BIOZONE

TEXAS
PROGRAMS

BIOZONE

Advanced Placement Titles

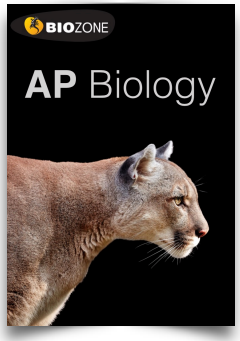
Overview:

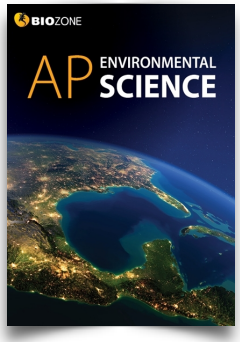
- BIOZONE's points of difference
- AP titles and support
- BIOZONE WORLD
- Wrap up and questions

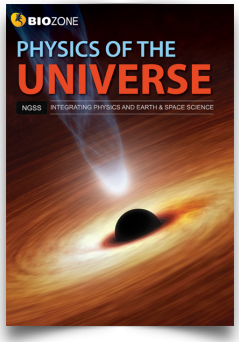
BIOZONE

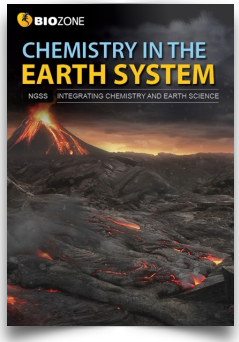
SCIENCE

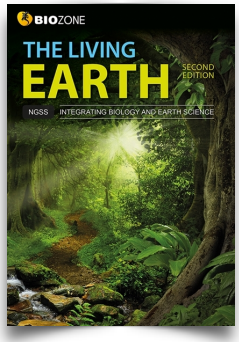
US PROGRAMS

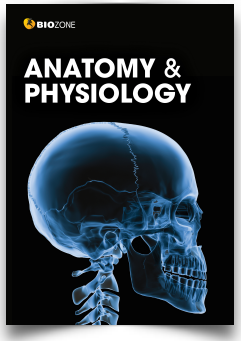


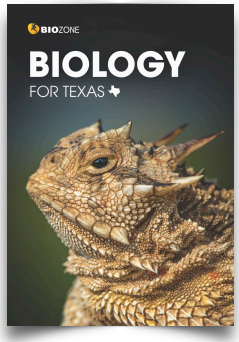


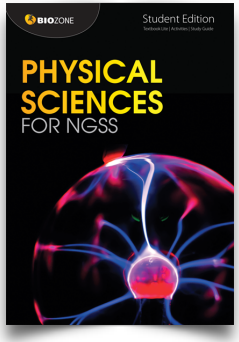


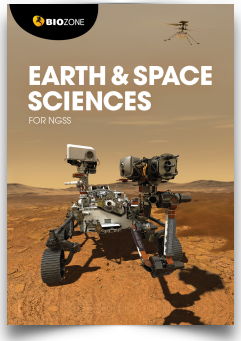


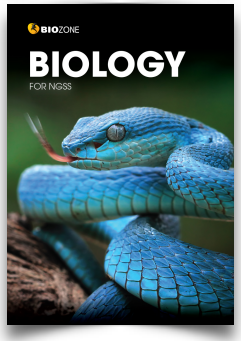


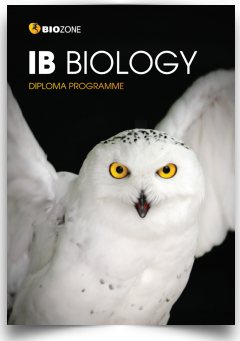


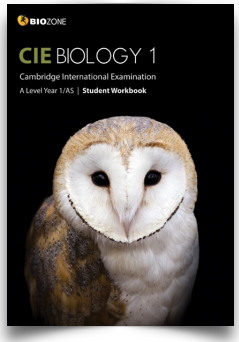


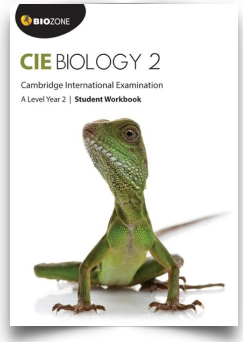




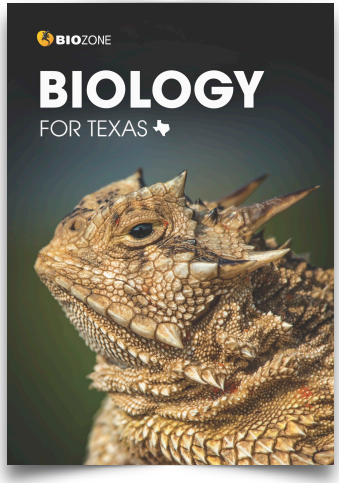


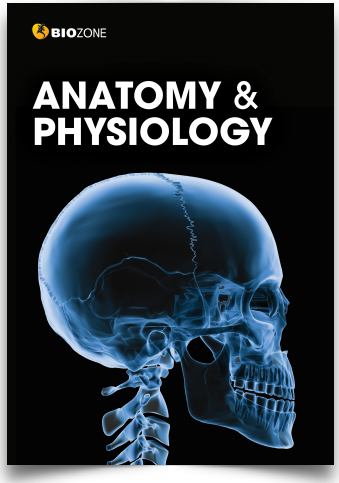


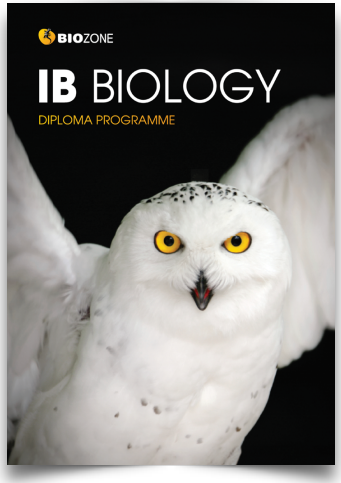




Recent Editions

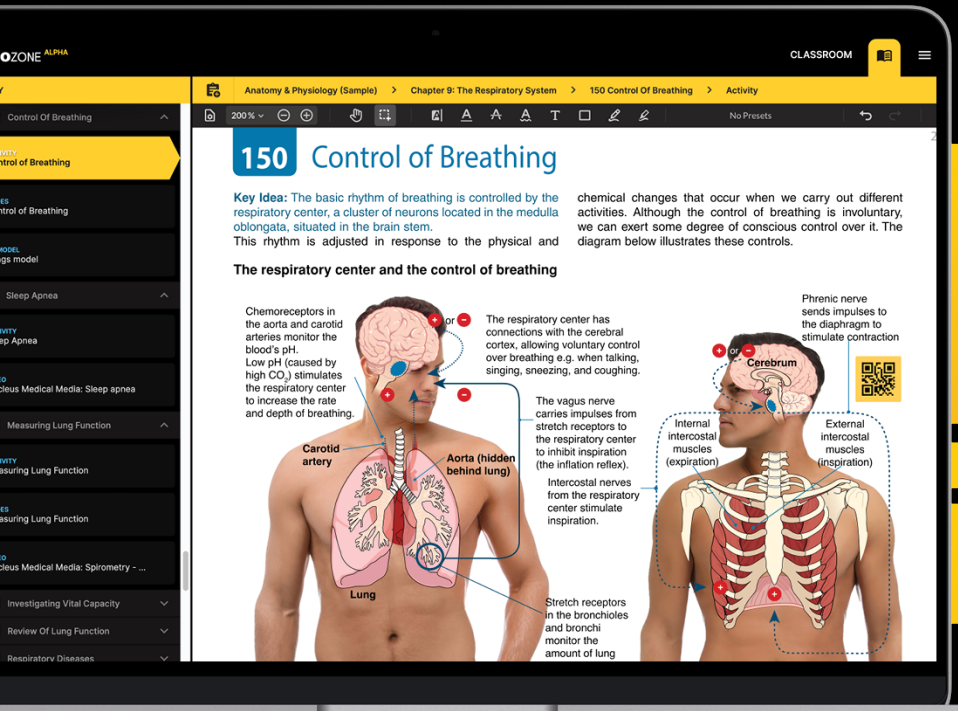


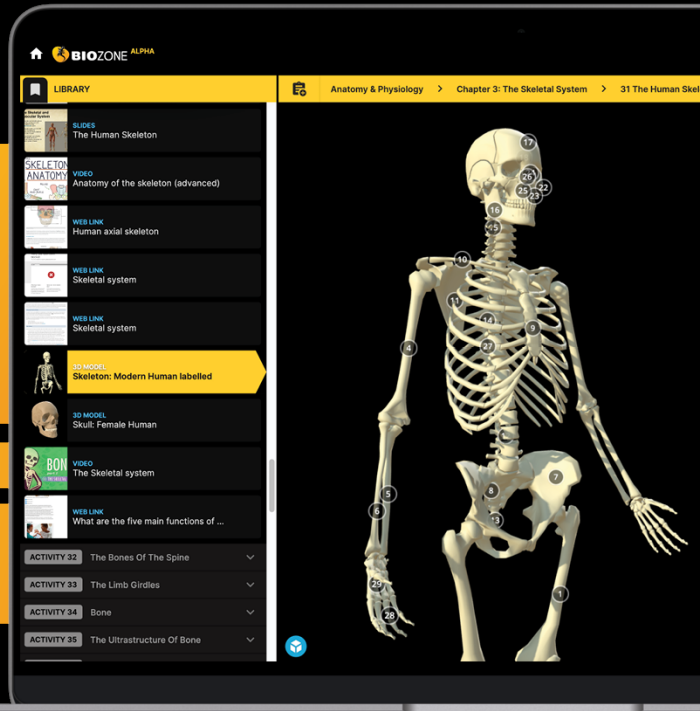




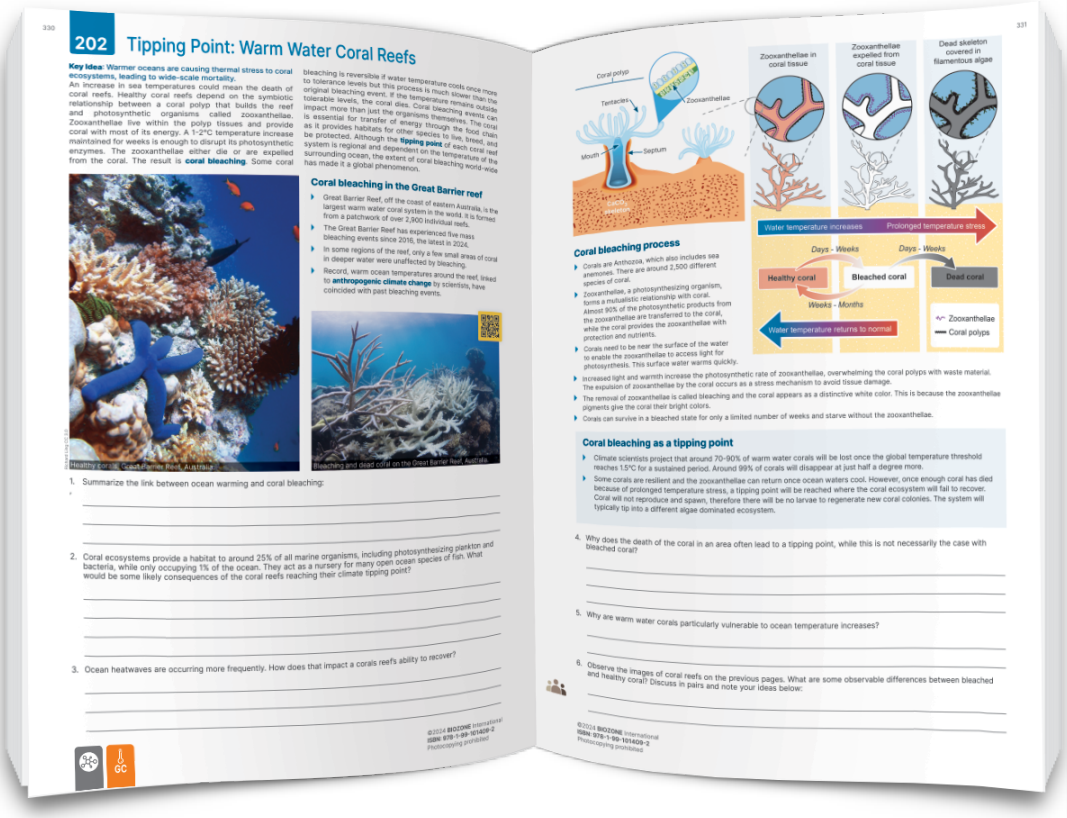
BIOZONE's delivery

Print | Digital | Blended





STUDENT OWNED RESOURCE



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202 Tipping Point: Warm Water Coral Reefs

Key idea: Warmer oceans are causing thermal stress to coral ecosystems, leading to wide-scale mortality.

An increase in sea temperatures could mean the death of coral reefs. Healthy coral reefs depend on the symbiotic relationship between a coral polyp that builds the reef and photosynthetic organisms called zooxanthellae. Zooxanthellae live within the polyp tissues and provide coral with most of its energy. A 1–2°C temperature increase maintained for weeks is enough to disrupt its photosynthetic enzymes. The zooxanthellae either die or are expelled from the coral. The result is **coral bleaching**. Some coral bleaching is reversible if water temperature cools once more to tolerance levels but this process is much slower than the original bleaching event. If the temperature remains outside tolerable levels, the coral dies. Coral bleaching events can impact more than just the organisms themselves. The coral is essential for transfer of energy through the food chain as it provides habitats for other species to live, breed, and be protected. Although the **tipping point** of each coral reef system is regional and dependent on the temperature of the surrounding ocean, the extent of coral bleaching world-wide has made it a global phenomenon.

Healthy coral, Great Barrier Reef, Australia

Coral bleaching in the Great Barrier reef

- Great Barrier Reef, off the coast of eastern Australia, is the largest warm water coral system in the world. It is formed from a patchwork of over 2,900 individual reefs.
- The Great Barrier Reef has experienced five mass bleaching events since 2016, the latest in 2024.
- In some regions of the reef, only a few small areas of coral in deeper water were unaffected by bleaching.
- Record, warm ocean temperatures around the reef, linked to **anthropogenic climate change** by scientists, have coincided with past bleaching events.

Bleaching and dead coral on the Great Barrier Reef, Australia

1. Summarize the link between ocean warming and coral bleaching:

2. Coral ecosystems provide a habitat to around 25% of all marine organisms, including photosynthesizing plankton and bacteria, while only occupying 1% of the ocean. They act as a nursery for many open ocean species of fish. What would be some likely consequences of the coral reefs reaching their climate tipping point?

3. Ocean heatwaves are occurring more frequently. How does that impact a corals reef's ability to recover?

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Coral bleaching process

- Corals are Anthozoa, which also includes sea anemones. There are around 2,500 different species of coral.
- Zooxanthellae, a photosynthesizing organism, forms a mutualistic relationship with coral. Almost 90% of the photosynthetic products from the zooxanthellae are transferred to the coral, while the coral provides the zooxanthellae with protection and nutrients.
- Corals need to be near the surface of the water to enable the zooxanthellae to access light for photosynthesis. This surface water warms quickly.
- Increased light and warmth increase the photosynthetic rate of zooxanthellae, overwhelming the coral polyps with waste material. The expulsion of zooxanthellae by the coral occurs as a stress mechanism to avoid tissue damage.
- The removal of zooxanthellae is called bleaching and the coral appears as a distinctive white color. This is because the zooxanthellae pigments give the coral their bright colors.
- Corals can survive in a bleached state for only a limited number of weeks and starve without the zooxanthellae.

Coral bleaching as a tipping point

- Climate scientists project that around 70–90% of warm water corals will be lost once the global temperature threshold reaches 1.5°C for a sustained period. Around 99% of corals will disappear at just half a degree more.
- Some corals are resilient and the zooxanthellae can return once ocean waters cool. However, once enough coral has died because of prolonged temperature stress, a tipping point will be reached where the coral ecosystem will fail to recover. Coral will not reproduce and spawn, therefore there will be no larvae to regenerate new coral colonies. The system will typically tip into a different algae dominated ecosystem.

4. Why does the death of the coral in an area often lead to a tipping point, while this is not necessarily the case with bleached coral?

5. Why are warm water corals particularly vulnerable to ocean temperature increases?

6. Observe the images of coral reefs on the previous pages. What are some observable differences between bleached and healthy coral? Discuss in pairs and note your ideas below:

A 3-in-1 hybrid resource:

Part textbook

Part study guide

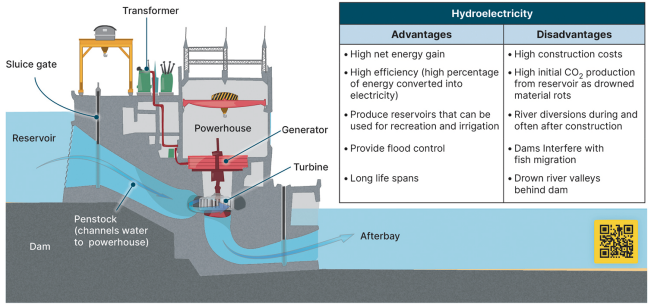
Part activity workbook

An all-in-one comprehensive resource,
eliminating the need for
a separate textbook.

127 Hydroelectricity

Key Idea: Hydroelectricity dams have the dual usage of both producing electricity and storing water for domestic and agricultural use.

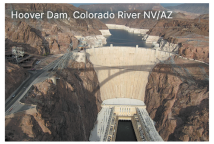
Hydroelectricity accounts for around 20% of global electricity production. Electricity is produced by utilizing the gravitational potential energy of water stored in reservoirs behind dams. As water falls, directed along pipes into the powerhouse, the potential energy is converted into kinetic energy, which turns turbines to generate electricity. The larger the volume of water and the further it has to fall, the greater the amount of energy it contains. Large dams can therefore produce large amounts of electricity. The generation of electricity itself produces no CO_2 emissions or other air pollution, but the construction of the dam requires massive amounts of energy and labor and often requires river diversions. Construction of large hydroelectric dams is highly controversial because creating a reservoir behind the dam often requires the submergence of towns and land. Dams constructed inefficiently can also fill up with silt and gradually decline in their generation capacity.



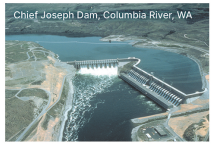
Hydroelectricity

Advantages	Disadvantages
• High net energy gain	• High construction costs
• High efficiency (high percentage of energy converted into electricity)	• High initial CO_2 production from reservoir as drowned material rots
• Produce reservoirs that can be used for recreation and irrigation	• River diversions during and often after construction
• Provide flood control	• Dams interfere with fish migration
• Long life spans	• Drown river valleys behind dam

Using hydroelectric power



The mass of water and the distance it falls are important in determining the amount of electricity that can be produced. The power (the energy produced per second) produced by a hydroelectric power plant can be approximated from the mass of water flowing past the turbine and the height of its fall.



Water doesn't have to be stored in a dam for a hydroelectric power plant to work. Water can be directed to flow past the turbine and simply use the force of the flowing water (called **run-of-the-river**). The dam is usually there to divert water towards the intake or powerhouse or to store water in case of lower river levels.

Pumped storage is a useful way of storing excess energy in hydroelectric plants. During off-peak times, water flowing through the plant is used to pump water to a higher storage pond. During high demand, this water can be run through a separate powerhouse to provide extra electricity to the local grid.

1. (a) Explain how hydroelectric dams are used to generate electricity: _____

_____

_____

_____

(b) Describe the relationship between water volume, height of the dam, and electricity production:

_____

_____

GR

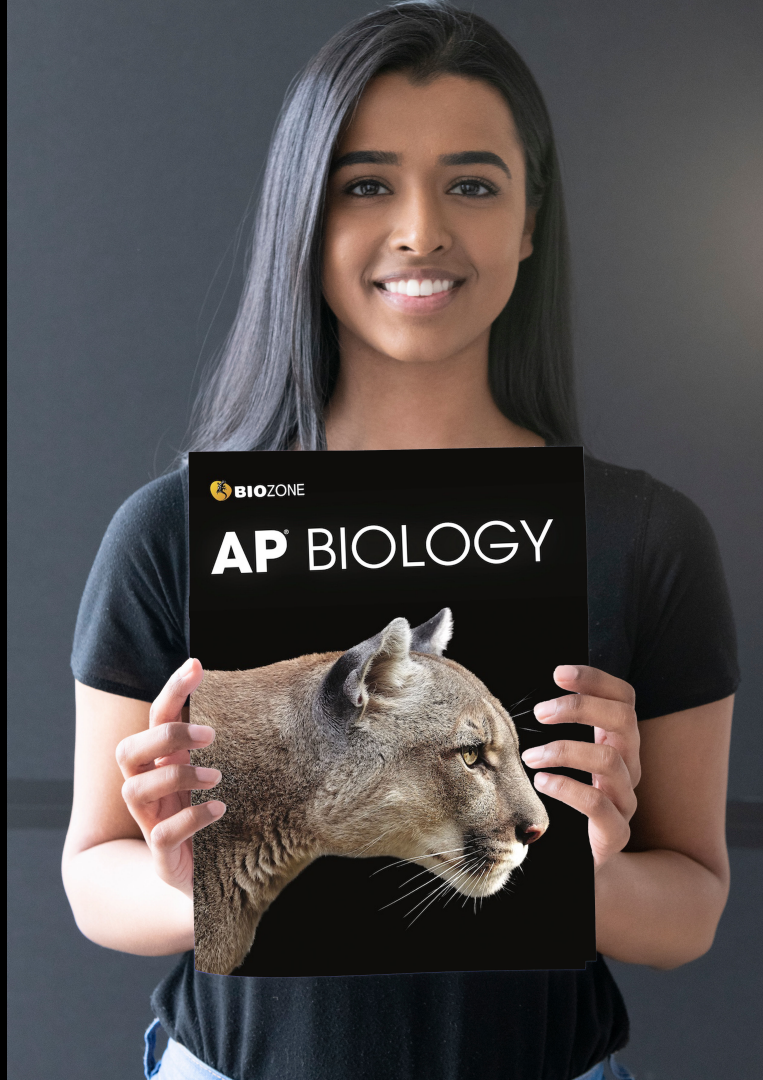
ISBN: 978-1-99-101409-2

Why are BIOZONE resources unique?

- A reputation for scientific rigor …
  … but our information is accessible.
  - Graphical delivery of science concepts.
  - Chunked text.
- Students interact directly with material:
  forms a record of work
  - Reinforces understanding.
  - Easy revision.
  - Self grading and answer refinement.

Advantages of the BIOZONE approach

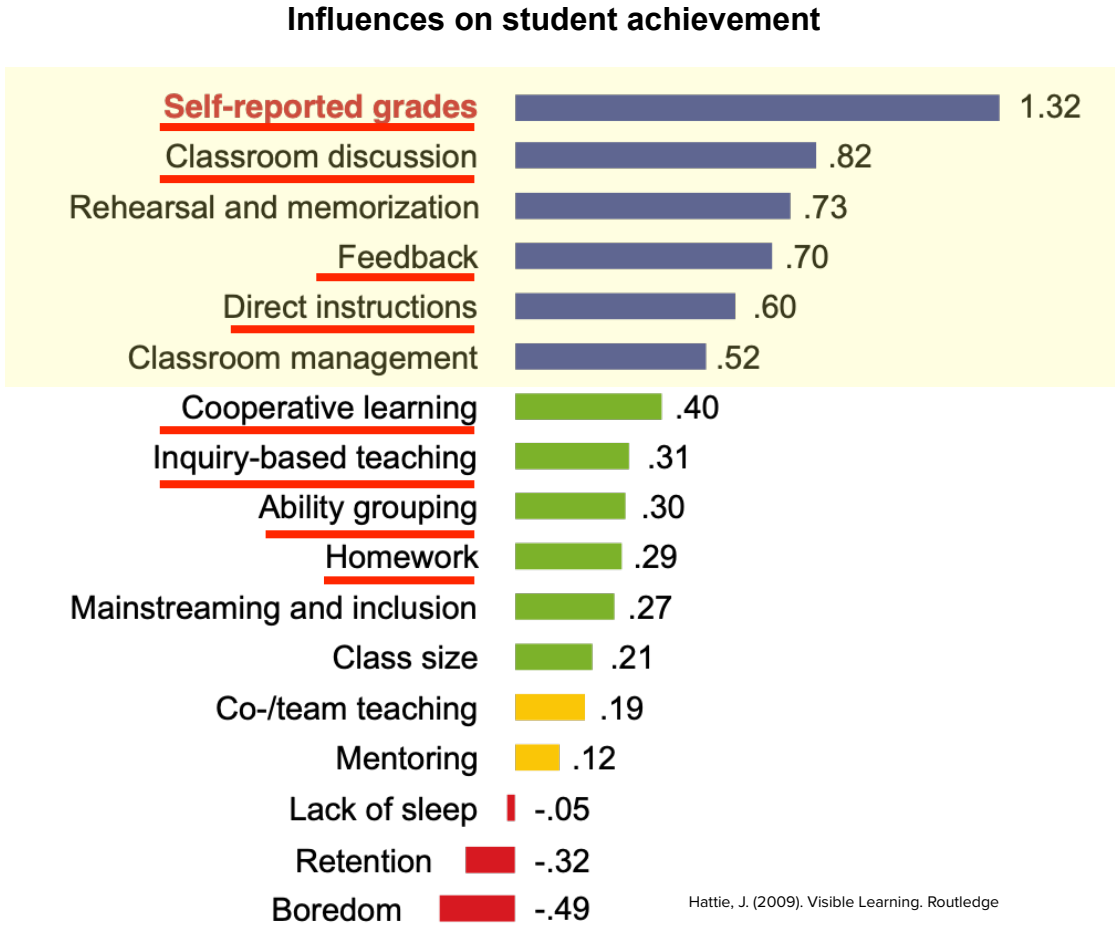
- Student ownership and engagement
- Empowers students to be fully involved in their learning journey
- Flexible delivery modes
- Regular updates:
    - Content
    - Pedagogy
    - Features
    - Support tools



Pedagogical tools

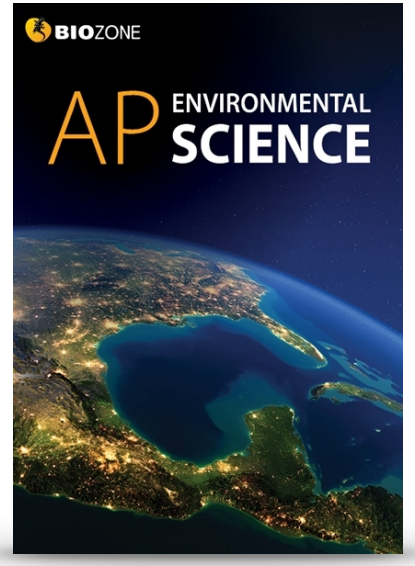
- Where does the data come from?
  A synthesis of >1,500 meta studies involving over 90,000 individual studies and 300 million students.

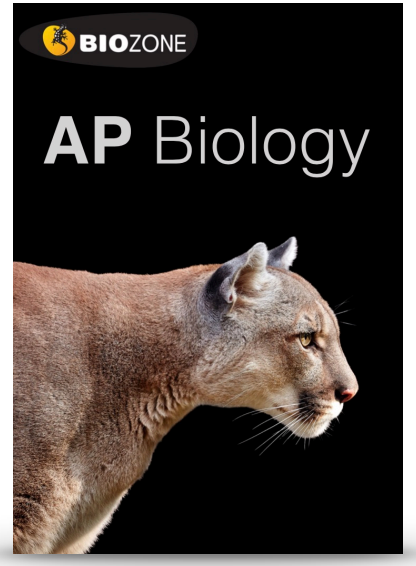
- BIOZONE products incorporate many of the factors shown to positively influence student achievement.



BIOZONE's AP RESOURCES

Written for the most recent CEDs





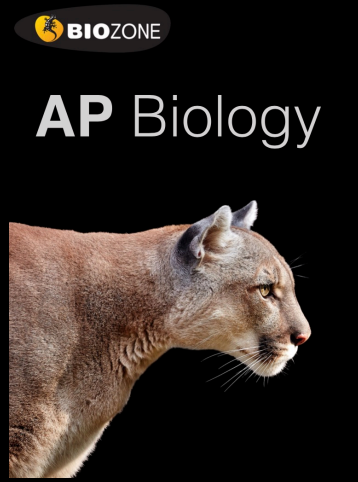
2019 AP Environmental Science CED	2020 AP Biology CED

Structured on the **Units of Study:** content delivery follows CED

Supports the **AP Instructional Model** of plan, teach, and assess

Features of AP Titles

- Structured on the Units of Study**:** content delivery follows CED
    - Required content, examples and components are integrated.
- Science practices and skills are identified by color coding on page
- Support for the 13 Practical investigations (Biology)
- Environmental legislation integrated (Environmental Science)
- Rich in data handling activities and case studies
- Support for science practices and skills provided in a dedicated chapter
- Unit assessment tasks prepare students for the AP exam



AP ENVIRONMENTAL SCIENCE

1. The Living World: Ecosystems
2. The Living World: Biodiversity
3. Populations
4. Earth Systems and Resources
5. Land and Water Use
6. Energy Resources and Consumption
7. Atmospheric Pollution
8. Aquatic and Terrestrial Pollution
9. Global Change
10. **Science Practices for AP Environmental Science**

BIOZONE

AP Biology

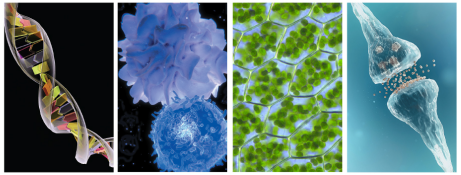
AP BIOLOGY

1. Chemistry of Life
2. Cell Structure and Function
3. Cellular Energetics
4. Cell Communication and Cell Cycle
5. Heredity
6. Gene Expression and Regulation
7. Natural Selection
8. Ecology
9. **Science Practices for AP Biology**

AP Biology is structured around the four big ideas, they form threads that run throughout the entire course

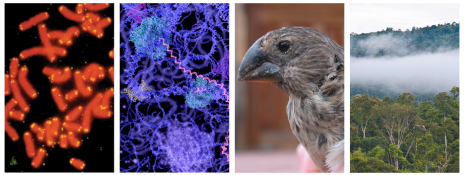
Big Ideas and Enduring Understandings

AP Biology is structured around four BIG IDEAS (below). These big ideas form threads that run throughout the entire course. The big ideas relate to several ENDURING UNDERSTANDINGS, which form the key concepts for learning and from which arise the learning objectives that form the basis of each unit introduction.

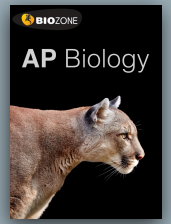


Big Ideas	Unit 1 Chemistry of Life	Unit 2 Cell Structure and Function	Unit 3 Cellular Energetics	Unit 4 Cell Communication and Cell Cycle
EVO **Evolution** The process of evolution drives the diversity and unity of life.		**EVO1** Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.		
ENE **Energetics** Biological systems use energy and molecular building blocks to grow, reproduce, and maintain dynamic homeostasis.	**ENE-1** The organization of living systems requires constant input of energy and the exchange of macromolecules.	**ENE-2** Cells have membranes that allow them to establish and maintain distinct internal environments.	**ENE-1**	**ENE-3** Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.
IST **Information Storage and Transmission** Living systems store, retrieve, transmit and respond to information essential to life processes.	**IST-1** Heritable information provides for the continuity of life.			**IST-1** **IST-3** Cells communicate by generating, transmitting, receiving, and responding to chemical signals.
SYI **Systems Interactions** Biological systems interact, and these systems and their interactions exhibit complex properties.	**SYI-1** Living systems are organized in a hierarchy of structural levels that interact.	**SYI-1**	**SYI-3** Natural diversity among and between compartments within biological systems affects interactions with the environment.	
PERSONAL PROGRESS CHECKS	20 multiple choice **Free response questions** • Conceptual analysis (partial) • Analyze visual representation or model (partial)	30 multiple choice **Free response questions** • Interpreting and evaluating experimental results (partial) • Analyze model or visual representation (partial)	20 multiple choice **Free response questions** • Interpreting and evaluating experimental results with graphing (partial) • Scientific investigation (partial)	25 multiple choice **Free response questions** • Interpreting and evaluating experimental results (partial) • Analyze data

As part of this learning structure, key science practices are integrated into the activities of this book. The science practices cover important skills students need to describe and analyze scientific ideas and data related to biology. These are described on page xii.



Unit 5 Heredity	Unit 6 Gene Expression and Regulation	Unit 7 Natural Selection	Unit 8 Ecology
EVO-2 Organisms are linked by lines of descent from common ancestry.		**EVO1** **EVO-2** **EVO-3** Life continues to evolve within a changing environment.	**EVO1**
			ENE-1 **ENE-3** **ENE-4** Communities and ecosystems change on the basis of interactions among populations and disruptions to the environment.
IST-1	**IST-1** **IST-2** Differences in gene expression account for some of the phenotypic differences between organisms. **IST-4** The processing of genetic information is imperfect and is a source of genetic variation.		**IST-5** Transmission of information results in changes within and between biological systems.
SYI-3		**SYI-3**	**SYI-1** **SYI-2** Competition and cooperation are important aspects of biological systems. **SYI-3**
25 multiple choice **Free response questions** • Interpreting and evaluating experimental results with graphing • Conceptual analysis	25 multiple choice **Free response questions** • Interpreting and evaluating experimental results • Analyze visual representation or model	40 multiple choice **Free response questions** • Interpreting and evaluating experimental results with graphing • Analyze data	20 multiple choice **Free response questions** • Interpreting and evaluating experimental results with graphing • Scientific investigation



APES is structured around the four big ideas, they form threads that run throughout the entire course

Big Ideas and Enduring Understandings

AP Environmental Science is structured around four BIG IDEAS (below). These big ideas form threads that run throughout the entire course. The big ideas relate to several ENDURING UNDERSTANDINGS, which form the key concepts for learning and from which arise the learning objectives that form the basis of each unit introduction. As part of this learning structure, key science practices are integrated into the activities of this book. The science practices cover important skills students need to describe and analyze scientific ideas and data related to environmental science. These are described on page xii.

BIG IDEA 1
Energy transfer (ENG):

Energy conversions underlie all ecological processes. Energy cannot be created or destroyed, only transferred and transformed. At each transfer energy is lost from the system to the environment.

BIG IDEA 2
Interactions between Earth systems (ERT):

The Earth is a complex interconnected system. Systems can change over time and vary in their ability to recover from disturbances.

Big Ideas	Unit 1 The Living World: Ecosystems	Unit 2 The Living World: Biodiversity	Unit 3 Populations	Unit 4 Earth Systems and Resources
Energy transfer ENG	**ENG1** Energy can be converted from one form to another.			**ENG-2** Most of the Earth's atmospheric processes are driven by input of energy from the Sun.
Interactions between Earth systems ERT	**ERT-1** Ecosystems are the result of biotic and abiotic interactions.	**ERT-2** Ecosystems have structure and diversity that change over time.	**ERT-3** Populations change over time in the reaction to a variety of factors.	**ERT-4** Earth's systems interact, resulting in a state of balance over time.
Interactions between different species and their environment EIN			**EIN-1** Human populations change in reaction to a variety of factors, including social and cultural factors.	
Sustainability STB				
PERSONAL PROGRESS CHECKS	24 multiple choice **Free response question** Analyze an environmental problem and propose a solution.	21 multiple choice **Free response question** Design an investigation.	24 multiple choice **Free response question** Analyze an environmental problem and propose a solution doing calculations.	15 multiple choice **Free response question** Design an investigation.

BIG IDEA 3
Interactions between different species and their environment (EIN):

Humans have altered the environment for millennia. The rate and scale of these changes are increasing as technology advances and the human population increases.

BIG IDEA 4
Sustainability (STB):

Human survival depends on developing sustainable solutions for managing resources that take into account social, cultural, and economic factors.

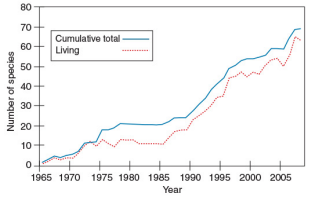
Unit 5 Land and Water Use	Unit 6 Energy Resources and Consumption	Unit 7 Atmospheric Pollution	Unit 8 Aquatic and Terrestrial Pollution	Unit 9 Global Change
	ENG-3 Humans use energy from a variety of sources, resulting in positive and negative consequences.			
EIN-2 When humans use natural resources, they alter natural systems.			**EIN-3** Pollutants can have both direct and indirect impacts on the health of organisms, including humans.	**EIN-4** The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact.
STB-1 Humans can mitigate their impact on land and water resources through sustainable use.		**STB-2** Human activities have physical, chemical, and biological consequences for the atmosphere.	**STB-3** Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.	**STB-4** Local and regional human activities can have impacts at the global level.
22 multiple choice **Free response question** Analyze an environmental problem and propose a solution.	28 multiple choice **Free response question** Analyze an environmental problem and propose a solution doing calculations.	28 multiple choice **Free response question** Design an investigation.	26 multiple choice **Free response question** Analyze an environmental problem and propose a solution doing calculations.	23 multiple choice **Free response question** Analyze an environmental problem and propose a solution.

Surtsey: A case study in primary succession

Surtsey Island is a volcanic island lying 33 km off the southern coast of Iceland. The island was formed over four years from 1963 to 1967 when a submarine volcano 130 m below the ocean surface built up an island that initially reached 174 m above sea level and covered 2.7 km^2. Erosion has since reduced the island to around 150 m above sea level and 1.4 km^2.

As an entirely new island, Surtsey was able to provide researchers with an ideal environment to study primary succession in detail. The colonization of the island by plants and animals has been recorded since the island's formation. The first vascular plant there (sea rocket) was discovered in 1965, two years before the eruptions on the island ended. Since then, 69 plant species have colonized the island and there are a number of established seabird colonies.

Number of vascular plant species found on Surtsey




Sea rocket


H. peploides


P. annua


S. phylicifolia

The first stage of colonization on Surtsey was dominated by shore plants colonizing the northern shores, brought by ocean currents. The most successful of these was *Honckenya peploides*, which established on tephra sand and gravel flats. It set seed in 1971 and subsequently spread across the island. This initial colonization by shore plants was followed by a lag phase with few new colonizers. A number of new plant species arrived after a gull colony became established at the southern end of the island.

Populations of plants within or near the gull colony expanded rapidly to about 3 ha, while populations outside the colony remained low but stable. Grasses such as *Poa annua* formed extensive patches of vegetation. After this rapid increase in plant diversity, the arrival of new colonizers again slowed. A third wave of colonizers began to establish following this slower phase and soil organic matter increased markedly. The first bushy plants established in 1998, with the arrival of willow *Salix phylicifolia*.

3. Explain why Surtsey provided ideal conditions for studying primary succession: _____

4. Explain why the first colonizing plants established in the north of the island, but later colonizers established in the south.

5. There are three distinct phases on Surtsey where species richness increased rapidly.
   (a) Label on the graph the three phases of increase in species richness on Surtsey.
   (b) Label the two lag phases where species richness increased slowly.

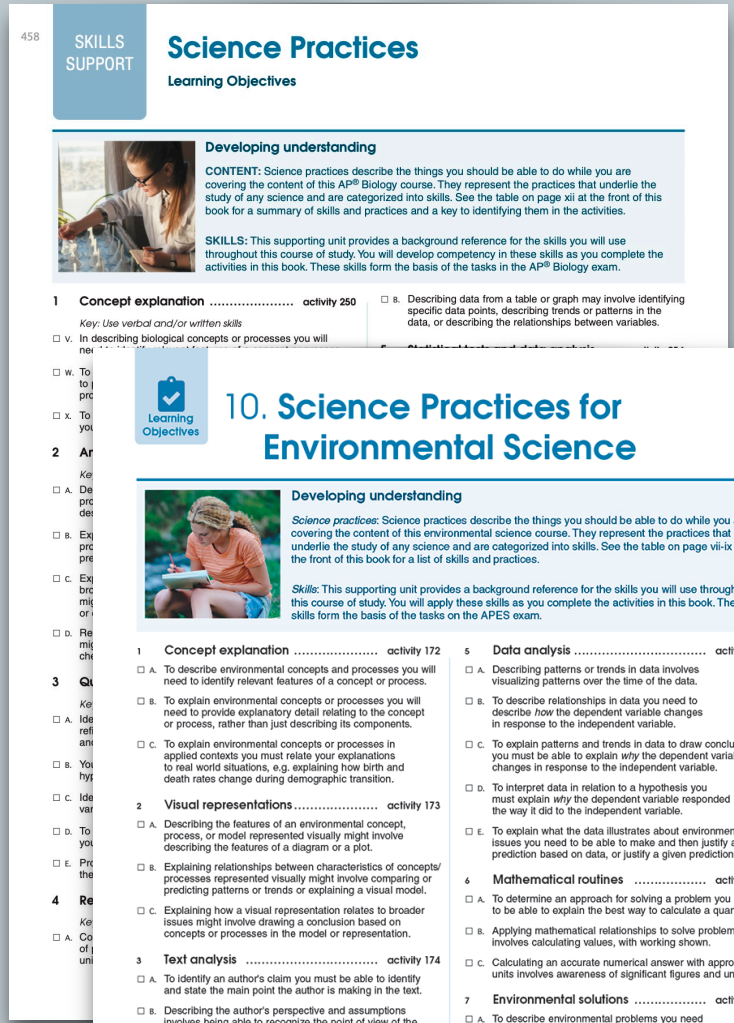
6. A gull colony established on the island in 1985. What was the effect on this on the number of plant species on the island?

7. Why is the living number of plant species on the island less than the cumulative number colonizing the island?

ISBN: 978-1-98-856632-0

Identifying Science Practices

- **Color coding** identifies a particular skill the colors match the coding in the CED
- Look out for where they appear on a page



Support for Science Practices

- **Dedicated chapter** to support students with **math and science skills**

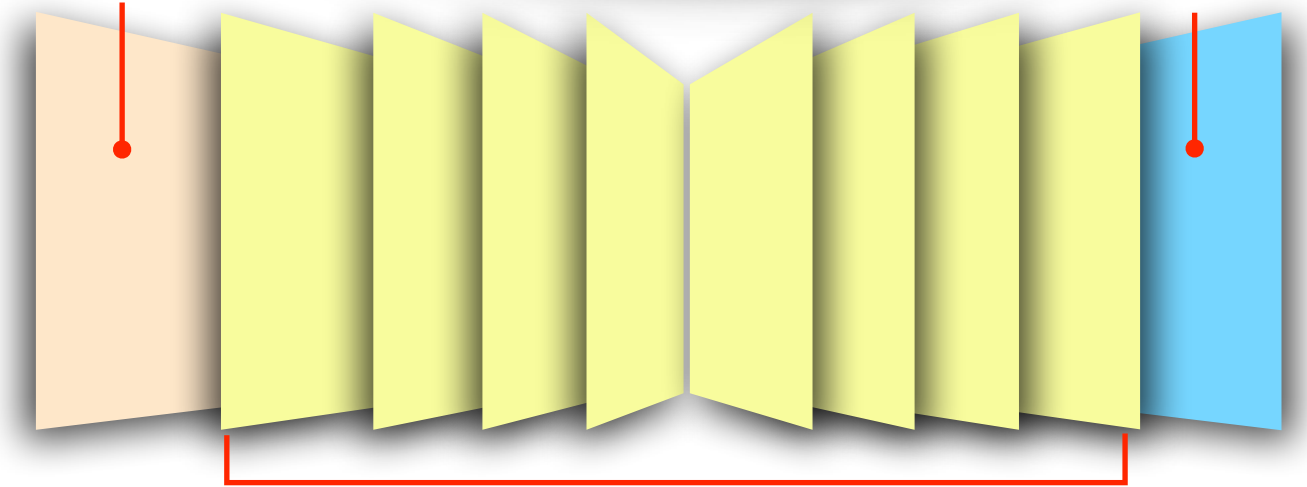
Chapter structure

UNIT INTRODUCTION

- Summarize key content, skills, and learning outcomes.
- Use as a checklist for setting work and viewing student progress.

PERSONAL PROGRESS CHECK

- Assess student understanding of the chapter content.
- Multiple choice and free response questions



ACTIVITY PAGES

- Engaging and informative activities have been designed to cover the required content and skills as stipulated in the AP CED
- Questions within activities are designed to evaluate the student's understanding of the content

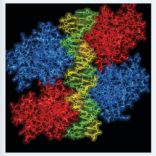
Unit (Chapter) Introduction

- Each unit (chapter) introduction highlights the content and skills required to develop understanding.
- **Key content**, **skills**, and **learning outcomes** are summarized in bullet points.
- Use the checklist boxes to set work and view student progress.

UNIT 1

Chemistry of Life

Learning Objectives



Developing understanding

CONTENT: This unit sets the foundation for understanding the chemical basis of life and includes a survey of the elements essential to carbon-based systems. You will learn about the central role of water in biological systems and build an understanding of how the organization of living systems depends on an input energy and an exchange of macromolecules. Understanding how macromolecules are constructed from monomers is central to this.

SKILLS: This unit emphasizes skills in describing biological processes, principles, and concepts represented visually. The skill of argumentation is introduced, using a model to predict the causes or effects of a change in a system.

1.1 Structure of water and hydrogen bonding ..... activity 1

- ☐ 1. Explain the structure of a water molecule, identifying how hydrogen bonding between water molecules accounts for water's unique properties. Use visual representations to explain the properties of water in its liquid and solid states.
- ☐ 2. Explain how living systems depend on the properties of water that arise from its polarity and hydrogen bonding. Include reference to cohesion, adhesion, thermal conductivity, high specific heat capacity, heat of vaporization, and heat of fusion, and role as a universal solvent.

1.2 Elements of life ..... activity 2

- ☐ 3. Identify the macromolecules required by living organisms and describe their composition. Describe how organisms must exchange matter with the environment to grow, reproduce, and maintain organization.
- ☐ 4. Describe how carbon moves from the environment to organisms and how it is used to build biological molecules and in storage and cell formation in all organisms.
- ☐ 5. Describe how nitrogen and phosphorus move from the environment to organisms and how they are used in building new molecules in organisms.

1.3 Introduction to biological macromolecules ..... activities 3-5, 10, 13

- ☐ 6. Describe how dehydration synthesis (condensation) and hydrolysis reactions are used to form and cleave covalent bonds between monomers in nucleic acids, proteins, carbohydrates, and lipids.

1.4 Properties of biological macromolecules ..... activities 4-14

- ☐ 7. Describe how biological information is encoded in sequences of nucleotide monomers. Describe the structural components of nucleotides.
- ☐ 8. Describe how the primary structure of a polypeptide determines the overall shape of a protein. Describe the structure of an amino acid and how the properties of the amino acid R groups and their interactions determine final protein structure and function.
- ☐ 9. Describe how the structures of carbohydrate monomers determine the properties and functions of the molecules.
- ☐ 10. Describe the non-polar nature of a typical lipid (e.g. a triacylglycerol) and explain how phospholipids differ in having polar and non-polar regions. Explain how differences in fatty acid saturation determine lipid structure and function.

1.5 Structure and function of biological macromolecules ..... activities 4-12

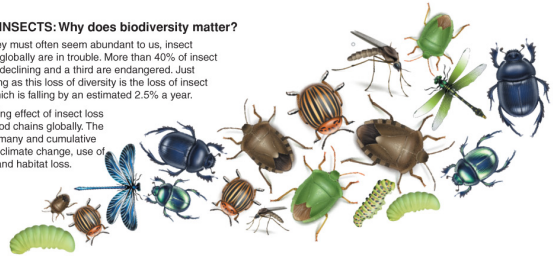
- ☐ 11. Explain how the nucleotides are organized into polymers called nucleic acids, including reference to the phosphodiester bonds that form between adjacent nucleotides. Interpret diagrams and models to explain the directionality of nucleic acids, defined by the 3' and a 5' carbons of the sugar in the nucleotide.
- ☐ 12. Explain the antiparallel, double helix structure of DNA, including how the directionality of the molecule determines the direction of nucleotide addition during DNA and RNA synthesis (5'→3'). Explain the role of hydrogen bonding between nucleobases in formation of the DNA double helix.
- ☐ 13. Explain how proteins have a primary structure comprising linear chains of amino acids connected by covalent peptide bonds formed at the carboxyl end of the growing polypeptide chain. Explain the interactions involved in creating a protein's primary, secondary, tertiary, and quaternary structures.
- ☐ 14. Explain the role of a protein's precise three-dimensional structure to its biological function. Explain how this precise structure can be disrupted and predict the consequences of such disruptions.
- ☐ 15. Explain how carbohydrates are made up of chains of monosaccharide monomers connected by covalent glycosidic bonds. Explain why some polysaccharides are linear and some are branched. To illustrate this, compare and contrast the structure of glucose polymers such as cellulose, starch, and glycogen.

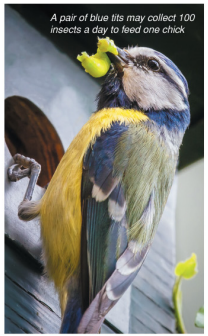
1.6 Nucleic acids ..... activities 3, 4

- ☐ 16. Describe the structural similarities and differences between DNA and RNA, including reference to the sugar present, the nucleobases present, and the number of strands usually present (single/double).

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 green lacewings feed on aphids and other soft bodied insect pests.

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.

1: PROVIDERS

Insects are part of almost all food chains as prey for a wide range of other animals, including birds, bats, amphibians, and fish. Recent declines in many bird populations have been linked to scarcity of insect prey.

PEST CONTROLLERS

Predatory insects play a critical role in controlling the pest insects that threaten crops. They help to reduce pest control costs and increase yields, saving billions of dollars every year.

What may happen without insects:

Species at higher trophic levels may decline in numbers and diversity.

Pests may increase, damaging crops and forests, and pesticide use may increase.

2. (a) Describe the primary cause of the current lack of genetic diversity in modern sea otter po

(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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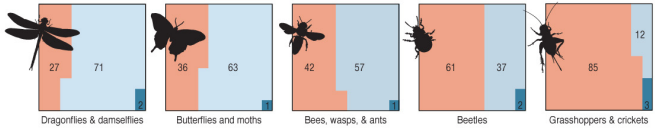
Insect declines: how they're tracking



Species in the five major insect orders (above) have all declined in recent decades. Of the 2200 species tracked by the IUCN almost half are declining. These 2200 species represent just a tiny proportion of total insect biodiversity. Even with today's technological advancement, only 20% of insects species are even identified. We will not even know if they are lost.

Dung beetles process cattle dung in 23 months compared to the 26 it would take without them.

Bumblebees are important pollinators of both crops and wildflowers. A single bee can visit several thousand flowers a day.

One termite colony can excavate 0.2 tonnes of soil per year.

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.

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.

SOIL ENGINEERS

Termites and ants are an essential part of arid 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.

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

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

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

ple, explain the importance of biodiversity to ecosystem function and to human wellbeing:

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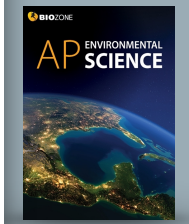
Content is accessible through the use of engaging diagrams and manageable blocks of text

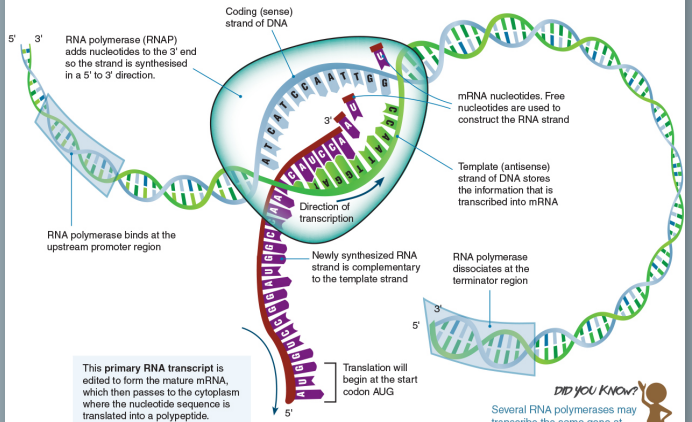


116 Transcription in Eukaryotes

Key Idea: Transcription is the first step of gene expression. It involves the enzyme RNA polymerase rewriting the information into a primary RNA transcript. In eukaryotes, transcription takes place in the nucleus.

Transcription is the first stage of gene expression. It takes place in the nucleus and is carried out by the enzyme RNA polymerase, which rewrites the DNA into a primary RNA transcript using a single template strand of DNA. The protein-coding portion of a gene is bounded by an upstream start (promoter) region and a downstream terminator region. These regions control transcription by telling RNA polymerase where to start and stop transcription. In eukaryotes, non protein-coding sections called **introns** must first be removed and the remaining **exons** spliced together to form the mature mRNA before the gene can be translated into a protein. This editing process also occurs in the nucleus.

Transcription is carried out by RNA polymerase (RNAP)



This **primary RNA transcript** is edited to form the mature mRNA, which then passes to the cytoplasm where the nucleotide sequence is translated into a polypeptide.

DID YOU KNOW?

Several RNA polymerases may transcribe the same gene at any one time, allowing a high rate of mRNA synthesis.

1. (a) Name the enzyme responsible for transcribing the DNA: _____
   (b) What strand of DNA does this enzyme use? _____
   (c) The code on this strand is the [same as / complementary to] the RNA being formed (circle correct answer).
   (d) Which nucleotide base replaces thymine in mRNA? _____
   (e) On the diagram, use a colored pen to mark the beginning and end of the protein-coding region being transcribed.
2. (a) In which direction is the RNA strand synthesized? _____
   (b) Explain why this is the case: _____
3. (a) Why is AUG called the start codon? _____
   (b) What would the three letter code be on the DNA codi

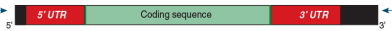
ISBN: 978-1-98-856656-6
DRAFT: REVIEW ONLY

117 mRNA Processing in Eukaryotes

Key Idea: Post transcriptional modifications of RNA include exon splicing and the addition of nucleotide caps and tails.

Once a gene is transcribed, the primary transcript is modified to produce the mRNA strand that will be translated in the cytoplasm. Modifications to the 5' and 3' ends of the transcript enable the mRNA to exit the nucleus and remain stable long enough to be translated. Other post transcriptional modifications remove non-protein coding intronic DNA and splice exons in different combinations to produce different protein end products.

Primary RNA is modified by the addition of caps and tails



CAP
A guanine nucleotide cap at the 5' end of the primary transcript stops degradation during transport from the nucleus and helps in the first phase of translation.

POLY-A TAIL
Adenosine nucleotides are added to the primary transcript. These poly-A tails aid nuclear export, translation, and stability of the mRNA.

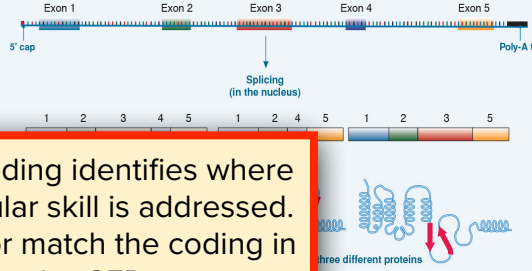
After transcription, the primary RNA transcript is modified by enzymes to create 'caps' and 'tails'. These modifications are part of the untranslated region (UTR) at each end of a gene. They stabilize the RNA, protect it from degradation, and help its transport through the nuclear pore. They are also important in translation although they are not translated themselves. The START and STOP points of translation are marked by darker green lines.

Modification after transcription

- As you have seen earlier, introns are removed from the primary mRNA transcript and the exons are spliced together. However, exons can be spliced together in different ways to create variations in the translated proteins. Exon splicing occurs in the nucleus, either during or immediately after transcription.
- In mammals, the most common method of alternative splicing involves exon skipping, in which not all exons are spliced into the final mRNA (below).

DID YOU KNOW?

Human DNA contains 25,000 genes, but produces up to 1 million different proteins. Modifications after transcription and translation allow several proteins to be produced from just one gene.



2. (a) What happens to the intronic sequences in DNA after transcription? _____
   (b) What is one possible fate for these introns? _____
3. How can so many proteins be produced from so few gene
4. If a human produces 1 million proteins, but human DNA codes for only 25,000 genes, on average how many proteins are produced per gene? _____

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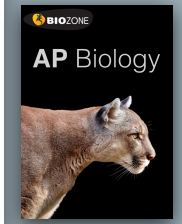
DRAFT: REVIEW ONLY

Color coding identifies where a particular skill is addressed. The color match the coding in the CED

The Big Idea and specific skill is identified here

Points to related content elsewhere in the book



149 The Covid-19 Pandemic

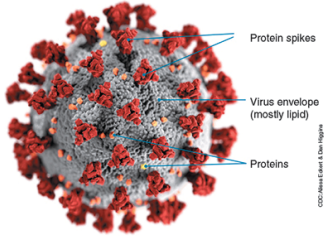
Key Question: What do we know about Covid-19 and how has it affected the environment?

In December 2019, a new strain of coronavirus was detected in Wuhan, China. The new virus was named Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). Infection with the virus causes a disease called Covid-19. The WHO declared a pandemic in March 2020 as the virus spread around the world and a pandemic status was still in place at the time of writing this book. The Covid-19 pandemic has disrupted the world travel and global economies. Millions of people have been infected and hundreds of thousands have died. Enormous stress has been placed on health systems, and the harsh financial impacts will be felt for years because millions of people have lost their jobs.

What is Covid-19?

- Covid-19 is the disease caused when someone is infected with the SARS-CoV-2 virus (right).
- The virus affects the respiratory system.
- 80% of infected people recover without hospital care.
- 20% of infected people develop severe breathing problems and may require high level hospital care. The elderly and people with underlying medical problems are most at risk of becoming very sick.
- The virus is spread through the environment in small droplets from the nose and mouth (e.g. when a person speaks, sneezes, or coughs). People become infected when they breathe these droplets in, or when they touch a surface contaminated with the virus.
- There is currently no vaccine, but attempts to develop one are underway.

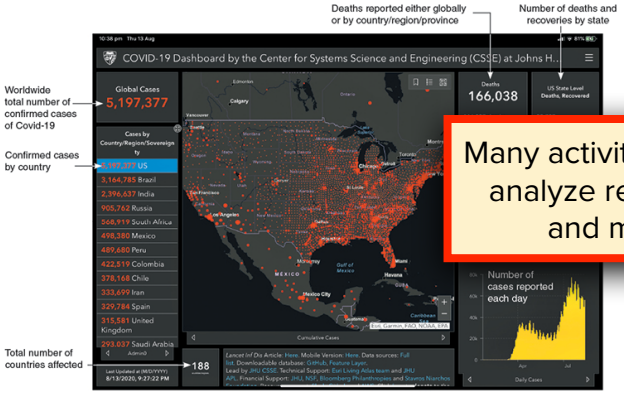
A representation of the SARS-CoV-2 virus



Spread of coronavirus

Reports of viral pneumonia (a lung infection) in Wuhan, China were reported on the 31st December 2019. Early in January 2020, a new coronavirus was identified as the cause of the infections. The new virus, SARS-CoV-2, is thought to have arisen in bats, passing to humans through another, as yet unknown, animal. SARS and MERS probably transferred to humans this way also.

Despite strict restrictions, including travel bans, being placed on the residents of Wuhan and the surrounding region, the virus began to spread through China. On the 13th January 2020 the first case outside of China was recorded in Thailand. Within 10 days the virus had spread to a number of countries, including the US, as infected travelers flew around the world. Over 188 countries and territories have reported infections. The situation is changing daily and the best way to find the most recent information is to visit the WHO Covid-19 Interactive Dashboard or the John Hopkins University of Medicine Covid-19 Dashboard. Find the details for both sites on **BIOZONE's Resource Hub**.



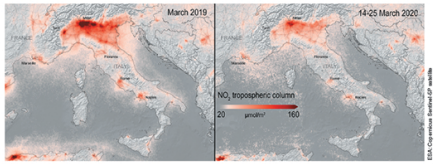
EIN-3 2.B | EIN-3 2.C | EIN-3 5.A

150 Environmental Effects of Covid-19

Key Question: How has Covid-19 affected the environment?

Many countries went into some level of lockdown as it became evident strong measures were needed to reduce the spread of the new coronavirus. For many countries this meant banning travel, and closing public facilities, schools, and physical places of business. Industrial activity, energy demand, and the number of vehicles on roads fell dramatically. Scientists have been monitoring the effect of these changes.

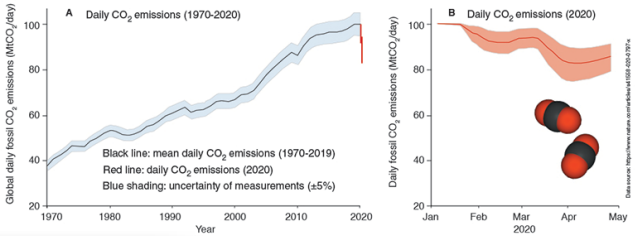
Italy was one of the first European countries to report Covid-19 cases. Italy went into a national lockdown in March 2020 in an attempt to reduce its spread. Within weeks a reduction in air pollution over Italy was observed. The images on the right show nitrogen dioxide concentrations over Italy in March 2019 (left) and during the lockdown in March 2020 (right). The main source of nitrogen dioxide from human activities is the combustion of fossil fuels (coal, gas and oil) especially fuel used in cars.



How has Covid-19 affected daily global CO_2 emissions?

The lockdown reduced the demand for energy and also reduced global carbon dioxide emissions (below). So, what does this mean for the environment? Many countries have signed the Kyoto Protocol, an international treaty designed to lower greenhouse gas emissions and help reduce the effects of global warming. Carbon dioxide is a greenhouse gas, so the reduced CO_2 emissions observed over lockdown are helpful in reducing the effects of global warming. However, for the Kyoto Protocol to succeed, the reduction in emissions must be sustained over a long period. Most researchers predict that maintaining the low emission levels seen between January and May 2020 will be very difficult once the world returns to a pre-pandemic level of activity.

Daily global CO_2 emissions (1970-2020)



...ental benefits observed during the Covid-19 lockdown: _____

...missions dropped significantly from 100 Mt CO_2 per day to around 85 Mt

...n nitrogen dioxide also dropped significantly as shown by the nitrogen oxide

...sphere in Italy between March 2019 and March 2020 (during lockdown).

2. Suggest why scientists do not think the reduction in emissions will be sustainable after the lockdowns are lifted:

The emissions dropped mostly because people stopped using cars and other forms of vehicular transport (because they were staying home) and some industries shut down or were reduced in output. Once the lockdowns are over, people will again be using vehicular transport and industry will resume full production capacity. It is entirely likely that the emissions will return to previous levels.

EIN-3 2.C

Many activities require students to analyze real second hand data and make conclusions

27 Factors Affecting Membrane Permeability

Key Question: How do temperature and solvents affect the structure of cellular membranes and alter their permeability?

Membrane permeability can be disrupted if membranes are subjected to high temperatures or solvents. At temperatures above the optimum, the membrane proteins become denatured. Alcohols, e.g. ethanol, can also denature proteins. In both instances, the denatured proteins no longer function properly and the membrane loses its selective permeability and becomes leaky. What's more, the combination of alcohol and high temperature can also dissolve lipids.

The aim and hypothesis

To investigate the effect of ethanol concentration on membrane permeability. The students hypothesized that the amount of pigment leaking from the beetroot cubes would increase with increasing ethanol concentration.

Background

Plant cells often contain a large central vacuole surrounded by a membrane called a **tonoplast**. In beetroot plants, the vacuole contains a water-soluble red pigment called betacyanin, which gives beetroot its color. If the tonoplast is damaged, the red pigment leaks out into the surrounding environment. The amount of leaked pigment relates to the amount of damage to the tonoplast.

Beetroot cubes

Method for determining effect of ethanol concentration on membrane permeability

Raw beetroot was cut into uniform cubes using a cork borer with a 4 mm internal diameter. The cubes were trimmed to 20 mm lengths and placed in a beaker of distilled water for 30 minutes. The following ethanol concentrations were prepared using serial dilution: 0, 6.25, 12.5, 25, 50, and 100%.

Eighteen clean test tubes were divided into six groups of three and labeled with one of the six ethanol concentrations. Three cm^3 of the appropriate ethanol solution was placed into each test tube. A beetroot cube (dried by blotting) was added to each test tube. The test tubes were covered with parafilm (plastic paraffin film with a paper backing) and left at room temperature. After one hour the beetroot cubes were removed and the absorbance measured at 477 nm. Results are tabulated, below.

Ethanol concentration (%)	Absorbance of beetroot samples at varying ethanol concentrations			
	Absorbance at 477 nm			Mean
	Sample 1	Sample 2	Sample 3	
0	0.014	0.038	0.038	
6.25	0.009	0.015	0.023	
12.5	0.010	0.041	0.018	
25	0.067	0.064	0.116	
50	0.945	1.100	0.731	
100	1.269	1.376	0.907	

1. Why is it important to wash the beetroot cubes in distilled water prior to carrying out the experiment? _____

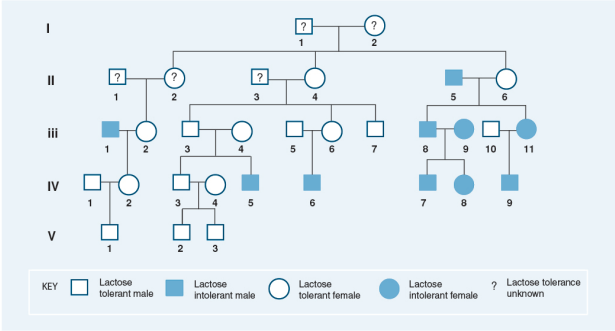
2. Complete the table above by calculating the mean absorbance for each ethanol conce

3. What is absorbance measuring and why is it increasing with increasing ethanol conce

ISBN: 978-1-98-856656-6

The pedigree of lactose intolerance

Lactose intolerance is the inability to digest the milk sugar lactose. It occurs because some people do not produce lactase, the enzyme needed to break down lactose. The pedigree chart below was one of the original studies to determine the inheritance pattern of lactose intolerance.



2. Use an analysis of the pedigree above to make a claim about the inheritance pattern of lactose intolerance. Support your claim with at least two pieces of evidence:

3. (a) Use the Punnett square below to show the cross between III-10 and III-11 in the pedigree chart above. Use the capital letter L for the dominant allele and the letter l for the recessive allele.

Male alleles

Female alleles

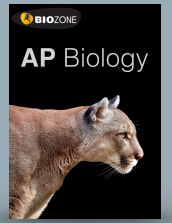
(b) Explain how you can be certain about III-10's genotype:

heterozygous for lactose intolerance (LI)? Show your working or justification:

5. Is there any chance that parents III-8 and III-9 could produce a lactose tolerant child? Explain: _____

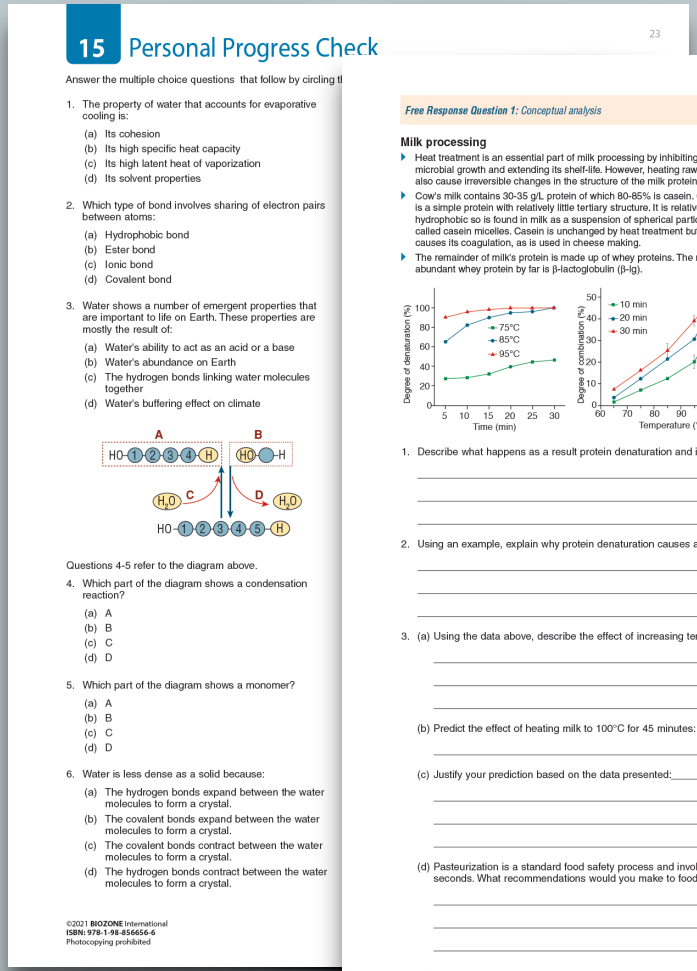
ISBN: 978-1-98-856656-6

Many activities require students to analyze real second hand data or case studies to make conclusions



College Board-Style Assessments

- **Personal Progress Checks** conclude each unit.
- These assessments follow the format stipulated in the CED.
  - **Multiple choice** questions
  - **Free response** questions
- Use as **formative assessment** or for **exam practice**.



15 Personal Progress Check

23

Answer the multiple choice questions that follow by circling th

1. The property of water that accounts for evaporative cooling is:
   (a) Its cohesion
   (b) Its high specific heat capacity
   (c) Its high latent heat of vaporization
   (d) Its solvent properties

2. Which type of bond involves sharing of electron pairs between atoms:
   (a) Hydrophobic bond
   (b) Ester bond
   (c) Ionic bond
   (d) Covalent bond

3. Water shows a number of emergent properties that are important to life on Earth. These properties are mostly the result of:
   (a) Water's ability to act as an acid or a base
   (b) Water's abundance on Earth
   (c) The hydrogen bonds linking water molecules together
   (d) Water's buffering effect on climate

Questions 4-5 refer to the diagram above.

4. Which part of the diagram shows a condensation reaction?
   (a) A
   (b) B
   (c) C
   (d) D

5. Which part of the diagram shows a monomer?
   (a) A
   (b) B
   (c) C
   (d) D

6. Water is less dense as a solid because:
   (a) The hydrogen bonds expand between the water molecules to form a crystal.
   (b) The covalent bonds expand between the water molecules to form a crystal.
   (c) The covalent bonds contract between the water molecules to form a crystal.
   (d) The hydrogen bonds contract between the water molecules to form a crystal.

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Free Response Question 1: *Conceptual analysis*

Milk processing

- Heat treatment is an essential part of milk processing by inhibiting microbial growth and extending its shelf-life. However, heating raw milk can also cause irreversible changes in the structure of the milk proteins.
- Cow's milk contains 30-35 g/L protein of which 80-85% is casein. Casein is a simple protein with relatively little tertiary structure. It is relatively hydrophobic so is found in milk as a suspension of spherical particles called casein micelles. Casein is unchanged by heat treatment but low pH causes its coagulation, as is used in cheese making.
- The remainder of milk's protein is made up of whey proteins. The most abundant whey protein by far is β-lactoglobulin (β-lg).

β-lactoglobulin

β-lg is a relatively small protein and makes up most of the volume of whey proteins in milk. It is acid stable but when exposed to heat it forms large aggregates by associating with the casein micelles. These aggregations compromise milk quality and digestibility in people with reduced digestive ability.

Researchers wanted to study the effect of different heat treatments on the extent of whey protein denaturation and combination with casein micelles. Raw milk was subjected to heat treatments at different temperatures (75-95°C) and for varying lengths of time (0-30 minutes). The proportion of whey proteins denatured or combining with casein micelles was determined.

1. Describe what happens as a result protein denaturation and identify likely causes: _____

2. Using an example, explain why protein denaturation causes a change in the properties or biological function of a protein:

3. (a) Using the data above, describe the effect of increasing temperature and heating time on the whey proteins in milk:

   (b) Predict the effect of heating milk to 100°C for 45 minutes: _____

   (c) Justify your prediction based on the data presented: _____

   (d) Pasteurization is a standard food safety process and involves heating milk for 63°C for 30 minutes or 72°C for 15 seconds. What recommendations would you make to food processors when receiving raw milk for processing?

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AP Environmental Science

Practical Investigations

- Investigations are varied:
  - Experiments
  - Paper practicals
  - Building models
  - Computer simulations
  - Computational models using spreadsheets
- No special kits are needed
- Equipment list provided in each book

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

3: Populations

INVESTIGATION 3.1
Creating a model of logistic growth

Per student/pair
Computer
Spreadsheet application e.g. ®Excel

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

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.

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&Ms®
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 6.4
Solar power

Per student/pair
Computer
Energy 2D software
https://energy.concord.org/energy2d/

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
60 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

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 *Saccharomyces* yeast
40 mL warm water
500 mL glucose solution (100 g/L)

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

88 Methods to Reduce Urban Runoff

Key Question: What methods could be used to reduce runoff or mitigate the effects of runoff?

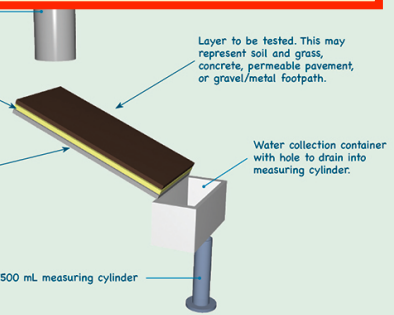
Localized flooding can be a real problem in cities where hard surfaces cover almost every part of the ground. Complex and costly drainage systems must be installed and maintained to remove stormwater, but if these become blocked, flooding can quickly occur. Changing ground coverings can change the rate 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.

INVE … list.

Differ… capac…

2. Set u…

Sprin… holes, to simulate rain.



3. The layers to be tested will be concrete, permeable pavement, gravel/metal footpath, and soil. To make it easier, these will be represented as more easily obtainable materials as follows:
   Concrete = one large floor tile,
   Permeable pavement = multiple small tiles placed side by side to cover the entire ramp.
   Gravel/metal footpath = layer of gravel and sand
   Soil and grass = large thin sponge or smaller sponges laid side by side.
4. To test the rate of water runoff for the first material, first wet the subsoil sponge, then wring it out as much as possible. Place the tile on top of the sponge on the ramp as shown above.
5. Measure 500 mL of water. Rather than just pouring the water straight onto the tile, you need to simulate rainfall. This can be done using a sprinkler container (e.g. a container with holes in the bottom, such as a metal can). This will also help to regulate the rate at which the water hits the surface being tested.
6. When you have set up the equipment start a stopwatch and pour all the wate… Direct the water onto the top of the ramp so it runs down into the collection … measuring cylinder.
7. In a notebook or your logbook, record the time it takes for the water to fill t… 100 mL, 200 mL, 300 mL, 400 mL, and 500, mL. Record the total amount of wa… may not be all the original 500 mL, so you might not record a time for 500 m…
8. Wring out the flat subsoil sponge as much as possible and repeat the process … times and final water volume collected each time. Average the time it took 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.

Group work/collaboration opportunities are identified

Practical investigations allow students to engage in the required practices and skills

ISBN: 978-1-98-856632-0

158 Climate Change and Polar Regions

Key Question: How will climate change affect polar habitats?

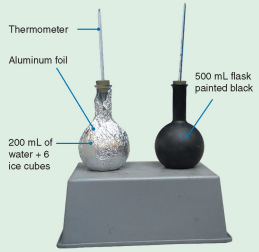
The surface temperature of the Earth is in part regulated by the amount of ice on its surface, which reflects a large amount of heat into space. However, the area and thickness of the polar sea-ice is rapidly decreasing. From 1980 to 2008 the Arctic summer sea-ice minimum almost halved, decreasing by more than 3 million square kilometers. The 2012 summer saw the greatest reduction in sea-ice since the beginning of satellite recordings. This melting of sea-ice can trigger a cycle where less heat is reflected into space during summer, warming seawater and reducing the area and thickness of ice forming in the winter. At the current rate of reduction, it is estimated that there may be no summer sea-ice left in the Arctic by 2050.

Modeling the effect of albedo on ice sheet melting

- The investigation below provides a model for you to explore and understand the importance of heat absorbance and reflectivity (albedo) to ice sheet melting.

INVESTIGATION 9.1: Albedo and ice cube melting See appendix for equipment list.

1. Work in pairs or groups of three. Collect two 500 mL Florence or Erlenmeyer flasks. Paint one of the flasks black and wrap the second flask in aluminum foil.
2. Weigh out six ice cubes (~60–90 g). Record the mass of the ice in the table below. Weigh out a second lot of ice cubes, it must have the same mass as the first.
3. Add 200 mL of 20°C water and the weighed ice cubes to each flask.
4. Seal the flasks and insert a thermometer into each. Record the temperature (time zero) on the table.
5. Place the flasks in a sunny spot and record the temperature every 2 minutes for 10 minutes. If it is not a sunny day, use a 60 W tungsten lamp placed 15 cm from the flasks as the heat source.
6. After 10 minutes remove the ice cubes and reweigh them. Record the values on the table below.



Time (minutes)	Temperature - black flask (°C)	Temperature - foil coated flask (°C)
0		
2		
4		
6		
8		
10		
Initial mass of ice (g)		

…igation: _____

_____

…the grid (above):

3. Which flask has the greatest albedo? _____
4. Calculate the change in mass of the ice cubes for both the black and foil covered flasks: _____

_____

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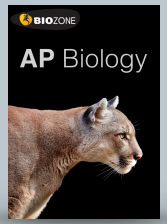
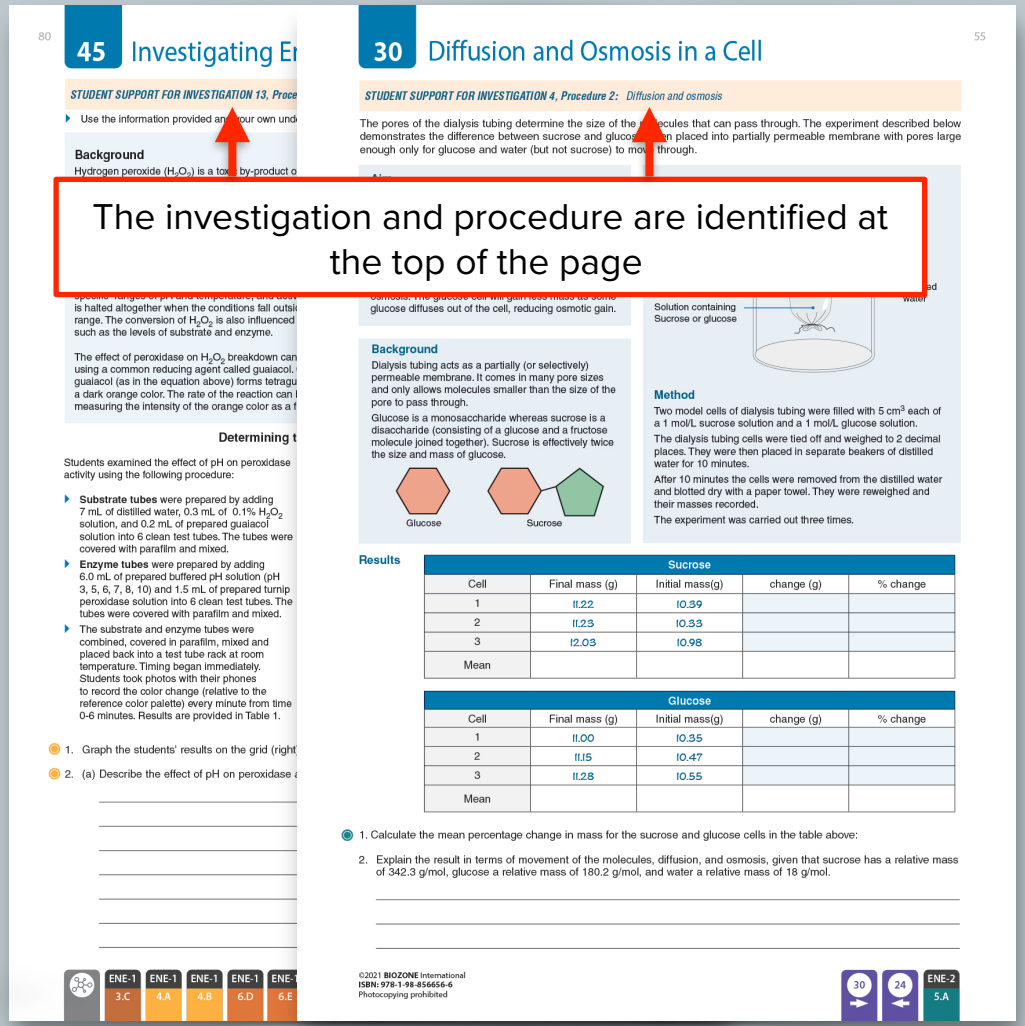
AP Biology

Supporting investigations

- Practical activities **support** the **13 AP Biology investigations**
- Not designed to replace the practicals
- Prepare students for the AP Practicals
- Integrated in context





Environmental legislation

- **Required environmental legislation** components are identified by a code on the page.
- A full list of the environmental legislation components can be viewed in the Teacher's Edition.

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

121 Reducing Air Pollution

Key Question: What methods can be used to reduce air pollution and are they effective?

In the US, the Clean Air Act was amended in 1970 to limit emissions from stationary and mobile sources (vehicles). At the same time, the National Ambient Air Quality Standards (NAAQS) were established. The purpose of this was to address the public health and welfare risks posed by widespread air pollutants. Other major amendments occurred in 1977 and 1990. New standards meant that ways had to be developed to reduce emissions. These generally fall into three categories; regulatory practices, conservation practices, and the use of alternative fuels.

Identifies where an environmental legislation component is covered

Regulatory practices

The US Environmental Protection Agency (EPA) establish health-based national air quality standards for common pollutants. Each state is responsible for implementing strategies to achieve these standards. For toxic pollutants or acid rain, the EPA may also monitor compliance in addition to setting limits. The image above shows a factory in Houston burning car batteries in 1972. The EPA shut this factory down in 1975.

Conservation practices

Reducing or conserving the use of fossil fuels reduces air pollution. There are a number of ways to achieve this:

- Riding a bicycle or walking instead of traveling in a vehicle.
- Using public transport or carpooling to minimize vehicle emissions.
- Using energy efficient light bulbs and appliances, and turning off lights and appliances when they are not in use conserves electricity.

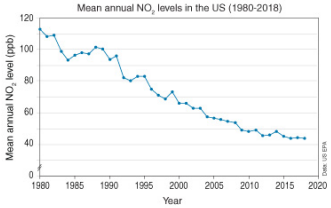
Alternative energy and fuel sources

Many processes still rely on combustion of fossil fuels, which is a major source of air pollutants. Solar cells, hydroelectricity, and wind farms produce electricity without emitting pollutants. Alternative fuels, called biofuels, can be used to replace gasoline in vehicles. Biofuels are made from renewable food crops such as corn or soya, or cellulose (e.g. forestry waste). Their use reduces air pollutant emissions, but reduces crop biomass available as food, and it can drive up the price of food.

1. Explain the role of the US EPA in reducing air pollution levels: _____

2. Why do you think it is important to use a combination of all three practices described above to reduce air pollution?

3. The graph on the right shows levels of atmospheric NO_2 in the US between 1980-2018. Use this data to evaluate the success of national initiatives to reduce NO_2 pollution:



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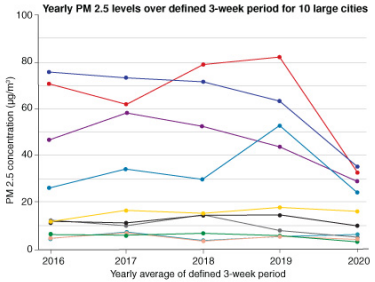
STB-2
7.D

How did Covid-19 help reduce air pollution levels?

- At the beginning of 2020 a pandemic was declared as the Covid-19 virus spread throughout the world. Many countries went into lock down to stop its spread, and millions of nonessential workers stayed at home for several weeks or months. The graph below shows the effects of the lock down on levels of the air pollutant PM 2.5 in 10 major cities.
- PM 2.5 (Particulate Matter 2.5), are particles or droplets in the air that are 2.5 microns or less in diameter. They are produced by vehicles, from operations where fuels such as wood, heating oil or coal are burned, and from forest and grass fires. Fine particles also form from the reaction of gases or droplets in the atmosphere from sources such as power plants.
- Particulate matter is harmful because it can be inhaled into the lungs. Long term exposure can cause cardiovascular and respiratory (breathing) diseases as well as increasing the risk of lung cancer.
- In many cities it is common to see people wearing face masks to protect themselves when air pollution levels are high (right).



Key	City	Date	Shift
	Seoul	26 Feb – 18 Mar	↓ -54%
	Wuhan	3 Feb – 24 Feb	↓ -44%
	Mumbai	23 Mar – 13 Apr	↓ -34%
	Delhi	23 Mar – 13 Apr	↓ -60%
	Rome	9 Mar – 30 Mar	↓ -19%
	Madrid	23 Mar – 13 Apr	↓ -11%
	London	23 Mar – 13 Apr	↓ -9%
	Sao Paolo	23 Mar – 13 Apr	↓ -32%
	New York	23 Mar – 13 Apr	↓ -25%
	Los Angeles	23 Mar – 13 Apr	↓ -31%

Adapted from IQAir (2020) COVID-19 air quality report.
*Note that Rome and Madrid track very closely until 2019-2020

5. (a) Study the graph of PM 2.5 levels above. Briefly describe the general trend between 2019 and 2020:

(b) Suggest what caused this trend: _____

(c) Predict what you think would have happened to air pollution levels when the lock down ended: _____

(d) From this study suggest one way in which large cities could reduce their level of air pollution: _____

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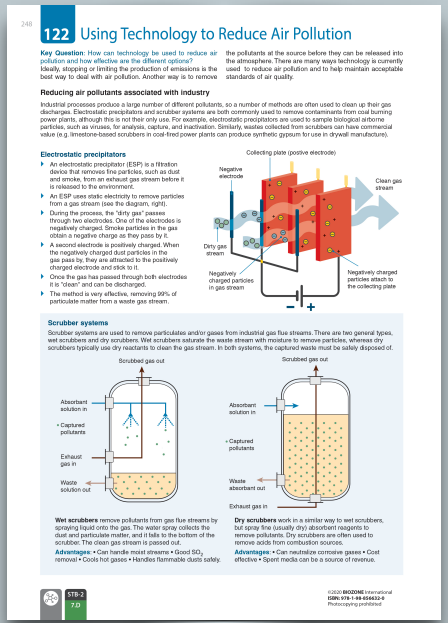
Environmental solutions

- Students have opportunities to propose solutions to the effect of human activity on the environment.
- Students draw on their understanding of environmental legislation, technology, and scientific knowledge to propose and justify their solutions.



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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 flue 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 reactants to clean the gas stream. In both systems, the captured waste must be safely disposed of.

Wet scrubbers remove pollutants from gas flue 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 moist streams • Good SO_2 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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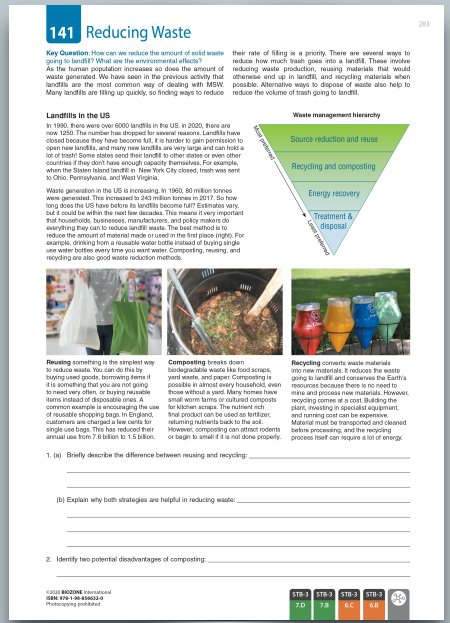
STB-2 7.D



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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 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 (right). 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.

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 cultured 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 comes at a cost. 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.

1. (a) Briefly describe the difference between reusing and recycling: _____

(b) Explain why both strategies are helpful in reducing waste: _____

2. Identify two potential disadvantages of composting: _____

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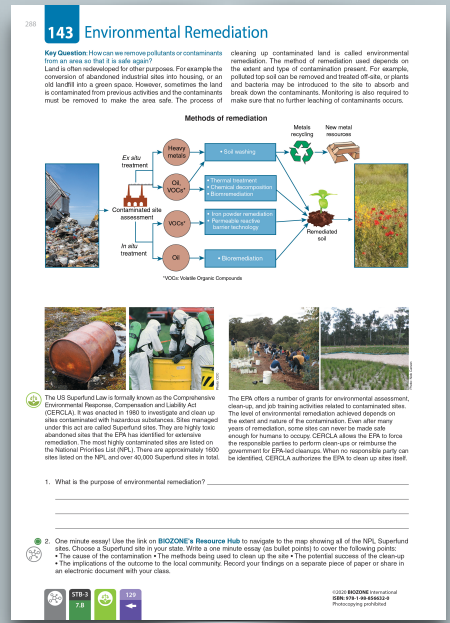
STB-3 7.D | STB-3 7.B | STB-3 6.C | STB-3 6.B



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143 Environmental Remediation

Key Question: How can we remove pollutants or contaminants from an area so that it is safe again?

Land is often redeveloped for other purposes. For example the conversion of abandoned industrial sites into housing, or an old landfill into a green space. However, sometimes the land is contaminated from previous activities and the contaminants must be removed to make the area safe. The process of cleaning up contaminated land is called environmental remediation. The method of remediation used depends on the extent and type of contamination present. For example, polluted top soil can be removed and treated off-site, or plants and bacteria may be introduced to the site to absorb and break down the contaminants. Monitoring is also required to make sure that no further leaching of contaminants occurs.

The US Superfund Law is formally known as the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). It was enacted in 1980 to investigate and clean up sites contaminated with hazardous substances. Sites managed under this act are called Superfund sites. They are highly toxic abandoned sites that the EPA has identified for extensive remediation. The most highly contaminated sites are listed on the National Priorities List (NPL). There are approximately 1600 sites listed on the NPL and over 40,000 Superfund sites in total.

The EPA offers a number of grants for environmental assessment, clean-up, and job training activities related to contaminated sites. The level of environmental remediation achieved depends on the extent and nature of the contamination. Even after many years of remediation, some sites can never be made safe enough for humans to occupy. CERCLA allows the EPA to force the responsible parties to perform clean-ups or reimburse the government for EPA-led cleanups. When no responsible party can be identified, CERCLA authorizes the EPA to clean up sites itself.

1. What is the purpose of environmental remediation? _____

2. One minute essay! Use the link on **BIOZONE's Resource Hub** to navigate to the map showing all of the NPL Superfund sites. Choose a Superfund site in your state. Write a one minute essay (as bullet points) to cover the following points:
   • The cause of the contamination • The methods being used to clean up the site • The potential success of the clean-up • The implications of the outcome to the local community. Record your findings on a separate piece of paper or share in an electronic document with your class.

ISBN: 978-1-98-856632-9

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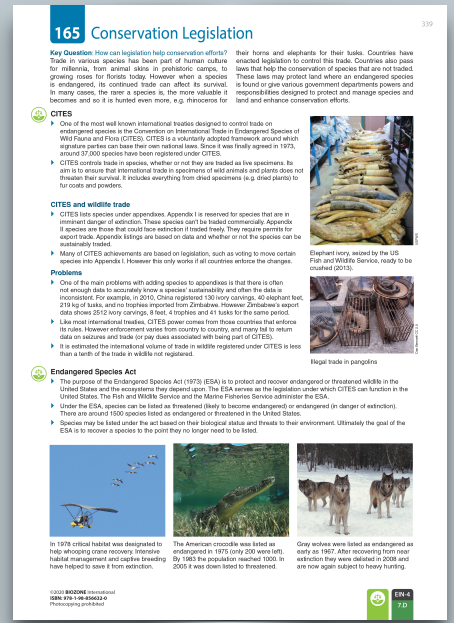


339

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 on 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.

Elephant ivory, seized by the US Fish and Wildlife Service, ready to be crushed (2013).

CITES and wildlife trade

- CITES lists species under appendices. Appendix I is reserved for species that are in imminent danger of extinction. These species can't be traded commercially. Appendix II species are those that could face extinction if traded freely. They require permits for export trade. Appendix listings are based on data and whether or not the species can be sustainably traded.
- 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 appendixes 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 tusks, and no trophies imported 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 return 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.

Illegal trade in pangolins

Endangered Species Act

- The purpose of the Endangered Species Act (1973) (ESA) 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 (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.

In 1978 critical habitat was designated to help whooping crane recovery. Intensive habitat management and captive breeding have helped to save it from extinction.

The American crocodile was listed as endangered in 1975 (only 200 were left). By 1983 the population reached 1000. In 2005 it was down listed to threatened.

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.

ISBN: 978-1-98-856632-9

EN-4 7.D

Glossary

- Key terms and their definitions are provided.
- Encourage students to use the glossary to:
  - Build their scientific vocabulary
  - Look up terms if they are unsure of their meaning

Appendix 2: Glossary

A

abiotic factor
Non-living component of the environment.

acid rain
Rain containing acids that form in the atmosphere when industrial gas emissions combine with water.

adaptation
A genetically determined characteristic that improves an organism's ability to survive and reproduce under prevailing environmental conditions.

albedo
A measure of how much light that hits a surface is reflected without being absorbed.

anoxic
Having no oxygen

antigenic drift
A mechanism for variation by viruses, where incremental mutations cause small changes in the virus over time.

antigenic shift
Major, rapid change caused when two viral strains (or different viruses) combine to form a new subtype.

anthropogenic
Of, relating to, or resulting from the influence of human beings on nature.

aquaculture
The rearing of aquatic animals or the cultivation of aquatic plants for food.

asthenosphere
The upper layer of the Earth's mantle, which lies below the lithosphere and is fluid-like with viscous and elastic behavior.

atmosphere, Earth's
The envelope of gases surrounding Earth.

B

bioaccumulation
The accumulation over time of a substance (especially a contaminant, such as a heavy metal) in a living organism.

biofuel
A fuel derived from biomass, such as plant or algae material or animal waste.

biomagnification
The process by which pesticides and other substances become more concentrated in each link of the food chain.

biome
Major regional ecological community of plants and animals.

biotic factor
Living component of the environment.

biotic potential
The capacity of a population of organisms to increase in numbers under optimum environmental conditions.

biochemical oxygen demand (BOD)
The amount of dissolved oxygen needed by aerobic biological organisms to break down organic material in a given water sample at certain temperature over a specific time.

C

carrying capacity
Number of individual organisms the resources of a given area can support, usually through the most unfavorable period of the year.

chlorofluorocarbon (CFC)
Any of several simple gaseous compounds that contain carbon, chlorine, fluorine, and sometimes hydrogen; a major cause of stratospheric ozone depletion.

commensalism
Relationship between species that is beneficial to one, but neutral or of no benefit to the other.

community
The living component of an ecosystem.

competition
Any interaction that is mutually detrimental to both participants, occuring between species that share limited resources.

condensation
The transformation of water vapor to a liquid state.

consumer
Any organism that lives on other organisms, dead or alive.

control (experimental)
A 'treatment' in an experiment designed to evaluate the effect of independent variable on the response variable. It usually lacks the variable being tested but is otherwise the same as all other treatments.

convergent plate boundary
A tectonic boundary where two plates are moving toward each other and colliding.

Coriolis effect
Physical consequence of the law of conservation of angular momentum; as a result of the Earth's rotation, a moving object veers to the right in the Northern Hemisphere and to the left in the Southern Hemisphere relative to the Earth's surface.

crust, Earth's
The outermost layer of the Earth, composed of a great variety of igneous, metamorphic, and sedimentary rocks.

D

decomposer
Organism that obtains energy from the breakdown of dead organic matter to simpler substances; most precisely refers to bacteria and fungi.

denitrification
Reduction of nitrates and nitrites to nitrogen by microorganisms.

dependent variable
The variable being tested and measured in an experiment, whose value depends on that of the independent variable.

detritivore
Organism that feeds on dead organic matter; usually applies to detritus-feeding organisms other than bacteria and fungi.

divergent plate boundary
A tectonic boundary where two plates are moving away from each other and new crust is forming from magma that rises to the Earth's surface between the two plates.

E

ecological succession
The process by which the structure of a biological community evolves over time. May be primary or secondary.

endangered species
A species of animal or plant that is facing a very high risk of extinction in the wild.

endemic disease
A disease that is restricted to a given region.

El Niño–Southern Oscillation
A recurring climate pattern involving changes in the temperature of waters in the central and eastern tropical Pacific Ocean.

epidemic
Rapid spread of a bacterial or viral disease in a human population.

erosion
The action of surface processes (water, wind or ice) that removes soil, rock, or dissolved material from one location and then transports it to another location.

estuary
A partially enclosed embayment where freshwater and seawater meet and mix.

eutrophic
Term applied to a body of water with high nutrient content and high productivity.

eutrophication
Nutrient enrichment of a body of water.

evaporation
Loss of water vapor from soil or open water or another exposed surface.

exponential growth
Instantaneous rate of population growth, expressed as a proportional increase per unit of time.

extinction
The dying out or extermination of a species.

extirpation
Local extinction; when a species ceases to exist in a chosen area of study, but still exists elsewhere.

F

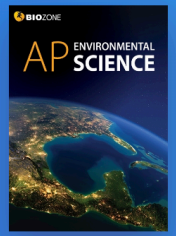
fertility
An organism's natural capacity to produce offspring.

fossil fuel
A natural fuel such as coal or gas, formed in the geological past from the remains of living organisms.

Glossary

Building scientific literacy

- Glossary of key terms provided in back of book
- Spanish glossary available on Resource Hub



Using BIOZONE's Resource Hub

BIOZONE's Resource Hub provides links to online content that supports the activities in the book. From this page, you can also check for any errata or clarifications to the book or model answers since printing.

The external websites are, for the most part, narrowly focused animations and video clips directly relevant to some aspect of the activity on which they are cited. They provide great support to help your understanding.

You can download the Pacing Guide for AP Environmental Science at this link.

You can download the glossaries for AP Environmental Science at this link.

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F

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fossil fuel
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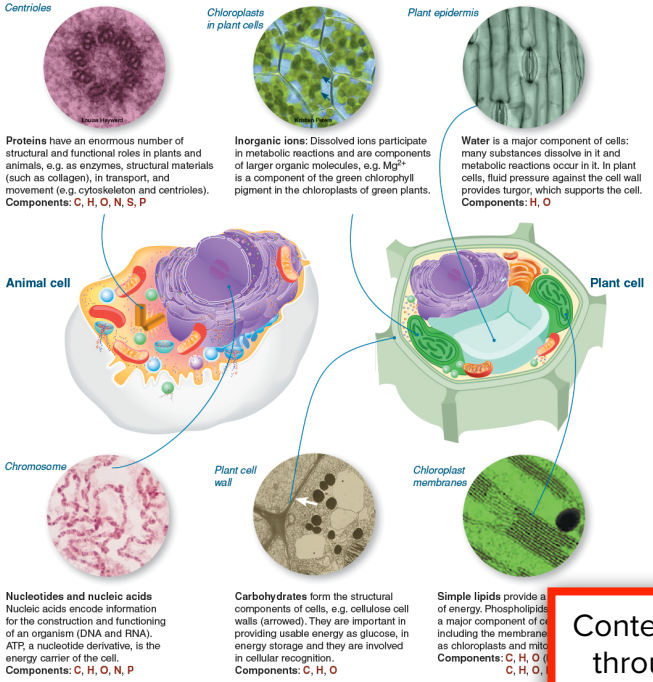
aerobic biological organisms to break down

2 The Biochemical Nature of the Cell

Key Question: What atoms and molecules do organisms obtain from their environment and what do they do with them?

Water is the main component of cells and organisms, providing an aqueous environment in which metabolic reactions can occur. Apart from water, most other substances in cells are compounds of carbon, hydrogen, oxygen, and nitrogen. Life on Earth is carbon based. Carbon is able to form up to four valence bonds with other atoms simultaneously so it can combine with many other elements to form a large number of carbon-based (or organic) molecules. The organic molecules that make up living things can be grouped into four broad classes: carbohydrates, lipids, proteins, and nucleic acids. In addition, a small number of inorganic ions are also components of larger molecules.

The components of cells



Proteins have an enormous number of structural and functional roles in plants and animals, e.g. as enzymes, structural materials (such as collagen), in transport, and movement (e.g. cytoskeleton and centrioles).
Components: C, H, O, N, S, P

Inorganic ions: Dissolved ions participate in metabolic reactions and are components of larger organic molecules, e.g. Mg^{2+} is a component of the green chlorophyll pigment in the chloroplasts of green plants.

Water is a major component of cells: many substances dissolve in it and metabolic reactions occur in it. In plant cells, fluid pressure against the cell wall provides turgor, which supports the cell.
Components: H, O

Nucleotides and nucleic acids
Nucleic acids encode information for the construction and functioning of an organism (DNA and RNA).
ATP, a nucleotide derivative, is the energy carrier of the cell.
Components: C, H, O, N, P

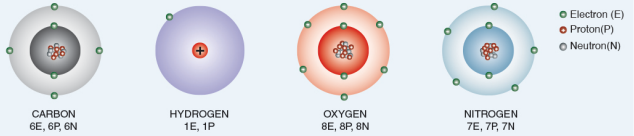
Carbohydrates form the structural components of cells, e.g. cellulose cell walls (arrowed). They are important in providing usable energy as glucose, in energy storage and they are involved in cellular recognition.
Components: C, H, O

Simple lipids provide a
of energy. Phospholipids
a major component of ce
including the membrane
as chloroplasts and mitc
Components: C, H, O (
C, H, O,

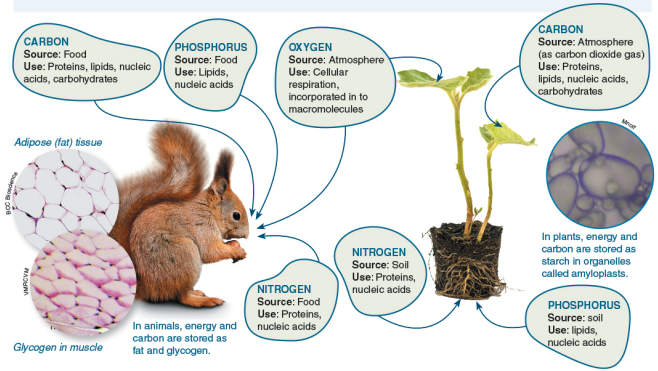
1. (a) List the four main macromolecule components of living organisms: _____

(b) List the elements that all these macromolecules share: _____

The elements of life



Carbon is very abundant. It has four valence (outer shell) electrons that are available to form up to four covalent (shared electron) bonds with other atoms. Complex biological molecules consist of carbon atoms bonded with other elements, especially oxygen and hydrogen, but also nitrogen, phosphorus, and sulfur. Carbon readily forms stable polymers that can participate in chemical reactions.



2. Summarize the role of each of the following cell components:

(a) Carbohydrates: _____

(b) Lipids: _____

(c) Proteins: _____

(d) Nucleic acids: _____

(e) Inorganic ions: _____

(f) Water: _____

so important for building the molecular components of an organism: _____

of carbon, phosphorus, and nitrogen for animals: _____

urce of carbon for plants: _____

urce of phosphorus and nitrogen for plants: _____

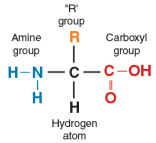
Content is accessible through the use of engaging diagrams and manageable blocks of text

5 Amino Acids

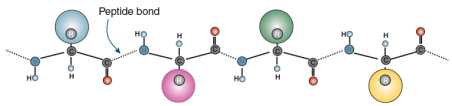
Key Question: How do amino acid monomers come together and interact to form polypeptides?

Amino acids are the basic units from which proteins are made. Twenty amino acids commonly occur in proteins and they can be linked together in a linear sequence by condensation reactions to form polypeptides. Proteins are made up of one or more polypeptide molecules. These can be broken apart by hydrolysis into their constituent amino acids.

The structure and properties of amino acids

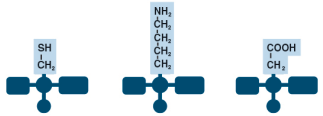


- Amino acids are the building blocks of proteins. They are linked by peptide bonds (below and opposite) for form long chains called polypeptides, which are the basis of proteins. All amino acids have a common structure (left) with an amine group (blue), a carboxyl group (red), a hydrogen atom, and a functional or 'R' group (orange).
- Each type of amino acid has a different functional R group (side chain). Each functional R group has a different chemical property.
- Amino acids are represented by a single upper case letter or a three-letter abbreviation. For example, proline is known by the letter P or the three-letter symbol Pro.



Different amino acids have different R groups

- The R group in the amino acid determines the chemical properties of the amino acid. Different amino acids have different R groups and therefore different chemical properties. Amino acids can be grouped according to these properties. Common groupings are nonpolar (hydrophobic), polar (hydrophilic), positively charged (basic), or negatively charged (acidic).
- The property of the R group determines how the amino acid will interacts with others and how the amino acid chain will fold up into a functional protein. For example, the hydrophobic R groups of soluble proteins will be folded into the protein's interior.



Cysteine
The 'R' group of cysteine forms **disulfide bridges** with other cysteines to create cross linkages in a polypeptide chain.

Lysine
The 'R' group of lysine gives the amino acid an **alkaline** property.

Aspartic acid
The 'R' group of aspartic acid gives the amino acid an **acidic**

1. What makes each of the amino acids in proteins unique and how does this uniqueness contribute to protein st

2. Do some research to assign each of the 20 amino acids found in proteins to one of the four groups below. Use standard 3-letter code to identify each amino acid:

   (a) Nonpolar (hydrophobic): _____

   (b) Polar (hydrophilic): _____

   (c) Positively charged (basic): _____

   (d) Negatively charged (acidic): _____

3. (a) Which type(s) of amino acids would you find on the surface of a soluble protein? Which type(s) would you find in the interior? Explain:

   _____

   _____

   (b) What distribution of amino acids would you expect to find in a protein embedded in a lipid bilayer?

   _____

   _____

Points to related content within the work text

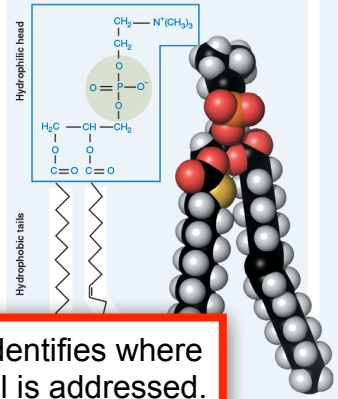
14 Phospholipids

Key Question: How are phospholipids formed, what are their characteristics, and what are their biological roles?

A phospholipid is structurally similar to a triglyceride except that a phosphate group and a nitrogen-containing compound replace one of the fatty acids attached to the glycerol. Phospholipids naturally form bilayers in aqueous solutions and are the main component of cellular membranes. The fatty acid tails can be saturated (straight chains) or unsaturated (kinked chains). The proportion of saturated versus unsaturated fatty acids affects the fluidity of the phospholipid bilayer.

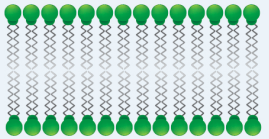
Phospholipids

Phospholipids consist of a glycerol attached to two fatty acid chains and a phosphate (PO_4^{3-}) group. The phosphate end of the molecule is attracted to water (hydrophilic) while the fatty acid end is repelled (hydrophobic). The hydrophobic ends turn inwards to form a **phospholipid bilayer**.

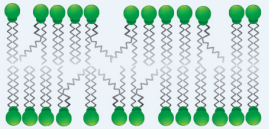


Phospholipids and membranes

The amphipathic (having hydrophobic and hydrophilic ends) nature of phospholipids means that when in water they spontaneously form bilayers. This bilayer structure forms the outer boundary of cells or organelles. Modifications to the different hydrophobic ends of the phospholipids cause the bilayer to change its behavior. The greater the number of double bonds in the hydrophobic tails, the greater the fluidity of the membrane.



Membrane containing only phospholipids with saturated fatty acid tails.



Membrane containing phospholipids with unsaturated fatty acid tails. The fact that the phospholipids do not stack neatly together produces a more fluid membrane.

Color coding identifies where a particular skill is addressed. The colour match the coding in the AP Biology CED

to their chemical properties and their functional role in cellular membranes:

_____

_____

_____

(b) Suggest how the cell membrane structure of an Arctic fish might differ from that of tropical fish species: _____

_____

_____

2. Explain why phospholipid bilayers containing many phospholipids with unsaturated tails are particularly fluid:

_____

_____

_____

_____

The Big Idea and specific skill is identified here

27 Factors Affecting Membrane Permeability

Key Question: How do temperature and solvents affect the structure of cellular membranes and alter their permeability?

Membrane permeability can be disrupted if membranes are subjected to high temperatures or solvents. At temperatures above the optimum, the membrane proteins become denatured. Alcohols, e.g. ethanol, can also denature proteins. In both instances, the denatured proteins no longer function properly and the membrane loses its selective permeability and becomes leaky. What's more, the combination of alcohol and high temperature can also dissolve lipids.

The aim and hypothesis

To investigate the effect of ethanol concentration on membrane permeability. The students hypothesized that the amount of pigment leaking from the beetroot cubes would increase with increasing ethanol concentration.

Background

Plant cells often contain a large central vacuole surrounded by a membrane called a **tonoplast**. In beetroot plants, the vacuole contains a water-soluble red pigment called betacyanin, which gives beetroot its color. If the tonoplast is damaged, the red pigment leaks out into the surrounding environment. The amount of leaked pigment relates to the amount of damage to the tonoplast.

Method for determining effect of ethanol concentration on membrane permeability

Raw beetroot was cut into uniform cubes using a cork borer with a 4 mm internal diameter. The cubes were trimmed to 20 mm lengths and placed in a beaker of distilled water for 30 minutes. The following ethanol concentrations were prepared using serial dilution: 0, 6.25, 12.5, 25, 50, and 100%.

Eighteen clean test tubes were divided into six groups of three and labeled with one of the six ethanol concentrations. Three cm^3 of the appropriate ethanol solution was placed into each test tube. A beetroot cube (dried by blotting) was added to each test tube. The test tubes were covered with parafilm (plastic paraffin film with a paper backing) and left at room temperature. After one hour the beetroot cubes were removed and the absorbance measured at 477 nm. Results are tabulated, below.

Ethanol concentration (%)	Absorbance of beetroot samples at varying ethanol concentrations			
	Absorbance at 477 nm			Mean
	Sample 1	Sample 2	Sample 3	
0	0.014	0.038	0.038	
6.25	0.009	0.015	0.023	
12.5	0.010	0.041	0.018	
25	0.067	0.064	0.116	
50	0.945	1.100	0.731	
100	1.269	1.376	0.907	

1. Why is it important to wash the beetroot cubes in distilled water prior to carrying out the experiment? _____

2. Complete the table above by calculating the mean absorbance for each ethanol

3. What is absorbance measuring and why is it increasing with increasing ethanol

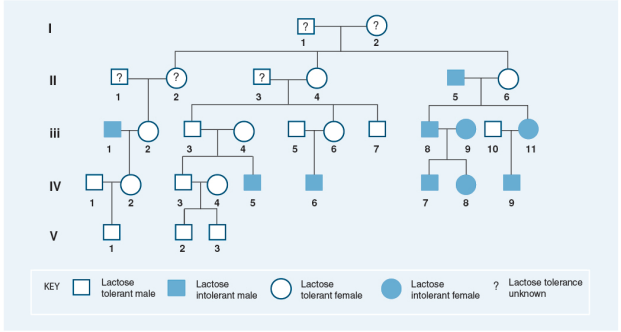
ENE-2 3.A | ENE-2 3.D | ENE-2 5.A | ENE-2 5.D | 26 | 253

ISBN: 978-1-98-856656-6

Many activities require students to analyze real second hand data or case studies to make conclusions

The pedigree of lactose intolerance

Lactose intolerance is the inability to digest the milk sugar lactose. It occurs because some people do not produce lactase, the enzyme needed to break down lactose. The pedigree chart below was one of the original studies to determine the inheritance pattern of lactose intolerance.



2. Use an analysis of the pedigree above to make a claim about the inheritance pattern of lactose intolerance. Support your claim with at least two pieces of evidence:

3. (a) Use the Punnett square below to show the cross between III-10 and III-11 in the pedigree chart above. Use the capital letter L for the dominant allele and the letter l for the recessive allele.

(b) Explain how you can be certain about III-10's genotype:

Male alleles

Female alleles

ozygous for lactose intolerance (LI)? Show your working or justification:

5. Is there any chance that parents III-8 and III-9 could produce a lactose tolerant child? Explain: _____

ISBN: 978-1-98-856656-6

9 Carbohydrate Chemistry

Key Question: Monosaccharides are the building blocks for larger carbohydrates. They can exist as isomers.

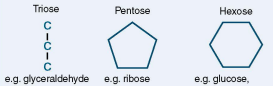
Sugars (monosaccharides and disaccharides) play a central role in cells, providing energy and joining together to form carbohydrate macromolecules, such as starch and glycogen.

Monosaccharide polymers form the major component of most plants (as cellulose). Monosaccharides are important as a primary energy source for cellular metabolism. Carbohydrates have the general formula $C_x(H_2O)_y$ where x and y are variable numbers (often but not always the same).

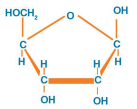
Monosaccharides

- Monosaccharides are single-sugar molecules and include glucose (grape sugar and blood sugar) and fructose (honey and fruit juices). They are used as a primary energy source for fuelling cell metabolism.
- They can be joined together to form disaccharides (two monomers) and polysaccharides (many monomers).
- Monosaccharides can be classified by the number of carbon atoms they contain. Some important monosaccharides are the hexoses (6 carbons) and the pentoses (5 carbons). The most common arrangements found in sugars are hexose (6 sided) or pentose (5 sided) rings (below).
- The commonly occurring monosaccharides contain between three and seven carbon atoms in their carbon chains and, of these, the 6C hexose sugars occur most frequently. All monosaccharides are reducing sugars (they can participate in reduction reactions).

Examples of monosaccharide structures

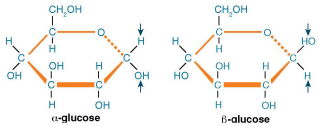


Ribose: a pentose monosaccharide



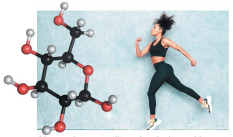
Ribose is a pentose (5 carbon) monosaccharide which can form a ring structure (left). Ribose is a component of the nucleic acid ribonucleic acid (RNA).

Glucose isomers



Isomers are compounds with the same chemical formula (same types and numbers of atoms) but different arrangements of atoms. The different arrangement of the atoms means that each isomer has different properties.

Molecules such as glucose can have many different isomers (e.g. α and β glu



Glucose is a versatile molecule. It provides energy to power cellular reactions, can form energy storage molecules such as glycogen, or it can be used to build structural molecules.

Plants make their glucose via the process of photosynthesis. Animals and other heterotrophic organisms obtain their glucose by consuming plants or other organisms.

Fructose, often called fruit sugar, is a simple monosaccharide. It is often derived from sugar cane (above). Both fructose and glucose can be directly absorbed into the bloodstream.

1. Describe the two major functions of monosaccharides:

   (a) *Primary energy source for cellular metabolism*

   (b) *Structural units for disaccharides and polysaccharides (energy sources and structural carbohydrates).*

2. Describe the structural differences between the ring forms of glucose and ribose: _____

   Glucose is a hexose sugar (6 carbon atoms). Ribose is a pentose sugar (5 carbon atoms).

3. Using glucose as an example, define the term isomer and state its importance: _____

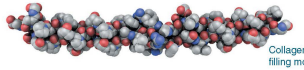
   Isomers have the same molecular formula but their atoms are linked in different sequences. α-glucose and β-glucose are isomers because although they have the same molecular formula, they are structurally different and have different properties.

ISBN: 978-1-98-856656-6

Fibrous proteins

Fibrous proteins are elongated and fibrous in nature or have a sheet like structure. These fibers and sheets are strong and water insoluble. Some, such as keratin, are even insoluble in organic solvents. They have important structural roles.

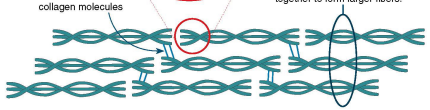
Properties of fibrous proteins	Functions of fibrous proteins
Water insoluble	Structural role in cells and organisms *e.g. collagen in connective tissues, skin, and blood vessel walls.*
Very tough physically; may be supple or stretchy	
Parallel polypeptide chains in long fibers or sheets	Contractile *e.g. myosin and actin polymers in muscles*



Collagen space filling model

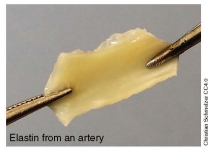
Covalent cross links between the collagen molecules

Many collagen molecules form fibrils and the fibrils group together to form larger fibers.



A collagen molecule consists of three polypeptides wound together to form a helical 'rope'. Every third amino acid in each polypeptide is a glycine (Gly) where hydrogen bonding holds the three polypeptides together. Collagen molecules self assemble into **fibrils** held together by **covalent cross linkages**. Bundles of fibrils form fibers. Collagen is the main component of connective tissue, e.g. tendons and skin.

The scales, beak, and feathers of birds are β keratin



Elastin from an artery

Christine Schwartz CC-BY-S

...ol, feathers, and the outer layers of ...ebrates and the harder β keratins, ...anged in parallel sheets held ...f keratins is the high sulfur content, ... residues. These form permanent, ...tional strength and rigidity.

Elastin is a connective tissue protein with elastic properties that enable tissues to resume their shape after stretching. Elastin has many hydrophobic amino acids, which form mobile hydrophobic regions flanked by covalent cross links between lysine residues.

3. How are fibrous proteins involved in the functioning of organisms? Use examples to help illustrate your answer:

   Fibrous proteins, such as collagen and elastin, are the major component of many connective tissues, including tendons and ligaments (and also in skin), providing support and rigidity to the more fluid components of tissues. Keratins are fibrous proteins that make up hair, nails, wool, feathers, horns, and hooves and are important in forming durable structural and functional components of organisms.

4. Using an example, explain how the shape and properties of a fibrous protein relate to its functional role: _____

   The tertiary structure of fibrous proteins produces long fibers or sheets, with many cross-linkages. This makes them very tough physically and ideal as structural molecules. For example collagen consists of polypeptides wound together to form rope like structures, which then self assemble into fibrils held together by covalent cross linkages.

5. What common feature contributes to the strength and stability of collagen, keratin, and elastin? _____

   All three fibrous proteins form stable covalent cross linkages between amino acid residues in adjacent polypeptide chains, making stable and strong fibrous structures.

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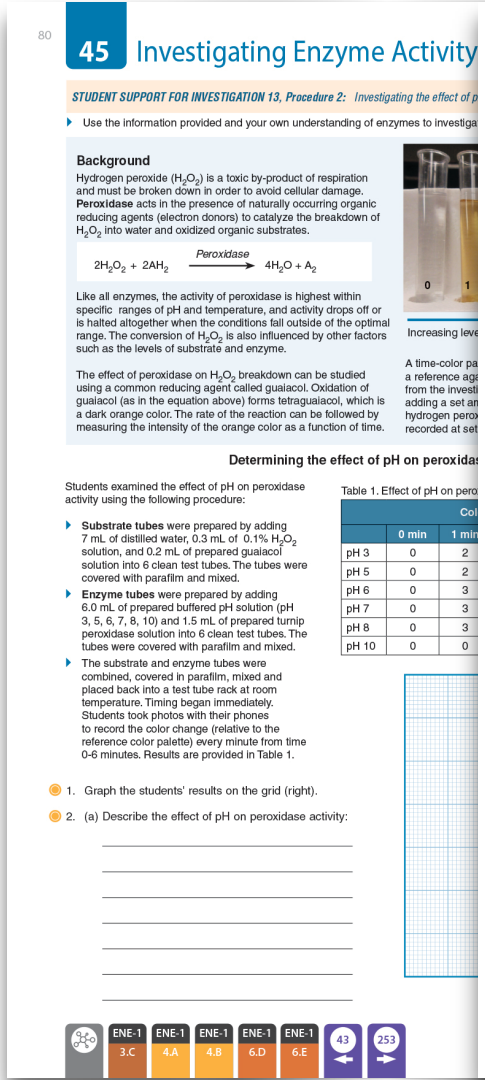
Answers are in place on the **Teacher's Editions** (printed and digital versions).

Support for investigations

- Activities providing **support** for specific aspects of each of the **13 investigations** are integrated in context throughout.
- The **investigation** and **procedure** are identified at the top of the page.



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45 Investigating Enzyme Activity

STUDENT SUPPORT FOR INVESTIGATION 13, Procedure 2: *Investigating the effect of p*

- Use the information provided and your own understanding of enzymes to investiga

Background

Hydrogen peroxide (H_2O_2) is a toxic by-product of respiration and must be broken down in order to avoid cellular damage. **Peroxidase** acts in the presence of naturally occurring organic reducing agents (electron donors) to catalyze the breakdown of H_2O_2 into water and oxidized organic substrates.

$$2H_2O_2 + 2AH_2 \xrightarrow{Peroxidase} 4H_2O + A_2$$

Like all enzymes, the activity of peroxidase is highest within specific ranges of pH and temperature, and activity drops off or is halted altogether when the conditions fall outside of the optimal range. The conversion of H_2O_2 is also influenced by other factors such as the levels of substrate and enzyme.

The effect of peroxidase on H_2O_2 breakdown can be studied using a common reducing agent called guaiacol. Oxidation of guaiacol (as in the equation above) forms tetraguaiacol, which is a dark orange color. The rate of the reaction can be followed by measuring the intensity of the orange color as a function of time.

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Determining the effect of pH on peroxida

Students examined the effect of pH on peroxidase activity using the following procedure:

- **Substrate tubes** were prepared by adding 7 mL of distilled water, 0.3 mL of 0.1% H_2O_2 solution, and 0.2 mL of prepared guaiacol solution into 6 clean test tubes. The tubes were covered with parafilm and mixed.
- **Enzyme tubes** were prepared by adding 6.0 mL of prepared buffered pH solution (pH 3, 5, 6, 7, 8, 10) and 1.5 mL of prepared turnip peroxidase solution into 6 clean test tubes. The tubes were covered with parafilm and mixed.
- The substrate and enzyme tubes were combined, covered in parafilm, mixed and placed back into a test tube rack at room temperature. Timing began immediately. Students took photos with their phones to record the color change (relative to the reference color palette) every minute from time 0-6 minutes. Results are provided in Table 1.

Table 1. Effect of pH on pero

	Col	
	0 min	1 min
pH 3	0	2
pH 5	0	2
pH 6	0	3
pH 7	0	3
pH 8	0	3
pH 10	0	0

1. Graph the students' results on the grid (right).
2. (a) Describe the effect of pH on peroxidase activity:

55

30 Diffusion and Osmosis in a Cell

STUDENT SUPPORT FOR INVESTIGATION 4, Procedure 2: *Diffusion and osmosis*

The pores of the dialysis tubing determine the size of the molecules that can pass through. The experiment described below demonstrates the difference between sucrose and glucose when placed into partially permeable membrane with pores large enough only for glucose and water (but not sucrose) to move through.

Aim

To demonstrate how the size difference between sucrose and glucose affects diffusion osmosis using a partially permeable membrane.

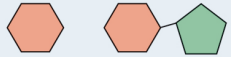
Hypothesis

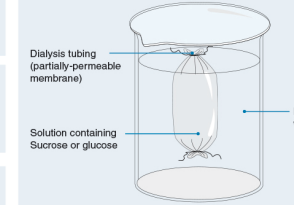
Sucrose larger than glucose and will remain inside the model cell and the cell will gain mass (water) by osmosis. The glucose cell will gain less mass as some glucose diffuses out of the cell, reducing osmotic gain.

Background

Dialysis tubing acts as a partially (or selectively) permeable membrane. It comes in many pore sizes and only allows molecules smaller than the size of the pore to pass through.

Glucose is a monosaccharide whereas sucrose is a disaccharide (consisting of a glucose and a fructose molecule joined together). Sucrose is effectively twice the size and mass of glucose.





Method

Two model cells of dialysis tubing were filled with 5 cm^3 each of a 1 mol/L sucrose solution and a 1 mol/L glucose solution.

The dialysis tubing cells were tied off and weighed to 2 decimal places. They were then placed in separate beakers of distilled water for 10 minutes.

After 10 minutes the cells were removed from the distilled water and blotted dry with a paper towel. They were reweighed and their masses recorded.

The experiment was carried out three times.

Results

Sucrose				
Cell	Final mass (g)	Initial mass(g)	change (g)	% change
1	11.22	10.39		
2	11.23	10.33		
3	12.03	10.98		
Mean				

Glucose				
Cell	Final mass (g)	Initial mass(g)	change (g)	% change
1	11.00	10.35		
2	11.15	10.47		
3	11.28	10.55		
Mean				

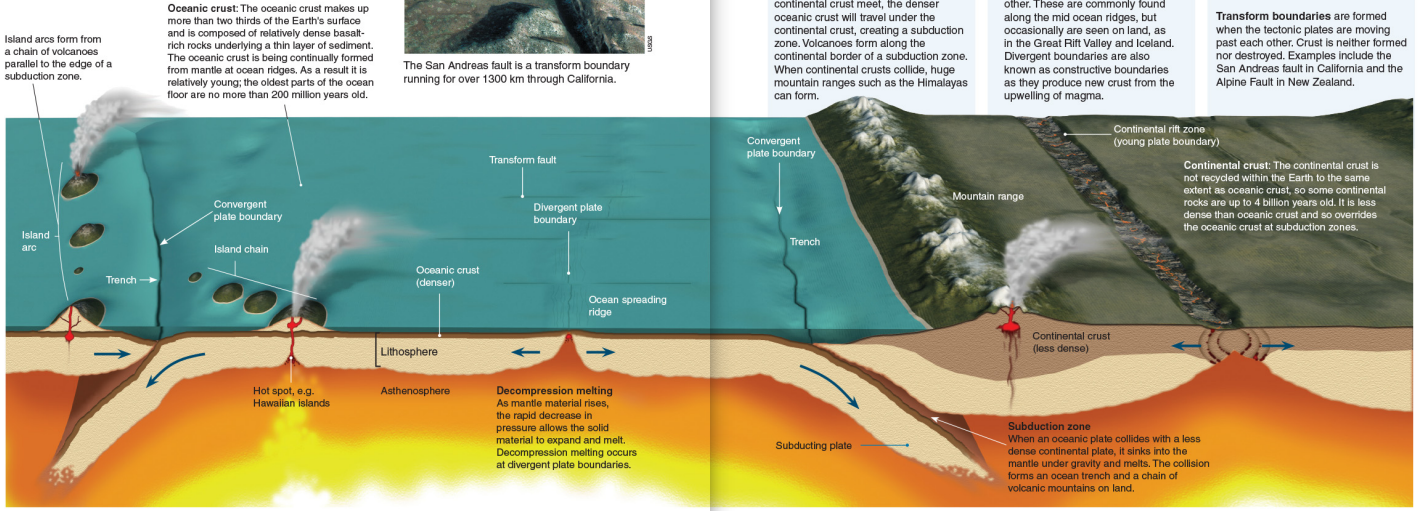
1. Calculate the mean percentage change in mass for the sucrose and glucose cells in the table above:
2. Explain the result in terms of movement of the molecules, diffusion, and osmosis, given that sucrose has a relative mass of 342.3 g/mol, glucose a relative mass of 180.2 g/mol, and water a relative mass of 18 g/mol.

ISBN: 978-1-98-856656-6

Plate boundaries

- Plate boundaries are marked by well-defined zones of seismic and volcanic activity. Plate growth occurs at **divergent boundaries** along sea floor spreading ridges (e.g. the Mid-Atlantic Ridge and the Red Sea) whereas plate attrition (decrease) occurs at **convergent boundaries** marked by deep ocean trenches and subduction zones. Divergent and convergent zones make up approximately 80% of plate boundaries. The remaining 20% are called **transform boundaries**, where two plates slide past one another with no significant change in the size of either plate.

The San Andreas fault is a transform boundary running for over 1300 km through California.



2. Describe what is happening at each of the following plate boundaries and identify an example in each case:

(a) Convergent plate boundary: _____

_____

_____

(b) Divergent plate boundary: _____

_____

_____

(c) Transform plate boundary: _____

_____

_____

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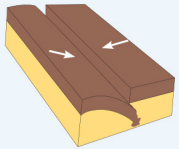
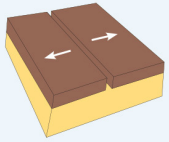
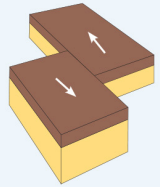


Plate boundaries moving towards each other are called **convergent plate boundaries**. Where oceanic crust and continental crust meet, the denser oceanic crust will travel under the continental crust, creating a subduction zone. Volcanoes form along the continental border of a subduction zone. When continental crusts collide, huge mountain ranges such as the Himalayas can form.



Divergent plate boundaries form where the tectonic plates are moving away from each other. These are commonly found along the mid ocean ridges, but occasionally are seen on land, as in the Great Rift Valley and Iceland. Divergent boundaries are also known as constructive boundaries as they produce new crust from the upwelling of magma.



Transform boundaries are formed when the tectonic plates are moving past each other. Crust is neither formed nor destroyed. Examples include the San Andreas fault in California and the Alpine Fault in New Zealand.

3. Identify the type of plate boundary at which each of the following occurs:

(a) Mountain building: _____ (c) Creation of new ocean floor: _____

(b) Subduction: _____ (d) Island arc: _____

4. Use the information represented visually above to:

(a) Explain why the oceanic crust subducts under the continental crust in a subduction zone: _____

_____

(b) What causes volcanoes to form along the continental plate boundary of a subduction zone? _____

_____

_____

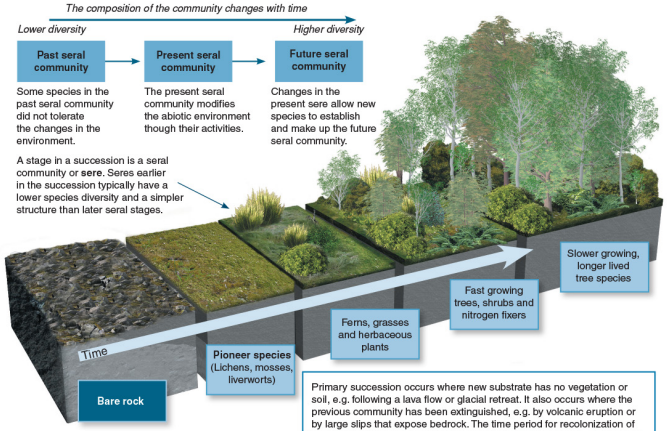
_____

ISBN: 978-1-98-856632-0

36 Primary Succession

Key Question: What is primary succession and what are the community changes that characterize it?

Ecological succession is a natural process of continuous, sequential change in an ecological community. It usually occurs in response to a disturbance and is the result of the dynamic interactions between biotic and abiotic factors over time. Earlier communities modify the physical environment, making it more favorable for the species that will make up later communities. Over time, a succession may result in a stable, mature, or climax, community, although this is not always the case. Succession occurring where there is no pre-existing vegetation or soil is called **primary succession**.



Primary succession occurs where new substrate has no vegetation or soil, e.g. following a lava flow or glacial retreat. It also occurs where the previous community has been extinguished, e.g. by volcanic eruption or by large slips that expose bedrock. The time period for recolonization of the area and the composition of the final community depend on the local environment. Recovery is quicker when vegetation is nearby.

Features of pioneer species

The earliest pioneer species are microorganisms (e.g. cyanobacteria) and simple photosynthetic plants and algae. They are able to survive on exposed substrates lacking in nutrients and make their own food using sunlight energy. Even at this level, ecological associations are important. Lichens, which are important pioneers, are a symbiosis between fungi and algae. Associations between mosses and cyanobacteria (which can fix nitrogen) are also important. Pioneers begin the process of soil formation by breaking down the substrate and adding organic matter through their own death and decay. Their growth therefore creates a more favorable environment for vascular plant growth.

Note the vascular plants establishing in the crevices where soil is forming.

Associations between mosses and cyanobacteria provides mosses with nitrogen.

1. Describe situations in which a primary succession is likely to occur: _____

2. (a) Identify pioneers during the colonization of bare rock: _____

   (b) Describe two important roles of the species that are early colonizers of bare slopes: _____

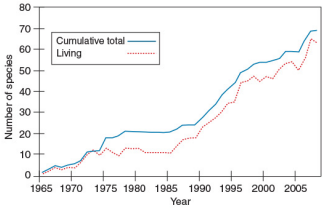
ISBN: 978-1-98-856632-0

Surtsey: A case study in primary succession

Surtsey Island is a volcanic island lying 33 km off the southern coast of Iceland. The island was formed over four years from 1963 to 1967 when a submarine volcano 130 m below the ocean surface built up an island that initially reached 174 m above sea level and covered 2.7 km^2. Erosion has since reduced the island to around 150 m above sea level and 1.4 km^2.

As an entirely new island, Surtsey was able to provide researchers with an ideal environment to study primary succession in detail. The colonization of the island by plants and animals has been recorded since the island's formation. The first vascular plant there (sea rocket) was discovered in 1965, two years before the eruptions on the island ended. Since then, 69 plant species have colonized the island and there are a number of established seabird colonies.

Number of vascular plant species found on Surtsey



The first stage of colonization on Surtsey was dominated by shore plants colonizing the northern shores, brought by ocean currents. The most successful of these was *Honckenya peploides*, which established on tephra sand and gravel flats. It set seed in 1971 and subsequently spread across the island. This initial colonization by shore plants was followed by a lag phase with few new colonizers. A number of new plant species arrived after a gull colony became established at the southern end of the island.

Populations of plants within or near the gull colony expanded rapidly to about 3 ha, while populations outside the colony remained low but stable. Grasses such as *Poa annua* formed extensive patches of vegetation. After this rapid increase in plant diversity, the arrival of new colonizers again slowed. A third wave of colonizers began to establish following this slower phase and soil organic matter increased markedly. The first bushy plants established in 1998, with the arrival of willow *Salix phylicifolia*.

3. Explain why Surtsey provided ideal conditions for studying primary succession: _____

4. Explain why the first colonizing plants established in the north of the island, but later colonizers established in the south.

5. There are three distinct phases on Surtsey where species richness increased rapidly.

   (a) Label on the graph the three phases of increase in species richness on Surtsey.

   (b) Label the two lag phases where species richness increased slowly.

6. A gull colony established on the island in 1985. What was the effect on this on the number of plant species on the island?

7. Why is the living number of plant species on the island less than the cumulative number colonizing the island?

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52 Populations and Resources

Key Question: How does the availability of resources influence population growth?

The **size** of populations can be altered by factors that may or may not be influenced by population density (i.e. density dependent vs density independent). However, population **growth** is regulated primarily by factors that alter the rates of births and/or deaths. These regulatory factors, such as competition for food, have a proportionately greater effect at higher population densities. Density-independent factors, such as natural disasters, can severely limit growth, e.g. by increasing death rates. Both density-dependent and density independent factors can alter the availability of resources and so directly or indirectly limit population growth and size.

Density-dependent and density-independent factors in populations

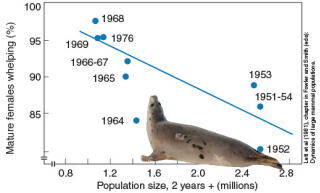
Density dependent factors in populations

- The effect of these on population growth is influenced by population density.
- They are most important at high population densities.
- Tend to be biotic factors such as competition and predation.
- Usually self regulating (negative feedback).
- **Alters resource availability through density-mediated effects.**

Density independent regulating factors

- The effect of these on population growth is independent of population density.
- Tend to be abiotic factors such as natural disasters (droughts, floods, and wildfires).
- May limit growth but do not regulate it, as regulation implies feedback.
- **Resource availability altered independently of the population density.**

Density-dependent and density-independent factors can alter the availability of resources



In mammals, there is a strong relationship between population density, population fertility, and population growth. For example, fertility in harp seals (above), as measured by the number of females breeding, is density dependent (above). Fertility declines were recorded at higher densities when the population was more resource limited. This decline slows population growth.

Density-independent factors can act indirectly on population growth. Climatic events can be unpredictable. A cold spring may kill oak flowers and cause the acorn crop to fail. Squirrels, which depend on plentiful acorns, may then starve the following winter. The proximate cause of starvation is the density of squirrels and lack of food, but the ultimate cause was climate related.

1. Explain how each of the following can influence the population growth through changes to resource availability:

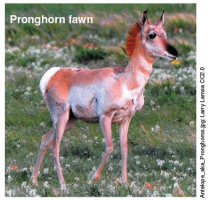
(a) Density dependent factors: _____

(b) Density independent factors: _____

ISBN: 978-1-98-856632-0

Population regulation in pronghorn antelope

- The Coronation Island example earlier in the chapter showed how biotic factors can influence population numbers. Abiotic factors are also important in regulating population growth and size. Drought (lower than average rainfall) is one such factor and can persist for many years.
- During the late 90s and early 2000s drought occurred in Arizona and New Mexico. Researchers studied the effect of the drought on the ecosystem. In particular, they wanted to know how populations were affected by changes to habitat and availability of food and water. One of the aspects they investigated was how drought affected the survival rate of pronghorn fawns in Arizona. Their results are shown in the table below right.



Antelope_calf_1 Pronghorns.jpg/ Larry Lamsa/ CCE 2.0

2. Plot the tabulated rainfall and fawn survival data on the grid below.

3. (a) Describe the plot for rainfall over time: _____

(b) Describe the fawn survival rate over time: _____

(c) Describe the relationship between rainfall and fawn survival:

Year	Rainfall (cm)	Fawns surviving to December per 100 females
1995	11	12
1996	3	0
1997	4	0
1998	19	32
1999	6	0
2000	5	15
2001	15	78
2002	2	9

Data after Bright, J. and J. Hervert (2005). Adult and fawn mortality of Sonoran pronghorn fawns in southwestern Arizona. *Wildlife Society Bulletin* 33(1):43–49.

(d) Explain why rainfall might be correlated with fluctuations in pronghorn fawn survival and predict the effects of these fluctuations on population growth:

ISBN: 978-1-98-856632-0

149 The Covid-19 Pandemic

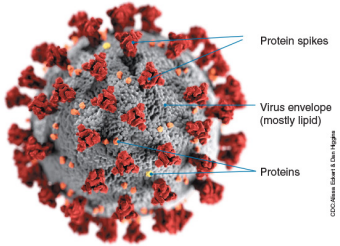
Key Question: What do we know about Covid-19 and how has it affected the environment?

In December 2019, a new strain of coronavirus was detected in Wuhan, China. The new virus was named Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). Infection with the virus causes a disease called Covid-19. The WHO declared a pandemic in March 2020 as the virus spread around the world and a pandemic status was still in place at the time of writing this book. The Covid-19 pandemic has disrupted the world travel and global economies. Millions of people have been infected and hundreds of thousands have died. Enormous stress has been placed on health systems, and the harsh financial impacts will be felt for years because millions of people have lost their jobs.

What is Covid-19?

- Covid-19 is the disease caused when someone is infected with the SARS-CoV-2 virus (right).
- The virus affects the respiratory system.
- 80% of infected people recover without hospital care.
- 20% of infected people develop severe breathing problems and may require high level hospital care. The elderly and people with underlying medical problems are most at risk of becoming very sick.
- The virus is spread through the environment in small droplets from the nose and mouth (e.g. when a person speaks, sneezes, or coughs). People become infected when they breathe these droplets in, or when they touch a surface contaminated with the virus.
- There is currently no vaccine, but attempts to develop one are underway.

A representation of the SARS-CoV-2 virus

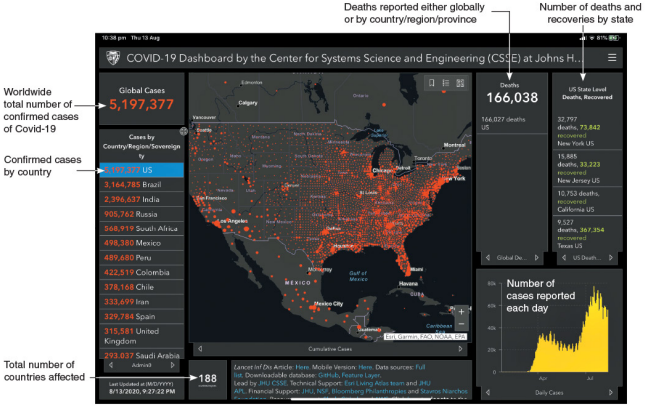


CDC/Alissa Eckert & Dan Higgins

Spread of coronavirus

Reports of viral pneumonia (a lung infection) in Wuhan, China were reported on the 31st December 2019. Early in January 2020, a new coronavirus was identified as the cause of the infections. The new virus, SARS-CoV-2, is thought to have arisen in bats, passing to humans through another, as yet unknown, animal. SARS and MERS probably transferred to humans this way also.

Despite strict restrictions, including travel bans, being placed on the residents of Wuhan and the surrounding region, the virus began to spread through China. On the 13th January 2020 the first case outside of China was recorded in Thailand. Within 10 days the virus had spread to a number of countries, including the US, as infected travelers flew around the world. Over 188 countries and territories have reported infections. The situation is changing daily and the best way to find the most recent information is to visit the WHO Covid-19 Interactive Dashboard or the John Hopkins University of Medicine Covid-19 Dashboard. Find the details for both sites on **BIOZONE's Resource Hub**.



EIN-3 2.B | EIN-3 2.C | EIN-3 5.A

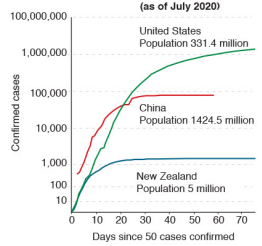
ISBN: 978-1-98-856632-0

Different countries, different outcomes

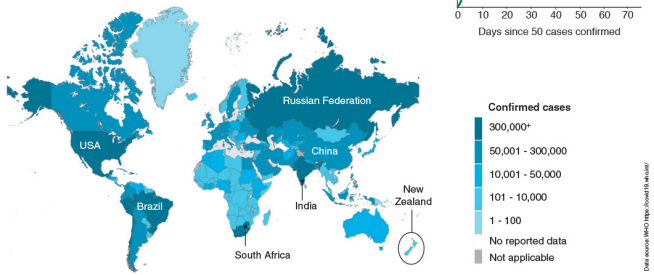
Some countries have been very successful in slowing or containing the spread of the virus, while in other countries the virus has spread widely causing high numbers of infections and deaths. The graph (right) shows the number of confirmed cases (July, 2020) for three countries; China, New Zealand, and the US. The way their governments, health departments, and populations responded to the disease has been important in thepattern of Covid-19 spread.

The diagram below shows the number of confirmed cases of Covid-19 by country as of 20 July 2020. The darker shades of blue indicate higher numbers of confirmed cases. Real time updates can be found on the WHO Covid-19 Dashboard.

Confirmed cases of Covid-19 (as of July 2020)



Confirmed cases of Covid-19 by country (as of 20 July 2020)



Modeling the spread of disease

Epidemiologists are people who study the spread of disease. They look at where disease originates, how it spreads, and who it infects. This information can help to evaluate control measures and determine who is most at risk. It also allows resources (equipment, medicines, and healthcare workers) to be distributed effectively.

Epidemiology relies heavily on mathematics, because mathematical models help to predict how a disease will behave in a population.

Week	S	I	R
0	7,000,000	2	0
1	6,999,986	15	1
2	6,999,881	113	8
3	6,999,090	847	65
4	6,993,162	6352	488
5	6,948,741	47,597	3664
6	6,618,002	354,538	27,462
7	4,271,669	2,523,602	204,731
8	0	5,533,470	1,466,532
9	0	2,766,735	4,233,267
10	0	1,383,368	5,616,634
11	0	691,684	6,308,318
12	0	345,842	6,654,160
13	0	172,921	6,827,081
14	0	86,460	6,913,542

A predictive mathematical model called SIR can be used to show the transmission of infectious diseases. In this model there are three compartments; **S** (the number of susceptible individuals), **I** (the number of infected individuals), and **R** the number removed (those who have been removed through recovery or death). Equations behind the calculations for each compartment are used to show the relationships and change over time between the three compartments.

The data in the table below left is a theoretical example. It assumes a closed system (e.g. a single state with no travel), no prior immunity (everyone is susceptible), no vaccine, and no physical distancing or other precautionary measures in place. Visit **BIOZONE's Resource hub** if you want to find out more about the mathematics used to show the relationships.

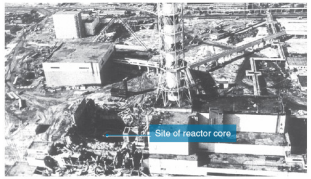
ISBN: 978-1-98-856632-0

1986: Chernobyl

On 26 April 1986, the number 4 reactor at the Chernobyl nuclear power plant exploded. Ironically, the explosion occurred during a safety test. The test was designed to evaluate the turbine's ability to supply electricity to the coolant pumps in the event of a reactor shut down and loss of power. It was assumed that as the turbine spun down (due to a lack of steam) it could be used to generate electricity to cover the 1 minute gap between the loss of power and the emergency diesel generators running up to full speed.

Cascading chain of events

1. The reactor was set to half its usual power output to begin the test, but the test was delayed by several hours. As a result, xenon levels in the reactor increased, creating unsuitable conditions for the test. This was either not realized or ignored.
2. As the test proceeded, the power output of the reactor was reduced. Unexpectedly, it then fell below the level needed for the test. To try to raise the power output, all but six of the control rods were removed from the core. Again, the unbalanced state of the core was ignored.
3. Pumps circulating coolant and steam to the turbine were turned off. Immediately, the reactor output rapidly increased, boiling the water in the core to steam. An emergency shut down was initiated. However as the control rods moved back into the core, the graphite tips actually *accelerated* the reaction.
4. The expanding steam jammed the control rods in place before they were fully inserted. An initial steam explosion blew the lid off the reactor, exposing the superheated interior to the air. This caused the larger explosion which destroyed the core and ejected large amounts of radioactive material into the atmosphere.



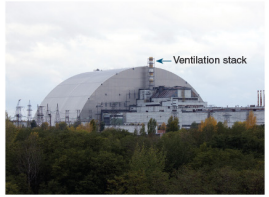
Cause of the accident

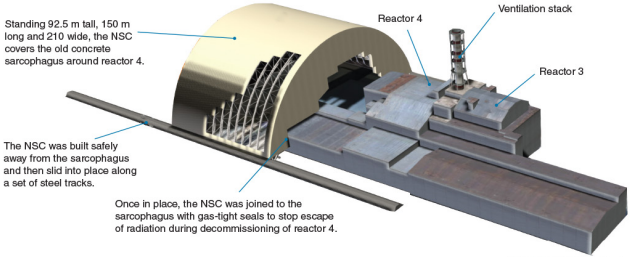
The investigation into the disaster found that the failure of the test and the subsequent explosion were due to:

- The postponement of the test by several hours so that senior operators were no longer on site.
- Extremely small operational safety margins and a lack of regard for safety.
- Inexperienced operators being in control of the test.
- Human error.
- Poor design of the reactor control rods.
- Poor design for overall control of the nuclear reaction.

Cleanup

- The Chernobyl explosion is the worst nuclear accident in history. The cleanup of the Chernobyl site, at least in the early stages, can probably best be described as monumental and even heroic, and involved more than half a million people.
- The radiation on top of the reactor building, near the ventilation stack (right), was so high it destroyed the circuits of robots that were initially used to try to clear the debris. Eventually workers were needed to clear the debris. They could work for only 90 seconds at a time and nearly 5000 people were needed for the job. Once the radioactive debris was cleared, a huge concrete sarcophagus was built around the building.
- The surrounding land up to 30 km from the power plant was evacuated and remains an exclusion zone due to radioactive isotopes in the soil. Soil was turned over and buried, along with parts of nearby forests.
- The sarcophagus around the number 4 reactor was built as an emergency containment and not designed as a permanent measure. In 2008, building began on the New Safe Confinement (NSC) structure (above and below). This was slid into place over the old sarcophagus. The structure was completed in 2018 at a cost of around $2 billion. Underneath it, the number 4 reactor can finally be decommissioned and made safe using remote controlled machinery.





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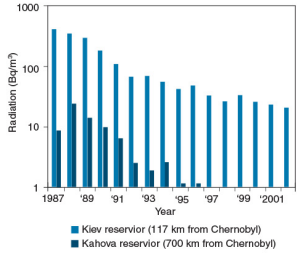
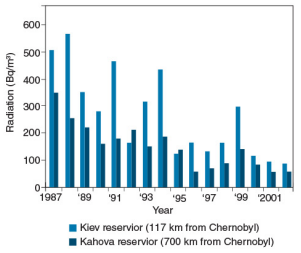
Environmental effects of the Chernobyl accident

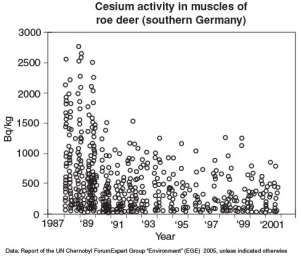
- Radioactive particles released by the explosion fell across a large area surrounding the plant, killing much of the nearby forest. In particular, an area of pine forest (later known as the Red Forest) received an extremely large dose of radioactive particles. The pine forest was bulldozed and buried after the pines died. Winds blew radioactive material over a large part of Europe. Radioactivity in surrounding waterways fell rapidly due to dilution and deposition, but wildlife around the area have suffered higher than normal rates of mutation, with many animals dying from thyroid disease. Much of the radioactivity is now concentrated in the soil.
- Major radionuclides released by the explosion were iodine-131, cesium-134 and 137, and plutonium isotopes.
- The exclusion zone around the power plant has become a wildlife refuge due to the evacuation of residents immediately following the disaster. Ecological succession has returned much of the land to forest or open meadow.
- It will take many generations before the area around Chernobyl will be safe for long term habitation by humans. The radioactive material in the destroyed reactor will remain dangerously radioactive for possibly another 20,000 years (but will likely be removed or well protected by that time). Because of the dynamic environment, pockets of the surrounding land are highly radioactive, while others are less so.


Chernobyl viewed from the abandoned city of Pripyat

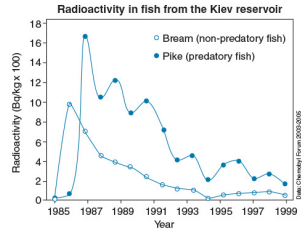

Vegetation overgrows recreational area in Pripyat







Data: Report of the UN Chernobyl ForumExpert Group "Environment" (EGE) 2005, unless indicated otherwise



ISBN: 978-1-98-856632-0

167 Wildfires

Key Question: What is the effect of global wildfires?

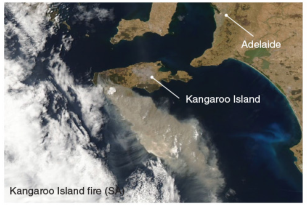
The decade 2010 to 2020 saw an unprecedented increase in the number, area, and intensity of forest and bush fires around the world. Forest fires has always been part of nature, with fire seasons occurring every year. However the last decade has seen fires begin earlier in the season and become larger and more frequent. Some of these fires are deliberately lit, either through arson or farm fires that get out of control. In some cases, the fires are set to clear debris after land has been logged, and so are not the direct cause of deforestation. Some arise naturally from lightning strikes. However, since the world is warming, the results of these lightning strikes are far more severe, especially after droughts, which themselves are becoming more frequent. Recent years have seen fires in the Alaskan and Siberian tundra which threaten to affect permafrost and fundamentally change the Arctic landscape.

Australian bush fires

Smoke from Australian bush fires as seen from the ISS

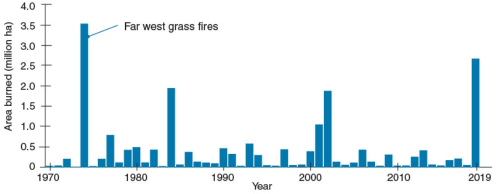
- The Australian bush fire season 2019-2020 (also known as the Black Summer) was a period of unusually intense bush fires throughout Australia.
- The fire season normally begins around August, but began earlier in 2019. Major fires peaked around January 2020. An estimated 186,000 square kilometers of bush and scrub land was destroyed.
- Australia is particularly prone to intense bush fires but the fires of 2019-2020 came after a prolonged drought and higher than normal temperatures. Bush and forest that would normally withstand or be a barrier to large fires were particularly dry and so burned.
- Australian bush fires often occur near populated regions and present a particular hazard to those living nearby. Fire fronts can move extremely quickly, fanned by high winds, trapping residents and fire fighters. Because of this, the fire fighting effort is extremely intensive, with many hundreds of people, fire trucks, helicopters, and planes employed to control the fires.
- Most of the fires in Australia are caused by lightning, and so are not linked to deforestation by farmers or logging.
- The fires have had a particularly devastating effect on Australian wildlife. Experts estimate more than a billion mammals, birds, and reptiles were killed in the 2019-2020 season. Deaths from starvation and thirst added to the large number of animal deaths from the fires. Kangaroo island, an important habitat for a number of native and endangered species was severely affected, with more than a third of the island burned.
- In December 2019, NASA estimated the fires had emitted over 300 million tonnes of carbon dioxide. The damage from the fires not only releases the carbon dioxide, but affect the forest's ability to absorb it.

Gospers Mountain fire NSW



Kangaroo Island fire (SA)

Total fire area in New South Wales



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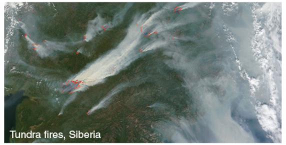
Arctic tundra



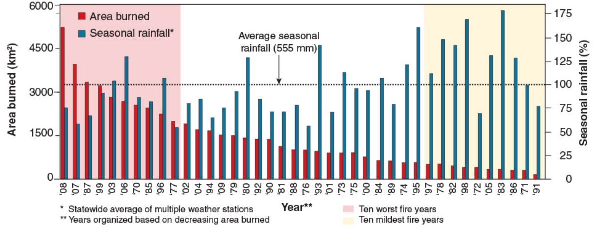
Tundra fires, Siberia

- The Arctic region is warming at twice the rate of the rest of the world. This heating is melting permafrost and then drying out the tundra, making it extremely susceptible to fire.
- Because of the freezing temperatures there is little decay of plant material on the tundra. Thus a large amount of organic material builds up over the centuries. This has helped to store vast quantities of carbon.
- Now that the Arctic is warming, that carbon is under threat of decaying and burning, both of which release carbon dioxide. And the more warming there is, the more carbon dioxide (and trapped methane) could be released and so there is more warming.
- Tundra in Alaska, Canada, Greenland, and Eastern Siberia has been affected. In 2019, more than 3 million hectares of tundra was affected by fire. The fires can be typical large surface fires, but they can also form slow smoldering fires. These smoldering fires can persist through cold and wet conditions. Because they burn longer, these fires can actually transfer heat deeper into the soil and permafrost, melting and burning it.
- Tundra fires in 2019 released at least 100 million tonnes of CO_2.

California wildfires

- Like Australia, California's hot dry environment is particularly prone to wildfires. Since the start of the century these wildfires have been becoming more intense. Fourteen of the largest 20 wildfires in California have occurred since 2007, and there are 78 more annual fire days now than 50 years ago.
- A number of factors influence the frequency and severity of fires (how often and how much land is burned). These include moisture level, the amount of undergrowth, tree density, and the types of trees present. Climate variability (especially moisture levels) is the main driver of forest fires. When fires become more frequent and more intense, the forest may be less able to regenerate (grow again with a similar makeup). There are several reasons for this:
  - Trees do not have time to regenerate or grow between fires, they reestablish more slowly, or fail to reestablish at all.
  - Fast growing shrubs and grasses establish more quickly than tree seedlings, which then cannot compete for resources (e.g. sunlight and space). Fewer tree species will establish, and the make-up of the area will change.
  - Seed stock is reduced, so fewer seedlings grow after a fire.

Comparison of area burned and seasonal rainfall in Californian wildfires between 1970-2000



Adapted from Rogers, P (01 June, 2010). Do wet winters mean bad summer fire season in California? Not usually according to History. Bay Area News
Original data from Cal fire, U.S. Forest Service and NOAA data

1. Study the graph above. What is the relationship between rainfall in California and the area burned? ____________________

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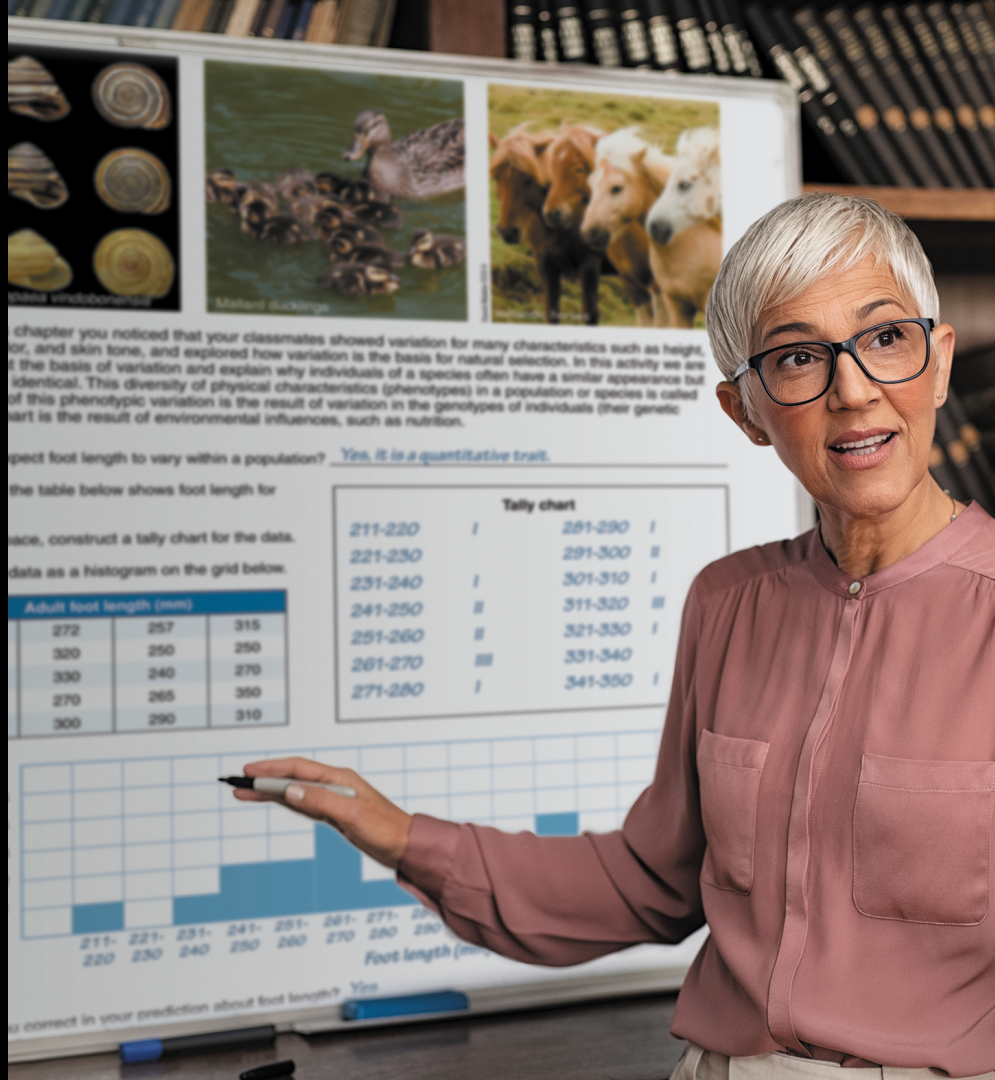
TEACHER SUPPORT MATERIALS

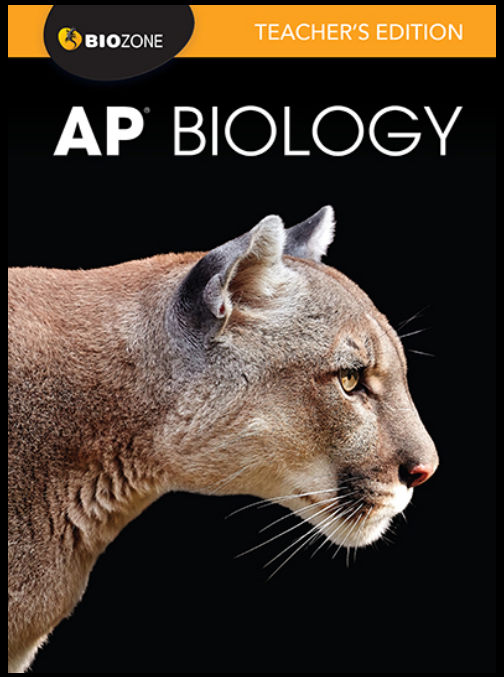
Teacher Support products

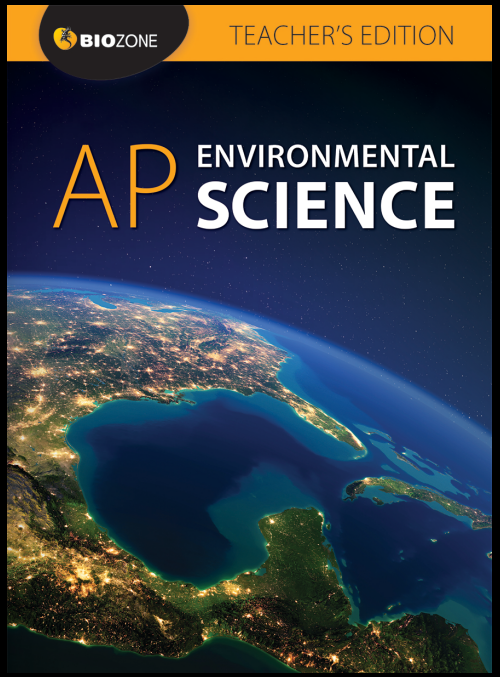
- The Student Edition is at the heart of BIOZONE's AP series
- These are supported by a suite of products designed for teachers:
  - Teacher's Edition (printed and digital)
  - Presentation slides
  - Classroom Guide
  - Resource Hub
  - Pacing Guide



Teacher's Edition

- Print and digital
- Classroom Guide in place
- Model answers in place

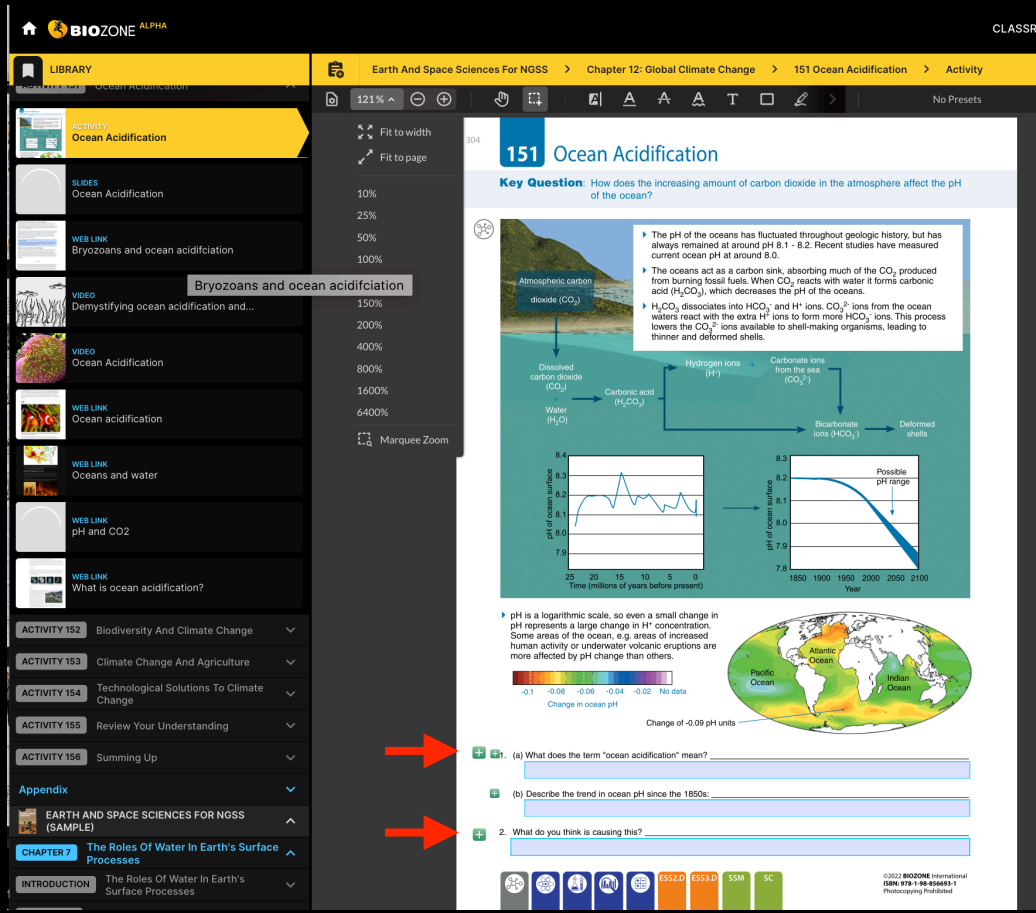




BIOZONE WORLD: Teacher's version

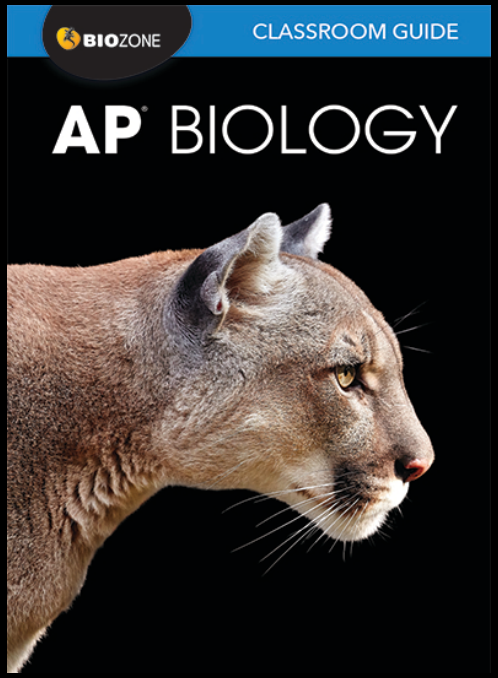
Introduce, unpack, review answers

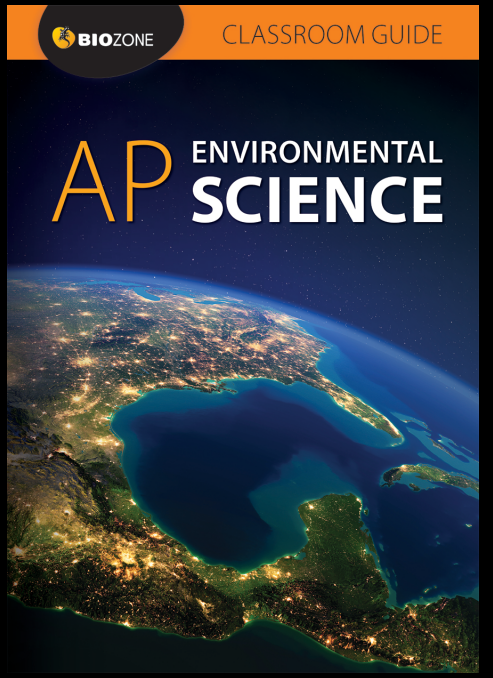
- Has answers in place.
- Has additional resources inbuilt
- Project on a shared screen.
- Introduce the topic.
- Wrap up a session.
- Review answers by toggling show/hide buttons



Classroom Guide

- Pedagogical tools and features explained
- Teacher toolkit resources
- Suggestions for using the resources including:
    - Collaborative learning in the classroom
    - Differentiated instruction
    - Practicals
    - Assessments





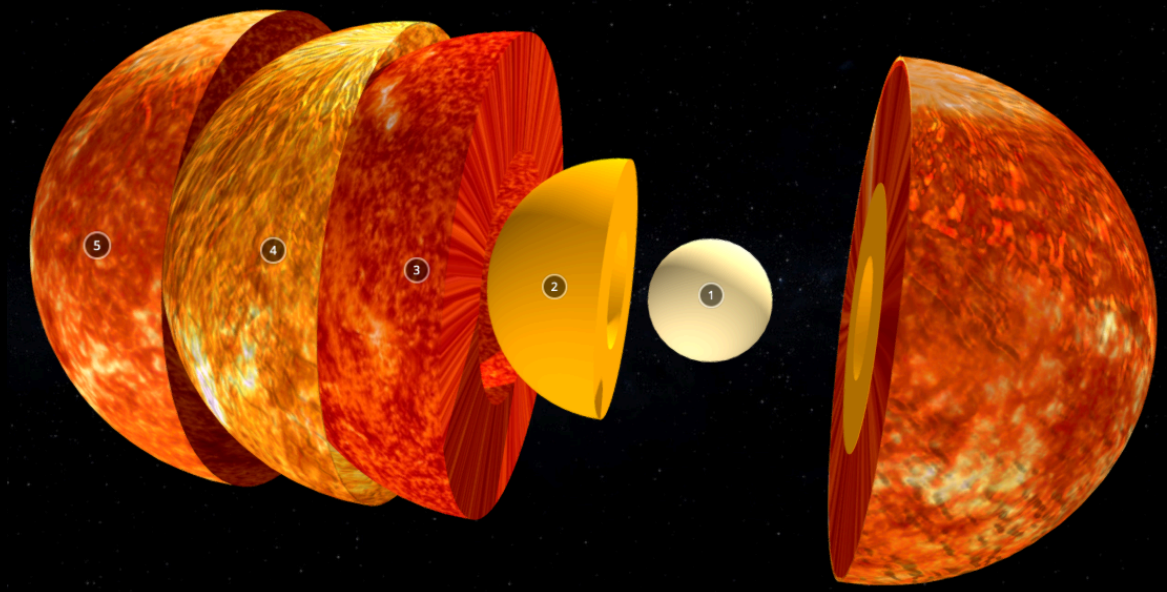
Located at the front of the Teacher's Edition
or download from BIOZONE's website

Resource Hub

Curated materials

- Curated materials support the content of the worktext.
- FREE resource for teachers and students
- Print and digital users

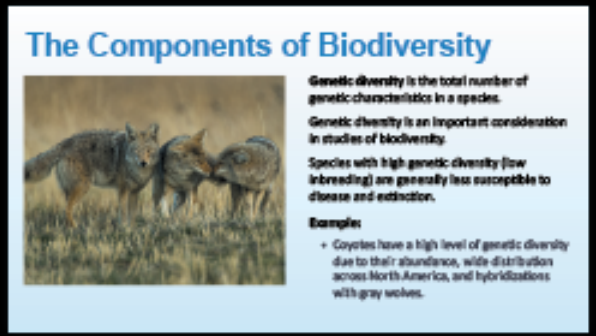
- Articles
- Videos
- Simulations
- Animations
- Games
- Spreadsheets
- 3D Models
- And more…

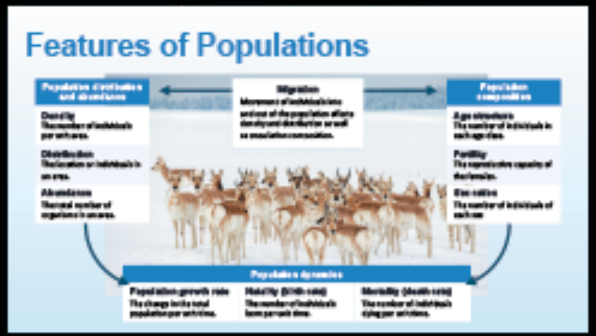


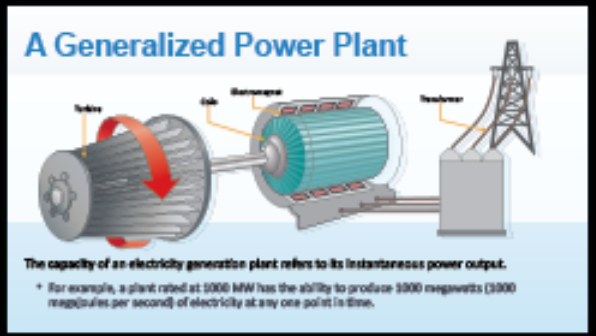
- Resources to engage all students
- Resources to extend Gifted & Talented students

Presentation Slides

- Presentation style slides.
- Inbuilt into BIOZONE WORLD
  Pop up automatically with an activity.
- Present to your students using a projector or interactive whiteboard.





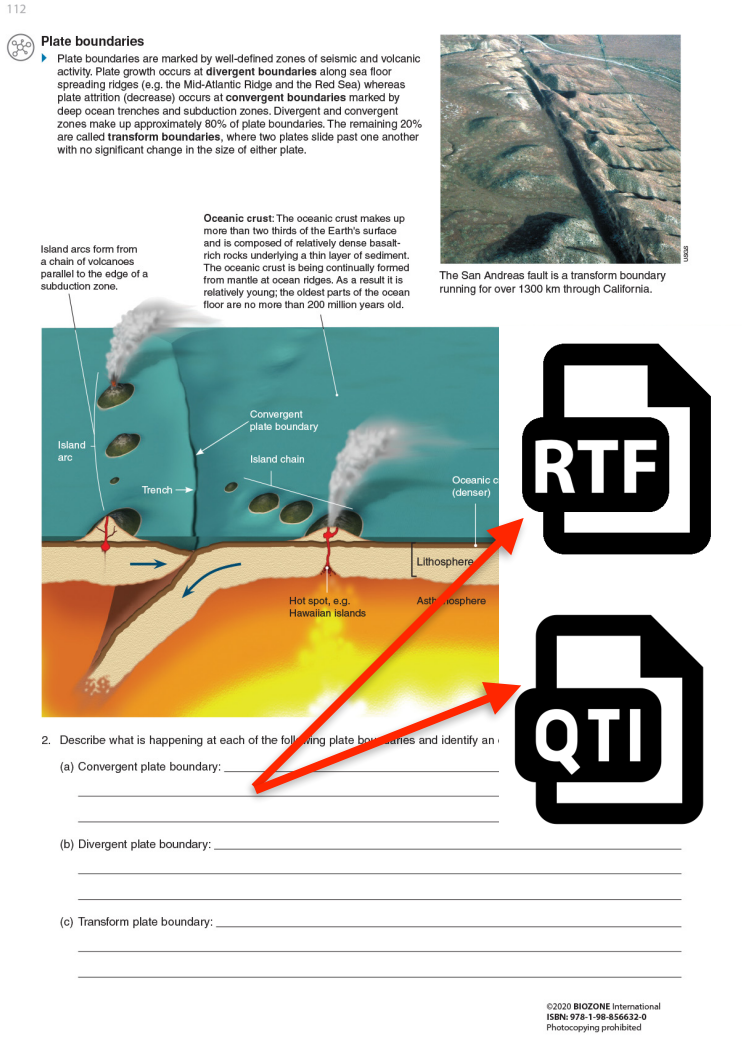


Question Library

- Embedded questions from the worktext are provided digitally as a **question library**.

- Question library allows you to:
  - Deliver the same questions from the print version to students via an online service.
  - Customize questions to suit reading ability.

NOTE: Question Library is only available to schools/districts committing to multi-year adoptions



Pacing Guide

- Suggested delivery /timing
- Highlights vocabulary
- Highlights investigations
- Highlights assessment

AP Biology (3rd edition) SUGGESTED PACING GUIDE BIOZONE

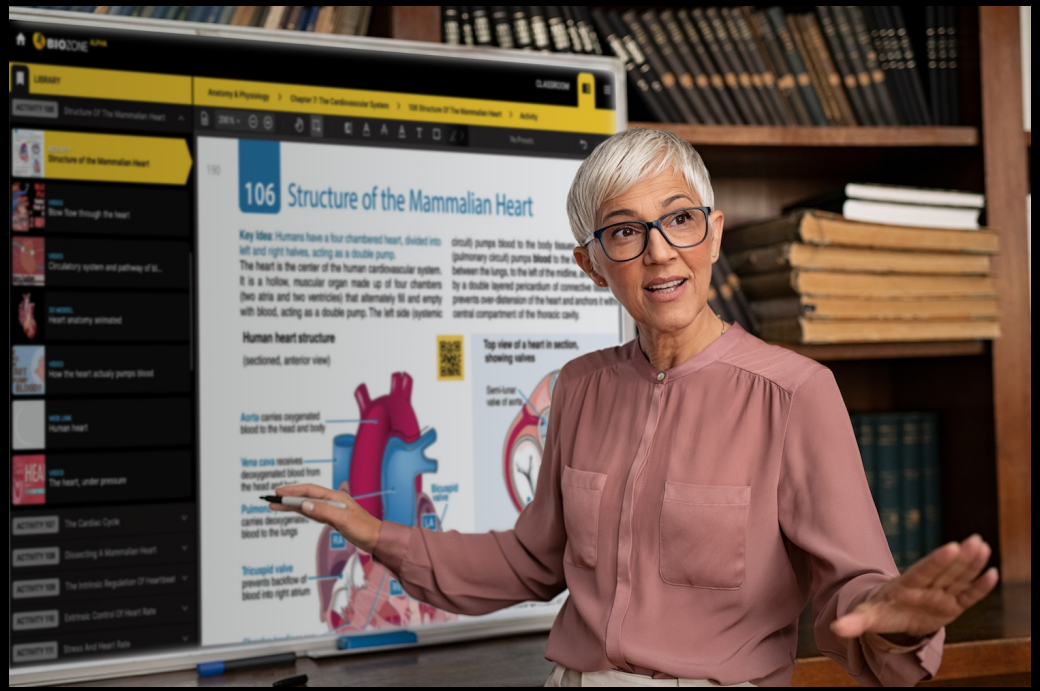
Unit 4: Cell Communication and Cell Cycle

Number of periods	Activity number	Notes	Lab / Practical activity	Formative (BR or TOTD) or Summative Assessment
2 periods	62 – 64	Vocab: ligand (biochemistry v chemistry def), receptors, gap junctions, plasmodesma Compare & contrast nervous system and hormonal communication		• Compare and contrast the different types of signalling • Compare & contrast short distance signalling in animals and plants
1 period	65 – 66	Vocab: reception, transduction, response, cascades, phosphorylation		• What is the difference between molecules that require an external receptor and an internal receptor (extracellular v intracellular)?
1 period	67 – 68	Vocab: quorum sensing, autoinducer		
1 period	69	Vocab: negative feedback, positive feedback		• Which type of feedback system maintains homeostasis?
3 periods	70 - 75	Vocab: mitosis, meiosis, n, 2n, haploid, diploid Vocab: cell cycle, G1, S, G2, M phase, cytokinesis, G_0, mitotic index Review chi-squared	**Activity 74**: Investigation 7, Part 1: Modeling Mitosis **Activity 75**: Investigation 7, Part 2: Environmental effects on mitosis	
2 periods	76 - 78	Vocab: MPF, kinase (CdK), cyclin, Proto-oncogenes, tumor-suppressor genes	**Activity 78**: Investigation 7, Part 3: Cell cycle control and cancer	
1 period	79			Assessment Unit 4


A single place of integration
BIOZONE WORLD

Streamline classroom-based

Collaborative Learning



Teacher
introduces Activity

Brief class discussion
to "unpack" the Activity's
infographic or **data**

Breakout into small student groups

Student Group A
Discuss, then create consensus answers

Student Group B
Discuss, then create consensus answers

Student Group C
Discuss, then create consensus answers

Students **quickly report back** via **teacher-led discussion** then **Self-grade** and **improve answers**

BIOZONE

Translation Rollover
Toggle On/Off

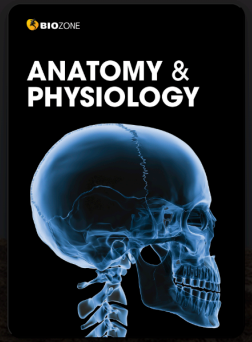
LB

MY CLASSROOM

DASHBOARD ASSIGNMENTS STUDENTS

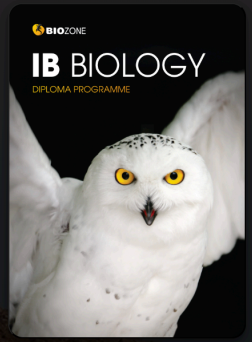
CLASS SETTINGS

ANATOMY & PHYSIOLOGY

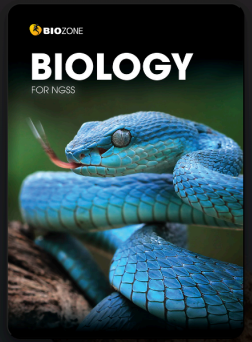


ENVIRONMENTAL SCIENCE

INTERNATIONAL BACCALAUREATE



STANDARD NGSS - BIO



STANDARD NGSS - ESS

LAST ACTIVITY

ACTIVITY
Gas Exchange Adaptations

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- ACTIVITY 130 Ocean Power
- ACTIVITY 131 Energy From Biomass
- ACTIVITY 132 Hydrogen Fuel Cells
- ACTIVITY 133 Comparing Fuel Choices
- ACTIVITY 134 Energy Conservation
- ACTIVITY 135 Energy Security
- ACTIVITY 136 Energy Storage
  - ACTIVITY Energy Storage
  - VIDEO Energy storage 101
- ACTIVITY 137 Rechargeable Batteries And Energy Storage
- ACTIVITY 138 Did You Get It?
- CHAPTER 7 Pollution
- CHAPTER 8 Conservation
- CHAPTER 9 Climate Change
- CHAPTER 10 Science Practices
- Appendix
- IB BIOLOGY

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136 Energy Storage

Key Idea: Energy storage is an important part of energy security and reliability. It is important on both small and large scales.

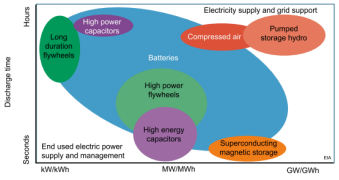
We are familiar with energy storage on small scales, in the form of cells, e.g. AA (commonly but incorrectly called batteries) for portable devices such as torches or lead-acid batteries in cars. As **renewable energy** becomes more important, the storage of excess energy on a large scale also becomes important. This helps to add extra power to the grid times when power supply is not able to match increased demand, e.g. solar not working at night or a decrease in wind during certain times of day. Energy storage also provides energy security, protecting against the failure of a production facility and providing energy on demand.

Energy storage and use

The type of energy storage needs to be matched to its use. In most large scale cases, energy storage deals with storing excess potential energy that cannot be stored naturally, or recovering potentially wasted energy. Small scale storage is useful for portable devices and is a convenient way of storing energy for personal use.

Pumped storage ponds can be used to store potential energy. During times when there is excess water in a dam, and energy demand is low, the excess water can be pumped uphill into storage ponds. The water can later be released through turbines to produce extra power when needed.

Range of energy storage



Batteries can be used in a domestic setting to store energy generated from home solar cells (or other generation devices). As domestic solar cells become more common there will be a greater desire to store excess power for use when the sun is not out, and so take greatest advantage of the solar cells.

Energy can also be stored in mechanical devices, including springs and flywheels. It can also in stored is pressurised vessels, such as air tanks. When the air pressure is released it can be used to power machinery. Compressed springs can release energy quickly to provide starting power for engines or spring loaded weapons (e.g. air rifles).

Excess energy can be stored in geological formations. Geological storage methods involve storage of **natural gas** and hydrogen, compressed air, pumped storage, and thermal storage. These can be stored in depleted gas reservoirs, mines, or purpose drill boreholes. Geological storage has the potential to store many GWh of energy.

1. (a) Explain why there is a need for storing energy: _____

(b) Explain why there is a need for several different ways of storing energy: _____

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GR

- Replicas of the printed books allow students to view content and answer questions online.
- Student view and teacher view.
- Direct access to:
  - Presentation slides
  - 3D models
  - Curated Videos
  - Websites

Digital platform

- Activity content and order are the same as the print resources.
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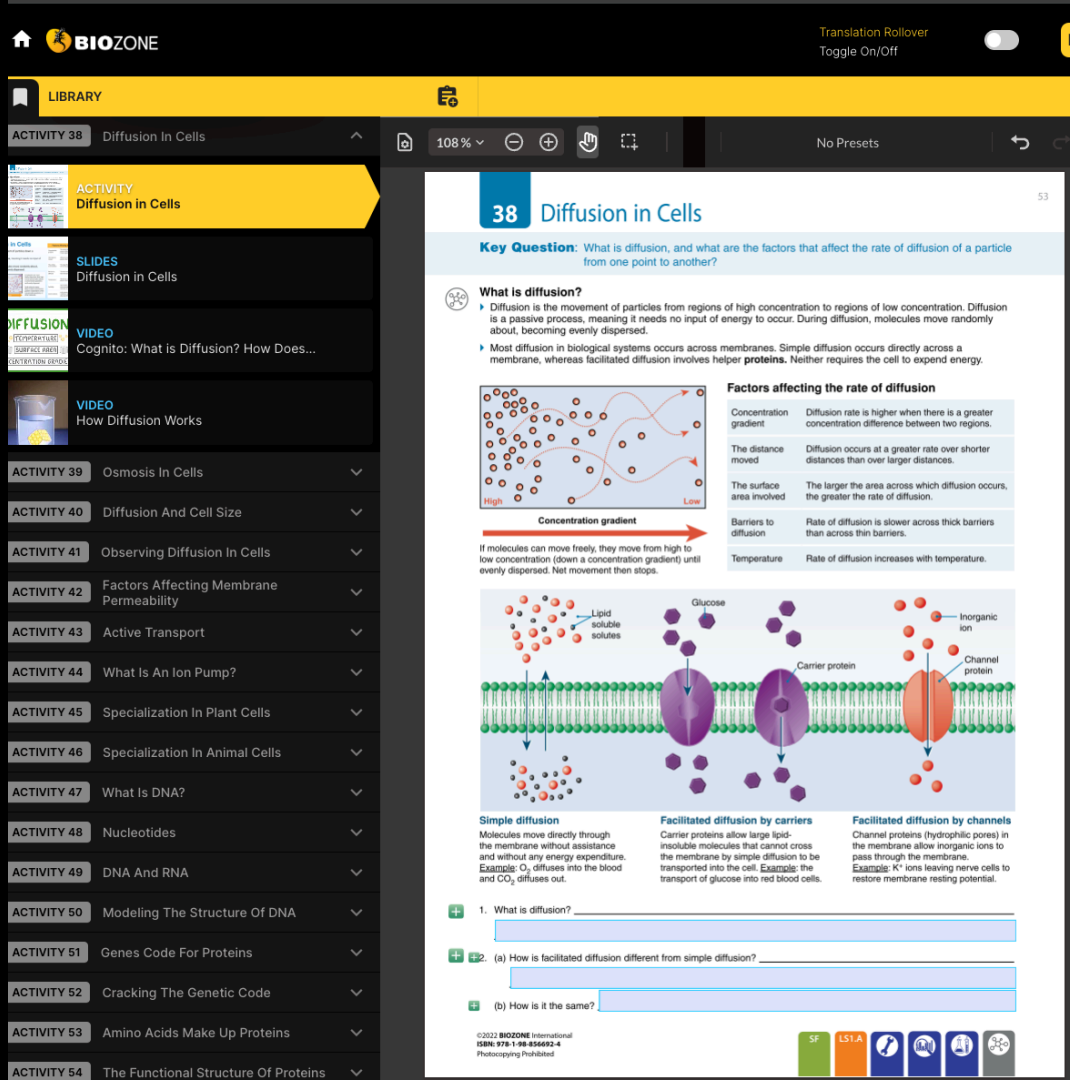

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ACTIVITY 18 El Niño And La Niña

ACTIVITY
El Niño and La Niña

VIDEO
El Nino

ACTIVITY 19 Water
ACTIVITY 20 Ocean Circulation And Currents
ACTIVITY 21 Earth's Past Climate
ACTIVITY 22 Did You Get It?

CHAPTER 2 Ecosystems
CHAPTER 3 Populations
CHAPTER 4 Investigating Ecosystems
CHAPTER 5 Land And Water
CHAPTER 6 Energy
CHAPTER 7 Pollution
CHAPTER 8 Conservation
CHAPTER 9 Climate Change
CHAPTER 10 Science Practices

Appendix

18 El Niño and La Niña

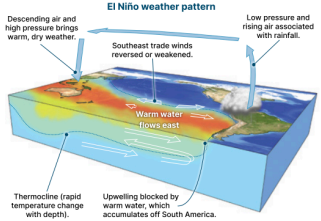
Key Idea: El-Niño is a major climate pattern that affects regions around the Pacific ocean.

The El-Niño-Southern Oscillation, which has a periodicity of three to seven years, is a climate cycle that occurs in the Pacific region. El-Niño years cause a reversal of the normal climate regime and are connected to events such as the collapse of fisheries stocks, flooding in the Mississippi Valley, drought-induced crop failures and forest fires in Australia and Indonesia. An intensification of the normal situation, called La Niña, often occurs soon after an El Niño event.

In non-El Niño conditions, a low pressure system over Australia draws the southeast trade winds across the eastern Pacific from a high pressure system over South America. This system produces rain in the area of Australasia and dry conditions on the coast of South America.

In an El Niño event (right), the pressure systems over Australia and South America are weakened or reversed, beginning with a rise in air pressure over the Indian Ocean, Indonesia, and Australia. Warm waters block the nutrient upwelling along the west coast of the Americas. El Niño brings drought to Indonesia and northeastern South America, while heavy rain over Peru and Chile causes the deserts to bloom.

El Niño weather pattern



During non-El Niño years, cool, nutrient-rich waters along the South American coast sustain huge populations of fish such as anchovy. During El Niño events, warm waters reduce nutrient supply, and fish populations either crash or move to feeding grounds elsewhere.

El Niño events bring more rain to deserts in parts of South America and Baja California. On the islands of the Gulf of California, plant cover increases from 0–4% during non-El Niño years to 54–89% during El Niño years. In Northern Chile, plant cover increases over five times during El Niño.

During La Niña, the southeastern trade winds intensify, blowing warm water closer to Asia than normal. Cold, nutrient rich waters well up along the coast of the Americas. Winter temperatures in the southern states are warmer than usual and the hurricane season is more severe.

La Niña conditions bring cold waters to the surface near the Americas. This tends to push the jet stream over North America further North. This results in droughts in the southern US and more rain and cooler temperatures in the Pacific Northwest.

1. Describe the events that cause El Niño conditions and its effects on ocean circulation:

2. Describe the effect of an El Niño year on:

(a) The climate of the western coast of South America: _____

(b) The climate of Indonesia and Australia: _____

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ES

- **Students can**:
  - Input answers into the platform for review and grading.
  - Add notes, draw on the page and highlight text passages.
- **Teachers can**:
  - View and show answers
  - Assign activities
  - Grade and return work
  - Force hand in

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CHAPTER 6 Energy

CHAPTER 7 Pollution

INTRODUCTION Pollution

ACTIVITY 139 Types Of Pollution

ACTIVITY 140 Water Pollution

ACTIVITY 141 Nitrogen Pollution

ACTIVITY 142 Eutrophication And Water Quality

ACTIVITY 143 Biomagnification

ACTIVITY 144 Sewage Treatment

ACTIVITY 145 Waste Management

ACTIVITY 146 Reducing Waste

ACTIVITY 147 Plastics In The Environment

ACTIVITY
Plastics in the Environment

3D MODEL
Hawkesbill turtle

WEB LINK
Our planet is choking on plastic

WEB LINK
Plastic island

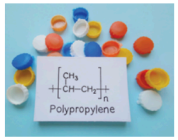
147 Plastics in the Environment

Key Idea: The widespread presence of plastic waste is causing significant harm to ecosystems and the organisms that inhabit them.

Almost every home and industry contains plastic: a synthetic substance that has only been introduced in the last 100 years. Plastic is widely used because it is convenient and easy to produce. However, its low cost of production also makes it easy to discard. Due to the ocean currents spreading the material, even the most remote parts of the world are now affected by **plastic pollution**. Currently, around 19–23 million tonnes of plastic are released into the environment each year as waste into lakes, rivers, and oceans. This problem will only be partially solved by plastic **recycling**. Instead, a shift to non-plastic products and the development of innovative breakdown processes that can tackle the issue of plastic permanence will be required.

Plastic permanence is a problem

- The problem with plastic is its stability. In nature, organic material is broken down by enzymes and microbes that have evolved over billions of years to deal with the chemical bonds found in nature. Plastic degradation is limited due to the difference of chemical bonds in most plastics compared to those found in nature. This results in only a small number of organisms capable of breaking down plastic.
- Plastics have a long-lasting presence in the environment, persisting for hundreds of years. The excessive disposal of plastic products over the past 50 years has led to significant environmental and **waste management** challenges.
- Environmental groups are collecting plastic from polluted areas, but the problem then becomes how to get rid of it completely.




Colorful, cheap plastic is in most homes.


Plastic pellets can be molded into products.


Waterway plastic pollution, Tamil Nadu

Plastic is everywhere
The earliest forms of synthetic plastics, such as Bakelite (1909), cellophane (1912), PVC (1926), and teflon and nylon (1938), revolutionized many products. Mass use in medical supplies and shopping bags increased during the 1970s. Fleece clothing entered the market in 1993. In a relatively short time, plastic became an indispensable material: light, cheap to make, and waterproof. Shops offer a huge variety of plastic products, and nearly every food and drink is packaged in plastic.

Plastics and health
The production of plastic from fossil fuels and other chemicals can have detrimental effects on the environment, including the emission of greenhouse gases. Elevated numbers of cancer cases have occurred in Louisiana near plastic production plants. Certain additives such as BPA, found in plastic, including children's toys, have been found to negatively impact both the reproductive and immune systems. Additionally, when waste plastic is incinerated, harmful fumes are released.

Plastic pollution and water supply
Plastic waste in waterways that supply water for human use can make much of it unusable. India is one country with a significant plastic pollution problem, partly because of the concentrated population. In Tamil Nadu, above, the local government is attempting to solve their plastic pollution by importing several 'boom interceptors' from the Netherlands. However, without an effective recycling plan, this will just collect and move the plastic from one site to another.

1. Why are so many products used by humans made from plastic? *The plastic is cheap to manufacture, is ideal for packaging food and drink, being waterproof and easy to sterilize. It can be molded into many different shapes. It is light to transport around.*
2. Explain why plastics persist in the environment: *The chemical bonds in plastics are not like those found in nature so there are very few organisms that can break the chemical bonds in plastic and degrade it.*
3. Explain how plastic pollution can impact human communities: *Plastic can be esthetically unpleasing and highly visible when discarded. The plastic can break down into small pieces that leach toxins (and forever chemicals) and be washed into the waterways, polluting drinking water and affecting taste. The plastic can block pipes. The plastic can impact the growth of plants and be ingested by farm animals, causing them harm.*

GC

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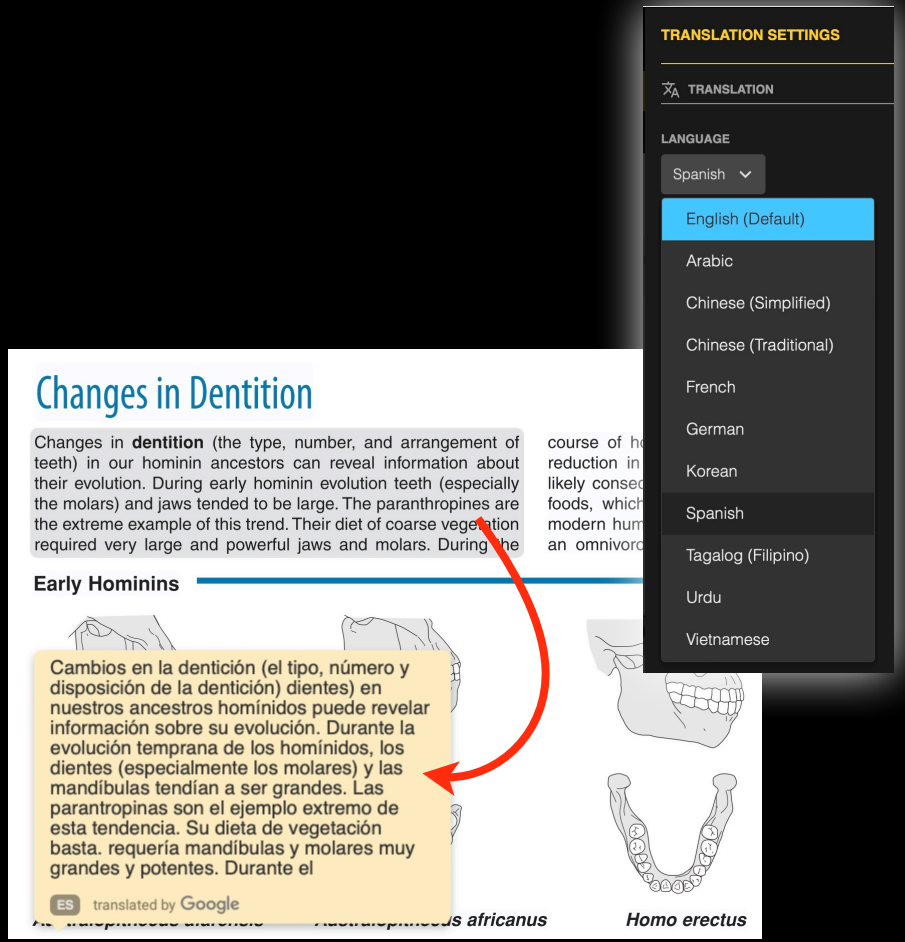
- Perfect for introducing or reviewing content with students via shared screen.
- Teacher can **display model answers** when they want.
- Simply click the buttons on the teacher view to reveal the answers.
- Students can refine their own answers based on the model answers.

Translation feature

- **Translation for 150 languages:** Realtime translation - highlight the English text to display text translation in the selected language.

- Once activated, pointing the mouse at a text block in the book page will show the translated version on a nearby pop-up panel.



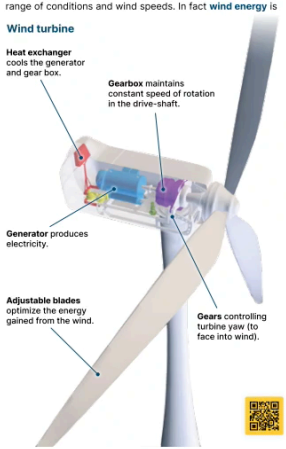
127% No Presets

126 Wind Power

Key Idea: Wind power provides a relatively simple and scalable way to produce electricity.

Wind power has been used for centuries to provide the mechanical energy to pump water or run milling machinery. Today, it is mainly used to produce electricity. Wind power is becoming increasingly reliable and cost effective as the technology develops and turbines are able to operate in a range of conditions and wind speeds. In fact **wind energy** is one of the cheapest types of energy to build, maintain, and use. Globally, wind power is steadily increasing in generation capacity, but wind is a variable energy provider. There can be problems matching output to demand, such as during seasonal demands and low (or extremely high) winds. This means systems for managing and distributing electricity will be required as well as backup or base load electricity supplies, e.g. hydro or geothermal power.

Wind turbine



Wind farms often cover large areas of land but turbines can be designed to operate at sea and, on a smaller scale, along highway edges. The scalability of **wind turbines** makes them simple to install in many locations, with turbine sizes ranging from a few metres to over 200 metres in diameter.

At the end of 2022, the power output from wind turbines was around 7% of global electricity production. Global installed capacity was more than 800 GW. Electricity generation from wind is rising every year.

1. A typical wind turbine produces around 2.3 MW. The average house uses 30 kWh of energy per day (a kilowatt hour is the equivalent of 1000 joules of energy per second (1kW) running for 1 hour). Calculate the following:

(a) The minimum number of wind turbines required to power a town of 20,000 households:

(b) Wind turbines cost around $1.3 million per MW of energy production to build. What will the be the cost of (a) above?

(c) The cost of building, running, and maintaining wind turbines over their 20 year lifetimes is about $50 per MWh. What could the 20,000 households using the wind turbines above expect to pay in dollars per year for the use of electricity provided by the wind turbines?

(d) Why can households actually expect to have to pay a lot more than this? _____

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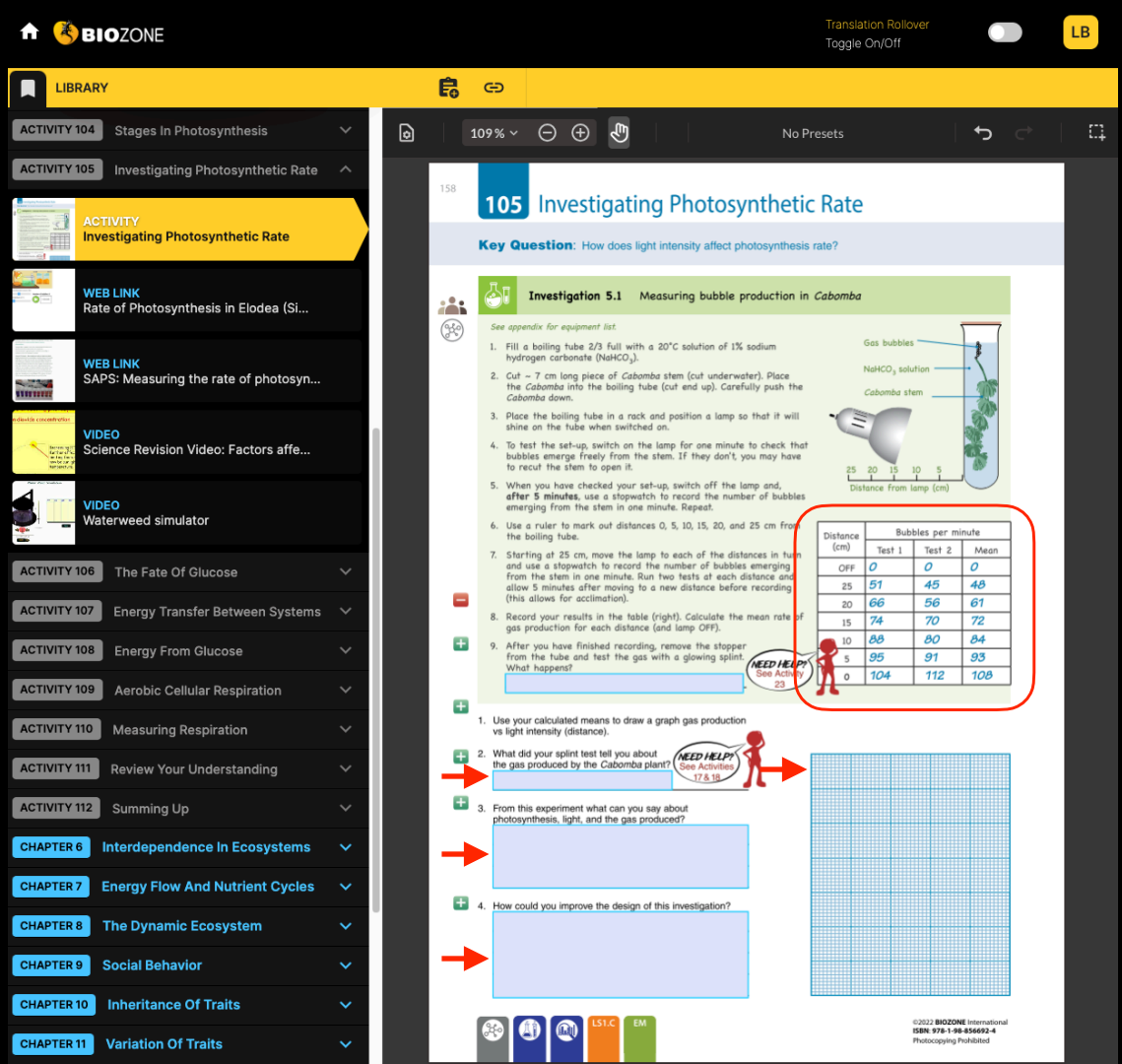
Practical Investigations

- Short on time?
- Student results can't be used?
- Share the model answer data.
- Students still do the graphing and analysis of results.



STUDENT Access

Digital interactive replica of the book:

- Students can view the book, add **annotations** and **markup**.
- Students can enter **answers online** and **submit** them to their teacher.
- Access embedded resources: **3D models**, **presentation slides**, curated OER **videos**, **weblinks**.

TEACHER Access

All the functions the student has plus:

- Teacher has access to **model answers** & can show/hide via display buttons.
- Teacher can **assign activities** to students.
- Force hand in.
- Teacher can **view**, **comment,** and **grade** student responses to questions.

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