Golgi body, endoplasmic reticulum, cell wall, and chloroplasts.) 12.A.4b

S.7.4.3 – Analyze concepts (diseases, deficiency, toxins, and other factors) that promote or disrupt the structure and function of living organisms and research and report findings. 12.A4a, 12.A.4b, 12.A.4c

S.7.4.4 – Observe cells functions similarly in all living organisms. 12.A.3c, 12.A.4b

S.7.4.5 – Explain how food, water and air provide molecules that serve as building materials to supply energy to organisms. (carbon dioxide/oxygen, water, nitrogen cycles, respiration, photosynthesis)

S.7.4.6 – Compare and contrast photosynthesis and respiration in terms of energy and materials. 12.A.4b

S.7.4.7 – Identify the roles of molecules (carbohydrates, proteins, water, and air) in the matter and energy of living organisms. 12.A.4b

S.7.4.8 – Model how cells divide to increase their numbers through a process called mitosis, which results in two daughter cells with identical sets of chromosomes. (Build models) 12.A.3b

S.7.4.9 – Observe mitotic changes under a microscope or time lapsed video or movie. (Observation and gather information) 12.A.3c

Outcome: **S.7.5** Students will establish that a typical cell of any organism contains genetic instructions that specify its traits. Those traits may be modified by environmental influences.

Components: **S.7.5.1** – Differentiate between the life cycles and reproduction methods of sexual and asexual organisms. 12.A.3b

S.7.5.2 – Identify that sexual reproduction produces offspring that inherit half their genes from each parent. (Meiosis) 12.A.3b

S.7.5.3 – Exhibit how one or more genes can determine an inherited trait.

S.7.5.4 – Determine that plant and animal cells contain many thousands of different genes and typically have two copies of every gene. The two copies (or alleles) of the gene may or may not be identical, and one may be dominant in determining the phenotype while the other is recessive. 12.A.4a

S.7.5.5 – Identify that DNA (deoxyribonucleic acid) is the genetic material of living organisms and is located in the chromosomes of each cell. 12.A.4b

S.7.5.6 – Explain that reproduction is necessary for inheritance of characteristics and continuation of species. 12.A.3b

S.7.5.7 – Use evidence to support the idea that through reproduction, sexual and asexual, (i.e., reproduction, cutting, selective breeding) genetic traits are passed on from one generation to the next. 12.A.3b, 12.A.4a

S.7.5.8 – Analyze and manipulate data from a genetic simulation lab using software or by creating a lab cross breeding plants with easy identifiable traits (e.g., Brassica rapa.) Determine accuracy of your predictions. 11.A.3e, 11.A.3f

S.7.5.9 – Use Punnett squares to predict ratios of traits. (Probability of outcomes) 11.A.3e

Focus: ***Physical Science***

Outcome: **S.7.6** Students will, as a basis for understanding scientific investigation and experimentation, develop their own questions and perform investigations that:

Components: **S.7.6.1** – Defend questions and perform investigations relevant to current unit of study. 11.B.3b, 11.B.3c

S.7.6.2 – Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data. 11.B.3d

S.7.6.3 – Use a variety of print and electronic resources (including the World Wide Web) to collect information and evidence as part of a research project.

S.7.6.4 – Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence. 11.B.3e

S.7.6.5 – Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., Cell structure). 11.A.3g

S.7.6.6 – Communicate the steps and results from an investigation in written reports and oral presentations. (Write lab reports, gather information) 11.B.3f

Science Curriculum
8th Grade

Focus: ***Physical Science – Sound and Light***

Outcome: **S.8.1** Students will assess the properties and the interaction of waves.

Components: **S.8.1.1** – Define waves and identify the cause of waves. 12.C.4a

S.8.1.2 – Identify and classify the main types of waves (transverse, longitudinal, and surface). 12.C.4a

S.8.1.3 – Model and describe the basic properties of waves. (Amplitude, length, speed, frequency, resonance) 12.C.4a

S.8.1.4 – Describe how a wave's speed is related to its wavelength and frequency to help calculate wave speed. 12.C.4a

S.8.1.5 – Identify and compare reflection, refraction and diffraction. 12.C.4a

S.8.1.6 – Describe the two types of interference of waves. (Constructive and destructive) 12.C.4a

Outcome: **S.8.2** Students will observe and explain concepts of sound.

Components: **S.8.2.1** – Define sound and explain how sound waves interact. 12.C.4a

S.8.2.2 – Identify variable that affect the speed and loudness of sound and identify variables that pitch of a sound depends on. 12.C.4a

S.8.2.3 – Explain the cause of the Doppler Effect. 12.C.4a

S.8.2.4 – Identify the parts and function of each section of the ear. 12.C.4a

S.8.2.5 – List the different uses of sound waves (ultrasound, music, echolocation, sonar). 12.C.4a

S.8.2.6 – Identify the societal effects of sound, both positive and negative. 12.C.4a

Outcome: **S.8.3** Students will explain the uses and function of electromagnetic waves and their place on the spectrum.

Components: **S.8.3.1** – Define an electromagnetic wave. 12.C.4a

S.8.3.2 – Identify models that explain the behavior of electromagnetic waves. (Quantum physics – wave vs. particle) 12.C.4a

S.8.3.3 – Compare and contrast the different types of electromagnetic waves. 12.C.4a

S.8.3.4 – Draw conclusions about light bulb economy. (CFL bulbs, etc.) 12.C.4a

S.8.3.5 – Explain the uses of all types of electromagnetic waves in technology and society. 12.C.4a

Outcome: **S.8.4** Students will examine light, color, and how light can be manipulated.

Components: **S.8.4.1** – Describe what happens to the light that strikes an object. 12.C.4a

S.8.4.2 – Describe how color is determined in an opaque, transparent, or translucent object. 12.C.4a

S.8.4.3 – Contrast and observe the mixing of pigments and the mixing of colors of light. (12.C.4a)

S.8.4.4 – Identify the kinds of reflection. 12.C.4a

S.8.4.5 – Differentiate concave and convex lenses. 12.C.4a

S.8.4.6 – Explain why light rays bend. 12.C.4a

S.8.4.7 – Describe the interaction of light and various lenses (contacts, eye glasses, telescopes). 12.C.4a

S.8.4.8 – Explain how the eye sees objects. 12.C.4a

S.8.4.9 – Explain how laser lights and optical fibers function. 12.C.4a

Focus: ***Chemistry***

Outcome: **S.8.5** Students will be able to describe the development and organization of the periodic table of elements.

Components: **S.8.5.1** – List information that can be found from each element listed on the periodic table. 12.C.3b

S.8.5.2 – Identify patterns of mass, reactivity, make up, and general properties of families and periods within the table. 12.C.3b

S.8.5.3 – Utilize a wide variety of information derived from the table. 12.C.3b

S.8.5.4 – Define pure substances, elements, compounds, and molecules. 12.C.3b

Outcome: **S.8.6** Students will be able to comprehend the history of atomic theory as well as the make up, reactivity and bonding ability of an atom.

Components: **S.8.6.1** – Describe how the atomic theory has started and changed throughout history leading to present day. 12.C.3b

S.8.6.2 – Explain how the reactivity and bonding ability of an element is related to the number of valance electrons it contains. 12.C.3b

S.8.6.3 – Demonstrate covalent and ionic bonds. 12.C.3b

S.8.6.4 – Explain how the atomic number is used to create a model of an atom. (Lewis structures, Bohr Diagrams) 12.C.3b

S.8.6.5 – Understand how a chemical formula is written. 12.C.3b

Outcome: **S.8.7** Students will observe chemical and physical changes and properties of matter.

Components: **S.8.7.1** – Explain the particle structure of the three states of matter and how matter can change phase. 12.C.3a

S.8.7.2 – Give real-world examples of physical and chemical changes. 12.C.3a

S.8.7.3 – Analyze the data on a graph when energy is added or taken away in a chemical or physical change. 12.C.3a

S.8.7.4 – State the principles of the Law of Conservation of Mass and Energy (balanced chemical equations). 12.C.3a

S.8.7.5 – Explain how the addition and subtraction of energy is related to physical and chemical changes in matter. 12.C.3a

S.8.7.6 – Compare and contrast physical and chemical changes. 12.C.3a

Focus: ***Force & Motion***

Outcome: **S.8.8** Students will understand motion, calculate speed, velocity, and acceleration and utilize the graphing of that data.

Components: **S.8.8.1** – Determine when an object is in motion using reference points. 12.D.3a

S.8.8.2 – Calculate an object's speed and velocity. 12.D.3a

S.8.8.3 – Demonstrate how to graph motion. 11.A.3e

S.8.8.4 – Graph average speed using distance time variables. 11.A.3e

S.8.8.5 – Describe the motion of an object as it accelerates. 12.D.3a

S.8.8.6 – Calculate acceleration. 12.D.3a, 12.D.4a

S.8.8.7 – Describe the graphs used to analyze the motion of an accelerating object. 12.D.4a

S.8.8.8 – Collect and interpret data from the motion of an accelerating object. 11.A.3c, 11.A.3f

S.8.8.9 – Understand how to calculate various types of units. (Metric to American standard)

Outcome: **S.8.9** Students will explain and apply various types of forces and there relationship to movement.

Components: **S.8.9.1** – Describe force. 12.D.3a

S.8.9.2 – Explain how balanced and unbalanced forces are related to an object's motion. 12.D.5a

S.8.9.3 – Describe the different types of friction, and identify factors that determine the friction force between two objects. 12.D.5a

S.8.9.4 – Identify the factors that affect the gravitational force between two objects. 12.D.3b

S.8.9.5 – Explain why objects accelerate during free fall. 12.D.3b

S.8.9.6 – Graph data of acceleration vs. force and interpret data about the relationship between force and acceleration for constant mass. 12.D.3b

S.8.9.7 – Apply and demonstrate Newton's first, second and third laws of motion. 13.B.3b

S.8.9.8 – Explain how an object's momentum is determined. 12.D.3b

S.8.9.9 – Understand the Law of Conservation of momentum and calculate how momentum is conserved during collisions. 12.D.3b

S.8.9.10 – Define and illustrate centripetal force. 12.D.4a

Outcome: **S.8.10** Explain and demonstrate pressure, fluid forces, density, Archimedes's, Pascal's and Bernoulli's Principles.

Components: **S.8.10.1** – Explain and calculate pressure. 12.D.3a

S.8.10.2 – Explain how fluids exert pressure. 12.D.3a

S.8.10.3 – Comprehend Archimedes's principle and how it affects buoyant force. 12.D.3a

S.8.10.4 – Explain and calculate how the density of an object determines whether it sinks or floats. 12.D.3a

S.8.10.5 – State Pascal's Principle and recognize its application. 13.B.3b

S.8.10.6 – Use Bernoulli's Principle to explain how fluid pressure is related to the motion of a fluid and list applications. 12.D.3a

Outcome: **S.8.11** The students will be able to identify and calculate work, power, and also be able to calculate the efficiency and mechanical advantage of simple machines.

Components: **S.8.11.1** – Identify and calculate when work is done on an object. 12.D.3a

S.8.11.2 – Define and calculate power. 12.C.4a

S.8.11.3 – Explain how machines make work easier. 12.D.3a

S.8.11.4 – Calculate the mechanical advantage of a machine. 12.C.4a

S.8.11.5 – Calculate the efficiency of a machine. 12.C.4a

S.8.11.6 – Describe the six kinds of simple machines and their uses. 12.D.3a

S.8.11.7 – Calculate the ideal mechanical advantage of each type of simple machine. 12.C.4a

S.8.11.8 – Describe compound machines. 12.D.3a

Outcome: **S.8.12** Students will understand and illustrate various forms of energy, how they are related, and how they are conserved.

Components: **S.8.12.1** – Describe how energy, work and power are related. 12.D.3a

S.8.12.2 – Describe and calculate kinetic and potential energy. 12.C.4a

S.8.12.3 – Explain the six forms of energy. (Mechanical, chemical, thermal, electromagnetic, nuclear, and electrical) 12.D.3b

S.8.12.4 – State and apply the Law of Conservation of energy and name common energy transformations. 12.C.4a

S.8.12.5 – Understand and illustrate the origin of fossil fuels and how its energy is still used to today. 12.E.3c

S.8.12.6 – Compare and contrast alternative forms of renewable energy. 12.E.3c, 13.B.3d

Focus: ***Astronomy***

Outcome: **S.8.13** Students will understand the scope, scale, and origins of the universe, the galaxies within, solar systems, stars, and planets.

Components: **S.8.13.1** – Describe how stars are classified. 12.F.3b

S.8.13.2 – Compare absolute and apparent magnitude and predict the parallax shift of an object at different distances.

S.8.13.3 – Describe the H - R diagram, a Star System, and explain how astronomers use it. 12.F.4a, 12.F.4b

S.8.13.4 – Identify the major types of galaxies. 12.F.4b

S.8.13.5 – Explain how astronomers describe the scale of the universe. 12.F.5b

S.8.13.6 – Describe the Big Bang Theory and compare the theory with what astronomers predict for the future of the universe. 12.F.4a

S.8.13.7 – Explain how our Solar System is unique and how the goldilocks effect states the essentials for life. 12.F.3a

S.8.13.8 – Explain how astronomers describe the scale of the universe, its origins, and future.

S.8.13.9 – Define what makes up our solar system. (8 major planets, comets, asteroids, dwarf planets)

Outcome: **S.8.14** Students will explain the origin and benefits of space technology and its influence on exploration and study.

Components: **S.8.14.1** – Explain how early and modern day rockets were developed and operate. 13.A.4c, 13.B.2b

S.8.14.2 – Describe the space race and how it led to the Apollo program and the moon landings. 13.B.2b, 13.B.3b, 13.B.3a

S.8.14.3 – Distinguish between the roles of space shuttles and those of space stations. 13.B.3a

S.8.14.4 – Identify the various types and uses of probes. 13.B.3a

S.8.14.5 – Describe some uses of satellites orbiting earth and integrate physics concepts into the explanation. 13.B.3a, 13.A.4c

S.8.14.6 – Debate whether space exploration is worth the cost. 13.A.4c

S.8.14.7 – Identify the benefits that space technology has provided for modern society. 13.B.2b, 13.B.3a, 13.A.4c

Outcome: **S.8.15** Students will describe the characteristics and relationship of the Earth, moon, and sun.

Components: **S.8.15.1** – Illustrate the causes of seasonal change, day and night, and tides. 12.F.3a, 12.F.3b

S.8.15.2 – Describe the origins and characteristics of the moon as well as its roll in eclipses and tidal changes. 12.F.3a, 12.F.3b

S.8.15.3 – Understand the composition of the sun nuclear fission and its role in the solar system. 12.F.3a, 12.F.3b, 12.F.3c

Science Curriculum

Introduction to Physical Science (IPS—Full year)

Focus: Students will implement the process of the scientific method and demonstrate proficiency in lab techniques.

Outcome: **IPS.1** Students will investigate and relate the concepts of volume and mass.

Component: **IPS1.1** – Estimate volume of a liquid by reading a graduated cylinder. 11.A.4c

IPS.1.2 – Using a ruler, estimate length, width, and height, of a regular shaped object to calculate volume. 11.A.4c

IPS.1.3 – Calculate volume of an irregular object using water displacement. 11.A.4c

IPS.1.4 – Explain the shortcomings of volume as a measure of matter. 11.A.4c

IPS.1.5 – Differentiate between mass and weight. 11.A.4c

IPS.1.6 – Manipulate numbers in the metric system. 11.A.4c

Outcome: **IPS.2** Students will know and apply the concepts, principles, and processes of scientific inquiry.

Component: **IPS.2.1** – Formulate a purpose and hypothesis that can be tested. 11.A.3a

IPS.2.2 – Compose a list of steps on how to perform the test from a written description.

IPS.2.3 – Conduct scientific experiments that control all but one variable. 11.A.3b

IPS.2.4 – Collect and record data accurately using consistent measuring and recording techniques and tools. 11.A.3c

IPS.2.5 – Evaluate data for accuracy and precision. (11.A.3e)

IPS.2.6 – Explain the difference between qualitative and quantitative data. 11.A.3f

IPS.2.7 – Explain the existence of unexpected results of analysis to produce findings. 11.A.3d

IPS.2.8 – Interpret and represent results of analysis to produce findings. 11.A.3f

IPS.2.9 – Report and display the process and results of a scientific inquiry. 11.A.3g

IPS.2.10 – Apply the safety rules set forth in the class to the appropriate experiment. 13.A.4a

Outcome: **IPS.3** Students will investigate the Law of Conservation of Mass.

Component: **IPS.3.1** – Distinguish between physical and chemical changes. 12.C.3b

IPS.3.2 – Calculate the change in mass of physical changes through experimentation. 11.A.4b

IPS.3.3 – Calculate the change in mass of chemical changes through experimentation. 11.A.4b

IPS.3.4 – Calculate the percent change in a reaction. 11.A.4d

IPS.3.5 – Distinguish between reactant and products.

IPS.3.6 – Evaluate the importance of a closed system. 11.A.4b

IPS.3.7 – Defend the law of conservation of mass. 12.C.4b

Outcome: **IPS.4** Students will investigate several characteristic properties (boiling point, condensing point, freezing point, melting point, density, solubility, and flammability) in order to differentiate between and/or identify substances.

Component: **IPS.4.1** – Distinguish between characteristic and object properties.

IPS.4.2 – Construct a graph from a set of data. 11.A.4c, 11.A.4f

IPS.4.3 – Conduct an experiment to determine the boiling point of a substance from a graph of its data. 11.A.4b, 11.A.4c, 12.C.5b

IPS.4.4 – Conduct an experiment to discover the melting/freezing point of a substance by graphing the results. 11.A.4b, 11.A.4c, 12.C.5b

IPS.4.5 – Identify phase changes from a cooling/heating curve.

11.A.4d, 12.C.5b

IPS.4.6 – Identify the relationship of mass and volume to density.

IPS.4.7 – Investigate density of solids, liquids, and gases through experimentation. 11.A.4b, 11.A.4c

IPS.4.8 – Investigate the affects of heat on the solubility of solids and gases through experimentation. 11.A.4b, 11.A.4c

IPS.4.9 – Investigate the affect of the type of solute on solubility.

IPS.4.10 – Differentiate between solute and solvent.

IPS.4.11 – Compare and contrast solubility and concentration. 12.C.5b

IPS.4.12 – Differentiate between concentration and density. 12.C.5b

IPS.4.13 – Conduct an experiment to investigate flammability as a characteristic of liquids and gases. 11.A.4b, 11.A.4c

IPS.4.14 – Interpret a solubility graph. 11.A.4d, 11.A.4f

IPS.4.15 – Identify how acid rain is produced and how it affects our environment. 12.C.5b

Outcome: **IPS.5** Students will investigate several separation techniques for various types of mixtures.

Component: **IPS.5.1** – Separate a mixture of solids based on solubility. 12.C.5b

IPS.5.2 – Use chromatography to separate a mixture of liquids. 12.C.5b

IPS.5.3 – Separate a mixture of solids based on density. 12.C.5b

IPS.5.4 – Separate a mixture of liquids based on its boiling point. 12.C.5b

IPS.5.5 – Use filtration to separate a solid/liquid mixture. 12.C.5b

IPS.5.6 – Differentiate between mixtures and pure substances. 12.C.5b

IPS.5.7 – Design and perform an experiment to separate and identify the substances within an unknown mixture. 11.A.4a, 11.A.5b, 11.A.5c

Outcome: **IPS.6** Students will distinguish between acidic and basic solutions.

Component: **IPS.6.1** – Define acid and base. 12.C.5b

IPS.6.2 – Investigate pH using indicators and pH meter.

IPS.6.3 – Describe the relationship between pH and hydrogen ion/hydroxide ion concentration. 12.C.5b

IPS.6.4 – Identify acids and bases using pH. 11.A.5b

IPS.6.5 – Deduce acid base strength using pH. 11.A.5d

IPS.6.6 – Identify properties of acids and bases. 12.C.5b

Science Curriculum
Earth Science

Outcome: **ES.1** Students will analyze various maps by integrating concepts and skills of mapping.

Components: **ES.1.1** – Explain how a magnetic compass can be used to find directions on the Earth's surface. 12.E.4a

ES.1.2 – Explain how scientists get data to make a map with a GPS and transom surveying. 17.A.4b, 17.A.3a

ES.1.3 – Describe the characteristics and uses of three types of map projections.

ES.1.4 – Demonstrate how to use keys, legends, and scales to read maps. 17.A.4b

ES.1.5 – Explain how elevation and topography are shown on a map. 17.A.3b

ES.1.6 – Describe three types of information shown on geologic maps and the relevance of that information. 17.A.4a

ES.1.7 – Demonstrate the ability to use the Illinois road map to find locations, calculate distances, and find points of interest between cities in Illinois.

Outcome: **ES.2** Students will analyze plate tectonics and infer probable changes in the Earth's surface.

Components: **ES.2.1** – Summarize Wegener's hypothesis of continental drift. 12.E.4a

ES.2.2 – Describe the process of sea-floor spreading and explain how magnetic polarity of rock provides support for the hypothesis of sea-floor spreading. 12.E.4a

ES.2.3 – Relate how sea-floor spreading provides a mechanism for continental drift. 12.E.4a

ES.2.4 – Summarize the theory of plate tectonics. 12.E.4a

ES.2.5 – Identify and describe the three types of plate boundaries. 12.E.4a

ES.2.6 – List and describe three causes of plate movement and how movements of tectonic plates change Earth's surface. 12.E.4a

ES.2.7 – Describe elastic rebound. 12.E.4a

ES.2.8 – Compare and contrast the three types of seismic waves and how the structure of the Earth's interior affects seismic waves. 12.E.4a

ES.2.9 – Explain why earthquakes generally occur at plate boundaries. 12.E.4a

ES.2.10 – Describe the instrument and scales used to measure and record earthquakes. (Seismograph)

ES.2.11 – Summarize the method scientists use to locate an epicenter.

ES.2.12 – Describe the relationship between tsunamis and earthquakes. 12.E.4a

ES.2.13 – Compare and contrast the types of volcanoes. 12.E.4a

Outcome: **ES.3** Students will analyze minerals according to their various properties.

Components: **ES.3.1** – Define mineral. 12.E.4b

ES.3.2 – List five special properties that may help identify certain minerals. 12.E.4b

ES.3.3 – Describe and use the seven physical properties (color, streak, luster, cleavage and fracture, hardness, density, crystal shape) that help distinguish one mineral from another. 12.E.4b

ES.3.4 – Compare and contrast the two main groups of minerals. 12.E.4b

ES.3.5 – Illustrate the six types of silicate crystalline structures. 12.E.4b

ES.3.6 – Describe the three common non-silicate crystalline structures. 12.E.4b

ES.3.7 – Demonstrate through use of a mineral key the concept of mineral identification. 12.E.4b

Outcome: **ES.4** Students will analyze the three rock classes and point out how the rock cycle affects each.

Components: **ES.4.1** – Identify the three major types of rock and explain how each type forms. 12.E.4b

ES.4.2 – Summarize the steps in the rock cycle. 12.E.4b

ES.4.3 – Summarize the factors that affect the stability of rocks. 12.E.4b

ES.4.4 – Describe how the cooling rate of magma and lava affects the texture of igneous rocks. 12.E.4b

ES.4.5 – Classify igneous rocks according to their composition and texture. 12.E.4b

ES.4.6 – Distinguish between intrusive and extrusive igneous rock structures. 12.E.4b

ES.4.7 – Compare and contrast the processes of compaction and cementation. 12.E.4b

ES.4.8 – Categorize how chemical, clastic, and organic sedimentary rocks form. 12.E.4b

ES.4.9 – Identify seven sedimentary rock features. 12.E.4b

ES.4.10 – Describe the process of metamorphism. 12.E.4b

ES.4.11 – Explain the difference between regional and contact metamorphism. 12.E.4b

ES.4.12 – Distinguish between foliated and non-foliated metamorphic rocks. 12.E.4b

Outcome: **ES.5** Students will appraise the human impact on the Earth's resources.

Components: **ES.5.1** – Explain what ores are and how they form. 13.B.3e

ES.5.2 – Identify four uses for mineral resources. 13.B.3d

ES.5.3 – Summarize two ways humans obtain mineral resources. 13.B.3e

ES.5.4 – Correlate the fossil fuels. 13.B.3

ES.5.5 – Describe how petroleum and natural gas form and how they are removed from Earth. 13.B.3e

ES.5.6 – Explain how water, wind, and geothermal energy may be used as substitutes for fossil fuels. 13.B.3f

ES.5.7 – Compare passive and active methods of harnessing energy from the sun. 13.B.3f

ES.5.8 – Catalog the environmental impacts of mining and the increased use of fossil fuels. 13.B.3e, 13.B.4d

ES.5.9 – Generate ideas for ways that the environmental impacts of mining can be reduced. 13.B.4d

ES.5.10 – Generate ideas for ways that an individual can conserve natural resources. 13.B.4a

Outcome: **ES.6** Students will interpret the important developments in the major geologic time divisions.

Components: **ES.6.1** – Summarize how scientists worked together to develop the geologic column. 12.E.4b

ES.6.2 – List the major divisions of geologic time. 12.E.4b

ES.6.3 – Recognize the characteristics of and identify the locations of Precambrian rock layers. 12.E.4b

ES.6.4 – Identify major geologic and biological developments during the Paleozoic Era. 12.E.4b

ES.6.5 – List the periods of the Mesozoic and Cenozoic Eras and document life forms in each. 12.E.4b

ES.6.6 – Identify major geologic and biological developments during the Mesozoic Era and Cenozoic Era. 12.E.4b

ES.6.7 – Distinguish between absolute age and relative age and explain how each are used to determine the age of a rock. 12.E.4b

Earth Science II

Purpose: Students will explore erosion, its causes and its specific effects on soil, freshwater and saltwater bodies and atmospheric forces. Students will participate in scientific reading and graphical analysis skills by interacting with information from a variety of sources. Students will utilize scientific methods to analyze and critique lab experiments.

Unit 1- Review of Scientific Methods/Skills and Erosion

Outcome: **ES2.1** Students will investigate basis for the study of changes in the earth, characterize properties of and perform a variety of basic laboratory procedures and calculations.

Components: Scientific Method and Measurement:

ES2.1.1 – Research and summarize information about a specific geological topic.

ES2.1.2 – Utilize the scientific method to test hypothesis about a geological issue.

ES2.1.3 – Perform calculations involving density and specific gravity.

ES2.1.4 – Discuss uncertainty in measurement including accuracy and precision.

Soil and Erosion:

ES2.1.5 – Define weathering, erosion and deposition.

ES2.1.6 – Differentiate between mechanical and chemical weathering and give examples of each.

ES2.1.7 – Identify and label the different layers within a developing soil.

ES2.1.8 – Compare physical properties of soils from a variety of locations.

ES2.1.9 – Compare and contrast wind and water erosion, emphasizing the effects on local populations.

Lab Components:

- Observe and analyze various soil samples to determine physical characteristics of each.

Unit 2: Freshwater

Outcome: **ES2.2** Students will explore the interconnectedness of the Earth's water, the formation of rivers and glaciers and the groundwater network. A

special emphasis will be placed on the Fox River and how people can impact the health of the Fox River.

Components: Rivers:

ES2.2.1 – Build a model to demonstrate the water cycle.

ES2.2.2 – Label the various parts of a stream as it develops into a river or flows into a lake.

ES2.2.3 – Analyze the effect of various physical factors (stream load, discharge, gradient, geography and deposition) on rivers.

Groundwater:

ES2.2.4 – Identify the properties of aquifers that affect the flow of groundwater.

ES2.2.5 – Describe the water table and its relationship to the land surface.

ES2.2.6 – Investigate the porosity and permeability of different types of rocks relate to the water table.

ES2.2.7 – Explain the formation of caverns and sinkholes.

Glaciers:

ES2.2.8 – Explain the formation of glaciers and distinguish between the two types of glaciers.

ES2.2.9 – Describe the glacial and interglacial periods within an ice age.

ES2.2.10 – Summarize the theory that best accounts for ice ages.

Lab Components:

- Create a model of the water cycle
- Investigate the ability of different soils to purify water
- Model glacial movement

Unit 3: Oceans

Outcome: **ES2.3** Students will describe the physical makeup of both ocean water and the oceans floor. Students will also investigate the causes of movements within the ocean and the effects of these movements on our weather.

Components: Oceans:

ES2.3.1 – Investigate different tools of oceanography. (sonar, submersibles, core samples)

ES2.3.2 – Describe the formation of different features on the ocean floor.

ES2.3.3 – Research the physical properties of ocean water.

ES2.3.4 – Describe the major zones of life in the ocean.

ES2.3.5 – Illustrate ways that we are dependent on the ocean.

Lab Components:

- Compare the density of hot and cold water as well as salt and freshwater.

Movements in the Oceans:

ES2.3.6 – Explain how the differences in density of ocean water affect the flow of deep currents.

ES2.3.7 – Describe how wind patterns, the rotation of the Earth and continental barriers affect the surface currents in the ocean.

ES2.3.8 – Describe how waves are formed and factors that might affect wave size.

ES2.3.9 – Explain how gravitational pull causes tides and how coastlines can affect these tides.

Unit 4 – Atmospheric Forces

Outcome: **ES2.4** Students will use a variety of meteorological tools to make measurements of atmospheric conditions and predict weather based on these conditions. Students will research climate change data and form opinions based on data presented.

Components: Atmosphere and the Water Within:

ES2.4.1 – Describe the composition of the Earth's atmosphere.

ES2.4.2 – Identify the layers of the Earth's atmosphere.

ES2.4.3 – Explain how radiation heats the surface of the Earth differently due to differences in the latitude, surface features and time of day and year.

Weather:

ES2.4.4 – Track local atmospheric conditions using meteorological equipment (thermometers, barometers, hygrometers, radar and anemometers).

ES2.4.5 – Describe the conditions that are necessary for clouds to form.

ES2.4.6 – Classify clouds based on physical features.

ES2.4.7 – Explain how computer models help meteorologist forecast weather.

Climate:

ES2.4.8 – Explain how and air mass forms.

ES2.4.9 – Investigate climate trends and factors that impact these trends.

ES2.4.10 – Identify ways that humans can minimize their effects on climate change.

Lab Components:

- Use thermometers, barometers and anemometers to test hypotheses made about atmospheric conditions.
- Research a small part of the “global warming” issue and present facts to support their assigned viewpoint.

Science Curriculum

Astronomy

Purpose: Students will explore motion of planets, stars and galaxies, maps of the heavens, information contained in light, forces acting on the heaves, how stars form, live and die, galaxies, the cosmos and the theory's of it's beginning, and whether or not there is intelligent life in the universe.

Unit 1-Exploring the Sky

Subtopics

Outcome: **AST.1** Math of astronomy.

Components: **AST.1.1** – Describe and account for the apparent motions of natural objects in the sky in terms of the actual motions of the Earth and the Moon.

AST.1.2 – Explain how astronomers use indirect measurement to measure the distances and sizes of faraway objects.

AST.1.3 – Explain the simple geometric reasoning that allows astronomers to measure the distances and sizes of faraway objects.

AST.1.4 – Use indirect measurement to measure objects like the moon.

Skills and Lab Components:

- Lab safety
- Reading the text with understanding
- Use of scientific notation, angles, and units of measurement
- Lab Paper moon; uses parallax to measure distant objects
- Indirect measurement of the solar system
- Lab Eclipse Movement of the Earth, moon and sun
- Lab shadow stick Astronomy

Outcome: **AST.2** Mapping the heavens.

Components: **AST.2.1** – Sketch the major contributions of ancient civilizations, Newton, Galileo, and Kepler to the development of our understanding of the solar system.

AST.2.2 – Sketch and describe the basic designs of the major types of optical telescopes used by astronomers.

AST.2.3 – Explain the concept of the celestial sphere as model of the sky. Locate objects in the sky using angular measurements of right ascension and declination.

AST.2.4 – Describe how the Sun, the Moon, and the stars appear to change their positions from night to night and from month to month.

AST.2.5 – Apply apparent motions in terms of the actual motions of Earth and the Moon.

AST.2.6 – Demonstrate how the relative motions of Earth, the Sun, and the Moon lead to eclipses.

Skills and Lab Components:

- Lab Pop up globe -Using plain sphere and celestial globe to find objects in the heavens.
- Lab mapping the sky

Outcome: **AST.3** Light

Components: **AST.3.1** – Explain the relationship between the elements and light of stars.

AST.3.2 – Calculate the wavelength and frequency of light in different types of light.

AST.3.3 – Calculate the energy produced by different wavelengths of light.

AST.3.4 – List and explain the kinds of information that can be obtained by analyzing the spectra of astronomical objects.

AST.3.5 – Discuss the nature of electromagnetic radiation and tell how that radiation transfers energy and information through interstellar space.

AST.3.6 – Describe the major regions of the electromagnetic spectrum and explain how the properties of Earth's atmosphere affect our ability to make astronomical observations at different wavelengths.

AST.3.7 – Explain what is meant by the term "blackbody radiation" and describe the basic properties of such radiation.

AST.3.8 – Tell how we can determine the temperature of an object by observing the radiation that it emits.

AST.3.9 – Show how the relative motion of a source of radiation and its observer can change the perceived wavelength of the radiation, and explain the importance of this phenomenon to astronomy.

Skills and Lab Components:

- Lab spectral analysis

- Lab Doppler shifting
- Lab expansion of the Universe

Outcome: **AST.4** Forces

Components: **AST.4.1** – Sketch the major contributions of Galileo and Kepler to the development of our understanding of the solar system.

AST.4.2 – State Kepler's laws of planetary motion.

AST.4.3 – Explain how Kepler's laws enable us to construct a scale model of the solar system, and explain the technique used to determine the actual size of the planetary orbits.

AST.4.4 – State Newton's laws of motion and universal gravitation and explain how they account for Kepler's laws.

AST.4.5 – Explain how the law of gravitation enables us to measure the masses of astronomical bodies.

Skills and or Lab Components:

- Lab orbital motion of the planets
- Lab magnetic fields
- Lab Retrograde motion of Mars
- Lab Gravity
- Lab Weight on Mars

Standards meet in this unit:

12.F.2a, 12.F.2b, 12.F.2c, 12.F.3b, 12.E.5, 12.F.5b, 13.B.4b, 13.A.5b, 11.A.3a-g, 11.A.4a-c

The Stars

Outcome: **AST. 5** The Sun.

Components: **AST.5.1** – Outline the process by which energy is produced in the Sun's interior.

AST.5.2 – Summarize the overall properties of the Sun.

AST.5.3 – Explain how energy travels from the solar core, through the interior, and out into space.

AST.5.4 – Name the Sun's outer layers and describe what those layers tell us about the Sun's surface composition and temperature.

AST.5.5 – Discuss the nature of the Sun's magnetic field and its relationship to the various types of solar activity.

Skills and or Lab Components:

- Lab Energy transport from the Sun
- Lab Sunspots
- Inverse-Square law activity

Outcome: **AST.6** Interstellar Medium and Star Formation

Components: **AST.6.1** – Discuss the factors that compete against gravity in the process of star formation.

AST.6.2 – Summarize the sequence of events leading to the formation of a star like our Sun.

AST.6.3 – Explain how the process of star formation depends on stellar mass.

AST.6.4 – Describe some of the observational evidence supporting the modern theory of star formation.

AST.6.5 – Explain the nature of interstellar shock waves and discuss their possible role in the formation of stars.

Outcome: **AST.7** Stellar evolution.

Components: **AST.7.1** – Explain why stars evolve off the main sequence.

AST.7.2 – Outline the events that occur after a Sun-like star exhausts the supply of hydrogen in its core.

AST.7.3 – Summarize the stages in the death of a typical low-mass star and describe the resulting remnant.

AST.7.4 – Contrast the evolutionary histories of high-mass and low-mass stars.

AST.7.5 – Discuss the observations that help verify the theory of stellar evolution.

AST.7.6 – Explain how the evolution of stars in binary systems may differ from that of isolated stars.

Skills and or Lab Components:

- Activity stages of a protostar
- Lab HR diagram

Outcome: **AST.8** Deaths of Stars.

Components: **AST.8.1** – Explain why stars evolve off the main sequence.

AST.8.2 – Outline the events that occur after a Sun-like star exhausts the supply of hydrogen in its core.

AST.8.3 – Summarize the stages in the death of a typical low-mass star and describe the resulting remnant.

AST.8.4 – Contrast the evolutionary histories of high-mass and low-mass stars.

AST.8.5 – Discuss the observations that help verify the theory of stellar evolution.

AST.8.6 – Explain how the evolution of stars in binary systems may differ from that of isolated stars.

Skills and or Lab Components:

- Lab supernova 1987a

Outcome: **AST.9** Neutron stars and Black holes.

Components: **AST.9.1** – Describe the properties of neutron stars and explain how these strange objects are formed.

AST.9.2 – Explain the nature and origin of pulsars and account for their characteristic radiation.

AST.9.3 – Describe how black holes are formed and discuss their effects on matter and radiation in their vicinity.

AST.9.4 – Relate the phenomena that occur near black holes due to the warping of space around them.

AST.9.5 – Discuss the difficulties in observing black holes and explain some of the ways in which the presence of a black hole might be detected.

Skills and or Lab Components:

- Lab special and general relativity
- Lab warpage of space time

Standards meet in this unit:

12.E.4a, 12.F.3b, 12.F.4b, 12.F.5a, 13.A.4c, 13.B.4b, 13.A.5c, 13.A.5b, 12.F.3c, 12.F.5b, 13.A.4c, 13.B.4b, 13.A.5c, 13.A.5b, 11.A.3a-g, 11.A.4a-c

The Universe

Outcome: **AST.10** The Milky Way.

Components: **AST.10.1** – Describe the overall structure of the Milky Way Galaxy and specify how the various regions differ from one another.

AST.10.2 – Explain the importance of variable stars in determining the size and shape of our Galaxy.

AST.10.3 – Discuss some possible explanations for the existence of the spiral arms observed in our own Galaxy and in many others, as well.

AST.10.4 – Explain what studies of galactic rotation reveal about the size and mass of our Galaxy and discuss the possible nature of dark matter.

AST.10.5 – Describe some of the phenomena observed at the center of our Galaxy.

Skills and or Lab Components:

- Lab spiral arms near the Sun
- Lab evidence for hidden mass

Outcome: **AST.11** Galaxies

Components: **AST.11.1** – Describe the basic properties of the main types of normal galaxies.

AST.11.2 – Identify and properly name galaxies.

AST.11.3 – Discuss the distance-measurement techniques that enable astronomers to map the universe beyond the Milky Way.

AST.11.4 – Summarize what is known about the large-scale distribution of galaxies in the universe.

AST.11.5 – Explain why astronomers think that most of the matter in the universe is invisible.

AST.11.6 – Discuss some theories of how galaxies form and evolve.

Skills and or Lab Components:

- Lab Identifying Galaxies
- Lab Galaxy Classification

Outcome: **AST.12** Cosmology

Components: **AST.12.1** – Explain how the age of the universe is determined and discuss the uncertainties involved. Summarize the process of cosmic evolution, as it is currently understood.

AST.12.2 – Explain how the age of the universe is determined and discuss the uncertainties involved.

AST.12.3 – Summarize the leading evolutionary models of the universe.

AST.12.4 – Discuss the factors that determine whether the universe will expand forever.

AST.12.5 – Explain what observations of the distant universe reveal about cosmic composition.

AST.12.6 – Explain the relationship between the future of the universe and the overall geometry of space.

AST.12.7 – Describe the cosmic microwave background radiation and explain its importance to our understanding of cosmology.

Skills and or Lab Components:

- Lab Expansion of the Universe
- Lab Galaxy Classification

Outcome: **AST.13** Astrobiology

Components: **AST.13.1** – Describe various probabilities used to estimate the number of advanced civilization the might exist in the Galaxy.

AST.13.2 – Summarize the process of cosmic evolution as it is currently understood.

AST.13.3 – Define what make a civilization advanced enough to find.

AST.13.4 – Evaluate the chances of finding life in the solar system.

AST.13.5 – Solve Drake's equation for the most unknown factor. (Intelligent life)

AST.13.6 – Summarize the various probabilities used to estimate the number of advanced civilizations that might exist in the Galaxy.

AST.13.7 – Discuss some of the techniques we might use to search for extraterrestrials and to communicate with them.

Skills and or Lab Components:

- Lab Extremophiles on Earth
- Lab hunt for life in the solar system

Standards meet in this unit:

12.F.3c, 12.F.5b, 13.A.4c, 13.B.4b, 13.A.5c, 13.A.5b, 11.A.3a-g, 11.A.4a-c

Current Science Topics

Grades 10 – 12

Purpose: This class is a combination of evaluating current topics in science, doing the science necessary to understand the topics studied and communicating the investigational findings. These goals will be accomplished through a variety of individual and group projects, class readings and discussions, weekly vocabulary building and laboratory experiences.

Focus: Students will read and discuss current technology, research and topics in science today.

Outcome: **CST.1** Critical Analysis of current science issues.

Components: **CST.1.1** – Daily reading of print media.

CST.1.2 – Semester project related to current science.

Outcome: **CST.2** Reading Comprehension

Components: **CST.2.1** – Reading guides and analysis.

Outcome: **CST.3** Improve vocabulary.

Components: **CST.3.1** – Root word lists (quizzes).

CST.3.2 – Word Journal

Outcome: **CST.4** Graphical Analysis

Outcome: **CST.5** Use the scientific method to set up and/or collect data relate to current science issues.

Science Curriculum

Freshman Honors Biology (9th Grade)

Outcome: **FHBIO.1** Students will demonstrate an understanding of process and methods used to gather scientific knowledge.

Components: **FHBIO.1.1** – Describe the importance of scientific process such as observation, inferring, hypothesizing and predicting. 13.A.5c

FHBIO.1.2 – Identify independent, dependent and standardized variables. 11.B.5b

FHBIO.1.3 – Identify appropriate levels of treatment in an experiment. 11.B.5b

FHBIO.1.4 – Explain the difference between control and experimental set-ups and the importance of each. 11.B.5d

FHBIO.1.5 – Identify ways that replication can be incorporated into a controlled experiment. 11.A.5c

FHBIO.1.6 – Select the best type of graph to construct (bar or line) based on the data to be graphed. 11.A.5e

FHBIO.1.7 – Construct appropriate data tables and graphs showing correct placement of all the components of the design. (Dependent and independent variables on an axis, scale numbers, and unit labels) 11.A.5e

FHBIO.1.8 – Design a controlled experiment, identifying appropriate independent, dependent and standardized variables; levels of treatment; and incorporating replication into the design. 11.B.5b

FHBIO.1.9 – Describe the relationship between a hypothesis, a theory and a law. 13.A.5b

FHBIO.1.10 – Critique an experiment, determining the appropriateness of all the components of the design. 11.B.5e

FHBIO.1.11 – Express metric measurements made with metric ruler, graduated cylinder and balance with the correct degree of precision.

FHBIO.1.12 – Express calculations made with metric measurements using the correct number of significant digits.

FHBIO.1.13 – Convert metric measurements from one unit to another using the method of Dimensional Analysis.

Outcome: **FHBIO.2** Students will demonstrate appropriate and safe use of the Compound Light Microscope and related equipment.

Components: **FHBIO.2.1** – Identify parts of the microscope.

FHBIO.2.2 – Calculate total magnification.

FHBIO.2.3 – Create a wet mount slide.

FHBIO.2.4 – Focus on a specimen using low and high power.

FHBIO.2.5 – Compare apparent to actual movement using both the Compound Light Microscope and the Stereomicroscope.

FHBIO.2.6 – Determine the most appropriate microscope to use based on the specimen.

FHBIO.2.7 – Describe the ways in which a specimen appears differently using the Compound Light Microscope compared to the unaided eye.

FHBIO.2.8 – Describe the ways in which a specimen's appearance changes from low to high power.

FHBIO.2.9 – Explain the relationship between magnification and resolution.

FHBIO.2.10 – Compare advantages and disadvantages of both the Compound Light Microscope and the Stereomicroscope.

Outcome: **FHBIO.3** Students will demonstrate an understanding of the interactions of matter.

Components: **FHBIO.3.1** – List the names and symbols of the first 20 elements. 12.C.4b

FHBIO.3.2 – Identify the charges, location, mass and symbol for each of the subatomic particles. 12.C.4b

FHBIO.3.3 – Use the periodic table to determine the number of protons, neutrons and electrons in an atom of a particular element. 12.C.4b

FHBIO.3.4 – Determine the number of atoms and/or molecules represented in a given chemical formula. 12.C.4b

FHBIO.3.5 – Model an atom showing the correct placement of electrons in the electron shells. 12.C.4b

FHBIO.3.6 – Determine the number of valence electrons in an atom. 12.C.4b

FHBIO.3.7 – Predict the number of electrons the atom will gain, lose, or share to become stable. 12.C.4b

FHBIO.3.8 – Determine if an atom will become a cation or an anion and the FHcorrect charge it will develop. 12.C.4b

FHBIO.3.9 – Predict the bond type based on the difference in electronegativities of two atoms. 12.C.5b

FHBIO.3.10 – Generate the correct chemical formula for a molecule or compound based on the ionic charges of two atoms. 12.C.4b

FHBIO.3.11 – Balance chemical equations. 12.C.4a

FHBIO.3.12 – Relate the polar nature of water to its properties. 12.C.4a

FHBIO.3.13 – Distinguish between acids and bases in regards to their affect on hydrogen ion concentration in a solution. 12.AC.5b

FHBIO.3.14 – Compare hydrogen and hydroxide ion concentrations using the pH scale. 12.C.5b

Outcome: **FHBIO.4** Students will examine general properties of macromolecules.

Components: **FHBIO.4.1** – Identify the four major groups of organic macromolecules. 12.A.4b

FHBIO.4.2 – Relate carbon's electron configuration to the number and kinds of bonds carbon atoms can form. 12.C.4a

FHBIO.4.3 – Recognize the functional groups (hydroxyl, aldehyde, ketone, carboxyl and amino, phosphate and sulfhydryl) and their properties. 12.A.4b

FHBIO.4.4 – Compare hydrolysis and condensation. 12.A.4b

FHBIO.4.5 – Recognize ATP as an important energy storing molecule in living things. 12.A.4b

FHBIO.4.6 – Relate hydrolysis and condensation to the conversion of ATP to ADP and back. 12.A.4b

FHBIO.4.7 – Compare endergonic and exergonic reactions. 12.A.5a

FHBIO.4.8 – Describe the role of enzymes in regards to activation energy of reactions. 12.A.4b

FHBIO.4.9 – Describe the enzyme-substrate relationship. 12.A.4b

FHBIO.4.10 – Distinguish between carbohydrates, lipids, and proteins based on their structure, chemical formula and functional groups. 12.A.5a

Outcome: **FHBIO.5** Students will integrate the structure, function and formation of carbohydrate monomers and polymers.

Components: **FHBIO.5.1** – Compare monosaccharides, disaccharides, and polysaccharides. 12.A.4b

FHBIO.5.2 – Recognize the functional groups found in carbohydrate molecules. 12.A.4b

FHBIO.5.3 – Identify examples of monosaccharides and recognize their biological function. 12.A.4b

FHBIO.5.4 – Identify examples of disaccharides and recognize their composition and biological function. 12.A.4b

FHBIO.5.5 – Identify examples of polysaccharides and recognize their composition and biological function. 12.A.4b

FHBIO.5.6 – Compare the formation of carbohydrate polymers to the break down of carbohydrate polymers. 12.A.4b

FHBIO.5.7 – Identify the role of the hormones (insulin and glucagon) in the homeostasis of blood sugar levels in humans. 12.A.5a, 12.A.5b

FHBIO.5.8 – Relate the cause and symptoms of lactose intolerance. 12.A.5b

FHBIO.5.9 – Describe physical and behavioral evolutionary adaptations of herbivores that enable digestion of plant fiber.

Outcome: **FHBIO.6** Students will integrate the structure, function and formation of lipid molecules and their relationship to our health.

Components: **FHBIO.6.1** – Identify the four major roles of lipids and examples of each. 12.A.4b

FHBIO.6.2 – Recognize the functional groups found in various lipid molecules. 12.A.4b

FHBIO.6.3 – Recognize the components of a fat molecule. 12.A.4b

FHBIO.6.4 – Identify the process by which fat molecules are formed and broken down. 12.A.5a

FHBIO.6.5 – Compare saturated, unsaturated (mono- and poly-), and hydrogenated fats and the health effects of each. 12.A.4b

FHBIO.6.6 – Compare HDLs, LDLs, and VLDLs in regards to their effects on blood lipid levels. 12.A.4b

FHBIO.6.7 – Recognize the structures of: a cholesterol molecule, phospholipid molecules, and wax molecules. 12.A.4b

FHBIO.6.8 – Compare the structure of fat, steroid, phospholipid and wax molecules. 12.A.4b

FHBIO.6.9 – Relate a saturated fat-rich diet to the effect on the structure of phospholipid and wax molecules. 12.A.4b

Outcome: **FHBIO.7** Students will integrate the structure, function and formation of protein monomers and polymers.

Components: **FHBIO.7.1** – Identify the functional groups found in all amino acids. 12.A.4b

FHBIO.7.2 – Compare essential and nonessential amino acids. 12.A.4b

FHBIO.7.3 – Identify examples of complete and incomplete sources of protein. 12.A.4b

FHBIO.7.4 – Identify the eight functions of proteins, and an example of each. 12.A.4b

FHBIO.7.5 – Determine how the properties of the "R" group affect protein structure. 12.A.4b

FHBIO.7.6 – Distinguish between the four levels of protein structure. 12.A.4b

FHBIO.7.7 – Draw the basic structure of an amino acid and label the amino group, the carboxyl group and the "R" group. 12.A.4b

FHBIO.7.8 – Describe the process by which amino acids are linked together to form a polypeptide. 12.A.4b

FHBIO.7.9 – Examine enzyme metabolism disorders and their connection to proteins. 12.A.4b

Outcome: **FHBIO.8** Students will examine the structure of DNA and RNA and use that information as it applies to the investigation of the processes of DNA replication and protein synthesis.

Components: **FHBIO.8.1** – Distinguish between genes, chromosomes and DNA. 12.A.5b

FHBIO.8.2 – Recognize scientists, their experiments and their discoveries that lead to an understanding of DNA. 13.A.4c, 13.A.5b

FHBIO.8.3 – Identify and/or model the components and structure of DNA. 12.A.5b

FHBIO.8.4 – Recognize complementary base pairs. 12.A.5b

FHBIO.8.5 – Identify the process and steps of DNA replication. 12.A.5b

FHBIO.8.6 – Compare and contrast DNA and RNA. 12.A.5b

FHBIO.8.7 – Distinguish between the three types of RNA. 12.A.5b

FHBIO.8.8 – Sequence the steps of transcription. 12.A.5b

FHBIO.8.9 – Order the steps and recognize molecules involved in translation.

FHBIO.8.10 – Describe the relationship between DNA codon, mRNA codon and tRNA anticodon. 12.A.5b

FHBIO.8.11 – Read and convert DNA and RNA base sequences to amino acid sequences and the reverse. 12.A.5b

FHBIO.8.12 – Explain the significance of base pairing to the processes of replication and protein synthesis (transcription and translation). 12.A.5b

FHBIO.8.13 – Evaluate consequences of base-pair mutations (insertion, deletion and substitution), and recognize when they occur. 12.A.5b

FHBIO.8.14 – Sequence the steps of replication.

Outcome: **FHBIO.9** Students will integrate an understanding of the complexity of organization within living things and the process which occur within them.

Components: **FHBIO.9.1** – List the components of the cell theory. 12.A.4b

FHBIO.9.2 – Recognize the characteristics of life. 12.A.4b

FHBIO.9.3 – Recognize the characteristics of life 12.A.4b

FHBIO.9.4 – Compare and contrast eukaryotic and prokaryotic cells. 12.A.4b

FHBIO.9.5 – Label cellular structures of plant, animal and prokaryotic cells on a diagram and identify the function of each. 12.A.4b

FHBIO.9.6 – Predict the direction of diffusion of both solute and solvent between a cell and its environment across a semipermeable membrane. 12.A.5a

FHBIO.9.7 – Differentiate between active and passive transport. 12.A.5a

FHBIO.9.8 – Sequence the levels of organization in living things and give examples of each. 12.A.4b

FHBIO.9.9 – Relate cell structure to its function. 12.A.4b

FHBIO.9.10 – Differentiate between plant, animal and prokaryotic cells. 12.A.4b

FHBIO.9.11 – Support the theory of endosymbiosis using evidence.

Outcome: **FHBIO.10** Students will examine the process of photosynthesis to compare how energy is captured, processed, converted and stored in living things.

Components: **FHBIO.10.1** – Identify the reactants and products in the photosynthesis equation. 12.A.4b

FHBIO.10.2 – Identify the roles of CO_2, O_2, H_2O, $C_6H_{12}O_6$ in the reaction. 12.A.4b

FHBIO.10.3 – Identify the location in the chloroplast where the light dependent and light independent reactions occur. 12.A.4b

FHBIO.10.4 – Identify the roles of sunlight and pigments in photosynthesis.

FHBIO.10.5 – Relate electron transport to the production of NADPH.

FHBIO.10.6 – Relate chemiosmosis to the production of ATP.

FHBIO.10.7 – Summarize the purpose of the light dependent reactions of photosynthesis. 12.A.5a

FHBIO.10.8 – Identify the role of ATP and NADPH in the light independent reactions. 12.A.5a

FHBIO.10.9 – Summarize the purpose of the light independent reactions of photosynthesis. 12.A.5a

FHBIO.10.10 – Analyze a diagram summarizing light dependent and light independent reactions of photosynthesis. 12.A.5a

FHBIO.10.11 – Differentiate between alternative mechanisms of carbon fixation that have evolved in hot and arid climates.

Outcome: **FHBIO.11** Students will examine the process of cellular respiration (aerobic and anaerobic) to analyze how energy is made available for cells.

Components: **FHBIO.11.1** – Identify the reactants and the products in the cellular respiration equation. 12.A.4b

FHBIO.11.2 – Identify the roles of ATP (ADP), NAD+ (NADH), FAD+ ($FADH_2$), glucose, pyruvic acid, CO_2, Acetyl-CoA, Citric Acid, O_2, and H_2O in aerobic respiration. 12.A.4b

FHBIO.11.3 – Identify the locations in the cell where glycolysis, Kreb's cycle, Electron Transport Chain, and Chemiosmosis takes place. 12.A.4b

FHBIO.11.4 – Determine the number of ATP generated per glucose molecule in glycolysis, Kreb's cycle and Electron Transport Chain. 12.A.4b

FHBIO.11.5 – Describe conditions necessary for anaerobic respiration to occur. 12.A.4b

FHBIO.11.6 – Identify the number of ATP generated in glycolysis and fermentation (anaerobic respiration). 12.A.4b

FHBIO.11.7 – Evaluate the benefits and problems of fermentation (anaerobic) compared to oxidative respiration (aerobic). 12.A.4b

FHBIO.11.8 – Compare photosynthesis and respiration. 12.A.4b

FHBIO.11.9 – Compare the structure and function of chloroplast and mitochondrion as they relate to the formation of ATP.

FHBIO.11.10 – Describe and similarities in roles of O_2 in respiration and pyruvate in fermentation.

Outcome: **FHBIO.12** Students will analyze cell division to relate it to growth and reproduction.

Components: **FHBIO.12.1** – Recognize the stages of the cell cycle and the end result. 12.A.4b

FHBIO.12.2 – Identify cellular structures involved in cell growth and the role of each. 12.A.4b

FHBIO.12.3 – Differentiate between the phases of mitosis and cytokinesis in both plant and animal cells. 12.A.4b

FHBIO.12.4 – Compare growth in normal cells vs. cancer cells. 12.A.4b

FHBIO.12.5 – Differentiate between meiosis I and meiosis II. 12.A.4b

FHBIO.12.6 – Identify the end result of meiosis in males and in females. 12.A.4b

FHBIO.12.7 – Compare and contrast mitosis and meiosis. 12.A.4b

FHBIO.12.8 – Compare sexual and sexual reproduction. 12.A.4b

FHBIO.12.9 – Evaluate advantages and disadvantages of sexual and asexual reproduction. 12.A.4b

FHBIO.12.10 – Describe the influence of chemotherapeutic drugs and radiation on mitosis of cancer cells.

Outcome: **FHBIO.13** Students will apply the concepts of heredity to solve inheritance problems.

Components: **FHBIO.13.1** – Recognize the principles of genetic dominance, segregation and independent assortment. 12.A.4a

FHBIO.13.2 – Integrate appropriate terminology and symbols in solving genetic problems using punnett squares (alleles, heterozygous, homozygous, purebred, hybrid, genotype, and phenotype). 12.A.4a

FHBIO.13.3 – Predict the probability of offspring for one and two factor crosses. 12.A.4a

FHBIO.13.4 – Predict the genetic consequence of crossover among homologous chromosomes. 12.A.4a

FHBIO.13.5 – Construct and interpret a karyotype. 12.A.4a

FHBIO.13.6 – Analyze a pedigree. 12.A.4a

FHBIO.13.7 – Distinguish between autosomes and sex chromosomes. 12.A.4a

FHBIO.13.8 – Describe how chromosomes determine gender. 12.A.4a

FHBIO.13.9 – Solve genetics problems involving incomplete dominance, co-dominance and sex-linked inheritance using punnett squares. 12.A.4a, 12.A.5b

FHBIO.13.10 – Identify disorders related to non-disjunction and the resulting chromosomal pattern of each. 12.A.5b

FHBIO.13.11 – Identify methods of detecting genetic disorders during pregnancy. 12.A.5b

FHBIO.13.12 – Describe the consequence of selective breeding. 12.B.5b

Outcome: **FHBIO.14** Students will integrate the principles of taxonomy and classification to assess the usefulness of classification systems.

Components: **FHBIO.14.1** – Demonstrate proper use of binomial nomenclature.

FHBIO.14.2 – List the different taxa comprising the classification system of Linnaeus and additions to it since.

FHBIO.14.3 – Identify characteristics used to place organisms in each of the kingdoms.

FHBIO.14.4 – Create and use a dichotomous key.

FHBIO.14.5 – Assess the usefulness of classification systems.

Outcome: **FHBIO.15** Students will investigate the interactions among populations to analyze human's impact on the environment.

Components: **FHBIO.15.1** – Identify methods used to measure population density and their limits. 12.B.4b

FHBIO.15.2 – Identify factors affecting population growth. 12.B.4b

FHBIO.15.3 – Recognize methods scientists use to predict population growth. 12.B.4b, 12.B.5b

FHBIO.15.4 – Identify causes and possible results of interspecific competition. 12.B.4a

FHBIO.15.5 – Identify adaptations of predators and prey. 12.B.4a

FHBIO.15.6 – Compare symbiotic relationships between organisms. 12.B.4a

FHBIO.15.7 – Distinguish between primary and secondary succession.

FHBIO.15.8 – Describe ways that humans have modified their environment (or atmosphere) and the possible consequences of these changes. 12.B.5b

FHBIO.15.9 – Define biodiversity. 12.B.5a

FH BIO.15.10 – Compare conservation and restoration. 12.B.5a

FHBIO.15.11 – Discuss the need for conserving biodiversity. 12.B.5a

Outcome: **FHBIO.16** Students will explore the concept of biological evolution to justify the diversity of species which exist today.

Components: **FHBIO.16.1** – Identify key observations from Darwin's voyage that lead to his theory. 12.A.4a

FHBIO.16.2 – Identify evidence that supports biological evolution over time (fossil record, geographic distribution, structural similarities, developmental similarities, and DNA similarities). 12.A.4c

FHBIO.16.3 – Summarize the two main points of Darwin's theory (descent with modification and natural selection). 12.B.5b

FHBIO.16.4 – Recognize factors which lead to a change in a population's gene pool. 12.B.5b

FHBIO.16.5 – Define species. 12.A.4a

FHBIO.16.6 – Summarize mechanisms that can lead to speciation. 12.A.4a

Outcome: **FHBIO.17** Students will explore recent research trends in DNA technology.

Components: **FHBIO.17.1** – Describe how bacteria have contributed to the development of recombinant DNA technology and genetic engineering.

FHBIO.17.2 – Summarize the procedure used to clone specific genes.

FHBIO.17.3 – Relate the use of Polymerase Chain Reaction (PCR) and Electrophoresis to comparison of DNA samples.

FHBIO.17.4 – Relate the influence of homeotic genes to the development of an organism.

FHBIO.17.5 – Assess the value of stem cells in treating disease.

FHBIO.17.6 – Summarize the controversy surrounding the use of cloning and GMO's.

Science Curriculum

Biology

Outcome: **BIO.1** Students will demonstrate an understanding of process and methods used to gather scientific knowledge.

Components: **BIO.1.1** – Describe the importance of scientific process such as observation, inferring, hypothesizing and predicting. 13.A.5c

BIO.1.2 – Identify independent, dependent and standardized variables. 11.B.5b

BIO.1.3 – Identify appropriate levels of treatment. 11.B.5b

BIO.1.4 – Explain the difference between control and experimental set-ups and the importance of each. 11.B.5d

BIO.1.5 – Identify ways that replication can be incorporated into a controlled experiment. 11.A.5c

BIO.1.6 – Select the best type of graph to construct (bar or line) based on the data to be graphed. 11.A.5e

BIO.1.7 – Construct appropriate data tables and graphs showing correct placement of all the components of the design. (dependent and independent variables on a Y axis, scale numbers, and unit labels) 11.A.5e

BIO.1.8 – Design a controlled experiment, identifying appropriate independent, dependent and standardized variables; levels of treatment; and incorporating replication into the design. 11.B.5b

BIO.1.9 – Describe the relationship between a hypothesis, a theory and a

law. 13.A.5b

BIO.1.10 – Critique an experiment, determining the appropriateness of all the components of the design. 11.B.5e

Outcome**:** **BIO.2** Students will demonstrate appropriate and safe use of the Compound Light Microscope and related equipment**.**

Components: **BIO.2.1** – Identify parts of the microscope.

BIO.2.2 – Calculate total magnification.

BIO.2.3 – Create a wet mount slide.

BIO.2.4 – Focus on a specimen using low and high power.

BIO.2.5 – Compare apparent to actual movement using both the Compound Light Microscope and the Stereomicroscope.

BIO.2.6 – Determine the most appropriate microscope to use based on the specimen.

BIO.2.7 – Describe the ways in which a specimen appears differently using the Compound Light Microscope compared to the unaided eye.

BIO.2.8 – Describe the ways in which a specimen's appearance changes from low to high power.

BIO.2.9 – Explain the relationship between magnification and resolution.

BIO.2.10 – Compare advantages and disadvantages of both the Compound light Microscope and the Stereomicroscope.

Outcome: **BIO.3** Students will demonstrate an understanding of the interactions of matter.

Components: **BIO.3.1** – List the names and symbols of the first 20 elements. 12.C.4b

BIO.3.2 – Identify the charges, location, mass and symbol for each of the subatomic particles. 12.C.4b

BIO.3.3 – Use the periodic table to determine the number of protons, neutrons and electrons in an atom of a particular element. 12.C.4b

BIO.3.4 – Determine the number of atoms and/or molecules represented in a given chemical formula. 12.C.4b

BIO.3.5 – Model an atom showing the correct placement of electrons in the electron shells. 12.C.4b

BIO.3.6 – Determine the number of valence electrons in an atom. 12.C.4b

BIO.3.7 – Predict the number of electrons the atom will gain, lose, or share to become stable. 12.C.4b

BIO.3.8 – Determine if an atom will become a cation or an anion and the correct charge it will develop. 12.C.4b

BIO.3.9 – Predict the bond type based on the difference in electronegativities of two atoms. 12.C.5b

BIO.3.10 – Generate the correct chemical formula for a molecule or compound based on the ionic charges of two atoms. 12.C.4b

BIO.3.11 – Balance chemical equations. 12.C.4a

BIO.3.12 – Relate the polar nature of water to its properties. 12.C.4a

BIO.3.13 – Distinguish between acids and bases in regards to their affect on hydrogen ion concentration in a solution. 12.C.5b

BIO.3.14 – Compare hydrogen and hydroxide ion concentrations using the pH scale. 12.C.5b

Outcome: **BIO.4** Students will examine general properties of macromolecules.

Components: **BIO.4.1** – Identify the four major groups of organic acromolecules. 12.A.4b

BIO.4.2 – Relate carbon's electron configuration to the number and kinds of bonds carbon atoms can form. 12.C.4a

BIO.4.3 – Recognize the functional groups (hydroxyl, aldehyde, ketone, carboxyl and amino) and their properties. 12.A.4b

BIO.4.4 – Compare hydrolysis and condensation. 12.A.4b

BIO.4.5 – Recognize ATP as an important energy storing molecule in living things. 12.A.4b

BIO.4.6 – Relate hydrolysis and condensation to the conversion of ATP to ADP and back. 12.A.4b

BIO.4.7 – Compare endergonic and exergonic reactions. 12.A.5a

BIO.4.8 – Describe the role of enzymes in regards to activation energy of reactions. 12.A.4b

BIO.4.9 – Describe the enzyme-substrate relationship. 12.A.4b

BIO.4.10 – Distinguish between carbohydrates, lipids, and proteins based on their structure, chemical formula and functional groups. 12.A.5a

Outcome: **BIO.5** Students will integrate the structure, function and formation of carbohydrate monomers and polymers.

Components: **BIO.5.1** – Compare monosaccharides, disaccharides, and polysaccharides. 12.A.4b

BIO.5.2 – Recognize the functional groups found in carbohydrate molecules. 12.A.4b

BIO.5.3 – Identify examples of monosaccharides and recognize their biological function. 12.A.4b

BIO.5.4 – Identify examples of disaccharides and recognize their composition and biological function. 12.A.4b

BIO.5.5 – Identify examples of polysaccharides and recognize their composition and biological function. 12.A.4b

BIO.5.6 – Compare the formation of carbohydrate polymers to the break down of carbohydrate polymers. 12.A.4b

BIO.5.7 – Distinguish between the cause and symptoms of lactose intolerance. 12.A.5b

BIO.5.8 – Identify the role of the hormones (insulin and glucagons) in blood sugar regulation in humans. 12.A.5a, 12.A.5b

Outcome**:** **BIO.6** Students will integrate the structure, function and formation of lipid molecules and their relationship to our health.

Components: **BIO.6.1** – Identify the four major roles of lipids and examples of each. 12.A.4b

BIO.6.2 – Recognize the functional groups found in various lipid molecules. 12.A.4b

BIO.6.3 – Recognize the components of a fat molecule. 12.A.4b

BIO.6.4 – Identify the process by which fat molecules are formed and broken down. 12.A.5a

BIO.6.5 – Compare saturated, unsaturated (mono- and poly-), and hydrogenated fats and the health effects of each. 12.A.4b

BIO.6.6 – Compare HDLs, LDLs, and VLDLs in regards to their effects on blood lipid levels. 12.A.4b

BIO.6.7 – Recognize the structures of: a cholesterol molecule, phospholipid molecules, wax molecules. 12.A.4b

BIO.6.8 – Compare the structure of fat, steroid, phospholipid and wax molecules. 12.A.4b

BIO.6.9 – Relate a saturated fat-rich diet to the effect on the structure of phospholipid and wax molecules. 12.A.4b

Outcome**:** **BIO.7** Students will integrate the structure, function and formation of protein monomers and polymers.

Components: **BIO.7.1** – Identify the functional groups found in all amino acids. 12.A.4b

BIO.7.2 – Compare essential and nonessential amino acids. 12.A.4b

BIO.7.3 – Identify examples of complete and incomplete sources of protein. 12.A.4b

BIO.7.4 – Identify the eight functions of proteins, and an example of each. 12.A.4b

BIO.7.5 – Determine how the properties of the “R” group affect protein structure. 12.A.4b

BIO.7.6 – Distinguish between the four levels of protein structure. 12.A.4b

BIO.7.7 – Draw the basic structure of an amino acid and label the amino group, the carboxyl group and the “R” group. 12.A.4b

BIO.7.8 – Describe the process by which amino acids are linked together to form a polypeptide. 12.A.4b

BIO.7.9 – Examine disorders and their connection to proteins. 12.A.4b

Outcome: **BIO.8** Students will examine the structure of DNA and RNA and use that information as it applies to the investigation of the processes of DNA replication and protein synthesis.

Components: **BIO.8.1** – Distinguish between genes, chromosomes and DNA. 12.A.5b

BIO.8.2 – Recognize scientists, their experiments and their discoveries that lead to an understanding of DNA. 13.A.4c, 13.A.5b

BIO.8.3 – Identify and/or model the components and structure of DNA. 12.A.5b

BIO.8.4 – Recognize complementary base pairs. 12.A.5b

BIO.8.5 – Identify the process and steps of DNA replication. 12.A.5b

BIO.8.6 – Compare and contrast DNA and RNA. 12.A.5b

BIO.8.7 – Distinguish between the three types of RNA. 12.A.5b

BIO.8.8 – Sequence the steps of transcription. 12.A.5b

BIO.8.9 – Order the steps and recognize molecules involved in translation.

BIO.8.10 – Describe the relationship between DNA codon, mRNA codon and tRNA anticodon. 12.A.5b

BIO.8.11 – Read and convert DNA and RNA base sequences to amino acid sequences and the reverse. 12.A.5b

BIO.8.12 – Explain the significance of base pairing to the processes of replication and protein synthesis (transcription and translation). 12.A.5b

BIO.8.13 – Evaluate consequences of base-pair mutations (insertion, deletion and substitution), and recognize when they occur. 12.A.5b

Outcome: **BIO.9** Students will integrate an understanding of the complexity of organization within living things and the process which occur within them.

Components: **BIO.9.1** – List the components of the cell theory. 12.A.4b

BIO.9.2 – Recognize the characteristics of life. 12.A.4b

BIO.9.3 – Distinguish between autotrophs and heterotrophs. 12.A.4b

BIO.9.4 – Compare and contrast eukaryotic and prokaryotic cells. 12.A.4b

BIO.9.5 – Label cellular structures on a diagram and identify the function of each. 12.A.4b

BIO.9.6 – Predict the direction of diffusion of both solute and solvent

between a cell and its environment across a semipermeable membrane. 12.A.5a

BIO.9.7 – Differentiate between active and passive transport. 12.A.5a

BIO.9.8 – Sequence the levels of organization in living things and give examples of each. 12.A.4b

BIO.9.9 – Relate cell structure to its function. 12.A.4b

BIO.9.10 – Differentiate between plant and animal cells. 12.A.4b

BIO.9.11 – Support the theory of endosymbiosis using evidence.

Outcome: **BIO.10** Students will examine the process of photosynthesis to compare how energy is captured, processes, converted and stored in living things.

Components: **BIO.10.1** – Identify the reactants and products in the photosynthesis equation. 12.A.4b

BIO.10.2 – Identify the roles of CO_2, O_2, H_2O, $C_6H_{12}O_6$ in the reaction. 12.A.4b

BIO.10.3 – Identify the location in the chloroplast where the light dependent and light independent reactions occur. 12.A.4b

BIO.10.4 – Identify the roles of sunlight and pigments in photosynthesis.

BIO.10.5 – Relate electron transport to the production of NADPH.

BIO.10.6 – Relate chemiosmosis to the production of ATP.

BIO.10.7 – Summarize the purpose of the light dependent reactions of photosynthesis. 12.A.5a

BIO.10.8 – Identify the role of ATP and NADPH in the light independent reactions. 12.A.5a

BIO.10.9 – Summarize the purpose of the light independent reactions of photosynthesis. 12.A.5a

BIO.10.10 – Analyze a diagram summarizing light dependent and light independent reactions of photosynthesis. 12.A.5a

Outcome: **BIO.11** Students will examine the process of cellular respiration (aerobic and anaerobic) to analyze how energy is made available for cells.

Components: **BIO.11.1** – Identify the reactants and the products in the cellular respiration equation. 12.A.4b

BIO.11.2 – Identify the roles of ATP (ADP), NAD^+ (NADH), FAD^+ ($FADH_2$), glucose, pyruvic acid, CO_2, Acetyl-CoA, Citric Acid, O_2, and H_2O in aerobic respiration. 12.A.4b

BIO.11.3 – Identify the locations in the cell where glycolysis, Kreb's

cycle and Electron Transport Chain takes place. 12.A.4b

BIO.11.4 – Determine the number of ATP generated per glucose molecule in glycolysis, Kreb's cycle and Electron Transport Chain. 12.A.4b

BIO.11.5 – Describe conditions necessary for anaerobic respiration to occur. 12.A.4b

BIO.11.6 – Identify the number of ATP generated in glycolysis and fermentation (anaerobic respiration). 12.A.4b

BIO.11.7 – Evaluate the benefits and problems of fermentation (anaerobic) compared to oxidative respiration (aerobic). 12.A.4b

BIO.11.8 – Compare photosynthesis and respiration. 12.A.4b

Outcome: **BIO.12** Students will analyze cell division to relate it to growth and reproduction.

Outcomes: **BIO.12.1** – Recognize the stages of the cell cycle and the end result. 12.A.4b

BIO.12.2 – Identify cellular structures involved in cell growth and the role of each. 12.A.4b

BIO.12.3 – Differentiate between the phases of mitosis and cytokinesis in both plant and animal cells. 12.A.4b

BIO.12.4 – Compare growth in normal cells vs. cancer cells. 12.A.4b

BIO.12.5 – Differentiate between meiosis I and meiosis II. 12.A.4b

BIO.12.6 – Identify the end result of meiosis in males and in females. 12.A.4b

BIO.12.7 – Compare and contrast mitosis and meiosis. 12.A.4b

BIO.12.8 – Compare sexual and sexual reproduction. 12.A.4b

BIO.12.9 – Evaluate advantages and disadvantages of sexual and asexual reproduction. 12.A.4b

Outcome: **BIO.13** Students will apply the concepts of heredity to solve inheritance problems.

Components: **BIO.13.1** – Recognize the principles of genetic dominance, segregation and independent assortment. 12.A.4a

BIO.13.2 – Integrate appropriate terminology and symbols in solving genetic problems using punnett squares. (alleles, heterozygous, homozygous, purebred, hybrid, genotype, and phenotype) 12.A.4a

BIO.13.3 – Predict the probability of offspring for one and two factor crosses. 12.A.4a

BIO.13.4 – Predict the genetic consequence of crossover among homologous chromosomes. 12.A.4a

BIO.13.5 – Construct and interpret a karyotype. 12.A.4a

BIO.13.6 – Analyze a pedigree. 12.A.4a

BIO.13.7 – Distinguish between autosomes and sex chromosomes. 12.A.4a

BIO.13.8 – Describe how chromosomes determine gender. 12.A.4a

BIO.13.9 – Solve genetics problems involving incomplete dominance, co-dominance and sex-linked inheritance using punnett squares. 12.A.4a, 12.A.5b

BIO.13.10 – Identify disorders related to non-disjunction and the resulting chromosomal pattern of each. 12.A.5b

BIO.13.11 – Identify methods of detecting genetic disorders during pregnancy. 12.A.5b

BIO.13.12 – Describe the consequence of selective breeding. 12.B.5b

Outcome: **BIO.14** Students will integrate the principles of taxonomy and classification to assess the usefulness of classification systems.

Components: **BIO.14.1** – Demonstrate proper use of binomial nomenclature.

BIO.14.2 – List the different taxa comprising the classification system of Linnaeus and additions to it since.

BIO.14.3 – Identify characteristics used to place organisms in each of the kingdoms.

BIO.14.4 – Create and use a dichotomous key.

BIO.14.5 – Assess the usefulness of classification systems.

Outcome: **BIO.15** Students will investigate the interactions among populations to analyze human's impact on the environment.

Components: **BIO.15.1** – Identify methods used to measure population density and their limits. 12.B.4b

BIO.15.2 – Identify factors affecting population growth. 12.B.4b

BIO.15.3 – Recognize methods scientists use to predict population growth. 12.B.4b, 12.B.5b

BIO.15.4 – Identify causes and possible results of interspecific competition. 12.B.4a

BIO.15.5 – Identify adaptations of predators and prey. 12.B.4a

BIO.15.6 – Compare symbiotic relationships between organisms. 12.B.4a

BIO.15.7 – Distinguish between primary and secondary succession.

BIO.15.8 – Describe ways that humans have modified their environment (or atmosphere) and the possible consequences of these changes. 12.B.5b

BIO.15.9 – Define biodiversity. 12.B.5a

BIO.15.10 – Compare conservation and restoration. 12.B.5a

BIO.15.11 – Discuss the need for conserving biodiversity. 12.B.5a

Outcome: **BIO.16** Students will explore the concept of biological evolution to justify the diversity of species which exists today.

Components: **BIO.16.1** – Identify key observations from Darwin's voyage that lead to his theory. 12.A.4a

BIO.16.2 – Identify evidence that supports biological evolution over time (fossil record, geographic distribution, structural similarities, developmental similarities, and DNA similarities). 12.A.4c

BIO.16.3 – Summarize the two main points of Darwin's theory. (descent with modification and natural selection) 12.B.5b

BIO.16.4 – Recognize factors which lead to a change in a population's gene pool. 12.B.5b

BIO.16.5 – Define species. 12.A.4a

BIO.16.6 – Summarize mechanisms that can lead to speciation. 12.A.4a

Science Curriculum
Applied Biology

Outcome: **AB.1** Students will differentiate between organisms and classify their relatedness and common ancestry through taxonomy.

Components: **AB.1.1** - List the different branches of Linnaeus' classification system called binomial nomenclature. 12.A.3c

AB.1.2 - Identify the components of an effective classification system and why they are used to group organisms. 13.A.4c

AB.1.3 - Classify leaves into appropriate genus and species using taxonomic keys. 13.A.4c, 11.A.4c

AB.1.4 - Construct and interpret cladograms that show relationships between living organisms. 11.A.4d

AB.1.5 - Predict evolutionary relationships and common ancestors based on homologous, analogous, and vestigial structures, fossil records and DNA comparisons. 12.A.4c

AB.1.6 - Create a taxonomic key based on a leaf collection that others could use to identify those leaves. 11.A.4c

Outcome: **AB.2** Students will demonstrate appropriate and safe use of the Compound Light Microscope.

Components: **AB.2.1 -** Identify parts of a microscope.

AB.2.2 - Calculate total magnification. 11.B.4a

AB.2.3 - Create a wet mount slide using proper technique. 11.B.4a

AB.2.4 - Focus on a specimen using low and high power settings. 11.B.4a

AB.2.5 - Describe the appearance of a specimen using the Compound Light Microscope compared to the unaided eye. 11.A.4f

AB.2.6 - Compare the ways in which a specimen's appearance changes from low to high power. 11.B.4a

Outcome: **AB.3** Students will construct an understanding that an ecosystem is the balance of competing effects of that ecosystem.

Components: **AB.3.1 -** Relate the importance and methods of counting populations. 13.A.4b

AB.3.2 - Discuss and demonstrate why populations change size. 12.B.4b

AB.3.3 - Explain limiting factors that affecting a population. 12.B.4b

AB.3.4 - Describe the different parts of a community. 12.B.4a

AB.3.5 - Explain and diagram the importance of producers, consumers and decomposers. 12.B.4b

AB.3.6 - Trace the path of energy and materials through a community. 12.B.4a

AB.3.7 - Compare and contrast symbiotic relationships. (mutualism, commensalisms, parasitism, and predation) 12.B.4b

AB.3.8 - Describe succession in land and water communities. 12.B.5b

AB.3.9 - Diagram how wildlife and plants are affected by humans. 12.B.5b

AB.3.10 - Examine and predict fossil fuels' impact on the future, considering amounts available and used, and pollution produced as a byproduct of these. 12.B.4a

AB.3.11 - Generate a plan to create an environment that uses its resources effectively and does not go over its carrying capacity. 12.B.4b

Outcome: **AB.4** Students will use evidence from events in geologic time to make deductions about natural selection and evolution.

Components: **AB.4.1 -** Analyze and interpret data to answer questions about life during the different eras in history. 12.A.4c

AB.4.2 - Construct an analogy of geologic time to one calendar year to demonstrate understanding of the role of humans in the planets history. 12.A.4c

AB.4.3 - Prepare a timeline of plants and animals that have lived through the geologic eras. 12.A.4c

AB.4.4 - Outline the precursors for life on Earth and the experiments that have been reenacted to hypothesize about how life began. 12.A.4c

AB.4.5 - Summarize Darwin's main ideas. 13.B.3b

AB.4.6 - Describe how adaptations help organisms survive. 12.B.5b

AB.4.7 - Explain how changes in life-forms occur. 12.B.5b

AB.4.8 - Describe the classification and evolution of primates and humans. 12.B.5b

AB.4.9 - Graph and interpret data gathered in natural selection reenactments. (peppered moth experiment) 11.A.4c, 11.A.4d

AB.4.10 - Reason with evidence about evolution to support Darwin's theory of natural selection. 11.A.4e

Outcome: **AB.5** Students will inventory the classifications used to qualify life and the processes that cells exhibit during asexual and sexual reproduction.

Components: **AB.5.1 -** Describe eight features common to all living things.

AB.5.2 - List the elements that make up living things.

AB.5.3 - State the major ideas of the cell theory. 12.A.4b

AB.5.4 - Identify and describe the functions of the cell parts. 12.A.4b

AB.5.5 - Describe the processes of osmosis and diffusion in a cell. 12.A.4b

AB.5.6 - Communicate how cells, tissues, organs, and organ systems are organized. 12.A.4b

AB.5.7 - Identify cell parts involved in mitosis. 12.A.4b

AB.5.8 - Trace the steps of mitosis. 12.A.4b

AB.5.9 - Differentiate between mitosis and meiosis. 12.A.4b

Outcome: **AB.6** Students will demonstrate knowledge of human genetics including chromosomes and inheritance patterns.

Components: **AB.6.1 -** Compare the number of chromosomes in body cells and sex cells. 12.A.4a

AB.6.2 - Describe methods that doctors use to study chromosomes of a fetus and the implications of those studies for the individuals. 12.A.4a

AB.6.3 - Compare the chromosomes of males and females. 12.A.4a

AB.6.4 - Compare recessive and dominant traits with incomplete dominance. 12.A.4a

AB.6.5 - Describe different ways human traits can be inherited. 12.A.4a

AB.6.6 - Predict combinations of alleles in a zygote from the genetic makeup of the parents using Punnett squares. 12.A.4a

AB.6.7 - Describe some genetic disorders in humans. 12.A.5b

AB.6.8 - Give examples of how genetic counseling can help families. 12.A.5b

AB.6.9 - Create a pedigree following one dominant/recessive trait through four generations of a family. 12.A.5b

AB.6.10 - Research a genetic disease and present the information to an audience. 11.A.4c, 11.A.4f, 12.A.5b

Outcome: **AB.7** Students will be able to appraise that genes are a set of instructions, encoded in the DNA sequence of each organism that specify the sequence of amino acids in proteins characteristic of the organism.

Components: **AB.7.1 -** Describe the structure of DNA. 12.A.4a

AB.7.2 - Explain how DNA controls genetic traits. 12.A.4a, 12.A.4b

AB.7.3 - Describe how DNA copies itself during replication. 12.A.4b

AB.7.4 - Describe the structure of RNA. 12.A.4b

AB.7.5 - Explain how RNA is involved in protein synthesis. 12.A.4b

AB.7.6 - Model the actions within a cell during protein synthesis. 12.A.4b

AB.7.7 - Describe how mutations occur. 12.A.4b

AB.7.8 - Deduce how cloning and breeding produce offspring with desired traits. 12.A.5b

AB.7.9 - Explain how recombinant DNA and gene therapy can help humans. 12.A.5b

Outcome: **AB.8** Students will be able to identify and differentiate between the different types of microorganisms on the planet and understand their impact on our surroundings.

Components: **AB.8.1 -** Identify the traits of bacteria, (shape, arrangement, gram-positive and gram negative.) 12.A.3b

AB.8.2 - Explain how bacteria affect other living things. 12.A.3b

AB.8.3 - Compare the traits of autotrophic and heterotrophic bacteria. 12.A.3b

AB.8.4 - Identify the traits of viruses. 12.A.3b

AB.8.5 - Diagram how viruses reproduce in a host cell. 12.A.3b

AB.8.6 - List examples of how viruses affect living organisms. 12.A.3b

AB.8.7 - Identify the general characteristics of protists. 12.A.3b

AB.8.8 - Compare the traits of animal-like protists, plant-like protists, and fungus like protists. 12.A.3b

AB.8.9 - Hypothesize how life would be different on our planet if there were no microorganisms. 12.B.5a

Outcome: **AB.9** Students will be able to identify and differentiate between key structures and functions of fungi and plants.

Components: **AB.9.1 -** List and compare the traits of the major kinds of fungi. 12.A.3c

AB.9.2 - Describe how fungi can be harmful and helpful. 12.A.3c

AB.9.3 - Describe two features common to most plants. 12.A.3c

AB.9.4 - Compare vascular and nonvascular plants. 12.A.3c

AB.9.5 - Compare mosses and liverworts with other plants. 12.A.3c

AB.9.6 - Compare the traits of ferns, conifers, and flowering plants. 12.A.3c

AB.9.7 - Examine and compare the parts of a leaf in angiosperms. 12.A.3c

AB.9.8 - Identify the functions of the various types of cells in a leaf. 12.A.4b

AB.9.9 - Diagram the process of transpiration. 12.A.4b

AB.9.10 - Describe the process of photosynthesis. 12.A.4b

AB.9.11 - List the parts of a flower and the function of each. 12.B.4a

AB.9.12 - Describe how fruits and seeds develop. 12.A.4b

AB.9.13 - Sequence the steps that lead to fertilization in flowering plants. 12.B.4a

Outcome: **AB.10** Students will categorize animals into unique groupings based on the special characteristics present in those animals. They will also be able to deduce relatedness among species and how adaptations have caused change over time in species.

Components: **AB.10.1 -** List four traits of animals. 12.B.3b

AB.10.2 - Identify nine major phyla of animals and give an example of each. 12.B.3b

AB.10.3 - Identify the main features of sponges, flatworms, roundworms, and segmented worms. 12.B.3b

AB.10.4 - Identify the major features of soft-bodied animals. 12.B.3b

AB.10.5 - Identify the major traits of joint-leg animals. 12.B.3b

AB.10.6 - Compare the traits of spiny-skin animals. 12.B.3b

AB.10.7 - Compare the traits of fish, (jawless, cartilage, and bony). 12.B.3b

AB.10.8 - Describe the major traits of amphibians, reptiles, and birds. 12.B.3b

AB.10.9 - Identify the characteristics of mammals. 12.B.3b

AB.10.10 - Examine different animals by dissection determine the organization and structures of various specimens. 11.A.4c, 11.A.4e

AP Biology
Grades 11-12

Course Overview:

Exploring Life on Its Many Levels

1. Briefly describe the unifying themes that characterize the biological sciences.
2. Diagram the hierarchy of structural levels in biological organization.
3. Explain how the properties of life emerge from complex organization.
4. Describe the two major dynamic processes of any ecosystem.
5. Distinguish between prokaryotic and eukaryotic cells.
6. Describe the basic structure and function of DNA.
7. Describe the dilemma of reductionism.
8. Discuss the goals and activities of systems biology. List three research developments that have advanced systems biology.
9. Explain the importance of regulatory mechanisms in living things. Distinguish between positive and negative feedback.

Evolution, Unity, and Diversity

10. Distinguish among the three domains of life. List and distinguish among the three kingdoms of multicellular, eukaryotic life.
12. Describe the observations and inferences that led Charles Darwin to his theory of evolution by natural selection.
13. Explain why diagrams of evolutionary relationships have a treelike form.

The Process of Science

14. Distinguish between discovery science and hypothesis-based science. Explain why both types of exploration contribute to our understanding of nature.
15. Distinguish between quantitative and qualitative data.
16. Distinguish between inductive and deductive reasoning.
17. Explain why hypotheses must be testable and falsifiable but are not provable.
18. Describe what is meant by a controlled experiment.
19. Distinguish between the everyday meaning of the term *theory* and its meaning to scientists.
20. Explain how science is influenced by social and cultural factors.
21. Distinguish between science and technology. Explain how science and technology are interdependent.

Elements and Compounds

22. Distinguish between an element and a compound.
23. Identify the four elements that make up 96% of living matter.
24. Define the term **trace element** and give an example.

Atoms and Molecules

25. Draw and label a simplified model of an atom. Explain how this model simplifies our understanding of atomic structure.
26. Distinguish between each of the following pairs of terms:
    a. neutron and proton
    b. atomic number and mass number
    c. atomic weight and mass number
27. Explain how the atomic number and mass number of an atom can be used to determine the number of neutrons.
28. Explain how two isotopes of an element are similar. Explain how they are different.
29. Describe two biological applications that use radioactive isotopes.
30. Define the terms **energy** and **potential energy.** Explain why electrons in the first electron shell have less potential energy than electrons in higher electron shells.
31. Distinguish among nonpolar covalent, polar covalent and ionic bonds.
32. Explain why strong covalent bonds and weak bonds are both essential in living organisms.
33. Distinguish between hydrogen bonds and van der Waals interactions.
34. Give an example that illustrates how a molecule's shape can determine its biological function.
35. Explain what is meant by a chemical equilibrium.

The Properties of Water

36. With the use of a diagram or diagrams, explain why water molecules are:

    Polar and capable of hydrogen bonding with four neighboring water molecules

37. List four characteristics of water that are emergent properties resulting from hydrogen bonding.
38. Define **cohesion** and **adhesion.** Explain how water's cohesion and adhesion contribute to the movement of water from the roots to the leaves of a tree.

39. Distinguish between heat and temperature, using examples to clarify your definitions.
40. Explain the following observations by referring to the properties of water:
    a. Coastal areas have milder climates than adjacent inland areas.
    b. Ocean temperatures fluctuate much less than air temperatures on land.
    c. Insects like water striders can walk on the surface of a pond without breaking the surface.
    d. If you slightly overfill a water glass, the water will form a convex surface above the top of the glass.
    e. If you place a paper towel so that it touches spilled water, the towel will draw in the water.
    f. Ice floats on water.
    g. Humans sweat and dogs pant to cool themselves on hot days.
41. Distinguish among a solute, a solvent, and a solution.
42. Distinguish between hydrophobic and hydrophilic substances.
43. Explain how you would make up a one molar (1*M*) solution of ethyl alcohol.

The Dissociation of Water Molecules

44. Name the products of the dissociation of water and give their concentration in pure water.
45. Define **acid, base,** and **pH.**
46. Explain how acids and bases may directly or indirectly alter the hydrogen ion concentration of a solution.
47. Using the bicarbonate buffer system as an example, explain how buffers work.
48. Briefly explain the causes and effects of acid precipitation.

The Importance of Carbon

49. Explain how carbon's electron configuration accounts for its ability to form large, complex, and diverse organic molecules.
50. Describe how carbon skeletons may vary, and explain how this variation contributes to the diversity and complexity of organic molecules.
51. Describe the basic structure of a hydrocarbon and explain why these molecules are hydrophobic.
52. Distinguish among the three types of isomers: structural, geometric, and enantiomer.

Functional Groups

53. Name the major functional groups found in organic molecules. Describe the basic structure of each functional group and outline the chemical properties of the organic molecules in which they occur.

The Principles of Polymers

54. List the four major classes of macromolecules.

55. Distinguish between monomers and polymers.

56. Draw diagrams to illustrate condensation and hydrolysis reactions.

Carbohydrates Serve as Fuel and Building Material

57. Distinguish among monosaccharides, disaccharides, and polysaccharides.

58. Describe the formation of a glycosidic linkage.

59. Distinguish between the glycosidic linkages found in starch and cellulose. Explain why the difference is biologically important.

60. Describe the role of symbiosis in cellulose digestion.

Lipids Are a Diverse Group of Hydrophobic Molecules

61. Describe the building-block molecules, structure, and biological importance of fats, phospholipids, and steroids.

62. Identify an ester linkage and describe how it is formed.

63. Distinguish between saturated and unsaturated fats.

64. Name the principal energy storage molecules of plants and animals.

Proteins Have Many Structures and Many Functions

65. Distinguish between a protein and a polypeptide.

66. Explain how a peptide bond forms between two amino acids.

67. List and describe the four major components of an amino acid. Explain how amino acids may be grouped according to the physical and chemical properties of the R group.

68. Explain what determines protein conformation and why it is important.

69. Explain how the primary structure of a protein is determined.

70. Name two types of secondary protein structure. Explain the role of hydrogen bonds in maintaining secondary structure.

71. Explain how weak interactions and disulfide bridges contribute to tertiary protein structure.

72. List four conditions under which proteins may be denatured.

Nucleic Acids Store and Transmit Hereditary Information

73. List the major components of a nucleotide, and describe how these monomers are linked to form a nucleic acid.

74. Distinguish between:

    a. pyrimidine and purine
    b. nucleotide and nucleoside
    c. ribose and deoxyribose
    d. 59 end and 39 end of a nucleotide

75. Briefly describe the three-dimensional structure of DNA.

How We Study Cells

76. Distinguish between magnification and resolving power.

77. Describe the principles, advantages, and limitations of the light microscope, transmission electron microscope, and scanning electron microscope.

78. Describe the major steps of cell fractionation and explain why it is a useful technique.

A Panoramic View of the Cell

79. Distinguish between prokaryotic and eukaryotic cells.

80. Explain why there are both upper and lower limits to cell size.

81. Explain the advantages of compartmentalization in eukaryotic cells.

The Nucleus and Ribosomes

82. Describe the structure and function of the nuclear envelope, including the role of the pore complex.

83. Briefly explain how the nucleus controls protein synthesis in the cytoplasm.

84. Explain how the nucleolus contributes to protein synthesis.

85. Describe the structure and function of a eukaryotic ribosome.

86. Distinguish between free and bound ribosomes in terms of location and function.

The Endomembrane System

87. List the components of the endomembrane system, and describe the structure and functions of each component.

88. Compare the structure and functions of smooth and rough ER.

89. Explain the significance of the *cis* and *trans* sides of the Golgi apparatus.

90. Describe the cisternal maturation model of Golgi function.
91. Describe three examples of intracellular digestion by lysosomes.
92. Name three different kinds of vacuoles, giving the function of each kind.

Other Membranous Organelles

93. Briefly describe the energy conversions carried out by mitochondria and chloroplasts.
94. Describe the structure of a mitochondrion and explain the importance of compartmentalization in mitochondrial function.
95. Distinguish among amyloplasts, chromoplasts, and chloroplasts.
96. Identify the three functional compartments of a chloroplast. Explain the importance of compartmentalization in chloroplast function.
97. Describe the evidence that mitochondria and chloroplasts are semiautonomous organelles.
98. Explain the roles of peroxisomes in eukaryotic cells.

The Cytoskeleton

99. Describe the functions of the cytoskeleton.

    Compare the structure, monomers, and functions of microtubules, microfilaments, and intermediate filaments.

100. Explain how the ultrastructure of cilia and flagella relates to their functions.

Cell Surfaces and Junctions

101. Describe the basic structure of a plant cell wall.
102. Describe the structure and list four functions of the extracellular matrix in animal cells.
103. Explain how the extracellular matrix may act to integrate changes inside and outside the cell.
104. Name the intercellular junctions found in plant and animal cells and list the function of each type of junction.

Membrane Structure

105. Explain why phospholipids are amphipathic molecules.
106. Explain what freeze-fracture techniques reveal about the arrangement of proteins in membranes.
107. Describe the fluidity of the components of a cell membrane and explain how membrane fluidity is influenced by temperature and membrane composition.

108. Explain how cholesterol resists changes in membrane fluidity with temperature change.

Traffic Across Membranes

109. Distinguish between peripheral and integral membrane proteins.
110. List six major functions of membrane proteins.
111. Explain the role of membrane carbohydrates in cell-cell recognition.
112. Explain how hydrophobic molecules cross cell membranes.
113. Distinguish between channel proteins and carrier proteins.
114. Define **diffusion.** Explain why diffusion is a spontaneous process.

    Explain why a concentration gradient of a substance across a membrane represents potential energy.

115. Distinguish among hypertonic, hypotonic, and isotonic solutions.
116. Define **osmosis** and predict the direction of water movement based on differences in solute concentrations.
117. Describe how living cells with and without cell walls regulate water balance.
118. Explain how transport proteins facilitate diffusion.
119. Distinguish among osmosis, facilitated diffusion, and active transport.
120. Describe the two forces that combine to produce an electrochemical gradient.
121. Explain how an electrogenic pump creates voltage across a membrane.
122. Describe the process of cotransport.
123. Explain how large molecules are transported across a cell membrane.
124. Distinguish between pinocytosis and receptor-mediated endocytosis.

Metabolism, Energy, and Life

125. Explain the role of catabolic and anabolic pathways in cellular metabolism.
126. Distinguish between kinetic and potential energy.
127. Explain why an organism is considered an open system.
128. Explain the first and second laws of thermodynamics in your own words.
129. Explain why highly ordered living organisms do not violate the second law of thermodynamics.
130. Distinguish between exergonic and endergonic reactions in terms of free energy change.

131. List the three main kinds of cellular work. Explain in general terms how cells obtain the energy to do cellular work.
132. Describe the structure of ATP and identify the major class of macromolecules to which ATP belongs.
133. Explain how ATP performs cellular work.

Enzymes Are Catalytic Proteins

134. Describe the function of enzymes in biological systems.
135. Explain why an investment of activation energy is necessary to initiate a spontaneous reaction.
136. Explain how enzyme structure determines enzyme specificity.
137. Explain the induced-fit model of enzyme function.
138. Describe the mechanisms by which enzymes lower activation energy.
139. Explain how substrate concentration affects the rate of an enzyme-catalyzed reaction.
140. Explain how temperature, pH, cofactors, and enzyme inhibitors can affect enzyme activity.

The Control of Metabolism

141. Explain how metabolic pathways are regulated.
142. Explain how the location of enzymes in a cell may help order metabolism.

The Principles of Energy Harvest

143. In general terms, distinguish between fermentation and cellular respiration.
144. Write the summary equation for cellular respiration. Write the specific chemical equation for the degradation of glucose.
145. Define *oxidation* and *reduction.*
146. Explain in general terms how redox reactions are involved in energy exchanges.
147. Describe the role of NAD^+ in cellular respiration.
148. In general terms, explain the role of the electron transport chain in cellular respiration.

The Process of Cellular Respiration

149. Name the three stages of cellular respiration and state the region of the eukaryotic cell where each stage occurs.
150. Describe how the carbon skeleton of glucose changes as it proceeds through glycolysis.

151. Explain why ATP is required for the preparatory steps of glycolysis.
152. Identify where substrate-level phosphorylation and the reduction of NAD^+ occur in glycolysis.
153. Describe where pyruvate is oxidized to acetyl CoA, what molecules are produced, and how this process links glycolysis to the citric acid cycle.
154. List the products of the citric acid cycle. Explain why it is called a cycle.
155. Describe the point at which glucose is completely oxidized during cellular respiration.
156. Distinguish between substrate-level phosphorylation and oxidative phosphorylation.
157. In general terms, explain how the exergonic "slide" of electrons down the electron transport chain is coupled to the endergonic production of ATP by chemiosmosis.
158. Explain where and how the respiratory electron transport chain creates a proton gradient.
159. Describe the structure and function of the four subunits of ATP synthase.
160. Summarize the net ATP yield from the oxidation of a glucose molecule by constructing an ATP ledger.
161. Explain why it is not possible to state an exact number of ATP molecules generated by the oxidation of glucose.

Related Metabolic Processes

162. State the basic function of fermentation.
163. Compare the fate of pyruvate in alcohol fermentation and in lactic acid fermentation.
164. Compare the processes of fermentation and cellular respiration.
165. Describe the evidence that suggests that glycolysis is an ancient metabolic pathway.
166. Describe how food molecules other than glucose can be oxidized to make ATP.
167. Explain how glycolysis and the citric acid cycle can contribute to anabolic pathways.
168. Explain how ATP production is controlled by the cell, and describe the role that the allosteric enzyme phosphofructokinase plays in the process.

The Process That Feeds the Biosphere

169. Distinguish between autotrophic and heterotrophic nutrition.
170. Distinguish between photoautotrophs and chemoautotrophs.
171. Describe the structure of a chloroplast, listing all membranes and compartments.

The Pathways of Photosynthesis

172. Write a summary equation for photosynthesis.

173. Explain van Niel's hypothesis and describe how it contributed to our current understanding of photosynthesis. Explain the evidence that supported his hypothesis.

174. In general terms, explain the role of redox reactions in photosynthesis.

175. Describe the two main stages of photosynthesis in general terms.

176. Describe the relationship between an action spectrum and an absorption spectrum. Explain why the action spectrum for photosynthesis differs from the absorption spectrum for chlorophyll *a*.

177. Explain how carotenoids protect the cell from damage by light.

178. List the wavelengths of light that are most effective for photosynthesis.

179. Explain what happens when a solution of chlorophyll *a* absorbs photons. Explain what happens when chlorophyll *a* in an intact chloroplast absorbs photons.

180. List the components of a photosystem and explain the function of each component.

181. Trace the movement of electrons in noncyclic electron flow. Trace the movement of electrons in cyclic electron flow.

182. Explain the functions of cyclic and noncyclic electron flow.

183. Describe the similarities and differences in chemiosmosis between oxidative phosphorylation in mitochondria and photophosphorylation in chloroplasts.

184. State the function of each of the three phases of the Calvin cycle.

185. Describe the role of ATP and NADPH in the Calvin cycle.

186. Describe what happens to rubisco when concentration is much higher than concentration.

187. Describe the major consequences of photorespiration. Explain why it is thought to be an evolutionary relict.

188. Describe two important photosynthetic adaptations that minimize photorespiration.

189. List the possible fates of photosynthetic products.

An Overview of Cell Signaling

190. Describe the basic signal-transduction pathway used for mating in yeast. Explain why we believe these pathways evolved before the first multicellular organisms appeared on Earth.

191. Define *paracrine signaling* and give an example.

192. Define *local regulation* and explain why hormones are not local regulators.

193. Explain how plant and animal hormones travel to target cells.

194. List and briefly define the three stages of cell signaling.

Signal Reception and the Initiation of Transduction

195. Describe the nature of a ligand-receptor interaction and state how such interactions initiate a signal-transduction system.

196. State where signal receptors may be located in target cells.

197. Compare and contrast G-protein-linked receptors, tyrosine-kinase receptors, and ligand-gated ion channels.

Signal-Transduction Pathways

198. Describe two advantages of using a multistep pathway in the transduction stage of cell signaling.

199. Explain how the original signal molecule can produce a cellular response when it may not even enter the target cell.

200. Describe how phosphorylation propagates signal information.

201. Explain why a single cell may require hundreds of different protein kinases.

202. Explain how protein phosphatases turn off signal-transduction pathways.

203. Define the term *second messenger.* Briefly describe the role of these molecules in signaling pathways.

204. Describe how cyclic AMP is formed and how it propagates signal information in target cells.

205. Explain how the cholera bacterium causes the symptoms of cholera by disrupting G-protein-signaling pathways.

206. Describe how the cytosolic concentration of $^{+}$ can be altered and how the increased pool of $^{+}$ is involved with signal transduction.

Cellular Responses to Signals

207. Describe how signal information is transduced into cellular responses in the cytoplasm and in the nucleus.

208. Describe how signal amplification is accomplished in target cells.

209. Explain why different types of cells may respond differently to the same signal molecule.

210. Explain how scaffolding proteins help to coordinate a cell's response to incoming signals.

The Key Roles of Cell Division h a p t e r 1 2

211. Explain how cell division functions in reproduction, growth, and repair.

212. Describe the structural organization of a prokaryotic and a eukaryotic genome.

213. Describe the major events of cell division that enable the genome of one cell to be passed on to two daughter cells.

214. Describe how chromosome number changes throughout the human life cycle.

The Mitotic Cell Cycle

215. List the phases of the cell cycle and describe the sequence of events that occurs during each phase.

216. List the phases of mitosis and describe the events characteristic of each phase.

217. Recognize the phases of mitosis from diagrams and micrographs.

218. Draw or describe the spindle apparatus, including centrosomes, kinetochore microtubules, nonkinetochore microtubules, asters, and centrioles (in animal cells).

219. Describe what characteristic changes occur in the spindle apparatus during each phase of mitosis.

220. Explain the current models for poleward chromosomal movement and elongation of the cell's polar axis.

221. Compare cytokinesis in animals and in plants.

222. Describe the process of binary fission in bacteria and explain how eukaryotic mitosis may have evolved from binary fission.

Regulation of the Cell Cycle

223. Describe the roles of checkpoints, cyclin, Cdk, and MPF in the cell cycle control system.

224. Describe the internal and external factors that influence the cell cycle control system.

225. Explain how the abnormal cell division of cancerous cells escapes normal cell cycle controls.

226. Distinguish among benign, malignant, and metastatic tumors.

The Basis of Heredity

227. Explain in general terms how traits are transmitted from parents to offspring.

228. Distinguish between asexual and sexual reproduction.

The Role of Meiosis in Sexual Life Cycles

229. Distinguish between the following pairs of terms:

    a. somatic cell and gamete
    b. autosome and sex chromosome

230. Explain how haploid and diploid cells differ from each other. State which cells in the human body are diploid and which are haploid.

231. Explain why fertilization and meiosis must alternate in all sexual life cycles.

232. Distinguish among the three life-cycle patterns characteristic of eukaryotes, and name one organism that displays each pattern.

233. List the phases of meiosis I and meiosis II and describe the events characteristic of each phase.

234. Recognize the phases of meiosis from diagrams or micrographs.

235. Describe the process of synapsis during prophase I and explain how genetic recombination occurs.

236. Describe three events that occur during meiosis I but not during mitosis.

Origins of Genetic Variation

237. Explain how independent assortment, crossing over, and random fertilization contribute to genetic variation in sexually reproducing organisms.

238. Explain why heritable variation is crucial to Darwin's theory of evolution by natural selection.

Gregor Mendel's Discoveries

239. Explain how Mendel's particulate mechanism differed from the blending theory of inheritance.

240. Define the following terms: *true-breeding, hybridization, monohybrid cross, P generation, F_1 generation,* and *F_2 generation.*

241. List and explain the four components of Mendel's hypothesis that led him to deduce the law of segregation.

242. Use a Punnett square to predict the results of a monohybrid cross, stating the phenotypic and genotypic ratios of the F_2 generation.

243. Distinguish between the following pairs of terms: *dominant* and *recessive; heterozygous* and *homozygous; genotype* and *phenotype.*

244. Explain how a testcross can be used to determine if an individual with the dominant phenotype is homozygous or heterozygous.

245. Use a Punnett square to predict the results of a dihybrid cross and state the phenotypic and genotypic ratios of the F_2 generation.

246. State Mendel's law of independent assortment and describe how this law can be explained by the behavior of chromosomes during meiosis.

247. Use the rule of multiplication to calculate the probability that a particular F_2 individual will be homozygous recessive or dominant.

248. Given a Mendelian cross, use the rule of addition to calculate the probability that a particular F_2 individual will be heterozygous.

249. Use the laws of probability to predict, from a trihybrid cross between two individuals that are heterozygous for all three traits, what expected proportion of the offspring would be:

    a. homozygous dominant for the three traits
    b. heterozygous for all three traits
    c. homozygous recessive for two specific traits and heterozygous for the third

250. Explain why it is important that Mendel used large sample sizes in his studies.

Extending Mendelian Genetics

251. Give an example of incomplete dominance and explain why it does not support the blending theory of inheritance.

252. Explain how phenotypic expression of the heterozygote differs with complete dominance, incomplete dominance, and codominance.

253. Explain why Tay-Sachs disease is considered recessive at the organismal level but codominant at the molecular level.

254. Explain why genetic dominance does not mean that a dominant allele subdues a recessive allele. Illustrate your explanation with the use of round versus wrinkled pea seed shape.

255. Explain why dominant alleles are not necessarily more common in a population. Illustrate your explanation with an example.

256. Describe the inheritance of the ABO blood system and explain why the I^A and I^B alleles are said to be codominant.

257. Define and give examples of *pleiotropy* and *epistasis.*

258. Describe a simple model for polygenic inheritance and explain why most polygenic characters are described in quantitative terms.

259. Describe how environmental conditions can influence the phenotypic expression of a character. Explain what is meant by "a norm of reaction."

260. Distinguish between the specific and broad interpretations of the terms *phenotype* and *genotype.*

Mendelian Inheritance in Humans

261. Explain why studies of human inheritance are not as easily conducted as Mendel's work with his peas.

262. Given a simple family pedigree, deduce the genotypes for some of the family members.

263. Explain how a lethal recessive allele can be maintained in a population.

264. Describe the inheritance and expression of cystic fibrosis, Tay-Sachs disease, and sickle-cell disease.

265. Explain why lethal dominant genes are much rarer than lethal recessive genes.

266. Give an example of a late-acting lethal dominant gene in humans and explain how it can escape elimination by natural selection.

267. Define and give examples of multifactorial disorders in humans.

268. Explain how carrier recognition, fetal testing, and newborn screening can be used in genetic screening and counseling.

Relating Mendelian Inheritance to the Behavior of Chromosomes

269. Explain why *Drosophila melanogaster* is a good experimental organism for genetic studies.

270. Explain why linked genes do not assort independently.

271. Distinguish between parental and recombinant phenotypes.

272. Explain how crossing over can unlink genes.

273. Explain how Sturtevant created linkage maps.

274. Define a map unit.

275. Explain why Mendel did not find linkage between seed color and flower color, despite the fact that these genes are on the same chromosome.

276. Explain how genetic maps are constructed for genes located far apart on a chromosome.

277. Explain the effect of multiple crossovers between loci.

278. Explain what additional information cytogenetic maps provide.

Sex Chromosomes

279. Describe how sex is genetically determined in humans and explain the significance of the *SRY* gene.

280. Distinguish between linked genes and sex-linked genes.

281. Explain why sex-linked diseases are more common in human males.

282. Describe the inheritance patterns and symptoms of color blindness, Duchenne muscular dystrophy, and hemophilia.

283. Describe the process of X inactivation in female mammals. Explain how this phenomenon produces the tortoiseshell coloration in cats.

Errors and Exceptions in Chromosomal Inheritance

284. Explain how nondisjunction can lead to aneuploidy.

285. Define *trisomy*, *triploidy*, and *polyploidy.* Explain how these major chromosomal changes occur and describe possible consequences.

286. Distinguish among deletions, duplications, inversions, and translocations.

287. Describe the type of chromosomal alterations responsible for the following human disorders: Down syndrome, Klinefelter syndrome, extra Y, triple-X syndrome, Turner syndrome, *cri du chat* syndrome, and chronic myelogenous leukemia.

288. Define *genomic imprinting.* Describe the evidence that suggests that the *Igf2* gene is maternally imprinted.

289. Explain why extranuclear genes are not inherited in a Mendelian fashion.

DNA as the Genetic Material

290. Explain why researchers originally thought protein was the genetic material.

291. Summarize the experiments performed by the following scientists that provided evidence that DNA is the genetic material:

    a. Frederick Griffith
    b. Oswald Avery, Maclyn McCarty, and Colin MacLeod
    c. Alfred Hershey and Martha Chase
    d. Erwin Chargaff

292. Explain how Watson and Crick deduced the structure of DNA and describe the evidence they used. Explain the significance of the research of Rosalind Franklin.

293. Describe the structure of DNA. Explain the base-pairing rule and describe its significance.

DNA Replication and Repair

294. Describe the semiconservative model of replication and the significance of the experiments of Matthew Meselson and Franklin Stahl.

295. Describe the process of DNA replication, including the role of the origins of replication and replication forks.

296. Explain the role of DNA polymerases in replication.

297. Explain what energy source drives the polymerization of DNA.

298. Define *antiparallel* and explain why continuous synthesis of both DNA strands is not possible.

299. Distinguish between the leading strand and the lagging strand.

300. Explain how the lagging strand is synthesized even though DNA polymerase can add nucleotides only to the 39 end. Describe the significance of Okazaki fragments.

301. Explain the roles of DNA ligase, primer, primase, helicase, topoisomerase, and single-strand binding proteins.

302. Explain why an analogy can be made comparing DNA replication to a locomotive made of DNA polymerase moving along a railroad track of DNA.

303. Explain the roles of DNA polymerase, mismatch repair enzymes, and nuclease in DNA proofreading and repair.

304. Describe the structure and function of telomeres.

305. Explain the possible significance of telomerase in germ cells and cancerous cells.

The Connection Between Genes and Proteins

306. Explain why dwarf peas have shorter stems than tall varieties.

307. Explain the reasoning that led Archibald Garrod to first suggest that genes dictate phenotypes through enzymes.

308. Describe Beadle and Tatum's experiments with *Neurospora* and explain the contribution they made to our understanding of how genes control metabolism.

309. Distinguish between the "one gene–one enzyme" hypothesis and the "one gene–one polypeptide" hypothesis and explain why the original hypothesis was changed.

310. Explain how RNA differs from DNA.

311. Briefly explain how information flows from gene to protein.

312. Distinguish between transcription and translation.

313. Compare where transcription and translation occur in prokaryotes and in eukaryotes.

314. Define *codon* and explain the relationship between the linear sequence of codons on mRNA and the linear sequence of amino acids in a polypeptide.

315. Explain the early techniques used to identify what amino acids are specified by the triplets UUU, AAA, GGG, and CCC.

316. Explain why polypeptides begin with methionine when they are synthesized.

317. Explain what it means to say that the genetic code is redundant and unambiguous.

318. Explain the significance of the reading frame during translation.

319. Explain the evolutionary significance of a nearly universal genetic code.

The Synthesis and Processing of RNA

320. Explain how RNA polymerase recognizes where transcription should begin. Describe the promoter, the terminator, and the transcription unit.

321. Explain the general process of transcription, including the three major steps of initiation, elongation, and termination.
322. Explain how RNA is modified after transcription in eukaryotic cells.
323. Define and explain the role of *ribozymes.*
324. Describe the functional and evolutionary significance of introns.

The Synthesis of Protein

325. Describe the structure and functions of tRNA.
326. Explain the significance of wobble.
327. Explain how tRNA is joined to the appropriate amino acid.
328. Describe the structure and functions of ribosomes.
329. Describe the process of translation (including initiation, elongation, and termination) and explain which enzymes, protein factors, and energy sources are needed for each stage.
330. Describe the significance of polyribosomes.
331. Explain what determines the primary structure of a protein and describe how a polypeptide must be modified before it becomes fully functional.
332. Describe what determines whether a ribosome will be free in the cytosol or attached to the rough endoplasmic reticulum.
333. Describe two properties of RNA that allow it to perform so many different functions.
334. Compare protein synthesis in prokaryotes and in eukaryotes.
335. Define *point mutations.* Distinguish between base-pair substitutions and base-pair insertions. Give examples of each and note the significance of such changes.
336. Describe several examples of mutagens and explain how they cause mutations.

The Genetics of Viruses

337. Recount the history leading up to the discovery of viruses. Include the contributions of Adolf Mayer, Dimitri Ivanowsky, Martinus Beijerinck, and Wendell Stanley.
338. List and describe the structural components of viruses.
339. Explain why viruses are obligate intracellular parasites.
340. Explain how a virus identifies its host cell.
344. Describe bacterial defenses against phages.
345. Distinguish between the lytic and lysogenic reproductive cycles, using phage lambda as an example.

346. Describe the reproductive cycle of an enveloped virus. Explain the reproductive cycle of the herpesvirus.
347. Describe the reproductive cycle of retroviruses.
348. List some characteristics that viruses share with living organisms and explain why viruses do not fit our usual definition of life.
349. Describe the evidence that viruses probably evolved from fragments of cellular nucleic acids.
350. Define and describe mobile genetic elements.
351. Explain how viral infections in animals cause disease.
352. Describe the best current medical defenses against viruses. Explain how AZT helps to fight HIV infections.
353. Describe the mechanisms by which new viral diseases emerge.
354. Distinguish between the horizontal and vertical routes of viral transmission in plants.
355. Describe viroids and prions.
356. Explain how a non-replicating protein can act as a transmissible pathogen.

The Genetics of Bacteria

347. Describe the structure of a bacterial chromosome.
348. Compare the sources of genetic variation in bacteria and humans.
349. Compare the processes of transformation, transduction, and conjugation.
350. Define an *episome.* Explain why a plasmid can be an episome.
351. Describe the significance of R plasmids. Explain how the widespread use of antibiotics contributes to R plasmid-related disease.
352. Explain how transposable elements may cause recombination of bacterial DNA.
353. Distinguish between an insertion sequence and a transposon.
354. Describe the role of transposase in the process of transposition.
355. Briefly describe two main strategies that cells use to control metabolism.
356. Explain the adaptive advantage of genes grouped into an operon.
357. Using the *trp* operon as an example, explain the concept of an operon and the function of the operator, repressor, and corepressor.
358. Distinguish between structural and regulatory genes.
359. Describe how the *lac* operon functions and explain the role of the inducer, allolactose.
360. Explain how repressible and inducible enzymes differ and how those differences reflect differences in the pathways they control.

361. Distinguish between positive and negative control and give examples of each from the *lac* operon.
362. Explain how cyclic AMP and catabolite activator protein are affected by glucose concentration.

The Structure of Eukaryotic Chromatin

1. Compare the structure and organization of prokaryotic and eukaryotic genomes.
2. Describe the current model for progressive levels of DNA packing in eukaryotes.
3. Explain how histones influence folding in eukaryotic DNA.
4. Distinguish between heterochromatin and euchromatin.

The Control of Gene Expression

5. Explain the relationship between differentiation and differential gene expression.
6. Describe at what level gene expression is generally controlled.
7. Explain how DNA methylation and histone acetylation affect chromatin structure and the regulation of transcription.
8. Define *epigenetic inheritance.*
9. Describe the processing of pre-mRNA in eukaryotes.
10. Define *control elements* and explain how they influence transcription.
11. Distinguish between general and specific transcription factors.
12. Explain the role that promoters, enhancers, activators, and repressors may play in transcriptional control.
13. Explain how eukaryotic genes can be coordinately expressed and give some examples of coordinate gene expression in eukaryotes.
14. Describe the process and significance of alternative RNA splicing.
15. Describe factors that influence the life span of mRNA in the cytoplasm. Compare the longevity of mRNA in prokaryotes and in eukaryotes.
16. Explain how gene expression may be controlled at the translational and post-translational level.

The Molecular Biology of Cancer

17. Distinguish between proto-oncogenes and oncogenes. Describe three genetic changes that can convert proto-oncogenes into oncogenes.
18. Explain how mutations in tumor-suppressor genes can contribute to cancer.
19. Explain how excessive cell division can result from mutations in the *ras* proto-oncogenes.

20. Explain why a mutation knocking out the *p53* gene can lead to excessive cell growth and cancer. Describe three ways that *p53* prevents a cell from passing on mutations caused by DNA damage.
21. Describe the set of genetic factors typically associated with the development of cancer.
22. Explain how viruses can cause cancer. Describe several examples.
23. Explain how inherited cancer alleles can lead to a predisposition to certain cancers.

Genome Organization at the DNA Level

24. Describe the structure and functions of the portions of eukaryotic DNA that do not encode protein or RNA.
25. Distinguish between transposons and retrotransposons.
26. Describe the structure and location of *Alu* elements in primate genomes.
27. Describe the structure and possible function of simple sequence DNA.
28. Using the genes for rRNA as an example, explain how multigene families of identical genes can be advantageous for a cell.
29. Using a-globin and b-globin genes as examples, describe how multigene families of nonidentical genes may have evolved.
30. Define *pseudogenes.* Explain how such genes may have evolved.
31. Describe the hypothesis for the evolution of a-lactalbumin from an ancestral lysozyme gene.
32. Explain how exon shuffling could lead to the formation of new proteins with novel functions.
33. Describe how transposition of an *Alu* element may allow the formation of new genetic combinations while retaining gene function.

DNA Cloning

1. Explain how advances in recombinant DNA technology have helped scientists study the eukaryotic genome.
2. Describe the natural function of restriction enzymes and explain how they are used in recombinant DNA technology.
3. Explain how the creation of sticky ends by restriction enzymes is useful in producing a recombinant DNA molecule.
4. Outline the procedures for cloning a eukaryotic gene in a bacterial plasmid.
5. Describe techniques that allow identification of recombinant cells that have taken up a gene of interest.

6. Define and distinguish between genomic libraries using plasmids, phages, and cDNA.
7. Describe the role of an expression vector.
8. Describe two advantages of using yeast cells instead of bacteria as hosts for cloning or expressing eukaryotic genes.
9. Describe two techniques to introduce recombinant DNA into eukaryotic cells.
10. Describe the polymerase chain reaction (PCR) and explain the advantages and limitations of this procedure.
11. Explain how gel electrophoresis is used to analyze nucleic acids and to distinguish between two alleles of a gene.
12. Describe the process of nucleic acid hybridization.
13. Describe the Southern blotting procedure and explain how it can be used to detect and analyze instances of restriction fragment length polymorphism (RFLP).
14. Explain how RFLP analysis facilitated the process of genomic mapping.

DNA Analysis and Genomics

15. Explain the goals of the Human Genome Project.
16. Explain how linkage mapping, physical mapping, and DNA sequencing each contributed to the genome mapping project.
17. Describe the alternate approach to whole-genome sequencing pursued byJ. Craig Venter and the Celera Genomics company.
18. Explain how researchers recognize protein-coding genes within DNA sequences.
19. Describe the surprising results of the Human Genome Project.
20. Explain how the vertebrate genome, including that of humans, generates greater diversity than the genomes of invertebrate organisms.
21. Explain how *in vitro* mutagenesis and RNA interference help researchers to discover the functions of some genes.
22. Explain the purposes of gene expression studies. Describe the use of DNA microarray assays and explain how they facilitate such studies.
23. Define and compare the fields of *proteomics* and *genomics.*
24. Explain the significance of single nucleotide polymorphisms in the study of the human evolution.

Practical Applications of DNA Technology

25. Describe how DNA technology can have medical applications in such areas as the diagnosis of genetic disease, the development of gene therapy, vaccine production, and the development of pharmaceutical products.

26. Explain how DNA technology is used in the forensic sciences.
27. Describe how gene manipulation has practical applications for environmental and agricultural work.
28. Describe how plant genes can be manipulated using the Ti plasmid carried by *Agrobacterium* as a vector.
29. Explain how DNA technology can be used to improve the nutritional value of crops and to develop plants that can produce pharmaceutical products.
30. Discuss the safety and ethical questions related to recombinant DNA studies and the biotechnology industry.

From Single Cell to Multicellular Organism

1. List the animals used as models for developmental biology research and provide a rationale for their choice.
2. Distinguish between the patterns of morphogenesis in plants and in animals.

Differential Gene Expression

3. Describe how genomic equivalence was determined for plants and animals.
4. Describe what kinds of changes occur to the genome during differentiation.
5. Describe the general process by which the ewe Dolly and the first mice were cloned.
6. Describe the characteristics of stem cells. Explain their significance to medicine.
7. Distinguish between determination and differentiation. Explain why determination precedes differentiation.
8. Describe the molecular basis of determination.
9. Describe the two sources of information that instruct a cell to express genes at the appropriate time.

Genetic and Cellular Mechanisms of Pattern Formation

10. Describe how *Drosophila* was used to investigate the basic aspects of pattern formation (axis formation and segmentation).
11. Explain how maternal genes affect polarity and development in *Drosophila* embryos.
12. Describe how gradients of morphogens may specify the axes of developing *Drosophila* embryos.
13. Describe how homeotic genes define the anatomical identity of the segments of a developing organism.
14. Describe how the study of nematodes contributed to an understanding of the role of induction in development.

15. Describe how apoptosis functions in normal and abnormal development.
16. Describe how the study of tomatoes has contributed to the understanding of flower development.
17. Describe how the study of *Arabidopsis* has contributed to the understanding of organ identity in plants.
18. Provide evidence of the conservation of homeobox patterns.

The Historical Context for Evolutionary Theory

1. Explain the mechanism for evolutionary change proposed by Charles Darwin in *On the Origin of Species.*
2. Define *evolution* and *adaptation.*
3. Compare and contrast Aristotle's *scala naturae* to Carolus Linnaeus' classification scheme.
4. Describe the theories of catastrophism, gradualism, and uniformitarianism.
5. Explain the mechanism for evolutionary change proposed by Jean-Baptiste de Lamarck. Explain why modern biology has rejected Lamarck's theories.

The Darwinian Revolution

6. Describe how Darwin's observations on the voyage of the HMS *Beagle* led him to formulate and support his theory of evolution.
7. Explain how the principle of gradualism and Charles Lyell's theory of uniformitarianism influenced Darwin's ideas about evolution.
8. Explain what Darwin meant by "descent with modification."
9. Explain what evidence convinced Darwin that species change over time.
10. Explain how Linnaeus' classification scheme fit Darwin's theory of evolution by natural selection.
11. Describe the three inferences Darwin made from his observations that led him to propose natural selection as a mechanism for evolutionary change.
12. Explain how an essay by the Rev. Thomas Malthus influenced Charles Darwin.
13. Distinguish between artificial selection and natural selection.
14. Explain why an individual organism cannot evolve.
15. Describe the experiments that supported Reznick and Endler's hypothesis that differences in life-history traits between guppy populations are due to selective pressure based on predation.
16. Explain how the existence of homologous and vestigial structures can be explained by Darwin's theory of natural selection.

17. Explain how evidence from biogeography supports the theory of evolution by natural selection.
18. Explain the problem with the statement that Darwinism is "just a theory." Distinguish between the scientific and colloquial use of the word *theory.*

Population Genetics

1. Explain the statement "It is the population, not the individual, that evolves."
2. Explain how Mendel's particulate hypothesis of inheritance provided much-needed support for Darwin's theory of evolution by natural selection.
3. Distinguish between discrete and quantitative traits. Explain how Mendel's laws of inheritance apply to quantitative traits.
4. Explain what is meant by "the modern synthesis."
5. Define the terms *population, species,* and *gene pool.*
6. Explain why meiosis and random fertilization alone will not alter the frequency of alleles or genotypes in a population.
7. List the five conditions that must be met for a population to remain in Hardy-Weinberg equilibrium.
8. Write the Hardy-Weinberg equation. Use the equation to calculate allele frequencies when the frequency of homozygous recessive individuals in a population is 25%.

Mutation and Sexual Recombination

9. Explain why the majority of point mutations are harmless.
10. Explain why mutation has little quantitative effect on allele frequencies in a large population.
11. Describe the significance of transposons in the generation of genetic variability.
12. Explain how sexual recombination generates genetic variability.

Natural Selection, Genetic Drift, and Gene Flow

13. Explain the following statement: "Only natural selection leads to the adaptation of organisms to their environment."
14. Explain the role of population size in genetic drift.
15. Distinguish between the bottleneck effect and the founder effect.
16. Describe how gene flow can act to reduce genetic differences between adjacent populations.

Genetic Variation, the Substrate for Natural Selection

17. Explain how quantitative and discrete characters contribute to variation within a population.
18. Distinguish between average heterozygosity and nucleotide variability. Explain why average heterozygosity tends to be greater than nucleotide variability.
19. Define a *cline.*
20. Define *relative fitness.*
    a. Explain why relative fitness is zero for a healthy, long-lived, sterile organism.
    b. Explain why relative fitness could be high for a short-lived organism.
21. Distinguish among directional, disruptive, and stabilizing selection. Give an example of each mode of selection.
22. Explain how diploidy can protect a rare recessive allele from elimination by natural selection.
23. Describe how heterozygote advantage and frequency-dependent selection promote balanced polymorphism.
24. Define *neutral variations*. Explain why natural selection does not act on thesealleles.
25. Distinguish between intrasexual selection and intersexual selection.
26. Explain how female preferences for showy male traits may benefit the female.
27. Describe the disadvantages of sexual reproduction.
28. Explain how the genetic variation promoted by sex may be advantageous to individuals on a generational time scale.
29. List four reasons why natural selection cannot produce perfect organisms.

An Overview of Land Plant Evolution

1. Describe four shared derived homologies that link charophyceans and land plants.
2. Distinguish among the kingdoms Plantae, Streptophyta, and Viridiplantae. Note which of these is used in the textbook.
3. Describe five characteristics that distinguish land plants from charophycean algae. Explain how these features are adaptive for life on land.
4. Define and distinguish among the stages of the alternation of generations life cycle.
5. Describe evidence that suggests that plants arose roughly 475 million years ago.

Bryophytes

6. List and distinguish among the three phyla of bryophytes. Briefly describe the characteristics of each group.
7. Distinguish between the phylum Bryophyta and the bryophytes.

8. Explain why bryophyte rhizoids are not considered roots.
9. Explain why most bryophytes grow close to the ground.
10. Diagram the life cycle of a bryophyte. Label the gametophyte and sporophyte stages and the locations of gamete production, fertilization, and spore production.
11. Describe the ecological and economic significance of bryophytes.

The Origin and Diversity of Vascular Plants

12. Describe the five traits that characterize modern vascular plants. Explain how these characteristics have contributed to their success on land.
13. Distinguish between microphylls and megaphylls.
14. Distinguish between the homosporous and heterosporous condition.
15. Explain why seedless vascular plants are most commonly found in damp habitats.
16. Name the two clades of living seedless vascular plants.
17. Explain how vascular plants differ from bryophytes.
18. Distinguish between giant and small lycophytes.
19. Explain why whisk ferns are no longer considered to be "living fossils."
20. Describe the production and dispersal of fern spores.

Key Terrestrial Adaptations Were Crucial to the Success of Seed Plants

1. Name five terrestrial adaptations that contributed to the success of seed plants.
2. Compare the size and independence of the gametophytes of bryophytes with those of seed plants.
3. Describe the ovule of a seed plant.
4. Contrast the male gametophytes of bryophytes with those of seed plants.
5. Explain why pollen grains were an important adaptation for successful reproduction on land.
6. Explain how a seed can be said to include contributions from three distinct generations.
7. Compare spores with seeds as dispersal stages in plant life cycles.

Gymnosperms

8. Explain how climatic changes with the formation of the supercontinent Pangaea favored the spread of gymnosperms.
9. List and distinguish among the four phyla of gymnosperms.

10. Describe the life history of a pine. Indicate which structures are part of the gametophyte generation and which are part of the sporophyte generation.

Angiosperms (Flowering Plants)

11. Identify the following floral structures and describe a function for each:

a. sepal	f. anther
b. petal	g. stigma
c. stamen	h. style
d. carpel	i. ovary
e. filament	j. ovule

12. Define *fruit.* Explain how fruits may be adapted to disperse seeds.
13. Explain why a cereal grain is a fruit rather than a seed.
14. Diagram the generalized life cycle of an angiosperm. Indicate which structures are part of the gametophyte generation and which are part of the sporophyte generation.
15. Describe the role of the generative cell and the tube cell within the angiosperm pollen grain.
16. Explain the process and function of double fertilization.
17. Explain the significance of *Archaefructus.*
18. Explain the significance of *Amborella*.
19. Distinguish between monocots and eudicots.
20. Explain how animals may have influenced the evolution of terrestrial plants and vice versa.

Plants and Human Welfare

21. Name the six angiosperms that are most important in the diet of the human species.
22. Describe the current threat to plant diversity caused by human population growth.

Introduction to the Fungi

Chpter 31

1. List the characteristics that distinguish fungi from members of other multicellular kingdoms.
2. Explain how fungi acquire their nutrients.
3. Describe the basic body plan of a fungus.
4. Describe the processes of plasmogamy and karyogamy in fungi.
5. Explain the significance of heterokaryotic stages in fungal life cycles.

Diversity of Fungi

6. Describe the evidence that suggests that Fungi and Animalia are sister kingdoms.
7. Explain the possible significance of the flagellated spores of members of the phylum Chytridiomycota.
8. Describe the life cycle of the black bread mold, *Rhizopus stolonifer*.
9. Describe two alternate hypotheses to explain the reduced mitochondria of the microsporidia.
10. Distinguish between ectomycorrhizae and endomycorrhizae.
11. Distinguish among the Zygomycota, Ascomycota, and Basidiomycota. Include a description of the sexual structure that characterizes each group and list some common examples of each group.

Ecological Impacts of Fungi

12. Describe some of the roles of fungi in ecosystems.
13. Describe the structure of a lichen. Explain the roles of the fungal component of the lichen.
14. Explain how lichens may act as pioneers on newly burned soil or volcanic rock.
15. Describe the role of fungi as agricultural pests.
16. Define mycosis, and describe some human mycoses.
17. Describe three commercial roles played by fungi.

What Is an Animal?

1. List the five characteristics that combine to define animals.
2. Describe the role of *Hox* genes in animal development.

The Origins of Animal Diversity

3. Describe the evidence that suggests animals may have first evolved about a billion years ago.
4. Explain the significance of the Cambrian explosion. Describe three hypotheses for the cause of the Cambrian explosion.
5. Outline the major grades of the animal kingdom based on symmetry, embryonic germ layers, the presence or absence and type of coelom, and protostome or deuterostome development.
6. Distinguish between radial and bilateral symmetry. Explain how animal symmetry may match the animal's way of life.

7. Distinguish among the acoelomate, pseudocoelomate, and coelomate grades. Explain the functions of a body cavity.
8. Distinguish between the following pairs of terms:
   a. diploblastic and triploblastic
   b. spiral and radial cleavage
   c. determinate and indeterminate cleavage
   d. schizocoelous and enterocoelous development
9. Compare the developmental differences between protostomes and deuterostomes, including:
   a. pattern of cleavage
   b. fate of the blastopore
   c. coelom formation
10. Name five major features of animal phylogeny that are supported by systematic analyses of morphological characters and recent molecular studies.
11. Distinguish between the ecdysozoans and the lophotrochozoans. Describe the characteristic features of each group.

Chapter 33 Sponges

1. From a diagram, identify the parts of a sponge (including the spongocoel, porocyte, epidermis, choanocyte, mesohyl, amoebocyte, osculum, and spicules) and describe the function of each.

Eumetazoa

2. List the characteristics of the phylum Cnidaria that distinguish it from the other animal phyla.
3. Describe the specialized cells that are found in Cnidarians.
4. Describe the two basic body plans in Cnidaria and their role in Cnidarian life cycles.
5. List the four classes of Cnidaria and distinguish among them based on life cycle and morphological characteristics.

Bilateria

6. Distinguish between:
   a. diploblastic and triploblastic development
   b. acoelomates and coelomates
   c. gastrovascular cavity and alimentary canal

d. protostome and deuterostome

7. List the characteristics of the phylum Platyhelminthes that distinguish it from the other animal phyla.
8. Distinguish among the four classes of Platyhelminthes and give examples of each.
9. Describe the generalized life cycle of a trematode and give an example of one fluke that parasitizes humans.
10. Explain how trematodes evade detection by the immune systems of their hosts.
11. Describe the anatomy and generalized life cycle of a tapeworm.
12. Describe unique features of rotifers that distinguish them from other pseudocoelomates.
13. Define *parthenogenesis* and describe asexual forms of rotifer reproduction.
14. Define *lophophore* and list three lophophorate phyla.
15. List the distinguishing characteristics of the phylum Nemertea.
16. Explain the relationship between nemerteans and flatworms.
17. List the characteristics that distinguish the phylum Mollusca from the other animal phyla.
18. Describe the basic body plan of a mollusc and explain how it has been modified in the Bivalvia, Cephalopoda, Gastropoda, and Polyplacophora.
19. List the characteristics that distinguish the phylum Annelida from other animal phyla.
20. Distinguish among the three classes of Annelida and give examples of each.
21. Describe the adaptations that enable some leeches to feed on blood.
22. List the characteristics of the phylum Nematoda that distinguish it from other wormlike animals.
23. Give examples of both parasitic and free-living species of nematodes.
24. List the characteristics of arthropods that distinguish them from the other animal phyla. List the three features that account for the success of this phylum.
25. Describe advantages and disadvantages of an exoskeleton.
26. Distinguish between hemocoel and coelom.
27. Define and distinguish between the major arthropod lines of evolution represented by:
    a. Cheliceriformes
    b. Hexapoda
    c. Crustacea
    d. Myriapoda
28. Describe three specialized features of spiders.

29. Describe two features that may account for the great diversity of insects.

Deuterostomia

30. List the characteristics of echinoderms that distinguish them from other animal phyla.
31. Distinguish among the six classes of echinoderms and give examples of each.
32. Explain why the phylum Chordata is included in a chapter on invertebrates.
33. Describe the developmental similarities between echinoderms and chordates.

The Plant Body

1. Describe and compare the three basic organs of vascular plants. Explain how these basic organs are interdependent.
2. List the basic functions of roots. Describe and compare the structures and functions of fibrous roots, taproots, root hairs, and adventitious roots.
3. Describe the basic structure of plant stems.
4. Explain the phenomenon of apical dominance.
5. Describe the structures and functions of four types of modified shoots.
6. Describe and distinguish between the leaves of monocots and those of eudicots.
7. Describe the three tissue systems that make up plant organs.
8. Describe and distinguish between the three basic cell types of plant tissues. For each tissue, describe one characteristic structural feature and explain its functional significance.
9. Explain the functional relationship between a sieve-tube member and its companion cell.

The Process of Plant Growth and Development

10. Distinguish between determinate and indeterminate growth. Give an example of each type of growth.
11. Distinguish among annual, biennial, and perennial plants.
12. Explain this statement: “In contrast to most animals, which have a stage of embryonic growth, plants have regions of embryonic growth.”
13. Distinguish between the primary and secondary plant body.
14. Describe in detail the primary growth of the tissues of roots and shoots.
15. Describe in detail the secondary growth of the tissues of roots and shoots.
16. Name the cells that make up the tissue known as wood. Name the tissues that comprise the bark.

Mechanisms of Plant Growth and Development

17. Explain why *Arabidopsis* is an excellent model for the study of plant development.
18. Explain what each of these *Arabidopsis* mutants has taught us about plant development:
    a. *fass* mutant
    b. *gnom* mutant
    c. *KNOTTED-1* mutant
    d. *GLABRA-2* mutant
19. Define and distinguish between *morphogenesis, differentiation,* and *growth.*
20. Explain why (a) the plane and symmetry of cell division, (b) the orientation of cell expansion, and (c) cortical microtubules are important determinants of plant growth and development.
21. Explain how pattern formation may be determined in plants.
22. Give an example to demonstrate how a cell's location influences its developmental fate.
23. Explain how a vegetative shoot tip changes into a floral meristem.
24. Describe how three classes of organ identity genes interact to produce the spatial pattern of floral organs in *Arabidopsis*.

An Overview of Transport Mechanisms in Plants

1. Describe how proton pumps function in transport of materials across plant membranes, using the terms *proton gradient, membrane potential, cotransport,* and *chemiosmosis.*
2. Define *osmosis* and *water potential.* Explain how water potential is measured.
3. Explain how solutes and pressure affect water potential.
4. Explain how the physical properties of plant cells are changed when the plant is placed into solutions that have higher, lower, or the same solute concentration.
5. Define the terms *flaccid, plasmolyze, turgor pressure,* and *turgid.*
6. Explain how aquaporins affect the rate of water transport across membranes.
7. Name the three major compartments in vacuolated plant cells.
8. Distinguish between the symplast and the apoplast.
9. Describe three routes available for lateral transport in plants.
10. Define *bulk flow* and describe the forces that generate pressure in the vascular tissue of plants.

11. Relate the structure of sieve-tube cells, vessel cells, and tracheids to their functions in bulk flow.

Absorption of Water and Minerals by Roots

12. Explain what routes are available to water and minerals moving into the vascular cylinder of the root.
13. Explain how mycorrhizae enhance uptake of materials by roots.
14. Explain how the endodermis functions as a selective barrier between the root cortex and vascular cylinder.

Transport of Xylem Sap

15. Describe the potential and limits of root pressure to move xylem sap.
16. Define the terms *transpiration* and *guttation.*
17. Explain how transpirational pull moves xylem sap up from the root tips to the leaves.
18. Explain how cavitation prevents the transport of water through xylem vessels.
19. Explain this statement: “The ascent of xylem sap is ultimately solar powered.”

The Control of Transpiration

20. Explain the importance and costs of the extensive inner surface area of a leaf.
21. Discuss the factors that may alter the stomatal density of a leaf.
22. Describe the role of guard cells in photosynthesis-transpiration.
23. Explain how and when stomata open and close. Describe the cues that trigger stomatal opening at dawn.
24. Explain how xerophytes reduce transpiration.
25. Describe crassulacean acid metabolism and explain why it is an important adaptation to reduce transpiration in arid environments.

Translocation of Phloem Sap

26. Define and describe the process of translocation. Trace the path of phloem sap from a primary sugar source to a sugar sink.
27. Describe the process of sugar loading and unloading.
28. Define *pressure flow*. Explain the significance of this process in angiosperms.

Signal Transduction and Plant Responses

1. Compare the growth of a plant in darkness (etiolation) to the characteristics of greening (de-etiolation).

2. Describe the signal pathways associated with de-etiolation.
3. Describe the role of second messengers in the process of de-etiolation.
4. Describe the two main mechanisms by which a signaling pathway can activate an enzyme.
5. Explain, using several examples, what researchers have learned about the activity of plant hormones by study of mutant plants.

Plant Responses to Hormones

6. For the following scientists, describe their hypothesis, experiments, and conclusions about the mechanism of phototropism:
   a. Charles and Francis Darwin
   b. Peter Boysen-Jensen
   c. Frits Went
7. List six classes of plant hormones, describe their major functions, and note where they are produced in the plant.
8. Explain how a hormone may cause its effect on plant growth and development.
9. Describe a possible mechanism for the polar transport of auxin.
10. According to the acid growth hypothesis, explain how auxin can initiate cell elongation.
11. Explain why 2,4-D is widely used as a weed killer.
12. Explain how the ratio of cytokinin to auxin affects cell division and cell differentiation.
13. Describe the evidence that suggests that factors other than auxin from the terminal bud may control apical dominance.
14. Describe how stem elongation and fruit growth depend on a synergism between auxin and gibberellins.
15. Explain the probable mechanism by which gibberellins trigger seed germination.
16. Describe the functions of brassinosteroids in plants.
17. Describe how abscisic acid (ABA) helps prepare a plant for winter.
18. Describe the effects of ABA on seed dormancy and drought stress.
19. Describe the role of ethylene in the triple response to mechanical stress, apoptosis, leaf abscission, and fruit ripening.

Plant Responses to Light

20. Define *photomorphogenesis* and note which colors are most important to this process.

21. Compare the roles of blue-light photoreceptors and phytochromes.
22. Describe the phenomenon of chromophore photoreversibility and explain its role in light-induced germination of lettuce seeds.
23. Define *circadian rhythm* and explain what happens when an organism is artificially maintained in a constant environment.
24. List some common factors that entrain biological clocks.
25. Define *photoperiodism.*
26. Distinguish among short-day, long-day, and day-neutral plants. Explain why these names are misleading.
27. Explain what factors other than night length may control flowering and what is necessary for flowering to occur.

Plant Responses to Environmental Stimuli Other than Light

28. Describe how plants apparently tell up from down. Explain why roots display positive gravitropism and shoots exhibit negative gravitropism.
29. Distinguish between thigmotropism and thigmomorphogenesis.
30. Describe how motor organs can cause rapid leaf movements.
31. Provide a plausible explanation for how a stimulus that causes rapid leaf movement can be transmitted through the plant.
32. Describe the challenges posed by, and the responses of plants to, the following environmental stresses: drought, flooding, salt stress, heat stress, and cold stress.

Plant Defense: Responses to Herbivores and Pathogens

33. Explain how plants deter herbivores with physical and chemical defenses.
34. Describe the multiple ways that plants defend against pathogens.

Circulation in Animals

1. Describe the need for circulatory and respiratory systems due to increasing animal body size.
2. Explain how a gastrovascular cavity functions in part as a circulatory system.
3. Distinguish between open and closed circulatory systems. List the three basic components common to both systems.
4. List the structural components of a vertebrate circulatory system and relate their structure to their functions.
5. Describe the general relationship between metabolic rates and the structure of the vertebrate circulatory system.

6. Using diagrams, compare and contrast the circulatory systems of fish, amphibians, non-bird reptiles, and mammals or birds.
7. Distinguish between pulmonary and systemic circuits and explain the functions of each.
8. Explain the advantage of double circulation over a single circuit.
9. Define a *cardiac cycle,* distinguish between systole and diastole, and explain what causes the first and second heart sounds.
10. Define *cardiac output* and describe two factors that influence it.
11. List the four heart valves, describe their location, and explain their functions.
12. Define *heart murmur* and explain its cause.
13. Define *sinoatrial (SA) node* and describe its location in the heart.
14. Distinguish between a myogenic heart and a neurogenic heart.
15. Describe the origin and pathway of the action potential (cardiac impulse) in the normal human heart.
16. Explain how the pace of the SA node can be modulated by nerves, hormones, body temperature, and exercise.
17. Relate the structures of capillaries, arteries, and veins to their functions.
18. Explain why blood flow through capillaries is substantially slower than it is through arteries and veins.
19. Define *blood pressure* and describe how it is measured.
20. Explain how peripheral resistance and cardiac output affect blood pressure.
21. Explain how blood returns to the heart even though it must sometimes travel from the lower extremities against gravity.
22. Explain how blood flow through capillary beds is regulated.
23. Explain how osmotic pressure and hydrostatic pressure regulate the exchange of fluid and solutes across capillaries.
24. Describe the composition of lymph and explain how the lymphatic system helps the normal functioning of the circulatory system. Explain the role of lymph nodes in body defense.
25. Describe the composition and functions of plasma.
26. Relate the structure of erythrocytes to their function.
27. List the five main types of white blood cells and characterize their functions.
28. Describe the structure of platelets.
29. Outline the formation of erythrocytes from their origin from stem cells in the red marrow of bones to their destruction by phagocytic cells.

30. Describe the hormonal control of erythrocyte production.
31. Outline the sequence of events that occurs during blood clotting and explain what prevents spontaneous clotting in the absence of injury.
32. Distinguish between a heart attack and a stroke.
33. Distinguish between low-density lipoproteins (LDLs) and high-density lipoproteins (HDLs).
34. List the factors that have been correlated with an increased risk of cardiovascular disease.

Gas Exchange in Animals

35. Define *gas exchange* and distinguish between a respiratory medium and a respiratory surface.
36. Describe the general requirements for a respiratory surface and list a variety of respiratory organs that meet these requirements.
37. Describe respiratory adaptations of aquatic animals.
38. Describe the advantages and disadvantages of water as a respiratory medium.
39. Describe countercurrent exchange and explain why it is more efficient than the concurrent flow of water and blood.
40. Describe the advantages and disadvantages of air as a respiratory medium and explain how insect tracheal systems are adapted for efficient gas exchange in a terrestrial environment.
41. For the human respiratory system, describe the movement of air through air passageways to the alveolus, listing the structures that air must pass through on its journey.
42. Compare positive and negative pressure breathing. Explain how respiratory movements in humans ventilate the lungs.
43. Distinguish between tidal volume, vital capacity, and residual volume.
44. Explain how the respiratory systems of birds and mammals differ.
45. Explain how breathing is controlled in humans.
46. Define *partial pressure* and explain how it influences diffusion across respiratory surfaces.
47. Describe the adaptive advantage of respiratory pigments in circulatory systems. Distinguish between hemocyanin and hemoglobin as respiratory pigments.
48. Draw the Hb-oxygen dissociation curve, explain the significance of its shape, and explain how the affinity of hemoglobin for oxygen changes with oxygen concentration.
49. Describe how carbon dioxide is picked up at the tissues and deposited in the lungs.

50. Describe the respiratory adaptations of the pronghorn that give it great speed and endurance.
51. Describe respiratory adaptations of diving mammals and the role of myoglobin.

An Overview of Osmoregulation

1. Define *osmoregulation* and *excretion.*
2. Define *osmolarity* and distinguish among isoosmotic, hyperosmotic, and hypoosmotic solutions.
3. Distinguish between osmoregulators and osmoconformers. Explain why osmoregulation has an energy cost.
4. Distinguish between stenohaline and euryhaline animals, and explain why euryhaline animals include both osmoconformers and osmoregulators.
5. Discuss the osmoregulatory strategies of marine animals.
6. Explain how the osmoregulatory problems of freshwater animals differ from those of marine animals.
7. Describe anhydrobiosis as an adaptation that helps tardigrades and nematodes to survive periods of dehydration.
8. Describe some adaptations that reduce water loss in terrestrial animals.
9. Describe the ultimate function of osmoregulation. Explain how hemolymph and interstitial fluids are involved in this process.
10. Explain the role of transport epithelia in osmoregulation and excretion.

Water Balance and Waste Disposal

11. Describe the production and elimination of ammonia. Explain why ammonia excretion is most common in aquatic species.
12. Compare the strategies to eliminate waste as ammonia, urea, or uric acid. Note which animal groups are associated with each process and why a particular strategy is most adaptive for a particular group.
13. Compare the amounts of nitrogenous waste produced by endotherms and ectotherms, and by predators and herbivores.

Excretory Systems

14. Describe the key steps in the process of urine production.
15. Describe how a flame-bulb (protonephridial) excretory system functions.
16. Explain how the metanephridial excretory tubule of annelids functions. Compare the structure to the protonephridial system.

17. Describe the Malpighian tubule excretory system of insects.
18. Using a diagram, identify and give the function of each structure in the mammalian excretory system.
19. Using a diagram, identify and describe the function of each region of the nephron.
20. Describe and explain the relationships among the processes of filtration, reabsorption, and secretion in the mammalian kidney.
21. Distinguish between cortical and juxtamedullary nephrons. Explain the significance of the juxtamedullary nephrons of birds and mammals.
22. Explain how the loop of Henle enhances water conservation by the kidney.
23. Explain how the loop of Henle functions as a countercurrent multiplier system.
24. Describe the nervous and hormonal controls involved in the regulation of the kidney.
25. Explain how the feeding habits of the South American vampire bat illustrate the versatility of the mammalian kidney.
26. Describe the structural and physiological adaptations in the kidneys of nonmammalian species that allow them to osmoregulate in different environments.

Student Misconceptions

1. Some students do not realize that *hyperosmotic, isoosmotic,* and *hypoosmotic* are relative terms. A solution is not hyperosmotic; it is hyperosmotic in relation to a reference solution.
2. Students may think—mistakenly—that the majority of the water reabsorbed from the glomerular filtrate moves back into the blood as the filtrate moves through the loop of Henle and the collecting duct. Clarify for your students that water reabsorption in the collecting duct is under hormonal control and that this region of the nephron plays a crucial role in regulating water uptake and thus controlling osmolarity of the blood. However, the majority of the water reabsorbed from the filtrate moves into the blood by osmosis from the proximal tubule, accompanying the reabsorption of nutrients and salts.
3. Some students think of mammalian urine as hyperosmotic to blood. These students may be surprised to find that mammals can also produce large amounts of hypoosmotic urine, at times when salt is scarce and fluid intake is high.
4. Many students have difficulty understanding the countercurrent multiplier system involving the loop of Henle and its role in the formation of concentrated urine. This material is challenging, and students may find it easier to master if you teach about a simpler countercurrent system earlier in your course, before the topic of osmoregulation and excretion is dealt with.

An Overview of Nervous Systems

1. Compare and contrast the nervous systems of the following animals and explain how variations in design and complexity relate to their phylogeny, natural history, and habitat: hydra, sea star, planarian, insect, squid, and vertebrate.
2. Name the three stages in the processing of information by nervous systems.
3. Distinguish among sensory neurons, interneurons, and motor neurons.
4. List and describe the major parts of a neuron and explain the function of each.
5. Describe the function of astrocytes, radial glia, oligodendrocytes, and Schwann cells.

The Nature of Nerve Signals

6. Define a *membrane potential* and a *resting potential.*
7. Describe the factors that contribute to a membrane potential.
8. Explain why the membrane potential of a resting neuron is typically around 260 to 280 mV.
9. Explain the role of the sodium-potassium pump in maintaining the resting potential.
10. Distinguish between gated and ungated ion channels and among stretch-gated ion channels, ligand-gated ion channels, and voltage-gated ion channels.
11. Define a *graded potential* and explain how it is different from a resting potential or an action potential.
12. Describe the characteristics of an *action potential.* Explain the role of voltage-gated ion channels in this process.
13. Describe the two main factors that underlie the repolarizing phase of the action potential.
14. Define the *refractory period.*
15. Explain how an action potential is propagated along an axon.
16. Describe the factors that affect the speed of action potentials along an axon and describe adaptations that increase the speed of propagation. Describe saltatory conduction.
17. Compare an electrical synapse and a chemical synapse.
18. Describe the structures of a chemical synapse and explain how they transmit an action potential from one cell to another.
19. Explain how excitatory postsynaptic potentials (EPSPs) and inhibitory postsynaptic potentials (IPSPs) affect the postsynaptic membrane potential.
20. Define *summation* and distinguish between temporal and spatial summation. Explain how summation applies to EPSPs and IPSPs.
21. Explain the role of the axon hillock.
22. Describe the role of signal transduction pathways in indirect synaptic transmission.

23. Describe the specific properties of the neurotransmitters acetylcholine and biogenic amines.
24. Identify and describe the functions of the four amino acids and several neuropeptides that work as neurotransmitters.
25. Explain how endorphins function as natural analgesics.
26. Describe the roles of nitric oxide and carbon monoxide as local regulators.

Vertebrate Nervous Systems

27. Compare the structures and functions of the central nervous system and the peripheral nervous system.
28. Distinguish between the functions of the autonomic nervous system and the somatic nervous system.
29. Describe the embryonic development of the vertebrate brain.
30. Describe the structures and functions of the following brain regions: medulla oblongata, pons, midbrain, cerebellum, thalamus, epithalamus, hypothalamus, and cerebrum.
31. Describe the specific functions of the reticular system.
32. Explain how the suprachiasmatic nuclei (SCN) function as a mammalian biological clock.
33. Relate the specific regions of the cerebrum to their functions.
34. Distinguish between the functions of the left and right hemispheres of the cerebrum.
35. Describe the specific functions of the brain regions associated with language, speech, emotions, memory, and learning.
36. Explain the possible role of long-term potentiation in memory storage and learning in the vertebrate brain.
37. Describe our current understanding of human consciousness.
38. Explain how research on stem cells and neural development may lead to new treatments for injuries and disease.
39. Describe current treatments for schizophrenia.
40. Distinguish between bipolar disorder and major depression.
41. Describe the symptoms and brain pathology that characterize Alzheimer's disease. Discuss possible treatments for this disease.
42. Explain the cause of Parkinson's disease.

Introduction to Behavior and Behavioral Ecology

1. Define *behavior.*

2. Distinguish between proximate and ultimate questions about behavior. Ask a proximate question and an ultimate question about bird song.
3. Explain how the classical discipline of ethology led to the modern study of behavioral ecology.
4. Define *fixed action patterns* and give an example.
5. Define *imprinting.* Suggest a proximate cause and an ultimate cause for imprinting in young geese.

Many Behaviors Have a Genetic Component

6. Explain how genes and environment contribute to behavior. Explain what is unique about innate behavior.
7. Distinguish between kinesis and taxis.
8. Distinguish between signal and pheromone.
9. Explain how Berthold's research demonstrated a genetic basis for blackcap migration.
10. Describe Insel's research on the genetic and physiological controls on parental behavior of prairie voles. Describe Bester-Meredith and Marler's research on the influence of social behavior on parental behavior of California mice.

Learning

11. Explain how habituation may influence behavior.
12. Describe Tinbergen's classic experiment on spatial learning in digger wasps.
13. Distinguish between landmarks and cognitive maps.
14. Describe how associative learning might help a predator to avoid toxic prey.
15. Distinguish between classical conditioning and operant conditioning.
16. Describe an experiment that demonstrates problem solving in nonhuman animals.

Behavioral Traits Can Evolve by Natural Selection

17. Explain how Hedrick and Riechert's experiments demonstrated that behavioral differences between populations might be the product of natural selection.
18. Use an example to show how researchers can demonstrate the evolution of behavior in laboratory experiments.
19. Explain optimal foraging theory.
20. Explain how behavioral ecologists carry out cost-benefit analyses to determine how an animal should forage optimally. Explain how Zach demonstrated that crows feed optimally on whelks.
21. Explain how predation risk may affect the foraging behavior of a prey species.

22. Define and distinguish among *promiscuous, monogamous,* and *polygamous* mating relationships. Define and distinguish between *polygyny* and *polyandry.*
23. Describe how the certainty of paternity influences the development of mating systems.
24. Explain why males are more likely than females to provide parental care in fishes.
25. Suggest an ultimate explanation for a female stalk-eyed fly's preference for mates with relatively long eyestalks.
26. Agonistic behavior in males is often a ritualized contest rather than combat. Suggest an ultimate explanation for this.
27. Explain how game theory may be used to evaluate alternative behavioral strategies.
28. Define *inclusive fitness* and *reciprocal altruism.* Discuss conditions that would favor the evolution of altruistic behavior.
29. Relate the coefficient of relatedness to the concept of altruism.
30. Define *Hamilton's rule* and the concept of *kin selection.*

Social Learning and Sociobiology

31. Define *social learning* and *culture.*
32. Explain why mate choice copying by a female may increase her fitness.
33. State the main premise of sociology.

**** Overview and learning objectives for College Board AP Biology Laboratory Exercises # 1-12**

[from Biology Laboratory Manual for Students: Exercises 1-12; (documentation text from http://apbio.biosci.uga.edu/lab/lab-obj.html)]

Note: all of the 12 listed AP Biology College Board recommended laboratories will be performed. Additional laboratory exercises will be completed as time and budgets allow.

LABORATORY 1. DIFFUSION AND OSMOSIS

OVERVIEW

In this laboratory you will investigate the process of diffusion and osmosis in a model of a membrane system. You also will investigate the effect of solute concentration on water potential as it relates to living plant tissues.

OBJECTIVES

Before doing this laboratory you should understand:

- the mechanisms of diffusion and osmosis and their importance to cells
- the effects of solute size and concentration gradients on diffusion across selectively permeable membranes
- the effects of a selectively permeable membrane on diffusion and osmosis between two solutions separated by the membrane
- the concept of water potential
- the relationship between solute concentration and pressure and the water potential of a solution
- the concept of molarity and its relationship to osmotic concentration

After doing this laboratory you should be able to:

- measure the water potential of a solution in a controlled experiment
- determine the osmotic concentration of living tissue or an unknown solution from experimental data
- describe the effects of water gain or loss in animal and plant cells
- relate osmotic potential to solute concentration and water potential
- explain how environmental factors affect the rate of enzyme-catalyzed reactions

LABORATORY 2. ENZYME CATALYSIS

OVERVIEW

In this laboratory you will measure the amount of product generated and then calculate the rate of conversion of hydrogen peroxide (H_2O_2) to water and oxygen gas by the enzyme catalase.

OBJECTIVES

Before doing this laboratory you should understand:

- the general functions and activities of enzymes
- the relationship between the structure and function of enzymes
- the concepts of initial reaction rates of enzymes
- how the concept of free energy relates to enzyme activity
- how pH relates to enzyme activity
- that changes in temperature, pH, enzyme concentration, and substrate concentration can affect the initial reaction rates of enzyme-catalyzed reactions

After doing this laboratory you should be able to:

- measure the effects of changes of temperature, pH, enzyme concentration, and substrate concentration on reaction rates of an enzyme-catalyzed reaction in a controlled experiment

LABORATORY 3. MITOSIS AND MEIOSIS

OVERVIEW

Exercise 3A is a study of mitosis. You will use prepared slides of onion root tips to study plant mitosis and to calculate the relative duration of the phases of mitosis in the meristem of root tissue. Prepared slides of the whitefish blastula will be used to study mitosis in animal cells and to compare animal mitosis and plant mitosis

Exercise 3B is a study of meiosis. You will simulate the stages of meiosis by using chromosome models. You will study the crossing over and recombination that occurs

during meiosis. You will observe the arrangements of ascospores in the asci from a cross between wild type and mutants for tan spore coat color in the fungus Sordaria fimicola. These arrangements will be used to estimate the percentage of crossing over that occurs between the centromere and the gene that controls that tan spore color.

OBJECTIVES

Before doing this laboratory you should understand:

- the key mechanical and genetic differences between meiosis and mitosis
- the events of mitosis in animal and plant cells
- the events of meiosis (gametogenesis) in animal and plant cells

After doing this laboratory you should be able to:

- recognize the stages of mitosis in a plant or animal cell
- calculate the relative duration of the cell cycle stages
- describe how independent assortment and crossing over can generate genetic variation among the products of meiosis
- use chromosome models to demonstrate the activity of chromosomes during Meiosis I and Meiosis II
- relate chromosome activity to Mendelian segregation and independent assortment
- calculate the map distance of a particular gene from a chromosome's center for between two genes using an organism of your choice in a controlled experiment
- demonstrate the role of meiosis in the formation of gametes using an organism of your choice, in a controlled experiment
- compare and contrast the results of meiosis and mitosis in plant cells
- compare and contrast the results of meiosis and mitosis in animal cells

LABORATORY 4. PLANT PIGMENTS AND PHOTOSYNTHESIS

OVERVIEW

In this laboratory you will separate plant pigments using chromatography. You also will measure the rate of photosynthesis in isolated chloroplasts. The measurement technique involves the reduction of the dye, DPIP. The transfer of electrons during the light-dependent reactions of photosynthesis reduces DPIP and changes its color from blue to colorless.

OBJECTIVES

Before doing this laboratory you should understand:

- how chromatography separates two or more compounds that are initially present in a mixture
- the process of photosynthesis
- the function of plant pigments
- the relationship between light wavelength or light intensity and photosynthetic rate

:After doing this laboratory you should be able to:

- separate pigments and calculate their Rf values
- describe a technique to determine photosynthetic rates
- compare photosynthetic rates at different temperatures, different light intensities, and different wavelengths of light in a controlled experiment
- explain why the rate of photosynthesis vary under different environmental conditions

LABORATORY 5. CELL RESPIRATION

OVERVIEW

Seeds are living but dormant. When conditions necessary to begin growth are achieved, germination occurs, cellular reactions are accelerated, and the rate of respiration greatly increases. In this laboratory you will measure oxygen consumption during respiration as the change in gas volume in respirometers containing either germinating or nongerminating peas. In addition, you will measure the respiration of these peas at two different temperatures.

OBJECTIVES

Before doing this laboratory you should understand:

- how a respirometer works in terms of the gas laws
- the general process of metabolism in living organisms

After doing this laboratory you should be able to:

- test the effects of temperature on the rate of cell respiration in ungerminated versus germinated seeds in a controlled experiment
- calculate the rate of cell respiration from experimental data
- relate gas production to respiration rate

LABORATORY 6. MOLECULAR BIOLOGY

OVERVIEW

In this laboratory, you will investigate some basic principles of genetic engineering.

In part A Plasmids containing specific fragments of foreign DNA will be used to transform *Escherichia coli* cells, conferring antibiotic (ampicillin) resistance.

In part B restriction enzyme digests of phage lambda DNA also will be used to demonstrate techniques for separating and identifying DNA fragments using gel electrophoresis.

OBJECTIVES

Before doing this laboratory you should understand:

- how gel electrophoresis separates DNA molecules present in a mixture
- the principles of bacterial transformation
- the conditions under which cells can be transformed
- the process of competent cell preparation
- how a plasmid can be engineered to include a piece of foreign DNA
- how plasmid vectors are used to transfer genes
- how antibiotic resistance is transferred between cells
- how restriction endonucleases function
- the importance of restriction enzymes to genetic engineering experiments

After doing this laboratory you should be able to:

- use plasmids as vectors to transform bacteria with a gene for antibiotic resistance in a controlled experiment
- demonstrate how restrictions enzymes are used in genetic engineering
- use electrophoresis to separate DNA fragments
- describe the biological process of transformation in bacteria
- calculate transformation efficiency
- be able to use multiple experimental controls
- design a procedure to select positively for antibiotic resistant transformed cells
- determine unknown DNA fragment sizes when given DNA fragments of known size

LABORATORY 7. GENETICS OF ORGANISMS

OVERVIEW

In this laboratory, you will use fruit flies (*Drosophila melanogaster*) to do genetic crosses. You will learn how to collect and manipulate fruit flies, collect data from F1 and F2 generations, and analyze the results from a monohybrid, dihybrid, or sex-linked cross.

OBJECTIVES

Before doing this laboratory you should understand:

- chi-square analysis of data
- the life cycle of diploid organisms useful in genetics studies

After doing this laboratory you should be able to:

- investigate the independent assortment of two genes and determine whether the two genes are autosomal or sex-linked using a multi-generation experiment
- analyze the data from your genetic crosses chi-square analysis techniques

LABORATORY 8. POPULATION GENETICS AND EVOLUTION

OVERVIEW

In this activity, you will learn about the Hardy-Weinberg law of genetic equilibrium and study the relationship between evolution and changes in allele frequency by using your class as a sample population.

OBJECTIVES

Before doing this laboratory you should understand:

- how natural selection can alter allelic frequencies in a population
- the Hardy-Weinberg equation and its use in determining the frequency of alleles in a population
- the effects on the allelic frequencies of selection against the homozygous recessive or other genotypes

After doing this laboratory you should be able to:

- calculate the frequencies of alleles and genotypes in the gene pool of a population using the Hardy-Weinberg formula
- discuss natural selection and other causes of microevolution as deviations from the conditions required to maintain Hardy-Weinberg equilibrium

LABORATORY 9. TRANSPIRATION

OVERVIEW

In this laboratory, you will apply what you learned about water potential from Laboratory 1 (Diffusion and Osmosis) to the movement of water within the plant. You will measure transpiration under different laboratory conditions. You also will study the organization of the plant stem and leaf as it relates to these processes by observing sections of tissue.

OBJECTIVES

Before doing this laboratory you should understand:

- how water moves from roots to leaves in terms of physical/chemical properties of water and the forces provided by differences in water potential
- the role of transpiration in the transport of water within a plant
- the structures used by plants to transport water and regulate water movement

After doing this laboratory you should be able to:

- test the effects of environmental variables on rates of transpiration using a controlled experiment
- make thin section of stem, identify xylem and phloem cells, and relate the function of these vascular tissues to the structures of their cells

LABORATORY 10. PHYSIOLOGY OF THE CIRCULATORY SYSTEM

OVERVIEW

In Exercise 10A, you will learn how to measure blood pressure. In Exercise 10B, you will measure pulse rate under different physiological conditions: standing, reclining, after the baroreceptor reflex, and during and immediately after exercise. The blood pressure and pulse rate will be analyzed and related to a relative fitness index. In Exercise 10C, you will measure the effect of temperature on the heart rate of the water flea, Daphnia magna.

OBJECTIVES

Before doing this laboratory you should understand:

- the relationship between temperature and rates of physiological processes
- basic anatomy of various circulatory systems

After doing this laboratory you should be able to:

- measure heart rate and blood pressure in a human volunteer
- describe the effect of changing body position on heart rate and blood pressure
- explain how exercise changes heart rate
- determine a human's fitness index
- analyze pooled cardiovascular data
- discuss and explain the relationship between heart rate and temperature

LABORATORY 11. ANIMAL BEHAVIOR

OVERVIEW In this laboratory, you will observe the behavior of an insect and design an experiment to investigate its responses to environmental variables. You also will observe and investigate mating behavior.

OBJECTIVES

Before doing this laboratory you should understand:

- the concept of distribution of organisms in a resource gradient
- the difference between a kinesis and a taxis

After doing this laboratory you should be able to:

- measure the effects of environmental variables on habitat selection in a controlled experiment
- describe the different types of insect mating behaviors

LABORATORY 12. DISSOLVED OXYGEN AND AQUATIC PRIMARY PRODUCTIVITY

OVERVIEW In Exercise 12A, you will measure and analyze the dissolved oxygen concentration in water samples at varying temperatures.

In Exercise 12B, you will measure and analyze the primary productivity of natural waters or laboratory cultures as a function of light intensity.

OBJECTIVES

Before doing this laboratory you should understand:

- the biological importance of carbon and oxygen cycling in ecosystems
- how primary productivity relates to the metabolism of organisms in an ecosystem
- the physical and biological factors that affect the solubility of gasses in aquatic ecosystems
- the relationship between dissolved oxygen and the process of photosynthesis and respiration as they affect primary productivity

After doing this laboratory you should be able to:

- measure primary productivity based on changes in dissolved oxygen in a controlled experiment
- investigate the effects of changing light intensity and/or inorganic nutrient concentrations on primary productivity in a controlled experiment

Science Curriculum

Chemistry

Purpose: Students will analyze Matter, Atomic Theory, and Stoichiometry, Electronic Structure of Atom and Periodicity, Chemical Bonding and Molecular Geometry, Gases, Liquids and Solids, Properties of Solutions and Acid Base Equilibria. Students will learn a variety of lab techniques and utilize scientific methods to plan, analyze and critique lab experiments.

Unit 1- Matter, Atomic Theory and Stoichiometry

Outcome: **CHEM.1** Students will investigate basis for the study of chemistry, characterize properties of elements, compounds and mixtures and perform a variety of basic laboratory procedures and calculations.

Matter:

Components: **CHEM.1.1** – Define chemistry and list the branches of chemistry.

CHEM.1.2 – Distinguish between physical and chemical properties and also between simple physical and chemical changes.

CHEM.1.3 – Differentiate between the three states of matter.

CHEM.1.4 – Distinguish between elements, compounds, and mixtures.

CHEM.1.5 – Memorize the symbols for the elements.

CHEM.1.6 – List the basic SI and metric units and the commonly used prefixes in scientific measurements.

CHEM.1.7 – Determine the number of significant figures in a measured quantity.

CHEM.1.8 – Express the result of a calculation with the proper number of significant figures.

CHEM.1.9 – Convert temperatures among the Fahrenheit, Celsius, and Kelvin scales.

CHEM.1.10 – Perform calculations involving density.

CHEM.1.11 – Convert measurements into scientific notation.

CHEM.1.12 – Discuss uncertainty in measurement including accuracy and precision.

Lab Components:

Observe a variety of physical and chemical changes, then construct a table comparing the observed changes and justify the placement of each change.

Create a graph comparing the mass, volume and density relationships of different metals.

Atomic Theory:

Components: **CHEM.2.1** – Describe the composition of an atom in terms of protons, neutrons, and electrons.

CHEM.2.2 – Give the approximate size, relative mass, and charge of an atom, proton, neutron, and electron.

CHEM.2.3 – Cite the evidence from experimental studies for the existence of subatomic particles.

CHEM.2.4 – Illustrate the Laws of Conservation of Mass, Definite Proportions, and Multiple Proportions.

CHEM.2.5 – Summarize the essential points of Dalton's atomic theory.

CHEM.2.6 – Define the term atomic weight and calculate the atomic weight of an element given its natural distribution of isotopes and isotopic masses.

CHEM.2.7 – Differentiate between atomic weight, mass number, and atomic number.

CHEM.2.8 – Determine the formula of an ionic compound formed between two given ions.

CHEM.2.9 – Determine the oxidation number for each element in a chemical formula.

CHEM.2.10 – Write the names of simple inorganic compounds, (binary molecular and ionic) having been given its chemical formula and perform the reverse reaction.

CHEM.2.11 – Write and name acids based on the anions whose names end in –ide, -ate, and –ite.

Stoichiometry:

Components: **CHEM.3.1** – Identify the reactants and products of a chemical equation.

CHEM.3.2 – Balance chemical equations.

CHEM.3.3 – Translate word equations into chemical equations.

CHEM.3.4 – Classify a chemical reaction as synthesis, decomposition, single replacement, double replacement, or combustion.

CHEM.3.5 – Predict the products of a chemical equation.

CHEM.3.6 – Calculate the percent composition of a given chemical compound.

CHEM.3.7 – Calculate the formula or molecular weight of a substance given its chemical formula.

CHEM.3.8 – Define mole, Avogadro's number, and molar mass.

CHEM.3.9 – Interconvert the number of moles of a substance and its mass.

CHEM.3.10 – Use Avogadro's number and molar mass to calculate the number of particles making up a substance and vice versa.

CHEM.3.11 – Define empirical formula.

CHEM.3.12 – Calculate the empirical and molecular formulas of a compound, having been given appropriate analytical data.

CHEM.3.13 – Calculate the mass of a particular substance produced or used in a chemical reaction (mass-mass problem).

CHEM.3.14 – Determine the limiting reactant in a reaction.

CHEM.3.15 – Distinguish between theoretical, actual, and percent yield.

CHEM.3.16 – Calculate the theoretical and percent yields of chemical reactions given the appropriate data.

Lab Components:

Analyze data to determine the empirical formula of a compound based on its reactions.

Assess the percent yield of a compound after a reaction.

Unit 2 – Electronic Structure of Atoms and Periodicity

Outcome: **CHEM.4** Students will investigate atomic structure, characterize chemical reactions and perform and utilize observed data to determine identity of unknowns.

Electron Structure of Atoms:

Components: **CHEM.4.1** – Describe the properties and characteristics of waves.

CHEM.4.2 – Use the relationship of speed=frequency x wavelength to solve for unknown values.

CHEM.4.3 – Explain the essential feature of Planck's quantum theory.

CHEM.4.4 – Use the relationship of energy=Planck's constant x frequency.

CHEM.4.5 – Describe a line spectrum.

CHEM.4.6 – Discuss the wave-particle duality of light.

CHEM.4.7 – Describe the Bohr model of the hydrogen atom.

CHEM.4.8 – Define the Heisenberg Uncertainty Principle.

CHEM.4.9 – Describe the quantum numbers used to define an orbital in an atom.

CHEM.4.10 – Describe the shapes of the s,p, and d orbitals.

CHEM.4.11 – State the Aufbau Principle, the Pauli Exclusion Principle, and Hund's rule and illustrate how they are used in writing electron structures for elements.

CHEM.4.12 – Construct electron configurations for atoms using the diagonal rule and noble gas notation.

CHEM.4.13 – Write the orbital diagram representation for electron configurations of atoms.

Periodicity:

Components: **CHEM.5.1** – Explain the arrangement of the periodic table.

CHEM.5.2 – List characteristics that distinguish metals, nonmetals, and metalloids.

CHEM.5.3 – Explain the roles of Mendeleev and Mosely in the development of the periodic table.

CHEM.5.4 – Explain how the periodic law can be used to predict the physical and chemical properties of elements.

CHEM.5.5 – Describe the general chemical and physical behavior of the alkali metals, alkaline earth metals, halogens, and noble gases.

CHEM.5.6 – Explain the general variations in atomic radii, ionization energy, electron affinity, and electronegativity among the elements.

Lab Components:

Perform flame tests and utilize spectroscopy to characterize the properties of various elements. Use the data to hypothesize the identity of an unknown substance.

Construct an activity series of halogens and metals and compare to published series. Use the data to hypothesize the identity of an unknown substance.

Unit 3: Chemical Bonding and Molecular Geometry

Outcome: **CHEM.6** Students will describe chemical bonds and illustrate molecular geometry.

Chemical Bonding and Molecular Geometry:

Components: **CHEM.6.1** – Describe the three types of chemical bonding: ionic, covalent, and metallic.

CHEM.6.2 – Determine the number of valence electrons for any atom, and write its Lewis symbol.

CHEM.6.3 – State the octet rule.

CHEM.6.4 – Define lattice energy.

CHEM.6.5 – Describe a single, double, and triple bond.

CHEM.6.6 – Predict the relative polarities of bonds using either the periodic table or electronegativity values.

CHEM.6.7 – Write the Lewis structures for molecules and ions containing covalent bonds.

CHEM.6.8 – Write resonace forms for molecules or polyatomic ions that are not adequately described by a single Lewis structure.

CHEM.6.9 – Explain the VSEPR Theory.

CHEM.6.10 – Construct the geometrical structure of a molecule or ion from its Lewis structure.

CHEM.6.11 – Predict the polarity of chemical bonds and molecules.

Unit 4 – States of Matter and Gases

Outcome: **CHEM.7** Students will compare the various states of matter, investigate the forces between in each type and observe their performance in the laboratory setting.

States of Matter:

Components: **CHEM.7.1** – Summarize the difference in properties between solids, liquids and gases based on Kinetic Molecular Theory.

CHEM.7.2 – Construct and evaluate phase diagrams including critical and triple points.

CHEM.7.3 – Compare and calculate heats of fusion and vaporization for a variety of substances.

CHEM.7.4 – Investigate heating and cooling curves of various substances.

CHEM.7.5 – Illustrate the differences between a variety of intermolecular forces (ion-dipole, dipole,-dipole, hydrogen bonding and London dispersion).

CHEM.7.6 – Examine different phase changes and classify their observations.

CHEM.7.7 – Compare the bonding in solids to the energy required to break and form different bonds.

CHEM.7.8 – Describe the relationship between the vapor pressure of a liquid and its boiling point.

CHEM.7.9 – Distinguish between crystalline and amorphous solids.

CHEM.7.10 – Predict the types of solid (molecular, covalent network, ionic or metallic) formed by a substance and predict its general properties.

Lab Component:

Construct and analyze a heating and a cooling curve for a compound.

Gases:

Outcome: **CHEM.8** Students explore the effects of various atmospheric conditions on gases both with situational examples and in the laboratory setting.

Components: **CHEM.8.1** – Define atmosphere, torr, pascal and mm of Hg and convert between these units.

CHEM.8.2 – Describe how a barometer and a manometer operate.

CHEM.8.3 – Apply the appropriate gas law (Boyle's, Charles', Gay-Lussac, Combined Gas Law, Avagadro's, Ideal gas law or Dalton's Law of Partial Pressures to solve situational gas law problems.

CHEM.8.4 – Compare the relationship between a gas's molecular mass and its characteristics properties of density, diffusion, effusion and compressibility (including Graham's Law of Effusion).

CHEM.8.5 – Verify the molar volume of a gas at specified temperature and pressure conditions by comparing it to the theoretical volume.

Lab Component*:*

Evaluate the actual volume of a gas produced versus its theoretical volume when gas is collected by water displacement.

Unit 5 - Properties of Solutions

Outcome: **CHEM.9** Students will investigate properties of solutions and their changes as a result of components, concentrations and atmospheric conditions.

Components: **CHEM.9.1** – Explain the solution process using appropriate vocabulary.

CHEM.9.2 – Differentiate between solutions, suspensions and colloids.

CHEM.9.3 – Describe the effects of pressure and temperature on solubilities.

CHEM.9.4 – Define electrolyte based on its performance in a solution.

CHEM.9.5 – Predict whether a substance is a nonelectrolyte, strong electrolyte or weak electrolyte from its chemical behavior.

CHEM.9.6 – Predict the solubility and type of solution based on the amount of solute, solubility rules and the solution conditions.

CHEM.9.7 – Apply the appropriate measure of concentration (mass percent, mole fraction, molarity or molality) to solve solution problems.

CHEM.9.8 – Describe how to make a solution from scratch and from a stock solution using the proper equipment and techniques.

CHEM.9.9 – Predict the effects of colligative properties on vapor pressure, osmotic pressure and freezing point depression and boiling point elevation of solutions.

Lab Component:

Evaluate the experimental molecular mass again the theoretical molar mass of a substance using the freezing point depression and boiling point evaluation of the substance.

Acids, Bases and Titrations

Outcome: **CHEM.10** Students will describe the properties and formation of acids and bases, the relationship between ion concentration and pH and use titration to determine the concentration of an unknown solution.

Components: **CHEM.10.1** – Identify characteristics and common examples of acids and bases (Knowledge).

CHEM.10.2 – Use a pH meter and various indicators (paper and liquid) to assess the pH of household items.

CHEM.10.3 – Summarize the differences between Arrhenius, Bronsted-Lowry and Lewis acids and bases.

CHEM.10.4 – Relate the auto-ionization of water to the formation of ions that define the pH of a solution.

CHEM.10.5 – Compute the pH, pOH and ion concentration of various solutions in situational problems.

CHEM.10.6 – Explain how a buffer acts to minimize the change in a solution's pH.

CHEM.10.7 – Construct a titration curve and identify the equivalence point as well as the correct choice of indicator for a specific titration.

Lab Component:

Assess the concentration of an unknown solution using the titration process.

Science Curriculum

Accelerated Chemistry

Purpose: Students will analyze Matter, Atomic Theory, and Stoichiometry, Electronic Structure of Atom and Periodicity, Chemical Bonding and Molecular Geometry, Gases, Liquids and Solids, Properties of Solutions, Acid Base Equilibria, and Equilibrium. Students will learn a variety of lab techniques and utilize scientific methods to plan, analyze and critique lab experiments and write formal laboratory reports.

Unit 1- Matter, Atomic Theory and Stoichiometry

Outcome: **ACHEM.1** Students will investigate basis for the study of chemistry, characterize properties of elements, compounds and mixtures and perform a variety of basic laboratory procedures and calculations.

Matter:

Components: **ACHEM.1.1** – Define chemistry and list the branches of chemistry.

ACHEM.1.2 – Distinguish between physical and chemical properties and also between simple physical and chemical changes.

ACHEM.1.3 – Differentiate between the three states of matter.

ACHEM.1.4 – Distinguish between elements, compounds, and mixtures.

ACHEM.1.5 – Memorize the symbols for the elements.

ACHEM.1.6 – List the basic SI and metric units and the commonly used prefixes in scientific measurements.

ACHEM.1.7 – Determine the number of significant figures in a measured quantity.

ACHEM.1.8 – Express the result of a calculation with the proper number of significant figures.

ACHEM.1.9 – Convert temperatures among the Fahrenheit, Celsius, and Kelvin scales.

ACHEM.1.10 – Perform calculations involving density.

ACHEM.1.11 – Convert measurements into scientific notation.

ACHEM.1.12 – Discuss uncertainty in measurement including accuracy and precision.

Lab Components:

Observe a variety of physical and chemical changes, then construct a table comparing the observed changes and justify the placement of each change.

Use pipeting techniques to determine the density of a beverage.

Perform a fractional crystallization to separate out the components of a mixture.

Atomic Theory:

Components: **ACHEM.2.1** – Describe the composition of an atom in terms of protons, neutrons, and electrons.

ACHEM.2.2 – Give the approximate size, relative mass, and charge of an atom, proton, neutron, and electron.

ACHEM.2.3 – Cite the evidence from experimental studies for the existence of subatomic particles.

ACHEM.2.4 – Illustrate the Laws of Conservation of Mass, Definite Proportions, and Multiple Proportions.

ACHEM.2.5 – Summarize the essential points of Dalton's atomic theory.

ACHEM.2.6 – Define the term atomic weight and calculate the atomic weight of an element given its natural distribution of isotopes and isotopic masses.

ACHEM.2.7 – Differentiate between atomic weight, mass number, and atomic number.

ACHEM.2.8 – Determine the formula of an ionic compound formed between two given ions.

ACHEM.2.9 – Determine the oxidation number for each element in a chemical formula.

ACHEM.2.10 – Write the names of simple inorganic compounds (binary molecular and ionic) having been given its chemical formula and perform the reverse reaction.

ACHEM.2.11 – Write and name acids based on the anions whose names end in –ide, -ate, and –ite.

Stoichiometry:

Components: **ACHEM.3.1** – Identify the reactants and products of a chemical equation.

ACHEM.3.2 – Balance chemical equations.

ACHEM.3.3 – Translate word equations into chemical equations.

ACHEM.3.4 – Classify a chemical reaction as synthesis, decomposition, single replacement, double replacement, or combustion.

ACHEM.3.5 – Write synthesis, decomposition, and combustion reactions given the reactants.

ACHEM.3.6 – Predict the products of a chemical equation given the reactants.

ACHEM.3.7 – Calculate the percent composition of a given chemical compound.

ACHEM.3.8 – Calculate the formula or molecular weight of a substance given its chemical formula.

ACHEM.3.9 – Define mole, Avogadro's number, and molar mass.

ACHEM.3.10 – Interconvert the number of moles of a substance and its mass.

ACHEM.3.11 – Use Avogadro's number and molar mass to calculate the number of particles making up a substance and vice versa.

ACHEM.3.12 – Define empirical formula.

ACHEM.3.13 – Calculate the empirical and molecular formulas of a compound, having been given appropriate analytical data.

ACHEM.3.14 – Calculate the mass of a particular substance produced or used in a chemical reaction (mass-mass problem).

ACHEM.3.15 – Determine the limiting reactant in a reaction.

ACHEM.3.16 – Distinguish between theoretical, actual, and percent yield.

ACHEM.3.17 – Calculate the theoretical and percent yields of chemical reactions given the appropriate data.

***Lab Components**:*

Analyze data to determine the empirical formula of a compound based on its reactions.

Assess the percent yield of a compound after a reaction.

Perform a gravimetric analysis to determine the composition of an unknown.

Unit 2 – Electronic Structure of Atoms and Periodicity

Outcome: **ACHEM.4** Students will investigate atomic structure, characterize chemical reactions and perform and utilize observed data to determine identity of unknowns.

Electron Structure of Atoms:

Components: **ACHEM.4.1** – Describe the properties and characteristics of waves.

ACHEM.4.2 – Use the relationship of speed=frequency x wavelength to solve for unknown values.

ACHEM.4.3 – Explain the essential feature of Planck's quantum theory.

ACHEM.4.4 – Use the relationship of energy=Planck's constant x frequency.

ACHEM.4.5 – Describe a line spectrum.

ACHEM.4.6 – Discuss the wave-particle duality of light.

ACHEM.4.7 – Describe Einstein's photoelectric effect.

ACHEM.4.8 – Describe the Bohr model of the hydrogen atom.

ACHEM.4.9 – Calculate the energy differences between two allowed energy states of the electron in hydrogen.

ACHEM.4.10 – Calculate the characteristic wavelength of a particle from the knowledge of its mass and velocity.

ACHEM.4.11 – Define the Heisenberg Uncertainty Principle.

ACHEM.4.12 – Describe the quantum numbers,n,l,m to define an orbital in an atom.

ACHEM.4.13 – Explain the concepts of electron spin and the electron spin quantum number.

ACHEM.4.14 – Describe the shapes of the s,p, and d orbitals.

ACHEM.4.15 – State the Aufbau Principle, the Pauli Exclusion Principle, and Hund's rule and illustrate how they are used in writing electron structures for elements.

ACHEM.4.16 – Construct electron configurations for atoms using the diagonal rule and noble gas notation.

ACHEM.4.17 – Write the orbital diagram representation for electron configurations of atoms.

Periodicity:

Components: **ACHEM.5.1** – Explain the arrangement of the periodic table.

ACHEM.5.2 – List characteristics that distinguish metals, nonmetals, and metalloids.

ACHEM.5.3 – Explain the roles of Mendeleev and Mosely in the development of the periodic table.

ACHEM.5.4 – Explain how the periodic law can be used to predict the physical and chemical properties of elements.

ACHEM.5.5 – Describe the general chemical and physical behavior of the alkali metals, alkaline earth metals, halogens, and noble gases.

ACHEM.5.6 – Explain the general variations in atomic radii, ionization energy, electron affinity, and electronegativity among the elements.

Lab Components*:*

Perform flame tests and utilize spectroscopy to characterize the properties of various elements. Use the data to hypothesize the identity of an unknown substance.

Construct an activity series of halogens and metals and compare to published series. Use the data to hypothesize the identity of an unknown substance.

Unit 3: Chemical Bonding and Molecular Geometry

Outcome: **ACHEM.6** Students will describe chemical bonds and illustrate molecular geometry.

Chemical Bonding and Molecular Geometry:

Components: **ACHEM.6.1** – Describe the three types of chemical bonding: ionic, covalent, and metallic.

ACHEM.6.2 – Determine the number of valence electrons for any atom, and write its Lewis symbol.

ACHEM.6.3 – State the octet rule.

ACHEM.6.4 – Define lattice energy.

ACHEM.6.5 – Describe a single, double, and triple bond.

ACHEM.6.6 – Predict the relative polarities of bonds using either the periodic table or electronegativity values.

ACHEM.6.7 – Write the Lewis structures for molecules and ions containing covalent bonds.

ACHEM.6.8 – Write resonance forms for molecules or polyatomic ions that are not adequately described by a single Lewis structure.

ACHEM.6.9 – Explain the VSEPR Theory.

ACHEM.6.10 – Construct the geometrical structure of a molecule or ion from its Lewis structure.

APCHEM.6.11 – Predict the polarity of chemical bonds and molecules.

APCHEM.6.12 – Calculate the enthalpy of a reaction given bond energies.

ACHEM.6.13 – Explain the concept of hybridization and its relationship to geometrical structure.

ACHEM.6.14 – Define and identify sigma and pi bonds in a molecule.

ACHEM.6.15 – Determine the bond angles in a molecule.

Unit 4 – States of Matter and Gases

Outcome: **ACHEM.7** Students will compare the various states of matter, investigate the forces between in each type and observe their performance in the laboratory setting.

States of Matter:

Components: **ACHEM.7.1** – Summarize the difference in properties between solids, liquids and gases based on Kinetic Molecular Theory.

ACHEM.7.2 – Define viscosity, surface tension, adhesion, cohesion, and capillary action.

ACHEM.7.3 – Construct and evaluate phase diagrams including critical and triple points.

ACHEM.7.4 – Compare and calculate heats of fusion and vaporization for a variety of substances.

ACHEM.7.5 – Investigate heating and cooling curves of various substances.

ACHEM.7.6 – Illustrate the differences between a variety of intermolecular forces (ion-dipole, dipole,-dipole, hydrogen bonding and London dispersion).

ACHEM.7.7 – Examine different phase changes and classify their observations.

ACHEM.7.8 – Compare the bonding in solids to the energy required to break and form different bonds.

ACHEM.7.9 – Describe the relationship between the vapor pressure of a liquid and its boiling point.

ACHEM.7.10 – Distinguish between crystalline and amorphous solids.

ACHEM.7.11 – Differentiate between primitive cubic, body-centered cubic, and face-centered cubic unit cells.

ACHEM.7.12 – Describe the most efficient packing patterns of equal-sized spheres.

ACHEM.7.13 – Predict the types of solid (molecular, covalent network, ionic or metallic) formed by a substance and predict its general properties.

Lab Component*:*

Construct and analyze a heating and a cooling curve for a compound.

Determine the latent heat of fusion of ice.

Gases:

Outcome: **ACHEM.8** Students explore the effects of various atmospheric conditions on gases both with situational examples and in the laboratory setting.

Components: **ACHEM.8.1** – Define atmosphere, torr, pascal and mm of Hg and convert between these units.

ACHEM.8.2 – Describe how a barometer and a manometer operate.

ACHEM.8.3 – Apply the appropriate gas law (Boyle's, Charles', Gay-Lussac, Combined Gas Law, Avagadro's, Ideal gas law or Dalton's Law of Partial Pressures to solve situational gas law problems.

ACHEM.8.4 – Compare the relationship between a gas's molecular mass and its characteristics properties of density, diffusion, effusion and compressibility (including Graham's Law of Effusion).

ACHEM.8.5 – Verify the molar volume of a gas at specified temperature and pressure conditions by comparing it to the theoretical volume.

ACHEM.8.6 – Calculate the root-mean-square speed of a gas at a given temperature.

ACHEM.8.7 – Know the conditions under which real gases behave ideally.

ACHEM.8.8 – Explain the origins of the correction terms to P and V that appear in the van der Waals equation.

Lab Component:

Evaluate the actual volume of a gas produced versus its theoretical volume when gas is collected by water displacement.

Determine the molecular weight of a volatile liquid via the Dumas method.

Unit 5 - Properties of Solutions

Outcome: **ACHEM.9** Students will investigate properties of solutions and their changes as a result of components, concentrations and atmospheric conditions.

Components: **ACHEM.9.1** – Explain the solution process using appropriate vocabulary.

ACHEM.9.2 – Differentiate between solutions, suspensions and colloids.

ACHEM.9.3 – Describe the effects of pressure and temperature on solubilities.

ACHEM.9.4 – Define electrolyte based on its performance in a solution.

ACHEM.9.5 – Predict whether a substance is a nonelectrolyte, strong electrolyte or weak electrolyte from its chemical behavior.

ACHEM.9.6 – Predict the solubility and type of solution based on the amount of solute, solubility rules and the solution conditions.

ACHEM.9.7 – Apply the appropriate measure of concentration (mass percent, mole fraction, molarity or molality) to solve solution problems.

ACHEM.9.8 – Describe how to make a solution from scratch and from a stock solution using the proper equipment and techniques.

ACHEM.9.9 – Describe the effects of colligative properties on vapor pressure, osmotic pressure, freezing point depression and boiling point elevation of solutions, and calculate any of these properties given appropriate concentration data.

ACHEM.9.10 – Know the solubility rules.

ACHEM.9.11 – Write double replacement and single replacement reactions given the reactants.

Lab Component:

Evaluate the experimental molecular mass again the theoretical molar mass of a substance using the freezing point depression and boiling point evaluation of the substance.

Unit 6 - Acids, Bases and Titrations

Outcome: **ACHEM.10** Students will describe the properties and formation of acids and bases, the relationship between ion concentration and pH and use titration to determine the concentration of an unknown solution.

Components: **ACHEM.10.1** – Identify characteristics and common examples of acids and bases (Knowledge).
ACHEM.10.2 – Use a pH meter and various indicators (paper and liquid) to assess the pH of household items.

ACHEM.10.3 – Summarize the differences between Arrhenius, Bronsted-Lowry and Lewis acids and bases.

ACHEM.10.4 – Relate the auto-ionization of water to the formation of ions that define the pH of a solution.

ACHEM.10.5 – Compute the pH, pOH and ion concentration of various solutions in situational problems.

ACHEM.10.6 – Explain plain how a buffer acts to minimize the change in a solution's pH.

ACHEM.10.7 – Construct a titration curve and identify the equivalence point as well as the correct choice of indicator for a specific titration.

ACHEM.10.8 – Identify the common strong acids and bases and calculate the pHs of their aqueous solutions given their concentrations.

ACHEM.10.9 – Calculate the Ka's and Kb's of weak acids and bases.

Lab Component:

Assess the concentration of an unknown solution using the titration process.

Unit 7 - Equilibrium

Outcome: **ACHEM.11** Students will investigate the concept of equilibrium and Le Chatelier's Principle.

Components: **ACHEM.11.1** – Define chemical equilibrium.

ACHEM.11.2 – Write the equilibrium-constant expression for a chemical system at equilibrium.

ACHEM.11.3 – Calculate the Kc from a knowledge of the equilibrium or initial concentrations of reactants or products.

ACHEM.11.4 – Determine the effect of adding stressors to a reaction using Le Chatelier's Principle.

Lab Component:

Observe the effects of adding stressors to various chemical reactions and then determine the equilibrium shift.

AP Chemistry Syllabus

Description of the Course:

AP Chemistry is designed to be equivalent to a first-year general college chemistry course. It is a second year chemistry course that meets every other day for 112 minutes due to our A/B block eight schedule. To enter the class, students must have an A or B in accelerated chemistry or an A in regular chemistry and a conference with the instructor. The course is structured so that review material (which is covered at a quick pace) is interspersed with new topics. First semester new topics include: thermochemistry, equilibrium, kinetics, and electrochemistry. Second semester new topics include: an in depth discussion of acid/base and other aqueous equilibria, organic chemistry, nuclear chemistry, and coordination compounds.

Assessment:

Assessments include: Multi-section and/or chapter quizzes (15% of quarter grade)
Chapter and/or unit tests (55% of quarter grade)
Formal written laboratory reports (25% of quarter grade)
Daily problem/question sets (5% of quarter grade)
Semester exams (15% of semester grade)
(the final exam is given the week before the AP chemistry exam)

Laboratory Component:

Students keep a formal laboratory notebook. A carbonless copy of each lab is submitted to the instructor for grading after each lab period. Prior to each lab period students must write the pre-lab portion of the report in their notebook which includes: the heading, purpose, theory, answers to the pre-lab questions, procedure, diagram of apparatus, and data tables. The lab portion includes making observations and recording data. The post-lab portion includes: interpreting results, doing calculations, answering the post-lab questions, and writing the conclusion. All labs are hands-on and are conducted approximately once every 1 1/2 weeks. The majority of the labs done are from "Lab Experiments for AP Chemistry". Labs denoted by a * indicate that the lab was performed during the first year chemistry course. First year chemistry class/lab periods are 82 minutes in length. AP chemistry lab periods are 112 minutes in length. All students must read and sign a safety contract and pass the lab safety quiz with a 93% or higher to begin lab work.

Textbook

"Chemistry The Central Science" (10th edition)
Authors: Theodore Brown & H. Eugene LeMay
Publisher: Prentice Hall (2006)

Other Materials Used

"Student's Guide Chemistry the Central Science" (10th edition)
Author: James C. Hill
Publisher: Prentice Hall (2006)

"The Ultimate Chemical Equations Handbook"
Authors: George Hague & Jane Smith
Publisher: Flinn Scientific (2001)

"Lab Experiments for AP Chemistry" (1st & 2nd editions)
Author: Sally Vonderbrink
Publisher: Flinn Scientific (1995 & 2006)

Topic Outline

SEMESTER ONE

Unit 1 (Matter, Atomic Theory, Stoichiometry; Chapters 1-3: review material)
Concepts:

Classification & properties of matter, measurement, density, atomic theory, discovery of atomic structure, atomic weights & isotopes, atomic number and mass number, naming ionic and molecular compounds, types of chemical reactions, formula weights, the mole, empirical & molecular formulas from analyses, stoichiometry including mass-mass and mass-volume, limiting reactants and percent yield.
Labs:
***Fractional Crystallization** (separating a mixture via fractional crystallization)
Chromatography (separating liquids from a homogeneous mixture via chromatography)
Empirical Formula of Silver Oxide (determining the empirical formula of silver oxide)
Synthesis & Analysis of Alum (determine melting point and the % water in alum)
***Gravimetric Analysis of a Metal Carbonate** (analytic gravimetric analysis)
***Mass/Mole Relationships** (determining mole ratios)

Unit 2 (Thermochemistry & Thermodynamics; Chapters 5 & 19: new material)
Concepts:

Energy, state functions, the three laws of thermodynamics, enthalpy, enthalpies of reactions and of formation, calorimetry, Hess's law, food and fuels, spontaneous processes, entropy, entropy changes in chemical reactions, Gibbs free energy, free energy and Keq, free energy and electrode potential.
Labs:
Specific Heat (determination of specific heat via Dulong & Petit)
Hess's Law (determination of enthalpy changes associated with a chemical reaction)

Unit 3 (Chemical Equilibrium and Kinetics; Chapters 14 & 15: new material)
Concepts:

Dynamic equilibrium, calculating equilibria constants including Kc and Kp, applications of equilibrium constants, LeChatelier's principle, factors that affect reaction rates, reaction rates, concentration and rate, temperature and rate including the Arrhenius equation, determining reaction orders via calculations and by graphs, activation energy, reactions mechanisms including the rate determining step, and catalysts.
Labs:
***Le Chatelier's Principle** (observe equilibrium shifts in several chemical reactions)
Keq for FeSCN (determination of the Keq for a reaction; spectrophotometric analysis)
Kinetics of a Reaction (determination of the rate of reaction and its order)

Unit 4 (Electronic Structure of Atoms & Periodic Properties of the Elements; Chapters 6 &7: review material)
Concepts:
Wave nature of light, quantized energy, the photoelectric effect, line spectra, the Bohr model of hydrogen, wave behavior of matter, quantum mechanics, atomic orbitals, electron configurations, development of the periodic table, trends in the periodic table including: atomic size, ionization energy, and electron affinity, metals, nonmetals, and metalloids, group trends for alkali metals, alkaline earth metals, halogens, noble gases, and the first series of the transition elements, writing various chemical equations including synthesis, decomposition, single replacement, double replacement, and combustion, oxidation numbers, qualitative analysis.
Labs:
***Flame Test & Spectroscopy** (conducts fame tests and observe various line spectra)
***Activity Series** (determination of electrochemical series of metals and the halogens)
Qualitative Analysis (qualitative analysis of cations & anions)

Unit 5 (Chemical Bonding & Molecular Geometry; Chapters 8 & 9: review material)
Concepts:

Types of chemical bonds including ionic, covalent and metallic, Lewis symbols, octet rule, bond polarity and electronegativity, drawing Lewis structures, resonance structures, exceptions to the octet, VSEPR theory, molecular shapes and polarity, dipole moments, sigma and pi bonds, hybrid orbitals, multiple bonds, molecular orbitals.
Labs:
***Molecular Models** (predicting & constructing 3-D molecular models after drawing Lewis structures)

Unit 6 (Electrochemistry; Chapter 20: new material)
Concepts:

Redox reations, balancing redox reactions, galvanic cells, cell emf, spontaneity of redox reactions, effect of concentration on cell emf, Faraday's laws, the Nernst equation, electrolysis, and electroplating.
Labs:
Analysis of Commercial Bleach (determination of concentration by a redox titration)
Electrochemical Cells (measurements using electrochemical cells and electroplating)

SEMESTER TWO

Unit 7 (Gases, Liquids & Solids: Chapters 10 & 11: review material)
Concepts:

Characteristics of gases, pressure, the gas laws of Boyle, Charles', Gay-Lussac, and Avogadro, the ideal gas law, molecular mass and density, Dalton's law of partial

pressures, kinetic molecular theory, effusion and diffusion, Graham's law of effusion, real gas deviations, intermolecular forces including ion-dipole, dipole-dipole, hydrogen bonding, and London dispersion, properties of liquids, phase changes, heats of vaporization and fusion, vapor pressure, phase diagrams including triple point and critical points, structures of solids, lattice energy, bonding in solids.
Labs:
***Molecular Weight via Dumas Method** (determination of molec. wt. by vapor density)
Molar Volume of Hydrogen Gas (determination of the molar volume of a gas)
***Mass/Volume Relationships** (compare the volume of gas produced to theoretical vol)
Heat of Vaporization of Water (determine Hvap via Clausius-Clayperon)

Unit 8 (Properties of Solutions; Chapters 4 & 13: review material)
Concepts:

The solution process, types of solutions, solubility, solubility rules, factors affecting solubility, Henry's law, expressing concentrations in terms of: mass percent, mole fraction, molarity, and molality, colligative properties including vapor pressure depression and Raoult's law, freezing point depression, boiling point elevation, osmosis; nonideal behavior of solutions, colloids.
Labs:
Molar Mass by Freezing Point Depression (determination of a molar mass via freezing point depression)

Unit 9 (Acid-Base Equilibria & Additional Aspects of Aqueous Equilibria; Chapters 16 & 17: new material)
Concepts:

Arrhenius, Bonsted-Lowry, and Lewis acids & bases, conjugate acids & bases, autoionization of water, pH scale, strong acids & bases, weak acids & bases including Ka's and Kb's, relationship between Ka and Kb, acid-base properties of salt solutions, acid-base behavior and chemical structure, hydrolysis, amphoterism, the common-ion effect, buffered solutions, the Henderson-Hasselbalch equation, acid-base titrations, solution equilibria and Ksp, factors that affect solubility, precipitation and separation of ions.
Labs:
Acid-Base Tirations (determination of concentration by an acid-base titration, including a weak acid or base; standardization of a solution by a primary standard)
pKa's of Weak Acids (determination of the pKa's of some weak acids, determination of appropriate indicators for acid-base titrations; pH determination)
Buffer Solutions (preparation and properties of buffer solutions)
Ksp of an Ionic Compound (determination of the Ksp of an ionic compound)

Unit 10 (Nuclear Chemistry; Chapter 21: new material)
Concepts:

Radioactivity, nuclear equations, patterns of nuclear stability, nuclear transmutations, rates of radioactivity and half-life, detection of radioactivity, energy changes in nuclear reactions, nuclear fission and fusion, biological effects of radiation.

<u>Unit 11</u> (Organic Chemistry; Chapter 25: new material)
Concepts:

Some general characteristics and properties of organic molecules, introduction to hydrocarbons, nomenclature, alkanes, alkenes, alkynes, functional groups, addition and substitution reactions, chirality.
Labs:
Preparation & Analysis of Aspirin (synthesis, purification, and analysis of an organic compound)

<u>Unit 12</u> (Coordination Compounds; Chapter 24: new material)
Concepts:

Metal complexes, ligands with more than one donor atom, nomenclature, isomerism
Labs:
Beer's Law (synthesis of a coordination compound and its spectrophotometric analysis)

Science Curriculum
Physics

Outcome: **PHY.1** Kinematics (including vectors, vector algebra, components of vectors, coordinate systems, displacement, velocity, and acceleration).

Components: **PHY.1.1** – Motion in one dimension.

PHY.1.2 – Students should understand the general relationships among position, velocity, and acceleration for the motion of a particle along a straight line, so that:

- Given a graph of one of the kinematic quantities, position, velocity, and acceleration, as a function of time, they can recognize in what time intervals the other two are positive, negative, or zero, and can identify or ketch a graph of each as a function of time.

PHY.1.3 – Students should understand the special case of motion with constant acceleration so they can:

- Write down expressions for velocity and positions as functions of time, and identify or sketch graphs of these quantities.
- Use the equations v= v0 +at, x= x0 + ½ at2, and v2 = v02 + 2a (x-x0) to solve problems involving one-dimensional motion with constant acceleration.

PHY.1.4 – Students should know how to deal with situations in which acceleration is a specified function of velocity.

Outcome: **PHY.2** Motion in tow dimensions, including projectile motion.

Components: **PHY.2.1** – Students should be able to add, subtract, and resolve displacement and velocity vectors, so they can:

- Determine components of a vector along two specified, mutually perpendicular axes.
- Determine the net displacement of a particle or the location of a particle relative to another.
- Determine the change in velocity of a particle or the velocity of one particle relative to another.

PHY.2.2 – Students should understand the motion of projectiles in a uniform gravitational field, so they can:

- Write down expressions for the horizontal and vertical components of velocity and position as functions of time, and sketch or identify graphs of these components.
- Use these expressions in analyzing the motion of a projectile that is projectile with an arbitrary initial velocity.

Outcome: **PHY.3** Newton's laws of motion.

Components: **PHY.3.1** – Static equilibrium (first law).

PHY.3.2 – Students should be able to analyze situations in which a particle remains at rest, or moves with constant velocity, under the influence of several forces.

PHY.3.3 – Dynamics of a single particle (second law).

PHY.3.4 – Students should understand the relation between the force that acts on an object and the resulting change in the object's velocity, so the can:

- Calculate, for an object moving in one dimension, the velocity change that results when a constant force F (t) acts over a specified time interval.
- Calculate, for an object moving in a plane whose velocity vector undergoes a specified change over a specified time interval.
- Determine, for an object moving in a plane whose velocity vector undergoes a specified change over a specified time interval, the average force that acted on the object.

PHY.3.5 – Students should understand how Newton's Second Law, F+F net= ma, applies to an object subject to forces such as gravity, the pull of strings, or contact forces, so they can:

- Draw a well-labeled, free-body diagram showing all real forces that act on the object.
- Write down the vector equation that results from applying a Newton's Second Law to the object, and take components of this equation along appropriate axes.

PHY.3.6 – Students should understand the significance of the coefficient of friction, so they can:

- Write down the relationship between the normal and frictional forces on a surface.
- Analyze situations in which an object moves along a rough inclined plane horizontal surface.

- Analyze under what circumstances an object will start to slip, or to calculate the magnitude of the force of static friction.

PHY.3.7 – Students should understand the effect of drag forces on the motion of an object, so they can:

- Find the terminal velocity of an object moving vertically under the influence of a retarding force dependent on velocity.
- Describe qualitatively, with the aid of graphs, the acceleration, velocity, and displacement of such a particle when it is released from rest.

PHY.3.8 – Systems of two or more objects (third law).

PHY.3.9 – Students should understand Newton's Third law so that, for a given system, they can identify the force pairs and the objects on which they act, and state the magnitude and direction of each force.

PHY.3.10 – Students should be able to apply Newton's Third Law in analyzing the force of contact between two objects that accelerate together along a horizontal or vertical line, or between tow surfaces that slide across one another.

Outcome: **PHY.4** Work, energy, power.

Components: **PHY.4.1** – Work and the work - energy theorem.

PHY.4.2 – Students should understand the definition of work, including when it is positive, negative, or zero, so they can:

- Calculate the work done by a specified constant force on an object that undergoes a specified displacement.
- Relate the work done by a force to the area under a graph of force as a function of a position, and calculate this work in the case where the force is a linear function of position.
- Use the scalar product operation to calculate the work performed by a specified constant force F on an object that undergoes a displacement in a plane.

PHY.4.3 – Students should understand and be able to apply the work-energy theorem, so they can:

- Calculate the change in kinetic energy or speed that results from performing a specified amount of work on an object.
- Calculate the work performed by the net force, on an object that undergoes a specified change in speed or kinetic energy.
- Apply the theorem to determine the change in an object's kinetic energy and speed that results from the application of specified

forces, or to determine the force that is required in order to bring an object to rest in a specified distance.

PHY.4.4 – Forces and potential energy.

PHY.4.5 – Students should understand the concept of potential energy so they can:

- State the general relation between force and potential energy, and explain why potential energy can be associated only with conservative forces.
- Calculate the potential energy of one or more objects in a uniform gravitational field.

PHY.4.6 – Conservation of energy.

PHY.4.7 – Students should understand the concept of mechanical energy and of total energy so they can:

- Describe and identify situations in which mechanical energy is converted to other forms of energy.

PHY.4.8 – Students should understand conservation of energy, so they can:

- Identify situations in which mechanical energy is or is not conserved.
- Apply conservation of energy in analyzing the motion of systems of connected objects.
- Apply conservation of energy in analyzing the motion of objects that move under the influence of springs.

Outcome: **PHY.5** Power

Components: **PHY.5.1** – Students should understand the definition of power, so they can:

- Calculate the power required to maintain the motion of an object with constant acceleration (e.g., to move an object along a level surface, to raise an object at a constant rate, or to overcome friction for an object that is moving at a constant speed).
- Calculate the work preformed by a force that supplied constant power, or the average power supplied by a force that performs a specified amount of work.

Outcome: **PHY.6** Impulse and momentum.

Components: **PHY.6.1** – Students should understand impulse and linear momentum, so they can:

- Relate mass, velocity, and linear momentum for a moving object, and calculate the total linear momentum of a system of objects.
- Relate impulse to the change in linear momentum and the average force acting on an object.

Outcome: **PHY.7** Conservation of linear momentum, collisions.

Components: **PHY.7.1** – Students should understand linear momentum conservation, so they can:

- Explain how linear momentum conservation follows as a consequence of Newton's Third Law of and isolated system.
- Identify situations in which linear momentum, or a component of the linear momentum vector, is converted.
- Apply linear momentum conservation to one-dimensional elastic and inelastic collisions and two-dimensional completely inelastic collisions.

PHY.7.2 – Students should understand frames of reference, so they can:

- Analyze the uniform motion of an object relative to a moving medium such as a flowing stream.

Outcome: **PHY.8** Oscillations and Gravitation.

Components: **PHY.8.1** – Simple harmonic motion (dynamics and energy relationships).

PHY.8.2 – Students should understand simple harmonic motion, so they can:

- State the relations between acceleration, velocity, and displacement, and identify points in the motion where these quantities are zero or achieve their greatest positive and negative values.
- State and apply the relations between frequency and period.
- State how the total energy of an oscillating system depends on the amplitude of the motion, sketch or identify a graph of kinetic or potential energy as a function of time, and identify points in the motion where this energy is all potential or all kinetic.
- Calculate the kinetic and potential energies of an oscillating system as functions of time, sketch or identify graphs of these functions, and prove that the sum of kinetic and potential energy is constant.

Outcome: **PHY.9** Mass on a spring.

Components: **PHY.9.1** – Students should be able to apply their knowledge of simple harmonic motion to the case of a mass on a spring so they can:

- Apply the expression for the period of oscillation of a mass on a spring.
- Analyze problems in which a mass hangs from a spring and oscillates vertically.
- Analyze problems in which a mass attached to a spring oscillates horizontally.

Outcome: **PHY.10** Pendulum and other oscillations.

Components: **PHY.10.1** – Students should be able to apply their knowledge of simple harmonic motion to the case of a pendulum, so they can:

- Apply the expression of the period of a simple pendulum.
- State what approximation must be made in deriving the period.
- Analyze the motion of a torsional pendulum or physical pendulum in order to determine the period of small oscillations.

Outcome: **PHY.11** Newton's law of gravity.

Components: **PHY.11.1** – Students should know Newton's Law of Universal Gravitation, so they can:

- Determine the force that one spherically symmetrical mass exerts on another.

Temperature and Heat

Outcome: **PHY.12** Mechanical equivalent of heat and heat transfer and thermal expansion.

Components: **PHY.12.1** – Students should understand the "mechanical equivalent of heat" so they can determine how much heat can be produced by the performance of a specified quantity of mechanical heat.

PHY.12.2 – Students should understand heat transfer and thermal expansion, so they can:

- Calculate how the flow of heat through a slab of material is affected by changes in the thickness or area of the slab, or the temperature difference between the two faces of the slab.

- Analyze what happens to the size of the shape of an object when it is heated.
- Analyze qualitatively the effect of conduction, radiation, and convection in thermal process.

Electricity and Magnetism - Electrostatics

Outcome: **PHY.13** Changes and Coulomb's Law.

Components: **PHY.13.1** – Students should understand the concept of electric change, so they can:

- Describe the types of changes and the attraction and repulsion of changes.
- Describe polarization and induced changes.

PHY.13.2 – Students should understand Coulomb's Law and the principle of superposition, so they can:

- Calculate the magnitude and direction of the force on a positive or negative charge due to other specified point changes.
- Analyze the motion of a particle of specified charge and mass under the influence of an electrostatic force.

Outcome: **PHY.14** Electric field and electric potential (including point charges).

Components: **PHY.14.1** – Students should understand the concept of electric field, so they can:

- Define it in terms of the force on a test charge.
- Describe and calculate the electric field of a single point charge.
- Calculate the magnitude and direction of the force on a positive or negative charge placed in a specified field.
- Interpret an electric field diagram.

PHY.14.2 – Students should understand the concept of electric potential, so they can:

- Determine the electric potential in the vicinity of one or more point charges.
- Determine the direction and approximate magnitude of the electric field at various positions given a sketch of equipotentials.
- Calculate the potential difference between two points in a uniform electric field, and state which point is at the higher potential.

Conductors, Capacitors, Dielectrics

Outcome: **PHY.15** Electrostatics with conductors.

Components: **PHY.15.1** – Students should understand the nature of electric field in and around conductors, so they can:

- Explain the mechanics responsible for the absence of electric field inside a conductor, and know that all excess charge must reside on the surface of the conductor.
- Explain why a conductor must be an equipotential, and apply this principle in analyzing what happens when conductors are connected by wires.
- Show that all excess charge on a conductor must reside on its surface and that the field outside the conductor must be perpendicular the surface.

PHY.15.2 – Students should be able to describe and sketch a graph of the electrical field and potential inside and outside a charged conducting sphere.

- Describe the process of charging by induction.
- Explain why a neutral conductor is attracted to a charged object.

AP Physics *(B Syllabus)*

Description of the Course:

AP Physics B is designed to be equivalent to a first-year college physics course. It is an introductory course that meets every other day for 112 minutes due to our A/B block eight schedule. Students must have the prerequisite of a B or better in Algebra 2 and Trigonometry and a conference with the instructor to enter the class. The class is fast-paced and covers the following topics: newtonian mechanics; fluids and thermal physics; electricity and magnetism; waves and optics; and atomic and nuclear physics.

Assessment:

Assessments include: Multi-section and/or chapter quizzes (15% of quarter grade)
Chapter and/or unit tests (55% of quarter grade)
Formal written laboratory reports (25% of quarter grade)
Daily problem/question sets (5% of quarter grade)
Semester exam (15% of semester grade)
Semester project (5% of semester grade)
Semester One: balsa wood bridge construction, efficiency, testing, and analysis
Semester Two: model rocket construction, flight, recovery, and analysis

Laboratory Component:

Students keep a formal laboratory notebook. A carbonless copy of each lab is submitted to the instructor for grading after each lab period. Prior to each lab period students must write the pre-lab portion of the report in their notebook which includes: the heading, purpose, theory, answers to the pre-lab questions, procedure, diagram of apparatus, and data tables. The post-lab portion includes: observations and data, calculations, answers to post-lab questions, and the conclusion. All labs are hands-on. The lab periods are 112 minutes in length. Approximately 1-2 labs are done per chapter. The labs are taken from various sources. All students must read and sign a safety contract and pass the safety quiz with a 93% or higher to begin lab work.

Textbook

"College Physics" (5th Edition)
Authors: Raymond A. Serway, and Jerry S. Faughn,
Publisher: Thomson/Brooks/Cole (1999)

Other Materials Used

"Student Study Guide: College Physics" (5th Edition)
Authors: Gordon, Teague, and Serway
Publisher: Thomson/Brooks/Cole (1999)

"The Mechanical Universe" video series

Topic Outline

SEMESTER ONE

Unit 1 (Newtonian Mechanics: Chapters 1,2,3,4,5,6,7,8)

Chapter 1: Measurement
Fundamental quantities and SI units, dimensional analysis, uncertainty in measurement including significant figures, orders of magnitude, graphical analysis, Fermi questions, problem-solving strategies.
Lab:
Measurement (determine the mass of an unknown object using an inertial balance)

Chapter 2: Motion In One Dimension
Displacement, average and instantaneous velocity, acceleration, graphical analysis of motion, freely falling objects.
Lab:
Measurement of Time (determine of "g" using an acceleration timer on freely falling masses)

Chapter 3: Vectors and Two-Dimensional Motion
Vectors vs scalars, properties of vectors, vector addition: head-to-tail and parallelogram methods, components of vectors, projectile motion, relative velocity.
Lab:
Tennis Ball Cannon (determine the exit velocity and maximum height reached by a tennis ball shot out of a cannon at various angles)

Chapter 4: The Laws of Motion
Four forces in nature, Newton's 3 laws of motion, Fnet=ma problems, friction.
Labs:
Atwood Machine (determine the acceleration of a falling mass and the friction of an Atwood's machine)
Coefficient of Friction (determine the coefficient of friction of different surfaces)

Chapter 7: Circular Motion and the Law of Gravity
Centripetal acceleration, forces causing centripetal acceleration, describing motion of a rotating system, Newton's universal law of gravitation, Kepler's laws.
Labs:
Centripetal Force (determine the centripetal acceleration of a rotating object)
Kepler's Law of Equal Areas (verify that the areas swept out in equal times are equal)

Chapter 8: Rotational Equilibrium & Dynamics
Torque, torque and the second condition for equilibrium, center of gravity, angular momentum.

Lab:
Torque (verify that the sum of the clockwise torques equal the sum of the counter-clockwise torques on a meter stick)

Chapter 5: Work and Energy

Work, kinetic energy and the work-energy theorem, potential energy, conservative and nonconservative forces, conservation of mechanical energy, nonconservative forces and the work-energy theorem, conservation of energy in general, power, simple machines.
Lab:
Horsepower (calculate horsepower by running up a flight of stairs)

Chapter 6: Momentum and Collisions

Momentum and impulse, conservation of momentum, collisions, glancing collisions.
Lab:
Ballistic Pendulum (determine the exit velocity of a ball shot from a spring loaded gun via projectile motion and the ballistic pendulum)

Unit 2 (Fluid Mechanics and Thermal Physics: Chapters 9,10,11,12)

Chapter 10: Thermal Physics

Temperature, thermometers and temperature scales, thermal expansion of solids and liquids, macroscopic description of an ideal gas, avogadro's number and the ideal gas law, the kinetic theory of gases.
Lab:
Coefficient of Linear Expansion (determine the coefficient of linear expansion for a several metal rods)

Chapter 11: Heat

Mechanical equivalent of heat, specific heat, conservation of energy: calorimetry, latent heat and phase changes, heat transfer by conduction, convection, radiation.
Labs:
Specific Heat (determine the specific heat of a metal)
Heat of Fusion of Ice (determine the latent heat of fusion of ice)

Chapter 12: The Laws of Thermodynamics

Heat and internal energy, work and heat, PV diagrams, adiabatic and isothermal processes, the three laws of thermodynamics, heat engines, reversible and irreversible processes, the Carnot engine, entropy.

Chapter 9: Solids and Fluids

Density and pressure, variation of pressure with depth, pressure measurements, buoyant forces and Archimedes's principle, fluids in motion, Bernoulli's equation.
Lab:
Archimedes's Principle (determine the specific gravity of solids and liquids)

SEMESTER TWO

Unit 3 Electricity & Magnetism

Chapter 15: Electric Forces and Fields
Properties of electric charges, insulators and conductors, charging by induction, coulomb's law, the electric field, electric field lines, lightning.
Lab:
Coulomb's Law (verify Coulomb's law by measuring the distance between two charged pith balls)

Chapter 16: Electric Energy & Capacitance
Potential difference, electric potential, potential energy due to point charges, potentials and charged conductors, equipotential lines, capacitance, parallel-plate capacitor, series and parallel combinations of capacitors, energy stored in a capacitor.
Lab:
Capacitors (study the relationship of current to time as a capacitor is charged and discharged)

Chapter 17: Current and Resistance
Electric Current, current and drift speed, resistance and Ohm's law, resistivity, temperature variation of resistance, superconductivity, electric energy and power.

Chapter 18: Direct Current Circuits
Sources of EMF, resistors in series and parallel, Kirchoff's rules and complex dc circuits, electrical safety.
Lab:
Ohm's Law (verify Ohm's law by taking voltmeter and ammeter readings of a dc circuit)

Chapter 19: Magnetism
Magnets, magnetic domains, magnetic field of the earth, magnetic fields, magnetic force on a current-carrying conductor, torque on a current loop, motion of a charged particle in a magnetic field, magnetic field of a long, straight wire, magnetic field of a current loop, magnetic field of a solenoid.
Lab:

Magnetic Field of a Solenoid (measure and plot the quantitative relationship between the magnetic induction inside a solenoid and the current in the solenoid)

Chapter 20: Induced Voltages & Inductances
Induced EMF and magnetic flux, Faraday's law of induction, motional EMF, Lenz's law eddy currents, generators, dc motors.
Lab:
DC Motor (construct a small dc motor)

Unit 4 Waves, Optics, Sound

Chapter 13: Vibrations and Waves
Hooke's Law, elastic potential energy, simple harmonic motion, motion of a pendulum, wave motion, types of waves, properties of waves, speed of waves on strings, superposition and interference of waves, reflection.
Lab:
Pendulum (determine the value of "g")
Slinky (observe various waves properties and motions using a large slinky)

Chapter 14 Sound
Characteristics of sound waves, the speed of sound, energy & intensity of sound waves, the Doppler effect, interference of sound waves, standing waves, resonance, standing waves in air columns and strings, beats.
Lab:
Speed of Sound (determine the speed of sound)

Chapter 22 Reflection & Refraction of Light
The nature of light, measurements of the speed of light, reflection and refraction, Snell's law, dispersion and prisms, then rainbow, Huygen's principle, total internal reflection.
Lab:
Snell's Law (determine the index of refraction of glass)

Chapter 23 Mirrors and Lenses
Flat mirrors, images formed by convex/concave lenses and mirrors, lens aberrations, atmospheric refraction, the camera and the eye.
Lab:
Curved Mirrors (measure focal length, object & image positions)
Convex Lenses (measure focal length, object & image positions)

Chapter 24 Wave Optics
Conditions for interference, Young's double-slit interference, interference of thin films, diffraction, single-slit diffraction, polarization of light waves.
Lab:
Wavelength of Light Waves (determine the wavelength of light by observing interference patterns)

SEMESTERS ONE & TWO
(done throughout the year as mini units)

<u>Unit 5</u> Modern Topics

Chapter 29 Nuclear Physics
Radioactivity, binding energy, decay processes, nuclear reactions.

Chapter 30 Nuclear Energy & Elementary Particles
Nuclear fission and fusion, elementary particles, fundamental forces in nature, standard model.
Field trip to Fermilab

Chapter 27 Quantum Physics
Photoelectric effect, Compton effect, wave properties of particles, Heisenberg's uncertainty principle.
Lab:
Photoelectric Effect (measure the kinetic energy of photoelectrons for various colors of light)

Chapter 28 Atomic Physics
Early models of the atom, atomic spectra, Bohr's model of hydrogen, De Broglie waves, quantum numbers, Pauli exclusion principle.
(All of this material is covered in chemistry classes)

Chapter 26 Relativity
Speed of light, Michelson-Morley experiment, Einstein's principle of relativity, length contraction, time dilation, mass increase, relativistic addition of velocities, relativistic energy.