Biology

Course Number: 3010, 3020, 3040

Course Level: Honors, Academic, Practical

Grade: 9-10

Time/Credit: 18 weeks / 1 credit

Development Date: 2025 – 2026

School Board Approval:

Central Bucks School District
20 Welden Drive
Doylestown, PA 18901

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Central Bucks School District

Teaching and Learning Principles

The Central Bucks School District's K-12 science education principles are aligned with
the **Pennsylvania S**cience, **T**echnology & **E**ngineering, and **E**nvironmental **L**iteracy & **S**ustainability **(STEELS)** Standards, which were adopted in July 2022**.** The STEELS Standards guide the study of the natural and human-made world through inquiry, problem solving, critical thinking, and authentic exploration. There are six principles that are important in the teaching of science, and they include:

- Children are born investigators.
- Science must focus on core ideas and practices.
- Understanding develops over time.
- Science and engineering require both knowledge and practices.
- Teaching science must connect with student interests.
- In the teaching of science, we promote equity.

Therefore, the goal of science education is to ensure that all students will be able to engage as technological and engineering literate members of a global society, using their learning to:

1. Approach science as a reliable and tentative way of knowing and explaining the natural world and designed world.
2. Weigh evidence and use scientific approaches to ask questions, investigate, and make informed decisions.
3. Make and use observations to analyze relationships and patterns to explain phenomena, develop models, and make predictions.
4. Evaluate systems, to connect how form determines function and how any change to one component affects the entire system.
5. Explain how the natural and designed worlds are interrelated, and the application of scientific knowledge and technology can have beneficial, detrimental, or unintended consequences.

Sources:

- National Research Council (NRC). 2012. *A Framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.
- Pennsylvania Department of Education (PDE). 2023. *Communities - SAS (pdesas.org)*
- Pennsylvania Department of Education (PDE). 2023. *STEELS Hub: Curriculum Frameworks: Science Long Term Transfer Goals*

Central Bucks School District
Enduring Understandings

Students will understand that:

Earth and Space Science

- The Universe is composed of a variety of different objects, which are organized into systems, each of which develops according to accepted physical processes and laws.
- Earth is a complex and dynamic set of interconnected systems (e.g. geosphere, hydrosphere, atmosphere, biosphere) that interact over a wide range of temporal and spatial scales.
- The Earth's surface processes affect and are affected by human activities.

Life Science

- All organisms are made of cells and can be characterized by common aspects of their structure and functioning.
- Organisms grow, reproduce, and perpetuate their species by obtaining necessary resources through interdependent relationships with other organisms and the physical environment.
- Heredity refers to specific mechanisms by which characteristics or traits are passed from one generation to the next via genes, and explains why offspring resemble, but are not identical to, their parents.
- Biological evolution explains both the unity and diversity of species and provides a unifying principle for the history and diversity of life on Earth.

Physical Science

- Matter can be understood in terms of the types of atoms present and the interactions both between and within atoms.
- All forces between objects arise from a few types of interactions: gravity, electromagnetism, and the strong and weak nuclear interactions.
- Interactions of objects or systems of objects can be predicted and explained using the concept of transfer of energy from one object or system of objects to another.
- Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter.

Environmental Literacy and Sustainability

- Living things, including humans, utilize natural resources in ways that impact agricultural and environmental systems.
- Human cultures and societies experience and interact with the environment in various ways.
- Watersheds and wetlands function as interconnected systems that support, impact, and are influenced by living things.
- The environment provides multi-faceted opportunities to develop and apply interdisciplinary literacy skills to investigate complex issues at various scales.
- Conducting scientific investigations using place-based inquiry and authentic, outdoor field experience(s) are essential to understanding local environmental issues.
- Best management practices and data driven resource management, as well as environmental laws and policies, encourage environmental sustainability.
- Environmental stewardship practices are essential to improving environmental quality, sustainability, and community well-being.
- Environmental justice plays an important role in providing equitable protection from environmental hazards or concerns for all people.

Technology and Engineering

- The study of technology and engineering requires knowledge of the natural world and the human-made world.
- Design is a fundamental human activity.
- There is no single, best solution as designs can always be improved and refined.

Central Bucks School District

Essential Questions

Students will understand:

Earth and Space Science

- What is the Universe and what is Earth's place in it?
- How and why is Earth constantly changing?
- How do Earth's processes and human activities affect each other?

Life Science

- How do organisms interact with their environment and what are the effects of these interactions?
- How are the characteristics of one generation passed to the next? How can individuals of the same species and even siblings have different characteristics?
- How can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms?

Physical Science

- How can one explain the structure, properties, and interactions of matter?
- How can one explain and predict interactions between objects within systems?
- How is energy transferred and conserved?
- How are waves used to transfer energy and information?

Environmental Literacy and Sustainability

- How do living things utilize natural resources in ways that impact agricultural and environmental systems? How do agricultural systems interact with environmental systems?
- How do human cultures and societies experience, interact, and value local, regional, and/or global environments? How do various human cultures express their beliefs about nature and the environment? How are natural resources managed by people from various cultures and communities?
- How do watersheds and wetlands function as interconnected systems that support, impact, and are influenced by living things? How do human actions impact the functions of watersheds and wetlands?
- How do investigations of local environmental issues expand understanding and facilitate potential solutions to other local, regional, and/or global environmental issues?
- How do we balance societal values, practices, and cost-benefit analysis (long-term and short-term) in addressing environmental issues? How can conducting local field investigations lead to identifying, understanding, and addressing environmental issues in my community?
- How do actions and regulations support the equitable availability of resources for current and future generations?
- How can human actions improve environmental quality, sustainability, and community well-being?
- How do human actions impact environmental justice issues for individuals and communities? How do human actions impact the equitable access, use, and disposal of natural resources?

Technology and Engineering

- Why is it important to have an understanding of the natural and human-made worlds?
- Why is design important to human activity?
- Why is there no single correct solution in design?

Central Bucks School District – Course of Study

Course Overview

Desired Results

Course Description:

3020 Academic Biology: (18 weeks, 1 credit)

Biology provides students with the fundamental principles that explain how life functions, grows, and evolves. The course begins with an exploration of how cells work together to form complex organisms, focusing on characteristics of life, cell specialization, and homeostasis. Students then examine how energy flows through living systems by studying photosynthesis, cellular respiration, and the role of key biological molecules. Students explore how traits are inherited, which is followed by the study of evolution, natural selection, and biodiversity. Inquiry-based labs, activities, and discussions help students build a strong foundation in life science and develop scientific thinking skills. The Biology Keystone Exam will be administered at the conclusion of this course. Prerequisite: Academic or Honors Environmental Science

3010 Honors Biology: (18 weeks, 1 credit)

Honors Biology covers the same core concepts as Academic Biology but is designed to challenge students with a faster pace, greater depth of content, and more complex scientific practices. Students are expected to work more independently, demonstrate higher-level thinking skills, and engage more deeply with scientific analysis and problem-solving. The course places increased emphasis on critical thinking, data interpretation, and application of knowledge, preparing students for advanced science coursework. The Biology Keystone Exam will be administered at the conclusion of this course. Prerequisite: Academic Environmental Science (A- or better) or Honors Environmental Science (B or better)

3040 Practical Biology: (18 weeks, 1 credit)

Practical Biology uses a problem-based approach to the biological sciences. The course content aligns with Academic Biology and covers the same core concepts while incorporating additional instructional supports and intervention strategies. Students explore how cells function within organisms, how energy moves through living systems, how traits are inherited, and how evolution shapes biodiversity. Through hands-on investigations, real-world applications, and structured learning experiences, students develop an understanding of fundamental biological concepts. The Biology Keystone Exam will be administered at the conclusion of this course. Prerequisite: Academic or Honors Environmental Science.

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Acceptable Evidence.

Course Grading:

Marking Period 1 – 50%
Marking Period 2 – 50%

Biology Pacing Guide

Content	Days
Unit 1 – From Cells to Organism: Structure and Function	**25**
Introduction to Cells	**8**
Characteristics of Life	1
Levels of Organization: Cells → Tissues → Organs → Organ Systems → Organism	1
Formative Assessments Interventions and Enrichments	1
Cell Overview: Prokaryotes vs Eukaryotes and Plant vs. Animal	1
Cell Structure and Function: Organelles as systems in a cell	2
Formative Assessments Interventions and Enrichments	1
Summative Assessment	1
Cell Cycle, Mitosis, and Differentiation	**7**
Overview of Cell Cycle (checkpoints and apoptosis)	2
Mitosis	1
Formative Assessments Interventions and Enrichments	1
Differentiation & Stem Cells / Epigenetic Signals	1
Formative Assessments Interventions and Enrichments	1
Summative Assessment	1
Homeostasis and Feedback Mechanisms	**8**
Overview of Homeostasis and feedback loops Positive vs Negative feedback	2
Formative Assessments Interventions and Enrichments	1
Cell Membrane and Transport Mechanisms Osmosis, Passive and Active Transport	2
Lab Focus (e.g., Osmosis/Membrane/Microscopy)	1
Formative Assessments Interventions and Enrichments	1
Summative Assessment	1
Unit Review	1
District Common Unit Summative Assessment	1
Unit 2 – From Light to Life	**19**
Chemical Reactions & Cell Energy (ATP; endergonic vs. exergonic)	2
Formative or Summative Assessments Interventions and Enrichments	1
Carbon-Based Molecules	2
Formative or Summative Assessments Interventions and Enrichments	1
Photosynthesis (inputs/outputs; rate factors)	3
Formative or Summative Assessments Interventions and Enrichments	1
Cell Respiration (aerobic/anaerobic; energy transfer)	3
Formative or Summative Assessments	1

Interventions and Enrichments	
Energy and Carbon Cycling (ecosystem flow; efficiencies)	2
Formative or Summative Assessments Interventions and Enrichments	1
Review	1
District Common Summative Assessment	1
Unit 3 – From Genes to Generations	**36**
Part 1. Inheritance and Variation of Traits	**21**
DNA Structure and Replication	2
Formative or Summative Assessments Interventions and Enrichments	1
Protein Synthesis (transcription/translation; mutations)	3
Formative or Summative Assessments Interventions and Enrichments	1
Gene Expression and Regulation	2
Formative or Summative Assessments Interventions and Enrichments	1
Meiosis (variation; errors/nondisjunction)	2
Formative or Summative Assessments Interventions and Enrichments	1
Mendel and Heredity (Punnett, pedigrees; non-Mendelian)	2
Traits and Probability	1
Formative or Summative Assessments Interventions and Enrichments	1
Mutations and Genetic Diversity	1
Formative or Summative Assessments Interventions and Enrichments	1
Unit Review	1
District Common Summative Assessment	1
Part 2: Natural Selection and Evolution	**15**
Lines of Evidence for Evolution (fossils, anatomy, embryos, molecular, biogeography)	3
Formative or Summative Assessments Interventions and Enrichments	1
Natural Selection (conditions; adaptation vs. acclimatization)	2
Formative or Summative Assessments Interventions and Enrichments	1
Evolution of Populations (patterns; speciation, isolation)	2
Formative or Summative Assessments Interventions and Enrichments	1
Biodiversity and Humans (resilience; human impacts; solutions)	2
Formative or Summative Assessments Interventions and Enrichments	1
Unit Review	1
District Common Summative Assessment	1
Keystone Review	2
Hominid Skulls Lab Exploration Human Impacts on Biodiversity Project	3

Total Days	85

NOTE: Additional remediation in standards/content from the grade level (or previous grade level) where the student completes this course will be provided for students when the teacher determines a student has not yet mastered that content. Enrichment opportunities will also be provided to meet the needs of students that acquire an understanding of the content faster than their class peers.

Required Texts and Software

Required Texts/Software:

HMH Biology Science Dimensions (v2: 2026)
- **ISBN-10:** 0544861787
- **ISBN-13:** 978-0544861787

Supplementary Texts/Software:

- **Explore Learning (Explorelearning.com):** *ExploreLearning.com houses the world's largest library of interactive online simulations for math and science education in grades 3-12. The online simulations are called Gizmos.*

Unit 1 – From Molecules to Organisms: Structure and Function

Desired Results:

Essential Questions:

- What structures and processes distinguish living systems from non-living systems?
- How does structure relate to function in cells and organisms?
- How do interactions among cells, tissues, organs, and organ systems support the functioning of multicellular organisms?
- How do organisms grow, repair, and maintain themselves over time?
- How can cells with the same genetic information become specialized for different roles?
- How do organisms maintain stable internal conditions in a changing environment?
- How do feedback mechanisms regulate biological systems and what happens when these systems are disrupted?

Enduring Understandings:

Students will understand that…

- Organisms have characteristic structures which enable functions and behaviors that allow them to grow, reproduce, and die.
- Cells are the fundamental unit of life, and their ability to carry out life functions depends on the coordinated interactions among specialized structures within the cell.
- In multicellular organisms, biological organization is hierarchical. Cells form tissues, tissues form organs, organs form organ systems, and these systems interact to support the functioning of the whole organism.
- Growth, maintenance, and repair in multicellular organisms depend on regulated cell division that produces genetically identical cells through mitosis.
- Although cells contain the same genetic information, selective gene expression allows cells to differentiate and develop specialized structures and functions.
- Cellular differentiation enables complex organisms to form specialized tissues and organs, supporting division of labor and system-level coordination.
- Organisms rely on a balance of cell division, specialization, and controlled cell death to grow, develop, and stay healthy.
- Living organisms maintain stable internal conditions through homeostatic mechanisms that respond to internal and external changes.
- Feedback mechanisms regulate biological systems. Negative feedback loops counteract change to maintain stability, while positive feedback loops amplify responses to complete specific biological processes.
- Cell membranes play a central role in maintaining homeostasis by controlling the movement of substances into and out of cells through passive and active transport mechanisms.
- Interacting systems at multiple levels, including cellular, tissue, organ, and organ system levels, work together to regulate vital processes such as temperature, glucose levels, and water balance.

Knowledge:

Part 1: Characteristics of Life and Introduction to Cells

Students will know:

- The characteristics of life that distinguish living from non-living systems.
- That a cell is the most basic unit of life and contains organelles that perform specific functions.
- The differences between prokaryotic and eukaryotic cells, including how organelle specialization provides advantages.
- The structural and functional differences between plant and animal cells.

- The hierarchical organization of biological structures: cells → tissues → organs → organ systems → organism.
- How the coordinated function of organelles enables cells to carry out processes necessary for life.
- Vocabulary: Cell, prokaryote, eukaryote, organelle, nucleus, mitochondria, cell membrane, cell wall, cytoplasm, chloroplast, tissue, organ, organ system, organism, structure-function, biotic, abiotic, growth and development, unicellular, multicellular, asexual reproduction, sexual reproduction.
- Honors Vocabulary: Endoplasmic reticulum (ER), Golgi apparatus, ribosome, lysosome

Part 2: Cell Cycle, Mitosis, and Differentiation

Students will know:

- Cells divide through the cell cycle, which includes DNA replication, mitosis, and cytokinesis.
- Mitosis produces two genetically identical daughter cells, enabling growth, repair, and maintenance in multicellular organisms.
- Cellular differentiation allows genetically identical cells to develop into specialized cell types, guided by gene expression and environmental signals.
- Stem cells vary in their differentiation potential: totipotent, pluripotent, multipotent, and unipotent.
- Selective gene expression influences cell differentiation and specialization.
- Dysregulated cell division (e.g., cancer) can disrupt normal growth and organismal function.
- The coordinated activity of specialized cells forms tissues, organs, and organ systems that work together to maintain life functions.
- Vocabulary: Cell cycle, DNA replication, interphase, mitosis, cytokinesis, daughter cell, stem cells, differentiation, gene expression, tissue, organ, organ system,
- Honors Vocabulary: Epigenetic, apoptosis, checkpoint, cancer, totipotent, pluripotent, multipotent, unipotent

Part 3: Transport, Homeostasis and Feedback Mechanisms

Students will know:

- Homeostasis is the regulation of stable internal conditions in organisms.
- Negative feedback loops counteract changes in internal conditions to maintain equilibrium (e.g., blood glucose regulation, thermoregulation).
- Positive feedback loops amplify responses until a physiological process is completed (e.g., blood clotting, labor).
- Cell membranes are selectively permeable structures that control the exchange of materials and play a critical role in maintaining cellular homeostasis through passive and active transport processes.
- How diffusion and facilitated diffusion allow molecules to move passively across membranes.
- How osmosis allows water to move across semipermeable membranes, and how osmoregulation maintains water balance in cells and organisms.
- Active transport moves molecules against concentration gradients using energy (ATP).
- How disruptions to homeostasis can be predicted and analyzed using feedback loop models.
- Vocabulary: Homeostasis, negative feedback loop, positive feedback loop, regulation, excretory system, heart rate, circulatory system, nervous system, transpiration, temperature regulation.
- Honors Vocabulary: phospholipid bilayer, selectively permeable, diffusion, facilitated diffusion, osmosis, osmoregulation, thermoregulation, active transport*,* concentration gradient, equilibrium, stimulus, response, receptor, hypertonic, hypotonic, isotonic, endocytosis, exocytosis.

Skills:

Students will be able to…

Part 1: Characteristics of Life and Introduction to Cells

- Identify and describe the characteristics of life in living organisms.
- Compare and contrast living vs. non-living systems using evidence from observations or investigations.
- Use models to illustrate the relationship between components of living and nonliving systems
- Distinguish between prokaryotic and eukaryotic cells, including structural differences and organelle functions.
- Compare plant and animal cell structures and explain how organelles support cell functions.

- Explain how the organization in eukaryotic cells allows these cells to perform specialized functions within an organism.
- Construct and interpret models of hierarchical biological organization: cells → tissues → organs → organ systems → organism.
- Explain how organelle interactions support life-sustaining cellular processes.
- Use microscopes to observe and describe cellular structures.
- Discuss examples of specialized cells and interpret how their structures relate to their functions.

Part 2: Cell Cycle, Mitosis, and Differentiation

- Observe stages of the cell cycle and mitosis using prepared slides or simulations.
- Model DNA replication, mitosis, and cytokinesis to explain how two identical daughter cells are formed.
- Explain how mitosis contributes to growth, repair, and maintenance in multicellular organisms.
- Analyze the regulation of the cell cycle, including checkpoints, apoptosis, and the role of environmental/internal signals.
- Compare normal and dysregulated cell division scenarios (e.g., cancer) and explain potential consequences.
- Explain the process of cellular differentiation and how stem cells become specialized cells.
- Describe how tissues, organs, and organ systems arise from coordinated cell differentiation and support organismal functions.

Part 3: Transport, Homeostasis and Feedback Mechanisms

- Plan and conduct investigations to examine feedback mechanisms in biological systems (e.g., heart rate, glucose regulation, stomatal responses).
- Analyze data sets to identify negative and positive feedback loops and predict outcomes of system perturbations.
- Construct and revise models/diagrams of feedback loops to represent homeostatic regulation.
- Interpret experimental or case study results to identify disruptions to homeostasis (e.g., dehydration, diabetes) and predict physiological responses.
- Analyze how the components of the cell membrane work together to regulate the movement of substances into and out of cells and maintain stable internal conditions.
- Investigate and model passive transport processes: diffusion and osmosis.
- Analyze osmoregulation examples in cells and organisms.
- Compare passive and active transport mechanisms and solve problems involving energy requirements.

Priority Standards:
3.1.9-12.B: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. *Assessment Boundary:* Assessment does not include interactions and functions at the molecular or chemical reaction levels.
3.19-12.C: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. *Assessment Boundary:* Assessment does not include the cellular processes involved in the feedback mechanism.
3.19-12.D: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. *Assessment Boundary: Assessment* does not include specific gene control mechanisms or rote memorization of the steps of mitosis.

Supporting Standards:
CC.3.5.9-10.G: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
CC.3.6.9-12.F: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
CC.3.6.9-10.G: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Acceptable Evidence:

Performance Tasks:

- Cell Structure & Function Model: Students develop a model of a cell showing organelles and their functions, linking structure to function.
- Homeostasis: Students analyze a scenario and construct a feedback loop diagram predicting physiological responses.
- Cell Cycle & Differentiation: Students model mitosis and differentiation to illustrate development from zygote to specialized cells.
- Levels of Biological Organization: Students develop a model tracing cells → tissues → organs → organ systems → organism.

Acceptable Evidence of Learning Other Than Performance Tasks:

Formative Assessment

- "Can You Explain It" Lesson Self Checks using HMH Biology Resource
- Classroom Discussions & Think-Pair-Share: Students discuss characteristics of life, homeostasis examples, or cell division concepts.
- Conceptual Check-ins (CERs): Students answer claim-evidence-reasoning questions related to phenomena such as sewer lice, osmosis investigations, or other phenomena.
- Interactive HMH Digital Quizzes/Activities: Short checks on cell types, organelle functions, transport mechanisms, and feedback loops.
- Exit Tickets & Quick Writes: Students summarize key concepts from lessons (e.g., models of mitosis, negative vs. positive feedback).
- Lab Observations & Data Analysis: Students record and interpret data from diffusion, osmosis, or heart rate investigations.
- Diagram/Model Tasks: Students model feedback loops, cell hierarchy diagrams, or cell cycle models.

Summative Assessment

- Chapter/Concept Assessments: Assess understanding of cell structures, organelle functions, homeostasis, feedback loops, cell cycle, mitosis, and differentiation.
- District Common Unit Assessments: Combination of multiple-choice, short answer, and applied tasks requiring modeling or explanation.
- Laboratory Reports
- Performance-Based Assessment: Graded models, diagrams, or simulations demonstrating mastery of key unit concepts.
- Canvas/Online Assignments: HMH-aligned tasks that require students to apply knowledge to case studies, simulations, and real-world scenarios.

Suggested Learning Experiences and Instruction

Learning Experiences:

Part 1: Characteristics of Life and Introduction to Cells

Students will:

- Analyze phenomena involving living vs. non-living systems to identify the characteristics of life.
- Observe cells using microscopes/images and compare structural features of different cell types (e.g., epithelial, muscle, nerve, plant epidermis).
- Construct models of the hierarchical organization of biological structures (cells → tissues → organs → organ systems → organism).
- Examine how cellular structures (ribosomes, ER, mitochondria, membrane, nucleus) contribute to the cellular processes that maintain life.

Part 2: Cell Cycle, Mitosis, and Differentiation
Students will…

- Observe prepared slides (e.g., onion root tip) or simulation to observe mitosis.
- Use models or simulations to illustrate DNA replication, mitosis, and the formation of two identical daughter cells.
- Analyze scenarios where cell division is dysregulated (e.g., cancer) and explain the consequences.
- Model how environmental and internal signals regulate cell cycle checkpoints and programmed cell death.
- Explain how mitosis supports growth, repair, and maintenance of multicellular organisms.

Part 3: Transport, Homeostasis and Feedback Mechanisms
Students will…

- Plan and conduct investigations on feedback mechanisms (e.g., heart rate changes under different conditions, plant stomate responses, glucose regulation simulations).
- Analyze datasets showing negative feedback loops (thermoregulation, blood glucose regulation) and positive feedback loops (blood clotting, labor).
- Construct and revise feedback loop diagrams that model the stability of internal conditions.
- Interpret disruptions to homeostasis (e.g., dehydration, diabetes) and predict how body systems respond.
- Explore cell membrane structure and function, focusing on phospholipids, transport proteins, and receptor proteins.
- Investigate simple diffusion and facilitated diffusion using models or demonstrations.
- Review osmosis and analyze osmoregulation case studies, showing how cells and organisms maintain water balance.
- Compare passive vs. active transport and complete targeted practice applying these concepts.

Instructional Strategies: Instruction is grounded in phenomena-driven learning and structured using the 5E Learning Cycle to support investigation, analysis, and application of learning.
Part 1: Characteristics of Life and Introduction to Cells

- Engage: Introduce the anchor phenomenon and facilitate initial predictions and CER responses to stimulate curiosity about what makes something alive.
- Explore: Conduct hands-on labs observing cells via microscopes and HMH digital images and use simulations to explore living vs. non-living, prokaryotic vs. eukaryotic cell differences and plant vs. animal cell organelles.
- Explain: Students create and explain hierarchical models of biological organization (cells → tissues → organs → organ systems → organism).
- Honors Level - Elaborate: Students apply structure-function understanding by modeling organelles as interacting systems within a cell. Extend learning with comparative analysis tasks using HMH digital resources.

Part 2: Cell Cycle, Mitosis, and Differentiation

- Engage: Present anchor phenomenon through HMH animations or videos showing growth from zygote to multicellular organism. Pose questions about cell division and differentiation to stimulate curiosity.
- Explore: Microscope labs or HMH virtual simulations to identify mitosis phases. Model DNA replication, mitosis, and cytokinesis.
- Explain: Students use guided notes to explain cell cycle regulation, checkpoints, apoptosis, and differentiation using HMH diagrams and resources. Connect observations to cell function and organismal growth.
- Honors Level - Elaborate: Students analyze dysregulated cell division scenarios (cancer, tissue damage) using case studies or HMH extensions. Apply understanding of differentiation to explain stem cell specialization and system-level coordination.

Part 3: Transport, Homeostasis and Feedback Mechanisms

- Engage: Present the anchor phenomenon via teacher-created, HMH case study videos or simulations. Elicit prior knowledge about feedback loops, homeostasis, and membrane transport.
- Explore: Students plan and conduct investigations of feedback mechanisms (heart rate, glucose regulation) using HMH lab simulations. Hands-on or virtual labs to investigate diffusion, facilitated diffusion, osmosis, and active transport. Analyze and model osmoregulation scenarios.

- Explain: Students use guided notes, animations, and interactive media to explain negative and positive feedback loops, cell membrane structure, and transport mechanisms. Students construct and revise feedback loop diagrams, connecting experimental observations to theoretical models.
- Honors Level - Elaborate: Students apply concepts to case studies of homeostatic disruptions (dehydration, diabetes). Use simulations to predict how internal and environmental changes affect system responses. Compare passive vs. active transport and analyze energy requirements in real-life examples.

Differentiation: Intervention/Enrichment Options:
Interventions:
- Scaffolded materials: Guided notes, labeled diagrams, chunked lessons.
- Visual supports: Graphic organizers, color-coded charts for organelles, feedback loops, and cell cycle.
- Hands-on activities: Physical models, manipulatives, labs for mitosis, diffusion, and osmosis.
- Stepwise guidance: Checklists, tiered questioning, think-aloud modeling.
- Peer & tech support: Collaborative learning, HMH simulations, text-to-speech.

Enrichments:
- Higher-order thinking: Analyze complex case studies, predict outcomes of disruptions.
- Research & projects: Stem cells, gene editing, organ system adaptations.
- Problem-based learning: Design experiments, model multicellular system responses.
- Cross-disciplinary connections: Math and chemistry applications for cellular processes.
- HMH honors extensions: Articles and simulations on viruses, epigenetics, and endocrine system regulation.

For Language Development:
- Create a student-made dictionary that includes terms, definitions, and examples organized by chapter.
- Teach only essential vocabulary (as indicated in knowledge section).
- Pre-teach vocabulary or have the ELD teacher pre-teach it if possible.
- Utilize Digital HMH Biology resource which contains translations to over 100 languages.

Unit 2 – From Light to Life: Matter and Energy in Organisms and Ecosystems

Desired Results:

Essential Questions:

- Why do living systems need energy, and how is it transferred and transformed?
- How do cells store and release energy to support life processes?
- How do we use sugar (energy) and rearrange C, H, O to create the molecules of life?
- How does carbon move through living systems and the environment?
- How does energy from the sun get converted to chemical energy living organisms can use to perform life functions?
- Where does the mass of photosynthetic organisms come from?
- How do photosynthesis and cellular respiration support life at multiple levels?
- How does energy flow and matter cycling differ across cells, organisms, and ecosystems?
- How do human activities affect the flow of energy and cycling of carbon in Earth systems?

Enduring Understandings:

Students will understand that…

- Living systems require a constant input and transformation of energy to power chemical reactions that support growth, maintenance, and reproduction.
- Chemical reactions in cells transfer and transform energy, with ATP serving as a temporary energy carrier that supports cellular work.
- Carbon atoms can be rearranged to form a wide variety of carbon-based molecules whose structures determine their functions in living organisms.
- Matter is conserved as atoms are reorganized and continuously cycled within and between living and Earth systems.
- Photosynthesis transforms light energy into stored chemical energy, providing the primary source of energy and matter for most life on Earth.
- Cellular respiration releases energy stored in food molecules through chemical reactions that result in a net transfer of energy usable for cellular work.
- Energy flows through biological systems and is ultimately dissipated as heat, while matter is recycled.
- Photosynthesis and cellular respiration are interconnected processes that drive the cycling of carbon and the flow of energy from cells to ecosystems, and human activities can alter these cycles with significant consequences.

Knowledge:

Part 1: Chemical Reactions & Cell Energy

Students will know:

- Cells require energy to carry out life processes.
- ATP is the main molecule cells use to transfer energy.
- Chemical reactions in cells transfer and transform energy.
- Some reactions release energy (exergonic), while others require energy (endergonic).
- Energy is conserved during energy transformations.
- Vocabulary: Mitochondria, cellular respiration, energy, chemical reaction, chemical energy, stored energy, ATP, ADP, metabolism, enzyme, reactant, product, input, output
- Honors Vocabulary: endothermic, exothermic, activation energy, catalyst

Part 2: Carbon-Based Molecules

Students will know:

- Carbon is a key element in organic molecules essential to life.
- Carbohydrates, lipids, proteins, and nucleic acids have specific structures and functions.
- Energy and matter in ecosystems are ultimately derived from carbon-based molecules.
- Vocabulary: Organic molecule/macromolecule, carbohydrate, lipid, protein, nucleic acid, monosaccharide, polysaccharide, polymer, monomer, hydrocarbon, amino acid, matter, element, metabolism, nucleotide.

Part 3: Photosynthesis
Students will know:
- Light energy is converted into chemical energy in plants and some bacteria.
- Photosynthesis produces carbohydrates and oxygen from carbon dioxide and water.
- Factors such as light intensity, water availability, and temperature affect the rate of photosynthesis.
- Vocabulary: Photosynthesis, chloroplast, chlorophyll, glucose, chemical energy, autotroph, light independent reactions, glucose, light energy.
- Honors Vocabulary: Light-dependent reactions, Calvin cycle, kinetic energy, potential energy, thylakoid, stroma, photosystems.

Part 4: Cellular Respiration
Students will know:
- Cells extract energy from glucose through aerobic and anaerobic respiration.
- ATP is generated by breaking chemical bonds in food molecules.
- Oxygen is required for aerobic respiration; anaerobic respiration occurs when oxygen is limited.
- Vocabulary: Cellular respiration, mitochondria, chemical energy, stored energy, ADP/ATP, aerobic, anaerobic, energy transfer.
- Honors Vocabulary: Glycolysis, Krebs cycle, electron transport chain

Part 5: Energy & Carbon Cycling
Students will know:
- Energy flows through ecosystems from producers to consumers to decomposers.
- Ecological efficiency limits energy transfer between trophic levels.
- Carbon cycles through the biosphere, atmosphere, hydrosphere, and geosphere via photosynthesis, respiration, and decomposition.
- Human activity (e.g., greenhouse gas emissions, deforestation) affects carbon cycling and ecosystem resilience.
- Vocabulary: Energy flow, trophic level, food chain, food web, carbon cycle, biosphere, atmosphere, hydrosphere, geosphere, human impact, ecosystem, greenhouse gas.
- Honors Vocabulary: ecological efficiency

Skills:
Students will be able to…
Part 1: Chemical Reactions & Cell Energy
- Explain the role of ATP in storing and transferring energy.
- Analyze chemical reactions as energy-releasing or energy-requiring.
- Model energy transformations in cellular processes.

Part 2: Carbon-Based Molecules
- Identify the function of carbohydrates, lipids, proteins, and nucleic acids.
- Understand that sugar molecules are composed of carbon, hydrogen and oxygen which can be rearranged to create other large macromolecules (such as proteins and DNA).
- Explain how carbon-based molecules provide energy and building blocks for cells.
- Relate organic molecules to energy flow in ecosystems.
- Model how matter and energy flow through different organizational levels of living systems by the rearrangement of elements within molecules.
- Model and describe the process of how polymers are formed from monomers as well as the process to break the polymers down to form monomers.

Part 3: Photosynthesis

- Model and explain the conversion of light energy into chemical energy.
- Model how plants take in water and carbon dioxide and convert them into glucose and oxygen.
- Identify and describe the inputs and outputs in photosynthesis.
- Analyze factors affecting photosynthesis rates using data from experiments or simulations.
- Explain the connection between photosynthesis and energy availability in ecosystems.

Part 4: Cellular Respiration

- Describe aerobic and anaerobic respiration pathways.
- Explain how ATP is produced and used in cellular activities.
- Model energy extraction from food molecules and its flow to the organism.
- Model how energy is transferred from one system of interacting molecules to another.
- Explain how energy is released by cellular respiration contributing to thermoregulation.

Part 5: Energy & Carbon Cycling

- Construct models of energy flow through ecosystems.
- Compare how matter and energy can move through ecosystems aerobically or anaerobically.
- Explain how photosynthesis, anaerobic/aerobic respiration provide most of the energy for life processes.
- Analyze ecological efficiency and its effect on energy transfer.
- Explain carbon cycling among living organisms and the environment.
- Evaluate human impact on carbon cycling and ecosystem resilience.

Priority Standards:
3.1.9-12.E: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. *Assessment Boundary: Assessment does not include specific biochemical steps.*
3.1.9-12.F: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. *Assessment Boundary: Assessment does not include the details of specific chemical reactions or identification of macromolecules.*
3.1.9-12.G: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. *Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.*
3.1.9-12.J: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. *Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration*
3.1.9-12.K: Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. *Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.*

Supporting Standards:
CC.3.5.9-12.A: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
CC.3.5.9-10.G: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
CC.3.6.9-12.B: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
CC.3.6.9-12.D: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
CC.3.6.9-12.H: Draw evidence from informational texts to support analysis, reflection, and research.

Acceptable Evidence:

Performance Tasks –

- Construct ATP cycle and energy transfer models.
- Model photosynthesis and cellular respiration pathways and connect to carbon cycling.
- Build ecosystem food webs showing energy flow and ecological efficiency.
- Analyze human impact on carbon cycling and predict ecosystem outcomes.

Acceptable evidence of learning other than Performance Tasks:

Formative Assessment:

- "Can You Explain It" Lesson Self Checks using HMH Biology Resource
- Classroom Discussions & Think-Pair-Share: Students discuss how energy flows through cells and ecosystems or compare photosynthesis and cellular respiration.
- CER Responses (Claim-Evidence-Reasoning): Students respond to questions about ATP production, energy transformations, ecological efficiency, or carbon cycling using HMH digital prompts or lab observations.
- HMH Interactive Quizzes & Simulations: Short formative checks on concepts like ATP usage, biomolecule functions, photosynthesis, cellular respiration, trophic levels, and carbon flow.
- Exit Tickets & Quick Writes: Students summarize key concepts, such as the effect of light intensity on photosynthesis or the role of decomposers in carbon cycling.
- Lab Observations & Data Analysis: Students record and interpret data from investigations of photosynthesis, respiration, or ecosystem energy transfer.
- Diagram/Model: Students develop models of energy flow, ATP cycles, photosynthesis/respiration, or carbon cycling.

Summative Assessment:

- Chapter/Concept Assessments: Assess understanding of energy transfer, ATP, photosynthesis, cellular respiration, biomolecule roles, trophic levels, ecological efficiency, and carbon cycling through multiple-choice, short answer, and applied modeling questions.
- District Common Unit Assessments: Combination of multiple-choice, short answer, and applied tasks requiring modeling or explanation.
- Laboratory Reports
- Performance-Based Assessments: Graded models or digital projects demonstrating mastery of energy transfer, ATP cycles, photosynthesis/respiration connections, or ecosystem energy flow.
- Canvas/HMH Assignments: Digital tasks requiring students to apply knowledge to case studies, simulations, or real-world phenomena

Suggested Learning Experiences and Instruction

Learning Experiences:

Part 1: Chemical Reactions & Cell Energy

Students will:

- Model ATP production and usage in cellular processes using HMH simulations.
- Demonstrate exergonic and endergonic reactions in lab or virtual activities.

Part 2: Carbon-Based Molecules

Students will:

- Explore macromolecule structure and function through models, interactive HMH activities, and lab investigations.
- Analyze nutrient composition in foods.

Part 3: Photosynthesis

Students will:

- Conduct hands-on or virtual experiments modeling light-dependent reactions and carbohydrate production.
- Examine factors affecting photosynthesis (light, water, temperature) using HMH labs.
- Relate this knowledge to cellular energy storage.

Part 4: Cellular Respiration

Students will:

- Simulate aerobic and anaerobic respiration in HMH virtual labs.
- Measure cellular respiration outputs in model organisms or lab simulations.

Part 5: Energy & Carbon Cycling
Students will:

- Build models of food webs, trophic levels, and energy flow using HMH interactive tools.
- Trace carbon cycling through ecosystems and model human impact using HMH case studies.

Instructional Strategies: Instruction is grounded in phenomena-driven learning and structured using the 5E Learning Cycle to support investigation, analysis, and application of learning.
Part 1: Chemical Reactions & Cell Energy

- Engage: Introduce the anchor phenomenon with HMH interactive simulations showing ATP generation and energy use in cells. Pose questions about everyday energy use in organisms to activate prior knowledge.
- Explore: Hands-on or virtual labs demonstrating exergonic vs. endergonic reactions. Model ATP hydrolysis and phosphorylation using physical manipulatives or HMH digital tools.
- Explain: Students use guided notes and animations to explain ATP as the energy currency of the cell and its role in cellular work. Students diagram energy transformations between ATP, ADP, and chemical reactions.
- Honors Level - Elaborate: Students apply concepts to real-world examples, such as muscle contraction or nerve signaling. Compare energy transfer efficiency in different reactions or organisms using HMH digital simulations.

Part 2: Carbon-Based Molecules

- Engage: Introduce phenomenon using HMH media showing how glucose is used to make larger carbon-based molecules. Pose guiding questions: “How does energy captured in molecules support life.
- Explore: Lab investigations identifying carbohydrates, lipids, proteins, and nucleic acids using qualitative tests or virtual labs. HMH interactive modeling of molecular structures and bonding.
- Explain: Guided instruction on monomers, polymers, and the relationship between molecular structure and function. Students create diagrams linking chemical structure to energy storage or functional roles in cells.
- Honors Level - Elaborate: Students apply concepts to compare energy content of carbohydrates, lipids, and proteins. Explore examples such as ATP synthesis, glucose storage, and macromolecule building in different organisms.

Part 3: Photosynthesis

- Engage: HMH videos or simulations showing light energy being converted into chemical energy in plant cells. Pose guiding questions: “Where does the mass of a plant come from?” and “How is sunlight used by cells?”
- Explore: Labs on photosynthesis (leaf disks, oxygen sensors, or virtual HMH labs). Modeling light-dependent and light-independent reactions with physical or digital manipulatives.
- Explain: Students use guided notes and interactive animations to explain the conversion of light energy to chemical energy (ATP, NADPH, glucose). Students relate photosynthesis to matter and energy flow in ecosystems.
- Honors Level - Elaborate: Students analyze factors affecting photosynthesis (light, CO_2, temperature). Connect photosynthesis to cellular respiration and energy cycling in ecosystems.

Part 4: Cellular Respiration

- Engage: HMH simulations showing glucose breakdown and ATP production in cellular respiration. Pose questions about why organisms need to perform respiration even if they perform photosynthesis.
- Explore: Lab investigations of cellular respiration (yeast, CO_2 sensors, or HMH virtual labs). Model glycolysis, Krebs cycle, and electron transport as energy transfer processes using manipulatives or digital simulations.
- Explain: Students link ATP production to energy use, matter cycling, and organismal function. Students diagram energy flow from glucose to ATP.
- Honors Level - Elaborate: Students compare aerobic vs. anaerobic respiration efficiency. Apply knowledge to real-life scenarios, e.g., exercise, fermentation, or plant metabolism at night.

Part 5: Energy & Carbon Cycling

- Engage: HMH ecosystem simulations demonstrating energy flow and carbon cycling. Discuss human impacts on ecosystems, such as deforestation and CO_2 emissions.
- Explore: Construct and analyze food webs and energy pyramids using HMH digital tools or manipulatives. Investigate carbon cycle case studies: photosynthesis, respiration, decomposition, fossil fuel emissions.
- Explain: Students use guided notes and HMH interactive media to explain energy transfer efficiency, trophic levels, and ecosystem carbon balance. Students connect cellular energy processes to ecosystem-level cycling.
- Honors Level - Elaborate: Students explore ecological efficiency and its limits on energy availability for successive trophic levels.

Differentiation/Intervention/Enrichment Options:
Interventions:
- Scaffolded materials: Guided notes, labeled diagrams, and chunked lessons for photosynthesis, cellular respiration, and energy flow in ecosystems.
- Visual supports: Graphic organizers and color-coded charts for energy transfer, trophic levels, carbon cycling, and metabolic pathways.
- Hands-on activities: Physical models, manipulatives, and labs for ATP production, photosynthesis, cellular respiration, and ecosystem simulations.
- Stepwise guidance: Checklists, tiered questioning, and think-aloud modeling for analyzing chemical reactions, carbon-based molecules, and energy/matter flow.
- Peer & tech support: Collaborative learning, HMH virtual labs, interactive simulations, and text-to-speech options to support comprehension of complex processes.

Enrichments:
- Higher-order thinking: Analyze complex case studies on energy efficiency, human impacts on carbon cycling, or extreme environmental conditions.
- Research & projects: Investigate cellular energy transformations, photosynthesis adaptations in different plants, or effects of climate change on ecosystems.
- Problem-based learning: Design experiments modeling energy and matter transfer, simulate ecosystem disruptions, or predict outcomes of altered carbon cycles.
- Cross-disciplinary connections: Explore math and chemistry applications in ATP calculations, energy budgets, and chemical reaction modeling.
- HMH honors extensions: Articles, simulations, and digital investigations on advanced topics such as cellular metabolism, global carbon cycling, and climate change impacts on ecosystems.

For Language Development:
- Create a student-made dictionary that includes terms, definitions, and examples organized by chapter.
- Teach only essential vocabulary (as indicated in knowledge section).
- Pre-teach vocabulary or have the ELD teacher pre-teach it if possible.
- Utilize Digital HMH Biology resource which contains translations to over 100 languages.

Central Bucks School District – Course of Study – Biology

Unit 3a – From Genes to Generations – Inheritance and Variation of Traits

Desired Results:

Essential Questions:

- How does the structure of DNA determine the structure and function of proteins and, ultimately, traits?
- How is genetic information passed from one generation to the next?
- Why do individuals of the same species have different traits?
- How are the characteristics of one generation related to the previous generation?
- Why (How) do individuals of the same species vary in how they look, function and behave?
- How can probability be used to predict the outcomes of a genetic cross?
- How can data be used to determine patterns of inheritance?
- How can biotechnology be used to address modern problems?
- What constitutes an ethical use of biotechnology?

Enduring Understandings:

Students will understand that…

- DNA provides the instructions for an organism's traits, and these traits are expressed through proteins.
- Environmental factors can influence the expression of traits in organisms.
- The reproductive process leads to genetic variation in a number of ways.
- Genetic inheritance usually follows predictable patterns, resulting in a variety of traits in offspring.
- Probability can be used to predict the likelihood of traits in offspring.
- Genetic diversity contributes to the survival and resilience of populations.
- Modern genetic techniques can be applied to many societal issues, but they involve ethical considerations.

Knowledge:

Part 1: DNA Structure and Replication

Students will know:

- DNA is the universal code of life, consisting of a double helix structure made of nucleotides (phosphate, deoxyribose sugar, nitrogenous base).
- Complementary base pairing (A–T, C–G) allows DNA to store and transmit genetic information.
- DNA replication is semi-conservative, producing two identical DNA molecules from one original molecule.
- Enzymes (such as DNA helicase, DNA polymerase, and ligase) are involved in DNA replication.
- Vocabulary: Nucleotide, DNA, RNA, Genes, Protein, Protein synthesis, DNA replication, transcription, translation
- Honors Vocabulary: Double helix, complementary base pairing, replication, semi-conservative, helicase, polymerase, ligase, template strand, daughter strand.

Part 2: Protein Synthesis

Students will know:

- Genes in DNA code for proteins, which carry out specific cellular functions.
- Transcription is the process of copying DNA into mRNA.
- Translation is the process by which ribosomes read mRNA to synthesize proteins using tRNA and amino acids.
- Mutations in DNA can affect protein structure and function.
- Vocabulary: Transcription, translation, codon, amino acid, ribosome, gene, protein, genetic mutation, gene expression, mRNA, tRNA, rRNA
- Honors Vocabulary: anticodon, stop codon, start codon

Part 3: Gene Expression and Regulation
Students will know:

- Gene expression is regulated, so not all genes are active in all cells or at all times.
- Cells with the same DNA can develop different structures and functions because they express different genes.
- Internal and external factors can influence gene expression.
- Both genetic and environmental factors contribute to the traits observed in organisms.
- Environmental conditions can affect the expression of traits without changing the DNA sequence.
- Vocabulary: DNA, gene, gene expression, regulation, protein, traits
- Honors: Epigenetic factors, such as DNA methylation and histone modification, can affect gene expression without changing the DNA sequence.
- Honors Vocabulary: epigenetics, transcription factors, promoter, environmental influence.

Part 4: Meiosis
Students will know:

- Meiosis is the process by which gametes (sperm and egg) are produced, halving the chromosome number.
- Meiosis introduces genetic variation through crossing over (prophase I) and independent assortment (metaphase I).
- Differences between meiosis and mitosis include number of divisions, chromosome number in daughter cells, and genetic variation.
- Errors in meiosis can lead to chromosomal disorders.
- Vocabulary: Meiosis, genetic mutation, genetic variation, homologous chromosomes
- Honors Vocabulary: gamete, sister chromatids, haploid, diploid, crossing over, independent assortment, tetrad, nondisjunction

Part 5: Mendel, Heredity, Traits, and Probability
Students will know:

- Mendelian inheritance involves dominant and recessive alleles and predictable ratios of phenotypes in offspring.
- Punnett squares, probability, and pedigrees can be used to predict inheritance patterns.
- Genetic variation results from meiosis, fertilization, mutations, and environmental influences.
- Vocabulary: DNA, gene, allele, chromosome, dominant, recessive, homozygous, heterozygous, genotype, phenotype, traits, Punnett square, probability, genetic mutation, genetic variation, inheritance.
- Honors Vocabulary: Non-Mendelian inheritance, incomplete dominance, codominance, polygenic trait, multiple alleles.

Skills:
Students will be able to…
Part 1: DNA Structure and Replication

- Describe the structure of DNA and explain how complementary base pairing allows for replication.
- Model the process of DNA replication, comparing the roles of enzymes (helicase, DNA polymerase, and ligase).
- Compare and contrast the template strand and daughter strand in replication.
- Explain how replication errors can lead to mutations.

Part 2: Protein Synthesis

- Model transcription and translation to explain how DNA codes for proteins.
- Use codons and anticodons to demonstrate the role of mRNA and tRNA in protein synthesis.
- Predict the effect of mutations on protein structure and function.
- Explain the functional relationship between genes, proteins, and cell function.

Part 3: Gene Expression and Regulation

- Explain how and why genes are regulated.
- Analyze how various other factors (such as environmental factors) can influence phenotype.
- Compare expressed and non-expressed genes and explain their effects on cell function.

Part 4: Meiosis

- Explain how meiosis produces genetically unique gametes.
- Compare meiosis and mitosis in terms of genetic variation.
- Explain how processes, such as crossing over and independent assortment, create genetic variation.
- Predict how errors during meiosis (e.g., nondisjunction) affect offspring.
- Make and defend a claim, using evidence, about how genetic variation occurs.

Part 5: Mendel, Heredity, Traits, and Probability

- Make and defend a claim about how genetic variation occurs.
- Use Punnett squares and probability as evidence to explain patterns of inheritance.
- Analyze pedigree data to determine inheritance patterns and support a claim.
- Explain how variation results from reproduction, DNA errors, and environmental mutations.

Priority Standards:
3.1.9-12.A: All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (This will also reoccur in Unit 3). *Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole-body systems, specific protein structures and functions, or the biochemistry of protein synthesis.*
3.1.9-12.P: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. *Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.*
3.1.9-12.Q: Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. *Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.*
3.1.9-12.R: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. *Assessment Boundary: Assessment does not include Hardy-Weinberg calculations*

Supporting Standards:
CC.3.5.9-12.A: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
CC.3.5.9-10.I: Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.
CC.3.6.9-12.A: Write arguments focused on discipline-specific content.
CC.3.6.9-12.B: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
CC.3.6.9-12.H: Draw evidence from informational texts to support analysis, reflection, and research.

Acceptable Evidence:

Performance Tasks –

- DNA & Protein Synthesis Model: Students build a model illustrating DNA replication, transcription, and translation.
- Gene Regulation Case Study: Students analyze environmental influences on gene expression and present predictions.
- Meiosis & Heredity: Model meiosis stages, crossing over, and independent assortment, linking to genetic variation in offspring.
- Genetic Probability Task: Solve Punnett square and pedigree problems, predicting inheritance patterns. (e.g. Dragon Genetics activity)

Acceptable evidence of learning other than Performance Tasks:

Formative Assessment:

- “Can You Explain It” Lesson Self Checks using HMH Biology Resource
- Classroom discussions, think-pair-share on DNA, proteins, and inheritance.

- HMH digital quizzes and practice problems on replication, transcription, translation, gene regulation, meiosis, and Punnett squares.
- Exit tickets summarizing gene expression, mutations, or inheritance patterns.
- Lab observations and data analysis for meiosis simulations or probability experiments.
- CER responses for phenomena like genetic variation and trait inheritance.

Summative Assessment:

- Chapter/Concept Assessments: covering DNA structure, protein synthesis, gene regulation, meiosis, and inheritance.
- District Common Unit Assessments: Combination of multiple-choice, short answer, and applied tasks requiring modeling or explanation
- Laboratory reports
- Performance-based assessment: DNA/protein models and genetic predictions.
- Canvas/HMH online assignments requiring applied explanations and analysis of genetic scenarios.

Suggested Learning Experiences and Instruction

Learning Experiences:

Part 1: DNA Structure and Replication

Students will:

- Build DNA models to visualize nucleotide pairing and double helix structure.
- Simulate DNA replication with physical or digital manipulatives.
- Analyze cases of replication errors and mutations.

Part 2: Protein Synthesis

Students will:

- Transcribe and translate DNA sequences into amino acid chains using codon charts.
- Use HMH simulations to visualize transcription and translation processes.
- Investigate real-world examples of mutations affecting protein function (e.g., sickle-cell anemia).

Part 3: Gene Expression and Regulation

Students will:

- Explore gene regulation using simulations or diagrams showing promoter interactions.
- Analyze how environmental changes can affect gene expression.
- Honors: Model epigenetic changes and their effects on phenotype.

Part 4: Meiosis

Students will:

- Observe meiosis through simulations, animations, or prepared slides.
- Model crossing over and independent assortment with manipulatives.
- Compare meiotic errors with case studies (e.g., Down syndrome, Turner syndrome).

Part 5: Mendel, Heredity, Traits, and Probability

Students will:

- Use Punnett squares to predict inheritance patterns and support claims about how traits are passed.
- Analyze pedigrees to identify patterns of inheritance and use data as evidence to support genetic claims.
- Conduct probability experiments (coins, dice, or genetic simulations) to model inheritance and use results as evidence to explain variation in traits.

Instructional Strategies: Instruction is grounded in phenomena-driven learning and structured using the 5E Learning Cycle to support investigation, analysis, and application of learning.

Part 1: DNA Structure and Replication

- Engage: Use animations showing DNA replication and real-world mutation examples.

- Explore: Build models of DNA and simulate replication.
- Explain: Students discuss roles of enzymes, such as helicase, polymerase, and ligase, using diagrams.
- Honors Level - Elaborate: Analyze replication errors and potential effects on proteins.

Part 2: Protein Synthesis

- Engage: Show simulations showing transcription and translation.
- Explore: Translate DNA sequences into amino acids using codon charts.
- Explain: Students explain relationship between DNA, RNA, and proteins.
- Honors Level - Elaborate: Predict outcomes of mutations using real-world examples.

Part 3: Gene Expression and Regulation

- Engage: Show cases of gene silencing or activation in cells.
- Explore: Simulate gene expression using interactive HMH digital tools.
- Explain: Students discuss and explain how gene expression is regulated and how differences in gene expression contribute to variations in cell function and observable traits.
- Honors Level - Elaborate: Examine environmental influence on gene expression.

Part 4: Meiosis

- Engage: Use animations to visualize chromosome behavior.
- Explore: Model meiosis and simulate gamete formation.
- Explain: Students compare meiosis to mitosis and highlight sources of variation.
- Honors Level - Elaborate: Predict consequences of meiotic errors.

Part 5: Mendel, Heredity, Traits, and Probability

- Engage: Present family pedigree examples.
- Explore: Solve Punnett square and probability problems.
- Explain: Discuss Mendelian vs. non-Mendelian inheritance patterns.
- Honors Level - Elaborate: Predict outcomes using data from pedigrees or probability simulations.

Differentiation/Intervention/Enrichment Options:

Interventions:

- Scaffolded materials: Guided notes, labeled DNA/protein synthesis diagrams, chunked lessons for replication, transcription, translation, and meiosis.
- Visual supports: Graphic organizers, color-coded charts for DNA structure, codon tables, gene expression pathways, and Punnett squares.
- Hands-on activities: Physical or digital models for DNA, RNA, proteins, meiosis, and inheritance patterns.
- Stepwise guidance: Checklists for completing Punnett square exercises, meiosis simulations, and gene expression models; tiered questioning to support comprehension.
- Peer & tech support: Collaborative learning, HMH simulations, interactive pedigree tools, text-to-speech features, and step-by-step HMH guided exercises.
- Simplified practice: Start with monohybrid crosses and gradually simple dihybrid and non-Mendelian patterns.

Enrichments:

- Higher-order thinking: Analyze complex case studies of genetic disorders, epigenetics, or population genetics.
- Research & projects: Investigate CRISPR, gene therapy, or biotechnology applications for solving societal problems.
- Problem-based learning: Design experiments to predict inheritance patterns, model genetic crosses, or simulate environmental impacts on gene expression.
- Cross-disciplinary connections: Use math to calculate probabilities in Punnett squares and Hardy-Weinberg equilibrium; incorporate chemistry to explore molecular structures of DNA and proteins.
- HMH honors extensions: Explore detailed simulations of gene regulation, genetic mutations, pedigrees, and the ethical implications of biotechnology.

For Language Development:

- Create a student-made dictionary that includes terms, definitions, and examples organized by chapter.

- Teach only essential vocabulary (as indicated in knowledge section).
- Pre-teach vocabulary or have the ELD teacher pre-teach it if possible.
- Utilize Digital HMH Biology resource which contains translations to over 100 languages.

Central Bucks School District – Course of Study – Biology
Unit 3b – From Genes to Generations – Natural Selection and Evolution

Desired Results:

Essential Questions:

- Why do individuals of the same species vary in how they look, function, and behave?
- How do patterns in data help explain why some traits become more common in a population?
- What evidence supports that all species are related through common ancestry?
- How does genetic variation affect survival and reproduction?
- How does natural selection lead to adaptation in populations?
- How does the environment influence populations over multiple generations?
- How can new species form over time?
- Why do some organisms go extinct, and how does this affect ecosystems?
- How does evolution explain both the similarities and diversity of life on Earth?
- What is biodiversity, and how do human activities impact it?

Enduring Understandings:

Students will understand that…

- Natural selection is a primary driving force of evolution, leading to adaptation of populations.
- Variation among individuals of the same species results from both genetic and environmental factors and provides the basis for natural selection.
- Genetic variation arises through multiple mechanisms and allows populations to adapt over time.
- In a given environment, individuals with certain traits are more likely to survive and reproduce, which can change the traits of a population over generations.
- All species share a common ancestor, and this relationship is supported by evidence from anatomical, developmental, and genetic similarities.
- Patterns in data and trait distributions can be used to explain how populations change over time.
- Barriers to reproduction can lead to the formation of new species.
- Extinction occurs when species lack adaptations needed for survival, and human activities are accelerating this process.
- Biodiversity results from ongoing evolutionary change, and greater biodiversity promotes ecosystem resilience.

Knowledge:

Part 1: Lines of Evidence for Evolution

Students will know:

- Fossil records, comparative anatomy, embryology, molecular biology, and biogeography provide evidence for evolution.
- Patterns of homology, analogy, and vestigial structures indicate evolutionary relationships.
- Multiple lines of evidence are used together to support the theory of evolution.
- Vocabulary: Fossil, homologous structures, analogous structures, vestigial structures, common ancestor, DNA evidence, biogeography.
- Honors Vocabulary: phylogeny, clade,

Part 2: Natural Selection

Students will know:

- Natural selection acts on variation within populations; survival and reproductive success depend on advantageous traits.
- Environmental pressures determine which traits are favorable.
- Vocabulary: Natural selection, biological fitness, adaptation, selective pressure, phenotype, genotype.

Part 3: Evolution of Populations

Students will know:
- Populations evolve over time through changes in allele frequencies caused by natural selection, mutation, and sexual reproduction.
- Data and graphical patterns can be used to show how traits change in populations over time.
- Reproductive barriers can lead to speciation.
- Vocabulary: Evolution, Population, gene pool, allele frequency, speciation, reproductive isolation, genetic variation, mutation, sexual reproduction.

Part 4: Biodiversity and Humans
Students will know:
- Biodiversity arises from evolutionary processes and contributes to ecosystem resilience.
- Human activities impact biodiversity, affecting ecosystems and species survival.
- Vocabulary: Biodiversity, extinction, conservation, ecosystem resilience, adaptation, sustainability, human disturbances.
- Honors Vocabulary: Anthropogenic impact

Skills:
Students will be able to….
Part 1: Lines of Evidence for Evolution
- Analyze and interpret fossil, anatomical, embryological, and molecular evidence to infer evolutionary relationships.
- Compare homologous, analogous, and vestigial structures to evaluate evidence of common ancestry and evolutionary change.
- Construct evidence-based explanations describing how multiple lines of evidence support the theory of evolution.
- Honors: Develop and interpret phylogenetic trees to illustrate evolutionary relationships among species.

Part 2: Natural Selection
- Describe the conditions necessary for natural selection to occur (variation, competition, differential survival, and reproduction).
- Model how advantageous traits increase in frequency in populations over generations.
- Compare acclimatization vs. adaptation in response to environmental change.
- Predict how environmental pressures influence population traits and outcomes.

Part 3: Evolution of Populations
- Model changes in allele frequencies in populations over time due to natural selection, mutation, and sexual reproduction.
- Compare and contrast the processes of speciation and reproductive isolation.
- Explain how genetic variation arises and contributes to population evolution.
- Analyze population-level data to identify patterns of evolutionary change.

Part 4: Biodiversity and Humans
- Evaluate how human-driven environmental changes affect biodiversity and ecosystem resilience.
- Develop and use models to predict the impact of environmental changes on species survival.
- Construct explanations linking natural selection to adaptation and speciation in populations.
- Analyze case studies to propose solutions for conservation and mitigating biodiversity loss.

Priority Standards:
3.1.9-12.R: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. *Assessment Boundary: Assessment does not include Hardy-Weinberg calculations*
3.1.9-12.S: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. *Assessment Boundary: N/A*
3.1.9-12.T: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to

mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. *Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.*
3.1.9-12.U: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.
3.1.9-12.V: Create or revise a simulation to test a solution to mitigate the adverse impacts of human activity on biodiversity. *Assessment Boundary: N/A*
3.1.9-12.W: Construct an explanation based on evidence for how natural selection leads to adaptation of populations. *Assessment Boundary: N/A*
3.1.9-12.X: Evaluate the evidence supporting claims that changes in environmental conditions may result in (1)increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. *Assessment Boundary: N/A*

Supporting Standards:
CC.3.5.9-12.A: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
CC.3.5.9-10.H: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem
CC.3.6.9-12.B: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
CC.3.6.9-12.D: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
CC.3.6.9-12.F: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
CC.3.6.9-12.H: Draw evidence from informational texts to support analysis, reflection, and research.

Acceptable Evidence:

Performance Tasks –

- Evolution: Students compile fossil, anatomical, embryological, and molecular evidence supporting evolutionary relationships. (e.g. analyzing primate protein)
- Natural Selection: Students conduct or view a simulation of selection pressures and analyze population changes over generations.
- Phylogenetic Tree: Construct trees showing relatedness among species based on anatomical or molecular data.
- Human Impact: Model human-driven environmental changes and propose biodiversity conservation strategies.

Formative Assessment:

- "Can You Explain It" Lesson Self Checks using HMH Biology Resource
- Classroom discussions and think-pair-share on evidence for evolution.
- Conceptual CER check-ins explaining adaptations or population changes.
- Interactive HMH quizzes on natural selection, speciation, and biodiversity.
- Exit tickets summarizing main lines of evidence or adaptation outcomes.

Summative Assessment:

- Chapter/Concept Assessments: Multiple-choice, short answer, and applied questions on evolution, natural selection, population evolution, and biodiversity.
- District Common Unit Assessments: Combination of multiple-choice, short answer, and applied tasks requiring modeling or explanation
- Lab Reports: Simulation analyses, fossil or anatomical evidence investigations.
- Performance-Based Assessment: Phylogenetic trees, population change models, or conservation proposals.

- HMH-aligned assignments: Case studies, modeling exercises, and evidence-based explanations.

Suggested Learning Experiences and Instruction

Learning Experiences:

Part 1: Lines of Evidence for Evolution

- Examine fossil casts, HMH simulations, and phylogenetic trees to identify evolutionary patterns.
- Compare homologous and analogous structures through images, models, or lab dissections.
- Analyze embryonic development stages to infer evolutionary relationships.

Part 2: Natural Selection

- Simulate natural selection using HMH digital labs (e.g., predator-prey models, beak size variations).
- Observe case studies of adaptations in modern populations.
- Analyze environmental pressures and resulting phenotypic changes.

Part 3: Evolution of Populations

- Model changes in allele frequencies over generations using simulations or physical manipulatives.
- Investigate speciation through examples of reproductive isolation.
- Construct population models to visualize genetic variation and selection effects.

Part 4: Biodiversity and Humans

- Explore real-world human impacts on biodiversity through case studies.
- Use HMH interactive simulations to model ecosystem resilience and species extinction.
- Research conservation strategies and propose mitigation solutions.

Instructional Strategies: Instruction is grounded in phenomena-driven learning and structured using the 5E Learning Cycle to support investigation, analysis, and application of learning.

Part 1: Lines of Evidence for Evolution

- Engage: Introduce fossil evidence or unusual species with shared traits.
- Explore: Hands-on fossil analysis, anatomical comparisons, embryology observations.
- Explain: Analyze how multiple lines of evidence, including fossils, comparative anatomy, embryology, molecular biology, and biogeography, support common ancestry and evolutionary change.
- Honors Level - Elaborate: Build phylogenetic trees using molecular or anatomical data.

Part 2: Natural Selection

- Engage: Present scenarios where populations face selective pressures.
- Explore: Simulate survival outcomes in varying environmental conditions.
- Explain: Discuss natural selection mechanisms using HMH models and videos.
- Honors Level - Elaborate: Students predict trait prevalence under hypothetical environmental changes.

Part 3: Evolution of Populations

- Engage: Show a population-level phenomenon (e.g., antibiotic resistance).
- Explore: Conduct simulations modeling allele frequency shifts across generations.
- Explain: Mini-lessons on reproductive isolation, mutation, and sexual reproduction effects.
- Honors Level - Elaborate: Predict outcomes for populations under different selective pressures.

Part 4: Biodiversity and Humans

- Engage: Examine local or global biodiversity issues.
- Explore: Investigate case studies on human impacts and ecosystem changes.
- Explain: Guided discussion on biodiversity, ecosystem resilience, and conservation.
- Honors Level - Elaborate: Propose solutions to mitigate biodiversity loss using simulations or research.

Differentiation/Intervention/Enrichment Options:

Interventions:

- Scaffolded materials: Guided notes, labeled diagrams for evolutionary evidence, HMH chunked lessons.
- Visual supports: Color-coded charts for adaptations, reproductive barriers, and phylogenetic trees.

- Hands-on activities: Physical or virtual models of selection, speciation, and population changes.
- Stepwise guidance: Checklists for simulations, Punnett-type adaptation predictions, and tree construction.
- Peer & tech support: Collaborative modeling, interactive HMH simulations, text-to-speech, and guided data interpretation.

Enrichments:

- Higher-order thinking: Analyze real-world biodiversity crises, predict adaptation outcomes, and evaluate conservation strategies.
- Research & projects: Study human evolution, endangered species, or long-term climate impacts on populations.
- Problem-based learning: Design models to test hypotheses about evolution under environmental pressures.
- Cross-disciplinary connections: Use statistics and probability to analyze trait distributions in populations.
- HMH honors extensions: Explore molecular evolution, genome comparisons, and advanced speciation case studies.

For Language Development:

- Create a student-made dictionary that includes terms, definitions, and examples organized by chapter.
- Teach only essential vocabulary (as indicated in knowledge section).
- Pre-teach vocabulary or have the ELD teacher pre-teach it if possible.
- Utilize Digital HMH Biology resource which contains translations to over 100 languages.