

# **Student Achievement Committee Meeting**

Wednesday, December 17, 2025 5:00 PM

BOE Auditorium and via Zoom Meeting Platform, 129 Church Street, Bristol, CT 06010

1. **Call to Order/ Pledge of Allegiance**

2. **Decision: Approval of Minutes**

3. **Public Comment**

4. **Decision**

4.1. 2026 Meeting Dates

4.2. AP Biology Curriculum Revision

4.3. ECE Biology Curriculum Revision

5. **Information**

5.1. 2025 CT Physical Fitness Data

6. **Adjournment**



**Student Achievement & Outcomes Committee**  
**November 19, 2025**  
**MINUTES**

*The minutes presented within this document are a summary of the discussion that took place at the Student Achievement Committee meeting. To view the meeting in its entirety and hear full reports please go to: [November 19, 2025 SAC Meeting Recording](#)*

PRESENT Committee members: Jill Fitzsimons-Bula, Kara Ledger, Barbara Tedesco

ALSO PRESENT: Ken Bagley (Zoom), Carly Fortin, Laura Lanza, Melanie Vetrano, Leszek Ward, Iris White

**Call to Order**

Commissioner Ledger called the meeting to order at 6:30 p.m.

**Decision: Approval of Minutes from October 15, 2025 meeting**

*On a motion made by Commissioner Fitzsimons-Bula and seconded by Commissioner Tedesco, it was unanimously;*

**VOTED: to move the October 15, 2025 meeting minutes to the full Board of Education for approval.**

**Public Comment:** No public comment.

**Decision: 2026 Meeting dates**

*On a motion made by Commissioner Tedesco and seconded by Commissioner Fitzsimons-Bula, it was unanimously;*

**VOTED: to table the 2026 meeting dates to the December SAC meeting.**

**Information: Curriculum Process Overview**

Carly Fortin, Chief of Academics, presented an overview of the curriculum process for Bristol Public Schools. The Bristol Public Schools curriculum process is a multi-year cycle that emphasizes a shared vision and ongoing refinement. It involves a multi-stage approach—learning, writing, implementation, and refinement—guided by documents like the Vision of the Graduate and a focus on equity and stakeholder involvement before and after formal Board of Education approval.

Questions and comments followed.

**Decision: Personal Finance curriculum revision**

Laura Lanza, Secondary STEM Supervisor, presented the curriculum revision for Personal Finance. This course provides students with the essential knowledge and skills to manage their personal finances and make informed financial decisions. Through real-world applications, interactive projects, and hands-on activities, students will learn about

behavioral economics, budgeting, banking, credit, paychecks and taxes, introductory investing, and retirement planning. By the end of the course, students will develop responsible financial habits. This class empowers students with the confidence to make smart financial choices, setting them up for lifelong financial success.

Comments followed.

*On a motion made by Commissioner Fitzsimons-Bula and seconded by Commissioner Tedesco, it was unanimously;*

**VOTED: to move the Personal Finance Curriculum Revision to the full Board of Education for approval.**

**Decision: PLTW Civil Engineering and Architecture curriculum revision**

Mrs. Lanza presented the curriculum revision for Civil Engineering and Architecture. Civil Engineering and Architecture is a specialization course in the PLTW Engineering Program. Students are introduced to important aspects of building and site design and development. They apply math, science, and standard engineering practices to design both residential and commercial projects and document their work using 3D architectural design software. Utilizing the activity-project-problem-based teaching and learning pedagogy, students will progress from completing structured activities to solving open-ended projects and problems that require them to develop planning, documentation, communication, and other professional skills.

Questions and comments followed.

**Information: 2024-2025 On-Track Graduation Rate**

Mrs. Fortin and Melanie Vetrano, Bristol Eastern High School Assistant Principal, presented the on-track graduation data from the 2024-2025 school year. The district's On-Track Rate reached 88.9%, the highest since 2019, driven by significant gains across all student subgroups, particularly those receiving specialized instruction (+6.7%). Key strategies included the use of On-Track Counselors, targeted math course restructuring (Everyday Math), and enhanced vertical articulation between middle and high schools, with the next focus being more immediate interventions and a deeper data analysis of students who receive specialized instruction.

Questions and comments followed.

There being no further discussion, Commissioner Ledger adjourned the meeting at 7:54pm.

Respectfully submitted,

***Katlyne Laprise***

Katlyne Laprise



## PROCEDURES FOR REMOTE PUBLIC COMMENT

Members of the public are invited to comment to the Board on any topic related to school business.

Items requiring consideration by the Board must be approved as an agenda item by a 2/3ds vote of the Board members present. Such items may be referred for further study and not necessarily acted upon at this meeting.

Anyone wishing to address the Board should adhere to the following procedures:

### **PUBLIC COMMENT**

#### **Before a Remote Meeting**

1. Send your comments to: [KatlyneLaprise@bristolk12.org](mailto:KatlyneLaprise@bristolk12.org)
2. Be sure to put **PUBLIC COMMENT-SAC** in the subject line.
3. Include your name and address.
4. Direct your comments to the Board Chair.
5. Your comments will be read at the meeting by the Board Chair.
6. All comments should be written in an appropriate manner, particularly if concerning a personnel matter.
7. Any comments not adhering to the guidelines will not be read at the meeting.

#### **During a Remote Meeting**

1. Everyone is requested to address the Chair for recognition.
2. Each speaker must state his/her name and address.
3. All speakers must observe rules of common etiquette. Personalities are not to be injected. Anyone violating this rule will be denied the floor. Unless waived by the Chairperson or a majority of the Board,
4. Each speaker shall limit his/her remarks to three (3) minutes.
5. A speaker will not be recognized for a second time on the same topic.
6. Each speaker must concern himself/herself with the topic under discussion. Anyone digressing from the topic will be ruled out of order.
7. Written statements and materials may be made available, in advance of comments, for distribution to Board members.
8. Speakers shall state their positions on the subject being discussed.
9. Board members will not respond directly to comments during the Board meeting. The Superintendent will direct the question to the appropriate staff member for follow-up.



Course Title:	Content Area:	Grade Level:	Credit (if applicable)
AP Biology	Science	11-12	1.0

**Course Description:**

The AP Biology course is designed to be the equivalent of a college introductory biology course, usually taken by biology majors during their first year. AP Biology will include those topics regularly covered in a college biology course for majors. The college course in biology differs significantly from the usual first high school course in biology concerning the kind of textbook used, the range and depth of topics covered, the kind of laboratory work done by students, and the time and effort required of students. The textbook and labs will be the equivalent of those college students use. The topics covered include Molecules and Cells, Heredity and Evolution, and Organisms and Populations. Students will be required to take the Advanced Placement Examination in May.

**Aligned Core Resources:** **Connection to the *BPS Vision of the Graduate***

<ul style="list-style-type: none"> <li>• <a href="#">Campbell Biology In Focus: AP Edition (2025) 4e</a></li> <li>• <a href="#">AP Biology CED</a></li> <li>• AP Classroom</li> </ul>	<p>The ECE program will provide students with a pathway to meet the Bristol Public School's vision of the graduate through advanced learning opportunities such as:</p> <ul style="list-style-type: none"> <li>• Problem solving</li> <li>• Critical thinking</li> <li>• Effective Communication</li> </ul> <p>The Science Practice Standards support the VOG Skills:</p> <ul style="list-style-type: none"> <li>• Science Practice 1: Effective Communication</li> <li>• Science Practice 2: Critical Thinking</li> <li>• Science Practice 3: Problem Solving</li> <li>• Science Practice 4: Effective Communication</li> <li>• Science Practice 5: Critical Thinking</li> <li>• Science Practice 6: Effective Communication</li> </ul>
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**Additional Course Information:** **Link to *Completed Equity Audit***  
**Knowledge/Skill Dependent courses/prerequisites**

<p><b>PREREQUISITES</b></p> <ul style="list-style-type: none"> <li>• Precalculus ACC taken concurrently or permission of instructor</li> <li>• Biology ACC - Minimum final grade of 83 or Biology ACA - Minimum final grade of 93</li> <li>• Biology ACC may be taken concurrently for grade 10 students with instructor permission if a final average of 83 was earned in Physical Science ACC.</li> </ul>	<p><a href="#">Equity Curriculum Review Audit - ECE/AP Bio (2025)</a></p>
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**Standard Matrix**

<u>Standard</u>	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Pre-Work
<b>Science Practice 1:</b> Explain biological concepts, processes, and models presented in written format.	✓	✓	✓	✓	✓	✓	✓	
<b>Science Practice 2:</b> Analyze visual representations of biological concepts and processes.	✓	✓				✓	✓	
<b>Science Practice 3:</b> Determine scientific questions and methods.		✓	✓		✓		✓	✓
<b>Science Practice 4:</b> Represent and describe data		✓	✓	✓			✓	✓
<b>Science Practice 5:</b> Perform statistical tests and mathematical calculations to analyze and interpret data.		✓		✓	✓		✓	✓

<b>Science Practice 6:</b> Develop and justify scientific arguments using evidence.	✓	✓	✓	✓	✓	✓	✓	✓
<b>Big Idea 1: Evolution (EVO)</b> The process of evolution drives the diversity and unity of life.		✓			✓		✓	✓
<b>Big Idea 2: Energetics (ENE)</b> Biological systems use energy and molecular building blocks to grow, reproduce, and maintain dynamic homeostasis	✓	✓	✓	✓				✓
<b>Big Idea 3: Information Storage and Transmission (IST)</b> Living systems store, retrieve, transmit, and respond to information essential to life processes.	✓			✓	✓	✓		✓
<b>Big Idea 4: Systems Interactions (SYI)</b> Biological systems interact, and these systems and their interactions exhibit complex properties	✓	✓	✓		✓		✓	✓

Unit Links								
<a href="#">Pre-Course Summer Work: Ecology (Unit 8 in AP Curriculum)</a>								
<a href="#">Unit 0: Experimental Design and Data Analysis</a>								
<a href="#">Unit 1: Chemistry of Life</a>								
<a href="#">Unit 2: Cell Structure and Function</a>								
<a href="#">Unit 3: Cellular Energetics</a>								
<a href="#">Unit 4: Cell Communication and Cell Cycle</a>								
<a href="#">Unit 5: Heredity</a>								
<a href="#">Unit 6: Gene Expression and Regulation</a>								
<a href="#">Unit 7: Natural Selection</a>								

<b>Unit Title:</b>	
Pre-Work: Ecology (Unit 8 in AP Curriculum)	
<b>Relevant Standards: Bold indicates priority</b>	
<b>Course Content:</b> Evolution (EVO) Energetics (ENE) Information Storage and Transmission (IST) Systems Interactions (SYI)	
<b>Science Practices:</b> 3 - Questions and Methods 3.C: Identify experimental procedures that align with the question, including identifying independent and dependent variables and appropriate controls. 4 - Representing and Describing Data 4.A: Construct a graph to represent the data, including: x-y graphs (bar, histogram, line, log scale, dual y), scatterplot, box and whisker plot, and pie chart. 5 - Statistical Tests and Data Analysis 5.A: Perform mathematical calculations, including mathematical equations in the curriculum, means, rates, ratios, percentages and percent changes 5.B: Use confidence intervals and error bars to estimate whether sample means are statistically different. 5.D: Use data to evaluate a hypothesis or prediction, including rejecting or failing to reject the null hypothesis. 6 - Argumentation 6.D: Explain the relationship between experimental results and larger biological concepts, processes, or theories. 6.E: Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
<b>Essential Question(s):</b>	<b>Enduring Understanding(s):</b>
<ul style="list-style-type: none"> <li>How does diversity among and between species in a biological system affect the evolution of species within the system?</li> <li>How does the acquisition of energy relate to the health of a biological system?</li> <li>How do communities and ecosystems change, for better or worse, due to biological disruption?</li> <li>How does a disruption of a biological system affect genetic information storage and transmission?</li> <li>How do species interactions affect the survival of an ecosystem?</li> </ul>	<p>Students learn how a system's interactions are directly related to the system's available energy and its ability to evolve and respond to changes in its environment.</p> <p>When highly complex living systems interact, communities and ecosystems change based on those interactions. The more biodiversity present in a system, the more likely that system is to maintain its health and success in the face of disruption. Energy flows through systems; the rate of flow determines the success of the species within the systems.</p>
<b>Demonstration of Learning:</b>	<b>Pacing for Unit</b>
<p>Students complete the majority of this unit independently before the course begins. Resources, including Google Slides and a comprehensive guided notes packet (with practice and application questions), will be provided via Google Classroom. Once available, AP Daily videos and topic questions will also be assigned via AP Classroom. Learning will be assessed on an open-note assessment using their completed guided notes packet, typically during the second week of school.</p> <p>Students will conduct a laboratory investigation in which they analyze three different "pasta ecosystems" and compare their relative biodiversity using Simpson's Diversity Index.</p>	Independent summer work plus 2-4 class periods at start of school year
<b>Family Overview:</b>	<b>Integration of Technology:</b>
<a href="#">AP Biology: Family Course Overview (English)</a> <a href="#">AP Biology: Family Course Overview (Spanish)</a>	<ul style="list-style-type: none"> <li>Google Slides</li> <li>AP Classroom Personal Progress Check, AP Daily videos and topic questions</li> <li><i>Desmos scientific calculator</i></li> </ul>

Unit-specific Vocabulary:	Aligned Unit Materials, Resources, and Technology (beyond core resources):																																																
<table border="0"> <tr><td>Ecosystem</td><td>Apex predator</td></tr> <tr><td>Community</td><td>Decomposer</td></tr> <tr><td>Population</td><td>Detritivore</td></tr> <tr><td>Biome</td><td>Food chain</td></tr> <tr><td>Habitat</td><td>Food web</td></tr> <tr><td>Niche</td><td>Biomass</td></tr> <tr><td>Abiotic</td><td>Water cycle</td></tr> <tr><td>Biotic</td><td>Hydrologic cycle</td></tr> <tr><td>Endotherm</td><td>Carbon cycle</td></tr> <tr><td>Ectotherm</td><td>Nitrogen cycle</td></tr> <tr><td>Photosynthetic</td><td>Phosphorus cycle</td></tr> <tr><td>Chemosynthetic</td><td>Population density</td></tr> <tr><td>Trophic level</td><td>Carrying capacity</td></tr> <tr><td>Trophic pyramid</td><td>Limiting factor (density dependent and independent)</td></tr> <tr><td>Producer</td><td>Exponential growth</td></tr> <tr><td>Consumer</td><td>Logistic growth</td></tr> <tr><td>Predator</td><td>Competition</td></tr> <tr><td>Prey</td><td>Predation</td></tr> <tr><td>Parasitism</td><td>Mutualisms</td></tr> <tr><td>Symbiosis</td><td>Commensalism</td></tr> <tr><td>Biodiversity</td><td>Eutrophication</td></tr> <tr><td>Species richness</td><td>Biomagnification</td></tr> <tr><td>Simpson's diversity index</td><td></td></tr> <tr><td>Invasive species</td><td></td></tr> </table>	Ecosystem	Apex predator	Community	Decomposer	Population	Detritivore	Biome	Food chain	Habitat	Food web	Niche	Biomass	Abiotic	Water cycle	Biotic	Hydrologic cycle	Endotherm	Carbon cycle	Ectotherm	Nitrogen cycle	Photosynthetic	Phosphorus cycle	Chemosynthetic	Population density	Trophic level	Carrying capacity	Trophic pyramid	Limiting factor (density dependent and independent)	Producer	Exponential growth	Consumer	Logistic growth	Predator	Competition	Prey	Predation	Parasitism	Mutualisms	Symbiosis	Commensalism	Biodiversity	Eutrophication	Species richness	Biomagnification	Simpson's diversity index		Invasive species		<ul style="list-style-type: none"> <li>• Campbell Biology In Focus Chapters 40-43</li> <li>• AP Classroom Unit 8</li> </ul>
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Opportunities for Interdisciplinary Connections:	Anticipated misconceptions:																																																
<ul style="list-style-type: none"> <li>• Math (algebra, statistics)</li> <li>• Health and Wellness</li> <li>• Chemistry</li> <li>• Anatomy and Physiology</li> <li>• Environmental Science/Sustainability studies</li> </ul>	<ul style="list-style-type: none"> <li>• Ecosystems are always changing, they are not stagnant and are not always stable.</li> <li>• Carrying capacity is not a fixed number, but can change as other biotic and abiotic factors in the ecosystem change.</li> <li>• Population growth cannot be infinitely exponential, and is actually both rare and temporary---eventually population size and growth will be limited by a variety of ecological factors.</li> <li>• Predators are not always “bad” for a prey population but rather they help cull unhealthy individuals and keep prey populations stable such that they don’t overuse resources.</li> <li>• Not all keystone species are producers nor apex predators.</li> <li>• Not all interactions between species are predator-prey.</li> <li>• Students often assume that invasive species spread because they are “stronger” or “better” than native species, but typically they gain a foothold in their new environment because of a lack of natural predators and/or competitors.</li> <li>• Students often struggle to see themselves/humans as part of the ecosystem and its nutrient cycles and energy flow.</li> </ul>																																																
Connections to Prior Units:	Connections to Future Units:																																																
N/A	Ecology shows how all preceding biological principles apply to the large-scale interactions of life. Ecological processes like energy flow and nutrient cycling are direct																																																

applications of the Laws of Thermodynamics and cellular processes like photosynthesis and cellular respiration established in Unit 3 (Energetics) and Unit 2 (The Cell). Crucially, ecology defines the selective pressures (biotic and abiotic factors) that are the driving force behind Natural Selection (Unit 7). The resulting adaptations and population dynamics are only possible because of heritable variation (Unit 5) and the mechanisms of Gene Expression (Unit 6), which allow organisms to respond to their environment.

## Differentiation through *Universal Design for Learning* Learning Targets and Teacher Actions

### Learning Target 1:

- Representation: Provide content via multiple modalities: text, video clips showing a plant growing toward light (phototropism), and diagrams/models of nerve reflexes.
- Action/Expression: Offer choices for explanation: oral presentation, written essay, or creating a flowchart/concept map showing the stimulus-response pathway.
- Engagement: Use real-world examples (e.g., a dog panting to cool off, pupils dilating in the dark). Allow students to choose an organism to research its unique detection/response system.

### Learning Target 2:

- Representation: Offer case studies with varied formats: written articles about mating rituals, infographics about foraging strategies, and video examples of cooperative behaviors.
- Action/Expression: Students can create a brief documentary about a specific adaptive behavior or design an infographic that links a behavior to increased survival/reproduction.
- Engagement: Use high-interest scenarios (e.g., fight-or-flight, mimicry, migration). Include a debate on whether a learned or inherited behavior contributes more to fitness.

### Learning Target 3:

- Representation: Use visual models: food chains, food webs, and energy pyramids. Incorporate digital simulations where students can adjust trophic levels and observe the energy transfer impact.
- Action/Expression: Students can physically model energy flow (e.g., using colored blocks or manipulatives), draw and label a food web, or write a narrative tracing a joule of energy through an ecosystem.
- Engagement: Relate to the student's local environment (schoolyard, local park) to build a food web. Use a gamified approach to calculate energy loss at each trophic level.

### Learning Target 4:

- Representation: Provide annotated diagrams of the water, carbon, and nitrogen cycles. Use a narrated animation to show the movement of an atom through the cycle components.
- Action/Expression: Students can create a 3D model of a cycle (e.g., using pipe cleaners and beads), present a multimedia report on human impact on one cycle, or write a children's book from the perspective of a carbon atom.
- Engagement: Connect cycles to global issues (e.g., carbon cycle and climate change, nitrogen cycle and fertilizer runoff). Allow students to choose which cycle they will focus their in-depth study on.

### Learning Target 5:

- Representation: Use graphs/data tables for different growth models (exponential vs. logistic). Provide scaffolding for mathematical models (e.g., templates, step-by-step guides, calculators).
- Action/Expression: Allow students to use a spreadsheet program to model population change, create a presentation analyzing real-world population data (e.g., human population or an endangered species), or write a detailed explanation of limiting factors.
- Engagement: Use simulations/online games to manage a virtual population (e.g., adjusting birth/death rates). Use a case study on a relevant local animal population or invasive species.

### Learning Target 6:

- Representation: Use a comparison chart to differentiate interaction types (competition, predation, symbiosis). Show paired video clips illustrating each interaction (e.g., a predator/prey clip next to a mutualism clip).
- Action/Expression: Students can role-play or use puppets to illustrate an interaction, design a visual matrix linking interactions to effects on energy/matter flow, or write a scientific abstract summarizing a key interaction.
- Engagement: Puzzles or matching activities to pair organisms with their interaction type. Use a jigsaw activity where groups become "experts" on one interaction type and teach the others.

**Learning Target 7:**

- Representation: Use visual metaphors (e.g., a diverse portfolio vs. a single investment) to explain resilience. Provide before-and-after case studies (written and visual) of ecosystems recovering from a disturbance.
- Action/Expression: Students can develop a conservation proposal justifying the protection of a diverse ecosystem, create a short public service announcement (PSA), or design a graphic organizer that illustrates the variables influencing resilience.
- Engagement: Introduce an authentic problem (e.g., coral bleaching, a major wildfire). Students brainstorm and evaluate solutions based on their understanding of biodiversity and resilience.

**Learning Target 8:**

- Representation: Use interactive maps/data visualizations that show the impact of a specific change (e.g., dam construction, invasive species). Provide annotated scientific articles summarizing major ecological disturbances.
- Action/Expression: Offer a structured analysis template (if writing a report), the option to create a "domino effect" diagram illustrating cascading impacts, or to build a computer-based model of a changing ecosystem.
- Engagement: Assign different roles to students (ecologist, politician, local resident) to analyze an ecosystem change from various perspectives. Use a "What If?" scenario activity to explore hypothetical disturbances.

**Supporting Multilingual/English Learners (CELP standards)****Differentiated Learning Targets**

	<b>Emerging</b>	<b>Bridging</b>	<b>Expanding</b>
<b>LT 1</b>	I can describe an organism's basic detection (stimulus) and response using a key term or phrase (e.g., detect, respond), perhaps with a simple model or drawing.	I can explain the process of how an organism detects and responds to a change, using a logical sequence of events and academic vocabulary.	I can analyze and explain in detail how an organism's body systems work together to detect a change and maintain homeostasis, using complex, descriptive language and precise academic terminology.
<b>LT 2</b>	I can name one behavior and identify how it helps an organism survive (e.g., The animal runs. It is safe.).	I can describe a behavior and explain how it increases an organism's survival or reproductive rate (fitness) using connected sentences and content-specific words (e.g., adaptation, survival).	I can analyze a complex behavioral adaptation (e.g., migration, social structure) and construct a detailed argument supported by evidence to explain its impact on an organism's fitness across generations.
<b>LT 3</b>	I can label the main parts of a simple food chain (e.g., producer, consumer) and show the direction of energy flow with an arrow.	I can describe the flow of energy in a food web, identifying the roles of different trophic levels, and use sequencing words to show the energy transfer.	I can create a detailed model of energy flow in an ecosystem and explain the concept of trophic efficiency (e.g., the 10% rule), using precise and sophisticated academic language.
<b>LT 4</b>	I can identify the key components (e.g., water, sun, plant) and a major step (e.g., rain) of a basic cycle using labeled diagrams or single sentences.	I can describe the main sequence of steps in a major biogeochemical cycle (e.g., carbon or water) using connecting words (e.g., after that, as a result) and content-specific terms.	I can explain and illustrate the different states and pathways of matter in a complex biogeochemical cycle (e.g., nitrogen or phosphorus), analyzing the role of living and nonliving factors using coherent and detailed language.
<b>LT 5</b>	I can list 2-3 factors that change a population's size (e.g., births, deaths, food) and identify the direction of the change (bigger or smaller).	I can describe the difference between density-dependent and density-independent factors and use a simple graph or equation to illustrate an example of growth.	I can analyze a population scenario and use a mathematical model to predict future growth, explaining the factors that regulate population size (e.g., carrying capacity) with supporting evidence and precise calculations.
<b>LT 6</b>	I can define one basic population interaction (e.g., predator-prey) and name the organisms involved.	I can describe and categorize different types of population interactions (e.g., mutualism, competition) and explain how one interaction affects the balance of energy access using transition words and academic terms.	I can analyze the complex web of interactions within a community (e.g., keystone species) and explain the resulting community structure and the differential access to energy and matter using detailed, evidence-based reasoning.
<b>LT 7</b>	I can define diversity and identify that more diversity helps when an	I can describe the relationship between biodiversity (e.g., species	I can evaluate the relationship between species diversity and ecosystem

	ecosystem changes.	richness) and an ecosystem's stability or resistance to a common change, using comparison/contrast language (e.g., in contrast, similarly).	resilience, using supporting examples and analyzing how specific environmental changes (e.g., invasive species) impact long-term stability using precise, academic discourse.
<b>LT 8</b>	I can identify one simple change to an ecosystem (e.g., a fire) and name one thing that changes as a result (e.g., plants die).	I can describe how a specific change (e.g., drought, human development) affects one or two components (e.g., structure, biodiversity) of an ecosystem using cause and effect language (e.g., because, leads to).	I can analyze a complex scenario of ecosystem change and construct a detailed explanation of the interdependent effects on ecosystem structure, biodiversity, and stability, using evidence-based claims and sophisticated vocabulary to support the analysis.
<b>Lesson Sequence</b>	<b>Learning Target</b>	<b>Success Criteria/Assessment/Resources</b>	
Pre-Work	<b>Learning Target 1</b> I can explain how organisms detect and respond to changes in their environment.	<ul style="list-style-type: none"> <li>I can differentiate between innate and learned behaviors.</li> <li>I can explain how signals (visual, auditory, tactile, chemical) trigger behavioral responses.</li> <li>I can describe how behavioral adaptations can influence the success and evolution of populations over time.</li> </ul>	
Pre-Work	<b>Learning Target 2</b> I can describe how behaviors increase an organism's fitness.	<ul style="list-style-type: none"> <li>I can provide examples of how behaviors such as cooperation, communication, or courtship improve survival or reproduction.</li> </ul>	
Pre-Work	<b>Learning Target 3</b> I can describe and model how energy flows through an ecosystem from producers to consumers.	<ul style="list-style-type: none"> <li>I can identify the roles of autotrophs (e.g., photosynthesizers or chemosynthesizers) and heterotrophs in energy flow.</li> <li>I can explain the 10% rule and calculate energy transfer between trophic levels.</li> <li>I can construct and interpret food webs, food chains, and trophic pyramids.</li> <li>I can identify how disruptions to one trophic level affect the entire system.</li> <li>I can differentiate between abiotic and biotic factors within an ecosystem.</li> </ul>	
Pre-Work	<b>Learning Target 4</b> I can describe how matter and nutrients cycle between organisms and the environment through biogeochemical cycles.	<ul style="list-style-type: none"> <li>I can identify reservoirs within major biogeochemical cycles (e.g., water, carbon, nitrogen) and describe the basic processes that move resources between reservoirs in these systems (e.g., evaporation, precipitation, nitrogen fixation, decomposition).</li> </ul>	
Pre-Work	<b>Learning Target 5</b> I can describe factors that influence population size and growth over time and use mathematical models to represent/predict population growth.	<ul style="list-style-type: none"> <li>I can interpret growth curves (exponential vs. logistic) and carrying capacity.</li> <li>I can calculate population growth using r and N values.</li> <li>I can explain how limiting factors regulate population size.</li> <li>I can explain how the density of a population affects and is determined by resource availability in the environment.</li> </ul>	
1	<b>Learning Target 6</b> I can explain how interactions among populations influence community structure and affect access to energy and matter within a community.	<ul style="list-style-type: none"> <li>I can identify and define examples of interspecies interactions (competition, predation, mutualism, commensalism, parasitism).</li> <li>I can explain how positive and negative interactions influence population sizes and distribution of species in a community.</li> <li>I can predict how changing one population (e.g.,</li> </ul>	

		predator removal) might impact the community.
2	<p><b>Learning Target 7</b></p> <p>I can describe the relationship between ecosystem diversity and its resilience to changes in the environment.</p>	<ul style="list-style-type: none"> <li>• I can define “biodiversity” in the context of species diversity and ecosystem complexity.</li> <li>• I can explain why ecosystems with greater diversity tend to be more stable and resilient to environmental changes.</li> <li>• I can describe how removing or losing a keystone species or a critical abiotic component can disproportionately affect the ecosystem.</li> </ul>
3	<p><b>Learning Target 8</b></p> <p>I can explain and analyze how changes to ecosystem components affect ecosystem structure, biodiversity, and stability.</p>	<ul style="list-style-type: none"> <li>• I can explain how invasive species affect ecosystem dynamics.</li> <li>• I can describe how human activities (such as biomagnification and eutrophication) can lead to changes in ecosystem structure and dynamics.</li> <li>• I can explain how geological and meteorological activity leads to changes in ecosystem structure and dynamics.</li> </ul>

<b>Unit Title:</b>	
Unit 0: Experimental Design and Data Analysis	
<b>Relevant Standards: Bold indicates priority</b>	
<b>Science Practices:</b>	
3 - Questions and Methods	
3.A: Identify or pose a testable question based on an observation, data, or a model	
3.B: State the null hypothesis or predict the results of an experiment	
3.C: Identify experimental procedures that align with the question, including identifying independent and dependent variables and appropriate controls.	
3.D: Propose a new investigation based on an evaluation of the experimental design or evidence.	
4 - Representing and Describing Data	
4.A: Construct a graph to represent the data, including: x-y graphs (bar, histogram, line, log scale, dual y), scatterplot, box and whisker plot, and pie chart.	
4.B: Describe data from a table or graph, including identifying specific data points, describing trends and patterns in the data, and describing relationships between variables.	
5 - Statistical Tests and Data Analysis	
5.A: Perform mathematical calculations, including mathematical equations in the curriculum, means, rates, ratios, percentages and percent changes	
5.B: Use confidence intervals and error bars to estimate whether sample means are statistically different.	
5.D: Use data to evaluate a hypothesis or prediction, including rejecting or failing to reject the null hypothesis.	
6 - Argumentation	
6.A: Make a scientific claim.	
6.B: Support a claim with evidence from biological principles, concepts, processes, and data.	
<b>Essential Question(s):</b>	<b>Enduring Understanding(s):</b>
<ul style="list-style-type: none"> <li>• How do scientists design experiments that produce reliable, unbiased, and meaningful data?</li> <li>• What is the role of the null and alternative hypotheses in helping scientists evaluate whether an effect or difference truly exists?</li> <li>• How do variables (independent, dependent, and controlled) shape the structure and interpretation of an experiment?</li> <li>• How can graphs, data tables, and statistical tools (such as standard error and error bars) help us understand patterns in biological data?</li> <li>• When does evidence allow us to reject or fail to reject a hypothesis, and how do we know whether differences in data are real or due to chance?</li> <li>• How do scientists use quantitative evidence and biological reasoning to build and defend scientific claims?</li> </ul>	Unit 0 is designed to build the scientific skills students will use throughout AP Biology. Its primary purpose is to teach students how to think and work like scientists. In this unit, students learn to ask testable questions, design valid experiments, represent data clearly, and use statistical tools to evaluate evidence. Since students have some of these skills already, the central focus is helping students identify variables and controls, differentiate between null and alternative hypotheses, and calculate and interpret the standard error of the mean (SEM).
<b>Demonstration of Learning:</b>	<b>Pacing for Unit</b>
<p>Students will complete several sets of practice problems and questions in which they must identify variables and control groups and calculate, graph, and interpret standard error of the mean.</p> <p>Students will conduct a lab investigation in which they determine whether “Double Stuf” Oreos are actually “double the stuff” of regular Oreos. Students must collect reliable data and analyze it, including determining and graphing mean and standard error of the mean, to determine whether their two data sets can be considered statistically meaningful.</p>	3-5 class periods

Students will be assessed on this content throughout the course, but specifically as part of the Unit 1 end-of-unit assessment.	
<b>Family Overview:</b>	<b>Integration of Technology:</b>
<a href="#">AP Biology: Family Course Overview (English)</a> <a href="#">AP Biology: Family Course Overview (Spanish)</a>	<ul style="list-style-type: none"> <li>• Google Slides</li> <li>• <i>Desmos scientific calculator</i></li> </ul>
<b>Unit-specific Vocabulary:</b>	<b>Aligned Unit Materials, Resources, and Technology (beyond core resources):</b>
Null hypothesis Alternative hypothesis Independent variable Dependent variable Constants Control group (positive and negative) Experimental group Data table Mean (average) Standard deviation Standard error of the mean Confidence interval Error bars Significant difference	None
<b>Opportunities for Interdisciplinary Connections:</b>	<b>Anticipated misconceptions:</b>
Math (algebra, statistics)	<ul style="list-style-type: none"> <li>• Students confuse the Null Hypothesis with a general statement of "no change."</li> <li>• Students write the Alternative Hypothesis as a simple, un-justified prediction or guess.</li> <li>• Students mistakenly identify the Dependent Variable as the factor the scientist changes or controls.</li> <li>• Students confuse the Control Group with the Controlled Variables (Constants).</li> <li>• Students believe the Control Group is simply the group where "everything is held constant."</li> <li>• Students struggle to understand the purpose of a Positive Control, believing only a negative control is necessary.</li> <li>• Students believe Standard Deviation measures the difference between two sample means.</li> <li>• Students use the terms Standard Error and Standard Deviation interchangeably.</li> <li>• Students believe that any overlap in error bars (specifically SEM) definitively proves the results are <i>not</i> statistically significant.</li> <li>• Students write a conclusion that only states whether the data "supported" or "did not support" the hypothesis, without citing specific evidence.</li> </ul>
<b>Connections to Prior Units:</b>	<b>Connections to Future Units:</b>
Students may make connections to the basic statistics and probability content covered in their Geometry course.	Unit 0 provides essential scientific skills that students will use throughout AP Biology. The ability to write hypotheses, identify variables and controls, construct graphs, calculate standard error, interpret error bars, and support claims with evidence forms the foundation for every content unit. Students apply these skills when analyzing enzyme activity and membrane transport (Units 1–2), evaluating rates of photosynthesis and respiration (Unit 3), interpreting cell signaling and division data (Unit

4), examining inheritance patterns (Unit 5), analyzing gene expression results (Unit 6), evaluating evolutionary changes (Unit 7), and interpreting ecological models and population data. In every unit, scientific practices introduced in Unit 0 enable students to understand data, evaluate evidence, and justify biological explanations.

**Differentiation through *Universal Design for Learning*  
Learning Targets and Teacher Actions**

**Learning Target 1:**

- Representation: Use a comparison table to clearly contrast the structure, notation, and verbal phrasing of the null hypothesis and the alternative hypothesis. Provide both simple, non-scientific examples (e.g., flipping a coin) and scientific examples (e.g., drug efficacy).
- Action/Expression: Students can be given a research question and asked to write both hypotheses in both symbolic and sentence form. Offer a multiple-choice quiz where students match given sentences to the correct hypothesis type.
- Engagement: Use "myth-busting" scenarios where the null hypothesis represents the established claim or common assumption that the alternative hypothesis attempts to discredit. This adds a compelling real-world challenge.

**Learning Target 2:**

- Representation: Use color-coding to consistently highlight the independent variable (the factor being manipulated), the dependent variable (the factor being measured), and the control group across different experimental descriptions. Use simple visual models to illustrate the relationship.
- Action/Expression: Provide short summaries of experiments and have students create a visual organizer (like a graphic organizer or Frayer Model) to define and list the variables for each study. Students can also design a simple experiment and label its components.
- Engagement: Use case studies related to student interests (e.g., sports performance, plant growth, reaction time) to practice identification. Use interactive drag-and-drop activities to label the parts of an experimental setup.

**Learning Target 3:**

- Representation: Provide the formula for SEM and a scaffolded template for calculation. Use visual representations like graphs with error bars (representing SEM) to show how the standard error relates to the spread of sample means and precision of estimation.
- Action/Expression: Students can use a spreadsheet program (like Excel or Google Sheets) to input data and calculate SEM, rather than manual calculation. They can also be asked to write a one-paragraph interpretation of a calculated SEM value in the context of a given study (e.g., "A small SEM suggests the sample mean is a highly precise estimate of the true population mean.").
- Engagement: Introduce SEM as the measure of confidence in their findings. Use a scenario where different groups collect data on the same topic, calculate their SEMs, and discuss which group's result is more reliable, fostering peer discussion and critical thinking about data quality. That's an essential skill for any science course! Here are the UDL strategies for the learning target focused on data and statistical reasoning.

**Learning Target 4:**

- Representation: Provide multiple examples of data analysis where the conclusion is well-supported versus poorly supported. This should include data presented in different formats: tables, various types of graphs (bar, line, scatter), and written statistical summaries.
- Action/Expression: Offer options for demonstrating understanding: Students can write a formal Conclusion section for a lab report, create a presentation where they walk through a dataset and justify their findings, or use an annotation tool to mark up a peer's conclusion, identifying where data is used effectively or ineffectively.
- Engagement: Use "Evidence vs. Claim" challenge cards where students are given a claim and must find the specific data points or statistical metrics (mean, median, SEM, etc.) that support or refute it. This introduces an element of intellectual play and forces focus on the data-to-conclusion link.

**Supporting Multilingual/English Learners (*CELP standards*)**

**Differentiated Learning Targets**

	<b>Emerging</b>	<b>Bridging</b>	<b>Expanding</b>
<b>LT 1</b>	I can identify the two types of hypotheses (null and alternative) and	I can distinguish between the null (H <sub>0</sub> ) and alternative (H <sub>a</sub> ) hypotheses by	I can formulate precise null and alternative hypotheses (H <sub>0</sub> and H <sub>a</sub> ) for

	state which one predicts no change using key terms (e.g., null, alternative).	writing a simple sentence for each based on a given research question.	a complex scientific investigation and explain the role of each in statistical inference using formal, sophisticated language.
<b>LT 2</b>	I can identify and label the three main parts of an experiment (Independent Variable, Dependent Variable, Control Group) using a diagram or a simple list.	I can describe the function of the independent variable, dependent variable, and control group in an experiment, using connecting words to explain their relationship (e.g., The IV changes, and the DV measures the result).	I can analyze a detailed experimental design and justify the selection of the independent and dependent variables, as well as the importance of the control group, using precise scientific vocabulary and clear rationale.
<b>LT 3</b>	I can define average (mean) and identify that the Standard Error of the Mean (SEM) relates to how accurate the average is.	I can calculate the SEM using a given formula and data set and describe its meaning in a simple sentence (e.g., The SEM tells us how close the sample mean is to the true population mean).	I can calculate and interpret the SEM for a data set, and use it to construct a margin of error or confidence interval, explaining how the SEM relates to sampling variability and statistical significance using mathematical precision and detailed analysis.
<b>LT 4</b>	I can look at a simple bar graph and state which groups are different.	I can describe a simple data pattern (e.g., increase/decrease) and use a piece of evidence (e.g., a mean or a simple p-value) to write a basic conclusion that addresses the research question.	I can evaluate complex data (including measures of variation and significance, like SEM or p-value) and construct an evidence-based conclusion that justifies the support or rejection of the null hypothesis using formal statistical reasoning and cohesive language.

<b>Lesson Sequence</b>	<b>Learning Target</b>	<b>Success Criteria/Assessment/Resources</b>
1	<b>Learning Target 1</b> I can distinguish between null and alternative hypotheses.	<ul style="list-style-type: none"> <li>I can correctly write a null hypothesis (<math>H_0</math>) that states there is no effect, no difference, or no relationship.</li> <li>I can write an alternative hypothesis (<math>H_1</math>) that proposes an expected effect, difference, or relationship.</li> <li>I can decide, based on data, whether to reject or fail to reject the null hypothesis.</li> </ul>
2	<b>Learning Target 2</b> I can identify independent variables, dependent variables, and control groups.	<ul style="list-style-type: none"> <li>I can correctly identify the independent variable (IV) and dependent variable (DV) in an experiment.</li> <li>I can propose reasonable, specific IV and DV for an experiment based on a scientific question or hypothesis.</li> <li>I can distinguish constants from variables and explain why consistency matters in a scientific experiment.</li> <li>I can identify or propose an appropriate control group for an investigation.</li> <li>I can distinguish between and identify positive and negative controls.</li> <li>I can explain how control groups help interpret the results of an experiment.</li> <li>I can evaluate whether an experimental design includes all necessary variables and controls.</li> </ul>
3	<b>Learning Target 3</b> I can calculate and interpret the standard error of the mean (SEM).	<ul style="list-style-type: none"> <li>I can calculate and describe standard deviation for a data set.</li> <li>I can calculate the standard error of the mean for a data set.</li> <li>I can accurately add error bars to a graph.</li> <li>I can interpret error bars to determine whether two</li> </ul>

		sample means are statistically significantly different from each other.
4	<p><b>Learning Target 4</b> I can use data and statistical reasoning to support a scientific conclusion.</p>	<ul style="list-style-type: none"> <li>• I can select accurate evidence from tables, graphs, or experiments.</li> <li>• I can state a clear claim that answers the investigative question.</li> <li>• I can use data patterns such as mean differences, trends, or error-bar interpretation as evidence to support my claim.</li> </ul>

<b>Unit Title:</b>	
Unit 1: Chemistry of Life	
<b>Relevant Standards:</b>	
<b>Course Content:</b> Energetics (ENE) Information Storage and Transmission (IST) Systems Interactions (SYI)	
<b>Science Practices:</b> 1 - Concept Explanation 1.A: Describe biological concepts and processes. 2 - Visual Representations 2.A: Describe characteristics of visual representations of biological concepts and processes. 6 - Argumentation 6.E: Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
<b>Essential Question(s):</b>	<b>Enduring Understanding(s):</b>
<ul style="list-style-type: none"> <li>• What is the role of energy in the making and breaking of polymers?</li> <li>• How do living systems transmit information in order to ensure their survival?</li> <li>• How would living systems function without the polarity of the water molecule?</li> </ul>	<p>This first unit sets the foundation for students to understand the chemical basis of life, which is needed for mastery of future areas of focus and provides students with a survey of the elements necessary for carbon-based systems to function. Students learn that water and the properties of water play a vital role in the survival of individuals and biological systems. They also learn that living systems exist in a highly complex organization that requires input of energy and the exchange of macromolecules. This unit also addresses in detail how and in what conformations molecules called monomers bond together to form polymers. The structure of monomers and polymers determines their function. In the units that follow, students will need to understand and explain the interaction and bonding of atoms to form molecules.</p>
<b>Demonstration of Learning:</b>	<b>Pacing for Unit</b>
<p>Students will construct and present a brief (2-3 minutes) lesson detailing a specific example of how water's unique properties contribute to the success of life on Earth.</p> <p>Students will plan and conduct an experiment investigating how adding solute may impact the surface tension of water.</p> <p>Students will complete the Personal Progress Check MCQs and FRQs for unit 1 on AP Classroom.</p> <p>Students will take a unit assessment at the end of the unit that includes AP-style multiple choice on AP Classroom as well as written responses.</p>	<p>6 class periods 2-3 lab days</p>
<b>Family Overview:</b>	<b>Integration of Technology:</b>
<p><a href="#">AP Biology: Family Course Overview (English)</a> <a href="#">AP Biology: Family Course Overview (Spanish)</a></p>	<ul style="list-style-type: none"> <li>• Google Slides</li> <li>• AP Classroom Personal Progress Check</li> </ul>
<b>Unit-specific Vocabulary:</b>	<b>Aligned Unit Materials, Resources, and Technology (beyond core resources):</b>
<p>Atom                      Cohesion Element                  Adhesion Compound                Capillary Action</p>	<p>Campbell Biology In Focus Chapter 2 and 3 AP Classroom Unit 1</p>

Molecule	pH	
Ion	Acid	
Covalent Bond	Base	
Ionic Bond	Buffer	
Hydrogen Bond	Macromolecule	
Polar	Monomer	
Nonpolar	Polymer	
Solvent	Carbohydrate	
Solute	Monosaccharide	
Solution	Disaccharide	
Hydrophilic	Polysaccharide	
Hydrophobic	Lipid	
Surface Tension	Fatty Acid	
Polypeptide	Triglyceride	
Enzyme	Phospholipid	
Denaturation	Steroid	
Nucleic Acid	Protein	
Nucleotide	Amino Acid	
DNA (Deoxyribonucleic Acid)	Peptide Bond	
RNA (Ribonucleic Acid)	Triphosphate	
Double Helix	Isomer	
Reactant	Functional Group	
Product	Saturated Fat	
ATP (Adenosine triphosphate)	Unsaturated Fat	
<b>Opportunities for Interdisciplinary Connections:</b>		<b>Anticipated misconceptions:</b>
<ul style="list-style-type: none"> <li>• Math (algebra, geometry, statistics)</li> <li>• Health and Wellness</li> <li>• Chemistry</li> <li>• Anatomy and Physiology</li> </ul>		<ul style="list-style-type: none"> <li>• Students confuse ionic bonds with covalent bonds and/or hydrogen bonds.</li> <li>• They confuse adhesion and cohesion, often believing that cohesion is water sticking to other substances, or that adhesion is only important in capillary action, ignoring its role in surface tension.</li> <li>• They think that a high specific heat means water heats up quickly, instead of understanding that it means water resists changes in temperature.</li> <li>• Students confuse dehydration synthesis (condensation) with hydrolysis, often mixing up which one forms polymers and which one breaks them down.</li> <li>• They believe lipids are made from the same monomer-to-polymer structure as other macromolecules; they don't grasp that lipids (like triglycerides) are assembled from smaller components (glycerol and fatty acids) but aren't true polymers.</li> </ul>
<b>Connections to Prior Units:</b>		<b>Connections to Future Units:</b>
This unit builds upon the subject matter covered in accelerated biology.		Properties of water as well as the structures and functions of biological macromolecules will be fundamental to all future units as they are the chemical building blocks of all life on Earth.
<b>Differentiation through <i>Universal Design for Learning</i></b>		
<b>Learning Targets and Teacher Actions</b>		
<b>Learning Targets 1 and 2:</b>		
<ul style="list-style-type: none"> <li>• Representation: Provide visual aids (diagrams or videos) showing water molecules and their interactions. Use analogies or metaphors (e.g., comparing water molecules to magnets) to explain polarity.</li> </ul>		

- Action/Expression: Act out “tug of war” with electrons between oxygen and hydrogen in a water molecule to demonstrate polarity. Students demonstrate understanding by creating a brief presentation of their own design to teach a property of water to their classmates.
- Engagement: Encourage group discussions and peer teaching to explore the properties of water. Incorporate hands-on activities, such as experiments demonstrating water’s properties (e.g., surface tension of water on a penny).

**Learning Target 3:**

- Representation: Provide models of macromolecules (carbohydrates, proteins, lipids, nucleic acids). Use videos or animations to show how macromolecules are formed and function.
- Action/Expression: Allow students to create a chart or poster summarizing the types of macromolecules and their functions. Encourage students to build a physical model of a macromolecule using craft materials.
- Engagement: Organize a scavenger hunt where students find examples of macromolecules in everyday items. Use gamification techniques to quiz students on the composition of macromolecules.

**Learning Target 4:**

- Representation: Provide labeled diagrams showing monomers and polymers with bond types highlighted. Use simulations to visualize the formation of bonds between monomers.
- Action/Expression: Allow students to create flashcards with monomers and their corresponding biological molecules. Encourage students to demonstrate understanding through a creative project, such as a comic strip.
- Engagement: Facilitate collaborative group work where students teach each other about different monomers and bonds. Utilize interactive quizzes or online platforms for students to engage with the content.

**Supporting Multilingual/English Learners (CELP standards)**

**Differentiated Learning Targets**

	<b>Emerging</b>	<b>Bridging</b>	<b>Expanding</b>
<b>LT 1</b>	I can label a water molecule as polar and name 2-3 of its basic properties (e.g., cohesion, good solvent).	I can describe how the partial charges on a water molecule lead to hydrogen bonding and explain two specific properties (e.g., cohesion and adhesion) using cause-and-effect language.	I can analyze and explain how the polarity of water and the resulting hydrogen bonds are responsible for at least three properties (e.g., high specific heat, surface tension, versatility as a solvent), using precise chemistry terminology.
<b>LT 2</b>	I can match one property of water (e.g., adhesion) to a simple function in a living thing (e.g., plants get water).	I can describe two specific ways water’s properties (e.g., high specific heat and low density of ice) support life on Earth, using connected sentences and academic terms (e.g., temperature regulation, insulation).	I can construct a detailed argument that explains and justifies at least three properties of water that are essential for maintaining biological processes (e.g., capillary action in plants, solvent capability in cells), using coherent, evidence-based reasoning.
<b>LT 3</b>	I can name the four types of macromolecules (e.g., carbohydrates, lipids, proteins, nucleic acids) and list one main element in each (e.g., carbon).	I can describe the basic elemental composition and general function for each of the four macromolecules (e.g., Carbohydrates have C, H, O and are for energy), using academic vocabulary.	I can compare and contrast the elemental composition and diverse functions of the four major macromolecules, analyzing how their chemical make-up dictates their roles in a cell, using detailed and precise scientific language.
<b>LT 4</b>	I can match each macromolecule with its correct monomer (e.g., protein: amino acid) and identify that a covalent bond connects them.	I can describe the relationship between monomers and polymers for at least three macromolecules and explain that a dehydration synthesis reaction creates the covalent bond that links them.	I can analyze and explain the process of polymerization (dehydration synthesis/hydrolysis) for at least three macromolecules, naming the specific covalent bonds (e.g., peptide bond, glycosidic bond) that link their monomers, using high-level scientific discourse.

<b>Lesson Sequence</b>	<b>Learning Target</b>	<b>Success Criteria/Assessments Resources</b>
1-2	<b>Learning Target 1</b>	<ul style="list-style-type: none"> <li>• I can define and connect key properties to molecular interactions: T</li> <li>• I can explain how water's polarity causes hydrogen</li> </ul>

	I can identify the properties of water that result from its polarity and hydrogen bonding.	<p>bonding.</p> <ul style="list-style-type: none"> <li>I can describe examples in nature and link them directly back to the unique properties of water driven by hydrogen bonding.</li> <li>I can compare and contrast water with a non-polar liquid by predicting differences in properties such as boiling point, solubility, or surface tension, and justifying these differences based on the presence or absence of hydrogen bonding.</li> </ul>
	<p><b>Learning Target 2</b></p> <p>I can explain specific ways in which the properties of water are critical to life on Earth.</p>	<ul style="list-style-type: none"> <li>I can link properties of water to biological processes or environmental functions..</li> <li>I can justify why specific functions of water are critical to the survival of an organism or ecosystem.</li> </ul>
3 - 6	<p><b>Learning Target 3</b></p> <p>I can describe the composition of macromolecules required by living organisms.</p>	<ul style="list-style-type: none"> <li>I can identify the biological macromolecules fundamental to all living things (carbohydrates, proteins, lipids, and nucleic acids).</li> <li>I can describe the role that carbon plays in biological molecules.</li> <li>I can identify the biological molecule types that use nitrogen and phosphorus in their structures.</li> </ul>
	<p><b>Learning Target 4</b></p> <p>I can name and describe the monomers in biological molecules as well as the types of bonds that connect them.</p>	<ul style="list-style-type: none"> <li>I can define the term hydrolysis and describe how it is used to cleave covalent bonds between monomers.</li> <li>I can define the term dehydration synthesis and describe how it is used to form covalent bonds between monomers.</li> <li>I can recognize, name and describe the monomers of nucleic acids.</li> <li>I can recognize, name and describe the monomers of proteins.</li> <li>I can recognize, name and describe the monomers of carbohydrates.</li> <li>I can describe the basic properties of lipids and explain how differences in saturation determine their structure and function.</li> <li>I can describe the structure of a phospholipid and explain how these molecules interact with one another to form membranes.</li> </ul>

<b>Unit Title:</b>	
Unit 2: Cell Structure and Function	
<b>Relevant Standards:</b>	
<b>Course Content:</b> Energetics (ENE) Evolution (EVO) Systems Interactions (SYI)	
<b>Science Practices:</b>	
1 - Concept Explanation 1.A: Describe biological concepts and processes. 1.B: Explain biological concepts and processes.	
2 - Visual Representations 2.A: Describe characteristics of visual representations of biological concepts and processes. 2.D: Represent relationships within biological models, including mathematical models, diagrams, flowcharts, and systems.	
3 - Questions and Methods 3.D: Propose a new investigation based on an evaluation of the experimental design or evidence.	
4 - Representing and Describing Data 4.A: Construct a graph to represent the data, including: x-y graphs (bar, histogram, line, log scale, dual y), scatterplot, box and whisker plot, and pie chart.	
5 - Statistical Tests and Data Analysis 5.A: Perform mathematical calculations, including mathematical equations in the curriculum, means, rates, ratios, percentages and percent changes 5.D: Use data to evaluate a hypothesis or prediction, including rejecting or failing to reject the null hypothesis.	
6 - Argumentation 6.A: Make a scientific claim. 6.B: Support a claim with evidence from biological principles, concepts, processes, and data. 6.E: Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
<b>Essential Question(s):</b>	<b>Enduring Understanding(s):</b>
<ul style="list-style-type: none"> <li>• How did eukaryotic cells originate?</li> <li>• How do the mechanisms for transport across membranes support energy conservation?</li> <li>• What are the advantages and disadvantages of cellular compartmentalization?</li> <li>• How are living systems affected by the presence or absence of subcellular components?</li> </ul>	The cell is the basic unit of life. Cells contribute to the organization of life and provide the environment in which organelles function. Organelles in turn provide compartmentalization and organize cellular products for dispersal and waste for disposal. Cells have membranes that allow them to establish and maintain an internal environment. These membranes also control the exchange of material with the cell's external environment.
<b>Demonstration of Learning:</b>	<b>Pacing for Unit</b>
<p>Students will create a "dating profile" or a chosen/assigned cell part and teach their classmates about its structure and function during a "speed dating" activity.</p> <p>Students will conduct and analyze an experiment investigating how cell size (and therefore surface area-to-volume ratio) impacts the efficiency of its access to materials in its environment.</p> <p>Students will conduct an experiment investigating the tonicity of potato cells and use the results to calculate the sucrose concentration of the potato cells.</p> <p>Students will complete the Personal Progress Check MCQs and FRQs for unit 2 on AP Classroom.</p> <p>Students will take a unit assessment at the end of the unit</p>	<p>7-10 class periods</p> <p>2-3 lab days</p>

that includes AP-style multiple choice on AP Classroom as well as written responses (FRQs).		
<b>Family Overview:</b>		<b>Integration of Technology:</b>
<a href="#">AP Biology: Family Course Overview (English)</a> <a href="#">AP Biology: Family Course Overview (Spanish)</a>		<i>AP Classroom</i> <i>Desmos scientific calculator</i> <i>Google Sheets</i> <i>Google Slides</i> <i>AP Classroom topic quizzes and Progress Check</i>
<b>Unit-specific Vocabulary:</b>		<b>Aligned Unit Materials, Resources, and Technology (beyond core resources):</b>
Cell Theory Prokaryotic Cell Eukaryotic Cell Plasma Membrane Cytoplasm Nucleus Nucleolus Nuclear Envelope Chromatin Ribosome Smooth Endoplasmic Reticulum (Smooth ER) Rough Endoplasmic Reticulum (Rough ER) Golgi Apparatus (Golgi Body) Lysosome Vacuole Peroxisome Mitochondrion Chloroplast Cytoskeleton Microtubules Microfilaments Intermediate Filaments	Centrioles Cilia Flagella Cell Wall Plasmodesmata Phospholipid Bilayer Fluid Mosaic Model Selective Permeability Transport Protein Diffusion Facilitated Diffusion Osmosis Isotonic Solution Hypertonic Solution Hypotonic Solution Active Transport Passive Transport Concentration Gradient Sodium-Potassium Pump Cotransport Endocytosis Exocytosis Phagocytosis Pinocytosis Receptor-Mediated Endocytosis	<ul style="list-style-type: none"> <li>• Campbell Biology In Focus Chapters 4 and 5</li> <li>• AP Classroom Unit 2</li> </ul>
<b>Opportunities for Interdisciplinary Connections:</b>		<b>Anticipated misconceptions:</b>
<ul style="list-style-type: none"> <li>• Math (algebra, geometry, statistics)</li> <li>• Health and Wellness</li> <li>• Chemistry</li> <li>• Anatomy and Physiology</li> </ul>		<ul style="list-style-type: none"> <li>• Students confuse the importance of cell size/volume with the importance of a high surface area-to-volume ratio. They often don't grasp that the ratio determines the efficiency of substance exchange, which limits cell size---it is not the cell size itself that is the key concept.</li> <li>• The typical process/flow of the endomembrane system can be difficult. Students find it hard to grasp the sequence of molecule production in the ER, vesicle transport to the Golgi for modification/sorting/packaging, and then subsequent transport to a variety of cellular regions depending on function.</li> <li>• Students often begin with the misconception that the cell membrane is a rigid, static barrier, not understanding that it is a fluid mosaic where proteins and lipids constantly shift position (lateral movement).</li> <li>• They confuse facilitated diffusion with active transport. Students struggle to remember that</li> </ul>

	<p>facilitated diffusion is still passive (no ATP is required) and moves substances down the concentration gradient, using a transport protein.</p> <ul style="list-style-type: none"> <li>• They assume all movement across a concentration gradient requires a pump, overlooking the role of co-transport which uses the energy of an existing gradient.</li> <li>• Hypotonic vs. hypertonic are confusing vocabulary terms. Students struggle to differentiate between the relative concentrations of water vs. relative concentrations of a solute in order to accurately compare tonicity and predict movement of water.</li> </ul>
<p><b>Connections to Prior Units:</b></p>	<p><b>Connections to Future Units:</b></p>
<p>Students will need to apply their knowledge of biological macromolecules from Unit 1 to understand the structural components of cell membranes and the various functions of those components.</p>	<p>The structure of membranes and organelles dictates where and how energy is harvested (Unit 3: Cellular Energetics), how the functions of membrane proteins are essential for receiving and relaying information (Unit 4: Cell Communication), and how the nucleus and ribosomes serve as the machinery for genetics and protein synthesis (Units 5 &amp; 6). Therefore, Unit 2 establishes the crucial context for compartmentalization, transport, and communication that defines life's processes.</p>
<p><b>Differentiation through <i>Universal Design for Learning</i></b>  <b>Learning Target and Teacher Actions</b></p>	
<p><b>Learning Target 1:</b></p> <ul style="list-style-type: none"> <li>• Representation: Provide detailed, color-coded diagrams of both prokaryotic and eukaryotic cells, along with a comparison chart summarizing the function of each key organelle (e.g., mitochondria, nucleus, endoplasmic reticulum). Use 3D models or virtual tours of a cell to visualize compartmentalization.</li> <li>• Action/Expression: Students can create a metaphor or analogy for a cell (e.g., the cell as a factory) and assign an organelle's function to a factory component. They can also build a presentation or write a report specifically explaining how the endosymbiotic theory relates to the origin of some organelles and compartmentalization.</li> <li>• Engagement: Introduce a "Cell City" design challenge where students must design and label a city based on organelle functions, reinforcing their roles and interactions.</li> </ul> <p><b>Learning Target 2:</b></p> <ul style="list-style-type: none"> <li>• Representation: Provide visual examples and mathematical calculations showing how the surface area-to-volume ratio changes as cell size increases. Use a graph to plot cell size to clearly show the diminishing ratio.</li> <li>• Action/Expression: Students can conduct a lab or simulation (e.g., using agar blocks) to calculate and visually compare the rate of diffusion in objects with different ratios. They could also write a persuasive argument explaining why cells must remain small or why large organisms require specialized exchange surfaces (like lungs or gills).</li> <li>• Engagement: Use real-world examples of optimization, such as the folding of the small intestine or the flatness of leaves, allowing students to choose an organism to analyze its structure based on this ratio.</li> </ul> <p><b>Learning Target 3:</b></p> <ul style="list-style-type: none"> <li>• Representation: Use a clear, labeled diagram of the plasma membrane that highlights and defines the roles of the key components: phospholipids, proteins (integral and peripheral), cholesterol, and glycocalyx (glycoproteins/glycolipids).</li> <li>• Action/Expression: Students can build a physical model of the cell membrane using different colored materials to represent the components. Alternatively, they can create a chart or table summarizing the specific function of each component (e.g., protein channels transport, cholesterol stability).</li> <li>• Engagement: Use a "Membrane Barrier" activity where students are given scenarios and must determine which membrane component is responsible for the interaction (e.g., receiving a signal, transport, or cell identification).</li> </ul> <p><b>Learning Target 4:</b></p> <ul style="list-style-type: none"> <li>• Representation: Use dynamic animations or video clips that illustrate the "fluid" nature of the membrane (lateral movement of phospholipids) and the "mosaic" nature (embedded, scattered proteins). Provide a</li> </ul>	

written definition alongside a visual metaphor.

- Action/Expression: Students can create an annotated drawing of the fluid mosaic model, labeling and explaining the two key terms ("fluid" and "mosaic"). They could also write a descriptive poem or narrative from the perspective of a protein moving within the lipid bilayer.
- Engagement: Introduce a compare/contrast task challenging students to explain how the modern Fluid Mosaic Model is different from earlier, more static models of the cell membrane.

**Learning Target 5:**

- Representation: Use a step-by-step flowchart illustrating the permeability path:
- Action/Expression: Students can be given a list of molecules and asked to predict and justify their ease of movement across the membrane. They could also create a "bouncer" analogy where the membrane structure acts as a bouncer, admitting only certain molecules.
- Engagement: Introduce a critical thinking task asking students to design a synthetic membrane and choose specific components to make it selectively permeable to a certain drug molecule.

**Learning Target 6:**

- Representation: Provide side-by-side diagrams and photos of plant cells, fungi cells, and bacterial cells, highlighting the cell wall structure and composition in each. Use written case studies on the structural differences between plant cells (cellulose) and bacterial cells (peptidoglycan).
- Action/Expression: Students can compare and contrast the primary role of the cell wall (structural support, protection, maintaining turgor) with the primary role of the plasma membrane. They could also create a model demonstrating how the cell wall prevents excessive water uptake (turgidity).
- Engagement: Discuss the medical relevance of the cell wall by exploring how antibiotics target the bacterial cell wall, which can lead to a discussion on antibiotic resistance.

**Learning Target 7:**

- Representation: Use visual examples of cells in different tonicity environments (isotonic, hypotonic, hypertonic), clearly showing the direction of water movement via osmosis. Provide a concept chart summarizing osmoregulatory mechanisms in different organisms (e.g., fish in fresh vs. salt water, plants in drought).
- Action/Expression: Students can draw and label the results of placing animal and plant cells in different solutions (e.g., hemolysis, plasmolysis, turgidity). They could also write an expository essay detailing the specific adaptations an organism uses to maintain water balance in a challenging environment.
- Engagement: Use a clinical case study about dehydration or kidney function to relate the concepts of solute and water balance to human homeostasis.

**Learning Target 8:**

- Representation: Use animated diagrams or videos to illustrate the processes of endocytosis (phagocytosis, pinocytosis, receptor-mediated endocytosis) and exocytosis. Provide a narrated explanation of the bulk transport mechanisms.
- Action/Expression: Students can create a sequence of panels (like a comic strip) to visually explain the steps of phagocytosis or exocytosis. They could also create a short skit or demonstration to act out the membrane changes required for bulk transport.
- Engagement: Discuss the roles of endocytosis and exocytosis in essential processes like neurotransmitter release at synapses or immune system activity (macrophages engulfing bacteria), highlighting biological significance.

**Learning Target 9:**

- Representation: Use simple, clear diagrams with color gradients to illustrate a concentration gradient. Use an analogy like a ball rolling down a hill (passive transport) versus a ball being pushed up a hill (active transport) to explain movement with and against the gradient.
- Action/Expression: Students can write a set of rules for molecular movement, stating whether a molecule will move up or down the gradient and whether energy is required. They could also design a simple experiment to show the effect of changing the steepness of a gradient on the rate of diffusion.
- Engagement: Use a sorting activity where students classify transport mechanisms (simple diffusion, facilitated diffusion, active transport) based on whether they require a gradient or energy (ATP).

**Supporting Multilingual/English Learners (GELP standards)**

**Differentiated Learning Targets**

	<b>Emerging</b>	<b>Bridging</b>	<b>Expanding</b>
<b>LT 1</b>	I can identify and name 3-4 major organelles (e.g., nucleus, mitochondria,	I can describe the basic structure and function of several organelles and explain that internal membranes	I can analyze and explain in detail how the unique structure of key organelles contributes to the overall function of

	chloroplast) and state their simple function.	create separate spaces (compartments) in a eukaryotic cell using connected sentences.	the cell, justifying how compartmentalization by internal membranes increases efficiency for complex processes using sophisticated and precise scientific language.
<b>LT 2</b>	I can identify that a smaller cell has a better ratio (more surface area for its inside volume).	I can describe the concept of the surface area-to-volume ratio (SA/V) and explain using a simple comparison how a high SA/V ratio facilitates more efficient exchange of materials (e.g., nutrients and waste).	I can calculate and analyze the SA/V ratio of different cell shapes/sizes, and construct a detailed argument to explain how organisms and cells (e.g., intestinal lining, plant roots) have structural modifications that increase the ratio for optimal exchange.
<b>LT 3</b>	I can label the main parts of the membrane (e.g., phospholipid, protein) and state that it controls what goes in and out.	I can describe the roles of the phospholipid bilayer and membrane proteins in maintaining homeostasis and regulating transport across the cell's internal environment, using academic vocabulary.	I can analyze the interplay between phospholipids, various proteins (e.g., integral, peripheral), and cholesterol, and explain how their specific molecular roles dynamically maintain the cell's internal environment and selective permeability.
<b>LT 4</b>	I can define fluid and mosaic in the context of the cell membrane model.	I can describe the fluid mosaic model by explaining that the proteins float within the fluid phospholipid bilayer, and use this to explain the dynamic nature of the membrane.	I can explain and justify why the fluid mosaic analogy is accurate, detailing how the lateral movement of phospholipids (fluid) and the random distribution of proteins (mosaic) contribute to the membrane's structure and function.
<b>LT 5</b>	I can identify that the membrane only lets some things in (selective) and name a molecule that can pass easily (e.g., water, oxygen).	I can explain how the nonpolar core of the phospholipid bilayer makes the membrane selectively permeable, and describe how the size and charge of a molecule affect its ability to cross.	I can analyze and explain how the interaction between the hydrophobic tails and hydrophilic heads of the bilayer, coupled with the presence of transport proteins, determines the passage of a diverse range of molecules, using precise chemistry and physics terms.
<b>LT 6</b>	I can name the type of cell that has a cell wall (e.g., plant, bacteria) and state that its function is for support/protection.	I can describe the structural composition of the cell wall in plants (or other cells) and explain how it maintains cell shape and prevents excessive water uptake (lysis).	I can compare and contrast the composition and specific roles of the cell wall in different domains (e.g., plants vs. fungi vs. bacteria), and analyze its importance in turgor pressure and overall organism function.
<b>LT 7</b>	I can define solute and water balance (osmosis) and identify that water moves from high to low concentration.	I can describe the process of osmosis and explain two mechanisms (e.g., contractile vacuole, turgor pressure) that organisms or cells use to achieve osmoregulation in different environments (e.g., fresh vs. salt water).	I can analyze and explain the mechanisms of osmoregulation and tonicity (hypo-, iso-, hypertonic) in both plant and animal cells, justifying the structural adaptations that allow different organisms to maintain solute and water homeostasis.
<b>LT 8</b>	I can name the two types of bulk transport (endocytosis and exocytosis) and state that they move big things.	Can describe the sequential steps of endocytosis and exocytosis using transition words (e.g., first, then, the vesicle moves).	Can explain and justify why bulk transport is the only viable mechanism for large molecules (like proteins or polysaccharides) that are too big for protein channels or carriers.
<b>LT 9</b>	I can identify and name 3-4 major organelles (e.g., nucleus, mitochondria, chloroplast) and state their simple function.	I can describe the basic structure and function of several organelles and explain that internal membranes create separate spaces (compartments) in a eukaryotic cell using connected sentences.	I can analyze and explain in detail how the unique structure of key organelles contributes to the overall function of the cell, justifying how compartmentalization by internal membranes increases efficiency for complex processes using sophisticated and precise scientific language.

Lesson Sequence	Learning Target	Success Criteria/Assessment/Resources
1	<p><b>Learning Target 1</b> I can explain how the structure and function of subcellular components and organelles contribute to the function of cells, and can describe how internal membranes/membrane-bound organelles contribute to compartmentalization of eukaryotic cell functions.</p>	<ul style="list-style-type: none"> <li>I can describe the structure and function of ribosomes.</li> <li>I can describe the structure and function of the endomembrane system that work together to modify, package, and transport macromolecules.</li> <li>I can identify the functions of the smooth and rough regions of the endoplasmic reticulum.</li> <li>I can identify the functions of organelles including the Golgi complex, mitochondria, lysosomes, vacuoles, and chloroplasts.</li> <li>I can describe how membranes and membrane-bound organelles within eukaryotic cells compartmentalize and facilitate intracellular metabolic processes.</li> </ul>
2	<p><b>Learning Target 2</b> I can explain the effect of surface area-to-volume ratios on the exchange of materials between cells or organisms and the environment.</p>	<ul style="list-style-type: none"> <li>I can describe how surface area-to-volume ratios affect the ability of a biological system to obtain necessary nutrients, eliminate waste products, and exchange chemicals and energy with the environment, thereby restricting cell size and shape.</li> </ul>
3	<p><b>Learning Target 3</b> I can describe the roles of each of the components of the cell membrane in maintaining the internal environment of the cell.</p>	<ul style="list-style-type: none"> <li>I can describe how the properties of phospholipids cause them to organize into bilayer membranes with polar external and nonpolar internal regions.</li> </ul>
4	<p><b>Learning Target 4</b> I can describe the fluid mosaic model of cell membranes.</p>	<ul style="list-style-type: none"> <li>I can explain how the structural components of membranes, including phospholipids, cholesterol, and proteins relate to describing membranes as “fluid mosaics”.</li> </ul>
5	<p><b>Learning Target 5</b> I can explain how the structure of biological membranes influences selective permeability and how the structure of a molecule affects its ability to pass through membranes.</p>	<ul style="list-style-type: none"> <li>I can explain how membranes separate the internal environment of the cell from the external environment.</li> <li>I can differentiate between molecules that can freely pass across the membrane, can pass in small amounts, or require facilitated transport based on their properties.</li> <li>I can describe the function of aquaporins.</li> </ul>
6	<p><b>Learning Target 6</b> I can describe the role of the cell wall in maintaining cell structure and function.</p>	<ul style="list-style-type: none"> <li>I can describe how the cell walls of bacteria, archaea, fungi and plants provide structural boundaries as well as permeability barriers.</li> <li>I can describe how cell walls provide protection from osmotic lysis.</li> </ul>
7	<p><b>Learning Target 7</b> I can describe the mechanisms that organisms use to maintain solute and water balance.</p>	<ul style="list-style-type: none"> <li>I can define the term concentration gradient and predict the direction of diffusion of molecules toward equilibrium.</li> <li>I can differentiate between passive and active transport of molecules across a membrane.</li> </ul>
8	<p><b>Learning Target 8</b> I can describe the mechanisms that organisms use to transport large molecules across the plasma membrane.</p>	<ul style="list-style-type: none"> <li>I can describe and differentiate between the processes of endocytosis and exocytosis.</li> </ul>
9	<p><b>Learning Target 9</b> I can explain how concentration gradients affect the movement of molecules across membranes.</p>	<ul style="list-style-type: none"> <li>I can compare hypotonic, hypertonic and isotonic environments.</li> <li>I can calculate water potential and use it to predict the movement of water by osmosis</li> <li>I can explain how osmoregulation contributes to the health and survival of organisms.</li> </ul>

**Unit Title:**

Unit 3: Cellular Energetics

**Relevant Standards:****Course Content:**

Energetics (ENE)

Systems Interactions (SYI)

**Science Practices:**

1 - Concept Explanation

1.B: Explain biological concepts and processes.

3 - Questions and Methods

3.C: Identify experimental procedures that align with the question, including identifying independent and dependent variables and appropriate controls.

4 - Representing and Describing Data

4.A: Construct a graph to represent the data, including: x-y graphs (bar, histogram, line, log scale, dual y), scatterplot, box and whisker plot, and pie chart.

6 - Argumentation

6.B: Support a claim with evidence from biological principles, concepts, processes, and data.

6.C: Provide reasoning to justify a claim by connecting evidence to biological theories.

6.E: Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.

**Essential Question(s):**

- How is energy captured and then used by a living system?
- How do organisms use energy or conserve energy to respond to environmental stimuli?

**Enduring Understanding(s):**

Living systems are complex in their organization and require constant energy input. This unit provides students with the knowledge necessary to master the concepts of energy capture and usage. Students work through enzyme structure and function, learning the ways in which the environment plays a role in how enzymes perform their function(s). Students gain a deeper understanding of the processes of photosynthesis and cellular respiration and how they are critical to transforming energy into usable forms for cellular process, which is knowledge they will use in Unit 6 while studying how cells use energy to fuel life processes.

**Demonstration of Learning:**

Students will participate in a demonstration of energy transfer and transformation within part 1 of photosynthesis by acting out the various proteins and protein complexes involved in the light-dependent reactions.

Students will conduct and analyze an experiment investigating how enzymes are impacted by a wide variety of environmental factors, including temperature, inhibitors, substrate concentration and enzyme concentration.

Students will conduct and analyze an experiment investigating the rate of cellular respiration in peas that have been subjected to different environmental temperatures.

Students will design and conduct an inquiry-based investigation into the relative rates of photosynthesis and cellular respiration in algae by manipulating one variable of their choosing (ex. temperature, pH, light intensity, light color).

**Pacing for Unit**

6-10 class periods  
2-3 lab days

<p>Students will complete the Personal Progress Check MCQs and FRQs for unit 3 on AP Classroom.</p> <p>Depending on timing, students may take a unit assessment at the end of the unit that includes AP-style multiple choice on AP Classroom as well as written responses (FRQs). If they do not take a stand-alone unit 3 assessment, they will instead be assessed on unit 3 content in a similar format as part of their midterm exam.</p>																																					
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<ul style="list-style-type: none"> <li>• Math (algebra, statistics)</li> <li>• Health and Wellness</li> <li>• Chemistry</li> <li>• Anatomy and Physiology</li> </ul>	<ul style="list-style-type: none"> <li>• Students often think enzymes provide energy to start a reaction instead of understanding that enzymes work by lowering the energy of activation</li> <li>• Students confuse or struggle to differentiate between allosteric binding sites and active sites of enzymes</li> <li>• Students often assume that oxygen gas is the goal/primary product of photosynthesis rather than a product of the processes needed to synthesize glucose.</li> <li>• Electron carriers (NADPH, NADH, FADH<sub>2</sub>) are not overall reactants/products of photosynthesis and cellular respiration, but rather temporarily store and transfer energy throughout these processes in the form of high-energy electrons.</li> <li>• Cellular respiration is not the same as breathing---it is a metabolic pathway in all organisms.</li> <li>• Students confuse protons and proteins often in the</li> </ul>																																				

	<p>unit as they sound similar and are both used frequently.</p> <ul style="list-style-type: none"> <li>Students sometimes struggle to understand that a proton gradient powers the process of synthesizing ATP from ADP but the ions themselves are not actually added to ADP.</li> </ul>
<p><b>Connections to Prior Units:</b></p>	<p><b>Connections to Future Units:</b></p>
<p>Unit 3 is the culmination of chemical and structural foundations from Units 1 and 2. The entire study of cellular energetics—how cells acquire and use energy—is fundamentally dependent on biological macromolecules (Unit 1), particularly enzymes (proteins) that catalyze every step in the metabolic pathways of photosynthesis and cellular respiration. Furthermore, these energy transformations occur within the physical confines established in Unit 2: Cell Structure and Function. Specifically, the elaborate membrane structure and compartmentalization of the mitochondria and chloroplasts are required to maintain the H<sup>+</sup> gradients that drive ATP synthesis via chemiosmosis.</p> <p>Moreover, the study of chloroplasts and mitochondria needed for photosynthesis and aerobic respiration provides key evidence for Evolution (Unit 7) through adaptation and endosymbiosis, and the overall balance between photosynthesis and respiration dictates the flow of energy through ecosystems, linking directly to Ecology (Pre-Work).</p>	<p>The chemical energy generated in Unit 3, primarily in the form of ATP, is the immediate energy currency that powers all processes studied in subsequent units. For example, ATP is required to fuel the pumps and active transport necessary for signal transduction in Cell Communication (Unit 4), and it provides the energy for the polymerization of DNA and RNA in Heredity and Gene Expression (Units 5 and 6).</p>
<p><b>Differentiation through <a href="#">Universal Design for Learning</a></b>  <b>Learning Targets and Teacher Actions</b></p>	
<p><b>Learning Target 1:</b></p> <ul style="list-style-type: none"> <li>Representation: Use dynamic animations or 3D models to show the induced-fit model of enzyme action, highlighting the active site and the interaction with the substrate. Provide a labeled diagram of an enzyme and substrate, along with a written explanation of how enzymes lower the activation energy.</li> <li>Action/Expression: Students can build a physical model of an enzyme, substrate, and active site using manipulatives. They could also create a flow chart showing how an enzyme speeds up a reaction, or write a short script explaining the lock-and-key or induced-fit analogy.</li> <li>Engagement: Introduce a real-world problem where an organism is lacking a critical enzyme (e.g., lactase deficiency) and have students explain the resulting chemical inefficiency.</li> </ul> <p><b>Learning Target 2:</b></p> <ul style="list-style-type: none"> <li>Representation: Provide graphs showing the effect of pH and temperature on enzyme activity, and clearly label the optimum conditions and the point of denaturation. Use a visual diagram to show the difference between competitive and non-competitive inhibitors.</li> <li>Action/Expression: Students can design and sketch a simple experiment to test how changing the temperature or pH affects a common enzyme (e.g., catalase or amylase). They could also create a comparison table detailing the mechanism and site of action for allosteric, competitive, and non-competitive regulators.</li> <li>Engagement: Use a case study on the medical use of enzyme inhibitors (e.g., certain drugs) or the effect of fever on human enzyme function to ground the concepts in health and medicine.</li> </ul> <p><b>Learning Target 3:</b></p> <ul style="list-style-type: none"> <li>Representation: Use a summary diagram of the light-dependent reactions that shows the flow of electrons through Photosystem II and I. Provide a narrated video explaining how pigments capture light energy and transfer it to the reaction center complex.</li> <li>Action/Expression: Students can create a labeled diagram of the thylakoid membrane, tracing the path of light, water, electrons, and resulting ATP and NADPH. They could also write a step-by-step procedure of the light-dependent reactions.</li> </ul>	

- Engagement: Use a digital simulation where students can adjust light intensity and wavelength to see the effect on ATP and NADPH production.

#### Learning Target 4:

- Representation: Provide a simplified cyclical diagram of the Calvin cycle, focusing on the key phases: carbon fixation, reduction, and regeneration of RuBP. Use an input/output chart to track the number of CO<sub>2</sub>, ATP and NADPH molecules required to produce one molecule of G3P.
- Action/Expression: Students can physically model the cycle using colored tokens or blocks to represent carbon molecules at each stage. They could also write a narrative from the perspective of a carbon atom traveling through the cycle.
- Engagement: Compare the Calvin cycle to a chemical "assembly line" that uses the energy currency ATP and NADPH created in the light reactions to build the final product.

#### Learning Target 5:

- Representation: Provide a flowchart of glycolysis that highlights the initial investment phase and the energy payoff phase, noting the production of ATP (net 2), NADH and pyruvate. Use a diagram to show the pyruvate oxidation step (transition) that prepares the molecule for the Krebs cycle.
- Action/Expression: Students can complete a balance sheet tracking the carbon atoms and energy molecules at the end of glycolysis and the transition phase. They could also create a labeled concept map detailing the location and inputs/outputs of these processes.
- Engagement: Use a gamified quiz where students have to correctly identify the location (cytoplasm vs. mitochondrion) and products of each stage of glucose breakdown.

#### Learning Target 6:

- Representation: Use a detailed diagram or animation showing the ETC in the mitochondrial inner membrane, illustrating how electrons from NADH and FADH<sub>2</sub> power the pumping of H<sup>+</sup> ions to create a gradient. Clearly show the role of ATP synthase and chemiosmosis (the flow of H<sup>+</sup> back into the matrix).
- Action/Expression: Students can create a visual model of the inner mitochondrial membrane to demonstrate the proton gradient and the action of ATP synthase. They could also write an explanation focusing on the role of oxygen as the final electron acceptor.
- Engagement: Use the analogy of a hydroelectric dam to explain how the H<sup>+</sup> gradient (water behind the dam) powers the ATP synthase (turbine) to generate energy.

#### Learning Target 7:

- Representation: Provide a comparison chart clearly contrasting aerobic respiration (requires O<sub>2</sub>) with the two main types of fermentation (lactic acid and alcohol). Use a diagram to specifically show how NADH is recycled back to NAD<sup>+</sup> during fermentation.
- Action/Expression: Students can create a small informational poster explaining the role of fermentation in a specific application (e.g., making yogurt or bread). They could also write a short answer explaining why NAD<sup>+</sup> regeneration is the key function of fermentation.
- Engagement: Engage students in a discussion about the "burn" felt in muscles during intense exercise (lactic acid fermentation) or the processes involved in making common fermented foods and drinks.

### Supporting Multilingual/English Learners ( [CELP standards](#) )

#### Differentiated Learning Targets

	Emerging	Bridging	Expanding
<b>LT 1</b>	I can define enzyme and identify the active site on a diagram. I can state that enzymes speed up reactions.	I can describe the lock-and-key or induced-fit model and explain how the specific shape of the active site allows the enzyme to efficiently catalyze (speed up) a reaction.	I can analyze and explain how the tertiary structure of an enzyme creates the specific microenvironment of the active site, and justify how this structural specificity lowers the activation energy to control reaction rates with precise vocabulary.
<b>LT 2</b>	I can identify two conditions that can stop an enzyme from working (e.g., high heat, extreme pH) and state that the enzyme becomes denatured.	I can describe how changes in pH and temperature affect an enzyme's three-dimensional structure and explain the difference between a competitive and non-competitive inhibitor using cause-and-effect language.	I can analyze and evaluate the effect of allosteric regulation and various environmental factors on enzyme kinetics, explaining how these regulatory mechanisms maintain cellular homeostasis and control metabolic pathways using detailed scientific rationale.
<b>LT 3</b>	I can identify the overall inputs (CO <sub>2</sub> , H <sub>2</sub> O) and outputs (O <sub>2</sub> , sugar) of	I can describe that the photosystems (I and II) in the thylakoid membranes	I can explain and analyze the conversion of light energy to chemical energy

	photosynthesis and state that it uses light energy.	capture light and use that energy to create ATP and NADPH, using sequencing words to show the flow of energy.	during the light-dependent reactions, detailing the excitation of electrons in photosystems and the subsequent generation of ATP and NADPH through an electron transport chain.
<b>LT 4</b>	I can name the Calvin Cycle and state that it uses CO <sub>2</sub> to make sugar (carbohydrates).	I can describe the Calvin cycle as the light-independent reactions and explain its role in fixing carbon from CO <sub>2</sub> into an organic molecule, using the energy from ATP and NADPH from the light reactions.	I can analyze and explain the three main phases of the Calvin cycle (carbon fixation, reduction, and regeneration), detailing the role of the enzyme RuBisCO and the net output of G3P, using complex academic language to connect the overall process.
<b>LT 5</b>	I can identify that glycolysis breaks glucose into two parts and produces a small amount of ATP in the cytoplasm.	I can describe that glycolysis is the first step of cellular respiration, produces pyruvate, and that this pyruvate is then oxidized as it moves into the mitochondria to become Acetyl-CoA for the Krebs cycle.	I can explain and analyze the net energy yield of glycolysis (ATP and NADH) and the decarboxylation of pyruvate during the transition step, justifying the movement of molecules and the readiness for the subsequent Krebs cycle.
<b>LT 6</b>	I can identify the ETC as the step that makes the most ATP and state that it uses oxygen and the inner mitochondrial membrane.	I can describe the role of NADH and FADH <sub>2</sub> in supplying electrons to the ETC, and explain how the movement of electrons powers proton pumps to build an H <sup>+</sup> gradient for chemiosmosis.	
<b>LT 7</b>	I can define enzyme and identify the active site on a diagram. I can state that enzymes speed up reactions.	I can describe the lock-and-key or induced-fit model and explain how the specific shape of the active site allows the enzyme to efficiently catalyze (speed up) a reaction.	I can analyze and explain how the tertiary structure of an enzyme creates the specific microenvironment of the active site, and justify how this structural specificity lowers the activation energy to control reaction rates with precise vocabulary.

<b>Lesson Sequence</b>	<b>Learning Target</b>	<b>Success Criteria/Assessment/Resources</b>
1	<b>Learning Target 1</b> I can explain how the structure and function of enzymes, including their active sites, help organisms efficiently control the rate of chemical reactions.	<ul style="list-style-type: none"> <li>I can explain that enzymes are proteins whose shape determines their function and specificity.</li> <li>I can describe the role of the active site in binding to a substrate.</li> <li>I can explain that enzymes lower the activation energy of a reaction without being consumed by it.</li> <li>I can identify and explain the steps of the Enzyme-Substrate Complex formation.</li> </ul>
2	<b>Learning Target 2</b> I can explain how enzyme function is affected by environmental conditions and other regulatory molecules.	<ul style="list-style-type: none"> <li>I can describe the effect of temperature and pH changes on enzyme shape and activity and can accurately apply the term denaturation.</li> <li>I can explain how changes in substrate, product or enzyme concentration affect the reaction rate.</li> <li>I can differentiate between competitive and noncompetitive inhibitors and explain their effect on enzyme activity.</li> <li>I can describe the process of allosteric regulation and feedback inhibition in metabolic pathways.</li> </ul>
3	<b>Learning Target 3</b> I can describe the process of photosynthesis and explain how photosystems capture and convert light energy into chemical energy.	<ul style="list-style-type: none"> <li>I can identify the primary locations of photosynthesis (chloroplasts, specifically thylakoids and stroma) in eukaryotic cells.</li> <li>I can explain the role of chlorophyll and other pigments in absorbing light energy.</li> <li>I can explain that Photosystem II splits water to replace lost electrons and release oxygen as a</li> </ul>

		<p>byproduct.</p> <ul style="list-style-type: none"> <li>• I can describe the movement of electrons through the electron transport chain of the light-dependent reactions of photosynthesis.</li> <li>• I can explain how a proton gradient is established and used to synthesize ATP and NADPH in the light-dependent reactions of photosynthesis.</li> </ul>
4	<p><b>Learning Target 4</b> I can describe and explain the role of the Calvin cycle in producing carbohydrates from CO<sub>2</sub>.</p>	<ul style="list-style-type: none"> <li>• I can identify the location of the Calvin cycle in chloroplasts.</li> <li>• I can describe how energy captured in the light reactions and transferred to ATP and NADPH powers the production of carbohydrate from carbon dioxide in the Calvin cycle.</li> </ul>
5	<p><b>Learning Target 5</b> I can describe the process of glycolysis and the transition to the Krebs cycle in breaking down glucose.</p>	<ul style="list-style-type: none"> <li>• I can identify the location of glycolysis and summarize its net results.</li> <li>• I can explain how pyruvate is modified (oxidized) as it moves into the mitochondrial matrix.</li> <li>• I can explain the role of the Krebs Cycle (Citric Acid Cycle) in producing electron carriers (NADH and FADH<sub>2</sub>).</li> </ul>
6	<p><b>Learning Target 6</b> I can explain how the electron transport chain (ETC) and chemiosmosis release energy to synthesize large amounts of ATP.</p>	<ul style="list-style-type: none"> <li>• I can identify the location of the ETC within the mitochondria.</li> <li>• I can explain how NADH and FADH<sub>2</sub> powers the ETC.</li> <li>• I can explain the role of oxygen in aerobic respiration.</li> <li>• I can explain how ATP synthase uses a proton gradient (chemiosmosis) to synthesize most of the cell's ATP.</li> </ul>
7	<p><b>Learning Target 7</b> I can explain how fermentation allows cells to continue glycolysis in the absence of oxygen.</p>	<ul style="list-style-type: none"> <li>• I can differentiate between aerobic and anaerobic processes.</li> <li>• I can describe how fermentation's main role is to regenerate NAD<sup>+</sup> for glycolysis and identify the organic byproducts (such as alcohol or lactic acid).</li> </ul>

<b>Unit Title:</b>	
Unit 4: Cell Communication and Cell Cycle	
<b>Relevant Standards: Bold indicates priority</b>	
<b>Course Content:</b> Energetics (ENE) Information Storage and Transmission (IST)	
<b>Science Practices:</b> 1 - Concept Explanation 1.A: Describe biological concepts and processes. 1.B: Explain biological concepts and processes. 4 - Representing and Describing Data 4.B: Describe data from a table or graph, including identifying specific data points, describing trends and patterns in the data, and describing relationships between variables. 5 - Statistical Tests and Data Analysis 5.A: Perform mathematical calculations, including mathematical equations in the curriculum, means, rates, ratios, percentages and percent changes 6 - Argumentation 6.C: Provide reasoning to justify a claim by connecting evidence to biological theories. 6.E: Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
<b>Essential Question(s):</b>	<b>Enduring Understanding(s):</b>
In what ways do cells use energy to communicate with one another?  How does the cell cycle aid in the conservation of genetic information?  Why and in what ways do cells communicate with one another?	Students continue to learn about the role of cells, focusing on how cells use energy and information transmission to communicate and replicate. Through systems of complex transduction pathways, cells can communicate with one another. Cells can also generate and receive signals, coordinate mechanisms for growth, and respond to environmental cues. To maintain homeostasis, cells respond to their environment. They can also replicate and regulate replication as part of the cell cycle that provides for the continuity of life.
<b>Demonstration of Learning:</b>	<b>Pacing for Unit</b>
Students will review their knowledge of nucleic acid from unit 1 so that it can be applied here and in subsequent units by using chalk markers to create illustrative diagrams on their desktops. These diagrams must include relevant structural features and vocabulary for both RNA and DNA, and must compare DNA in prokaryotes and eukaryotes.  Students will create and present a brief lesson to teach their classmates about a specific feedback mechanism found in organisms or ecosystems.  Students will create a live-action or animated video or a hand-drawn poster showing and explaining two different cell signaling pathways: an intracellular hormone receptor pathway and a G-protein coupled receptor pathway.  Students will complete the Personal Progress Check MCQs and FRQs for unit 4 on AP Classroom.  Students will take a unit assessment at the end of the unit that includes AP-style multiple choice on AP Classroom as well as written responses (FRQs).	6-7 class periods 2-3 lab days

<b>Family Overview:</b>	<b>Integration of Technology:</b>
<a href="#">AP Biology: Family Course Overview (English)</a> <a href="#">AP Biology: Family Course Overview (Spanish)</a>	<ul style="list-style-type: none"> <li>● Google Slides</li> <li>● AP Classroom Personal Progress Check, AP Daily videos and topic quizzes</li> <li>● <i>Desmos scientific calculator</i></li> <li>● <i>YouTube</i></li> </ul>
<b>Unit-specific Vocabulary:</b>	<b>Aligned Unit Materials, Resources, and Technology (beyond core resources):</b>
Ligand Receptor Signal transduction pathway Second messenger Hormone Feedback (positive and negative) Homeostasis Checkpoint Cell cycle Cyclin Cyclin-dependent kinase (CDK) Apoptosis Interphase Mitosis Prophase Metaphase Anaphase telophase Cytokinesis	<ul style="list-style-type: none"> <li>● Campbell Biology In Focus Chapter 9</li> <li>● AP Classroom Unit 4</li> </ul>
<b>Opportunities for Interdisciplinary Connections:</b>	<b>Anticipated misconceptions:</b>
<ul style="list-style-type: none"> <li>● Math</li> <li>● Visual arts</li> <li>● Health and Wellness</li> <li>● Chemistry</li> <li>● Anatomy and Physiology</li> </ul>	<ul style="list-style-type: none"> <li>● Cell signaling is not limited to hormones or nerves, but rather all kinds of different cells use cell signaling pathways including short-distance signaling and self-signaling.</li> <li>● Responses are not immediate once a signal reaches a receptor, but rather there are usually many steps in between as cells use chains of molecules and multi-step cascades to transfer and amplify signals.</li> <li>● Different cells can react differently to the same signal because they have different receptors and different proteins within a signal transduction pathway.</li> <li>● The cell cycle doesn't happen randomly, but rather cells move through the cycle in a specific order and use checkpoints controlled by cyclins and CDKs to regulate this process.</li> <li>● Cell division is not just for overall organism growth, but also for development and damage repair.</li> <li>● "Any mistake in the cell cycle automatically causes cancer" is a common misconception. Not every error leads to cancer, and cells have multiple safeguards that lead to repair or apoptosis instead.</li> <li>● Positive feedback does not = "good" or beneficial results and negative feedback does not mean the response is "bad" but rather these terms refer to whether a response is increasing/amplifying or decreasing/stopping a stimulus.</li> </ul>

Connections to Prior Units:	Connections to Future Units:
<p>Cell Communication heavily relies on Unit 2, as it requires an understanding of the plasma membrane. Furthermore, the ultimate cellular response to a signal often involves gene regulation, linking directly to DNA and protein synthesis, so the biochemistry of Unit 1 is an important foundation here. The cell cycle also requires knowledge of Unit 1 for the replication of DNA and the role of enzymes. Therefore, Unit 4 brings together the structure of the cell, the molecular machinery of proteins, and the information stored in DNA to regulate life-sustaining processes.</p>	<p>Unit 4 lays the foundational mechanisms for nearly all subsequent AP Biology units. The concept of signal transduction (cell communication) is crucial for understanding Unit 6: Gene Expression and Regulation, as many signaling pathways ultimately control which genes are turned on or off. This control, in turn, dictates cellular differentiation and function, linking directly to the section of the Pre-Work: Ecology that pertains to how organisms respond to environmental signals and Unit 7: Natural Selection as it pertains to how changes in signaling pathways can lead to evolutionary adaptations. Furthermore, the Cell Cycle provides the context for Unit 5: Heredity, as meiosis is a modified cell cycle that ensures the proper transmission of chromosomes to gametes, thereby establishing the principles of inheritance. Without Unit 4, the regulation, adaptation, and inheritance discussed in the later units would lack their essential mechanistic basis.</p>

**Differentiation through *Universal Design for Learning*  
Learning Targets and Teacher Actions**

**Learning Target 1:**

- Representation: Use a clear, step-by-step diagram or flowchart to illustrate the three stages of the pathway: Reception, Transduction, and Response. Provide a vocabulary list defining key terms like ligand, receptor protein, and second messenger.
- Action/Expression: Students can create a three-panel comic strip or a narrative that traces a specific signal (ligand) from its arrival at the cell surface to the final cellular response. They could also write a function matrix listing each component and its specific role.
- Engagement: Introduce an analogy of a cell signal pathway as a cellular telephone system or a relay race to make the abstract sequence more concrete and memorable.

**Learning Target 2:**

- Representation: Use side-by-side diagrams contrasting a normally shaped signaling molecule (ligand) with a mutated or inhibited ligand, showing how the change prevents binding to the receptor. Provide case studies of drugs that mimic or block natural signaling molecules.
- Action/Expression: Students can be given a specific structural change (e.g., loss of a functional group) and asked to predict and justify the resulting effect on the pathway's activation or termination. They could also write a short mechanism of action for a drug that targets a specific step in a pathway.
- Engagement: Introduce a medical puzzle related to a disease caused by a faulty receptor or an altered signaling molecule, encouraging students to analyze the structural consequence.

**Learning Target 3:**

- Representation: Provide two distinct flowcharts clearly illustrating a negative feedback loop (output reduces input, e.g., body temperature regulation) and a positive feedback loop (output intensifies input, e.g., labor contractions). Use color-coding to highlight the component that acts to either reverse or amplify the original stimulus.
- Action/Expression: Students can select two real-world examples (one positive, one negative) and draw and label their own diagram of the feedback mechanism. They could also write a short comparative essay on which type of loop is more common in maintaining stability.
- Engagement: Use a scenario-based activity where students must categorize several biological processes as either positive or negative feedback and justify their choice.

**Learning Target 4:**

- Representation: Use a visual diagram of the cell cycle (Interphase: G1, G2; and Mitotic Phase: Mitosis and Cytokinesis), including a brief description of the key events occurring in each phase (e.g., DNA synthesis in S. Provide a written summary of the cell cycle's overall function (growth, repair, asexual reproduction).
- Action/Expression: Students can create a timeline or storyboard of the cell cycle, depicting the main events in each phase. They could also write a brief report contrasting the cell cycle in somatic cells versus germ cells.
- Engagement: Use a digital matching game where students pair descriptions of cellular activity (e.g., cell growth, chromosome alignment) with the correct phase of the cell cycle.

**Learning Target 5:**

- Representation: Provide detailed, sequential diagrams or animations of the stages of mitosis (Prophase, Metaphase, Anaphase, Telophase). Emphasize the role of the spindle fibers and show how the process results in two genetically identical daughter cells.
- Action/Expression: Students can use pipe cleaners or physical models to manipulate chromosomes and model the movement through each phase of mitosis. They could also write a short, instructional manual titled "How to Divide a Cell to Maintain Genetic Consistency."
- Engagement: Use a "Chromosome Tracker" activity where students are given a starting cell (e.g.,  $2n=4$ ) and must track the number of chromosomes and DNA molecules through all the stages of mitosis and cytokinesis.

**Learning Target 6:**

- Representation: Use a diagram of the cell cycle showing the major checkpoints (G1, G2, and M checkpoint). Introduce key regulatory molecules like cyclins and cyclin-dependent kinases Cdks and show how their concentration changes to control the cycle.
- Action/Expression: Students can create a metaphor for the cell cycle checkpoints (e.g., traffic lights, quality control stations). They could also research and present a report on how disruptions to cell cycle regulation lead to cancer.
- Engagement: Introduce a role-playing scenario where one student is a Cdk and another is a cyclin, explaining their interaction and the consequences if the Cdk is permanently activated.

**Supporting Multilingual/English Learners ( [CELP standards](#) )****Differentiated Learning Targets**

	<b>Emerging</b>	<b>Bridging</b>	<b>Expanding</b>
<b>LT 1</b>	I can label the three main stages of the pathway (reception, transduction, response) and name the signaling molecule (ligand).	I can describe the three stages of a pathway and explain how the signal is transferred from the outside of the cell to the inside, using sequencing words and academic terms (e.g., receptor, relay proteins).	I can analyze and explain how a conformational change in the receptor initiates a phosphorylation cascade (transduction) to amplify and produce a specific cellular response, detailing the role of each component.
<b>LT 2</b>	I can identify that if the signaling molecule's shape changes, it will not fit the receptor, and the cell will not respond.	I can describe how a structural change in the signaling molecule (or the receptor) prevents it from binding or activating the receptor, using this to explain why the signaling pathway is disrupted.	I can analyze a specific example (e.g., a drug or toxin) that alters the structure of a component (ligand or receptor) and predict and justify the resulting loss or gain of function in the signaling pathway and the cellular response.
<b>LT 3</b>	I can define homeostasis and identify the difference between positive (more/increase) and negative (less/stop) feedback loops.	I can describe both positive and negative feedback loops and explain the role of each in maintaining a stable internal environment (e.g., body temperature or childbirth) using cause-and-effect language.	I can compare and contrast the specific regulatory roles of positive and negative feedback systems, analyzing how they dynamically maintain biological set points and the conditions under which a positive feedback loop is beneficial or detrimental.
<b>LT 4</b>	I can list the main phases of the cell cycle (G1,S,G2,M) and state that its function is to make new cells.	I can describe the main events of Interphase (G1,S,G2) and Mitosis (M), explaining the biological function of the cycle (growth, repair, or reproduction) using sequential transition words.	I can analyze the cell cycle, detailing the precise molecular events that occur during each phase and justifying why the cell cycle is essential for both asexual reproduction and the maintenance of multicellularity in complex organisms.
<b>LT 5</b>	I can name the main stages of mitosis (Prophase, Metaphase, Anaphase, Telophase) and state that the daughter cells are identical to the parent cell.	I can describe the movement of chromosomes during each stage of mitosis and explain how the process ensures that each new daughter cell receives an identical set of genetic material (chromosomes).	I can analyze and explain how the precise mechanisms (e.g., spindle fiber attachment, sister chromatid separation) of mitosis guarantee the fidelity of chromosome transmission from a parent cell to two genetically identical daughter cells.
<b>LT 6</b>	I can identify that the cell cycle has checkpoints and that if regulation fails, it can lead to cancer.	I can describe the main cell cycle checkpoints (G1,G2,M) and explain that key regulatory proteins (e.g., cyclins	I can analyze and explain the role of cyclin-CDK complexes and tumor suppressor genes (e.g., p53) in

		and CDK) control the progression of the cycle.	regulating the cell cycle, and justify how specific disruptions (e.g., mutation in p53) lead to uncontrolled cell division and tumor formation.
Lesson Sequence	Learning Target	Success Criteria/Assessment/Resources	
1	<b>Learning Target 1</b> I can identify the components of a signal transduction pathway and describe their role in producing a cellular response.	<ul style="list-style-type: none"> <li>I can describe the roles of ligands and receptor proteins in signal transduction.</li> <li>I can describe how signaling cascades relay signals from receptors to cellular targets, including through amplification.</li> <li>I can describe the role of G-protein coupled receptors, second messengers, and hormones in signaling cascades</li> <li>I can identify different types of cellular responses elicited by a signal transduction pathway.</li> </ul>	
2	<b>Learning Target 2</b> I can explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway	<ul style="list-style-type: none"> <li>I can describe how mutations in components of a signaling pathway may affect the downstream components.</li> <li>I can describe how chemicals that interact with components of a signaling pathway may activate or inhibit the pathway.</li> </ul>	
3	<b>Learning Target 3</b> I can describe how positive and negative feedback help maintain homeostasis.	<ul style="list-style-type: none"> <li>I can explain negative feedback and describe how these mechanisms maintain homeostasis at the molecular, cellular, and organismal levels.</li> <li>I can explain positive feedback and describe how these mechanisms amplify a stimulus and result in changes to a system.</li> </ul>	
4	<b>Learning Target 4</b> I can describe the events of the cell cycle and its biological function.	<ul style="list-style-type: none"> <li>I can describe the purpose of the cell cycle for growth, repair, and asexual reproduction.</li> <li>I can identify the main events that occur in each phase of Interphase (G1, S, G2).</li> <li>I can identify the role of G0 in the cell cycle</li> <li>I can identify the timing and role of mitosis and cytokinesis in the cell cycle.</li> </ul>	
5	<b>Learning Target 5</b> I can explain how mitosis results in the transmission of chromosomes from one generation of cells to the next.	<ul style="list-style-type: none"> <li>I can name the sequential steps of mitosis and describe the main events that occur in each step.</li> <li>I can describe the process and result of cytokinesis in animal cells and in plant cells.</li> </ul>	
6	<b>Learning Target 6</b> I can describe how the cell cycle is regulated and the effects of disruptions to the cell cycle on the cell or organism.	<ul style="list-style-type: none"> <li>I can explain the role of checkpoints in regulating progression through the cell cycle.</li> <li>I can describe the role of cyclins and cyclin-dependent kinases in controlling the cell cycle.</li> <li>I can describe how and why disruptions to the cell cycle may result in cancer or apoptosis.</li> </ul>	

<b>Unit Title:</b>	
Unit 5: Heredity	
<b>Relevant Standards:</b>	
<b>Course Content:</b> Evolution (EVO) Information Storage and Transmission (IST) Systems Interactions (SYI)	
<b>Science Practices:</b> 1 - Concept Explanation. 1.B: Explain biological concepts and processes. 1.C: Explain biological concepts and processes in applied contexts. 3 - Questions and Methods 3.A: Identify or pose a testable question based on an observation, data, or a model 5 - Statistical Tests and Data Analysis 5.C: Perform chi-square hypothesis testing. 6 - Argumentation 6.E: Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
<b>Essential Question(s):</b>	<b>Enduring Understanding(s):</b>
<ul style="list-style-type: none"> <li>• How is our understanding of evolution influenced by our knowledge of genetics?</li> <li>• Why is it important that not all inherited characteristics get expressed in the next generation?</li> <li>• How would Mendel's laws have been affected if he had studied a different type of plant?</li> <li>• How does the diversity of a species affect inheritance?</li> </ul>	Unit 5 focuses on heredity and the biological concepts and processes involved in ensuring the continuity of life. Students learn that the storage and transmission of genetic information via chromosomes from one generation to the next occur through meiosis. Meiotic division ensures genetic diversity, which is crucial to the survival of a species. In this unit, students gain a deeper understanding of Mendelian genetics and learn how non-Mendelian genetics describes patterns of inheritance that seem to violate Mendel's laws. This unit also covers the roles played by chromosomal inheritance, environmental factors, and nondisjunction on an individual's phenotype.
<b>Demonstration of Learning:</b>	<b>Pacing for Unit</b>
<p>Students will conduct a DNA extraction and amplification of the ACE gene using micropipetting techniques and PCR. They will then genotype their samples using gel electrophoresis to determine which samples are homozygous for either version of the gene or heterozygous for the ACE gene.</p> <p>Students will complete practice problems for both Mendelian and non-Mendelian genetics scenarios.</p> <p>Students will complete the Personal Progress Check MCQs and FRQs for unit 5 on AP Classroom.</p> <p>Students will take a unit assessment at the end of the unit that includes AP-style multiple choice on AP Classroom as well as written responses (FRQs).</p>	5-6 class periods 2-3 lab days
<b>Family Overview:</b>	<b>Integration of Technology:</b>
<a href="#">AP Biology: Family Course Overview (English)</a> <a href="#">AP Biology: Family Course Overview (Spanish)</a>	<ul style="list-style-type: none"> <li>• Google Slides</li> <li>• AP Classroom Personal Progress Check, AP Daily videos and topic quizzes</li> <li>• <i>Desmos scientific calculator</i></li> <li>• <i>Google Sheets</i></li> <li>• <i>Gel electrophoresis</i></li> </ul>

	<ul style="list-style-type: none"> <li>• PCR</li> </ul>
<b>Unit-specific Vocabulary:</b>	<b>Aligned Unit Materials, Resources, and Technology (beyond core resources):</b>
Gene                                      Phenotype Allele                                      Phenotypic ratio Locus                                        Genotypic ratio Homologous chromosomes Punnett square Haploid (n)                                pedigree Diploid (2n)                                Monohybrid Gamete                                        Dihybrid Zygote                                        non-Mendelian inheritance Meiosis                                        Incomplete dominance Crossing over                                Codominance Independent assortment                Multiple alleles Mendelian genetics                        Polygenic inheritance Homozygous                                Pleiotropy Heterozygous                                Epistasis dominant                                      Phenotypic plasticity Recessive Genotype	<ul style="list-style-type: none"> <li>• Campbell Biology In Focus Chapters 10-13</li> <li>• AP Classroom Unit 5</li> <li>• Jackson Laboratories Teaching the Genome</li> <li>• Generation (TtGG) extraction</li> <li>• PCR and gel electrophoresis protocols</li> <li>• BioRad pGlo bacterial transformation lab (or similar kit)</li> <li>• miniPCR BioBits Central Dogma experiment</li> </ul>
<b>Opportunities for Interdisciplinary Connections:</b>	<b>Anticipated misconceptions:</b>
<ul style="list-style-type: none"> <li>• Math (statistics)</li> <li>• Health and Wellness</li> <li>• Chemistry</li> <li>• Anatomy and Physiology</li> </ul>	<ul style="list-style-type: none"> <li>• Students struggle to differentiate between and appropriately apply the terms “gene” and “allele”.</li> <li>• Dominant traits are not necessarily more common or “better” than recessive traits, but students often assume one or both of these to be true.</li> <li>• A common misconception is that Punnett squares predict what offspring will be/look like, but rather they show possibilities and probabilities (not guarantees).</li> <li>• Some students struggle with the concept of sex-linked traits and have a hard time explaining why x-linked traits show up more often in males.</li> <li>• Mutations do not always cause visible changes, and can happen in noncoding DNA since not every single nucleotide base is directly part of a gene.</li> </ul>
<b>Connections to Prior Units:</b>	<b>Connections to Future Units:</b>
Unit 5 acts as the crucial link between the cellular machinery and evolutionary change. It builds upon Unit 1 (Chemistry of Life) and Unit 2 (The Cell) by explaining how the physical structure of DNA and chromosomes within the nucleus determines traits. Most critically, Unit 5 utilizes the processes of meiosis and the Cell Cycle (Unit 4) to explain the reliable transmission of genetic material, which forms the basis for Mendel's Laws and the concept of heritable variation.	Unit 5 becomes the foundation for all remaining material: it defines the genotype that is physically expressed via Gene Expression (Unit 6) and provides the essential genetic variation (through crossing over and mutation) that is required for Natural Selection and Evolution (Unit 7) to occur in the context of Ecology (Pre-Work).
<b>Differentiation through <i>Universal Design for Learning</i></b>	
<b>Learning Targets and Teacher Actions</b>	
<b>Learning Target 1:</b> <ul style="list-style-type: none"> <li>• Representation: Use sequential animations or labeled diagrams to show the stages of Meiosis I and Meiosis II, emphasizing the reduction in chromosome number and the production of four non-identical haploid cells. Provide a visual explanation of key events like crossing over and independent assortment to show how variation is generated.</li> <li>• Action/Expression: Students can model meiosis using colored string or pipe cleaners, physically tracking one pair of homologous chromosomes through both divisions. They could also write a comparative essay</li> </ul>	

contrasting the outcomes and biological functions of mitosis and meiosis.

- Engagement: Introduce the concept of genetic variation as an "advantage" of sexual reproduction. Use a simulation to show how different outcomes of independent assortment affect the final gametes.

**Learning Target 2:**

- Representation: Clearly define and illustrate Mendel's Laws (Segregation and Independent Assortment). Use Punnett Squares (monohybrid and dihybrid) with color-coding to visualize how alleles separate and recombine. Provide a glossary of terms like allele, homozygous, heterozygous, genotype, and phenotype.
- Action/Expression: Students can solve a variety of genetic crosses using Punnett Squares, probability rules, or pedigree charts. They could also create an instructional video explaining how to calculate the probability of a specific genotype from a dihybrid cross.
- Engagement: Use a role-playing scenario where students act as Mendel's pea plants to demonstrate segregation and independent assortment. Use real-world examples of simple human genetic traits (e.g., earlobe attachment).

**Learning Target 3:**

- Representation: Provide a comparison chart that summarizes the non-Mendelian patterns: Incomplete Dominance, Codominance, Multiple Alleles, Polygenic Inheritance, and Sex-Linked Inheritance. Use a distinct example for each (e.g., blood types for multiple alleles, red/white/pink flowers for incomplete dominance).
- Action/Expression: Students can be given a specific inheritance pattern (e.g., codominance) and asked to develop a Punnett Square key and solve a problem demonstrating the phenotypic ratios. They could also create a presentation on one deviation and its real-world impact (e.g., colorblindness as a sex-linked trait).
- Engagement: Introduce a "Genetic Detective" challenge where students must analyze a pedigree chart or phenotypic data set and determine which pattern of inheritance (Mendelian or non-Mendelian) best explains the results.

**Learning Target 4:**

- Representation: Use visual examples of epigenetic influences or environmental effects on phenotype (e.g., Himalayan rabbits whose fur color changes with temperature, or human height/weight influenced by diet). Provide a concept diagram showing Genotype + Environment to Phenotype.
- Action/Expression: Students can write a short case study explaining how pH affects the color of hydrangea flowers, linking the genetic potential to the environmental factor. They could also create a simple experiment proposal to test the effect of a specific environmental variable on a given organism's trait.
- Engagement: Discuss the concept of nature vs. nurture and engage students in a debate or discussion about which plays a stronger

**Supporting Multilingual/English Learners ( [CELP standards](#) )  
Differentiated Learning Targets**

	<b>Emerging</b>	<b>Bridging</b>	<b>Expanding</b>
<b>LT 1</b>	I can define meiosis and state that it makes sex cells (gametes) and reduces the number of chromosomes by half.	I can describe the main goal of meiosis and explain how the process ensures that each resulting gamete receives one set of chromosomes from the parent cell, using sequencing words to show the two divisions.	I can analyze and explain the precise mechanisms of Meiosis I and Meiosis II, detailing how events like crossing over and independent assortment generate genetic variation and ensure the halving of the chromosome number for sexual reproduction.
<b>LT 2</b>	I can define dominant and recessive alleles and identify the genotypes and phenotypes for a simple monohybrid trait.	I can use a Punnett square to predict the offspring's genotypic and phenotypic ratios for a single-gene cross and explain the difference between a homozygous and heterozygous individual.	I can apply statistical reasoning to a dihybrid cross or complex inheritance problem, calculating and justifying the probabilities of specific genotypes/phenotypes based on the principles of Segregation and Independent Assortment.
<b>LT 3</b>	I can name one non-Mendelian pattern (e.g., incomplete dominance) and identify that the results are not simple dominant/recessive.	I can describe different non-Mendelian patterns (e.g., codominance, sex-linked traits) and explain how these patterns lead to phenotypic ratios that deviate from Mendel's simple 3:1 or 9:3:3:1 ratios.	I can analyze and justify the inheritance pattern of complex traits (e.g., epistasis, polygenic traits) by comparing them to Mendelian principles and explaining the molecular reasons for the observed phenotypic ratios.

<b>LT 4</b>	I can identify that the environment (e.g., sun, food) can change how a trait looks, even if the gene is the same.	I can describe a specific example (e.g., hydrangea color or coat color in some animals) where the environment modifies the expression of a gene, and explain the resulting phenotypic plasticity in a clear sentence.	I can analyze and evaluate empirical data to show how the reaction norm of a specific genotype is influenced by a range of environmental factors (e.g., temperature, nutrition), constructing a detailed argument on gene-environment interaction.
<b>Lesson Sequence</b>	<b>Learning Target</b>	<b>Success Criteria/Assessment/Resources</b>	
1	<b>Learning Target 1</b> I can explain how meiosis results in the transmission of chromosomes from one generation to the next.	<ul style="list-style-type: none"> <li>• I can name and describe the features of each step of meiosis.</li> <li>• I can identify the intended outcome of meiosis and its role in sexually reproducing diploid organisms.</li> <li>• I can describe similarities and differences between the phases and outcomes of mitosis and meiosis.</li> <li>• I can explain how the process of meiosis generates genetic diversity.</li> </ul>	
2	<b>Learning Target 2</b> I can explain the inheritance of genes and traits as described by Mendel's laws.	<ul style="list-style-type: none"> <li>• I can describe Mendel's laws of segregation and independent assortment.</li> <li>• I can apply the rules of probability to predict and analyze the passing of single-gene traits from parent to offspring in monohybrid, dihybrid and test crosses.</li> <li>• I can apply the terms homozygous and heterozygous when describing an organism's genotype.</li> <li>• I can differentiate between genotype and phenotype.</li> <li>• I can describe patterns of inheritance, both autosomal and sex-linked, dominant and recessive.</li> <li>• I can use Punnett squares to predict the genotypes and phenotypes of parents and offspring.</li> </ul>	
3-4	<b>Learning Target 3</b> I can explain deviations from Mendel's model of the inheritance of traits.	<ul style="list-style-type: none"> <li>• I can identify and describe patterns of inheritance that do not follow the ratios predicted by Mendel's laws, including codominance, incomplete dominance, sex-linked traits, and pleiotropy.</li> <li>• I can describe the probability of genes segregating together can be used for gene mapping.</li> <li>• I can identify sources of non-nuclear genetic inheritance in plants and animals.</li> </ul>	
5	<b>Learning Target 4</b> I can explain how the same genotype can result in multiple phenotypes under different environmental conditions	<ul style="list-style-type: none"> <li>• I can describe how environmental conditions influence gene expression and can lead to phenotypic plasticity.</li> </ul>	

<b>Unit Title:</b>	
Unit 6: Gene Expression and Regulation	
<b>Relevant Standards: Bold indicates priority</b>	
<b>Course Content:</b> Information Storage and Transmission (IST)	
<b>Science Practices:</b>	
1 - Concept Explanation. 1.C: Explain biological concepts and processes in applied contexts.	
2 - Visual Representations 2.B: Explain relationships between characteristics of biological models in both theoretical and applied contexts. 2.C: Explain how biological models relate to larger principles, concepts, processes, systems, or theories 2.D: Represent relationships within biological models, including mathematical models, diagrams, flowcharts, and systems.	
6 - Argumentation 6.A: Make a scientific claim. 6.B: Support a claim with evidence from biological principles, concepts, processes, and data. 6.D: Explain the relationship between experimental results and larger biological concepts, processes, or theories. 6.E: Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
<b>Essential Question(s):</b>	<b>Enduring Understanding(s):</b>
<ul style="list-style-type: none"> <li>• How does gene regulation relate to the continuity of life?</li> <li>• How is the genetic information of a species diversified from generation to generation?</li> </ul>	Progressing from the continuity of life to gene expression, students gain in-depth knowledge about nucleic acids and their role in gene expression in this unit. There is also a finer focus on the comparison between the structures of DNA and RNA. This unit highlights how an individual's genotype is physically expressed through their phenotype, thus emphasizing the importance of protein synthesis (transcription and translation) in gene expression. Regulation of gene expression and cell specialization are instrumental in ensuring survival within an individual and across populations.
<b>Demonstration of Learning:</b>	<b>Pacing for Unit</b>
<p>Students will conduct the miniPCR “biobits” Central Dogma experiment using p51 fluorescence viewers, which will require them to apply their knowledge of transcription, translation, and gene regulation to make and defend predictions and explain observed results.</p> <p>Students will use a PhET simulator to explore the parts of the lac operon and ultimately use their findings to explain the definition and function of prokaryotic operons.</p> <p>Students will create and present a brief lesson to teach their classmates about a specific type of genetic mutation, including its consequences at the DNA, RNA, and protein level and at least one specific example of a trait/condition/disease/syndrome caused by that type of mutation .</p> <p>Students will complete the Personal Progress Check MCQs and FRQs for unit 6 on AP Classroom.</p> <p>Students will take a unit assessment at the end of the unit that includes AP-style multiple choice on AP Classroom</p>	9-11 class periods 2-3 lab days

as well as written responses (FRQs).		
<b>Family Overview:</b>		<b>Integration of Technology:</b>
<a href="#">AP Biology: Family Course Overview (English)</a> <a href="#">AP Biology: Family Course Overview (Spanish)</a>		<ul style="list-style-type: none"> <li>• Google Slides</li> <li>• AP Classroom Personal Progress Check, AP Daily videos and topic quizzes</li> <li>• <i>Desmos scientific calculator</i></li> <li>• <i>Google Sheets</i></li> <li>• <i>YouTube</i></li> <li>• <i>miniPCR P51 fluorescence viewers</i></li> </ul>
<b>Unit-specific Vocabulary:</b>		<b>Aligned Unit Materials, Resources, and Technology (beyond core resources):</b>
DNA RNA (mRNA, tRNA, rRNA) Nucleotide Base pairing Double helix Antiparallel 5' and 3' ends DNA replication Semiconservative Origin of replication Helicase DNA polymerase Leading strand Lagging strand Okazaki fragment Ligase Replication fork Point mutation Frameshift mutation Insertion PCR		Deletion Transcription RNA processing Intron Exon Splicing 5' cap poly-A tail Translation Codon Anticodon Start codon Stop codon Ribosome Gene expression Differentiation Recombinant DNA Cloning Genetic engineering Electrophoresis
<b>Opportunities for Interdisciplinary Connections:</b>		<b>Anticipated misconceptions:</b>
<ul style="list-style-type: none"> <li>• Math</li> <li>• Biotechnology and Forensics</li> <li>• Health and Wellness</li> <li>• Chemistry</li> <li>• Anatomy and Physiology</li> </ul>		<ul style="list-style-type: none"> <li>• What makes cells within an organism different is not that they have different genes, but rather that they express/regulate expression of the same set of DNA differently.</li> <li>• Students often confuse the roles of different types of RNA (mRNA, tRNA, rRNA).</li> <li>• Students sometimes struggle to understand that transcribing mRNA doesn't guarantee the production of a protein (since cells can regulate gene expression after transcription as well as during/before it).</li> <li>• While the central dogma of DNA to RNA to protein is essentially the same across all life, the regulation of this flow of information is different in prokaryotes vs. eukaryotes.</li> <li>• Operons are coordinated units of genes that are controlled/regulated as a unit/system, not just genes that happen to be located near each other.</li> <li>• Not every trait is controlled by a single gene, but rather most phenotypes are the result of many genes and often environmental factors as well.</li> <li>• Not all mutations are the same, and they are not necessarily "bad"---rather, there are many different</li> </ul>

ways in which DNA can be altered, which can in turn have a variety of implications for gene regulation, expression, and overall phenotype. The significance of a mutation ranges from incompatible with life to irrelevant to survival to evolutionarily advantageous depending on the type, severity, and environmental context.

**Connections to Prior Units:**

Unit 6 explains how the genetic blueprint translates into observable traits, tightly integrating with and completing the story started in prior units while setting the stage for future concepts. It relies heavily on Unit 1 (Chemistry of Life) and Unit 2 (The Cell) for the structure and function of DNA, RNA, ribosomes, and enzymes necessary for transcription and translation. It utilizes the concept of DNA replication from Unit 4 (Cell Cycle), as mutations introduced during replication are the basis for new alleles and changes in protein sequence. Crucially, it takes the genotype transmitted through Heredity (Unit 5) and provides the mechanism—the Central Dogma—by which the phenotype is physically expressed.

**Connections to Future Units:**

The principles of gene regulation (e.g., operons, transcription factors) connect directly to Unit 7 (Natural Selection) by showing how organisms evolve mechanisms to adapt to changing environments by altering which proteins they produce. This regulation informs the complexity of organismal function and interaction, which is critical for understanding Ecology (Pre-Work).

**Differentiation through *Universal Design for Learning*  
Learning Targets and Teacher Actions**

**Learning Target 1:**

- Representation: Use visual aids that clearly depict the hierarchical structures of hereditary information: DNA → Gene → Chromosome. Provide labeled diagrams of the eukaryotic chromosome structure, showing DNA wrapped around histone proteins.
- Action/Expression: Students can create a set of nested boxes or models to demonstrate the size relationship between a nucleotide, a gene, and a chromosome. They could also write a descriptive essay explaining why the chromosome structure is essential for efficiently packing and transmitting genetic material.
- Engagement: Use a jigsaw activity where groups become "experts" on one structure (DNA, Gene, Chromosome) and teach the others, reinforcing the roles of each.

**Learning Target 2:**

- Representation: Use 3D models or animations of the double helix structure to highlight key characteristics: the sugar-phosphate backbone, the nitrogenous bases, and the complementary base pairing (A with T, C with G). Provide a summary chart listing the four key characteristics: stability, ability to replicate, information storage, and capacity for change (mutation).
- Action/Expression: Students can construct a paper model or digital drawing of a short segment of DNA, correctly labeling the bases and showing the complementary pairing. They could also write an argument explaining how the double helix structure enables reliable replication.
- Engagement: Introduce the history of DNA discovery (Watson, Crick, Franklin) to provide context and appreciation for the evidence that established DNA as the hereditary material.

**Learning Target 3:**

- Representation: Use sequential animations or flowcharts to illustrate the steps of semiconservative DNA replication, focusing on the roles of key enzymes like DNA polymerase, helicase, and ligase. Clearly differentiate between the synthesis of the leading strand and the lagging strand (Okazaki fragments).
- Action/Expression: Students can create a comic strip or short animation explaining the "replication bubble" and the different roles of the leading and lagging strands. They could also write a detailed sequence of events that occurs at the replication fork.
- Engagement: Use a "Build a Molecule" simulation where students must correctly place the replication enzymes and nucleotides to successfully copy a DNA strand.

**Learning Target 4:**

- Representation: Use a clear, three-step diagram of the Central Dogma (Transcription → Translation). Provide separate visual models for the process of Transcription (DNA to mRNA) in the nucleus and Translation (mRNA to protein) on the ribosome.

- Action/Expression: Students can create a concept map linking the three molecules (DNA, RNA, Protein) and the processes that connect them. They could also transcribe and translate a short segment of a gene, using a codon chart to determine the resulting amino acid sequence.
- Engagement: Introduce the concept of the genetic code as the universal language of life, and use a decoding challenge where students must translate mRNA sequences into polypeptide chains.

**Learning Target 5:**

- Representation: Provide visual examples of both prokaryotic regulation (e.g., the lac or trp operon) and eukaryotic regulation (e.g., transcription factors, RNA processing, chromatin modification). Use a comparison chart to categorize regulation by level: transcriptional, post-transcriptional, translational, and post-translational.
- Action/Expression: Students can draw and label the components of an operon and explain how a repressor molecule blocks transcription. They could also write a short mechanism of action for a specific type of eukaryotic gene regulation, such as gene silencing by microRNA.
- Engagement: Discuss how the regulation of gene expression is the reason why different cells in the body (e.g., a skin cell vs. a nerve cell) can perform unique functions despite having the same DNA.

**Learning Target 6:**

- Representation: Use a clear sequence diagram showing the flow: DNA Mutation → Altered mRNA → Altered Protein → Altered Phenotype. Provide specific examples of point mutations (silent, missense, nonsense) and frameshift mutations, explaining how each affects the final protein product.
- Action/Expression: Students can be given a wild-type DNA sequence and then asked to model a mutation and determine the resulting amino acid change and potential phenotypic consequence. They could also write a detailed case study on a disorder caused by a single gene mutation (e.g., sickle cell anemia).
- Engagement: Use a "Domino Effect" analogy to show how a small change in the DNA sequence can lead to large, cascading effects on protein structure and organismal function.

**Learning Target 7:**

- Representation: Provide flowcharts or labeled diagrams of key techniques, such as Polymerase Chain Reaction (PCR), gel electrophoresis, and the use of restriction enzymes and plasmids in recombinant DNA technology.
- Action/Expression: Students can write a short procedure explaining how to clone a gene into a bacterial plasmid. They could also create an infographic detailing the steps and purpose of PCR.
- Engagement: Discuss the ethical and societal implications of genetic engineering (e.g., genetically modified organisms or gene therapy) through a class debate or ethical scenario analysis.

**Supporting Multilingual/English Learners ( *CELP standards* )  
Differentiated Learning Targets**

	<b>Emerging</b>	<b>Bridging</b>	<b>Expanding</b>
<b>LT 1</b>	I can name the main structure (DNA) and the location where it is found (nucleus/cell).	I can describe the relationship between DNA, genes, and chromosomes, and explain that these structures are the physical carriers of hereditary information.	I can analyze and explain the hierarchical organization of genetic material, detailing how the structure of chromosomes (histones, chromatin) allows for the efficient storage and faithful transmission of DNA across cell generations.
<b>LT 2</b>	I can identify DNA's key features: it is a double helix and it has four bases (A, T, C, G).	I can describe the basic structure of the DNA molecule and explain the role of complementary base pairing in ensuring that the genetic code can be read and copied accurately.	I can analyze and justify how the double helix structure, the complementary base pairing, and the stability provided by hydrogen bonds are essential features that enable DNA to store and accurately replicate genetic information.
<b>LT 3</b>	I can state that DNA is copied and that the two new copies are the same as the original.	I can describe the overall process of DNA replication and explain the role of unwinding and complementary base pairing in producing two identical DNA molecules for transmission.	I can analyze and explain the precise molecular mechanisms of DNA replication (e.g., leading vs. lagging strand, role of polymerases) and justify why the process is considered semiconservative for faithful inheritance.

<b>LT 4</b>	I can state the Central Dogma (DNA → RNA → Protein) and name the steps: transcription and translation.	I can describe the two-step flow of information (transcription and translation) and explain the role of mRNA and the ribosome in converting the genetic code into a sequence of amino acids.	I can analyze and explain the complex process of gene expression (The Central Dogma), detailing the roles of regulatory sequences and the coordinated action of various RNA types in producing a functional protein.
<b>LT 5</b>	I can identify that not all genes are on at the same time and that gene regulation saves energy.	I can describe different levels of gene regulation (e.g., transcription vs. translation) and explain how the cell uses these interactions to control the amount of protein produced.	I can analyze and explain the roles of specific regulatory elements (e.g., transcription factors, enhancers, and operons) in controlling the timing and amount of gene expression, justifying the need for this control in specialized cells.
<b>LT 6</b>	I can define genotype and phenotype and state that a change in the gene (genotype) can change the trait (phenotype).	I can describe how a gene mutation alters the sequence of a protein and explain how this structural change can lead to a different or nonfunctional phenotype (trait).	I can analyze and predict the effect of different classes of gene mutations (e.g., frameshift vs. point, regulatory vs. coding sequence) on the resulting protein structure and its phenotypic outcome, using the genetic code to support the analysis.
<b>LT 7</b>	I can name one technique (e.g., gene therapy) and state that it is used to change DNA to fix a problem.	I can describe a common genetic engineering technique (e.g., recombinant DNA technology) and explain its purpose in isolating, modifying, or transferring genetic material between organisms.	I can analyze and justify the ethical and practical applications of advanced techniques like CRISPR-Cas9, PCR, or gel electrophoresis, detailing the precise molecular mechanisms used to manipulate or analyze DNA in research or medicine.

<b>Lesson Sequence</b>	<b>Learning Target</b>	<b>Success Criteria/Assessment/Resources</b>
1	<b>Learning Target 1</b> I can describe the structures involved in passing hereditary information from one generation to the next.	<ul style="list-style-type: none"> <li>I can describe how genetic information is stored in and passed to subsequent generations through DNA (and in some cases RNA) molecules.</li> <li>I can compare and contrast chromosome structure in prokaryotes and eukaryotes.</li> </ul>
2	<b>Learning Target 2</b> I can describe the characteristics of DNA that allow it to be used as hereditary material.	<ul style="list-style-type: none"> <li>I can explain the structure and pairing patterns of nucleotide bases in RNA and DNA.</li> </ul>
3-4	<b>Learning Target 3</b> I can describe the mechanisms by which genetic information is copied for transmission between generations.	<ul style="list-style-type: none"> <li>I can describe the steps, direction and involved enzymes (including helicase, topoisomerase, DNA polymerase, and ligase) of DNA synthesis .</li> <li>I can describe how DNA replication is a semiconservative process.</li> </ul>
5-6	<b>Learning Target 4</b> I can describe the mechanisms by which genetic information flows from DNA to RNA to protein.	<ul style="list-style-type: none"> <li>I can describe how RNA polymerase synthesizes mRNA molecules by reading a template DNA strand during the process of transcription.</li> <li>I can identify ways in which mRNA transcripts are modified in eukaryotes, including the addition of a poly-A tail and GTP cap, and through splicing.</li> <li>I can explain the process of translating mRNA to generate a polypeptide and describe the role of ribosomes in this process.</li> <li>I can compare the timing and location of translation in prokaryotes and eukaryotes.</li> <li>I can describe the flow of genetic information in retroviruses and how it is made possible by reverse transcriptase.</li> </ul>

7	<p><b>Learning Target 5</b> I can describe the types of interactions that regulate gene expression.</p>	<ul style="list-style-type: none"> <li>● I can explain how regulatory sequences in DNA are used to control transcription.</li> <li>● I can describe how epigenetic changes can affect gene expression.</li> <li>● I can describe how the phenotype of an organism is determined by its genotype as well as the ways and amounts in which genes are expressed.</li> <li>● I can describe the flow of genetic information in retroviruses and how it is made possible by reverse transcriptase.</li> <li>● I can describe how prokaryotes regulate operons through inducible or repressible systems.</li> <li>● I can explain how the binding of transcription factors to promoter regions affects gene expression and the phenotype of the organism.</li> <li>● I can explain how gene regulation results in differential gene expression and influences cell products and functions.</li> </ul>
8	<p><b>Learning Target 6</b> I can explain how changes in genotype may result in changes in phenotype.</p>	<ul style="list-style-type: none"> <li>● I can describe the various types of mutations, including point mutations, frameshift mutations, nonsense mutations, and silent mutations.</li> <li>● I can identify ways in which random mutations can arise, including during DNA replication, mitosis or meiosis, and from external/environmental factors.</li> <li>● I can explain how alterations in DNA sequences contribute to variation that can be subject to natural selection.</li> </ul>
9-10	<p><b>Learning Target 7</b> I can explain the use of genetic engineering techniques in analyzing or manipulating DNA.</p>	<ul style="list-style-type: none"> <li>● I can describe the process of gel electrophoresis and draw conclusions from resulting data.</li> <li>● I can describe the steps of polymerase chain reaction (PCR).</li> <li>● I can explain how bacterial transformation introduce foreign DNA into bacterial cells.</li> <li>● I can describe how DNA sequencing technology and techniques allow for the comparison of DNA sequences from various samples.</li> </ul>

<b>Unit Title:</b>	
Unit 7: Natural Selection	
<b>Relevant Standards:</b>	
<b>Course Content:</b> Evolution (EVO) Systems Interactions (SYI)	
<b>Science Practices:</b>	
1 - Concept Explanation. 1.B: Explain biological concepts and processes. 1.C: Explain biological concepts and processes in applied contexts.	
2 - Visual Representations 2.A: Describe characteristics of visual representations of biological concepts and processes. 2.B: Explain relationships between characteristics of biological models in both theoretical and applied contexts. 2.D: Represent relationships within biological models, including mathematical models, diagrams, flowcharts, and systems.	
3 - Questions and Methods 3.B: State the null hypothesis or predict the results of an experiment 3.D: Propose a new investigation based on an evaluation of the experimental design or evidence.	
4 - Representing and Describing Data 4.B: Describe data from a table or graph, including identifying specific data points, describing trends and patterns in the data, and describing relationships between variables.	
5 - Statistical Tests and Data Analysis 5.A: Perform mathematical calculations, including mathematical equations in the curriculum, means, rates, ratios, percentages and percent changes	
6 - Argumentation 6.C: Provide reasoning to justify a claim by connecting evidence to biological theories. 6.E: Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
<b>Essential Question(s):</b>	<b>Enduring Understanding(s):</b>
<ul style="list-style-type: none"> <li>• What conditions in a population make it more or less likely to evolve?</li> <li>• What evidence is available that scientifically defends the theory of evolution?</li> <li>• How does species interaction encourage or slow changes in species?</li> </ul>	The concepts in Unit 7 build on foundational content from previous units as students discover natural selection—a mechanism of evolution. Natural selection is the theory that populations that are better adapted to their environment will survive and reproduce. Thus, the evolution of a species involves a change in its genetic makeup over time. In this unit, students study the evidence for and mechanisms of evolutionary change. Students also learn what happens when a species does not adapt to a changing or volatile environment and about the Hardy-Weinberg equilibrium as a model for describing and predicting allele frequencies in nonevolving populations. Students will learn to calculate and draw conclusions about the evolution, or lack thereof, of a population from data related to allele frequencies.
<b>Demonstration of Learning:</b>	<b>Pacing for Unit</b>
Students will complete Hardy-Weinberg equilibrium practice problems.  Students will conduct a chi-square analysis lab investigation using m&ms.  Students will apply their understanding of cladograms to create and defend their own cladogram when provided either a varied assortment of Peeps/related candy or teddy grahams/related cookies, depending on	10-12 class periods 2-3 lab days

<p>materials availability.</p> <p>Students will complete the Personal Progress Check MCQs and FRQs for unit 7 on AP Classroom.</p> <p>If there is time before the AP test, students will take a unit assessment at the end of the unit that includes AP-style multiple choice on AP Classroom as well as written responses (FRQs).</p>																											
<p><b>Family Overview:</b></p>	<p><b>Integration of Technology:</b></p>																										
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<p><b>Unit-specific Vocabulary:</b></p>	<p><b>Aligned Unit Materials, Resources, and Technology (beyond core resources):</b></p>																										
<table border="0"> <tr> <td>Natural selection</td> <td>Species</td> </tr> <tr> <td>Artificial selection</td> <td>Allopatric</td> </tr> <tr> <td>Fitness</td> <td>Sympatric</td> </tr> <tr> <td>Adaptation</td> <td>Reproductive isolation</td> </tr> <tr> <td>Selective pressure</td> <td>Common ancestor</td> </tr> <tr> <td>Genetic drift</td> <td>Phylogeny/phylogenetic</td> </tr> <tr> <td>Gene flow</td> <td>tree</td> </tr> <tr> <td>Bottleneck effect</td> <td>clade/cladogram</td> </tr> <tr> <td>Founder effect</td> <td>Homologous structure</td> </tr> <tr> <td>Population genetics</td> <td>Analogous structure</td> </tr> <tr> <td>Allele frequency</td> <td>Vestigial structure</td> </tr> <tr> <td>Hardy-Weinberg equilibrium</td> <td>Molecular evolution</td> </tr> <tr> <td>Speciation</td> <td></td> </tr> </table>	Natural selection	Species	Artificial selection	Allopatric	Fitness	Sympatric	Adaptation	Reproductive isolation	Selective pressure	Common ancestor	Genetic drift	Phylogeny/phylogenetic	Gene flow	tree	Bottleneck effect	clade/cladogram	Founder effect	Homologous structure	Population genetics	Analogous structure	Allele frequency	Vestigial structure	Hardy-Weinberg equilibrium	Molecular evolution	Speciation		<ul style="list-style-type: none"> <li>• Campbell Biology In Focus Chapters 18-23</li> <li>• AP Classroom Unit 7</li> </ul>
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Speciation																											
<p><b>Opportunities for Interdisciplinary Connections:</b></p>	<p><b>Anticipated misconceptions:</b></p>																										
<ul style="list-style-type: none"> <li>• Math (algebra, statistics)</li> <li>• Anatomy and Physiology</li> </ul>	<ul style="list-style-type: none"> <li>• Individuals don't evolve, populations do (over many generations).</li> <li>• Organisms do not evolve because they need or want to, nor does life progress toward "perfect"---rather, changes happen because of random mutations that happen to be beneficial to survival and reproduction within the context of that population's ecosystem.</li> <li>• "Fittest" does not mean "strongest" in the context of natural selection, but rather the most successful at reproduction of surviving offspring.</li> <li>• Adaptations must be heritable to be relevant to evolution; acquired traits cannot be passed to the next generation so they are not considered adaptations.</li> <li>• Adaptations are environment-specific. Traits that are "good" in one environment might be a detriment to survival in another.</li> <li>• Not all changes in populations are because of natural selection, but rather random changes in allele frequency can occur as well (genetic drift).</li> <li>• Small and large populations do not evolve the same way (especially due to bottlenecks and founder effects), and not all evolution occurs at the same pace.</li> <li>• Humans did not "evolve from monkeys" but rather humans and modern primates share a recent common ancestor.</li> <li>• A theory is not just a guess, but rather it is a</li> </ul>																										

	well-supported explanation backed by a tremendous amount of supporting and corroborating evidence.
<b>Connections to Prior Units:</b>	<b>Connections to Future Units:</b>
<p>Unit 7: Natural Selection is the unifying theme of biology, directly connecting the molecular processes of the cell to the patterns observed in nature. It depends on heritable variation, drawing directly from the mechanisms introduced in Unit 5 (Heredity) and Unit 6 (Gene Expression), where mutations and crossing over generate the variation upon which selection acts. The unit also relies on Unit 4 (Cell Cycle), as the frequency of reproduction (and therefore fitness) is linked to the rate of cell division. Understanding how organisms adapt requires knowledge of metabolic pathways (Unit 3: Energetics) and cell structures (Unit 2) that provide different functional efficiencies.</p> <p>The environmental pressures discussed in Pre-Work: Ecology (predation, resource availability, competition) are the selective agents that drive evolutionary change, shaping the distribution, abundance, and interactions of species in an ecosystem.</p>	None
<b>Differentiation through <a href="#">Universal Design for Learning</a></b> <b>Learning Targets and Teacher Actions</b>	
<b>Learning Target 1:</b> <ul style="list-style-type: none"> <li>Representation: Provide the four key postulates of natural selection (variation, inheritance, overproduction, differential survival/reproduction) in a sequential checklist or flow chart. Use a real-world case study like the peppered moth or antibiotic resistance to illustrate the process.</li> <li>Action/Expression: Students can write a detailed explanation of how a specific trait (e.g., a long giraffe neck) became prevalent in a population, using all four postulates. They could also create a short narrative from the perspective of an individual organism, explaining its struggle for existence.</li> <li>Engagement: Use a simulation or game where students "act" as the selective pressure, making choices that determine which traits survive and reproduce over generations.</li> </ul>	
<b>Learning Target 2:</b> <ul style="list-style-type: none"> <li>Representation: Use case studies (written and visual) on both positive and negative human impacts, specifically contrasting artificial selection (e.g., dog breeding, crop modification) with effects like habitat fragmentation or overharvesting.</li> <li>Action/Expression: Students can design a public service announcement (PSA) warning against a human activity that decreases genetic diversity (e.g., monoculture farming). They could also write a comparative analysis of natural vs. artificial selection, focusing on the selection criteria.</li> <li>Engagement: Engage students in a debate on the ethical implications of genetic engineering or selective breeding, focusing on the risks of reducing genetic variation.</li> </ul>	
<b>Learning Target 3:</b> <ul style="list-style-type: none"> <li>Representation: Clearly define and provide examples for Genetic Drift (specifically the bottleneck effect and the founder effect) and Gene Flow. Use a visual analogy like marbles being randomly drawn from a bag to demonstrate the chance events in genetic drift.</li> <li>Action/Expression: Students can analyze two different population scenarios (one a bottleneck, one a founder effect) and explain the long-term impact on allele frequencies. They could also model the concept of gene flow between two populations using visual manipulatives.</li> <li>Engagement: Introduce a historical disaster scenario (e.g., a massive flood or disease) and have students predict the impact on the remaining genetic diversity of a small, isolated population.</li> </ul>	
<b>Learning Target 4:</b> <ul style="list-style-type: none"> <li>Representation: Provide graphs illustrating different modes of selection (directional, stabilizing, and disruptive) and explain how each changes the allele and phenotype frequencies of a population over time. Define the term microevolution as change in allele frequency.</li> <li>Action/Expression: Students can be given a specific environmental pressure (e.g., an extremely cold winter) and asked to sketch or describe the expected shift in the frequency distribution of a trait (e.g., fur thickness).</li> </ul>	

- Engagement: Use a "Trait Tracker" activity where students follow the frequency of a certain allele in a virtual population as various selective pressures are introduced.

**Learning Target 5:**

- Representation: Provide the two Hardy-Weinberg equations along with a scaffolded template for applying them. Clearly list the five conditions required for a population to be in non-evolving equilibrium.
- Action/Expression: Students can solve calculation problems to determine allele and genotype frequencies. They could also write a justification for why Hardy-Weinberg is considered a "null hypothesis" in evolutionary studies.
- Engagement: Challenge students to analyze a real population's data and determine if it is currently evolving, using the Hardy-Weinberg equations to identify which condition for equilibrium is likely being violated.

**Learning Target 6:**

- Representation: Provide a comparison matrix summarizing the major lines of evidence: Fossil Record, Biogeography, Comparative Anatomy (homologous vs. analogous structures), Comparative Embryology, and Molecular Biology protein sequence comparisons). Use simple analogies to explain homologous structures.
- Action/Expression: Students can choose one line of evidence and create a visual report or presentation highlighting three specific examples that support the theory of descent with modification. They could also write an analytical essay arguing which type of evidence provides the strongest support for common ancestry.
- Engagement: Use a "Mystery Box" activity where students examine different "artifacts" (pictures of bones, DNA sequences, geographic maps) and must deduce which line of evidence they represent.

**Learning Target 7:**

- Representation: Clearly define speciation and differentiate between the two main modes: allopatric (geographic separation) and sympatric (no geographic separation). Provide a flowchart detailing the role of reproductive isolation in preventing gene flow.
- Action/Expression: Students can create a short story or scenario illustrating how a single population of birds could evolve into two distinct species via allopatric speciation (e.g., separated by a new mountain range). They could also compare and contrast prezygotic vs. postzygotic barriers.
- Engagement: Use a map analysis task where students identify natural geographic barriers that could potentially lead to allopatric speciation in different regions of the world.

**Learning Target 8:**

- Representation: Use a visual comparison to contrast the rates of evolution: gradualism (slow, steady change) versus punctuated equilibrium (long periods of stasis interrupted by rapid change). Explain how ecological factors like a stable environment versus sudden environmental shifts drive these different rates.
- Action/Expression: Students can sketch two phylogenetic trees, one representing gradualism and one representing punctuated equilibrium, labeling the axes and nodes to explain the difference in rate. They could also write an argument supporting which model better explains the origin of human evolution.
- Engagement: Analyze the fossil record for examples that support one model over the other, encouraging students to interpret empirical data.

**Learning Target 9:**

- Representation: Use hypothetical scenarios comparing two populations: one with high genetic diversity (many alleles) and one with low diversity (few alleles). Show how a new environmental pressure (e.g., a new disease or change in temperature) affects each population differently.
- Action/Expression: Students can write a formal paragraph explaining the evolutionary advantage of high genetic diversity, using terms like "buffering capacity" and "adaptation potential." They could also create a graph showing the relationship between genetic diversity and extinction risk.
- Engagement: Use a current event case study (e.g., the low genetic diversity in cheetahs or the Tasmanian devil) to discuss the real-world vulnerability of species with restricted gene pools

**Supporting Multilingual/English Learners ( [CELP standards](#) )**

**Differentiated Learning Targets**

	<b>Emerging</b>	<b>Bridging</b>	<b>Expanding</b>
<b>LT 1</b>	I can name the four basic steps of natural selection (e.g., variation, selection) and state that it leads to better survival.	I can analyze and construct a detailed explanation of how the four principles of natural selection (variation, inheritance, overproduction, differential survival/reproduction) interact to drive adaptive evolution in a specific environment.	I can describe the four main tenets of natural selection and explain how a species with an advantageous trait will have a better chance of survival and reproduction in a specific environment.

<b>LT 2</b>	I can identify two ways people change animals/plants (e.g., hunting, breeding) and state that it makes them less diverse.	I can analyze and justify the long-term impacts of human activities (e.g., habitat fragmentation, over-harvesting, or artificial selection) on a population's genetic diversity and its future evolutionary potential.	I can describe both artificial selection (selective breeding) and human-caused environmental changes, and explain how each can quickly increase or decrease the genetic diversity of a population.
<b>LT 3</b>	I can name two random events (e.g., fire, flood) and state that they change the genes in a population by chance.	I can compare and contrast the effects of different forms of genetic drift (bottleneck and founder effect) and analyze and explain how these random events disproportionately impact the genetic makeup of small populations.	I can describe the mechanisms of genetic drift and gene flow and explain how these random processes lead to non-adaptive changes in a population's allele frequencies.
<b>LT 4</b>	I can define evolution and state that a population's traits change over many years.	I can analyze and explain the definition of evolution in terms of changes in allele frequencies over generations, detailing how microevolutionary forces (selection, drift, etc.) contribute to this change.	I can describe how the percentage of different traits (or alleles) in a population can increase or decrease over time, and explain that this change is the definition of evolution.
<b>LT 5</b>	I can identify that the Hardy-Weinberg formula can predict if a population is not changing (not evolving).	I can calculate and interpret allele (p,q) and genotype ( $p^2, 2pq, q^2$ ) frequencies in a population, analyzing whether the population is in equilibrium and justifying which assumption of H-W is being violated if it is not.	I can state the Hardy-Weinberg equation ( $p+q=1$ and $p^2+2pq+q^2=1$ ) and explain what p and q represent in terms of allele frequencies.
<b>LT 6</b>	I can name two types of evidence (e.g., fossils, DNA) and state that they show animals change over time.	I can analyze and evaluate multiple lines of evidence (e.g., comparative embryology, molecular data, biogeography) and construct a detailed argument explaining how they collectively support the theory of descent with modification and common ancestry.	I can describe the evidence provided by the fossil record and homologous structures, and explain how these data points suggest a common ancestor and evolutionary relationships.
<b>LT 7</b>	I can define species and state that a new species forms when two groups of animals cannot reproduce anymore.	I can analyze and explain the different forms of reproductive isolation (pre-zygotic and post-zygotic) and justify how these mechanisms lead to the divergence of populations and the formation of new species (speciation).	I can describe the condition of geographic isolation and explain how the lack of gene flow between two isolated populations allows them to diverge and potentially form a new species.
<b>LT 8</b>	I can state that evolution can happen slowly or quickly and that the environment affects the speed.	I can compare and contrast the models of gradualism and punctuated equilibrium, and analyze how differing ecological conditions (e.g., stable vs. rapidly changing) drive different rates and patterns of speciation.	I can describe the two general paces of evolution (fast and slow) and explain how sudden environmental changes can lead to a rapid rate of speciation.
<b>LT 9</b>	I can identify that a population with more types of genes is safer when the environment changes.	I can analyze and evaluate the relationship between high genetic diversity and population fitness, justifying why diverse populations are more resilient to major environmental changes or disease outbreaks.	I can describe what genetic diversity is and explain how a population with many different alleles is more likely to have individuals with traits that allow them to survive a new environmental pressure.
<b>Lesson Sequence</b>	<b>Learning Target</b>	<b>Success Criteria/Assessment/Resources</b>	
1	<b>Learning Target 1</b> I can describe the causes and effects of natural selection according to Darwin's theory.	<ul style="list-style-type: none"> <li>I can explain how competition for limited resources results in differential survival and reproduction of offspring, which in turn influences the phenotypes of subsequent generations.</li> <li>I can compare biotic and abiotic environmental factors and explain how they can affect the rate and direction of evolution.</li> </ul>	

		<ul style="list-style-type: none"> <li>I can describe the importance of phenotypic variation in a population.</li> <li>I can explain how variation in molecules within cells connects to the fitness of an organism.</li> </ul>
2	<b>Learning Target 2</b> I can explain how humans can affect diversity within a population.	<ul style="list-style-type: none"> <li>I can describe how humans affect variation in other species through artificial selection.</li> </ul>
3	<b>Learning Target 3</b> I can explain how random occurrences affect the genetic makeup of a population.	<ul style="list-style-type: none"> <li>I can explain how evolution is driven not only by natural selection, but also by random occurrences and genetic drift.</li> <li>I can describe how the bottleneck effect, founder effect, and migration affect allele frequencies in a population.</li> </ul>
4	<b>Learning Target 4</b> I can describe the change in the genetic makeup of a population over time.	<ul style="list-style-type: none"> <li>I can explain how changes in allele frequencies provide evidence for the occurrence of evolution in a population.</li> <li>I can explain how evolution is an ongoing process in all living organisms.</li> </ul>
5-6	<b>Learning Target 5</b> I can use the Hardy-Weinberg Equilibrium model to describe and predict allele frequencies in non-evolving populations.	<ul style="list-style-type: none"> <li>I can identify the conditions for a population or allele to be in Hardy-Weinberg equilibrium and use them to provide a null hypothesis.</li> </ul>
7	<b>Learning Target 6</b> I can describe the types of data that provide evidence for evolution.	<ul style="list-style-type: none"> <li>I can explain how morphological and geological data provide evidence that organisms have changed over time, including from fossils, vestigial structures, and morphological homologies.</li> <li>I can explain how the comparison of DNA nucleotide sequences and protein amino acid sequences from both extant and extinct organisms provide biochemical evidence for evolution and common ancestry.</li> <li>I can describe structural and functional evidence indicating common ancestry of all eukaryotes, including membrane-bound organelles, linear chromosomes, and genes that include introns.</li> <li>I can use phylogenetic trees and cladograms to show and infer evolutionary relatedness.</li> <li>I can describe the scientific evidence that supports models of the origin of life on earth.</li> </ul>
8	<b>Learning Target 7</b> I can describe the conditions under which new species may arise.	<ul style="list-style-type: none"> <li>I can define speciation and identify what makes one species different from another.</li> </ul>
9	<b>Learning Target 8</b> I can describe the rate and driving processes of evolution and speciation under different ecological conditions.	<ul style="list-style-type: none"> <li>I can define and compare punctuated equilibrium and gradualism.</li> <li>I can define and compare divergent and convergent evolution.</li> <li>I can define and compare sympatric and allopatric speciation.</li> </ul>
10	<b>Learning Target 9</b> I can explain how the genetic diversity of a species or population affects its ability to withstand environmental pressures.	<ul style="list-style-type: none"> <li>I can describe how and why species and populations with little genetic diversity are at risk of decline or extinction while genetically diverse populations are more resilient to environmental perturbation.</li> <li>I can explain how the adaptiveness of an allele is environment-specific due to different selective pressures.</li> </ul>

Course Title:	Content Area:	Grade Level:	Credit (if applicable)
ECE Biology - UConn 1107	Biology	11-12	4
<b>Course Description:</b>			
<p>UConn Biology is designed to provide a foundation for more advanced courses in Biology and related sciences. This course will acquaint students with scientific thought, observation, experimentation, and formal hypothesis testing, and enable students to consider the impact that developments in science and technology have on the nature and quality of life. Topics covered include molecular and cell biology, animal anatomy and physiology. Lab exercises include dissection of preserved animals.</p>			
<p>Upon completion of this course, the student should be able to:</p>			
<ol style="list-style-type: none"> <li>1. Examine the underlying principle that structure leads to function in living systems and how our understanding of this physiology can enable human beings to more efficiently address modern societal issues.</li> <li>2. Describe current methods used in biotechnology, such as Gel Electrophoresis, and how it would be used to gain scientific or technical knowledge.</li> <li>3. Explain the conceptual basis of the Scientific Method, including its definition, motivation, steps of application, hypothesis testing, and misapplications.</li> <li>4. Analyze published articles from scientific journals to discern integrity of scientific claims</li> </ol>			
<p>UConn Early College Experience (UConn ECE) provides students with the opportunity to take university courses while in high school. These challenging courses allow students to preview college work, build confidence in their readiness for college, and earn college credits that provide both an academic and a financial head start on a college degree and other post-secondary opportunities. UConn ECE Instructors are high school teachers certified by the University and affiliated with their corresponding academic department. UConn ECE Instructors foster independent learning, creativity, and critical thinking - all important for success in college and careers. Bristol Public Schools offers UConn courses in many disciplines. To support rigorous learning, University of Connecticut academic resources, including library and online classroom access, are available to all UConn ECE Students.</p>			
<p>Adapted from: <a href="https://biosci.clas.uconn.edu/courses/course/BIOL/1107/">https://biosci.clas.uconn.edu/courses/course/BIOL/1107/</a> and <a href="https://ece.media.uconn.edu/wp-content/uploads/sites/2571/2020/02/BIOL-Spring-2019-Syllabus-1107_Final.pdf">https://ece.media.uconn.edu/wp-content/uploads/sites/2571/2020/02/BIOL-Spring-2019-Syllabus-1107_Final.pdf</a></p>			
<b>Aligned Core Resources:</b>		<b>Connection to the <i>BPS Vision of the Graduate</i></b>	
<ul style="list-style-type: none"> <li>• <a href="#">Campbell Biology in Focus (Urry, Cain, et al) (Pearson 2025)</a></li> <li>• UConn, Storrs publishes its own laboratory manuals for Biology 1107</li> </ul>		<p>The ECE program will provide students with a pathway to meet the Bristol Public School's vision of the graduate through advanced learning opportunities such as:</p> <ul style="list-style-type: none"> <li>• Problem solving</li> <li>• Critical thinking</li> <li>• Effective Communication</li> </ul> <p>The Science Practice Standards support the VOG Skills:</p> <ul style="list-style-type: none"> <li>• Science Practice 1: Effective Communication</li> <li>• Science Practice 2: Critical Thinking</li> <li>• Science Practice 3: Problem Solving</li> <li>• Science Practice 4: Effective Communication</li> <li>• Science Practice 5: Critical Thinking</li> <li>• Science Practice 6: Effective Communication</li> </ul>	
<b>Additional Course Information:</b>		<b>Link to <i>Completed Equity Audit</i></b>	
<p><b>Knowledge/Skill Dependent courses/prerequisites</b></p> <p><b>PREREQUISITES</b></p> <ul style="list-style-type: none"> <li>• Precalculus ACC taken concurrently or permission of instructor</li> <li>• Biology ACC - Minimum final grade of 83 or Biology ACA - Minimum final grade of 93</li> <li>• Biology ACC may be taken concurrently for grade 10 students with instructor permission if a final average of 83 was earned in Physical Science ACC.</li> </ul>		<p><a href="#">Equity Curriculum Review Audit - ECE/AP Bio (2025)</a></p>	

**Standard Matrix**

<u>Standard</u>	<b>Unit 1</b>	<b>Unit 2</b>	<b>Unit 3</b>	<b>Unit 4</b>
<b>Science Practice 1:</b> Explain biological concepts, processes, and models presented in written format.	✓	✓	✓	✓
<b>Science Practice 2:</b> Analyze visual representations of biological concepts and processes.		✓	✓	✓
<b>Science Practice 3:</b> Determine scientific questions and methods.	✓			
<b>Science Practice 4:</b> Represent and describe data	✓	✓	✓	✓
<b>Science Practice 5:</b> Perform statistical tests and mathematical calculations to analyze and interpret data.	✓		✓	
<b>Science Practice 6:</b> Develop and justify scientific arguments using evidence.		✓	✓	✓
<b>Big Idea 1: Evolution (EVO)</b> The process of evolution drives the diversity and unity of life.				✓
<b>Big Idea 2: Energetics (ENE)</b> Biological systems use energy and molecular building blocks to grow, reproduce, and maintain dynamic homeostasis		✓		
<b>Big Idea 3: Information Storage and Transmission (IST)</b> Living systems store, retrieve, transmit, and respond to information essential to life processes.		✓	✓	
<b>Big Idea 4: Systems Interactions (SYI)</b> Biological systems interact, and these systems and their interactions exhibit complex properties	✓	✓	✓	✓

**Unit Links**

[Unit 1: Cell Biology and Biochemistry](#)

[Unit 2: Genetics and Molecular Biology](#)

[Unit 3: Animal Physiology and Homeostasis](#)

[Unit 4: Evolution](#)

<b>Unit Title:</b>		
Unit 1: Cell Biology and Biochemistry		
<b>Relevant Standards:</b>		
<b>Big Idea 1: Evolution (EVO)</b> The process of evolution drives the diversity and unity of life.		
<b>Science Practice 1:</b> Explain biological concepts, processes, and models presented in written format.		
<b>Science Practice 3:</b> Determine scientific questions and methods.		
<b>Science Practice 4:</b> Represent and describe data		
<b>Science Practice 5:</b> Perform statistical tests and mathematical calculations to analyze and interpret data.		
<b>Essential Question(s):</b>		<b>Enduring Understanding(s):</b>
<ul style="list-style-type: none"> <li>How is function tied to form at the cellular and molecular levels?</li> <li>What fundamental chemical rules govern all life processes?</li> <li>How do cells coordinate their complex activities in a multicellular organism?</li> <li>If a single component in a signaling pathway is altered, how does this ripple effect impact the ultimate cellular response?</li> </ul>		<ul style="list-style-type: none"> <li>Biological systems are built on a hierarchical structure where structure dictates function.</li> <li>Life processes fundamentally obey the laws of chemistry and physics.</li> <li>Communication is essential for the survival and coordination of both single cells and multicellular organisms.</li> <li>Changes in molecular structure, no matter how small, can drastically alter the outcome of a biological process.</li> </ul>
<b>Demonstration of Learning:</b>		<b>Pacing for Unit</b>
<ul style="list-style-type: none"> <li>Laboratory investigations, experiments, and reports</li> <li>Written &amp; oral explanations in collaborative settings</li> <li>Unit Quizzes and Tests</li> </ul>		Approximately 15 Class Periods and 2 Lab Days
<b>Family Overview</b>		<b>Integration of Technology:</b>
<ul style="list-style-type: none"> <li><a href="#">Family Overview: UConn ECE Biology (English)</a></li> <li><a href="#">Family Overview: UConn ECE Biology (Spanish)</a></li> </ul>		<ul style="list-style-type: none"> <li>Virtual Labs &amp; 3D Modeling: Simulate complex cellular processes (e.g., photosynthesis, diffusion) using platforms (PhET, Labster, Gizmos). Explore structures in detail with 3D models (Visible Body, Merge EDU) and molecular modeling software.</li> <li>Data Processing: Record, analyze, and visualize experimental data using software like Google Sheets, Excel, or specialized graphing programs.</li> <li>Digital Observation &amp; Sharing: Capture real-time observations with digital microscopes or smartphone adapters. Facilitate sharing of reports, maps, and projects using collaboration platforms (Google Classroom, Padlet).</li> </ul>
<b>Unit-specific Vocabulary:</b>		<b>Aligned Unit Materials, Resources, and Technology (beyond core resources):</b>
Element	Carbonyl group	None
Compound	Carboxyl group	
Atom	Amino group	
Proton	Sulfhydryl group	
Neutron	Phosphate group	
Electron	Methyl group	
Atomic number	ATP (adenosine triphosphate)	
Mass number	Macromolecule	
Isotope	Monomer	
Valence shell		

Valence electrons	Polymer
Covalent bond	Dehydration reaction
Ionic bond	Hydrolysis
Electronegativity	Carbohydrate
Hydrogen bond	Monosaccharide
Van der Waals interactions	Disaccharide
Polar molecule	Polysaccharide
Cohesion	Lipid
Adhesion	Fat
Surface tension	Phospholipid
Specific heat	Steroid
Evaporative cooling	Saturated fat
Hydrophilic	Unsaturated fat
Hydrophobic	Protein
Solution	Amino acid
Solvent	Peptide bond
Solute	Polypeptide
pH scale	Primary structure
Acid	Secondary structure
Base	Tertiary structure
Buffer	Quaternary structure
Organic chemistry	Denaturation
Hydrocarbon	Nucleic acid
Isomer	DNA
Structural isomer	RNA nucleotide
Cis-trans isomer	Sugar-phosphate backbone
Enantiomer	
Functional group	Nitrogenous base
Hydroxyl group	

Opportunities for Interdisciplinary Connections:	Anticipated misconceptions:
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<p><b>Chemistry</b> Underpins molecular structures, bonding, reactions, and macromolecule formation.</p> <p><b>Physics</b> Explains energy transfer, thermodynamics, and molecular motion.</p> <p><b>Mathematics</b> Supports quantitative analysis, data interpretation, and experimental design.</p> <p><b>Computer science/technology</b> Enables modeling, bioinformatics, and visualization of molecules, DNA sequences, and cellular processes.</p> <p><b>Earth and environmental sciences</b> Connect biological systems to climate, biogeochemical cycles, water distribution, and carbon cycling, demonstrating how life interacts with global systems.</p>	<ul style="list-style-type: none"> <li>• Atoms in a compound retain their individual properties (they do not).</li> <li>• Electrons orbit the nucleus in fixed circular paths like planets (modern models use probability clouds).</li> <li>• Covalent bonds are always stronger than ionic bonds (depending on the environment, ionic bonds weaken in water).</li> <li>• All atoms of an element are identical (isotopes exist).</li> <li>• Hydrogen bonds occur only in water (they can form in many biological molecules).</li> <li>• Hydrogen bonds are the same as covalent bonds (they are much weaker and form between molecules).</li> <li>• Water is always neutral and cannot vary in pH (it can self-ionize slightly).</li> <li>• Ice is denser than liquid water (it's actually less dense, which allows ice to float).</li> <li>• Cohesion and adhesion are the same process.</li> <li>• Hydrophobic substances "repel" water with force (they simply do not form hydrogen bonds with it).</li> <li>• All molecules containing carbon are organic (CO<sub>2</sub> and carbonates are exceptions).</li> <li>• Carbon can only form single bonds (it can form single, double, or triple bonds).</li> <li>• Functional groups don't affect molecular behavior (they determine chemical properties).</li> <li>• Isomers have the same properties since they have the same formula (structure determines function).</li> <li>• ATP "stores energy in its bonds" like a battery (energy</li> </ul>
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	<p>is released when bonds are rearranged, not simply broken).</p> <ul style="list-style-type: none"> <li>• All macromolecules are polymers (lipids are not true polymers).</li> <li>• Dehydration and hydrolysis are the same process (they are opposites).</li> <li>• Proteins are functional immediately after being synthesized (they must fold properly first).</li> <li>• Denaturation breaks peptide bonds (it disrupts shape, not the covalent backbone).</li> <li>• DNA and RNA have the same function (DNA stores genetic information; RNA carries it and plays multiple roles).</li> <li>• Carbohydrates are only for energy (they also serve structural and signaling functions).</li> </ul>
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Connections to Prior Units:	Connections to Future Units:
<p>This unit builds upon the subject matter covered in accelerated biology</p> <p><b>Introduction to Biology / Scientific Practices</b> Unit 1 builds on foundational skills in scientific inquiry, data collection, and lab techniques introduced in the introductory unit. Students apply observation, measurement, graphing, and experimental design skills to investigate cells and molecular processes.</p> <p><b>Chemistry Foundations</b> Concepts from students' previous chemistry course (atomic structure, bonding, hydrogen bonding, and chemical reactions) underpin understanding of biomolecules and cellular chemistry. Knowledge of acids, bases, pH, and solution chemistry helps students understand enzyme activity, protein structure, and cellular processes.</p> <p><b>Energy and Matter in Biological Systems</b> Students use prior understanding of energy and matter to explore how cells capture, store, and transform energy in biochemical reactions. Conservation of matter and energy principles support analysis of molecular interactions, enzyme activity, and metabolic pathways.</p> <p><b>Foundational Biology Vocabulary</b> Key terms such as molecule, atom, energy, and reaction are reinforced and expanded to include macromolecules, organelles, and cellular processes.</p>	<p>Unit 1 provides the foundational knowledge necessary for understanding later units in the course. Concepts such as biomolecules, molecular interactions, and enzyme function prepare students to explore energy transformations in Unit 3 (Cellular Energetics), including photosynthesis and cellular respiration. Similarly, DNA, RNA, and protein structure and function introduced in Unit 1 are essential for studying gene expression, transcription, translation, and inheritance in Unit 4 (Genetics and Molecular Biology). Knowledge of membrane structure and molecular interactions also sets the stage for future exploration of cell signaling, homeostasis, and feedback mechanisms.</p> <p>Additionally, the laboratory and research skills developed in Unit 1 are applied across future units, including investigations in metabolism, genetics, and biotechnology. Biochemical foundations such as energy flow and molecular interactions also connect to ecological and evolutionary concepts, helping students understand how cellular processes influence populations, ecosystems, and adaptations.</p>

**Differentiation through *Universal Design for Learning***  
**Learning Targets and Teacher Actions**

	Engagement	Representation	Action & Expression
<b>LT 1</b>	<p>Challenge students to research a disease or condition linked to a malfunctioning organelle to establish relevance.</p> <p>Offer choice in exploration: a virtual lab, a reading, or a video documentary.</p> <p>Facilitate small group "Organelle Expert" sessions where groups teach one organelle to the class.</p>	<p>Offer diagrams, 3D models, and animations to demonstrate structure and function.</p> <p>Use metaphors and analogies (e.g., the cell as a factory or city) to connect functions to familiar concepts.</p> <p>Provide text descriptions in varied formats (digital, printed, audio-recorded).</p>	<p>Allow students to demonstrate knowledge by: drawing/labeling, building a 3D model, creating a presentation, or writing a detailed explanatory paragraph.</p> <p>Provide a variety of scaffolding/supports (checklists, graphic organizers, sentence starters) for describing function.</p>

<b>LT 2</b>	Start with a brief, intriguing story or video about a rapid body response (like "fight or flight") to pique interest. Use a sorting or matching game where students match the communication type to its description and example.	Use labeled diagrams and flowcharts to illustrate the different types of cell signaling (paracrine, endocrine, autocrine, direct contact). Provide real-world examples for each type (e.g., synaptic signaling, hormones in the bloodstream).	Have students create a storyboard or a short skit demonstrating the process of each communication type. Offer a template for a comparison chart to describe the four main ways cells communicate.
<b>LT 3</b>	Use a "Cell Mail Carrier" simulation/activity where students act as signaling molecules, demonstrating short (local) vs. long (systemic) delivery. Encourage peer discussion on which method is faster/slower and why (promoting self-regulation).	Use a visual continuum or scale to represent distance (from direct contact to long-distance endocrine signaling). Explicitly use consistent vocabulary and provide a glossary of terms related to distance and signaling mechanisms.	Ask students to write an analogy or metaphor explaining the difference between short- and long-distance signaling (e.g., a text message vs. a package). Require students to draw a concept map linking the different mechanisms based on distance and speed.
<b>LT 4</b>	Have students build a physical model of the pathway components using everyday objects (e.g., a tennis ball for a ligand, a bucket for a receptor). Use "jigsaw" activities where groups specialize in one component and teach it to others.	Break the pathway down into the three distinct stages: Reception, Transduction, and Response. Provide a simple, clear graphic organizer or labeled diagram of a generic pathway, clearly naming the ligand, receptor, relay molecules, and effector protein	Students can create a "How-To" guide for the pathway, outlining each component's role. Offer multiple-choice or drag-and-drop activities to assess component identification.
<b>LT 5</b>	Use a case study (e.g., epinephrine/adrenaline signaling) to show how the pathway components actually work together in a real-world scenario. Implement an interactive quiz/poll where students predict the outcome if one component is missing or mutated.	Use an animation that highlights what changes in each component (e.g., the receptor changing shape, relay molecules being activated/phosphorylated). Provide a key/legend that shows the function of common components (e.g., kinases, second messengers).	Students annotate a diagram of a pathway, focusing on describing the action (verb) of each component. Use a verbal explanation or a short video recording to describe the sequence of events.

**Supporting Multilingual/English Learners (CELP standards)**  
**Differentiated Learning Targets**

	<b>Emerging</b>	<b>Expanding</b>	<b>Bridging</b>
<b>LT1</b>	I can describe one or two key features of a few common subcellular components using simple sentences and basic science vocabulary, with prompting and support.	I can describe the structure and function of multiple subcellular components and organelles using facts and relevant details, employing general academic and content-specific vocabulary.	I can coherently describe the structure and function of organelles, comparing or analyzing their interdependent roles using a wide variety of complex, precise vocabulary.
<b>LT2</b>	I can state a limited relationship between a basic chemistry concept and a simple life process using simple sentences and basic science vocabulary, with prompting and support.	I can relate multiple basic chemistry and biochemistry concepts to life processes by providing a reasoned explanation supported by specific details and content-specific vocabulary.	I can explain and evaluate how changes in chemistry/biochemistry affect life processes, presenting a coherent analysis using a wide variety of complex, precise vocabulary.
<b>LT3</b>	I can identify one or two key terms related to cell communication (e.g., ligand, receptor) and use simple sentences to provide a very limited explanation, with prompting and support.	I can explain the mechanism of cell communication over both short and long distances, using a structured response and providing specific details and content-specific vocabulary.	I can provide a coherent, detailed analysis that explains and compares different cell communication mechanisms, utilizing a wide variety of complex, precise vocabulary.

<b>LT4</b>	I can list a few major components of a pathway using simple sentences and basic science vocabulary, with prompting and support.	I can describe all key components of a signal transduction pathway, using specific facts and relevant details and employing general academic and content-specific vocabulary.	I can provide a detailed description of the components, including a precise analysis of their structural relationships, utilizing a wide variety of complex, precise vocabulary.
<b>LT5</b>	I can state the basic action of one or two pathway components using simple sentences and basic science vocabulary, with prompting and support.	I can describe the roles of multiple components of the pathway and how they lead to the cellular response, providing specific details and employing general academic and content-specific vocabulary.	I can provide a coherent, detailed analysis of the entire pathway, describing the precise role of each component and evaluating their sequential actions, utilizing a wide variety of complex, precise vocabulary.

<b>Lesson Sequence</b>	<b>Learning Target</b>	<b>Success Criteria</b>	<b>Assessment</b>
1-3	<b>Learning Target 1</b> I can describe the structure and/or function of subcellular components and organelles.	I can... <ul style="list-style-type: none"> <li>Describe how ribosomes comprise ribosomal RNA (rRNA) and protein. Ribosomes synthesize protein according to mRNA sequence.</li> <li>Explain how ribosomes are found in all forms of life, reflecting the common ancestry of all known life.</li> <li>Explain how endoplasmic reticulum (ER) occurs in two forms—smooth and rough. Rough ER is associated with membrane-bound ribosomes— <ol style="list-style-type: none"> <li>Rough ER compartmentalizes the cell.</li> <li>Smooth ER functions include detoxification and lipid synthesis.</li> </ol> </li> <li>Explain how golgi complex is a membrane-bound structure that consists of a series of flattened membrane sacs— <ol style="list-style-type: none"> <li>Functions of the Golgi include the correct folding and chemical modification of newly synthesized proteins and packaging for protein trafficking.</li> <li>Mitochondria have a double membrane. The outer membrane is smooth, but the inner membrane is highly convoluted, forming folds.</li> <li>Lysosomes are membrane-enclosed sacs that contain hydrolytic enzymes.</li> <li>A vacuole is a membrane-bound sac that plays many and differing roles. In plants, a specialized large vacuole serves multiple functions.</li> <li>Chloroplasts are specialized organelles that are found in photosynthetic algae and plants. Chloroplasts have a double outer membrane.</li> </ol> </li> </ul>	Model project- trace the path of a protein being synthesized.
4-6	<b>Learning Target 2</b> I can relate basic chemistry and biochemistry to life processes.	I can... <ul style="list-style-type: none"> <li>Identify the four major classes of biomolecules based on their chemical structures or descriptions.</li> <li>Explain how monomers are assembled into polymers (and vice versa) through</li> </ul>	Calorimetry lab

		<p>dehydration synthesis and hydrolysis reactions.</p> <ul style="list-style-type: none"> <li>• Relate the structure of a given biomolecule (e.g., enzyme, cell membrane component) to its specific function in the cell.</li> <li>• Explain the basic principles of energy flow (e.g., laws of thermodynamics) as they relate to cellular chemical reactions.</li> <li>• Distinguish between catabolic and anabolic pathways in terms of energy requirements and outcomes.</li> </ul>	
7-9	<p><b>Learning Target 3</b> I can explain how cells communicate with one another over short and long distances.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• List the ways in which cells communicate: <ul style="list-style-type: none"> <li>a. cell-to-cell contact,</li> <li>b. local regulators,</li> <li>c. or by long distances.</li> <li>d. Signal transduction may result in changes in gene expression and cell function, which may alter phenotype or result in programmed cell death (apoptosis).</li> </ul> </li> </ul>	<p>1. Written analogy or metaphor explaining the difference between short- and long-distance signaling, focusing on changes to structure and function of the molecules. 2. Create a cause-and-effect chain.</p>
10-12	<p><b>Learning Target 4</b> I can describe the components of a signal transduction pathway.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Explain how signal transduction pathways include protein modification and phosphorylation cascades.</li> <li>• Describe how signaling begins with the recognition of a chemical messenger—a ligand—by a receptor protein in a target cell— <ul style="list-style-type: none"> <li>a. The ligand-binding domain of a receptor recognizes a specific chemical messenger, which can be a peptide, a small chemical, or protein, in a specific one-to-one relationship.</li> <li>b. G protein-coupled receptors are an example of a receptor protein in eukaryotes.</li> </ul> </li> </ul>	
13-15	<p><b>Learning Target 5</b> I can describe the role of components of a signal transduction pathway in producing a cellular response and how a change in the structure of any signaling molecule affects the activity of the signaling pathway</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• List how signaling cascades relay signals from receptors to cell targets. <ul style="list-style-type: none"> <li>a. After the ligand binds, the intracellular domain of a receptor protein changes shape, initiating transduction of the signal.</li> <li>b. Second messengers (such as cyclic AMP) are molecules that relay and amplify the intracellular signal.</li> <li>c. Binding of ligand-to-ligand-gated channels can cause the channel to open or close.</li> </ul> </li> </ul>	

<b>Unit Title: Bio Energetics</b>	
Unit 2: Genetics and Molecular Biology	
<b>Relevant Standards:</b>	
<p><b>Big Idea 2: Energetics (ENE)</b> Biological systems use energy and molecular building blocks to grow, reproduce, and maintain dynamic homeostasis</p> <p><b>Big Idea 3: Information Storage and Transmission (IST)</b> Living systems store, retrieve, transmit, and respond to information essential to life processes.</p> <p><b>Big Idea 4: Systems Interactions (SYI)</b> Biological systems interact, and these systems and their interactions exhibit complex properties</p> <p><b>Science Practice 1:</b> Explain biological concepts, processes, and models presented in written format.</p> <p><b>Science Practice 2:</b> Analyze visual representations of biological concepts and processes.</p> <p><b>Science Practice 4:</b> Represent and describe data</p> <p><b>Science Practice 6:</b> Develop and justify scientific arguments using evidence.</p>	
<b>Essential Question(s):</b>	<b>Enduring Understanding(s):</b>
<ul style="list-style-type: none"> <li>• How is the organization and compartmentalization of a cell essential for life?</li> <li>• How does the specific arrangement of atoms determine the function of the molecules of life?</li> <li>• How do cells and organisms maintain the necessary dynamic balance for survival?</li> <li>• How do scientists use quantitative evidence to understand and model the invisible, dynamic processes within a cell?</li> </ul>	<ul style="list-style-type: none"> <li>• Cellular function depends on the precise location and interaction of specialized, membrane-bound components.</li> <li>• The specific structure of macromolecules, determined by their subunits and chemical bonds, dictates their unique functional roles in all biological systems.</li> <li>• Life requires the continuous, selective movement of materials across membranes, and the concentration gradients that drive this movement are crucial for energy and signaling.</li> <li>• All living systems utilize feedback mechanisms at the molecular, cellular, and organismal levels to maintain the dynamic steady state (homeostasis) essential for life.</li> </ul>
<b>Demonstration of Learning:</b>	<b>Pacing for Unit</b>
<ul style="list-style-type: none"> <li>• Laboratory investigations, experiments, and reports</li> <li>• Written &amp; oral explanations in collaborative settings</li> <li>• Unit Quizzes and Tests</li> </ul>	Approximately 24 Class Periods and 2 Lab Days
<b>Family Overview</b>	<b>Integration of Technology:</b>
<ul style="list-style-type: none"> <li>• <a href="#">Family Overview: UConn ECE Biology (English)</a></li> <li>• <a href="#">Family Overview: UConn ECE Biology (Spanish)</a></li> </ul>	<ul style="list-style-type: none"> <li>• Use PhET, HHMI BioInteractive, or Learn Genetics simulations to demonstrate DNA replication, transcription, translation, and Punnett squares. PhET simulations on osmosis/diffusion, enzyme activity; Labster virtual labs on cell biology and molecular interactions.</li> <li>• HHMI BioInteractive videos on cell structure, organelles, and biomolecular functions.</li> <li>• 3D cell and organelle models (Merge EDU, Visible Body) to visualize structures and processes.</li> <li>• Google Sheets or Excel for lab results, graphs, and quantitative analysis of enzyme kinetics or diffusion rates.</li> <li>• Google Classroom and Docs for shared lab notebooks, discussion boards, and group projects.</li> </ul>
<b>Unit-specific Vocabulary:</b>	<b>Aligned Unit Materials, Resources, and Technology (beyond core resources):</b>

Gene	Complementary base pairing	None
Trait	Replication	
Heredity	DNA polymerase	
Genetics	Helicase	
Allele	Ligase	
Dominant	Leading strand	
Recessive	Lagging strand	
Genotype	Okazaki fragments	
Phenotype	Template strand	
Homozygous	Transcription	
Heterozygous	Translation	
Purebred	mRNA (messenger RNA)	
Hybrid	tRNA (transfer RNA)	
Punnett square	rRNA (ribosomal RNA)	
Probability	Codon	
Monohybrid cross	Anticodon	
Dihybrid cross	Ribosome	
Law of Segregation	Start codon	
Law of Independent Assortment	Stop codon	
Test cross	RNA polymerase	
Chromosome	Promoter	
Chromatin	Terminator	
Homologous chromosomes	Introns	
Sister chromatids	Exons	
Diploid (2n)	Splicing	
Haploid (n)	Mutation	
Gamete	Point mutation	
Somatic cell	Frameshift mutation	
Meiosis	Gene regulation	
Crossing over	Operon (e.g., lac operon)	
Independent assortment	Genetic engineering	
Nondisjunction	Recombinant DNA	
Karyotype	Restriction enzyme	
Sex chromosomes	Gel electrophoresis	
Autosomes	DNA fingerprinting	
DNA (deoxyribonucleic acid)	Polymerase Chain Reaction (PCR)	
RNA (ribonucleic acid)	Cloning	
Nucleotide	Plasmid	
Nitrogenous base	Vector	
Adenine	Transformation	
Thymine	Genome	
Cytosine	Gene therapy	
Guanine	CRISPR-Cas9	
Uracil	Bioinformatics	
Double helix	Human Genome Project	
<b>Opportunities for Interdisciplinary Connections:</b>		<b>Anticipated misconceptions:</b>
<p><b>Chemistry</b> DNA and RNA structure involves covalent and hydrogen bonding; enzymes catalyze reactions in replication and transcription.</p> <p><b>Mathematics</b> Probability and statistics apply to inheritance patterns and genotype ratios. Use Punnett squares and chi-square analysis to test Mendelian ratios in simulated crosses.</p>		<ul style="list-style-type: none"> <li>• Each trait is controlled by a single gene.</li> <li>• Genes and chromosomes are the same thing.</li> <li>• DNA strands are made of amino acids.</li> <li>• DNA replication happens only once in a lifetime.</li> <li>• Base-pairing rules are A-G and C-T.</li> <li>• Transcription and translation are the same process.</li> <li>• tRNA carries amino acids to DNA instead of the ribosome.</li> </ul>

<p><b>Environmental Science</b> Genetic diversity supports ecosystem stability and adaptation.</p> <p><b>Language Arts / Humanities</b> Genetics raises social, ethical, and historical questions; historical contributions of Mendel and Franklin.</p> <p><b>Health &amp; Medical Science</b> Genetic knowledge is applied in medicine for diagnosis and treatment.</p>	<ul style="list-style-type: none"> <li>• Every DNA mutation changes a protein.</li> <li>• Dominant traits are always more common or stronger.</li> <li>• Heterozygotes express both traits equally.</li> <li>• All offspring show only parental traits.</li> <li>• Meiosis and mitosis are the same process.</li> <li>• Gametes have the same number of chromosomes as body cells.</li> <li>• Crossing over always produces identical gametes.</li> <li>• Genetic modification always involves adding foreign DNA.</li> </ul>
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<b>Connections to Prior Units:</b>	<b>Connections to Future Units:</b>
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<p><b>Unit 1: Cell Biology and Biochemistry</b> Builds on understanding of basic cell structure, organelles, and biomolecules. Uses foundational knowledge of macromolecules, molecular interactions, and chemical principles to explore more complex cellular processes, such as transport mechanisms, energy transfer, and enzyme activity.</p> <p><b>Introduction to Biology / Scientific Practices</b> Reinforces skills in observation, measurement, experimental design, and data analysis from Unit 1. Students apply prior lab techniques to investigate diffusion, osmosis, enzyme kinetics, and membrane function.</p> <p><b>Chemistry Foundations</b> Prior knowledge of atomic structure, chemical bonding, polarity, and solution chemistry underpins understanding of biomolecular structure and function. Concepts such as hydrogen bonding and pH are essential for exploring protein folding, enzyme activity, and cellular homeostasis.</p> <p><b>Mathematics and Data Analysis</b> Builds on graphing, quantitative reasoning, and statistical skills from earlier units to analyze lab data and model cellular processes.</p>	<p>Unit 2 helps to bridge over to genetics in Unit 3</p>
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**Differentiation through [Universal Design for Learning](#)**  
**Learning Targets and Teacher Actions**

	<b>Engagement</b>	<b>Representation</b>	<b>Action &amp; Expression</b>
<b>LT 1</b>	Recruit Interest: Students choose 3-4 organelles to "pitch" to a committee, arguing why their chosen organelles are the most essential for cell survival.	Vary Presentation: Present organelles using physical 3D models and high-resolution, color-coded diagrams to highlight structural differences.	Compose & Construct: Students can demonstrate understanding by building a model (digital or physical) of a eukaryotic cell and labeling the function of the organelles, or by writing a comparative essay.
<b>LT 2</b>	Optimize Challenge: Introduce a "Molecular Mystery" where students are given a cell's symptoms (e.g., loss of energy storage) and must diagnose which biomolecule is malfunctioning.	Highlight Relationships: Use concept maps and simplified chemical structures to show the structure-function link (e.g., the folded shape of a protein dictates its function).	Use Manipulatives: Provide molecular model kits or digital modeling software for students to physically or virtually build the monomers of two different biomolecules (e.g., amino acid and glucose).
<b>LT 3</b>	Sustain Effort: Allow students to choose the medium for their practice problems: either traditional written calculations of water potential ( $\Psi$ ) or an interactive, digital	Vary Presentation: Present the Fluid Mosaic Model using both static diagrams and a dynamic animation showing protein movement, diffusion, and active transport.	Support Planning: Provide a decision tree or flowchart guiding students to predict the direction of water movement based on given external and internal

	simulation where they control concentration gradients.		concentrations, and justify the mechanism (passive vs. active).
<b>LT 4</b>	Recruit Interest: Use the analogy of a "Cellular Factory" or an assembly line and assign students roles that correspond to the function of the ribosome, ER, and Golgi.	Highlight Patterns: Provide a clear flowchart or diagram that shows the sequential movement of a protein from the mRNA's creation to its final destination (export or membrane insertion).	Compose & Construct: Students can demonstrate understanding by drawing and annotating the entire pathway, or by writing a "travel journal" from the perspective of an exported protein detailing its processing at each organelle.
<b>LT 5</b>	Optimize Challenge: Students participate in a virtual enzyme kinetics lab where they can digitally manipulate temperature and pH and observe the effects on reaction rate and enzyme shape.	Non-Linguistic Illustrations: Use animated visuals (digital or video) to show the conformational change of the active site upon substrate binding (induced fit).	Use Manipulatives: Students use physical objects (like LEGOs) to model the binding of a substrate and the mechanism of a competitive inhibitor blocking the active site.
<b>LT 6</b>	Sustain Effort: Provide scaffolding choices for analysis: students can choose between a simpler data set requiring only graphical interpretation or a more complex one requiring Q10 calculation.	Highlight Patterns: Provide annotated example graphs of enzyme activity showing how to find the optimal pH or temperature and clearly identifying the regions of denaturation.	Support Planning & Strategy: Give students a Claim-Evidence-Reasoning (CER) template for writing conclusions, emphasizing the need to cite specific numbers from the provided tables/graphs as evidence.
<b>LT 7</b>	Recruit Interest: Begin with a scenario of cellular stress (e.g., a rapid increase in waste products) and ask students to brainstorm solutions to bring the cell "back to normal."	Non-Linguistic Illustrations: Use a clear, simple diagram of a feedback loop with visual icons for the stimulus, sensor, and response, focusing on the correcting action.	Compose & Construct: Students can demonstrate understanding by creating a labeled diagram/model of a negative feedback mechanism (e.g., pH regulation) or by writing a sequenced explanation of the process.
<b>LT 8</b>	Foster Collaboration: Assign groups to investigate one specific homeostasis system (e.g., glucose, temperature, water balance) and trace its regulation from the organismal level down to the cellular mechanism.	Highlight Relationships: Use a multi-level diagram that explicitly connects the organ system (e.g., pancreas/liver) down to the cellular level (e.g., insulin binding to a cell receptor).	Support Expression: Students write a short explanation connecting the need for ATP (from cellular respiration) to the sustained function of an entire organismal system (e.g., the sodium-potassium pump in the nervous system).

**Supporting Multilingual/English Learners ( [CELP standards](#) )  
Differentiated Learning Targets**

	<b>Emerging</b>	<b>Expanding</b>	<b>Bridging</b>
<b>LT1</b>	Use large, labeled diagrams and sentence frames to state one function for each of two organelles. Product: Match the organelle name to its primary function and general location.	Write simple comparative sentences (e.g., "Prokaryotes do not have a nucleus, but eukaryotes do"). Product: Fill in a structured T-Chart comparing 3-4 organelles between prokaryotic and eukaryotic cells, using descriptive adjectives.	Justify the structural differences between organelles (e.g., why mitochondria have a folded inner membrane). Product: Write a compare/contrast paragraph analyzing the structural adaptations of three organelles (e.g., mitochondria, chloroplast, nucleus) that support their function.
<b>LT2</b>	Match a simplified chemical model (e.g., chain of hexagons) to the correct biomolecule name. Product: Label the monomer (single unit) of two biomolecules using one-word labels.	Use sequence words and simple causal language (e.g., "because of") to describe the function of one biomolecule. Product: Write short descriptive sentences detailing the	Analyze the impact of a structural change on function (e.g., saturated vs. unsaturated fat). Product: Model and explain how the primary structure of a protein determines

		primary function of each of the four biomolecules.	its 3D folding and specific catalytic function.
<b>LT3</b>	Label a diagram of the cell membrane using visual cues. Product: Identify the direction of water movement (in, out, or none) in a simple hypertonic or hypotonic scenario using a labeled arrow.	Use comparative language (e.g., "unlike, both") to distinguish between simple diffusion and active transport. Product: Write a descriptive paragraph explaining the difference between passive and active transport, including the need for ATP.	Apply water potential ( $\Psi$ ) concepts to predict outcomes and justify the prediction. Product: Justify a prediction of cell volume change in a specific molar concentration using precise terms like water potential, osmosis, and hypotonic.
<b>LT4</b>	Use labeled sequence cards to order the path of an exported protein (Ribosome →ER→Golgi). Product: Use a simple sentence to state the function of the ER and the Golgi in protein processing.	Use sequencing language (e.g., "first, next, finally") to describe the steps of protein modification and transport. Product: Write a short, descriptive sequence of how a hormone (an exported protein) is processed and released from the cell.	Evaluate the interconnectedness of organelles to explain a system. Product: Illustrate and explain the collaborative roles of the nucleus, ribosomes, RER, and Golgi in synthesizing, modifying, and exporting a specific protein.
<b>LT5</b>	Label a diagram with the key terms: enzyme, substrate, active site. Product: Match the environmental factor (pH or temperature) to its potential effect (denaturation or optimal function).	Use causal language ("causes, results in") to explain why high temperature causes denaturation. Product: Write simple explanatory sentences describing how enzymes speed up a reaction and how pH affects their activity.	Explain the kinetic effects of inhibitors and environmental changes. Product: Write an argumentative summary explaining the relationship between an enzyme's shape, its optimal environmental conditions, and the concept of induced fit.
<b>LT6</b>	Identify the highest data point on a graph of enzyme activity vs. pH to find the optimum. Product: Identify the independent and dependent variables in a simple data table.	Use sentence frames to describe a trend shown on a graph (e.g., "As the temperature increases, the enzyme rate..."). Product: Plot provided data points onto a pre-labeled graph and correctly identify the optimum condition.	Synthesize data and quantitative concepts (Q10) to draw a formal conclusion. Product: Write a claim-evidence-reasoning (CER) paragraph analyzing an experimental data table and justifying a conclusion about enzyme function.
<b>LT7</b>	Match the component of a feedback loop (stimulus, sensor, response) to its definition. Product: Label the components of a simple negative feedback loop (e.g., maintaining pH) on a provided diagram.	Write simple, sequenced sentences (e.g., "The sensor detects the change, then the response corrects it"). Product: Describe the function of buffers and how they help the cell maintain its internal pH stability.	Differentiate the functional impact of positive vs. negative feedback loops. Product: Model and explain a specific cellular-level negative feedback mechanism, using precise vocabulary like dynamic homeostasis and set point.
<b>LT8</b>	Match a cellular process (e.g., cellular respiration) to its organismal result (e.g., heat production). Product: Identify the two main hormones (insulin, glucagon) involved in blood glucose regulation.	Write sentences to describe the role of ATP (from cellular respiration) in maintaining a body function (e.g., nerve signaling). Product: Write a descriptive paragraph explaining how the body regulates blood glucose levels using both the pancreas and the liver.	Trace the entire regulatory pathway across multiple levels of organization. Product: Write a well-structured explanation connecting the cellular function of insulin receptors to the overall organismal goal of maintaining blood glucose levels.

Lesson Sequence	Learning Target	Success Criteria	Assessment
1-3	<b>Learning Target 1</b> I can compare and contrast the structure and function of major	I can... <ul style="list-style-type: none"> <li>Accurately label and describe the unique</li> </ul>	<i>To be formalized during Implementation Year</i> Update: <a href="#">ECE Biology</a>

	organelles in prokaryotic and eukaryotic cells, including the nucleus, mitochondria, chloroplasts, and ribosomes.	<p>function of at least five major organelles on a diagram of a eukaryotic cell .</p> <ul style="list-style-type: none"> <li>• Explain the endosymbiotic theory by comparing and contrasting the structure of mitochondria and chloroplasts with that of prokaryotic cells.</li> <li>• Create a Venn diagram that correctly identifies structures shared by all cell types (prokaryotic and eukaryotic) and those unique to each.</li> </ul>	<a href="#">Implementation Guide (2021)</a>
4-6	<p><b>Learning Target 2</b></p> <p>I can model and explain the relationship between the structure of the four major biomolecules (carbohydrates, lipids, proteins, nucleic acids) and their specific functional roles in the cell (e.g., energy storage, information transfer, or catalysis)</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Identify the monomer and polymer forms (e.g., amino acid → polypeptide) for all four major biomolecules.</li> <li>• Describe the structural differences between saturated and unsaturated fats and explain how this difference impacts membrane fluidity.</li> <li>• Describe the four levels of protein structure (primary, secondary, tertiary, and quaternary) and explain how changes in primary structure can lead to loss of function (e.g., sickle cell anemia).</li> </ul>	
7-9	<p><b>Learning Target 3</b></p> <p>I can predict the direction and rate of material movement across a cell membrane (e.g., water, ions, macromolecules) given specific concentrations, and distinguish between passive and active transport mechanisms</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Create a model of the cell membrane (Fluid Mosaic Model) to identify the roles of phospholipids, cholesterol, and various membrane proteins</li> <li>• Calculate and use water potential to accurately predict the direction of water movement (osmosis) across a semi-permeable membrane in hypertonic, hypotonic, and isotonic solutions.</li> <li>• Distinguish between and provide examples of simple diffusion, facilitated diffusion, and</li> </ul>	

		active transport (including the use of ATP).	
10-12	<p><b>Learning Target 4</b></p> <p>I can illustrate and explain how multiple cell components (e.g., ribosomes, ER, Golgi) work collaboratively to synthesize, modify, and transport a protein required for an essential life process.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>Trace the path of a protein intended for export, beginning with transcription in the nucleus and ending with exocytosis .</li> <li>Identify the specific roles of the rough endoplasmic reticulum (RER) and the Golgi apparatus in the modification, sorting, and packaging of proteins.</li> <li>Explain the potential consequences for a cell if the function of the ribosome, RER, or Golgi apparatus is compromised.</li> </ul>	
13-15	<p><b>Learning Target 5</b></p> <p>I can explain the catalytic action of enzymes and demonstrate how changes in environmental factors (e.g., temperature, <math>\text{pH}</math>, substrate concentration) will affect the enzyme's reaction rate</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>Label the active site, substrate, and enzyme-substrate complex on a diagram and explain the concept of induced fit.</li> <li>Predict the effect of denaturing an enzyme and identify factors (e.g., extreme heat or pH) that cause irreversible denaturation.</li> <li>Differentiate between competitive and non-competitive enzyme inhibitors and explain the impact of each on the enzyme's maximum reaction rate.</li> </ul>	
16-18	<p><b>Learning Target 6</b></p> <p>I can analyze and interpret quantitative experimental data (e.g., graphs, tables, <math>Q_{10}</math> calculations) to draw conclusions about the effects of variables on enzyme activity or molecular interactions.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>Plot, label, and interpret a standard enzyme kinetics curve, identifying <math>V_{\text{max}}</math> and Michaelis constant.</li> <li>Calculate the <math>Q_{10}</math> value from provided temperature and reaction rate data and explain the biological meaning of the result.</li> <li>Analyze a data table or graph from a molecular interaction experiment and use the evidence to state and justify a</li> </ul>	

		conclusion.	
19-21	<p><b>Learning Target 7</b></p> <p>I can describe and model how cellular-level feedback mechanisms (e.g., changes in pH) or enzyme regulation) maintain dynamic homeostasis within the cell</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Define dynamic homeostasis and explain why it is essential for cell survival.</li> <li>• Differentiate between positive and negative feedback loops and provide a specific, accurate example of each at the cellular or molecular level.</li> <li>• Diagram a negative feedback mechanism, labeling the stimulus, receptor, control center, and effector, using a cellular example.</li> </ul>	
21-24	<p><b>Learning Target 8</b></p> <p>I can connect a specific cellular process (e.g., cellular respiration, gene regulation) to the overall regulation of internal conditions (e.g., body temperature, blood glucose levels) in a complex organism.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Explain how the process of cellular respiration contributes to organismal homeostasis for active transport and muscle contraction).</li> <li>• Describe the roles of specific hormones and their target cells in maintaining blood glucose homeostasis.</li> <li>• Trace the regulatory pathway, from stimulus to response, that an organism uses to maintain body temperature (thermoregulation).</li> </ul>	

<b>Unit Title:</b>	
Unit 3: Animal Physiology and Homeostasis	
<b>Relevant Standards: Bold indicates priority</b>	
<p><b>Big Idea 3: Information Storage and Transmission (IST)</b> Living systems store, retrieve, transmit, and respond to information essential to life processes.</p> <p><b>Big Idea 4: Systems Interactions (SYI)</b> Biological systems interact, and these systems and their interactions exhibit complex properties</p> <p><b>Science Practice 1:</b> Explain biological concepts, processes, and models presented in written format.</p> <p><b>Science Practice 2:</b> Analyze visual representations of biological concepts and processes.</p> <p><b>Science Practice 4:</b> Represent and describe data</p> <p><b>Science Practice 5:</b> Perform statistical tests and mathematical calculations to analyze and interpret data.</p> <p><b>Science Practice 6:</b> Develop and justify scientific arguments using evidence.</p>	
<b>Essential Question(s):</b>	<b>Enduring Understanding(s):</b>
<ul style="list-style-type: none"> <li>• What fundamental trade-offs exist between acquiring energy and using energy for survival and reproduction?</li> <li>• How do the behavioral choices of individual organisms scale up to affect the structure and success of an entire ecosystem?</li> <li>• To what extent is all ecological stability fundamentally dependent on the capture of solar energy?</li> <li>• How does the availability of energy act as the ultimate constraint on life at all biological levels?</li> </ul>	<ul style="list-style-type: none"> <li>• Organisms employ diverse, evolved strategies to acquire, transform, and utilize energy, which directly influences their overall fitness.</li> <li>• Energy flows through an ecosystem, beginning with the autotrophs, and is subject to the laws of thermodynamics, which fundamentally limits the structure of food webs.</li> <li>• The behavioral responses of organisms are adaptations that enhance fitness and serve as a key mechanism for energy acquisition and defense within a population.</li> <li>• The dynamics and stability of populations and entire ecosystems are critically dependent upon the availability and distribution of energy resources.</li> </ul>
<b>Demonstration of Learning:</b>	<b>Pacing for Unit</b>
<ul style="list-style-type: none"> <li>• Laboratory investigations, experiments, and reports</li> <li>• Written &amp; oral explanations in collaborative settings</li> <li>• Unit Quizzes and Tests</li> </ul>	Approximately 12 Class Periods and 2 Lab Days
<b>Family Overview</b>	<b>Integration of Technology:</b>
<ul style="list-style-type: none"> <li>• <a href="#">Family Overview: UConn ECE Biology (English)</a></li> <li>• <a href="#">Family Overview: UConn ECE Biology (Spanish)</a></li> </ul>	<ul style="list-style-type: none"> <li>• PhET “Cellular Respiration” and “Photosynthesis” simulations; Labster virtual labs.</li> <li>• 3D models and animations of chloroplasts, mitochondria, and the electron transport chain help students visualize complex cellular processes.</li> <li>• HHMI Biointeractive videos on mitochondria, chloroplasts, and energy flow.</li> <li>• Molecular modeling software can illustrate ATP synthesis, electron flow, and chemical reactions in metabolism.</li> <li>• Use Google Sheets, Excel, or graphing software to record experimental data from virtual or classroom labs. Students can analyze trends, calculate rates of photosynthesis or respiration, and create graphs or charts.</li> </ul>
<b>Unit-specific Vocabulary:</b>	<b>Aligned Unit Materials, Resources, and Technology (beyond core resources):</b>

<p>Homeostasis  Negative feedback  Positive feedback  Set point  Stimulus  Sensor / Receptor  Effector  Control center  Thermoregulation  Osmoregulation  Endotherm  Ectotherm  Poikilotherm  Homeotherm  Ion Channel  Membrane potential  Resting potential  Action potential  Depolarization  Repolarization  Hyperpolarization  Neurotransmitter  Synapse  Hormone  Receptor  Second messenger  Signal transduction  Atrium / Ventricle  Artery / Vein / Capillary  Blood  Red blood cell / White blood cell  Platelet  Plasma  Hemoglobin  Oxygen transport  Carbon dioxide transport  Pulmonary circuit / Systemic circuit  Respiration  Ventilation</p>	<p>Gas exchange  Nephron  Glomerulus  Bowman's capsule  Proximal tubule  Loop of Henle  Distal tubule  Collecting duct  Filtration  Reabsorption  Secretion  Excretion  Urea / Ammonia / Uric acid  Osmotic gradient  Antidiuretic hormone (ADH)  Enzyme  Substrate  Absorption  Peristalsis  Small intestine / Large intestine  Liver / Pancreas / Gallbladder  Metabolism  Anabolism / Catabolism  ATP / Energy balance  Central nervous system (CNS)  Peripheral nervous system (PNS)  Brain / Spinal cord  Neuron  Dendrite / Axon / Synaptic terminal  Myelin sheath  Reflex arc  Sensory neuron / Motor neuron / Interneuron  Endocrine gland  Exocrine gland  Pituitary / Thyroid / Adrenal / Pancreas  Feedback regulation</p>	<p>None</p>
<p><b>Opportunities for Interdisciplinary Connections:</b></p> <p><b>Chemistry</b>  Chemical basis of physiological processes: ion gradients, neurotransmitters, enzyme activity, ATP, pH, and buffer systems.</p> <p><b>Mathematics</b>  Analyze physiological data; graph homeostatic set points; model diffusion rates and enzyme kinetics.</p> <p><b>Physics</b>  Fluid dynamics in circulation, diffusion, gas exchange, thermodynamics in heat regulation, electrophysiology.</p> <p><b>Environmental Science</b>  Effects of temperature, salinity, and water availability on homeostasis; adaptations to extreme environments; survival strategies.</p>		<p><b>Anticipated misconceptions:</b></p> <ul style="list-style-type: none"> <li>• Homeostasis means the body keeps everything constant (students may think all internal conditions stay the same, rather than within set ranges).</li> <li>• Positive feedback always “corrects” changes (students may confuse it with negative feedback; it actually amplifies changes).</li> <li>• Endotherms do not rely on the environment for temperature regulation (students may overlook behavioral or physiological thermoregulation).</li> <li>• Ectotherms are “cold-blooded” in the sense that their body is always cold (students may not realize they can regulate temperature behaviorally).</li> <li>• Action potentials are caused by “flowing electricity” rather than ion movement across membranes.</li> <li>• All neurons have the same resting potential or</li> </ul>

	<p>respond the same way (students may neglect variation in neuron type or threshold).</p> <ul style="list-style-type: none"> <li>• Enzymes and hormones are interchangeable (students may confuse biochemical signals with catalysts).</li> <li>• Blood always carries oxygen the same way in all animals (students may ignore hemoglobin differences or dissolved oxygen).</li> <li>• Kidneys “store” urine rather than filtering and concentrating it continuously.</li> <li>• Osmoregulation only occurs in aquatic environments (students may not consider terrestrial animals or humans).</li> <li>• Gas exchange occurs in all animals the same way (students may overgeneralize lungs, gills, or diffusion across skin).</li> <li>• Reflexes involve conscious thought (students may not understand that many reflex arcs bypass the brain).</li> <li>• Heat loss and heat gain are always passive processes (students may not account for active physiological mechanisms like shivering or sweating).</li> <li>• Hormone levels act instantly and always have uniform effects (students may not understand timing, receptor sensitivity, or feedback control).</li> <li>• Digestive enzymes can digest any food without specificity (students may not understand enzyme-substrate specificity).</li> </ul>
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<b>Connections to Prior Units:</b>	<b>Connections to Future Units:</b>
Macromolecules in Unit 1 ties genetics and cell communication together.	Cell communication helps students understand the undertones of evolution and evolutionary progression.

**Differentiation through *Universal Design for Learning***  
**Learning Targets and Teacher Actions**

	<b>Engagement</b>	<b>Representation</b>	<b>Action &amp; Expression</b>
<b>LT 1</b>	Recruit Interest: Present a "Behavioral Choice" scenario (e.g., risk of foraging vs. safety of hiding) and allow students to collaboratively debate and predict the optimal strategy for maximum fitness.	Vary Presentation: Present behavior examples through both video clips (e.g., animal communication, foraging ) and written case studies focused on specific behavioral patterns.	Support Planning & Strategy: Offer a structured template for analyzing behavior that includes prompts for identifying the cost, benefit, and impact on fitness. Allow students to present findings via oral report or infographic.
<b>LT 2</b>	Sustain Effort: Give students a choice of species (e.g., predator, grazer, filter feeder, parasite) to investigate in depth. Students research the specific structural adaptations used for their chosen species' energy acquisition.	Clarify Vocabulary: Use graphic organizers that visually categorize organisms by their energy source (e.g., Autotroph → Photoautotroph → Chemolithoautotroph), defining the terms with simple visuals.	Use Multi-Media: Students demonstrate understanding by either drawing/labeling an organism and its feeding structure or by writing a comparison summary of two different energy strategies (e.g., bulk feeding vs. fluid feeding).
<b>LT 3</b>	Optimize Challenge: Introduce a simulation or game (digital or physical) where students manage a model ecosystem and must make decisions based on changing energy resources (e.g., drought)	Highlight Patterns: Use the 10% rule to model energy flow. Display the pattern using both a numerical data table and a logarithmic-scale energy pyramid diagram.	Compose and Construct: Students analyze a data set showing population changes following an environmental shift. They must then write a predictive explanation using causal language (e.g., "The decrease

	and observe the population consequences.		in X caused a decrease in Y..." about the ecosystem change.
<b>LT 4</b>	Foster Collaboration: Conduct a "Molecule Exchange" activity where one half of the class represents autotrophs and the other half represents heterotrophs, and they must physically exchange tokens representing CO <sub>2</sub> , O <sub>2</sub> , and glucose.	Highlight Relationships: Use a circular diagram or cyclical flowchart that clearly illustrates how the products of photosynthesis are the reactants for cellular respiration, and vice-versa, demonstrating the continuous energy cycle.	Support Executive Function: Provide a step-by-step checklist for the final product. Students must illustrate the processes. Allow students to present the content via annotated poster or a simple, labeled digital animation.

**Supporting Multilingual/English Learners ( [CELP standards](#) )  
Differentiated Learning Targets**

	<b>Emerging</b>	<b>Expanding</b>	<b>Bridging</b>
<b>LT1</b>	Match a simple behavior (e.g., migration, hiding) to its survival benefit. Product: Use a simple sentence to state how one behavior helps an animal survive (e.g., Migration helps the birds find food).	Write simple cause-and-effect sentences linking a behavior to reproduction and survival. Product: Write a descriptive paragraph explaining how a specific behavioral response (e.g., a mating ritual) contributes to an individual's fitness.	Analyze a case study of a behavioral trade-off (e.g., predator avoidance vs. foraging). Product: Explain and justify how the cost and benefit of a complex behavior (e.g., territoriality) impacts the overall success of a population.
<b>LT2</b>	Match images of different feeding strategies (e.g., grazing, filtering, predation) to their names. Product: Identify the primary source of energy (e.g., sun, plants, other animals) for two types of organisms.	Use descriptive verbs to explain how two different organisms (e.g., a plant and a cow) acquire energy. Product: Write a comparison paragraph detailing the different structures and methods organisms use to gather energy (e.g., roots vs. mouth).	Analyze the efficiency and trade-offs of different energy acquisition strategies. Product: Explain and justify why a specific strategy (e.g., being an endotherm vs. ectotherm) is advantageous for an organism in a particular environment.
<b>LT3</b>	Label a simple food chain and identify the producer and primary consumer. Product: Complete sentence frames to show a simple cause-and-effect relationship (e.g., Less sun means less food for the...).	Use sequential language (e.g., "if... then... therefore") to describe the impact of a change at one trophic level. Product: Write a short descriptive passage explaining how a decrease in the number of producers would affect the primary consumer population.	Analyze the efficiency of energy transfer (10% rule) and predict long-term changes. Product: Write a predictive explanation detailing how a 10% decrease in available energy at the producer level affects the carrying capacity of the tertiary consumer population.
<b>LT4</b>	Define autotroph and heterotroph using simple synonyms (e.g., Autotroph: makes own food). Product: Identify the two main processes (photosynthesis and cellular respiration) used by autotrophs and heterotrophs.	Write simple explanatory sentences detailing the specific roles of autotrophs and heterotrophs in the ecosystem. Product: Create a simple diagram or flowchart showing the sequential flow of energy from the sun through the producer to the consumer.	Explain the biochemical processes that drive energy flow. Product: Write an analytical summary explaining how the outputs of photosynthesis (glucose and oxygen) are the essential inputs for cellular respiration, demonstrating the continuous cycle of energy flow.

<b>Lesson Sequence</b>	<b>Learning Target</b>	<b>Success Criteria</b>	<b>Assessment</b>
1-3	<b>Learning Target 1</b> I can explain how the behavioral responses of organisms affect their	I can... <ul style="list-style-type: none"> <li>Describe how responses to information and communication of information are vital to natural selection</li> </ul>	<i>To be formalized during Implementation Year Update: <a href="#">ECE Biology Implementation Guide</a></i>

	overall fitness and may contribute to the success of the population.	<p>and evolution such as:</p> <ul style="list-style-type: none"> <li>• a. Natural selection favors innate and learned behaviors that increase survival and reproductive fitness.</li> <li>• b. Cooperative behavior tends to increase the fitness of the individual and the survival of the population.</li> </ul>	<a href="#">(2021)</a>
4-6	<p><b>Learning Target 2</b></p> <p>I can describe the strategies organisms use to acquire and use energy.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Describe how organisms use energy to maintain organization, grow, and reproduce.</li> <li>• Explain ethology behavior proximate cause innate behaviors, learned behaviors and ultimately cause fixed action patterns.</li> <li>• Describe how pheromones sign stimulus migration.</li> <li>• Define: Kinesis, taxis, phototaxis, chemotaxis and Geotaxis.</li> <li>• Compare and contrast primary producer, heterotrophs, primary consumer, secondary consumer, tertiary consumer and decomposers.</li> </ul>	
7-9	<p><b>Learning Target 3</b></p> <p>I can explain how changes in energy availability affect populations and ecosystems.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Describe the difference between a food chain and a food web.</li> <li>• Describe how organisms use different strategies to regulate body temperature and metabolism: <ul style="list-style-type: none"> <li>a. Endotherms use thermal energy generated by metabolism to maintain homeostatic body temperatures.</li> <li>b. Ectotherms lack efficient internal mechanisms for maintaining body temperature, though they may regulate their temperature behaviorally by moving into the sun or shade or by aggregating with other individuals.</li> </ul> </li> <li>• Describe how different organisms use various reproductive strategies in response to energy availability.</li> <li>• Explain how a net gain in energy results in energy storage or the growth of an organism and how a net loss of energy results in loss of mass and, ultimately, the death of an organism.</li> <li>• Explain how changes in energy availability can result in changes in population size.</li> <li>• List how changes in energy availability can result in disruptions to an ecosystem in the following ways: <ul style="list-style-type: none"> <li>a. A change in energy resources such as sunlight can affect the number and size of the trophic levels.</li> <li>b. A change in the producer level can affect the number and size of other trophic levels.</li> </ul> </li> </ul>	
10-12	<p><b>Learning Target 4</b></p> <p>I can explain how the</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Describe how autotrophs capture energy</li> </ul>	

	activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem	from physical or chemical sources in the environment such as: a. Photosynthetic organisms capture energy present in sunlight. b. Chemosynthetic organisms capture energy from small inorganic molecules present in their environment, and this process can occur in the absence of oxygen. • Describe how heterotrophs capture energy present in carbon compounds produced by other organisms.	
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<b>Unit Title:</b>	
Unit 4: Evolution	
<b>Relevant Standards: Bold indicates priority</b>	
<b>Big Idea 1: Evolution (EVO)</b> The process of evolution drives the diversity and unity of life.	
<b>Big Idea 4: Systems Interactions (SYI)</b> Biological systems interact, and these systems and their interactions exhibit complex properties	
<b>Science Practice 1:</b> Explain biological concepts, processes, and models presented in written format.	
<b>Science Practice 2:</b> Analyze visual representations of biological concepts and processes.	
<b>Science Practice 4:</b> Represent and describe data	
<b>Science Practice 6:</b> Develop and justify scientific arguments using evidence.	
<b>Essential Question(s):</b>	<b>Enduring Understanding(s):</b>
<ul style="list-style-type: none"> <li>• How does natural selection drive evolution and what factors influence this process?</li> <li>• What evidence supports the theory of evolution and how scientists interpret this evidence?</li> <li>• How do genetic mutations and environmental factors contribute to variation within a population?</li> <li>• How does the process of speciation occur and what role does it play in the diversity of life?</li> <li>• In what ways can human activity influence evolutionary processes?</li> </ul>	<ul style="list-style-type: none"> <li>• Natural selection is the primary, non-random process where environmental pressures act upon heritable variation, leading to the differential survival and reproduction of individuals and the gradual adaptation of populations.</li> <li>• The theory of descent with modification from a common ancestor is supported by independent and converging lines of evidence from multiple scientific disciplines, including the fossil record, comparative anatomy, and molecular biology.</li> <li>• Evolutionary change is fundamentally dependent on genetic variation, which originates from mutation and meiosis, and is shaped by both selective forces and random events like genetic drift.</li> <li>• Speciation results from the establishment of reproductive isolation, and human activities are now powerful selective pressures that influence the rate, direction, and magnitude of evolutionary change.</li> </ul>
<b>Demonstration of Learning:</b>	<b>Pacing for Unit</b>
<ul style="list-style-type: none"> <li>• Laboratory investigations, experiments, and reports</li> <li>• Written &amp; oral explanations in collaborative settings</li> <li>• Unit Quizzes and Tests</li> </ul>	Approximately 24 Class Periods and 2 Lab Days
<b>Family Overview</b>	<b>Integration of Technology:</b>
<ul style="list-style-type: none"> <li>• <a href="#">Family Overview: UConn ECE Biology (English)</a></li> <li>• <a href="#">Family Overview: UConn ECE Biology (Spanish)</a></li> </ul>	<ul style="list-style-type: none"> <li>• PhET Simulations to experiment with concepts like enzyme activity, diffusion, or genetic crosses without needing lab materials.</li> <li>• Gizmos virtual labs for more complex experiments (e.g., DNA extraction, photosynthesis measurements).</li> <li>• Google Sheets/Excel to plot population growth, enzyme activity, or experimental results.</li> <li>• Students can use tools like NCBI BLAST or DNA sequence simulators.</li> <li>• 3D models: Programs like Visible Body or Tinkercad for molecular and cellular structures.</li> <li>• Augmented reality apps like Merge EDU can bring structures like DNA or the heart to life in 3D.</li> </ul>
<b>Unit-specific Vocabulary:</b>	<b>Aligned Unit Materials, Resources, and Technology (beyond</b>

		core resources):
Biogeography	Phylogenetic tree	None
Evolution	Systemics	
Descent with modification	Basal taxon	
Natural selection	Sister taxa	
Fitness	Monophyletic group	
Competition	Derived characteristic	
Biotic factors	Ancestral characteristic	
Abiotic factors	Synapomorphy	
Selective pressures	Paraphyletic group	
Adaptations	Polyphyletic group	
Phenotype	Taxonomy	
Genotype	Phylogenetics	
Mutation	Root	
Population	Outgroup	
Gene pool	Parsimony	
Fixed	Species	
Genetic drift	Speciation	
Bottleneck effect	Geography	
Founder effect	Temporal isolation	
Gene flow	Prezygotic barrier	
Directional selection	Postzygotic barrier	
Stabilizing selection	Sympatric speciation	
Disruptive selection	Behavioral isolation	
Sexual selection	Mechanical isolation	
Hardy Weinberg equilibrium	Reduced hybrid viability	
	Reduced hybrid fertility	
Comparative morphology	Punctuated equilibrium	
Analogous structures	Macroevolution	
Embryonic homology	Hybrid breakdown	
Vestigial structure	Gradualism	
Molecular homology	Divergent evolution	
Homologous structures	Convergent evolution	
Common ancestor	Allopatric speciation	
Convergent evolution	Gametic isolation	
Homology	Microevolution	
Fossil	Adaptive radiation	
Node	Habitat isolation	
Cladogram		
<b>Opportunities for Interdisciplinary Connections:</b>		<b>Anticipated misconceptions:</b>
<p><b>Chemistry</b> Reactions like ATP hydrolysis, enzyme activity, and macromolecule structure</p> <p><b>Physics</b> Energy transformations, diffusion, fluid dynamics, and optic</p> <p><b>Mathematics</b> Statistical analysis, probability in genetics, and modeling population growth.</p> <p><b>Social Studies</b> Discussions of human impacts on ecosystems, conservation, and genetic engineering.</p>		<ul style="list-style-type: none"> <li>• Belief that individual organisms evolve, rather than populations over generations.</li> <li>• Misunderstanding adaptation: thinking traits appear “because organisms need them” rather than via variation and selection.</li> <li>• Confusing fitness with strength or speed rather than reproductive success.</li> </ul>
<b>Connections to Prior Units:</b>		<b>Connections to Future Units:</b>
Builds on knowledge of DNA, RNA, proteins, and enzyme activity introduced in Unit 1. Understanding of biomolecules and molecular		None

interactions supports the study of transcription, translation, and replication.	
Reinforces concepts of organelle function, particularly the nucleus, ribosomes, and endoplasmic reticulum, in gene expression and protein synthesis from Unit 2.	

**Differentiation through *Universal Design for Learning***  
**Learning Targets and Teacher Actions**

	<b>Engagement</b>	<b>Representation</b>	<b>Action &amp; Expression</b>
<b>LT 1</b>	Optimize Challenge: Provide a choice between two real-world case studies (e.g., antibiotic resistance or fish evolution due to fishing) for analysis, allowing students to select the topic most intriguing to them.	Clarify Vocabulary: Use a structured glossary tool that provides definitions, visual diagrams, and non-linguistic examples for core terms like heritability, fitness, and adaptation.	Use Multi-Media: Allow students to demonstrate their understanding of the four steps of natural selection by either writing a detailed narrative or creating a short narrated video explaining the process.
<b>LT 2</b>	Recruit Interest: Present a "Mystery Population" scenario where different groups are given data showing the effects of either genetic drift (bottleneck), gene flow, or non-random mating, requiring them to first identify the mechanism at play.	Highlight Patterns: Provide a color-coded graphic organizer that visually compares and contrasts the source, magnitude of effect, and randomness of the five evolutionary forces.	Support Planning: Give students a step-by-step checklist for using the Hardy-Weinberg equation, including reminders on when to use allele vs. genotype frequencies for calculations.
<b>LT 3</b>	Sustain Effort: Allow students to choose their evidence focus (e.g., a student interested in vertebrates chooses homologous anatomy; a student interested in ancient life chooses the fossil record).	Vary Presentation: Present the evidence through both physical models (3D printed homologies) and virtual exploration (online interactive fossil databases or 3D digital fossil reconstructions).	Compose and Construct: Students can demonstrate understanding by either drawing/labeling homologous structures or by writing a comparative essay justifying why specific structures prove common ancestry.
<b>LT 4</b>	Foster Community: Assign pairs to collaboratively build a phylogenetic tree using provided sequence data, requiring each partner to take responsibility for different parts of the analysis (e.g., one analyzes molecular data, the other constructs the tree).	Use Scaffolded Visualization: Provide a template for a phylogenetic tree and an interactive, digital tool where students can plug in molecular distance data to visualize the branching patterns immediately.	Monitor Progress: Provide a digital self-assessment quiz that focuses only on phylogenetic tree interpretation (e.g., identifying sister taxa and common ancestors) to allow students to check their comprehension before a final exam.
<b>LT 5</b>	Individual Choice: Allow students to choose the specific type of mutation or meiotic event they want to study in depth (e.g., point mutation vs. aneuploidy) for a mini-presentation or modeling activity.	Non-Linguistic Illustrations: Use animated GIFs or short video clips to clearly illustrate the dynamic processes of crossing over and independent assortment during meiosis, alongside static diagrams.	Use Manipulatives: Provide pipe cleaner or paper chromosome models to allow students to physically model the impact of a non-disjunction or a successful crossing-over event, explaining the resulting genetic variation.
<b>LT 6</b>	Recruit Interest: Begin the lesson with an engaging "What If?" scenario (e.g., What if a sudden canyon formed through a deer habitat?) to immediately relate speciation to a real-world, high-stakes event.	Clarify Syntax and Symbols: Use concept maps or flowcharts that visually organize the cause-and-effect relationship between geographic isolation, reproductive isolation, and the formation of a new species.	Use Scaffolds for Synthesis: Provide a Speciation Event Template that prompts students to identify the environment, the specific pre- or postzygotic barrier, and the type of speciation (allopatric or sympatric) for three distinct case studies.

<b>LT 7</b>	Optimize Challenge: Introduce opposing scientific quotes regarding the validity of gradualism vs. punctuated equilibrium, requiring students to take a side and defend it using provided fossil data examples.	Multiple Analogies: Explain the two models using a range of analogies (e.g., comparing a smoothly rising ramp vs. a flight of stairs) and ask students to choose the analogy that best helps them conceptualize the difference.	Differentiate Expression: Allow students to either sketch and annotate the two models of evolutionary tempo on a graph or write a journal entry from the perspective of a paleontologist arguing for one model based on their fossil finds.
<b>LT 8</b>	Promote Self-Reflection: Conclude the unit by having students participate in a structured debate or Socratic Seminar on the ethical and evolutionary consequences of human actions (e.g., genetic engineering vs. conservation efforts).	Highlight Critical Features: Use annotated graphs and data tables from current scientific journals (e.g., data on fish size over time due to human harvesting) to clearly highlight the cause-and-effect patterns of human selective pressure.	Provide Sentence Starters/Tools: For the analytical essay or debate preparation, provide argumentation sentence starters ("This evidence shows directional selection because...", "A counter-argument to this is...") to help students formulate clear, evidence-based claims.

**Supporting Multilingual/English Learners ( [CELP standards](#) )  
Differentiated Learning Targets**

	<b>Emerging</b>	<b>Expanding</b>	<b>Bridging</b>
<b>LT 1</b>	Use sentence frames and visual aids (diagrams with arrows) to label the four components of Natural Selection. Product: Define the terms using one-word labels or short, familiar phrases.	Use simple, compound sentences to describe the relationship between the four components. Product: Write a short paragraph or create a labeled flowchart explaining the process of natural selection in a case study.	Use complex sentences and domain-specific vocabulary (e.g., differential survival). Product: Write a two-paragraph analytical response explaining how a change in environment drives a specific mode of selection.
<b>LT 2</b>	Match images or definitions of Bottleneck, Founder Effect, and Gene Flow to the correct term. Product: Create a T-Chart listing key differences using nouns and simple verbs (e.g., Drift: small population, random).	Write comparative sentences using signal words (e.g., while, similarly) to distinguish between two forces. Product: Write a short comparison/contrast detailing the impact of gene flow vs. genetic drift on allele frequency.	Synthesize information to evaluate the relative importance of each force in a given scenario. Product: Write a justified conclusion about which force is most likely acting on a population, supported by evidence from a provided data set.
<b>LT 3</b>	Label diagrams of homologous and analogous structures. Product: Use a short sentence/caption to identify whether a structure is evidence of shared ancestry or convergent evolution.	Use descriptive language to explain the relationship between a structure (e.g., bone arrangement in a whale fin) and a common ancestor. Product: Complete a fill-in-the-blank paragraph explaining how the fossil record shows transitional forms.	Analyze images of different anatomical structures and justify their classification. Product: Write an evidence-based paragraph using precise vocabulary to argue how vestigial structures support the theory of descent with modification.
<b>LT 4</b>	Correctly identify the common ancestor and sister taxa on a simplified phylogenetic tree. Product: Answer single-word or short-phrase questions about relationships on the tree.	Write sentences to describe relationships (e.g., "Species A is more closely related to B than C"). Product: Construct a basic phylogenetic tree from highly simplified molecular distance data.	Analyze quantitative data (e.g., sequence comparison percentages) to build a tree and draw conclusions. Product: Justify the placement of a novel organism on a phylogenetic tree using molecular clock data and advanced reasoning.
<b>LT 5</b>	Label a diagram of crossing over and a diagram of a point mutation. Product: Define mutation and meiosis using a simple dictionary definition or image.	Describe, using sequencing language (e.g., first, then, resulting in), how crossing over increases genetic variation. Product: Write a descriptive paragraph explaining why sexual reproduction creates more variation than asexual reproduction.	Synthesize the concepts of gene flow, mutation, and meiosis to assess their combined role. Product: Write a coherent argument explaining why variation is the prerequisite for evolution and why new mutations are essential.

<b>LT 6</b>	Match visual examples (e.g., different mating dances) to the correct prezygotic barrier name. Product: Create a simple two-column chart listing prezygotic barriers and postzygotic barriers using short phrases.	Use comparison language to explain the difference between a prezygotic barrier (no fertilization) and a postzygotic barrier (inviolate/sterile offspring). Product: Write descriptive sentences for 3-4 different reproductive isolation mechanisms.	Analyze a case study of two populations and determine the type of speciation and the barrier responsible. Product: Write an explanatory text outlining the sequence of events that led to either allopatric or sympatric speciation, using precise domain vocabulary.
<b>LT 7</b>	Match a graph of gradualism to its definition, and a graph of punctuated equilibrium to its definition. Product: Use simple, comparative sentences (e.g., Gradualism is slow. Punctuated is fast).	Use transition words (e.g., in contrast, however) to explain the main difference between the two models. Product: Write a comparison paragraph detailing why the fossil record often appears to support punctuated equilibrium.	Analyze a provided fossil data set and interpret the rate of change. Product: Write an argumentative summary justifying which model (gradualism or punctuated equilibrium) best fits the provided evidence.
<b>LT 8</b>	Match images of human activities (e.g., pollution, farming) to the evolutionary effect (e.g., resistance, small size). Product: Answer "yes/no" or true/false questions about whether a human action acts as a selective pressure.	Write sentences describing how a specific human activity acts as a directional selective pressure. Product: Write a short explanation detailing how the use of pesticides has caused the evolution of resistance in insect populations.	Evaluate the long-term impact of human actions on genetic diversity and extinction rates. Product: Write a well-developed persuasive paragraph discussing the ethical and biological consequences of human-induced rapid evolutionary change.

<b>Lesson Sequence</b>	<b>Learning Target</b>	<b>Success Criteria</b>	<b>Assessment</b>
1-3	<b>Learning Target 1</b> I can explain the process of natural selection as the primary mechanism driving evolution and identify the four key components necessary for it to occur.	I can... <ul style="list-style-type: none"> <li>Define and provide examples for the four components of natural selection: variation, inheritance, selection (differential survival/reproduction), and time.</li> <li>Differentiate between the three modes of natural selection (directional, stabilizing, and disruptive) and sketch a graph illustrating the change in phenotype distribution for each.</li> <li>Apply the principles of natural selection to explain the rapid evolution of antibiotic resistance in bacteria.</li> </ul>	<i>To be formalized during Implementation Year Update: <a href="#">ECE Biology Implementation Guide (2021)</a></i>
4-6	<b>Learning Target 2</b> I can compare and contrast the roles of genetic drift, gene flow, mutation, and non-random mating in altering allele and genotype frequencies within a population.	I can... <ul style="list-style-type: none"> <li>Distinguish between the bottleneck effect and the founder effect as mechanisms of genetic drift, and explain their impact on genetic diversity, particularly in small populations.</li> <li>Explain how gene flow (migration) and mutation introduce or create new genetic variation in a population, while non-random mating only rearranges existing alleles.</li> <li>Calculate the impact of an evolutionary force on allele</li> </ul>	

		frequencies using the Hardy-Weinberg equation.	
7-9	<p><b>Learning Target 3</b></p> <p>I can evaluate evidence from the fossil record and comparative anatomy to support the theory of descent with modification from a common ancestor.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Interpret a series of fossil strata to infer evolutionary changes in morphology and identify transitional fossils that link major taxonomic groups.</li> <li>• Define and provide examples of homologous structures (e.g., vertebrate forelimbs), vestigial structures, and explain how they provide evidence for shared ancestry.</li> <li>• Differentiate between homologous structures and analogous structures (convergent evolution) and explain how each supports the theory of evolution.</li> </ul>	
10-12	<p><b>Learning Target 4</b></p> <p>I can interpret molecular evidence, such as DNA sequences and protein comparisons, to establish evolutionary relationships and construct phylogenetic trees.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Explain the concept of a molecular clock and use differences in DNA or amino acid sequences between species to infer time since divergence.</li> <li>• Interpret a phylogenetic tree or cladogram by identifying the most recent common ancestor, sister taxa, and outgroups .</li> <li>• Analyze data on gene or protein similarity across multiple species (e.g., comparing cytochrome c or hemoglobin) and use that data to correctly construct a basic phylogenetic tree.</li> </ul>	
13-15	<p><b>Learning Target 5</b></p> <p>I can explain how genetic mutations and meiotic processes create the heritable variation upon which selection acts.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Define mutation and explain how point mutations and chromosome mutations introduce new alleles into a population's gene pool.</li> <li>• Explain the three meiotic processes (crossing over, independent assortment, and random fertilization) that lead to recombination and genetic variation in offspring.</li> <li>• Explain why only mutations in gametes (sex cells), and not somatic (body) cells, are heritable and relevant to the long-term evolutionary change of a species.</li> </ul>	
16-18	<p><b>Learning Target 6</b></p> <p>I can describe the process of speciation and differentiate between the various forms of prezygotic and</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Define speciation and distinguish between allopatric speciation (geographic isolation) and sympatric speciation (no geographic isolation).</li> </ul>	

	postzygotic reproductive isolation.	<ul style="list-style-type: none"> <li>• Provide specific examples and mechanisms for at least three types of prezygotic barriers (e.g., habitat, temporal, behavioral, mechanical).</li> <li>• Explain the difference between reduced hybrid viability and reduced hybrid fertility (postzygotic barriers) and how both prevent gene flow between incipient species.</li> </ul>	
19-21	<p><b>Learning Target 7</b></p> <p>I can compare and contrast the models of gradualism and punctuated equilibrium to describe the varying tempo of evolutionary change.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Describe the theory of gradualism and identify fossil evidence that would be interpreted to support this model of slow, steady change.</li> <li>• Describe the theory of punctuated equilibrium and explain why the fossil record often shows long periods of stasis followed by rapid morphological change.</li> <li>• Explain how environmental changes (e.g., mass extinction events) can influence the rate and scale of speciation and extinction events.</li> </ul>	
22-24	<p><b>Learning Target 8</b></p> <p>I can evaluate the ways in which human activities act as selective pressures and influence the direction and rate of evolutionary change.</p>	<p>I can...</p> <ul style="list-style-type: none"> <li>• Explain how practices like intensive pesticide use or industrial fishing can lead to rapid, unintended directional selection in target populations.</li> <li>• Analyze a case study (e.g., changes in flowering time due to climate change, or the evolution of drug-resistant pathogens) and identify the specific human-induced selective pressure.</li> <li>• Discuss the ethical and biological implications of human activities that reduce genetic diversity (e.g., habitat fragmentation, artificial selection) on the long-term adaptability of populations</li> </ul>	