

AP[®] BIOLOGY



Contents

CLASSROOM GUIDE

Teacher Support Materials.....	CG2
The Structure of the Book.....	CG3
The AP Biology Instructional Model.....	CG4
The Contents: A Planning Tool	CG5
Identifying Learning Intentions and Goals	CG6
Support for AP Biology Practical Investigations.....	CG7
Support for Science Practices	CG9
Evaluating Student Performance	CG10
Teaching Strategies for Classroom Use	CG11
Differentiated Learning	CG13
The Digital Teacher's Edition.....	CG14

STUDENT EDITION

Student Edition with Answers in Place	i-484
---	-------

APPENDIX

Answers to Long Answer Questions.....	A1
---------------------------------------	----

ISBN 978-1-98-856657-3

Third Edition 2021

Copyright © 2021 Richard Allan

Published by BIOZONE International Ltd

**Purchases of this book may be
made direct from the publisher:**



BIOZONE Corporation

USA and Canada

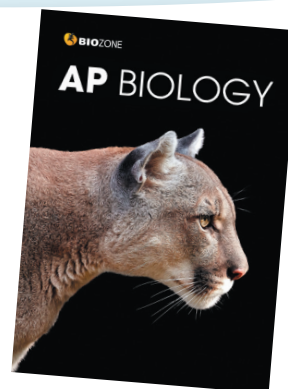
FREE phone: 1-855-246-4555

FREE fax: 1-855-935-3555

Email: sales@thebiozone.com

Web: www.thebiozone.com

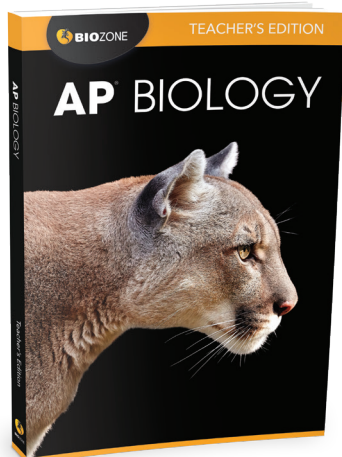
FAQs ABOUT AP BIOLOGY



What extra resources are available to support teachers?	CG2, CG14
How is AP Biology structured?	CG3
How does the book employ the AP Instructional Model?	CG4
How can I plan my lessons?	CG4-CG5
Are the learning objectives clearly stated for each unit?	CG6
Is there a suggested way to deliver content?	CG4, CG11
How do I evaluate student performance?	CG4, CG10
Do the personal progress checks mimic the AP exam format?	CG10
Does the book contain support for the 13 practical investigations?	CG7- CG8
How do I use the student book in the classroom?	CG11- CG13
Are there tools for differentiated instruction (including gifted and talented students)?	CG13
What is the Digital Teacher's Edition?	CG14

Teacher Support Materials

BIOZONE's AP Biology Teacher's Edition forms the core of your AP Biology teacher support resources. Utilize this resource to learn more the structure, tools, and resources provided for effective delivery and assessment of AP Biology. BIOZONE has developed a suite of additional materials to support your delivery of AP Biology. These are described below.



TEACHER'S EDITION

The AP Biology Teacher's Edition provides a teacher's companion to the student book. It presents the student book, with all suggested model answers in place, enabling quick and seamless reference to the information required for your lesson planning. A comprehensive preface provides a guide to best use of BIOZONE's AP Biology resources. It covers strategies for teaching online and in differentiated classrooms, using student personal progress checks, the benefits of collaborative learning, and supporting essential skills in science practices.

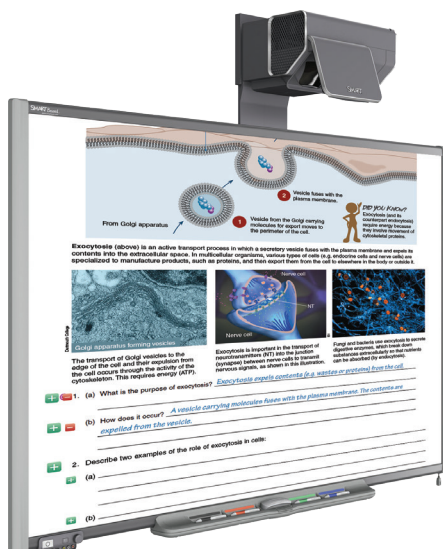
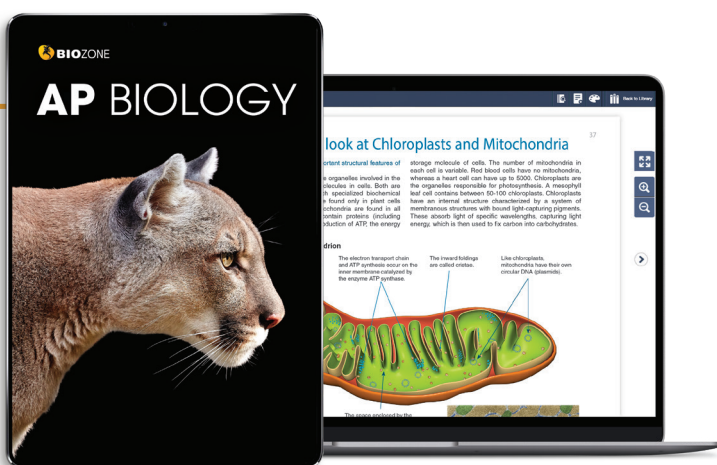
EBOOK VERSION

Our eBooks provide a digital replica of the printed pages.

With our eBook PLUS on a School Managed Licence, students can answer most questions online, although a small number of questions require offline responses or a download. These are mostly associated with essential skills, such as plotting and graphical representations.

The eBook TEACHER'S EDITION is also available with answers in place and some additional features.

Visit: thebiozone.com/ebooks for more information



DIGITAL TEACHER'S EDITION

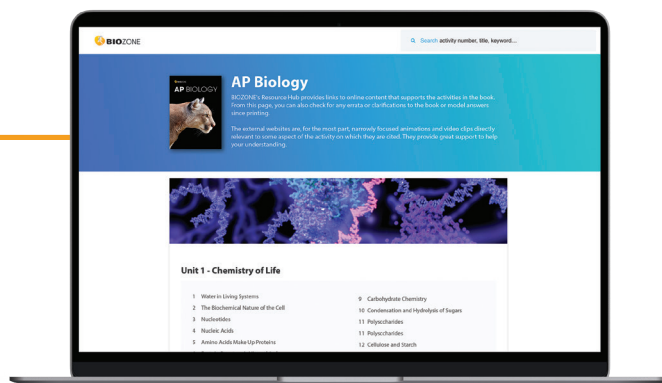
This PDF version of the book is ideal for introducing and reviewing activities using an interactive whiteboard. This teacher's resource features a non-printable PDF version of the Teacher's Edition, with a useful feature to hide and display the suggested answers. Supplied as a direct download.

RESOURCE HUB

Be sure to visit BIOZONE's RESOURCE HUB, which is fully accessible and free of charge to you and your students. It offers a curated collection of videos, animations, 3D models, and supporting content for the activities in this book.

Teachers can also find the original reference material for some activities, including the Free Response Questions.

Visit: www.BIOZONEhub.com Your code is **APB1-6566**



The Structure of the Book

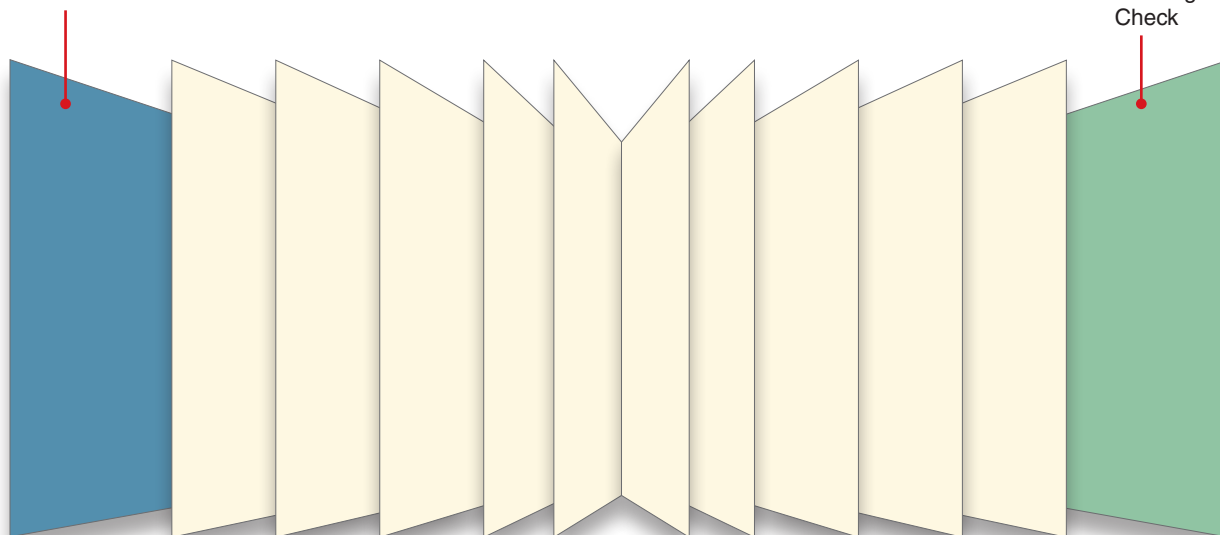
The content of the *AP Biology* is organized into 9 chapters. The first eight chapters are based on the units of study described in the *AP Biology Course and Exam Description* (CED). The final chapter, *Science Practices*, provides comprehensive support for each of the science practices identified in the CED. Students can find out about the key skills embodied in these practices and learn to apply them in different contexts. They have many opportunities throughout the book to practice these skills and they can return to the chapter at any time to review their understanding.

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

- Unit introductions summarize the key content, skills, and learning outcomes for each unit, providing a checklist for students and a record of progress for teachers. See more about these on page CG6.
- Activities make up the bulk of each chapter. The activities have been designed so that by the end of the program the students have covered the required content knowledge and skills specified in the *AP Biology* CED. Activities have been designed to be engaging, informative, and (where appropriate) challenging. Data, annotated diagrams, and photographs, provide much of the information in context, and there are many topical and interesting case studies. The student's understanding of the information is evaluated through questions and/or tasks involving describing and explaining principles and concepts, handling and evaluating data, and argumentation.
- Chapters 1-8 each conclude with a Personal Progress Check (PPC) to assess student understanding. These comprise both multiple choice questions and two free response questions per unit.

Unit introduction

Personal Progress Check



Activity pages

7 Protein Shape is Related to Function

Key Question: How does a protein's three-dimensional shape reflect its role and enable it to function?

As we have seen, a protein may consist of one polypeptide chain, or several polypeptide chains linked together. Hydrogen bonds between amino acids cause the polypeptide chain to form its **secondary structure**, either an α -helix or a β -pleated sheet. The interaction between R groups causes a polypeptide to fold into its **tertiary structure**. A three-dimensional shape held by ionic bonds and disulfide bridges. Bonds are broken (through denaturation), the protein loses its tertiary structure, and its functionality.

The shape of a protein reflects its biological role

Active site formed by the precise configuration of a protein

Channel proteins
Proteins that form channels in the plasma membrane present non-polar R groups to the membrane and polar R groups to the inside of the channel. Hydrophobic molecules and ions are then able to pass through these channels into the interior of the cell. Ion channels are found in nearly all cells and many organelles.

Enzymes
Enzymes are globular proteins that catalyze reactions. They are specific to their substrate and their tertiary structure creates an **active site** where the substrate can bind and the reaction can occur. The specificity of the active site is determined by the interactions of amino acid R groups. Denaturation alters the active site and causes a loss of function.

Sub-unit proteins
Many proteins, e.g. insulin and hemoglobin, consist of two or more sub-units in a complex quaternary structure, often associated with a metal ion. Active insulin is formed by two polypeptide chains stabilized by disulfide bridges between neighboring cysteines. Insulin stimulates glucose uptake by cells.

Protein denaturation
When the chemical bonds holding a protein together become broken, the protein can no longer hold its three-dimensional shape. This process is called **denaturation**, and the protein usually loses its ability to carry out its biological function.

There are many causes of denaturation including exposure to heat or pH outside of the protein's optimum range. The main protein in egg white is albumin. It has a clear, thick fluid appearance in a raw egg (left). Heat (cooking) denatures the albumin protein and it becomes insoluble, clumping together to form a thick white substance (far right).

1. Using the example of insulin, explain how interactions between R groups stabilize the protein's functional structure:

2. Why do channel proteins often fold with non-polar R groups to the channel's exterior and polar R groups to its interior?

3. Why does denaturation often result in the loss of protein functionality?

8 Comparing Fibrous and Globular Proteins

Key Question: How do the structure and properties of globular and fibrous proteins reflect their contrasting roles?

Globular and fibrous proteins can be classified according to structure or function. Globular and fibrous proteins form two of the main broad structural groups of proteins (the others being membrane proteins and disordered proteins such as caspase). Globular proteins are spherical and somewhat soluble forming colloids in water (e.g. enzymes). Fibrous proteins have an elongated structure and are not water soluble. They provide stiffness and rigidity to the more fluid components of cells and tissues.

Globular proteins
The shape of globular proteins is a function of their tertiary structure. Some proteins (e.g. α -actin and tubulin) are globular and soluble as monomers, but polymerize to form long, stiff fibers.

Properties of globular proteins

- Easily water soluble
- Tertiary structure critical to function
- Polypeptide chains folded into a spherical shape

Functions of globular proteins

- Catalytic, e.g. enzymes
- Regulatory, e.g. hormones (insulin)
- Transport, e.g. hemoglobin
- Protective, e.g. immunoglobulins (antibodies)
- Structural (rarely), e.g. actin and tubulin monomers (cytoskeletal elements)

Insulin is a peptide hormone involved in the regulation of blood glucose. Insulin is composed of two polypeptide chains linked together by two disulfide bonds.

Rubisco is a large multi-unit enzyme. It catalyzes the first step of carbon fixation in photosynthesis. It consists of 8 large and 8 small subunits and is the most abundant protein on Earth.

Hemoglobin is a multi-unit oxygen-transporting protein found in vertebrate red blood cells. One hemoglobin molecule consists of four polypeptide subunits (two red and two blue). Each subunit holds an oxygen-binding heme group (green).

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

2. (a) Explain how the shape and properties of a globular protein relate to its functional role:

(b) How would its function be affected by a change in tertiary structure?

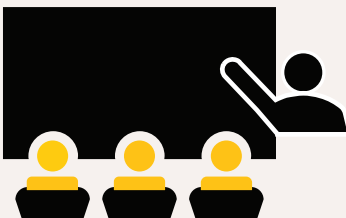
The AP Instructional Model

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



Plan

- The structure of *AP Biology* follows the unit plan specified in the CED. Teachers can be assured that all of the essential components of the framework are covered, ensuring easy and efficient lesson planning with no content gaps.
- Use the unit introductions to assign students work for each lesson.
- Add interest to your lessons by utilizing the FREE resources on **BIOZONE's Resource Hub** in your planning. Resources for specific activities are identified on the Resource Hub, saving you having to locate your own resources.
- Want to refresh your knowledge before you teach, or extend gifted and talented students? Resources specifically set for teachers or gifted and talented students are identified on **BIOZONE's Resource Hub**. You can assign these to students at your discretion.
- A green bullet next to an activity in the contents pages identifies where support for one of the 13 investigations is included. They are also clearly identified on the activity page.



Teach

- Teach the content in the order presented in BIOZONE's *AP Biology*. Content covered in the early chapters lays the foundation for more in-depth material and specific examples covered in later units.
- Have students complete a skills support activity in the final chapter (*Science Practices*) before attempting the relevant unit activity. These can be assigned as homework or they can be completed in class if students need support.
- Assign students into groups of mixed abilities when carrying out group research projects or practical investigations to encourage peer-to-peer learning.
- Activities that manipulate data using formulas may be supported by spreadsheets on **BIOZONE's Resource Hub**. Assign these activities to students so they can develop a deeper understanding of the value of data manipulation. You can tailor how you use the spreadsheets. If time permits, have students graph the data themselves. Alternatively, have students analyze the completed data set (including graphs) to save time.
- Extend students' scientific vocabulary by encouraging them to look up words they are unfamiliar with in the **glossary** (Appendix 2).
- Use the Digital Teacher's Edition to review answers in class or on-line quickly and efficiently. Choose when and how you reveal the answers. To promote student discussion, reveal answers only once the students have shared their ideas. Reveal all the answers if you want the students to self mark their own work.



Assess

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

The Contents: A Planning Tool

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

Contents

Using This Book	vi
Using BIOZONE'S Resource Hub	viii
Big Ideas and Enduring Understandings	x
Science Practices and Skills	xii

UNIT 1. Chemistry of Life

<input type="checkbox"/> 1	Learning Objectives	1
<input type="checkbox"/> 2	Water in Living Systems	2
<input type="checkbox"/> 3	The Biochemical Nature of the Cell	4
<input type="checkbox"/> 4	Nucleotides	6
<input type="checkbox"/> 5	Proteins	7
<input type="checkbox"/> 6	Comparing Fibrous and Globular Proteins.....	13
<input type="checkbox"/> 7	Carbohydrate Chemistry	15
<input type="checkbox"/> 8	Condensation and Hydrolysis of Sugars.....	16
<input type="checkbox"/> 9	Polysaccharides	17
<input type="checkbox"/> 10	Cellulose and Starch.....	19
<input type="checkbox"/> 11	Lipids	20
<input type="checkbox"/> 12	Personal Progress Check	67

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

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

<input type="checkbox"/> 16	Learning Objectives	27
<input type="checkbox"/> 17	Prokaryotic vs Eukaryotic Cells	28
<input type="checkbox"/> 18	Looking at Cells	29
<input type="checkbox"/> 19	Animal Cells	31
<input type="checkbox"/> 20	Plant Cells	33
<input type="checkbox"/> 21	Cell Structures and Organelles	35
<input type="checkbox"/> 22	A Closer Look at Chloroplasts and Mitochondria	37
<input checked="" type="checkbox"/> 23	Cell Sizes	38
<input checked="" type="checkbox"/> 24	Limitations to Cell Size	39
<input checked="" type="checkbox"/> 25	Surface Area and Volume	40
<input checked="" type="checkbox"/> 26	Efficient Exchange	41
<input checked="" type="checkbox"/> 27	The Structure of Membranes	42
<input checked="" type="checkbox"/> 28	Factors Affecting Diffusion	43
<input checked="" type="checkbox"/> 29	The Role of the Cell Wall	52
<input checked="" type="checkbox"/> 30	Passive Transport	53
<input checked="" type="checkbox"/> 31	Diffusion and Osmosis in a Cell	55
<input checked="" type="checkbox"/> 32	Water Relations in Plants	56
<input checked="" type="checkbox"/> 33	Solute Potential and Osmosis in Potatoes	57
<input checked="" type="checkbox"/> 34	Active Transport	58
<input checked="" type="checkbox"/> 35	Ion Pumps	59
<input checked="" type="checkbox"/> 36	Cytoskeleton	60
<input checked="" type="checkbox"/> 37	Compartmentalization	61
<input checked="" type="checkbox"/> 38	Origins of Cellular Compartments	66
<input checked="" type="checkbox"/> 39	Personal Progress Check	67

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

Activities covering content and skills to support the 13 investigations are identified by a green bullet next to the activity number.

UNIT 3. Cellular Energetics

Learning Objectives	71
The Properties of Enzymes	72
How Enzymes Work	74

UNIT 1. Chemistry of Life

Learning Objectives	1
Water in Living Systems	2
The Biochemical Nature of the Cell	4
Nucleotides	6
Proteins	7
Comparing Fibrous and Globular Proteins.....	13
Carbohydrate Chemistry	15
Condensation and Hydrolysis of Sugars.....	16
Polysaccharides	17
Cellulose and Starch.....	19
Lipids	20

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

Learning Objectives	110
Types of Cell Signaling.....	111
Cell to Cell Communication.....	113
Communication Over Short and Long Distances	114
Signals and Signal Transduction	116
Cellular Signal Transduction	118
Signal Transduction and Environment.....	120
Changes in Signal Transduction Pathways	122
Feedback	124
Cell Division	127
The Eukaryotic Cell Cycle.....	128
The Outcome of Mitosis	129
Mitosis and Cytokinesis	130
Modeling Mitosis	133
The Effect of Environment on Mitosis	134
Regulation of the Cell Cycle.....	135
Defective Gene Regulation in Cancer.....	137
Analyzing the Effects of Cell Cycle Errors	139
Personal Progress Check	140

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

Identifying Learning Intentions and Goals

BIOZONE's *AP Biology* has been written specifically to address the *AP Biology Course and Exam Description*. Each unit is prefaced with a chapter introduction. The units are organized into topics, and these are aligned to specific activities. The key content, skills, and learning objectives for each unit are summarized here.

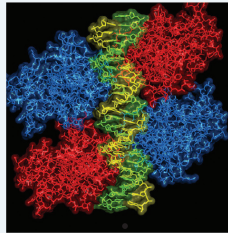
This identifies the unit to which this chapter applies.

UNIT 1

Chemistry of Life

Learning Objectives

1



Developing understanding

CONTENT: This unit sets the foundation for the study of biology. It includes a survey of the elements essential for life, the central role of water in biological systems, and the importance of living systems depends on an input of energy. Understanding how macromolecules are synthesized and function.

SKILLS: This unit emphasizes skills in visualizing concepts represented visually. The skill of understanding the causes or effects of a change in a system.

Content summary

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

Skills summary

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

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

1.1 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 break covalent bonds between monomers in nucleic acids, proteins, carbohydrates, and lipids.

The learning objectives for each topic within the unit are listed here. Students can tick them off as they cover them.

activities 4 - 14

- ☐ 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 the phosphodiester bonds that form between nucleotides. Interpret diagrams and models of the directionality of nucleic acids, defining the 5' and 3' carbons of the sugar in the nucleotide.
- ☐ 12. Explain the antiparallel, double helix structure of DNA, including how the directionality of the sugar-phosphate backbone 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).

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

Support for AP Biology Practical Investigations

Throughout the book, you will find activities, integrated in context, to support the 13 required practical investigations. These are not intended to duplicate the AP Biology investigations already provided by the AP College Board's comprehensive lab book. Rather, they focus on supporting student understanding of the principles, concepts, procedures, and analysis involved in each investigation. We recommend using these activities to prepare students for their practical work. Each activity focuses on a specific aspect of an investigation and provides second hand data for analysis. By completing these activities, students can approach their own investigations with greater confidence. These activities are clearly identified by a green bullet in the contents (CG5) and by a banner on the activity page itself. A complete list is provided on the next page.

30 Diffusion and Osmosis in a Cell

55

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 that sucrose is too large to pass through the dialysis tubing. The glucose solution is placed into partially permeable membrane with pores large enough for glucose to pass through.

Aim

To demonstrate that sucrose and glucose can pass through a partially permeable membrane.

Hypothesis

Sucrose is 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 molecule joined together). Sucrose is larger than glucose.



Glucose



Sucrose

Dialysis tubing (partially-permeable membrane)

Solution containing sucrose or glucose

Distilled water

Method

Two model cells of dialysis tubing were filled with 5 cm³ each of a 1 mol/L glucose solution.

The cells were weighed to 2 decimal places in separate beakers of distilled water.

The cells were removed from the distilled water and weighed. They were reweighed and weighed a third time.

Students are provided with enough information to understand how the experiment was set up. This allows them to be able to carry out any data analysis, and answer the related questions.

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				

Cell	Final mass (g)	Initial mass(g)	change (g)	% change
1				
2				
3	11.28	10.55		
Mean				

Real world second-hand data sets are provided for analysis. They are typical of results students might obtain themselves.

1. Calculate the mean percentage change.
2. Explain the result in terms of movement of water. (sucrose has a relative mass of 342.3 g/mol, glucose a relative mass of 180 g/mol.)

Questions addressing specific skills in one or more of the six science practices are identified by a color coded bullet in the margin and at the bottom of the page.

A list of the activities supporting the mandatory AP Biology investigations are provided in the table below.



AP Biology practical investigation		Activity name	Activity number
Investigation 1:	Artificial selection	• Selection in Fast Plants	157
Investigation 2:	Mathematical modeling: Hardy-Weinberg	• Analysis of a Squirrel Gene Pool	165
Investigation 3:	Comparing DNA sequences to understand evolutionary relationships with BLAST	• Investigating Molecular Diversity	202
Investigation 4:	Diffusions and osmosis	• Surface Area and Cell Size (procedure 1)	24
		• Diffusion and Osmosis in a Cell (procedure 2)	30
		• Osmosis in Potato Cells (procedure 3)	33
Investigation 5:	Photosynthesis	• Investigating Photosynthesis	53
Investigation 6:	Cellular respiration	• Investigating Cellular Respiration	58
Investigation 7:	Cell division: Mitosis and Meiosis	• Modeling Mitosis (part 1)	74
		• The Effect of Environment on Mitosis (part 2)	75
		• Analyzing the Effects of Cell Cycle Errors (part 3)	78
		• Modeling Meiosis (part 4)	81
		• Mapping Chromosomes Using Linked Genes (part 5)	96
Investigation 8:	Biotechnology: Bacterial transformation	• Aseptic Technique and Streak Plating	139
		• Testing for Transformation	140
Investigation 9:	Biotechnology: Restriction enzyme analysis of DNA	• DNA Profiling Lab	143
Investigation 10:	Energy dynamics	• Investigating Trophic Efficiencies	236
Investigation 11:	Transpiration	• Investigating Plant Transpiration	213
Investigation 12:	Fruit fly behavior	• Choice Chamber Investigations	216
Investigation 13:	Enzyme activity	• Investigating Enzyme Activity (procedure 2)	45

Support for Science Practices

The science practices are a core component of AP Biology. As students work through the units, there are many opportunities for them to develop skills in science practices and apply them within the context of an activity. Regular practice helps students become proficient in using these skills when they encounter them in the AP Biology exam. A dedicated chapter at the end of the book, Science Practices, provides support for each of the six science practices. Have students visit this chapter regularly if they need support or guidance, or assign the activities as homework before they attempt a specific topic in class.

Specific questions relating to a science practice are identified on an activity page using the color codes shown on the right.



Concept explanation

Visual representations

Questions and methods

Representing and describing data

Statistical tests and data analysis

Argumentation

Science practice 1: Concept explanation

250 Concept Explanation

Key Question: How can concepts, processes and models be presented in a written format?

Key Question: How can concepts, processes and models be presented in a written format? Some data or diagrams can be complex or show multiple concepts. It is important to be able to describe and explain these and how they relate to each other.

Describing a concept may include...

- Describing characteristics and attributes using defining terms, e.g. describing proteins as a polymer or a complex.
- Classifying or grouping concepts or parts of concepts, e.g. identifying trophic levels.
- Describing components, e.g. describing the parts involved in carbon cycling.
- Describing a process or process, e.g. giving a simple description of an ecological process.
- Describing structure and function, e.g. describing the structure of energy pyramids and the function of each component.
- Describing trends and patterns, e.g. describing patterns in graphs or data tables.

Explaining a concept may include...

- Explaining each of the points in the description table on the left.
- Explaining these points in applied contexts. This might include:
 - Explaining the effect of denaturation on solubility.
 - Explaining the relationship between photosynthesis and carbon cycling.
 - Explaining competition or cooperation between different species.
 - Explaining how birth rate change as countries become more developed or industrialized.

Salivary amylase is a digestive enzyme that breaks the starch (complex carbohydrates) in food into smaller sugar molecules.

The activity of amylase can be tested using the iodine test. Iodine solution is a yellowish color and the test shows starch is present. If the iodine solution stays yellowish after the addition of a sample, there is no starch present in the sample. The sample turns blue/black if starch is present in the sample.

The table below shows how long it took for salivary amylase to completely break down the starch over a range of temperatures.

Temperature (°C)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N
20	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N
30	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
40	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N
50	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N
60	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Y = starch is present, N = starch is absent

1. Describe how temperature affects how quickly salivary amylase breaks down starch.

2. Explain the effect of temperature on the rate of this reaction.

Explain biological concepts, processes, and models presented in written format.

Science practice 2: Visual representations

251 Visual Representations

Key Question: How are visual representations useful for scientific concepts and ideas visually? They help to visualize concepts and ideas visually. They can be used to show the complexity of relationships within a system.

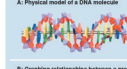
Describing visual representations may include...

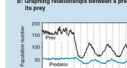
- Describing the characteristics of the visual representation, e.g. describing a graph, a diagram, a table, etc.
- Explaining the concept being represented visually, e.g. explaining what the flow diagram is showing.

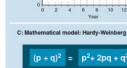
Explaining visual representations may include...


- Comparing patterns or trends, e.g. comparing mitosis and meiosis.
- Explaining the concept being represented visually, e.g. explaining what the flow diagram is showing.
- Predicting patterns based on the representation, e.g. drawing conclusions based on the information being represented visually.

1. Describe what each of the models, A - D, is showing:

A: 

B: 

C: 

D: 

2. Explain the pattern shown in the graph B (left):

Analyze visual representations of biological concepts and processes.

Science practice 3: Questions and methods

252 Questions and Methods

Key Question: Once we have asked a scientific question, how do we design an experiment to answer it? A scientific question is asked and a hypothesis is generated. The researcher then designs an experimental procedure to collect the kind of data needed to answer their question. During the experiment, data is collected and recorded before undergoing analysis. Based on the findings, the hypothesis can be accepted or rejected. Often, results show further questions, and experimental design and procedure must be redesigned or reevaluated to address these new questions.

Describing aspects of scientific investigations may include...

- Identifying the purpose or aim of the investigation, or the hypothesis being tested.
- Identifying and describing the method, including the dependent and independent variables and how they will be measured.
- Identifying the control of present and justifying any factors that need to be controlled.
- Being able to draw data from the method and results, including photographs and diagrams (e.g. graphs).
- Identifying and describing how a method could be modified or refined to obtain more accurate data.

Carrying out a scientific investigation may include...

- Identifying the aim and writing a hypothesis.
- Deciding which variable will be changed (the independent variable) and which will be measured (the dependent variable) and how they will be measured.
- Using the method of data collection so that it can be followed and repeated by someone else.
- Recording data in a systematic way.
- Drawing conclusions from the data.
- Writing a concluding statement identifying what the method used and any limitations in the investigation.

Start with observation, ask questions, make hypotheses and predictions

Observations normally start from observations, rather than a previous investigation or from observations of previous events. An observation could be: There are more houseflies in the room than 10 years ago. This is a very general observation. A hypothesis could be: There are more houseflies in the room because the room is becoming more crowded. A prediction could be: If the room is becoming more crowded, then the number of houseflies will increase. A hypothesis could be: If the room is becoming more crowded, then the number of houseflies will increase. A prediction could be: If the room is becoming more crowded, then the number of houseflies will increase.

Identifying variables

Dependent variable: The variable that is measured or observed. It is the variable that changes in response to the independent variable. It is the variable that is the result of the experiment.

Independent variable: The variable that is manipulated or changed. It is the variable that is the cause of the change in the dependent variable. It is the variable that is the factor being tested.

Controlled variables: The variables that are kept constant or controlled. They are the variables that are not being tested. They are the variables that are the same for all groups in the experiment.

1. What are the independent and dependent variables for the example in red text above?

(a) Dependent:
 (b) Independent:
 (c) Controlled:
 (d) Experimental:
 (e) Hypothesis:
 (f) Prediction:
 (g) Observation:
 (h) Question:
 (i) Method:
 (j) Results:
 (k) Conclusion:
 (l) Statement:
 (m) Fact:
 (n) Opinion:
 (o) Assumption:
 (p) Inference:
 (q) Deduction:
 (r) Induction:
 (s) Abduction:
 (t) Retention:
 (u) Rejection:
 (v) Acceptance:
 (w) Denial:
 (x) Approval:
 (y) Disapproval:
 (z) Preference:
 (aa) Dispreference:
 (ab) Tolerance:
 (ac) Intolerance:
 (ad) Indifference:
 (ae) Apathy:
 (af) Enthusiasm:
 (ag) Disenchantment:
 (ah) Disillusionment:
 (ai) Disappointment:
 (aj) Disillusionment:
 (ak) Disappointment:
 (al) Disillusionment:
 (am) Disappointment:
 (an) Disillusionment:
 (ao) Disappointment:
 (ap) Disillusionment:
 (aq) Disappointment:
 (ar) Disillusionment:
 (as) Disappointment:
 (at) Disillusionment:
 (au) Disappointment:
 (av) Disillusionment:
 (aw) Disappointment:
 (ax) Disillusionment:
 (ay) Disappointment:
 (az) Disillusionment:
 (ba) Disappointment:
 (bb) Disillusionment:
 (bc) Disappointment:
 (bd) Disillusionment:
 (be) Disappointment:
 (bf) Disillusionment:
 (bg) Disappointment:
 (bh) Disillusionment:
 (bi) Disappointment:
 (bj) Disillusionment:
 (bk) Disappointment:
 (bl) Disillusionment:
 (bm) Disappointment:
 (bn) Disillusionment:
 (bo) Disappointment:
 (bp) Disillusionment:
 (bq) Disappointment:
 (br) Disillusionment:
 (bs) Disappointment:
 (bt) Disillusionment:
 (bu) Disappointment:
 (bv) Disillusionment:
 (bw) Disappointment:
 (bx) Disillusionment:
 (by) Disappointment:
 (bz) Disillusionment:
 (ca) Disappointment:
 (cb) Disillusionment:
 (cc) Disappointment:
 (cd) Disillusionment:
 (ce) Disappointment:
 (cf) Disillusionment:
 (cg) Disappointment:
 (ch) Disillusionment:
 (ci) Disappointment:
 (cj) Disillusionment:
 (ck) Disappointment:
 (cl) Disillusionment:
 (cm) Disappointment:
 (cn) Disillusionment:
 (co) Disappointment:
 (cp) Disillusionment:
 (cq) Disappointment:
 (cr) Disillusionment:
 (cs) Disappointment:
 (ct) Disillusionment:
 (cu) Disappointment:
 (cv) Disillusionment:
 (cw) Disappointment:
 (cx) Disillusionment:
 (cy) Disappointment:
 (cz) Disillusionment:
 (da) Disappointment:
 (db) Disillusionment:
 (dc) Disappointment:
 (dd) Disillusionment:
 (de) Disappointment:
 (df) Disillusionment:
 (dg) Disappointment:
 (dh) Disillusionment:
 (di) Disappointment:
 (dj) Disillusionment:
 (dk) Disappointment:
 (dl) Disillusionment:
 (dm) Disappointment:
 (dn) Disillusionment:
 (do) Disappointment:
 (dp) Disillusionment:
 (dq) Disappointment:
 (dr) Disillusionment:
 (ds) Disappointment:
 (dt) Disillusionment:
 (du) Disappointment:
 (dv) Disillusionment:
 (dw) Disappointment:
 (dx) Disillusionment:
 (dy) Disappointment:
 (dz) Disillusionment:
 (ea) Disappointment:
 (eb) Disillusionment:
 (ec) Disappointment:
 (ed) Disillusionment:
 (ee) Disappointment:
 (ef) Disillusionment:
 (eg) Disappointment:
 (eh) Disillusionment:
 (ei) Disappointment:
 (ej) Disillusionment:
 (ek) Disappointment:
 (el) Disillusionment:
 (em) Disappointment:
 (en) Disillusionment:
 (eo) Disappointment:
 (ep) Disillusionment:
 (eq) Disappointment:
 (er) Disillusionment:
 (es) Disappointment:
 (et) Disillusionment:
 (eu) Disappointment:
 (ev) Disillusionment:
 (ew) Disappointment:
 (ex) Disillusionment:
 (ey) Disappointment:
 (ez) Disillusionment:
 (fa) Disappointment:
 (fb) Disillusionment:
 (fc) Disappointment:
 (fd) Disillusionment:
 (fe) Disappointment:
 (ff) Disillusionment:
 (fg) Disappointment:
 (fh) Disillusionment:
 (fi) Disappointment:
 (fj) Disillusionment:
 (fk) Disappointment:
 (fl) Disillusionment:
 (fm) Disappointment:
 (fn) Disillusionment:
 (fo) Disappointment:
 (fp) Disillusionment:
 (fq) Disappointment:
 (fr) Disillusionment:
 (fs) Disappointment:
 (ft) Disillusionment:
 (fu) Disappointment:
 (fv) Disillusionment:
 (fw) Disappointment:
 (fx) Disillusionment:
 (fy) Disappointment:
 (fz) Disillusionment:
 (ga) Disappointment:
 (gb) Disillusionment:
 (gc) Disappointment:
 (gd) Disillusionment:
 (ge) Disappointment:
 (gf) Disillusionment:
 (gg) Disappointment:
 (gh) Disillusionment:
 (gi) Disappointment:
 (gj) Disillusionment:
 (gk) Disappointment:
 (gl) Disillusionment:
 (gm) Disappointment:
 (gn) Disillusionment:
 (go) Disappointment:
 (gp) Disillusionment:
 (gq) Disappointment:
 (gr) Disillusionment:
 (gs) Disappointment:
 (gt) Disillusionment:
 (gu) Disappointment:
 (gv) Disillusionment:
 (gw) Disappointment:
 (gx) Disillusionment:
 (gy) Disappointment:
 (gz) Disillusionment:
 (ha) Disappointment:
 (hb) Disillusionment:
 (hc) Disappointment:
 (hd) Disillusionment:
 (he) Disappointment:
 (hf) Disillusionment:
 (hg) Disappointment:
 (hh) Disillusionment:
 (hi) Disappointment:
 (hj) Disillusionment:
 (hk) Disappointment:
 (hl) Disillusionment:
 (hm) Disappointment:
 (hn) Disillusionment:
 (ho) Disappointment:
 (hp) Disillusionment:
 (hq) Disappointment:
 (hr) Disillusionment:
 (hs) Disappointment:
 (ht) Disillusionment:
 (hu) Disappointment:
 (hv) Disillusionment:
 (hw) Disappointment:
 (hx) Disillusionment:
 (hy) Disappointment:
 (hz) Disillusionment:
 (ia) Disappointment:
 (ib) Disillusionment:
 (ic) Disappointment:
 (id) Disillusionment:
 (ie) Disappointment:
 (if) Disillusionment:
 (ig) Disappointment:
 (ih) Disillusionment:
 (ii) Disappointment:
 (ij) Disillusionment:
 (ik) Disappointment:
 (il) Disillusionment:
 (im) Disappointment:
 (in) Disillusionment:
 (io) Disappointment:
 (ip) Disillusionment:
 (iq) Disappointment:
 (ir) Disillusionment:
 (is) Disappointment:
 (it) Disillusionment:
 (iu) Disappointment:
 (iv) Disillusionment:
 (iw) Disappointment:
 (ix) Disillusionment:
 (iy) Disappointment:
 (iz) Disillusionment:
 (ja) Disappointment:
 (jb) Disillusionment:
 (jc) Disappointment:
 (jd) Disillusionment:
 (je) Disappointment:
 (jf) Disillusionment:
 (jg) Disappointment:
 (jh) Disillusionment:
 (ji) Disappointment:
 (jj) Disillusionment:
 (jk) Disappointment:
 (jl) Disillusionment:
 (jm) Disappointment:
 (jn) Disillusionment:
 (jo) Disappointment:
 (jp) Disillusionment:
 (jq) Disappointment:
 (jr) Disillusionment:
 (js) Disappointment:
 (jt) Disillusionment:
 (ju) Disappointment:
 (jv) Disillusionment:
 (jw) Disappointment:
 (jx) Disillusionment:
 (jy) Disappointment:
 (jz) Disillusionment:
 (ka) Disappointment:
 (kb) Disillusionment:
 (kc) Disappointment:
 (kd) Disillusionment:
 (ke) Disappointment:
 (kf) Disillusionment:
 (kg) Disappointment:
 (kh) Disillusionment:
 (ki) Disappointment:
 (kj) Disillusionment:
 (kk) Disappointment:
 (kl) Disillusionment:
 (km) Disappointment:
 (kn) Disillusionment:
 (ko) Disappointment:
 (kp) Disillusionment:
 (kq) Disappointment:
 (kr) Disillusionment:
 (ks) Disappointment:
 (kt) Disillusionment:
 (ku) Disappointment:
 (kv) Disillusionment:
 (kw) Disappointment:
 (kx) Disillusionment:
 (ky) Disappointment:
 (kz) Disillusionment:
 (la) Disappointment:
 (lb) Disillusionment:
 (lc) Disappointment:
 (ld) Disillusionment:
 (le) Disappointment:
 (lf) Disillusionment:
 (lg) Disappointment:
 (lh) Disillusionment:
 (li) Disappointment:
 (lj) Disillusionment:
 (lk) Disappointment:
 (ll) Disillusionment:
 (lm) Disappointment:
 (ln) Disillusionment:
 (lo) Disappointment:
 (lp) Disillusionment:
 (lq) Disappointment:
 (lr) Disillusionment:
 (ls) Disappointment:
 (lt) Disillusionment:
 (lu) Disappointment:
 (lv) Disillusionment:
 (lw) Disappointment:
 (lx) Disillusionment:
 (ly) Disappointment:
 (lz) Disillusionment:
 (ma) Disappointment:
 (mb) Disillusionment:
 (mc) Disappointment:
 (md) Disillusionment:
 (me) Disappointment:
 (mf) Disillusionment:
 (mg) Disappointment:
 (mh) Disillusionment:
 (mi) Disappointment:
 (mj) Disillusionment:
 (mk) Disappointment:
 (ml) Disillusionment:
 (mm) Disappointment:
 (mn) Disillusionment:
 (mo) Disappointment:
 (mp) Disillusionment:
 (mq) Disappointment:
 (mr) Disillusionment:
 (ms) Disappointment:
 (mt) Disillusionment:
 (mu) Disappointment:
 (mv) Disillusionment:
 (mw) Disappointment:
 (mx) Disillusionment:
 (my) Disappointment:
 (mz) Disillusionment:
 (na) Disappointment:
 (nb) Disillusionment:
 (nc) Disappointment:
 (nd) Disillusionment:
 (ne) Disappointment:
 (nf) Disillusionment:
 (ng) Disappointment:
 (nh) Disillusionment:
 (ni) Disappointment:
 (nj) Disillusionment:
 (nk) Disappointment:
 (nl) Disillusionment:
 (nm) Disappointment:
 (nn) Disillusionment:
 (no) Disappointment:
 (np) Disillusionment:
 (nq) Disappointment:
 (nr) Disillusionment:
 (ns) Disappointment:
 (nt) Disillusionment:
 (nu) Disappointment:
 (nv) Disillusionment:
 (nw) Disappointment:
 (nx) Disillusionment:
 (ny) Disappointment:
 (nz) Disillusionment:
 (oa) Disappointment:
 (ob) Disillusionment:
 (oc) Disappointment:
 (od) Disillusionment:
 (oe) Disappointment:
 (of) Disillusionment:
 (og) Disappointment:
 (oh) Disillusionment:
 (oi) Disappointment:
 (oj) Disillusionment:
 (ok) Disappointment:
 (ol) Disillusionment:
 (om) Disappointment:
 (on) Disillusionment:
 (oo) Disappointment:
 (op) Disillusionment:
 (oq) Disappointment:
 (or) Disillusionment:
 (os) Disappointment:
 (ot) Disillusionment:
 (ou) Disappointment:
 (ov) Disillusionment:
 (ow) Disappointment:
 (ox) Disillusionment:
 (oy) Disappointment:
 (oz) Disillusionment:
 (pa) Disappointment:
 (pb) Disillusionment:
 (pc) Disappointment:
 (pd) Disillusionment:
 (pe) Disappointment:
 (pf) Disillusionment:
 (pg) Disappointment:
 (ph) Disillusionment:
 (pi) Disappointment:
 (pj) Disillusionment:
 (pk) Disappointment:
 (pl) Disillusionment:
 (pm) Disappointment:
 (pn) Disillusionment:
 (po) Disappointment:
 (pp) Disillusionment:
 (pq) Disappointment:
 (pr) Disillusionment:
 (ps) Disappointment:
 (pt) Disillusionment:
 (pu) Disappointment:
 (pv) Disillusionment:
 (pw) Disappointment:
 (px) Disillusionment:
 (py) Disappointment:
 (pz) Disillusionment:
 (qa) Disappointment:
 (qb) Disillusionment:
 (qc) Disappointment:
 (qd) Disillusionment:
 (qe) Disappointment:
 (qf) Disillusionment:
 (qg) Disappointment:
 (qh) Disillusionment:
 (qi) Disappointment:
 (qj) Disillusionment:
 (qk) Disappointment:
 (ql) Disillusionment:
 (qm) Disappointment:
 (qn) Disillusionment:
 (qo) Disappointment:
 (qp) Disillusionment:
 (qq) Disappointment:
 (qr) Disillusionment:
 (qs) Disappointment:
 (qt) Disillusionment:
 (qu) Disappointment:
 (qv) Disillusionment:
 (qw) Disappointment:
 (qx) Disillusionment:
 (qy) Disappointment:
 (qz) Disillusionment:
 (ra) Disappointment:
 (rb) Disillusionment:
 (rc) Disappointment:
 (rd) Disillusionment:
 (re) Disappointment:
 (rf) Disillusionment:
 (rg) Disappointment:
 (rh) Disillusionment:
 (ri) Disappointment:
 (rj) Disillusionment:
 (rk) Disappointment:
 (rl) Disillusionment:
 (rm) Disappointment:
 (rn) Disillusionment:
 (ro) Disappointment:
 (rp) Disillusionment:
 (rq) Disappointment:
 (rr) Disillusionment:
 (rs) Disappointment:
 (rt) Disillusionment:
 (ru) Disappointment:
 (rv) Disillusionment:
 (rw) Disappointment:
 (rx) Disillusionment:
 (ry) Disappointment:
 (rz) Disillusionment:
 (sa) Disappointment:
 (sb) Disillusionment:
 (sc) Disappointment:
 (sd) Disillusionment:
 (se) Disappointment:
 (sf) Disillusionment:
 (sg) Disappointment:
 (sh) Disillusionment:
 (si) Disappointment:
 (sj) Disillusionment:
 (sk) Disappointment:
 (sl) Disillusionment:
 (sm) Disappointment:
 (sn) Disillusionment:
 (so) Disappointment:
 (sp) Disillusionment:
 (sq) Disappointment:
 (sr) Disillusionment:
 (ss) Disappointment:
 (st) Disillusionment:
 (su) Disappointment:
 (sv) Disillusionment:
 (sw) Disappointment:
 (sx) Disillusionment:
 (sy) Disappointment:
 (sz) Disillusionment:
 (ta) Disappointment:
 (tb) Disillusionment:
 (tc) Disappointment:
 (td) Disillusionment:
 (te) Disappointment:
 (tf) Disillusionment:
 (tg) Disappointment:
 (th) Disillusionment:
 (ti) Disappointment:
 (tj) Disillusionment:
 (tk) Disappointment:
 (tl) Disillusionment:
 (tm) Disappointment:
 (tn) Disillusionment:
 (to) Disappointment:
 (tp) Disillusionment:
 (tq) Disappointment:
 (tr) Disillusionment:
 (ts) Disappointment:
 (tt) Disillusionment:
 (tu) Disappointment:
 (tv) Disillusionment:
 (tw) Disappointment:
 (tx) Disillusionment:
 (ty) Disappointment:
 (tz) Disillusionment:
 (ua) Disappointment:
 (ub) Disillusionment:
 (uc) Disappointment:
 (ud) Disillusionment:
 (ue) Disappointment:
 (uf) Disillusionment:
 (ug) Disappointment:
 (uh) Disillusionment:
 (ui) Disappointment:
 (uj) Disillusionment:
 (uk) Disappointment:
 (ul) Disillusionment:
 (um) Disappointment:
 (un) Disillusionment:
 (uo) Disappointment:
 (up) Disillusionment:
 (uq) Disappointment:
 (ur) Disillusionment:
 (us) Disappointment:
 (ut) Disillusionment:
 (uu) Disappointment:
 (uv) Disillusionment:
 (uw) Disappointment:
 (ux) Disillusionment:
 (uy) Disappointment:
 (uz) Disillusionment:
 (va) Disappointment:
 (vb) Disillusionment:
 (vc) Disappointment:
 (vd) Disillusionment:
 (ve) Disappointment:
 (vf) Disillusionment:
 (vg) Disappointment:
 (vh) Disillusionment:
 (vi) Disappointment:
 (vj) Disillusionment:
 (vk) Disappointment:
 (vl) Disillusionment:
 (vm) Disappointment:
 (vn) Disillusionment:
 (vo) Disappointment:
 (vp) Disillusionment:
 (vq) Disappointment:
 (vr) Disillusionment:
 (vs) Disappointment:
 (vt) Disillusionment:
 (vu) Disappointment:
 (vv) Disillusionment:
 (vw) Disappointment:
 (vx) Disillusionment:
 (vy) Disappointment:
 (vz) Disillusionment:
 (wa) Disappointment:
 (wb) Disillusionment:
 (wc) Disappointment:
 (wd) Disillusionment:
 (we) Disappointment:
 (wf) Disillusionment:
 (wg) Disappointment:
 (wh) Disillusionment:
 (wi) Disappointment:
 (wj) Disillusionment:
 (wk) Disappointment:
 (wl) Disillusionment:
 (wm) Disappointment:
 (wn) Disillusionment:
 (wo) Disappointment:
 (wp) Disillusionment:
 (wq) Disappointment:
 (wr) Disillusionment:
 (ws) Disappointment:
 (wt) Disillusionment:
 (wu) Disappointment:
 (wv) Disillusionment:
 (ww) Disappointment:
 (wx) Disillusionment:
 (wy) Disappointment:
 (wz) Disillusionment:
 (xa) Disappointment:
 (xb) Disillusionment:
 (xc) Disappointment:
 (xd) Disillusionment:
 (xe) Disappointment:
 (xf) Disillusionment:
 (xg) Disappointment:
 (xh) Disillusionment:
 (xi) Disappointment:
 (xj) Disillusionment:
 (xk) Disappointment:
 (xl) Disillusionment:
 (xm) Disappointment:
 (xn) Disillusionment:
 (xo) Disappointment:
 (xp) Disillusionment:
 (xq) Disappointment:
 (xr) Disillusionment:
 (xs) Disappointment:
 (xt) Disillusionment:
 (xu) Disappointment:
 (xv) Disillusionment:
 (xw) Disappointment:
 (xx) Disillusionment:
 (xy) Disappointment:
 (xz) Disillusionment:
 (ya) Disappointment:
 (yb) Disillusionment:
 (yc) Disappointment:
 (yd) Disillusionment:
 (ye) Disappointment:
 (yf) Disillusionment:
 (yg) Disappointment:
 (yh) Disillusionment:
 (yi) Disappointment:
 (yj) Disillusionment:
 (yk) Disappointment:
 (yl) Disillusionment:
 (ym) Disappointment:
 (yn) Disillusionment:
 (yo) Disappointment:
 (yp) Disillusionment:
 (yq) Disappointment:
 (yr) Disillusionment:
 (ys) Disappointment:
 (yt) Disillusionment:
 (yu) Disappointment:
 (yv) Disillusionment:
 (yw) Disappointment:
 (yx) Disillusionment:
 (yz) Disillusionment:
 (za) Disappointment:
 (zb) Disillusionment:
 (zc) Disappointment:
 (zd) Disillusionment:
 (ze) Disappointment:
 (zf) Disillusionment:
 (zg) Disappointment:
 (zh) Disillusionment:
 (zi) Disappointment:
 (zj) Disillusionment:
 (zk) Disappointment:
 (zl) Disillusionment:
 (zm) Disappointment:
 (zn) Disillusionment:
 (zo) Disappointment:
 (zp) Disillusionment:
 (zq) Disappointment:
 (zr) Disillusionment:
 (zs) Disappointment:
 (zt) Disillusionment:
 (zu) Disappointment:
 (zv) Disillusionment:
 (zw) Disappointment:
 (zx) Disillusionment:
 (zy) Disappointment:
 (zz) Disillusionment:
 (Aa) Disappointment:
 (Ab) Disillusionment:
 (Ac) Disappointment:
 (Ad) Disillusionment:
 (Ae) Disappointment:
 (Af) Disillusionment:
 (Ag) Disappointment:
 (Ah) Disillusionment:
 (Ai) Disappointment:
 (Aj) Disillusionment:
 (Ak) Disappointment:
 (Al) Disillusionment:
 (Am) Disappointment:
 (An) Disillusionment:
 (Ao) Disappointment:
 (Ap) Disillusionment:
 (Aq) Disappointment:
 (Ar) Disillusionment:
 (As) Disappointment:
 (At) Disillusionment:
 (Au) Disappointment:
 (Av) Disillusionment:
 (Aw) Disappointment:
 (Ax) Disillusionment:
 (Ay) Disappointment:
 (Az) Disillusionment:
 (Ba) Disappointment:
 (Bb) Disillusionment:
 (Bc) Disappointment:
 (Bd) Disillusionment:
 (Be) Disappointment:
 (Bf) Disillusionment:
 (Bg) Disappointment:
 (Bh) Disillusionment:
 (Bi) Disappointment:
 (Bj) Disillusionment:
 (Bk) Disappointment:
 (Bl) Disillusionment:
 (Bm) Disappointment:
 (Bn) Disillusionment:
 (Bo) Disappointment:
 (Bp) Disillusionment:
 (Bq) Disappointment:
 (Br) Disillusionment:
 (Bs) Disappointment:
 (Bt) Disillusionment:
 (Bu) Disappointment:
 (Bv) Disillusionment:
 (Bw) Disappointment:
 (Bx) Disillusionment:
 (By) Disappointment:
 (Bz) Disillusionment:
 (Ca) Disappointment:
 (Cb) Disillusionment:
 (Cc) Disappointment:
 (Cd) Disillusionment:
 (Ce) Disappointment:
 (Cf) Disillusionment:
 (Cg) Disappointment:
 (Ch) Disillusionment:
 (Ci) Disappointment:
 (Cj) Disillusionment:
 (Ck) Disappointment:
 (Cl) Disillusionment:
 (Cm) Disappointment:
 (Cn) Disillusionment:
 (Co) Disappointment:
 (Cp) Disillusionment:
 (Cq) Disappointment:
 (Cr) Disillusionment:
 (Cs) Disappointment:
 (Ct) Disillusionment:
 (Cu) Disappointment:
 (Cv) Disillusionment:
 (Cw) Disappointment:
 (Cx) Disillusionment:
 (Cy) Disappointment:
 (Cz) Disillusionment:
 (Da) Disappointment:
 (Db) Disillusionment:
 (Dc) Disappointment:
 (Dd) Disillusionment:
 (De) Disappointment:
 (Df) Disillusionment:
 (Dg) Disappointment:
 (Dh) Disillusionment:
 (Di) Disappointment:
 (Dj) Disillusionment:
 (Dk) Disappointment:
 (Dl) Disillusionment:
 (Dm) Disappointment:
 (Dn) Disillusionment:
 (Do) Disappointment:
 (Dp) Disillusionment:
 (Dq) Disappointment:
 (Dr) Disillusionment:
 (Ds) Disappointment:
 (Dt) Disillusionment:
 (Du) Disappointment:
 (Dv) Disillusionment:
 (Dw) Disappointment:
 (Dx) Disillusionment:
 (Dy) Disappointment:
 (Dz) Disillusionment:
 (Ea) Disappointment:
 (Eb) Disillusionment:
 (Ec) Disappointment:
 (Ed) Disillusionment:
 (Ee) Disappointment:
 (Ef) Disillusionment:
 (Eg) Disappointment:
 (Eh) Disillusionment:
 (Ei) Disappointment:
 (Ej) Disillusionment:
 (Ek) Disappointment:
 (El) Disillusionment:
 (Em) Disappointment:
 (En) Disillusionment:
 (Eo) Disappointment:
 (Ep) Disillusionment:
 (Eq) Disappointment:
 (Er) Disillusionment:
 (Es) Disappointment:
 (Et) Disillusionment:
 (Eu) Disappointment:
 (Ev) Disillusionment:
 (Ew) Disappointment:
 (Ex) Disillusionment:
 (Ey) Disappointment:
 (Ez) Disillusionment:
 (Fa) Disappointment:
 (Fb) Disillusionment:
 (Fc) Disappointment:
 (Fd) Disillusionment:
 (Fe) Disappointment:
 (Ff) Disillusionment:
 (Fg) Disappointment:
 (Fh) Disillusionment:
 (Fi) Disappointment:
 (Fj) Disillusionment:
 (Fk) Disappointment:
 (Fl) Disillusionment:
 (Fm) Disappointment:
 (Fn) Disillusionment:
 (Fo) Disappointment:
 (Fp) Disillusionment:
 (Fq) Disappointment:
 (Fr) Disillusionment:
 (Fs) Disappointment:
 (Ft) Disillusionment:
 (Fu) Disappointment:
 (Fv) Disillusionment:
 (Fw) Disappointment:
 (Fx) Disillusionment:
 (Fy) Disappointment:
 (Fz) Disillusionment:
 (Ga) Disappointment:
 (Gb) Disillusionment:
 (Gc) Disappointment:
 (Gd) Disillusionment:
 (Ge) Disappointment:
 (Gf) Disillusionment:
 (Gg) Disappointment:
 (Gh) Disillusionment:
 (Gi) Disappointment:
 (Gj) Disillusionment:
 (Gk) Disappointment:
 (Gl) Disillusionment:
 (Gm) Disappointment:
 (Gn) Disillusionment:
 (Go) Disappointment:
 (Gp) Disillusionment:
 (Gq) Disappointment:
 (Gr) Disillusionment:
 (Gs) Disappointment:
 (Gt) Disillusionment:
 (Gu) Disappointment:
 (Gv) Disillusionment:
 (Gw) Disappointment:
 (Gx) Disillusionment:
 (Gy) Disappointment:
 (Gz) Disillusionment:
 (Ha) Disappointment:
 (Hb) Disillusionment:
 (Hc) Disappointment:
 (Hd) Disillusionment:
 (He) Disappointment:
 (Hf) Disillusionment:
 (Hg) Disappointment:
 (Hh) Disillusionment:
 (Hi) Disappointment:
 (Hj) Disillusionment:
 (Hk) Disappointment:
 (Hl) Disillusionment:
 (Hm) Disappointment:
 (Hn) Disillusionment:
 (Ho) Disappointment:
 (Hp) Disillusionment:
 (Hq) Disappointment:
 (Hr) Disillusionment:
 (Hs) Disappointment:
 (Ht) Disillusionment:
 (Hu) Disappointment:
 (Hv) Disillusionment:
 (Hw) Disappointment:
 (Hx) Disillusionment:
 (Hy) Disappointment:
 (Hz) Disillusionment:
 (Ia) Disappointment:
 (Ib) Disillusionment:
 (Ic) Disappointment:
 (Id) Disillusionment:
 (Ie) Disappointment:
 (If) Disillusionment:
 (Ig) Disappointment:
 (Ih) Disillusionment

Evaluating Student Performance

Personal Progress Checks conclude each of the units (1-8). Each one comprises 20-40 multiple choice questions followed by two free response questions, simulating the types of questions students encounter in the AP Biology exam. Teachers may assign these as formal assessments to gauge student understanding (e.g. taken in class under test conditions) or they can be given as formative assessments providing opportunities for exam practice before students sit the online tests provided in the AP classroom. We have followed the format stipulated in the AP Biology CED when designing these assessments.

PERSONAL PROGRESS CHECK							
UNIT 1 Chemistry of Life	UNIT 2 Cell Structure and Function	UNIT 3 Cellular Energetics	UNIT 4 Cell Communication and Cell Cycle	UNIT 5 Heredity	UNIT 6 Gene Expression and Regulation	UNIT 7 Natural Selection	UNIT 8 Ecology
20 multiple choice	30 multiple choice	20 multiple choice	25 multiple choice	25 multiple choice	25 multiple choice	40 multiple choice	20 multiple choice
Conceptual analysis (part)	Interpreting and evaluating experimental results (part)	Interpreting and evaluating experimental results with graphing (part)	Interpreting and evaluating experimental results (part)	Interpreting and evaluating experimental results with graphing	Interpreting and evaluating experimental results	Interpreting and evaluating experimental results with graphing	Interpreting and evaluating experimental results with graphing
Analyze visual representation or model (part)	Analyze visual representation or model (part)	Scientific investigation (part)	Analyze data	Conceptual analysis	Analyze visual representation or model	Analyze data	Scientific investigation

79 Personal Progress Check

Answer the multiple choice questions that follow by circling the correct answer. Don't forget to read the question carefully!

- In local regulation, the signaling molecule affects only:
 - Target cells distant from the secreting cell
 - Target cells close to the secreting cell
 - Both (a) and (b)
 - None of the above
- Cytokines can act as:
 - Local regulators
 - Endocrine regulators
 - Both (a) and (b)
 - None
- Synaptic clefts are called:
 - G protein
 - Neurotransmitter
 - Secretory
 - Cytokine
- When a cell is specialized, it:
 - Signaling molecule, receptor, G protein.
 - Signaling molecule, target cell, G protein.
 - Signaling molecule, target cell, receptor.
 - Signaling molecule, receptor, kinase.
- Which of the following is true about a hydrophilic signaling molecule?
 - It is a steroid.
 - Its receptor is located in the cytoplasm of the target cell.
 - It might trigger a signal cascade that causes an effect in a cell.
 - It can enter the cell, so it directly affects some specific cell process.
- What is the name of the hormone that alters glucose uptake, and where would its receptors be located?
 - Epinephrine; liver
 - Insulin; different cell types that use glucose for fuel
 - Insulin; beta cells of pancreas
 - Epinephrine, beta cells of pancreas
- Hydrophobic signal molecules are _____ and include _____ like _____.
 - Lipid soluble; steroid hormones; estrogen
 - Lipid insoluble; protein hormones; insulin
 - Lipid soluble; amino acid derivatives; epinephrine
 - Lipid insoluble; steroid hormones; estrogen

Question 16 refers to the plot below, which shows fluctuations in serum insulin and blood glucose after sucrose-rich or starch-rich meals.

Questions 22-23 refers to the image below.

22. The phase of mitosis pictured is.

- Prophase
- Telophase
- Metaphase
- Anaphase

23. Cells that no longer divide (such as certain specialized cells in the brain) stay in which phase of the cell cycle?

- S phase
- G₂ phase
- G₁ phase
- Interphase

24. Errors in which of the following genes are involved in cancer?

- BRCA1
- p53
- (a) and (b)
- None of the above

25. The phase of mitosis that is associated with the formation of the nuclear envelope, is:

- Prophase
- Metaphase
- Anaphase
- Telophase

26. The phase of mitosis that is associated with the breakdown of the nuclear envelope, is:

- Prophase
- Prometaphase
- Metaphase
- Anaphase

27. The phase of mitosis that is associated with the separation of chromatids to opposite poles, is:

- Prometaphase
- Metaphase
- Anaphase
- Telophase

Multiple choice questions require students to analyze numerical and text-based information including the analysis quantitative data and data in the form of models and representations. Multiple choice questions make up the first two (or three) pages of the personal progress check.

Free Response Question: Analyze data

Much cancer research is directed at finding ways to identify cell cycle errors and target stages in the cell cycle that can slow or stop the unregulated division of cancer cells.

Taxol is one of a number of anticancer drugs that target cytoskeletal proteins. It stabilizes spindle microtubules, preventing their disassembly. Chromosomes cannot achieve a metaphase spindle configuration, and this blocks the progression of mitosis.

Stathmin is a protein that regulates the cell cycle. One of its normal roles is promote depolymerization (instability) of spindle microtubules. Its activity is regulated by cell-cycle-specific phosphorylation. In normal cells, stathmin activity is switched off by phosphorylation as the cell enters M phase. Phosphatases remove these phosphates in late mitosis so the cell can exit M-phase. Aggressive forms of breast cancer are resistant to Taxol chemotherapy alone. In these cancers, the stathmin gene is overexpressed.

HYPOTHESIS

The researchers hypothesized that because stathmin decreases the stability of microtubules, switching off its production would enhance the ability of Taxol to stabilize microtubules and cause mitosis to be arrested more effectively in cancerous cells.

INVESTIGATION AND RESULTS

Researchers investigated tumor volume over time in mice with aggressive cancers under three treatments: No treatment (control), Taxol treatment, and Taxol + stathmin treatment.

Free response questions are designed to match the six question types asked in the exam. Partial versions of the free response questions are provided to prepare students for the more complex, full questions that they will encounter in the AP Exam. Each personal progress check has two free response questions.

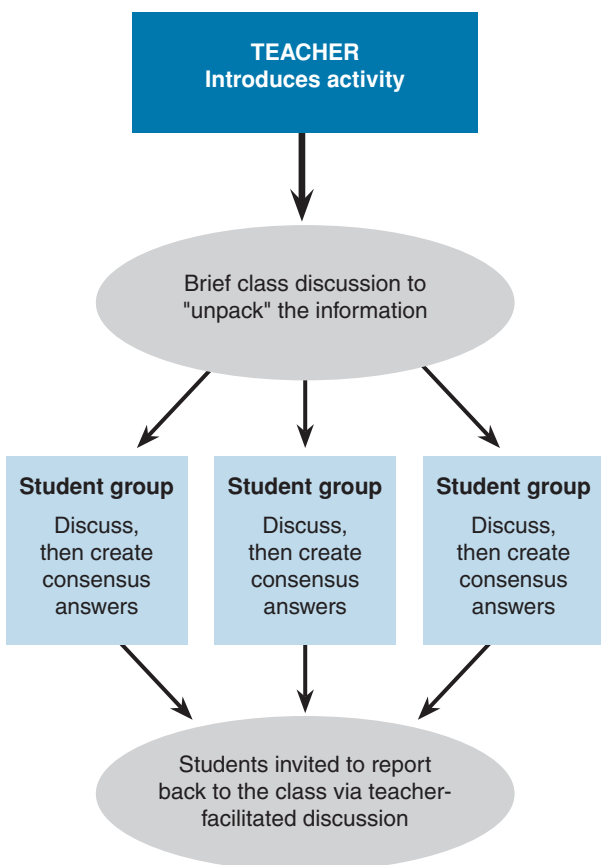
- Interpreting and evaluating experimental results
- Interpreting and evaluating experimental results with graphing
- Scientific investigation
- Conceptual analysis
- Analyze model or visual representation
- Analyze data

Teaching Strategies for Classroom Use

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

MAKING A START

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



Using collaboration to maximize learning outcomes

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



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



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



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



Peer to peer support

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

198

111 Creating a DNA Model

Key Question: What are the base pairing rules for DNA. How can they be modelled?

Recall that DNA is made up of structures called nucleotides. Two primary factors control the way in which these nucleotide building blocks are linked together: the available space within the DNA double helix and the hydrogen-bonding capability of the bases. These factors cause the nucleotides to join together in a predictable way, referred to as the **base pairing rule**. It is derived from Chargaff's rules which state that % A = % T and % C = % G for both strands of the DNA.

DNA base pairing rule			
Adenine	is always attracted to	Thymine	A \leftrightarrow T
Thymine	is always attracted to	Adenine	T \leftrightarrow A
Cytosine	is always attracted to	Guanine	C \leftrightarrow G
Guanine	is always attracted to	Cytosine	G \leftrightarrow C

- (a) Cut out the opposite page. Cut out the gray template strand. Dark black lines should be cut. The dashed gray lines represent the hydrogen bonds. Fold on the red dotted lines so that the gray surfaces are facing (a valley fold). Do not cut around the hydrogen bonds on each base. These are just to show you where you will join your bases.
(b) Cut out the complementary strand. The first base (G) is already in position as a guide. Again fold on the red line so that the blue surfaces are facing each other.
- Paper practical activities and modeling provide opportunities for students to work in pairs or small groups**

In this activity, they can work together to explore the base pairing rule and create and evaluate a DNA model. Sharing ideas and observations promotes scientific dialogue.
- Cut out the bases and slot them into the slots on the complementary strand using the order in the table above. Use tape to fix them in position. Make sure the blue surfaces are facing and the base is in the same orientation as the guide (G).
- Line up the first base pairs (C and G) and stick them together with tape. Note that the bases are facing in opposite directions.
- Continue sticking base pairs together, working your way around the helix, to complete the DNA molecule.
- What does anti-parallel mean? _____
- Explain how the concept of base pairing allowed you to easily model a DNA molecule using the template provided:

©2021 BIOZONE International
ISBN: 978-1-98-856656-6
Photocopying prohibited

324

The emergence of Covid-19

Reports of viral pneumonia (a lung infection) in Wuhan, China were reported on the 31st December 2019. Early in January 2020, a new coronavirus, SARS-CoV-2, was identified as the cause of the infections.

What is Covid-19?

- ▶ Covid-19 is the disease caused by infection 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.
- ▶ Vaccines have now been developed.

A representation of the SARS-CoV-2 virus

Proteins
Viral envelope (mostly lipid)
Glycoprotein spikes

Changes in coronavirus

Students look at the emergence of new diseases, and discover how some diseases reemerge in our communities. As a group, students look at the emergence and features of the SARS-CoV2 virus responsible for Covid-19.

They complete an online search and discuss the challenges around developing a vaccine. This provides an opportunity for peer group discussion and sharing ideas.

- Explain why SARS-CoV-2 cannot undergo antigenic shift: _____
- As a group, discuss the main challenges around developing a Covid-19 vaccine. Do some online searches of reliable sources and explain how were these were or are being overcome. Summarize your group's response as points below.

©2021 BIOZONE International
ISBN: 978-1-98-856656-6
Photocopying prohibited

Collaboration and discovery

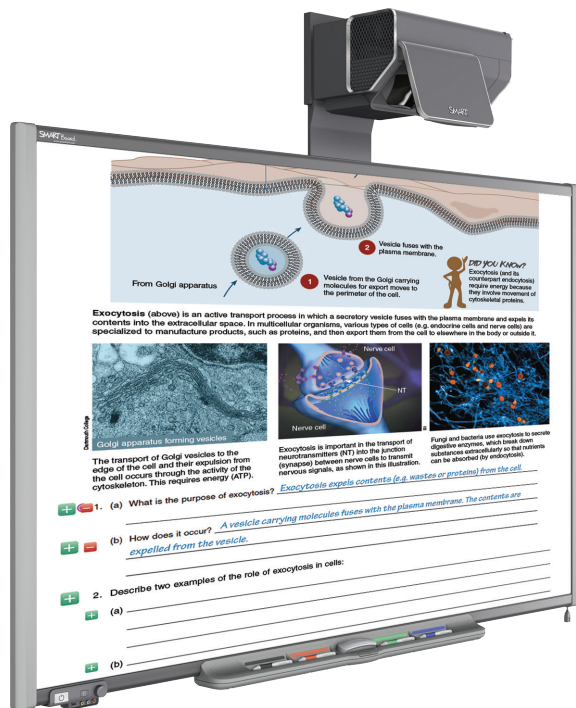
- BIOZONE's *AP Biology* allows for collaboration and discovery. By working together and sharing ideas, students are exposed to different perspectives and levels of knowledge about biological concepts.
- BIOZONE's *AP Biology* uses the CED framework to develop student understanding by providing a range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



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

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

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



Interactive revision of tasks in class

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

Differentiated Learning

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

A-1 Appendix 1: Summary of Mathematical Formulas

Mathematics is used to analyze, interpret, and compare data. It is important that you are familiar with mathematical notation (the language of mathematics) and can confidently apply some basic mathematical principles and calculations to your data. Data collected in the field or laboratory is called **raw data**. It often needs to be transformed to reveal trends or patterns. This page summarizes some of the transformations and statistical formulae you might use to summarize and test your data. Some of the required mathematical formulae are covered in the book as indicated.

Using mathematical routines may include:

- Determining the best method to solve a mathematical problem, e.g. exploring the best way to compare water intake in different ponds.
- Applying appropriate mathematical routines or relationships to solve a problem, with working shown, e.g. calculating population growth over time.
- Calculating a numeric answer to a problem, using the appropriate units, e.g. calculating the rate of water loss from a plant over 24 hours.

Units of measure

Name	Unit	Symbol
Mass	gram	g
Length	meter	m
Time	second	s
Temperature	Celsius	°C
	Kelvin	K
Volume	Liter	L

*Gram (g) is the unit of mass, but kilogram (kg) is the SI unit.

Prefixes

Units of measure can be prefixed with a multiplier:

Prefix	Symbol	Multiplier
milli	10 ⁻³	1/1000
centi	10 ⁻²	1/100
deci	10 ⁻¹	1/10
hecto	10 ²	100
kilo	10 ³	1000

Ratios

Ratios give the relative amount of two or more quantities, and provide an easy way to identify patterns.

- Ratios do not require units.
- Ratios are expressed as a:b.
- Ratios are calculated by dividing all the values by the smallest number.

Pea pod shape	Number	Ratio
Inflated	882	2.85
Constricted	299	1

Pea seed shape and color	Number	Ratio
Round, yellow	493	9
Wrinkled, yellow	152	2.8
Round, green	138	2.8
Wrinkled, green	55	1

Percentages

To calculate percentages, simply calculate the fraction of the total x 100. For example 25 = 4 x 100 = 40%.

Percentages will show what fraction (out of 100) falls into a particular category, e.g. for sex graphs.

Percentages can be used to express concentrations and to allow meaningful comparisons between samples with different starting points, e.g. different numbers or masses.

Volume of food consumed (cm ³)	Volume of growing (%)	Concentration of growing (%)
10	0	100
8	2	80
6	4	60
4	6	40
2	8	20
0	10	0

Percentage change

Percentage change shows how much a value has changed (e.g. between time 1 and time 2). Calculating percentage change is easy. Determine the difference between the old and new values, divide by the old value, and multiply by 100.

$$\% \text{ change} = \frac{\text{new value} - \text{old value}}{\text{old value}} \times 100$$

- A positive value = percentage increase.
- A negative value = percentage decrease.
- Percentage change is useful in studies of natural populations and when analyzing mass changes in experiments.

Example: There were 118 mice in a local population, but after a successful breeding season, the number was 150. What was the percentage change?

Working:

$$150 - 118 = 32 \div 118 \times 100 = 27.1\%$$

27.1% x 100 = 27.1% increase.

201 Diversity and Resilience

Key Question: How does genetic diversity affect a population's ability to resist and recover from disturbance?

Genetic diversity refers to the variety of alleles and genotypes present in a population. It is important to the survival and adaptability of a species because populations with low genetic diversity generally show poor resilience. This means that they are less able to respond to, or recover from, environmental changes and so are at greater risk of extinction. In contrast, species with greater genetic diversity are more likely to have the genetic resources to respond to environmental change through adaptation (in response to natural selection). This increases their chance of survival as a species.

Genetic diversity in prairie chickens

In 1982, a translocation program began, bringing 271 birds from Kansas and Nebraska. There was a rapid population response, as fertility and egg viability increased. The population is now recovering (1985, right).

Southern corn leaf blight

A particularly devastating episode of corn blight occurred in crops of US corn. One strain in 1970, at the time 10% of the US corn crop was the type T-Strain (Class cytoplasmic male sterile). At the same time, a new strain (T-Strain) of the fungus *Bipolaris maydis* emerged, which produced a T-Strain. T-Strain proved to be highly susceptible to the new fungus. Corn losses were 50-100% depending on the location. It is estimated that up to \$1 billion dollars worth of crops were lost.

There are several corn types: normal cytoplasm, T-Strain, and cytoplasmic male sterile (CMS). T-Strain was developed because removing the pollen-producing pollen from the top of the plant was simpler, making cross breeding simpler.

However, some corn plants have naturally inherited a gene that makes them resistant to the T-Strain. T-Strain is now being used to create the T-Strain.

Problems with artificial selection

Selection for a desired characteristic can have unintended consequences. For example, the German Shepherd is a working dog, originally bred to be a guard dog. It is so much that it causes problems for its owners. In addition, artificial selection has increased the incidence of certain diseases.

Artificial selection

Artificial selection is the process by which humans choose which individuals to breed based on desired traits. This can lead to the loss of genetic diversity and the emergence of new diseases.

Artificial selection in dogs

Dogs are a classic example of artificial selection. All breeds of dog are members of the same species, *Canis familiaris*, and provide an excellent example of artificial selection. The dog was the first domesticated species and, over centuries, humans have selected for various traits, so extensively that there are now more than 400 breeds of dogs.

Artificial selection in crops

Artificial selection has been used to create many of the crops we eat today. For example, the corn we eat today is a hybrid of two wild ancestors, which gave rise to the corn we eat today. Based on genetic analysis, the most common ancestor of modern-day corn is thought to have descended from these ancestors.

The origins of domestic dogs

All breeds of dog are members of the same species, *Canis familiaris*, and provide an excellent example of artificial selection. The dog was the first domesticated species and, over centuries, humans have selected for various traits, so extensively that there are now more than 400 breeds of dogs.

Artificial selection in crops

Artificial selection has been used to create many of the crops we eat today. For example, the corn we eat today is a hybrid of two wild ancestors, which gave rise to the corn we eat today. Based on genetic analysis, the most common ancestor of modern-day corn is thought to have descended from these ancestors.

Artificial selection in dogs

Dogs are a classic example of artificial selection. All breeds of dog are members of the same species, *Canis familiaris*, and provide an excellent example of artificial selection. The dog was the first domesticated species and, over centuries, humans have selected for various traits, so extensively that there are now more than 400 breeds of dogs.

Artificial selection in crops

Artificial selection has been used to create many of the crops we eat today. For example, the corn we eat today is a hybrid of two wild ancestors, which gave rise to the corn we eat today. Based on genetic analysis, the most common ancestor of modern-day corn is thought to have descended from these ancestors.

Students requiring math support should be encouraged to use the resources found in **Appendix 1**. It contains a variety of useful information including a summary of basic data transformations (percentages, percentage change, rates), a table listing some common units of measure, support for working with ratios, an overview of basic statistical formulas (and a worked example), criteria and formulas for four common statistical tests, and equations students will find useful as they progress through the AP Biology program. Some math support is also provided in the Science Practices chapter.

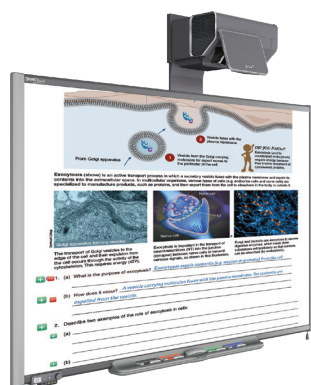
BIOZONE's Resource Hub provides curated content to support the activities in the book. Videos, animations, simulations, and 3D models support students of all abilities, while some resources (interactive spreadsheets, fact sheets, and reference papers) may be used as part of group work or extension.

Teacher resource material and material for gifted and talented students have been specifically identified on the Resource Hub. A gray hub icon at the bottom of the page indicates the activity has online support.

A group symbol indicates where students can work together. Group work provides opportunities for student collaboration and peer-to-peer support to explore the principles, concepts, and theories they are engaged with in their course.

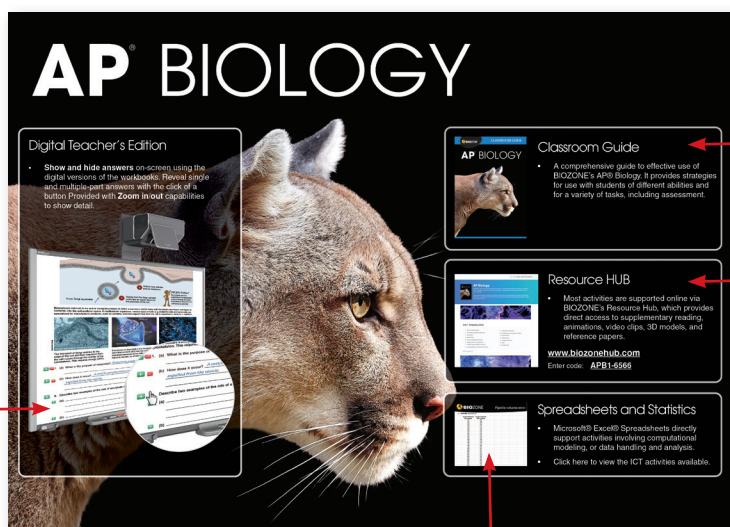
Working in groups, students can experience the benefits of collaboration in the scientific process of discovery. By speaking and listening to each other, they develop and extend their communication skills and scientific vocabulary.

The Digital Teacher's Edition



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

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



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

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

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

12 Cellulose and Starch

Key Question: What structural and functional characteristics distinguish the plant polysaccharides, starch and cellulose? Glucose monomers can be linked in condensation reactions to form large structural and energy storage polysaccharides.

Plant cells are surrounded by a cell wall made from cellulose microfibrils. They provide the cell with strength and rigidity.

The microfibrils (below) consist of between 40-70 cellulose chains joined by hydrogen bonds.

Cellulose is an unbranched polymer of β -glucose molecules bonded by extremely stable β -1, 4 glycosidic bonds. The unbranched structure of cellulose produces parallel chains which become cross linked with hydrogen bonds to form strong microfibrils.

Starch is a non-pigment storage carbohydrate. Cellulose is a structural polysaccharide.

Amylose makes up 25-30% of starch.

Amylose is made from α -glucose monomers, which form a helical structure. Every turn of the helix contains α -glucose molecules. 30% of the structure is amylose.

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 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 shape.

BIOZONE
© 2021 BIOZONE International Ltd
This worksheet has been provided by BIOZONE International Ltd as a worked example and may be used as the basis for setting up and completing a similar statistical analysis based on different data.

Select View > Formula bar from the menu to view the formulae for each cell.
Select View > Comments from the menu to view the comments for each cell.

Year	Time period	Population
1979	0	0
1981	2	5
1983	4	6
1985	6	9
1987	8	20
1989	10	15
1991	12	16
1993	14	38
1995	16	52
1997	18	60
1999	20	52
2001	22	75
2003	24	125
2005	26	190
2007	28	252
2009	30	420
2011	32	521
2013	34	651
2014	36	620
		552

The final years of the wolf population are omitted from the graph to more easily calculate an exponential curve during the given time periods (i.e. 1 year = 1 time period).

Wolves of Montana
Wolf population in Montana
 $y = 4.777e^{0.1531x}$

1. (a) Relate the structure of phospholipids to their chemical properties and their functional role in cellular membranes. **Phospholipids are amphipathic, they have a polar hydrophilic end and a hydrophobic tail. This structure causes them to orientate in aqueous solutions so that the hydrophobic tails are hidden from water.**

(b) Suggest how the cell membrane structure of an Arctic fish might differ from that of tropical fish species. **The membranes of an Arctic fish could be expected to contain a higher proportion of unsaturated fatty acids. This would help them to remain functional at low temperatures.**

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

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

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