College Board Pre-AP®

Pre-AP® Biology

COURSE GUIDE

INCLUDES

- Approach to teaching and learning
- Course map
- Course framework
- Sample assessment questions

CollegeBoard Pre-AP®

Pre-AP® Biology

COURSE GUIDE

Updated Fall 2020

Please visit Pre-AP online at **preap.org** for more information and updates about the course and program features.

ABOUT COLLEGE BOARD

College Board is a mission-driven not-for-profit organization that connects students to college success and opportunity. Founded in 1900, College Board was created to expand access to higher education. Today, the membership association is made up of over 6,000 of the world's leading educational institutions and is dedicated to promoting excellence and equity in education. Each year, College Board helps more than seven million students prepare for a successful transition to college through programs and services in college readiness and college success—including the SAT® and the Advanced Placement Program®. The organization also serves the education community through research and advocacy on behalf of students, educators, and schools.

For further information, visit **www.collegeboard.org**.

PRE-AP EQUITY AND ACCESS POLICY

College Board believes that all students deserve engaging, relevant, and challenging grade-level coursework. Access to this type of coursework increases opportunities for all students, including groups that have been traditionally underrepresented in AP and college classrooms. Therefore, the Pre-AP program is dedicated to collaborating with educators across the country to ensure all students have the supports to succeed in appropriately challenging classroom experiences that allow students to learn and grow. It is only through a sustained commitment to equitable preparation, access, and support that true excellence can be achieved for all students, and the Pre-AP course designation requires this commitment.

ISBN: 978-1-4573-1513-8

1 2 3 4 5 6 7 8 9 10

Contents

Acknowledgments

College Board would like to acknowledge the following committee members, consultants, and reviewers for their assistance with and commitment to the development of this course. All individuals and their affiliations were current at the time of contribution.

Jason Crean, *Lyons Township High School, Lagrange, IL*

Rick Duschl, *Penn State University, University Park, PA*

Mark Eberhard, *St. Clair High School, St. Clair, MI*

Amy Fassler, *Marshfield High School, Marshfield, WI*

David Hong, *Diamond Bar High School, Diamond Bar, CA*

Kenneth Huff, *Mill Middle School, Williamsville, IL*

Michelle Koehler, *Riverside Brookfield High School, Riverside, IL*

Courtney Mayer, *Northside Independent School District, San Antonio, TX*

Elisa McCracken, *Brandeis High School, San Antonio, TX*

Jennifer Pfannerstill, *North Shore Country Day School, Winnetka, IL*

Nancy Ramos, *Northside Health Careers High School, San Antonio, TX*

Jim Smanik, *Sycamore High, Cincinnati, OH*

Keri Shingleton, *Holland Hall, Tulsa, OK*

COLLEGE BOARD STAFF

Karen Lionberger, *Senior Director, Pre-AP STEM Curriculum, Instruction, and Assessment*

Beth Hart, *Senior Director, Pre-AP Assessment*

Mitch Price, *Director, Pre-AP STEM Assessment*

Natasha Vasavada, *Executive Director, Pre-AP Curriculum, Instruction, and Assessment*

About Pre-AP

Introduction to Pre-AP

Every student deserves classroom opportunities to learn, grow, and succeed. College Board developed Pre-AP® to deliver on this simple premise. Pre-AP courses are designed to support all students across varying levels of readiness. They are not honors or advanced courses.

Participation in Pre-AP courses allows students to slow down and focus on the most essential and relevant concepts and skills. Students have frequent opportunities to engage deeply with texts, sources, and data as well as compelling higher-order questions and problems. Across Pre-AP courses, students experience shared instructional practices and routines that help them develop and strengthen the important critical thinking skills they will need to employ in high school, college, and life. Students and teachers can see progress and opportunities for growth through varied classroom assessments that provide clear and meaningful feedback at key checkpoints throughout each course.

DEVELOPING THE PRE-AP COURSES

Pre-AP courses are carefully developed in partnership with experienced educators, including middle school, high school, and college faculty. Pre-AP educator committees work closely with College Board to ensure that the course resources define, illustrate, and measure grade-level-appropriate learning in a clear, accessible, and engaging way. College Board also gathers feedback from a variety of stakeholders, including Pre-AP partner schools from across the nation who have participated in multiyear pilots of select courses. Data and feedback from partner schools, educator committees, and advisory panels are carefully considered to ensure that Pre-AP courses provide all students with grade-level-appropriate learning experiences that place them on a path to college and career readiness.

PRE-AP PROGRAM COMMITMENTS

The Pre-AP Program asks participating schools to make four commitments:

1. **Pre-AP for All:** Pre-AP frameworks and assessments serve as the foundation for all sections of the course at the school.
2. **Course Frameworks:** Teachers align their classroom instruction with the Pre-AP course frameworks.
    - Schools commit to provide the core resources to ensure Pre-AP teachers and students have the materials they need to engage in the course.

3. **Assessments:** Teachers administer at least one learning checkpoint per unit on Pre-AP Classroom and four performance tasks.
4. **Professional Learning:** Teachers complete the foundational professional learning (Online Foundational Modules or Pre-AP Summer Institute) and at least one online performance task scoring module. The current Pre-AP coordinator completes the Pre-AP Coordinator Online Module.

PRE-AP EDUCATOR NETWORK

Similar to the way in which teachers of Advanced Placement® (AP®) courses can become more deeply involved in the program by becoming AP Readers or workshop consultants, Pre-AP teachers also have opportunities to become active in their educator network. Each year, College Board expands and strengthens the Pre-AP National Faculty—the team of educators who facilitate Pre-AP Professional Learning Workshops. Pre-AP teachers can also become curriculum and assessment contributors by working with College Board to design, review, or pilot the course resources.

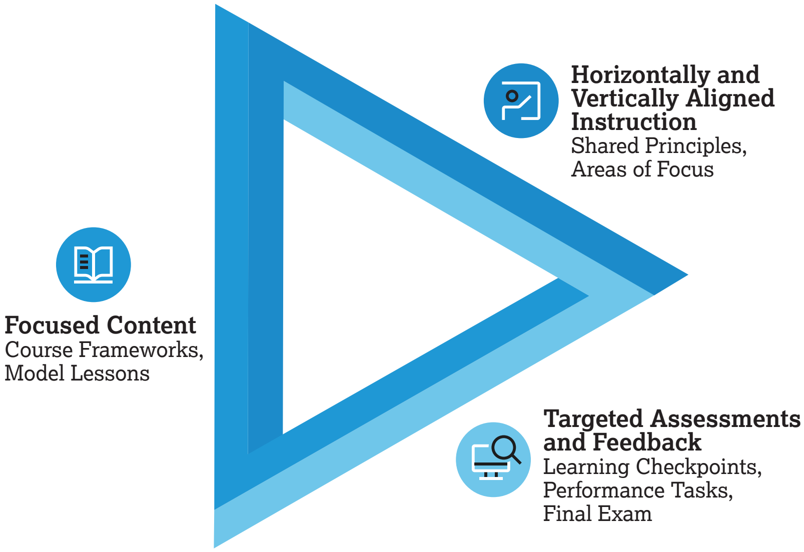
HOW TO GET INVOLVED

Schools and districts interested in learning more about participating in Pre-AP should visit **preap.org/join** or contact us at **preap@collegeboard.org**.

Teachers interested in becoming members of Pre-AP National Faculty or participating in content development should visit **preap.org/national-faculty** or contact us at **preap@collegeboard.org**.

Pre-AP Approach to Teaching and Learning

Pre-AP courses invite all students to learn, grow, and succeed through focused content, horizontally and vertically aligned instruction, and targeted assessments for learning. The Pre-AP approach to teaching and learning, as described below, is not overly complex, yet the combined strength results in powerful and lasting benefits for both teachers and students. This is our theory of action.



FOCUSED CONTENT

Pre-AP courses focus deeply on a limited number of concepts and skills with the broadest relevance for high school coursework and college and career success. The course framework serves as the foundation of the course and defines these prioritized concepts and skills. Pre-AP model lessons and assessments are based directly on this focused framework. The course design provides students and teachers with intentional permission to slow down and focus.

HORIZONTALLY AND VERTICALLY ALIGNED INSTRUCTION

Shared principles cut across all Pre-AP courses and disciplines. Each course is also aligned to discipline-specific areas of focus that prioritize the critical reasoning skills and practices central to that discipline.

SHARED PRINCIPLES

All Pre-AP courses share the following set of research-supported instructional principles. Classrooms that regularly focus on these cross-disciplinary principles allow students to effectively extend their content knowledge while strengthening their critical thinking skills. When students are enrolled in multiple Pre-AP courses, the horizontal alignment of the shared principles provides students and teachers across disciplines with a shared language for their learning and investigation and multiple opportunities to practice and grow. The critical reasoning and problem-solving tools students develop through these shared principles are highly valued in college coursework and in the workplace.

Close Observation and Analysis

Students are provided time to carefully observe one data set, text, image, performance piece, or problem before being asked to explain, analyze, or evaluate. This creates a safe entry point to simply express what they notice and what they wonder. It also encourages students to slow down and capture relevant details with intentionality to support more meaningful analysis, rather than rushing to completion at the expense of understanding.

Higher-Order Questioning

Students engage with questions designed to encourage thinking that is elevated beyond simple memorization and recall. Higher-order questions require students to make predictions, synthesize, evaluate, and compare. As students grapple with these questions, they learn that being inquisitive promotes extended thinking and leads to deeper understanding.

Evidence-Based Writing

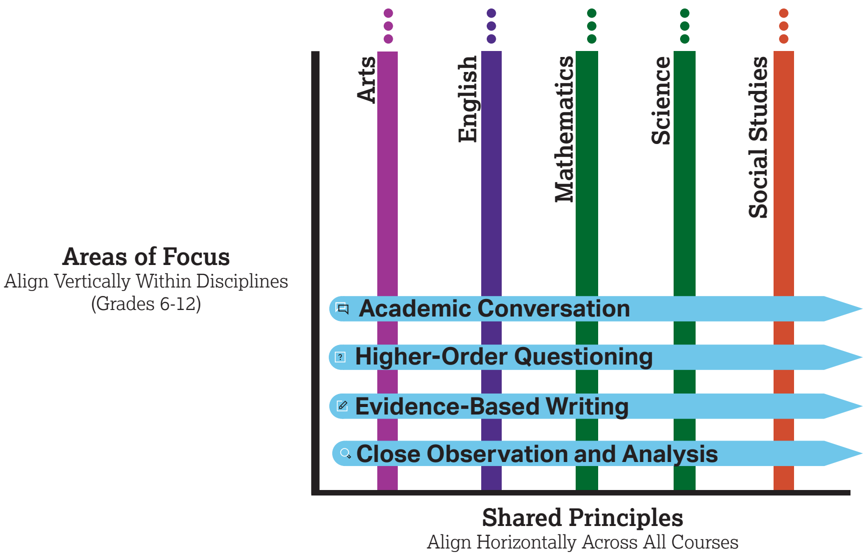
With strategic support, students frequently engage in writing coherent arguments from relevant and valid sources of evidence. Pre-AP courses embrace a purposeful and scaffolded approach to writing that begins with a focus on precise and effective sentences before progressing to longer forms of writing.

Academic Conversation

Through peer-to-peer dialogue, students' ideas are explored, challenged, and refined. As students engage in academic conversation, they come to see the value in being open to new ideas and modifying their own ideas based on new information. Students grow as they frequently practice this type of respectful dialogue and critique and learn to recognize that all voices, including their own, deserve to be heard.

AREAS OF FOCUS

The areas of focus are discipline-specific reasoning skills that students develop and leverage as they engage with content. Whereas the shared principles promote horizontal alignment across disciplines, the areas of focus provide vertical alignment within a discipline, giving students the opportunity to strengthen and deepen their work with these skills in subsequent courses in the same discipline.



For information about the Pre-AP science areas of focus, see page 13.

TARGETED ASSESSMENTS FOR LEARNING

Pre-AP courses include strategically designed classroom assessments that serve as tools for understanding progress and identifying areas that need more support. The assessments provide frequent and meaningful feedback for both teachers and students across each unit of the course and for the course as a whole. For more information about assessments in Pre-AP Biology, see page 54.

Pre-AP Professional Learning

As part of the program commitments, Pre-AP teachers agree to engage in two professional learning opportunities:

1. The first commitment is designed to help prepare teachers to teach their specific course. There are two options to meet this commitment: the Pre-AP Summer Institute (Pre-APSI) and the Online Foundational Modules. Both options provide continuing education units upon completion.
   - The Pre-AP Summer Institute provides a collaborative experience that empowers participants to prepare and plan for their Pre-AP course. While attending, teachers engage with Pre-AP course frameworks, shared principles, areas of focus, and sample model lessons. Participants are given supportive planning time where they work with peers to begin building their Pre-AP course plan.
   - Online Foundational Modules are available to all teachers of Pre-AP courses. In their 12- to 20-hour asynchronous course, teachers explore course materials and experience model lessons from the student's point of view. They also begin building their Pre-AP course plan.
2. The second professional learning opportunity helps teachers prepare for the performance tasks. As part of this commitment, teachers agree to complete at least one online performance task scoring module. Online scoring modules offer guidance and practice applying scoring guidelines and examining student work. Teachers may complete the modules independently or with teachers of the same course in their school's professional learning communities.

About Pre-AP Biology

Introduction to Pre-AP Biology

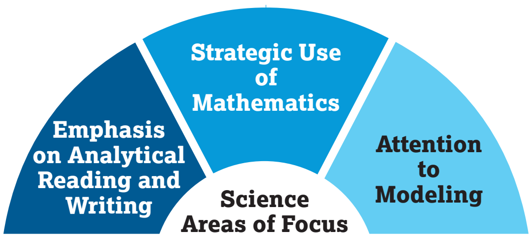
The Pre-AP Biology course emphasizes the integration of content with science practices—powerful reasoning tools that support students in analyzing the natural world around them. Having this ability is one of the hallmarks of scientific literacy and is critical for numerous college and career endeavors in science and the social sciences.

Rather than seeking to cover all topics traditionally included in a standard biology textbook, this course focuses on the foundational biology knowledge and skills that matter most for college and career readiness. The Pre-AP Biology Course Framework highlights how to guide students to connect core ideas within and across the units of the course, promoting the development of a coherent understanding of biological systems.

The components of this course have been crafted to prepare not only the next generation of biologists but also a broader base of biology-informed citizens who are well equipped to respond to the array of science-related issues that impact our lives at the personal, local, and global levels.

PRE-AP SCIENCE AREAS OF FOCUS

The Pre-AP science areas of focus, shown below, are science practices that students develop and leverage as they engage with content. They were identified through educator feedback and research about where students and teachers need the most curriculum support. These areas of focus are vertically aligned to the science practices embedded in other science courses in high school, including AP, and in college, giving students multiple opportunities to strengthen and deepen their work with these skills throughout their educational career. They also support and align to the NGSS and AP science practices of theory building and refinement.



Emphasis on Analytical Reading and Writing

Students engage in analytical reading and writing to gain, retain, and apply scientific knowledge and to carry out scientific argumentation.

In prioritizing analytical reading, Pre-AP Biology classrooms ask students to extract, synthesize, and compare complex information, often by moving between texts and multiple representations, such as tables and graphs. Through analytical writing activities, Pre-AP Biology students must integrate and translate that information to generate scientific questions, design methods for answering questions, and develop scientific arguments. Moreover, the application of these skills to the understanding of informal science texts, such as articles found in newspapers, online sources, and magazines, prepares students to be discerning consumers of scientific information.

Strategic Use of Mathematics

Students use mathematics strategically in order to understand and express the quantitative aspects of biology, to record and interpret experimental data, and to solve problems as they arise.

The ability to analyze and interpret data collected while investigating the natural world is a critical practice for scientists. Once collected, data must be translated into forms that can be analyzed in an attempt to reveal meaningful patterns and relationships. These patterns and relationships are not always immediately obvious, so students must become strategic in how they choose to apply mathematical and statistical thinking in order to analyze data.

Attention to Modeling

Students go beyond labeling diagrams to creating, revising, and using models to explain key patterns, interactions, and relationships in biological systems.

Modeling is a core practice for scientists as they use a variety of models to develop, refine, and communicate their ideas about the natural world. Engaging students in modeling also reinforces other scientific reasoning skills, such as data analysis and scientific argumentation. Modeling also helps illustrate for students how scientific knowledge is constructed and modified over time as new data and evidence emerge and models are revised based on this new information.

PRE-AP BIOLOGY AND CAREER READINESS

The Pre-AP Biology course resources are designed to expose students to a wide range of career opportunities that depend on biology knowledge and skills. Examples include not only careers within the life sciences, such as marine ecologist or wildlife geneticist, but also other endeavors where biology knowledge is relevant, such as the work of a park ranger or healthcare policymaker.

Career clusters that involve biology, along with examples of careers in biology or related to biology, are provided below. Teachers should consider discussing these with students throughout the year to promote motivation and engagement.

Career Clusters Involving Biology	
agriculture, food, and natural resources healthcare and health science human services manufacturing STEM (science, technology, engineering, and math)	
Examples of Biology Careers	**Examples of Biology Related Careers**
biology teacher/professor botanist ecologist genetic counselor marine biologist microbiologist neurologist primary care physician veterinarian zoologist	anthropologist biochemist dental assistant/dentist environmental scientist forensic scientist medical assistant nurse pharmacist physician assistant science writer

Source for Career Clusters: "Advanced Placement and Career and Technical Education: Working Together." Advance CTE and the College Board. October 2018. **https://careertech.org/resource/ap-cte-working-together.**

For more information about careers that involve biology, teachers and students can visit and explore the College Board's Big Future resources: **https://bigfuture.collegeboard.org/majors/biological-biomedical-sciences-biology-general**.

SUMMARY OF RESOURCES AND SUPPORTS

Teachers are strongly encouraged to take advantage of the full set of resources and supports for Pre-AP Biology, which is summarized below. Some of these resources are part of the Pre-AP Program commitments that lead to Pre-AP Course Designation. To learn more about the commitments for course designation, see details below and on page 71.

COURSE FRAMEWORK

Included in this guide as well as in the *Pre-AP Biology Teacher Resources*, the framework defines what students should know and be able to do by the end of the course. It serves as an anchor for model lessons and assessments, and it is the primary resource needed to plan the course. **Teachers commit to aligning their classroom instruction with the course framework**. *For more details see page 20.*

MODEL LESSONS

Teacher resources, available in print and online, include a robust set of model lessons that demonstrate how to translate the course framework, shared principles, and areas of focus into daily instruction. **Use of the model lessons is encouraged**. *For more details see page 52.*

LEARNING CHECKPOINTS

Accessed through Pre-AP Classroom (the Pre-AP digital platform), these short formative assessments provide insight into student progress. They are automatically scored and include multiple-choice and technology-enhanced items with rationales that explain correct and incorrect answers. **Teachers commit to administering one learning checkpoint per unit**. *For more details see page 54.*

PERFORMANCE TASKS

Available in the printed teacher resources as well as on Pre-AP Classroom, performance tasks allow students to demonstrate their learning through extended problem-solving, writing, analysis, and/or reasoning tasks. Scoring guidelines are provided to inform teacher scoring, with additional practice and feedback suggestions available in online modules on Pre-AP Classroom. **Teachers commit to using each unit's performance task**. *For more details see page 56.*

PRACTICE PERFORMANCE TASKS

Available in the student resources, with supporting materials in the teacher resources, these tasks provide an opportunity for students to practice applying skills and knowledge as they would in a performance task, but in a more scaffolded environment. **Use of the practice performance tasks is encouraged**. *For more details see page 57.*

FINAL EXAM

Accessed through Pre-AP Classroom, the final exam serves as a classroom-based, summative assessment designed to measure students' success in learning and applying the knowledge and skills articulated in the course framework. **Administration of the final exam is encouraged**. *For more details see page 64.*

PROFESSIONAL LEARNING

Both the Pre-AP Summer Institute (Pre-APSI) and the Online Foundational Modules support teachers in preparing and planning to teach their Pre-AP course. **All Pre-AP teachers make a commitment to either attend the Pre-APSI (in person or virtually) or complete the Online Foundational Modules. In addition, teachers agree to complete at least one Online Performance Task Scoring module**. *For more details see page 9.*

Course Map

PLAN

The course map shows how components are positioned throughout the course. As the map indicates, the course is designed to be taught over 140 class periods (based on 45-minute class periods), for a total of 28 weeks.

Model lessons are included for approximately 50% of the total instructional time, with the percentage varying by unit. Each unit is divided into key concepts.

TEACH

The model lessons demonstrate how the Pre-AP shared principles and science areas of focus come to life in the classroom.

Shared Principles
Close observation and analysis
Higher-order questioning
Evidence-based writing
Academic conversation

Science Areas of Focus
Emphasis on analytical reading and writing
Strategic use of mathematics
Attention to modeling

ASSESS AND REFLECT

Each unit includes two learning checkpoints and a performance task. These formative assessments are designed to provide meaningful feedback for both teachers and students. Opportunities for formative assessment are also provided throughout the model lessons.

Note: The final exam, offered during a six-week window in the spring, is not represented in the map.

UNIT 1 Ecological Systems

~25 Class Periods

Pre-AP model lessons provided for approximately 70% of instructional time in this unit

KEY CONCEPT ECO 1
Cycling of Matter in the Biosphere

KEY CONCEPT ECO 2
Population Dynamics

Learning Checkpoint 1

KEY CONCEPT ECO 3
Defining Ecological Communities

KEY CONCEPT ECO 4
Ecological Community Dynamics

KEY CONCEPT ECO 5
Changes in Ecological Communities

Learning Checkpoint 2

Performance Task for Unit 1

UNIT 2 Evolution

~20 Class Periods

Pre-AP model lessons provided for approximately 40% of instructional time in this unit

KEY CONCEPT EVO 1
Patterns of Evolution

KEY CONCEPT EVO 2
Mechanisms of Evolution

Learning Checkpoint 1

KEY CONCEPT EVO 3
Speciation

Learning Checkpoint 2

Performance Task for Unit 2

UNIT 3 Cellular Systems

~50 Class Periods

Pre-AP model lessons provided for approximately 40% of instructional time in this unit

KEY CONCEPT CELLS 1
Chemistry of Life

KEY CONCEPT CELLS 2
Cell Structure and Function

KEY CONCEPT CELLS 3
Cell Transport and Homeostasis

KEY CONCEPT CELLS 4
Organisms Maintaining Homeostasis

Learning Checkpoint 1

KEY CONCEPT CELLS 5
Cell Growth and Division

KEY CONCEPT CELLS 6
Photosynthesis

KEY CONCEPT CELLS 7
Cellular Respiration and Fermentation

Learning Checkpoint 2

Performance Task for Unit 3

UNIT 4 Genetics

~45 Class Periods

Pre-AP model lessons provided for approximately 35% of instructional time in this unit

KEY CONCEPT GEN 1
Structure of DNA

KEY CONCEPT GEN 2
DNA Synthesis

KEY CONCEPT GEN 3
Protein Synthesis

Learning Checkpoint 1

KEY CONCEPT GEN 4
Asexual and Sexual Passing of Traits

KEY CONCEPT GEN 5
Inheritance Patterns

KEY CONCEPT GEN 6
Biotechnology

Learning Checkpoint 2

Performance Task for Unit 4

Pre-AP Biology Course Framework

INTRODUCTION

Based on the Understanding by Design® (Wiggins and McTighe) model, the Pre-AP Biology Course Framework is back mapped from AP expectations and aligned to essential grade-level expectations. The course framework serves as a teacher's blueprint for the Pre-AP Biology instructional resources and assessments.

The course framework was designed to meet the following criteria:

- **Focused:** The framework provides a deep focus on a limited number of concepts and skills that have the broadest relevance for later high school, college, and career success.
- **Measurable:** The framework's learning objectives are observable and measurable statements about the knowledge and skills students should develop in the course.
- **Manageable:** The framework is manageable for a full year of instruction, fosters the ability to explore concepts in depth, and enables room for additional local or state standards to be addressed where appropriate.
- **Accessible:** The framework's learning objectives are designed to provide all students, across varying levels of readiness, with opportunities to learn, grow, and succeed.

COURSE FRAMEWORK COMPONENTS

The Pre-AP Biology Course Framework includes the following components:

Big Ideas

The big ideas are recurring themes that allow students to create meaningful connections between course concepts. Revisiting the big ideas throughout the course and applying them in a variety of contexts allows students to develop deeper conceptual understandings.

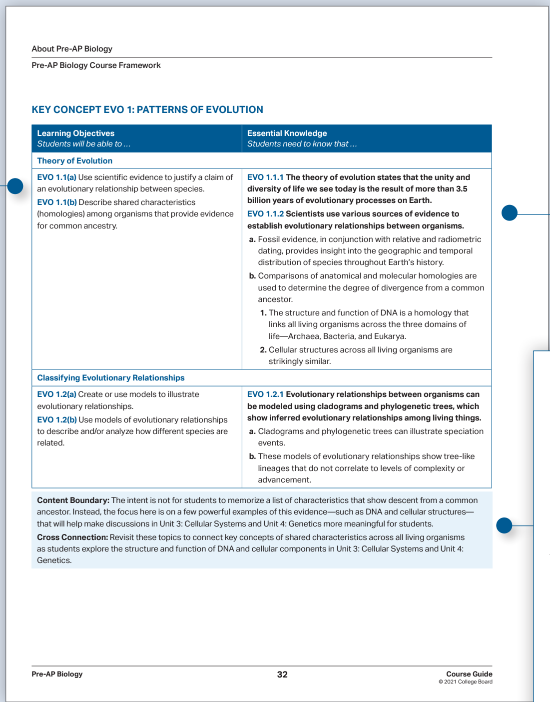
Enduring Understandings

Each unit focuses on a small set of enduring understandings. These are the long-term takeaways related to the big ideas that leave a lasting impression on students. Students build and earn these understandings over time by exploring and applying course content throughout the year.

Key Concepts

To support teacher planning and instruction, each unit is organized by key concepts. Each key concept includes relevant **learning objectives** and **essential knowledge statements** and may also include **content boundary and cross connection statements**. These are illustrated and defined below.

Learning Objectives: These objectives define what a student needs to be able to do with essential knowledge in order to progress toward the enduring understandings. The learning objectives serve as actionable targets for instruction and assessments.



About Pre-AP Biology

Pre-AP Biology Course Framework

KEY CONCEPT EVO 1: PATTERNS OF EVOLUTION

Learning Objectives *Students will be able to …*	Essential Knowledge *Students need to know that …*
Theory of Evolution	
EVO 1.1(a) Use scientific evidence to justify a claim of an evolutionary relationship between species. EVO 1.1(b) Describe shared characteristics (homologies) among organisms that provide evidence for common ancestry.	EVO 1.1.1 **The theory of evolution states that the unity and diversity of life we see today is the result of more than 3.5 billion years of evolutionary processes on Earth.** EVO 1.1.2 **Scientists use various sources of evidence to establish evolutionary relationships between organisms.** **a.** Fossil evidence, in conjunction with relative and radiometric dating, provides insight into the geographic and temporal distribution of species throughout Earth's history. **b.** Comparisons of anatomical and molecular homologies are used to determine the degree of divergence from a common ancestor. **1.** The structure and function of DNA is a homology that links all living organisms across the three domains of life—Archaea, Bacteria, and Eukarya. **2.** Cellular structures across all living organisms are strikingly similar.
Classifying Evolutionary Relationships	
EVO 1.2(a) Create or use models to illustrate evolutionary relationships. EVO 1.2(b) Use models of evolutionary relationships to describe and/or analyze how different species are related.	EVO 1.2.1 **Evolutionary relationships between organisms can be modeled using cladograms and phylogenetic trees, which show inferred evolutionary relationships among living things.** **a.** Cladograms and phylogenetic trees can illustrate speciation events. **b.** These models of evolutionary relationships show tree-like lineages that do not correlate to levels of complexity or advancement.

Content Boundary: The intent is not for students to memorize a list of characteristics that show descent from a common ancestor. Instead, the focus here is on a few powerful examples of this evidence—such as DNA and cellular structures—that will help make discussions in Unit 3: Cellular Systems and Unit 4: Genetics more meaningful for students.

Cross Connection: Revisit these topics to connect key concepts of shared characteristics across all living organisms as students explore the structure and function of DNA and cellular components in Unit 3: Cellular Systems and Unit 4: Genetics.

Pre-AP Biology 32 Course Guide © 2021 College Board

Essential Knowledge Statements: The essential knowledge statements are linked to one or more learning objectives. These statements describe the knowledge required to perform the learning objective(s).

Content Boundary and Cross Connection Statements: When needed, content boundary statements provide additional clarity about the content and skills that lie within versus outside of the scope of this course.

Cross connection statements highlight important connections that should be made between key concepts within and across the units.

BIG IDEAS IN PRE-AP BIOLOGY

While the Pre-AP Biology framework is organized into four core units of study, the content is grounded in four big ideas, which are cross-cutting concepts that build conceptual understanding and spiral throughout the course. These ideas cut across all four units of the course and serve as the underlying foundation for the enduring understandings, key concepts, learning objectives, and essential knowledge statements that make up the focus of each unit.

The four big ideas that are central to deep and productive understanding in Pre-AP Biology are:

- The process of evolution drives the diversity and unity of life.
- Growth and reproduction in biological systems are dependent upon the cycling of matter and the transformation of energy.
- Biological systems, occurring at various scales, respond and adapt to stimuli in order to maintain dynamic homeostasis.
- Genetic mechanisms are essential to maintaining biological systems.

OVERVIEW OF PRE-AP BIOLOGY UNITS AND ENDURING UNDERSTANDINGS

Unit 1: Ecological Systems (ECO)	Unit 2: Evolution (EVO)
▪ Biological systems depend on the cycling of matter within and between Earth's systems. ▪ Most ecosystems rely on the conversion of solar energy into chemical energy for use in biological processes. ▪ The dependence on the availability of abiotic and biotic resources results in complex and dynamic interactions between organisms and populations. ▪ Changes to the environment can alter interactions between organisms.	▪ The theory of evolution states that all organisms descend from a common ancestor and share some characteristics. ▪ Biological evolution is observable as phenotypic changes in a population over multiple successive generations. ▪ Speciation, extinction, and the abundance and distribution of organisms occur in response to environmental conditions.
Unit 3: Cellular Systems (CELLS)	**Unit 4: Genetics (GEN)**
▪ Four classes of macromolecules serve as the primary building blocks of biological systems. ▪ Biological systems have specialized structures that enable specific functions necessary to sustain life. ▪ Biological systems must respond to changes in internal and external environments in order to maintain dynamic homeostasis. ▪ In order to sustain complex processes, biological systems must have mechanisms for growth and repair.	▪ The molecular structure of DNA enables its function of storing life's genetic information. ▪ Encoded in DNA is the heritable information responsible for synthesis of RNA, which makes gene expression possible. ▪ Organisms have diverse strategies for passing their genetic material on to the next generation. ▪ Models can be used to illustrate and predict the inheritance of traits.

Unit 1: Ecological Systems

Suggested Timing: Approximately 5 weeks

In this unit, students deepen and expand prior knowledge, gained in a middle school life science course, of how the cycling of matter and flow of energy regulate ecosystems. Students also apply proportional reasoning skills to examine data, especially bivariate data, in order to analyze and make scientific claims about patterns, relationships, and changes in the structure and distribution of ecological populations and communities. This unit provides students an opportunity to build on and deepen their understanding of the living and nonliving components that regulate the structure and function of ecological systems. Students should begin to gain an appreciation for the intricate and often fragile interdependent relationships that ecological communities rely on. Students also explore how communities change over time, both through naturally occurring processes and through human activities.

ENDURING UNDERSTANDINGS

Students will understand that …

- Biological systems depend on the cycling of matter within and between Earth's systems.
- Most ecosystems rely on the conversion of solar energy into chemical energy for use in biological processes.
- The dependence on the availability of abiotic and biotic resources results in complex and dynamic interactions between organisms and populations.
- Changes to the environment can alter interactions between organisms.

KEY CONCEPTS

- ECO 1: Cycling of Matter in the Biosphere
- ECO 2: Population Dynamics
- ECO 3: Defining Ecological Communities
- ECO 4: Ecological Community Dynamics
- ECO 5: Changes in Ecological Communities

KEY CONCEPT ECO 1: CYCLING OF MATTER IN THE BIOSPHERE

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Hydrologic Cycle	
ECO 1.1(a) Explain how the unique properties and phase changes of water enable and regulate biological reactions and/or processes. **ECO 1.1(b)** Create and/or use a model to explain how biological systems function in the hydrologic cycle as water is transferred, transported, and/or stored.	**ECO 1.1.1 Water cycles between abiotic and biotic systems in a process known as the hydrologic cycle.** **a.** The polar nature of water results in properties on which biological systems depend, such as dissolving organic and inorganic nutrients. **b.** The hydrologic cycle is driven by energy from the sun and gravity. **c.** The largest reservoir of water in the global hydrologic cycle is the world's oceans. **d.** Only a small portion of the water on Earth is fresh water, which is required for life by all terrestrial organisms, including humans.
Carbon and Nutrient Cycles	
ECO 1.2(a) Explain the importance of the cycling of carbon for biological systems. **ECO 1.2(b)** Create and/or use models to illustrate how organisms' capture and use of energy plays a role in the cycling of carbon in ecosystems. **ECO 1.2(c)** Explain the importance of the cycling of nutrients for biological systems. **ECO 1.2(d)** Create and/or use models to describe the cycling of nitrogen between biotic and abiotic systems.	**ECO 1.2.1 Elements that are building blocks of macromolecules are transported from abiotic to biotic systems through gaseous and sedimentary cycles.** **a.** The carbon cycle is a series of molecular transformations that includes photosynthesis and cellular respiration. **b.** The nitrogen cycle is a series of transformations that includes the conversion of nitrogen gas (the largest reservoir of nitrogen on Earth) into biologically available nitrogen-containing molecules (e.g., nitrates). **c.** Phosphorus is a critical element for organisms, as it helps make up numerous biomolecules (e.g., ATP, DNA).

Content Boundary: An understanding of the cycling of sulfur and phosphorus in the ecosystem is beyond the scope of this course. Students should understand why phosphorus is an important element, as it serves as a monomer in many important biomolecules (e.g., ATP, DNA), but the understanding of the cycle will not be assessed. Also, students should be able to model the nitrogen cycle from a general standpoint of how biotic and abiotic components interact and depend on one another. However, an understanding of all the chemical conversions during this cycle is beyond the scope of this course.

KEY CONCEPT ECO 2: POPULATION DYNAMICS

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Population Structure	
ECO 2.1(a) Explain the role abiotic and/or biotic resources play in defining the niche of a species. **ECO 2.1(b)** Collect and/or use data to predict population size, density, and/or distribution. **ECO 2.1(c)** Create and/or use models to illustrate how environmental changes can alter the availability of biotic and/or abiotic resources.	**ECO 2.1.1 Species live in a defined range of abiotic and biotic conditions, or niche.** **a.** Sunlight serves as the primary energy input for most ecosystems. **b.** Species have a range of tolerance for abiotic resources and conditions (e.g., sunlight, nutrients, pH, temperature). **c.** Biotic conditions, such as the behavior of social groups or intraspecific competition for mates and food, also influence population structure. **d.** Environmental changes can alter the availability of abiotic and biotic resources and conditions (e.g., climate changes, drought, fire, floods).
Population Growth	
ECO 2.2(a) Use data to explain the growth of a population. **ECO 2.2(b)** Explain the relationship between resource availability and a population's growth pattern. **ECO 2.2(c)** Explain how competition for resources shapes populations.	**ECO 2.2.1 Population growth patterns are influenced by the availability of resources and the interactions that occur within and between populations of species.** **a.** All organisms have the potential for exponential growth, but few organisms demonstrate this growth pattern. **b.** Both density-dependent (e.g., nutrients and food) and density-independent (e.g., weather, natural disasters) factors regulate population growth. **c.** The availability of a single resource may limit the survival of an organism or population (e.g., nitrates in soil are a limiting factor for plant growth). **d.** Due to dynamic resource availability, many populations fluctuate around their carrying capacity, thus demonstrating a logistical growth pattern. **ECO 2.2.2 Populations demonstrate diverse growth strategies.** **a.** r-selected species are typically short-lived. Therefore, they invest energy in producing many offspring during reproduction but provide little to no care for those offspring. **b.** K-selected species typically live longer. Therefore, they have fewer offspring during reproduction but invest energy in the care of those offspring to ensure survival.

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Food Webs and Transfer of Energy in Ecosystems	
ECO 2.3(a) Create and/or use models to explain the transfer of energy through the food web of a community. **ECO 2.3(b)** Analyze data about species distributions to make predictions about the availability of resources. **ECO 2.3(c)** Make predictions about the energy distribution in an ecosystem based on the energy available to organisms.	**ECO 2.3.1 Energy availability helps shape ecological communities.** **a.** Typically, only 10 percent of the total energy in a given trophic level is available to organisms in the next higher trophic level. **b.** The metabolic activity required to utilize the energy available in any given trophic level results in a loss of thermal energy to the environment, as heat. **c.** The energy available to organisms decreases from lower-order trophic levels (primary producers) to higher-order trophic levels (tertiary consumers).

Content Boundary: Students should begin to gain a conceptual understanding of how populations grow (e.g., exponential versus logistical growth). However, many students may not be able to distinguish the subtle mathematical differences between these two growth curves, especially in early generations. Therefore, assessment questions about growth patterns will be limited to what influences these types of growth; calculations of growth curves are beyond the scope of this course.

Cross Connection: Students should have strong familiarity with food webs from middle school life science. This course should give students opportunities to make connections and extend their understanding of characteristics of organisms and food webs to deeper conceptual knowledge about how energy is transferred through diverse ecosystems.

KEY CONCEPT ECO 3: DEFINING ECOLOGICAL COMMUNITIES

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Importance of Biodiversity	
ECO 3.1(a) Describe how ecological processes rely on the biological diversity of the community. **ECO 3.1(b)** Given a specific biome, describe the ecological services that are provided that benefit humans.	**ECO 3.1.1 Reductions in local and global biodiversity can significantly alter the stability of ecosystem processes and services.** **a.** Biologically diverse ecological communities are more resilient to environmental changes. **b.** Ecosystems rely on biological diversity to sustain necessary processes, such as cycling of nutrients and transfer of energy through food webs. **c.** Diverse ecosystems provide many necessary services that humans rely on, such as climate regulation, carbon storage, filtration of drinking water, pollination, and flood/erosion control.
Types of Ecological Communities	
ECO 3.2(a) Describe differences in the abiotic and/or biotic factors that shape aquatic and terrestrial communities. **ECO 3.2(b)** Use data to make predictions about how abiotic and/or biotic factors shape an ecological community.	**ECO 3.2.1 Terrestrial biomes are classified by geographic locations and the abiotic factors that shape the unique ecological communities.** **a.** Two major abiotic factors that help define terrestrial biomes are climate (temperature, precipitation) and soil type. **b.** Ecological communities in terrestrial biomes are shaped by the availability and abundance of the abiotic factors in that region. **ECO 3.2.2 Aquatic biomes can generally be classified according to their salt concentrations: oceanic, brackish, and freshwater.** **a.** Ecological communities in aquatic biomes are shaped by water depth (amount of sunlight), salinity, temperature, nutrients, and flow rates (currents). **b.** Estuaries are brackish ecological communities, as they form in areas where freshwater rivers meet the sea. Their ecological communities are uniquely shaped by the ocean tides. **c.** The three major freshwater communities are rivers/streams, lakes/ponds, and freshwater wetlands.

Content Boundary: Students should gain an understanding of the type of abiotic and biotic components of ecosystems that shape communities of living organisms. They should be able to describe how these components differ for terrestrial and aquatic ecosystems. However, a deep knowledge of chemical regulatory processes (e.g., dissolved oxygen in aquatic systems) is beyond the scope of this course.

Cross Connection: Students should connect key concepts of the carbon cycle from earlier in the unit to the importance of ecosystems, such as forests and oceans, as reservoirs for carbon.

KEY CONCEPT ECO 4: ECOLOGICAL COMMUNITY DYNAMICS

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Interspecific Competition	
ECO 4.1(a) Explain how competition shapes community characteristics. **ECO 4.1(b)** Use data to analyze how competition influences niche-partitioning in an ecological community. **ECO 4.1(c)** Create and/or use models to explain predictions about the possible effects of changes in the availability of resources on the interactions between species.	**ECO 4.1.1 Competition between species drives complex interactions in ecosystems.** **a.** Predator and prey populations respond dynamically to each other. **b.** Keystone species have a dramatic impact on the structure and diversity of ecological communities (e.g., trophic cascade). **c.** Competition will lead to the exclusion of all but one species when two or more species attempt to occupy the same niche. **d.** Niche-partitioning is a means of reducing competition for resources.
Symbiosis	
ECO 4.2(a) Describe what type of symbiotic relationship exists between two organisms. **ECO 4.2(b)** Explain how a symbiotic relationship provides an advantage for an organism by reducing one or more environmental pressures.	**ECO 4.2.1 Competition in ecosystems has led to symbiotic relationships where two or more species live closely together.** **a.** Mutualistic relationships often form to provide food or protection for both of the organisms involved. **b.** Parasitic relationships benefit only one organism in the relationship (the symbiont) and harm the host. **c.** Commensalism is a kind of relationship that benefits only one organism in the relationship (the symbiont); the host is neither harmed nor helped.

KEY CONCEPT ECO 5: CHANGES IN ECOLOGICAL COMMUNITIES

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Natural Changes in Biodiversity	
ECO 5.1(a) Explain how natural changes in the ecosystem affect ecosystem dynamics. **ECO 5.1(b)** Create and/or use models to make predictions about how changes in biodiversity affect local ecosystems. **ECO 5.1(c)** Analyze data to make predictions about the effects on biodiversity in response to environmental changes.	**ECO 5.1.1 Ecosystem biodiversity is influenced by several naturally occurring factors that alter the environment.** **a.** Changes in energy, nutrient, and niche availability influence an ecosystem's biodiversity. **b.** Major disturbances (e.g., forest fires, hurricanes, volcanic eruptions) initiate ecological succession. **c.** Mass extinctions open new, available niches for colonization and therefore can have significant impacts on biodiversity (e.g., the mammalian diversity explosion post-dinosaur extinction, 65 million years ago). **d.** Keystone species and ecosystem engineers (e.g., elephants, beavers) dramatically affect biodiversity in the ecosystem.
Human-Induced Changes in Biodiversity	
ECO 5.2(a) Use evidence to support the claim that changes in ecosystems have resulted from human activities. **ECO 5.2(b)** Given a human activity, predict the potential biological consequences for an ecosystem's biodiversity. **ECO 5.2(c)** Create and/or use models to design solutions that mitigate the adverse effects of a human-induced environmental change on the biodiversity of an ecosystem.	**ECO 5.2.1 Human activities (e.g., urbanization, farming, tree harvesting) also alter availability of nutrients, food, and niches for species and therefore affect population and community dynamics.** **a.** Human activities include anthropogenic climate change, the introduction of invasive species, habitat destruction, and air/water pollution. **b.** The effects of human-induced environmental changes and their impact on species are the subject of a significant amount of current scientific research.

Content Boundary: There are numerous examples of human-induced changes to ecosystems. The focus here is on identifying a few examples of how human activities affect interactions in ecological systems by reducing biodiversity. Understanding topics such as desertification and salinization resulting from human activity are beyond the scope of this course.

Unit 2: Evolution

Suggested Timing: Approximately 4 weeks

In this unit, students explore the diverse types of data and multiple lines of evidence that have informed our understanding of the theory of evolution over time. Students should have a general familiarity with concepts associated with evolution from middle school life science. This course is designed to build on that general understanding to provide a foundation in the mechanisms of evolution. This includes both small-scale evolution (changes in the relative frequency of a gene in a population from one generation to the next) and large-scale evolution (speciation events over many generations).

ENDURING UNDERSTANDINGS

Students will understand that …

- The theory of evolution states that all organisms descend from a common ancestor and share some characteristics.
- Biological evolution is observable as phenotypic changes in a population over multiple successive generations.
- Speciation, extinction, and the abundance and distribution of organisms occur in response to environmental conditions.

KEY CONCEPTS

- EVO 1: Patterns of Evolution
- EVO 2: Mechanisms of Evolution
- EVO 3: Speciation

KEY CONCEPT EVO 1: PATTERNS OF EVOLUTION

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Theory of Evolution	
EVO 1.1(a) Use scientific evidence to justify a claim of an evolutionary relationship between species. **EVO 1.1(b)** Describe shared characteristics (homologies) among organisms that provide evidence for common ancestry.	EVO 1.1.1 **The theory of evolution states that the unity and diversity of life we see today is the result of more than 3.5 billion years of evolutionary processes on Earth.** EVO 1.1.2 **Scientists use various sources of evidence to establish evolutionary relationships between organisms.** **a.** Fossil evidence, in conjunction with relative and radiometric dating, provides insight into the geographic and temporal distribution of species throughout Earth's history. **b.** Comparisons of anatomical and molecular homologies are used to determine the degree of divergence from a common ancestor. **1.** The structure and function of DNA is a homology that links all living organisms across the three domains of life—Archaea, Bacteria, and Eukarya. **2.** Cellular structures across all living organisms are strikingly similar.
Classifying Evolutionary Relationships	
EVO 1.2(a) Create or use models to illustrate evolutionary relationships. **EVO 1.2(b)** Use models of evolutionary relationships to describe and/or analyze how different species are related.	EVO 1.2.1 **Evolutionary relationships between organisms can be modeled using cladograms and phylogenetic trees, which show inferred evolutionary relationships among living things.** **a.** Cladograms and phylogenetic trees can illustrate speciation events. **b.** These models of evolutionary relationships show tree-like lineages that do not correlate to levels of complexity or advancement.

Content Boundary: The intent is not for students to memorize a list of characteristics that show descent from a common ancestor. Instead, the focus here is on a few powerful examples of this evidence—such as DNA and cellular structures—that will help make discussions in Unit 3: Cellular Systems and Unit 4: Genetics more meaningful for students.

Cross Connection: Revisit these topics to connect key concepts of shared characteristics across all living organisms as students explore the structure and function of DNA and cellular components in Unit 3: Cellular Systems and Unit 4: Genetics.

KEY CONCEPT EVO 2: MECHANISMS OF EVOLUTION

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Natural Selection Theory	
EVO 2.1(a) Describe the scientific discoveries that informed the theory of natural selection.	**EVO 2.1.1 Key discoveries made by several scientists contributed significantly to Darwin's understanding of biological evolution.** **a.** Several naturalists, such as Lamarck and Wallace, contributed models of evolution that informed Darwin's theories. **b.** Darwin's ideas about evolution were influenced by the work of geologists Hutton and Lyell, whose work highlighted the slow-acting geological processes that shape Earth's features.
Selective Mechanisms	
EVO 2.2(a) Describe how selective pressures in the environment can affect an organism's fitness. **EVO 2.2(b)** Explain how selective pressures in the environment could cause shifts in phenotypic and/or allele frequencies. **EVO 2.2(c)** Use data to describe how changes in the environment affect phenotypes in a population. **EVO 2.2(d)** Predict how allelic frequencies in a population shift in response to a change in the environment.	**EVO 2.2.1 Darwin's theory of natural selection is that a selective mechanism in biological evolution may lead to adaptations.** **a.** Abiotic ecosystem components (e.g., nutrients) and biotic ecosystem components (e.g., predators) act as selective pressures. **b.** Favorable traits in a given environment lead to differential reproductive success, or fitness, and over time can produce changes in phenotypic and/or allele frequencies. **c.** Heritable traits that increase an organism's fitness are called adaptations. **d.** Over time, the relative frequency of adaptations in a population's gene pool can increase. **e.** Patterns of natural selection can include phenomena such as coevolution, artificial selection, and sexual selection. **EVO 2.2.2 Favorable traits are relative to their environment and subject to change.** **a.** Changes in the environment happen both naturally (e.g., floods, fires, climate change) and through human-induced activities (e.g., pollution, habitat destruction, climate change).

Cross Connection: Revisit these topics in Unit 4: Genetics to connect key concepts involving genetic processes. Mutation types in DNA sequence, replication errors, and the random nature of independent assortment can lead to phenotypic variations on which natural selection can act. Also, connect key concepts to Unit 1: Ecological Systems. Changes in resources (e.g., nutrients from biogeochemical cycles and predator–prey interactions) can act as selective pressures on organisms.

KEY CONCEPT EVO 3: SPECIATION

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Mechanisms of Speciation	
EVO 3.1(a) Explain how geographic separation events can lead to the formation of new species. **EVO 3.1(b)** Describe mechanisms that contribute to reproductive separation that could lead to speciation.	**EVO 3.1.1 Speciation occurs when populations of the same species are separated, resulting in reduced gene flow, which over time allows populations to become genetically distinct from one another.** **a.** Geographic separation: a physical barrier (e.g., rivers changing course, glacial movement, continental drift). **b.** Habitat specialization: niche differentiation from others in the population. **c.** Behavioral separation: different mating habits, times, or locations from others in the population. **d.** Mechanical separation: structural differences in sex organs that make individuals within a population unable to reproduce with one another.
Rates of Speciation	
EVO 3.2(a) Describe factors that affect the rate of speciation. **EVO 3.2(b)** Use evidence to support the claim that rates of speciation have varied throughout Earth's history. **EVO 3.2(c)** Explain how environmental change can result in the extinction of a species.	**EVO 3.2.1 Rates of speciation and extinction have fluctuated throughout Earth's history in response to changing environmental conditions.** **a.** Gradualism is a model of evolution whereby lineages accumulate small genetic changes over time. **b.** Punctuated equilibrium indicates that periods of stability for species can be punctuated with periods of rapid speciation, or splitting of lineages. **c.** Extinction events that occur simultaneously across numerous species, within a relatively short period of geologic time, are known as mass extinctions. **d.** There have also been human-induced extinctions due to overharvesting and/or changes in habitat (e.g., great auk, passenger pigeon).

Content Boundary: Assessments will not require students to recall dates of major mass extinction events. Instead, the focus here should be on a few diverse examples of evidence that illustrate scientists' current understanding of the rate of speciation and extinction and how that shapes biodiversity.

Unit 3: Cellular Systems

Suggested Timing: Approximately 10 weeks

Students are introduced to cellular structure and function in middle school life science. Therefore, this unit deepens and expands students' knowledge as they explore how cellular structures function together to support a cellular system that grows and develops, responds to a changing environment, and obtains and uses energy. Through concepts of homeostasis, students should gain an appreciation for how interdependent cellular structures are on one another to maintain proper cellular functions. Students then build on their knowledge of cellular systems as they examine how specific structures participate in the process of capturing, storing, and using energy to drive cellular processes. They also connect their understanding of ecological roles of organisms, from Unit 1: Ecological Systems, to the various types of cellular energy processes—photosynthesis, cellular respiration, and fermentation. Concepts in the cellular systems unit may be difficult for some students due to the microscopic, seemingly intangible nature of these ideas and phenomena. One way this course addresses this challenge is through introducing systems-based thinking early on, in Unit 1: Ecological Systems. Now, in Unit 3, students are equipped to use systems-based thinking to develop productive analogies for cellular systems, which can aid in comprehension.

ENDURING UNDERSTANDINGS

Students will understand that …

- Four classes of macromolecules serve as the primary building blocks of biological systems.
- Biological systems have specialized structures that enable specific functions necessary to sustain life.
- Biological systems must respond to changes in internal and external environments in order to maintain dynamic homeostasis.
- In order to sustain complex processes, biological systems must have mechanisms for growth and repair.

KEY CONCEPTS

- CELLS 1: Chemistry of Life
- CELLS 2: Cell Structure and Function
- CELLS 3: Cell Transport and Homeostasis
- CELLS 4: Organisms Maintaining Homeostasis
- CELLS 5: Cell Growth and Division
- CELLS 6: Photosynthesis
- CELLS 7: Cellular Respiration and Fermentation

KEY CONCEPT CELLS 1: CHEMISTRY OF LIFE

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Biomolecules	
CELLS 1.1(a) Differentiate between the major macromolecules based on their structure and/or function. **CELLS 1.2(a)** Explain the role macromolecules play in supporting cellular function.	**CELLS 1.1.1 The four classes of organic macromolecules are proteins, carbohydrates, lipids, and nucleic acids. Each class has unique chemical structures.** **a.** These organic macromolecules are primarily made up of just a few elements—carbon, hydrogen, nitrogen, oxygen, sulfur, and phosphorus. **b.** Most macromolecules are polymers that are made up of specific, smaller subunits called monomers. **CELLS 1.2.1 Each class of macromolecule carries out specific functions in biological systems.** **a.** Carbohydrates serve as the primary source of energy for organisms in the forms of glycogen and starch, and as structural support in plant cell walls in the form of cellulose. **b.** Lipids are used as a source of energy and as building blocks of biological membranes. **c.** Proteins are responsible for numerous cellular functions, such as catalyzing reactions, providing structure, and aiding in cell transport and signaling. **d.** Nucleic acids are responsible for storing and transferring genetic information in the form of DNA and RNA.
Enzymes	
CELLS 1.3(a) Describe the effect of enzymes on the rate of chemical reactions in biological systems. **CELLS 1.3(b)** Predict how a change in pH and/or temperature will affect the function of an enzyme.	**CELLS 1.3.1 Enzymes are proteins that are catalysts in biochemical reactions and essential for maintaining life processes.** **a.** The rate of a chemical reaction is affected by the concentration of substrates and enzymes. **b.** Enzymes have specific shapes that bind to specific substrates in a precise location called the active site. **c.** Enzymes function optimally in a specific pH and temperature range.

Learning Objectives *Students will be able to ...*	**Essential Knowledge** *Students need to know that ...*
Cellular Energy Requirements	
CELLS 1.4(a) Explain the role of ATP in supporting processes in biological systems. **CELLS 1.4(b)** Explain why different species demonstrate diverse energy and nutrient requirements. **CELLS 1.4(c)** Use data to predict the energy requirements of diverse species.	**CELLS 1.4.1 Cells transfer and use energy from a variety of molecules in order to perform cellular functions.** **a.** ATP is a high-energy molecule used in the cell to carry out many cellular processes. **b.** The amount of energy available to organisms from the breakdown of macromolecules varies based on their chemical composition. **CELLS 1.4.2 Because organisms have diverse ecological roles, they also have diverse energy requirements.**

Content Boundary: While students should recognize that sulfur is one of the most common elements in living systems, a deeper understanding of the role sulfur plays in biological systems is beyond the scope of this course.

Deep understanding of bond energy is beyond the scope of this course. However, students should have a basic understanding that in order to break any bond, energy must be absorbed. Conversely, in order to form any bond, energy must be released. Therefore, energy is available to biological systems when more stable bonds are formed in chemical reactions; the high-energy bonds in ATP are an example of this.

Cross Connection: Students should connect key concepts to Unit 1: Ecological Systems. The cycling of matter in the biosphere provides the building blocks for development of macromolecules. Students should make connections between the role of enzymes in biological systems and how those systems can be affected by mutations during replication—specifically, when these mutations result in changes to enzymes produced during protein synthesis (Unit 4: Genetics). Students should expand on that understanding to see how changes in proteins (enzymes) influence an organism's fitness, connecting to key concepts in Unit 2: Evolution.

KEY CONCEPT CELLS 2: CELL STRUCTURE AND FUNCTION

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Cell Structure and Function	
CELLS 2.1(a) Provide evidence to support the claim that all biological systems demonstrate some shared characteristics. **CELLS 2.2(a)** Develop and/or use models to compare and contrast cell structures of different cells.	**CELLS 2.1.1 The cell is the basic unit of biological systems, and there are some shared characteristics among all cells.** **a.** All cells possess a plasma membrane, ribosomes, genetic material, and cytoplasm. **b.** All cells result from the division of preexisting cells. **CELLS 2.2.1 Cells have specialized structures that perform specific functions.** **a.** Some cells (eukaryotes) have a nucleus that houses their DNA. **b.** Cell structures can be organized based on four primary functions: **1.** Energy transfer (e.g., chloroplasts, mitochondria). **2.** Production of proteins (e.g., ribosomes, ER, Golgi apparatus). **3.** Storage and recycling of materials (e.g., lysosomes, vacuoles, vesicles). **4.** Support and movement (e.g., cell walls, cytoskeleton, flagella).
Specialized Cells	
CELLS 2.3(a) Explain how cell structures in different types of organisms enable specialized cell functions. **CELLS 2.3(b)** Describe how cell structures support an organism's ecological role.	**CELLS 2.3.1 Multicellular organisms have specialized cells that perform a wide variety of functions.** **a.** During development, cells become specialized and develop into higher-order systems (i.e., tissues, organs). **b.** Specialized cells perform a wide variety of unique functions for organisms (e.g., muscle cells, red blood cells). **CELLS 2.3.2 Cell structures can differ across organisms and often give insight into an organism's ecological role.** **a.** Prokaryotes lack a nucleus and membrane-bound organelles, whereas eukaryotes possess a nucleus and complex, membrane-bound organelles. **b.** Within the Eukarya domain, cellular structures and functions differ among organisms. **1.** Plant cells have large, central vacuoles and chloroplasts that enable photosynthesis. **2.** Some cells have rigid cell walls (e.g., fungi, plants).

Content Boundary: Assessments will not require students to recall an exhaustive list of organelles and their functions. Instead the focus is on how an organelle's function sustains specific biological systems. Therefore, ideally, deeper understanding of organelles is developed in context throughout the course based on their function (e.g., nucleus—genetic processes, mitochondria—respiration, chloroplast—photosynthesis, ribosomes—protein synthesis, lysosomes—transport).

KEY CONCEPT CELLS 3: CELL TRANSPORT AND HOMEOSTASIS

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Cell Membrane Structure	
CELLS 3.1(a) Explain how cell membranes function in maintaining dynamic homeostasis for biological systems. **CELLS 3.1(b)** Create and/or use models to explain the structure and function of cell membrane components.	**CELLS 3.1.1 Cells have phospholipid membranes that are selectively permeable.** **a.** All cells have membranes that separate the cell from the external environment; some cells also have a cell wall for structure and protection. **b.** Membranes consist of a phospholipid bilayer with numerous proteins embedded within and across the surfaces of the membrane. **c.** Carbohydrate chains attach to some surface proteins, and together they contribute to cell-to-cell chemical identification.
Cell Transport	
CELLS 3.2(a) Use data to investigate how various solutes and/or solvents passively move across membranes. **CELLS 3.2(b)** Explain how materials move into or out of the cell across the cell membrane. **CELLS 3.2(c)** Create and/or use representations and/or models to predict the movement of solutes into or out of the cell.	**CELLS 3.2.1 Cells depend on the structure of the cell membrane to move materials into and out of the cell in order to maintain dynamic homeostasis.** **a.** Passive transport involves the movement of solutes across the membrane along the concentration gradient, without the use of additional energy. **b.** Active transport involves the movement of solutes across the membrane against their concentration gradients with the use of additional energy. **c.** Bulk transport of molecules across the membrane is accomplished using endocytosis or exocytosis.
Cell Size and Diffusion	
CELLS 3.3(a) Describe how the size of a cell affects its ability to function efficiently.	**CELLS 3.3.1 Diffusion is most efficient when the surface area is high and the volume is low.** **a.** Small cell size creates a surface-area-to-volume ratio that enables more efficient diffusion. **b.** The surface-area-to-volume ratio gets smaller as the cell gets larger.

Cross Connection: Students should make connections to key concepts from Unit 1: Ecological Systems. The cycling of matter contributes to the type of materials that the cell will transport to sustain necessary functions and support cellular energy processes.

KEY CONCEPT CELLS 4: ORGANISMS MAINTAINING HOMEOSTASIS

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Organ/Tissue Systems	
CELLS 4.1(a) Describe how organ systems work together to maintain homeostasis. **CELLS 4.1(b)** Predict the consequence of a disruption in homeostasis.	**CELLS 4.1.1 Multicellular organisms rely on tissues and organ systems to transport nutrients and waste in order to maintain dynamic homeostasis.** **a.** Animals have organ systems that work together to transport nutrients and excrete waste. **1.** The digestive system is needed to derive nutrients and basic building blocks (monomers) from food, which are required for cellular functioning and growth. **2.** The respiratory system is needed for gas exchange to obtain oxygen and remove carbon dioxide. **3.** The circulatory system is needed to transport oxygen and nutrients to cells. **4.** The excretory system is needed to remove toxins and nitrogenous wastes from the body and to maintain water balance with the help of the circulatory system. **b.** Plants have specialized vascular tissues and cells that transport nutrients, water, and waste. **1.** Plants depend on xylem to transport water and nutrients for photosynthesis from the roots to the leaves and on phloem to transport sugars from the leaves to the rest of the plant. **2.** Plants excrete waste products from photosynthesis through the stomata in their leaves.
Response to Stimuli	
CELLS 4.2(a) Describe the benefits associated with tropisms and/or taxes in organisms in response to an external stimulus. **CELLS 4.2(b)** Predict how an organism might respond to a change from the external environment in order to maintain homeostasis.	**CELLS 4.2.1 Organisms have positive or negative responses to external stimuli in their environment in order to maintain dynamic homeostasis.** **a.** Plants exhibit tropisms that determine direction of growth toward or away from a stimulus, such as light, chemicals, gravity, touch, and water. **b.** Animals exhibit taxes that enable them to move in response to a stimulus, such as food, light, or pH.

Content Boundary: It is not the intent for students to develop a deep understanding of body systems. The focus here is on using a few key systems—digestive, respiratory, circulatory, and excretory—as a means to understanding how systems work together to support overall functions in a multicellular organism. These systems help deepen students' understanding about cellular energy, eliminating waste, and the role of diffusion in those processes. The nervous and endocrine systems are beyond the scope of this course.

Content Boundary: Understanding of the role of hormones (e.g., auxin) in plant tropisms is beyond the scope of this course.

KEY CONCEPT CELLS 5: CELL GROWTH AND DIVISION

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Cell Cycle: Interphase	
CELLS 5.1(a) Describe the importance of the growth phases in the cell cycle. **CELLS 5.1(b)** Explain how the cell cycle is regulated.	**CELLS 5.1.1 Generally, the cell spends 90 percent of its time in interphase.** **a.** During the growth phases of interphase (G1 and G2) the cell is producing new organelles and proteins. There are cell division checkpoints at the end of both of these phases. **b.** During the synthesis phase of interphase, DNA uncoils to replicate itself. Afterward, each chromosome consists of two double-stranded copies of identical DNA.
Cell Cycle: Cell Division	
CELLS 5.2(a) Explain why chromosome duplication must occur prior to mitotic division. **CELLS 5.2(b)** Create and/or use models to explain the phases of mitosis. **CELLS 5.2(c)** Predict consequences for biological systems if cell cycle regulation is altered.	**CELLS 5.2.1 Multicellular organisms use mitotic cell division in order to replace dying or damaged cells.** **a.** Mitosis, the fourth phase of the cell cycle, consists of a series of sub-phases (prophase, metaphase, anaphase, and telophase) whereby the parent nucleus produces two genetically identical daughter nuclei. **b.** There is a cell division checkpoint during metaphase. **c.** Cancer cells form when cell division continues without regulation.
Viruses	
CELLS 5.3(a) Describe the structural differences between viruses and cells. **CELLS 5.3(b)** Explain how viruses affect functions in biological systems.	**CELLS 5.3.1 Viruses must utilize cellular machinery in biological systems in order to replicate their genetic material.** **a.** Viruses lack the ability to perform reactions that require energy, such as replicating their own genetic material. **b.** Viruses bind to and release their genetic material into host cells, which allows the cellular machinery to be hijacked to produce viral proteins and genomes. **c.** Viral infection may disrupt biological systems by manipulating cell cycle regulation and altering the normal synthesis of proteins, causing disease or cell death in organisms.

Content Boundary: The focus on the cell cycle, including mitosis, is not on memorizing phases in the appropriate order, but rather how those individual phases support other vital functions that sustain biological systems. Students should see the need for cells to grow in size and increase the number of organelles prior to cellular division. They should also understand why regulating cell size through mitotic division is necessary. This keeps cell sizes small in order to support diffusion rates and improve efficiency of cellular processes.

KEY CONCEPT CELLS 6: PHOTOSYNTHESIS

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Photosynthesis	
CELLS 6.1(a) Explain why the products of photosynthesis are ecologically important. **CELLS 6.1(b)** Create and/or use models to explain the process of converting solar energy into chemical energy through photosynthesis. **CELLS 6.1(c)** Use data to describe what factors affect rates of photosynthesis.	**CELLS 6.1.1 Photosynthetic organisms have the cellular structures to absorb solar radiation and convert it into chemical energy.** **a.** Photosynthetically active radiation wavelengths occur in the visible light spectrum. **b.** Photosynthetic organisms have specialized pigments, membranes, and/or organelles that absorb solar radiation and convert it into chemical energy. **c.** Photosynthetic organisms rely on properties of water, such as cohesion, adhesion, and surface tension, which result in capillary action. **d.** Photosynthesis is divided into two stages: light-dependent and light-independent reactions. **1.** Light-dependent reactions require sunlight energy and H_2O to transfer energy to ATP and NADPH. A byproduct of this process is oxygen. **2.** Light-independent reactions use CO_2, ATP, and NADPH to produce sugars.

Content Boundary: The intent is not for students to memorize details of chemical reactions that occur during photosynthesis. Instead the focus here is on understanding the role of the main reactants and byproducts (as defined in the essential knowledge) at each stage of energy transfer. A deep understanding of photosystems I and II and specific steps of the Calvin cycle is beyond the scope of this course.

KEY CONCEPT CELLS 7: CELLULAR RESPIRATION AND FERMENTATION

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Cellular Respiration	
CELLS 7.1(a) Explain why the cellular energy processes in producers and consumers are dependent on one another. **CELLS 7.1(b)** Create and/or use models to explain how consumers obtain usable energy from the products of photosynthesis. **CELLS 7.1(c)** Describe how consumers store the energy acquired through cellular respiration.	**CELLS 7.1.1 Cellular respiration is a series of enzymatic reactions that utilize electron carrier molecules to synthesize ATP molecules.** **a.** Transfer of energy through cellular respiration begins with the carbon compounds generated by producers during photosynthesis. **b.** Glycolysis, an anaerobic process that occurs in the cytoplasm, uses glucose and two molecules of ATP to produce NADH, pyruvic acid, and four molecules of ATP. **c.** The Krebs cycle, an aerobic process that occurs in the mitochondria, uses pyruvic acid to produce ATP and electron carriers called NADH and $FADH_2$. Carbon dioxide is produced as a waste product during these chemical reactions. **d.** The electron transport chain transfers the high-energy electrons from NADH and $FADH_2$ to oxygen, producing H_2O. **e.** The build-up of hydrogen ions in the inner mitochondrial space produces a gradient that allows the production of 36–38 ATP molecules from each glucose molecule.
Fermentation	
CELLS 7.2(a) Explain the biological importance of fermentation. **CELLS 7.2(b)** Describe how energy transfer in the cell occurs under anaerobic conditions in consumers.	**CELLS 7.2.1 Organisms have processes for the transfer of energy under completely anaerobic conditions.** **a.** Fermentation allows for production of two molecules of ATP during glycolysis if no oxygen is present. **b.** Two common forms of fermentation are alcohol and lactic acid. **1.** Yeast uses alcohol fermentation to transfer energy from glucose and to release CO_2 as a byproduct. This is an economically important process because it is used to make many food products. **2.** Bacterial and animal cells are able to utilize lactic acid fermentation to transfer energy from glucose in the absence of oxygen.

Content Boundary: The focus for this key concept is on the understanding of how the products from photosynthesis enable the process of cellular respiration. It is more important for students to be able to use reactants and products to explain the interdependence between photosynthesis and cellular respiration than to memorize a series of steps that occur during these processes.

Cross Connection: In discussing electron transport chain processes whereby intermembrane proteins (enzymatic) allow movement of hydrogen ions, students should make connections to key concepts involving the role of proteins, membrane structures, and diffusion from earlier in this unit.

Unit 4: Genetics

Suggested Timing: Approximately 9 weeks

Similar to the study of cellular systems, many key concepts in genetics can be somewhat abstract for students because they are on a scale that cannot be seen with the eye. Therefore, in order to better visualize genetic processes, such as DNA and protein synthesis, in this unit students engage with models, diagrams, and computer simulations. Students build on prior basic understanding of the passing of traits, from middle school life science, by developing a strong foundational understanding of the molecular processes responsible for the passing of traits. They also use mathematics and pedigree models to analyze and predict inheritance patterns, and explore current biotechnology associated with the study and manipulation of genes.

ENDURING UNDERSTANDINGS

Students will understand that …

- The molecular structure of DNA enables its function of storing life's genetic information.
- Encoded in DNA is the heritable information responsible for synthesis of RNA, which makes gene expression possible.
- Organisms have diverse strategies for passing their genetic material on to the next generation.
- Models can be used to illustrate and predict the inheritance of traits.

KEY CONCEPTS

- GEN 1: Structure of DNA
- GEN 2: DNA Synthesis
- GEN 3: Protein Synthesis
- GEN 4: Asexual and Sexual Passing of Traits
- GEN 5: Inheritance Patterns
- GEN 6: Biotechnology

KEY CONCEPT GEN 1: STRUCTURE OF DNA

Learning Objectives *Students will be able to ...*	**Essential Knowledge** *Students need to know that ...*
Race to Discover DNA	
GEN 1.1(a) Explain how models of DNA changed over time as new scientific evidence emerged, resulting in the final consensus model.	**GEN 1.1.1 Several scientists' models of DNA contributed to the final consensus model of DNA's structure produced by Watson and Crick.** **a.** Chargaff observed 1:1 ratios between certain nitrogenous bases in DNA's nucleotides (A-T, G-C). **b.** Franklin's work showed that DNA was in the shape of a helix and suggested that the nitrogenous bases were near the center. **c.** Watson and Crick built the consensus model of DNA known today.
The Structure of DNA	
GEN 1.2(a) Describe how DNA is organized differently in prokaryotes and eukaryotes. **GEN 1.2(b)** Describe the monomers necessary for cells to build DNA.	**GEN 1.2.1 DNA is the genetic material found in all living organisms.** **a.** Living systems obtain the monomers, such as nitrogen, to build DNA strands using products from metabolic reactions. **b.** In prokaryotes, genomic DNA is organized into a single, circular chromosome. **c.** In eukaryotes, genomic DNA is organized into multiple, linear chromosomes found in the nucleus. **1.** DNA is a double helix with the two strands running in opposite directions (antiparallel). **2.** Nitrogenous base pairing occurs in between the two strands, each of which contains a sugar–phosphate backbone.

Content Boundary: Assessments will not require students to recall a list of scientists and their contributions to the discovery of the structure of DNA. The focus here is on how scientific knowledge (e.g., work from Pauling, Chargaff, Franklin, Watson, and Crick) developed over time, finally leading to the understanding of the consensus model of DNA.

Cross Connection: Connect key concepts from the cycling of matter in the biosphere (Unit 1: Ecological Systems) and the chemistry of life (Unit 3: Cellular Systems) to help students understand where the building blocks to make these nucleic acids (both DNA and RNA) come from.

KEY CONCEPT GEN 2: DNA SYNTHESIS

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
DNA Synthesis (Replication)	
GEN 2.1(a) Describe the importance of DNA synthesis. **GEN 2.1(b)** Create and/or use models to explain how DNA synthesis occurs. **GEN 2.1(c)** Explain the function of enzymes in DNA synthesis.	**GEN 2.1.1 All living cells have a mechanism for DNA synthesis (replication) in order to pass on genetic information to new cells.** **a.** Each of the two strands of DNA serves as a template for a new complementary strand in a semiconservative process of replication. **b.** DNA helicase and DNA polymerase are the primary enzymes required for the replication process.

Content Boundary: Understanding of in-depth DNA replication processes, such as formation of leading and lagging strands, Okazaki fragments, and DNA polymerase working in the 5′-to-3′ direction, is beyond the scope of this course.

KEY CONCEPT GEN 3: PROTEIN SYNTHESIS

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
RNA Structure	
GEN 3.1(a) Explain structural differences between RNA and DNA.	**GEN 3.1.1 The unique structure of RNA enables its function in protein synthesis.** **a.** Types of RNA may vary in structure, but they all have important structural differences from DNA: **1.** All types of RNA contain the sugar ribose instead of deoxyribose. **2.** All types of RNA contain the nitrogen base uracil instead of thymine. **3.** mRNA is single-stranded instead of double-stranded like DNA.
RNA Transcription	
GEN 3.2(a) Describe how heritable information stored in DNA is transferred to RNA through transcription.	**GEN 3.2.1 RNA synthesis, or transcription, results in three forms of the polymer.** **a.** RNA synthesis occurs in the cytoplasm of prokaryotes and in the nucleus of eukaryotes. **b.** During transcription, a single strand of DNA is used as a template to synthesize a complementary strand of RNA. **c.** RNA transcription results in the synthesis of messenger RNA (mRNA), transfer RNA (tRNA), and ribosomal RNA (rRNA).

<table>
<tr><th>Learning Objectives
Students will be able to …</th><th>Essential Knowledge
Students need to know that …</th></tr>
<tr><td colspan="2">Translation</td></tr>
<tr><td>GEN 3.3(a) Explain the role of mRNA in protein synthesis.
GEN 3.3(b) Identify the role of amino acids in protein synthesis.
GEN 3.3(c) Create and/or use models to demonstrate how the information in genes is expressed as proteins.
GEN 3.3(d) Explain how the structure of DNA relates to an organism’s phenotype and genotype.</td><td>GEN 3.3.1 Gene expression includes the process of protein synthesis, which requires transcribing heritable information stored in DNA and translating it into polypeptides.
a. Genes are certain sections of DNA on chromosomes that contain the instructions for making specific proteins, and make up an organism’s genotype and determine its phenotype.
b. Information carried on genes in the template strand of DNA is transcribed into a strand of mRNA during transcription.
c. Translation of mRNA into the sequence of amino acids (protein) occurs with the help of ribosomes in the cytoplasm.
1. mRNA is read by the ribosome three bases at a time (a codon), which corresponds to a specific amino acid that the ribosome incorporates into a growing polypeptide chain.
2. Translation begins and ends with specific start and stop codons.
3. The particular sequence of amino acids determines the shape and function of the expressed protein.</td></tr>
<tr><td colspan="2">Mutations</td></tr>
<tr><td>GEN 3.4(a) Describe how changes in DNA sequences may affect protein structure and function.
GEN 3.4(b) Create and/or use models to explain the consequences of changes in DNA.
GEN 3.4(c) Analyze data to make predictions about how changes in DNA affect an organism’s phenotype.</td><td>GEN 3.4.1 Mutations are heritable changes to DNA sequences.
a. Mutations are random changes in DNA sequences that may occur as a result of errors during replication or the effects of environmental mutagens (e.g., UV light, x-rays, and carcinogens).
b. A change in a DNA sequence occurs when a nucleotide is substituted into the original sequence (causing a point mutation) or inserted into or deleted from the sequence (causing a frameshift mutation).
c. Depending on how the changes impact gene expression, mutations may cause negative disruption in gene and protein function, have little to no effect on organisms, or produce beneficial variation.</td></tr>
</table>

Content Boundary: It is important for students to realize that all forms of RNA are made from DNA and to understand how forms of RNA work together to make proteins. However, assessments will not require students to recall a step-by-step list of the process. Instead, they should focus on how the structure of each form of RNA fits its role in protein synthesis and why this process is important (for how genotypes determine phenotypes). Students should understand that only some regions of DNA carry genetic information for proteins (genes). However, specifics about introns and exons are beyond the scope of this course.

Cross Connection: Make connections to key concepts from Unit 2: Evolution of how mutations serve as sources of genetic variation on which natural selection mechanisms work.

KEY CONCEPT GEN 4: ASEXUAL AND SEXUAL PASSING OF TRAITS

<table>
<tr><th>Learning Objectives
Students will be able to …</th><th>Essential Knowledge
Students need to know that …</th></tr>
<tr><td colspan="2">Asexual Reproduction</td></tr>
<tr><td>GEN 4.1(a) Explain why asexual reproductive strategies do not lead to genetic diversity.
GEN 4.1(b) Explain the advantage(s) of asexual reproduction strategies for organisms.</td><td>GEN 4.1.1 Most unicellular and some multicellular organisms can reproduce through asexual processes that do not increase genetic variation in the population.
a. Binary fission is a form of asexual cell division that results in a symmetrical genetic clone of the parent cell (e.g., bacteria, amoebas).
b. Budding is a form of asexual cell division that results in a diploid, asymmetrical genetic clone of the parent cell (e.g., corals, yeast).
c. Some forms of parthenogenesis are a form of asexual reproduction in some species, where offspring are produced by females without the genetic contribution of a male (e.g., bees, lizards, sharks).
d. Asexual reproduction can be performed without the need to find mates and can lead to rapid proliferation of a population over time.</td></tr>
<tr><td colspan="2">Sexual Reproduction (Meiosis)</td></tr>
<tr><td>GEN 4.2(a) Explain why reduction division must occur to produce gametes.
GEN 4.2(b) Explain how meiotic cellular division followed by fertilization leads to genetic diversity within a population.
GEN 4.2(c) Create and/or use models to explain how chromosome number is halved during meiosis.</td><td>GEN 4.2.1 Some unicellular and most eukaryotic organisms reproduce sexually, requiring a process called meiosis that results in genetic variation in the population.
a. Meiotic division requires two distinct nuclear divisions in order to reduce one diploid (2N) cell into four haploid (N) cells.
1. During the first division in meiosis, homologous chromosomes pair together in a tetrad and crossing-over occurs, which increases genetic variation.
2. At the end of the first division (meiosis I), homologous chromosomes are separated and two daughter cells are formed.
3. At the end of the second meiotic division (meiosis II), the two cells are separated into four genetically diverse haploid cells, which in animals differentiate into gametes.
b. Sexual reproduction occurs via fertilization, when sperm and egg gametes fuse and form a zygote, restoring the diploid number of chromosomes.</td></tr>
</table>

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Chromosomal Disorders	
GEN 4.3(a) Describe how some organisms have structurally altered chromosomes in their genome. **GEN 4.3(b)** Predict how altered chromosome numbers may affect organisms.	**GEN 4.3.1 Chromosomal disorders occur when the structure or number of chromosomes has been altered, which often impairs normal function and development in organisms.** **a.** Unequal crossing-over events can lead to chromosomal disorders. **b.** Random nondisjunction events may occur in meiosis when chromosomes fail to separate. This may result in viable offspring with an abnormal number of chromosomes.

Content Boundary: Students will not be assessed on the molecular details of the asexual reproductive strategies of budding and binary fission, nor on which organisms utilize asexual reproduction. The focus here is on how this reproductive strategy leads to the genetic clone of the parent cell, the impact on gene pool diversity, and why that process is advantageous for the organism at that time.

Cross Connection: Students should make connections to key concepts in Unit 1: Ecological Systems and Unit 2: Evolution, recognizing how changes in the environment and natural selection act on variation in traits that emerge through meiosis. These processes lead to phenotypic variation in species and populations.

KEY CONCEPT GEN 5: INHERITANCE PATTERNS

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
Inheritance Patterns	
GEN 5.1(a) Explain the relationship between genotype and phenotype. **GEN 5.1(b)** Describe the type of inheritance pattern based on data and/or use of models.	**GEN 5.1.1 Investigation of Mendelian, or single-gene, traits reveals the basis for understanding patterns of inheritance.** **a.** Many of an organism's traits (phenotype) are determined by the organism's genes (genotype), which are passed from one generation to the next. **b.** Somatic cells of sexually reproducing organisms have two copies of each gene (one inherited from each parent). **c.** Each gene copy may have variants called alleles. **d.** If present, dominant alleles are expressed, whereas recessive alleles are expressed only in the absence of a dominant allele. **GEN 5.1.2 Most traits do not follow Mendelian inheritance patterns.** **a.** Some traits are determined by genes on sex chromosomes, and some are influenced by environmental factors. **b.** Most of our traits involve the interactions of multiple genes. **1.** Codominance occurs when both alleles of homologous chromosomes are fully expressed. **2.** Incomplete dominance occurs when neither of the alleles from a homologous chromosome pair are completely dominant.
Predicting Inheritance	
GEN 5.2(a) Create and/or use models to analyze the probability of the inheritance of traits. **GEN 5.2(b)** Predict the inheritance of traits that do not follow Mendelian patterns. **GEN 5.2(c)** Use a pedigree to predict the inheritance of a trait within a family.	**GEN 5.2.1 The inheritance of certain traits from parents to offspring can be predicted using models.** **a.** Rules of probability can be applied to make predictions about the passage of alleles from parent to offspring using mathematical models (Punnett squares). **b.** Pedigrees are useful tools for modeling inheritance patterns to examine and/or make predictions about inheritance of a specific trait from one generation to the next.

Content Boundary: Students will be expected to know non-Mendelian inheritance patterns, such as codominance and incomplete dominance. However, epistatic genes are beyond the scope of this course.

KEY CONCEPT GEN 6: BIOTECHNOLOGY

Learning Objectives *Students will be able to …*	**Essential Knowledge** *Students need to know that …*
GEN 6.1(a) Use data to examine inheritance and/or chromosomal disorders. **GEN 6.1(b)** Describe techniques used to manipulate DNA. **GEN 6.1(c)** Explain potential benefits and/or consequences of manipulating DNA of organisms.	**GEN 6.1.1 Biotechnology enables scientists to study and engineer heritable traits of organisms.** **a.** Karyotypes are used to examine inheritance and help identify and predict possible chromosomal genetic disorders. **b.** Diverse methods, including PCR, gel electrophoresis, and DNA profiling, are used to study organisms' DNA. **c.** Genetic engineering techniques (e.g., cloning, GMOs) can manipulate the heritable information of DNA, resulting in both positive and negative consequences.

Content Boundary: Students will not be assessed on a deep understanding of the molecular processes for manipulating DNA. Instead the focus should be on giving a high-level understanding of common processes that allow development of appropriate quantities of DNA to be studied and manipulated. Also, students should learn about exciting new advancements in this field.

Pre-AP Biology Model Lessons

Model lessons in Pre-AP Biology are developed in collaboration with biology educators across the country and are rooted in the course framework, shared principles, and areas of focus. Model lessons are carefully designed to illustrate on-grade-level instruction. Pre-AP strongly encourages teachers to internalize the lessons and then offer the supports, extensions, and adaptations necessary to help all students achieve the lesson goals.

The purpose of these model lessons is twofold:

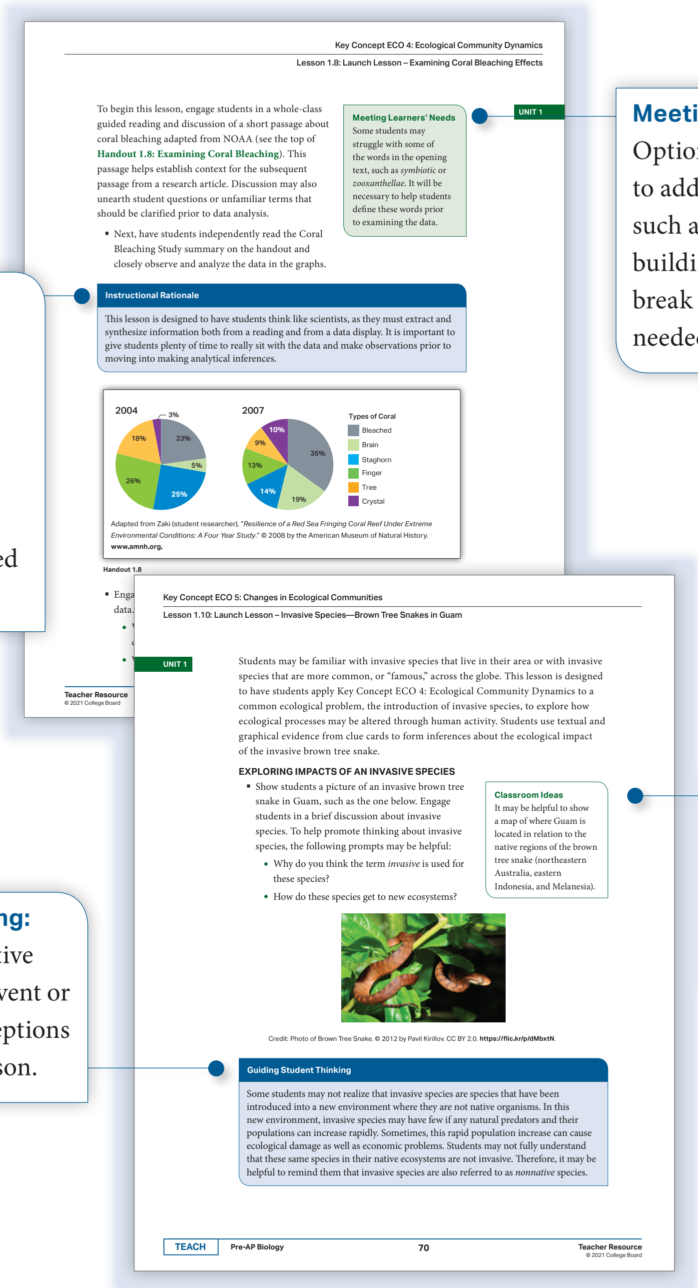
- **Robust instructional support for teachers:** Pre-AP Biology model lessons are comprehensive lesson plans that, along with accompanying student resources, embody the Pre-AP approach to teaching and learning. Model lessons provide clear and substantial instructional guidance to support teachers as they engage students in the shared principles and areas of focus.
- **Key instructional strategies:** Commentary and analysis embedded in each lesson highlight not just what students and teachers do in the lesson, but also how and why they do it. This educative approach provides a way for teachers to gain unique insight into key instructional moves that are powerfully aligned with the Pre-AP approach to teaching and learning. In this way, each model lesson works to support teachers in the moment of use with students in their classroom.

Teachers have the option to use any or all model lessons alongside their own locally developed instructional resources. Model lessons target content areas that tend to be challenging for teachers and students. While the lessons are distributed throughout all four units, they are concentrated more heavily in the beginning of the course to support teachers and students in establishing a strong foundation in the Pre-AP approach to teaching and learning.

SUPPORT FEATURES IN MODEL LESSONS

The following support features recur throughout the Pre-AP Biology lessons, to promote teacher understanding of the lesson design and provide direct-to-teacher strategies for adapting lessons to meet their students' needs:

- Instructional Rationale
- Guiding Student Thinking
- Meeting Learners' Needs
- Classroom Ideas



Key Concept ECO 4: Ecological Community Dynamics

Lesson 1.8: Launch Lesson – Examining Coral Bleaching Effects

UNIT 1

To begin this lesson, engage students in a whole-class guided reading and discussion of a short passage about coral bleaching adapted from NOAA (see the top of **Handout 1.8: Examining Coral Bleaching**). This passage helps establish context for the subsequent passage from a research article. Discussion may also unearth student questions or unfamiliar terms that should be clarified prior to data analysis.

- Next, have students independently read the Coral Bleaching Study summary on the handout and closely observe and analyze the data in the graphs.

Meeting Learners' Needs
Some students may struggle with some of the words in the opening text, such as *symbiotic* or *zooxanthellae*. It will be necessary to help students define these words prior to examining the data.

Instructional Rationale
This lesson is designed to have students think like scientists, as they must extract and synthesize information both from a reading and from a data display. It is important to give students plenty of time to really sit with the data and make observations prior to moving into making analytical inferences.

Adapted from Zaki (student researcher), "*Resilience of a Red Sea Fringing Coral Reef Under Extreme Environmental Conditions: A Four Year Study.*" © 2008 by the American Museum of Natural History. **www.amnh.org.**

Handout 1.8

Teacher Resource
© 2021 College Board

Key Concept ECO 5: Changes in Ecological Communities

Lesson 1.10: Launch Lesson – Invasive Species—Brown Tree Snakes in Guam

UNIT 1

Students may be familiar with invasive species that live in their area or with invasive species that are more common, or "famous," across the globe. This lesson is designed to have students apply Key Concept ECO 4: Ecological Community Dynamics to a common ecological problem, the introduction of invasive species, to explore how ecological processes may be altered through human activity. Students use textual and graphical evidence from clue cards to form inferences about the ecological impact of the invasive brown tree snake.

EXPLORING IMPACTS OF AN INVASIVE SPECIES

- Show students a picture of an invasive brown tree snake in Guam, such as the one below. Engage students in a brief discussion about invasive species. To help promote thinking about invasive species, the following prompts may be helpful:
  - Why do you think the term *invasive* is used for these species?
  - How do these species get to new ecosystems?

Classroom Ideas
It may be helpful to show a map of where Guam is located in relation to the native regions of the brown tree snake (northeastern Australia, eastern Indonesia, and Melanesia).

Credit: Photo of Brown Tree Snake. © 2012 by Pavil Kirillov. CC BY 2.0. **https://flic.kr/p/dMbxtN**.

Guiding Student Thinking
Some students may not realize that invasive species are species that have been introduced into a new environment where they are not native organisms. In this new environment, invasive species may have few if any natural predators and their populations can increase rapidly. Sometimes, this rapid population increase can cause ecological damage as well as economic problems. Students may not fully understand that these same species in their native ecosystems are not invasive. Therefore, it may be helpful to remind them that invasive species are also referred to as *nonnative* species.

TEACH Pre-AP Biology 70 Teacher Resource © 2021 College Board

Meeting Learners' Needs: Optional differentiation strategies to address diverse learning needs, such as ideas for just-in-time skill building during a lesson or ways to break a task into smaller tasks, if needed, to make it more accessible.

Instructional Rationale: Insight into the strategic design and purpose of the instructional choices, flow, and scaffolding within the model lesson. Rationales often describe how a concept is continued later in the lesson or unit.

Classroom Ideas: Tips related to the logistics of the instruction, such as suggestions for alternative laboratory materials, or ways to alleviate pacing concerns.

Guiding Student Thinking: Ways to facilitate productive student thinking and prevent or address student misconceptions in critical areas of the lesson.

Pre-AP Biology Assessments for Learning

Pre-AP Biology assessments function as a component of the teaching and learning cycle. Progress is not measured by performance on any single assessment. Rather, Pre-AP Biology offers a place to practice, to grow, and to recognize that learning takes time. The assessments are updated and refreshed periodically.

LEARNING CHECKPOINTS

Based on the Pre-AP Biology Course Framework, the learning checkpoints require students to examine data, models, diagrams, and short texts—set in authentic contexts—in order to respond to a targeted set of questions that measure students' application of the key concepts and skills from the unit. All eight learning checkpoints are automatically scored, with results provided through feedback reports that contain explanations of all questions and answers as well as individual and class views for educators. Teachers also have access to assessment summaries on Pre-AP Classroom, which provide more insight into the question sets and targeted learning objectives for each assessment event.

The following tables provide a synopsis of key elements of the Pre-AP Biology learning checkpoints.

Format	Two learning checkpoints per unit Digitally administered with automated scoring and reporting Questions target both concepts and skills from the course framework
Time Allocated	Designed for one 45-minute class period per assessment
Number of Questions	11–14 questions per assessment ▪ 9–12 four-option multiple choice ▪ 2–5 technology-enhanced questions

Domains Assessed	
Learning Objectives	Learning objectives within each key concept in the course framework
Skills	Three skill categories aligned to the Pre-AP science areas of focus are assessed with regular frequency across all eight learning checkpoints: ▪ emphasis on analytical reading and writing ▪ strategic use of mathematics ▪ attention to modeling

Question Styles	Question sets consist of two to three questions that focus on a single stimulus or group of related stimuli, such as texts, graphs, or tables. Questions are set in authentic biological contexts. *Please see page 66 for a sample question set that illustrates the types of questions included in Pre-AP learning checkpoints and the Pre-AP final exam.*

PERFORMANCE TASKS

Each unit includes one performance-based assessment designed to evaluate the depth of student understanding of key concepts and skills that are not easily assessed in a multiple-choice format.

Performance tasks in the ecology and cellular systems units mirror the AP free-response question style. Students demonstrate their understanding of content by analyzing scientific texts, data, and models in order to develop analytical written responses to open-ended questions.

Performance tasks in the evolution and genetics units actively engage students in hands-on data analysis and modeling skills as they demonstrate their understanding of key concepts in those two units.

Both types of performance tasks give students an opportunity to closely observe and analyze real-world biological problems and apply the skills and concepts from across the course units.

These tasks, developed for students across a broad range of readiness levels, are accessible while still providing sufficient challenge and the opportunity to practice the analytical skills that will be required in AP science courses and for college and career readiness. Teachers participating in the official Pre-AP Program will receive access to online learning modules to support them in evaluating student work for each performance task.

Format	One performance task per unit Administered in print Educator-scored using scoring guidelines
Time Allocated	Approximately 45 minutes or as indicated
Number of Questions	An open-response task with multiple parts

Domains Assessed	
Key Concepts	Key concepts and prioritized learning objectives from the course framework
Skills	Three skill categories aligned to the Pre-AP science areas of focus: ▪ emphasis on analytical reading and writing ▪ strategic use of mathematics ▪ attention to modeling

PRACTICE PERFORMANCE TASKS

Practice performance tasks in each unit provide students with the opportunity to practice applying skills and knowledge in a context similar to a performance task, but in a more scaffolded environment. These tasks include strategies for adapting instruction based on student performance and ideas for modifying or extending tasks based on students' needs.

SAMPLE PERFORMANCE TASK AND SCORING GUIDELINES

The following task and set of scoring guidelines are representative of what students and educators will encounter on the performance tasks. (The example below is a practice performance task in Unit 1.)

PRACTICE PERFORMANCE TASK

Termites, Guardians of the Soil

OVERVIEW

DESCRIPTION

Students read an excerpt from a *New York Times* article about the role of termites as soil engineers. Students must then use evidence from the article and from previous lessons to support claims about the cycling of matter.

CONTENT FOCUS

This practice performance task allows students an opportunity to transfer the knowledge they've developed in recent activities to a novel context, termites. This final task for Key Concept ECO 1: Cycling of Matter in the Biosphere is also a great transition to the next key concept of population dynamics.

AREA OF FOCUS

- Emphasis on Analytical Reading and Writing

SUGGESTED TIMING

~45 minutes

HANDOUT

- Practice Performance Task: Termites, Guardians of the Soil

MATERIALS

- copies of scoring guidelines for student use (optional)

Practice Performance Task: Termites, Guardians of the Soil

The giant termite mounds that rise up from the sands of the African savanna are so distinctive it's tempting to give them names, like "Art Deco Skyline" or "Trumpeting Elephant."

Researchers at Princeton University and their colleagues recently reported in the journal *Science* that termite mounds may serve as oases in the desert, allowing the plants that surround them to persist on a fraction of the annual rainfall otherwise required to bounce back after a withering drought.

And while the public may view termites as pale, blind, half-inch vermin, only a handful of them are actually pests. "They're the ultimate soil engineers," said David Bignell, a termite expert and emeritus professor of zoology at Queen Mary University of London. By poking holes, or macropores, as they dig through the ground, termites allow rain to soak deep into the soil rather than running off or evaporating. Termites artfully mix inorganic particles of sand, stone and clay with organic bits of leaf litter, discarded exoskeletons and the occasional squirrel tail, a blending that helps the soil retain nutrients, such as nitrogen and phosphorous, and resist erosion.

The stickiness of a termite's feces and other bodily excretions lend structure and coherence to the soil, which also prevents erosion. Bacteria in the termite's gut are avid nitrogen fixaters, able to extract the vital element from the air and convert it into a usable sort of fertilizer in the soil, benefiting the termite host and the vast plant community.

Adapted from Natalie Angier, "Termites: Guardians of the Soil." © 2015 by *The New York Times*.

1. Write three sentences about the role termites play in modifying the natural process of the water, carbon, or nitrogen cycle. Use the following words in order at the beginning of your claims: *although*, *when*, *if*.

   Although ____

   ____.

   When ____

   ____.

   If ____

   ____.

2. Read the following claim:

   Termite activities influence the cycling of matter in ways that are beneficial to their ecosystem.

   State whether you support or refute this claim. Then, in the table below, provide evidence and reasoning to support your view.

   Do you support or refute this claim?

Evidence from Text	Scientific Reasoning
1	
2	

3. Describe two ways that humans influence the cycling of matter in ecosystems.

SCORING GUIDELINES

There are 9 possible points for this practice performance task.

Question 1

<table>
<tr><th>Sample Solutions</th><th>Points Possible</th></tr>
<tr><td>Responses will vary. Some possible answers include:
Example 1:
Although some termites are considered pests, termites help plants get water.
When termites dig into the soil, they allow more water to move down into the soil and reach the plants' roots.
If termites were not in the ecosystem, more water would evaporate or run off instead of going into the soil.
Example 2:
Although termites are very small, they can be a big help to plants by providing nutrients.
When bacteria in termites' guts convert nitrogen into usable fertilizer, plant communities benefit.
If termites did not have these bacteria in their guts, the plant community might not grow as well.</td><td>3 points maximum
1 point for each appropriate sentence
Scoring note: While it would be ideal if students used the three sentences together to form one idea, it is not necessary at this point. Each sentence could represent a different idea as this is just an opening question to get them into the text.</td></tr>
<tr><th colspan="2">Targeted Feedback for Student Responses</th></tr>
<tr><td colspan="2">Since this is just practice, it is okay for students to form three disconnected sentences, all focusing on unique ideas. However, if they do, provide feedback that it is better to form connected sentences to support one idea, and challenge them to write two connected sentences from one of their current ones.</td></tr>
</table>

TEACHER NOTES AND REFLECTIONS

Question 2

Sample Solutions		Points Possible
Evidence from Text ▪ Allowing the plants that surround them to persist on a fraction of the annual rainfall otherwise required to bounce back after a withering drought ▪ Poking holes, or macropores, as they dig through the ground ▪ Allow rain to soak deep into the soil rather than running off or evaporating ▪ Artfully mix inorganic particles of sand, stone and clay with organic bits of leaf litter ▪ Blending that helps the soil retain nutrients and resist erosion ▪ Stickiness of a termite's feces and other bodily excretions lend structure and coherence to the soil, which also prevents erosion ▪ Bacteria in the termite's gut are avid nitrogen fixaters, able to extract the vital element from the air and convert it into a usable sort of fertilizer	**Scientific Reasoning** Each piece of evidence should be adequately paired with a reason as to why this is beneficial to a particular cycle. Some examples include: **Example 1:** **Evidence:** Allow rain to soak deep into the soil rather than running off or evaporating **Reasoning:** This impacts the water cycle in a way that is beneficial to plants since more water will be available in the soil for them to use. **Example 2:** **Evidence:** Artfully mix inorganic particles of sand, stone and clay with organic bits of leaf litter **Reasoning:** This impacts the carbon and nitrogen cycle since it speeds up deposition and helps the soil hold more nutrients such as nitrogen and phosphorus.	**4 points maximum** 1 point for each piece of evidence pulled from text that aligns to an impact in a cycle 1 point for each appropriate reasoning statement attached to the evidence
Targeted Feedback for Student Responses		
If students don't cite specific evidence from the reading, have them return to the text to find specific examples.		

Question 3

Sample Solutions	Points Possible
▪ Removing water from storage for drinking impacts the water cycle. ▪ Farming practices increase evaporation from soil and runoff impacts the water and nitrogen cycles. ▪ Using fossil fuels for energy releases carbon dioxide and ammonia into the atmosphere, which impacts the carbon and nitrogen cycles. ▪ Using nitrogen-based fertilizers in farming impacts the nitrogen cycle.	**2 points maximum** 1 point for each correct description of a human activity that affects the cycling of matter 1 point for each appropriate sentence

Targeted Feedback for Student Responses
Some students may use more vague language to describe the human activities. If they do, have them return to their carbon and nitrogen models from the prior lessons to find more specific language to include.

TEACHER NOTES AND REFLECTIONS

FINAL EXAM

Pre-AP Biology includes a final exam featuring multiple-choice and technology-enhanced questions as well as an open-response question. The final exam is a summative assessment designed to measure students' success in learning and applying the knowledge and skills articulated in the Pre-AP Biology Course Framework. The final exam's development follows best practices such as multiple levels of review by educators and experts in the field for content accuracy, fairness, and sensitivity. The questions on the final exam have been pretested, and the resulting data are collected and analyzed to ensure that the final exam is fair and represents an appropriate range of the knowledge and skills of the course.

The final exam is designed to be delivered on a secure digital platform in a classroom setting. Educators have the option of administering the final exam in a single extended session or two shorter consecutive sessions to accommodate a range of final exam schedules.

Multiple-choice and technology-enhanced questions are delivered digitally and scored automatically with detailed score reports available to educators. This portion of the final exam is designed to build on the question styles and formats of the learning checkpoints; thus, in addition to their formative purpose, the learning checkpoints provide practice and familiarity with the final exam. The open-response question, modeled after the performance tasks, is delivered as part of the digital final exam but is designed to be scored separately by educators using scoring guidelines that are designed and vetted with the question.

The following tables provide a synopsis of key elements of the Pre-AP Biology Final Exam.

Format	Digitally administered Questions target both concepts and skills from the course framework A scientific calculator feature is enabled on the platform, but its use is not required.
Time Allocated	One 105-minute session or two sessions of 60 minutes and 45 minutes
Number of Questions	30–35 questions ▪ four-option multiple-choice questions ▪ technology-enhanced questions ▪ one multipart open-response question

Scoring	▪ automatic scoring for multiple-choice and technology-enhanced questions ▪ educator scoring for open-response question ▪ comprehensive score reports with individual student and class views for educators

Domains Assessed	
Content	Key concepts and prioritized learning objectives from the course framework
Skills	Three skill categories aligned to the Pre-AP science areas of focus: ▪ emphasis on analytical reading and writing ▪ strategic use of mathematics ▪ attention to modeling

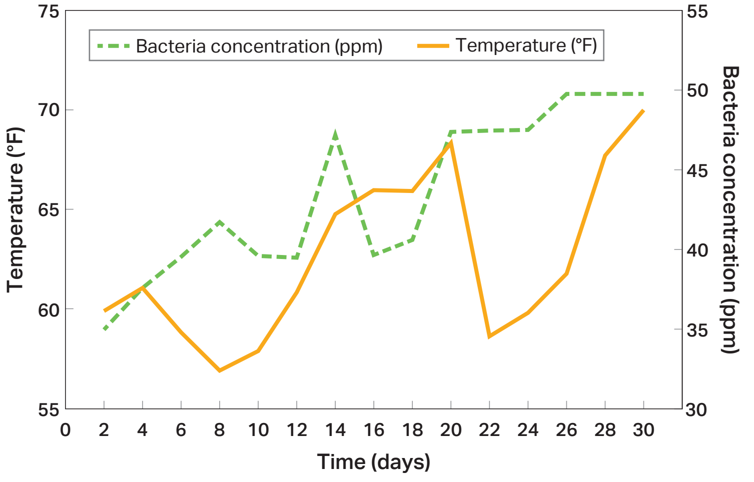
Question Styles	Question sets consist of two to three questions that focus on a single stimulus or group of related stimuli, such as texts, graphs, or tables. Questions are set in authentic biological contexts. *Please see page 66 for a sample question set that illustrates the types of questions included in Pre-AP learning checkpoints and the Pre-AP final exam.*

SAMPLE ASSESSMENT QUESTIONS

The following questions are representative of what students and educators will encounter on the learning checkpoints and final exam.

ANALYZING SCIENTIFIC DATA

Clostridium perfringens is a species of heterotrophic bacteria that is commonly found consuming decaying organic matter in the sediments of freshwater lakes. An investigation was conducted into the effect of temperature on growth of *C. perfringens.* Researchers recorded the temperature of a 1-liter sample of lake water and the concentration of bacteria in the water over a 30-day period. The data are represented in the graph.



Examination of 1-liter samples of lake water over a 30-day period

1. Which of the following statements best describes the relationship between temperature and growth of the bacterial population?
   - (A) Temperature has a direct effect on the growth of the bacterial population since both the temperature and bacteria concentration are highest at day 30.
   - (B) Temperature has a negative effect on the growth of the bacterial population since there are instances when temperature increases and bacteria concentration decreases.
   - (C) Temperature is a limiting resource for the growth of the bacterial population since the bacterial concentration line is nearly always above the temperature line.
   - (D) Resources other than temperature can limit the growth of the bacterial population since there is not a direct correlation between water temperature and bacteria concentration.

Assessment Focus

Question 1 requires students to extract relevant information from a text, analyze data, and use quantitative reasoning to construct an argument about the relationship between an abiotic resource, light, and the growth of a population.

Correct Answer: D

Learning Objective:

ECO 2.2(b) Explain the relationship between resource availability and a population's growth pattern.

Area of Focus: Strategic Use of Mathematics

2. The biologists are interested in analyzing other environmental conditions that may regulate the growth of the bacterial population. Which of the following is the LEAST likely to affect the population growth of the bacteria in the lake?
   (A) Amount of sunlight reaching the lake bottom
   (B) Dissolved oxygen level in the lake
   (C) Amount of decaying organic matter in the sediments
   (D) pH of the lake water

Assessment Focus

Question 2 extends student thinking from the first question as it asks students to demonstrate their understanding of the abiotic and biotic niche requirements for heterotrophic organisms that may be responsible for the trends in data.

Correct Answer: A

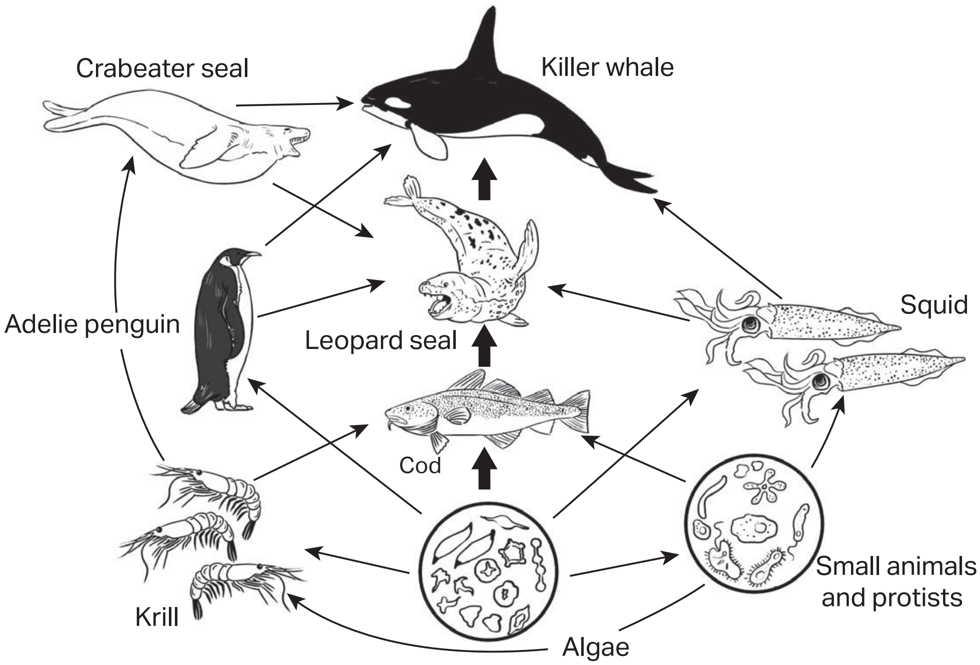
Learning Objective:

ECO 2.2(a) Use data to explain the growth of a population.

Area of Focus: Emphasis on Analytical Reading and Writing

USING A MODEL

The diagram represents a model of a typical food web from coastal waters in cool temperate and subpolar seas, such as those around Antarctica. Use the model to answer the following question.



3. If cod were overfished in this Antarctic region and were not an available food source, which of the following changes in the community is most likely to occur as a result?
   (A) The squid population will increase because there is reduced competition for food.
   (B) The killer whale population will increase because there are more leopard seals.
   (C) The crabeater seal population will decrease because there is a decrease in the krill population.
   (D) The squid population will decrease because there is a decrease in the algae population.

Assessment Focus

Question 3 assesses students' ability to use a model to make predictions about how the flow of energy through this food web would change if organisms are depleted. Students must also apply their understanding of ecological roles (e.g., primary consumers) and community dynamics (e.g., competition for food) at each trophic level in order to make this prediction.

Correct Answer: A

Learning Objectives:

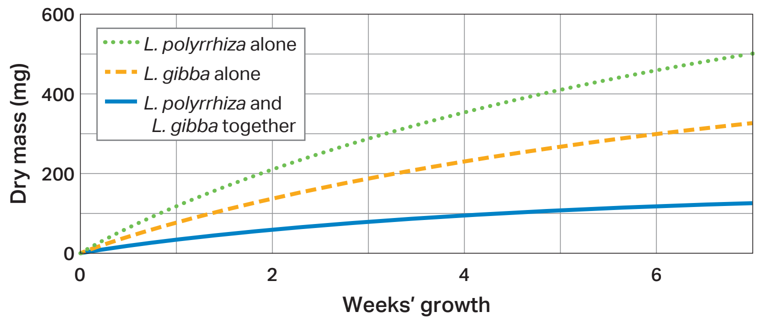
ECO 2.3(a) Create and/or use models to explain the transfer of energy through the food web of a community.

ECO 2.3(c) Make predictions about the energy distribution in an ecosystem based on the energy available to organisms.

Area of Focus: Attention to Modeling

DATA ANALYSIS

Duckweeds are small aquatic plants that live in freshwater ponds and streams throughout North America. Scientists conducted an experiment to determine how two different species of duckweed, *Lemna polyrrhiza* and *Lemna gibba,* affect each other's growth. They set up three containers: one with only *Lemna polyrrhiza,* one with only *Lemna gibba,* and one with both species together. The graph shows the results of all three experimental trials.



4. Which of the following claims is most consistent with the results of the experiment?
   (A) The niches of the two organisms do not overlap; therefore, even when grown together, they are both able to continue to grow at their maximum growth rate.
   (B) There is interspecific competition between the two species; therefore, the growth of the *L. polyrrhiza* population is stimulated.
   (C) The niches of both organisms likely overlap; therefore, when they are grown together, interspecific competition reduces the growth of both populations.
   (D) *L. polyrrhiza* has a wider niche than *L. gibba*; therefore, *L. polyrrhiza* experiences a greater population growth even when the species are grown together.

Assessment Focus

Question 4 assesses students' ability to use quantitative reasoning as they analyze data from a graph. In order to select the appropriate claim based on the data, they must apply their understanding of interspecific versus intraspecific competition and niche.

Correct Answer: C

Learning Objectives:

ECO 2.2(c) Explain how competition for resources shapes populations.

ECO 2.3(b) Analyze data about species distributions to make predictions about the availability of resources.

Area of Focus: Strategic Use of Mathematics

Pre-AP Biology Course Designation

Schools can earn an official Pre-AP Biology course designation by meeting the program commitments summarized below. Pre-AP Course Audit Administrators and teachers will complete a Pre-AP Course Audit process to attest to these commitments. All schools offering courses that have received a Pre-AP Course Designation will be listed in the Pre-AP Course Ledger, in a process similar to that used for listing authorized AP courses.

PROGRAM COMMITMENTS

- Teachers have read the most recent *Pre-AP Biology Course Guide*.
- The school ensures that Pre-AP frameworks and assessments serve as the foundation for all sections of the course at the school. This means that the school must not establish any barriers (e.g., test scores, grades in prior coursework, teacher or counselor recommendation) to student access and participation in Pre-AP Biology coursework.
- Teachers administer at least one of two learning checkpoints per unit on Pre-AP Classroom and one performance task per unit.
- Teachers complete the foundational professional learning (Online Foundational Modules or Pre-AP Summer Institute) and at least one online performance task scoring module. The current Pre-AP coordinator completes the Pre-AP Coordinator Online Module.
- Teachers align instruction to the Pre-AP Biology Course Framework and ensure their course meets the curricular commitments summarized below.
- The school ensures that the resource commitments summarized below are met.

CURRICULAR COMMITMENTS

- The course provides opportunities for students to develop understanding of the Pre-AP Biology key concepts and skills articulated in the course framework through the four units of study.
- The course provides opportunities for students to engage in the Pre-AP shared instructional principles.
    - close observation and analysis
    - evidence-based writing
    - higher-order questioning
    - academic conversation

- The course provides opportunities for students to engage in the three Pre-AP science areas of focus. The areas of focus are:
  - emphasis on analytical reading and writing
  - strategic use of mathematics
  - attention to modeling
- The instructional plan for the course includes opportunities for students to continue to practice and develop disciplinary skills.
- The instructional plan reflects time and instructional methods for engaging students in reflection and feedback based on their progress.
- The instructional plan reflects making responsive adjustments to instruction based on student performance.

RESOURCE REQUIREMENTS

- The school ensures that participating teachers and students are provided computer and internet access.
- Teachers should have consistent access to a video projector for sharing web-based instructional content and short web videos.
- The school ensures teachers have access to laboratory equipment and consumable resources so that students can engage in the Pre-AP Biology inquiry-based model lessons.

Accessing the Digital Materials

Pre-AP Classroom is the online application through which teachers and students can access Pre-AP instructional resources and assessments. The digital platform is similar to AP Classroom, the online system used for AP courses.

Pre-AP coordinators receive access to Pre-AP Classroom via an access code delivered after orders are processed. Teachers receive access after the Pre-AP Course Audit process has been completed.

Once teachers have created course sections, student can enroll in them via access code. When both teachers and students have access, teachers can share instructional resources with students, assign and score assessments, and complete online learning modules; students can view resources shared by the teacher, take assessments, and receive feedback reports to understand progress and growth.

CollegeBoard Pre-AP®

preap.org/Biology-CG

 01560-064

978-1-4573-1513-8