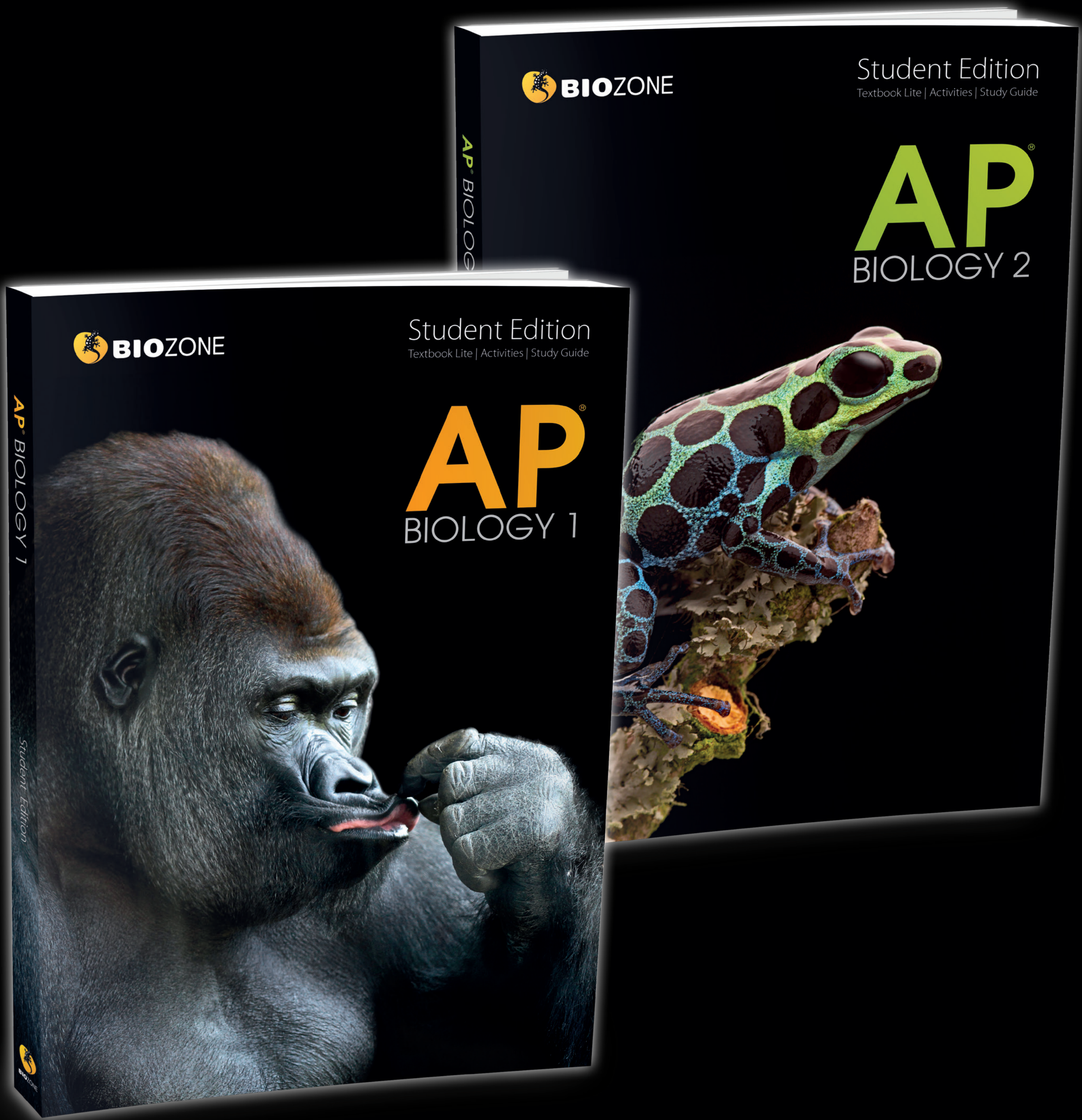
BIOZONE

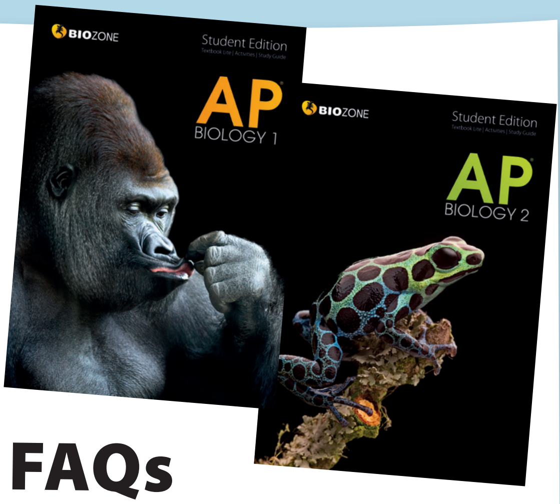
CLASSROOM GUIDE

AP® BIOLOGY



Contents

Making the most of AP *BIOLOGY 1 & 2*



FAQs
ABOUT OUR AP BIOLOGY STUDENT BOOKS

BIOZONE

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Creating Lifelong Learners

We want today's biology students to be self-motivated, lifelong learners, to develop a sound grasp or biological knowledge, to plan and evaluate their work, and to think critically and independently. We have addressed five key competencies (the five Es) relating to these competencies. BIOZONE's books and associated products provide a varied and interesting suite of resources which, if used effectively, can help your students achieve key competencies in all areas of biology. Implicit in achieving these aims is the requirement for a flexible resource; one that can be used in a variety of ways, alongside the many other resources that are now be available to teachers in various topic areas. BIOZONE's books provide this flexibility, with activities that can be used in a variety of ways.

BIOZONE encourages the development of the AP learner profile using the 5 Es model

The Five Es

Engage:	make connections between past and present learning experiences.
Explore:	become actively involved in the activity.
Explain:	communicate the learning experience.
Elaborate:	expand on the concepts learned.
Evaluate:	assess understanding of the concepts.

ENGAGE: Highly visual activities	Use activities in class to engage a student when introducing a topic, or to consolidate student understanding and summarize the material covered by other methods. Using activities in class provides valuable opportunities for peer-to-peer learning.
ENGAGE: A connected plan of study	The check-box format of the contents pages and the chapter introductions provides a focus for planning achievement.
EXPLORE: Independent, self directed study	Activities are self-contained so students are encouraged to be independent learners and seek the answers to questions posed by the activity. Capable students can work quickly and independently through the material and can use the time for extension. Less able students can review or finish activities at home. Most activities are supported by web-based resources in the form of animations and video clips.
EXPLAIN: Communicating is the key to consolidation	All activities first engage the student with a key idea and a visually inviting delivery of content. Student engagement with this material leads them to the questions in which they must communicate their understanding of the content. Students are encouraged to use appropriate biological terms as referenced in the chapter introduction (key terms).
ELABORATE: Building up	Most introductory activities are supported by activities in which students apply their understanding of ideas to a new situation. These 'follow-on' activities often involve data analysis, and support science practices.
EVALUATE: Easy assessment	Encourage self assessment with chapter reviews (these can be graded if desired) or use specific activities to evaluate a student's skills and understanding or ideas. This is also the phase in which students might provide evidence for changes to their understanding.
WHAT ABOUT HOMEWORK?	Assign activities as homework to review a completed topic, explore a related concept, or introduce a topic prior to in-class practical work.

AP Biology Guide

The AP biology program is organized into four underlying big ideas. The guide below lists the enduring understandings for each big idea, and identifies where the material is located in **AP Biology 1** (blue) or **AP Biology 2** (black).

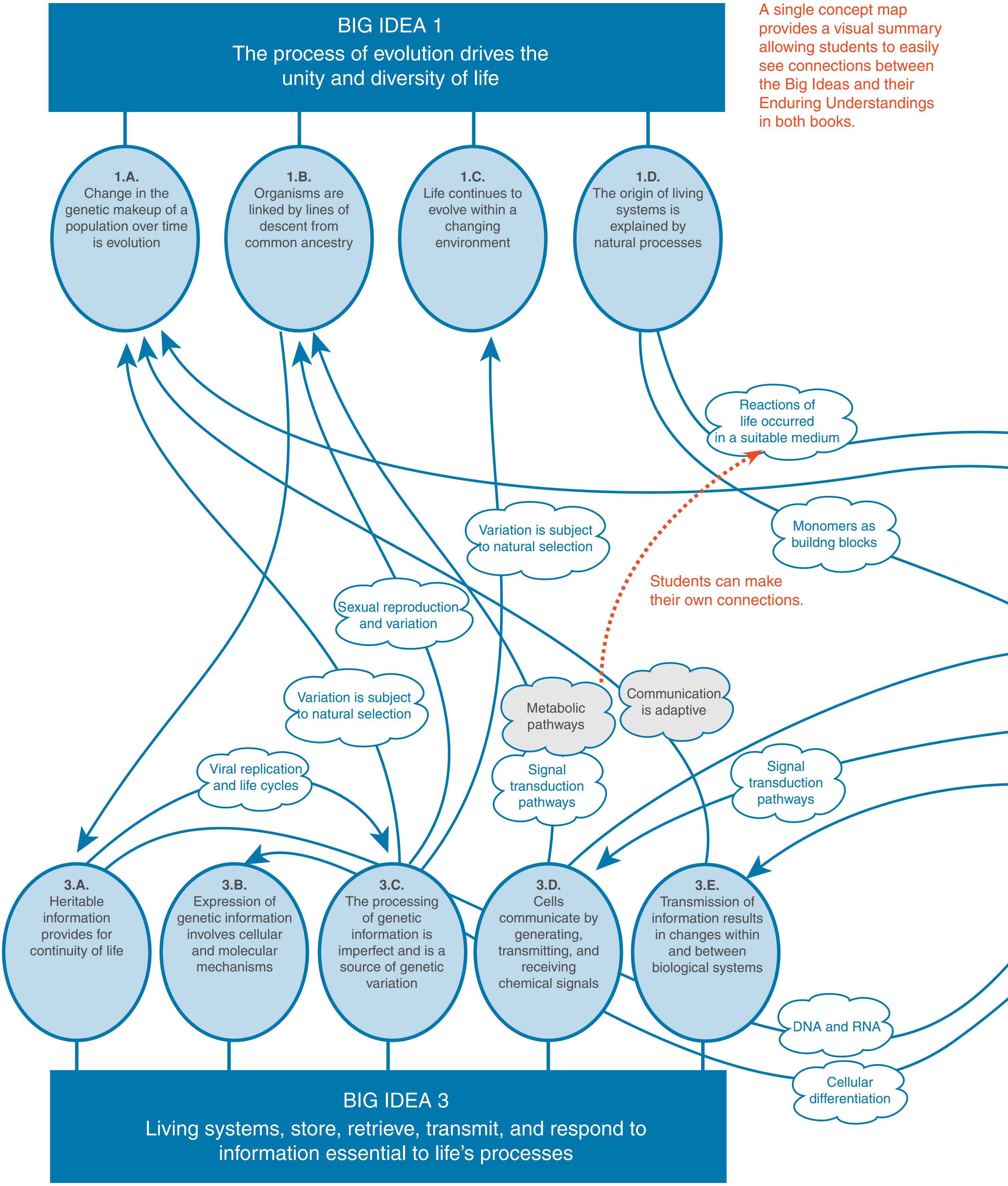
Big Idea 1: The process of evolution drives the diversity and unity of life		
1A: Change in the genetic makeup of a population over time is evolution		
1.A.1	Natural selection is a major mechanism of evolution	Genetic Change in Populations
1.A.2	Natural selection acts on phenotypic variations in populations	
1.A.3	Evolutionary change is also driven by random processes	
1.A.4	Biological evolution is supported by scientific evidence from many disciplines	Evidence for Biological Evolution
1B: Organisms are linked by lines of descent from common ancestry		
1.B.1	Organisms share many conserved core processes and features that have evolved	The Relatedness of Organisms
1.B.2	Phylogenetic trees and cladograms are graphical models of evolutionary history	
1C: Life continues to evolve within a changing environment		
1.C.1	Speciation and extinction have occurred throughout the Earth's history	Speciation and Extinction
1.C.2	Speciation may occur when populations become reproductively isolated	
1.C.3	Populations continue to evolve	
1D: The origin of living systems is explained by natural processes		
1.D.1	Hypotheses about the natural origin of life	The Origin of Living Systems
1.D.2	Scientific evidence from different disciplines supports models of life's origin	
Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis		
2A: Growth, reproduction and maintenance of the organization of living systems require free energy and matter		
2.A.1	All living systems require energy	Energy in Living Systems, Homeostasis & Energy Allocation
2.A.2	Organisms capture and store free energy for use in biological processes	Energy in Living Systems, Energy Flow & Nutrient Cycles
2.A.3	Energy exchange maintains life processes	The Biochemistry of Life
2B: Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments		
2.B.1	Cell membranes are selectively permeable	Cell Structure and Processes
2.B.2	Movement of molecules across membranes maintains growth and homeostasis	
2.B.3	Internal membranes in eukaryotic cells partition the cell into specialized regions	
2C: Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis		
2.C.1	Organisms used feedback mechanisms to maintain internal environments	Homeostasis & Energy Allocation
2.C.2	Organisms respond to change in their external environments	Homeostasis & Energy Allocation, Timing & Coordination
2D: Growth & dynamic homeostasis are influenced by changes in the environment		
2.D.1	Biotic and abiotic factors affect biological systems	Populations & Communities
2.D.2	Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments	Homeostasis & Energy Allocation, Plant Structure & Adaptation, Comparing Animal Systems, Interactions in Physiological Systems, The Diversity & Stability of Ecosystems (2.D.3 only)
2.D.3	Biological systems are affected by disruptions to their dynamic homeostasis*	
2.D.4	Plants and animals have chemical defenses against infections	Internal Defense, Plant Structure & Adaptation
2E: Many biological processes involved in growth, reproduction & dynamic homeostasis include temporal regulation & coordination		
2.E.1	Timing and coordination of events are regulated and necessary for development	Regulation of Gene Expression
2.E.2	Multiple mechanisms regulate timing & coordination of physiological events	Timing & Coordination
2.E.3	Timing and coordination are regulated and are important in natural selection	

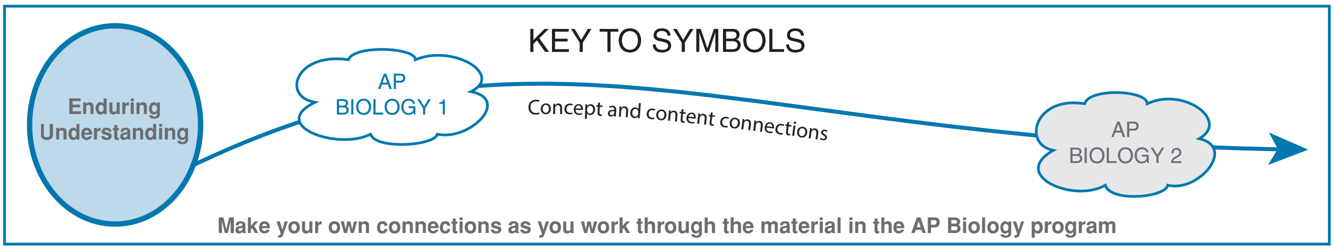
Big Idea 3: Living systems store, retrieve, transmit & respond to information essential to life processes		
3A: Heritable information provides for continuity of life		
3.A.1	DNA, and in some cases RNA, is the primary source of heritable information	DNA and RNA
3.A.2	In eukaryotes, heritable information is passed on via the cell cycle and mitosis or meiosis plus fertilization	Chromosomes & Cell Division
3.A.3	The chromosomal basis of inheritance gives an understanding of transmission of genes from parent to offspring	Chromosomes & Cell Division, The Chromosomal Basis of Inheritance
3.A.4	The inheritance pattern of many traits is not explained by Mendelian genetics	The Chromosomal Basis of Inheritance
3B: Expression of genetic information involves cellular and molecular mechanisms		
3.B.1 3.B.2	Gene regulation results in differential gene expression and cell specialization Signals mediate gene expression	Regulation of Gene Expression
3C: Processing of genetic information is imperfect and a source of genetic variation		
3.C.1 3.C.2 3.C.3	Genotype changes can alter phenotype Processes that increase genetic variation Viral replication and genetic variation	Sources of Variation
3D: Cells communicate by generating, transmitting and receiving chemical signals		
3.D.1 3.D.2 3.D.3 3.D.4	Commonalities in cell communication Signaling by direct contact or chemicals Signal transduction pathways Changes to signal transduction pathways	Cellular Communication
3E: Transmission of information results in changes within and between systems		
3.E.1	Communicating information with others	Communicating & Responding
3.E.2	Nervous systems and responses	
Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties		
4A: Interactions within biological systems lead to complex properties		
4.A.1	Properties of a molecule are determined by its molecular construction	The Biochemistry of Life, DNA and RNA
4.A.2	The structure and function of subcellular components, and their interactions, provide essential cellular processes	Cell Structure and Processes Energy in Living Systems
4.A.3	Gene expression results in specialization of cells, tissues and organs	Regulation of Gene Expression
4.A.4	Organisms exhibit complex properties due to interactions between their parts	Plant Structure & Adaptation, Comparing Animal Systems, Interactions in Physiological Systems
4.A.5	Communities are composed of populations that interact in complex ways	Populations and Communities
4.A.6	Movement of matter and energy	Populations & Communities, Energy Flow & Nutrient Cycles, The Diversity and Stability of Ecosystems
4B: Competition and cooperation are important aspects of biological systems		
4.B.1	Interactions between molecules affect their structure and function	Enzymes & Metabolism
4.B.2	Cooperative interactions within organisms promote efficiency	Plant Structure & Adaptation, Comparing Animal Systems, Interactions in Physiological Systems
4.B.3	Population interactions influence species distribution and abundance	Populations & Communities, The Diversity & Stability of Ecosystems
4.B.4	Ecosystem distribution changes over time	The Diversity & Stability of Ecosystems
4C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment		
4.C.1*	Variation in molecular units provides cells with a wider range of functions	Internal Defense
4.C.2*	Environmental factors influence the expression of the genotype	The Chromosomal Basis of Inheritance
4.C.3 4.C.4	Variation in populations affects dynamics Diversity may influence ecosystem stability	Populations & Communities, The Diversity & Stability of Ecosystems

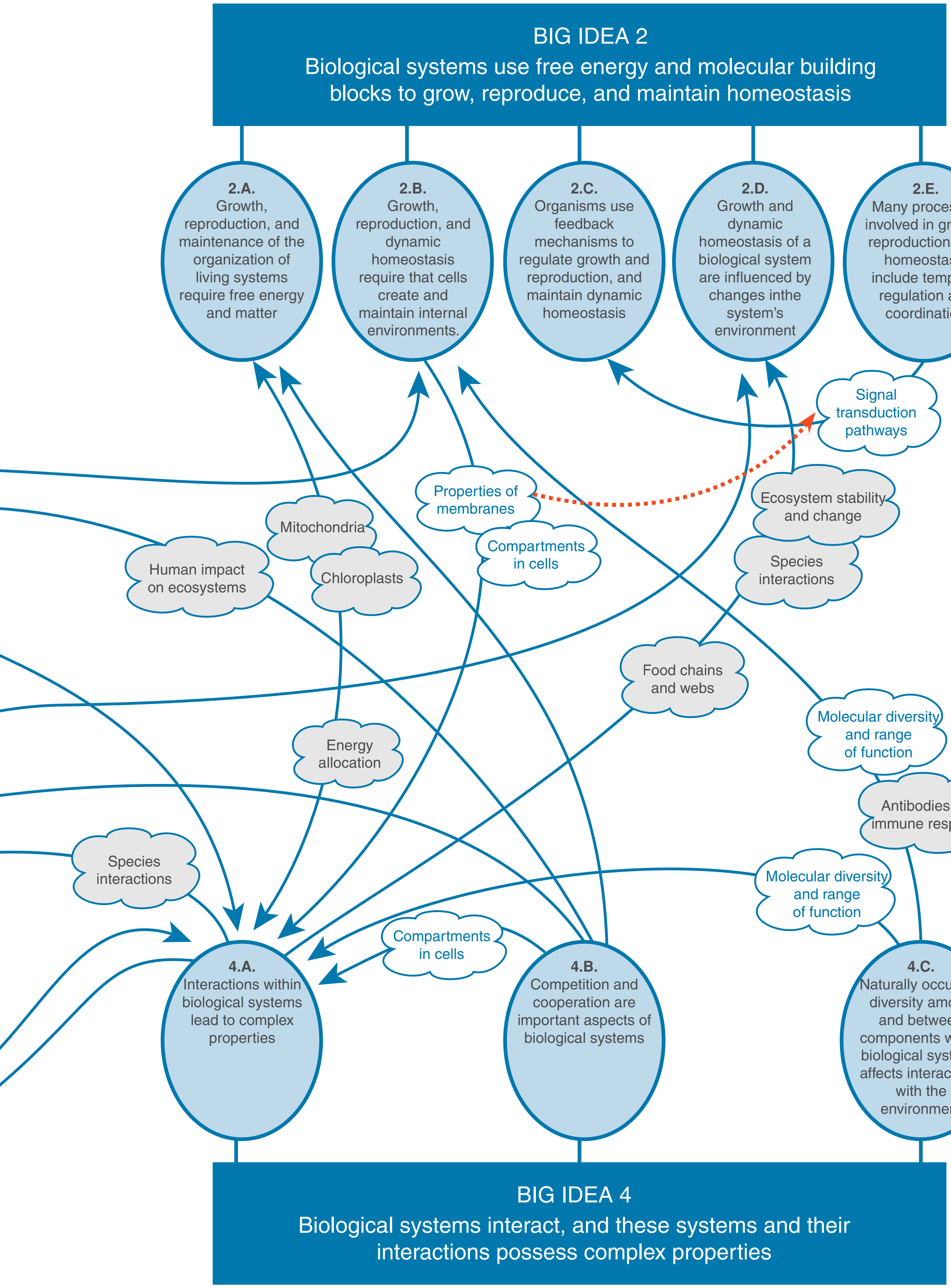
* 4.C.1 and 4.C.2 also see Sources of Variation

The Concept Maps

- The concept map in the introductory section of BIOZONE's **AP Biology** books provides an overview of the program content.
- The map provides an overall structure and the "big picture" approach helps students to make the conceptual connections between different parts of the program.
- Students can make their own connections between ideas on the concept maps as they work through the topics. This helps to reinforce the connectedness of the program content.




KEY TO SYMBOLS
Enduring Understanding
AP BIOLOGY 1
Concept and content connections
AP BIOLOGY 2
Make your own connections as you work through the material in the AP Biology program


BIG IDEA 2
Biological systems use free energy and molecular building blocks to grow, reproduce, and maintain homeostasis
2.A. Growth, reproduction, and maintenance of the organization of living systems require free energy and matter
2.B. Growth, reproduction, and dynamic homeostasis require that cells create and maintain internal environments.
2.C. Organisms use feedback mechanisms to regulate growth and reproduction, and maintain dynamic homeostasis
2.D. Growth and dynamic homeostasis of a biological system are influenced by changes inthe system's environment
2.E. Many processes involved in growth, reproduction, and homeostasis include temporal regulation and coordination
Signal transduction pathways
Properties of membranes
Ecosystem stability and change
Mitochondria
Compartments in cells
Human impact on ecosystems
Chloroplasts
Species interactions
Food chains and webs
Molecular diversity and range of function
Energy allocation
Antibodies and immune response
Species interactions
Molecular diversity and range of function
Compartments in cells
4.A. Interactions within biological systems lead to complex properties
4.B. Competition and cooperation are important aspects of biological systems
4.C. Naturally occurring diversity among and between components within biological systems affects interactions with the environment
BIG IDEA 4
Biological systems interact, and these systems and their interactions possess complex properties

The Contents: A Plan of Action

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. The teacher can also see at a glance how quickly the student is progressing through the assigned material.

Contents

CODES: **Activity** is marked: to be done

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.

EK 2.A., 3.A.
Cellular Communication

Essential knowledge 101
77 Signals and Signal Transduction 103
78 The Nature of Signaling Molecules 105
79 Communication Among Unicellular Organisms. 106
80 Types of Cell Signaling................................... 108
81 Cell to Cell Communication............................ 110
82 Local Regulators 111
83 Action of Insulin 112
84 Hormones are Regulated by Negative Feedback 113
85 Types of Signal Transduction (Overview) 114
86 Signal Transduction Using Second Messengers 116

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

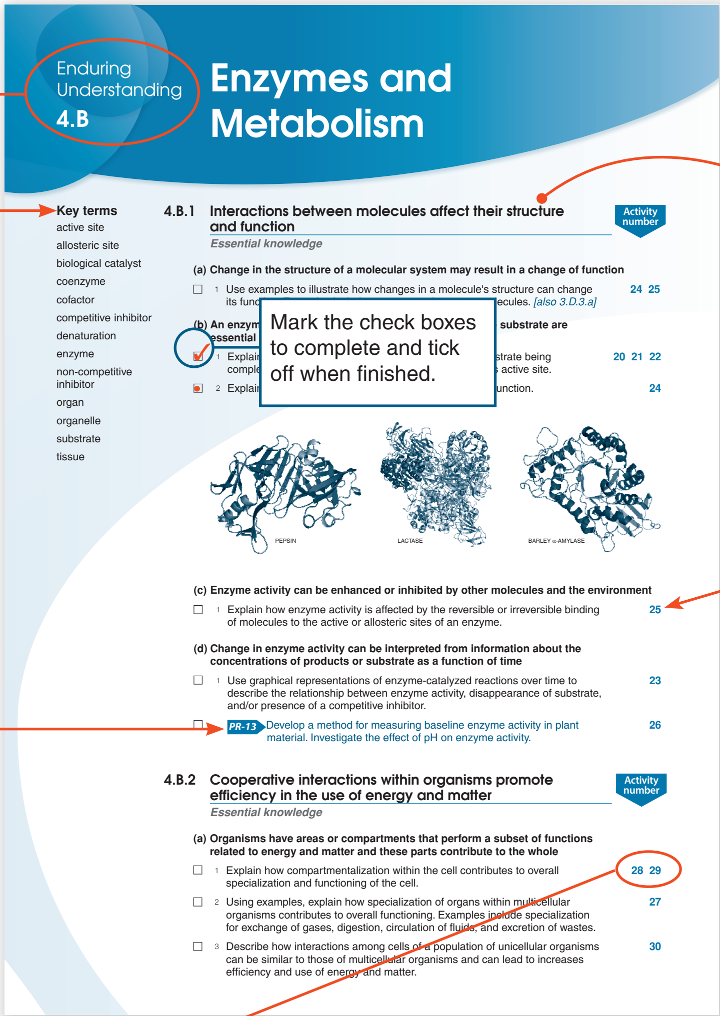
Introducing the AP Biology Content

Each chapter in AP Biology is prefaced with an introduction, providing students with an overview of the chapter content and organization. Each of the numbered learning outcomes pertains to a point of essential knowledge, skill, or practical investigation, and is matched to one or more activities. A list of key terms for the chapter is also included. The comprehensive, but accessible, list of learning outcomes encourages students to approach each topic confidently. Familiarity with the scientific terms used in each topic is implicit in this.

This identifies the Enduring Understanding code or codes to which this chapter applies.

The list of **key terms** can be used to create a glossary for revision and encourages appropriate use of the correct terms when answering questions.

Activities to support the 13 required **AP investigations** are identified by a blue flag.

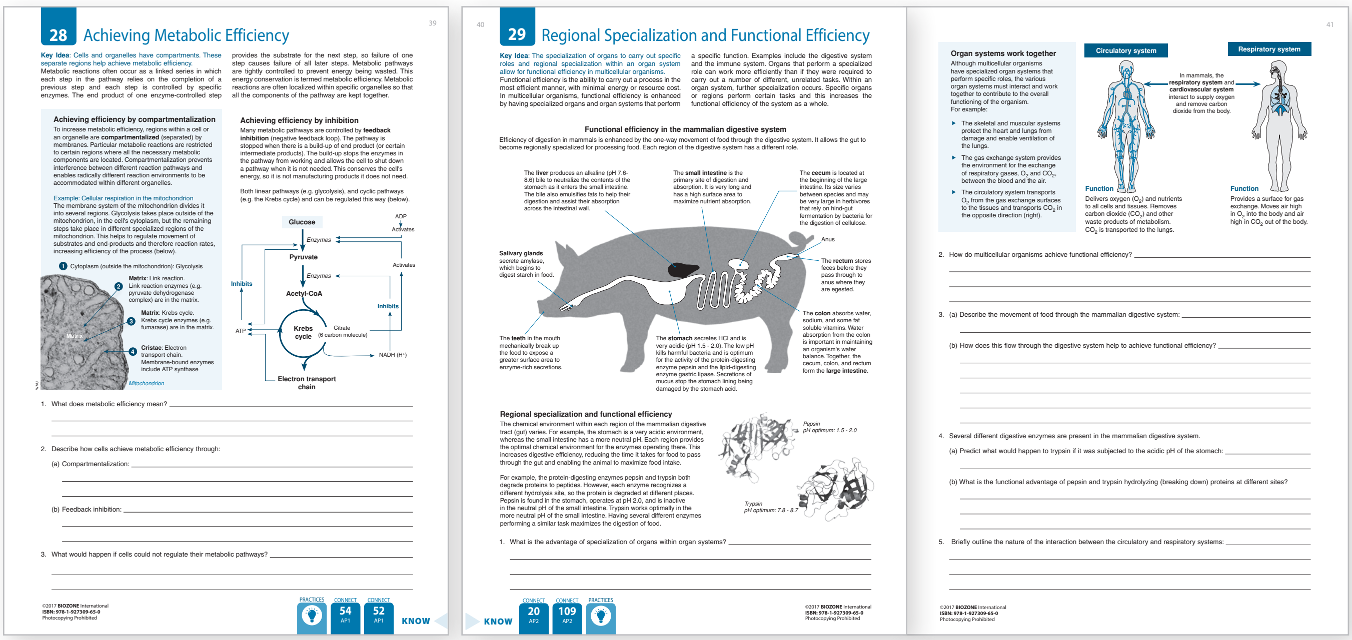


A summary of **essential knowledge** and skills are drawn from the study design. They are purposefully brief, with enough information to provide a framework, but not so much that students are overwhelmed.

The activities in the book with the activities pertaining to these key knowledge outcomes

Introduce the concept with a grounding activity

Follow with an activity expanding on that concept



Using the Activities

The content of AP Biology is organized into 26 chapters, over two companion volumes. Each chapter begins with an introduction and all except *Essential Skills for AP Biology* conclude with a student's self-test of understanding and vocabulary. Inviting, concept-based activities make up the bulk of each chapter, with each activity focusing on the student developing understanding of a concept, applying that understanding to another scenario, and/or developing an essential skill, such as graphing, data analysis, or biological drawing.

An important feature of each activity is the key idea, which encapsulates the main focus of the activity's content. Clear annotated diagrams and photographs are a major part of most activities and the student's understanding of the information is evaluated through questions and/or tasks involving data handling and interpretation.

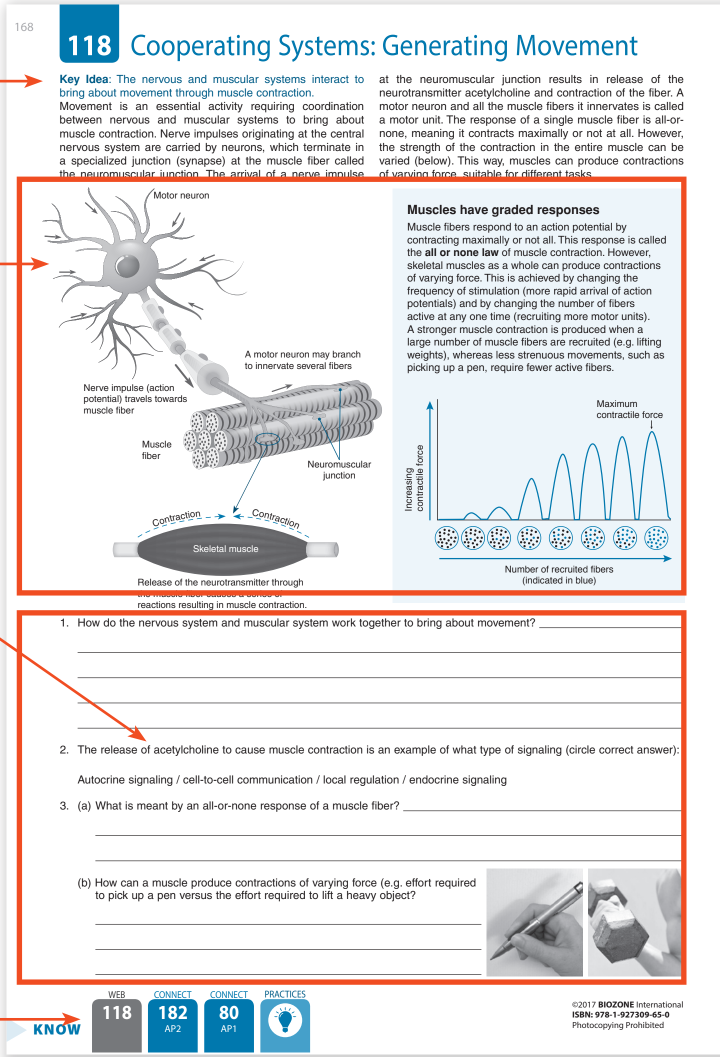
The task code for each activity identifies the nature of the activity, the connect tabs identify connections across Big Ideas and Enduring Understandings, the practices icon indicates a particular Science Practice that is emphasized within the activity. Gray weblink tabs indicate if the activity is supported by an external weblink.

The **key idea** provides a focus for each activity. It summarizes the focus of the activity and provides a clear take-home message for the student.

Annotated diagrams, photographs, and graphs explain the content of the page, providing the information necessary to complete the activity.

Understanding of content is tested through questions, data handling, analysis, prediction, or summary. Students are often required to apply their understanding to a new scenario or draw on knowledge acquired through completing earlier, related material. Students must interact with the information on the page in order to complete the activity. It is this interaction that provides the valuable learning experience and reinforcement and explanation of the key idea.

Related content is identified through the tab system. This activity also has a **weblink** assigned to it (see below).


168

118 Cooperating Systems: Generating Movement

Key Idea: The nervous and muscular systems interact to bring about movement through muscle contraction.
Movement is an essential activity requiring coordination between nervous and muscular systems to bring about muscle contraction. Nerve impulses originating at the central nervous system are carried by neurons, which terminate in a specialized junction (synapse) at the muscle fiber called the neuromuscular junction. The arrival of a nerve impulse at the neuromuscular junction results in release of the neurotransmitter acetylcholine and contraction of the fiber. A motor neuron and all the muscle fibers it innervates is called a motor unit. The response of a single muscle fiber is all-or-none, meaning it contracts maximally or not at all. However, the strength of the contraction in the entire muscle can be varied (below). This way, muscles can produce contractions of varying force, suitable for different tasks.

Muscles have graded responses
Muscle fibers respond to an action potential by contracting maximally or not all. This response is called the **all or none law** of muscle contraction. However, skeletal muscles as a whole can produce contractions of varying force. This is achieved by changing the frequency of stimulation (more rapid arrival of action potentials) and by changing the number of fibers active at any one time (recruiting more motor units). A stronger muscle contraction is produced when a large number of muscle fibers are recruited (e.g. lifting weights), whereas less strenuous movements, such as picking up a pen, require fewer active fibers.

1. How do the nervous system and muscular system work together to bring about movement?

2. The release of acetylcholine to cause muscle contraction is an example of what type of signaling (circle correct answer):

Autocrine signaling / cell-to-cell communication / local regulation / endocrine signaling

3. (a) What is meant by an all-or-none response of a muscle fiber?

(b) How can a muscle produce contractions of varying force (e.g. effort required to pick up a pen versus the effort required to lift a heavy object)?

KNOW | WEB 118 | CONNECT 182 AP2 | CONNECT 80 AP1 | PRACTICES

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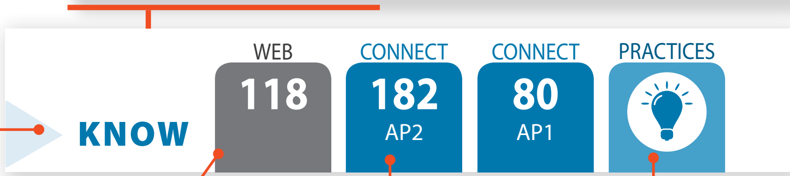


TASK CODES

These identify the nature of the activity

- **COMP** = comprehension of text
- **DATA** = data handling and interpretation
- **KNOW** = content you need to know
- **PRAC** = supports one of the 13 AP Biology investigations
- **REFER** = reference - use for information
- **SKILL** = supporting a mathematical or practical skill
- **TEST** = test your understanding

CONNECT
Concept and content connections are made to other activities within AP1 or in AP2.

PRACTICES
Picture codes indicate where one of the 7 science practices is emphasized.

Weblinks

For AP Biology 1: www.thebiozone.com/weblink/AP1-9629

For AP Biology 2: www.thebiozone.com/weblink/AP2-9650

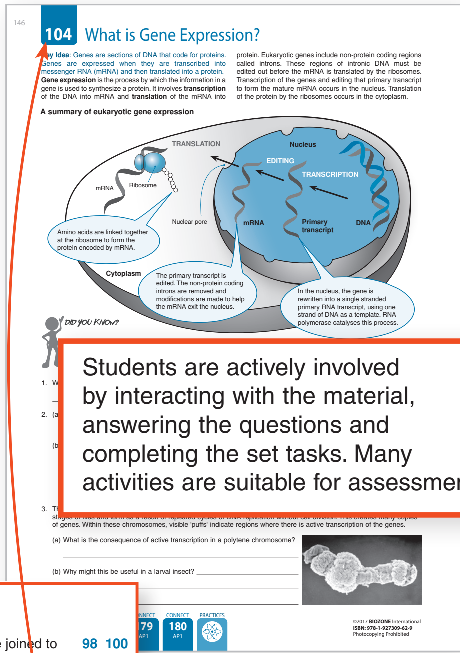
Bookmark these sites to access the external URLs provided.

Engage, Explore, Explain, Elaborate, and Evaluate

In developing AP Biology, we have used the four big ideas to provide a thematic framework for the books. The activities in AP Biology have been specifically written to address the content and skills requirements for the AP Biology program. Our focus is student engagement through the use of a concept-based, highly visual content coupled with the opportunity to demonstrate skills and understanding.

The introduction to each chapter provides a summary of the learning outcomes and appropriate investigations, presented as a series of short student learning outcomes. The students use the activities indicated to demonstrate that they have met the knowledge and skills requirements outlined in each numbered point.

Activities are written and presented so that students progressively extend and deepen their understanding, using what they have learned in earlier activities to complete later related activities and to solve new problems.



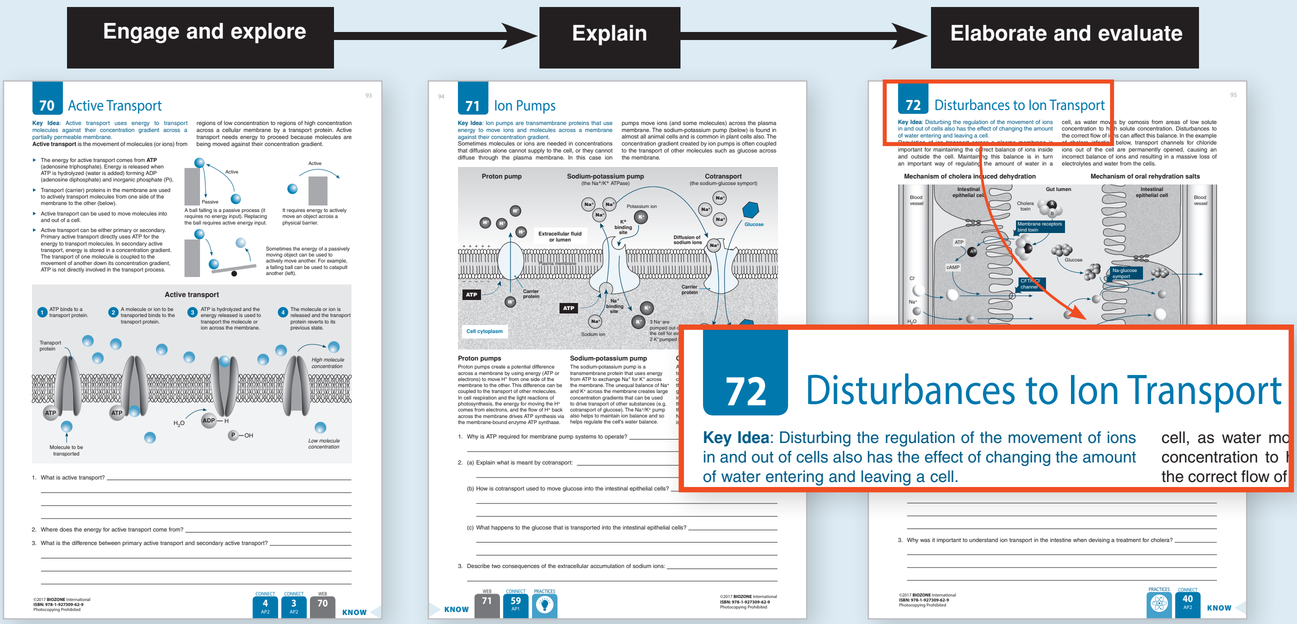
Students are actively involved by interacting with the material, answering the questions and completing the set tasks. Many activities are suitable for assessment.

(b) DNA and RNA have similarities and differences that define function

☐ 1	Describe the structure of a nucleotide and explain how nucleotides are joined to form linear DNA and RNA molecules with specific properties.	98 100
☐ 2	Identify differences and similarities between DNA and RNA.	98 100
☐ 3	Describe the base pairing rule and its universal and conserved nature. Distinguish between purines and pyrimidines and explain the significance of the differences.	98 100
☐ 4	Relate RNA structure to function. Describe the structure and role of mRNA, tRNA, rRNA, and RNAi.	98 99

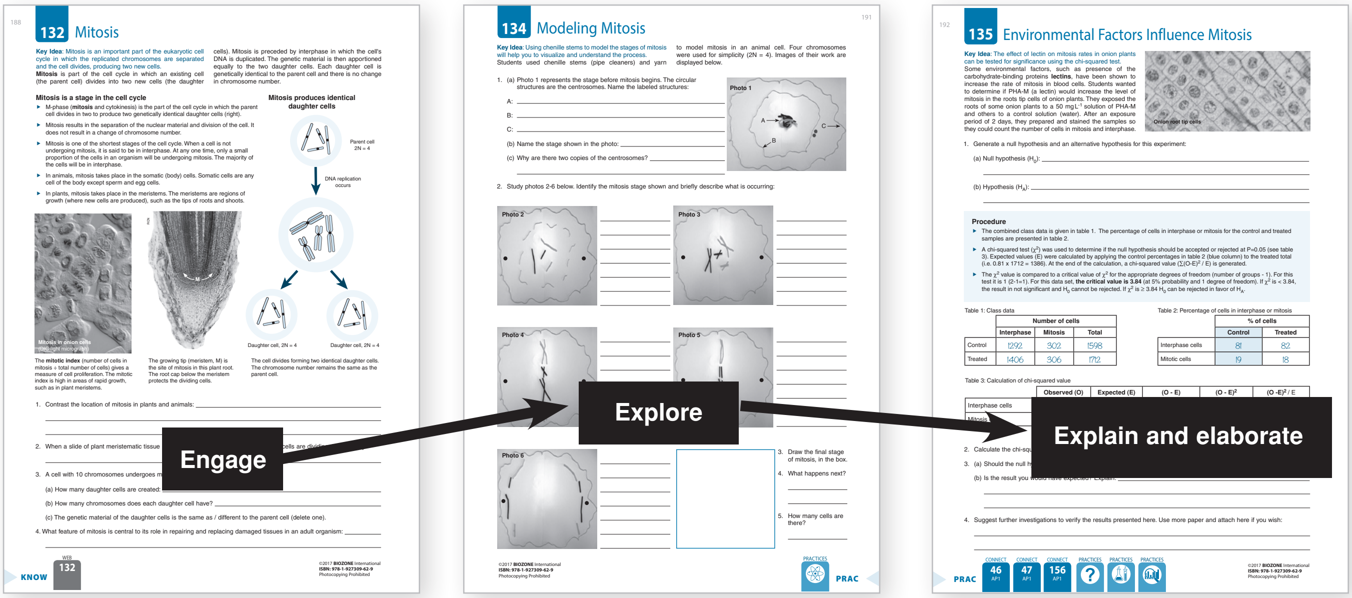
(c) Genetic information flows from gene to protein

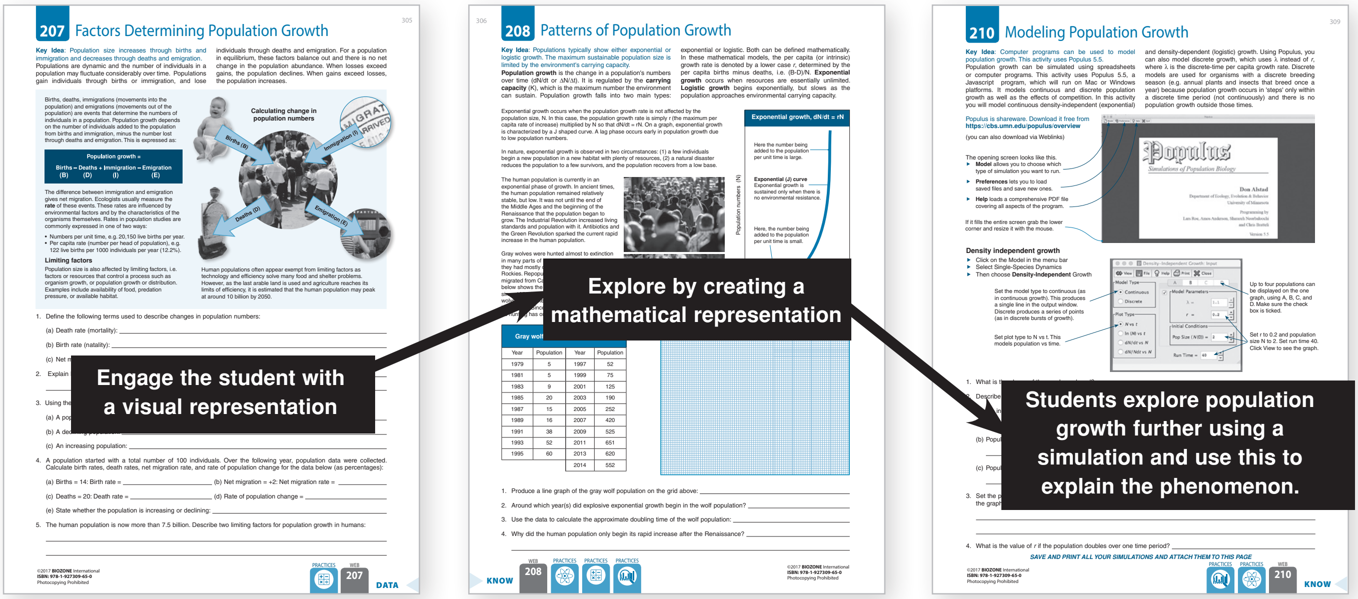
☐ 1	Describe transcription of DNA by RNA polymerase to produce mRNA.	104 106
☐ 2	Describe modifications to the primary mRNA transcript in eukaryotes, including addition of caps and tails and removal of introns.	104 107
☐ 3	Know that translation of mRNA occurs on ribosomes in the cytoplasm.	104 108
☐ 4	Know that transcription and translation are coupled processes in prokaryotes. Describe steps in translation (initiation, elongation, termination). Describe how the mRNA is read by ribosomes and the role of tRNAs and start and stop codons.	104-106 108 109



Engage, explain, elaborate, and evaluate:
Activities are nested, with later activities in a sequence building on understanding so that students can confidently apply a scientific approach to new situations and information.

The KEY IDEA:
Provides a focus for each activity. The key ideas through a chapter provide a concise summary of the chapter content.





This activity engages the student with a visual representation of the factors affecting change in population size.

Students explore their understanding of population growth by representing it mathematically using second hand data.

Students can explore further by running a population growth simulation, manipulating variables and then explaining their results.

Groups of activities build knowledge and understanding by giving students the chance to learn and apply their knowledge in a series of linked activities.

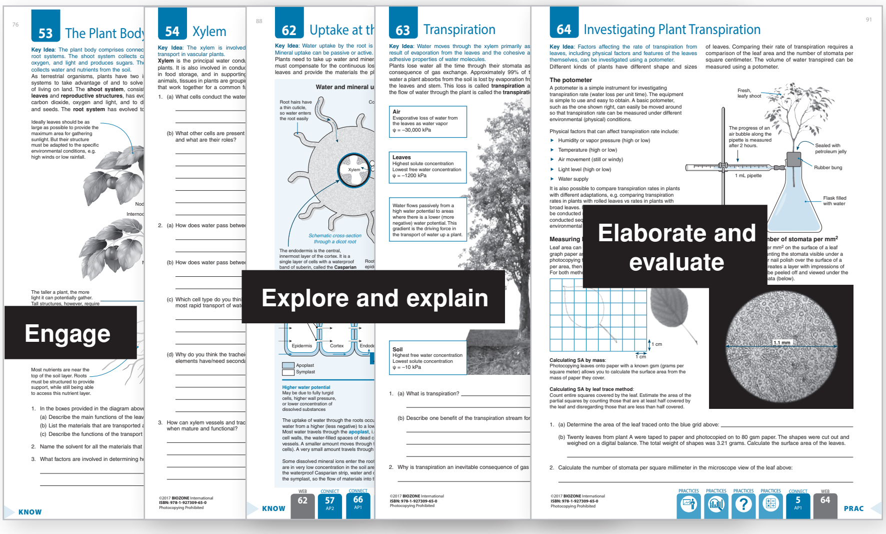
Engage: visualize the concept of hierarchical organization

Explore: relate structure to function

Explain: present supporting evidence

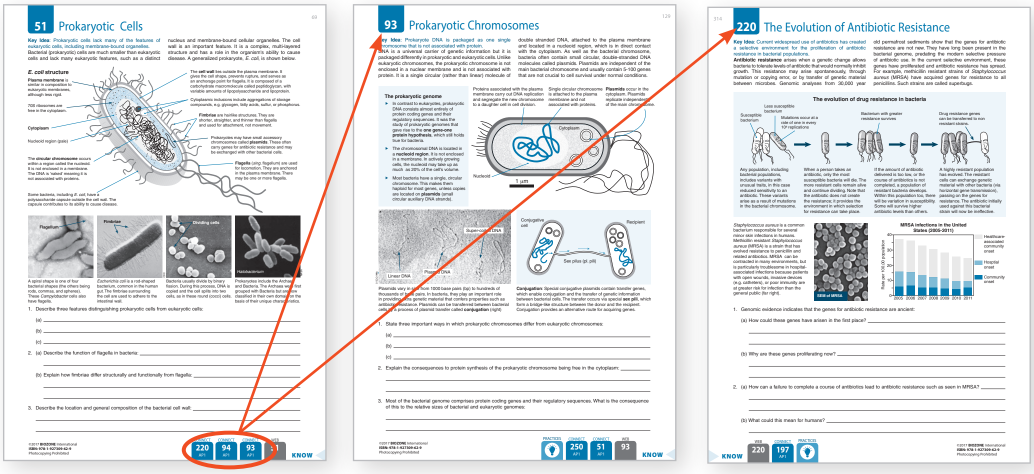
Elaborate: apply understanding to a new scenario

Evaluate: the student's record of work can be assessed formally or informally



CONNECT Tabs - Making Connections

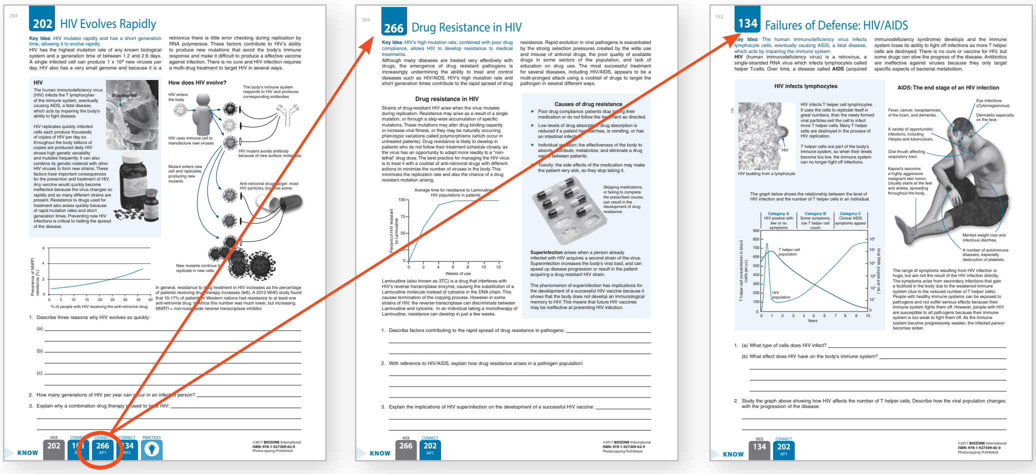
The **CONNECT** tabs help students to make concept and content connections across the entire AP biology program. Use these tabs, identified by AP1 or AP2 subscripts, to reinforce connections between Big Ideas and their Enduring Understandings across all topics. Connections may be made to activities that build on or develop an idea, utilize the same core principles in another biological context, or examine the evidence for a biological process. The connections help students to appreciate that the same core principles underlie many biological phenomena and there is evidence to support them. Understanding these core principles brings understanding to a wide range of contexts and situations, even if they are unfamiliar.



EXAMPLE 1

Prokaryotic cells

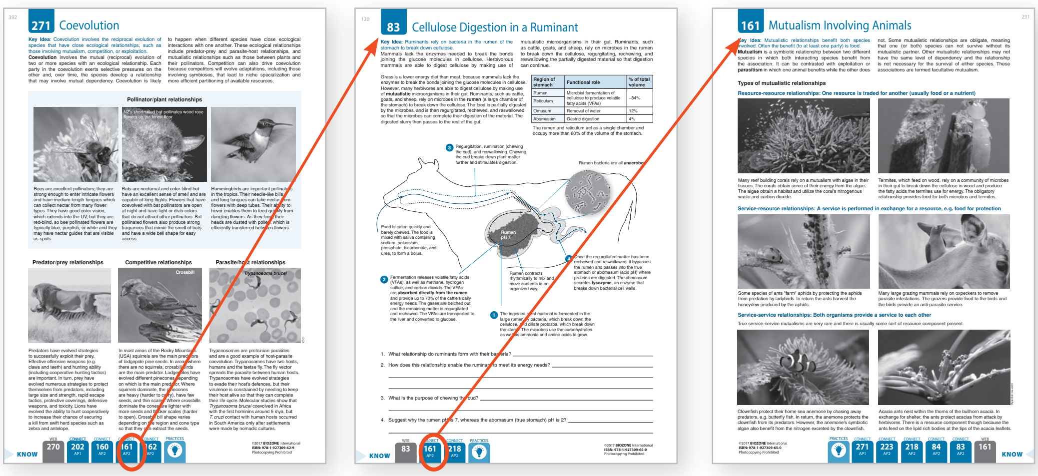
The structure and features of prokaryotic cells are presented in an introductory activity. The nature of the prokaryotic genetic material is explored further in the context of the heritability of information, and connections made to the mechanisms involved in the evolution of antibiotic resistance in bacterial populations.



EXAMPLE 2

Mutations in HIV

In these activities, concept and content connections are made between mutation as a source of variation, and high mutation rates, rapid evolution, and drug resistance in HIV (AP1). Students can then draw on this understanding when they explore the mechanisms and consequences of HIV infection (AP2).

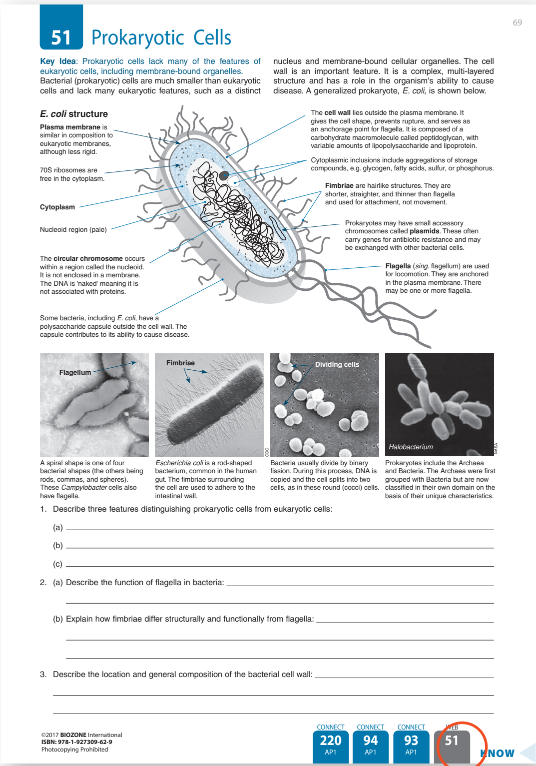


EXAMPLE 3

Relationships between organisms

The complexity of species interactions is addressed through several contexts: evolution, form and function, cooperation, and adaptation. Students explore the mechanisms by which mutualistic relationships arise, how these relationships are maintained through cooperation and efficiency of function, and how adaptation promotes efficiencies in ecosystems (AP2-218 not shown).

Using Weblinks and 3D Models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51 Prokaryotic Cells

Key Idea: Prokaryotic cells lack many of the features of eukaryotic cells, including membrane-bound organelles. Bacterial (prokaryotic) cells are much smaller than eukaryotic cells and lack many eukaryotic features, such as a distinct nucleus and membrane-bound cellular organelles. The cell wall is an important feature. It is a complex, multi-layered structure and has a role in the organism's ability to cause disease. A generalized prokaryote, *E. coli*, is shown below.

A spiral shape is one of four bacterial shapes (the others being rods, commas, and spheres). These *Campylobacter* cells also have flagella.

Escherichia coli is a rod-shaped bacterium, common in the human gut. The fimbriae surrounding the cell are used to adhere to the intestinal wall.

Bacteria usually divide by binary fission. During this process, DNA is copied and the cell splits into two cells, as in these round (cocci) cells.

Prokaryotes include the Archaea and Bacteria. The Archaea were first grouped with Bacteria but are now classified in their own domain on the basis of their unique characteristics.

1. Describe three features distinguishing prokaryotic cells from eukaryotic cells:
   (a) ____
   (b) ____
   (c) ____
2. (a) Describe the function of flagella in bacteria: ____
   (b) Explain how fimbriae differ structurally and functionally from flagella: ____
3. Describe the location and general composition of the bacterial cell wall: ____

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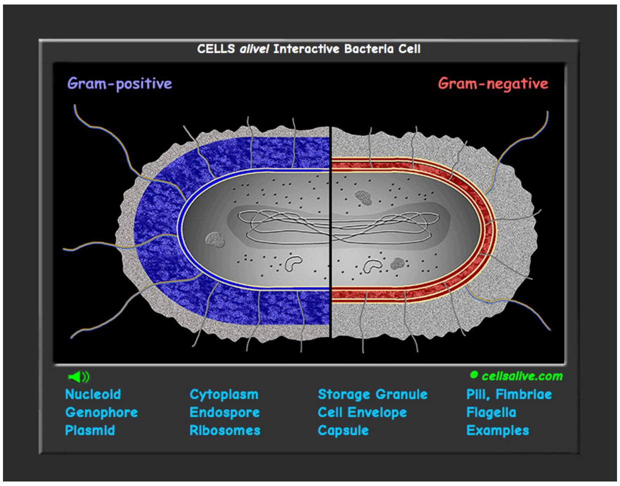
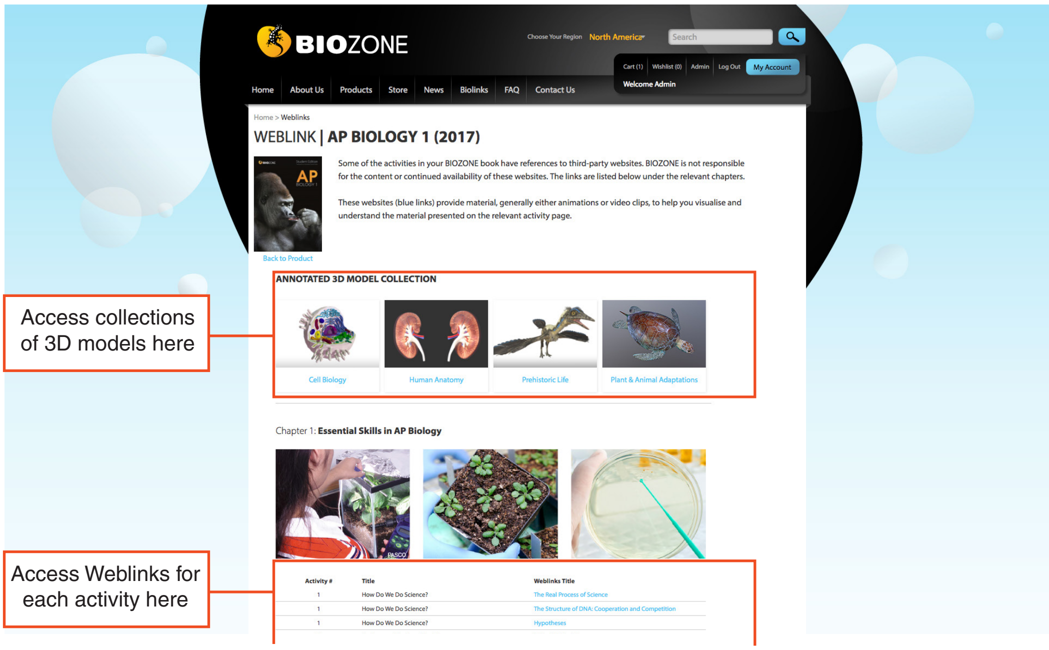
CONNECT 220 AP1 | CONNECT 94 AP1 | CONNECT 93 AP1 | WEB 51 | KNOW

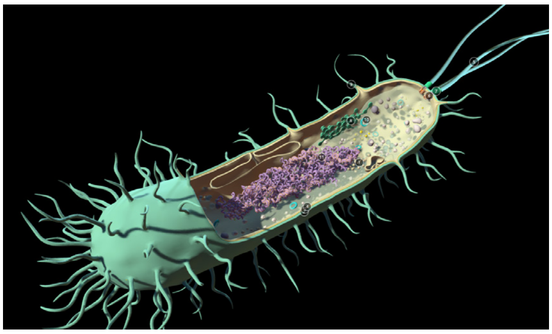
Weblinks

The gray WEB tab at the base of an activity shows that there is a weblink available to support the activity's content. Weblinks exist for most of the activities in the book. They are coded with the activity number and are accessed via a specific url (below). Bookmark the address below at the start of your course to have it easily accessible. Weblinks comprise mostly short video clips or animations aimed specifically at the activity content. They offer great support to help understanding of basic concepts, especially for visual learners. Weblinks are external sites from a wide range of reputable sources. We endeavour to keep all links current, so please notify us if you find a broken link and we can fix it!



www.thebiozone.com/weblink/AP1-9629

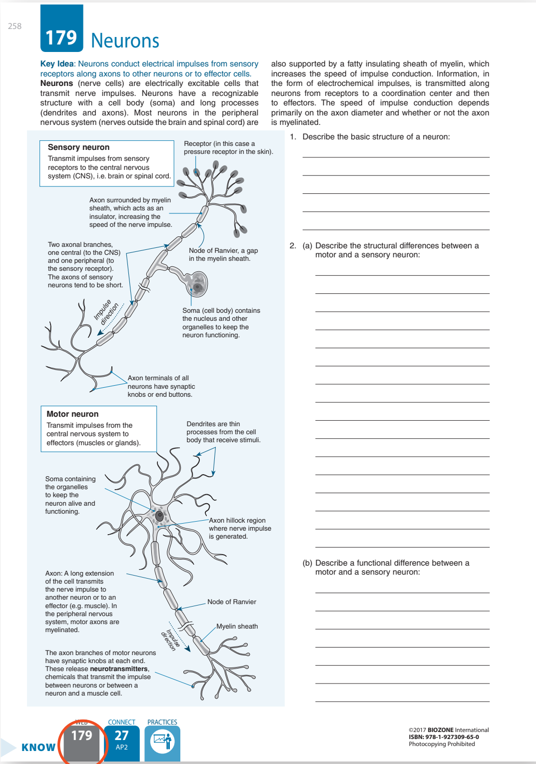




3D Models

BIOZONE's extensive collection of annotated 3D models adds another dimension to the student learning experience. Rotate, zoom in, and view annotations describing structure and function.

Models can be accessed from the banner on the Weblinks page and are sorted into broad categories. Choose those relevant to your current area of study or just explore! A good starting point for student discussion of form and function and great for reviewing understanding of content in visual learners.


258

179 Neurons

Key Idea: Neurons conduct electrical impulses from sensory receptors along axons to other neurons or to effector cells.

Neurons (nerve cells) are electrically excitable cells that transmit nerve impulses. Neurons have a recognizable structure with a cell body (soma) and long processes (dendrites and axons). Most neurons in the peripheral nervous system (nerves outside the brain and spinal cord) are also supported by a fatty insulating sheath of myelin, which increases the speed of impulse conduction. Information, in the form of electrochemical impulses, is transmitted along neurons from receptors to a coordination center and then to effectors. The speed of impulse conduction depends primarily on the axon diameter and whether or not the axon is myelinated.

1. Describe the basic structure of a neuron:

2. (a) Describe the structural differences between a motor and a sensory neuron:

(b) Describe a functional difference between a motor and a sensory neuron:

KNOW | WEB 179 | CONNECT 27 AP2 | PRACTICES

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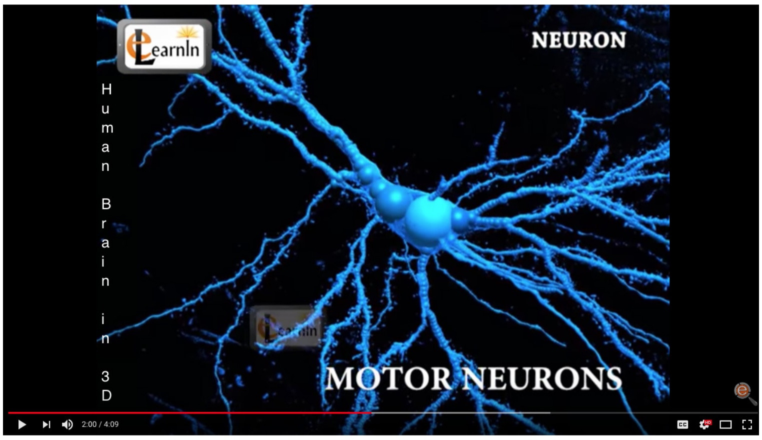
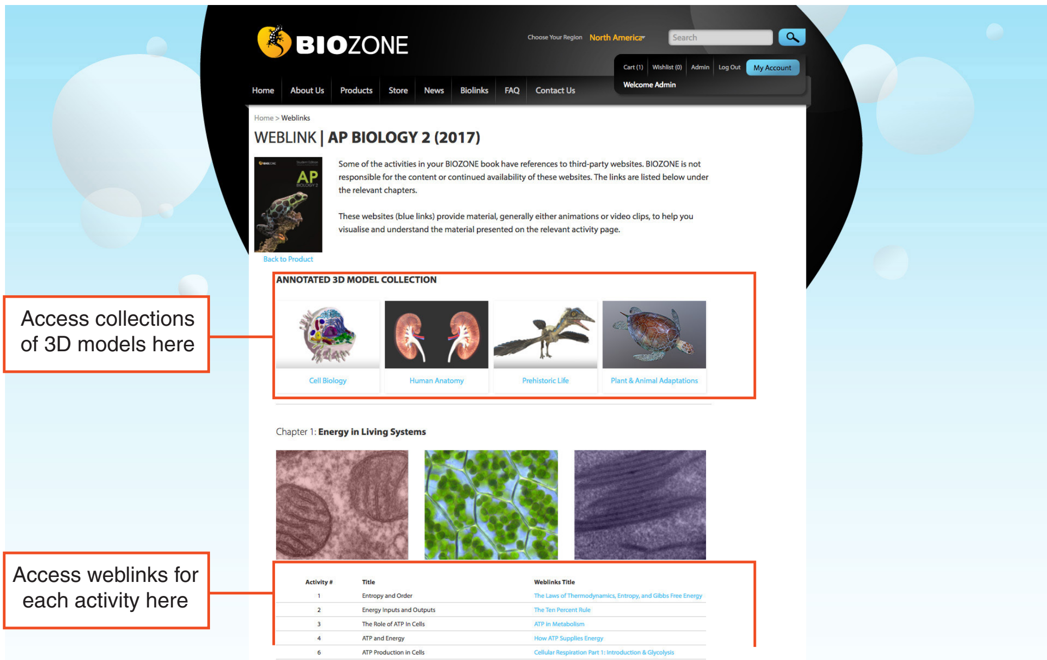


Check the Weblinks regularly!

Corrections and clarifications to editions in print are always posted on the Weblinks page

A weblink and a 3D model support the activity on neuron structure.

www.thebiozone.com/weblink/AP2-9650



Access collections of 3D models here

Access weblinks for each activity here

Essential Skills for AP Biology

Essential Skills for AP Biology supports students to become familiar and confident with the basic protocols and skills required to carry out the practical work required by the AP Biology program. Although mathematical and scientific skills are specifically addressed in this chapter, they are also provided in context throughout the book.

Science Practices

Essential Skills for AP Biology

Key terms
accuracy
chi-squared
control
controlled variable
dependent variable
experiment
graph
hypothesis
independent variable
mean
median
model (scientific)
observation
percentage
precision
prediction
rate
scientific method
statistical test
table
trend
variable

Inquiry is the basis of science

Essential knowledge [points also covered in activities throughout AP1&2] — Activity number

Inquiry begins with observation

- ☐ 1 Describe the role of inquiry-based investigations in science. Show, through your work, your understanding of science as a non-linear process. *[SP3]* — 1
- ☐ 2 Use a variety of methods to answer questions you raise as a result of observation. These include field and laboratory-based investigations, simulations and models, and data analysis. *[SP3] [SP4]* — 4 5
- ☐ 3 Use scientific models to illustrate biological processes and concepts, communicate information, make predictions, and describe systems. *[SP1]* — 2

Communication

Essential knowledge [points also covered in activities throughout AP1&2] — Activity number

The results of investigations must be communicated to peers to have value

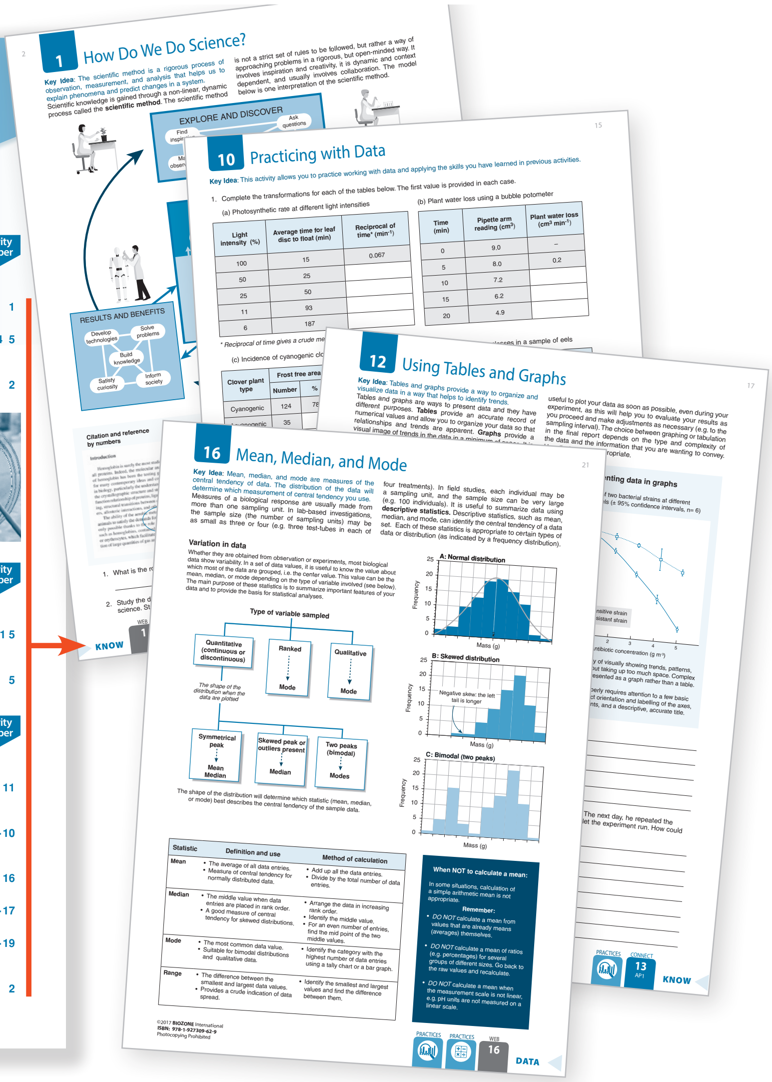
- ☐ 1 Demonstrate an ability to communicate the findings of your investigations through oral and written presentations, including lab reports, and through graphs and/or contributions to online resources. *[SP3] [SP4]* — 1 5
- ☐ 2 Use a lab notebook or portfolio to organize your work and provide a record of ideas, methods, results, further questions, and references. *[SP3] [SP4]* — 5

Quantitative skills

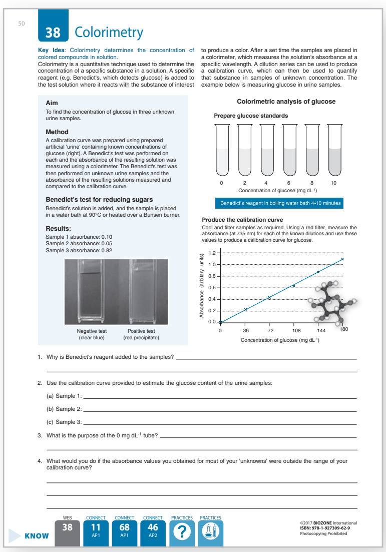
Essential knowledge [points also covered in activities throughout AP1&2] — Activity number

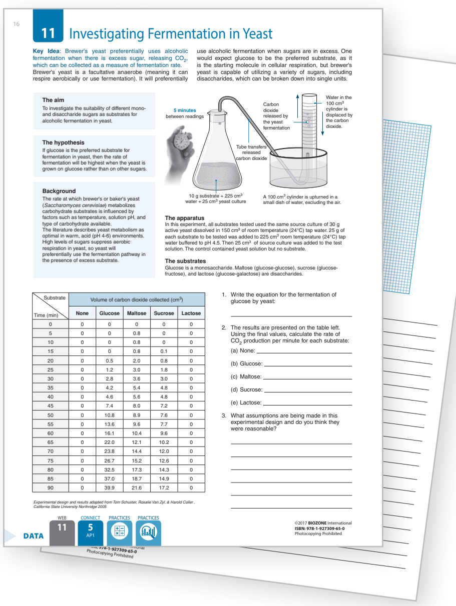
Quantitative reasoning is an essential part of inquiry in biology

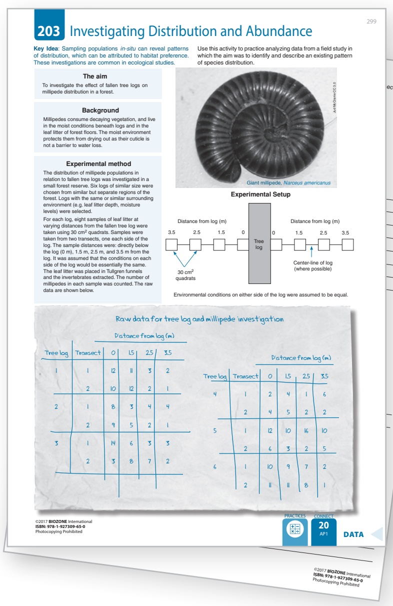
- ☐ 1 Demonstrate ability to use basic mathematical skills to collect data. These include making counts and measurements. Distinguish between accuracy and precision and explain their importance when collecting quantitative data. *[SP2]* — 3-6 11
- ☐ 2 Demonstrate appropriate application of mathematical routines to data., e.g. determining mean and median, calculating rates and percentages, and chi-square analysis. *[SP2]* — 6-10
- ☐ 3 Use tables or spreadsheets to organize different types of data, including any calculated values (e.g. means and standard deviation). *[SP2] [SP5]* — 12 16
- ☐ 4 Construct graphs for different types of data, including that collected during your investigations. Indicate error in calculated values as appropriate. *[SP2] [SP5]* — 12-17
- ☐ 5 Use descriptive statistics (e.g. mean and standard deviation) and simple statistical tests (e.g. chi-squared, Student's t test, correlation) to analyze your data and test your hypothesis. *[SP2] [SP5]* — 16-19
- ☐ 6 Develop and use quantitative models (e.g. spreadsheet models) to analyze biological phenomena (e.g. population growth) and predict outcomes. *[SP1]* — 2



Activities outlining simple practical investigations with second hand data provided for analysis are included in context, as appropriate.







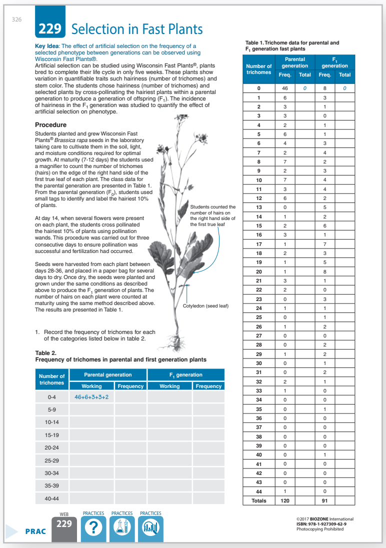
Addressing the AP Biology Practical Investigations

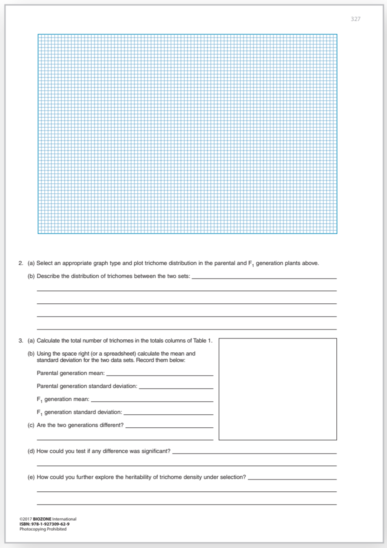
Activities supporting the 13 required AP Biology practical investigations are identified in chapter introductions with a blue flag. In some instances, the components of an AP practical investigation are supported over several activities. These activities can be used to provide grounding for students before they attempt the practical themselves or if they are opting to do an approved alternative AP investigation. Some of these alternatives are provided by BIOZONE's supporting partner Carolina® (see later).

BIG IDEA 1: EVOLUTION

Investigation 1: Artificial Selection

This activity outlines a procedure for investigating the effects of artificial selection on trichrome number in Wisconsin Fast Plants®. After carrying out analysis of the second hand data provided, students determine if the trichrome frequencies between the parental and F_1 generation differ (i.e. did their selection process for hairy plants have an effect on hairiness in the next generation).





Applications

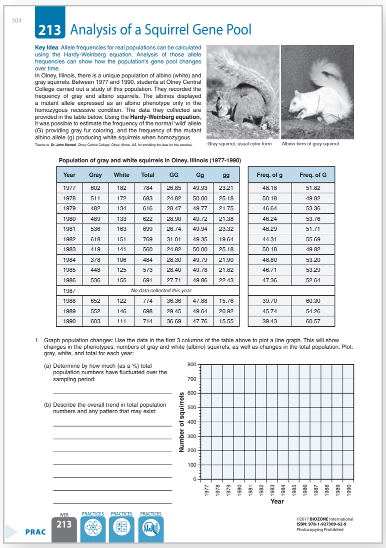
- This activity provides an opportunity to consider experimental design. Students can use it to plan their own investigation of artificial selection.
- Practice is gained in the mathematical and graphing skills required for this investigation.
- This activity could be used if there is insufficient time or resources to devote to a practical investigation, if plants fail to grow during the investigation and there are no results, or if an alternative practical investigation has been selected because of the resources available.

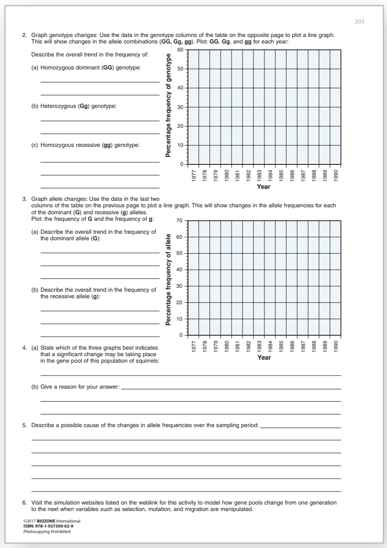
Where to next?

- Students can design further experiments to investigate the effect of artificial selection on the frequency of a trait, or explore the trait's possible adaptive value.
- The significance of their results could be tested using analysis such as Student's *t* test.

Investigation 2: Modeling Hardy-Weinberg

Using a real life data set from Olney, Illinois, students apply their knowledge of the Hardy-Weinberg equation (gained from previous activities) to analyze changes in the allele frequency of a squirrel gene pool.





Applications

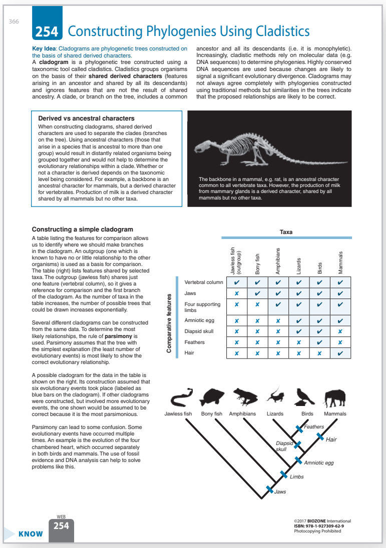
- Use this activity to help students become confident with analyses of population allele, genotype, and phenotype frequencies before constructing models or simulations of their own.
- There is ample opportunity for students to practice graphing and data analysis.

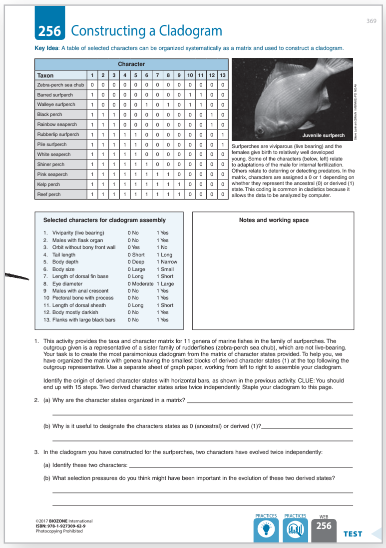
Where to next?

- Students can design or use spreadsheet models or computer simulations to model hypothetical gene pool changes between generations. Possible examples are provided via Weblinks. Greater complexity can be added to the models and simulations so they become more realistic.
- Students can attempt to apply the model to a real-world situation (e.g. frequency of supertasters in a population).

Investigation 3: Comparing DNA Sequences to Understand Evolutionary Relationships

Evolutionary relationships can be expressed visually using phylogenetic trees. Students are shown how a phylogenetic tree can be constructed on the basis of shared derived characteristics. Students apply this knowledge to constructing and interpreting cladograms (phylogenies based on cladistics) themselves.





Applications

- These activities provide grounding and practice in constructing and interpreting cladograms based on synapomorphies. These principles can also be applied to constructing cladograms from DNA sequences.

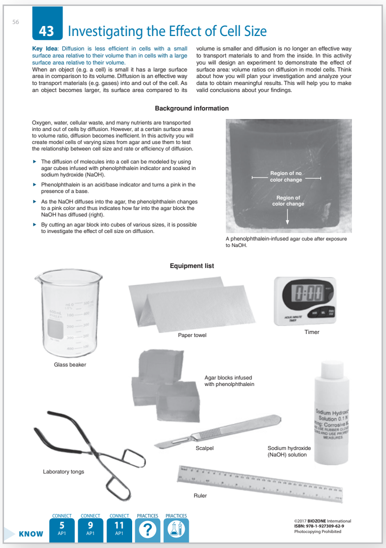
Where to next?

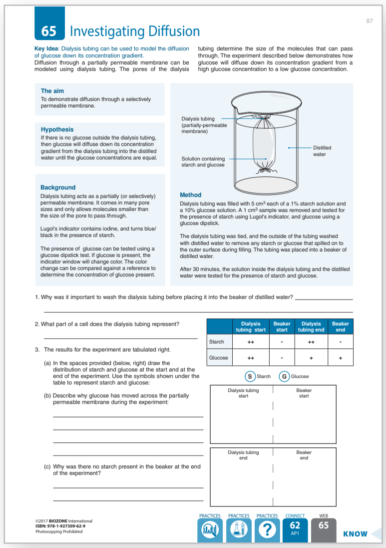
- Activity 256 (*Constructing a Cladogram*) could be set as a summative test.
- Students can apply the principles learned here to construct cladograms from BLAST gene analysis to determine relatedness.
- Carry out independent BLAST investigations on genes of interest (e.g. DNA polymerase gene).

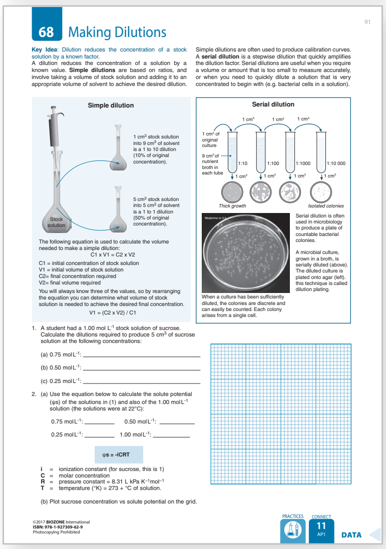
BIG IDEA 2: CELLULAR PROCESSES: ENERGY AND COMMUNICATION

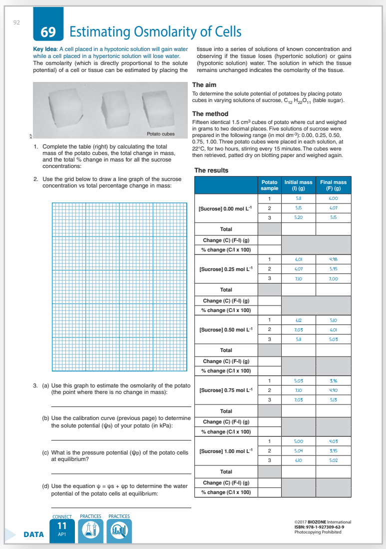
Investigation 4: Diffusion and Osmosis

It is recommended that students carry out all the activities in this series to cover the three procedures outlined for investigation 4. Students design an experiment using artificial cells to study the relationship between surface area and cell volume and make predictions about how these influence the rate of diffusion. The process and principles of diffusion are investigated across a partially-permeable membrane using dialysis tubing to simulate a plasma membrane. Lastly, students can apply their knowledge to a real life situation when they investigate osmosis in living cells using potato cubes.









Applications

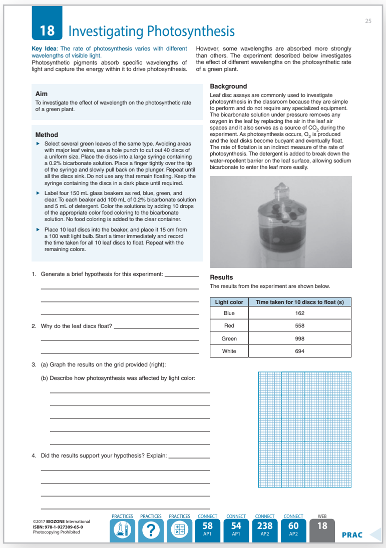
- Ideally each of these activities would be used to provide an introduction to the topic before the student carried out their own investigation. They also provide opportunities to practice the mathematical skills required to successfully complete the investigation.
- In activity 43 students plan their own experiment (with guidance) and consider what factors they must include to ensure valid and meaningful results are obtained.
- These activities could be used in place of carrying out a practical investigation if time is short. In addition,the data provided could be utilized by the students if their own experiment fails.

Where to next?

- Pose the following question to students "do fungal cells have turgor pressure?" The students can generate a hypothesis and then design an experiment to test their hypothesis. This could be carried out in small groups or by individuals. If time permits, they can carry out their experiment.

Investigation 5: Photosynthesis

The effect of light color on photosynthetic rate can be studied in green plants using the leaf disc assay. In this activity students are provided with an outline of the experimental method, background information about the leaf disc assay itself, and some data to analyze.


18 Investigating Photosynthesis

Light color	Time taken for 10 discs to float (s)
Blue	162
Red	558
Green	998
White	694

Applications

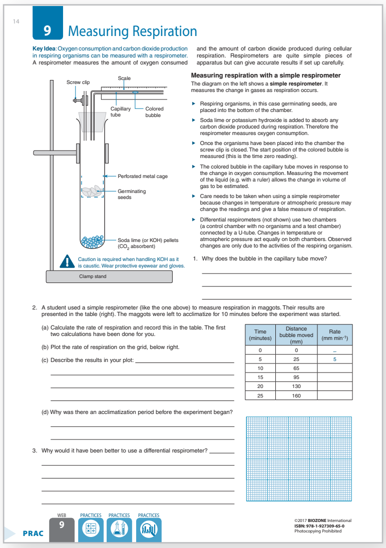
- Students can pose scientific questions regarding the effect of light color on photosynthetic rate.
- Students can practice the required graphing and data presentation skills.
- The second hand data provided can be used in the place of student data if their own experiment fails. Alternatively, it could be used as comparative data to see if the student's own work obtained similar results and used as a discussion point if the results differ.

Where to next?

- If equipment is available, the experiment could be repeated using an oxygen probe interfaced with a data logger to provided more accurate data on the photosynthetic rate.
- Students could pose questions about environmental conditions that might affect the results (e.g. high CO_2 environment) or physical differences in the leaves themselves that may affect the results (e.g. a hairy leaf compared to a smooth ivy leaf).

Investigation 6: Cellular Respiration

A respirometer is a simple piece of equipment and can be used to measure the rate of cellular respiration in organisms such as germinating seeds or small invertebrates (e.g. maggots). The simple respirometer described here measures oxygen consumption and uses this as a measure of cellular respiration. Students are provided with background information about how to set up use a respirometer and some second hand data to analyze.


9 Measuring Respiration

Time (minutes)	Distance bubble moved (mm)	Rate (mm min⁻¹)
0	0	–
5	25	5
10	65	
15	95	
20	130	
25	160	

Applications

- Using an example, students gain familiarity with the set up and consider the limitations of measuring cellular respiration with a simple respirometer. The activity provides background to help them design a good experiment of their own to collect valid data.
- Students can practice mathematical skills (calculation of rates) and graphing skills, both helpful for when they must transform and present their own data.

Where to next?

- If equipment was available, students could use gas sensor probes to measure oxygen consumption.
- Students could pose questions about what factors (e.g. temperature) might affect the rate of cellular respiration, and then go on to design and carry out further experiments if time allows.
- Studying invertebrates, the relationship between the mass of an organism and its rate of cellular respiration could be determined.

BIG IDEA 3: GENETICS AND INFORMATION TRANSFER

Investigation 7: Cell Division, Mitosis, and Meiosis

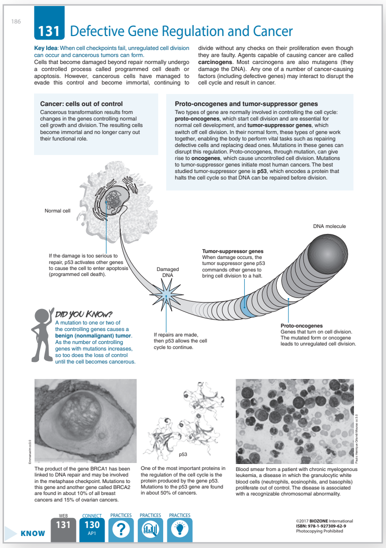
The activities listed here are designed to cover the first four procedures of investigation 7.
The *Modeling Mitosis* activity provides an alternative way for students to visualize and then summarize the steps of mitosis. Once the process is reinforced, students can investigate how environmental factors (e.g. the presence of lectin proteins) can influence the rate of mitosis in onion cells. Certain forms of leukemia produce abnormal karyograms containing Philadelphia chromosomes. These indicate a loss of normal cell cycle regulation. Students can compare normal and abnormal karyograms in activity 131. The last modeling activity in this series allows students to model the steps of meiosis. It reinforces the key features of meiotic division and helps to differentiate meiosis from mitosis.

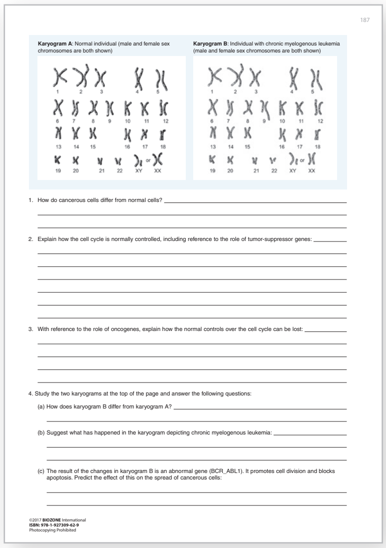
Applications

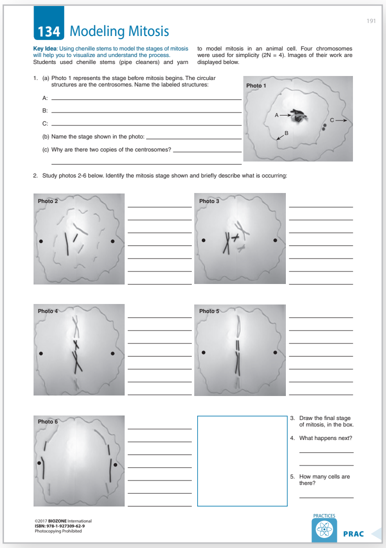
- Students gain experience in reading karyograms by comparing two karyograms to identify the presence of Philadelphia chromosomes. They must apply their knowledge of cell cycle regulation to determine why these abnormalities arise.
- Students can model the steps in *Modeling Mitosis* themselves using pipe cleaners and yarn to learn the phases of mitosis.
- Students are introduced to the Chi-squared test in an easy to use table format to determine if lectin protein influences rate of mitosis. They become familiar with its use for determining significance.
- *Modeling Meiosis* provides a chance for collaborative work and is an opportunity to pair students of different abilities together. Better able students will clarify their own understandings through explanation and the less able students improve their understanding through peer-to-peer interaction. Student's can investigate a trait of interest to themselves.

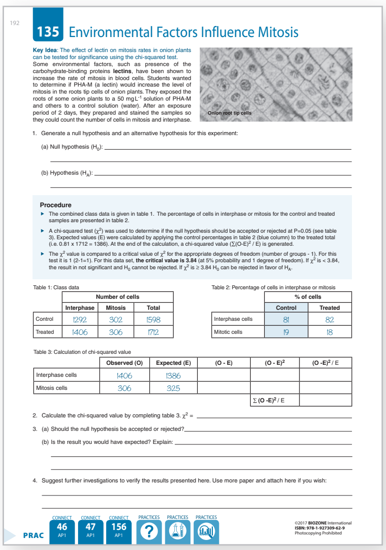
Where to next?

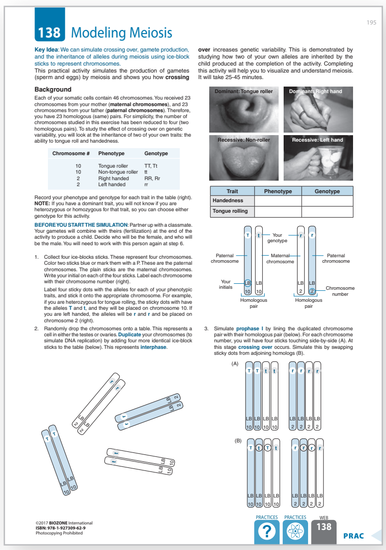
- Pairs of students could video and narrate models depicting mitosis and meiosis and share with the class.
- Students can research how certain cancers (e.g. human papillomavirus) affect the cell cycle and result in their proliferation. Alternatively, they could research the breast cancer genes (BRCA) to see how they affect the cell cycle.
- Ask students to discuss the role of crossing over in increasing genetic variation in individuals and populations. How much variability would there be without it? Students can construct models to visually show the differences.
- Students could work in groups and give short presentations about the how crossing over, independent assortment, segregation,non-disjunction, and random fertilization contribute to genetic diversity.
- Facilitate a discussion about how mutation contributes to genetic variability and how mutations can be caused by specific mutagens.





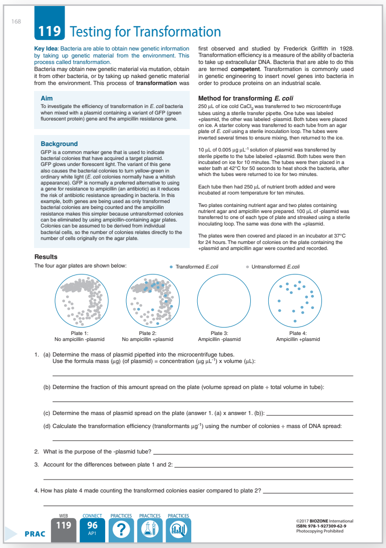






Investigation 8: Biotechnology: Bacterial Transformations

Students are introduced to the methods involved in bacterial transformation using the uptake of green fluorescent protein (gfp) and ampicillin genes by *E.coli* as an example.



Applications

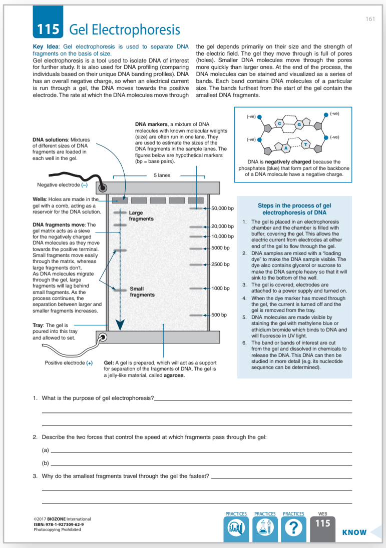
- This activity provides students with the background needed to understand how to carry out their own bacterial transformation.
- Targeted questions about the results require students to analyze the data and determine if the transformation has been successful.
- Students can practice the mathematical skills required to successfully complete this investigation (e.g. calculation of transformation efficiency).

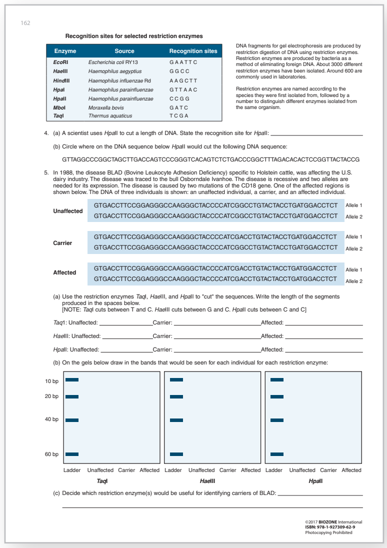
Where to next?

- Students can apply their theoretical knowledge of transformation to designing their own experiments and analyzing their results.
- Transformation can be explored in more depth. For example they may wish to investigate the ability of the transformed gene to induce mutation using an observable phenotype as the basis of their investigation. The effect of environment on transformation may also be explored.
- Students can research the ethical, social, or medical issues raised by transformation. Students can hold a debate or write a balanced article based on scientific fact surrounding the topic (e.g. are GM foods safe to eat?).

Investigation 9: Biotechnology: Restriction Enzyme Analysis of DNA

This activity provides background information on gel electrophoresis and restriction enzymes, two techniques students need to know about in order to complete investigation 9.





Applications

- This activity provides an introduction to gel electrophoresis and restriction enzymes. It provides students with the background knowledge they require before carrying out their own practical investigation.
- Students must make the connection that the properties of DNA (i.e. its overall negative charge) can be used to separate DNA via gel electrophoresis.
- A range of profiles produced using different restriction enzymes allows students to practice analyzing gels and reinforces that different restriction enzymes cut in different places.

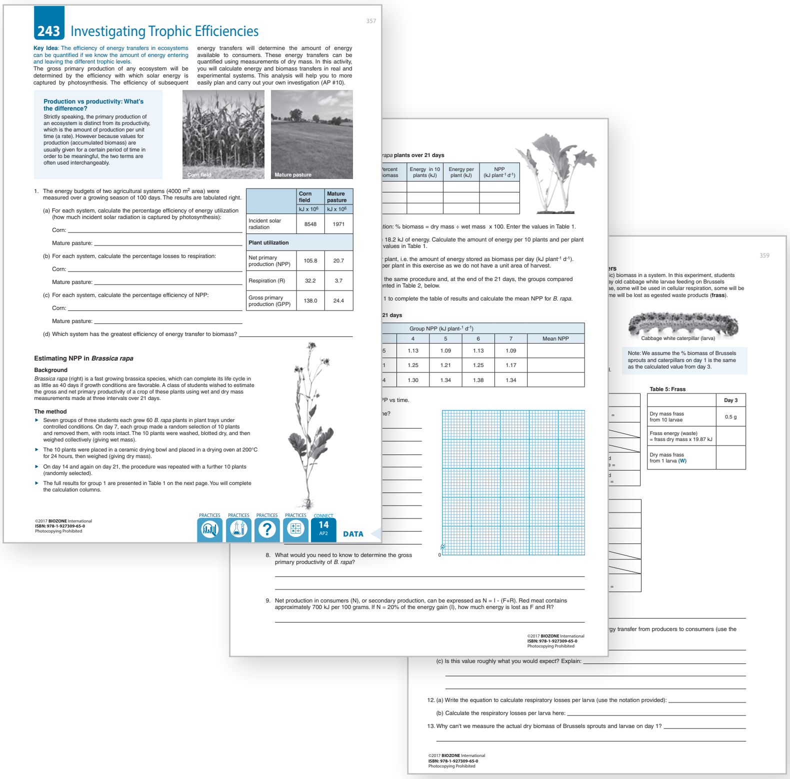
Where to next?

- Students can research the uses of these techniques. They should realize they are used for more than just crime scene analysis (e.g. determining the composition of food, tracing the source of food, determining paternity, and analyzing for the presence of an inherited disorder).
- This investigation provides an opportunity to discuss the social and ethical issues surrounding the technique.

BIG IDEA 4: INTERACTIONS

Investigation 10: Energy Dynamics

A simplified ecosystem model is presented for students to study energy dynamics in ecosystems. In the first part of this activity students calculate net primary productivity in fast growing *Brassica rapa* plants. The focus of the second part of the activity is on calculating the efficiency of energy transfer from producers to consumers.



Applications

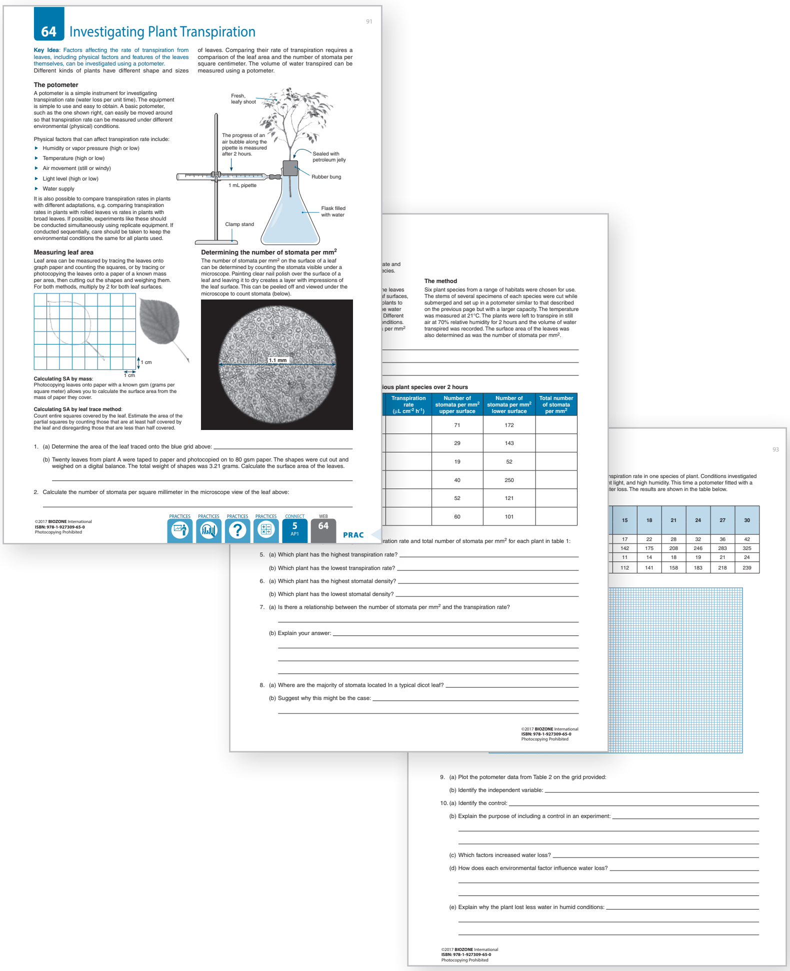
- The simplified ecosystem model provides students with ample opportunity to practice the mathematical calculations and data analysis required to complete their own investigation.
- If time is short, the data provided can be used in place of the student's own investigation, or if their own investigation fails (e.g. caterpillars or plants die).

Where to next?

- Students struggling with the concept could use an analogy, such as a simple financial budget, to help consolidate the principles. Money, like energy, is a limited commodity and must be budgeted to meet all our needs (e.g. what proportion is allocated to food, heating, etc).
- Students could manipulate the model system to determine how changes in the environment (e.g. increased temperature) affect energy flow.

Investigation 11: Transpiration

This activity prepares students to carry out their own investigation into plant transpiration. Introductory information is followed by two investigations. The first looks at the effect of stomatal density on transpiration rate. The second investigation looks at how environmental factors can effect transpiration rate in one species of plant.



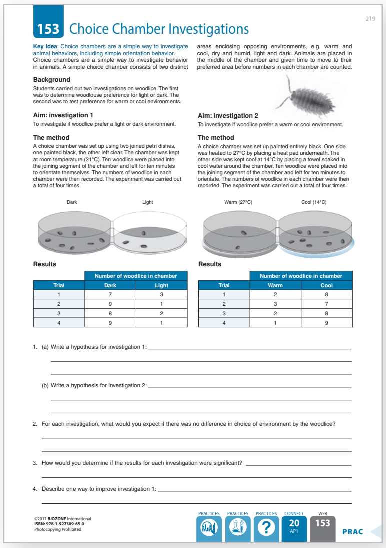
Applications

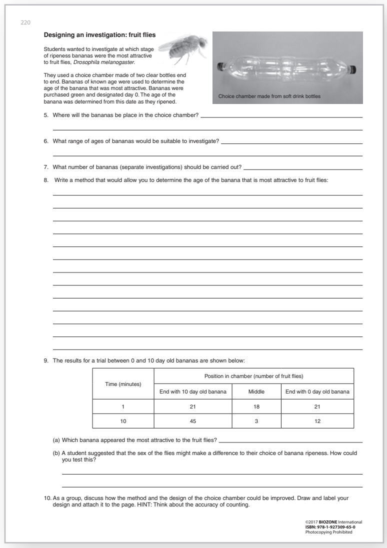
- Completing this activity will help students plan their own transpiration investigation; what questions do they need to ask, what equipment is needed, how will data be measured and recorded?
- Background information includes how to set up a potometer and calculation of stomatal density.
- Practice is gained over a range of skills including microscopy, measurement, mathematics, graphing, and data analysis.
- The data provided can be used in place of the student's own investigation, or if their own investigation fails to produce valid data.

Where to next?

- Students can revise their method and suggest how it could be improved.
- Students can make predictions about the transpiration rates of two different types of plant (e.g. xerophyte vs mesophyte) and design an experiment to test their hypothesis.
- Students can investigate how the opening and closing of stomata is controlled (e.g. role of potassium and abscisic acid).

Investigation 12: Fruit Fly Behavior





The background information in this activity introduces students to the concept of a choice chamber and how they can be used to test an organism's preference for certain environmental conditions. In the second part of the activity, a series of questions prompts students to think about how they would design their own choice chamber experiment to test fruit fly preference for banana at various stages of ripeness.

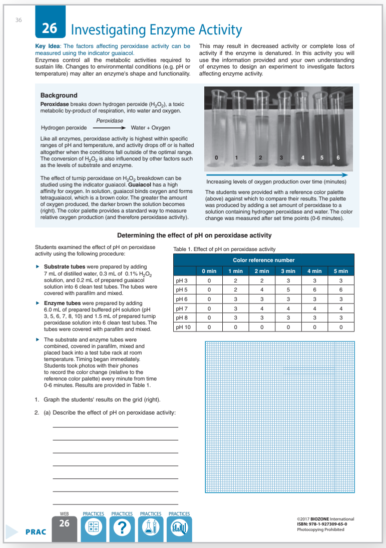
Applications

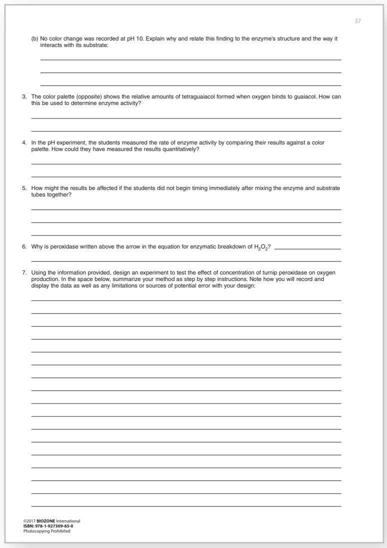
- Ideally this activity should be completed before students attempt their own investigation. It provides valuable insight into the design, set-up, and use of choice chambers, and prompts the students to consider possible challenges and how these can be overcome.
- The data provided allows students to practice analyzing results and understand their meaning.
- Students can use this activity to plan their own choice chamber investigation. The design can be peer reviewed and then approved by a teacher before it is carried out.

Where to next?

- Students can extend their skills by designing an investigation to test the behavior in another organism (e.g. mealworm, ladybug, or housefly). They can carry it out if time permits.

Investigation 13: Enzyme Activity





In this activity, students explore the influence of biotic and abiotic factors on the activity of turnip peroxidase. In the first section, students are provided with a guided example exploring the effect of pH on enzyme activity. They apply the knowledge gained from this (and their own understanding of enzyme activity) to design their own investigation.

Applications

- The guided example (effect of pH on turnip peroxidase activity) is intended as a guide for students planning their own investigation.
- The second hand data provides an opportunity to practice graphing and analytical skills.
- By analyzing the example, students are encouraged to think about how the method can be improved to obtain better results, and include the refinements in their own design.
- Students plan their own investigation to test the effect of enzyme concentration on reaction rate. This can be used as the basis for planning their own investigation. The experiment could be designed for other factors such as temperature and substrate concentration if desired.

Where to next?

- Students might want to research the literature about the optimal conditions for turnip peroxidase and compare these with their own results. Can they account for any differences?
- How do abiotic factors influence structural integrity? How does this affect functionality?
- How do biotic factors (e.g. inhibitors) influence peroxidase activity? How do these affect functionality?

Supporting Resources: Carolina Investigations® Series

- BIOZONE's student books for AP® Biology contain many activities designed to support the 13 practical investigations outlined in the 'AP® Biology Investigative Labs'.Their intention is to prepare students to design and carry out their own investigations, but they are not wet labs. However, BIOZONE's supporting partner, Carolina Biological Supply (www.carolina.com), provides a variety of tools and equipment to support the practical requirements of AP® Biology.

- The current AP® Biology program does not limit students to a specific set of investigations, so teachers can address the practical components of the course using labs that fit their classroom and their students' interests. Carolina offers unique kits and activities exclusively designed for the AP® curriculum. The Carolina Investigations® series is specifically aligned to the Big Ideas and Science Practices, and was built from the ground up with the help of expert AP® teachers. The kits are designed to meet the requirements of the new AP® Biology curriculum and focus on making inquiry in the classroom easier for students and teachers.

- Each kit features activities that allow students to take a guided approach to inquiry while building their science practices and connecting the Big Ideas. Each kit offers an initial skill-building activity that features a more traditional classroom approach, followed by a secondary investigation that utilizes a unique experimental design template to help guide invaluable student-driven, inquiry-based learning opportunities. For information, type the product code into the website's search function.

BIG IDEA 1: EVOLUTION

Carolina Investigations® for AP® Biology: Origin of Life

Students learn about various scientific models concerning the origin of life and then extend their knowledge through hands-on inquiry and exploration. This lab challenges students to explore the origin of life by creating coacervate-phospholipid vesicles similar to those created in the laboratory of Alexander Oparin in the 1920s. Students then design an additional experiment to investigate the impact of various environmental factors on coacervate formation and movement.

Item number: 747500

Carolina Investigations® for AP® Biology: Population Genetics and Evolution

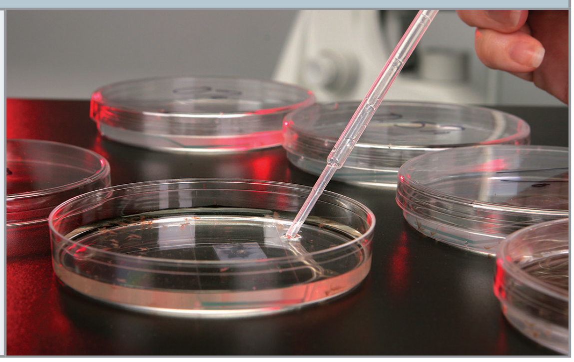
Using direct counting, students calculate the allele frequency of traits such as stem and leaf type in a population of Wisconsin Fast Plants®. They compare the results with the calculated allele frequency determined by applying the Hardy-Weinberg equilibrium model. Students then design their own experiment to prove the model.

Item number: 747510

Carolina Investigations® for AP® Biology: Natural Selection

Students investigate natural selection using brine shrimp. After quantifying brine shrimp hatch rates in environments of different salinity to determine viability, students investigate other environmental changes that might affect viability and change the population.

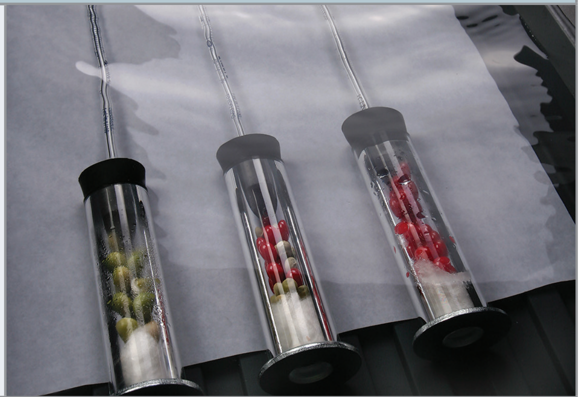
Item number: 747520



Carolina Investigations® for AP® Biology: Cell Respiration

Students construct respirometers to create closed systems for measuring relative oxygen consumption. They extend this learning into their own investigations, during which they can manipulate environmental variables and compare the respiration rates of various seeds.

Item number: 747600



Carolina Investigations® for AP® Biology: Transpiration

Students explore transpiration by using a potometer to measure water loss in bush bean seedlings. Then, to extend their new knowledge of transpiration, students design an investigation into the various environmental factors that affect plant transpiration rate.

Item number: 747610

Carolina Investigations® for AP® Biology: Plant Pigments and Photosynthesis

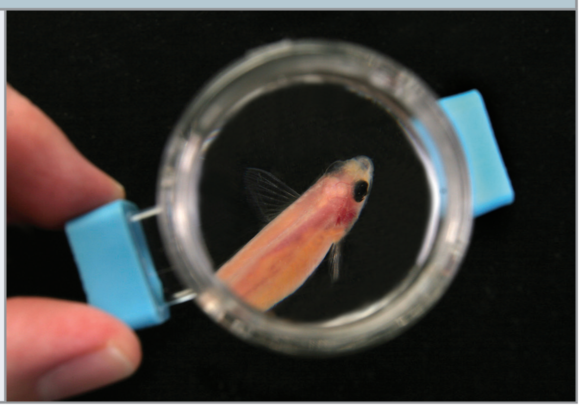
Understanding the process of photosynthesis and the pigments involved has never been easier. Using chromatography, students separate plant pigments from their own samples and then identify them based on R_f values. Continuing their exploration, students then study the impact of various environmental factors on the photosynthesis reaction rates in different plants using DPIP indicator solution and a spectrophotometer.

Item number: 747800

Carolina Investigations® for AP® Biology: Physiology of the Circulatory System

Students use *Daphnia* and Casper Fish™ to observe the differences between open and closed circulatory systems. In the inquiry activity, students monitor Daphnia's heart rate to investigate the organism's response to various environmental changes.

Item number: 747620



Carolina Investigations® for AP® Biology: Transformation

Students discover and explore the process of transformation, a key technique in genetic engineering. They perform a classic transformation activity, to build background knowledge regarding plasmid function, genotype/phenotype connection, and antibiotic resistance. Using proper sterile technique and inquiry, students then design a new experiment to distinguish between 3 different plasmids and determine their gene function.

Item number: 747730

Carolina Investigations® for AP® Biology: Electrophoresis and Simulated Genetic Screen

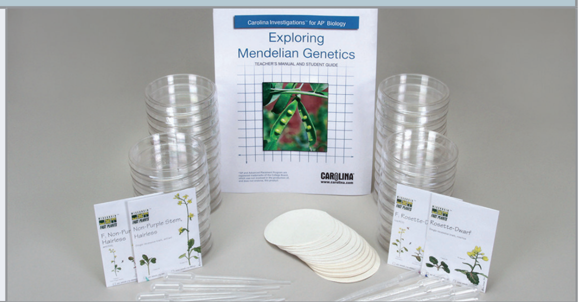
Students learn how to perform gel electrophoresis as they begin to understand the roles of restriction enzymes, genetic inheritance, and polymerase chain reaction (PCR) in this key genetic engineering process. Following their initial experimentation, students dive deeper into the activity by working to optimize the technique and completing a simulated genetic screen.

Item number: 747710

Carolina Investigations® for AP® Biology: Exploring Mendelian Genetics

Students uncover and experience the mechanism of Mendelian genetics hands on with Wisconsin Fast Plants®. Using Fast Plants® seedlings, students germinate F_1 and F_2 generations of a population to learn about the inheritance of traits, including stem color and length. After drawing conclusions about inheritance in the population, students are tasked with using inquiry to determine the genotype of an unknown sample of Fast Plants® seed.

Item number: 747720



Carolina Investigations® for AP® Biology: Cell Communication

Students put their microscopy skills to the test as they use sterile technique to investigate the life cycle of yeast cells. As they build an understanding of the yeast life cycle, they delve deeper into the process of yeast reproduction. Students then culture and mix 2 strains of yeast and observe the role pheromones play in the cell communication. Students further investigate mating pheromone communication by designing individual experiments using both a-factor and alpha-factor yeast cells.

Item number: 747740

Carolina Investigations® for AP® Biology: Quantitative Analysis and Statistics

This advanced kit, which reinforces data analysis, visualization, and statistical evaluation skills, is a great opener or end-of-year review for your AP® Biology class. The optional pre-lab inquiry, when students test a hypothesis during a demonstrated magic trick, emphasizes to students the value of statistics when applied to hypothesis testing. Next, students complete any or all of 3 guided-inquiry-based activities, using genetic corn to reinforce Mendelian genetics and chi-square test for fit.

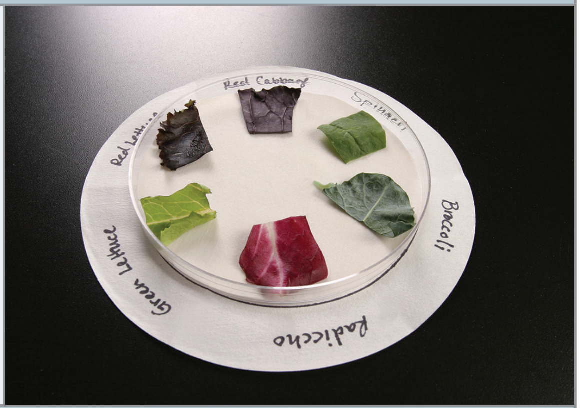
Item number: 747805

BIG IDEA 4: INTERACTIONS

Carolina Investigations® for AP® Biology: Animal Behavior

Students set up a choice experiment to determine the food preferences of *Brassica* larvae. Results are collected and quantified, and their significance is determined using chi-square analysis. Applying these techniques, students pose proximate and ultimate questions about other *Brassica* larvae behaviors and design an experiment to answer the questions.

Item number: 747700



Carolina Investigations® for AP® Biology: Species Interactions

Help your students make a big picture connection across communities and populations by characterizing food webs and other factors, such as predation and abiotic factors. Students master the Winkler titration method for measuring dissolved oxygen concentrations. Using this tool, they measure dissolved oxygen fluctuations to assess the relationships between species in an aquatic food chain (*Daphnia*, *Chlorella*, and *Hydra*). After understanding the dynamics of the aquatic food chain, students introduce new variables to design their own experiment using the producers and consumers

Item number: 747810

Carolina Investigations® for AP® Biology: Evolving Enzymes

Students explore in-depth the interactions of enzymes and substrates through this hands-on activity that helps them understand enzyme kinetics. After investigating the relationship between enzymes and substrates, students conduct a bioinformatics analysis to explore the evolutionary relationship of catalase in 4 different species. Combining their earlier lab experiences, students then design their own investigations focused on exploring the impacts of environmental conditions on catalase and/or the activity of catalase from various enzyme sources.

Item number: 747820

Carolina Investigations® for AP® Biology: Primary Consumer Energy Flow

As an alternative to measuring energy flow through primary productivity, students measure the transfer of energy at a higher trophic level and modify environmental conditions to explore their effects on energy consumption. In this lab, *Vanessa cardui* (painted lady butterfly) larvae, representing a primary consumer, feed on a growth medium that represents a primary producer. Students investigate how efficiently developing butterflies convert food into body mass. They then analyze results, calculate efficiency, and build food chains by constructing ecological pyramids.

Item number: 181079

Addressing the Science Practices

The AP Biology Science Practices are addressed in context throughout AP Biology 1 & 2. As students progress through their program of work, they can identify the Science Practices associated with each activity by the picture tab system at the bottom of the activity page. Activities relating to the specific Science Practices are identified in the tables on the following pages.

PRACTICES

SCIENCE PRACTICE 1

Use representations and models to communicate scientific phenomena and solve scientific problems. Includes creating, describing, refining, and using representations and models of natural or man-made phenomena and systems.

Practice number	Practice description	Activity number in AP1	Activity number in AP2
1.1	The student can *create representations* and models of natural or man-made phenomena and systems in the domain.	66, 77, 100, 138, 145, 174, 189, 240, 256	125, 126, 132, 178, 180-181, 210, 212, 226
1.2	The student can *describe representations* and models of natural or man-made phenomena and systems in the domain.	2, 28, 40, 51, 52, 54, 77,100, 104, 106, 129, 154, 179, 264, 277, 278	21, 125, 126, 132, 166 (bonus content), 178, 185-186, 205, 208, 210, 212, 226, 259
1.3	The student can *refine representations* and models of natural or man-made phenomena and systems in the domain.	66, 210	21, 23, 104, 190, 210, 226, 241, 259-260
1.4	The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively.	51, 52, 54, 66, 72, 77, 100, 134, 138, 169, 172, 176, 179, 197, 210, 248	5, 6, 107, 205, 208, 210, 212, 226, 241, 259-260
1.5	The student can *reexpress key elements* of natural phenomena across multiple representations in the domain.	77, 106, 179, 213	93, 135, 157, 213, 236, 237, 248, 249, 266, 274

PRACTICES

SCIENCE PRACTICE 2

Use mathematics appropriately, including justifying the use of mathematical routines, applying mathematical routines, and making numerical estimates.

Practice number	Practice description	Activity number in AP1	Activity number in AP2
2.1	The student can *justify the selection* of a mathematical routine to solve problems.	8, 16, 20, 49, 211-213, 223	11, 18, 26, 197, 203
2.2	The student can *apply mathematical routines* to quantities that describe natural phenomena.	3, 6-10,16-19, 42-43, 48-49, 67, 69, 156-157, 184-185, 211-213, 215, 221, 223, 235	9, 11, 23, 32-33, 64, 105, 114, 194, 197-198, 200-203, 205, 207-208, 212-213, 226, 229, 239, 241, 243, 256-257, 271
2.3	The student can *estimate numerically quantities* that describe natural phenomena.	6	23, 208

PRACTICES

SCIENCE PRACTICE 3

Engage in scientific questioning to extend thinking or to guide investigations, including posing, refining, and evaluating scientific questions.

Practice number	Practice description	Activity number in AP1	Activity number in AP2
3.1	The student can *pose scientific questions.*	1, 43, 63, 79, 122, 135, 138, 162, 185, 250, 254	18, 64, 153
3.2	The student can *refine scientific questions.*	38, 115,135, 185, 229	26,153, 225, 229, 259
3.3	The student can *evaluate scientific questions.*	38, 43, 63, 65, 100, 115, 119, 122-125, 131, 135, 138, 185, 229, 276, 278	18, 26, 64, 153, 201, 241, 243, 258-260

PRACTICES

SCIENCE PRACTICE 4

Plan and implement data collection strategies appropriate to a particular scientific question. Includes posing, refining, and evaluating scientific questions as well as drawing conclusions from the experimental results of other scientists.

Practice number	Practice description	Activity number in AP1	Activity number in AP2
4.1	The student can *justify the selection of the kind of data* needed to answer a particular scientific question.	4, 45, 47, 96-97, 115, 126, 229, 278	139, 140, 201
4.2	The student can *design a plan* for collecting data to answer a particular scientific question.	4, 11, 38, 43, 46, 63, 115, 126, 229	26, 139, 153, 201
4.3	The student can *collect data* to answer a particular scientific question.	43, 63, 118, 229	153
4.4	The student can *evaluate sources of data* to answer a particular scientific question.	5, 38, 60, 63, 65, 68-69, 96-97,103, 115, 119, 135, 229, 276-278	8, 18, 26, 65, 139-140, 153, 201, 225, 229, 243

PRACTICES

SCIENCE PRACTICE 5

Perform data analysis and evaluation of evidence, including analyzing data to identify patterns or relationships and evaluating evidence provided by data in relation to a particular question.

Practice number	Practice description	Activity number in AP1	Activity number in AP2
5.1	The student can *analyze data* to identify patterns and relationships.	12-20, 63-65, 69, 97, 119, 135, 143, 184-185, 213, 215, 217, 229, 234, 236-237, 240, 242-244, 256-257, 263	9, 11, 25, 26, 32-34, 39-40, 64, 101, 105, 146-147, 151, 153, 160, 171, 177, 188, 203-205, 208, 210-213, 216, 224, 226-227, 229-230, 243, 250, 258, 264-266, 268, 271-272
5.2	The student can *refine observations and measurements* based on data analysis.	38, 60, 97, 229	9, 26, 153, 210, 226, 229
5.3	The student can evaluate the *evidence provided by data sets* in relation to a particular scientific question.	18-19, 60, 63-65, 69, 97, 103, 119, 130-131,135,143, 184-185, 213, 215, 217, 229, 234, 240, 242-248, 255-257, 263, 267	9, 26, 40, 45, 64, 139-140, 153, 156, 210, 216, 224, 226, 229, 243, 258, 268

PRACTICES

SCIENCE PRACTICE 6

Work with scientific explanations and theories, including justifying claims with evidence, constructing explanations and making claims and predictions about natural phenomena.

Practice number	Practice description	Activity number in AP1	Activity number in AP2
6.1	The student can *justify claims with evidence*.	32, 60, 89, 103, 171, 184, 185, 217, 221, 250-251, 277-278	13, 64, 139-140, 188, 229
6.2	The student can *construct explanations of phenomena based on evidence* produced through scientific practices.	41-43, 60-61, 64, 79, 97, 103, 111, 112, 129, 135, 144, 173, 183, 190, 191, 193, 197, 199, 201, 203, 217, 278	2, 5, 6, 8, 14, 32, 63, 105, 117, 139-141, 178-183, 188, 229, 258, 260
6.3	The student can *articulate the reasons that scientific explanations and theories are refined or replaced*.	60, 97, 103, 205, 216, 250, 278	140, 229, 259-260, 262, 268
6.4	The student can *make claims and predictions about natural phenomena* based on scientific theories and models.	28, 40, 64, 73, 97, 103, 110, 129, 236, 144, 183, 193, 206, 214, 216, 217, 221-223, 250, 251, 265-267, 272, 277	8, 13, 42-43, 45, 60, 64, 139-141, 180, 182, 188, 229, 250, 252, 254, 257-259
6.5	The student can *evaluate alternative scientific explanations*.	62, 63, 97, 103, 147-150, 153-155, 159-160, 164, 166, 167, 216, 276	229, 260

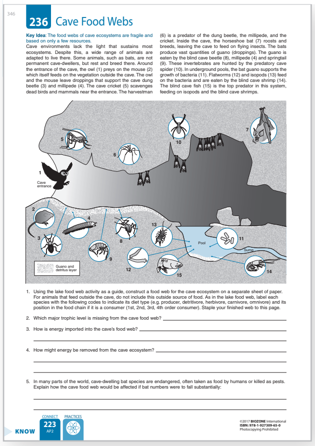
PRACTICES

SCIENCE PRACTICE 7

Connect and relate knowledge across various scales, concepts, and representations in and across domains. Includes connecting phenomena and models across scales such as time, size, and complexity, and describing how enduring understandings and/or big ideas are connected.

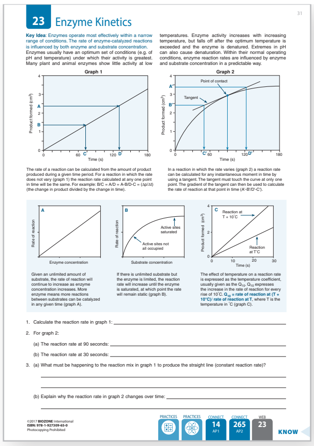
Practice number	Practice description	Activity number in AP1	Activity number in AP2
7.1	The student can *connect phenomena and models* across spatial and temporal scales.	22, 28, 40, 42, 73-74, 78-80, 92, 94, 110, 137, 142, 162, 167, 169-172, 174, 176-177, 182, 187, 196-197, 202, 207-208, 217, 220-223, 228, 236, 238, 242-245, 251, 256-257, 262, 267, 270-272	13, 28, 30, 41-42, 63, 79, 83-84, 89, 94, 96, 100-101, 115, 120, 122, 136, 161-162, 168, 169, 174, 175, 178, 180, 183, 206, 216, 218-223, 226, 229, 245-247, 253, 261
7.2	The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.	21-23, 27-28, 31-32, 34-35, 39-40, 42, 59, 62, 66-67, 73-74, 78-87, 92-95, 110, 130-131, 142, 144, 162, 167, 169-178, 182, 187, 189, 196-197, 202, 207-208, 217, 220-223, 228, 236, 238, 242-245, 251, 256-257, 262-263, 267, 270-272, 274	3-4, 8, 13, 28-30, 41-42, 61, 63, 67, 76-77, 79, 83-84, 87-89, 94, 96, 100-101, 115, 118, 120, 122, 126, 131, 136, 161-162, 169, 180, 182, 201, 206, 216, 218-223, 226, 229, 245-247, 253, 261

PRACTICES



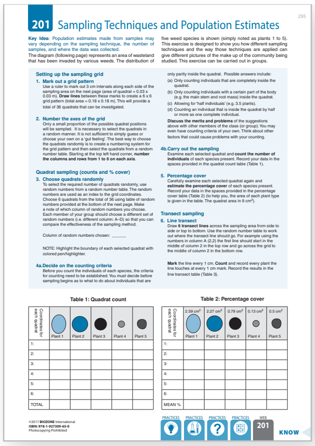
Reexpress the information provided as a diagram.

PRACTICES



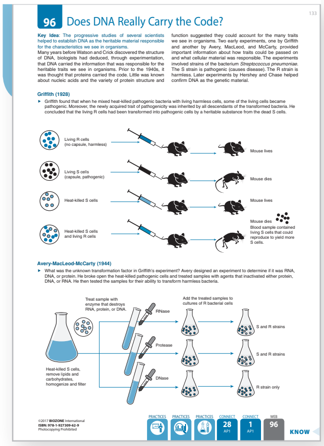
Apply a mathematical routine to determine reaction rate and Q_{10}.

PRACTICES



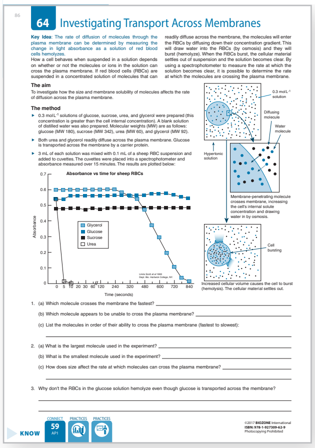
Evaluate scientific questions about sampling techniques.

PRACTICES



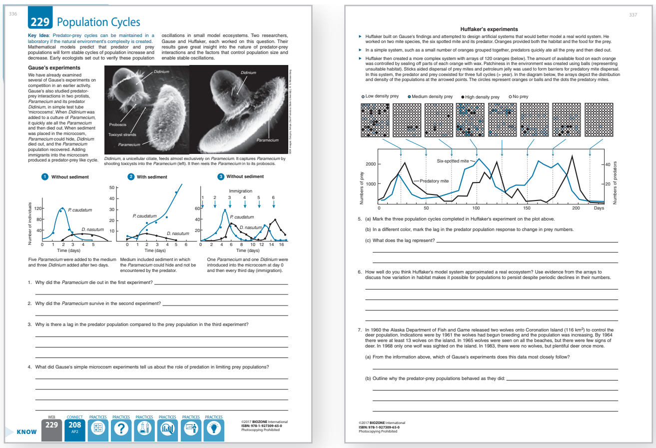
Evaluate data from experiments investigating scientific questions.

PRACTICES



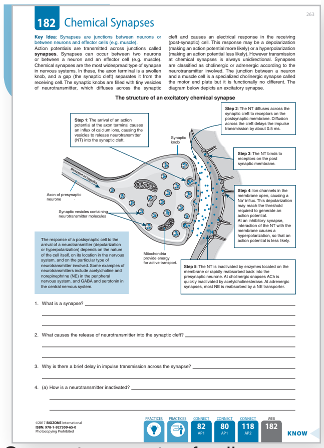
Evaluate the results of an investigation of cellular transport.

PRACTICES



Using the presented results of several key historical investigations to explain phenomena and understand how explanations are refined.

PRACTICES



Connect concepts of cell signaling across domains.

Addressing Student Learning Objectives

The Learning Objectives for AP Biology are summarized below together with the activities through which they can be wholly or partly met. In some cases, Learning Objectives are met though an instructional sequence of several related activities. The activities identified support the student's achievement of the learning objective directly (e.g. require the student to evaluate evidence provided by data) or sometimes indirectly (e.g. by providing the background to enable the student to pose a scientific question or design a plan to collect data, which may not be required of them in the activity *per se*.). It is BIOZONE's plan to extend this support of Learning Objectives further in our print and online resources.

BIG IDEA 1: The process of evolution drives the diversity and unity of life				
Enduring Understanding 1A: Change in the genetic makeup of a population over time is evolution				
	Learning Objectives	**SP**	**EK**	**Activities**
1.1	The student is able to convert a data set from a table of numbers that reflect a change in the genetic makeup of a population over time and to apply mathematical methods and conceptual understandings to investigate the cause(s) and effect(s) of this change.	1.5 2.2	1A1	213, 215, 229
1.2	The student is able to evaluate evidence provided by data to qualitatively and quantitatively investigate the role of natural selection in evolution.	2.2 5.3	1A1	213-220
1.3	The student is able to apply mathematical methods to data from a real or simulated population to predict what will happen to the population in the future.	2.2	1A1	211, 213, 216, 219-223
1.4	The student is able to evaluate data-based evidence that describes evolutionary changes in the genetic makeup of a population over time.	5.3	1A2	213, 215, 218, 226, 229
1.5	The student is able to connect evolutionary changes in a population over time to a change in the environment.	7.1	1A2	217, 220, 236, 238, 244-247
1.6	The student is able to use data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and effects of selection in the evolution of populations.	1.4 2.1	1A3	212-213, 223
1.7	The student is able to justify data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and the effects of selection in the evolution of specific populations.	2.1	1A3	212-213, 223
1.8	The student is able to make predictions about the effects of genetic drift, migration and artificial selection on the genetic makeup of a population.	6.4	1A3	221-224, 226-229
1.9	The student is able to evaluate evidence provided by data from many scientific disciplines that support biological evolution.	5.3	1A4	234, 240-248
1.10	The student is able to refine evidence based on data from many scientific disciplines that support biological evolution.	5.2	1A4	231-249
1.11	The student is able to design a plan to answer scientific questions regarding how organisms have changed over time using information from morphology, biochemistry and geology.	4.2	1A4	247, 248
1.12	The student is able to connect scientific evidence from many scientific disciplines to support the modern concept of evolution.	7.1	1A4	231-249
1.13	The student is able to construct and/or justify mathematical models, diagrams or simulations that represent processes of biological evolution.	1.1 2.1	1A4	240
Enduring Understanding 1B: Organisms are linked by lines of descent from common ancestry				
1.14	The student is able to pose scientific questions that correctly identify essential properties of shared, core life processes that provide insights into the history of life on Earth.	3.1	1B1	250
1.15	The student is able to describe specific examples of conserved core biological processes and features shared by all domains or within one domain of life, and how these shared, conserved core processes and features support the concept of common ancestry for all organisms.	7.2	1B1	251
1.16	The student is able to justify the scientific claim that organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.	6.1	1B1	250-251
1.17	The student is able to pose scientific questions about a group of organisms whose relatedness is described by a phylogenetic tree or cladogram in order to (1) identify shared (derived) characteristics, (2) make inferences about the evolutionary history of the group, and (3) identify character data that could extend or improve the phylogenetic tree.	3.1	1B2	252-256
1.18	The student is able to evaluate evidence provided by a data set in conjunction with a phylogenetic tree or a simple cladogram to determine evolutionary history and speciation.	5.3	1B2	254-256
1.19	The student is able create a phylogenetic tree or simple cladogram that correctly represents evolutionary history and speciation from a provided data set.	1.1	1B2	256
Enduring Understanding 1C: Life continues to evolve within a changing environment				
1.20	The student is able to analyze data related to questions of speciation and extinction throughout the Earth's history.	5.1	1C1	257
1.21	The student is able to analyze data related to questions of speciation and extinction throughout the Earth's history.	4.2	1C1	257, 263, 265-272, 274

1.22	The student is able to use data from a real or simulated population(s), based on graphs or models of types of selection, to predict what will happen to the population in the future.	6.4	1C2	265-267
1.23	The student is able to justify the selection of data that address questions related to reproductive isolation and speciation.	4.1	1C2	258-263
1.24	The student is able to describe speciation in an isolated population and connect it to change in gene frequency, change in environment, natural selection and/or genetic drift.	7.2	1C2	263
1.25	The student is able to describe a model that represents evolution within a population.	1.2	1C3	244, 263-264
1.26	The student is able to evaluate given data sets that illustrate evolution as an ongoing process.	5.3	1C3	244, 263, 265-267
Enduring Understanding 1D: The origin of living systems is explained by natural processes				
1.27	The student is able to describe a scientific hypothesis about the origin of life on Earth.	1.2	1D1	276-278
1.28	The student is able to evaluate scientific questions based on hypotheses about the origin of life on Earth	3.3	1D1	276-278
1.29	The student is able to describe the reasons for revisions of scientific hypotheses of the origin of life on Earth.	6.3	1D1	276-278
1.30	The student is able to evaluate scientific hypotheses about the origin of life on Earth.	6.5	1D1	276
1.31	The student is able to evaluate the accuracy and legitimacy of data to answer scientific questions about the origin of life on Earth.	4.4	1D1	276-278
1.32	The student is able to justify the selection of geological, physical, and chemical data that reveal early Earth conditions.	4.1	1D2	278
BIG IDEA 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis				
Enduring Understanding 2A: Growth, reproduction and maintenance of the organization of living systems require free energy and matter				
2.1	The student is able to explain how biological systems use free energy based on empirical data that all organisms require constant energy input to maintain organization, to grow and to reproduce.	6.2	2A1	1-2, 32
2.2	The student can justify a scientific claim that free energy is required for living systems to maintain organization, to grow or to reproduce, but that multiple strategies exist in different living systems.	6.1	2A1	1-2, 32, 34-36
2.3	The student is able to predict how changes in free energy availability affect organisms, populations and ecosystems.	6.4	2A1	2, 32, 34-39
2.4	The student is able to use representations to pose scientific questions about what mechanisms and structural features allow organisms to capture, store, and use free energy.	1.4 3.1	2A2	2, 5, 10, 14, 32-39
2.5	The student is able to construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy.	6.2	2A2	2, 5, 8, 10, 14
2.41	The student is able to evaluate data to show the relationship between photosynthesis and respiration in the flow of free energy through a system.	5.3 7.1	2A2	2, 5
2.6	The student is able to use calculated surface area-to-volume ratios to predict which cell(s) might eliminate wastes or procure nutrients faster by diffusion.	2.2	2A3	41-43
2.7	Students will be able to explain how cell size and shape affect the overall rate of nutrient intake and the rate of waste elimination.	6.2	2A3	41-43
2.8	The student is able to justify the selection of data regarding the types of molecules that an animal, plant or bacterium will take up as necessary building blocks and excrete as waste products.	4.1	2A3	21, 24, 25
2.9	The student is able to represent graphically or model quantitatively the exchange of molecules between an organism and its environment, and the subsequent use of these molecules to build new molecules that facilitate dynamic homeostasis, growth and reproduction.	1.1 1.4	2A3	25
Enduring Understanding 2B: Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.				
2.10	The student is able to use representations and models to pose scientific questions about the properties of cell membranes and selective permeability based on molecular structure.	1.4 3.1	2B1	59-60, 63-66
2.11	The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function.	1.1 7.1 7.2	2B1	63-66
2.12	The student is able to use representations and models to analyze situations or solve problems qualitatively and quantitatively to investigate whether dynamic homeostasis is maintained by the active movement of molecules across membranes.	1.4	2B2	63-66, 71-74
2.13	The student is able to explain how internal membranes and organelles contribute to cell functions.	6.2	2B3	51-58, 61
2.14	The student is able to use representations and models to describe differences in prokaryotic and eukaryotic cells.	1.2 1.4	2B3	51, 52, 54
Enduring Understanding 2C: Organisms use feedback mechanisms to regulate growth and reproduction, and maintain dynamic homeostasis				
2.15	The student can justify a claim made about the effect(s) on a biological system at the molecular, physiological or organismal level when given a scenario in which one or more components within a negative regulatory system is altered.	6.1	2C1	41, 43-49

2.16	The student is able to connect how organisms use negative feedback to maintain their internal environments.	7.2	2C1	41, 43-45, 47-49
2.17	The student is able to evaluate data that show the effect(s) of changes in concentrations of key molecules on negative feedback mechanisms.	5.3	2C1	45
2.18	The student can make predictions about how organisms use negative feedback mechanisms to maintain their internal environments.	6.4	2C1	41, 43-45, 47-49
2.19	The student is able to make predictions about how positive feedback mechanisms amplify activities and processes in organisms based on scientific theories and models.	6.4	2C1	42-43, 50
2.20	The student is able to justify that positive feedback mechanisms amplify responses in organisms.	6.1	2C1	42-43, 50
2.21	The student is able to justify the selection of the kind of data needed to answer scientific questions about the relevant mechanism that organisms use to respond to changes in their external environment.	4.1	2C2	44-45, 136-148
2.42	The student is able to pose a scientific question concerning the behavioral or physiological response of an organism to a change in its environment.	3.1	2C2	151-153
Enduring Understanding 2D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment				
2.22	The student is able to refine scientific models and questions about the effect of complex biotic and abiotic interactions on all biological systems, from cells and organisms to populations, communities and ecosystems	1.3 3.2	2D1	18, 23, 193, 217, 220-225, 227, 229
2.23	The student is able to design a plan for collecting data to show that all biological systems (cells, organisms, populations, communities and ecosystems) are affected by complex biotic and abiotic interactions.	4.2 7.2	2D1	197-203
2.24	The student is able to analyze data to identify possible patterns and relationships between a biotic or abiotic factor and a biological system (cells, organisms, populations, communities or ecosystems).	5.1	2D1	203
2.25	The student can construct explanations based on scientific evidence that homeostatic mechanisms reflect continuity due to common ancestry and/or divergence due to adaptation in different environments.	6.2	2D2	59-63, 68-93, 98, 101-105, 117
2.26	The student is able to analyze data to identify phylogenetic patterns or relationships, showing that homeostatic mechanisms reflect both continuity due to common ancestry and change due to evolution in different environments.	5.1	2D2	61, 68, 70-72, 75-92, 95, 101
2.27	The student is able to connect differences in the environment with the evolution of homeostatic mechanisms.	7.1	2D2	61, 68-92, 101
2.28	The student is able to use representations or models to analyze quantitatively and qualitatively the effects of disruptions to dynamic homeostasis in biological systems.	1.4	2D3	47, 48, 106, 120, 133-134
2.29	The student can create representations and models to describe immune responses.	1.1 1.2	2D4	128, 130-132
2.30	The student can create representations or models to describe nonspecific immune defenses in plants and animals.	1.1 1.2	2D4	124-126
2.43	The student is able to connect the concept of cell communication to the functioning of the immune system.	7.2	2D4	126, 130, 133 also 80-81
Enduring Understanding 2E: Many biological processes involved in growth, reproduction, and dynamic homeostasis include temporal regulation and coordination				
2.31	The student can connect concepts in and across domains to show that timing and coordination of specific events are necessary for normal development in an organism and that these events are regulated by multiple mechanisms.	7.2	2E1	169-177
2.32	The student is able to use a graph or diagram to analyze situations or solve problems (quantitatively or qualitatively) that involve timing and coordination of events necessary for normal development in an organism.	1.4	2E1	170-173, 175-176
2.33	The student is able to justify scientific claims with scientific evidence to show that timing and coordination of several events are necessary for normal development in an organism and that these events are regulated by multiple mechanisms.	6.1	2E1	170-176
2.34	The student is able to describe the role of programmed cell death in development and differentiation, the reuse of molecules, and the maintenance of dynamic homeostasis.	7.1	2E1	130-131, 177
2.35	The student is able to design a plan for collecting data to support the scientific claim that the timing and coordination of physiological events involve regulation.	4.2	2E2	140, also 173
2.36	The student is able to justify scientific claims with evidence to show how timing and coordination of physiological events involve regulation.	6.1	2E2	136, 139-141, 144-147
2.37	The student is able to connect concepts that describe mechanisms that regulate the timing and coordination of physiological events.	7.2	2E2	136-149, 170-176
2.38	The student is able to analyze data to support the claim that responses to information and communication of information affect natural selection.	5.1	2E3	137, 141, 144, 147-152, 156-164 also 170, 173-177

2.39	The student is able to justify scientific claims, using evidence, to describe how timing and coordination of behavioral events in organisms are regulated by several mechanisms.	6.1	2E3	139-144, 147, 148, 156-159
2.40	The student is able to connect concepts in and across domain(s) to predict how environmental factors affect responses to information and change behavior.	7.2	2E3	151-153, 156-157
BIG IDEA 3: Living systems store, retrieve, transmit, and respond to information essential to life processes				
Enduring Understanding 3A: Heritable information provides for continuity of life				
3.1	The student is able to construct scientific explanations that use the structures and mechanisms of DNA and RNA to support the claim that DNA and, in some cases, that RNA are the primary sources of heritable information.	6.2 6.5	3A1	96-98, 100, 103
3.2	The student is able to justify the selection of data from historical investigations that support the claim that DNA is the source of heritable information.	4.1	3A1	96-97
3.3	The student is able to describe representations and models that illustrate how genetic information is copied for transmission between generations.	1.2	3A1	100-103
3.4	The student is able to describe representations and models illustrating how genetic information is translated into polypeptides	1.2	3A1	104-109
3.5	The student can justify the claim that humans can manipulate heritable information by identifying at least two commonly used technologies	6.2 6.4	3A1	111-126
3.6	The student can predict how a change in a specific DNA or RNA sequence can result in changes in gene expression.	6.4	3A1	105, 110
3.7	The student can make predictions about natural phenomena occurring during the cell cycle	6.2 6.5	3A2	129
3.8	The student can describe the events that occur in the cell cycle.	1.2	3A2	129
3.9	The student is able to construct an explanation, using visual representations or narratives, as to how DNA in chromosomes is transmitted to the next generation via mitosis, or meiosis followed by fertilization.	6.2	3A2	132-139
3.10	The student is able to represent the connection between meiosis and increased genetic diversity necessary for evolution	7.1	3A2	137
3.11	The student is able to evaluate evidence provided by data sets to support the claim that heritable information is passed from one generation to another generation through mitosis, or meiosis followed by fertilization.	5.3	3A2	143
3.12	The student is able to construct a representation that connects the process of meiosis to the passage of traits from parent to offspring.	1.1 7.2	3A3	144-145
3.13	The student is able to pose questions about ethical, social or medical issues surrounding human genetic disorders.	3.1	3A3	162-163
3.14	The student is able to apply mathematical routines to determine Mendelian patterns of inheritance provided by data sets.	2.2	3A3	156-158
3.15	The student is able to explain deviations from Mendel's model of the inheritance of traits.	6.2 6.5	3A4	147-150, 153-155, 159-160, 164, 166-167
3.16	The student is able to explain how the inheritance patterns of many traits cannot be accounted for by Mendelian genetics.	6.3	3A4	147-150, 153-155, 159-160, 164, 166-167
3.17	The student is able to describe representations of an appropriate example of inheritance patterns that cannot be explained by Mendel's model of the inheritance of traits.	1.2	3A4	153-155, 166-167
Enduring Understanding 3B: Expression of genetic information involves cellular and molecular mechanisms				
3.18	The student is able to describe the connection between the regulation of gene expression and observed differences between different kinds of organisms	7.1	3B1	171-176, also 243
3.19	The student is able to describe the connection between the regulation of gene expression and observed differences between individuals in a population.	7.1	3B1	171-176, also 243
3.20	The student is able to explain how the regulation of gene expression is essential for the processes and structures that support efficient cell function.	6.2	3B1	173
3.21	The student can use representations to describe how gene regulation influences cell products and function.	1.4	3B1	169-173
3.22	The student is able to explain how signal pathways mediate gene expression, including how this process can affect protein production.	6.2	3B2	169, 172-173 also 77, 79, 82-83
3.23	The student can use representations to describe mechanisms of the regulation of gene expression.	1.4	3B2	172-173, 178-180
Enduring Understanding 3C: The processing of genetic information is imperfect and is a source of genetic variation				
3.24	The student is able to predict how a change in genotype, when expressed as a phenotype, provides a variation that can be subject to natural selection.	6.4 7.2	3C1	182-183
3.25	The student can create a visual representation to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced.	1.1	3C1	187, 189

3.26	The student is able to explain the connection between genetic variations in organisms and phenotypic variations in populations.	7.2	3C1	187-197
3.27	The student is able to compare and contrast processes by which genetic variation is produced and maintained in organisms from multiple domains.	6.2	3C2	182-183, 187-197, also 242
3.28	The student is able to construct an explanation of the multiple processes that increase variation within a population.	1.4	3C2	182-183, 187-197, also 242
3.29	The student is able to construct an explanation of how viruses introduce genetic variation in host organisms.	6.2	3C3	197-202
3.30	The student is able to use representations and appropriate models to describe how viral replication introduces genetic variation in the viral population	1.4	3C3	197-198, 200-202
Enduring Understanding 3D: Cells communicate by generating, transmitting, and receiving chemical signals				
3.31	The student is able to describe basic chemical processes for cell communication shared across evolutionary lines of descent.	7.2	3D1	77-79
3.32	The student is able to generate scientific questions involving cell communication as it relates to the process of evolution.	3.1	3D1	78-82
3.33	The student is able to use representation(s) and appropriate models to describe features of a cell signaling pathway.	1.4	3D1	77, 85
3.34	The student is able to construct explanations of cell communication through cell-to-cell direct contact or through chemical signaling.	6.2	3D2	77, 79-82, 172
3.35	The student is able to create representation(s) that depict how cell-to-cell communication occurs by direct contact or from a distance through chemical signaling.	1.1	3D2	77
3.36	The student is able to describe a model that expresses the key elements of signal transduction pathways by which a signal is converted to a cellular response.	1.5	3D3	77, 85-87
3.37	The student is able to justify claims based on scientific evidence that changes in signal transduction pathways can alter cellular response.	6.1	3D4	89
3.38	The student is able to describe a model that expresses key elements to show how change in signal transduction can alter cellular response.	1.5	3D4	88, 89
3.39	The student is able to construct an explanation of how certain drugs affect signal reception and, consequently, signal transduction pathways.	6.2	3D4	89
Enduring Understanding 3E: Transmission of information results in changes within and between biological systems				
3.40	The student is able to analyze data that indicate how organisms exchange information in response to internal changes and external cues, and which can change behavior.	5.1	3E1	167, 171, 174-177
3.41	The student is able to create a representation that describes how organisms exchange information in response to internal changes and external cues, and which can result in changes in behavior.	1.1	3E1	167, 171, 174-177
3.42	The student is able to describe how organisms exchange information in response to internal changes or environmental cues.	7.1	3E1	168, 174-175
3.43	The student is able to construct an explanation, based on scientific theories and models, about how nervous systems detect external and internal signals, transmit and integrate information, and produce responses.	6.2 7.1	3E2	178-183
3.44	The student is able to describe how nervous systems detect external and internal signals.	1.2	3E2	166, 178
3.45	The student is able to describe how nervous systems transmit information.	1.2	3E2	178-182
3.46	The student is able to describe how the vertebrate brain integrates information to produce a response.	1.2	3E2	181, 185-186
3.47	The student is able to create a visual representation of complex nervous systems to describe/explain how these systems detect external and internal signals, transmit and integrate information, and produce responses.	1.1	3E2	178
3.48	The student is able to create a visual representation to describe how nervous systems detect external and internal signals.	1.1	3E2	166, 178
3.49	The student is able to create a visual representation to describe how nervous systems transmit information.	1.1	3E2	180-181
3.50	The student is able to create a visual representation to describe how the vertebrate brain integrates information to produce a response.	1.1	3E2	185-186
BIG IDEA 4: Biological systems interact, and these systems and their interactions possess complex properties				
Enduring Understanding 4A: Interactions within biological systems lead to complex properties				
4.1	The student is able to explain the connection between the sequence and the subcomponents of a biological polymer and its properties.	7.1	4A1	27-32, 34-36, 39-40, 91
4.2	The student is able to refine representations and models to explain how the subcomponents of a biological polymer and their sequence determine the properties of that polymer.	1.2	4A1	27-32, 34-36, 39-40, 91, 100
4.3	The student is able to use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule.	6.1 6.4	4A1	31-35, 39-40, 100

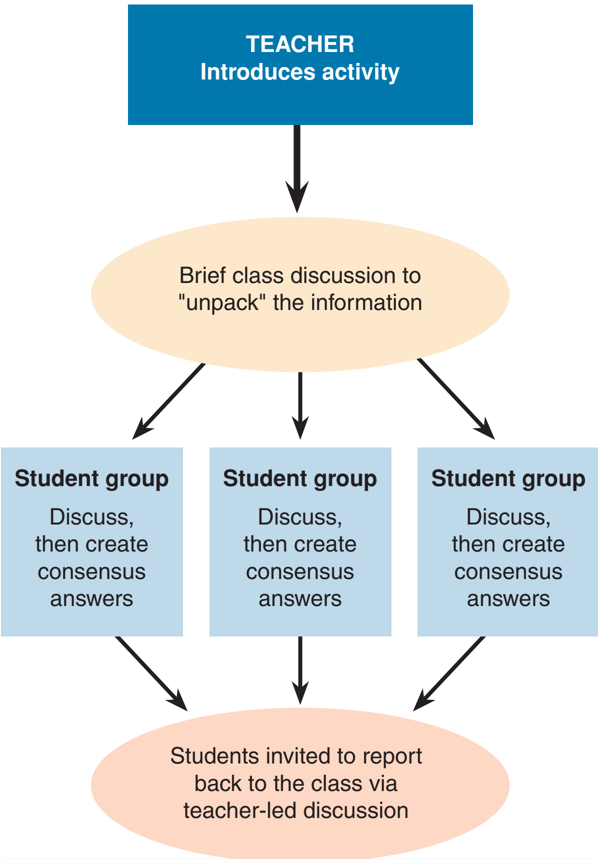
4.4	The student is able to make a prediction about the interactions of subcellular organelles.	6.4	4A2	73
4.5	The student is able to construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions.	6.2	4A2	61,73 6-7
4.6	The student is able to use representations and models to analyze situations qualitatively to describe how interactions of subcellular structures, which possess specialized functions, provide essential functions.	1.4	4A2	61,72-73 6-7
4.7	The student is able to refine representations to illustrate how interactions between external stimuli and gene expression result in specialization of cells, tissues and organs.	1.3	4A3	169-170, 173
4.8	The student is able to evaluate scientific questions concerning organisms that exhibit complex properties due to the interaction of their constituent parts.	3.3	4A4	53-63, 64, 65, 72-74, 82, 85, 88, 118, 94, 96-97, 107-118
4.9	The student is able to predict the effects of a change in a component(s) of a biological system on the functionality of an organism(s).	6.4	4A4	59-61, 64, 66,73-74, 76,101,104-105, 118
4.10	The student is able to refine representations and models to illustrate biocomplexity due to interactions of the constituent parts.	1.3	4A4	64, 98, 104-105,190
4.11	The student is able to justify the selection of the kind of data needed to answer scientific questions about the interaction of populations within communities.	1.4 4.1	4A5	193-194, 197-203, 226, 231
4.12	The student is able to apply mathematical routines to quantities that describe communities composed of populations of organisms that interact in complex ways.	2.2	4A5	194, 197-198, 201-203, 226
4.13	The student is able to predict the effects of a change in the community's populations on the community.	6.4	4A5	207, 210-213, 250-252,
4.14	The student is able to apply mathematical routines to quantities that describe interactions among living systems and their environment, which result in the movement of matter and energy.	2.2	4A6	239, 241, 243, 257, 274
4.15	The student is able to use visual representations to analyze situations or solve problems qualitatively to illustrate how interactions among living systems and with their environment result in the movement of matter and energy.	1.4	4A6	234-237, 240-244, 246-248
4.16	The student is able to predict the effects of a change of matter or energy availability on communities.	6.4	4A6	235, 241, 243, 254, 257
Enduring Understanding 4B: Competition and cooperation are important aspects of biological systems.				
4.17	The student is able to analyze data to identify how molecular interactions affect structure and function.	5.1	4B1	25
4.18	The student is able to use representations and models to analyze how cooperative interactions within organisms promote efficiency in the use of energy and matter.	1.4	4B2	59, 83-84, 107
4.19	The student is able to use data analysis to refine observations and measurements regarding the effect of population interactions on patterns of species distribution and abundance.	2.2 5.2	4B3	226, 229
4.20	The student is able to explain how the distribution of ecosystems changes over time by identifying large-scale events that have resulted in these changes in the past.	6.2 6.3	4B4	262, 268
4.21	The student is able to predict consequences of human actions on both local and global ecosystems.	6.4	4B4	254-267
Enduring Understanding 4C: Naturally occurring diversity among and between components within biological systems affects interaction with the environment.				
4.22	The student is able to construct explanations based on evidence of how variation in molecular units provides cells with a wider range of functions.	6.2	4C1	189, 191-193
4.23	The student is able to construct explanations of the influence of environmental factors on the phenotype of an organism.	6.2	4C2	179, 182-183
4.24	The student is able to predict the effects of a change in an environmental factor on the genotypic expression of the phenotype.	6.4	4C2	179, 182-185
4.25	The student is able to use evidence to justify a claim that a variety of phenotypic responses to a single environmental factor can result from different genotypes within the population.	6.1	4C3	182-183, 188-193
4.26	The student is able to use theories and models to make scientific claims and/ or predictions about the effects of variation within populations on survival and fitness.	6.4	4C3	188-193, also 206-207
4.27	The student is able to make scientific claims and predictions about how species diversity within an ecosystem influences ecosystem stability.	6.4	4C4	249, 253, 263, 270-272

Teaching Strategies for Classroom Use

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

MAKING A START

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



Using collaboration to maximize learning outcomes

- The structure of the AP Biology books 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.
- 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 paper practical activity, to research a topic, 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.

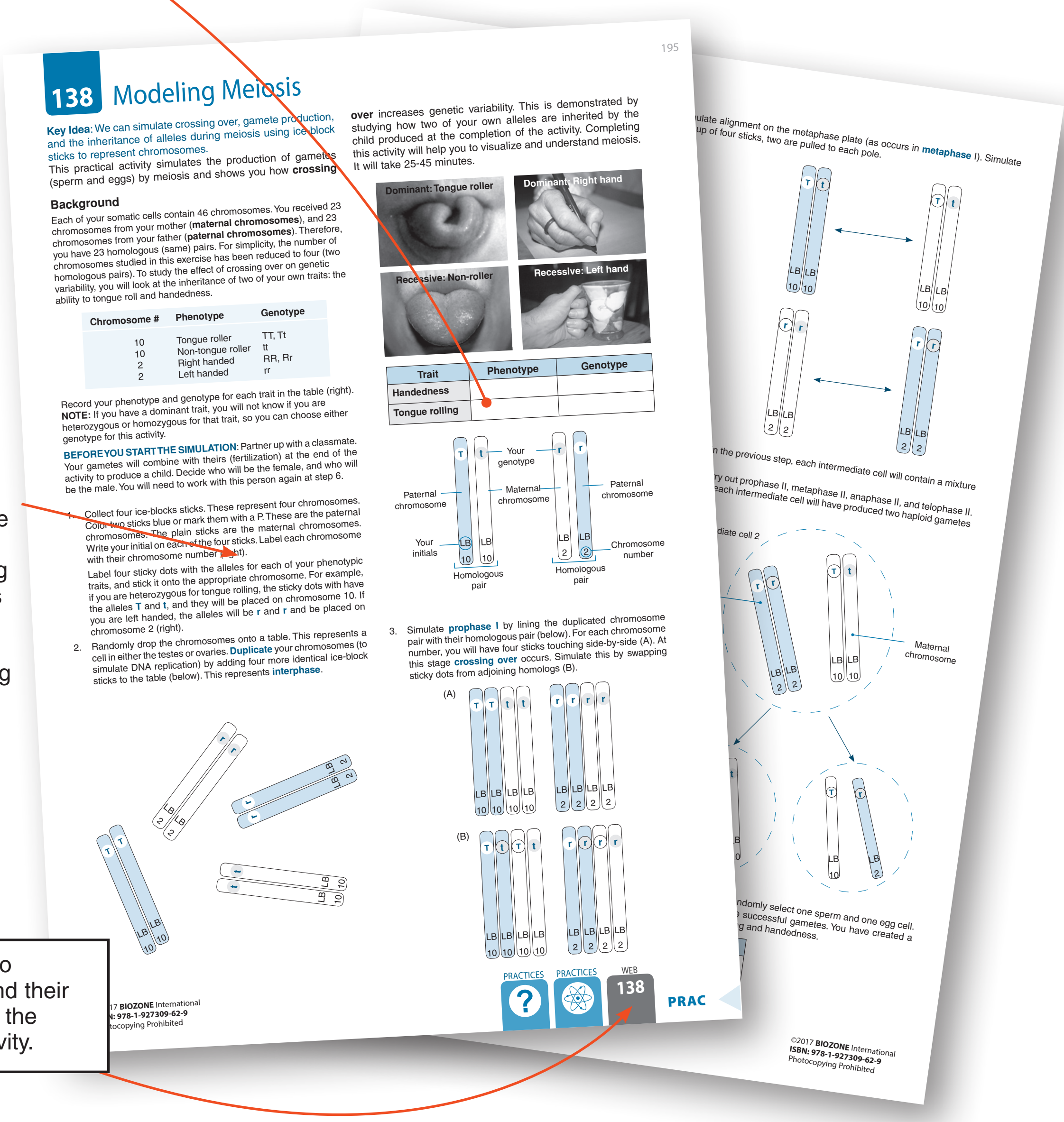
Students work in small groups so everyone's contribution is heard. They collaborate, share ideas, and engage in discourse. The emphasis is on discussing questions and formulating a consensus answer, not just sharing ideas.

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

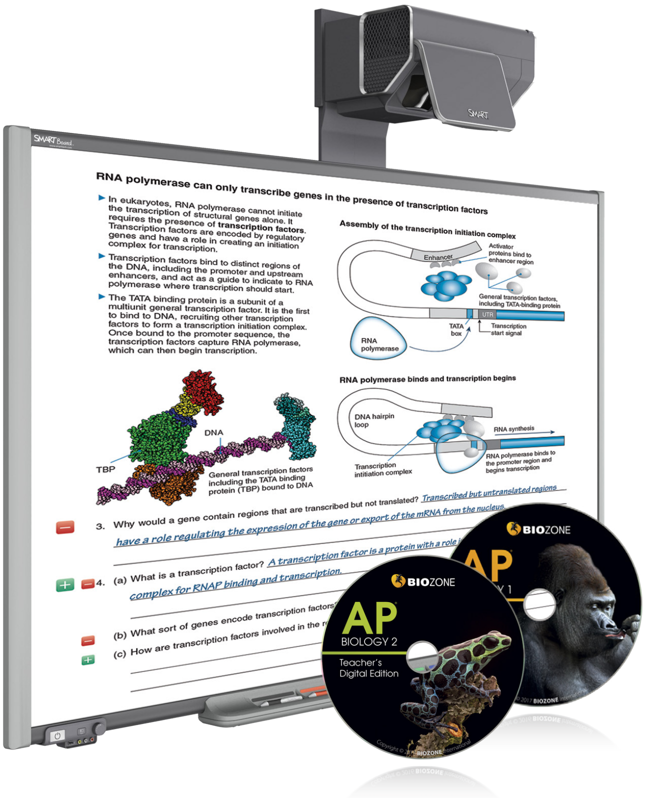
- **Peer-to-peer learning** can be used for any activities, but is particularly valuable for more challenging activities in which the content is more complex or the questions require students to draw on several areas of their knowledge to synthesize an answer. Examples of such activities include modeling activities, activities with a design component, or activities involving data analysis, graphing, and evaluation.
- Stronger peers can assist weaker students and both groups benefit from verbalizing their thoughts and presenting them to a group. Students for whom English is a second language can ask their peers to explain unfamiliar terms (both scientific and English) and this benefits both parties.

Paper practicals and simulation activities (e.g. *Modeling Mitosis, Modeling Meiosis, Modeling Population Growth, Creating a DNA Model, Modeling Interspecific Competition, and Gene Pool Exercise*) are an ideal vehicle for this kind of peer-to-peer learning. They are not only enjoyable, but they prompt students to ask questions and think about how they could use the model to answer those questions.



In Modeling Meiosis, students can collaborate in pairs to determine the outcome of a mating between two individuals with different traits. This tests and creates understanding by putting theory into practice.

Encourage students to consolidate and extend their knowledge by visiting the **Weblinks** for the activity.

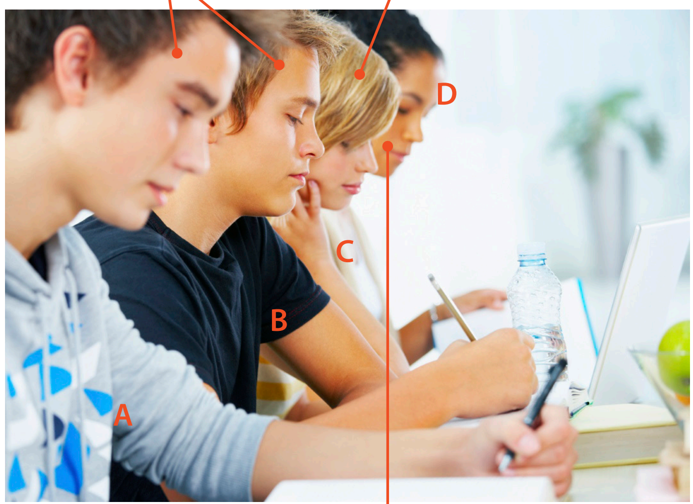


Interactive revision of tasks in class

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

Students A and B will work through simpler questions themselves but may require assistance with the more challenging questions in this activity.

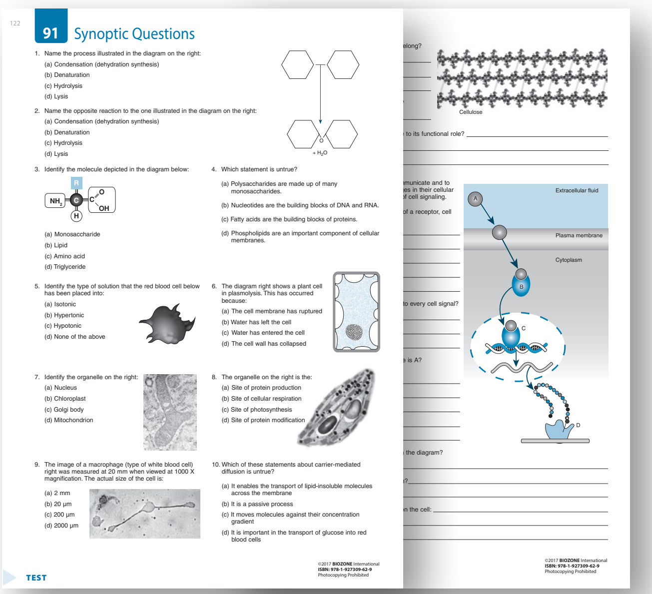
Student C is capable. She completes all of this activity including the more challenging questions.



Student D is capable and needs extension. She works quickly, completing her set work. She can demonstrate her understanding in the synoptic question.

Gaining confidence

- The questions in the activities have generally been written in a direct questioning style, e.g. "What are the differences between A and B", or "Why are A and B different?". This makes it easier for the students to understand what is required to answer the question.
- Questions are also arranged so that simpler questions (describe, what, identify, name) are generally asked first, followed by questions demanding an explanation (explain, how, why, account for). This allows students to gain confidence from answering the simpler questions first before attempting the questions that require more comprehensive answers.
- This arrangement also allows teachers to direct students appropriately so that some may attempt only the simpler questions themselves and work with peers to attempt the more challenging questions.

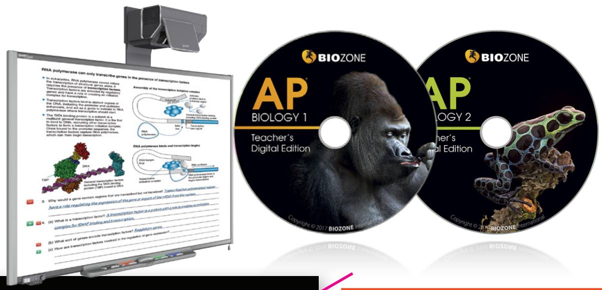


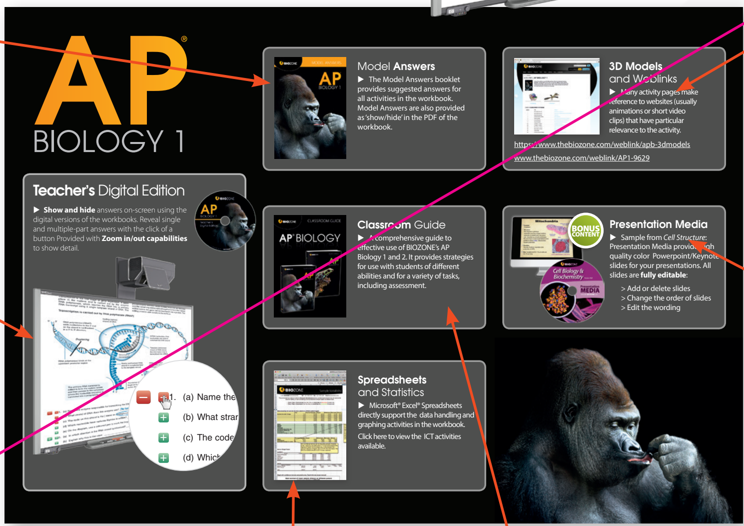
Moving on to Synoptic Questions

- BIOZONE's AP Biology contains synoptic questions at the end of each major section of work. These require students to draw on the knowledge gained in a range of activities to answer the questions.
- The synoptic questions include multi-choice, short answer, and longer answer questions. Students are given introductory information and asked to discuss certain aspects of the topic relating to the information. The examples used in the questions may not directly relate to examples in the book, but the ideas and concepts required to answer the question will have been covered in the preceding activities.
- Sometimes students will need to interpret the information given in the question's introduction and integrate their interpretation into their answer.

The Teacher's Digital Edition

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





Digital copy of the Model Answers (non-printable). Suggested answers are provided to all activities. Some include explanatory detail.

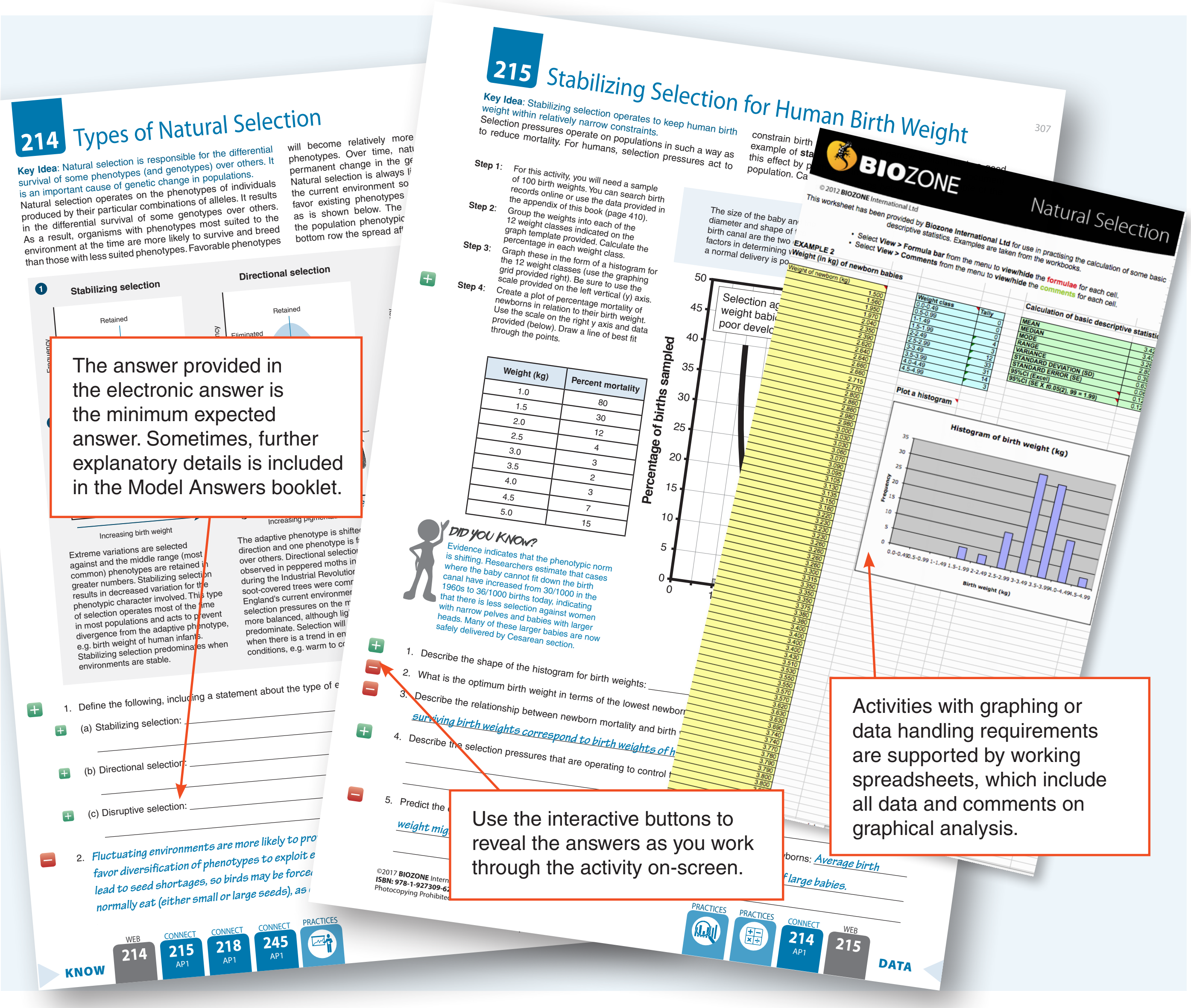
A digital (PDF) version of the student edition (non-printable). Use the interactive buttons to HIDE or SHOW the answers.

Access the *Weblinks* directly from this link for a range of animations and video clips to support the activities.

A **BONUS** sample copy of a Presentation Media title is included. In AP1 the title is 'Cell Structure', in AP2 the title is 'Populations and Interactions'. Both are fully editable.

Link to ***Excel***® **spreadsheets** for all activities with a graphing or data analysis component.

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



The answer provided in the electronic answer is the minimum expected answer. Sometimes, further explanatory details is included in the Model Answers booklet.

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

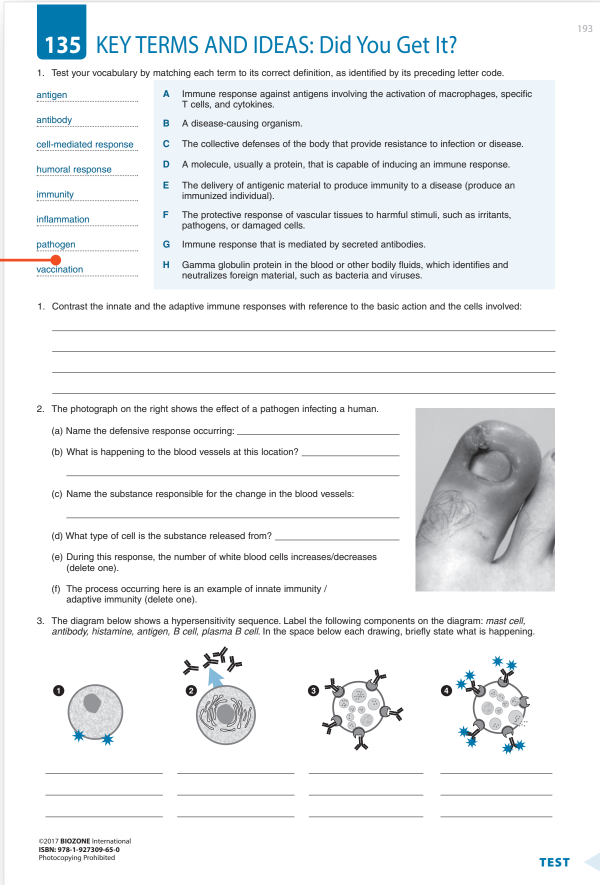
Activities with graphing or data handling requirements are supported by working spreadsheets, which include all data and comments on graphical analysis.

Formative and Summative Assessments

AP Biology provides ample opportunity for students to demonstrate their understanding and proficiency across all four Big Ideas. Most of the activities in the book can be used for formative assessment to provide feedback to the student during the learning process. Synoptic questions at the end of each section can be used as summative assessment tasks.

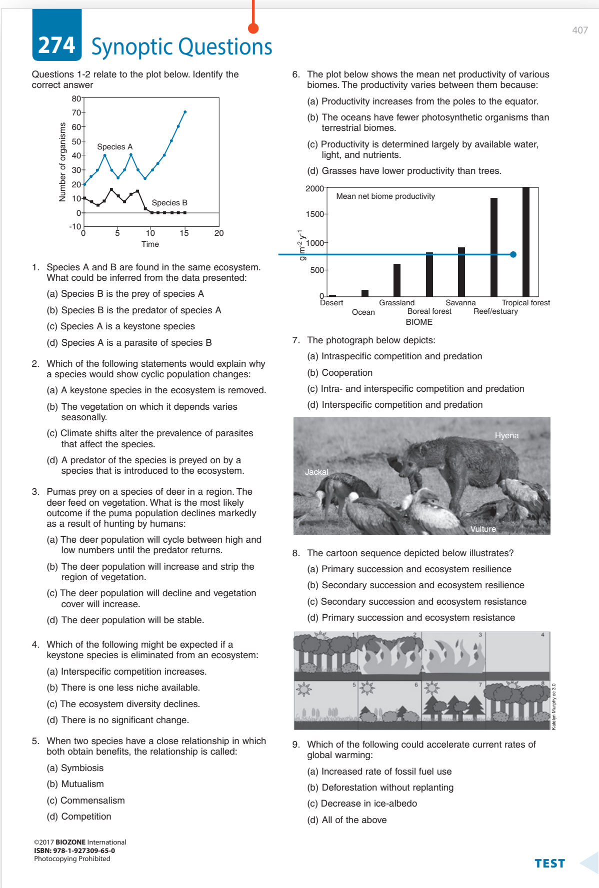
Formative assessment

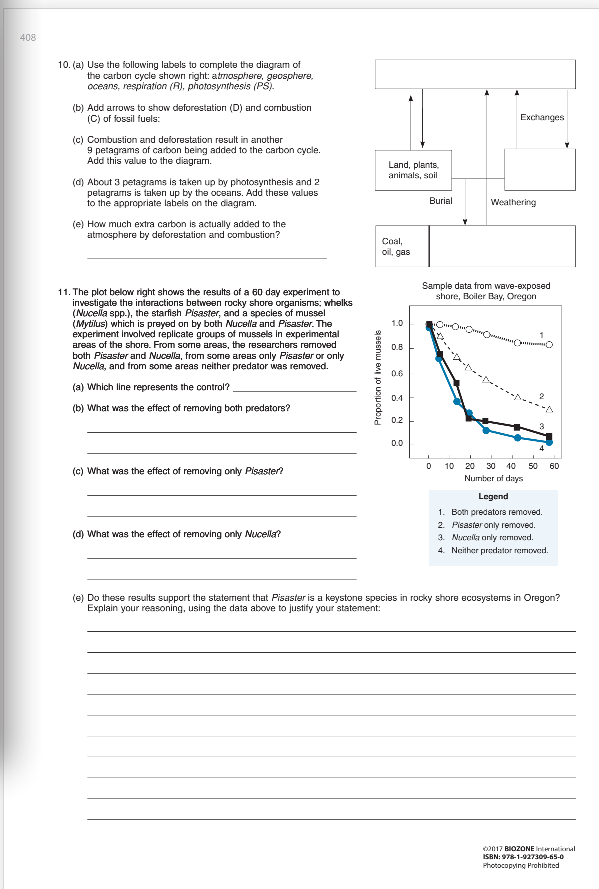
Individual activities, or an instructional sequence, can be used as formative assessments to determine how a student's knowledge is progressing within a selected topic. Teachers can revise their instruction, revisit material, or set further tasks if a student is having difficulty with the material.
KEY TERMS AND IDEAS: Did You Get It? activities at the end of each chapter can be used for formal testing as a class, or set as an informal check point where students use the activity as a opportunity for self assessment.



Summative assessment

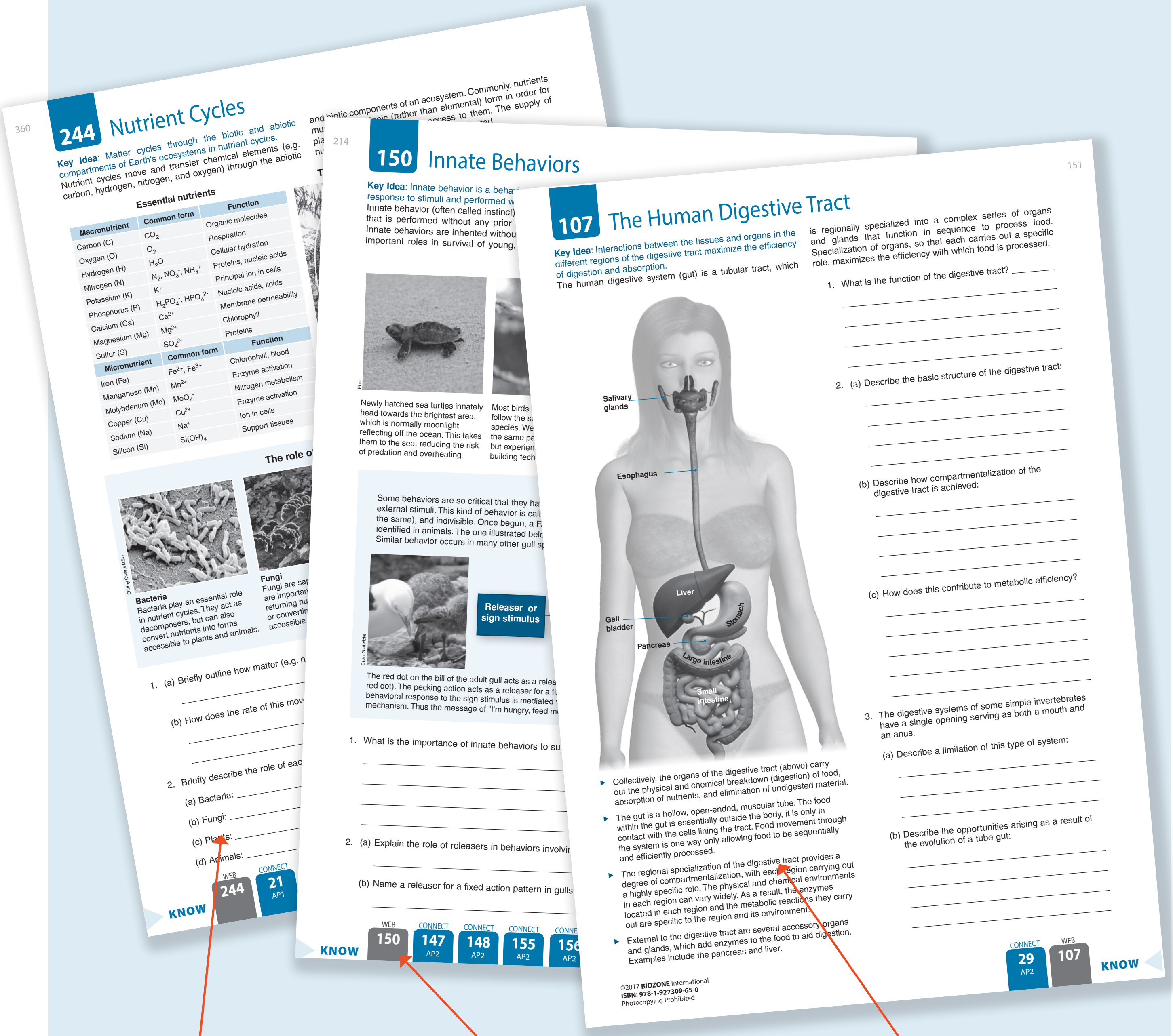
Each section of work concludes with synoptic questions. These activities may be administered at the end of a unit of instruction as a formal or semi-formal test. They are designed to test a student's ability to apply their knowledge and understanding of a particular topic.





Choosing Activities for Home Study

Many of the book's activities are ideal for homework or as vehicles for a quick self assessment. Review activities are ideal as homework. They provide a way to review a topic that has recently been completed, while at the same time facilitating consolidation by presenting the material in a slightly different way. The information for review activities can be found within the chapter, although stronger students may not need to refer back to source material to complete the set work. Generally, homework activities should revise completed topics or provide a basic entry-level introduction.



Tailor your program so that simpler activities are most often set as homework exercises, especially for less able students who may be easily discouraged.

Most students will have access to the internet. If they are having trouble understanding a subject or visualizing a process, encourage them to visit the assigned **Weblinks** where these are provided.

Summary activities are ideal as homework because they involve reviewing completed work. This activity provides an opportunity for students to recall and apply knowledge about regional and functional specialization in mammalian digestive tracts.