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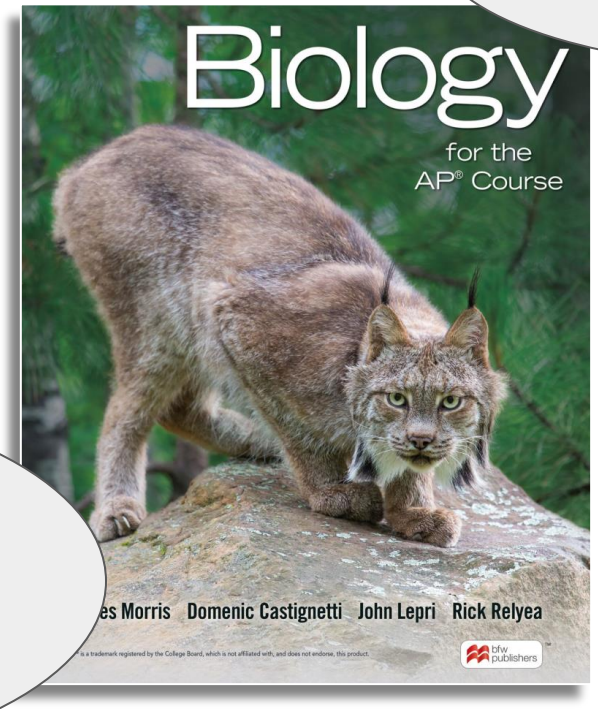
The word is out…

This is a textbook I would actually use in class instead of a reference book that I [tell] students to keep at home. ~ AP® Biology Teacher | Atlanta, GA

[*Biology for the AP® Course* is] not just a repurposed college text. ~ Mary Jane Davis, Red Bank Catholic HS, NJ



I was impressed that the sequencing of materials was so logical. It was incredible that it followed exactly the sequence that I use when I teach without a textbook. I love the integration of statistics which I don't feel most textbooks include. ~ Brandy Tanner | Mt. Abram High School, ME

I love the organization of this book [as] It is very streamlined. I was super excited to see built in science skill practice within the modules, such as the [Analyzing Statistics and Data Boxes]. I usually have to build a separate unit and find a way to put this missing material in, [so] I could see this simplifying my job and helping my students, reducing all of our stress levels. ~ Andrea Schmidt | Platte County HS, MO

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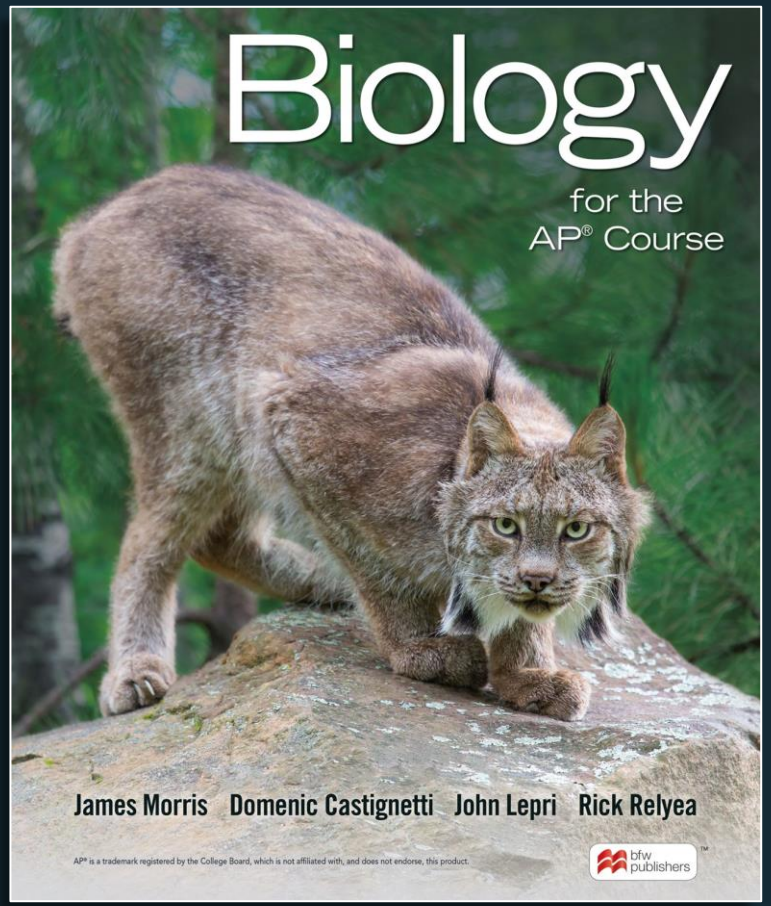

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The Editorial Story… Starts with Jen

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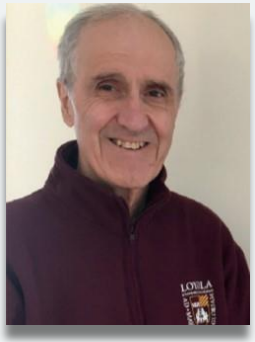
James Morris



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What does this mean?

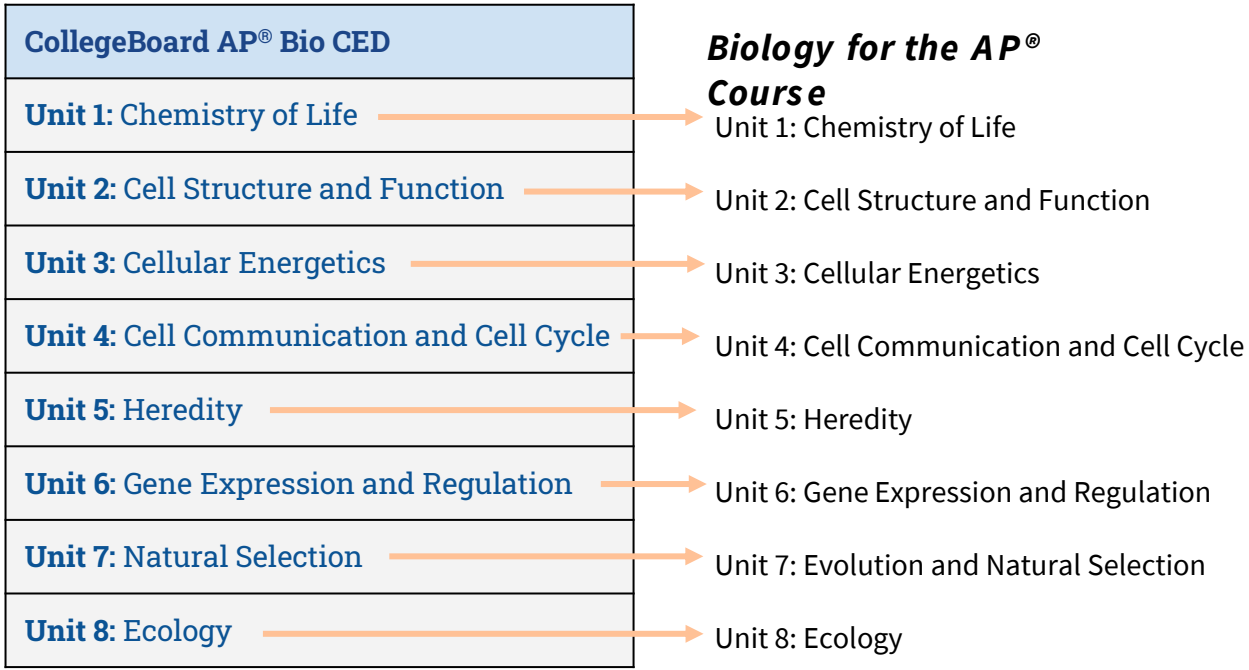
Start with the CED

Develop AP® Program

Deliver a Program That Fits

Fully Aligned to the New CED

- **Units**



Fully Aligned to the New CED

- Units
- **Modules**
  - Modules correspond to topic areas in the AP® framework
  - Scaffolded
  - Contains material for 1-2 class periods
  - Includes review and practice

Unit 1: Chemistry of Life
Module 0: Introduction
Tutorial 1: Statistics
Module 1: Elements of Life
Module 2: Water and Life
Module 3: Carbohydrates and Lipids
Module 4: Proteins
Module 5: Nucleic Acids

Unit 2: Cell Structure and Function
Module 6: An Introduction to the Cell
Module 7: Subcellular Compartments of Eukaryotes
Module 8: Cell and Organism Size
Module 9: Cell Membranes
Module 10: Membrane Transport
Module 11: Water Movement: Osmosis, Tonicity, and Osmoregulation
Module 12: Origin of Compartmentalization and the Eukaryotic Cell

Unit 3: Cellular Energetics
Module 13: Cellular Energy
Module 14: Enzymes
Module 15: Photosynthesis I: Overview
Module 16: Photosynthesis II: Biochemistry
Module 17: Cellular Respiration I: Overview
Module 18: Cellular Respiration II: Biochemistry
Module 19: Metabolism, the Environment, and Evolutionary Fitness

Unit 4: Cell Communication and Cell Cycle
Module 20: Cell Communication
Module 21: Signal Transduction
Module 22: Changes in Signal Transduction Pathways
Module 23: Feedback in Cell Communication
Module 24: The Cell Cycle
Module 25: Regulation of the Cell Cycle

Unit 5: Heredity
Module 26: Meiosis and Genetic Diversity
Module 27: Mendelian Genetics
Tutorial 2: Probability
Module 28: Non-Mendelian Genetics
Module 29: Environmental Effects on Phenotypes
Module 30: Chromosomal Inheritance

Unit 6: Gene Expression and Regulation
Module 31: DNA and RNA Structure and Function
Module 32: DNA Replication
Module 33: Transcription and RNA Processing
Module 34: Translation
Module 35: Regulation of Gene Expression
Module 36: Cell Specialization and Development
Module 37: Mutations
Module 38: Biotechnology
Module 39: Viruses

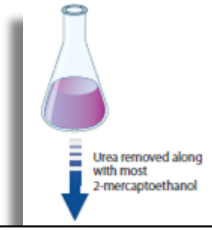
Unit 7: Evolution and Natural Selection
Module 40: Introduction to Evolution and Natural Selection
Module 41: Natural and Artificial Selection
Module 42: Population Genetics
Module 43: Hardy–Weinberg Equilibrium
Module 44: Evidence of Common Ancestry and Evolution
Module 45: Continuing Evolution
Module 46: Phylogeny
Module 47: Speciation
Module 48: Extinction
Module 49: Variation in Populations
Module 50: Origin of Life on Earth

Unit 8: Ecology
Module 51: Responses to the Environment
Module 52: Energy Flow through Ecosystems
Module 53: Population Ecology
Module 54: Effect of Density of Populations
Tutorial 3: Rate and Growth in Population Ecology
Module 55: Community Ecology
Module 56: Biodiversity
Module 57: Disruptions to Ecosystems

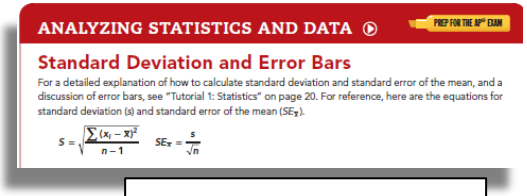
Cumulative AP® Biology Practice Exam
Tutorial 4: Graphing
Glossary/Glosario
Index
Answers to Concept Check and Review Questions
The Periodic Table of the Elements

Fully Aligned to the New CED

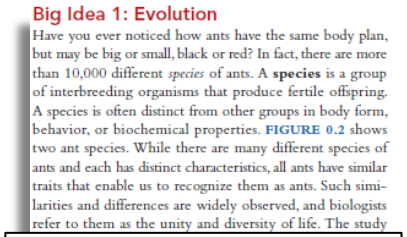
- Units
- Modules
- **Science Practices**



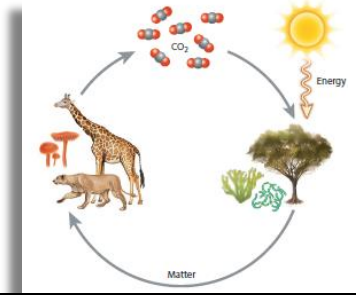
SP3: Questions and Methods



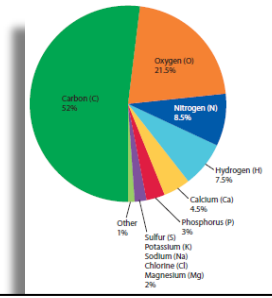
SP5: Data Analysis and Statistics



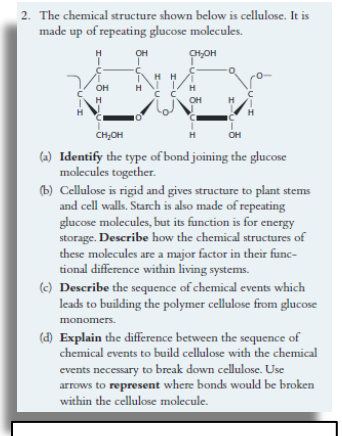
SP1: Concept Explanation



SP2: Visual Representation



SP4: Representing Data

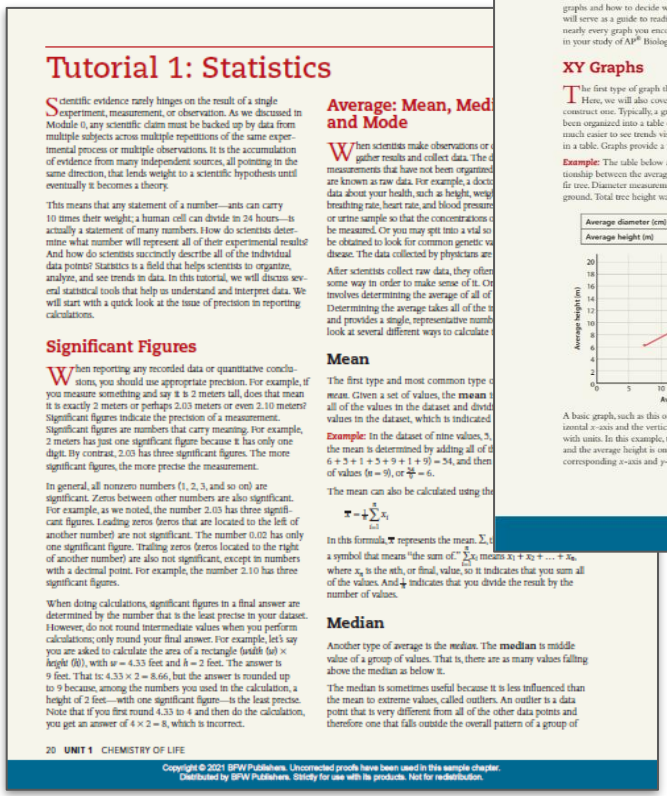


SP6: Argumentation

Science Practices

Tutorials (pg 21)

- Comprehensive explanations
  - statistics
  - growth equations
  - probability
  - graphing skills
- Points to relevant Analyzing Statistics and Data boxes for additional practice.



Tutorial 1: Statistics

Scientific evidence rarely hinges on the result of a single experiment, measurement, or observation. As we discussed in Module 0, any scientific claim must be backed up by data from multiple subjects across multiple repetitions of the same experimental process or multiple observations. It is the accumulation of evidence from many independent sources, all pointing in the same direction, that lends weight to a scientific hypothesis until eventually it becomes a theory.

This means that any statement of a number—ants can carry 10 times their weight; a human cell can divide in 24 hours—is actually a statement of many numbers. How do scientists determine what number will represent all of their experimental results? And how do scientists succinctly describe all of the individual data points? Statistics is a field that helps scientists to organize, analyze, and see trends in data. In this tutorial, we will discuss several statistical tools that help us understand and interpret data. We will start with a quick look at the issue of precision in reporting calculations.

Significant Figures

When reporting any recorded data or quantitative conclusions, you should use appropriate precision. For example, if you measure something and say it is 2 meters tall, does that mean it is exactly 2 meters or perhaps 2.03 meters or even 2.10 meters? Significant figures indicate the precision of a measurement. Significant figures are numbers that carry meaning. For example, 2 meters has just one significant figure because it has only one digit. By contrast, 2.03 has three significant figures. The more significant figures, the more precise the measurement.

In general, all nonzero numbers (1, 2, 3, and so on) are significant. Zeros between other numbers are also significant. For example, as we noted, the number 2.03 has three significant figures. Leading zeros (zeros that are located to the left of another number) are not significant. The number 0.02 has only one significant figure. Trailing zeros (zeros located to the right of another number) are also not significant, except in numbers with a decimal point. For example, the number 2.10 has three significant figures.

When doing calculations, significant figures in a final answer are determined by the number that is the least precise in your dataset. However, do not round intermediate values when you perform calculations; only round your final answer. For example, let's say you are asked to calculate the area of a rectangle (*width* (*w*) × *height* (*h*)), with $w = 4.33$ feet and $h = 2$ feet. The answer is 9 feet. That is: $4.33 \times 2 = 8.66$, but the answer is rounded up to 9 because, among the numbers you used in the calculation, a height of 2 feet—with one significant figure—is the least precise. Note that if you first round 4.33 to 4 and then do the calculation, you get an answer of $4 \times 2 = 8$, which is incorrect.

Average: Mean, Medi and Mode

When scientists make observations or gather results and collect data. The measurements that have not been organized are known as raw data. For example, a doctor data about your health, such as height, weight, breathing rate, heart rate, and blood pressure or urine sample so that the concentrations be measured. Or you may spit into a vial so be obtained to look for common genetic va disease. The data collected by physicians are

After scientists collect raw data, they often some way in order to make sense of it. Or involves determining the average of all of Determining the average takes all of the and provides a single, representative numb look at several different ways to calculate

Mean

The first type and most common type *mean*. Given a set of values, the **mean** all of the values in the dataset and divid values in the dataset, which is indicated

Example: In the dataset of nine values, 3, the mean is determined by adding all of 6 + 3 + 1 + 5 + 9 + 1 + 9) = 54, and then of values (*n* = 9), or $\frac{54}{9} = 6$.

The mean can also be calculated using the

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

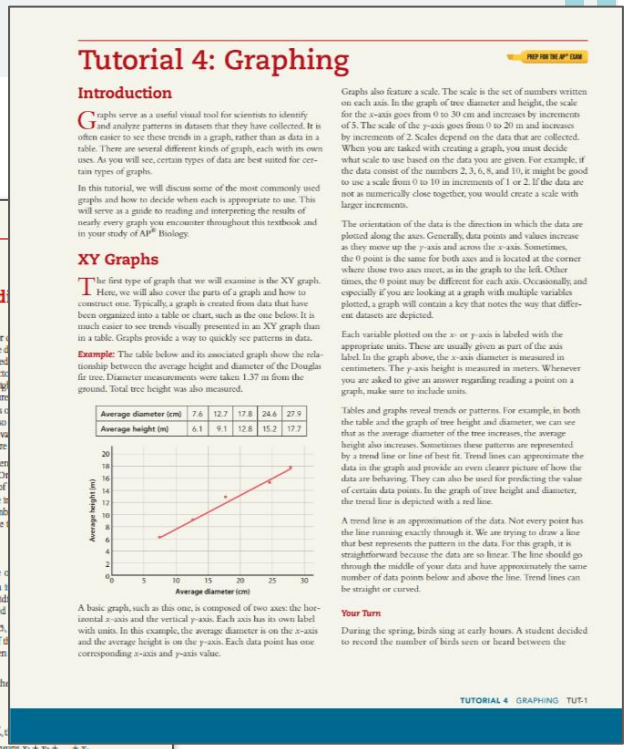
In this formula, $\bar{x}$ represents the mean. $\sum$, a symbol that means "the sum of." $\sum_{i=1}^{n} x_i$ means $x_1 + x_2 + \ldots + x_n$, where x_n is the *n*th, or final, value, so it indicates that you sum all of the values. And $\frac{1}{n}$ indicates that you divide the result by the number of values.

Median

Another type of average is the *median*. The **median** is middle value of a group of values. That is, there are as many values falling above the median as below it.

The median is sometimes useful because it is less influenced than the mean to extreme values, called outliers. An outlier is a data point that is very different from all of the other data points and therefore one that falls outside the overall pattern of a group of

20 UNIT 1 CHEMISTRY OF LIFE



Tutorial 4: Graphing

PREP FOR THE AP® EXAM

Introduction

Graphs serve as a useful visual tool for scientists to identify and analyze patterns in datasets that they have collected. It is often easier to see these trends in a graph, rather than as data in a table. There are several different kinds of graph, each with its own uses. As you will see, certain types of data are best suited for certain types of graphs.

In this tutorial, we will discuss some of the most commonly used graphs and how to decide when each is appropriate to use. This will serve as a guide to reading and interpreting the results of nearly every graph you encounter throughout this textbook and in your study of AP® Biology.

XY Graphs

The first type of graph that we will examine is the XY graph. Here, we will also cover the parts of a graph and how to construct one. Typically, a graph is created from data that have been organized into a table or chart, such as the one below. It is much easier to see trends visually presented in an XY graph than in a table. Graphs provide a way to quickly see patterns in data.

Example: The table below and its associated graph show the relationship between the average height and diameter of the Douglas fir tree. Diameter measurements were taken 1.37 m from the ground. Total tree height was also measured.

Average diameter (cm)	7.6	12.7	17.8	24.6	27.9
Average height (m)	6.1	9.1	12.8	15.2	17.7

A basic graph, such as this one, is composed of two axes: the horizontal *x*-axis and the vertical *y*-axis. Each axis has its own label with units. In this example, the average diameter is on the *x*-axis and the average height is on the *y*-axis. Each data point has one corresponding *x*-axis and *y*-axis value.

Graphs also feature a scale. The scale is the set of numbers written on each axis. In the graph of tree diameter and height, the scale for the *x*-axis goes from 0 to 30 cm and increases by increments of 5. The scale of the *y*-axis goes from 0 to 20 m and increases by increments of 2. Scales depend on the data that are collected. When you are tasked with creating a graph, you must decide what scale to use based on the data you are given. For example, if the data consist of the numbers 2, 3, 6, 8, and 10, it might be good to use a scale from 0 to 10 in increments of 1 or 2. If the data are not as numerically close together, you would create a scale with larger increments.

The orientation of the data is the direction in which the data are plotted along the axes. Generally, data points and values increase as they move up the *y*-axis and across the *x*-axis. Sometimes, the 0 point is the same for both axes and is located at the corner where those two axes meet, as in the graph to the left. Other times, the 0 point may be different for each axis. Occasionally, and especially if you are looking at a graph with multiple variables plotted, a graph will contain a key that notes the way that different datasets are depicted.

Each variable plotted on the *x*- or *y*-axis is labeled with the appropriate units. These are usually given as part of the axis label. In the graph above, the *x*-axis diameter is measured in centimeters. Sometimes these patterns are represented by a trend line or line of best fit. Trend lines can approximate the data in the graph and provide an even clearer picture of how the data are behaving. They can also be used for predicting the value of certain data points. In the graph of tree height and diameter, the trend line is depicted with a red line.

A trend line is an approximation of the data. Not every point has the line running exactly through it. We are trying to draw a line that best represents the pattern in the data. For this graph, it is straightforward because the data are so linear. The line should go through the middle of your data and have approximately the same number of data points below and above the line. Trend lines can be straight or curved.

Your Turn

During the spring, birds sing at early hours. A student decided to record the number of birds seen or heard between the

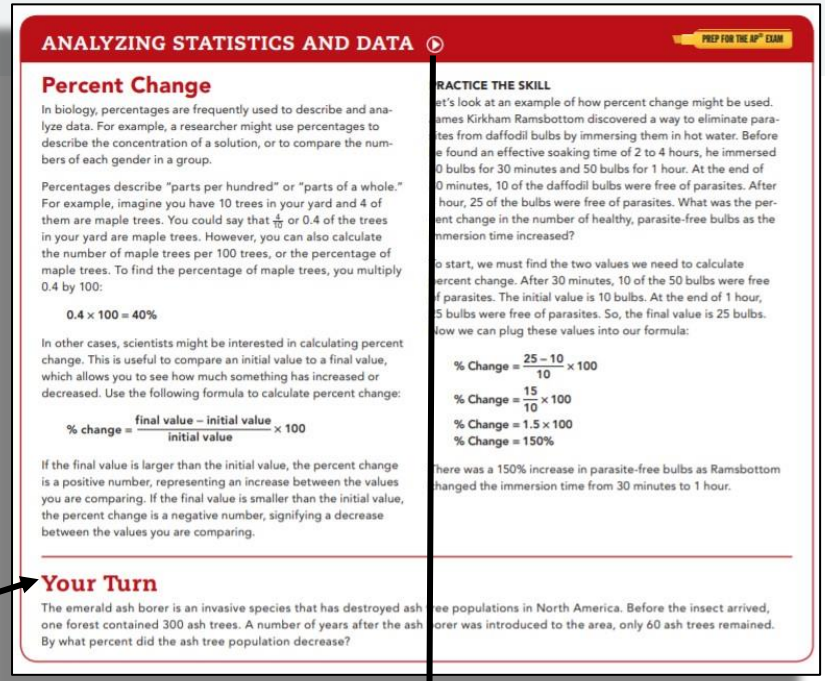
TUTORIAL 4 GRAPHING TUT-1

SP5: Data Analysis and Statistics

Science Practices

Analyzing Statistics & Data Boxes (pg 28-29)

- Covers the statistics and mathematical tools in AP® Biology
- Reviews important skills from other courses such as working with scientific notation and percentages.
- Each box walks students through a practice problem and provides a **Your Turn** problem to try.
- Further practice is available in the Teacher's Resource Materials and we include video walkthroughs for students in the digital platform.



ANALYZING STATISTICS AND DATA

PREP FOR THE AP® EXAM

Percent Change

In biology, percentages are frequently used to describe and analyze data. For example, a researcher might use percentages to describe the concentration of a solution, or to compare the numbers of each gender in a group.

Percentages describe "parts per hundred" or "parts of a whole." For example, imagine you have 10 trees in your yard and 4 of them are maple trees. You could say that $\frac{4}{10}$ or 0.4 of the trees in your yard are maple trees. However, you can also calculate the number of maple trees per 100 trees, or the percentage of maple trees. To find the percentage of maple trees, you multiply 0.4 by 100:

$$0.4 \times 100 = 40\%$$

In other cases, scientists might be interested in calculating percent change. This is useful to compare an initial value to a final value, which allows you to see how much something has increased or decreased. Use the following formula to calculate percent change:

$$\%\ \text{change} = \frac{\text{final value} - \text{initial value}}{\text{initial value}} \times 100$$

If the final value is larger than the initial value, the percent change is a positive number, representing an increase between the values you are comparing. If the final value is smaller than the initial value, the percent change is a negative number, signifying a decrease between the values you are comparing.

PRACTICE THE SKILL

Let's look at an example of how percent change might be used. James Kirkham Ramsbottom discovered a way to eliminate parasites from daffodil bulbs by immersing them in hot water. Before he found an effective soaking time of 2 to 4 hours, he immersed 50 bulbs for 30 minutes and 50 bulbs for 1 hour. At the end of 30 minutes, 10 of the daffodil bulbs were free of parasites. After 1 hour, 25 of the bulbs were free of parasites. What was the percent change in the number of healthy, parasite-free bulbs as the immersion time increased?

To start, we must find the two values we need to calculate percent change. After 30 minutes, 10 of the 50 bulbs were free of parasites. The initial value is 10 bulbs. At the end of 1 hour, 25 bulbs were free of parasites. So, the final value is 25 bulbs. Now we can plug these values into our formula:

$$\%\ \text{Change} = \frac{25 - 10}{10} \times 100$$

$$\%\ \text{Change} = \frac{15}{10} \times 100$$

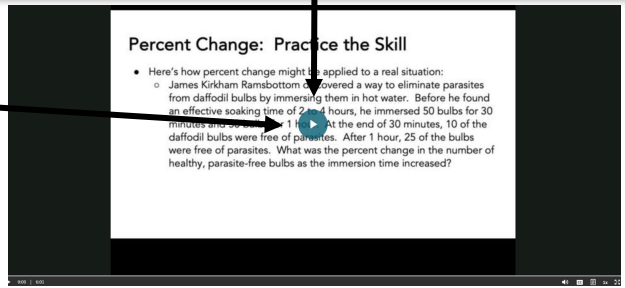
$$\%\ \text{Change} = 1.5 \times 100$$

$$\%\ \text{Change} = 150\%$$

There was a 150% increase in parasite-free bulbs as Ramsbottom changed the immersion time from 30 minutes to 1 hour.

Your Turn

The emerald ash borer is an invasive species that has destroyed ash tree populations in North America. Before the insect arrived, one forest contained 300 ash trees. A number of years after the ash borer was introduced to the area, only 60 ash trees remained. By what percent did the ash tree population decrease?



SP5: Data Analysis and Statistics

Science Practices

Practicing Science Boxes

- Evaluate key experiments in the history of biology, while addressing the science practice of questions and methods
- **AP® FRQ Practice Question** concludes each box pg 74

SP3: Questions and Methods

Practicing Science 0.1

PREP FOR THE AP® EXAM

Using observation and experimentation to investigate a horticultural problem

Background Scientific inquiry is often called upon to address problems that arise in society and industry. In 1916, British horticulturalists were concerned with a disease that killed daffodils. Daffodils grow from bulbs, which are large underground stems that store energy and are seen in many plants, such as daffodils, tulips, and onions. However, the disease caused leaves to wither, bulbs to become discolored, and eventually death of the plant. The demise of the plants represented a substantial loss of commercial production and income to the horticultural industry. While some suspected a fungus caused the plant deaths, no one was able to determine the source of the problem.

The British Royal Horticultural Society took up the cause and assigned the problem to James Kirkham Ramsbottom. At the time he was a top student at the Royal Horticultural Society's garden in Wisley, a community near London.

Observation and Hypothesis Ramsbottom began by making observations. He examined hundreds of diseased bulbs, preparing microscopic slides and studying them closely. While he did see fungi, Ramsbottom observed that all of the diseased bulbs contained a parasitic worm, *Tylenchus devastratix*. Ramsbottom hypothesized that the worm was the cause of the disease afflicting the plants and predicted that if he could devise a way to kill the worm without killing the bulbs, the disease would be eliminated.

Experimentation Ramsbottom launched a series of experiments where he examined a number of agents that might selectively kill the worm while keeping the plant alive. He tried chemical treatments, spraying the plants and dousing them. He experimented with both gas and formaldehyde. He settled on the use of heat. Ramsbottom immersed the bulbs for different amounts of time in hot water. The photograph shows the removable wire basket and copper boiler that permitted Ramsbottom to heat the daffodil bulbs for different periods of time. He determined that soaking them in 110°F (43°C) water for 2 to 4 hours left the bulbs intact while the parasite was eliminated. Untreated, infected daffodil bulbs failed to grow, died, and did not produce flowers. The heat-treated daffodil bulbs grew normally and produced the sought-after plant and flower. Today, the Ramsbottom heat treatment is still used in virtually the same manner as he developed it.

SOURCE
Flower Preservation, 1916. *The Scientist*, 2:64. Photo: RHS Lindley Collections

AP® PRACTICE QUESTION

James Kirkham Ramsbottom used the process of scientific inquiry to figure out what was causing the death of daffodils. Organize the description of his experiment by identifying the following:

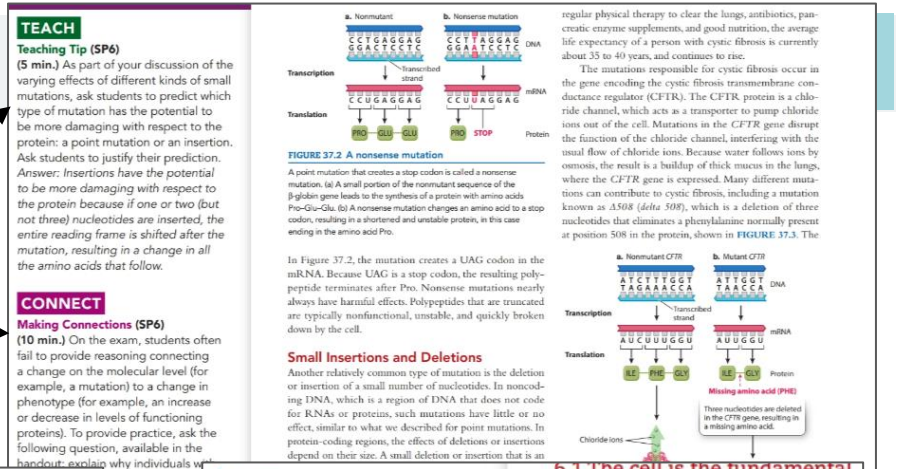
1. The scientific (testable) question
2. The hypothesis
3. The independent variable
4. The dependent variable
5. The experimental group
6. The control group

Science Practices

Argumentation

- Teaching tips (note the SP numbers)
- Activities
- FRQs

SP6: Argumentation



TEACH

Teaching Tip (SP6)

(5 min.) As part of your discussion of the varying effects of different kinds of small mutations, ask students to predict which type of mutation has the potential to be more damaging with respect to the protein: a point mutation or an insertion. Ask students to justify their prediction. *Answer: Insertions have the potential to be more damaging with respect to the protein because if one or two (but not three) nucleotides are inserted, the entire reading frame is shifted after the mutation, resulting in a change in all the amino acids that follow.*

CONNECT

Making Connections (SP6)

(10 min.) On the exam, students often fail to provide reasoning connecting a change on the molecular level (for example, a mutation) to a change in phenotype (for example, an increase or decrease in levels of functioning proteins). To provide practice, ask the following question, available in the handout: explain why individuals wi

ve the phenotype
thick, sticky mu
onnect what
on that causes cys
ement of ions acro
osmosis. *Answer:*
s missing an amino
e shape of the prot
e protein is a chlo
rmally transports
t of the cell. The al
e channel does not
rane, which mean
n't move out of the
ws solutes in osmo
moves out of the c
builds up in the lun
ts have written an
them to switch pa
and underline the
e, circle the evide
ut a box around th
onnects the two.

FIGURE 37.2 A nonsense mutation

A point mutation that creates a stop codon is called a nonsense mutation. (a) A small portion of the nonmutant sequence of the β-globin gene leads to the synthesis of a protein with amino acids Pro–Glu–Glu. (b) A nonsense mutation changes an amino acid to a stop codon, resulting in a shortened and unstable protein, in this case ending in the amino acid Pro.

In Figure 37.2, the mutation creates a UAG codon in the mRNA. Because UAG is a stop codon, the resulting polypeptide terminates after Pro. Nonsense mutations nearly always have harmful effects. Polypeptides that are truncated are typically nonfunctional, unstable, and quickly broken down by the cell.

Small Insertions and Deletions

Another relatively common type of mutation is the deletion or insertion of a small number of nucleotides. In noncoding DNA, which is a region of DNA that does not code for RNAs or proteins, such mutations have little or no effect, similar to what we described for point mutations. In protein-coding regions, the effects of deletions or insertions depend on their size. A small deletion or insertion that is an

regular physical therapy to clear the lungs, antibiotics, pancreatic enzyme supplements, and good nutrition, the average life expectancy of a person with cystic fibrosis is currently about 35 to 40 years, and continues to rise.

The mutations responsible for cystic fibrosis occur in the gene encoding the cystic fibrosis transmembrane conductance regulator (CFTR). The CFTR protein is a chloride channel, which acts as a transporter to pump chloride ions out of the cell. Mutations in the *CFTR* gene disrupt the function of the chloride channel, interfering with the usual flow of chloride ions. Because water follows ions by osmosis, the result is a buildup of thick mucus in the lungs, where the *CFTR* gene is expressed. Many different mutations can contribute to cystic fibrosis, including a mutation known as *ΔI508* (*delta 508*), which is a deletion of three nucleotides that eliminates a phenylalanine normally present at position 508 in the protein, shown in FIGURE 37.3. The

Missing amino acid (PHE)

Three nucleotides are deleted in the *CFTR* gene, resulting in a missing amino acid.

Chloride ions

Section 2: Free-Response Question

Write your answer to each part clearly. Support your answers with relevant information and examples. Where calculations are required, show your work.

Variation in the DNA sequences of genes encoding proteins can result in different individuals in a population carrying versions of the protein that have different amino acid sequences. The proteins can be isolated from tissue samples and separated with gel electrophoresis. The migration patterns of the isolated proteins reflect the genotype of the individual from which the proteins were isolated.

A researcher isolated a specific protein from blood samples taken from a mother bird and the six chicks in her nest. The researcher separated the proteins on a gel and obtained the pattern shown in the figure. The gene encoding the protein is encoded by a single gene that is on an autosomal chromosome.

Mother bird, Chick 1, Chick 2, Chick 3, Chick 4, Chick 5, Chick 6

Loading wells

Direction of DNA migration

(a) **Identify** two properties of proteins that cause them to migrate to different positions on gels.

(b) **Predict** the number of bands that would be observed on the gel if proteins were isolated from a bird that is homozygous for one allele of the gene encoding the protein.

(c) The researcher claims that the gel shown in the figure indicates that some birds in the nest may have different fathers. Provide evidence to **justify** whether you support or refute this claim.

Bell Ringer

6.1 Cell Theory (SP6)

(15 min.) The cell theory, a unifying concept in biology, has three critical claims: all organisms are made up of cells; cells are the fundamental unit of life; and cells come from preexisting cells. Ask students to consider what they already know about cells, then choose one of these three claims, turn to a partner, and *describe* evidence in support of the claim. Students can fill out their claims and evidence in the table, which is available in reproducible form in the handout.

Answers will vary but may include:

Claim	Evidence
All organisms are made up of cells.	*Look under a microscope to see that organisms are composed of cells.*
Cells are the fundamental unit of life.	*All the metabolic processes that keep an organism alive occur at the cellular level.* *If you explore anything smaller than the cellular level, the characteristics of life cannot be supported.*
Cells come from preexisting cells.	*Cells multiply through cell division to produce more cells.*

6.1 The cell is the fundamental unit of life

The cell is the simplest structure that exists as an indepe
dent unit of life. Every living organism is either a sing
cell— unicellular—or a group of a few to many cells
multicellular. FIGURE 6.1 shows examples of both unicell
lar and multicellular organisms. Most bacteria, yeasts, and t
tiny algae that float in oceans and ponds spend their lives
single cells. In contrast, plants and animals contain billions
trillions of cells that function in a coordinated fashion.

FIGURE 6.2 shows examples of different types of cel
Most cells are tiny, with dimensions that are too small
the naked eye to see. The cells that make up the layers

92 UNIT 2 CELL STRUCTURE AND FUNCTION

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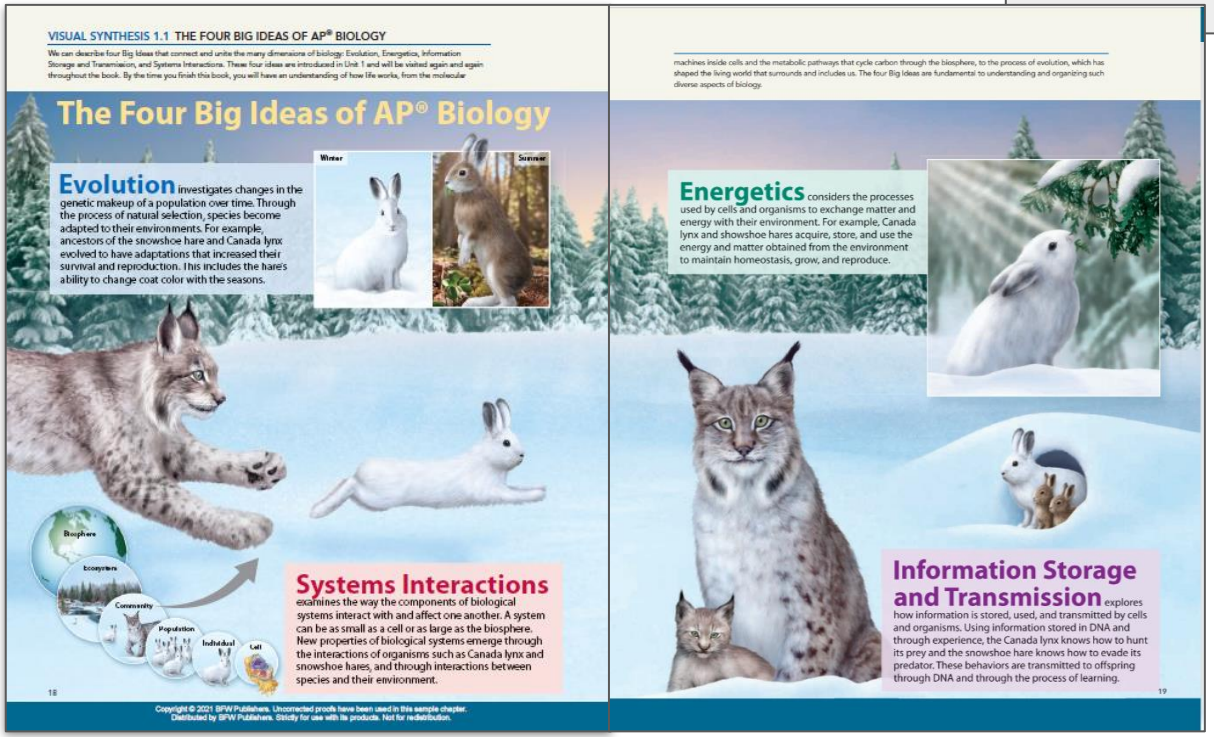
An Essential Visual Program

Visual Synthesis Figures
These graphics present key concepts in a visual way, while helping students make connections among Biology topics. Pg 19, 261



SP2: Visual Representation

An Essential Visual Program

- Hundreds of **PHOTOS** bring biology to life and figures help communicate concepts.

SP2: Visual Representation

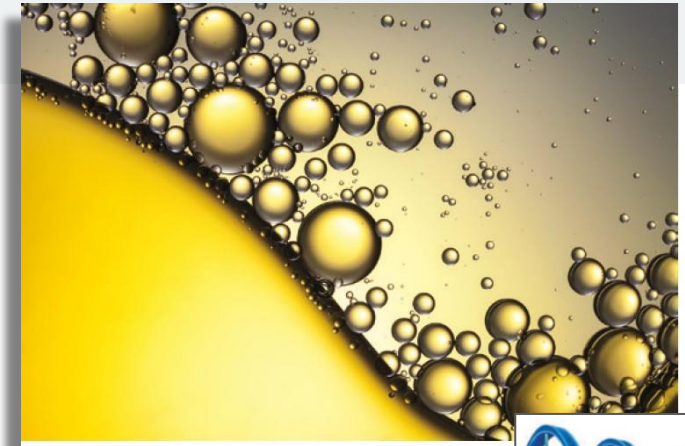


FIGURE 1.15 Lipids

When oil, which is a lipid, is mixed in water, it forms dr
minimize its contact with water. Oil, like all lipids, is hy

FIGURE 31.10 Chromosome packaging

DNA is wrapped around nucleosomes to a structure sometimes called "beads on a string," which becomes condensed into progressively shorter and thicker structures.

An Essential Visual Program

- Hundreds of **PHOTOS** bring biology to life.
- **GRAPHS** appear in both the text and problems, providing ample opportunities to learn how to read graphs and understand the relationship between data and visual display.

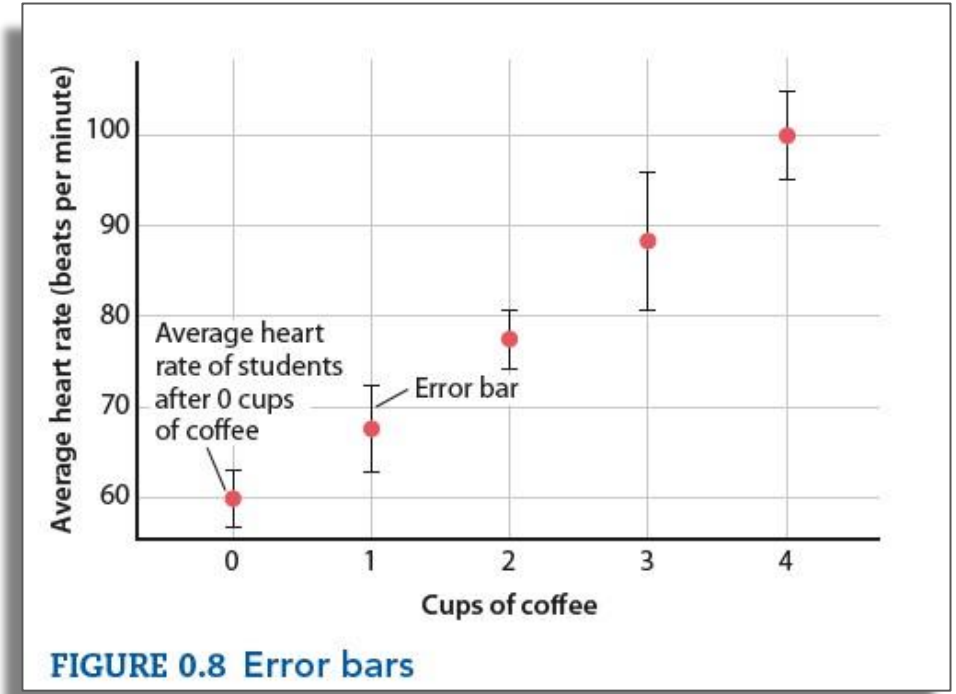


FIGURE 0.8 Error bars

An Essential Visual Program

- Hundreds of **PHOTOS** bring biology to life.
- **GRAPHS** appear in both the text and problems, providing ample opportunities to learn how to read graphs and understand the relationship between data and visual display.
- **ILLUSTRATIONS** show key concepts that provide details that help students understand structure and function.

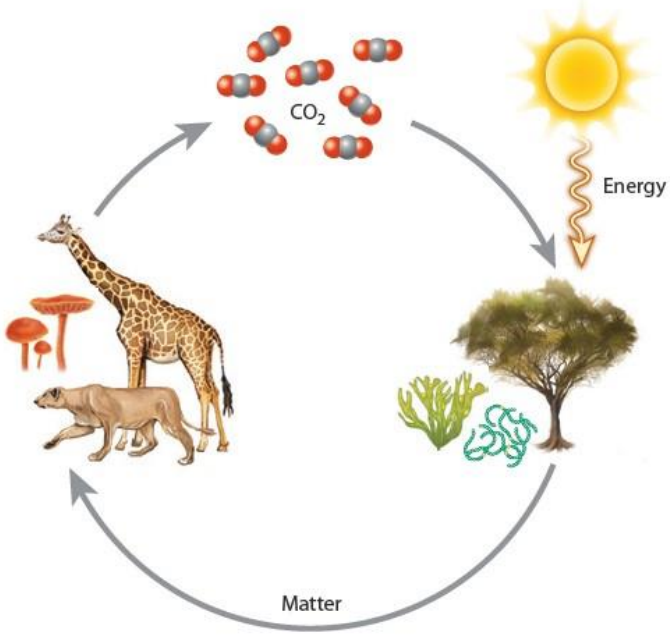


FIGURE 1.1 Flow of matter and energy

Matter, such as a carbon atom, cycles among organisms and the physical environment. Energy, like solar and chemical energy, is harnessed by organisms to do work and needs to be constantly added to the system to sustain life.

SP2: Visual Representation

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Other Features

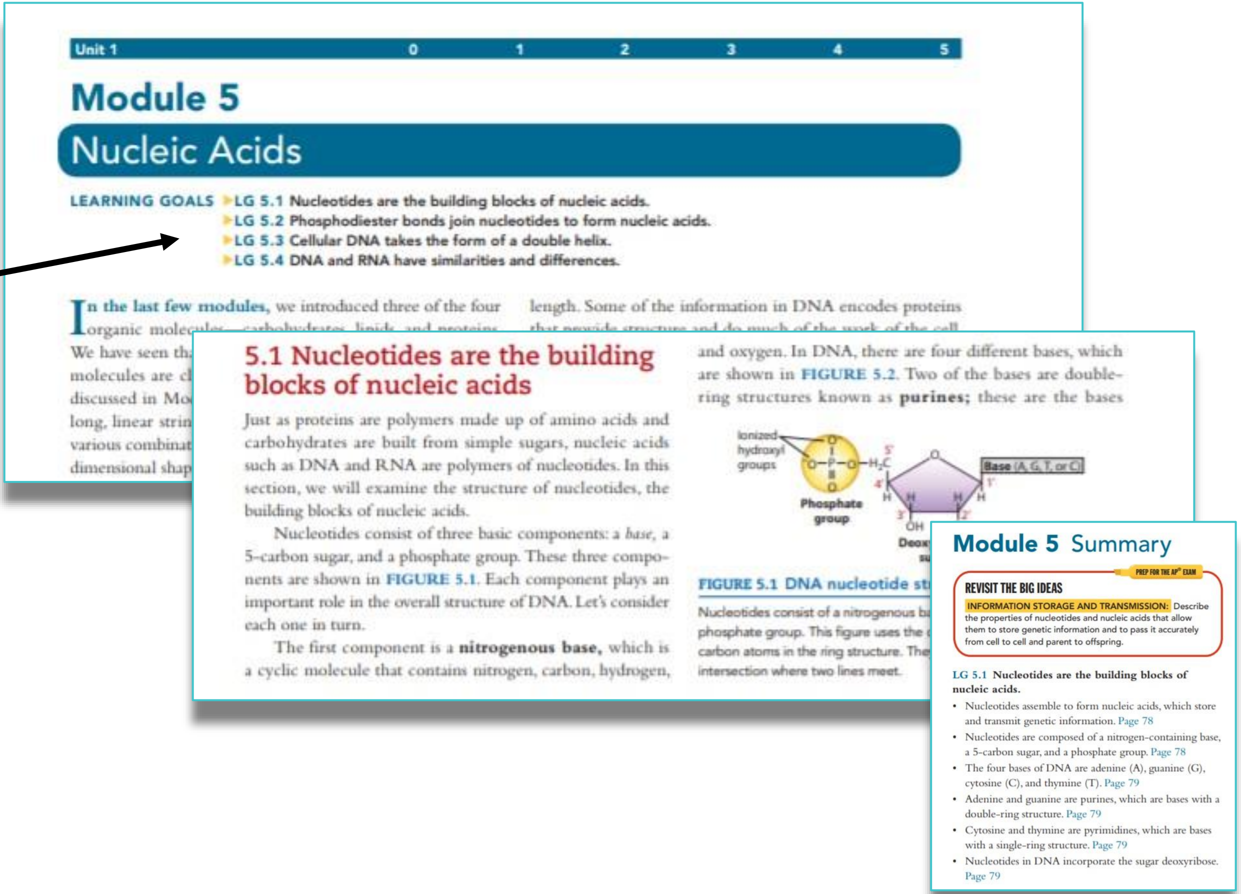
bfwpub.com

Interweaving the Four Big Ideas of AP® Biology

Each module is framed with a **Focus on the Big Ideas** prompt at the beginning and a related **Revisit the Big Ideas** question at the end.

Form and Function Combined.

- **Learning Goals**



Unit 1 0 1 2 3 4 5

Module 5

Nucleic Acids

LEARNING GOALS
- LG 5.1 Nucleotides are the building blocks of nucleic acids.
- LG 5.2 Phosphodiester bonds join nucleotides to form nucleic acids.
- LG 5.3 Cellular DNA takes the form of a double helix.
- LG 5.4 DNA and RNA have similarities and differences.

In the last few modules, we introduced three of the four organic molecules—carbohydrates, lipids, and proteins. We have seen th… molecules are c… discussed in Mo… long, linear strin… various combinat… dimensional shap…

length. Some of the information in DNA encodes proteins that provide structure and do much of the work of the cell.

5.1 Nucleotides are the building blocks of nucleic acids

Just as proteins are polymers made up of amino acids and carbohydrates are built from simple sugars, nucleic acids such as DNA and RNA are polymers of nucleotides. In this section, we will examine the structure of nucleotides, the building blocks of nucleic acids.

Nucleotides consist of three basic components: a *base*, a 5-carbon sugar, and a phosphate group. These three components are shown in FIGURE 5.1. Each component plays an important role in the overall structure of DNA. Let's consider each one in turn.

The first component is a **nitrogenous base,** which is a cyclic molecule that contains nitrogen, carbon, hydrogen, and oxygen. In DNA, there are four different bases, which are shown in FIGURE 5.2. Two of the bases are double-ring structures known as **purines;** these are the bases

FIGURE 5.1 DNA nucleotide st…

Nucleotides consist of a nitrogenous ba… phosphate group. This figure uses the… carbon atoms in the ring structure. The… intersection where two lines meet.

Module 5 Summary

PREP FOR THE AP® EXAM

REVISIT THE BIG IDEAS

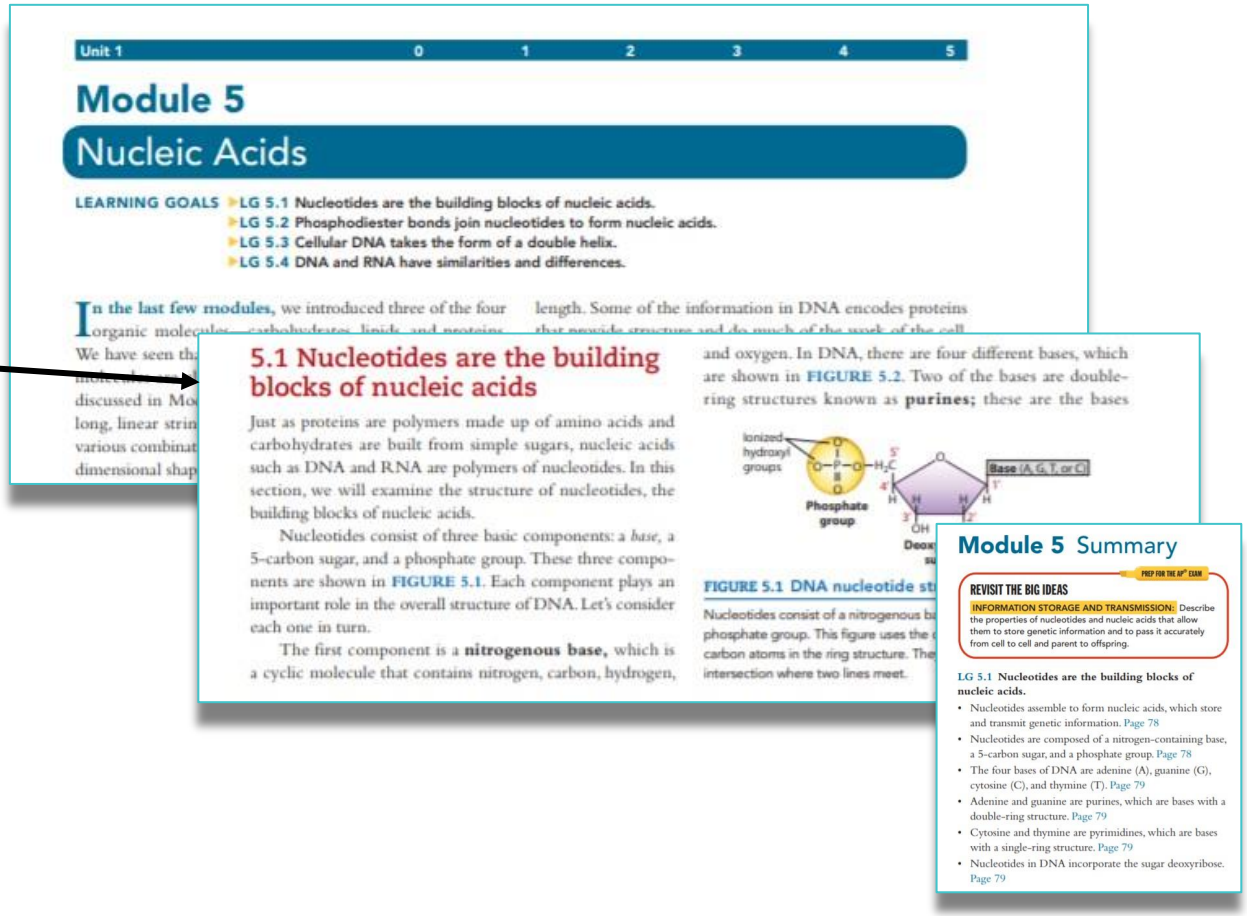
INFORMATION STORAGE AND TRANSMISSION: Describe the properties of nucleotides and nucleic acids that allow them to store genetic information and to pass it accurately from cell to cell and parent to offspring.

LG 5.1 **Nucleotides are the building blocks of nucleic acids.**

- Nucleotides assemble to form nucleic acids, which store and transmit genetic information. Page 78
- Nucleotides are composed of a nitrogen-containing base, a 5-carbon sugar, and a phosphate group. Page 78
- The four bases of DNA are adenine (A), guanine (G), cytosine (C), and thymine (T). Page 79
- Adenine and guanine are purines, which are bases with a double-ring structure. Page 79
- Cytosine and thymine are pyrimidines, which are bases with a single-ring structure. Page 79
- Nucleotides in DNA incorporate the sugar deoxyribose. Page 79

Form and Function Combined.

- Learning Goals
- **Section Heads**



Unit 1 0 1 2 3 4 5

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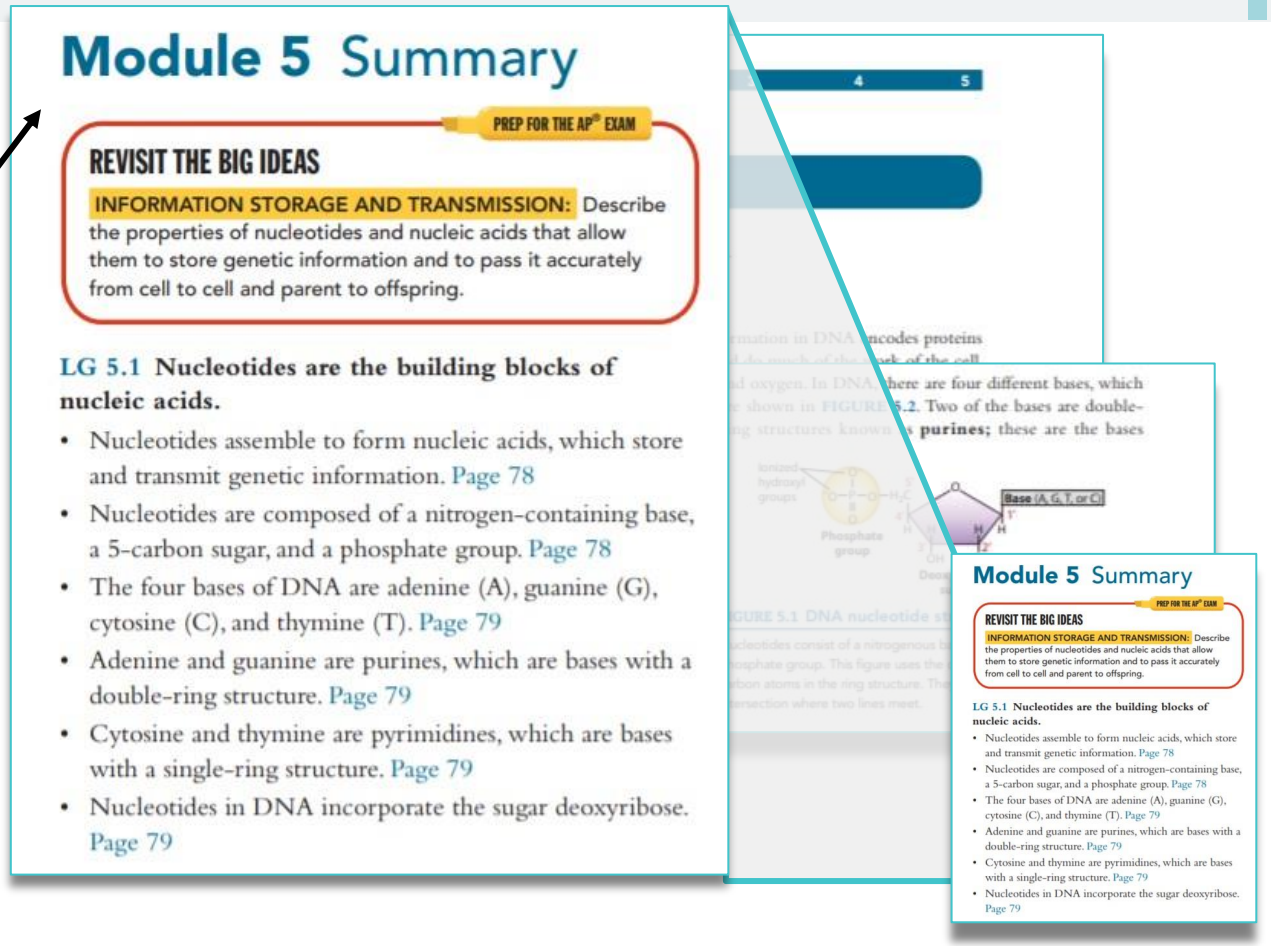
Form and Function Combined.

- Learning Goals
- Section Heads
- **Summaries**



Module 5 Summary

PREP FOR THE AP® EXAM

REVISIT THE BIG IDEAS

INFORMATION STORAGE AND TRANSMISSION: Describe the properties of nucleotides and nucleic acids that allow them to store genetic information and to pass it accurately from cell to cell and parent to offspring.

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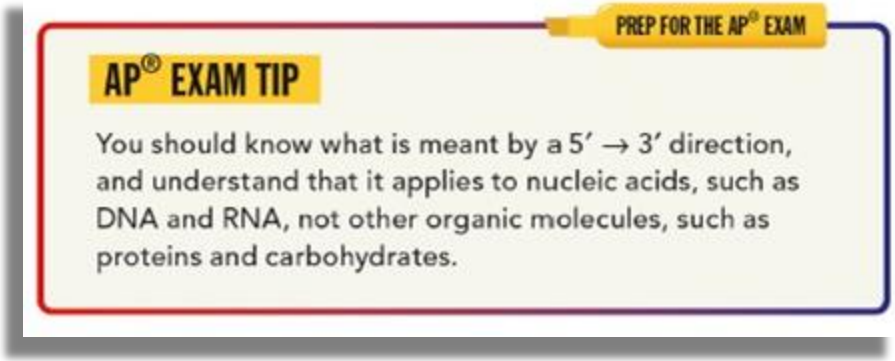
AP® Exam Tips pg 27

Written by two former chief readers, AP® Exam Tips in each module highlight key content students are likely to see on the exam and provide guideposts on concepts they should be sure to review.

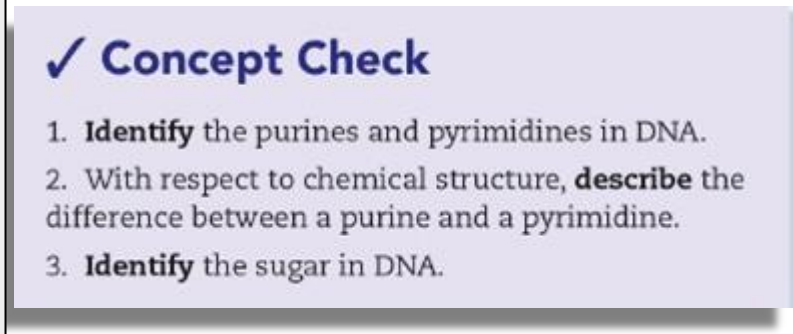

PREP FOR THE AP® EXAM

AP® EXAM TIP

You should know what is meant by a 5′ → 3′ direction, and understand that it applies to nucleic acids, such as DNA and RNA, not other organic molecules, such as proteins and carbohydrates.

Build confidence with multiple layers of assessment.

- Every section within a module concludes with a **Concept Check** (pg 27) with 2-4 questions, allowing students to check their reading comprehension.

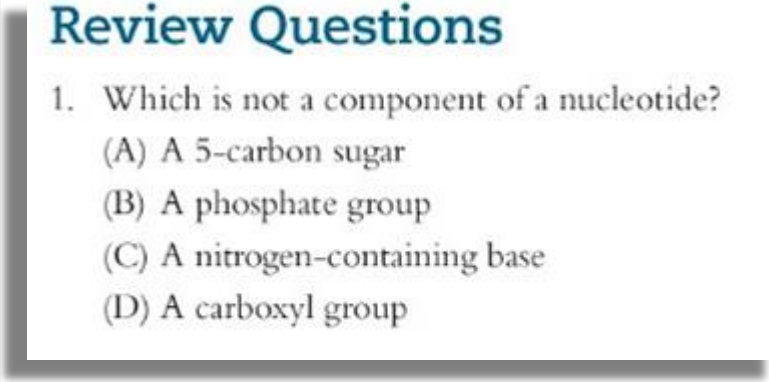


✓ Concept Check

1. **Identify** the purines and pyrimidines in DNA.
2. With respect to chemical structure, **describe** the difference between a purine and a pyrimidine.
3. **Identify** the sugar in DNA.

Build confidence with multiple layers of assessment .

- Pg 41 Every section within a module concludes with a **Concept Check** with 2-4 questions, allowing students to check their reading comprehension.
- **Review Questions** at the end of every module.

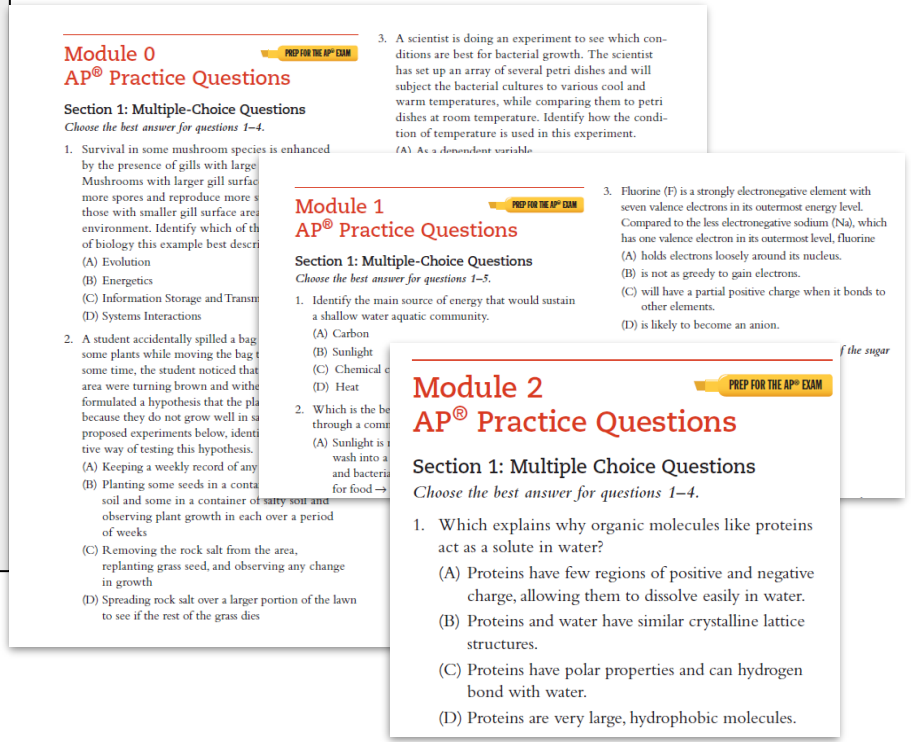


Review Questions

1. Which is not a component of a nucleotide?
   (A) A 5-carbon sugar
   (B) A phosphate group
   (C) A nitrogen-containing base
   (D) A carboxyl group

Build confidence with multiple layers of assessment.

- Every section within a module concludes with a **Concept Check** with 2-4 questions, allowing students to check their reading comprehension.
- **Review Questions** at the end of every module.
- Following each module, **Module AP® Practice Questions** tests students' ability to apply the Science Practices to module concepts



Module 0
AP® Practice Questions

PREP FOR THE AP® EXAM

Section 1: Multiple-Choice Questions

Choose the best answer for questions 1–4.

1. Survival in some mushroom species is enhanced by the presence of gills with large
Mushrooms with larger gill surfac
more spores and reproduce more s
those with smaller gill surface area
environment. Identify which of th
of biology this example best descri
(A) Evolution
(B) Energetics
(C) Information Storage and Transm
(D) Systems Interactions

2. A student accidentally spilled a bag
some plants while moving the bag t
some time, the student noticed that
area were turning brown and withe
formulated a hypothesis that the pla
because they do not grow well in sa
proposed experiments below, identi
tive way of testing this hypothesis.
(A) Keeping a weekly record of any
(B) Planting some seeds in a conta
soil and some in a container of salty soil and
observing plant growth in each over a period
of weeks
(C) Removing the rock salt from the area,
replanting grass seed, and observing any change
in growth
(D) Spreading rock salt over a larger portion of the lawn
to see if the rest of the grass dies

3. A scientist is doing an experiment to see which conditions are best for bacterial growth. The scientist has set up an array of several petri dishes and will subject the bacterial cultures to various cool and warm temperatures, while comparing them to petri dishes at room temperature. Identify how the condition of temperature is used in this experiment.
(A) As a dependent variable

Module 1
AP® Practice Questions

PREP FOR THE AP® EXAM

Section 1: Multiple-Choice Questions

Choose the best answer for questions 1–5.

1. Identify the main source of energy that would sustain a shallow water aquatic community.
(A) Carbon
(B) Sunlight
(C) Chemical e
(D) Heat

2. Which is the be
through a comm
(A) Sunlight is
wash into a
and bacteri
for food →

3. Fluorine (F) is a strongly electronegative element with seven valence electrons in its outermost energy level. Compared to the less electronegative sodium (Na), which has one valence electron in its outermost level, fluorine
(A) holds electrons loosely around its nucleus.
(B) is not as greedy to gain electrons.
(C) will have a partial positive charge when it bonds to other elements.
(D) is likely to become an anion.

f the sugar

Module 2
AP® Practice Questions

PREP FOR THE AP® EXAM

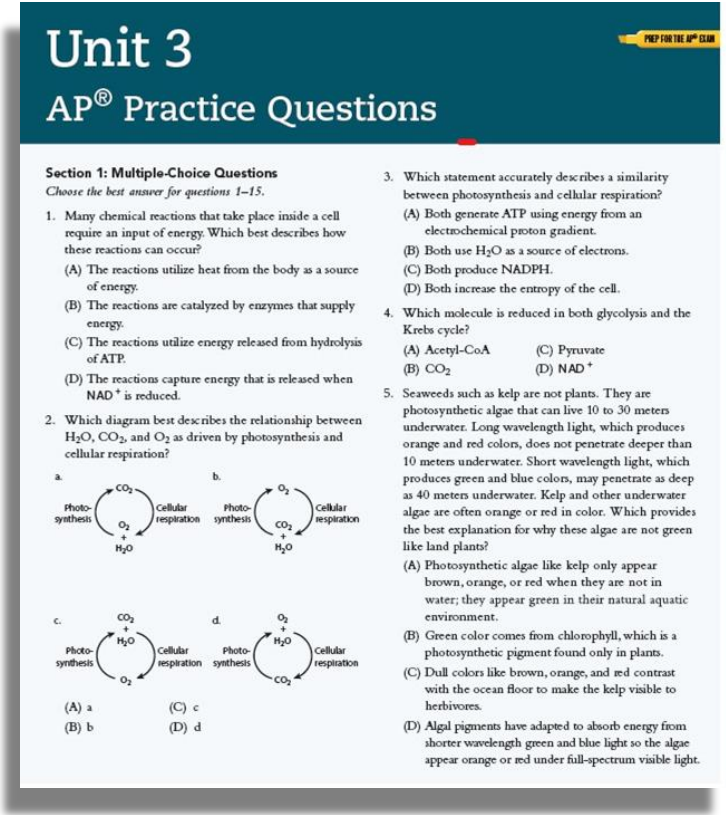
Section 1: Multiple Choice Questions

Choose the best answer for questions 1–4.

1. Which explains why organic molecules like proteins act as a solute in water?
(A) Proteins have few regions of positive and negative charge, allowing them to dissolve easily in water.
(B) Proteins and water have similar crystalline lattice structures.
(C) Proteins have polar properties and can hydrogen bond with water.
(D) Proteins are very large, hydrophobic molecules.

Build confidence with multiple layers of assessment.

- Every section within a module concludes with a **Concept Check** with 2-4 questions, allowing students to check their reading comprehension.
- **Review Questions** at the end of every module.
- Following each module, **Module AP® Practice Questions** tests students' ability to apply the Science Practices to module concepts
- **Unit AP® Practice Questions** at the end of each unit (pg 89)



Unit 3

PREP FOR THE AP® EXAM

AP® Practice Questions

Section 1: Multiple-Choice Questions

Choose the best answer for questions 1–15.

1. Many chemical reactions that take place inside a cell require an input of energy. Which best describes how these reactions can occur?
   (A) The reactions utilize heat from the body as a source of energy.
   (B) The reactions are catalyzed by enzymes that supply energy.
   (C) The reactions utilize energy released from hydrolysis of ATP.
   (D) The reactions capture energy that is released when NAD^+ is reduced.
2. Which diagram best describes the relationship between H_2O, CO_2, and O_2 as driven by photosynthesis and cellular respiration?

a. Photosynthesis: CO_2 + O_2 + H_2O → Cellular respiration

b. Photosynthesis: O_2 + CO_2 + H_2O → Cellular respiration

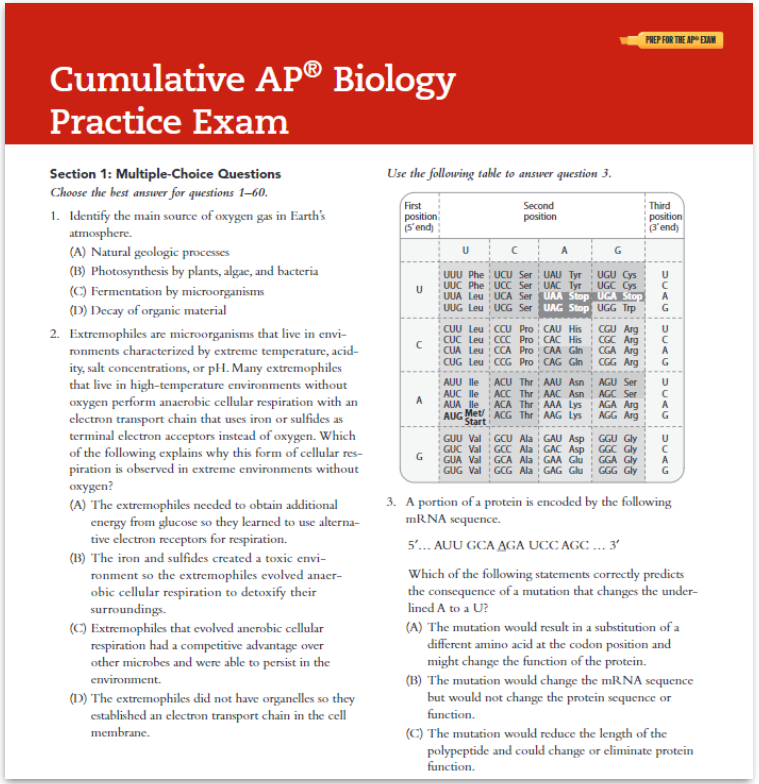
c. Photosynthesis: CO_2 + H_2O → Cellular respiration: O_2

d. Photosynthesis: O_2 + H_2O → Cellular respiration: CO_2

   (A) a (C) c
   (B) b (D) d
3. Which statement accurately describes a similarity between photosynthesis and cellular respiration?
   (A) Both generate ATP using energy from an electrochemical proton gradient.
   (B) Both use H_2O as a source of electrons.
   (C) Both produce NADPH.
   (D) Both increase the entropy of the cell.
4. Which molecule is reduced in both glycolysis and the Krebs cycle?
   (A) Acetyl-CoA (C) Pyruvate
   (B) CO_2 (D) NAD^+
5. Seaweeds such as kelp are not plants. They are photosynthetic algae that can live 10 to 30 meters underwater. Long wavelength light, which produces orange and red colors, does not penetrate deeper than 10 meters underwater. Short wavelength light, which produces green and blue colors, may penetrate as deep as 40 meters underwater. Kelp and other underwater algae are often orange or red in color. Which provides the best explanation for why these algae are not green like land plants?
   (A) Photosynthetic algae like kelp only appear brown, orange, or red when they are not in water; they appear green in their natural aquatic environment.
   (B) Green color comes from chlorophyll, which is a photosynthetic pigment found only in plants.
   (C) Dull colors like brown, orange, and red contrast with the ocean floor to make the kelp visible to herbivores.
   (D) Algal pigments have adapted to absorb energy from shorter wavelength green and blue light so the algae appear orange or red under full-spectrum visible light.

Build confidence with multiple layers of assessment.

BONUS! Cumulative Practice AP® Exam at the end of the book that matches the full structure and scope of the actual AP® Biology Exam. pg 835



PREP FOR THE AP® EXAM

Cumulative AP® Biology Practice Exam

Section 1: Multiple-Choice Questions

Choose the best answer for questions 1–60.

1. Identify the main source of oxygen gas in Earth's atmosphere.
   (A) Natural geologic processes
   (B) Photosynthesis by plants, algae, and bacteria
   (C) Fermentation by microorganisms
   (D) Decay of organic material

2. Extremophiles are microorganisms that live in environments characterized by extreme temperature, acidity, salt concentrations, or pH. Many extremophiles that live in high-temperature environments without oxygen perform anaerobic cellular respiration with an electron transport chain that uses iron or sulfides as terminal electron acceptors instead of oxygen. Which of the following explains why this form of cellular respiration is observed in extreme environments without oxygen?
   (A) The extremophiles needed to obtain additional energy from glucose so they learned to use alternative electron receptors for respiration.
   (B) The iron and sulfides created a toxic environment so the extremophiles evolved anaerobic cellular respiration to detoxify their surroundings.
   (C) Extremophiles that evolved anerobic cellular respiration had a competitive advantage over other microbes and were able to persist in the environment.
   (D) The extremophiles did not have organelles so they established an electron transport chain in the cell membrane.

Use the following table to answer question 3.

First position (5′ end)	Second position U	Second position C	Second position A	Second position G	Third position (3′ end)
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met/Start	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

3. A portion of a protein is encoded by the following mRNA sequence.

   5′… AUU GCA AGA UCC AGC … 3′

   Which of the following statements correctly predicts the consequence of a mutation that changes the underlined A to a U?
   (A) The mutation would result in a substitution of a different amino acid at the codon position and might change the function of the protein.
   (B) The mutation would change the mRNA sequence but would not change the protein sequence or function.
   (C) The mutation would reduce the length of the polypeptide and could change or eliminate protein function.

Changes to the FRQs

Any student practicing from FRQs from our book will be able to tackle this just fine, you may even say the FRQs will be easier for them now - one skill we teach from the beginning of the book is the reading of stimuli and then breaking it into parts, what is what this new layout does for them now.

TE Note pg 17

Also, tweaked some of the FRQs

Practice FRQ in the NEW 2024 Layout - from UNIT 2 of *Biology for the AP® Course* (pp. 183)

UNIT 2

Section 2: Free-Response Question 1

Write your answer to each part clearly. Support your answers with relevant information and examples. Where calculations are required, show your work.

1. *Lactococcus lactis* is a spherical bacterium commonly found in products such as yogurt. *L. lactis* ferments dairy products like yogurt by absorbing the sugar lactose through its membrane and breaking the lactose into its component sugars, glucose and galactose. Researchers grew *L. lactis* and grouped the cells by volume in order to study the rate of breakdown of lactose. The same number of *L. lactis* cells are present in each group. Data collected for this experiment are listed in the table.

Group	1	2	3	4
Radius (µm)	0.3	0.5	0.7	1.0
Surface area (μm^2)	1.13	3.14	6.16	12.6
Volume (μm^3)	0.11	0.53	1.44	4.19
Rate of lactose breakdown (µmol/min)	9.0	7.1	4.9	3.2

(a)

(i) **Construct** an appropriately labeled graph using the data in the table to show the rate of galactose breakdown of the groups.

AP® EXAM SKILL

Reading for Key Information

This may be the first time students have seen a free-response question in this kind of format, with an extensive stem that requires a lot of reading. Students may be intimidated by the amount of text in this question's stimulus, or by the combination of text and data. A key skill for students to learn early on is how to read stimuli, determine what is being asked, and isolate relevant pieces of information. If students are having difficulty with this, they should try reading the questions before the stimulus in

dependent variables, the experimental and control groups, and the null and alternative hypotheses.

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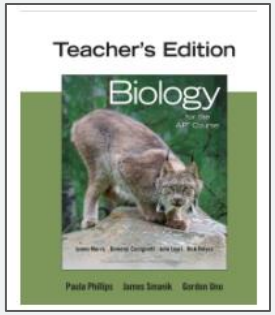

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Meet the Teacher's Edition Authors

Paula Phillips

- Taught AP® Biology and other related courses for over three decades-currently teaching HS in Lansing, NY.
- Involved in the AP® reading since 1994–has been a reader, table leader, and assistant chief reader.
- Conducts summer workshops.
- 2016 Outstanding Biology Teacher of the Year from NABT

James Smanik

- Taught AP® Biology and other courses for over 34 years-currently teaching HS in Cincinnati.
- Involved in the AP® reading for 28 years–has been reader, table leader.
- Conducts summer workshops.
- Served on AP® Biology development committee 2011-2016.

Gordon Uno

- Currently teaching at University of OK.
- Member of the AP® Biology committee that revised the CED 2010-2016, co-chair for four years.
- Was elected president of the NABT.

Unit-opening planning pages

Unit 3
Cellular Energetics

Unit 3 Overview

Now that students know about the chemistry of life and the fundamentals of cell structure and function, they are ready to learn more about the transfers of energy within organisms and through ecosystems. Unit 3 begins by establishing the rules governing chemical reactions in Module 13, since life is an emergent property of the chemistry occurring inside and outside of cells. Because all these reactions require enzymes in order to occur, Module 14 is about enzymes. Then the question arises, if energy cannot be created, where do we get ATP? Modules 15 and 16 explain how plants harness energy from the sun and transfer that energy into chemical potential energy. Modules 17 and 18 investigate the mechanism that many cells use to transfer the energy from food to ATP. Module 19 steps back and considers Big Idea 1: Evolution, by discussing the many different mechanisms that organisms utilize to harness energy from the sun and to transfer it to ATP. Unit 3 is challenging for many students as there are a lot of details and terminology, and the biochemistry is somewhat abstract. The two tools that may be most helpful are the photosynthesis and cellular respiration organizers, which help students focus on comparable information across the various pathways they will study, as well as the modeling of chemiosmosis which helps make the processes of electron transport, oxidation reduction reactions, and ATP synthesis within the organelles more concrete.

Module 13: Cellular Energetics

Module 13 lays out the role of energy in life, explaining the basic concepts of energy transfer that are the foundation for the rest of Unit 3. The Module begins by identifying and describing the molecules, concepts, and laws that play a role in energy transfer in living organisms. Life is an emergent property of all the metabolic pathways and their regulation. The key takeaways are that the transfer of energy in chemical reactions is governed by the laws of thermodynamics, and that reactions that require energy to move forward are non-spontaneous while reactions that release free energy are considered spontaneous. Both reactions require enzymes. The introduction of these takeaways should only take one class period since they will be utilized and applied throughout the Unit, providing opportunities for reinforcement.

Differentiate: The concept of entropy is very abstract but since they are familiar with transfers of energy producing heat, students should intuitively understand that in metabolism an increase in entropy manifests as heat energy. Students need to understand ATP is the usable form of chemical energy in cells.

3-2 UNIT 3 CELLULAR ENERGETICS

Pacing Guide

Module	Learning Goals	Key Activities (pages)		
13	**13.1** Kinetic and potential energy are two forms of energy. **13.2** The laws of thermodynamics govern energy flow in biological systems. **13.3** Chemical reactions transform molecules and transfer energy in cells.	Paula & Jim's Corner (184) TRM **Teaching the AP® Tip:** Energy Map (190) TRM **Teaching with Figure 13.8** (191)		
14	**14.1** Enzymes increase the rates of chemical reactions. **14.2** Enzymes bind reactants at active sites, which are highly specific. **14.3** Enzymes are influenced by the environment, activators, and inhibitors.	TRM **Activity:** Graphing Catalysis (196) TRM **Teaching with Figures 14.4 and 14.6** (202) TRM **Activity:** Modeling Inhibition (206)		
15	**15.1** Photosynthesis is the major entry point for energy into biological systems. **15.2** Photosynthesis is a redox reaction. **15.3** Photosynthesis takes place in two main stages.	**Common Misconception:** 3-Carbon Product of Photosynthesis (212) TRM **Activity:** Modeling Redox (214) TRM **Activity:** Photosynthesis Organizer (217)		
16	**16.1** The light reactions use sunlight to produce ATP and NADPH. **16.2** The Calvin cycle uses ATP and NADPH to build carbohydrates.	TRM **Teaching the AP® Tip:** Modeling the Light Reactions (226) TRM **Teaching with Figure 16.10** (227)		
17	**17.1** Cellular respiration harnesses energy of carbohydrates and other fuel molecules. **17.2** Cellular respiration takes place in four stages. **17.3** Cellular respiration can make use of diverse organic molecules.	TRM **Activity:** Modeling Electron Carriers (236) TRM **Activity:** Cellular Respiration Organizer (237) TRM **Teaching with Figure 17.9** (240)	1½	¾
18	**18.1** Glycolysis, pyruvate oxidation, and the Krebs cycle break down organic molecules. **18.2** Oxidative phosphorylation involves an electron transport chain and ATP synthesis. **18.3** Fermentation and cellular respiration meet the energy needs of a cell.	**Teaching with Figure 18.4** (248) TRM **Activity:** Modeling ATP Synthesis (249) TRM **Teaching with Figures 18.8 and 18.9** (255)	3	1½

Module	Learning Goals	Key Activities (pag
19	**19.1** The earliest cells used anaerobic metabolism to survive and reproduce. **19.2** Photosynthesis transformed life on Earth. **19.3** Metabolic variation affects survival and reproduction.	TRM **Bell Ringer:** Energy Ad TRM **Teaching the AP® Tip:** Traits (266) TRM **Making Connections:** Claim (266)
	Unit 3 assessment	**Mini-Exam:** Unit 3 AP® Practic

Unit 3 Resources

Unit 3
- Unit 3 Overview Video
- Illustrative Example: An Unusual Partnership
- Unit 3 Additional FRQ
- Answers to all Unit exam questions

Module 13
- Lecture Slide Presentation 13
- BiologyExtras Module 13
- 13.1 Bell Ringer: Food Chain
- 13.2 Focus on the Big Ideas: Energy Needs and Strategies
- 13.3 Animation Activity: Kinetic and Potential Energy Animation
- 13.4 Making Connections: Cellular Processes
- 13.5 Teaching the AP® Tip: Kinetic versus Potential Energy
- 13.6 Making Connections: Energy in Macromolecules
- 13.7 Making Connections: Bond Energy in Dot Diagrams
- 13.8 Teaching with Figure 13.4
- 13.9 Teaching Tip: Justify Statements
- 13.10 Making Connections: Energy in Glycolysis
- 13.11 Activity: Draw the 1st Law
- 13.12 Activity: Draw the 2nd Law
- 13.13 Activity: Modeling Entropy
- 13.14 Teaching Tip: Calculating Energy
- 13.15 Teaching the AP® Tip: Energy Map
- 13.16 Animation Activity: Chemical Reactions Animation
- 13.17 Teaching Tip: Absolute Values
- 13.18 Teaching with Figure 13.8
- 13.19 Making Connections: Active Transport
- 13.20 Teaching Tip: Matching Terms
- 13.21 Teaching with Figure 13.11
- Answers to all Module 13 questions

Module 14
- Lecture Slide Presentation 14
- BiologyExtras Module 14
- 14.1 Bell Ringer: Spontaneity of Rolling Rocks
- 14.2 Teaching Tip: Metabolic Map
- 14.3 Activity: Graphing Catalysis
- 14.4 Teaching the AP® Tip: Increasing the Rate of Reaction
- 14.5 Teaching Tip: Enzyme Features Catalog
- 14.6 Making Connections: Chemical Equilibrium
- 14.7 Additional Your Turn Question: Rates
- 14.13: Making Connections: Subst Binding
- 14.14 Teaching with Figure 14.8
- 14.15 Mini-Lab: Food Enzymes
- 14.16 Teaching with Figure 14.9
- 14.17 Mini-Lab: Modeling Inhibiti
- Answers to all Module 14 questio

Module 15
- Lecture Slide Presentation 15
- BiologyExtras Module 15
- 15.1 Bell Ringer: Book Logic
- 15.2 Making Connections: Estimat Tree Photosynthesis
- 15.3 Activity: Phytoplankton Hall o
- 15.4 Activity: Tracking Redox
- 15.5 Activity: Modeling Redox
- 15.6 Teaching the AP® Tip: Overa Equation
- 15.7 Teaching with Figures 15.5 a

3-6 UNIT 3 CELLULAR ENERGETICS

Illustrative Example for Unit 3

TRM Illustrative Examples are case studies that present a "story" in biology and ask students to work with the data and the information provided to make predictions, conduct outside research, and apply what they have learned in the course so far. Unit 3's Illustrative Example describes a partnership between algae and salamanders that makes for a seemingly photosynthetic animal. Students are asked to reach back to what they learned in Unit 2 about symbiotic relationships that evolve over time, and apply what they now know about photosynthesis and cellular respiration to predict the effects of the organisms' relationship and analyze related data. The Illustrative Example is best used toward the end of Unit 3.

AP® Laboratory Guide

The AP® Biology Lab Manual includes three popular labs which can also be time consuming. There are many variations of enzymatic reaction labs, so feel free to utilize the one with which you feel most comfortable. Most protocols provide the opportunity to discover the effect of changes in concentrations of enzymes or substrates as well as changes in the environment. They also provide the opportunity for student inquiry. Investigation 5, Photosynthesis, in the AP® Biology Lab Manual is a simple protocol using leaf discs that also lends itself to student inquiry. It is vital for students to master the procedure described in order to get consistent data. It seems obvious, but it is worth emphasizing that the plants used must be healthy looking and at room temperature, and the light source must be of high enough intensity so photosynthesis occurs. Investigation 6, Cellular Respiration, can be time consuming without the use of compu
up manual respirometers
It is valuable to do one o
test to give students time

AP® FRQ Practice

Year	Question	Content
2013	4	Interaction of photosynthesis and cellular respiration in the cycling of carbon between carbon dioxide and organic molecules
2015	2	Role of each pathway in cellular respiration in the making of ATP; justify claim that glycolysis evolved early; calculations of efficiency of ATP production and connection to entropy; connection to process of science
2021	3	Compare relative ATP production via cellular respiration versus fermentation; negative controls; predictions due to a change in the protocol; role of oxygen in electron transport and connection to protocol

Correlation to the AP® Course and Exam Description*

Module	Enduring Understanding	Learning Objective	Essential Knowledge	Science Practice
13	ENE-1	ENE-1.H	ENE-1.H.1 ENE-1.H.2 ENE-1.H.3	6.C
14	ENE-1	ENE-1.D ENE-1.E ENE-1.F ENE-1.G	ENE-1.D.1 ENE-1.E.1 ENE-1.F.1 ENE-1.F.2 ENE-1.G.1 ENE-1.G.2 ENE-1.G.3 ENE-1.G.4	1.B 3.C.b 3.C.c 6.E.c
15	ENE-1	ENE-1.I	ENE-1.I.1 ENE-1.I.2	6.B
16	ENE-1	ENE-1.J	ENE-1.J.1 ENE-1.J.2 ENE-1.J.3 ENE-1.J.4 ENE-1.J.5	6.B
17	ENE-1	ENE-1.K	ENE-1.K.1 ENE-1.K.2 ENE-1.K.3	4.A
18	ENE-1	ENE-1.L	ENE-1.L.1 ENE-1.L.2 ENE-1.L.3 ENE-1.L.4 ENE-1.L.5 ENE-1.L.6 ENE-1.L.7	4.A
19	SYI-1	SYI-3.A	SYI-3.A.1 SYI-3.A.2	6.C

* Should changes be made to the Course and Exam Description in the future, an updated alignment will be placed on BFW's AP® updates page at go.bfwpub.com/ap-updates.

Marginal notes

Teach
Engage
Assess
Connect
Extend
Teaching the AP Tip
Differentiate
Paula & Jim's Corner

TEACH

TRM Teaching Tip
13.17 Absolute Values (SP1)
(10 min.) Students do not need to memorize the Gibbs free energy equation, but they do need to know and apply changes in free energy over the course of a chemical reaction. Remind them that free energy is the energy that is actually available to do work. The table in the handout shows some reactions and the *absolute* values of their associated free energy changes. Ask students to fill in the last two columns, indicating whether the ΔG is positive or negative, and whether the reaction is spontaneous.

TEACHING THE AP® TIP

(SP1, SP2)
(10 min.) Many cellular reactions are reversable, such as the synthesis and catalysis of carbonic acid shown in Figure 13.7. This may be new for some students, so review by asking students to pair up and for each reaction in the reversable reaction shown in Figure 13.7, identify the reactant(s) and the product(s). *Answer: For the forward reaction, the reactants are carbon dioxide and water, and the product is carbonic acid. In the reverse reaction, the reactant is carbonic acid and the products are carbon dioxide and water.*

ENGAGE

TRM Animation Activity
13.3 Kinetic and Potential Energy Animation
(10 min.) Go to the online platform to watch our kinetic and potential energy animation, using art from the book.

Differentiate: If students need additional review, download the handout, which contains questions about the animation.

Differentiate: If students are struggling to fill in the type of condition in which each type of extremophile lives, advise them to break the word down into prefix and root word using a dictionary, if necessary. Alternatively, provide the extreme condition, and have students just predict the adaptations.

EXTEND

TRM Enrichment
6.9 Extremophiles (SP6)
(15 min.) In this activity, encourage students to think like a research scientist and make predictions about a biological system. Show students the short video about extremophiles (linked in BiologyExtras), and then ask them to work with a partner to fill in the table in the handout. The table lists different extremophiles.

ASSESS

Answers to Concept Checks 6–7
6. The amount of energy available to do work is called Gibbs free energy (G). In a chemical reaction, you compare the free energy of the reactants and products to determine whether there is energy available to do work. This difference is called ΔG.
7. Catabolism and anabolism are both metabolic processes. Catabolism is the set of chemical reactions that breaks down macromolecules into smaller units, releasing energy, usually in the form of ATP. Anabolism is the set of chemical reactions that builds macromolecules from smaller units and requires an input of energy, usually in the form of ATP.

PD Unit 3 Overview Video
A video overview of Unit 3 for teachers is available in the Teacher's Resource Materials.

TRM Lecture Slide Presentation 13
A lecture slide presentation for Module 13 is available in the Teacher's Resource Materials.

TRM BiologyExtras: Module 13
BiologyExtras is a curated guide to additional animations and videos you may wish to include in your course, when time permits, to enhance your instructions and meet the unique needs of your classroom.

TRM Bell Ringer
13.1 Food Chain (SP5)
(15 min.) Present students with a description of a simple food chain in order to have them use Science Practice 5, Data Analysis, to start thinking about Big Idea 2: Energetics. In providing the food chain description (which, in the handout, includes numbers indicating how much energy each member of the chain obtains from their food source), the focus is not on ecology, but rather the transfer of energy from one member of the food chain to another. Conveniently, this example can be used several times throughout the year so by the time you teach ecology, students will be very familiar with the concept of a food chain. The scenario and questions are available in the handout.

Paula & Jim's CORNER

Framing Energy for Biology
There are many terms and details in Module 13, and it can be a challenge to help students keep their eyes on the big picture. Tell students that we are amazing walking chemistry sets. Life is an emergent property of chemistry, so it will help if they can learn how cells control these reactions. How do cells turn them on and off? How do they speed them up or slow them down? Module 13 begins to outline how this is accomplished. The main concepts in Module 13 can be distilled down to key ideas that are applicable to the biochemistry that students will learn in the remainder of Unit 3:

1. The laws of thermodynamics state that energy cannot be created or destroyed, but it can be transferred from one form to another. However, this transfer is not 100% efficient, so entropy increases and in many of the metabolic reactions we see in cells, this means heat is produced.
2. Though not discussed until Module 14, all of the cellular reactions require an enzyme.
3. There are two major types of chemical reactions based on energy transfer: spontaneous (exergonic) and non-spontaneous (endergonic).
   a. Exergonic reactions only need an enzyme in order to occur and result in energy being released.
   b. Endergonic reactions require enzymes, but they also require the input of energy into the system for the reaction to occur. This energy source is usually ATP.
4. After covering the fundamental rules governing cellular energetics in Module 14, the rest of Unit 3 examines important components of energy transfer in living organisms. Since all reactions require enzymes, Module 14 has a focus on how

Unit 3
Cellular Energetics

Module 13
Cellular Energy

LEARNING GOALS
- LG 13.1 Kinetic and potential energy are two forms of energy.
- LG 13.2 The laws of thermodynamics govern energy flow in biological systems.
- LG 13.3 Chemical reactions transform molecules and transfer energy in cells.

In the last unit, we focused on the structure and function of cells. Cells come in many different shapes and sizes, but they are all able to harness energy from the environment. This unit focuses on what energy is and how cells use it to carry out their functions.

As we discussed in Unit 1, energy is the ability to do work. Cells need energy to do all kinds of work. They grow and divide. They move, change shape, pump ions in and out, and transport vesicles. They also synthesize macromolecules such as nucleic acids, proteins, carbohydrates, and lipids. These activities are all considered work, and they all require energy. Cells are also highly organized, with cell membranes and genetic material interacting as a system in a precise manner so that a cell can carry out its functions. Maintaining this high level of organization also requires a sustained input of energy.

We are all familiar with different sources of energy, including the sun and wind, as well as fossil fuels such as oil and natural gas. We have learned to harness the energy from these sources and convert it to other forms, such as electricity, to provide needed power to our homes, schools, cars, planes, towns, and cities. In a similar way, cells harness energy from the environment and convert it to a form that allows them to do the work necessary to sustain life. Cells harness energy from just two sources: the sun and chemical compounds. You learned about these chemical compounds in Unit 1, including carbohydrates, lipids, and proteins. The food we eat, for example, contains energy. Although the source of energy may differ among cells, all cells transfer energy to a form that can be easily used to drive cellular processes.

In this module, we consider energy in the context of cells. We will introduce two forms of energy, and then consider what happens when energy is transferred from one form to another, and from one molecule to another. Finally, we will examine chemical reactions. Chemical reactions are processes by which molecules are transformed into other molecules by the breaking and forming of chemical bonds. They are also the way in which energy is transferred in cells.

PREP FOR THE AP® EXAM

FOCUS ON THE BIG IDEAS
ENERGETICS: Look for the many ways that cells make use of energy and note the strategies cells utilize to capture, convert, and store energy.

Teacher's Resource Materials

- Pacing Guides
- Worksheets/Handouts
- Overview Videos & Animations
- Additional math practice questions for each Analyzing Statistics and Data box
- Additional AP-style FRQ for each Unit review
- BiologyExtras: Outside web resources
- Lecture Slides for each Module
- PD video for each Unit
- Answer Keys/Suggested Responses

Assessment

- Over 2,000 questions
- The platform is fully customizable, allowing you to enter your own questions and edit existing questions
- To discourage cheating, the test bank can scramble answers and change the order of questions
- Can easily export into most common LMSs
- Our BFW Test Generator is cloud-based and does not require installation
- Works seamlessly on a Mac or PC

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ACHIEVE digital platform

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Using **AP®**Classroom in conjunction with Achieve

Achieve can function as your **primary tool**, offering:

- daily practice that builds AP®-level mastery.
- AP®- style questions, including a full exam, that have never been seen before (not released qs)
- formative wrong-answer feedback for multiple-choice questions in most course areas, and Learning Curve adaptive formative assessment in other course areas. All this formative assessment is guiding students to understanding.
- unique Goal-Setting and Reflections surveys, designed to help students become better students and learners – to maximize study time and refine habits with tips from the science of learning. These are pre-made and easy to assign.
- great flexibility to customize as you see fit.
- all your teacher resources.
- integration with common LMS and rostering systems.

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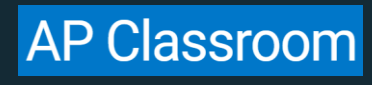
- daily videos (flipped classrooms/remediation/absences).
- topic questions/progress checks that are helpful for checking basic understanding.
- full exams for end-of-year review.



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Achieve

is

Online Courseware

- E-book
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- Adaptive Quizzing
- Summative Quizzes
- Gradebook

Coming Fall 2025 – Respondus Lockdown Browser!!

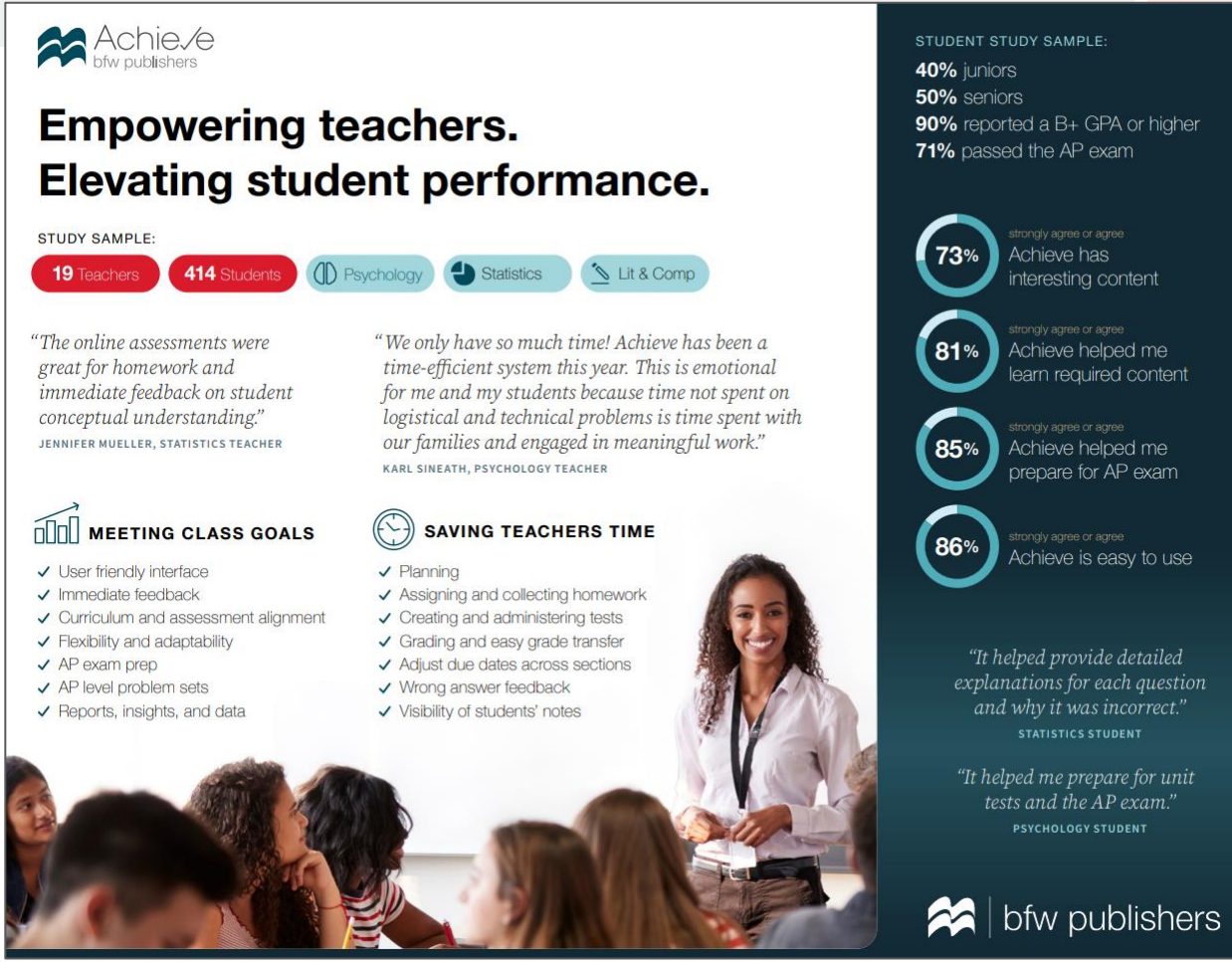
Our research on Achieve

Saves teachers time

- planning
- assigning/collecting HW
- grading, etc.

Meets class goals

- alignment
- exam prep
- differentiation
- insights/reports/data



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Ebook:

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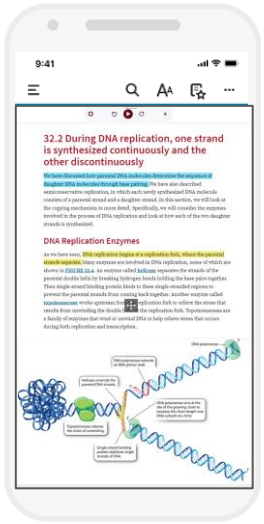
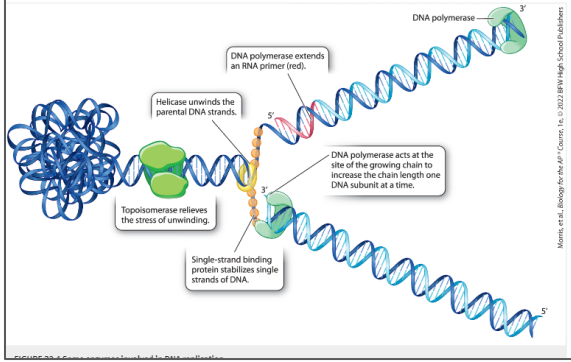


32.2 During DNA replication, one strand is synthesized continuously and the other discontinuously

We have discussed how parental DNA molecules determine the sequence of daughter DNA molecules through base pairing. We have also described semiconservative replication, in which each newly synthesized DNA molecule consists of a parental strand and a daughter strand. In this section, we will look at the copying mechanism in more detail. Specifically, we will consider the enzymes involved in the process of DNA replication and look at how each of the two daughter strands is synthesized.

DNA Replication Enzymes

As we have seen, DNA replication begins at a replication fork, where the parental strands separate. Many enzymes are involved in DNA replication, some of which are shown in FIGURE 32.4. An enzyme called helicase separates the strands of the parental double helix by breaking hydrogen bonds holding the base pairs together. Then single-strand binding protein binds to these single-stranded regions to prevent the parental strands from coming back together. Another enzyme called topoisomerase works upstream from the replication fork to relieve the stress that results from unwinding the double helix at the replication fork. Topoisomerases are a family of enzymes that wind or unwind DNA to help relieve stress that occurs during both replication and transcription.



9/8/2023
Important for exam.

Reader Preferences

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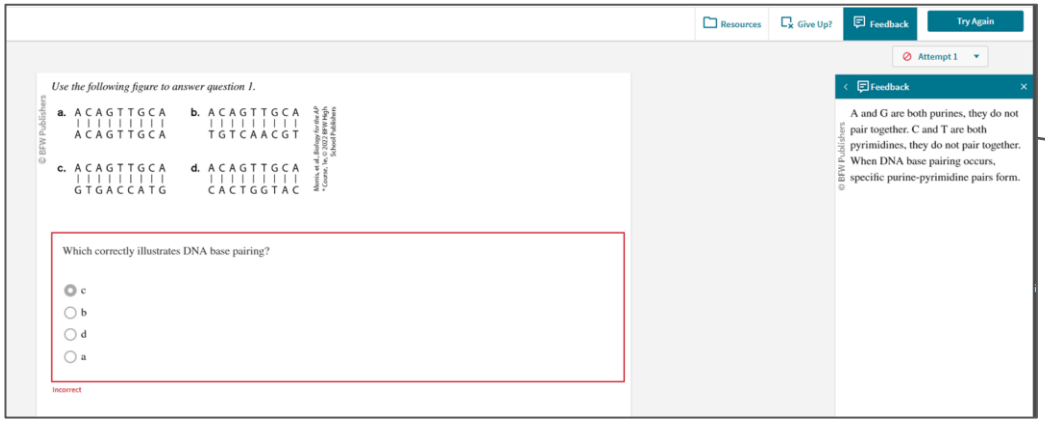
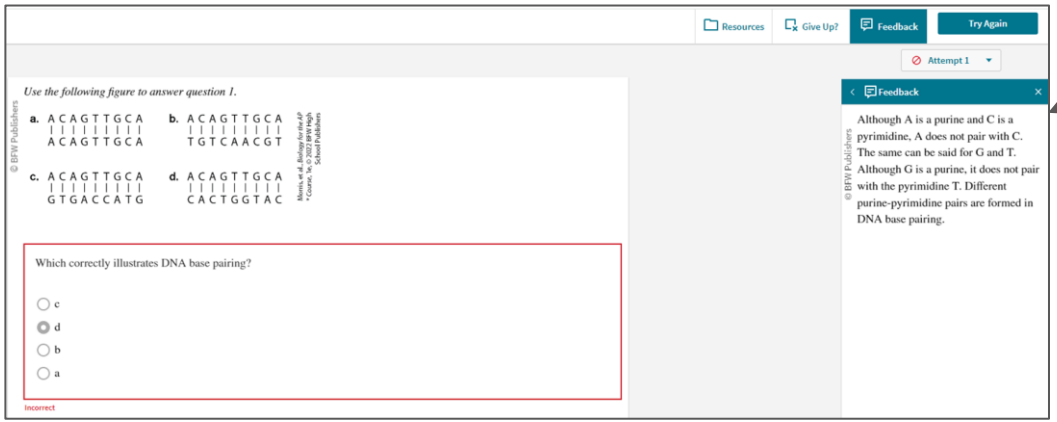
Animations/simulations

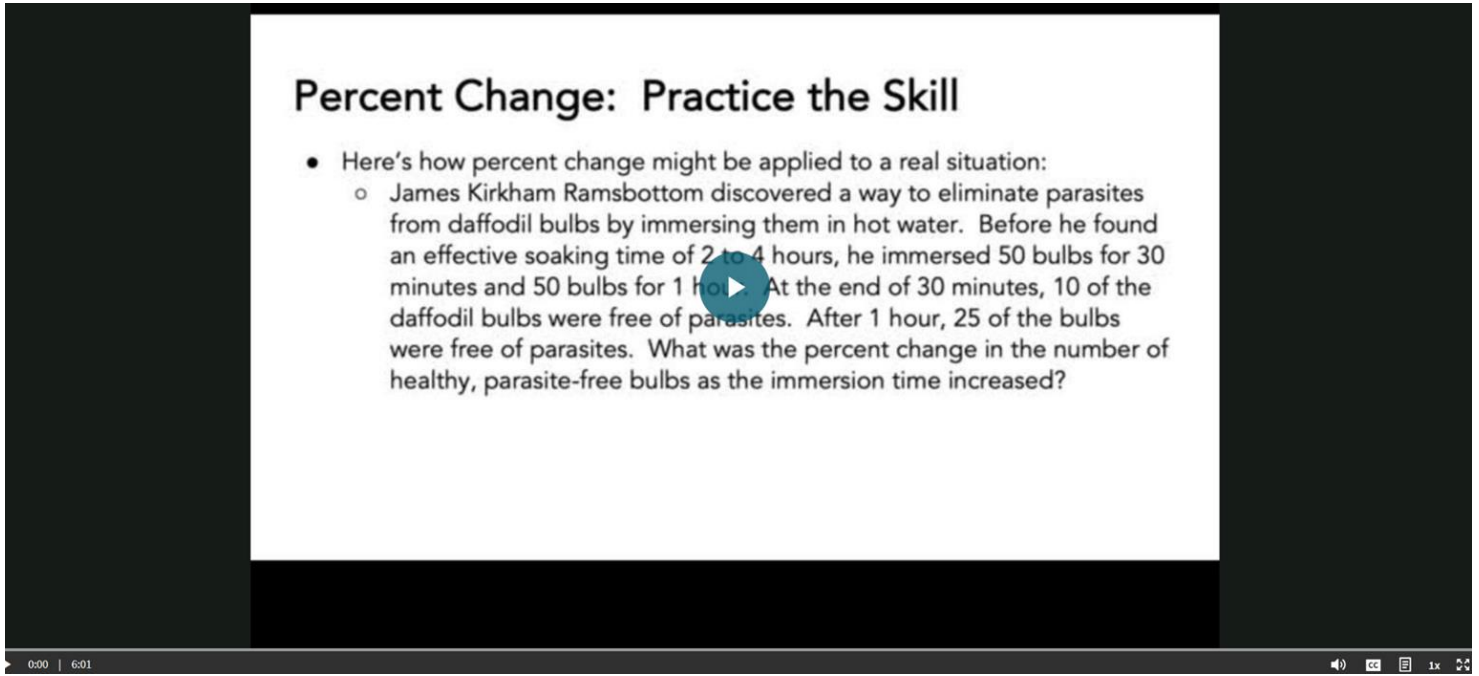
Assessment/AP Exam practice





Different wrong answer- different feedback

Analyzing Statistics and Data videos



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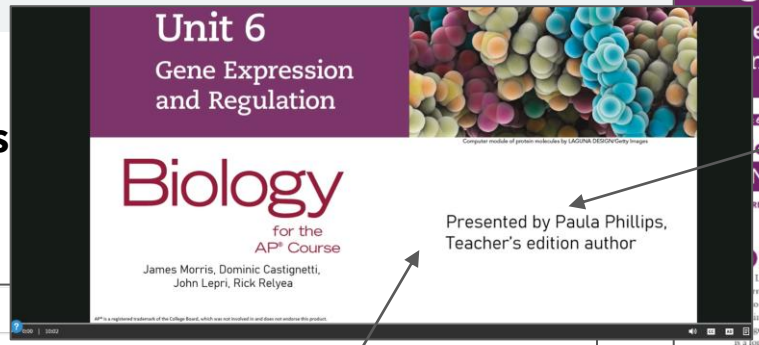
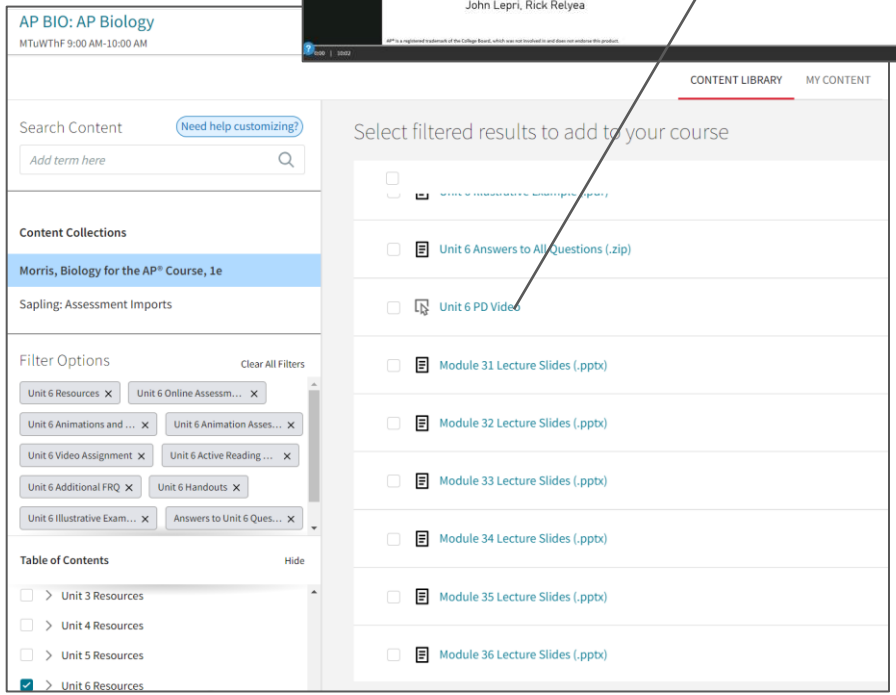
Teacher ebook
Teacher resources



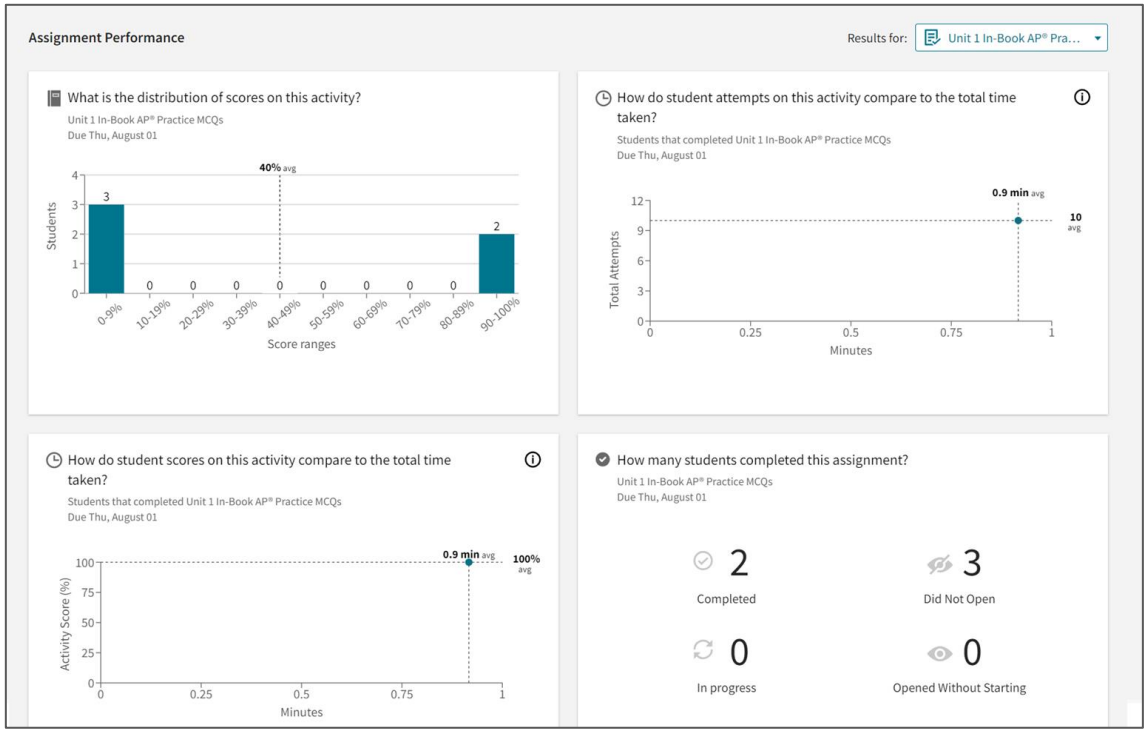
Presented by Paula Phillips, Teacher's edition author



Reports and Insights

Use this information to assess students' progress so you can adjust accordingly

- Top assignments to review
- How often are students logging in?
- What's the distribution of scores on an activity?
- How do students scores on an activity compare to time taken?
- How many students completed an assignment?
- Performance by unit, learning objective, and student



Goal Setting and Reflections Survey

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Goal-Setting and Reflections Surveys

In recent weeks…

How often did you give yourself enough time to complete assignments on time or start early?

- ◯ 5 - Always
- ◯ 4 - Often
- ◯ 3 - Sometimes
- ◯ 2 - Rarely
- ◯ 1 - Never

Category 1: Space it out!

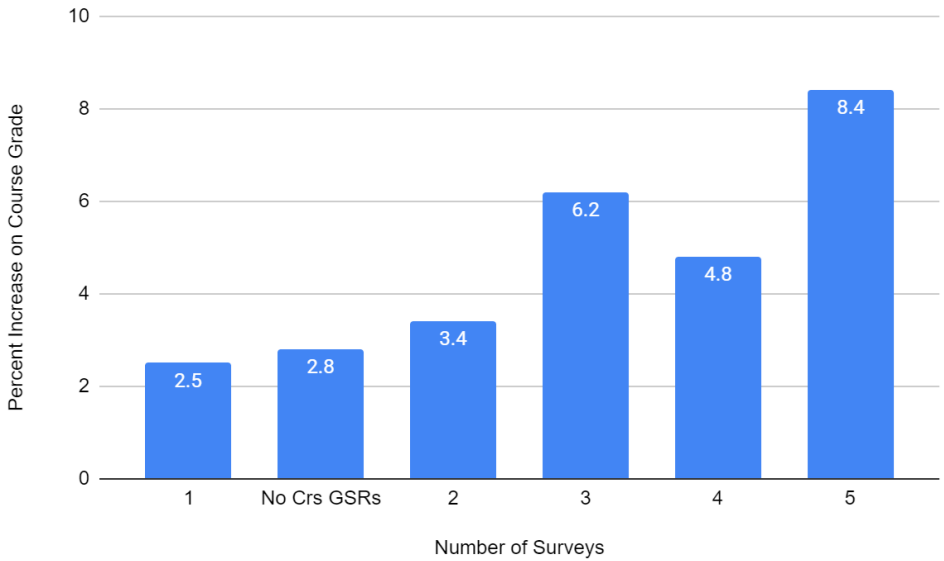
Learning happens over time, not all at once.

Research has shown memory benefits from spacing studying/review sessions over time rather than trying to "cram" right before a test. Our Brains take time to consolidate information into long-term memory. Therefore, we're better able to recall information and concepts if we learn them in multiple, spread-out sessions.

Teacher slides

Research suggests…

Completing just 3 surveys increased course grades by 6.2%. We saw an increase of 8.4% when 5 surveys were completed (n=2,529 students).



Students found the Goal Setting & Reflection Surveys valuable for their learning.

Survey Item	*Agree/Strongly Agree*
The surveys helped me improve as a student this semester.	**75%**
The surveys were a valuable use of my time.	**62%**
The surveys helped me think about my goals/learning habits in and outside of class.	**80%**
The surveys helped me learn something new about how I can manage my time, studying, or learning.	**79%**

Study included college students taking intro-level chemistry, biochem, bio, calc, precalc, econ, & English classes

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But what about AP® Classroom?

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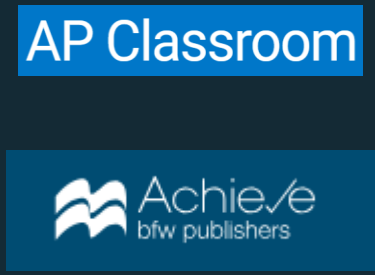

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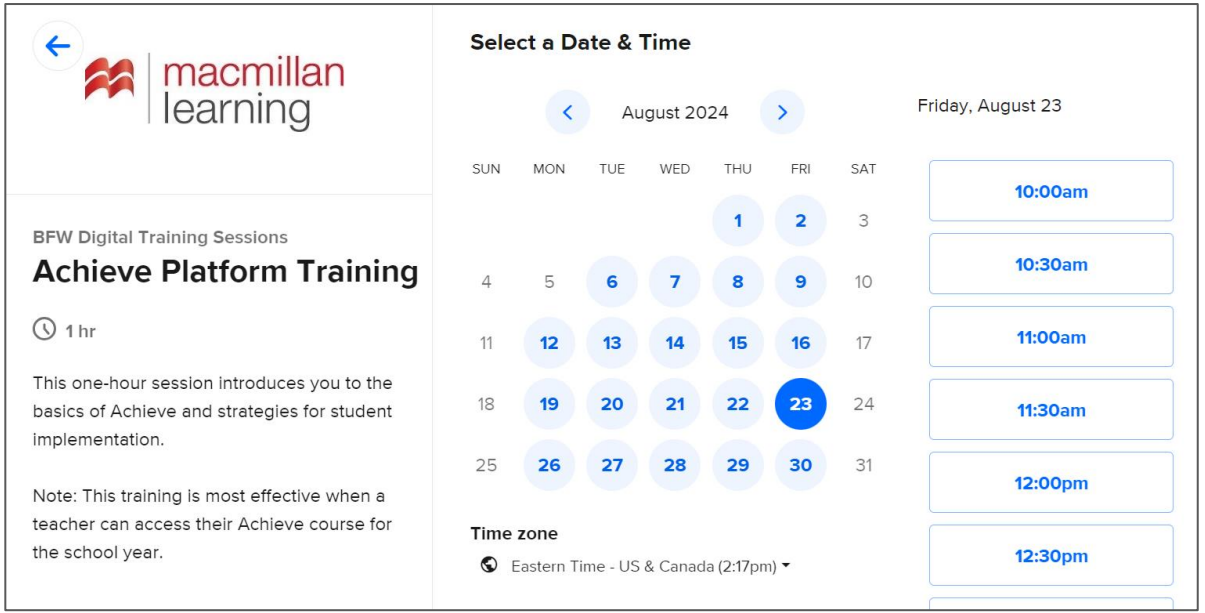
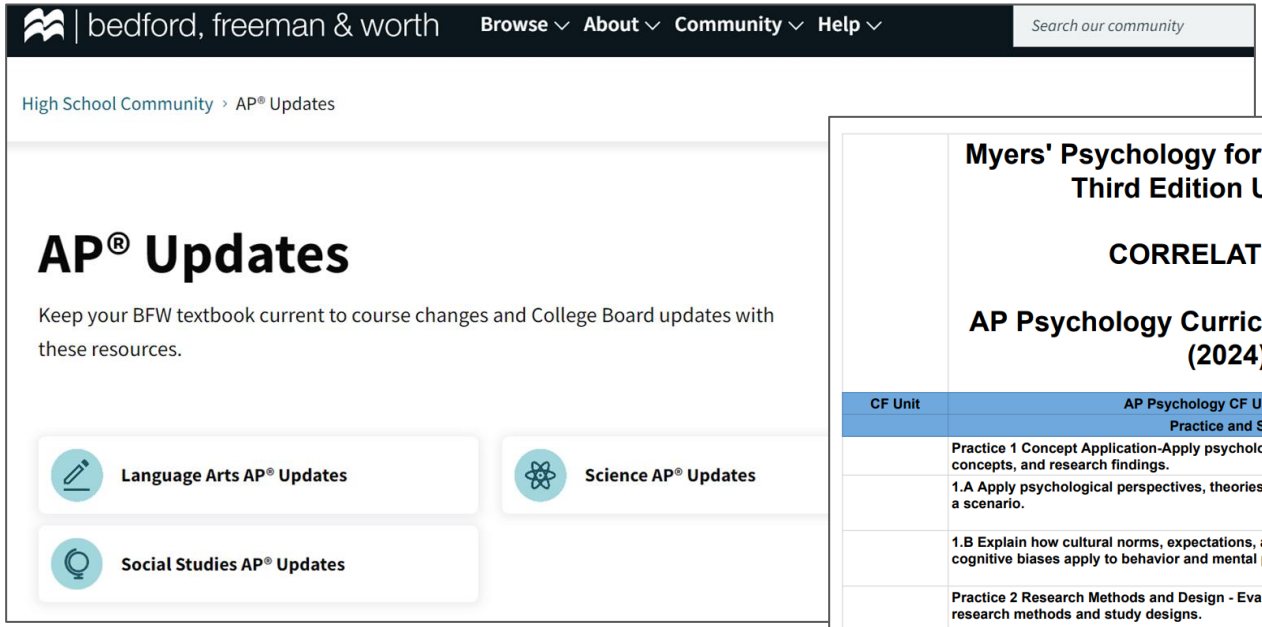
  - Test bank
  - LMS



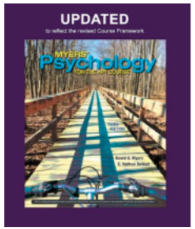
AP® Changes? We've got you covered!



Myers' Psychology for the AP® Course, Third Edition UPDATED

CORRELATED TO

AP Psychology Curriculum Framework (2024)



CF Unit	AP Psychology CF Unit + Topic	Textbook Unit and/or Module
	Practice and Skill	
	Practice 1 Concept Application-Apply psychological perspectives, theories, concepts, and research findings.	Unit 1: Scientific Foundations of Psychology
	1.A Apply psychological perspectives, theories, concepts, and research findings to a scenario.	Module 1: Psychology and Its History; Module 2: Today's Psychology and Its Approaches; Module 3 Subfields in Psychology
	1.B Explain how cultural norms, expectations, and circumstances, as well as cognitive biases apply to behavior and mental processes.	Module 1: Psychology and Its History; Module 2: Today's Psychology and Its Approaches; Module 3 Subfields in Psychology
	Practice 2 Research Methods and Design - Evaluate qualitative and quantitative research methods and study designs.	Unit 1: Scientific Foundations of Psychology-Part II: Research Methods: Thinking Critically with Psychological Science
	2.A Determine the type of research design(s) used in a given study.	Module 7: Research Design and Ethics in Psychology
	2.B Evaluate the appropriate use of research design elements in experimental methodology.	Module 7: Research Design and Ethics in Psychology
	2.C Evaluate the appropriate use of research design elements in non-experimental	Module 7: Research Design and Ethics in

Why this book?

- Fully aligned the CED
- AP Tips and AP exam practice
- Focus on Big Ideas and Science Practices
- Tutorials and Analyzing Stats and Data boxes
- Teacher resources
- ACHIEVE digital platform