

AP ENVIRONMENTAL SCIENCE



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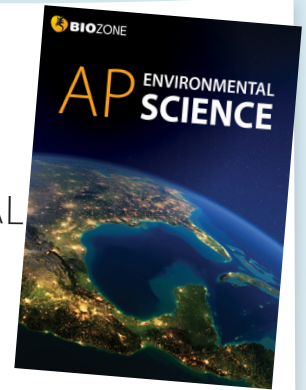
FREE phone: 1-855-246-4555

FREE fax: 1-855-935-3555

Email: sales@thebiozone.com

Web: www.thebiozone.com

FAQs ABOUT AP ENVIRONMENTAL SCIENCE



How is the book structured?	CG3
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The Structure of the Book

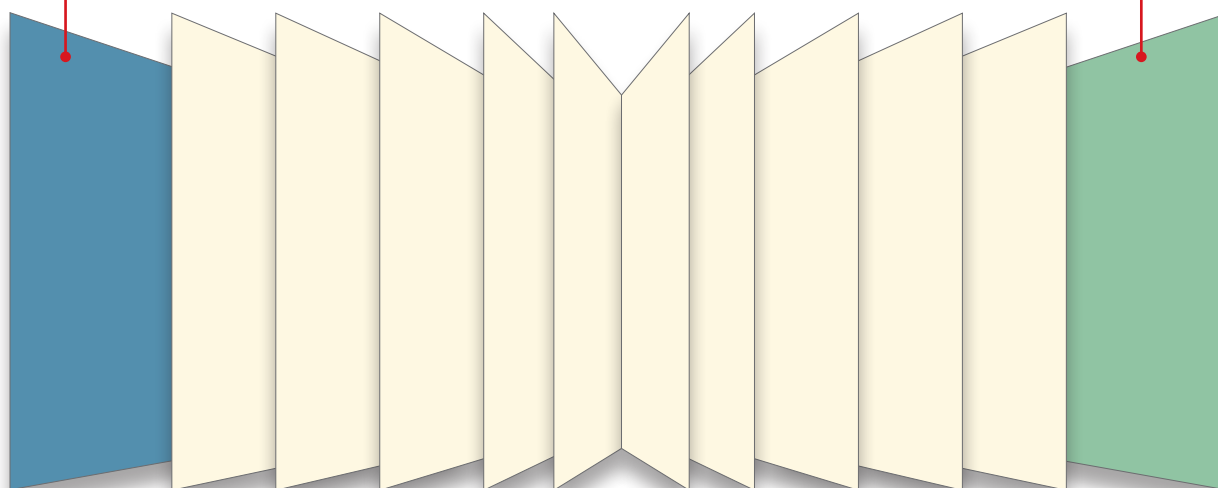
The content of the *AP Environmental Science* is organized into 10 chapters. The first nine chapters are based on the units of study described in the *AP Environmental Science Course and Exam Description* (CED). The final chapter, *Science Practices for Environmental Science*, has been designed to provide support for each of the science practices identified in the CED. They can review or practice key skills and science practices before applying them to the activities in each of the units.

The structure of the book helps teachers apply the instructional model of plan, teach, and assess:

- Unit introductions summarize the key content, skills, and learning outcomes for each unit, providing a checklist for students and a record of progress for teachers. See more about these on page CG6.
- Activities make up the bulk of each chapter. The activities have been designed so that by the end of the program the students have covered the required content knowledge and skills specified in the *AP Environmental Science* CED. Activities have been designed to be engaging, informative, and (where appropriate) challenging. Data, annotated diagrams, and photographs, provide much of the information in context, and there are many topical and interesting case studies (e.g. the effect of the Covid-19 pandemic on air quality). The student's understanding of the information is evaluated through questions and/or tasks involving data handling and interpretation.
- Chapters 1-9 each conclude with a Personal Progress Check (PPC) to assess student understanding. These comprise both multiple choice free response questions.

Unit introduction

Personal Progress Check



Activity pages

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24 **VANISHING INSECTS: Why does biodiversity matter?**

Although they must often seem abundant to us, insect populations globally are in trouble. More than 40% of insect species are declining and a third are endangered, just as concerning as this loss of diversity is the loss of insect biomass, which is falling by an estimated 2.5% a year.

The cascading effect of insect loss threatens food chains globally. The causes are many and cumulative and include climate change, use of pesticides, and habitat loss.

A pair of blue tits may collect 100 insects a day to feed one chick.

The winter moth caterpillar is an invasive species in the US but provides abundant food for birds.

The larvae of ground beetles on leaf on agave and other tall-topped insect shells.

FIVE CRUCIAL INSECT ROLES

Insects have a central role in the ecosystem services humans rely on for survival. The decline in the numbers and diversity of insects has serious consequences for a sustainable future.

What may happen without insects:

2. (a) Describe the primary cause of the current lack of genetic diversity in modern seed oiler populations:

(b) Describe the likely reason for the low genetic diversity in the California population:

(c) How might this be related to more recent declines in the California population:

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Insect declines: how they're tracking

Species in the five major insect orders (above) have all declined in recent decades. Of the 2000 species tracked by the IUCN almost half are declining. These 2000 species represent just a tiny proportion of total insect biodiversity. Even with today's technological advancement, only 25% of insects species are even identified. We will not even know if they are lost.

Insect Order	% of species declining	% of species stable	% of species increasing
Dragonflies & damselflies	57	71	
Butterflies and moths	58	63	
Bees, wasps, & ants	42	57	
Beetles	61	37	
Greenhoppers & crickets	85	12	

DECOMPOSERS

Insects that feed on wastes and dead material, such as dung, carrion, and dead plants, have an important role in nutrient cycles. Their activities release nutrients that would otherwise remain locked up for a considerable time.

Waste material would be recycled more slowly, disrupting nutrient cycling.

POLLINATORS

Around 75% of crops benefit from insect pollination even if they do not completely depend on it. As the production of pollinator-dependent crops increases, so too does our dependence on insect pollinators, which are declining.

Crops may reproduce poorly and some key food sources may be lost.

SOIL ENGINEERS

Termites and ants are an essential part of soil and ecosystems. Their activities aerate hard ground, adding nutrients, improving soil structure, and allowing water to penetrate. They have even been used to rehabilitate regions affected by desertification.

Soils in arid regions may become barren, leading to crop failure and desertification.

One female colony can excavate 0.2 metres of soil per year.

3. Using insects as an example, explain the importance of biodiversity to ecosystem function and to human wellbeing:

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The AP Instructional Model

BIOZONE's *AP Environmental Science* has been designed so that teachers can deliver the essential components of the framework using the AP instructional model of **plan, teach, and assess**.



Plan

- The structure of *AP Environmental Science* follows the unit plan specified in the CED. Teachers can be assured that all of the essential components of the framework are covered, ensuring easy and efficient lesson planning with no content gaps.
- Use the unit introductions to assign students work for each lesson.
- Add interest to your lessons by utilizing the FREE resources on [BIOZONE's Resource Hub](#) in your planning. Resources for specific activities are identified on the Resource Hub, saving you having to locate your own resources.
- Want to refresh your knowledge before you teach, or extend gifted and talented students? Resources specifically set for teachers or gifted and talented students are identified on [BIOZONE's Resource Hub](#). You can assign these to students as extension material as required.
- A green circle next to an activity in the contents identifies where a practical investigation is included. The full methodology is given in the activity, and the equipment list is provided (Appendix 3), making preparation and incorporation of practical work easy.



Teach

- Teach the content in the order presented in BIOZONE's *AP Environmental Science*. Content covered in the early chapters lays the foundation for more in-depth material and specific examples covered in later units.
- Have students complete a skills support activity in the final chapter (*Science Practices for Environmental Science*) before attempting the relevant unit activity. These can be assigned as homework or they can be completed in class if students need support.
- Assign students into groups of mixed abilities when carrying out group research projects or practical investigations to encourage peer-to-peer learning.
- Activities that manipulate data using formulae may be supported by spreadsheets on [BIOZONE's Resource Hub](#). Assign these activities to students so they can develop a deeper understanding of the value of data manipulation. You can tailor how you use the spreadsheets. If time permits, have students graph the data themselves. Alternatively, have students analyze the completed data set (including graphs) to save time.
- Extend students' scientific vocabulary by encouraging them to look up words they are unfamiliar with in the glossary (Appendix 2).
- Add variation to your content delivery by utilizing BIOZONE's Presentation Media in your lesson. This fully editable digital resource can be adapted to complement your teaching plan. The Presentation Media includes extra examples not found in the Student Edition. They can be used to provide additional examples for the entire class or extension material for gifted and talented students.
- Use the Teacher's Digital Edition to review answers in class or on-line quickly and efficiently. Choose when and how you reveal the answers. To promote student discussion, reveal answers only once the students have shared their ideas. Reveal all the answers if you want the students to self mark their own work.



Assess

- Provide feedback (formative and summative) to students to update them on their progress. This can highlight areas they are strong in or areas needing work.
- Use formative assessment to identify areas the class needs to revisit before progressing to the next topic or unit. Methods of formative assessment include reviewing student answers on an activity page, observing students carrying out practical work, or evaluating their contribution and understanding in research projects.
- Use the personal progress checks at the end of each unit (chapter) to assess student understanding. This could be carried out as a form test in class. Alternatively, you can set personal progress checks as homework or open book assessments if you wish.
- Create additional practice opportunities by assigning students questions from the AP Question Bank (via AP Classroom).

The Contents: A Planning Tool

The contents pages are not merely a list of the activities in the student edition. Encourage your students to use them as a planning tool for their program of work. Students can identify the activities they are to complete and then tick them off when completed. Teachers can see at a glance how quickly the student is progressing through the assigned material.

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Students can mark the check boxes to indicate the activities they should complete. This helps them to quantify the work to be done and to plan their work.

Ticking off the activities as they are completed gives students a sense of progression and helps them to be more personally organized in their work.

Activities containing practical investigations are identified by a green bullet next to the activity number.

The teacher can see at a glance how this student is progressing through this unit of work. Any concerns with progress can be addressed early.

The teacher has an alternative activity of their own they wish to use, so they indicate to the students to skip this activity.

CODES: Activity is marked: ☐ to be done ☒ when completed ☒ Includes practical investigation

Identifying Learning Intentions and Goals

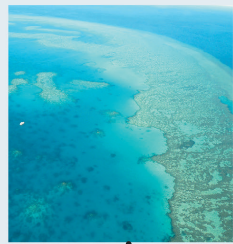
BIOZONE's *AP Environmental Science* is a new resource written specifically to address the APES CED. Each unit is prefaced with a chapter introduction. The units are organized into topics, and these are aligned to specific activities. The key content, skills, and learning objectives for each unit are summarized here.

This identifies the unit to which this chapter applies.



1. The Living World: Ecosystems

1



Developing understanding

Content: This unit provides the base for understanding the interdependent components, processes, and interactions that influence the interactions we see and the ways in which species in ecosystems can interact over resources, distinguishing between predation, symbiosis, and competition and their characteristics. Biogeochemical cycles are central to understanding ecosystems.

Skills: This unit emphasizes skills in understanding relationships, using visual representation, and practicing your quantitative skills in analysis.

Content summary

This statement outlines the main content points covered in the chapter.

Skills summary

An overview of the suggested skills for this unit are presented here.

Topic number: these are presented in the same order as the CED

1.1 Introduction to ecosystems activities 1 - 7

- ☐ 1. Identify the components of ecosystems, distinguishing between biotic and abiotic factors. Describe the ways in which species in ecosystems can interact over resources, distinguishing between predation, symbiosis, and competition and their characteristics.
- ☐ 2. Describe the nature of predator-prey interactions including the way in which these interactions are affected by changes in the availability of resources.
- ☐ 3. Describe the nature of symbiotic relationships to include mutualism, commensalism, and parasitism.
- ☐ 4. Distinguish between intraspecific and interspecific competition. Describe the role of resource limitation in determining the intensity of intraspecific competition and in regulating population size. Describe evidence for competitive exclusion in competing species and explain how naturally occurring species with similar resource needs reduce competition through resource partitioning.

1.2 Terrestrial biomes activities 8 - 11

- ☐ 5. Describe the global distribution and main environmental aspects of the major terrestrial biomes. Explain how the transport of heat around the globe accounts for the occurrence of certain biomes in particular regions.
- ☐ 6. Explain how the combination of climate, geography, latitude and altitude, nutrient availability, and soil type influence the global distribution of non-mineral terrestrial resources such as water, wood, coal, peat, soil, and gravel.

The learning objectives for each activity within the unit are listed here. Students can tick off each activity as they complete it.

ation
on

..... activity 12

atures

- ☐ 7. Describe the characteristics of the major aquatic biomes, including the role of freshwater ecosystems in providing drinking water.
- ☐ 9. Describe the role of algae and cyanobacteria as producers in marine biomes, including their role in supplying oxygen and removing and storing atmospheric carbon.
- ☐ 10. Where is most of marine life located? Explain how the physical conditions in oceans vary globally and how these differences can be related to the distribution of non-mineral marine natural resources such as fish and shellfish.

1.4 The carbon cycle activity 14

- ☐ 11. Explain how carbon cycles between the biotic and abiotic environments, identifying different reservoirs and comparing the relative time that carbon spends in each.

- ☐ 12. Explain how the decomposition of organisms has led to the storage of carbon over millions of years and describe the processes by which this stored carbon is being rapidly moved into the atmospheric reservoir.

1.5 The nitrogen cycle activity 15

- ☐ 13. Explain how nitrogen cycles between the biotic and abiotic environments, with emphasis on the role of bacteria in nitrogen transformations, including nitrogen fixation. Identify the main reservoir of nitrogen and explain how humans intervene in the nitrogen cycle by altering the amount of nitrogen that is stored in the biosphere.

1.6 The phosphorus cycle activity 16

- ☐ 14. Identify the main reservoirs for phosphorus and explain how it cycles between the biotic and abiotic environments. Explain why the phosphorus cycle is relatively slow compared to other biogeochemical cycles and the consequences of this to biological systems.

The activity in the book addressing the learning objectives for this topic.

1.7 The hydrologic (water) cycle activity 17

- ☐ 15. Identify the main reservoirs for water. Explain how water cycles through the biotic and abiotic environments, identifying its different states and describing the processes involved in the transformations between states.

1.8 Primary productivity activities 18 - 19

- ☐ 16. Distinguish between gross and net primary productivity and compare the Earth's ecosystems in terms of their productivity. What factors limit productivity and how are they different in aquatic and terrestrial environments?

1.9 Trophic levels activities 13, 20

- ☐ 17. Explain how energy flows and matter cycles through trophic levels in ecosystems. Explain the role of biogeochemical cycles in moving nutrients within and among ecosystems (matter is conserved).

1.10 Energy flow and the 10% rule activities 21 - 22

- ☐ 18. Use quantitative analysis to determine how the amount of energy available decreases as it is transferred from one trophic level to the next. How is this energy lost? Interpret energy flow diagrams and ecological pyramids to provide evidence for the 10% rule.

1.11 Food chains and webs activities 23 - 24

- ☐ 19. Describe food chains and webs and identify the organisms in them by trophic level. Describe how the organisms in ecosystems are connected through their feeding relationships and predict the effects of adding or removing organisms to a specific food web.

Practical Investigations

Throughout *AP Environmental Science*, students are given opportunities to practice and develop their practical skills through experimentation and field work. These investigations are opportunities for students to develop competency in laboratory procedures and field studies, to practice and refine skills in observation and analysis, and to manipulate data.

The investigations provide an excellent opportunity for collaborative work and will stimulate discussion and the sharing of ideas. You may wish to pair students of different abilities together. Confident students can guide and encourage less able students and, in this relaxed environment, striving students will be encouraged to share their own observations and thoughts. Collaboration through paired practical work provides an excellent opportunity for students to interact in meaningful ways to extend their scientific vocabulary and improve communication skills.



Each investigation is clearly numbered (sequentially through the chapter).

- ▶ Ensure your students read through the procedure fully *before beginning* the investigation.
- ▶ Highlight any hazardous or important steps, and make sure the students follow your directions.

Appendix 3: Equipment list		
The equipment list provides the material and equipment needed per student, pair, or group.		
1: The Living World: Ecosystems INVESTIGATION 1.1 Carbon cycling simulation Per student/pair Computer Spreadsheet application e.g. Excel INVESTIGATION 1.2 Determining primary productivity in grass Per student/pair Pre-prepared plots of watered grass (20 x 40 cm) Fertilizer (e.g. urea) Light source (e.g. desk lamp) Scissors Ruler Drying oven Aluminum foil Electronic balance	5: Land and Water Use INVESTIGATION 5.1 The Tragedy of the Commons Per 4 students Scissors. Packets of wrapped candy. INVESTIGATION 5.2 Testing water runoff Per student/pair Container (500 mL, yoghurt container, metal can or similar) with holes in the bottom for water to run through. 500 mL measuring cylinder. Metal tray or ramp (or similar). Container that will fit at bottom of ramp to collect water to drain to measuring cylinder. Sponge or towel that will cover the metal tray of ramp. Large floor tile that will cover the ramp. Small tiles with enough total area to cover the ramp. Enough gravel to cover the ramp. Thin sponge or sponges that will cover the ramp.	7: Atmospheric Pollution INVESTIGATION 7.1 Measuring particles in the air Per student/pair Thick cardboard sheets Scissors Grid paper Petroleum jelly or similar Stereomicroscope or magnifying glass Tape or Blu-tak 8: Aquatic and Terrestrial Pollution INVESTIGATION 8.1 Cleaning up oil spills Per group of students 4 liter bucket or container 40 mL vegetable oil Food coloring Mixing container (e.g. 100 mL beaker) Craft or ice block stick Oil clean up material e.g. cotton or paper towels, straw, Flexible straws Detergent
3: Populations INVESTIGATION 3.1 Creating a model of logistic growth Per student/pair Computer Spreadsheet application e.g. @Excel	6: Energy Resources and Consumption INVESTIGATION 6.1 Home electricity survey No equipment requirements INVESTIGATION 6.2 Using M&M's® to model half lives Per group 100 M&M's® 1 x lidded container 1 x plate INVESTIGATION 6.3 Solar heating house Per student/pair Computer Energy 2D software https://energy.concord.org/energy2d/	INVESTIGATION 8.2 Recording your trash Per student Spill proof bags Latex or chemical proof gloves INVESTIGATION 8.3 The role of microbes in sewage treatment Per student/pair/group 1 x stirring rod 8 x 1 L beakers Aeration unit with four tubes Plastic wrap Water bath Glucose test paper strips 14 g dried <i>Saccharomyces</i> yeast 40 mL warm water 500 mL glucose solution (100 g/L)
4: Earth Systems and Resources INVESTIGATION 4.1 Identifying soil type part 1 Per student/pair Samples of sand, silt, and clay. Measuring cylinders Stirring rods INVESTIGATION 4.2 Identifying soil type part 2 Per student/pair Three different soil samples. Measuring cylinders Stirring rods INVESTIGATION 4.3 Measuring energy Per student/pair Torch Protractor device to measure angles Clamp stand or similar Grid paper	9: Global Change INVESTIGATION 9.1 Albedo and ice cube melting Per pair/group 2 x Florence or Erlenmeyer flasks Black paint Aluminum foil Ice cubes 2 x thermometers 60W tungsten lamp (optional) Timer	

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INVESTIGATION: 4.3 Measuring Energy See appendix for equipment list.

1. Using a stand and protractor to measure angle, set up a flashlight pointing straight down (90° angle) at a piece of grid paper from a distance of 30 cm (a darkened room works best) as shown in the diagram below:

2. Draw around the illuminated part of the grid paper and then use the grid paper to help find the area illuminated.

3. Area illuminated (90°): _____

4. Tilt the clamp stand to a 66° angle, measuring 30 cm from the center of the flashlight front along the angle to the center of the illuminated area on the grid paper. Again, draw around and calculate the area of grid paper illuminated.

5. Area illuminated (66°): _____

6. Repeat this procedure for 45° and 33°.

Area illuminated (45°): _____ Area illuminated (33°): _____

4. (a) How does the area of graph paper illuminated change with the angle of the torch?

(b) For each could you use constant receiving?

(c) Attach a

The investigations have been designed using everyday materials and equipment easily found in most high school laboratories. No special kits are required.

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A list of the equipment and reagents required for each investigation is provided in appendix 3. Only standard equipment is used (no special kits are required).

PERSONAL PROGRESS CHECK								
UNIT 1 The Living World: Ecosystems	UNIT 2 The Living World: Biodiversity	UNIT 3 Populations	UNIT 4 Earth Systems & Resources	UNIT 5 Land & Water Use	UNIT 6 Energy Resources & Consumption	UNIT 7 Atmospheric Pollution	UNIT 8 Aquatic & Terrestrial Pollution	UNIT 9 Global Change
24 multiple choice	21 multiple choice	24 multiple choice	15 multiple choice	22 multiple choice	28 multiple choice	28 multiple choice	26 multiple choice	23 multiple choice
Analyze an environmental problem and propose a solution	Design an investigation	Analyze an environmental problem and propose a solution doing calculations	Design an investigation	Analyze an environmental problem and propose a solution	Analyze an environmental problem and propose a solution doing calculations	Design an investigation	Analyze an environmental problem and propose a solution doing calculations	Analyze an environmental problem and propose a solution

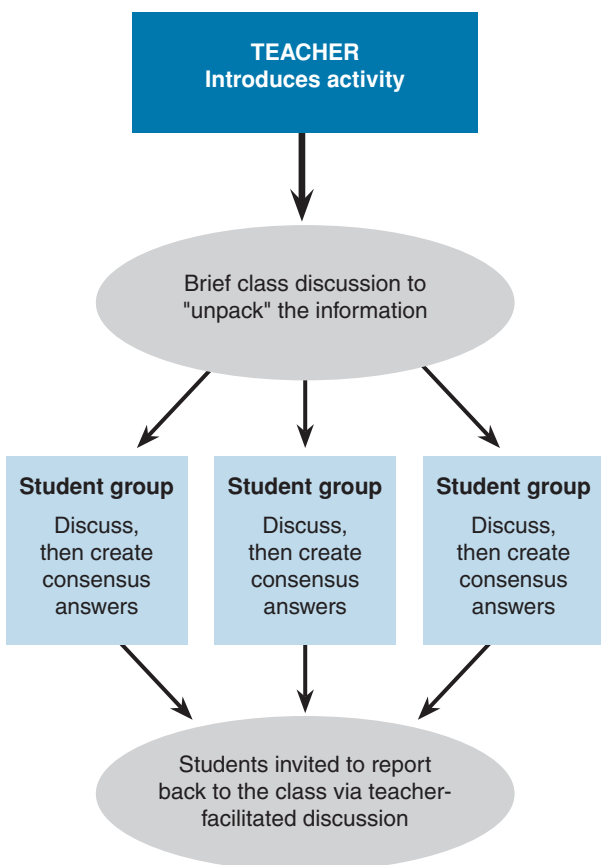
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Teaching Strategies for Classroom Use

Achieving effective differential instruction in classes is a teaching challenge. Students naturally have mixed abilities, varying backgrounds in the subject, and different language skills. Used effectively, BIOZONE's student books and supporting resources can make teaching a mixed ability class easier. Here, we suggest some approaches for differential instruction.

MAKING A START

Regardless of which activity you might be attempting in class, a short introduction to the task by the teacher is a useful orientation for all students. For collaborative work, the teacher can then divide the class into appropriate groups, each with a balance of able and less able students. Depending on the activity, the class may regroup at the end of the lesson for discussion.



Using collaboration to maximize learning outcomes

- The structure of *AP Environmental Science* allows for a flexible approach to unpacking the content with your students.
- The content can be delivered in a way to support collaboration, where students work in small groups to share ideas and information to answer and gain a better understanding of a topic, or design a solution to a problem.
- By working together to ask questions and evaluate each other's ideas, students maximize their own and each other's learning opportunities. They are exposed to ideas and perspectives they may not have come up with on their own.
- Collaboration, listening to others, and voicing their own ideas is valuable for supporting English language learners and developing their English and scientific vocabularies.
- Use a short, informal collaborative learning session to get students to exchange ideas about the answer to a question. Alternatively, collaboration may take a more formal role that lasts for a longer period of time (e.g. assign groups to work together for a practical activity, to research an extension question, or design a solution to a problem).



The teacher introduces the topic. They provide structure to the session by providing background information and setting up discussion points and clear objectives. Collaboration is emphasized to encourage participation from the entire group. If necessary, students in a group can be assigned specific tasks.



Students work in small groups so everyone's contribution is heard. They collaborate, share ideas, and engage in discourse. The emphasis is on discussing questions and formulating a consensus answer, not just sharing ideas.



At the end of the session, students report back on their findings. Each student should have enough knowledge to report back on the group's findings. Reporting consists primarily of providing answers to questions, but may involve presenting a report, model, or slide show, or contributing to a debate.



Peer to peer support

- **Peer-to-peer learning** is emphasized throughout the book, and is particularly valuable for more challenging activities in which the content is more complex or the questions require students to draw on several areas of their knowledge to solve a problem.
- **Practical investigations** and **group research projects** are an ideal vehicle for peer-to-peer learning. Students can work together to review and discuss their results, ask and answer questions, and describe phenomena.

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88 Methods to Reduce Urban Runoff

Key Question: What methods could be used to reduce runoff or mitigate the effects of runoff?
Localized flooding can be a real problem in cities where hard surfaces cover almost every part of the ground. Complex and costly drainage systems must be installed and maintained to remove stormwater, but if these become blocked, flooding can quickly occur. Changing ground coverings can change the rate of flooding and runoff and reduce the need for complex drainage systems. Some systems can help absorb and so reduce pollutants such as oil from stormwater runoff.

INVESTIGATION 5.2: Testing water runoff See appendix for equipment list.

1. Different kinds of pavement and ground cover have different rates of water infiltration and water holding capacity and so different rates of water runoff. In this investigation you will measure these rates.
2. Set up the following:
 - Sprinkler container with holes, to simulate rain.
 - Thin sponge or towel. This represents the slightly permeable and slightly absorbent subsoil.
 - Ramp made from flat metal tray. This represents the impermeable and non-absorbent bedrock. Angle should be about 20°.
 - Layer to be tested. This may represent soil and grass, concrete, permeable pavement, or gravel/metal footpath.
 - Water collection container with hole to drain into measuring cylinder.
3. The layers, from top to bottom, are: Concrete, Permeable Gravel/metal, Soil and grass.
4. To test the layers, place the sponge or towel on the ramp, then place the layer to be tested on top of the sponge or towel.
5. Measure the rainfall. The metal can will collect the water.
6. When you have set up the equipment, start the sprinkler and pour all the water into the rain container. Direct the water onto the top of the ramp so it runs down into the collection container and into the measuring cylinder.
7. In a notebook or your logbook, record the time it takes for the water to fill the measuring cylinder to 100 mL, 200 mL, 300 mL, 400 mL, and 500 mL. Record the total amount of water collected. In some cases it may not be all the original 500 mL, so you might not record a time for 500 mL, or even 400 mL.
8. Wring out the flat subsoil sponge as much as possible and repeat the process above twice more. Record the times and final water volume collected each time. Average the time it took to reach each volume (100 mL to 500 mL). Calculate a mean of the final water volume collected.
9. Repeat steps 4-7 for the small tiles, to represent permeable pavement.
10. Repeat steps 4-7 for the gravel and sand, to represent a gravel/metal footpath.
11. Repeat steps 4-7 for the sponge, to represent soil.

Students work in pairs or small groups to determine how different surfaces (e.g. concrete, gravel, grass) influence water runoff. Sharing ideas and observations promotes scientific dialogue.

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4. (a) Which surface produced the **least** water runoff?
(b) How would this affect the way water enters gutters, stormwater drains and rivers?

Students work in groups to debate the pros and cons of creating green spaces in urban areas. During this process, students draw on their own knowledge and can carry out additional research so they can contribute to the debate. This provides an opportunity for peer discussion and sharing ideas.

Reducing water runoff
Reducing the need to remove water runoff from hard city surfaces can be achieved using a variety of methods.

Public transport can reduce water runoff in two ways. Use of public transport requires fewer roads and so fewer hard surfaces. The rail system of trains usually has bedding and grass strips which are permeable and allow water to infiltrate.

Sidewalks that are built using pavers rather than poured concrete create gaps through which water can escape. Planting trees also give spaces for water to infiltrate. The trees help by absorbing any excess water that enters the ground.

Building up rather than out (creating urban sprawl) can allow more area for green space and increase the surface area for water infiltration and groundwater recharge. This greatly reduces runoff and the need for complex stormwater systems.

6. Why would reducing stormwater runoff be of benefit to a city? _____

7. Look at the picture of the pavement above center carefully. Explain why this method of reducing water runoff has its own set of problems: _____

8. Creating green spaces has both advantages and disadvantages. Divide the class into two groups. One group will discuss and summarize the benefits of green spaces. The other group will discuss and summarize the potential disadvantages of green spaces. You can draw on what you have learned so far and do your own research if you wish.

Summarize your discussion in point form and have one member of your group present the group's summary to the class. Keep a summary of the arguments from both sides and attach it to this page (organize the summary as a table if you wish). Do you think the advantages of green spaces outweigh the disadvantages?

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Collaboration and discovery

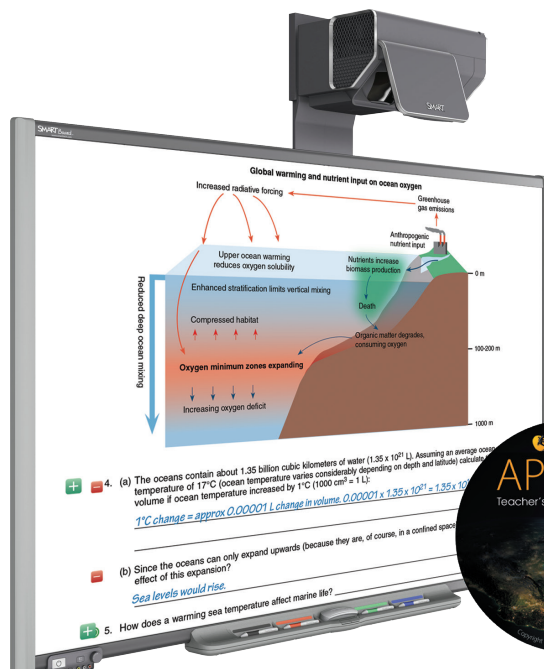
- BIOZONE's *AP Environmental Science* provides multiple chances for collaboration and discovery. By working together and sharing ideas, students are exposed to different perspectives and levels of knowledge about environmental concepts.
- BIOZONE's *AP Environmental Science* uses the CED framework to develop student understanding by providing a range of activities. These include getting students to think about and share what they already know and then build on this knowledge by exploring and explaining phenomena.



Student A is capable. He helps to lead the discussion and records the discussion in a structured way.

Students B and C are also capable but less willing to lead discussion they will add ideas to the discussion but need a little direction from A to do so.

Student D is less able but gains ideas and understanding from the discussion of students A, B, and C. She may add to the discussion as she gains confidence in the material being studied.

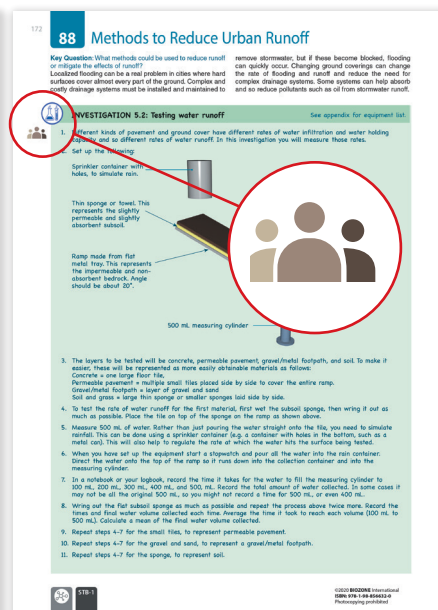
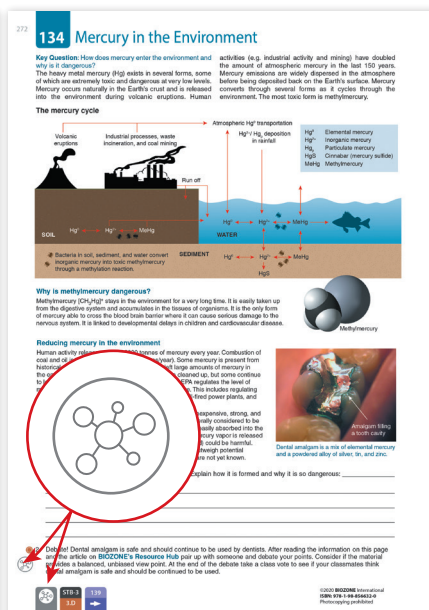
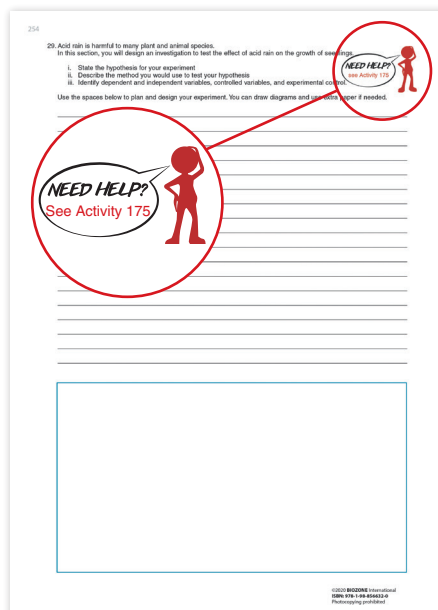


Interactive revision of tasks in class

- The **Teacher's Digital Edition** provides a digital rights managed (DRM) version of the student book as PDF files. It features useful HIDE/SHOW answers, which can be used to review activities in class using a data projector or interactive whiteboard (left).
- Students benefit from the feedback in class, where questions can be addressed, and teachers benefit by having students self-mark their work and receive helpful feedback on their responses.
- This approach is particularly suited to activities with questions requiring a discussion, as students will be able to clarify some aspects of their responses. Stronger students can benefit by contributing to the explanatory feedback and class discussion.

Differentiated Learning

Tools for differentiated instruction within *AP Environmental Science* help teachers to cater for students of all abilities. BIOZONE's collaborative approach to science inquiry encourages students to share their ideas and knowledge with their peers while at the same time broadening their own understanding. There are several ways you can use *AP Environmental Science* in a differentiated classroom:



A red figure with a NEED HELP? icon helps students identify where they can go to get help with a specific skill. Relevant skills are provided in the *Science Practices for Environmental Science* chapter at the end of the book. Students can visit this chapter regularly, or you can assign activities as homework before they attempt a specific task in class.

Animations and videos: Use the videos and animations on **BIOZONE's Resource Hub** to help student understanding of content. The Resource Hub also provides data sources, fact sheets, and material tagged for gifted and talented students. A gray hub icon at the bottom of the page indicates the activity has online support. Some hub resources are specific to a certain part of an activity. This is indicated by a hub icon in the page margin.

A group symbol indicates where students can work together. Group work provides opportunities for student collaboration and peer-to-peer support to explore phenomena. Working in groups, students can experience the benefits of collaboration in the scientific process of discovery. By speaking and listening to each other, communication skills and scientific vocabulary are extended.

Environmental Legislation

280 **140 Solid Waste Disposal**

Key Question: What is solid waste, how is it disposed of, and how does its disposal affect the environment?

Almost every activity we carry out generates waste. The Resource Conservation and Recovery Act (1976) is the principal federal law in the United States governing the disposal of solid waste. It ensures waste is safely disposed of so that people and the environment are not harmed. The EPA definition of solid waste includes not only wastes that are physically solid, but also liquid, semi-solid, or contained gaseous materials. For the purposes of this activity we will focus on municipal solid waste (MSW), i.e. the everyday waste generated in homes, schools, hospitals, and businesses.

What makes up our waste?

- The US EPA began collecting and reporting data about waste 30 years ago. This information is used to measure the success of materials management programs and provides information about what type of waste is produced.
- In 2017, 243 million tonnes of MSW was produced in the US. This is around 2 kg of waste per person every day. The diagram on the right shows the composition of the total MSW in 2017.
- One type of waste not specifically identified on the diagram is electronic waste (e-waste). This is the waste produced from discarded electronic devices (e.g. cell phones and computers).

Landfills

Landfills are specially engineered areas where waste is disposed. Landfills are the oldest and most common form of waste disposal and they are often used to get rid of MSW. It was once common for contaminants from landfills to escape (leach out) and contaminate ground water, or for the gases produced from waste decomposition to pollute the air. Modern landfills are designed to protect people and the environment by controlling emissions into water and air (opposite page). Regular monitoring helps to make sure no dangerous contaminants are escaping landfills.

Some waste is banned from MSW landfills because of the risk it poses to ~~the~~ **the** environment. Banned waste includes paints, chemicals and cleaning solvents, motor oil, batteries, pesticides, and electronics. These wastes are treated differently under the Resource Conservation and Recovery Act (RCRA).

Composition of US municipal solid waste (2017)

Material	Percentage
Paper & paperboard	25.0%
Food	13.2%
Metals	9.4%
Glass	4.2%
Textiles	5.3%
Rubber & leather	3.4%
Wood	6.7%
Misc inorganic waste	1.5%
Other	1.9%

The South-East New Territories Landfill (Hong Kong) covers 100 hectares (1 km²). It now only accepts construction waste.

1. If one person generates 2 kg of waste a day, how much do they generate in a year? _____

2. (a) Of the MSW generated in 2017, 61 million tonnes was recycled and 24 million tonnes was composted. What percentage of the total MSW generated was either recycled or composted? _____

(b) A further 31 million tonnes of MSW was combusted for energy recovery. What percentage of MSW actually went to landfill in 2017? _____

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Environmental legislation refers to a collection of laws and regulations designed to help protect the environment and reduce or mitigate the negative effects of human activity.

The AP Environmental Science CED lists a number of required pieces of environmental legislation that teachers are encouraged to incorporate into their classes. Where possible, we have incorporated these into the activities in *AP Environmental Science*. These are identified in the green cells in the table below.

Activities containing environmental policy or legislation are identified by way of a green environmental icon at the bottom of the first page of the activity (left). An environmental icon in the page margin identifies specifically where in the activity that piece of environmental legislation is covered.

Additional, highly relevant, environmental legislation not mentioned in the CED is also covered in some activities. These are also identified in the table below (brown cells).

Environmental legislation/policy	US domestic (D) or International (I) policy	Activity number
Required legislation		
Clean Air Act	D	116, 121
Clean Water Act	D	127, 130
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	I	165
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	D	143
Montreal Protocol	I	153
Kyoto Protocol	I	150, 154
Endangered Species Act	D	165
Safe Drinking Water Act (SDWA)	D	131
Delaney Clause of Food, Drug, and Cosmetic Act	D	79
Resource Conservation and Recovery Act (RCRA)	D	140

Additional legislation		
Taylor Grazing Act	D	74
The Corporate Average Fuel Economy (CAFE) standards	D	114
RAMSAR Convention on Wetlands of International Importance	I	136

Environmental Solutions

Environmental science often only makes the headlines for negative reasons, leaving students feeling overwhelmed with what may seem like constant bad news. It is important for students to realize that environmental science is also about designing solutions to combat the effects of human activity on the environment. Within *AP Environmental Science*, students are given opportunities to propose solutions to environmental problems. Students draw on their understanding of environmental legislation, technology, and scientific knowledge to propose and justify their solutions. Some examples are provided below.

122 Using Technology to Reduce Air Pollution

Key Question: How can technology be used to reduce air pollution and how effective are the different options? Ideally, stopping or limiting the production of emissions is the best way to deal with air pollution. Another way is to remove the pollutants at the source before they can be released into the atmosphere. There are many ways technology is currently used to reduce air pollution and to help maintain acceptable standards of air quality.

Reducing air pollutants associated with industry

Industrial processes produce a large number of different pollutants, so a number of methods are often used to clean up their gas discharges. Electrostatic precipitators and scrubber systems are both commonly used to remove contaminants from coal burning power plants, although this is not their only use. For example, electrostatic precipitators are used to sample biological airborne particles, such as viruses, for analysis, capture, and inactivation. Similarly, wastes collected from scrubbers can have commercial value (e.g. limestone-based scrubbers in coal-fired power plants can produce synthetic gypsum for use in drywall manufacture).

Electrostatic precipitators

- An electrostatic precipitator (ESP) is a filtration device that removes fine particles, such as dust and smoke, from an exhaust gas stream before it is released to the environment.
- An ESP uses static electricity to remove particles from a gas stream (see the diagram, right).
- During the process, the "dirty" gas passes through two electrodes. One of the electrodes is negatively charged. Smoke particles in the gas obtain a negative charge as they pass by it.
- A second electrode is positively charged. When the negatively charged dust particles in the gas pass by, they are attracted to the positively charged electrode and stick to it.
- Once the gas has passed through both electrodes it is "clean" and can be discharged.
- The method is very effective, removing 99% of particulate matter from a waste gas stream.

Scrubber systems

Scrubber systems are used to remove particulates and/or gases from industrial gas flow streams. There are two general types, wet scrubbers and dry scrubbers. Wet scrubbers saturate the waste stream with moisture to remove particles, whereas dry scrubbers typically use dry reagents to clean the gas stream. In both systems, the captured waste must be safely disposed of.

Wet scrubbers remove pollutants from gas flow streams by spraying liquid onto the gas. The water spray collects the dust and particulate matter, and it falls to the bottom of the scrubber. The clean gas stream is passed out.

Advantages: • Can handle most streams • Good SO₂ removal • Cools hot gases • Handles flammable dusts safely

Dry scrubbers work in a similar way to wet scrubbers, but spray fine (usually dry) absorbent reagents to remove pollutants. Dry scrubbers are often used to remove acids from combustion sources.

Advantages: • Can neutralize corrosive gases • Cost effective • Spent media can be a source of revenue.

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Students explore technological ways to remove particulate matter from industrial gas streams (and on the next page reducing transport related air pollutants) as a means of improving air quality.

140 Solid Waste Disposal

Key Question: What is solid waste, how is it disposed of, and how does its disposal affect the environment? Almost every activity we carry out generates waste. The Resource Conservation and Recovery Act (1976) is the principal federal law in the United States governing the disposal of solid waste. It ensures waste is safely disposed of so that people and the environment are not harmed. The EPA definition of solid waste includes not only wastes that are physically solid, but also liquid, semi-solid, or contained gaseous materials. For the purposes of this activity we will focus on municipal solid waste (MSW), i.e. the everyday waste generated in homes, schools, hospitals, and businesses.

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Some waste is banned from MSW landfills because of the risk it poses to health and the environment. Banned waste includes paints, chemicals and cleaning solutions, motor oil, batteries, pesticides, and electronics. These wastes are treated differently under the Resource Conservation and Recovery Act (RCRA).

Composition of US municipal solid waste (2017)

The South East New Territories Landfill (Hong Kong) covers 100 hectares (1 km²). It now only accepts construction waste.

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Historical landfills often leaked waste into the surrounding environment. Technological advances coupled with environmental legislation have resulted in the construction of safe landfills to prevent this occurring.

141 Reducing Waste

Key Question: How can we reduce the amount of solid waste going to landfill? What are the environmental effects? As the human population increases so does the amount of waste generated. We have seen in the previous activity that landfills are the most common way of dealing with MSW. Many landfills are filling up quickly, so finding ways to reduce their rate of filling is a priority. There are several ways to reduce how much trash goes into a landfill. These involve reducing waste production, reusing materials that would otherwise end up in landfill, and recycling materials when possible. Alternative ways to dispose of waste also help to reduce the volume of trash going to landfill.

Landfills in the US

In 1990, there were over 6000 landfills in the US. In 2020, there are now 1250. The number has dropped for several reasons. Landfills have closed because they have become full. It is harder to gain permission to open new landfills, and many new landfills are very large and can hold a lot of trash! Some states send their landfill to other states or even other countries if they don't have enough capacity themselves. For example, when the Staten Island landfill in New York City closed, trash was sent to Ohio, Pennsylvania, and West Virginia.

Waste generation in the US is increasing. In 1960, 80 million tonnes were generated. This increased to 243 million tonnes in 2017. So how long does the US have before its landfills become full? Estimates vary, but it could be within the next few decades. This means it is very important that households, businesses, manufacturers, and policy makers do everything they can to reduce landfill waste. The best method is to reduce the amount of material made or used in the first place (left). For example, drinking from a reusable water bottle instead of buying single use water bottles every time you want water. Composting, reusing, and recycling are also good waste reduction methods.

Waste management hierarchy

Reusing something is the simplest way to reduce waste. You can do this by buying used goods, borrowing items if it is something that you are not going to need very often, or buying reusable items instead of disposable ones. A common example is encouraging the use of reusable shopping bags. In England, customers are charged a few cents for single use bags. This has reduced their annual use from 7.6 billion to 1.5 billion.

Composting breaks down biodegradable waste like food scraps, yard waste, and paper. Composting is possible in almost every household, even those without a yard. Many homes have small worm farms or outdoor composts for kitchen scraps. The nutrient rich final product can be used as fertilizer, returning nutrients back to the soil. However, composting can attract rodents or begin to smell if it is not done properly.

Recycling converts waste materials into new materials. It reduces the waste going to landfill and conserves the Earth's resources because there is no need to mine and process new materials. However, recycling costs a lot. Building the plant, investing in specialist equipment, and running cost can be expensive. Material must be transported and cleaned before processing, and the recycling process itself can require a lot of energy.

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US landfills are reaching maximum capacity as the population grows and more waste is generated. Students look at ways to reduce the amount of waste entering landfills, in attempt to prolong the use of landfills.

165 Conservation Legislation

Key Question: How can legislation help conservation efforts? Trade in various species has been part of human culture for millennia, from animal skins in prehistoric camps, to growing roses for florists today. However when a species is endangered, its continued trade can affect its survival. In many cases, the rarer a species is, the more valuable it becomes and so it is hunted even more, e.g. rhinoceros for their horns and elephants for their tusks. Countries have enacted legislation to control this trade. Countries also pass laws that help the conservation of species that are not traded. These laws may protect land where an endangered species is found or give various government departments powers and responsibilities designed to protect and manage species and land and enhance conservation efforts.

CITES

- One of the most well known international treaties designed to control trade in endangered species is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES is a voluntarily adopted framework around which signature parties can base their own national laws. Since it was finally agreed in 1973, around 37,000 species have been registered under CITES.
- CITES controls trade in species, whether or not they are traded as live specimens. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. It includes everything from dried specimens (e.g. dried plants) to fur coats and powders.

CITES and wildlife trade

- CITES lists species under Appendix I, Appendix II, and Appendix III. Appendix I lists species that are in imminent danger of extinction. These species can't be traded commercially. Appendix II lists species that could face extinction if traded freely. They require permits for export trade. Appendix III lists species that are threatened or endangered but are not listed in Appendix I or II.
- Many of CITES' achievements are based on legislation, such as voting to move certain species into Appendix I. However this only works if all countries enforce the changes.

Problems

- One of the main problems with adding species to appendices is that there is often not enough data to accurately know a species' sustainability and often the data is inconsistent. For example, in 2010, China registered 130 ivory carvings, 40 elephant feet, 219 kg of tusk, and no trophies reported from Zimbabwe. However Zimbabwe's export data shows 2512 ivory carvings, 8 feet, 4 trophies and 41 tusks for the same period.
- Like most international treaties, CITES power comes from those countries that enforce its rules. However enforcement varies from country to country, and many fail to turn data on seizures and trade (or pay dues associated with being part of CITES).
- It is estimated the international volume of trade in wildlife registered under CITES is less than a tenth of the trade in wildlife not registered.

Endangered Species Act

- The purpose of the Endangered Species Act (ESA) (1973) is to protect and recover endangered or threatened wildlife in the United States and the ecosystems they depend upon. The ESA serves as the legislation under which CITES can function in the United States. The Fish and Wildlife Service and the Marine Fisheries Service administer the ESA.
- Under the ESA, species can be listed as threatened (likely to become endangered or endangered) or endangered (in danger of extinction). There are around 1500 species listed as endangered or threatened in the United States.
- Species may be listed under the act based on their biological status and threats to their environment. Ultimately the goal of the ESA is to recover a species to the point they no longer need to be listed.

Illegal trade in pangolins

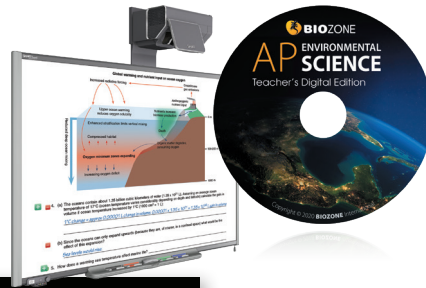
Gray wolves were listed as endangered as early as 1967. After recovering from near extinction they were delisted in 2008 and are now again subject to heavy hunting.

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Species conservation is important for ecosystem health and function. Domestic and international conservation legislation have helped stabilize populations of some endangered species (above). Technology also plays an important role.

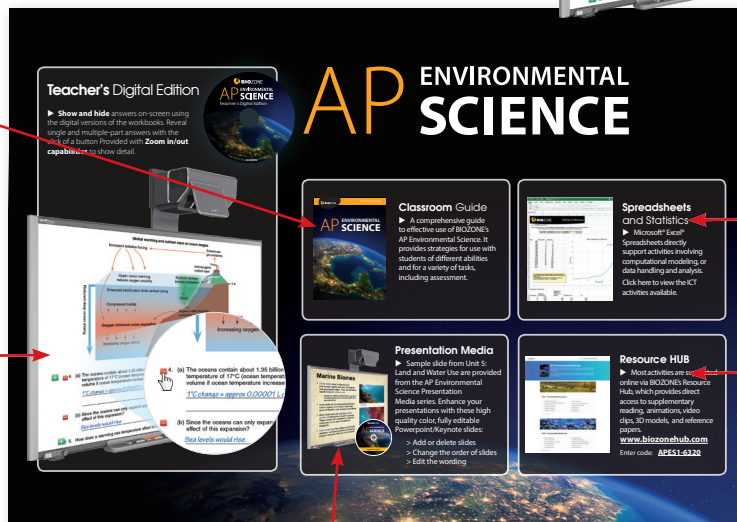
The Teacher's Digital Edition

The *Teacher's Digital Edition* is a DRM product, sold separately, and aimed primarily at extending the pedagogical tools at a teacher's disposal. Many of the features of this resource have been developed in response to requests from teachers themselves.



The **Classroom Guide** is provided as a printable PDF.

A digital (PDF) version of the Teacher's Edition (non-printable) is provided. Use the interactive buttons to HIDE or SHOW the answers.



Link to **Excel®** spreadsheets for selected activities with a data analysis or computer modeling component.

Access **BIOZONE's Resource Hub** directly from this link for a range of resources to support the activities.

A **BONUS** sample from the upcoming Presentation Media for *The Living World: Ecosystems*. It is fully editable.

Ocean warming affects oxygen saturation

- Warm water holds less oxygen than cold water. Thus as the oceans warm, oxygen saturation of the oceans has declined by about 2% since the middle of the 19th century.
- This could cause shifts in species distribution, expanding algal blooms, and reduction in human sustainability.
- Much of the ocean's oxygen is concentrated in the upper 1000 meters. This is the area where oxygen is produced by photosynthesis.
- Warm water increases the oxygen demand of organisms. As a result organisms in the lower layers suffer from a lack of oxygen (hypoxia). Eutrophication due to runoff from the land increases the oxygen demand of the lower layers of the ocean.
- Additionally, warming the upper layer of the ocean increases stratification (layering) of the water. Thus deep ocean waters will become even more oxygen depleted.

Global warming and nutrient input on ocean oxygen

4. (a) The oceans contain about 1.35 billion cubic kilometers of water. If the temperature of the oceans increased by 1°C (100°F), how much water would evaporate?

(b) Since the oceans can only expand upwards (due to the effect of this expansion)?

5. How does a warming sea temperature affect marine life?

6. Explain the effect of ocean temperature on oxygen levels.

17 The Hydrologic Cycle

Key Question: What processes move water between the oceans and the land?

Powered by energy from the sun, the hydrologic cycle collects, purifies, and distributes water. The oceans are the main source of water. Water constantly changes as it moves through the cycle. Besides rainwater causes erosion.

Wolves of Montana

This worksheet has been provided by BIOZONE International Ltd as a worked example and may be used as the basis for setting up and completing a similar statistical analysis based on different data.

Select View a formulae bar from the menu to view the formulae for each cell.

Select View a Comments bar from the menu to view the comments for each cell.

Year	Time period	Population
1972	0	0
1981	9	5
1985	13	5
1987	15	10
1989	17	20
1991	19	15
1993	21	16
1995	23	30
1997	25	50
1999	27	50
2001	29	50
2003	31	125
2005	33	180
2007	35	350
2009	37	400
2011	39	600
2013	41	650
2014	42	552

The first three years of the wolves population are omitted from the graph to more clearly establish an exponential curve during the given time periods (i.e. 1 year = 1 time period).

Although the population growth equation for an exponentially growing population is often represented as $y = a \cdot b^x$ when graphed as produced. Hence the term exponential growth.

The trendline and equation can be used to calculate the population at any point on the graph and into the future.

To insert a trendline select a data point, right click and select Add Trendline from the menu. Check the Exponential trend line (in the case of exponential growth).

To add an equation select as described above.

An R² value can be added to the line. This shows the relationship of the data point. In this case the R² value is 0.97, a very close relationship they show almost perfect exponential growth.

1. Identify the main source of energy for the processes involved in the hydrologic cycle? *The Sun*

2. Identify the main reservoirs for fresh water? *The oceans*

3. What is the ultimate source of energy for the processes involved in the hydrologic cycle? *The Sun*

4. Describe what is involved in each of the following processes and its role in the hydrologic cycle:

(a) Evaporation: *Change of state from liquid water to water vapor. Returns water to the atmosphere.*

(b) Precipitation: *Returns water to the land or water.*

(c) Condensation: *Change of state from water vapor to liquid water.*

(d) Transpiration: *Water vapor is released from plants into the atmosphere.*

Activities that manipulate data using formulas are supported by spreadsheets. These include all data and comments on graphical analysis.

Use the interactive buttons to reveal the answers as you work through the activity on-screen.