BIOZONE

CLASSROOM GUIDE

AP® BIOLOGY

Contents

CLASSROOM GUIDE

STUDENT EDITION

APPENDIX

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Third Edition 2021

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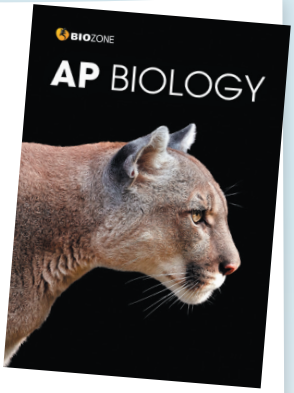
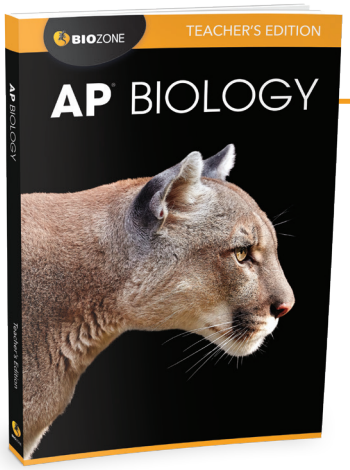
FAQs
ABOUT AP BIOLOGY



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.

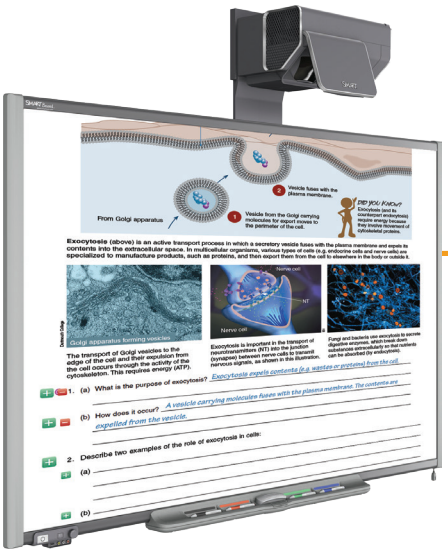
EBOOK VERSION

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

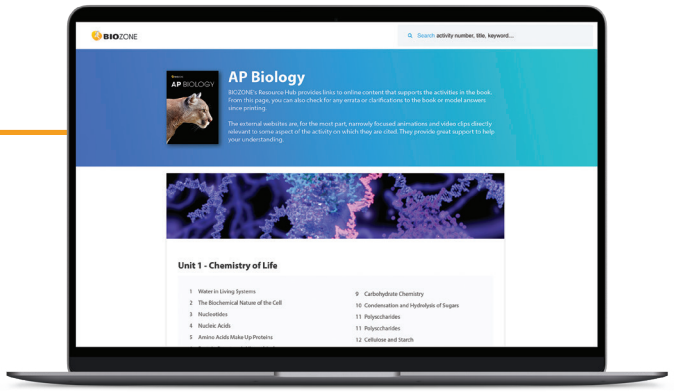
This PDF version of the book is ideal for introducing and reviewing activities using an interactive whiteboard. This teacher's resource features a non-printable PDF version of the Teacher's Edition, with a useful feature to hide and display the suggested answers. Supplied as a direct download.

RESOURCE HUB

Be sure to visit BIOZONE's RESOURCE HUB, which is fully accessible and free of charge to you and your students. If 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**

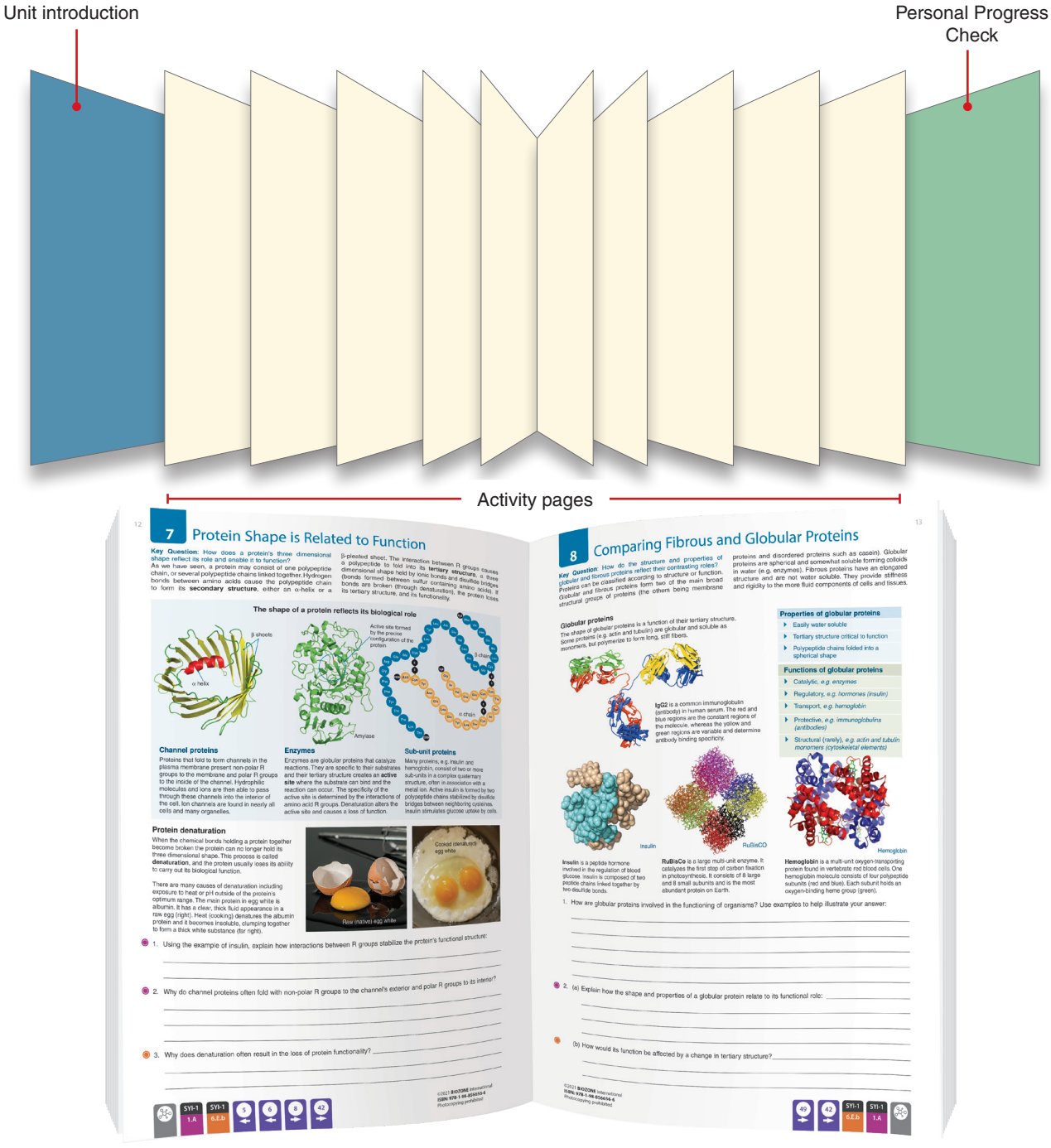


The Structure of the Book

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.

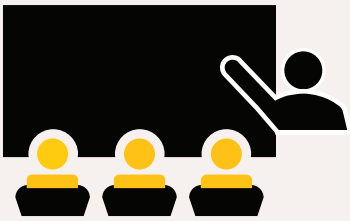


The AP Instructional Model

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

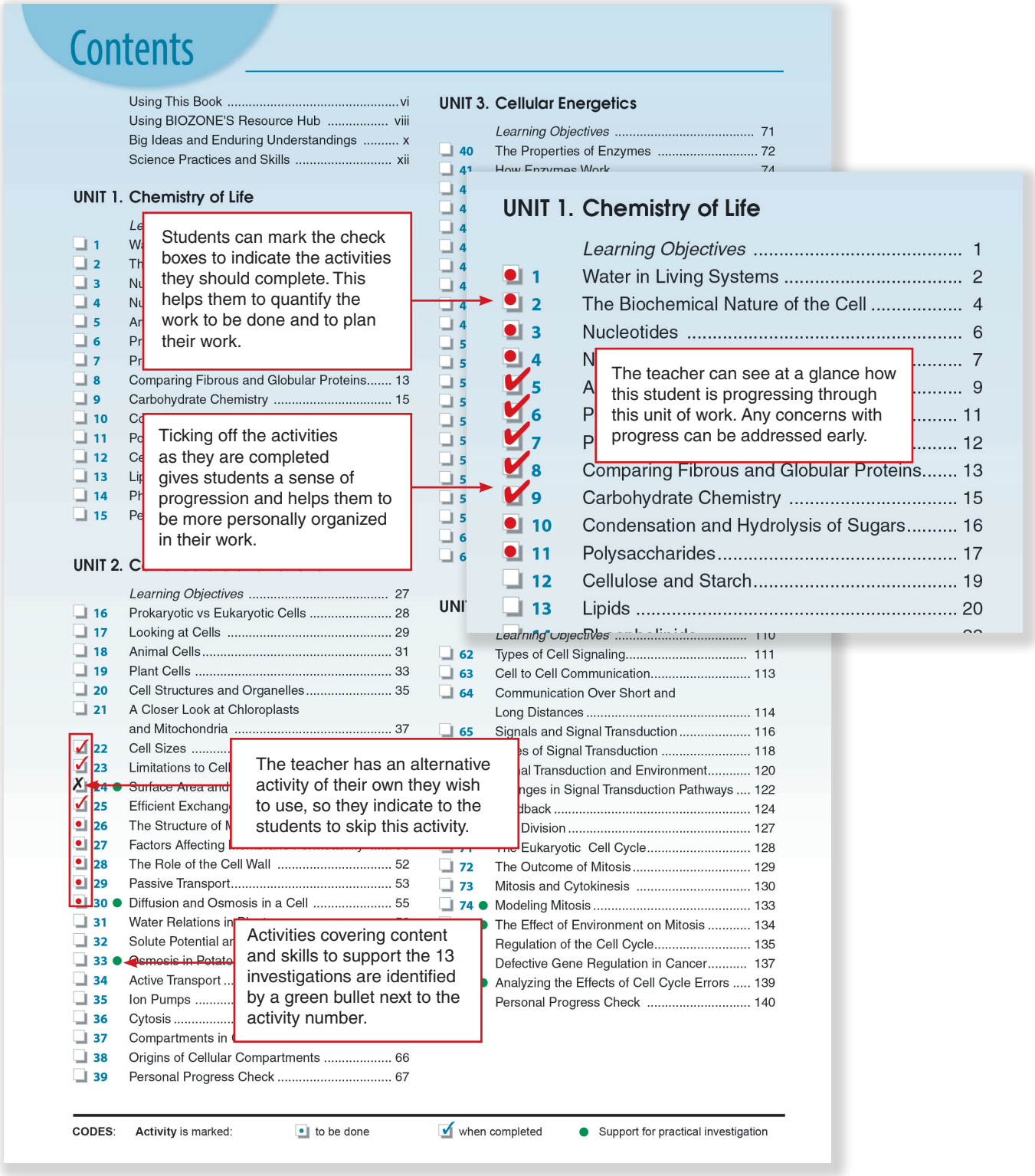
- Teach the content in the order presented in BIOZONE's *AP Biology.* Content covered in the early chapters lays the foundation for more in-depth material and specific examples covered in later units.
- Have students complete a skills support activity in the final chapter (*Science Practices*) before 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.



Identifying Learning Intentions and Goals

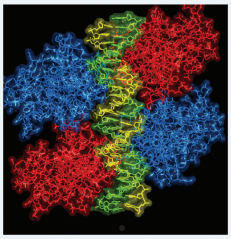
BIOZONE's *AP Biology* has been written specifically to address the *AP Biology Course and Exam Description*. Each unit is prefaced with a chapter introduction. The units are organized into topics, and these are aligned to specific activities. The key content, skills, and learning objectives for each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

This identifies the unit to which this chapter applies.

UNIT 1

Chemistry of Life

Learning Objectives



Developing understanding

CONTENT: This unit sets the foundation... includes a survey of the elements essen... central role of water in biological system... of living systems depends on an input e... Understanding how macromolecules are...

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

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 cleave 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, includin... the phosphodiester bonds that form b... nucleotides. Interpret diagrams and m... the directionality of nucleic acids, defi... and a 5' carbons of the sugar in the n...
- ☐ 12. Explain the antiparallel, double helix s... including how the directionality of the ... 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.

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

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).

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

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 th…n placed into partially permeable membrane with pores large enough only for…rough.

The investigation number and procedure (where applicable) supported by the activity are identified here.

Aim

To demonstrat… sucrose and g… partially perme…

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.

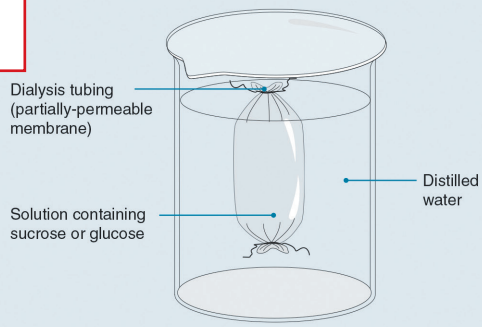
Background

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 wherea… disaccharide (consisting of a glucose… molecule joined together). Sucrose is… the size and mass of glucose.

Glucose

Suc…



Method

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

…ed off and weighed to 2 decimal …in separate beakers of distilled …

… removed from the distilled water …wel. They were reweighed and …

…t three times.

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			…ange (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… table above:
2. Explain the result in terms of moveme… …n that sucrose has a relative mass of 342.3 g/mol, glucose a relative mas… …8 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.

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30 24 ENE-2 5.A

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) • Diffusion and Osmosis in a Cell (procedure 2) • Osmosis in Potato Cells (procedure 3)	24 30 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) • The Effect of Environment on Mitosis (part 2) • Analyzing the Effects of Cell Cycle Errors (part 3) • Modeling Meiosis (part 4) • Mapping Chromosomes Using Linked Genes (part 5)	74 75 78 81 96
Investigation 8:	**Biotechnology: Bacterial transformation**	• Aseptic Technique and Streak Plating • Testing for Transformation	139 140
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

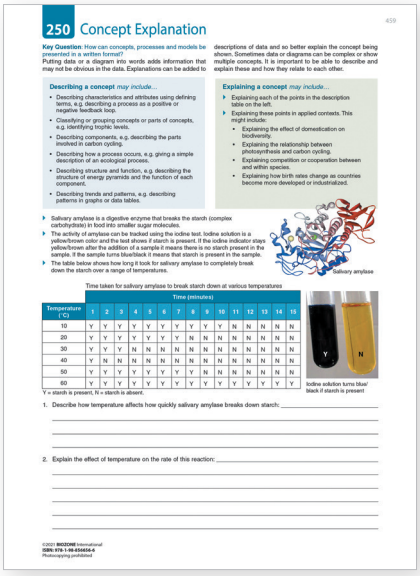
Support for Science Practices

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?

Describing a concept may include...
- Explaining characteristics and attributes using defining terms, e.g. describing a process as a positive or negative feedback loop.
- 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 how a process occurs, 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 domestication on biodiversity.
  - Explaining the relationship between photosynthesis and carbon cycling.
  - Explaining competition or cooperation between and within species.
  - Explaining how birth rates change as countries become more developed or industrialized.

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

The activity of amylase can be tracked using the iodine test. Iodine solution is a yellow/brown color and the test shows if starch is present. If the iodine indicator stays yellow/brown after the addition of a sample it means there is no starch present in the sample. If the sample turns blue/black it means that 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.

Time taken for salivary amylase to break starch down at various temperatures

Temperature (°C)	Time (minutes)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
10	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N
20	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
30	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N
40	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N
50	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N
60	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Y = starch is present, N = starch is absent.

Iodine solution turns blue/black if starch is present

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 explaining scientific concepts?

Describing visual representations may include...
- Describing the characteristics of the representation, e.g. describing the relationship between variables.
- Describing patterns or trends, e.g. describing a trend in a graph.

Explaining visual representations may include...
- Compare 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/model.
- 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): _____

A: Physical model of a DNA molecule

B: Graphing relationships between a predator and its prey

C: Mathematical model: Hardy-Weinberg equation

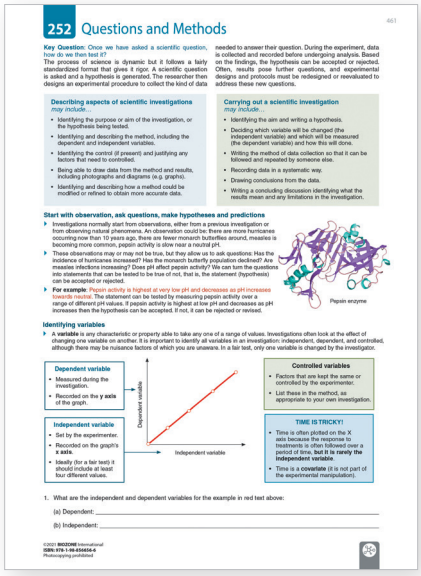
$(p + q)^2 = p^2 + 2pq + q^2 = 1$

p and q = allele types within a population

D: Diagram of nutrient cycling in an ecosystem

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 then test it?

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.
- Identifying the control (if present) and justifying any factors that need to 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 this will done.
- Writing 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 discussion identifying what the results mean and any limitations in the investigation.

Start with observation, ask questions, make hypotheses and predictions
- Investigations normally start from observations, either from a previous investigation or from observing natural phenomena. An observation could be: there are more hurricanes occurring now than 10 years ago, there are fewer monarch butterflies around, measles is becoming more common, pepsin activity is slow near a neutral pH.
- These observations may or may not be true, but they allow us to ask questions: Has the incidence of hurricanes increased? Has the monarch butterfly population declined? Are measles infections increasing? Does pH affect pepsin activity? We can turn the questions into statements that can be tested to be true of not, that is, the statement (hypothesis) can be accepted or rejected.
- For example, Pepsin activity is highest at very low pH and decreases as pH increases towards neutral. The statement can be tested by measuring pepsin activity over a range of different pH values. If pepsin activity is highest at low pH and decreases as pH increases then the hypothesis can be accepted. If not, it can be rejected or revised.

Pepsin enzyme

Identifying variables
- A variable is any characteristic or property able to take any one of a range of values. Investigations often look at the effect of changing one variable on another. It is important to identify all variables in an investigation: independent, dependent, and controlled, although there may be nuisance factors of which you are unaware. In a fair test, only one variable is changed by the investigator.

Dependent variable
- Measured during the investigation.
- Recorded on the y axis of the graph.

Independent variable
- Set by the experimenter.
- Recorded on the graph's x axis.
- Ideally (for a fair test) it should include at least four different values.

Controlled variables
- Factors that are kept the same or controlled by the experimenter.
- List these in the method, as appropriate to your own investigation.

TIME IS TRICKY!
- Time is often plotted on the X axis because the response to treatments is often followed over a period of time, **but it is rarely the independent variable.**
- Time is a **covariate** (it is not part of the experimental manipulation).

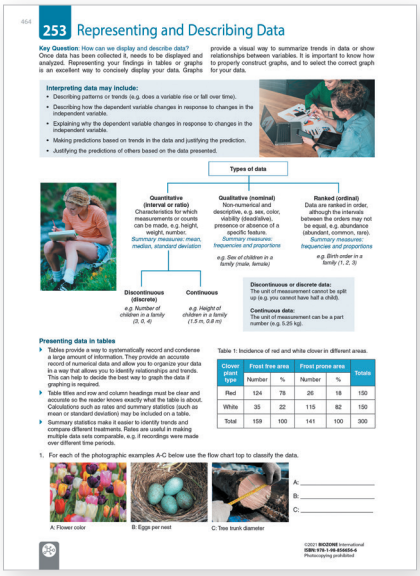
1. What are the independent and dependent variables for the example in red text above:

(a) Dependent: _____

(b) Independent: _____

Determine and evaluate scientific questions and methods.

Science practice 4: Representing & describing data


253 Representing and Describing Data

Key Question: How can we display and describe data?

Interpreting data may include:
- Describing patterns or trends (e.g. does a variable rise or fall over time).
- Describing how the dependent variable changes in response to changes in the independent variable.
- Explaining why the dependent variable changes in response to changes in the independent variable.
- Making predictions based on trends in the data and justifying the prediction.
- Justifying the predictions of others based on the data presented.

Types of data

Quantitative (interval or ratio): Characteristics for which measurements or counts can be made, e.g. height, weight, number. *Summary measures: mean, median, standard deviation*

Discontinuous (discrete): *e.g. Number of children in a family (0, 2, 4)*

Continuous: *e.g. Height of children in a family (1.3 m, 0.8 m)*

Discontinuous or discrete data: The unit of measurement cannot be split up (e.g. you cannot have half a child).

Continuous data: The unit of measurement can be a part number (e.g. 5.25 kg).

Qualitative (nominal): Non-numerical and descriptive, e.g. sex, color, viability (dead/alive), presence or absence of a specific feature. *Summary measures: frequencies and proportions*

e.g. Sex of children in a family (male, female)

Ranked (ordinal): Data are ranked in order, although the intervals between the orders may not be equal, e.g. abundance (abundant, common, rare). *Summary measures: frequencies and proportions*

e.g. Birth order in a family (1, 2, 3)

Presenting data in tables
- Tables provide a way to systematically record and condense a large amount of information. They provide an accurate record of numerical data and allow you to organize your data in a way that allows you to identify relationships and trends. This can help to decide the best way to graph the data if graphing is required.
- Table titles and row and column headings must be clear and accurate so the reader knows exactly what the table is about. Calculations such as rates and summary statistics (such as mean or standard deviation) may be included on a table.
- Summary statistics make it easier to identify trends and compare different treatments. Rules are useful in making multiple data sets comparable, e.g. if recordings were made over different time periods.

Table 1: Incidence of red and white clover in different areas.

Clover plant type	Frost free area		Frost prone area		Totals
	Number	%	Number	%	
Red	124	78	26	18	150
White	35	22	115	82	150
Total	159	100	141	100	300

1. For each of the photographic examples A-C below use the flow chart top to classify the data.

A: _____

B: _____

C: _____

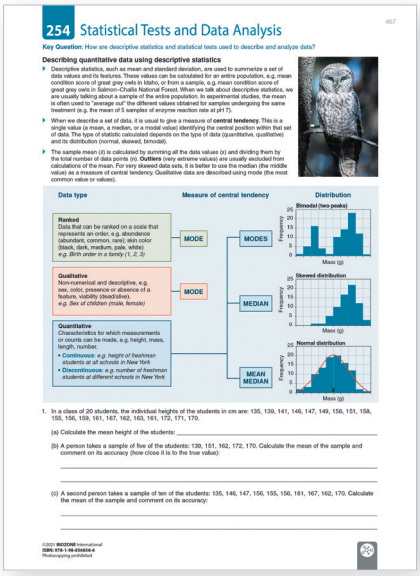
A: Flower color

B: Eggs per nest

C: Tree trunk diameter

Represent and describe data.

Science practice 5: Statistical tests & data analysis


254 Statistical Tests and Data Analysis

Key Question: How are descriptive statistics and statistical tests used to describe and analyze data?

Describing quantitative data using descriptive statistics
- Descriptive statistics, such as mean and standard deviation, are used to summarize a set of data values and its features. These values can be calculated for an entire population, e.g. mean condition score of great grey owls in Idaho, or from a sample, e.g. mean condition score of great grey owls in Salmon–Challis National Forest. When we talk about descriptive statistics, we are usually talking about a sample of the entire population. In experimental studies, the mean is often used to "average out" the different values obtained for samples undergoing the same treatment (e.g. the mean of 5 samples of enzyme reaction rate at pH 7).
- When we describe a set of data, it is usual to give a measure of **central tendency.** This is a single value (a mean, a median, or a modal value) identifying the central position within that set of data. The type of statistic calculated depends on the type of data (quantitative, qualitative) and its distribution (normal, skewed, bimodal).
- The sample mean ($\bar{x}$) is calculated by summing all the data values (x_i) and dividing them by the total number of data points (n). **Outliers** (very extreme values) are usually excluded from calculations of the mean. For very skewed data sets, it is better to use the median (the middle value) as a measure of central tendency. Qualitative data are described using mode (the most common value or values).

Data type

Ranked: Data that can be ranked on a scale that represents an order, e.g. abundance (abundant, common, rare); skin color (black, dark, medium, pale, white). *e.g. Birth order in a family (1, 2, 3)*

Qualitative: Non-numerical and descriptive, e.g. sex, color, presence or absence of a feature, viability (dead/alive). *e.g. Sex of children (male, female)*

Quantitative: Characteristics for which measurements or counts can be made, e.g. height, mass, length, number.
- Continuous: *e.g. height of freshman students at all schools in New York*
- Discontinuous: *e.g. number of freshman students at different schools in New York*

Measure of central tendency

Ranked → MODE → MODES

Qualitative → MODE

Quantitative → MEDIAN → MEAN MEDIAN

Distribution

Bimodal (two peaks)

Skewed distribution

Normal distribution

1. In a class of 20 students, the individual heights of the students in cm are: 135, 139, 141, 146, 147, 149, 156, 151, 158, 155, 156, 159, 161, 167, 162, 163, 161, 172, 171, 170.

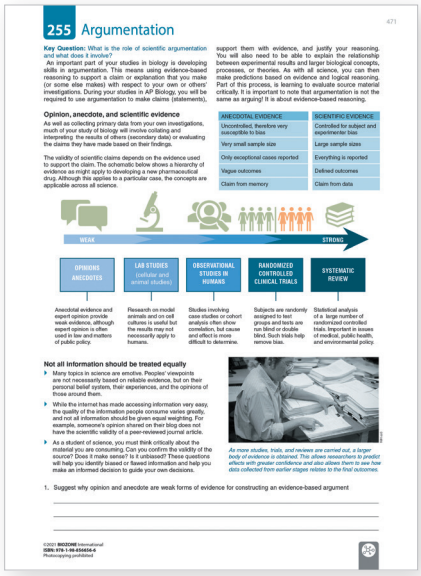
(a) Calculate the mean height of the students: _____

(b) A person takes a sample of five of the students: 139, 151, 162, 172, 170. Calculate the mean of the sample and comment on its accuracy (how close it is to the true value):

(c) A second person takes a sample of ten of the students: 135, 146, 147, 156, 155, 156, 161, 167, 162, 170. Calculate the mean of the sample and comment on its accuracy:

Perform calculations and statistical tests to analyze and evaluate data.

Science practice 6: Argumentation


255 Argumentation

Key Question: What is the role of scientific argumentation and what does it involve?

An important part of your studies in biology is developing skills in argumentation. This means using evidence-based reasoning to support a claim or explanation that you make (or some else makes) with respect to your own or others' investigations. During your studies in AP Biology, you will be required to use argumentation to make claims (statements), support them with evidence, and justify your reasoning. You will also need to be able to explain the relationship between experimental results and larger biological concepts, processes, or theories. As with all science, you can then make predictions based on evidence and logical reasoning. Part of this process, is learning to evaluate source material critically. It is important to note that argumentation is not the same as arguing! It is about evidence-based reasoning.

Opinion, anecdote, and scientific evidence

As well as collecting primary data from your own investigations, much of your study of biology will involve collating and interpreting the results of others (secondary data) or evaluating the claims they have made based on their findings.

The validity of scientific claims depends on the evidence used to support the claim. The schematic below shows a hierarchy of evidence as might apply to developing a new pharmaceutical drug. Although this applies to a particular case, the concepts are applicable across all science.

ANECDOTAL EVIDENCE	SCIENTIFIC EVIDENCE
Uncontrolled, therefore very susceptible to bias	Controlled for subject and experimenter bias
Very small sample size	Large sample sizes
Only exceptional cases reported	Everything is reported
Vague outcomes	Defined outcomes
Claim from memory	Claim from data

WEAK → STRONG

OPINIONS ANECDOTES: Anecdotal evidence and expert opinions provide weak evidence, although expert opinion is often used in law and matters of public policy.

LAB STUDIES (cellular and animal studies): Research on model animals and on cell cultures is useful but the results may not necessarily apply to humans.

OBSERVATIONAL STUDIES IN HUMANS: Studies involving case studies or cohort analysis often show correlation, but cause and effect is more difficult to determine.

RANDOMIZED CONTROLLED CLINICAL TRIALS: Subjects are randomly assigned to test groups and tests are run blind or double blind. Such trials help remove bias.

SYSTEMATIC REVIEW: Statistical analysis of a large number of randomized controlled trials. Important in issues of medical, public health, and environmental policy.

Not all information should be treated equally
- Many topics in science are emotive. Peoples' viewpoints are not necessarily based on reliable evidence, but on their personal belief system, their experiences, and the opinions of those around them.
- While the internet has made accessing information very easy, the quality of the information people consume varies greatly, and not all information should be given equal weighting. For example, someone's opinion shared on their blog does not have the scientific validity of a peer-reviewed journal article.
- As a student of science, you must think critically about the material you are consuming. Can you confirm the validity of the source? Does it make sense? Is it unbiased? These questions will help you identify biased or flawed information and help you make an informed decision to guide your own decisions.

As more studies, trials, and reviews are carried out, a larger body of evidence is obtained. This allows researchers to predict effects with greater confidence and also allows them to see how data collected from earlier stages relates to the final outcomes.

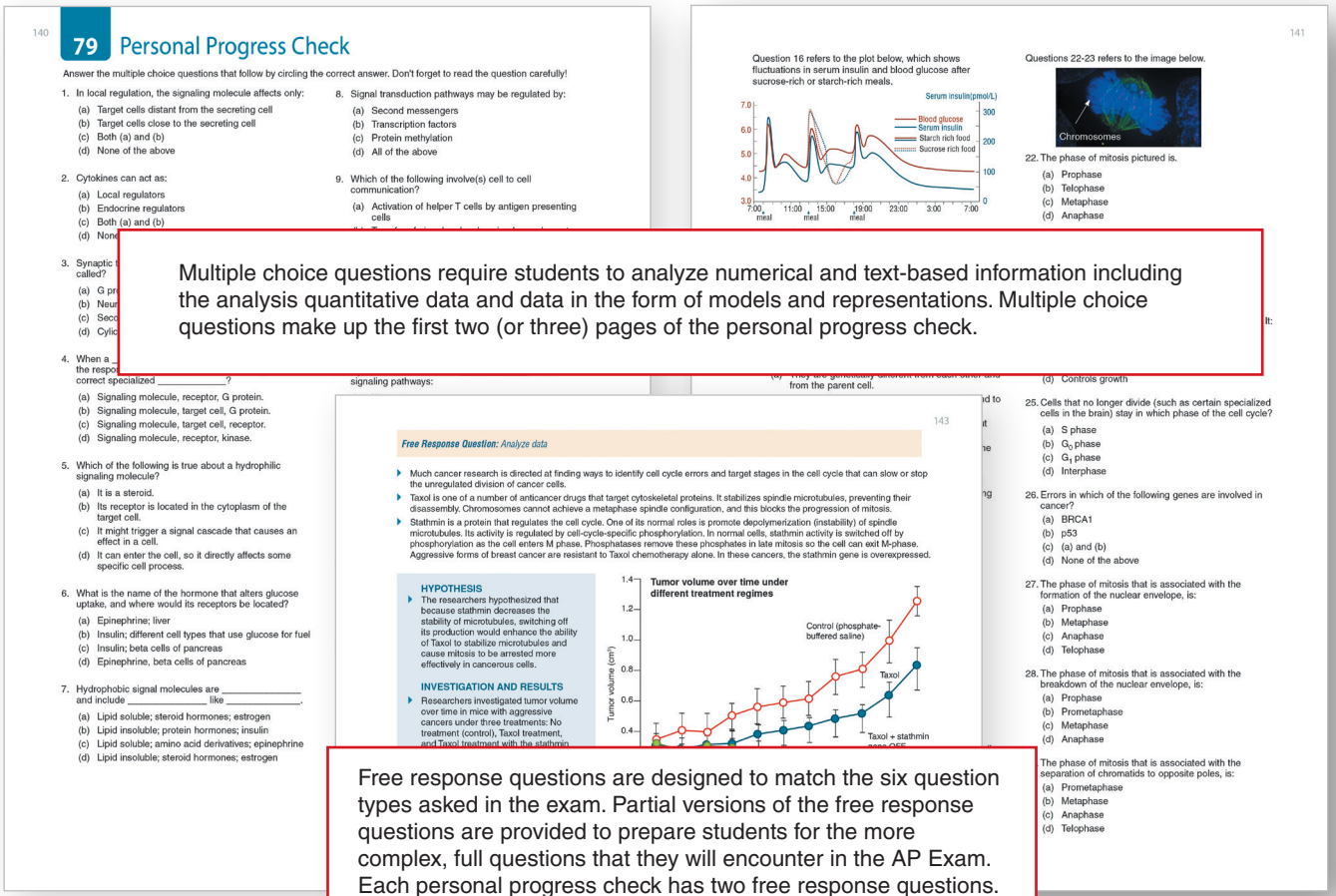
1. Suggest why opinion and anecdote are weak forms of evidence for constructing an evidence-based argument

Develop and justify scientific arguments using evidence.

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 Conceptual analysis (part) Analyze visual representation or model (part)	30 multiple choice Interpreting and evaluating experimental results (part) Analyze visual representation or model (part)	20 multiple choice Interpreting and evaluating experimental results with graphing (part) Scientific investigation (part)	25 multiple choice Interpreting and evaluating experimental results (part) Analyze data	25 multiple choice Interpreting and evaluating experimental results with graphing Conceptual analysis	25 multiple choice Interpreting and evaluating experimental results Analyze visual representation or model	40 multiple choice Interpreting and evaluating experimental results with graphing Analyze data	20 multiple choice Interpreting and evaluating experimental results with graphing Scientific investigation



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 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.

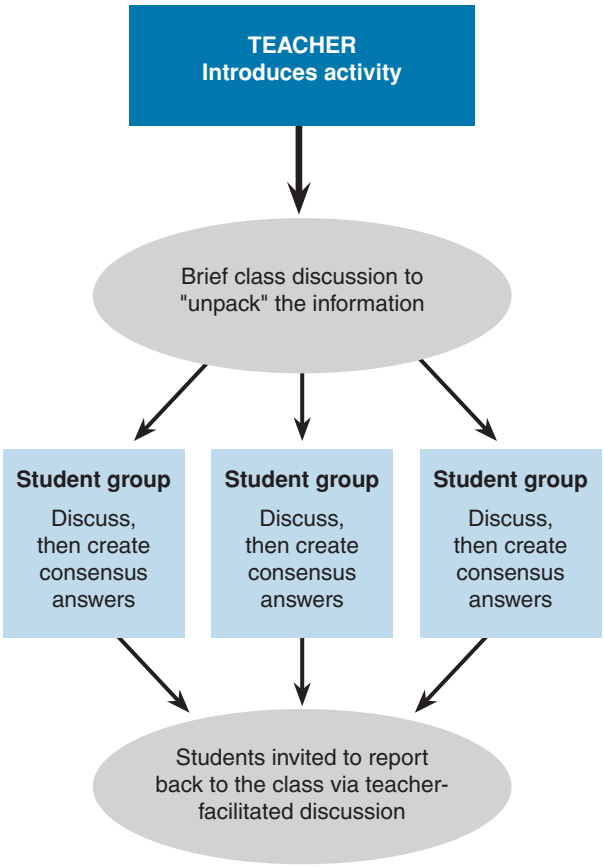
- Interpreting and evaluating experimental results
- Interpreting and evaluating experimental results with graphing
- Scientific investigation
- Conceptual analysis
- Analyze model or visual representation
- Analyze data

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).

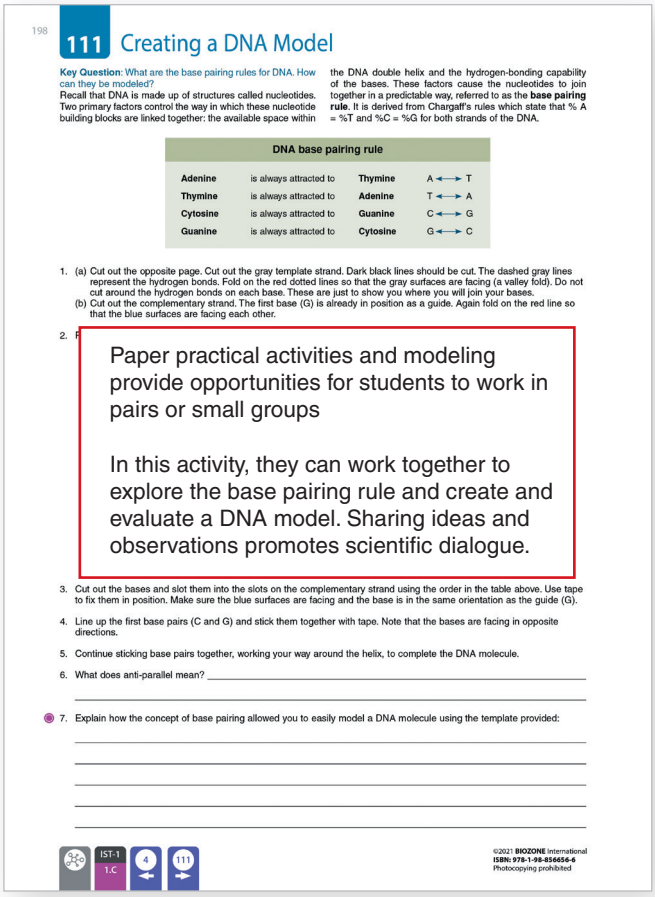
The teacher introduces the topic. They provide structure to the session by providing background information and setting up discussion points and clear objectives. Collaboration is emphasized to encourage participation from the entire group. If necessary, students in a group can be assigned specific tasks.

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.



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111 Creating a DNA Model

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

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 ⟷ T
Thymine	is always attracted to	Adenine	T ⟷ A
Cytosine	is always attracted to	Guanine	C ⟷ G
Guanine	is always attracted to	Cytosine	G ⟷ C

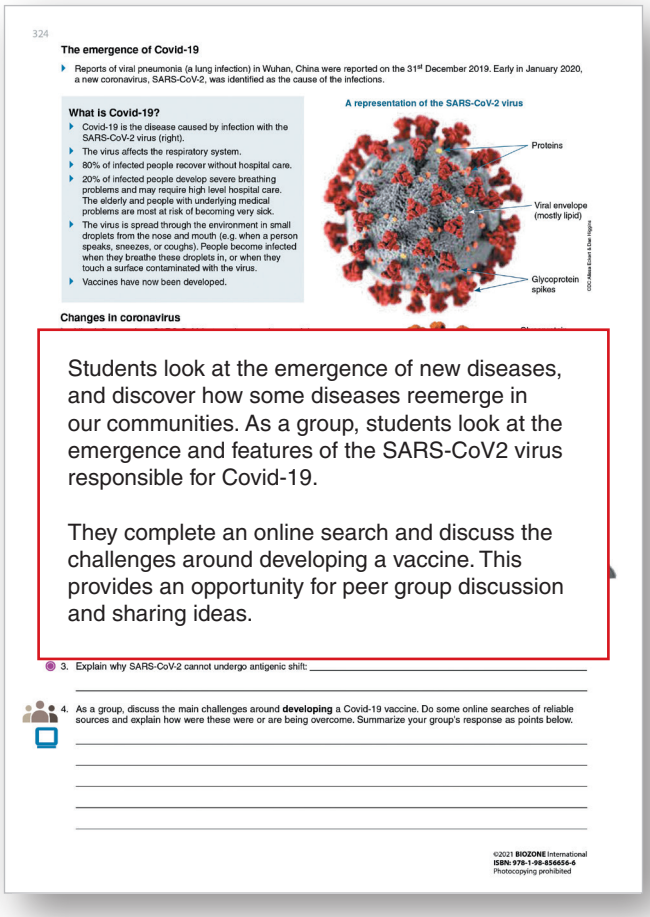
1. (a) Cut out the opposite page. Cut out the gray template strand. Dark black lines should be cut. The dashed gray lines represent the hydrogen bonds. Fold on the red dotted lines so that the gray surfaces are facing (a valley fold). Do not cut around the hydrogen bonds on each base. These are just 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.
2. P

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.

3. 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).
4. Line up the first base pairs (C and G) and stick them together with tape. Note that the bases are facing in opposite directions.
5. Continue sticking base pairs together, working your way around the helix, to complete the DNA molecule.
6. What does anti-parallel mean? _____
7. Explain how the concept of base pairing allowed you to easily model a DNA molecule using the template provided:

IST-1 1.C 4 111



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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.

3. Explain why SARS-CoV-2 cannot undergo antigenic shift: _____
4. 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.

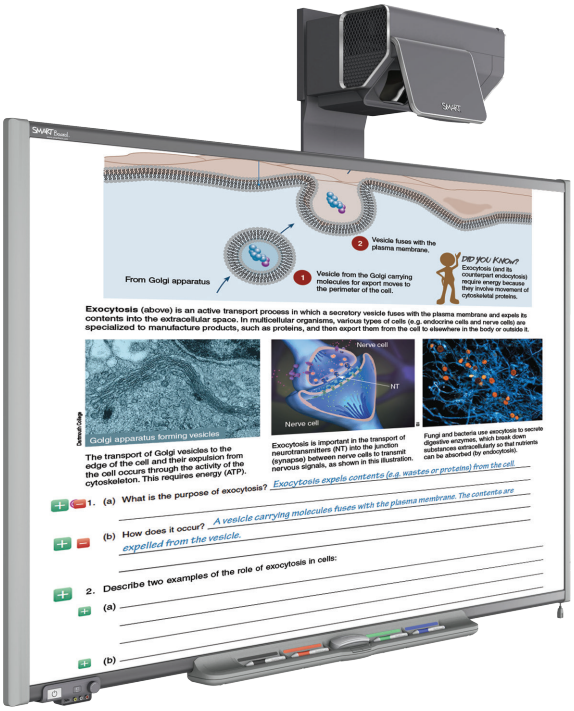
Collaboration and discovery

- 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.

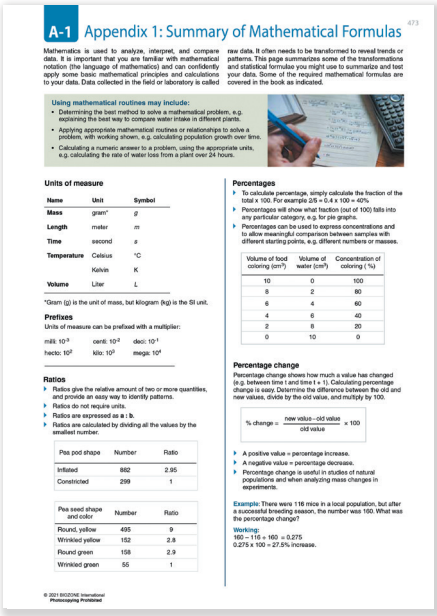


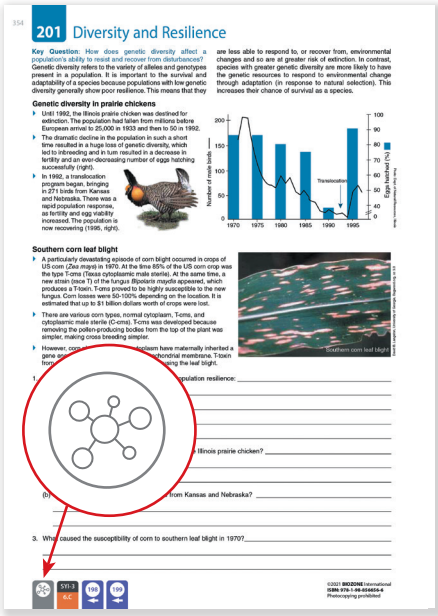
Interactive revision of tasks in class

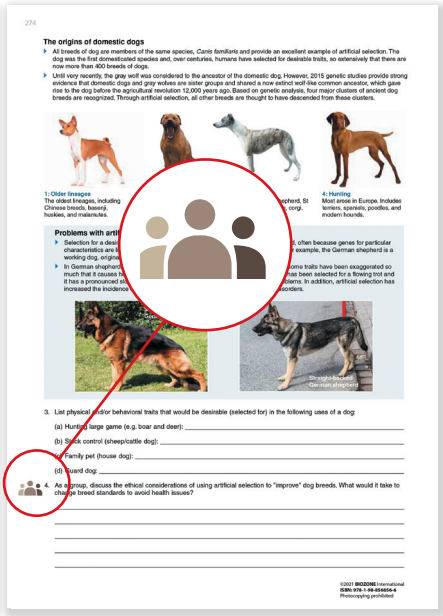
- The **Digital Teacher's Edition** provides a digital rights managed (DRM) version of the student book as PDF files. It features useful HIDE/SHOW answers, which can be used to review activities in class using a data projector or interactive whiteboard (left).
- Students benefit from the feedback in 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:







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.

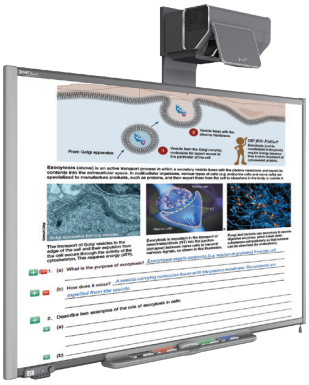
BIOZONE's Resource Hub provides curated content to support the activities in the book. Videos, animations, simulations, and 3D models support students of all abilities, while some resources (interactive spreadsheets, fact sheets, and reference papers) may be used as part of group work or extension.

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.

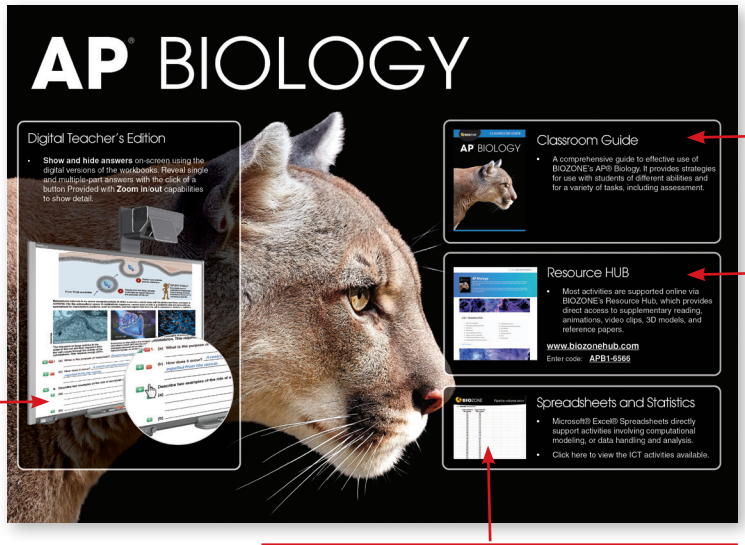
A group symbol indicates where students can work together. Group work provides opportunities for student collaboration and peer-to-peer support to explore the principles, concepts, and theories they are engaged with in their course.

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



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.



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

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.