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Springfield Public Schools
Springfield, New Jersey 07081

AP Environmental Science

Curriculum Guide

2025

This curriculum may be modified through varying materials, techniques, and strategies as per an individual student's IEP.

Springfield Board of Education
Approved August 25, 2025

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Springfield, New Jersey

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Introduction

This template is the product of an initiative led by the New Jersey Department of Education, Office of Academic Standards, in partnership with the New Jersey Association for Supervision and Curriculum Development (NJASCD) and the New Jersey Principals and Supervisors Association (NJPSA). The project was undertaken with the assistance of New Jersey content area supervisors, curriculum coordinators, and teachers during spring-summer 2009. The goal of the project was to design exemplar unit plans and accompanying lesson plans aligned with the New Jersey Student Learning Standards that may be used by districts as models for the development of local curricula.

The Unit Overview Template, which follows, is a tool that can help districts define one unit plan of several that comprise a specific course in the curriculum for any content area. It is designed, once completed, to summarize the content and objectives for the unit, outline lessons and assessments that support the unit, and provide links to documents that facilitate delivery of the unit, such as student materials, background information, resources, and performance rubrics. To see how the units fit together in the design of a course, see the Curriculum Design Template included at the end of this document.

Seven content area Unit Overviews were created as part of the project to serve as exemplar unit plans that are aligned with the New Jersey Student Learning Standards and that assist in achieving the goal of engaging students, fostering achievement, and cultivating 21st-century global skills. The units stress the integration of 21st-century themes and skills, global perspectives, technology, and cross-curricular connections.

We encourage districts to use the exemplars in conjunction with the curriculum development tools and templates that emanated from this project as models for teaching and learning based on the New Jersey Student Learning Standards.



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CollegeBoard AP

INCLUDES

- ✓ Course framework
- ✓ Instructional section
- ✓ Sample exam questions

AP® Environmental Science

COURSE AND EXAM DESCRIPTION

Effective **Fall 2020**



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AP® Environmental Science

COURSE AND EXAM DESCRIPTION

Effective
Fall 2020

AP COURSE AND EXAM DESCRIPTIONS ARE UPDATED PERIODICALLY

Please visit AP Central (apcentral.collegeboard.org) to determine whether a more recent course and exam description is available.



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 more than 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 **collegeboard.org**.

AP Equity and Access Policy

College Board strongly encourages educators to make equitable access a guiding principle for their AP programs by giving all willing and academically prepared students the opportunity to participate in AP. We encourage the elimination of barriers that restrict access to AP for students from ethnic, racial, and socioeconomic groups that have been traditionally underrepresented. Schools should make every effort to ensure their AP classes reflect the diversity of their student population. College Board also believes that all students should have access to academically challenging course work before they enroll in AP classes, which can prepare them for AP success. It is only through a commitment to equitable preparation and access that true equity and excellence can be achieved.

Designers: Sonny Mui and Bill Tully

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About AP

College Board's Advanced Placement® Program (AP®) enables willing and academically prepared students to pursue college-level studies—with the opportunity to earn college credit, advanced placement, or both—while still in high school. Through AP courses in 38 subjects, each culminating in a challenging exam, students learn to think critically, construct solid arguments, and see many sides of an issue—skills that prepare them for college and beyond. Taking AP courses demonstrates to college admission officers that students have sought the most challenging curriculum available to them, and research indicates that students who score a 3 or higher on an AP Exam typically experience greater academic success in college and are more likely to earn a college degree than non-AP students. Each AP teacher's syllabus is evaluated and approved by faculty from some of the nation's leading colleges and universities, and AP Exams are developed and scored by college faculty and experienced AP teachers. Most four-year colleges and universities in the United States grant credit, advanced placement, or both on the basis of successful AP Exam scores; more than 3,300 institutions worldwide annually receive AP scores.

AP Course Development

In an ongoing effort to maintain alignment with best practices in college-level learning, AP courses and exams emphasize challenging, research-based curricula aligned with higher education expectations.

Individual teachers are responsible for designing their own curriculum for AP courses, selecting appropriate college-level readings, assignments, and resources. This course and exam description presents the content and skills that are the focus of the corresponding college course and that appear on the AP Exam. It also organizes the content and skills into a series of units that represent a sequence found in widely adopted college textbooks and that many AP teachers have told us they follow in order to focus their instruction. The intention of this publication is to respect teachers' time and expertise by providing a roadmap that they can modify and adapt to their local priorities and preferences. Moreover, by organizing the AP course content and skills into units, the AP Program is able to provide teachers and students with free formative assessments—Personal Progress Checks—that teachers can assign throughout the year to measure student progress as they acquire content knowledge and develop skills.

Enrolling Students: Equity and Access

College Board strongly encourages educators to make equitable access a guiding principle for their AP programs by giving all willing and academically prepared students the opportunity to participate in AP. We encourage the elimination of barriers that restrict access to AP for students from ethnic, racial, and socioeconomic groups that have been traditionally underserved. College Board also believes that all students should have access to academically challenging coursework before they enroll in AP classes, which can prepare them for AP success. It is only through a commitment to equitable preparation and access that true equity and excellence can be achieved.

Offering AP Courses: The AP Course Audit

The AP Program unequivocally supports the principle that each school implements its own curriculum that will enable students to develop the content understandings and skills described in the course framework.

While the unit sequence represented in this publication is optional, the AP Program does have a short list of curricular and resource requirements that must be fulfilled before a school can label a course "Advanced Placement" or "AP." Schools wishing to offer AP courses must participate in the AP Course Audit, a process through which AP teachers' course materials are reviewed by college faculty. The AP Course Audit was created to provide teachers and administrators with clear guidelines on curricular and resource requirements for AP courses and to help colleges and universities validate courses marked "AP" on students' transcripts. This process ensures that AP teachers' courses meet or exceed the curricular and resource expectations that college and secondary school faculty have established for college-level courses.

The AP Course Audit form is submitted by the AP teacher and the school principal (or designated administrator) to confirm awareness and understanding of the curricular and resource requirements. A syllabus or course outline, detailing how course requirements are met, is submitted by the AP teacher for review by college faculty.

Please visit **collegeboard.org/apcourseaudit** for more information to support the preparation and submission of materials for the AP Course Audit.

How the AP Program Is Developed

The scope of content for an AP course and exam is derived from an analysis of hundreds of syllabi and course offerings of colleges and universities. Using this research and data, a committee of college faculty and expert AP teachers work within the scope of the corresponding college course to articulate what students should know and be able to do upon the completion of the AP course. The resulting course framework is the heart of this course and exam description and serves as a blueprint of the content and skills that can appear on an AP Exam.

The AP Test Development Committees are responsible for developing each AP Exam, ensuring the exam questions are aligned to the course framework. The AP Exam development process is a multiyear endeavor; all AP Exams undergo extensive review, revision, piloting, and analysis to ensure that questions are accurate, fair, and valid, and that there is an appropriate spread of difficulty across the questions.

Committee members are selected to represent a variety of perspectives and institutions (public and private, small and large schools and colleges), and a range of gender, racial/ethnic, and regional groups. A list of each subject's current AP Test Development Committee members is available on **apcentral.collegeboard.org**.

Throughout AP course and exam development, College Board gathers feedback from various stakeholders in both secondary schools and higher education institutions. This feedback is carefully considered to ensure that AP courses and exams are able to provide students with a college-level learning experience and the opportunity to demonstrate their qualifications for advanced placement or college credit.

How AP Exams Are Scored

The exam scoring process, like the course and exam development process, relies on the expertise of both AP teachers and college faculty. While multiple-choice questions are scored by machine, the free-response questions and through-course performance assessments, as applicable, are scored by thousands of college faculty and expert AP teachers. Most are scored at the annual AP Reading, while a small portion is scored online. All AP Readers are thoroughly trained, and their work is monitored throughout the Reading for fairness and consistency. In each subject, a highly respected college faculty member serves as Chief Faculty Consultant and, with the help of AP Readers in leadership positions, maintains the accuracy of the scoring standards. Scores on the free-response questions and performance assessments are weighted and combined with the results of the computer-scored multiple-choice questions, and this raw score is converted into a composite AP score on a 1–5 scale.

AP Exams are **not** norm-referenced or graded on a curve. Instead, they are criterion-referenced, which means that every student who meets the criteria for an AP score of 2, 3, 4, or 5 will receive that score, no matter how many students that is. The criteria for the number of points students must earn on the AP Exam to receive scores of 3, 4, or 5—the scores that research consistently validates for credit and placement purposes—include:

- The number of points successful college students earn when their professors administer AP Exam questions to them.
- The number of points researchers have found to be predictive that an AP student will succeed when placed into a subsequent, higher-level college course.
- Achievement-level descriptions formulated by college faculty who review each AP Exam question.

Using and Interpreting AP Scores

The extensive work done by college faculty and AP teachers in the development of the course and exam and throughout the scoring process ensures that AP Exam scores accurately represent students' achievement in the equivalent college course. Frequent and regular research studies establish the validity of AP scores as follows:

AP Score	Credit Recommendation	College Grade Equivalent
5	Extremely well qualified	A
4	Well qualified	A–, B+, B
3	Qualified	B–, C+, C
2	Possibly qualified	n/a
1	No recommendation	n/a

While colleges and universities are responsible for setting their own credit and placement policies, most private colleges and universities award credit and/or advanced placement for AP scores of 3 or higher. Additionally, most states in the U.S. have adopted statewide credit policies that ensure college credit for scores of 3 or higher at public colleges and universities. To confirm a specific college's AP credit/placement policy, a search engine is available at **apstudent.org/creditpolicies**.

BECOMING AN AP READER

Each June, thousands of AP teachers and college faculty members from around the world gather for seven days in multiple locations to evaluate and score the free-response sections of the AP Exams. Ninety-eight percent of surveyed educators who took part in the AP Reading say it was a positive experience.

There are many reasons to consider becoming an AP Reader, including opportunities to:

- **Bring positive changes to the classroom:** Surveys show that the vast majority of returning AP Readers—both high school and college educators—make improvements to the way they teach or score because of their experience at the AP Reading.
- **Gain in-depth understanding of AP Exam and AP scoring standards:** AP Readers gain exposure to the quality and depth of the responses from the entire pool of AP Exam takers, and thus are better able to assess their students' work in the classroom.
- **Receive compensation:** AP Readers are compensated for their work during the Reading. Expenses, lodging, and meals are covered for Readers who travel.
- **Score from home:** AP Readers have online distributed scoring opportunities for certain subjects. Check **collegeboard.org/apreading** for details.
- **Earn Continuing Education Units (CEUs):** AP Readers earn professional development hours and CEUs that can be applied to PD requirements by states, districts, and schools.

How to Apply

Visit **collegeboard.org/apreading** for eligibility requirements and to start the application process.

AP Resources and Supports

By completing a simple activation process at the start of the school year, teachers and students receive access to a robust set of classroom resources.

AP Classroom

AP Classroom is a dedicated online platform designed to support teachers and students throughout their AP experience. The platform provides a variety of powerful resources and tools to provide yearlong support to teachers and enable students to receive meaningful feedback on their progress.

UNIT GUIDES

Appearing in this publication and on AP Classroom, these planning guides outline all required course content and skills, organized into commonly taught units. Each unit guide suggests a sequence and pacing of content, scaffolds skill instruction across units, organizes content into topics, and provides tips on taking the AP Exam.

PERSONAL PROGRESS CHECKS

Formative AP questions for every unit provide feedback to students on the areas where they need to focus. Available online, Personal Progress Checks measure knowledge and skills through multiple-choice questions with rationales to explain correct and incorrect answers, and free-response questions with scoring information. Because the Personal Progress Checks are formative, the results of these assessments cannot be used to evaluate teacher effectiveness or assign letter grades to students, and any such misuses are grounds for losing school authorization to offer AP courses.*

PROGRESS DASHBOARD

This dashboard allows teachers to review class and individual student progress throughout the year. Teachers can view class trends and see where students struggle with content and skills that will be assessed on the AP Exam. Students can view their own progress over time to improve their performance before the AP Exam.

AP QUESTION BANK

This online library of real AP Exam questions provides teachers with secure questions to use in their classrooms. Teachers can find questions indexed by course topics and skills, create customized tests, and assign them online or on paper. These tests enable students to practice and get feedback on each question.

* To report misuses, please call 877-274-6474 (International: +1 212-632-1781).

Digital Activation

In order to teach an AP class and make sure students are registered to take the AP Exam, teachers must first complete the digital activation process. Digital activation gives students and teachers access to resources and gathers students' exam registration information online, eliminating most of the answer sheet bubbling that has added to testing time and fatigue.

AP teachers and students begin by signing in to **My AP** and completing a simple activation process at the start of the school year, which provides access to all AP resources, including AP Classroom.

To complete digital activation:

- Teachers and students sign in to or create their College Board accounts.
- Teachers confirm that they have added the course they teach to their AP Course Audit account and have had it approved by their school's administrator.
- Teachers or AP Coordinators, depending on who the school has decided is responsible, set up class sections so students can access AP resources and have exams ordered on their behalf.
- Students join class sections with a join code provided by their teacher or AP Coordinator.
- Students will be asked for additional registration information upon joining their first class section, which eliminates the need for extensive answer sheet bubbling on exam day.

While the digital activation process takes a short time for teachers, students, and AP coordinators to complete, overall it helps save time and provides the following additional benefits:

- **Access to AP resources and supports:** Teachers have access to resources specifically designed to support instruction and provide feedback to students throughout the school year as soon as activation is complete.
- **Streamlined exam ordering:** AP Coordinators can create exam orders from the same online class rosters that enable students to access resources. The coordinator reviews, updates, and submits this information as the school's exam order in the fall.
- **Student registration labels:** For each student included in an exam order, schools will receive a set of personalized AP ID registration labels, which replaces the AP student pack. The AP ID connects a student's exam materials with the registration information they provided during digital activation, eliminating the need for pre-administration sessions and reducing time spent bubbling on exam day.
- **Targeted Instructional Planning Reports:** AP teachers will get Instructional Planning Reports (IPRs) that include data on each of their class sections automatically rather than relying on special codes optionally bubbled in on exam day.

Instructional Model

Integrating AP resources throughout the course can help students develop skills and conceptual understandings. The instructional model outlined below shows possible ways to incorporate AP resources into the classroom.

Plan

Teachers may consider the following approaches as they plan their instruction before teaching each unit.

- Review the overview at the start of each **unit guide** to identify essential questions, conceptual understandings, and skills for each unit.
- Use the **Unit at a Glance** table to identify related topics that build toward a common understanding, and then plan appropriate pacing for students.
- Identify useful strategies in the **Instructional Approaches** section to help teach the concepts and skills.

Teach

When teaching, supporting resources can be used to build students' conceptual understanding and their mastery of skills.

- Use the topic pages in the **unit guides** to identify the required content.
- Integrate the content with a skill, considering any appropriate scaffolding.
- Employ any of the instructional strategies previously identified.
- Use the available resources on the topic pages to bring a variety of assets into the classroom.

Assess

Teachers can measure student understanding of the content and skills covered in the unit and provide actionable feedback to students.

- At the end of each unit, use **AP Classroom** to assign students the online **Personal Progress Checks**, as homework or an in-class task.
- Provide question-level feedback to students through answer rationales; provide unit- and skill-level feedback using the performance dashboard.
- Create additional practice opportunities using the **AP Question Bank** and assign them through **AP Classroom**.

About the AP Environmental Science Course

The AP Environmental Science course is designed to engage students with the scientific principles, concepts, and methodologies required to understand the interrelationships within the natural world. The course requires that students identify and analyze natural and human-made environmental problems, evaluate the relative risks associated with these problems, and examine alternative solutions for resolving or preventing them. Environmental science is interdisciplinary, embracing topics from geology, biology, environmental studies, environmental science, chemistry, and geography.

College Course Equivalent

The AP Environmental Science course is designed to be the equivalent of a one-semester, introductory college course in environmental science.

Prerequisites

Students should have completed two years of high school laboratory science—one year of life science and one year of physical science (e.g., a year of biology and a year of chemistry). Due to the quantitative analysis required in the course, students should also have taken at least one year of algebra. Also desirable (but not necessary) is a course in earth science.

Lab Requirement

Although there are no specific AP Environmental Science labs or field investigations required for the course, it is required that students have the opportunity to spend a minimum of 25% of instructional time engaged in hands-on, inquiry-based laboratory and/or fieldwork investigations.

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AP ENVIRONMENTAL SCIENCE

Course Framework



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Introduction

The AP Environmental Science course outlined in this framework reflects learning that analyzes environmental concepts and processes to achieve understanding in order to propose and justify solutions to environmental problems. The course teaches students how to apply science to the solutions of important social problems. It also provides opportunities to practice applying scientific methods to practical, real-life problems.

The AP Environmental Science course provides students with the scientific principles, concepts, and methodologies required to understand the interrelationships of the natural world. The course helps students identify and analyze natural and human-induced environmental problems. It enables them to learn how to assess the risks associated with these problems and evaluate alternative solutions for resolving and preventing them. To accomplish this goal, the *AP Environmental Science Course and Exam Description* defines concepts, skills, and understandings required by representative colleges and universities for granting college credit and placement.

Course Framework Components

Overview

This course framework provides a clear and detailed description of the course requirements necessary for student success.

The course framework includes two essential components:

1 SCIENCE PRACTICES

The science practices are central to the study and practice of environmental science. Students should develop and apply the described practices on a regular basis over the span of the course.

2 COURSE CONTENT

The course content is organized into commonly taught units of study that provide a suggested sequence for the course. These units comprise the content and conceptual understandings that colleges and universities typically expect students to master to qualify for college credit and/or placement. This content is grounded in big ideas, which are cross-cutting concepts that build conceptual understanding and spiral throughout the course.

1

AP ENVIRONMENTAL SCIENCE

Science Practices

The AP Environmental Science practices describe what a student should be able to do while exploring course concepts. The table that follows presents these practices, which students should develop during the AP Environmental Science course. These practices are categorized into skills, which form the basis of the tasks on the AP Exam.

The unit guides later in this publication embed and spiral these skills throughout the course, providing teachers with one way to integrate the skills in the course content with sufficient repetition to prepare students to transfer those skills when taking the AP Exam. Course content may be paired with a variety of skills on the AP Exam.

More detailed information about teaching the science practices can be found in the Instructional Approaches section of this publication.

AP ENVIRONMENTAL SCIENCE

Science Practices

Practice 1	Practice 2	Practice 3	Practice 4
Concept Explanation 1 Explain environmental concepts, processes, and models presented in written format.	***Visual Representations*** 2 Analyze visual representations of environmental concepts and processes.	***Text Analysis*** 3 Analyze sources of information about environmental issues	***Scientific Experiments*** 4 Analyze research studies that test environmental principles

SKILLS

1.A Describe environmental concepts and processes.	2.A Describe characteristics of an environmental concept, process, or model represented visually.	3.A Identify the author's claim.	4.A Identify a testable hypothesis or scientific question for an investigation.
1.B Explain environmental concepts and processes.	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: ▪ In theoretical contexts ▪ In applied contexts	3.B Describe the author's perspective and assumptions.	4.B Identify a research method, design, and/or measure used.
1.C Explain environmental concepts, processes, or models in applied contexts.	2.C Explain how environmental concepts and processes represented visually relate to broader environmental issues.	3.C Describe the author's reasoning (use of evidence to support a claim).	4.C Describe an aspect of a research method, design, and/or measure used.
		3.D Evaluate the credibility of a source *(not assessed)*: ▪ Recognize bias ▪ Scientific accuracy	4.D Make observations or collect data from laboratory setups *(not assessed)*.
		3.E Evaluate the validity of conclusions of a source or research study *(not assessed)*.	4.E Explain modifications to an experimental procedure that will alter results.

AP ENVIRONMENTAL SCIENCE

Science Practices *(cont'd)*

Practice 5	Practice 6	Practice 7
Data Analysis 5 Analyze and interpret quantitative data represented in tables, charts, and graphs	***Mathematical Routines*** 6 Apply quantitative methods to address environmental concepts	***Environmental Solutions*** 7 Propose and justify solutions to environmental problems
5.A Describe patterns or trends in data.	**6.A** Determine an approach or method aligned with the problem to be solved.	**7.A** Describe environmental problems.
5.B Describe relationships among variables in data represented.	**6.B** Apply appropriate mathematical relationships to solve a problem, with work shown (e.g., dimensional analysis).	**7.B** Describe potential responses or approaches to environmental problems.
5.C Explain patterns and trends in data to draw conclusions.	**6.C** Calculate an accurate numeric answer with appropriate units.	**7.C** Describe disadvantages, advantages, or unintended consequences for potential solutions.
5.D Interpret experimental data and results in relation to a given hypothesis.		**7.D** Use data and evidence to support a potential solution.
5.E Explain what the data implies or illustrates about environmental issues.		**7.E** Make a claim that proposes a solution to an environmental problem in an applied context.
		7.F Justify a proposed solution, by explaining potential advantages.

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2

AP ENVIRONMENTAL SCIENCE

Course Content

Based on the Understanding by Design® (Wiggins and McTighe) model, this course framework provides a clear and detailed description of the course requirements necessary for student success. The framework specifies what students must know, be able to do, and understand, with a focus on big ideas that encompass core principles and theories of the discipline. The framework also encourages instruction that prepares students for advanced environmental science coursework.

Big Ideas

The big ideas serve as the foundation of the course and allow students to create meaningful connections among concepts. They are often overarching concepts or themes that become threads that run throughout the course. Revisiting the big ideas and applying them in a variety of contexts allows students to develop deeper conceptual understanding. Below are the big ideas of the course and a brief description of each.

BIG IDEA 1: ENERGY TRANSFER (ENG)
Energy conversions underlie all ecological processes. Energy cannot be created; it must come from somewhere. As energy flows through systems, at each step, more of it becomes unusable.

BIG IDEA 2: INTERACTIONS BETWEEN EARTH SYSTEMS (ERT)
The Earth is one interconnected system. Natural systems change over time and space. Biogeochemical systems vary in ability to recover from disturbances.

BIG IDEA 3: INTERACTIONS BETWEEN DIFFERENT SPECIES AND THE ENVIRONMENT (EIN)
Humans alter natural systems and have had an impact on the environment for millions of years. Technology and population growth have enabled humans to increase both the rate and scale of their impact on the environment.

BIG IDEA 4: SUSTAINABILITY (STB)
Human survival depends on developing practices that will achieve sustainable systems. A suitable combination of conservation and development is required. The management of resources is essential. Understanding the role of cultural, social, and economic factors is vital to the development of solutions.

UNITS

The course content is organized into commonly taught units. The units have been arranged in a logical sequence frequently found in many college courses and textbooks.

The nine units in AP Environmental Science, and their weighting on the multiple-choice section of the AP Exam, are listed below.

Pacing recommendations at the unit level and on the Course at a Glance provide suggestions for how to teach the required course content and administer the Personal Progress Checks. The suggested class periods are based on a schedule in which the class meets five days a week for 45 minutes each day. While these recommendations have been made to aid planning, teachers should of course adjust the pacing based on the needs of their students, alternate schedules (e.g., block scheduling), or their school's academic calendar.

TOPICS

Each unit is broken down into teachable segments called topics. The topic pages (starting on page 36) contain the required content for each topic.

Units	Exam Weighting
Unit 1: The Living World: Ecosystems	**6–8%**
Unit 2: The Living World: Biodiversity	**6–8%**
Unit 3: Populations	**10–15%**
Unit 4: Earth Systems and Resources	**10–15%**
Unit 5: Land and Water Use	**10–15%**
Unit 6: Energy Resources and Consumption	**10–15%**
Unit 7: Atmospheric Pollution	**7–10%**
Unit 8: Aquatic and Terrestrial Pollution	**7–10%**
Unit 9: Global Change	**15–20%**

Spiraling the Big Ideas

The following table shows how the big ideas spiral across units.

Big Ideas	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9
	The Living World: Ecosystems	The Living World: Biodiversity	Populations	Earth Systems and Resources	Land and Water Use	Energy Resources and Consumption	Atmospheric Pollution	Aquatic and Terrestrial Pollution	Global Change
Energy Transfer ENG	✓			✓		✓			
Interactions Between Earth Systems ERT	✓	✓	✓	✓					
Interactions Between Different Species and the Environment EIN			✓		✓			✓	✓
Sustainability STB					✓		✓	✓	✓



Course at a Glance

Plan

The Course at a Glance provides a useful visual organization of the AP Environmental Science curricular components, including:

- Sequence of units, along with approximate weighting and suggested pacing. Please note, pacing is based on 45-minute class periods, meeting five days each week for a full academic year.
- Progression of topics within each unit.
- Spiraling of the big ideas and science practices across units.

Teach

SCIENCE PRACTICES
Science practices spiral throughout the course.

1. Concept Explanation
2. Visual Representations
3. Text Analysis
4. Scientific Experiments
5. Data Analysis
6. Mathematical Routines
7. Environmental Solutions

BIG IDEAS
Big ideas spiral across topics and units.

- ENG Energy Transfer
- ERT Interactions Between Earth Systems
- EIN Interactions Between Different Species and the Environment
- STB Sustainability

Assess

Assign the Personal Progress Checks—either as homework or in class—for each unit. Each Personal Progress Check contains formative multiple-choice and free-response questions. The feedback from the Personal Progress Checks shows students the areas where they need to focus.

UNIT 1 The Living World: Ecosystems

~14–15 Class Periods | **6–8%** AP Exam Weighting

ERT 1	1.1 Introduction to Ecosystems
ERT 1	1.2 Terrestrial Biomes
ERT 1	1.3 Aquatic Biomes
ERT 2	1.4 The Carbon Cycle
ERT 2	1.5 The Nitrogen Cycle
ERT 2	1.6 The Phosphorus Cycle
ERT 2	1.7 The Hydrologic (Water) Cycle
ENG 1	1.8 Primary Productivity
ENG 1	1.9 Trophic Levels
ENG 6	1.10 Energy Flow and the 10% Rule
ENG 2	1.11 Food Chains and Food Webs

Personal Progress Check 1

- **Multiple-choice: ~30 questions**
- **Free-response: 1 question (partial)**
  - Analyze an environmental problem and propose a solution

UNIT 2 The Living World: Biodiversity

~11–12 Class Periods | **6–8%** AP Exam Weighting

ERT 1	2.1 Introduction to Biodiversity
ERT 1	2.2 Ecosystem Services
ERT 1	2.3 Island Biogeography
ERT 3	2.4 Ecological Tolerance
ERT 5	2.5 Natural Disruptions to Ecosystems
ERT 5	2.6 Adaptations
ERT 5	2.7 Ecological Succession

Personal Progress Check 2

- **Multiple-choice: ~20 questions**
- **Free-response: 1 question (partial)**
  - Design an investigation

Note: Partial versions of the free-response questions are provided to prepare students for more complex, full questions that they will encounter on the AP Exam.



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UNIT 3 Populations

~12–13 Class Periods | **10–15%** AP Exam Weighting

ERT 1	3.1	Generalist and Specialist Species
ERT 5	3.2	K-Selected r-Selected Species
ERT 5	3.3	Survivorship Curves
ERT 5	3.4	Carrying Capacity
ERT 6	3.5	Population Growth and Resource Availability
EIN 5	3.6	Age Structure Diagrams
EIN 5	3.7	Total Fertility Rate
EIN 7	3.8	Human Population Dynamics
EIN 1	3.9	Demographic Transition

Personal Progress Check 3

- **Multiple-choice: ~20 questions**
- **Free-response: 1 question (partial)**
  - Analyze an environmental problem and propose a solution doing calculations

UNIT 4 Earth Systems and Resources

~11–12 Class Periods | **10–15%** AP Exam Weighting

ERT 2	4.1	Plate Tectonics
ERT 4	4.2	Soil Formation and Erosion
ERT 4	4.3	Soil Composition and Properties
ERT 2	4.4	Earth's Atmosphere
ERT 2	4.5	Global Wind Patterns
ERT 1	4.6	Watersheds
ENG 2	4.7	Solar Radiation and Earth's Seasons
ENG 2	4.8	Earth's Geography and Climate
ENG 7	4.9	El Niño and La Niña

Personal Progress Check 4

- **Multiple-choice: ~25 questions**
- **Free-response: 1 question**
  - Design an investigation

UNIT 5 Land and Water Use

~18–19 Class Periods | **10–15%** AP Exam Weighting

EIN 1	5.1	The Tragedy of the Commons
EIN 1	5.2	Clearcutting
EIN 3	5.3	The Green Revolution
EIN 1	5.4	Impacts of Agricultural Practices
EIN 7	5.5	Irrigation Methods
EIN 7	5.6	Pest Control Methods
EIN 5	5.7	Meat Production Methods
EIN 7	5.8	Impacts of Overfishing
EIN 7	5.9	Impacts of Mining
EIN 7	5.10	Impacts of Urbanization
EIN 5	5.11	Ecological Footprints
STB 5	5.12	Introduction to Sustainability
STB 4	5.13	Methods to Reduce Urban Runoff
STB 7	5.14	Integrated Pest Management
STB 7	5.15	Sustainable Agriculture
STB 7	5.16	Aquaculture
STB 7	5.17	Sustainable Forestry

Personal Progress Check 5

- **Multiple-choice: ~35 questions**
- **Free-response: 1 question**
  - Analyze an environmental problem and propose a solution



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UNIT 6 Energy Resources and Consumption

~16–17 Class Periods | **10–15%** AP Exam Weighting

- ENG 1 — 6.1 Renewable and Nonrenewable Resources
- ENG 6 — 6.2 Global Energy Consumption
- ENG 1 — 6.3 Fuel Types and Uses
- ENG 2 — 6.4 Distribution of Natural Energy Resources
- ENG 7 — 6.5 Fossil Fuels
- ENG 2 — 6.6 Nuclear Power
- ENG 7 — 6.7 Energy from Biomass
- ENG 5 — 6.8 Solar Energy
- ENG 7 — 6.9 Hydroelectric Power
- ENG 1 — 6.10 Geothermal Energy
- ENG 1 — 6.11 Hydrogen Fuel Cell
- ENG 7 — 6.12 Wind Energy
- ENG 6 — 6.13 Energy Conservation

Personal Progress Check 6

- **Multiple-choice: ~35 questions**
- **Free-response: 1 question**
  - Analyze an environmental problem and propose a solution doing calculations

UNIT 7 Atmospheric Pollution

~11–12 Class Periods | **7–10%** AP Exam Weighting

- STB 4 — 7.1 Introduction to Air Pollution
- STB 5 — 7.2 Photochemical Smog
- STB 2 — 7.3 Thermal Inversion
- STB 4 — 7.4 Atmospheric CO_2 and Particulates
- STB 5 — 7.5 Indoor Air Pollutants
- STB 7 — 7.6 Reduction of Air Pollutants
- STB 4 — 7.7 Acid Rain
- STB 3 — 7.8 Noise Pollution

Personal Progress Check 7

- **Multiple-choice: ~20 questions**
- **Free-response: 1 question**
  - Design an investigation

UNIT 8 Aquatic and Terrestrial Pollution

~19–20 Class Periods | **7–10%** AP Exam Weighting

- STB 1 — 8.1 Sources of Pollution
- STB 6 — 8.2 Human Impacts on Ecosystems
- STB 1 — 8.3 Endocrine Disruptors
- STB 7 — 8.4 Human Impacts on Wetlands and Mangroves
- STB 2 — 8.5 Eutrophication
- STB 1 — 8.6 Thermal Pollution
- STB 1 — 8.7 Persistent Organic Pollutants (POPs)
- STB 4 — 8.8 Bioaccumulation and Biomagnification
- STB 7 — 8.9 Solid Waste Disposal
- STB 6 — 8.10 Waste Reduction Methods
- STB 2 — 8.11 Sewage Treatment
- EIN 6 — 8.12 Lethal Dose 50% (LD_{50})
- EIN 5 — 8.13 Dose Response Curve
- EIN 4 — 8.14 Pollution and Human Health
- EIN 2 — 8.15 Pathogens and Infectious Diseases

Personal Progress Check 8

- **Multiple-choice: ~35 questions**
- **Free-response: 1 question**
  - Analyze an environmental problem and propose a solution doing calculations



UNIT 9 Global Change

~19–20 Class Periods | **15–20%** AP Exam Weighting

STB 1	9.1	Stratospheric Ozone Depletion
STB 7	9.2	Reducing Ozone Depletion
STB 1	9.3	The Greenhouse Effect
STB 2	9.4	Increases in the Greenhouse Gases
STB 5	9.5	Global Climate Change
STB 7	9.6	Ocean Warming
STB 1	9.7	Ocean Acidification
EIN 7	9.8	Invasive Species
EIN 7	9.9	Endangered Species
EIN 7	9.10	Human Impacts on Biodiversity

Personal Progress Check 9

- **Multiple-choice: ~25 questions**
- **Free-response: 1 question**
  - Analyze an environmental problem and propose a solution

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AP ENVIRONMENTAL SCIENCE

Unit Guides

Introduction

Designed with extensive input from the community of AP Environmental Science educators, the unit guides offer teachers helpful guidance in building students' skills and knowledge. The suggested sequence was identified through a thorough analysis of the syllabi of highly effective AP teachers and the organization of typical college textbooks.

This unit structure respects new AP teachers' time by providing one possible sequence they can adopt or modify rather than having to build from scratch. An additional benefit is that these units enable the AP Program to provide interested teachers with formative assessments—the Personal Progress Checks—that they can assign their students at the end of each unit to gauge progress toward success on the AP Exam. However, experienced AP teachers who are satisfied with their current course organization and exam results should feel no pressure to adopt these units, which comprise an optional sequence for this course.

Required Environmental Legislation

The following list represents the required environmental policies and legislation for the course as they relate to solutions to environmental problems. Teachers are encouraged to incorporate an understanding of legislation and policies and how they impact the environment.

- CLEAN AIR ACT
- CLEAN WATER ACT
- CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA (CITES)
- COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)
- MONTREAL PROTOCOL
- KYOTO PROTOCOL
- ENDANGERED SPECIES ACT
- SAFE DRINKING WATER ACT (SWDA)
- DELANEY CLAUSE OF FOOD, DRUG, AND COSMETIC ACT
- RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

Using the Unit Guides



UNIT 1 | 6–8% AP EXAM WEIGHTING | ~14–15 CLASS PERIODS

The Living World: Ecosystems

Developing Understanding

The first unit sets the foundation for the course by examining the Earth as a system with interdependent components, processes, and relationships. Students will examine the distribution of resources in ecosystems and its influences on species interactions. There is a global distribution of terrestrial and aquatic biomes—regional ecosystems—that each have specific environmental features based on their shared climate. This distribution is dynamic, and it has changed due to global climate change. Each ecosystem relies on biogeochemical cycles for survival. These cycles facilitate the acquisition and transfer of energy into usable forms, and they can be altered by human activities. In subsequent units, students will apply their understanding of ecosystems to the living world and examine the importance of biodiversity.

BIG IDEA 1
Energy Transfer ENE
- How does energy change form?

BIG IDEA 2
Interactions Between Earth Systems ESS
- How old is the water you drink?

Building the Science Practices

LO 1.A LO 1.B LO 4.B LO 4.C

The ability to describe environmental processes and relationships within an environment is central to this unit. Students can practice this skill with visual representations and models, particularly those of biogeochemical cycles, food chains, food webs, and trophic diagrams. By the end of this unit, students should be able to use visual representations to describe the individual steps of the hydrologic, carbon, nitrogen, and phosphorus cycles and then explain how each chemical is either stored or transferred throughout its cycle. Students should also be able to predict the effects of a change in one or more parts of a given cycle, including impacts to humans and the ecosystem at large.

In this unit, students should also develop a foundational understanding of biomes and describe how relationships between organisms are affected by environmental conditions. They should develop the quantitative skills to calculate the decrease of energy as it passes through ecosystems and then explain the transfer of energy through ecosystems.

Preparing for the AP Exam

On the AP Exam, students must be able to apply environmental concepts and processes in real-world situations. This starts with the ability to identify and describe the biogeochemical cycles and then predict the effects of a change within a cycle. For example, while students can identify the biogeochemical cycle, they often struggle to describe each of the steps. Students also struggle to identify the reservoir portion of the cycle, which is the step that takes the longest to complete. To combat these challenges, providing visual representations of biogeochemical cycles can help students organize information. Students can also write step-by-step descriptions of the cycles, including characteristics and attributes.

AP Environmental Science Course and Exam Description — Course Framework V.1 | 33

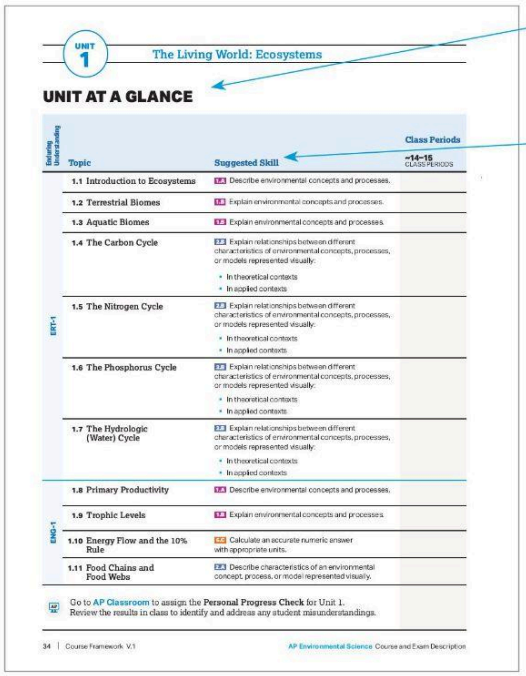
UNIT OPENERS

Developing Understanding provides an overview that contextualizes and situates the key content of the unit within the scope of the course.

Big ideas serve as the foundation of the course and help develop understanding as they spiral throughout the course. The **essential questions** are thought-provoking questions that motivate students and inspire inquiry.

Building the Science Practices describes specific aspects of the practices that are appropriate to focus on in that unit.

Preparing for the AP Exam provides helpful tips and common student misunderstandings identified from prior exam data.



UNIT 1 | The Living World: Ecosystems

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods ~14–15 CLASS PERIODS
	1.1 Introduction to Ecosystems	1.A Describe environmental concepts and processes.	
	1.2 Terrestrial Biomes	1.B Explain environmental concepts and processes.	
	1.3 Aquatic Biomes	1.B Explain environmental concepts and processes.	
ERT-1	1.4 The Carbon Cycle	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: • In theoretical contexts • In applied contexts	
ERT-1	1.5 The Nitrogen Cycle	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: • In theoretical contexts • In applied contexts	
ERT-1	1.6 The Phosphorus Cycle	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: • In theoretical contexts • In applied contexts	
ERT-1	1.7 The Hydrologic (Water) Cycle	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: • In theoretical contexts • In applied contexts	
ENG-1	1.8 Primary Productivity	1.A Describe environmental concepts and processes.	
ENG-1	1.9 Trophic Levels	1.B Explain environmental concepts and processes.	
ENG-1	1.10 Energy Flow and the 10% Rule	4.C Calculate an accurate numeric answer with appropriate units.	
ENG-1	1.11 Food Chains and Food Webs	2.A Describe characteristics of an environmental concept, process, or model represented visually.	

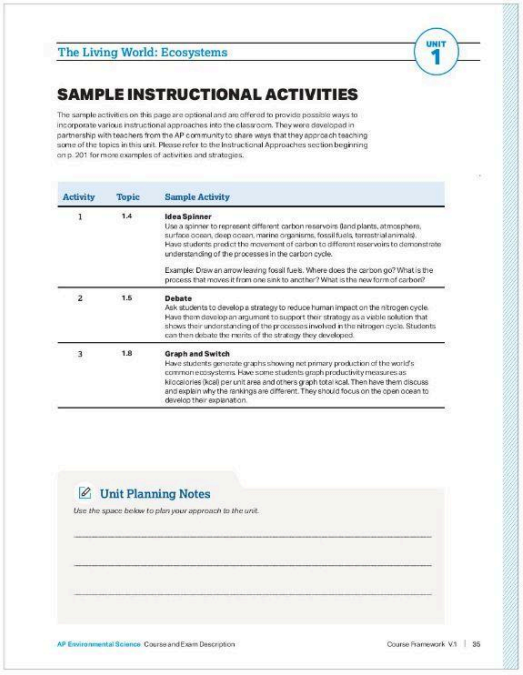
RE Go to AP Classroom to assign the **Personal Progress Check** for Unit 1. Review the results in class to identify and address any student misunderstandings.

34 | Course Framework V.1 — AP Environmental Science Course and Exam Description

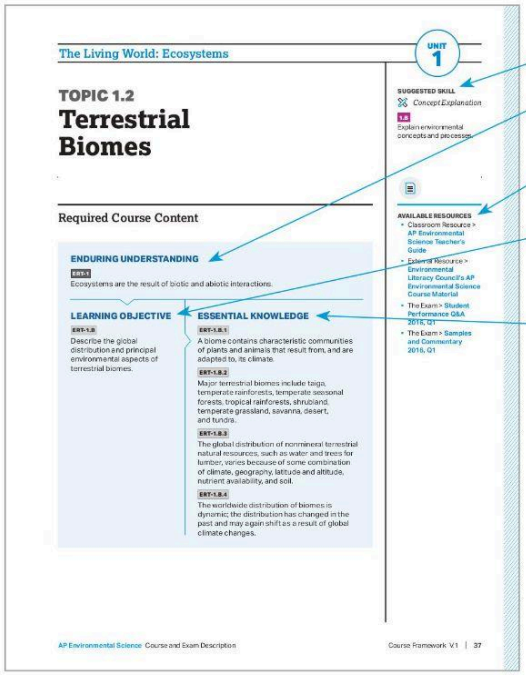
The **Unit at a Glance** table shows the topics, related enduring understandings, and suggested skills. The class periods column has been left blank so that teachers can customize the time they spend on each topic.

The **suggested skills** for each topic show one way to link the content in that topic to a specific AP Environmental Science skill. The individual skills have been thoughtfully chosen in a way that allows teachers to scaffold the skills throughout the course. The questions on the Personal Progress Checks are based on this pairing. However, AP Exam questions can pair the content with any of the skills.

Using the Unit Guides


The Living World: Ecosystems
UNIT 1
SAMPLE INSTRUCTIONAL ACTIVITIES
The sample activities on this page are optional and are offered to provide possible ways to incorporate various instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 201 for more examples of activities and strategies.
Activity | Topic | Sample Activity
1 | 1.4 | Idea Spinner — Use a spinner to represent different carbon reservoirs (land plants, atmosphere, surface ocean, deep ocean, marine organisms, fossil fuels, terrestrial animals). Have students predict the movement of carbon to different reservoirs to demonstrate understanding of the processes in the carbon cycle. Example: Draw an arrow leaving fossil fuels. Where does the carbon go? What is the process that moves it from one sink to another? What is the new form of carbon?
2 | 1.5 | Debate — Ask students to develop a strategy to reduce human impact on the nitrogen cycle. Have them develop an argument to support their strategy as a viable solution that shows their understanding of the processes involved in the nitrogen cycle. Students can then debate the merits of the strategy they developed.
3 | 1.8 | Graph and Switch — Have students generate graphs showing net primary production of the world's common ecosystems. Have some students graph productivity measures as kilocalories (kcal) per unit area and others graph total kcal. Then have them discuss and explain why the rankings are different. They should focus on the open ocean to develop their explanation.
Unit Planning Notes
Use the space below to plan your approach to the unit.
AP Environmental Science Course and Exam Description
Course Framework V.1 | 35

The **Sample Instructional Activities** page includes optional activities that can help teachers tie together the content and skill of a particular topic. Additionally, this page offers space for teachers to make notes on their approach to the individual topics and the unit as a whole.


The Living World: Ecosystems
UNIT 1
TOPIC 1.2
Terrestrial Biomes
Required Course Content
ENDURING UNDERSTANDING
ENT-1
Ecosystems are the result of biotic and abiotic interactions.
LEARNING OBJECTIVE
ENT-1.D
Describe the global distribution and principal environmental aspects of terrestrial biomes.
ESSENTIAL KNOWLEDGE
ENT-1.D.1
A biome contains characteristic communities of plants and animals that result from, and are adapted to, its climate.
ENT-1.D.2
Major terrestrial biomes include taiga, temperate rainforests, temperate seasonal forests, tropical rainforests, shrubland, temperate grassland, savanna, desert, and tundra.
ENT-1.D.3
The global distribution of nonmineral terrestrial natural resources, such as water and trees for lumber, varies because of some combination of climate, geography, latitude and altitude, nutrient availability, and soil.
ENT-1.D.4
The worldwide distribution of biomes is dynamic; the distribution has changed in the past and may again shift as a result of global climate changes.
SUGGESTED SKILL
Concept Explanation
1.8
Explain environmental concepts and processes.
AVAILABLE RESOURCES
• Classroom Resource > AP Environmental Science Teacher's Guide
• External Resource > Environmental Literacy Council's AP Environmental Science Course Material
• The Exam > Student Performance Q&A 2016, Q1
• The Exam > Samples and Commentary 2016, Q1
AP Environmental Science Course and Exam Description
Course Framework V.1 | 37

TOPIC PAGES

The **suggested skill** offers a possible skill to pair with the topic.

Enduring understandings are the long-term takeaways related to the big ideas that leave a lasting impression on students.

Where possible, **available resources** are listed that might help teachers address a particular topic.

Learning objectives define what a student needs to be able to do with content knowledge in order to progress toward the enduring understandings.

Essential knowledge statements describe the knowledge required to perform the learning objective.

REQUIRED COURSE CONTENT LABELING SYSTEM

BIG IDEA	ENDURING UNDERSTANDING	LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ERT Interactions Between Earth Systems	**ERT-1** Ecosystems are the result of biotic and abiotic interactions.	**ERT-1.A** Explain how the availability of resources influences species interactions.	**ERT-1.A.2** Symbiosis is a close and long-term interaction between two species in an ecosystem. Types of symbiosis include mutualism, commensalism, and parasitism.

NOTE: Labels are used to distinguish each unique element of the required course content and are used throughout this course and exam description. Additionally, they are used in the AP Question Bank and other resources found in AP Classroom. Enduring understandings are labeled sequentially according to the big idea that they are related to. Learning objectives are labeled to correspond with the enduring understanding they relate to. Finally, essential knowledge statements are labeled to correspond with the learning objective they relate to.

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AP ENVIRONMENTAL SCIENCE

UNIT 1

The Living World: Ecosystems

6–8%
AP EXAM WEIGHTING

~14–15
CLASS PERIODS

Remember to go to **AP Classroom** to assign students the online **Personal Progress Check** for this unit.

Whether assigned as homework or completed in class, the **Personal Progress Check** provides each student with immediate feedback related to this unit's topics and skills.

Personal Progress Check 1

Multiple-choice: ~30 questions
Free-response: 1 question (partial)

- Analyze an environmental problem and propose a solution

UNIT 1 | 6–8% AP EXAM WEIGHTING | ~14–15 CLASS PERIODS

The Living World: Ecosystems

BIG IDEA 1
Energy Transfer ENG
- How does energy change forms?

BIG IDEA 2
Interactions Between Earth Systems ERT
- How old is the water you drink?

Developing Understanding

The first unit sets the foundation for the course by examining the Earth as a system with interdependent components, processes, and relationships. Students will examine the distribution of resources in ecosystems and its influences on species interactions. There is a global distribution of terrestrial and aquatic biomes—regional ecosystems—that each have specific environmental features based on their shared climate. This distribution is dynamic, and it has changed due to global climate change. Each ecosystem relies on biogeochemical cycles for survival. These cycles facilitate the acquisition and transfer of energy into usable forms, and they can be altered by human activities. In subsequent units, students will apply their understanding of ecosystems to the living world and examine the importance of biodiversity.

Building the Science Practices

1.A 1.B 2.A 2.B 6.C

The ability to describe environmental processes and relationships within an environment is central to this unit. Students can practice this skill with visual representations and models, particularly those of biogeochemical cycles, food chains, food webs, and trophic diagrams. By the end of this unit, students should be able to use visual representations to describe the individual steps of the hydrologic, carbon, nitrogen, and phosphorus cycles and then explain how each chemical is either stored or transferred throughout its cycle. Students should also be able to predict the effects of a change in one or more parts of a given cycle, including impacts to humans and the ecosystem at large.

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Preparing for the AP Exam

On the AP Exam, students must be able to apply environmental concepts and processes in real-world situations. This starts with the ability to identify and describe the biogeochemical cycles and then predict the effects of a change within a cycle. For example, while students can identify the biogeochemical cycle, they often struggle to describe each of the steps. Students also struggle to identify the reservoir portion of the cycle, which is the step that takes the longest to complete. To combat these challenges, providing visual representations of biogeochemical cycles can help students organize information. Students can also write step-by-step descriptions of the cycles, including characteristics and attributes.

UNIT 1

The Living World: Ecosystems

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods ~14–15 CLASS PERIODS
ERT-1	1.1 Introduction to Ecosystems	1.A Describe environmental concepts and processes.	
	1.2 Terrestrial Biomes	1.B Explain environmental concepts and processes.	
	1.3 Aquatic Biomes	1.B Explain environmental concepts and processes.	
	1.4 The Carbon Cycle	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: ▪ In theoretical contexts ▪ In applied contexts	
	1.5 The Nitrogen Cycle	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: ▪ In theoretical contexts ▪ In applied contexts	
	1.6 The Phosphorus Cycle	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: ▪ In theoretical contexts ▪ In applied contexts	
	1.7 The Hydrologic (Water) Cycle	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: ▪ In theoretical contexts ▪ In applied contexts	
ENG-1	1.8 Primary Productivity	1.A Describe environmental concepts and processes.	
	1.9 Trophic Levels	1.B Explain environmental concepts and processes.	
	1.10 Energy Flow and the 10% Rule	6.C Calculate an accurate numeric answer with appropriate units.	
	1.11 Food Chains and Food Webs	2.A Describe characteristics of an environmental concept, process, or model represented visually.	

Go to **AP Classroom** to assign the **Personal Progress Check** for Unit 1.
Review the results in class to identify and address any student misunderstandings.

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional and are offered to provide possible ways to incorporate various instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 201 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	1.4	**Idea Spinner** Use a spinner to represent different carbon reservoirs (land plants, atmosphere, surface ocean, deep ocean, marine organisms, fossil fuels, terrestrial animals). Have students predict the movement of carbon to different reservoirs to demonstrate understanding of the processes in the carbon cycle. Example: Draw an arrow leaving fossil fuels. Where does the carbon go? What is the process that moves it from one sink to another? What is the new form of carbon?
2	1.5	**Debate** Ask students to develop a strategy to reduce human impact on the nitrogen cycle. Have them develop an argument to support their strategy as a viable solution that shows their understanding of the processes involved in the nitrogen cycle. Students can then debate the merits of the strategy they developed.
3	1.8	**Graph and Switch** Have students generate graphs showing net primary production of the world's common ecosystems. Have some students graph productivity measures as kilocalories (kcal) per unit area and others graph total kcal. Then have them discuss and explain why the rankings are different. They should focus on the open ocean to develop their explanation.

Unit Planning Notes

Use the space below to plan your approach to the unit.

UNIT 1

The Living World: Ecosystems

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- The Exam > Chief Reader Report (**2018, Q2, 2017, Q1**)
- The Exam > Samples and Commentary (**2018, Q2, 2017, Q1**)

TOPIC 1.1
Introduction to Ecosystems

Required Course Content

ENDURING UNDERSTANDING

ERT-1

Ecosystems are the result of biotic and abiotic interactions.

LEARNING OBJECTIVE

ERT-1.A

Explain how the availability of resources influences species interactions.

ESSENTIAL KNOWLEDGE

ERT-1.A.1

In a predator-prey relationship, the predator is an organism that eats another organism (the prey).

ERT-1.A.2

Symbiosis is a close and long-term interaction between two species in an ecosystem. Types of symbiosis include mutualism, commensalism, and parasitism.

ERT-1.A.3

Competition can occur within or between species in an ecosystem where there are limited resources. Resource partitioning—using the resources in different ways, places, or at different times—can reduce the negative impact of competition on survival.

TOPIC 1.2
Terrestrial Biomes

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- The Exam > **Student Performance Q&A 2016, Q1**
- The Exam > **Samples and Commentary 2016, Q1**

Required Course Content

ENDURING UNDERSTANDING

ERT-1

Ecosystems are the result of biotic and abiotic interactions.

LEARNING OBJECTIVE

ERT-1.B

Describe the global distribution and principal environmental aspects of terrestrial biomes.

ESSENTIAL KNOWLEDGE

ERT-1.B.1

A biome contains characteristic communities of plants and animals that result from, and are adapted to, its climate.

ERT-1.B.2

Major terrestrial biomes include taiga, temperate rainforests, temperate seasonal forests, tropical rainforests, shrubland, temperate grassland, savanna, desert, and tundra.

ERT-1.B.3

The global distribution of nonmineral terrestrial natural resources, such as water and trees for lumber, varies because of some combination of climate, geography, latitude and altitude, nutrient availability, and soil.

ERT-1.B.4

The worldwide distribution of biomes is dynamic; the distribution has changed in the past and may again shift as a result of global climate changes.

UNIT 1

The Living World: Ecosystems

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- The Exam > **Chief Reader Report 2017, Q1**
- The Exam > **Student Performance Q&A 2015, Q1**
- The Exam > Samples and Commentary (**2017 Q1, 2015, Q1**)

TOPIC 1.3
Aquatic Biomes

Required Course Content

ENDURING UNDERSTANDING

ERT-1

Ecosystems are the result of biotic and abiotic interactions.

LEARNING OBJECTIVE

ERT-1.C

Describe the global distribution and principal environmental aspects of aquatic biomes.

ESSENTIAL KNOWLEDGE

ERT-1.C.1

Freshwater biomes include streams, rivers, ponds, and lakes. These freshwater biomes are a vital resource for drinking water.

ERT-1.C.2

Marine biomes include oceans, coral reefs, marshland, and estuaries. Algae in marine biomes supply a large portion of the Earth's oxygen, and also take in carbon dioxide from the atmosphere.

ERT-1.C.3

The global distribution of nonmineral marine natural resources, such as different types of fish, varies because of some combination of salinity, depth, turbidity, nutrient availability, and temperature.

TOPIC 1.4
The Carbon Cycle

Required Course Content

ENDURING UNDERSTANDING

ERT-1

Ecosystems are the result of biotic and abiotic interactions.

LEARNING OBJECTIVE

ERT-1.D

Explain the steps and reservoir interactions in the carbon cycle.

ESSENTIAL KNOWLEDGE

ERT-1.D.1

The carbon cycle is the movement of atoms and molecules containing the element carbon between sources and sinks.

ERT-1.D.2

Some of the reservoirs in which carbon compounds occur in the carbon cycle hold those compounds for long periods of time, while some hold them for relatively short periods of time.

ERT-1.D.3

Carbon cycles between photosynthesis and cellular respiration in living things.

ERT-1.D.4

Plant and animal decomposition have led to the storage of carbon over millions of years. The burning of fossil fuels quickly moves that stored carbon into atmospheric carbon, in the form of carbon dioxide.

SUGGESTED SKILL

Visual Representations

2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- Classroom Resource > **Outdoor Education Experiences and AP Environmental Science**
- The Exam > **Chief Reader Report 2018, Q1**
- The Exam > **Student Performance Q&A 2014, Q4**
- The Exam > Samples and Commentary (**2018, Q1, 2014, Q4**)

SUGGESTED SKILL

Visual Representations

2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

AVAILABLE RESOURCES

- Classroom Resource > **Agriculture and the Nitrogen Cycle**
- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- Classroom Resource > **Ecology**
- Classroom Resource > **Nitrogen Cycling in Ecosystems**
- The Exam > Chief Reader Report (**2018, Q1**, **2017, Q1**)
- The Exam > Samples and Commentary (**2018, Q1**, **2017 Q1**)

TOPIC 1.5
The Nitrogen Cycle

Required Course Content

ENDURING UNDERSTANDING

ERT-1

Ecosystems are the result of biotic and abiotic interactions.

LEARNING OBJECTIVE

ERT-1.E

Explain the steps and reservoir interactions in the nitrogen cycle.

ESSENTIAL KNOWLEDGE

ERT-1.E.1

The nitrogen cycle is the movement of atoms and molecules containing the element nitrogen between sources and sinks.

ERT-1.E.2

Most of the reservoirs in which nitrogen compounds occur in the nitrogen cycle hold those compounds for relatively short periods of time.

ERT-1.E.3

Nitrogen fixation is the process in which atmospheric nitrogen is converted into a form of nitrogen (primarily ammonia) that is available for uptake by plants and that can be synthesized into plant tissue.

ERT-1.E.4

The atmosphere is the major reservoir of nitrogen.

TOPIC 1.6
The Phosphorus Cycle

Required Course Content

ENDURING UNDERSTANDING

ERT-1

Ecosystems are the result of biotic and abiotic interactions.

LEARNING OBJECTIVE

ERT-1.F

Explain the steps and reservoir interactions in the phosphorus cycle.

ESSENTIAL KNOWLEDGE

ERT-1.F.1

The phosphorus cycle is the movement of atoms and molecules containing the element phosphorus between sources and sinks.

ERT-1.F.2

The major reservoirs of phosphorus in the phosphorus cycle are rock and sediments that contain phosphorus-bearing minerals.

ERT-1.F.3

There is no atmospheric component in the phosphorus cycle, and the limitations this imposes on the return of phosphorus from the ocean to land make phosphorus naturally scarce in aquatic and many terrestrial ecosystems. In undisturbed ecosystems, phosphorus is the limiting factor in biological systems.

SUGGESTED SKILL

Visual Representations

2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- Classroom Resource > **Outdoor Education Experiences and AP Environmental Science**
- The Exam > Student Performance Q&A (**2014 Q4, 2015, Q1**)
- The Exam > Samples and Commentary (**2014 Q4, 2015, Q1**)

UNIT 1

The Living World: Ecosystems

SUGGESTED SKILL

Visual Representations

2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- Classroom Resource > **Outdoor Education Experiences and AP Environmental Science**
- Collaborations with AP > **Access to Clean Water**

TOPIC 1.7

The Hydrologic (Water) Cycle

Required Course Content

ENDURING UNDERSTANDING

ERT-1

Ecosystems are the result of biotic and abiotic interactions.

LEARNING OBJECTIVE

ERT-1.G

Explain the steps and reservoir interactions in the hydrologic cycle.

ESSENTIAL KNOWLEDGE

ERT-1.G.1

The hydrologic cycle, which is powered by the sun, is the movement of water in its various solid, liquid, and gaseous phases between sources and sinks.

ERT-1.G.2

The oceans are the primary reservoir of water at the Earth's surface, with ice caps and groundwater acting as much smaller reservoirs.

TOPIC 1.8
Primary Productivity

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- Classroom Resource > **Outdoor Education Experiences and AP Environmental Science**
- The Exam > **Chief Reader Report 2018, Q2**
- The Exam > **Samples and Commentary 2018, Q2**

Required Course Content

ENDURING UNDERSTANDING

ENG-1

Energy can be converted from one form to another.

LEARNING OBJECTIVE

ENG-1.A

Explain how solar energy is acquired and transferred by living organisms.

ESSENTIAL KNOWLEDGE

ENG-1.A.1

Primary productivity is the rate at which solar energy (sunlight) is converted into organic compounds via photosynthesis over a unit of time.

ENG-1.A.2

Gross primary productivity is the total rate of photosynthesis in a given area.

ENG-1.A.3

Net primary productivity is the rate of energy storage by photosynthesizers in a given area, after subtracting the energy lost to respiration.

ENG-1.A.4

Productivity is measured in units of energy per unit area per unit time (e.g., kcal/m^2/yr).

ENG-1.A.5

Most red light is absorbed in the upper 1m of water, and blue light only penetrates deeper than 100m in the clearest water. This affects photosynthesis in aquatic ecosystems, whose photosynthesizers have adapted mechanisms to address the lack of visible light.

UNIT 1

The Living World: Ecosystems

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- Classroom Resource > **An Energy Primer for the AP Environmental Science**
- Classroom Resource > **Outdoor Education Experiences and AP Environmental Science**
- The Exam > Chief Reader Report (**2018, Q3**, **2017, Q1**)
- The Exam > Samples and Commentary (**2018, Q3**, **2017, Q1**)

TOPIC 1.9 Trophic Levels

Required Course Content

ENDURING UNDERSTANDING

ENG-1

Energy can be converted from one form to another.

LEARNING OBJECTIVE

ENG-1.B

Explain how energy flows and matter cycles through trophic levels.

ESSENTIAL KNOWLEDGE

ENG-1.B.1

All ecosystems depend on a continuous inflow of high-quality energy in order to maintain their structure and function of transferring matter between the environment and organisms via biogeochemical cycles.

ENG-1.B.2

Biogeochemical cycles are essential for life and each cycle demonstrates the conservation of matter.

ENG-1.B.3

In terrestrial and near-surface marine communities, energy flows from the sun to producers in the lowest trophic levels and then upward to higher trophic levels.

TOPIC 1.10

Energy Flow and the 10% Rule

Required Course Content

ENDURING UNDERSTANDING

ENG-1

Energy can be converted from one form to another.

LEARNING OBJECTIVE

ENG-1.C

Determine how the energy decreases as it flows through ecosystems.

ESSENTIAL KNOWLEDGE

ENG-1.C.1

The 10% rule approximates that in the transfer of energy from one trophic level to the next, only about 10% of the energy is passed on.

ENG-1.C.2

The loss of energy that occurs when energy moves from lower to higher trophic levels can be explained through the laws of thermodynamics.

SUGGESTED SKILL

Mathematical Routines

6.C

Calculate an accurate numeric answer with appropriate units.

AVAILABLE RESOURCES

- Classroom Resource > **An Energy Primer for the AP Environmental Science**
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**
- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- Classroom Resource > **Outdoor Education Experiences and AP Environmental Science**
- The Exam > **Chief Reader Report 2018, Q2**
- The Exam > **Samples and Commentary 2018, Q2**

UNIT 1

The Living World: Ecosystems

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of an environmental concept, process, or model represented visually.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- Classroom Resource > **Outdoor Education Experiences and AP Environmental Science**
- The Exam > Chief Reader Report (**2018 Q3**, **2017, Q1**)
- The Exam > Samples and Commentary (**2018 Q3**, **2017 Q1**)

TOPIC 1.11
Food Chains and Food Webs

Required Course Content

ENDURING UNDERSTANDING

ENG-1

Energy can be converted from one form to another.

LEARNING OBJECTIVE

ENG-1.D

Describe food chains and food webs, and their constituent members by trophic level.

ESSENTIAL KNOWLEDGE

ENG-1.D.1

A food web is a model of an interlocking pattern of food chains that depicts the flow of energy and nutrients in two or more food chains.

ENG-1.D.2

Positive and negative feedback loops can each play a role in food webs. When one species is removed from or added to a specific food web, the rest of the food web can be affected.

AP ENVIRONMENTAL SCIENCE

UNIT 2

The Living World: Biodiversity

6–8%
AP EXAM WEIGHTING

~11–12
CLASS PERIODS

Remember to go to **AP Classroom** to assign students the online **Personal Progress Check** for this unit.

Whether assigned as homework or completed in class, the **Personal Progress Check** provides each student with immediate feedback related to this unit's topics and skills.

Personal Progress Check 2

Multiple-choice: ~20 questions
Free-response: 1 question (partial)

- Design an investigation

UNIT 2 | 6–8% AP EXAM WEIGHTING | ~11–12 CLASS PERIODS

The Living World: Biodiversity

BIG IDEA 2
Interactions Between Earth Systems ERT
- Can an invasive species be considered a native species if it occupies a place for a long time?

Developing Understanding

Biodiversity, which includes genetic, species, and habitat diversity, is critically important to ecosystems. Biodiversity in ecosystems is a key component to sustaining life within the living world. Natural and human disruptions have short- and long-term impacts on ecosystems. Ecological succession can occur in terrestrial and aquatic ecosystems in both developed and developing areas. Organisms within ecosystems must adapt to the changes created by these disruptions. In subsequent units, students will examine in greater detail how populations change over time.

Building the Science Practices

1.A 1.B 5.A 5.B 5.C

Data analysis is an important skill to begin developing at this point in the course. Quantitative information about changes in populations or the environment due to human activities is often represented in tables and graphs. Students should understand that tables and graphs are important tools of communication used to identify patterns and trends that indicate environmental problems. Students will then learn to describe the characteristics of data in tables or graphs and identify patterns or trends.

In this unit, students should also be able to describe and explain the environmental concepts and processes of biodiversity. It is important that they understand the differences between similar concepts and clearly articulate those differences in their written and verbal explanations. For example, they should be able to articulate the differences among species, genetic, and habitat diversity; between keystone and indicator species; and between ecosystem services and ecological services.

Preparing for the AP Exam

On the AP Exam, students must be able to explain environmental science concepts that are represented using tables, charts, and graphs. They must also be able to explain patterns and trends related to data. Additionally, they must be able to give several examples of ecosystems and ecological services. Students often confuse environmental science terminology, like ecological service and ecological function of an ecosystem, and biodiversity and genetic diversity. To combat this, students can explain environmental concepts in context, rather than memorizing textbook definitions without a full understanding of the context. Students can benefit from practice providing ecological services for different ecosystems. They should be able to indicate the direction of change to a species as a result of disruptions to the ecosystem based on data. Students should also be able to describe whether or not a species can adapt to an environmental change.

UNIT 2

The Living World: Biodiversity

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods
			~11–12 CLASS PERIODS
ERT-2	2.1 Introduction to Biodiversity	1.A Describe environmental concepts and processes.	
	2.2 Ecosystem Services	1.B Explain environmental concepts and processes.	
	2.3 Island Biogeography	1.A Describe environmental concepts and processes.	
	2.4 Ecological Tolerance	3.A Identify the author's claim.	
	2.5 Natural Disruptions to Ecosystems	5.A Describe patterns or trends in data.	
	2.6 Adaptations	5.B Describe relationships among variables in data represented.	
	2.7 Ecological Succession	5.C Explain patterns and trends in data to draw conclusions.	
	Go to AP Classroom to assign the **Personal Progress Check** for Unit 2. Review the results in class to identify and address any student misunderstandings.		

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional and are offered to provide possible ways to incorporate various instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 201 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	2.3	**Construct an Argument** Provide students biodiversity data (species and count) from a set of islands with variable size and distance from mainland. Have them work together to draw a conclusion about how those two variables impact the species richness and number of individuals within the species.
2	2.2	**One-Minute Essay** Give students one minute to respond to the following prompt: Identify one ecosystem service of wetlands and give one example of how they fulfill that function and benefit humans. Ask them to state their claim and support it with evidence/examples.
3	2.6	**Misconception Check** Present students with several statements referring to adaptation and natural selection. Address misconceptions by asking them to explain why a statement is true or false.

Unit Planning Notes

Use the space below to plan your approach to the unit.

UNIT 2

The Living World: Biodiversity

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2017, Q3 & Q4**
- The Exam > Samples and Commentary (**2017, Q3**, **2017, Q4**)
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**
- Collaborations with AP > **Loss of Biodiversity**

TOPIC 2.1
Introduction to Biodiversity

Required Course Content

ENDURING UNDERSTANDING

ERT-2

Ecosystems have structure and diversity that change over time.

LEARNING OBJECTIVE

ERT-2.A

Explain levels of biodiversity and their importance to ecosystems.

ESSENTIAL KNOWLEDGE

ERT-2.A.1

Biodiversity in an ecosystem includes genetic, species, and habitat diversity.

ERT-2.A.2

The more genetically diverse a population is, the better it can respond to environmental stressors. Additionally, a population bottleneck can lead to a loss of genetic diversity.

ERT-2.A.3

Ecosystems that have a larger number of species are more likely to recover from disruptions.

ERT-2.A.4

Loss of habitat leads to a loss of specialist species, followed by a loss of generalist species. It also leads to reduced numbers of species that have large territorial requirements.

ERT-2.A.5

Species richness refers to the number of different species found in an ecosystem.

TOPIC 2.2
Ecosystem Services

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > Chief Reader Report (**2018, Q1, 2017, Q1**)
- The Exam > **Student Performance Q&A 2016, Q1**
- The Exam > Samples and Commentary (**2018 Q1, 2017, Q1, 2016, Q1**)

Required Course Content

ENDURING UNDERSTANDING

ERT-2

Ecosystems have structure and diversity that change over time.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ERT-2.B Describe ecosystem services.	**ERT-2.B.1** There are four categories of ecosystem services: provisioning, regulating, cultural, and supporting.
ERT-2.C Describe the results of human disruptions to ecosystem services.	**ERT-2.C.1** Anthropogenic activities can disrupt ecosystem services, potentially resulting in economic and ecological consequences.

UNIT 2

The Living World: Biodiversity

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > Chief Reader Report (**2018, Q1, 2017, Q1**)
- The Exam > **Student Performance Q&A 2016, Q1**
- The Exam > Samples and Commentary (**2018, Q1, 2017, Q1, 2016, Q1**)
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**

TOPIC 2.3
Island Biogeography

Required Course Content

ENDURING UNDERSTANDING

ERT-2

Ecosystems have structure and diversity that change over time.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ERT-2.D Describe island biogeography.	ERT-2.D.1 Island biogeography is the study of the ecological relationships and distribution of organisms on islands, and of these organisms' community structures. ERT-2.D.2 Islands have been colonized in the past by new species arriving from elsewhere.
ERT-2.E Describe the role of island biogeography in evolution.	ERT-2.E.1 Many island species have evolved to be specialists versus generalists because of the limited resources, such as food and territory, on most islands. The long-term survival of specialists may be jeopardized if and when invasive species, typically generalists, are introduced and outcompete the specialists.

TOPIC 2.4
Ecological Tolerance

SUGGESTED SKILL

Text Analysis

3.A

Identify the author's claim.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**

Required Course Content

ENDURING UNDERSTANDING

ERT-2

Ecosystems have structure and diversity that change over time.

LEARNING OBJECTIVE

ERT-2.F

Describe ecological tolerance.

ESSENTIAL KNOWLEDGE

ERT-2.F.1

Ecological tolerance refers to the range of conditions, such as temperature, salinity, flow rate, and sunlight that an organism can endure before injury or death results.

ERT-2.F.2

Ecological tolerance can apply to individuals and to species.

UNIT 2

The Living World: Biodiversity

SUGGESTED SKILL

Data Analysis

5.A

Describe patterns or trends in data.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**

TOPIC 2.5
Natural Disruptions to Ecosystems

Required Course Content

ENDURING UNDERSTANDING

ERT-2

Ecosystems have structure and diversity that change over time.

LEARNING OBJECTIVE

ERT-2.G

Explain how natural disruptions, both short- and long-term, impact an ecosystem.

ESSENTIAL KNOWLEDGE

ERT-2.G.1

Natural disruptions to ecosystems have environmental consequences that may, for a given occurrence, be as great as, or greater than, many human-made disruptions.

ERT-2.G.2

Earth system processes operate on a range of scales in terms of time. Processes can be periodic, episodic, or random.

ERT-2.G.3

Earth's climate has changed over geological time for many reasons.

ERT-2.G.4

Sea level has varied significantly as a result of changes in the amount of glacial ice on Earth over geological time.

ERT-2.G.5

Major environmental change or upheaval commonly results in large swathes of habitat changes.

ERT-2.G.6

Wildlife engages in both short- and long-term migration for a variety of reasons, including natural disruptions.

TOPIC 2.6
Adaptations

SUGGESTED SKILL

Data Analysis

5.B

Describe relationships among variables in data represented.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**
- Collaborations with AP > **Loss of Biodiversity**
- The Exam > Chief Reader Report (**2018, Q1 & Q4, 2017, Q2**)
- The Exam > Samples and Commentary (**2018, Q1, 2018, Q4, 2017, Q2**)
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**

Required Course Content

ENDURING UNDERSTANDING

ERT-2

Ecosystems have structure and diversity that change over time.

LEARNING OBJECTIVE

ERT-2.H

Describe how organisms adapt to their environment.

ESSENTIAL KNOWLEDGE

ERT-2.H.1

Organisms adapt to their environment over time, both in short- and long-term scales, via incremental changes at the genetic level.

ERT-2.H.2

Environmental changes, either sudden or gradual, may threaten a species' survival, requiring individuals to alter behaviors, move, or perish.

UNIT 2

The Living World: Biodiversity

SUGGESTED SKILL

Data Analysis

5.C

Explain patterns and trends in data to draw conclusions.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- The Exam > **Student Performance Q&A 2014, Q3**
- The Exam > **Samples and Commentary 2014, Q3**

TOPIC 2.7
Ecological Succession

Required Course Content

ENDURING UNDERSTANDING

ERT-2

Ecosystems have structure and diversity that change over time.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ERT-2.I Describe ecological succession.	**ERT-2.I.1** There are two main types of ecological succession: primary and secondary succession.
	ERT-2.I.2 A keystone species in an ecosystem is a species whose activities have a particularly significant role in determining community structure.
	ERT-2.I.3 An indicator species is a plant or animal that, by its presence, abundance, scarcity, or chemical composition, demonstrates that some distinctive aspect of the character or quality of an ecosystem is present.
ERT-2.J Describe the effect of ecological succession on ecosystems.	**ERT-2.J.1** Pioneer members of an early successional species commonly move into unoccupied habitat and over time adapt to its particular conditions, which may result in the origin of new species.
	ERT-2.J.2 Succession in a disturbed ecosystem will affect the total biomass, species richness, and net productivity over time.

AP ENVIRONMENTAL SCIENCE

UNIT 3

Populations

10–15%
AP EXAM WEIGHTING

~12–13
CLASS PERIODS

Remember to go to **AP Classroom** to assign students the online **Personal Progress Check** for this unit.

Whether assigned as homework or completed in class, the **Personal Progress Check** provides each student with immediate feedback related to this unit's topics and skills.

Personal Progress Check 3

Multiple-choice: ~20 questions
Free-response: 1 question (partial)

- Analyze an environmental problem and propose a solution doing calculations

UNIT 3 | 10–15% AP EXAM WEIGHTING | ~12–13 CLASS PERIODS

Populations

BIG IDEA 2
Interactions Between Earth Systems ERT
- How do changes in habitats influence changes in species over time?

BIG IDEA 3
Interactions Between Different Species and the Environment EIN
- How is educational opportunity for women connected to human population changes?

Developing Understanding

Populations within ecosystems change over time in response to a variety of factors. This unit examines the relationship between the type of species and the changes in a habitat over time. Specialist species are advantaged by habitats that remain constant, while generalist species tend to be advantaged by habitats that are changing. Different reproductive patterns, including those exhibited by K- and r-selected species, also impact changes to population. Population growth is limited by environmental factors, especially by the availability of resources and space. In subsequent units, students will explore how increases in populations affect earth systems and resources, land and water use, and energy resources.

Building the Science Practices

5.A 5.C 5.E 6.B

Comparing trends and patterns in data helps students interpret experimental data in order to explain environmental changes that occur over time. These skills can help predict short- and long-term changes in an environment. As students build their skills in data analysis, they will learn how the data illustrate environmental concepts. It is also important that they learn to predict patterns and trends based on information provided in graphs and tables. Analyzing population growth, age structure diagrams, and survivorship curves can help students develop these skills.

While calculator use is permitted on the AP Exam, students still have to show their work, including the numbered steps they used to obtain an answer, with appropriate units. Without the appropriate units, a calculation is meaningless, even with correct computation. In this unit, students may benefit from having multiple opportunities to practice calculations such as population growth and the application of the rule of 70. Students can also practice selecting the appropriate calculation that is required in the analysis of a data set.

Preparing for the AP Exam

On the AP Exam, students must be able to explain trends in population data for organisms. To practice this, students can look at a variety of human population graphs from various countries and then explain the trends in the data to draw conclusions about changes in the populations. This is also an opportunity for students to explain population density and population growth. Students can also practice interpreting population growth curves for other species. When explaining the survival of a species, students should consider population size and emphasize problems associated with reduced genetic diversity. It is helpful for students to connect data represented by tables, charts, and graphs to real-life examples of population changes.

UNIT 3

Populations

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods
			~12–13 CLASS PERIODS
ERT-3	3.1 Generalist and Specialist Species	1.B Explain environmental concepts and processes.	
ERT-3	3.2 K-Selected r-Selected Species	5.A Describe patterns or trends in data.	
ERT-3	3.3 Survivorship Curves	5.C Explain patterns and trends in data to draw conclusions.	
ERT-3	3.4 Carrying Capacity	5.E Explain what the data implies or illustrates about environmental issues.	
ERT-3	3.5 Population Growth and Resource Availability	6.B Apply appropriate mathematical relationships to solve a problem, with work shown (e.g., dimensional analysis).	
EIN-1	3.6 Age Structure Diagrams	5.C Explain patterns and trends in data to draw conclusions.	
EIN-1	3.7 Total Fertility Rate	5.A Describe patterns or trends in data.	
EIN-1	3.8 Human Population Dynamics	7.A Describe environmental problems.	
EIN-1	3.9 Demographic Transition	1.C Explain environmental concepts, processes, or models in applied contexts.	
	Go to AP Classroom to assign the **Personal Progress Check** for Unit 3. Review the results in class to identify and address any student misunderstandings.		

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional and are offered to provide possible ways to incorporate various instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 201 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	3.2	**Think-Pair-Share** Ask students to respond to the following prompt: Which reproductive strategy is more prone to creating an invasive species, and which is more prone to creating an endangered species? Have them develop a claim and support it with evidence (e.g., characteristics of species). After writing for two to three minutes, they can pair with a nearby partner to share responses. Select one group to share their response with the class. The class can add additional information or challenge a response.
2	3.5	**Error Analysis** Have students perform per capita ecological footprint calculations using dimensional analysis to compare developed vs. developing countries. Have them compare answers with a partner to determine errors in their calculations. Then ask them to explain the concept of per capita resources consumption as compared to the size of the population.
3	3.9	**Idea Spinner** Create a spinner with four quadrants labeled "Predict," "Explain," "Summarize," and "Evaluate." After new material is presented, spin the spinner and ask students to answer a question based on the location of the spinner. For example, after providing students with demographic data and characteristics that describe different phases of the demographic transition, ask students to predict what would happen if there were a change in one of the variables that affects a demographic transition.

Unit Planning Notes

Use the space below to plan your approach to the unit.

UNIT 3

Populations

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**

TOPIC 3.1
Generalist and Specialist Species

Required Course Content

ENDURING UNDERSTANDING

ERT-3

Populations change over time in reaction to a variety of factors.

LEARNING OBJECTIVE

ERT-3.A

Identify differences between generalist and specialist species.

ESSENTIAL KNOWLEDGE

ERT-3.A.1

Specialist species tend to be advantaged in habitats that remain constant, while generalist species tend to be advantaged in habitats that are changing.

TOPIC 3.2
K-Selected r-Selected Species

SUGGESTED SKILL

Data Analysis

5.A

Describe patterns or trends in data.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

Required Course Content

ENDURING UNDERSTANDING

ERT-3

Populations change over time in reaction to a variety of factors.

LEARNING OBJECTIVE

ERT-3.B

Identify differences between K- and r-selected species.

ESSENTIAL KNOWLEDGE

ERT-3.B.1

K-selected species tend to be large, have few offspring per reproduction event, live in stable environments, expend significant energy for each offspring, mature after many years of extended youth and parental care, have long life spans/life expectancy, and reproduce more than once in their lifetime. Competition for resources in K-selected species' habitats is usually relatively high.

ERT-3.B.2

r-selected species tend to be small, have many offspring, expend or invest minimal energy for each offspring, mature early, have short life spans, and may reproduce only once in their lifetime. Competition for resources in r-selected species' habitats is typically relatively low.

ERT-3.B.3

Biotic potential refers to the maximum reproductive rate of a population in ideal conditions.

continued on next page

UNIT 3

Populations

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ERT-3.B Identify differences between K- and r- selected species.	**ERT-3.B.4** Many species have reproductive strategies that are not uniquely r-selected or K-selected, or they change in different conditions at different times. **ERT-3.B.5** K-selected species are typically more adversely affected by invasive species than r-selected species, which are minimally affected by invasive species. Most invasive species are r-selected species.

TOPIC 3.3 Survivorship Curves

SUGGESTED SKILL

Data Analysis

5.C

Explain patterns and trends in data to draw conclusions.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**

Required Course Content

ENDURING UNDERSTANDING

ERT-3

Populations change over time in reaction to a variety of factors.

LEARNING OBJECTIVE

ERT-3.C

Explain survivorship curves.

ESSENTIAL KNOWLEDGE

ERT-3.C.1

A survivorship curve is a line that displays the relative survival rates of a cohort—a group of individuals of the same age—in a population, from birth to the maximum age reached by any one cohort member. There are Type I, Type II, and Type III curves.

ERT-3.C.2

Survivorship curves differ for K-selected and r-selected species, with K-selected species typically following a Type I or Type II curve and r-selected species following a Type III curve.

UNIT 3

Populations

SUGGESTED SKILL

Data Analysis

5.E

Explain what the data implies or illustrates about environmental issues.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 3.4
Carrying Capacity

Required Course Content

ENDURING UNDERSTANDING

ERT-3

Populations change over time in reaction to a variety of factors.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ERT-3.D Describe carrying capacity.	**ERT-3.D.1** When a population exceeds its carrying capacity (carrying capacity can be denoted as K), overshoot occurs. There are environmental impacts of population overshoot, including resource depletion.
ERT-3.E Describe the impact of carrying capacity on ecosystems.	**ERT-3.E.1** A major ecological effect of population overshoot is dieback of the population (often severe to catastrophic) because the lack of available resources leads to famine, disease, and/or conflict.

TOPIC 3.5
Population Growth and Resource Availability

Required Course Content

ENDURING UNDERSTANDING

ERT-3

Populations change over time in reaction to a variety of factors.

LEARNING OBJECTIVE

ERT-3.F

Explain how resource availability affects population growth.

ESSENTIAL KNOWLEDGE

ERT-3.F.1

Population growth is limited by environmental factors, especially by the available resources and space.

ERT-3.F.2

Resource availability and the total resource base are limited and finite over all scales of time.

ERT-3.F.3

When the resources needed by a population for growth are abundant, population growth usually accelerates.

ERT-3.F.5

When the resource base of a population shrinks, the increased potential for unequal distribution of resources will ultimately result in increased mortality, decreased fecundity, or both, resulting in population growth declining to, or below, carrying capacity.

SUGGESTED SKILL

Mathematical Routines

6.B

Apply appropriate mathematical relationships to solve a problem, with work shown (e.g., dimensional analysis).

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2017, Q1**
- The Exam > **Samples and Commentary 2017, Q1**

UNIT 3

Populations

SUGGESTED SKILL

Data Analysis

5.C

Explain patterns and trends in data to draw conclusions.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 3.6
Age Structure Diagrams

Required Course Content

ENDURING UNDERSTANDING

EIN-1

Human populations change in reaction to a variety of factors, including social and cultural factors.

LEARNING OBJECTIVE

EIN-1.A

Explain age structure diagrams.

ESSENTIAL KNOWLEDGE

EIN-1.A.1

Population growth rates can be interpreted from age structure diagrams by the shape of the structure.

EIN-1.A.2

A rapidly growing population will, as a rule, have a higher proportion of younger people compared to stable or declining populations.

TOPIC 3.7
Total Fertility Rate

SUGGESTED SKILL

Data Analysis

5.A

Describe patterns or trends in data.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**

Required Course Content

ENDURING UNDERSTANDING

EIN-1

Human populations change in reaction to a variety of factors, including social and cultural factors.

LEARNING OBJECTIVE

EIN-1.B

Explain factors that affect total fertility rate in human populations.

ESSENTIAL KNOWLEDGE

EIN-1.B.1

Total fertility rate (TFR) is affected by the age at which females have their first child, educational opportunities for females, access to family planning, and government acts and policies.

EIN-1.B.2

If fertility rate is at replacement levels, a population is considered relatively stable.

EIN-1.B.3

Factors associated with infant mortality rates include whether mothers have access to good healthcare and nutrition. Changes in these factors can lead to changes in infant mortality rates over time.

UNIT 3

Populations

SUGGESTED SKILL

Environmental Solutions

7.A

Describe environmental problems.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2017, Q3**
- The Exam > **Student Performance Q&A 2016, Q1**
- The Exam > Samples and Commentary (**2017, Q3**, **2016, Q1**)

TOPIC 3.8
Human Population Dynamics

Required Course Content

ENDURING UNDERSTANDING

EIN-1

Human populations change in reaction to a variety of factors, including social and cultural factors.

LEARNING OBJECTIVE

EIN-1.C.1

Explain how human populations experience growth and decline.

ESSENTIAL KNOWLEDGE

EIN-1.C.1

Birth rates, infant mortality rates, and overall death rates, access to family planning, access to good nutrition, access to education, and postponement of marriage all affect whether a human population is growing or declining.

EIN-1.C.2

Factors limiting global human population include the Earth's carrying capacity and the basic factors that limit human population growth as set forth by Malthusian theory.

EIN-1.C.3

Population growth can be affected by both density-independent factors, such as major storms, fires, heat waves, or droughts, and density-dependent factors, such as access to clean water and air, food availability, disease transmission, or territory size.

EIN-1.C.4

The rule of 70 states that dividing the number 70 by the percentage population growth rate approximates the population's doubling time.

TOPIC 3.9
Demographic Transition

SUGGESTED SKILL

Concept Explanation

1.C

Explain environmental concepts, processes, or models in applied contexts.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

Required Course Content

ENDURING UNDERSTANDING

EIN-1

Human populations change in reaction to a variety of factors, including social and cultural factors.

LEARNING OBJECTIVE

EIN-1.D

Define the demographic transition.

ESSENTIAL KNOWLEDGE

EIN-1.D.1

The demographic transition refers to the transition from high to lower birth and death rates in a country or region as development occurs and that country moves from a pre-industrial to an industrialized economic system. This transition is typically demonstrated through a four-stage demographic transition model (DTM).

EIN-1.D.2

Characteristics of developing countries include higher infant mortality rates and more children in the workforce than developed countries.

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AP ENVIRONMENTAL SCIENCE

UNIT 4

Earth Systems and Resources

10–15%
AP EXAM WEIGHTING

~11–12
CLASS PERIODS

Remember to go to **AP Classroom** to assign students the online **Personal Progress Check** for this unit.

Whether assigned as homework or completed in class, the **Personal Progress Check** provides each student with immediate feedback related to this unit's topics and skills.

Personal Progress Check 4

Multiple-choice: ~25 questions
Free-response: 1 question

- Design an investigation

UNIT 4 | 10–15% AP EXAM WEIGHTING | ~11–12 CLASS PERIODS

Earth Systems and Resources

BIG IDEA 1
Energy Transfer ENG
- How does energy from the sun influence the weather?

BIG IDEA 2
Interactions Between Earth Systems ERT
- How can earthquakes be predicted?

Developing Understanding

This unit explores earth systems and its resources that support life. Geological changes that occur to earth systems at convergent and divergent boundaries can result in the creation of mountains, island arcs, earthquakes, volcanoes, and seafloor spreading. Soils are a resource, formed when parent material is weathered, transported, and deposited. The atmosphere is another resource, composed of certain percentages of major gases. Climate is influenced by the sun's energy, Earth's geography, and the movement of air and water. In subsequent units, students will examine how humans use natural resources and the impact on the environment.

Building the Science Practices

1.C 2.A 2.B

In this unit, students can practice analyzing and interpreting qualitative models and representations of environmental issues. The ability to describe global maps and maps of plate boundaries is key to explaining the global changes that occur at plate boundaries. Climatograms may also be introduced in this unit. To develop an understanding of the relationship between the geography of the earth and climate, students may benefit from describing the impact of El Niño on marine food chains, and other specific examples.

Students should be able to identify and describe environmental processes displayed visually. They can also practice explaining the meaning of a diagram or infographic, ultimately building to the ability to explain the consequences of a change in an environmental process (i.e., "What would happen if …") in later units. To help students build understanding in this area, it may be useful for them to perform a soil/water capacity lab.

Preparing for the AP Exam

On the AP Exam, students must be able to explain representations of convergent, divergent, and transform boundaries present on a global map. To practice this, students can examine global maps to identify the distribution of global plate boundaries. Students should also practice analyzing characteristics of soil. They can perform guided inquiry labs related to soil analysis and formation. Data show a strong correlation between the strength of students' conceptual understanding and their experience performing hands-on labs.

Students can also practice identifying how climate factors influence the rate of soil formation. They should indicate if that factor speeds up or slows down the rate of formation. Students may benefit from connecting visual representations with explanations of the Earth's atmosphere/geography, climate, global wind patterns, solar radiation, and the Earth's seasons.

UNIT 4

Earth Systems and Resources

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods
			~11–12 CLASS PERIODS
ERT-4	4.1 Plate Tectonics	2.C Explain how environmental concepts and processes represented visually relate to broader environmental issues.	
	4.2 Soil Formation and Erosion	4.B Identify a research method, design, and/or measure used.	
	4.3 Soil Composition and Properties	4.C Describe an aspect of a research method, design, and/or measure used.	
	4.4 Earth's Atmosphere	2.A Describe characteristics of an environmental concept, process, or model represented visually.	
	4.5 Global Wind Patterns	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: ▪ In theoretical contexts ▪ In applied contexts	
	4.6 Watersheds	1.C Explain environmental concepts, processes, or models in applied contexts.	
ENG-2	4.7 Solar Radiation and Earth's Seasons	2.A Describe characteristics of an environmental concept, process, or model represented visually.	
	4.8 Earth's Geography and Climate	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: ▪ In theoretical contexts ▪ In applied contexts	
	4.9 El Niño and La Niña	7.A Describe environmental problems.	
	Go to AP Classroom to assign the **Personal Progress Check** for Unit 4. Review the results in class to identify and address any student misunderstandings.		

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional and are offered to provide possible ways to incorporate various instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 201 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	4.1	**Construct an Argument** Provide students with a map and coordinates for earthquakes and volcanoes. Have them plot the location of these events and then compare their map to a map where the major plate boundaries are drawn. Then ask them to explain why these activities occur at plate boundaries.
2	4.4	**One-Minute Essay** Ask students to identify the four major layers of the atmosphere and describe the general temperature profile for each layer. They should also explain briefly why the troposphere and the stratosphere are impacted by air pollution.
3	4.9	**Ask the Expert** Divide the class into two groups that represent El Niño experts and two others that represent La Niña experts. Have students rotate through the groups with index cards. As they rotate, have them collect information on El Niño and La Niña and their impact on global weather pattern.

Unit Planning Notes

Use the space below to plan your approach to the unit.

UNIT 4

Earth Systems and Resources

SUGGESTED SKILL

Visual Representations

2.C

Explain how environmental concepts and processes represented visually relate to broader environmental issues.

AVAILABLE RESOURCES

- Classroom Resource > **Understanding Topographic Maps and Their Construction**
- The Exam > **Student Performance Q&A 2014, Q3**
- The Exam > **Samples and Commentary 2014, Q3**

TOPIC 4.1
Plate Tectonics

Required Course Content

ENDURING UNDERSTANDING

ERT-4

Earth's systems interact, resulting in a state of balance over time.

LEARNING OBJECTIVE

ERT-4.A

Describe the geological changes and events that occur at convergent, divergent, and transform plate boundaries.

ESSENTIAL KNOWLEDGE

ERT-4.A.1

Convergent boundaries can result in the creation of mountains, island arcs, earthquakes, and volcanoes.

ERT-4.A.2

Divergent boundaries can result in seafloor spreading, rift valleys, volcanoes, and earthquakes.

ERT-4.A.3

Transform boundaries can result in earthquakes.

ERT-4.A.4

Maps that show the global distribution of plate boundaries can be used to determine the location of volcanoes, island arcs, earthquakes, hot spots, and faults.

ERT-4.A.5

An earthquake occurs when stress overcomes a locked fault, releasing stored energy.

TOPIC 4.2
Soil Formation and Erosion

Required Course Content

ENDURING UNDERSTANDING

ERT-4

Earth's systems interact, resulting in a state of balance over time.

LEARNING OBJECTIVE

ERT-4.B

Describe the characteristics and formation of soil.

ESSENTIAL KNOWLEDGE

ERT-4.B.1

Soils are formed when parent material is weathered, transported, and deposited.

ERT-4.B.2

Soils are generally categorized by horizons based on their composition and organic material.

ERT-4.B.3

Soils can be eroded by winds or water. Protecting soils can protect water quality as soils effectively filter and clean water that moves through them.

SUGGESTED SKILL

Scientific Experiments

4.B

Identify a research method, design, and/or measure used.

AVAILABLE RESOURCES

- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- The Exam > Chief Reader Report (**2018 Q2 & Q4, 2017, Q1, Q3, & Q4**)
- The Exam > Samples and Commentary (**2018, Q2, 2018, Q4, 2017, Q3, 2017, Q4**)

UNIT 4

Earth Systems and Resources

SUGGESTED SKILL

Scientific Experiments

4.C

Describe an aspect of a research method, design, and/or measure used.

AVAILABLE RESOURCES

- External Resource > Environmental Literacy Council's AP Environmental Science Course Material

TOPIC 4.3
Soil Composition and Properties

Required Course Content

ENDURING UNDERSTANDING

ERT-4

Earth's systems interact, resulting in a state of balance over time.

LEARNING OBJECTIVE

ERT-4.C

Describe similarities and differences between properties of different soil types.

ESSENTIAL KNOWLEDGE

ERT-4.C.1

Water holding capacity—the total amount of water soil can hold—varies with different soil types. Water retention contributes to land productivity and fertility of soils.

ERT-4.C.2

The particle size and composition of each soil horizon can affect the porosity, permeability, and fertility of the soil.

ERT-4.C.3

There are a variety of methods to test the chemical, physical, and biological properties of soil that can aid in a variety of decisions, such as irrigation and fertilizer requirements.

ERT-4.C.4

A soil texture triangle is a diagram that allows for the identification and comparison of soil types based on their percentage of clay, silt, and sand.

TOPIC 4.4
Earth's Atmosphere

Required Course Content

ENDURING UNDERSTANDING

ERT-4

Earth's systems interact, resulting in a state of balance over time.

LEARNING OBJECTIVE

ERT-4.D

Describe the structure and composition of the Earth's atmosphere.

ESSENTIAL KNOWLEDGE

ERT-4.D.1

The atmosphere is made up of major gases, each with its own relative abundance.

ERT-4.D.2

The layers of the atmosphere are based on temperature gradients and include the troposphere, stratosphere, mesosphere, thermosphere, and exosphere.

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of an environmental concept, process, or model represented visually.

AVAILABLE RESOURCES

- Classroom Resource > **"Weather or Not": AP Environmental Science and the Atmosphere**
- Classroom Resource > **Introductory Concepts for Understanding Climate**
- The Exam > **Chief Reader Report 2018, Q4**
- The Exam > **Samples and Commentary 2018, Q4**

UNIT 4

Earth Systems and Resources

SUGGESTED SKILL

Visual Representations

2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

AVAILABLE RESOURCES

- Classroom Resource > **"Weather or Not": AP Environmental Science and the Atmosphere**
- Classroom Resource > **Introductory Concepts for Understanding Climate**
- The Exam > **Chief Reader Report 2018, Q2**
- The Exam > **Samples and Commentary 2018, Q2**

TOPIC 4.5
Global Wind Patterns

Required Course Content

ENDURING UNDERSTANDING

ERT-4

Earth's systems interact, resulting in a state of balance over time.

LEARNING OBJECTIVE

ERT-4.E

Explain how environmental factors can result in atmospheric circulation.

ESSENTIAL KNOWLEDGE

ERT-4.E.1

Global wind patterns primarily result from the most intense solar radiation arriving at the equator, resulting in density differences and the Coriolis effect.

TOPIC 4.6
Watersheds

SUGGESTED SKILL

Concept Explanation

1.C

Explain environmental concepts, processes, or models in applied contexts.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2017, Q3**
- The Exam > **Samples and Commentary 2017, Q3**

Required Course Content

ENDURING UNDERSTANDING

ERT-4

Earth's systems interact, resulting in a state of balance over time.

LEARNING OBJECTIVE

ERT-4.F

Describe the characteristics of a watershed.

ESSENTIAL KNOWLEDGE

ERT-4.F.1

Characteristics of a given watershed include its area, length, slope, soil, vegetation types, and divides with adjoining watersheds.

UNIT 4

Earth Systems and Resources

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of an environmental concept, process, or model represented visually.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- Classroom Resource > **Energy and Climate Change**
- The Exam > **Chief Reader Report 2017, Q3**
- The Exam > **Student Performance Q&A 2014, Q2**
- The Exam > Samples and Commentary (**2017, Q3, 2014, Q2**)

TOPIC 4.7
Solar Radiation and Earth's Seasons

Required Course Content

ENDURING UNDERSTANDING

ENG-2

Most of the Earth's atmospheric processes are driven by input of energy from the sun.

LEARNING OBJECTIVE

ENG-2.A

Explain how the sun's energy affects the Earth's surface.

ESSENTIAL KNOWLEDGE

ENG-2.A.1

Incoming solar radiation (insolation) is the Earth's main source of energy and is dependent on season and latitude.

ENG-2.A.2

The angle of the sun's rays determines the intensity of the solar radiation. Due to the shape of the Earth, the latitude that is directly horizontal to the solar radiation receives the most intensity.

ENG-2.A.3

The highest solar radiation per unit area is received at the equator and decreases toward the poles.

ENG-2.A.4

The solar radiation received at a location on the Earth's surface varies seasonally, with the most radiation received during the location's longest summer day and the least on the shortest winter day.

ENG-2.A.5

The tilt of Earth's axis of rotation causes the Earth's seasons and the number of hours of daylight in a particular location on the Earth's surface.

TOPIC 4.8
Earth's Geography and Climate

Required Course Content

ENDURING UNDERSTANDING

ENG-2

Most of the Earth's atmospheric processes are driven by input of energy from the sun.

LEARNING OBJECTIVE

ENG-2.B

Describe how the Earth's geography affects weather and climate.

ESSENTIAL KNOWLEDGE

ENG-2.B.1

Weather and climate are affected not only by the sun's energy but by geologic and geographic factors, such as mountains and ocean temperature.

ENG-2.B.2

A rain shadow is a region of land that has become drier because a higher elevation area blocks precipitation from reaching the land.

SUGGESTED SKILL

Visual Representations

2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- Classroom Resource > **Introductory Concepts for Understanding Climate**
- The Exam > **Chief Reader Report, 2017 Q3**
- The Exam > **Student Performance Q&A 2016, Q1 & Q4**
- The Exam > Samples and Commentary (**2017 Q3, 2016, Q1, 2016, Q4**)

UNIT 4

Earth Systems and Resources

SUGGESTED SKILL

Environmental Solutions

7.A

Describe environmental problems.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- Classroom Resource > **Introductory Concepts for Understanding Climate**

TOPIC 4.9
El Niño and La Niña

Required Course Content

ENDURING UNDERSTANDING

ENG-2

Most of the Earth's atmospheric processes are driven by input of energy from the sun.

LEARNING OBJECTIVE

ENG-2.C

Describe the environmental changes and effects that result from El Niño or La Niña events (El Niño–Southern Oscillation).

ESSENTIAL KNOWLEDGE

ENG-2.C.1

El Niño and La Niña are phenomena associated with changing ocean surface temperatures in the Pacific Ocean. These phenomena can cause global changes to rainfall, wind, and ocean circulation patterns.

ENG-2.C.2

El Niño and La Niña are influenced by geological and geographic factors and can affect different locations in different ways.

AP ENVIRONMENTAL SCIENCE

UNIT 5

Land and Water Use

10–15%
AP EXAM WEIGHTING

~18–19
CLASS PERIODS

Remember to go to **AP Classroom** to assign students the online **Personal Progress Check** for this unit.

Whether assigned as homework or completed in class, the **Personal Progress Check** provides each student with immediate feedback related to this unit's topics and skills.

Personal Progress Check 5

Multiple-choice: ~35 questions
Free-response: 1 question

- Analyze an environmental problem and propose a solution

UNIT 5 | 10–15% AP EXAM WEIGHTING | ~18–19 CLASS PERIODS

Land and Water Use

BIG IDEA 3
Interactions Between Different Species and the Environment EIN
- How does your use of natural resources impact the world?

BIG IDEA 4
Sustainability STB
- Why are sustainable practices difficult to implement?

Developing Understanding

This unit explores human activities that disrupt ecosystems both positively and negatively and the methods employed to reduce impact. It examines human use of natural resources through many means, including mining and clearcutting, and the impacts on the environment. Agricultural practices in particular can cause environmental disruption. For example, one of the largest uses of freshwater is for irrigation. Every irrigation method employed for agriculture has its own benefits and drawbacks. In subsequent units, students will examine different types of energy resources, the consumption of these resources, and the impact on the environment.

Building the Science Practices

7.B 7.C 7.D 7.E 7.F

In this unit, students can practice identifying environmental problems (e.g., pollution, depletion of the ozone layer, global climate change). They can also practice thinking critically about the problem, and when evaluating a given solution, articulating its benefits and drawbacks. The ability to describe and propose viable solutions for environmental problems is critical for this unit.

Students will benefit from opportunities to practice describing the development process for legislation enacted to mitigate environmental problems and the effects of the legislation on the various stakeholders. Most importantly, students should have many opportunities to evaluate a proposed solution to an environmental problem and/or the legislation that addresses it and then describe benefits and drawbacks to the solution.

Preparing for the AP Exam

On the AP Exam, students must be able to describe and explain concepts related to the tragedy of the commons, clearcutting, agricultural practices, and mining. To practice this, case studies that represent real-world examples of human activities can be helpful, focusing on understanding concepts within applied contexts. Case studies can also be used to help students practice proposing solutions to environmental problems and describing the benefits or disadvantages of those solutions.

Students may benefit from opportunities to analyze text-based resources about environmental issues and the impact of human activities on the environment. Teachers can guide students in identifying the author's claim, perspective, and/or assumptions. It may be especially helpful to utilize sources of information that have quantitative data so that students can provide explanations that both describe the data and connect the data to an environmental issue.

UNIT 5

Land and Water Use

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods
			~18–19 CLASS PERIODS
EIN-2	5.1 The Tragedy of the Commons	1.B Explain environmental concepts and processes.	
	5.2 Clearcutting	1.A Describe environmental concepts and processes.	
	5.3 The Green Revolution	3.B Describe the author's perspective and assumptions.	
	5.4 Impacts of Agricultural Practices	1.A Describe environmental concepts and processes.	
	5.5 Irrigation Methods	7.C Describe disadvantages, advantages, or unintended consequences for potential solutions.	
	5.6 Pest Control Methods	7.E Make a claim that proposes a solution to an environmental problem in an applied context.	
	5.7 Meat Production Methods	5.E Explain what the data implies or illustrates about environmental issues.	
	5.8 Impacts of Overfishing	7.B Describe potential responses or approaches to environmental problems.	
	5.9 Impacts of Mining	7.E Make a claim that proposes a solution to an environmental problem in an applied context.	
	5.10 Impacts of Urbanization	7.C Describe disadvantages, advantages, or unintended consequences for potential solutions.	
	5.11 Ecological Footprints	5.E Explain what the data implies or illustrates about environmental issues.	

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UNIT AT A GLANCE *(cont'd)*

Enduring Understanding	Topic	Suggested Skill	Class Periods
			~18–19 CLASS PERIODS
STB-1	**5.12 Introduction to Sustainability**	5.E Explain what the data implies or illustrates about environmental issues.	
	5.13 Methods to Reduce Urban Runoff	4.B Identify a research method, design, and/or measure used.	
	5.14 Integrated Pest Management	7.D Use data and evidence to support a potential solution.	
	5.15 Sustainable Agriculture	7.E Make a claim that proposes a solution to an environmental problem in an applied context.	
	5.16 Aquaculture	7.C Describe disadvantages, advantages, or unintended consequences for potential solutions.	
	5.17 Sustainable Forestry	7.F Justify a proposed solution, by explaining potential advantages.	
	Go to AP Classroom to assign the **Personal Progress Check** for Unit 5. Review the results in class to identify and address any student misunderstandings.		

UNIT 5

Land and Water Use

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional and are offered to provide possible ways to incorporate various instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 201 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	5.6	**Construct an Argument** Divide the class into nine groups. Assign each group one of the nine statements from **free-response question 4 (part 1)** on the 1999 AP Exam. Have students develop an argument where they defend or refute the statement. Then have them present their arguments to the class.
2	5.11	**One-Minute Essay** Have students use an ecological footprint calculator to calculate their ecological footprint (in class or for homework). Ask them to write about what contributes to their ecological footprint or one change they could make to substantially lower it.

Unit Planning Notes

Use the space below to plan your approach to the unit.

TOPIC 5.1
The Tragedy of the Commons

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

AVAILABLE RESOURCES

- External Resource > Environmental Literacy Council's AP Environmental Science Course Material

Required Course Content

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE

EIN-2.A

Explain the concept of the tragedy of the commons.

ESSENTIAL KNOWLEDGE

EIN-2.A.1

The tragedy of the commons suggests that individuals will use shared resources in their own self-interest rather than in keeping with the common good, thereby depleting the resources.

UNIT 5

Land and Water Use

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 5.2
Clearcutting

Required Course Content

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE

EIN-2.B

Describe the effect of clearcutting on forests.

ESSENTIAL KNOWLEDGE

EIN-2.B.1

Clearcutting can be economically advantageous but leads to soil erosion, increased soil and stream temperatures, and flooding.

EIN-2.B.2

Forests contain trees that absorb pollutants and store carbon dioxide. The cutting and burning of trees releases carbon dioxide and contributes to climate change.

TOPIC 5.3
The Green Revolution

SUGGESTED SKILL

Text Analysis

3.B

Describe the author's perspective and assumptions.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

Required Course Content

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE

EIN-2.C

Describe changes in agricultural practices.

ESSENTIAL KNOWLEDGE

EIN-2.C.1

The Green Revolution started a shift to new agricultural strategies and practices in order to increase food production, with both positive and negative results. Some of these strategies and methods are mechanization, genetically modified organisms (GMOs), fertilization, irrigation, and the use of pesticides.

EIN-2.C.2

Mechanization of farming can increase profits and efficiency for farms. It can also increase reliance on fossil fuels.

UNIT 5

Land and Water Use

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2017, Q3**
- The Exam > **Samples and Commentary 2017, Q3**

TOPIC 5.4
Impact of Agricultural Practices

Required Course Content

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE

EIN-2.D

Describe agricultural practices that cause environmental damage.

ESSENTIAL KNOWLEDGE

LOR-2.D.1

Agricultural practices that can cause environmental damage include tilling, slash-and-burn farming, and the use of fertilizers.

TOPIC 5.5 Irrigation Methods

SUGGESTED SKILL

Environmental Solutions

7.C

Describe disadvantages, advantages, or unintended consequences for potential solutions.

AVAILABLE RESOURCES

- Classroom Resource > **Agriculture and the Nitrogen Cycle**

Required Course Content

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
EIN-2.E Describe different methods of irrigation.	**EIN-2.E.1** The largest human use of freshwater is for irrigation (70%). **EIN-2.E.2** Types of irrigation include drip irrigation, flood irrigation, furrow irrigation, drip irrigation, and spray irrigation.
EIN-2.F Describe the benefits and drawbacks of different methods of irrigation.	**EIN-2.F.1** Waterlogging occurs when too much water is left to sit in the soil, which raises the water table of groundwater and inhibits plants' ability to absorb oxygen through their roots. **EIN-2.F.2** Furrow irrigation involves cutting furrows between crop rows and filling them with water. This system is inexpensive, but about 1/3 of the water is lost to evaporation and runoff. **EIN-2.F.3** Flood irrigation involves flooding an agricultural field with water. This system sees about 20% of the water lost to evaporation and runoff. This can also lead to waterlogging of the soil.

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UNIT 5

Land and Water Use

LEARNING OBJECTIVE

EIN-2.F

Describe the benefits and drawbacks of different methods of irrigation.

ESSENTIAL KNOWLEDGE

EIN-2.F.4

Spray irrigation involves pumping ground water into spray nozzles across an agricultural field. This system is more efficient than flood and furrow irrigation, with only 1/4 or less of the water lost to evaporation or runoff. However, spray systems are more expensive than flood and furrow irrigation, and also requires energy to run.

EIN-2.F.5

Drip irrigation uses perforated hoses to release small amounts of water to plant roots. This system is the most efficient, with only about 5% of water lost to evaporation and runoff. However, this system is expensive and so is not often used.

EIN-2.F.6

Salinization occurs when the salts in groundwater remain in the soil after the water evaporates. Over time, salinization can make soil toxic to plants.

EIN-2.F.7

Aquifers can be severely depleted if overused for agricultural irrigation, as has happened to the Ogallala Aquifer in the central United States.

TOPIC 5.6
Pest Control Methods

SUGGESTED SKILL

Environmental Solutions

7.E

Make a claim that proposes a solution to an environmental problem in an applied context.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018, Q1**
- The Exam > **Student Performance Q&A 2015, Q1**
- The Exam > Samples and Commentary (**2018, Q1**, **2015, Q1**)

Required Course Content

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE

EIN-2.G

Describe the benefits and drawbacks of different methods of pest control.

ESSENTIAL KNOWLEDGE

EIN-2.G.1

One consequence of using common pest-control methods such as pesticides, herbicides, fungicides, rodenticides, and insecticides is that organisms can become resistant to them through artificial selection. Pest control decreases crop damage by pest and increases crop yields.

EIN-2.G.2

Crops can be genetically engineered to increase their resistance to pests and diseases. However, using genetically engineered crops in planting or other ways can lead to loss of genetic diversity of that particular crop.

UNIT 5

Land and Water Use

SUGGESTED SKILL

Data Analysis

5.E

Explain what the data implies or illustrates about environmental issues.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**

TOPIC 5.7
Meat Production Methods

Required Course Content

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE

EIN-2.H

Identify different methods of meat production.

EIN-2.I

Describe the benefits and drawbacks of different methods of meat production.

ESSENTIAL KNOWLEDGE

EIN-2.H.1

Methods of meat production include concentrated animal feeding operations (CAFOs), also called feedlots, and free-range grazing.

EIN-2.I.1

Meat production is less efficient than agriculture; it takes approximately 20 times more land to produce the same amount of calories from meat as from plants.

EIN-2.I.2

Concentrated animal feeding operation (CAFOs) are used as a way to quickly get livestock ready for slaughter. They tend to be crowded, and animals are fed grains or feed that are not as suitable as grass. Additionally, feedlots generate a large amount of organic waste, which can contaminate ground and surface water. The use of feedlots are less expensive than other methods, which can keep costs to consumers down.

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Land and Water Use

UNIT 5

LEARNING OBJECTIVE

EIN-2.I

Describe the benefits and drawbacks of different methods of meat production.

ESSENTIAL KNOWLEDGE

EIN-2.1.3

Free range grazing allows animals to graze on grass during their entire lifecycle. Meat from free range animals tends to be free from antibiotics and other chemicals used in feedlots. Organic waste from these animals acts as fertilizer. Free range grazing requires large areas of land and the meat produced is more expensive for consumers.

EIN-2.I.4

Overgrazing occurs when too many animals feed on a particular area of land. Overgrazing causes loss of vegetation, which leads to soil erosion.

EIN-2.I.5

Overgrazing can cause desertification. Desertification is the degradation of low precipitation regions toward being increasingly arid until they become deserts.

EIN-2.I.6

Less consumption of meat could reduce CO_2, methane, and N_2O emissions; conserve water; reduce the use of antibiotics and growth hormones; and improve topsoil.

UNIT 5

Land and Water Use

SUGGESTED SKILL

Environmental Solutions

7.B

Describe potential responses or approaches to environmental problems.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**

TOPIC 5.8
Impacts of Overfishing

Required Course Content

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE

EIN-2.J

Describe causes of and problems related to overfishing.

ESSENTIAL KNOWLEDGE

EIN-2.J.1

Overfishing has led to the extreme scarcity of some fish species, which can lessen biodiversity in aquatic systems and harm people who depend on fishing for food and commerce.

TOPIC 5.9
Impacts of Mining

Required Course Content

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
EIN-2.K Describe natural resource extraction through mining.	EIN-2.K.1 As the more accessible ores are mined to depletion, mining operations are forced to access lower grade ores. Accessing these ores requires increased use of resources that can cause increased waste and pollution. EIN-2.K.2 Surface mining is the removal of large portions of soil and rock, called overburden, in order to access the ore underneath. An example is strip mining, which removes the vegetation from an area, making the area more susceptible to erosion.
EIN-2.L Describe ecological and economic impacts of natural resource extraction through mining.	EIN-2.L.1 Mining wastes include the soil and rocks that are moved to gain access to the ore and the waste, called slag and tailings that remain when the minerals have been removed from the ore. Mining helps to provide low cost energy and material necessary to make products. The mining of coal can destroy habitats, contaminate ground water, and release dust particles and methane. EIN-2.L.2 As coal reserves get smaller, due to a lack of easily accessible reserves, it becomes necessary to access coal through subsurface mining, which is very expensive.

SUGGESTED SKILL

Environmental Solutions

7.E

Make a claim that proposes a solution to an environmental problem in an applied context.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018, Q2**
- The Exam > **Student Performance Q&A 2016, Q2**
- The Exam > Samples and Commentary (**2018, Q2, 2016, Q2**)

UNIT 5

Land and Water Use

SUGGESTED SKILL

Environmental Solutions

7.C

Describe disadvantages, advantages, or unintended consequences for potential solutions.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Student Performance Q&A 2015, Q4**
- The Exam > **Samples and Commentary 2015, Q4**

TOPIC 5.10
Impacts of Urbanization

Required Course Content

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE

EIN-2.M

Describe the effects of urbanization on the environment.

ESSENTIAL KNOWLEDGE

EIN-2.M.1

Urbanization can lead to depletion of resources and saltwater intrusion in the hydrologic cycle.

EIN-2.M.2

Urbanization, through the burning of fossil fuels and landfills, affects the carbon cycle by increasing the amount of carbon dioxide in the atmosphere.

EIN-2.M.3

Impervious surfaces are human-made structures—such as roads, buildings, sidewalks, and parking lots—that do not allow water to reach the soil, leading to flooding.

EIN-2.M.4

Urban sprawl is the change in population distribution from high population density areas to low density suburbs that spread into rural lands, leading to potential environmental problems.

TOPIC 5.11 Ecological Footprints

SUGGESTED SKILL

Data Analysis

5.E

Explain what the data implies or illustrates about environmental issues.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

Required Course Content

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE

EIN-2.N

Explain the variables measured in an ecological footprint.

ESSENTIAL KNOWLEDGE

EIN-2.N.1

Ecological footprints compare resource demands and waste production required for an individual or a society.

UNIT 5

Land and Water Use

SUGGESTED SKILL

Data Analysis

5.E

Explain what the data implies or illustrates about environmental issues.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > Chief Reader Report (**2018 Q1, 2017, Q3**)
- The Exam > Samples and Commentary (**2018, Q1, 2017, Q3**)

TOPIC 5.12
Introduction to Sustainability

Required Course Content

ENDURING UNDERSTANDING

STB-1

Humans can mitigate their impact on land and water resources through sustainable use.

LEARNING OBJECTIVE

STB-1.A

Explain the concept of sustainability.

ESSENTIAL KNOWLEDGE

STB-1.A.1

Sustainability refers to humans living on Earth and their use of resources without depletion of the resources for future generations. Environmental indicators that can guide humans to sustainability include biological diversity, food production, average global surface temperatures and CO_2 concentrations, human population, and resource depletion.

STB-1.A.2

Sustainable yield is the amount of a renewable resource that can be taken without reducing the available supply.

TOPIC 5.13
Methods to Reduce Urban Runoff

Required Course Content

ENDURING UNDERSTANDING

STB-1

Humans can mitigate their impact on land and water resources through sustainable use.

LEARNING OBJECTIVE

STB-1.B

Describe methods for mitigating problems related to urban runoff.

ESSENTIAL KNOWLEDGE

STB-1.B.1

Methods to increase water infiltration include replacing traditional pavement with permeable pavement, planting trees, increased use of public transportation, and building up, not out.

SUGGESTED SKILL

Scientific Experiments

4.B

Identify a research method, design, and/or measure used.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

UNIT 5

Land and Water Use

SUGGESTED SKILL

Environmental Solutions

7.D

Use data and evidence to support a potential solution.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 5.14
Integrated Pest Management

Required Course Content

ENDURING UNDERSTANDING

STB-1

Humans can mitigate their impact on land and water resources through sustainable use.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-1.C Describe integrated pest management.	**STB-1.C.1** Integrated pest management (IPM) is a combination of methods used to effectively control pest species while minimizing the disruption to the environment. These methods include biological, physical, and limited chemical methods such as biocontrol, intercropping, crop rotation, and natural predators of the pests.
STB-1.D Describe the benefits and drawbacks of integrated pest management (IPM).	**STB-1.D.1** The use of integrated pest management (IPM) reduces the risk that pesticides pose to wildlife, water supplies, and human health. **STB-1.D.2** Integrated pest management (IPM) minimizes disruptions to the environment and threats to human health but can be complex and expensive.

TOPIC 5.15
Sustainable Agriculture

Required Course Content

ENDURING UNDERSTANDING

STB-1

Humans can mitigate their impact on land and water resources through sustainable use.

LEARNING OBJECTIVE

STB-1.E

Describe sustainable agricultural and food production practices.

ESSENTIAL KNOWLEDGE

STB-1.E.1

The goal of soil conservation is to prevent soil erosion. Different methods of soil conservation include contour plowing, windbreaks, perennial crops, terracing, no-till agriculture, and strip cropping.

STB-1.E.2

Strategies to improve soil fertility include crop rotation and the addition of green manure and limestone.

STB-1.E.3

Rotational grazing is the regular rotation of livestock between different pastures in order to avoid overgrazing in a particular area.

SUGGESTED SKILL

Environmental Solutions

7.E

Make a claim that proposes a solution to an environmental problem in an applied context.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2017, Q3**
- The Exam > **Samples and Commentary 2017, Q3**

UNIT 5

Land and Water Use

SUGGESTED SKILL

Environmental Solutions

7.C

Describe disadvantages, advantages, or unintended consequences for potential solutions.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 5.16
Aquaculture

Required Course Content

ENDURING UNDERSTANDING

STB-1

Humans can mitigate their impact on land and water resources through sustainable use.

LEARNING OBJECTIVE

STB-1.F

Describe the benefits and drawbacks of aquaculture.

ESSENTIAL KNOWLEDGE

STB-1.F.1

Aquaculture has expanded because it is highly efficient, requires only small areas of water, and requires little fuel.

STB-1.F.2

Aquaculture can contaminate wastewater, and fish that escape may compete or breed with wild fish. The density of fish in aquaculture can lead to increases in disease incidences, which can be transmitted to wild fish.

TOPIC 5.17 Sustainable Forestry

Required Course Content

ENDURING UNDERSTANDING

STB-1

Humans can mitigate their impact on land and water resources through sustainable use.

LEARNING OBJECTIVE

STB-1.G

Describe methods for mitigating human impact on forests.

ESSENTIAL KNOWLEDGE

STB-1.G.1

Some of the methods for mitigating deforestation include reforestation, using and buying wood harvested by ecologically sustainable forestry techniques, and reusing wood.

STB-1.G.2

Methods to protect forests from pathogens and insects include integrated pest management (IPM) and the removal of affected trees.

STB-1.G.3

Prescribed burn is a method by which forests are set on fire under controlled conditions in order to reduce the occurrence of natural fires.

SUGGESTED SKILL

Environmental Solutions

7.F

Justify a proposed solution, by explaining potential advantages.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2017, Q1**
- The Exam > **Samples and Commentary 2017, Q1**

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AP ENVIRONMENTAL SCIENCE

UNIT 6

Energy Resources and Consumption

10–15%
AP EXAM WEIGHTING

~16–17
CLASS PERIODS

Remember to go to **AP Classroom** to assign students the online **Personal Progress Check** for this unit.

Whether assigned as homework or completed in class, the **Personal Progress Check** provides each student with immediate feedback related to this unit's topics and skills.

Personal Progress Check 6

Multiple-choice: ~35 questions
Free-response: 1 question

- Analyze an environmental problem and propose a solution doing calculations

UNIT 6 | 10–15% AP EXAM WEIGHTING | ~16–17 CLASS PERIODS

Energy Resources and Consumption

BIG IDEA 1
Energy Transfer ENG
- Why are fossil fuels the most widely used energy resources if they are nonrenewable?

Developing Understanding

This unit examines human use of renewable and nonrenewable sources of energy and its impact on the environment. Energy consumption differs throughout the world and the availability of natural energy resources depends on the region's geologic history. Subsequent units will examine the impact of human activity on the atmosphere, land, and water.

Building the Science Practices

1.A 1.B 1.C

In this unit, students can practice identifying where natural energy resources occur (e.g., coal, crude oil, ores) on a global map. They can also practice describing other forms of energy and differentiating between nonrenewable and renewable forms of energy. Students may struggle with vocabulary related to this subject matter. Students also tend to misunderstand radioactivity and think that all radiation is bad.

Text analysis is also an important skill for students to build upon in this unit. When reading texts about topics in this unit, students can practice identifying the claims as well as describing the perspectives and assumptions of the author.

Preparing for the AP Exam

On the AP Exam, students must be able to explain concepts related to renewable and nonrenewable energy sources. They may benefit from in-class opportunities to practice comparing and contrasting different sources of fuel and how they are used, with an emphasis on the impacts of usage on the environment. Students often struggle with applying appropriate mathematical relationships to determine the amount of energy produced or used based on the given information. To combat this, teachers can provide multiple opportunities for students to manipulate formulae and use the data provided to solve a problem, especially problems that use dimensional analysis and multiple steps. They should provide a numerical answer and unit, if required.

Students will also need to explain environmental problems related to the use of different energy resources and propose solutions. To that end, students may benefit from multiple opportunities to propose realistic solutions to environmental problems related to the use of different energy sources.

UNIT 6

Energy Resources and Consumption

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods
			~16–17 CLASS PERIODS
ENG-3	6.1 Renewable and Nonrenewable Resources	1.C Explain environmental concepts, processes, or models in applied contexts.	
	6.2 Global Energy Consumption	6.C Calculate an accurate numeric answer with appropriate units.	
	6.3 Fuel Types and Uses	1.A Describe environmental concepts and processes.	
	6.4 Distribution of Natural Energy Resources	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: ▪ In theoretical contexts ▪ In applied contexts	
	6.5 Fossil Fuels	7.A Describe environmental problems.	
	6.6 Nuclear Power	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: ▪ In theoretical contexts ▪ In applied contexts	
	6.7 Energy from Biomass	7.B Describe potential responses or approaches to environmental problems.	
	6.8 Solar Energy	5.C Explain patterns and trends in data to draw conclusions.	
	6.9 Hydroelectric Power	7.F Justify a proposed solution, by explaining potential advantages.	
	6.10 Geothermal Energy	1.B Explain environmental concepts and processes.	
	6.11 Hydrogen Fuel Cell	1.C Explain environmental concepts, processes, or models in applied contexts.	
	6.12 Wind Energy	7.B Describe potential responses or approaches to environmental problems.	
	6.13 Energy Conservation	6.C Calculate an accurate numeric answer with appropriate units.	
	Go to AP Classroom to assign the **Personal Progress Check** for Unit 6. Review the results in class to identify and address any student misunderstandings.		

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional and are offered to provide possible ways to incorporate various instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 201 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	6.1	**Fishbowl** Divide students into two groups and arrange them in an inner and outer circle. Assign students in the inner group a type of nonrenewable resource and assign the students in the outer group a type of renewable resource. Have them move through the circle reporting on one pro and one con for each resource. Then have them make a list summarizing the pros and cons of each resource.
2	6.9	**Debate** Divide the class into three groups. Assign one group to represent the pros of creating a dam for hydroelectric power. Assign the second group to represent the cons of creating a dam for hydroelectric power. Assign the third group to represent the panel of judges. Have students debate the merits of each side and allow the panel of judges to vote on the winner of the debate.

Unit Planning Notes

Use the space below to plan your approach to the unit.

UNIT 6

Energy Resources and Consumption

SUGGESTED SKILL

Concept Explanation

1.C

Explain environmental concepts, processes, or models in applied contexts.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018 Q1 & Q2**
- The Exam > Samples and Commentary (**2018 Q1**, **2018, Q2**)

TOPIC 6.1
Renewable and Nonrenewable Resources

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE

ENG-3.A

Identify differences between nonrenewable and renewable energy sources.

ESSENTIAL KNOWLEDGE

ENG-3.A.1

Nonrenewable energy sources are those that exist in a fixed amount and involve energy transformation that cannot be easily replaced.

ENG-3.A.2

Renewable energy sources are those that can be replenished naturally, at or near the rate of consumption, and reused.

TOPIC 6.2
Global Energy Consumption

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE

ENG-3.B

Describe trends in energy consumption.

ESSENTIAL KNOWLEDGE

ENG-3.B.1

The use of energy resources is not evenly distributed between developed and developing countries.

ENG-3.B.2

The most widely used sources of energy globally are fossil fuels.

ENG-3.B.3

As developing countries become more developed, their reliance on fossil fuels for energy increases.

ENG-3.B.4

As the world becomes more industrialized, the demand for energy increases.

ENG-3.B.5

Availability, price, and governmental regulations influence which energy sources people use and how they use them.

SUGGESTED SKILL

Mathematical Routines

6.C

Calculate an accurate numeric answer with appropriate units.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**
- The Exam > **Chief Reader Report 2018, Q1**
- The Exam > **Samples and Commentary 2018, Q1**

UNIT 6

Energy Resources and Consumption

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide
- The Exam > Chief Reader Report (2018 Q1 & Q2, 2017, Q4)
- The Exam > Samples and Commentary (2018 Q1, 2018, Q2, 2017, Q4)

TOPIC 6.3
Fuel Types and Uses

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE

ENG-3.C

Identify types of fuels and their uses.

ESSENTIAL KNOWLEDGE

ENG-3.C.1

Wood is commonly used as fuel in the forms of firewood and charcoal. It is often used in developing countries because it is easily accessible.

ENG-3.C.2

Peat is partially decomposed organic material that can be burned for fuel.

ENG-3.C.3

Three types of coal used for fuel are lignite, bituminous, and anthracite. Heat, pressure, and depth of burial contribute to the development of various coal types and their qualities.

ENG-3.C.4

Natural gas, the cleanest of the fossil fuels, is mostly methane.

ENG-3.C.5

Crude oil can be recovered from tar sands, which are a combination of clay, sand, water, and bitumen.

ENG-3.C.6

Fossil fuels can be made into specific fuel types for specialized uses (e.g., in motor vehicles).

ENG-3.C.7

Cogeneration occurs when a fuel source is used to generate both useful heat and electricity.

TOPIC 6.4
Distribution of Natural Energy Resources

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE

ENG-3.D

Identify where natural energy resources occur.

ESSENTIAL KNOWLEDGE

ENG-3.D.1

The global distribution of natural energy resources, such as ores, coal, crude oil, and gas, is not uniform and depends on regions' geologic history.

SUGGESTED SKILL

Visual Representations

2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

UNIT 6

Energy Resources and Consumption

SUGGESTED SKILL

Environmental Solutions

7.A
Describe environmental problems.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018, Q1**
- The Exam > **Samples and Commentary 2018, Q1**

TOPIC 6.5
Fossil Fuels

Required Course Content

ENDURING UNDERSTANDING

ENG-3
Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ENG-3.E Describe the use and methods of fossil fuels in power generation.	**ENG-3.E.1** The combustion of fossil fuels is a chemical reaction between the fuel and oxygen that yields carbon dioxide and water and releases energy. **ENG-3.E.2** Energy from fossil fuels is produced by burning those fuels to generate heat, which then turns water into steam. That steam turns a turbine, which generates electricity. **ENG-3.E.3** Humans use a variety of methods to extract fossil fuels from the earth for energy generation.
ENG-3.F Describe the effects of fossil fuels on the environment.	**ENG-3.F.1** Hydrologic fracturing (fracking) can cause groundwater contamination and the release of volatile organic compounds.

TOPIC 6.6
Nuclear Power

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE

ENG-3.G

Describe the use of nuclear energy in power generation.

ESSENTIAL KNOWLEDGE

ENG-3.G.1

Nuclear power is generated through fission, where atoms of Uranium-235, which are stored in fuel rods, are split into smaller parts after being struck by a neutron. Nuclear fission releases a large amount of heat, which is used to generate steam, which powers a turbine and generates electricity.

ENG-3.G.2

Radioactivity occurs when the nucleus of a radioactive isotope loses energy by emitting radiation.

ENG-3.G.3

Uranium-235 remains radioactive for a long time, which leads to the problems associated with the disposal of nuclear waste.

ENG-3.G.4

Nuclear power generation is a nonrenewable energy source. Nuclear power is considered a cleaner energy source because it does not produce air pollutants, but it does release thermal pollution and hazardous solid waste.

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SUGGESTED SKILL

Visual Representations

2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Student Performance Q&A 2014, Q1**
- The Exam > **Samples and Commentary 2014, Q1**

UNIT 6

Energy Resources and Consumption

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ENG-3.H Describe the effects of the use of nuclear energy on the environment.	**ENG-3.H.1** Three Mile Island, Chernobyl, and Fukushima are three cases where accidents or natural disasters led to the release of radiation. These releases have had short- and long-term impacts on the environment. **ENG-3.H.2** A radioactive element's half-life can be used to calculate a variety of things, including the rate of decay and the radioactivity level at specific points in time.

TOPIC 6.7
Energy from Biomass

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE

ENG-3.I

Describe the effects of the use of biomass in power generation on the environment.

ESSENTIAL KNOWLEDGE

ENG-3.I.1

Burning of biomass produces heat for energy at a relatively low cost, but it also produces carbon dioxide, carbon monoxide, nitrogen oxides, particulates, and volatile organic compounds. The overharvesting of trees for fuel also causes deforestation.

ENG-3.I.2

Ethanol can be used as a substitute for gasoline. Burning ethanol does not introduce additional carbon into the atmosphere via combustion, but the energy return on energy investment for ethanol is low.

SUGGESTED SKILL

Environmental Solutions

7.B

Describe potential responses or approaches to environmental problems.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018, Q4**
- The Exam > **Samples and Commentary 2018, Q4**

UNIT 6

Energy Resources and Consumption

SUGGESTED SKILL

Data Analysis

5.C

Explain patterns and trends in data to draw conclusions.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018, Q1**
- The Exam > **Student Performance Q&A 2014, Q2**
- The Exam > Samples and Commentary (**2018, Q1**, **2014, Q2**)

TOPIC 6.8 Solar Energy

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ENG-3.J Describe the use of solar energy in power generation.	**ENG-3.J.1** Photovoltaic solar cells capture light energy from the sun and transform it directly into electrical energy. Their use is limited by the availability of sunlight.
	ENG-3.J.2 Active solar energy systems use solar energy to heat a liquid through mechanical and electric equipment to collect and store the energy captured from the sun.
	ENG-3.J.3 Passive solar energy systems absorb heat directly from the sun without the use of mechanical and electric equipment, and energy cannot be collected or stored.
ENG-3.K Describe the effects of the use of solar energy in power generation on the environment.	**ENG-3.K.1** Solar energy systems have low environmental impact and produce clean energy, but they can be expensive. Large solar energy farms may negatively impact desert ecosystems.

TOPIC 6.9
Hydroelectric Power

SUGGESTED SKILL

Environmental Solutions

7.F

Justify a proposed solution, by explaining potential advantages.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018, Q1 & Q4**
- The Exam > Samples and Commentary (**2018, Q1**, **2018, Q4**)

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ENG-3.L Describe the use of hydroelectricity in power generation.	**ENG-3.L.1** Hydroelectric power can be generated in several ways. Dams built across rivers collect water in reservoirs. The moving water can be used to spin a turbine. Turbines can also be placed in small rivers, where the flowing water spins the turbine. **ENG-3.L.2** Tidal energy uses the energy produced by tidal flows to turn a turbine.
ENG-3.M Describe the effects of the use of hydroelectricity in power generation on the environment.	**ENG-3.M.1** Hydroelectric power does not generate air pollution or waste, but construction of the power plants can be expensive, and there may be a loss of or change in habitats following the construction of dams.

UNIT 6

Energy Resources and Consumption

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 6.10 Geothermal Energy

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ENG-3.N Describe the use of geothermal energy in power generation.	**ENG-3.N.1** Geothermal energy is obtained by using the heat stored in the Earth's interior to heat up water, which is brought back to the surface as steam. The steam is used to drive an electric generator.
ENG-3.O Describe the effects of the use of geothermal energy in power generation on the environment.	**ENG-3.O.1** The cost of accessing geothermal energy can be prohibitively expensive, as is not easily accessible in many parts of the world. In addition, it can cause the release of hydrogen sulfide.

TOPIC 6.11
Hydrogen Fuel Cell

SUGGESTED SKILL

Concept Explanation

1.C

Explain environmental concepts, processes, or models in applied contexts.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE

ENG-3.P

Describe the use of hydrogen fuel cells in power generation.

ENG-3.Q

Describe the effects of the use of hydrogen fuel cells in power generation on the environment.

ESSENTIAL KNOWLEDGE

ENG-3.P.1

Hydrogen fuel cells are an alternate to non-renewable fuel sources. They use hydrogen as fuel, combining the hydrogen and oxygen in the air to form water and release energy (electricity) in the process. Water is the product (emission) of a fuel cell.

ENG-3.Q.1

Hydrogen fuel cells have low environmental impact and produce no carbon dioxide when the hydrogen is produced from water. However, the technology is expensive and energy is still needed to create the hydrogen gas used in the fuel cell.

UNIT 6

Energy Resources and Consumption

SUGGESTED SKILL

Environmental Solutions

7.B

Describe potential responses or approaches to environmental problems.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018, Q2**
- The Exam > **Samples and Commentary 2018, Q2**

TOPIC 6.12
Wind Energy

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ENG-3.R Describe the use of wind energy in power generation.	**ENG-3.R.1** Wind turbines use the kinetic energy of moving air to spin a turbine, which in turn converts the mechanical energy of the turbine into electricity.
ENG-3.S Describe the effects of the use of wind energy in power generation on the environment.	**ENG-3.S.1** Wind energy is a renewable, clean source of energy. However, birds and bats may be killed if they fly into the spinning turbine blades.

TOPIC 6.13
Energy Conservation

Required Course Content

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE

ENG-3.T

Describe methods for conserving energy.

ESSENTIAL KNOWLEDGE

ENG-3.T.1

Some of the methods for conserving energy around a home include adjusting the thermostat to reduce the use of heat and air conditioning, conserving water, use of energy-efficient appliances, and conservation landscaping.

ENG-3.T.2

Methods for conserving energy on a large scale include improving fuel economy for vehicles, using BEVs (battery electric vehicles) and hybrid vehicles, using public transportation, and implementing green building design features.

SUGGESTED SKILL

Mathematical Routines

6.C

Calculate an accurate numeric answer with appropriate units.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018, Q1**
- The Exam > **Samples and Commentary 2018, Q1**
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**

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AP ENVIRONMENTAL SCIENCE

UNIT 7

Atmospheric Pollution

7–10%
AP EXAM WEIGHTING

~11–12
CLASS PERIODS

Remember to go to **AP Classroom** to assign students the online **Personal Progress Check** for this unit.

Whether assigned as homework or completed in class, the **Personal Progress Check** provides each student with immediate feedback related to this unit's topics and skills.

Personal Progress Check 7

Multiple-choice: ~20 questions
Free-response: 1 question

- Design an investigation



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UNIT 7 | 7–10% AP EXAM WEIGHTING | ~11–12 CLASS PERIODS

Atmospheric Pollution

BIG IDEA 4
Sustainability STB
- Where does air pollution go once it is airborne?

Building Understanding

Air pollution has many sources and effects, both indoors and outdoors. Air is a natural resource that covers the Earth and crosses many system boundaries. Human activities affect the quality of the air both indoors and outdoors. Through legislation, the Clean Air Act regulates the emission of air pollutants that affect human health. The gases and particulates in the atmosphere come from both natural and human sources; once air pollution sources are identified, methods can be used to reduce it. Subsequent units will focus on pollution's impacts to land and water.

Building the Science Practices

5.B 5.C 7.D

In this unit, students can practice comparing and predicting patterns and/or trends in a graph or table to explain how the data or representation illustrates environmental concepts. They can also practice drawing conclusions about an environmental concept based on a comparison of the patterns and trends in a graph or table.

Students can also practice proposing solutions to combat the effects of air pollution on human health and, most importantly, using data or evidence to support their solutions. In order to understand the implications of environmental legislation, it is important to know how environmental policies are applied and what the outcomes are in a variety of contexts. With that knowledge, students can then explain why those outcomes occurred and how the policy affected the outcomes.

Preparing for the AP Exam

On the AP Exam, students must be able to describe or identify a research method used to understand air pollution. They will also have to explain the patterns and trends in data related to air pollution and describe the relationship among variables of data represented graphically. Students may benefit from time in class devoted to hands-on laboratory activities related to air pollution. Teachers can also provide students practice in identifying information from graphs, diagrams, or infographics related to air pollution. Students often struggle to identify specific air pollutants and related illnesses. To combat this, teacher can provide opportunities for students to identify air pollutants and their impacts on human health.

UNIT 7

Atmospheric Pollution

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods
			~11–12 CLASS PERIODS
STB-2	7.1 Introduction to Air Pollution	4.E Explain modifications to an experimental procedure that will alter results.	
	7.2 Photochemical Smog	5.B Describe relationships among variables in data represented.	
	7.3 Thermal Inversion	2.C Explain how environmental concepts and processes represented visually relate to broader environmental issues.	
	7.4 Atmospheric CO_2 and Particulates	4.C Describe an aspect of a research method, design, and/or measure used.	
	7.5 Indoor Air Pollutants	5.C Explain patterns and trends in data to draw conclusions.	
	7.6 Reduction of Air Pollutants	7.D Use data and evidence to support a potential solution.	
	7.7 Acid Rain	4.B Identify a research method, design, and/or measure used.	
	7.8 Noise Pollution	3.C Describe the author's reasoning (use of evidence to support a claim).	
	Go to **AP Classroom** to assign the **Personal Progress Check** for Unit 7. Review the results in class to identify and address any student misunderstandings.		

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional and are offered to provide possible ways to incorporate various instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 201 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	7.1	**Ask the Expert (or Students as Experts)** Divide students into five groups. Each group will become experts on the major criteria used to determine the air quality index (AQI): particulate matter, sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and ozone (O_3). Have students rotate through expert stations to learn about how AQI is determined.
2	7.5	**Graph and Switch** Divide students into groups and have them assemble air traps by placing a small dab of petroleum jelly on an index card. Have them place the cards in different locations. Then have them collect the traps and analyze the different PM products collected in the trap by observing a sample under a stereomicroscope. Ask students to graph their data and share with the rest of the class.
3	7.6	**Idea Spinner** Provide students with information on global climate change and the effects of increasing CO_2 emissions on oceans and climate. Divide students into groups and give them a spinner with four quadrants labeled "Predict," "Explain," "Summarize," and "Evaluate." Have students take turns spinning the idea spinner and communicating their thoughts within the group.
4	7.7	**Graph and Switch** Have students add vinegar (simulated acid rain) to chalk (simulated limestone) and calculate the rates of decomposition on different-sized pieces of chalk over time. Then have them create graphs and analyze each other's data.

Unit Planning Notes

Use the space below to plan your approach to the unit.

UNIT 7

Atmospheric Pollution

SUGGESTED SKILL

Scientific Experiments

4.E

Explain modifications to an experimental procedure that will alter results.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018, Q4**
- The Exam > **Student Performance Q&A 2016, Q3**
- The Exam > Samples and Commentary (**2018, Q4, 2016, Q3**)

TOPIC 7.1
Introduction to Air Pollution

Required Course Content

ENDURING UNDERSTANDING

STB-2

Human activities have physical, chemical, and biological consequences for the atmosphere.

LEARNING OBJECTIVE

STB-2.A

Identify the sources and effects of air pollutants.

ESSENTIAL KNOWLEDGE

STB-2.A.1

Coal combustion releases air pollutants including carbon dioxide, sulfur dioxide, toxic metals, and particulates.

STB-2.A.2

The combustion of fossil fuels releases nitrogen oxides into the atmosphere. They lead to the production of ozone, formation of photochemical smog, and convert to nitric acid in the atmosphere, causing acid rain. Other pollutants produced by fossil fuel combustion include carbon monoxide, hydrocarbons, and particulate matter.

STB-2.A.3

Air quality can be affected through the release of sulfur dioxide during the burning of fossil fuels, mainly diesel fuels.

STB-2.A.4

Through the Clean Air Act, the Environmental Protection Agency (EPA) regulated the use of lead, particularly in fuels, which dramatically decreased the amount of lead in the atmosphere.

STB-2.A.5

Air pollutants can be primary or secondary pollutants.

TOPIC 7.2
Photochemical Smog

SUGGESTED SKILL

Data Analysis

5.B

Describe relationships among variables in data represented.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

Required Course Content

ENDURING UNDERSTANDING

STB-2

Human activities have physical, chemical, and biological consequences for the atmosphere.

LEARNING OBJECTIVE

STB-2.B

Explain the causes and effects of photochemical smog and methods to reduce it.

ESSENTIAL KNOWLEDGE

STB-2.B.1

Photochemical smog is formed when nitrogen oxides and volatile organic hydrocarbons react with heat and sunlight to produce a variety of pollutants.

STB-2.B.2

Many environmental factors affect the formation of photochemical smog.

STB-2.B.3

Nitrogen oxide is produced early in the day. Ozone concentrations peak in the afternoon and are higher in the summer because ozone is produced by chemical reactions between oxygen and sunlight.

STB-2.B.4

Volatile Organic Compounds (VOCs), such as formaldehyde and gasoline, evaporate or sublimate at room temperature. Trees are a natural source of VOCs.

STB-2.B.5

Photochemical smog often forms in urban areas because of the large number of motor vehicles there.

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UNIT 7

Atmospheric Pollution

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-2.B Explain the causes and effects of photochemical smog and methods to reduce it.	**STB-2.B.6** Photochemical smog can be reduced through the reduction of nitrogen oxide and VOCs. **STB-2.B.7** Photochemical smog can harm human health in several ways, including causing respiratory problems and eye irritation.

TOPIC 7.3 Thermal Inversion

Required Course Content

ENDURING UNDERSTANDING

STB-2

Human activities have physical, chemical, and biological consequences for the atmosphere.

LEARNING OBJECTIVE

STB-2.C

Describe thermal inversion and its relationship with pollution.

ESSENTIAL KNOWLEDGE

STB-2.C.1

During a thermal inversion, the normal temperature gradient in the atmosphere is altered as the air temperature at the Earth's surface is cooler than the air at higher altitudes.

STB-2.C.2

Thermal inversion traps pollution close to the ground, especially smog and particulates.

SUGGESTED SKILL

Visual Representations

2.C

Explain how environmental concepts and processes represented visually relate to broader environmental issues.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

UNIT 7

Atmospheric Pollution

SUGGESTED SKILL

Scientific Experiments

4.C

Describe an aspect of a research method, design, and/or measure used.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 7.4
Atmospheric CO_2 and Particulates

Required Course Content

ENDURING UNDERSTANDING

STB-2

Human activities have physical, chemical, and biological consequences for the atmosphere.

LEARNING OBJECTIVE

STB-2.D

Describe natural sources of CO_2 and particulates.

ESSENTIAL KNOWLEDGE

STB-2.D.1

CO_2 appears naturally in the atmosphere from sources such as respiration, decomposition, and volcanic eruptions.

STB-2.D.2

There are a variety of natural sources of particulate matter.

TOPIC 7.5
Indoor Air Pollutants

SUGGESTED SKILL

Data Analysis

5.C

Explain patterns and trends in data to draw conclusions.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018, Q1**
- The Exam > Student Performance Q&A (**2016, Q3, 2014, Q1**)
- The Exam > Samples and Commentary (**2018, Q1, 2016, Q3, 2014, Q1**)

Required Course Content

ENDURING UNDERSTANDING

STB-2

Human activities have physical, chemical, and biological consequences for the atmosphere.

LEARNING OBJECTIVE

STB-2.E

Identify indoor air pollutants.

ESSENTIAL KNOWLEDGE

STB-2.E.1

Carbon monoxide is an indoor air pollutant that is classified as an asphyxiant.

STB-2.E.2

Indoor air pollutants that are classified as particulates include asbestos, dust, and smoke.

STB-2.E.3

Indoor air pollutants can come from natural sources, human-made sources, and combustion.

STB-2.E.4

Common natural source indoor air pollutants include radon, mold, and dust.

STB-2.E.5

Common human-made indoor air pollutants include insulation, Volatile Organic Compounds (VOCs) from furniture, paneling and carpets; formaldehyde from building materials, furniture, upholstery, and carpeting; and lead from paints.

STB-2.E.6

Common combustion air pollutants include carbon monoxide, nitrogen oxides, sulfur dioxide, particulates, and tobacco smoke.

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UNIT 7

Atmospheric Pollution

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-2.E Identify indoor air pollutants.	STB-2.E.7 Radon-222 is a naturally occurring radioactive gas that is produced by the decay of uranium found in some rocks and soils.
STB-2.F Describe the effects of indoor air pollutants.	STB-2.F.1 Radon gas can infiltrate homes as it moves up through the soil and enters homes via the basement or cracks in the walls or foundation. It is also dissolved in groundwater that enters homes through a well. STB-2.F.2 Exposure to radon gas can lead to radon-induced lung cancer, which is the second leading cause of lung cancer in America.

TOPIC 7.6
Reduction of Air Pollutants

Required Course Content

ENDURING UNDERSTANDING

STB-2

Human activities have physical, chemical, and biological consequences for the atmosphere.

LEARNING OBJECTIVE

STB-2.G

Explain how air pollutants can be reduced at the source.

ESSENTIAL KNOWLEDGE

STB-2.G.1

Methods to reduce air pollutants include regulatory practices, conservation practices, and alternative fuels.

STB-2.G.2

A vapor recovery nozzle is an air pollution control device on a gasoline pump that prevents fumes from escaping into the atmosphere when fueling a motor vehicle.

STB-2.G.3

A catalytic converter is an air pollution control device for internal combustion engines that converts pollutants (CO, NO*x*, and hydrocarbons) in exhaust into less harmful molecules (CO_2, N_2, O_2, and H_2O).

STB-2.G.4

Wet and dry scrubbers are air pollution control devices that remove particulates and/or gases from industrial exhaust streams.

STB-2.G.5

Methods to reduce air pollution from coal-burning power plants include scrubbers and electrostatic precipitators.

SUGGESTED SKILL

Environmental Solutions

7.D

Use data and evidence to support a potential solution.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Chief Reader Report 2018, Q1**
- The Exam > **Student Performance Q&A 2016, Q3**
- The Exam > Samples and Commentary (**2018, Q1, 2016, Q3**)

UNIT 7

Atmospheric Pollution

SUGGESTED SKILL

Scientific Experiments

4.B

Identify a research method, design, and/or measure used.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**

TOPIC 7.7
Acid Rain

Required Course Content

ENDURING UNDERSTANDING

STB-2

Human activities have physical, chemical, and biological consequences for the atmosphere.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-2.H Describe acid deposition.	**STB-2.H.1** Acid rain and deposition is due to nitrogen oxides and sulfur oxides from anthropogenic and natural sources in the atmosphere. **STB-2.H.2** Nitric oxides that cause acid deposition come from motor vehicles and coal-burning power plants. Sulfur dioxides that cause acid deposition come from coal-burning power plants.
STB-2.I Describe the effects of acid deposition on the environment.	**STB-2.I.1** Acid deposition mainly affects communities that are downwind from coal-burning power plants. **STB-2.I.2** Acid rain and deposition can lead to the acidification of soils and bodies of water and corrosion of human-made structures. **STB-2.I.3** Regional differences in soils and bedrock affect the impact that acid deposition has on the region—such as limestone bedrock's ability to neutralize the effect of acid rain on lakes and ponds.

TOPIC 7.8
Noise Pollution

SUGGESTED SKILL

Text Analysis

3.C

Describe the author's reasoning (use of evidence to support a claim).

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

Required Course Content

ENDURING UNDERSTANDING

STB-2

Human activities have physical, chemical, and biological consequences for the atmosphere.

LEARNING OBJECTIVE

STB-2.J

Describe human activities that result in noise pollution and its effects.

ESSENTIAL KNOWLEDGE

STB-2.J.1

Noise pollution is sound at levels high enough to cause physiological stress and hearing loss.

STB-2.J.2

Sources of noise pollution in urban areas include transportation, construction, and domestic and industrial activity.

STB-2.J.3

Some effects of noise pollution on animals in ecological systems include stress, the masking of sounds used to communicate or hunt, damaged hearing, and causing changes to migratory routes.

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AP ENVIRONMENTAL SCIENCE

UNIT 8

Aquatic and Terrestrial Pollution

7–10%
AP EXAM WEIGHTING

~19–20
CLASS PERIODS

Remember to go to **AP Classroom** to assign students the online **Personal Progress Check** for this unit.

Whether assigned as homework or completed in class, the **Personal Progress Check** provides each student with immediate feedback related to this unit's topics and skills.

Personal Progress Check 8

Multiple-choice: ~35 questions
Free-response: 1 question

- Analyze an environmental problem and propose a solution doing calculations

UNIT 8 | 7–10% AP EXAM WEIGHTING | ~19–20 CLASS PERIODS

Aquatic and Terrestrial Pollution

BIG IDEA 3
Interactions Between Different Species and the Environment EIN
- How does pollution impact your health?

BIG IDEA 4
Sustainability STB
- How can you decrease your waste?

Developing Understanding

Pollution created by human activities directly impacts ecosystems in the air, on land, and in water. The source of pollution can sometimes be easy to identify, but other times the source is diffused. There are many human health issues that can be linked to pollution. Legislation has been created to reduce discharges of pollution in water and regulate drinking water. Increases in waste cause global concerns for organisms that live on land and in water. In the final unit, students will explore how local and regional human activities can have a global impact.

Building the Science Practices

2.A 2.B 2.C 6.A 6.B

Students should be able to think critically about an environmental problem and evaluate a given solution, articulating the benefits and drawbacks. Students should also be able to propose their own solutions to environmental problems. In order to understand the implications of environmental legislation, students need to see how policies are applied in different contexts. They also need to see the outcomes of those policies in context to fully address an environmental problem. Students should then be able to explain why those outcomes occurred and how the policy affected the outcomes.

Quantitative skills are also important in this unit and can be addressed by having students perform water quality or dissolved oxygen labs. This will give them the opportunity to perform calculations with their data. These lab experiences will also provide students contexts to evaluate environmental problems.

Preparing for the AP Exam

On the AP Exam, students must be able to explain concepts related to the different types of pollution that impact land and water. Students often struggle with evaluating data related to pollution. To combat this, teachers can practice through hands-on laboratory activities related to pollution. Students can then discuss their observations and data. They may also benefit from multiple opportunities to analyze data by describing the relationships among the variables. They can explain the meaning of the data and the implications the data illustrate about pollution.

Students often struggle if problems on the AP Exam require multiple steps to obtain an answer. Teachers can provide students with practice solving problems related to pollution using appropriate methods to calculate numerical answers, with appropriate units. As students practice calculations, it is often helpful to emphasize a logical step-by-step method that shows how their problem solving ends with a numerical answer and appropriate units.

UNIT 8

Aquatic and Terrestrial Pollution

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods
			~19–20 CLASS PERIODS
STB-3	8.1 Sources of Pollution	1.A Describe environmental concepts and processes.	
	8.2 Human Impacts on Ecosystems	6.B Apply appropriate mathematical relationships to solve a problem, with work shown (e.g., dimensional analysis).	
	8.3 Endocrine Disruptors	1.A Describe environmental concepts and processes.	
	8.4 Human Impacts on Wetlands and Mangroves	7.B Describe potential responses or approaches to environmental problems.	
	8.5 Eutrophication	2.C Explain how environmental concepts and processes represented visually relate to broader environmental issues.	
	8.6 Thermal Pollution	1.C Explain environmental concepts, processes, or models in applied contexts.	
	8.7 Persistent Organic Pollutants (POPs)	1.B Explain environmental concepts and processes.	
	8.8 Bioaccumulation and Biomagnification	4.A Identify a testable hypothesis or scientific question for an investigation.	
	8.9 Solid Waste Disposal	7.D Use data and evidence to support a potential solution.	
	8.10 Waste Reduction Methods	6.B Apply appropriate mathematical relationships to solve a problem, with work shown (e.g., dimensional analysis).	
	8.11 Sewage Treatment	2.A Describe characteristics of an environmental concept, process, or model represented visually.	

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UNIT AT A GLANCE *(cont'd)*

Enduring Understanding	Topic	Suggested Skill	Class Periods ~19–20 CLASS PERIODS
EIN-3	**8.12** Lethal Dose 50% (LD_{50})	6.A Determine an approach or method aligned with the problem to be solved.	
	8.13 Dose Response Curve	5.E Explain what the data implies or illustrates about environmental issues.	
	8.14 Pollution and Human Health	4.C Describe an aspect of a research method, design, and/or measure used.	
	8.15 Pathogens and Infectious Diseases	2.B Explain relationships between different characteristics of environmental concepts, processes, or models represented visually: ▪ In theoretical contexts ▪ In applied contexts	
	Go to **AP Classroom** to assign the **Personal Progress Check** for Unit 8. Review the results in class to identify and address any student misunderstandings.		

UNIT 8

Aquatic and Terrestrial Pollution

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional and are offered to provide possible ways to incorporate various instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 201 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	8.7	**One-Minute Essay** Have students read the EPA's summary on Polychlorinated biphenyls (PCBs). Give them one minute to respond to the prompt: Explain the long-term effects of PCBs in the environment.
2	8.5	**Index Card Summaries/Questions** Show students a diagram of the eutrophication process at the beginning or the end of class. On one side of an index card, have them summarize what they understand about the topic. On the other side, have them write what they don't understand. Address all questions that day or during the next class.
3	8.11	**Ask the Expert (or Students as Experts)** Divide students into groups. Each group will become experts on the major criteria used to determine the steps involved in waste water treatment (primary, secondary, tertiary, etc.). Have them rotate through expert stations to learn about how waste water is treated.

Unit Planning Notes

Use the space below to plan your approach to the unit.

TOPIC 8.1
Sources of Pollution

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.A

Identify differences between point and nonpoint sources of pollution.

ESSENTIAL KNOWLEDGE

STB-3.A.1

A point source refers to a single, identifiable source of a pollutant, such as a smokestack or waste discharge pipe.

STB-3.A.2

Nonpoint sources of pollution are diffused and can therefore be difficult to identify, such as pesticide spraying or urban runoff.

UNIT 8

Aquatic and Terrestrial Pollution

SUGGESTED SKILL

Mathematical Routines

6.B

Apply appropriate mathematical relationships to solve a problem, with work shown (e.g., dimensional analysis).

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- The Exam > **Student Performance Q&A 2015, Q3**
- The Exam > **Samples and Commentary 2015, Q3**

TOPIC 8.2
Human Impacts on Ecosystems

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.B

Describe the impacts of human activities on aquatic ecosystems.

ESSENTIAL KNOWLEDGE

STB-3.B.1

Organisms have a range of tolerance for various pollutants. Organisms have an optimum range for each factor where they can maintain homeostasis. Outside of this range, organisms may experience physiological stress, limited growth, reduced reproduction, and in extreme cases, death.

STB-3.B.2

Coral reefs have been suffering damage due to a variety of factors, including increasing ocean temperature, sediment runoff, and destructive fishing practices.

STB-3.B.3

Oil spills in marine waters cause organisms to die from the hydrocarbons in oil. Oil that floats on the surface of water can coat the feathers of birds and fur of marine mammals. Some components of oil sink to the ocean floor, killing some bottom-dwelling organisms.

STB-3.B.4

Oil that washes up on the beach can have economic consequences on the fishing and tourism industries.

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Aquatic and Terrestrial Pollution

UNIT 8

LEARNING OBJECTIVE

STB-3.B

Describe the impacts of human activities on aquatic ecosystems.

ESSENTIAL KNOWLEDGE

STB-3.B.5

Oceanic dead zones are areas of low oxygen in the world's oceans caused by increased nutrient pollution.

STB-3.B.6

An oxygen sag curve is a plot of dissolved oxygen levels versus the distance from a source of pollution, usually excess nutrients and biological refuse.

STB-3.B.7

Heavy metals used for industry, especially mining and burning of fossil fuels, can reach the groundwater, impacting the drinking water supply.

STB-3.B.8

Litter that reaches aquatic ecosystems, besides being unsightly, can create intestinal blockage and choking hazards for wildlife and introduce toxic substances to the food chain.

STB-3.B.9

Increased sediment in waterways can reduce light infiltration, which can affect primary producers and visual predators. Sediment can also settle, disrupting habitats.

STB-3.B.10

When elemental sources of mercury enter aquatic environments, bacteria in the water convert it to highly toxic methylmercury.

UNIT 8

Aquatic and Terrestrial Pollution

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 8.3
Endocrine Disruptors

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-3.C Describe endocrine disruptors.	**STB-3.C.1** Endocrine disruptors are chemicals that can interfere with the endocrine system of animals.
STB-3.D Describe the effects of endocrine disruptors on ecosystems.	**STB-3.D.1** Endocrine disruptors can lead to birth defects, developmental disorders, and gender imbalances in fish and other species.

TOPIC 8.4

Human Impacts on Wetlands and Mangroves

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.E

Describe the impacts of human activity on wetlands and mangroves.

ESSENTIAL KNOWLEDGE

STB-3.E.1

Wetlands are areas where water covers the soil, either part or all of the time.

STB-3.E.2

Wetlands provide a variety of ecological services, including water purification, flood protection, water filtration, and habitat.

STB-3.E.3

Threats to wetlands and mangroves include commercial development, dam construction, overfishing, and pollutants from agriculture and industrial waste.

SUGGESTED SKILL

Environmental Solutions

7.B

Describe potential responses or approaches to environmental problems.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- The Exam > **Student Performance Q&A 2015, Q1**
- The Exam > **Samples and Commentary 2015, Q1**
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**

UNIT 8

Aquatic and Terrestrial Pollution

SUGGESTED SKILL

Visual Representations

2.C

Explain how environmental concepts and processes represented visually relate to broader environmental issues.

AVAILABLE RESOURCES

- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**

TOPIC 8.5
Eutrophication

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.F

Explain the environmental effects of excessive use of fertilizers and detergents on aquatic ecosystems.

ESSENTIAL KNOWLEDGE

STB-3.F.1

Eutrophication occurs when a body of water is enriched in nutrients.

STB-3.F.2

The increase in nutrients in eutrophic aquatic environments causes an algal bloom. When the algal bloom dies, microbes digest the algae, along with the oxygen in the water, leading to a decrease in the dissolved oxygen levels in the water. The lack of dissolved oxygen can result in large die-offs of fish and other aquatic organisms.

STB-3.F.3

Hypoxic waterways are those bodies of water that are low in dissolved oxygen.

STB-3.F.4

Compared to eutrophic waterways, oligotrophic waterways have very low amounts of nutrients, stable algae populations, and high dissolved oxygen.

STB-3.F.5

Anthropogenic causes of eutrophication are agricultural runoff and wastewater release.

TOPIC 8.6 Thermal Pollution

SUGGESTED SKILL

Concept Explanation

1.C

Explain environmental concepts, processes, or models in applied contexts.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.G

Describe the effects of thermal pollution on aquatic ecosystems.

ESSENTIAL KNOWLEDGE

STB-3.G.1

Thermal pollution occurs when heat released into the water produces negative effects to the organisms in that ecosystem.

STB-3.G.2

Variations in water temperature affect the concentration of dissolved oxygen because warm water does not contain as much oxygen as cold water.

UNIT 8

Aquatic and Terrestrial Pollution

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 8.7
Persistent Organic Pollutants (POPs)

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.H

Describe the effect of persistent organic pollutants (POPs) on ecosystems.

ESSENTIAL KNOWLEDGE

STB-3.H.1

Persistent organic pollutants (POPs) do not easily break down in the environment because they are synthetic, carbon-based molecules (such as DDT and PCBs).

STB-3.H.2

Persistent organic pollutants (POPs) can be toxic to organisms because they are soluble in fat, which allows them to accumulate in organisms' fatty tissues.

STB-3.H.3

Persistent organic pollutants (POPs) can travel over long distances via wind and water before being redeposited.

TOPIC 8.8
Bioaccumulation and Biomagnification

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-3.I Describe bioaccumulation and biomagnification.	STB-3.I.1 Bioaccumulation is the selective absorption and concentration of elements or compounds by cells in a living organism, most commonly fat-soluble compounds. STB-3.I.2 Biomagnification is the increase in concentration of substances per unit of body tissue that occurs in successively higher trophic levels of a food chain or in a food web.
STB-3.J Describe the effects of bioaccumulation and biomagnification.	STB-3.J.1 Some effects that can occur in an ecosystem when a persistent substance is biomagnified in a food chain include eggshell thinning and developmental deformities in top carnivores of the higher trophic levels. STB-3.J.2 Humans also experience harmful effects from biomagnification, including issues with the reproductive, nervous, and circulatory systems. STB-3.J.3 DDT, mercury, and PCBs are substances that bioaccumulate and have significant environmental impacts.

SUGGESTED SKILL

Scientific Experiments

4.A

Identify a testable hypothesis or scientific question for an investigation.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- The Exam > Chief Reader Report (**2018, Q3, 2017, Q1**)
- The Exam > Samples and Commentary (**2018, Q3, 2017, Q1**)
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**

UNIT 8

Aquatic and Terrestrial Pollution

SUGGESTED SKILL

Environmental Solutions

7.D

Use data and evidence to support a potential solution.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- The Exam > Chief Reader Report (**2018, Q3, 2017, Q1**)
- The Exam > Samples and Commentary (**2018, Q3, 2017, Q1**)
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**

TOPIC 8.9
Solid Waste Disposal

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-3.K Describe solid waste disposal methods.	**STB-3.K.1** Solid waste is any discarded material that is not a liquid or gas. It is generated in domestic, industrial, business, and agricultural sectors.
	STB-3.K.2 Solid waste is most often disposed of in landfills. Landfills can contaminate groundwater and release harmful gases.
	STB-3.K.3 Electronic waste, or e-waste, is composed of discarded electronic devices including televisions, cell phones, and computers.
	STB-3.K.4 A sanitary municipal landfill consists of a bottom liner (plastic or clay), a storm water collection system, a leachate collection system, a cap, and a methane collection system.
STB-3.L Describe the effects of solid waste disposal methods.	**STB-3.L.1** Factors in landfill decomposition include the composition of the trash and conditions needed for microbial decomposition of the waste.

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Aquatic and Terrestrial Pollution

UNIT 8

LEARNING OBJECTIVE

STB-3.L

Describe the effects of solid waste disposal methods.

ESSENTIAL KNOWLEDGE

STB-3.L.2

Solid waste can also be disposed of through incineration, where waste is burned at high temperatures. This method significantly reduces the volume of solid waste but releases air pollutants.

STB-3.L.3

Some items are not accepted in sanitary landfills and may be disposed of illegally, leading to environmental problems. One example is used rubber tires, which when left in piles can become breeding grounds for mosquitoes that can spread disease.

STB-3.L.4

Some countries dispose of their waste by dumping it in the ocean. This practice, along with other sources of plastic, has led to large floating islands of trash in the oceans. Additionally, wildlife can become entangled in the waste, as well as ingest it.

UNIT 8

Aquatic and Terrestrial Pollution

SUGGESTED SKILL

Mathematical Routines

6.B

Apply appropriate mathematical relationships to solve a problem, with work shown (e.g., dimensional analysis).

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- The Exam > Chief Reader Report (**2018, Q3, 2017, Q1**)
- The Exam > Samples and Commentary (**2018, Q3, 2017, Q1**)
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**

TOPIC 8.10
Waste Reduction Methods

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.M

Describe changes to current practices that could reduce the amount of generated waste and their associated benefits and drawbacks.

ESSENTIAL KNOWLEDGE

STB-3.M.1

Recycling is a process by which certain solid waste materials are processed and converted into new products.

STB-3.M.2

Recycling is one way to reduce the current global demand on minerals, but this process is energy-intensive and can be costly.

STB-3.M.3

Composting is the process of organic matter such as food scraps, paper, and yard waste decomposing. The product of this decomposition can be used as fertilizer. Drawbacks to composting include odor and rodents.

STB-3.M.4

E-waste can be reduced by recycling and reuse. E-wastes may contain hazardous chemicals, including heavy metals such as lead and mercury, which can leach from landfills into groundwater if they are not disposed of properly.

STB-3.M.5

Landfill mitigation strategies range from burning waste for energy to restoring habitat on former landfills for use as parks.

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Aquatic and Terrestrial Pollution

UNIT 8

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-3.M Describe changes to current practices that could reduce the amount of generated waste and their associated benefits and drawbacks.	STB-3.M.6 The combustion of gases produced from decomposition of organic material in landfills can be used to turn turbines and generate electricity. This process reduces landfill volume.

UNIT 8

Aquatic and Terrestrial Pollution

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of an environmental concept, process, or model represented visually.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- The Exam > **Chief Reader Report 2017, Q1**
- The Exam > **Student Performance Q&A 2014, Q2**
- The Exam > Samples and Commentary (**2017, Q1**, **2014, Q2**)
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**

TOPIC 8.11
Sewage Treatment

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.N

Describe best practices in sewage treatment.

ESSENTIAL KNOWLEDGE

STB-3.N.1

Primary treatment of sewage is the physical removal of large objects, often through the use of screens and grates, followed by the settling of solid waste in the bottom of a tank.

STB-3.N.2

Secondary treatment is a biological process in which bacteria break down organic matter into carbon dioxide and inorganic sludge, which settles in the bottom of a tank. The tank is aerated to increase the rate at which the bacteria break down the organic matter.

STB-3.N.3

Tertiary treatment is the use of ecological or chemical processes to remove any pollutants left in the water after primary and secondary treatment.

STB-3.N.4

Prior to discharge, the treated water is exposed to one or more disinfectants (usually, chlorine, ozone, or UV light) to kill bacteria.

TOPIC 8.12
Lethal Dose 50% (LD_{50})

Required Course Content

ENDURING UNDERSTANDING

EIN-3

Pollutants can have both direct and indirect impacts on the health of organisms, including humans.

LEARNING OBJECTIVE

EIN-3.A

Define lethal dose 50% (LD_{50}).

ESSENTIAL KNOWLEDGE

EIN-3.A.1

Lethal dose 50% (LD_{50}) is the dose of a chemical that is lethal to 50% of the population of a particular species.

SUGGESTED SKILL

Mathematical Routines

6.A

Determine an approach or method aligned with the problem to be solved.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**

UNIT 8

Aquatic and Terrestrial Pollution

SUGGESTED SKILL

Data Analysis

5.E

Explain what the data implies or illustrates about environmental issues.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**

TOPIC 8.13
Dose Response Curve

Required Course Content

ENDURING UNDERSTANDING

EIN-3

Pollutants can have both direct and indirect impacts on the health of organisms, including humans.

LEARNING OBJECTIVE

EIN-3.B

Evaluate dose response curves.

ESSENTIAL KNOWLEDGE

EIN-3.B.1

A dose response curve describes the effect on an organism or mortality rate in a population based on the dose of a particular toxin or drug.

TOPIC 8.14
Pollution and Human Health

Required Course Content

ENDURING UNDERSTANDING

EIN-3

Pollutants can have both direct and indirect impacts on the health of organisms, including humans.

LEARNING OBJECTIVE

EIN-3.C

Identify sources of human health issues that are linked to pollution.

ESSENTIAL KNOWLEDGE

EIN-3.C.1

It can be difficult to establish a cause and effect between pollutants and human health issues because humans experience exposure to a variety of chemicals and pollutants.

EIN-3.C.2

Dysentery is caused by untreated sewage in streams and rivers.

EIN-3.C.3

Mesothelioma is a type of cancer caused mainly by exposure to asbestos.

EIN-3.C.4

Respiratory problems and overall lung function can be impacted by elevated levels of tropospheric ozone.

SUGGESTED SKILL

Scientific Experiments

4.C

Describe an aspect of a research method, design, and/or measure used.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- The Exam > Chief Reader Report (**2018, Q4, 2017, Q1**)
- The Exam > Samples and Commentary (**2018, Q4, 2017, Q1**)
- Classroom Resource > **Quantitative Skills in the AP Sciences (2018)**

UNIT 8

Aquatic and Terrestrial Pollution

SUGGESTED SKILL

Visual Representations

2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 8.15
Pathogens and Infectious Diseases

Required Course Content

ENDURING UNDERSTANDING

EIN-3

Pollutants can have both direct and indirect impacts on the health of organisms, including humans.

LEARNING OBJECTIVE

EIN-3.D

Explain human pathogens and their cycling through the environment.

ESSENTIAL KNOWLEDGE

EIN-3.D.1

Pathogens adapt to take advantage of new opportunities to infect and spread through human populations.

EIN-3.D.2

Specific pathogens can occur in many environments regardless of the appearance of sanitary conditions.

EIN-3.D.3

As equatorial-type climate zones spread north and south in to what are currently subtropical and temperate climate zones, pathogens, infectious diseases, and any associated vectors are spreading into these areas where the disease has not previously been known to occur.

EIN-3.D.4

Poverty-stricken, low-income areas often lack sanitary waste disposal and have contaminated drinking water supplies, leading to havens and opportunities for the spread of infectious diseases.

EIN-3.D.5

Plague is a disease carried by organisms infected with the plague bacteria. It is transferred to humans via the bite of an infected organism or through contact with contaminated fluids or tissues.

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Aquatic and Terrestrial Pollution

UNIT 8

LEARNING OBJECTIVE

EIN-3.D

Explain human pathogens and their cycling through the environment.

ESSENTIAL KNOWLEDGE

EIN-3.D.6
Tuberculosis is a bacterial infection that typically attacks the lungs. It is spread by breathing in the bacteria from the bodily fluids of an infected person.

EIN-3.D.7
Malaria is a parasitic disease caused by bites from infected mosquitoes. It is most often found in sub-Saharan Africa.

EIN-3.D.8
West Nile virus is transmitted to humans via bites from infected mosquitoes.

EIN-3.D.9
Severe acute respiratory syndrome (SARS) is a form of pneumonia. It is transferred by inhaling or touching infected fluids.

EIN-3.D.10
Middle East Respiratory Syndrome (MERS) is a viral respiratory illness that is transferred from animals to humans.

EIN-3.D.11
Zika is a virus caused by bites from infected mosquitoes. It can be transmitted through sexual contact.

EIN-3.D.12
Cholera is a bacterial disease that is contracted from infected water.

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AP ENVIRONMENTAL SCIENCE

UNIT 9

Global Change

15–20%
AP EXAM WEIGHTING

~19–20
CLASS PERIODS

Remember to go to **AP Classroom** to assign students the online **Personal Progress Check** for this unit.

Whether assigned as homework or completed in class, the **Personal Progress Check** provides each student with immediate feedback related to this unit's topics and skills.

Personal Progress Check 9

Multiple-choice: ~25 questions
Free-response: 1 question

- Analyze an environmental problem and propose a solution

UNIT 9 | 15–20% AP EXAM WEIGHTING | ~19–20 CLASS PERIODS

Global Change

BIG IDEA 3
Interactions Between Different Species and the Environment EIN
- Why are laws created to protect endangered species?

BIG IDEA 2
Sustainability STB
- How can local human activities have a global impact?

Building Understanding

A central aspect of environmental science is to understand the global impact of local and regional human activities. Humans can mitigate their impact through sustainable use of resources. Human activities can cause ozone depletion in the stratosphere and increases in the greenhouse gases in the atmosphere. Increases in greenhouse gases can cause human health and environmental problems. These environmental problems include global climate change, ocean warming, and endangered species. Overall, this course provides an opportunity to examine the interrelationships among the natural world and challenges students to evaluate and propose solutions to a variety of environmental problems.

Building the Science Practices

1.A 1.B 1.C 7.A 7.B 7.C 7.D 7.E

In this final unit, the goal is for students to describe and explain global changes in the environment, the causes of these changes, and their consequences. Students can build on their skills from previous units, where they described and evaluated solutions, to propose their own solutions as they learn about problems caused by global changes in the environment. They can practice using data as evidence to support their proposed solution or legislation. Students can also explain how the solution or legislation solves the problem in question.

Preparing for the AP Exam

On the AP Exam, students often struggle with discussing strategies that would prevent extinction. Students are able to identify a strategy, but they are not able to explain how the strategy could be implemented to prevent extinction. Students incorrectly imply that small populations are threatened populations. To combat this, teachers can provide opportunities for students to read multiple sources that allow them to propose realistic solutions that would prevent the extinction of certain species. Students may benefit from opportunities to explain the advantages, disadvantages, or unintended consequences of efforts to prevent extinction.

Students also confuse the terms global climate change and ozone depletion. Teachers can provide multiple opportunities to practice using scientific vocabulary in the proper context in verbal and written explanations of environmental concepts. Diagrams and models that illustrate global climate change can also be helpful. Emphasis can be placed on the effects of global climate change with visual representations of changes over time. Students can then explain how the visual representation illustrates an environmental science concept or process.

UNIT 9

Global Change

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods
			~19–20 CLASS PERIODS
STB-4	9.1 Stratospheric Ozone Depletion	1.A Describe environmental concepts and processes.	
	9.2 Reducing Ozone Depletion	7.B Describe potential responses or approaches to environmental problems.	
	9.3 The Greenhouse Effect	1.B Explain environmental concepts and processes.	
	9.4 Increases in the Greenhouse Gases	2.C Explain how environmental concepts and processes represented visually relate to broader environmental issues.	
	9.5 Global Climate Change	5.D Interpret experimental data and results in relation to a given hypothesis.	
	9.6 Ocean Warming	7.A Describe environmental problems.	
	9.7 Ocean Acidification	1.C Explain environmental concepts, processes, or models in applied contexts.	
EIN-4	9.8 Invasive Species	7.E Make a claim that proposes a solution to an environmental problem in an applied context.	
	9.9 Endangered Species	7.D Use data and evidence to support a potential solution.	
	9.10 Human Impacts on Biodiversity	7.C Describe disadvantages, advantages, or unintended consequences for potential solutions.	
	Go to AP Classroom to assign the **Personal Progress Check** for Unit 9. Review the results in class to identify and address any student misunderstandings.		

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional and are offered to provide possible ways to incorporate various instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 201 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	9.8	**Ask the Expert (or Students as Experts)** Divide students into groups. Each group will become experts on a case study involving a classic invasive species (e.g., zebra mussels, cane toad, and black rats). Then have students rotate through the groups to learn about each invasive species.
2	9.10	**Debate** Provide students with the following scenario: *There is a proposal to construct a new mall. The mall would be located in a 20-acre wetland estuary near a wooded section adjacent to the school.* Divide the class into two teams. One team argues that biodiversity will not be affected by the mall; the other team argues that it will. The debate should focus on the impact of the eliminated waterway.

Unit Planning Notes

Use the space below to plan your approach to the unit.

UNIT 9

Global Change

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- External Source > **GLOBE for the Environmental Science Classroom**

TOPIC 9.1
Stratospheric Ozone Depletion

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.A

Explain the importance of stratospheric ozone to life on Earth.

ESSENTIAL KNOWLEDGE

STB-4.A.1

The stratospheric ozone layer is important to the evolution of life on Earth and the continued health and survival of life on Earth.

STB-4.A.2

Stratospheric ozone depletion is caused by anthropogenic factors, such as chlorofluorocarbons (CFCs), and natural factors, such as the melting of ice crystals in the atmosphere at the beginning of the Antarctic spring.

STB-4.A.3

A decrease in stratospheric ozone increases the UV rays that reach the Earth's surface. Exposure to UV rays can lead to skin cancer and cataracts in humans.

TOPIC 9.2
Reducing Ozone Depletion

SUGGESTED SKILL

Environmental Solutions

7.B

Describe potential responses or approaches to environmental problems.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- External Source > **GLOBE for the Environmental Science Classroom**

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.B

Describe chemicals used to substitute for chlorofluorocarbons (CFCs).

ESSENTIAL KNOWLEDGE

STB-4.B.1

Ozone depletion can be mitigated by replacing ozone-depleting chemicals with substitutes that do not deplete the ozone layer. Hydrofluorocarbons (HFCs) are one such replacement, but some are strong greenhouse gases.

UNIT 9

Global Change

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- External Source > **GLOBE for the Environmental Science Classroom**

TOPIC 9.3
The Greenhouse Effect

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-4.C Identify the greenhouse gases.	**STB-4.C.1** The principal greenhouse gases are carbon dioxide, methane, water vapor, nitrous oxide, and chlorofluorocarbons (CFCs). **STB-4.C.2** While water vapor is a greenhouse gas, it doesn't contribute significantly to global climate change because it has a short residence time in the atmosphere. **STB-4.C.3** The greenhouse effect results in the surface temperature necessary for life on Earth to exist.
STB-4.D Identify the sources and potency of the greenhouse gases.	**STB-4.D.1** Carbon dioxide, which has a global warming potential (GWP) of 1, is used as a reference point for the comparison of different greenhouse gases and their impacts on global climate change. Chlorofluorocarbons (CFCs) have the highest GWP, followed by nitrous oxide, then methane.

Global Change

UNIT 9

TOPIC 9.4
Increases in the Greenhouse Gases

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.E

Identify the threats to human health and the environment posed by an increase in greenhouse gases.

ESSENTIAL KNOWLEDGE

STB-4.E.1

Global climate change, caused by excess greenhouse gases in the atmosphere, can lead to a variety of environmental problems including rising sea levels resulting from melting ice sheets and ocean water expansion, and disease vectors spreading from the tropics toward the poles. These problems can lead to changes in population dynamics and population movements in response.

SUGGESTED SKILL

Visual Representations

2.C

Explain how environmental concepts and processes represented visually relate to broader environmental issues.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- External Source > **GLOBE for the Environmental Science Classroom**

UNIT 9

Global Change

SUGGESTED SKILL

Data Analysis

5.D

Interpret experimental data and results in relation to a given hypothesis.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- External Source > **GLOBE for the Environmental Science Classroom**
- The Exam > **Student Performance Q&A 2014, Q4**
- The Exam > **Samples and Commentary 2014, Q4**

TOPIC 9.5
Global Climate Change

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.F

Explain how changes in climate, both short- and long-term, impact ecosystems.

ESSENTIAL KNOWLEDGE

STB-4.F.1

The Earth has undergone climate change throughout geologic time, with major shifts in global temperatures causing periods of warming and cooling as recorded with CO_2 data and ice cores.

STB-4.F.2

Effects of climate change include rising temperatures, melting permafrost and sea ice, rising sea levels, and displacement of coastal populations.

STB-4.F.3

Marine ecosystems are affected by changes in sea level, some positively, such as in newly created habitats on now-flooded continental shelves, and some negatively, such as deeper communities that may no longer be in the photic zone of seawater.

STB-4.F.4

Winds generated by atmospheric circulation help transport heat throughout the Earth. Climate change may change circulation patterns, as temperature changes may impact Hadley cells and the jet stream.

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Global Change

UNIT 9

LEARNING OBJECTIVE

STB-4.F

Explain how changes in climate, both short- and long-term, impact ecosystems.

ESSENTIAL KNOWLEDGE

STB-4.F.5

Oceanic currents, or the ocean conveyor belt, carry heat throughout the world. When these currents change, it can have a big impact on global climate, especially in coastal regions.

STB-4.F.6

Climate change can affect soil through changes in temperature and rainfall, which can impact soil's viability and potentially increase erosion.

STB-4.F.7

Earth's polar regions are showing faster response times to global climate change because ice and snow in these regions reflect the most energy back out to space, leading to a positive feedback loop.

STB-4.F.8

As the Earth warms, this ice and snow melts, meaning less solar energy is radiated back into space and instead is absorbed by the Earth's surface. This in turn causes more warming of the polar regions.

STB-4.F.9

Global climate change response time in the Arctic is due to positive feedback loops involving melting sea ice and thawing tundra, and the subsequent release of greenhouse gases like methane.

STB-4.F.10

One consequence of the loss of ice and snow in polar regions is the effect on species that depend on the ice for habitat and food.

UNIT 9

Global Change

SUGGESTED SKILL

Environmental Solutions

7.A

Describe environmental problems.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**

TOPIC 9.6
Ocean Warming

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.G

Explain the causes and effects of ocean warming.

ESSENTIAL KNOWLEDGE

STB-4.G.1

Ocean warming is caused by the increase in greenhouse gases in the atmosphere.

STB-4.G.2

Ocean warming can affect marine species in a variety of ways, including loss of habitat, and metabolic and reproductive changes.

STB-4.G.3

Ocean warming is causing coral bleaching, which occurs when the loss of algae within corals cause the corals to bleach white. Some corals recover and some die.

TOPIC 9.7
Ocean Acidification

SUGGESTED SKILL

Concept Explanation

1.C

Explain environmental concepts, processes, or models in applied contexts.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.H

Explain the causes and effects of ocean acidification.

ESSENTIAL KNOWLEDGE

STB-4.H.1

Ocean acidification is the decrease in pH of the oceans, primarily due to increased CO_2 concentrations in the atmosphere, and can be expressed as chemical equations.

STB-4.H.2

As more CO_2 is released into the atmosphere, the oceans, which absorb a large part of that CO_2, become more acidic.

STB-4.H.3

Anthropogenic activities that contribute to ocean acidification are those that lead to increased CO_2 concentrations in the atmosphere: burning of fossil fuels, vehicle emissions, and deforestation.

STB-4.H.4

Ocean acidification damages coral because acidification makes it difficult for them to form shells, due to the loss of calcium carbonate.

UNIT 9

Global Change

SUGGESTED SKILL

Environmental Solutions

7.E

Make a claim that proposes a solution to an environmental problem in an applied context.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 9.8
Invasive Species

Required Course Content

ENDURING UNDERSTANDING

EIN-4

The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact.

LEARNING OBJECTIVE

EIN-4.A

Explain the environmental problems associated with invasive species and strategies to control them.

ESSENTIAL KNOWLEDGE

EIN-4.A.1

Invasive species are species that can live, and sometimes thrive, outside of their normal habitat. Invasive species can sometimes be beneficial, but they are considered invasive when they threaten native species.

EIN-4.A.2

Invasive species are often generalist, r-selected species and therefore may outcompete native species for resources.

EIN-4.A.3

Invasive species can be controlled through a variety of human interventions.

Global Change

UNIT 9

TOPIC 9.9 Endangered Species

Required Course Content

ENDURING UNDERSTANDING

EIN-4

The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact.

LEARNING OBJECTIVE

EIN-4.B

Explain how species become endangered and strategies to combat the problem.

ESSENTIAL KNOWLEDGE

EIN-4.B.1

A variety of factors can lead to a species becoming threatened with extinction, such as being extensively hunted, having limited diet, being outcompeted by invasive species, or having specific and limited habitat requirements.

EIN-4.B.2

Not all species will be in danger of extinction when exposed to the same changes in their ecosystem. Species that are able to adapt to changes in their environment or that are able to move to a new environment are less likely to face extinction.

EIN-4.B.3

Selective pressures are any factors that change the behaviors and fitness of organisms within an environment.

EIN-4.B.4

Species in a given ecosystem compete for resources like territory, food, mates, and habitat, and this competition may lead to endangerment or extinction.

EIN-4.B.5

Strategies to protect animal populations include criminalizing poaching, protecting animal habitats, and legislation.

SUGGESTED SKILL

Environmental Solutions

7.D

Use data and evidence to support a potential solution.

AVAILABLE RESOURCES

- Classroom Resource > **AP Environmental Science Teacher's Guide**
- External Resource > **Environmental Literacy Council's AP Environmental Science Course Material**
- External Resource > **GLOBE for the Environmental Science Classroom**
- The Exam > **Chief Reader Report 2017, Q2**
- The Exam > **Student Performance Q&A 2016, Q1**
- The Exam > Samples and Commentary (**2017, Q2, 2016, Q1**)

UNIT 9

Global Change

SUGGESTED SKILL

Environmental Solutions

7.C

Describe disadvantages, advantages, or unintended consequences for potential solutions.

AVAILABLE RESOURCES

- Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 9.10
Human Impacts on Biodiversity

Required Course Content

ENDURING UNDERSTANDING

EIN-4

The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact.

LEARNING OBJECTIVE

EIN-4.C

Explain how human activities affect biodiversity and strategies to combat the problem.

ESSENTIAL KNOWLEDGE

EIN-4.C.1

HIPPCO (habitat destruction, invasive species, population growth, pollution, climate change, and over exploitation) describes the main factors leading to a decrease in biodiversity.

EIN-4.C.2

Habitat fragmentation occurs when large habitats are broken into smaller, isolated areas. Causes of habitat fragmentation include the construction of roads and pipelines, clearing for agriculture or development, and logging.

EIN-4.C.3

The scale of habitat fragmentation that has an adverse effect on the inhabitants of a given ecosystem will vary from species to species within that ecosystem.

EIN-4.C.4

Global climate change can cause habitat loss via changes in temperature, precipitation, and sea level rise.

EIN-4.C.5

Some organisms have been somewhat or completely domesticated and are now managed for economic returns, such as honeybee colonies and domestic livestock. This domestication can have a negative impact on the biodiversity of that organism.

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Global Change

UNIT 9

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
EIN-4.C Explain how human activities affect biodiversity and strategies to combat the problem.	EIN-4.C.6 Some ways humans can mitigate the impact of loss of biodiversity include creating protected areas, use of habitat corridors, promoting sustainable land use practices, and restoring lost habitats.

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SPRINGFIELD PUBLIC SCHOOLS

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AP ENVIRONMENTAL SCIENCE

Laboratory Investigations



Springfield Public Schools

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Lab Experience

The laboratory experience, when used effectively, should augment students' understanding of content and build skills in the science practices. Teachers are expected to devote 25% of instructional time to lab investigations. Student-directed, inquiry-based lab experiences support the AP Environmental Science course and the AP Course Audit curricular requirements. These experiences also provide opportunities for students to design experiments, collect data, apply mathematical routines and methods, and refine testable explanations and predictions. An inquiry-based approach allows students to develop and use investigations they design based on their own experiences. In conducting lab investigations, students should be encouraged to:

- Generate questions for investigation
- Choose which variables to investigate
- Design and conduct experiments
- Design their own experimental procedures
- Collect, analyze, interpret, and display data
- Determine how to present their conclusions

Lab Manuals

While there is no formal lab manual for the course, many teachers use **Environmental Science Lab and Field Activities** by the Environmental Science Literacy Council as a guide for providing their students practical experiences.

Some textbook publishers may provide a lab manual that is ancillary to the textbook. Most science classroom supply companies also offer lab manuals. Teachers should consider the course audit requirements, student needs, and cost before purchasing or requiring students to purchase a lab manual.

Lab Notebooks and Student Workbooks

Many publishers and science classroom material distributors offer affordable lab notebooks and student workbooks with associated practice problems and solutions. Students can use any type of notebook to fulfill the lab notebook requirement, even an online document. Teachers should consider their own needs and those of their students when deciding what type of lab notebook to use.

Lab Materials

AP Environmental Science is a college-level course, but the equipment and materials needed for the labs are comparable to those required for a high-school-level environmental science course. Most lab manuals provide a list of materials and equipment needed for each laboratory investigation. Teachers should consult their lab manual and calculate how much of a particular substance or material may be needed for the number of students they have before purchasing.

Students will need access to basic lab equipment and glassware (e.g., beakers, petri dishes, rulers, and thermometers). Access to some specialized equipment, such as pH meters, water and soil testing equipment, and aquariums, may be needed to complete some investigations for this course. The use of probes or computer sensors for data collection, which are more expensive tools, is not required, though they can be used if available. It is recommended that teachers have a computer and projector to show computer-based animations and simulations for pre-lab activities. However, a paper-based alternative can easily be provided if the equipment is unavailable. Students may use computers or graphing calculators to analyze data and present their findings, but they do not need to do so.

There are avenues that teachers can explore as a means of obtaining access to more expensive equipment, such as microscopes, test kits, and probes. Chemical companies often have equipment that can be borrowed; company representatives should have this information. Alternatively, local colleges or universities may allow high school students to complete a lab as a field trip on their campus, or they may allow teachers to borrow their equipment. They may even donate their old equipment. Some schools have partnerships with local businesses that can help with lab equipment and materials. There are many grant programs that teachers can apply to for funds to purchase equipment and supplies. Teachers can also utilize online donation sites such as Donors Choose and Adopt-A-Classroom.

Lab Time

It is critical that lab work is an important part of an AP Environmental Science course so that the course is comparable to a college-level course for Environmental Science majors. Data show that increased lab time is correlated with higher AP scores. Flexible or modular scheduling may be implemented in order to meet the time requirements for lab and field experiences. At a minimum, one double period a week may be needed to allow adequate time for authentic lab experiences.

Recommended Experiments

The AP Environmental Science Exam directly assesses the learning objectives of the course framework, which means the inclusion of appropriate experiments aligned with those learning objectives is important for student success. Selecting experiments that provide students with the broadest lab experience possible is important when designing the course.

Upon completion of the environmental science lab program, students should be able to describe how to collect data, use data to form conclusions, and apply their conclusions to larger environmental concepts. Students should report recorded data and quantitative conclusions drawn from the data with appropriate precision. Students should also develop an understanding of how changes in the design of the experiments would impact the validity and accuracy of their results. Many questions on the AP Exam are written in an experimental context, so these skills will prove invaluable for both concept comprehension and exam performance.

How to Set Up a Lab Program

Getting Students Started

There are no prescriptive "steps" to the iterative process of inquiry-based investigations. However, there are some common characteristics of inquiry that will support students in designing their investigations. Often, this simply begins with using the learning objectives to craft a question for students to investigate. Teachers may choose to give students a list of materials they are allowed to use in their experimental design or require that students request the equipment they feel they need to investigate the question. Working with learning objectives to craft questions may include the following:

- Selecting learning objectives from the course framework that relate to the subject currently under study, and which may set forth specific tasks, in the form of "Design an experiment to "
- Rephrasing or refining the learning objectives that align to the unit of study to create an inquiry-based investigation for students

Students should be given latitude to make design modifications or ask for additional equipment appropriate for their design. It is also helpful for individual groups to share with the class their basic design to elicit feedback on feasibility. During labs, students are encouraged to proceed independently, receiving only minor guidance from the teacher by the end of the course. Students should have many opportunities for post-lab reporting to share the successes and challenges of individual lab designs.

Students need instruction and multiple opportunities for practice with laboratory tools and techniques so that they can become more proficient investigators. Teachers can ensure that students understand how to choose an instrument that will help them gather the observations or measurements required to answer a question. They can also ensure that students know how to properly record, organize, display, and interpret the measurements made via the chosen instrument in order to support a conclusion or claim pertaining to a particular question. If access to instrumentation is a challenge, online and local university resources may be available.

Prior to performing lab experiments and field experiences, teachers can provide meaning and purpose for these activities by giving students the opportunity to practice lab skills and scientific thinking. Pre-lab work that is acknowledged/checked can help determine what gaps students may have prior to engagement with the lab. Modeling lab skills and procedures is sometimes necessary for students to have a successful lab experience.

At the conclusion of each experiment, students should compose a lab report for which they receive feedback. It is important to identify and address gaps in skills or lab procedures. Conducting post-lab discussions is an excellent strategy to ensure that students are mastering laboratory and inquiry techniques and skills. These discussions also help students connect the lab investigation to the big ideas.

The lab, as well as pre- and post-lab work, should be extensions of student learning in the classroom rather than discrete activities. Teachers can design pre-lab exercises and discussions that prepare students for each laboratory experience and then follow up each investigation with a post-lab discussion to debrief procedures, errors, conclusions, and so forth. Teachers can also test students' understanding of environmental science concepts by asking them "what if" questions, like, "Predict what will happen if ", or "What should the next experiment be if "

Observations and Data Manipulation

Students should practice making careful observations and accurately recording what they observe. Too frequently students confuse what they see with what they think they are supposed to see. They should be encouraged to be accurate reporters, even when their findings seem to conflict with what they are led to expect by the textbook or lab procedure. Proper interpretation of observations is also important. Students should be able to find evidence of change (growth, color change, temperature change, gas evolution, etc.) and its absence. Students should know how to make and interpret quantitative measurements correctly. This includes knowing the appropriate instrument for making the measurement.

Teachers should emphasize analysis and interpretation of quantitative data represented, for example, line and bar graphs and dose response curves that will allow students to make connections between the raw data

they obtain from their investigations and the ways they communicate their results. Students should be able to evaluate whether the data are graphed correctly and appropriately for the investigation that was conducted. It is important to consistently assess students' understanding and skill with all aspects of creating a graph including correct scaling and units.

Communication and Group Collaboration

Lab work is an excellent means through which students can develop and practice communication skills. Success in subsequent work in the field of environmental science depends heavily on an ability to communicate about observations, ideas, and conclusions. Working in a truly collaborative manner to plan and execute experiments will help students learn oral communication skills and practice teamwork. Students should be encouraged to take individual responsibility for the success or failure of the collaboration.

After students are given a question for investigation, they may report their findings to their teacher and/or their peers for feedback. Students should be encouraged to critique and challenge one another's claims based on the evidence collected during the investigation.

Lab Safety

A successful AP Environmental Science lab program will instill in each student a lifelong "safety sense" that will ensure their safe transition into more advanced work in college or university labs or into the industrial workplace environment. It is important that certain concerns regarding lab safety be addressed in every environmental science course, including the following:

- All facilities should conform to federal, state, and local laws and guidelines pertaining to the safety of students and instructors.
- Teachers with a limited background in environmental science should receive additional safety training specific to environmental science labs before teaching AP Environmental Science.
- Lab experiments and demonstrations should not be carried out if they could expose students to unnecessary risks or hazards.
- Students should be fully informed of potential lab hazards relating to chemicals and equipment before performing specific experiments.
- Storage and disposal of hazardous chemicals must be done in accordance with local regulations and policies. Teachers and students should know what these regulations are.

Basic laboratory safety instruction should be an integral part of each lab experience. Topics that should be covered include the following:

- Simple first aid for cuts and thermal and chemical burns
- Use of safety goggles, eye washes, body showers, fire blankets, and fire extinguishers
- Safe handling of glassware, hot plates, burners and other heating devices, and electrical equipment
- Proper interpretation of material safety data sheets (MSDS) and hazard warning labels
- Proper use and reuse practices (including proper labeling of interim containers) for reagent bottles



SPRINGFIELD PUBLIC SCHOOLS

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AP ENVIRONMENTAL SCIENCE

Instructional Approaches



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Selecting and Using Course Materials

Textbooks

The AP Environmental Science course requires the use of a college-level textbook. It is important to select a textbook that covers the content in the course framework. Regardless of the textbook chosen, teachers can supplement it with other primary and secondary sources. Additionally, the textbook should provide multiple opportunities for student practice with data analysis in varying contexts. Ideally, the textbook will use sufficient examples and approaches that enable students to make connections across different domains within environmental science and between environmental science and other social and natural sciences.

College Board provides a **list of sample textbooks** that teachers may consult to help determine whether a text is considered acceptable in meeting the AP Environmental Science Course Audit curricular requirements. Lab materials are also essential for AP Environmental Science and are detailed starting on page 197.

Primary Sources

Many teachers augment their courses with journal articles and/or abstracts from scientific literature. While an increasing number of textbooks include primary source material, it is important to introduce students to a wide variety of materials in order to provide opportunities to analyze data from diverse sources. These sources should include data tables, charts, graphs, and diagrams. Teachers may also use ancillary materials and online resources that accompany recently published textbooks to find quality materials to supplement classroom instruction.

ENVIRONMENTAL LEGISLATION

The AP Environmental Science course requires that students have an understanding of 10 pieces of legislation and environmental policies. There are many environmental policies and legislation that are important to the field of environmental science, including those that protect animals and regulate clean water, clean air, and food sources. It is critical for students to understand the impact of these policies and legislation and why they are necessary. Understanding of legislation and policies should focus on how they were created as solutions to environmental problems.

The 10 required pieces of legislation and policy for AP Environmental Science are listed on page 26.

Guided Inquiry in AP Environmental Science

The process of following an experimental procedure to confirm a known outcome can build basic laboratory skills; however, authentic inquiry allows students opportunities to develop and refine higher-order scientific thinking skills. Inquiry skills are built through gradual release in lessons (scaffolding levels). Creating opportunities for open-ended (inquiry-based) laboratory exercises allows students to formulate questions, troubleshoot problems, and make appropriate adjustments. The National Research Council (2000) advises that students are engaged in inquiry when they:

- Are engaged with scientifically oriented questions.
- Give priority to evidence.
- Formulate evidence-based explanations.
- Compare and evaluate the merit of explanations.
- Communicate and justify explanations.

The four levels of inquiry, according to *The Nature of Scientific Enquiry,* are as follows:

1. **Confirmation:** Students confirm a principle through an activity in which the results are known in advance.
2. **Structured Inquiry:** Students investigate a teacher-presented question through a prescribed procedure.
3. **Guided Inquiry:** Students investigate a teacher-presented question using student-designed/selected procedures.
4. **Open Inquiry:** Students investigate topic-related questions that are student formulated through student-designed/selected procedures.[1]

For each level of inquiry, see the table below for whether a question, procedure, and/or solution should be provided by the teacher or generated by students.

Level of Inquiry	Question	Procedure	Solution
Level 1: Confirmation	Provided	Provided	Provided
Level 2: Structured Inquiry	Provided	Provided	Student generated
Level 3: Guided Inquiry	Provided	Student generated	Student generated
Level 4: Open Inquiry	Student generated	Student generated	Student generated

1 Marshall D. Herron. (1971, February). "The Nature of Scientific Enquiry." *The School Review* 79(2), 171–212.

Instructional Strategies

The AP Environmental Science course framework outlines the concepts and skills students need to master to be successful on the AP Exam. In order to address those concepts and skills effectively, it helps to incorporate a variety of instructional approaches into daily lessons and activities. The following table presents strategies that can help students apply their understanding of course concepts.

Strategy	Definition	Purpose	Example
Ask the Expert (or Students as Experts)	Students are assigned as "experts" on problems they have mastered; groups rotate through the expert stations to learn about problems they have not yet mastered.	Provides opportunities for students to share their knowledge and learn from one another.	Assign students as "experts" on environmental legislation. Have students rotate through stations in groups, working with the station expert to complete a series of questions on the topic.
Construct an Argument	Students use scientific reasoning to present assumptions about biological situations, support conjectures with scientifically relevant and accurate data, and provide a logical progression of ideas leading to a conclusion that makes sense.	Helps develop the process of evaluating scientific information, developing reasoning skills, and enhancing communication skills in supporting conjectures and conclusions.	Present students with a written or visual scenario of the results of a laboratory investigation and then have them work together to draw conclusions about scientific investigations. They can support their conclusions with data by having each student or group of students add a sentence to the conclusion. Once the conclusion is complete, read it (or show it on a screen) and then facilitate a class discussion.
Debate	Engaging in an informal or formal argumentation of an issue.	Provides an opportunity for students to collect and orally present evidence supporting the affirmative and negative arguments of a proposition or issue.	Have students debate realistic solutions to environmental problems. This can be more meaningful for students if the problem selected is specific to the school and students have the opportunity to present their solutions to school administrators.

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Strategy	Definition	Purpose	Example
Error Analysis	Students analyze an existing solution to determine whether (or where) errors have occurred.	Allows students to troubleshoot errors and focus on solutions that may arise when they do the same procedures themselves.	Have students analyze their work to determine whether their answer is realistic. For example, if they are working on an energy calculation, they can't end up with more energy than they started with.
Fishbowl	Some students form an inner circle and model appropriate discussion techniques, while an outer circle of students listens, responds, and evaluates.	Provides students with an opportunity to engage in a formal discussion and to experience the roles of both participant and active listener; students also have the responsibility of supporting their opinions and responses using specific evidence.	Divide students into two groups and ask them to form two concentric circles. The inner circle can explain ecosystem services to the students in the outer circle, and the outer circle can explain ecological services to students in the inner circle. The circles rotate to enable students to share their knowledge and learn to communicate with their peers.
Graph and Switch	Generating a graph to represent data and then switch papers to review each other's representations.	Allows students to practice creating different representations of data and both give and receive feedback on each other's work.	Give students a data table and ask them to graph the data. Then have them switch papers and offer one another feedback on whether they graphed the data appropriately. This can be scaffolded by distributing multiple data tables that require different types of graphs.
Idea Spinner	The teacher creates a spinner marked into four quadrants and labeled "Predict," "Explain," "Summarize," and "Evaluate." After new material is presented, the teacher spins the spinner and asks students to answer a question based on the location of the spinner. For example, if the spinner lands in the "Summarize" quadrant, the teacher might say, "List the key concepts just presented."	Functions as a formative assessment technique.	Present students with a written or visual scenario of the results of a laboratory investigation. Using the spinner, ask students to predict what would happen if one of the experimental conditions changed, explain the results, summarize the results, and evaluate the methods used.

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Strategy	Definition	Purpose	Example
Index Card Summaries/ Questions	Periodically, distribute index cards and ask students to write on both sides, with these instructions: (Side 1) Based on our study of (unit topic), list a big idea that you understand and word it as a summary statement. (Side 2) Identify something about (unit topic) that you do not yet fully understand and word it as a statement or question.	Functions as a formative assessment technique.	At the beginning or end of class, show students an image of food chains or food webs. On one side of an index card, have students summarize energy flow through ecosystems. On the other side, have them write a question they have about the topic. Collect the cards and read through them, noting any trends in student responses. Address all questions that day (if done at the beginning of class) or the next day (if given at the end of class).
Misconception Check	Present students with common or predictable misconceptions about a designated concept, principle, or process. Ask them whether they agree or disagree and to explain why. The misconception check can also be presented in the form of a multiple-choice or true or false quiz.	Functions as a formative assessment technique.	Provide students with a statement on the board, or on paper, such as, "Climate change and ozone depletion are the same." Ask them whether the statement is true or false and then ask them to explain their reasoning. Address any misconceptions according to the answers they give.
One-Minute Essay	A one-minute essay question (or a one-minute question) is a focused question with a specific goal that can, in fact, be answered within a minute or two.	Functions as a formative assessment technique.	Give students one minute to respond to a prompt, such as, "Explain the relationship between photosynthesis at the cellular level and environmental carbon cycling."
Quickwrite	Writing for a short, specific amount of time about a designated topic related to a text.	Helps students generate multiple ideas in a quick fashion that could be turned into longer pieces of writing at a later time (may be considered as part of the drafting process).	Prior to teaching about endangered species, ask students to take a few minutes to explain whether the Endangered Species Act is necessary. At the conclusion of the lesson, students can revisit their answer and revise it to reflect what they learned.

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Strategy	Definition	Purpose	Example
Think–Pair–Share	Considering and thinking about a topic or question and then writing what has been learned; pairing with a peer or a small group to share ideas; and sharing ideas and discussion with a larger group.	Helps students to construct meaning about a topic or question; test thinking in relation to the ideas of others; and prepare for a discussion with a larger group.	When engaging students in a post-lab discussion, have students reflect on their analysis of the data by asking them, "What is the relationship between the dependent variable and the independent variable?" After 1–2 minutes of reflection, have students turn to a neighbor and share their answer. After 2–3 minutes of sharing, engage the class in a whole-group discussion to ensure that students are building the necessary foundational understandings.

Developing the Science Practices

Throughout the course, students will develop science practices that are fundamental to the discipline of environmental science.

The tables that follow provide sample activities and instructional strategies for incorporating the individual skills into the course.

Science Practice 1: Explain environmental concepts, processes, and models presented in written format

The ability to use verbal and/or written explanations that describe environmental processes is an important learning outcome of the AP Environmental Science course. It is important to make clear the distinction between memorizing details and demonstrating an integrated understanding of how a concept or process connects to the overall function of the environment. Students should have a deep enough understanding of the overall processes to predict the effect of environmental changes on those processes and justify their prediction.

Science Practice 1: *Concept Explanation*

Skill	Tasks/Questions	Sample Activity	Instructional Strategies
1.A. *Describe environmental concepts and/or processes.*	▪ Describe characteristics, attributes, traits, and elements in defining terms and concepts. ▪ Classify concepts. ▪ Describe the components of a process. ▪ Describe how a process occurs. ▪ Describe structures and functions. ▪ Describe patterns and/or trends.	To teach predator–prey relationships, use the lynx and snowshoe hare activity. Use tape to form a 12×12 square and put three hare cards inside the square. Throw the lynx card into the square and remove any hare card that the lynx card touches (captures). Repeat for several throws (generations), keeping track of the lynx the hares have eaten and the hares remaining in a data table. Then have students graph the data of the population totals and answer analysis questions.	Misconception Check

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Science Practice 1: *Concept Explanation (cont'd)*

Skill	Tasks/Questions	Sample Activity	Instructional Strategies
1.B. *Explain environmental concepts and/or processes.*	▪ Explain characteristics, attributes, traits, and elements in defining terms and concepts. ▪ Explain concepts. ▪ Explain the relationship between components of a process. ▪ Explain how a process occurs. ▪ Explain the relationship between structures and functions.	Give students tables containing monthly precipitation and temperature data for various cities for one year, without revealing the names of the cities. Students then graph both sets of data on the same graph for each city. Ask the students to guess the city based on the data.	One-Minute Essay
1.C. *Explain environmental concepts, processes, and/or models in applied contexts.*	▪ Explain how natural selection explains biodiversity. ▪ Explain the relationship between photosynthesis at the cellular level and environmental carbon cycling. ▪ Explain the relationship between biomass generation and climate change. ▪ Explain competition and cooperation from in populations. ▪ Explain how birth and death rates change as a country develops from a pre-industrial to an industrial economic system.	Use the **Watershed Assessment lab** to study a 100-meter length of a nearby stream. Have students test water pollutants and soil macronutrients using test kits. Also have them conduct soil surveys and learn to read quadrangle maps. After collecting data for several months, have students use their data to explain changes in the watershed.	Think–Pair–Share

Science Practice 2: Analyze visual representations of environmental concepts and processes

Visual representations are tools for learning and exploring scientific concepts and ideas. Examples of visual representations include, but are not limited to, biogeochemical cycles, food chains, food webs, trophic levels, wastewater treatment, integrated pest management, mining, maps, and soil composition diagrams.

Science Practice 2: *Visual Representations*

Skill	Tasks/Questions	Sample Activity	Instructional Strategies
2.A. *Describe characteristics of an environmental concept, process, or model represented visually.*	▪ Describe the characteristics of a representation. ▪ Describe patterns or trends in the representation.	Have students draw a food chain or food web on a poster. Students can be divided into groups to draw food chains or webs for specific biomes. Groups can switch posters and then describe energy flow through the different ecosystems.	Index Card Summaries/ Questions
2.B. *Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:* • *In theoretical contexts.* • *In applied contexts.*	▪ Compare patterns and/or trends in a representation. ▪ Explain the concept the model is representing. ▪ Predict patterns and/ or trends based on a representation.	Using a graph or other visual data representations of experimental results, have students describe the relationship between the independent and the dependent variables. Data can be obtained from experiments that students perform in class.	Ask the Expert (or Students as Experts)
2.C. *Explain how environmental concepts and processes represented visually relate to broader environmental issues.*	▪ Draw a conclusion based upon the environmental principles or concepts in the model or representation.	Assign students to use a diagram/map/model to represent plate boundaries and locations of plate boundaries. Give students a map of the earth and have them draw earthquake data from usgs.gov, as well as mountain ranges and volcanoes.	One-Minute Essay

Science Practice 3: Analyze sources of information about environmental issues

Reading and analyzing information from a text is an important skill for students to master in the AP Environmental Science course. Considering the volume of information available on the internet, it is important that students can evaluate the validity and credibility of written text in order to make informed decisions about the solutions for environmental problems.

Science Practice 3: *Text Analysis*

Skill	Tasks/Questions	Sample Activity	Instructional Strategies
3.A. *Identify the author's claim.*	▪ State the author's main point.	Have students collect articles about current environmental issues. For each article, have them state the main point. Divide students into groups to share articles and discuss the claims of each article.	Misconception Check
3.B. *Describe the author's perspective and assumptions.*	▪ Describe the author's perspective. ▪ Describe the author's assumptions.	Have students collect articles about current environmental issues. For each article, have them describe the author's perspective and assumptions.	Quickwrite
3.C. *Describe the author's reasoning (use of evidence to support a claim).*	▪ Describe the evidence that supports the author's claim.	Provide students with an article to read from a scientific journal. Have them identify the claims made in the article and describe the evidence that supports the claim. Divide students into teams to debate their arguments.	Debate
3.D. *Evaluate the credibility of a source:* • *Recognize bias* • *Scientific accuracy*	▪ Describe the bias that the author may have. ▪ Describe factors that may affect the accuracy of the source.	Provide students with an article to read from an online source such as Science Daily. After reading the article, have students reflect on any biases the author may have and describe factors that may be influencing the accuracy of the article. Have them discuss their thoughts with a partner then participate in a class discussion.	Think–Pair–Share

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Science Practice 3: *Text Analysis (cont'd)*

Skill	Tasks/Questions	Sample Activity	Instructional Strategies
3.E. *Evaluate the validity of conclusions of a source or research study.*	▪ Describe the limitations of the investigation and its conclusions.	Provide students with an article to read from a scientific journal about a research study. Give students one minute to describe the conclusions of the research study and the limitations of the investigation.	One-Minute Essay

Science Practice 4: Analyze research studies that test environmental principles

The table that follows provides examples of tasks, activities, and suggested strategies for helping students to develop the skills involved in research analysis.

Science Practice 4: *Scientific Experiments*

Skill	Tasks/Questions	Sample Activity	Instructional Strategies
4.A. *Identify a testable hypothesis or scientific question for an investigation.*	▪ Pose, refine, and evaluate scientific questions about natural phenomena.	Provide students with an article from a scientific journal. Ask them to identify the hypothesis being tested in the experiment described in the article.	Misconception Check
4.B. *Identify a research method, design, and/or measure used.*	▪ Identify the dependent variables in an experiment. ▪ Identify the independent variable in an experiment. ▪ Identify the control group and the experimental groups. ▪ Justify the control group. ▪ Identify the environmental factors that must be controlled.	Have students design an experiment to test a hypothesis about an observation. They should identify needed controls and supplies and equipment from a given list of resources. As part of their design, they should develop or follow an experimental protocol to collect data. Once their experiment is complete, have them analyze their data and draw conclusions from the results of their investigation.	Think–Pair–Share
4.C. *Describe an aspect of a research method, design, and/or measure used.*	▪ Describe the variables in an experiment. ▪ Describe the environmental factors that must be controlled. ▪ Describe the data collection method(s).	Provide students with an article from a scientific journal. Ask them to describe how the data were collected, including in their description of the experimental variables, as well as other variables that were controlled during data collection (e.g., using the same thermometer for all temperature measurements).	Debate
4.D. *Make observations or collect data from laboratory setups.*	▪ Make observations from representations of laboratory setups or results. ▪ Collect data from representations of laboratory setups or results.	Provide students with a diagram, photograph, or demonstration of a lab setup. Ask them to collect the data from the setup.	Index Card Summaries/ Questions

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Science Practice 4: *Scientific Experiments (cont'd)*

Skill	Tasks/Questions	Sample Activity	Instructional Strategies
4.E. *Explain modifications to an experimental procedure that will alter results.*	▪ Evaluate and refine scientific questions about natural phenomena and investigate answers through experimentation, research, and information gathering and discussion.	After performing an experiment or participating in a field experience, have students identify possible sources of error in an experimental procedure and revise the protocol to obtain more valid results. Then have students propose a related experiment to gain new information in their lab reports.	Fishbowl

Science Practice 5: Analyze and interpret quantitative data represented in tables, charts, and graphs

Students should be able to analyze data collected from an experimental procedure or from a given source to determine whether the data support or do not support a conclusion or hypothesis. They should be able to construct a graph based on the collected data and use the graph to formulate statements, conclusions, and possibly a hypothesis. Alternatively, students can draw conclusions from a provided data set. Students should also assess the validity of experimental evidence.

Science Practice 5: *Data Analysis*

Skill	Tasks/Questions	Sample Activity	Instructional Strategies
5.A. *Describe patterns or trends in data.*	▪ Look at visual representations of data over time of data (e.g., earthquake data and fertility rates).	Have students draw a storyboard on how a natural disruption like an earthquake affects the environment.	Think–Pair–Share
5.B. *Describe relationships among variables in data represented.*	▪ Describe how the dependent variable changes in response to the independent variable.	Provide students with a graph of data where there is a relationship between changes in the environment and the way that organisms adapt (i.e , if the temperature changes, how does the animal survive) and ask them to describe the relationship.	Graph and Switch
5.C. *Explain patterns and trends in data to draw conclusions.*	▪ Explain why the dependent variable changes in response to the independent variable.	Have students **download smog data** from their local area over a period of years. Have them graph their data and then explain how the air changes over time (i.e., January vs. July).	Think–Pair–Share
5.D. *Interpret experimental data and results in relation to a given hypothesis.*	▪ Explain why the dependent variable responded the way it did to the independent variable.	Provide students with data on global climate change. Divide students into groups and have them debate the effects of rising temperatures on the environment.	Debate
5.E. *Explain what the data implies or illustrates about environmental issues.*	▪ Make a prediction using the data and then justify the prediction. ▪ Given data and a prediction, justify the prediction.	Have students conduct an LD_{50} lab with radish seeds. Then ask them to use their data to create an LD_{50} curve and then make and justify predictions about the effect of the treatment on the organism.	Idea Spinner

Science Practice 6: Apply quantitative methods to address environmental concepts

The table that follows provides examples of questions, activities, and suggested strategies for helping students to develop the skills involved in the application of quantitative methods.

Science Practice 6: *Mathematical Routines*

Skill	Tasks/Questions	Sample Activity	Instructional Strategies
6.A. *Determine an approach or method aligned with the problem to be solved.*	▪ Explain the best way to calculate a quantity such as LD_{50}.	Have students conduct an LD_{50} lab with radish seeds. Then ask them to use their data to create an LD_{50} curve which can be used to calculate the lethal dose of the drug used in the experiment.	Error Analysis
6.B. *Apply appropriate mathematical relationships to solve a problem, with work shown (e.g., dimensional analysis).*	▪ Calculate amount or percentage of population growth.	Provide students with data on population growth. Have students graph their data then calculate how much the population grew (birth rate—death rate, and % population growth)	Graph and Switch
6.C. *Calculate an accurate numeric answer with appropriate units.*	▪ Calculate how much energy is lost or consumed; include units in the final answer.	Provide students with a diagram of a food chain or food web. The diagram should indicate how much energy originally enters the ecosystem from the sun. Using the 10% rule, have students calculate how much energy is transferred from one trophic level to another, including units.	Index Card Summaries/ Questions

Science Practice 7: Propose and justify solutions to environmental problems

Students should be able to write and evaluate scientific descriptions, explanations, and theories that describe environmental phenomena and processes. They should also be able to call upon current knowledge and historical experiments and draw inferences from their explorations to justify claims with evidence. In addition, the ability to analyze, interpret, and make predictions from a model or the data obtained in an experiment is essential, as is the ability to justify the reasoning for a prediction and/or an explanation. It is also important that they be able to evaluate the merits of alternative scientific explanations or conclusions.

Science Practice 7: *Environmental Solutions*

Skill	Tasks/Questions	Sample Activity	Instructional Strategies
7.A. *Describe environmental problems.*	▪ Describe when human population is a problem.	Have students watch a featured clip from the documentary, **New Frontiers, Engineering the Golden Age of Green**. Then ask them to explain the impacts of using renewable and nonrenewable sources of energy.	Index Card Summaries/ Questions
7.B. *Describe potential responses or approaches to environmental problems.*	▪ Describe the impacts of human activities.	Teach students about urbanization in a short lecture. Ask students to conduct their own research about urbanization and then have them discuss with one another the impacts of urbanization on environmental processes such as the hydrological cycle.	Fishbowl
7.C. *Describe disadvantages, advantages, or unintended consequences for potential solutions.*	▪ Analyze whether or not a solution is realistic.	Have students analyze the state of recycling at their school. Then have them do research to propose solutions to current problems. Students can present their findings to school administrators for consideration and then volunteer to assist in the implementation of their ideas.	Construct an Argument

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Science Practice 7: *Environmental Solutions (cont'd)*

Skill	Tasks/Questions	Sample Activity	Instructional Strategies
7.D. *Use data and evidence to support a potential solution.*	▪ Are all solutions viable? Why or why not? What data support the solution? ▪ Propose a solution based in data gathered over a period of time.	Have students research solutions for controlling pest species. Then have them debate how the evidence in the articles they read supports the proposed solutions. Questions could include the following: Are GMOs that are resistant to pests better than spraying non-GMO plants with pesticides? Is organic better than non-organic?	Debate
7.E. *Make a claim that proposes a solution to an environmental problem in an applied context.*	▪ Propose a solution for sustainable agriculture.	Have students perform a copper mining lab to extract copper from copper ore. Based on their observations and the data, have them discuss the environmental problems caused by mining and propose solutions to said problems.	Quickwrite
7.F. *Justify a proposed solution, by explaining potential advantages.*	▪ Explain the advantages of renewable and nonrenewable energy sources.	Have students research alternative vehicle energy sources so that they learn the difference between electric cars and cars that run on gasoline. Then have them debate the pros and cons of buying one over the other.	One-Minute Essay

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AP ENVIRONMENTAL SCIENCE

Exam Information



Springfield Public Schools

ENGAGING STUDENTS • FOSTERING ACHIEVEMENT • CULTIVATING 21ST CENTURY GLOBAL SKILLS

Exam Overview

The AP Environmental Science Exam assesses student understanding of the science practices and learning objectives outlined in the course framework. The exam is 2 hours and 40 minutes long and includes 80 multiple-choice questions and 3 free-response questions. A four-function, scientific, or graphing calculator is allowed on both sections of the exam. The details of the exam, including exam weighting and timing, can be found below:

Section	Question Type	Number of Questions	Exam Weighting	Timing
I	Multiple-choice questions	80	60%	90 minutes
II	Free-response questions	3	40%	70 minutes
	Question 1: Design an investigation (10 points)			
	Question 2: Analyze an environmental problem and propose a solution (10 points)			
	Question 3: Analyze an environmental problem and propose a solution doing calculations (10 points)			

The exams assess content from the four big ideas of the course.
Big Idea 1: Energy Transfer
Big Idea 2: Interactions between Earth systems
Big Idea 3: Interactions between different species and the environment
Big Idea 4: Sustainability

The multiple-choice section of the exam assesses the nine units of the course with the following exam weighting:

Units	Exam Weighting
Unit 1: The Living World: Ecosystems	**6–8%**
Unit 2: The Living World: Biodiversity	**6–8%**
Unit 3: Populations	**10–15%**
Unit 4: Earth Systems and Resources	**10–15%**
Unit 5: Land and Water Use	**10–15%**
Unit 6: Energy Resources and Consumption	**10–15%**
Unit 7: Atmospheric Pollution	**7–10%**
Unit 8: Aquatic and Terrestrial Pollution	**7–10%**
Unit 9: Global Change	**15–20%**

How Student Learning Is Assessed on the AP Exam

The AP Environmental Science practices are assessed on the AP Exam as detailed below.

Science Practice	Multiple-Choice Section Exam Weighting	Free-Response Section Exam Weighting
Practice 1: Concept Explanation	**30–38%**	**13–20%**
Practice 2: Visual Representations	**12–19%**	**6–10%**
Practice 3: Text Analysis	**6–8%**	Practice 3 is not explicitly assessed in the free-response section.
Practice 4: Scientific Experiments	**2–4%**	**10–14%**
Practice 5: Data Analysis	**12–19%**	**6–10%**
Practice 6: Mathematical Routines	**6–9%**	**20%**
Practice 7: Environmental Solutions	**17–23%**	**26–34%**

Section I: Multiple-Choice

The multiple-choice section includes both individual and set-based questions. All set-based questions include stimulus material:

- Three to four sets include quantitative data, such as data tables, charts, or graphs. These questions primarily assess Practice 5, but can also assess Practices 1, 4, 6, or 7.
- Three to four sets include qualitative data or information, such as models, representations, or maps. These questions primarily assess Practice 2, but can also assess Practices 1, 4, or 7.
- Two sets include text-based sources. These questions primarily assess Practice 3, but can also assess Practices 1, 6, or 7.

Section II: Free-Response

The second section of the AP Environmental Science Exam includes three free-response questions.

FREE-RESPONSE QUESTION 1

Design an investigation presents students with an authentic environmental scenario accompanied by either a model/visual representation or quantitative data, and may assess student ability to:

- Describe and/or explain environmental concepts, processes, and models presented in written format (Practice 1).
- Analyze visual representations or data (Practice 2 and/or 5).
- Analyze research studies that test environmental principles (Practice 4).
- Describe environmental problems and/or potential responses (Practice 7).

FREE-RESPONSE QUESTION 2

Analyze an environmental problem and propose a solution presents students with an authentic environmental scenario accompanied by either a model/visual representation or quantitative data, and may assess student ability to:

- Describe and/or explain environmental concepts, processes, and models presented in written format (Practice 1).
- Analyze visual representations or data (Practice 2 and/or 5).
- Propose and justify solutions to environmental problems (Practice 7).

FREE-RESPONSE QUESTION 3

Analyze an environmental problem and propose a solution doing calculations presents students with an authentic environmental scenario and may assess student ability to:

- Describe or environmental concepts, processes, and models presented in written format (Practice 1).
- Apply quantitative methods to address environmental concepts (Practice 6).
- Propose and justify solutions to environmental problems (Practice 7).

Task Verbs Used in Free-Response Questions

The following task verbs are commonly used in the free-response questions:

Calculate: Perform mathematical steps to arrive at a final answer, including algebraic expressions, properly substituted numbers, and correct labeling of units. Showing work is required.

Describe: Provide the relevant characteristics of a specified topic.

Explain: Provide information about how or why a relationship, process, pattern, position, situation, or outcome occurs, using evidence and/or reasoning to support or qualify a claim. Explain "how" typically requires analyzing the relationship, process, pattern, position, situation, or outcome; whereas, explain "why" typically requires analysis of motivations or reasons for the relationship, process, pattern, position, situation, or outcome. Also phrased as "give one reason."

Identify: Indicate or provide information about a specified topic, without elaboration or explanation.

Justify: Provide evidence to support, qualify, or defend a claim and/or provide reasoning to explain how that evidence supports or qualifies the claim.

Make a claim: Make an assertion that is based on evidence or knowledge.

Propose a solution: Provide a proposed solution to a problem based on evidence or knowledge.

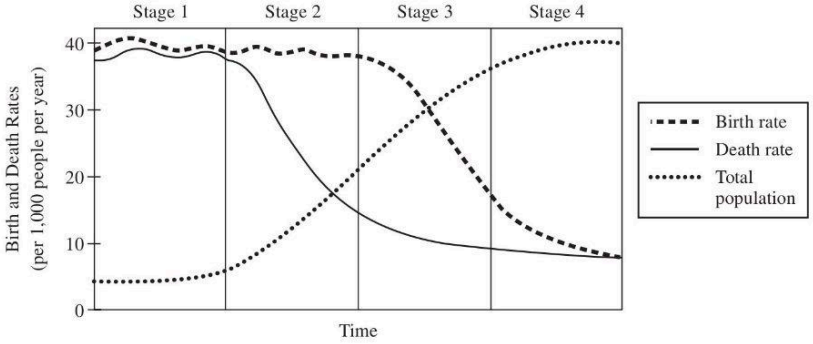
Sample Exam Questions

The sample exam questions that follow illustrate the relationship between the course framework and AP Environmental Science Exam and serve as examples of the types of questions that appear on the exam. After the sample questions is a table that shows which skill, learning objective(s), and unit each question relates to. The table also provides the answers to the multiple-choice questions.

Section I: Multiple-Choice

The following are examples of the kinds of multiple-choice questions found on the exam.

1. Which of the following best describes a country in stage 2 of the demographic transition, based on the model shown below?



(A) Birth and death rates are both high, and the population is experiencing a slow rate of increase.

(B) Birth and death rates are both low, and the population is stable.

(C) Birth rates are high and death rates are declining, and the population is increasing rapidly.

(D) Birth rates are low and death rates are high, and the population is declining rapidly.

2. Which of the following is a nonanthropogenic source of carbon dioxide emissions into the atmosphere?

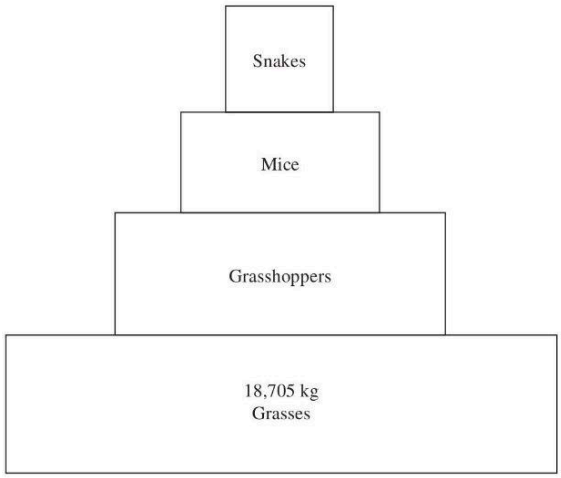
(A) Cellular respiration

(B) Photosynthesis

(C) A coal-fired power plant

(D) A hydrogen-powered car

Questions 3 and 4 refer to the diagram below of a biomass pyramid in a grassland ecosystem.



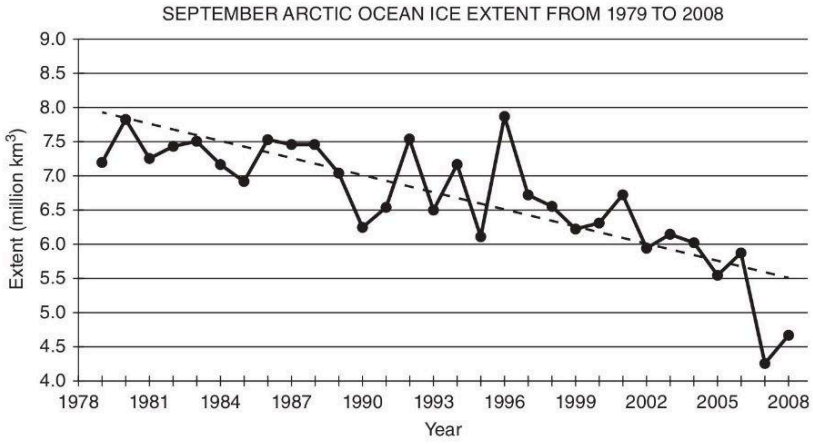
3. Based on the diagram, which group of organisms would be considered herbivores?
   (A) Snakes
   (B) Mice
   (C) Grasshoppers
   (D) Grasses

4. Based on the laws of thermodynamics, which of the following is the applied mathematical routine used to estimate the biomass of the mice in the pyramid?
   (A) 18,705 kg × 10
   (B) 18,705 kg/10 × 100
   (C) 18,705 kg × 0.10 × 0.10
   (D) 18,705 kg/0.10

5. Scientists are interested in determining the impact of the construction of a hydroelectric dam on a population of salmon that live downstream of a populated area. They measure the health of the salmon population in its current state, several years after the dam was constructed. Which of the following would be the best to use as a control in this study?
   (A) The health of the salmon population in the river before humans lived in the area
   (B) The health of the salmon population at the apex of the dam's construction
   (C) The health of the salmon population just after the dam's construction was completed
   (D) The health of the salmon population prior to any dam construction

6. Which of the following describes a component of a modern sanitary landfill?
   (A) A series of screens and grates to prevent large objects from entering the landfill
   (B) A bottom liner of plastic or clay to prevent groundwater contamination
   (C) Aerated tanks in which bacteria break down organic matter
   (D) Chemical or ultraviolet light systems that kill pathogens

Questions 7 and 8 refer to the graph below.



7. Based on the data in the graph, by approximately what percent did the sea ice decrease from 1980 to 2005?
   (A) 10%
   (B) 30%
   (C) 50%
   (D) 70%

8. Which of the following is the most likely consequence of the trend for the change in sea ice shown in the graph, creating a positive feedback loop in the Arctic?
   (A) Increasing albedo and increasing absorption of heat by the ocean
   (B) Increasing albedo and decreasing absorption of heat by the ocean
   (C) Decreasing albedo and increasing absorption of heat by the ocean
   (D) Decreasing albedo and decreasing absorption of heat by the ocean

9. Which of the following is a disadvantage associated with the genetic modification of crops?
   (A) Genetically modified crops have a decreased resistance to drought.
   (B) Genetically modified crops have a shorter shelf life and are more difficult to transport long distances.
   (C) Genetically modifications can decrease the genetic diversity of crop species.
   (D) Genetic modifications decrease nutritional content in foods.

10. The table below shows volcano and earthquake data for four countries that are approximately equal in size.

Country	Number of active volcanoes	Number of earthquakes ≥ magnitude 5 since 1900
Country A	0	0
Country B	4	0
Country C	0	18
Country D	16	41

Based on the data in the table, which of the countries is most likely located at a subduction zone between an oceanic tectonic plate and a continental tectonic plate?

(A) Country A

(B) Country B

(C) Country C

(D) Country D

Questions 11–13 refer to the information below.

The Chernobyl nuclear disaster led to the release of massive radiation, specifically iodine-131 and cesium-137, which has been connected to a variety of environmental problems in the 30 years following the disaster.

11. A meltdown in which of the following structures at a nuclear power plant, such as Chernobyl, would most likely lead to the accidental release of radiation?

(A) Cooling tower

(B) Turbine

(C) Generator

(D) Reactor core

12. Which of the following best describes the process of electricity generation at a nuclear power plant?

(A) Nuclear power is generated through fission, which releases a large amount of heat. The heat is used to generate steam, which turns a turbine that powers a generator.

(B) Nuclear power is generated when photons are converted to a direct current using a semiconducting material such as silicon. An inverter is used to convert the direct-current electricity into an alternating current.

(C) Nuclear power is generated from the thermal energy of Earth, which is a result of radioactive decay. The water underground is turned to steam, which turns a turbine to produce electricity.

(D) Nuclear power is generated from the combustion of mined uranium, which provides enough heat to power a generator. The generator turns a turbine to create electricity.

13. A soil sample near Chernobyl was found to contain 187 kBq/m^2 of cesium-137. If the half-life of cesium-137 is approximately 30 years, how much cesium-137 will remain in the sample after 90 years?

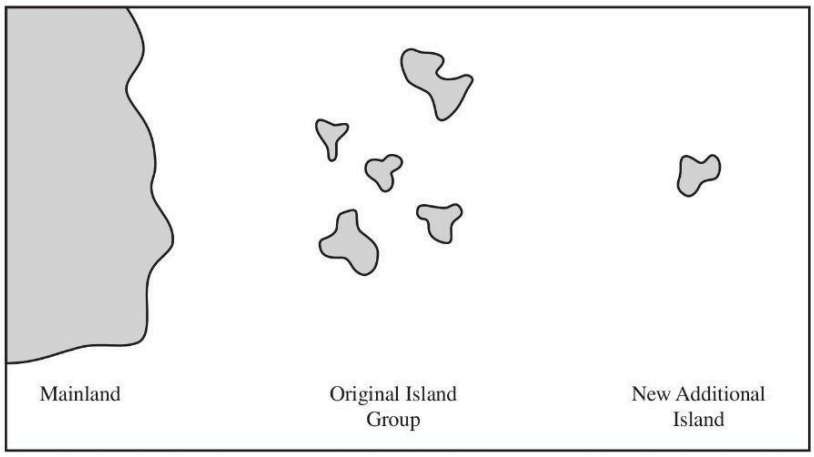
(A) 93.50 kBq/m^2

(B) 23.38 kBq/m^2

(C) 6.23 kBq/m^2

(D) 1.58 kBq/m^2

14. Scientists are interested in determining the average number of species that have migrated from the mainland to a group of islands, as shown below. Partway through their study, they decided to include an additional island in their study group.



Based on the theory of island biogeography, which of the following best explains how the scientists' calculation of average number of species would change with the inclusion of this new island in their study?

(A) The average would increase because more species would have migrated directly to the farther island.

(B) The average would decrease because fewer species would have migrated directly to the farther island.

(C) The average would not change because it is likely that the additional island has about the same number of species that migrated as the original island group.

(D) The average would not change because the island is approximately the same size as those in the original group and therefore just as likely to recruit species from the mainland.

15. During an El Niño event, warm surface water moves from the western equatorial Pacific Ocean to the eastern equatorial region. Which of the following best describes how the warm water will affect upwelling off the coast of equatorial South America?

(A) The warm surface water will not change upwelling because this region is at the equator and always has warm water.

(B) The warm surface water will increase upwelling because of the difference in salinity between the warm surface water and the cold deep water.

(C) The warm surface water will decrease upwelling because the cooler temperatures on land in the region will prevent upwelling.

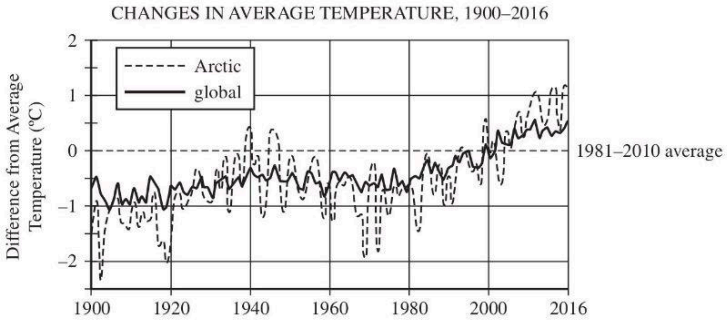
(D) The warm surface water will decrease upwelling because of the density difference between the warm surface water and the cold deep water.

Section II: Free-Response

The following are examples of the kinds of free-response questions found on the exam. Note that on the actual AP Exam, there are three free-response questions.

ANALYZE AN ENVIRONMENTAL PROBLEM AND PROPOSE A SOLUTION (FREE-RESPONSE QUESTION 2)

The graph below shows temperature anomalies from 1900 to 2016 globally and in the Arctic.



(a) Refer to the graph above to answer the following questions.

i. Based on the data in the graph, **identify** the change in the difference from average temperature in the Arctic between 1980 and 2016.

ii. **Describe** the difference in the change in temperatures in the Arctic with the change in global temperatures from 2000 to 2016.

(b) The cause of the temperature trend seen in the map is a result of increasing concentrations of greenhouse gases in the atmosphere.

i. **Identify** a greenhouse gas that has a global warming potential (GWP) that is greater than 1.

ii. **Identify** an anthropogenic source that contributes to greenhouse gas emissions.

iii. **Explain** how increasing amounts of greenhouse gases in the atmosphere are linked to a change in pH of the ocean.

(c) Greenhouse gases can pose threats to both human health and the environment.

i. **Describe** TWO impacts that global climate change can have on human health.

ii. **Describe** one effect global climate change can have on marine organisms.

(d) In order to reduce the effect of greenhouse gases on ecosystems, greenhouse gas emissions must be reduced.

i. **Propose** one realistic solution to reduce greenhouse gas emissions.

ii. **Justify** how the solution posed in (d)(i) would lead to a decrease in greenhouse gas emissions.

ANALYZE AN ENVIRONMENTAL PROBLEM AND PROPOSE A SOLUTION DOING CALCULATIONS (FREE-RESPONSE QUESTION 3)

An individual has decided to convert a grassy area on property to a large garden in order to grow food, primarily vegetables. The garden measures 50 meters in length by 7 meters in width.

(a) **Describe** one environmental advantage of producing food locally.

(b) Vegetable production in the garden was less than expected for the season.

i. **Identify** one soil property that affects crop production.

ii. The gardener applied a synthetic fertilizer to the garden for the next growing season. **Describe** one benefit of using synthetic fertilizer in the garden.

iii. A neighbor proposes using compost rather than a synthetic fertilizer on the garden, stating that composting is a more sustainable agricultural practice. **Justify** this claim.

(c) The gardener finds a synthetic fertilizer with 34% nitrogen and a recommended application rate of 1 kg of nitrogen per 70.0 square meters. **Calculate** the number of kilograms of synthetic nitrogen fertilizer that should be spread on the garden area. **Show** your work.

(d) The gardener also finds a local compost source with 2.5% nitrogen. **Calculate** the number of kilograms of compost that would need to be added to the garden to provide as much nitrogen as using the synthetic fertilizer. **Show** your work.

(e) The price of a kilogram of synthetic fertilizer is $3.11, while the price of a kilogram of compost is $0.04. **Calculate** the savings to provide 1 kg of nitrogen per 70 square meters using compost rather than nitrogen. **Show** your work.

Answer Key and Question Alignment to Course Framework

Multiple-Choice Question	Answer	Skill	Learning Objective	Unit
1	C	2.B	EIN-1.D	3
2	A	1.A	STB-2.D	7
3	C	2.B	ENG-1.B	1
4	C	6.A	ENG-1.C	1
5	D	4.C	ERT-2.H	2
6	B	1.B	STB-3.K	8
7	B	6.C	STB-4.F	9
8	C	5.E	STB-4.F	9
9	C	7.C	EIN-2.G	5
10	D	5.B	ERT-4.A	4
11	D	1.C	ENG-3.H	6
12	A	1.C	ENG-3.G	6
13	B	6.C	ENG-3.H	6
14	B	4.E	ERT-2.D	2
15	D	7.A	ENG-2.C	4

Free-Response Question	Question Type	Skill	Learning Objective	Unit
2	Analyze an Environmental Problem and Propose a Solution	1.A, 1.B, 5.A, 5.B, 7.A, 7.E, 7.F	STB-1.A, STB-3.M, ERT-4.C, EIN-2.D	4, 5, 8
3	Analyze an Environmental Problem and Propose a Solution Doing Calculations	1.A, 6.B, 6.C, 7.C, 7.F	STB-4.D, STB-4.E, STB-4.F, STB-4.G, STB-4.H	9

The scoring information for the questions within this course and exam description, along with further exam resources, can be found on the **AP Environmental Science Exam Page** on AP Central.

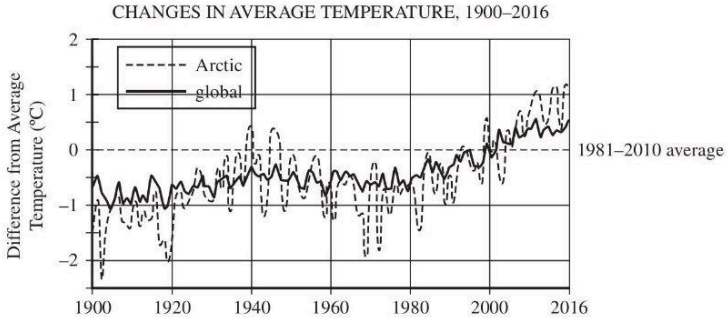
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AP ENVIRONMENTAL SCIENCE

Scoring Guidelines

Question 2: Analyze an Environmental Problem and Propose a Solution

The graph below shows temperature anomalies from 1900 to 2016 globally and in the Arctic.



(a) Refer to the graph above to answer the following questions.

i. Based on the data in the graph, **identify** the change in the difference from average temperature in the Arctic between 1980 and 2016.

ii. **Describe** the difference in the change in temperatures in the Arctic with the change in global temperatures from 2000 to 2016.

(b) The cause of the temperature trend seen in the map is a result of increasing concentrations of greenhouse gases in the atmosphere.

i. **Identify** a greenhouse gas that has a global warming potential (GWP) that is greater than 1.

ii. **Identify** an anthropogenic source that contributes to greenhouse gas emissions.

iii. **Explain** how increasing amounts of greenhouse gases in the atmosphere are linked to a change in pH of the ocean.

(c) Greenhouse gases can pose threats to both human health and the environment.

i. **Describe** TWO impacts that global climate change can have on human health.

ii. **Describe** one effect global climate change can have on marine organisms.

(d) In order to reduce the effect of greenhouse gases on ecosystems, greenhouse gas emissions must be reduced.

i. **Propose** one realistic solution to reduce greenhouse gas emissions.

ii. **Justify** how the solution posed in (d)(i) would lead to a decrease in greenhouse gas emissions.

Scoring Guidelines for Question 2: Analyze an Environmental Problem and Propose a Solution — 10 points

Learning Objectives: STB-4.D STB-4.E STB-4.F STB-4.G STB-4.H

General Scoring Note

When scoring questions with multiple correct answers, only score the first response given.

(a) i. Based on the data in the graph, **identify** the change in the difference from average temperature in the Arctic between 1980 and 2016. — **1 point** — 5.A — STB-4.F

- Increased 1.5 degrees C

ii. **Describe** the difference in the change in temperatures in the Arctic with the change in global temperatures from 2000 to 2016. — **1 point** — 5.B — STB-4.F

- The temperature is increasing/warming faster/at a greater rate in the Arctic.

Total for part (a) — **2 points**

(b) i. **Identify** a greenhouse gas that has a global warming potential (GWP) that is greater than 1. — **1 point** — 1.A — STB-4.D

Accept one of the following:

- Chlorofluorocarbons (CFCs)/Hydrofluorocarbons (HFCs)
- Methane (CH_4)
- Nitrous Oxide (N_2O)

ii. **Identify** an anthropogenic source that contributes to greenhouse gas emissions. — **1 point** — 1.A — STB-4.D

Accept one of the following:

- Burning of fossil fuels
- Deforestation/Land use changes
- Livestock fermentation (methane release) and waste management
- Use of CFCs in products such as refrigeration systems, air conditioners, and manufacturing
- Use of fertilizer

iii. **Explain** how increasing amounts of greenhouse gases in the atmosphere are linked to a change in pH of the ocean. — **1 point** — 5.C — STB-4.H

- Increased global temperature leads to increased ocean acidification because more CO_2 is absorbed by ocean waters which decreases the pH of the ocean water.

Total for part (b) — **3 points**

continued on next page

(c) **i. Describe** TWO impacts that global climate change can have on human health. **2 points**

7.A

STB-4.E

One point each for the following (max 2):

- Increase in spread of vector diseases as habitat moves from tropics to poles.
- Increase in algal blooms and waterborne diseases from increased water temperature.
- Increase in exposure to extreme heat and cold/increase risk of illness and death from exposure to increased extreme temperatures.
- Increase in chronic conditions (cardiovascular disease, respiratory disease, etc.) from prolonged exposure to temperature extremes.
- Decrease in air quality leading to increased respiratory and cardiovascular diseases (i.e. asthma)
- Decreased water quality leading to contact with contaminated drinking water/water used for recreation/water used for sanitation
- Decreased food security/disruption to available food/disruption to access to food.

ii. Describe one effect global climate change can have on marine organisms. **1 point**

7.A

STB-4.G

Accept one of the following:

- Ocean warming can lead to loss of habitat for marine species.
- Ocean warming can alter metabolic rates (increase) for marine species.
- Ocean warming can alter reproductive rates and sex ratios in certain species.
- Ocean warming can cause coral bleaching/loss of algae within corals
- Ocean warming may cause organisms, such as fish, to migrate toward the poles where water is cooler.

Total for part (c) **3 points**

(d) **i. Propose** one realistic solution to reduce greenhouse gas emissions. **1 point**

7.E

STB-4.H

Accept one of the following:

- Use more energy efficient vehicles/decrease driving distances
- Decrease electricity use to decrease reliance on fossil fuels
- Use less heat/less air conditioning to reduce amount of energy to heat/cool home.
- Switch from fossil fuel generated electricity to electricity generated from renewable sources
- Harvest methane from landfills for energy generation
- Sequester carbon through planting vegetation/reinjection
- Decrease use of plastics/fertilizers/products that require fossil fuels for production
- Decrease purchasing of products with plastic packaging
- Reduce meat consumption/switch to a vegetarian or vegan diet

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ii. Justify how the solution posed in (d)(i) would lead to a decrease in greenhouse gas emissions. **1 point**

7.F

STB-4.H

Accept any of the following justifications.

Solution proposed in (d)(i)	Justification of how solutions will reduce greenhouse gas emissions
Use more energy efficient vehicles/decrease driving distances.	• Using more energy efficient vehicles or decreasing driving distances will decrease the amount of fossil fuels burned, which will decrease the amount of greenhouse gases, such as carbon dioxide, released into the atmosphere
Use less heat/less air conditioning to reduce amount of energy to heat/ cool home.	• Decreasing the use of electric heat/air conditioning will decrease the amount of fossil fuels burned for electricity generation, which will decrease the amount of greenhouse gases, such as carbon dioxide, released into the atmosphere
Decrease electricity use to decrease reliance on fossil fuels.	• Decreasing the use of electricity used will decrease the amount of fossil fuels burned for electricity generation, which will decrease the amount of greenhouse gases, such as carbon dioxide, released into the atmosphere
Switch from fossil fuel generated electricity to electricity generated from renewable sources	• Renewable sources, such as solar or wind power, do not release greenhouse gases. Switching energy source will decrease the amount of fossil fuels burned, which will decrease the amount of greenhouse gases, such as carbon dioxide, released into the atmosphere
Harvest methane from landfills for energy generation	• The methane gas released from landfills can be collected and used for energy generation, which reduces the amount of methane released to the atmosphere
Sequester carbon through planting vegetation/ reinjection	• Trees and other plans absorb carbon dioxide through photosynthesis which will decrease the amount of carbon dioxide in the atmosphere. • Greenhouse gases, such as carbon dioxide and hydrogen sulfide, can be captured and injected into geothermal reservoirs, reducing the amount of greenhouse gases in the atmosphere.
Decrease use of plastics/ fertilizers/products that require fossil fuels for production	• Products such as plastics and fertilizers are made using fossil fuels so reducing in purchasing these products will decrease the demand for fossil fuels in production, which decreases the amount of greenhouse gases released into the atmosphere. • Plastics releases several greenhouse gases as they degrade. Purchasing fewer plastics will decrease the amount of plastics in landfills and decrease the release of greenhouse gases into the atmosphere during degradation.
Decrease purchasing of products with plastic packaging	• Plastics releases several greenhouse gases as they degrade. Purchasing fewer plastics will decrease the amount of plastics in landfills and decrease the release of greenhouse gases into the atmosphere during degradation.
Reduce meat consumption/ switch to a vegetarian or vegan diet	• Raising livestock produce large amounts of greenhouse gas emissions, specifically methane (from gut fermentation). Decomposition of manure from these operations also releases large amounts of CO_2 and/or methane so a reduction in meat consumption or switching to a vegetarian or vegan diet could significantly reduce the amount of greenhouse gasses emitted into the atmosphere.

Total for part (d) **2 points**

Total for question 2 **10 points**

Question 3: Analyze an Environmental Problem and Propose a Solution Doing Calculations

An individual has decided to convert a grassy area on property to a large garden in order to grow food, primarily vegetables. The garden measures 50 meters in length by 7 meters in width.

(a) **Describe** one environmental advantage of producing food locally.

(b) Vegetable production in the garden was less than expected for the season.

i. **Identify** one soil property that affects crop production.

ii. The gardener applied a synthetic fertilizer to the garden for the next growing season. **Describe** one benefit of using synthetic fertilizer in the garden.

iii. A neighbor proposes using compost rather than a synthetic fertilizer on the garden, stating that composting is a more sustainable agricultural practice. **Justify** this claim.

(c) The gardener finds a synthetic fertilizer with 34% nitrogen and a recommended application rate of 1 kg of nitrogen per 70.0 square meters. **Calculate** the number of kilograms of synthetic nitrogen fertilizer that should be spread on the garden area. **Show** your work.

(d) The gardener also finds a local compost source with 2.5% nitrogen. **Calculate** the number of kilograms of compost that would need to be added to the garden to provide as much nitrogen as using the synthetic fertilizer. **Show** your work.

(e) The price of a kilogram of synthetic fertilizer is $3.11, while the price of a kilogram of compost is $0.04. **Calculate** the savings to provide 1 kg of nitrogen per 70 square meters using compost rather than nitrogen. **Show** your work.

Scoring Guidelines for Question 3: Analyze an Environmental Problem and Propose a Solution Doing Calculations — 5 points

Learning Objectives: STB-1.A STB-3.M ERT-4.C EIN-2.D

(a) **Describe** one environmental advantage of producing food locally. — **1 point** (7.C, STB-1.A)

Accept one of the following:

- reduced atmospheric CO_2 emissions from fewer trucks transporting food
- reduced fossil fuel consumption from fewer trucks transporting food
- increased genetic diversity of crops/increased biodiversity
- ability to improve soil quality and nutrients
- increased food security

Total for part (a) — **1 point**

(b) **i. Identify** one soil property that affects crop production. — **1 point** (1.A, ERT-4.C)

Accept one of the following:

- Soil texture
- Organic matter content
- pH
- Water holding capacity

ii. Describe one benefit of using synthetic fertilizer in the garden. — **1 point** (7.C, EIN-2.D)

Accept one of the following:

- The nutrients in synthetic fertilizers are readily available and can be taken up by the plant in a short period of time (days, not weeks).
- Synthetic fertilizers are formulated to have a certain ratio of nutrients, so only the limited nutrient(s) can be added to the soil.
- Synthetic fertilizers are inexpensive and easily available

iii. A neighbor proposes using compost, rather than a synthetic fertilizer on the garden, stating that composting is a more sustainable agricultural practice. **Justify** this claim. — **1 point** (7.F, STB-3.M)

Accept one of the following:

- Production of synthetic fertilizer production requires the burning of fossil fuels and composting does not
- Compost maintains soil porosity, which limits runoff and synthetic fertilizers do not
- Compost reduces the amount of waste generated by using food scraps, paper, and yard wastes to create the organic fertilizer.
- Composting reduces the amount of atmospheric methane since there is less food waste decomposing in landfills
- Compost can be produced on site and does not require transportation (less CO_2, less fossil fuel combustion)

Total for part (b) — **3 points**

continued on next page

(c) **Calculate** the number of kilograms of synthetic nitrogen fertilizer that should be spread on the garden area. **Show** your work. **2 points**

6.B
6.C
EIN-2.D

One point for correct setup to calculate the number of kg of synthetic N fertilizer

- Garden area = 50 m x 7 m = 350 m^2

$$350\ m^2 \times \frac{1\ kg}{70\ m^2}$$

One point for the correct calculation of the number of kg of synthetic N fertilizer

- Fertilizer amount = 5.0 kg

Total for part (c) **2 points**

(d) **Calculate** the number of kilograms of compost that would need to be added to the garden to provide as much nitrogen as using the synthetic fertilizer. **Show** your work. **2 points**

6.B
6.C
EIN-2.D

One point for the correct setup to calculate the number of kg of compost

- $5\ kg\ fertilizer \times \frac{0.34\ N}{1\ kg\ fertilizer} \times \frac{1\ kg\ compost}{0.025\ N}$ OR $\frac{0.34\ N\ in\ fertilizer}{0.025\ N\ in\ compost} \times 5.0\ kg\ fertilizer$

One point for the correct calculation of the number of kg of compost

- Compost amount = 68 kg

Total for part (d) **2 points**

(e) **Calculate** the savings to provide 1 kg of nitrogen per 70 square meters using compost rather than nitrogen. **Show** your work. **2 points**

6.B
6.C
EIN-2.D

One point for the correct setup to calculate the amount of savings

- Price of synthetic fertilizer = $\frac{\$3.11}{kg\ fertilizer} \times 5\ kg\ fertilizer = \$15.55$

One point for the correct calculation of the amount of savings

- Price of compost = $\frac{\$0.04}{kg\ compost} \times 68\ kg\ compost = \$2.72$

Difference in cost: $\$15.55 - \$2.72 = \$12.83\ per\ kg$

NOTE: If the student did not correctly calculate part (c) and/or part (d), the response for part (e) can earn points if the incorrect values were used correctly in the equations in part (e).

Total for part (e) **2 points**

Total for question 3 **10 points**

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