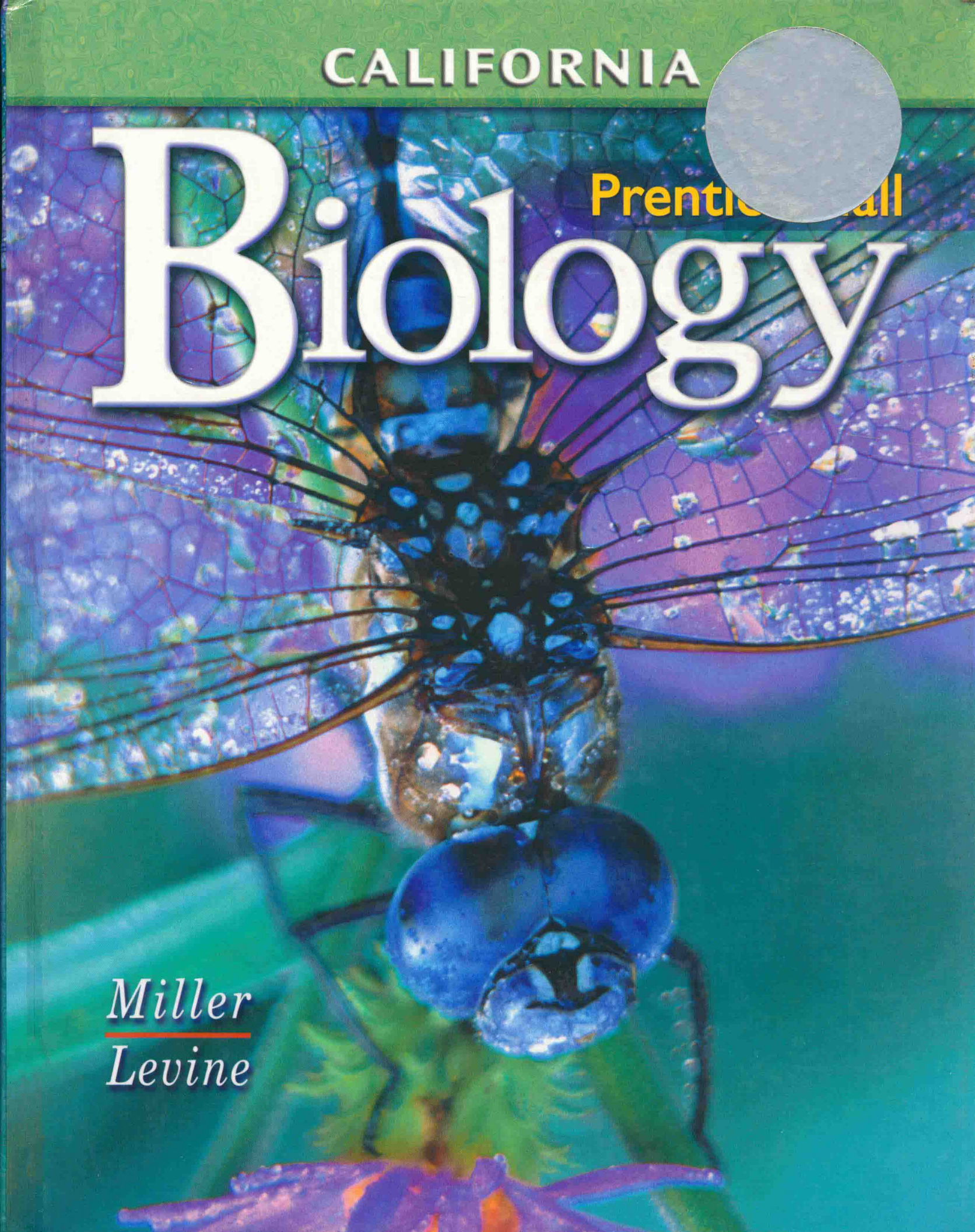
CALIFORNIA

Biology

Prentice Hall



Miller

Levine

PEARSON
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Upper Saddle River, New Jersey
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Prentice Hall Biology

Print Components

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Laboratory Manual B
Laboratory Manual B,
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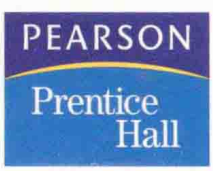


ISBN 0-13-201352-5
1 2 3 4 5 6 7 8 9 10 10 09 08 07 06

Safety Symbols

These symbols appear in laboratory activities to alert you to possible dangers and to remind you to work carefully.

Safety Goggles Always wear safety goggles to protect your eyes during any activity involving chemicals, flames or heating, or the possibility of flying objects, particles, or substances.

Lab Apron Wear a laboratory apron to protect your skin and clothing from injury.

Breakage Handle breakable materials such as thermometers and glassware with care. Do not touch broken glass.

Heat-Resistant Gloves Use an oven mitt or other hand protection when handling hot materials. Heating plates, hot water, and glassware can cause burns. Never touch hot objects with your bare hands.

Plastic Gloves Wear disposable plastic gloves to protect yourself from contact with chemicals or organisms that could be harmful. Keep your hands away from your face, and dispose of the gloves according to your teacher's instructions at the end of the activity.

Heating Use a clamp or tongs to hold hot objects. Do not touch hot objects with your bare hands.

Sharp Object Scissors, scalpels, pins, and knives are sharp. They can cut or puncture your skin. Always direct sharp edges and points away from yourself and others. Use sharp instruments only as directed.

Electric Shock Avoid the possibility of electric shock. Never use electrical equipment around water or when the equipment or your hands are wet. Be sure cords are untangled and cannot trip anyone. Disconnect equipment when it is not in use.

Corrosive Chemical This symbol indicates the presence of an acid or other corrosive chemical. Avoid getting the chemical on your skin or clothing or in your eyes. Do not inhale the vapors. Wash your hands when you are finished with the activity.

Poison Do not let any poisonous chemical get on your skin, and do not inhale its vapor. Wash your hands when you are finished with the activity.

Physical Safety This activity involves physical activity. Use caution to avoid injuring yourself or others. Follow instructions from your teacher. Alert your teacher if there is any reason that you should not participate in the activity.

Animal Safety Treat live animals with care to avoid injuring the animals or yourself. Working with animal parts or preserved animals may also require caution. Wash your hands when you are finished with the activity.

Plant Safety Handle plants only as your teacher directs. If you are allergic to any plants used in an activity, tell your teacher before the activity begins. Avoid touching poisonous plants and plants with thorns.

Flames Tie back loose hair and clothing, and put on safety goggles before working with fire. Follow instructions from your teacher about lighting and extinguishing flames.

No Flames Flammable materials may be present. Make sure there are no flames, sparks, or exposed sources of heat present.

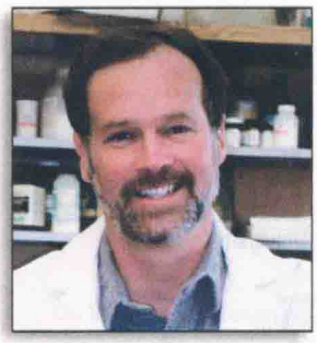
Fumes Poisonous or unpleasant vapors may be produced. Work in a ventilated area. Avoid inhaling a vapor directly. Test an odor only when directed to do so by your teacher, using a wafting motion to direct the vapor toward your nose.

Disposal Chemicals and other materials used in the activity must be disposed of safely. Follow the instructions from your teacher.

Hand Washing Wash your hands thoroughly when finished with the activity. Use antibacterial soap and warm water. Lather both sides of your hands and between your fingers. Rinse well.

General Safety Awareness You may see this symbol when none of the symbols described earlier applies. In this case, follow the specific instructions provided. You may also see this symbol when you are asked to design your own experiment. Do not start your experiment until your teacher has approved your plan.

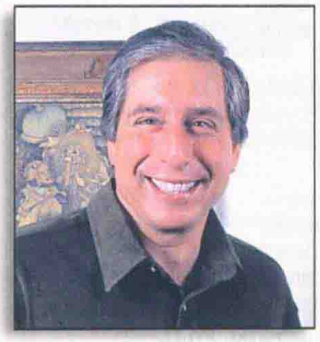
About the Authors



Kenneth R. Miller grew up in Rahway, New Jersey, attended the local public schools, and graduated from Rahway High School in 1966. Miller attended Brown University on a scholarship and graduated with honors. He was awarded a National Defense Education Act fellowship for graduate study, and earned his Ph.D. in Biology at the University of Colorado. Miller is Professor of Biology at Brown University in Providence, Rhode Island, where he teaches courses in general biology and cell biology.

Miller's research specialty is the structure of biological membranes. He has published more than 70 research papers in journals such as *CELL, Nature,* and *Scientific American.* In 1999, he wrote the popular trade book *Finding Darwin's God.*

Miller lives with his wife, Jody, on a small farm in Rehoboth, Massachusetts. He is the father of two daughters, one of whom is a wildlife biologist. He swims competitively in the masters' swimming program and umpires high school and collegiate softball.



Joseph S. Levine was born in Mount Vernon, New York, where he attended public schools. He earned a B.S. in Biology at Tufts University, a master's degree from the Boston University Marine Program, and a Ph.D. at Harvard University. His research has been published in scientific journals ranging from *Science* to *Scientific American,* and in several academic books. He taught introductory biology, marine ecology, and neurobiology for six years at Boston College.

After receiving a Macy Fellowship in Science Broadcast Journalism at WGBH-TV, Levine dedicated himself to improving public understanding of science. His popular scientific writing has appeared in five trade books and in magazines such as *Smithsonian, GEO,* and *Natural History.* He has produced science features for National Public Radio and has designed exhibit programs for state aquarium projects in Texas, New Jersey, and Florida.

Since 1987, Levine has served as scientific advisor at WGBH, where he worked on *NOVA* programs and on projects including the film *Cocos: Island of Sharks* and the series *The Secret of Life.* Most recently, he served as Science Editor for *The Evolution Project.*

Levine and his family live in Concord, Massachusetts, a short distance from Thoreau's Walden Pond.

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Consultants

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Dear Student

Joe Levine and I wrote this book for a very simple reason: We wanted to let you in on a secret. Biology isn't just a "subject" in school. Biology is the science of life itself. Biology is the study of what makes an eagle fly, a flower bloom, or a caterpillar turn into a butterfly. It's the study of ourselves—of how our bodies grow and change and respond to the outside world, and it's the study of our planet, a world transformed by the actions of living things. Of course, you might have known some of this already. So, what's the secret?

The secret is that you've come along at just the right time. In all of human history, there has never been a moment like the present, a time when we stood so close to the threshold of answering the most fundamental questions about the nature of life. You belong to the first generation of students who can read the human genome almost as your parents might have read a book or a newspaper. You are the first students who will grow up in a world that has a chance to use that information for the benefit of humanity, and you are the very first to bear the burden of using that knowledge wisely.

If all of this seems like heavy stuff, it is. But there is another reason we wrote this book, and we hope that is not a secret at all. Science is fun! Biologists aren't a bunch of serious, grim-faced, middle-aged folks in lab coats who think of nothing but work. In fact, most of the people we know in science would tell you honestly, with broad grins on their faces, that they have the best jobs in the world. They would say there's nothing that compares to the excitement of doing scientific work, and that the beauty and variety of life make every day a new adventure.

We agree, and we hope that you'll keep something in mind as you begin the study of biology. You don't need a lab coat or a degree or a laboratory to be a scientist. What you do need is an inquiring mind, the patience to look at nature carefully, and the willingness to figure things out. We've filled this book with some of the latest and most important discoveries about living things, but we hope we've also filled it with something else: our wonder, our amazement, and our sheer delight in the variety of life itself. Come on in, and enjoy the journey!

Sincerely,

Ken Miller

Dear Student

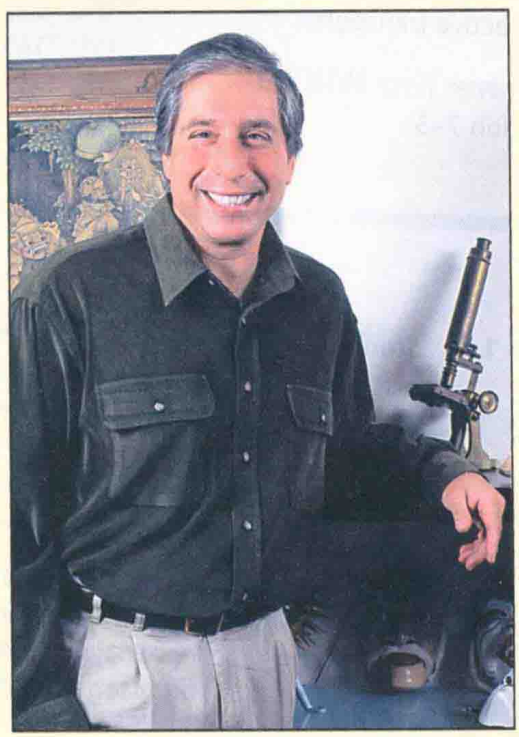
What do you think about biology? Are you interested in the natural world and the workings of your body? Or could you care less, and do you find yourself wondering "What's in it for me?" However you think, Ken and I wrote this book to convince you that biology is exciting, fascinating—and important to you. In fact, biology is more important to the daily lives of all humans today than it has ever been.

Why? You could answer in three words: "We are one." Now, this is a science text, so this statement isn't meant in any kind of "touchy-feely" or "New Age" way. "We" means all living things on earth. And "are one" means that all of us are tied together more tightly, in more different ways, than anyone ever dreamed of until recently. That's what biology tells us.

All forms of life—from bacteria to palm trees to humans are based on information written in a single, universal code carried in our genes. As biologists "read" those genes, they find nearly identical instructions directing life's processes in all of us. That's why medical researchers can learn about human diseases—diseases that may strike you or your family—by studying yeast. We are one on the molecular level.

All organisms interact with one another and with the environment in ways that create our planet's web of life. Organisms make tropical rain forests and coral reefs, prairies and swamps—and farms and cities. Our interactions involve not only each other—but also the winds and ocean currents that tie our planet together. Human activity can change, and is changing, local and global environments in ways that alter our ability to produce food and protect ourselves from diseases. We are one on the global ecological level.

All organisms change over time as they adapt to their surroundings. If humans alter the environment, we encourage other organisms to change. When we deploy antibiotics against bacteria, they develop resistance to our drugs. If we use pesticides against insects, they become immune to our poisons. We are one in our ability to evolve over time.



Those are the kinds of connections you will find in this book. Microscopic. Enormous. Amusing. Threatening. But always fascinating. That's why—no matter where you start off in your attitude about biology—we think you are in for some surprises!

Sincerely,

Joe Levine

Biology/Life Science Content Standards

The *Science Content Standards for California Public Schools* was adopted in 1998. The California Biology/Life Science strand is organized into 11 general standard sets. The standard sets are Cell Biology, Genetics (Meiosis and Fertilization), Genetics (Mendel's Laws), Genetics (Molecular Biology), Genetics (Biotechnology), Ecology, Evolution (Population Genetics), Evolution (Speciation), Physiology (Homeostasis), Physiology (Infection and Immunity), and Investigation and Experimentation. Each standard set is divided into a series of specific topic standards. Use this section as a preview for your Biology course and as a review guide when you study for exams. In each of the Practice Problems, the correct answer is marked with an asterisk. If a standard has an asterisk, it means that you won't be tested on the item.

Standard Set 1. Cell Biology

1. The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells. As a basis for understanding this concept:

1.a. *Students know* cells are enclosed within semipermeable membranes that regulate their interaction with their surroundings.

What It Means to You

All cells are surrounded by a cell membrane. The cell membrane controls what enters and leaves the cell. It also protects and supports the cell. Materials move in and out of the cell by diffusion, osmosis, and active transport.

Where You Will Learn It

Section 7–3

PRACTICE PROBLEM

A substance that moves across a cell membrane without using the cell's energy tends to move

A away from the area of equilibrium.
B away from the area where it is less concentrated.
C* away from the area where it is more concentrated.
D toward the area where it is more concentrated.

1.b. *Students know* enzymes are proteins that catalyze biochemical reactions without altering the reaction equilibrium and the activities of enzymes depend on the temperature, ionic conditions, and the pH of the surroundings.

What It Means to You

Enzymes are proteins that act as biological catalysts. They speed up chemical reactions in cells. Like other catalysts, enzymes work by lowering the activation energy of a reaction. Enzymes provide a site where reactants are brought together but do not participate in the reaction themselves.

Where You Will Learn It

Section 2–4

PRACTICE PROBLEM

At what temperature do most enzymes in the human body function best?

A 0°C
B* 37°C
C 98°C
D 100°C

1.c. *Students know* how prokaryotic cells, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure.

What It Means to You

The student understands that all cells are surrounded by a cell membrane. All cells contain DNA at some point in their lives. However, eukaryotic cells are usually larger than prokaryotic cells and have a nucleus that contains their genetic material. The student also knows that viruses are much smaller and simpler than cells. They do not have cell membranes or nuclei. Unlike cells, viruses cannot reproduce by themselves.

Where You Will Learn It

Section 7–1, Section 7–2, Section 19–2

PRACTICE PROBLEM

How is a eukaryotic cell different from a prokaryotic cell?

A It has a cell membrane.
B It contains DNA.
C* It has a nucleus.
D It carries out functions necessary for life.

1.d. *Students know* the central dogma of molecular biology outlines the flow of information from transcription of ribonucleic acid (RNA) in the nucleus to translation of proteins on ribosomes in the cytoplasm.

What It Means to You

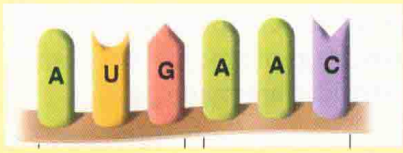
DNA stores the information needed to make proteins. This information is copied, or transcribed, from DNA into messenger RNA (mRNA), which carries the message out of the nucleus to the ribosomes. The mRNA is then used as a template to assemble proteins.

Where You Will Learn It

Section 12–3

PRACTICE PROBLEM

From which DNA template was this mRNA strand transcribed?



A* TACTTG
B ATGAAC
C AUGAAC
D UACUUG

1.e. *Students know* the role of the endoplasmic reticulum and Golgi apparatus in the secretion of proteins.

What It Means to You

There are two types of endoplasmic reticulum (ER)—rough and smooth. Rough ER makes proteins. Smooth ER makes membrane lipids. Proteins produced in the rough ER move into the Golgi apparatus, where they are modified. The Golgi apparatus then sorts and packages the proteins for storage or secretion outside the cell.

Where You Will Learn It

Section 7–2

PRACTICE PROBLEM

Which of these is the correct sequence in the processing of proteins?

A ribosomes to Golgi apparatus to rough endoplasmic reticulum
B Golgi apparatus to ribosomes to rough endoplasmic reticulum
C* ribosomes to rough endoplasmic reticulum to Golgi apparatus
D rough endoplasmic reticulum to Golgi apparatus to ribosomes

1.f. *Students know* usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.

1.g. *Students know* the role of the mitochondria in making stored chemical-bond energy available to cells by completing the breakdown of glucose to carbon dioxide.

What It Means to You

Photosynthesis uses the energy of sunlight to convert water and carbon dioxide into high-energy sugars and oxygen. Plants gather the sun's energy with chlorophyll—a light-absorbing molecule found in chloroplasts. Mitochondria are organelles within eukaryotic cells that release energy by breaking down food molecules in the presence of oxygen. This process is called cellular respiration.

Where You Will Learn It

Section 7–2, Section 8–2, Section 8–3, Section 9–1, Section 9–2

PRACTICE PROBLEM

Living things store energy in the chemical bonds of compounds. One of the principal chemical compounds that living things use to store energy is

A DNA.
B* sugar.
C water.
D carbon dioxide.

1.h. *Students know* most macromolecules (polysaccharides, nucleic acids, proteins, lipids) in cells and organisms are synthesized from a small collection of simple precursors.

What It Means to You

Many of the large carbon compound molecules in living things are made up of smaller parts. For example, polysaccharides are made up of monosaccharides.

Where You Will Learn It

Section 2–3

PRACTICE PROBLEM

A polymer is a large molecule made up of smaller units called monomers. Proteins are polymers. What monomer makes up proteins?

A lipids
B carbohydrates
C* amino acids
D nucleic acids

***1.i.** *Students know* how chemiosmotic gradients in the mitochondria and chloroplast store energy for ATP production.

What It Means to You

You will learn that, in the light-dependent reactions of photosynthesis, energy from the sun is used to move hydrogen ions through the thylakoid membrane. As the ions pass back through the membrane, their energy is used to make ATP. A similar process occurs in the electron transport chain of cellular respiration. Energy from NADH is used to move hydrogen ions through the inner mitochondrial membrane. The ions pass back through the membrane, creating energy to make ATP.

Where You Will Learn It

Section 8–3, Section 9–2

PRACTICE PROBLEM

The light-dependent reactions and the Calvin cycle together make up the process

A* photosynthesis.
B cellular respiration.
C glycolysis.
D fermentation.

***1.j.** *Students know* **how eukaryotic cells are given shape and internal organization by a cytoskeleton or cell wall or both.**

What It Means to You

Eukaryotic cells have a network of protein filaments, called the cytoskeleton, that helps support the cell and is also involved in movement. Many organisms also have cell walls, tough layers outside the cell membrane that protect and support the cell.

Where You Will Learn It

Section 7–2, Section 7–3

PRACTICE PROBLEM

Which groups of organisms have cells with cell walls?

A eukaryotes only
B plants only
C* plants, algae, fungi, and many prokaryotes
D algae and fungi only

Standard Set 2. Genetics (Meiosis and Fertilization)

2. Mutation and sexual reproduction lead to genetic variation in a population. As a basis for understanding this concept:

2.a. *Students know* meiosis is an early step in sexual reproduction in which the pairs of chromosomes separate and segregate randomly during cell division to produce gametes containing one chromosome of each type.

2.b. *Students know* only certain cells in a multicellular organism undergo meiosis.

What It Means to You

Meiosis is the process in which cells divide in two twice, cutting the number of cells in half through the separation of homologous chromosomes in a diploid cell. Unlike mitosis, meiosis occurs only in the sex cells of sexually reproducing organisms. The end result of meiosis is gametes: sperm and eggs.

Where You Will Learn It

Section 11–4

Practice Problem

Meiosis begins with a single diploid cell and produces

A two diploid cells.
B two haploid cells.
C four diploid cells.
D* four haploid cells.

2.c. *Students know* **how random chromosome segregation explains the probability that a particular allele will be in a gamete.**

2.d. *Students know* **new combinations of alleles may be generated in a zygote through the fusion of male and female gametes (fertilization).**

What It Means to You

You will learn that during meiosis, homologous chromosomes separate and different alleles are segregated from one another. You will also learn that when male and female gametes combine during fertilization, new combinations of alleles form.

Where You Will Learn It

Section 11–1, Section 11–2, Section 11–4

PRACTICE PROBLEM

If two plants with *Tt* alleles for height are crossed, what are the possible gametes that can form?

A* *T*, *t*
B *tt*, *Tt*
C *T*
D *tt*, *Tt*, *TT*

2.e. *Students know* **why approximately half of an individual's DNA sequence comes from each parent.**

2.f. *Students know* **the role of chromosomes in determining an individual's sex.**

What It Means to You

Individuals get half of their chromosomes from each parent. Because chromosomes carry the DNA, half of the DNA comes from each parent. Humans have 46 chromosomes: 44 are autosomes and 2 are sex chromosomes. The sex chromosomes determine whether a person is male or female. Each person gets an X chromosome from his or her mother and either a Y or an X chromosome from his or her father. People with XX are female; those with XY are male.

Where You Will Learn It

Section 11–4, Section 14–1

PRACTICE PROBLEM

An individual's sex is determined by the chromosome(s) received from his or her

A mother.
B* father.
C both mother and father.
D siblings.

2.g. *Students know* **how to predict possible combinations of alleles in a zygote from the genetic makeup of the parents.**

What It Means to You

The gene combinations that might result from a genetic cross can be determined by using a Punnett square. The types of gametes from each of the F_1 parents are shown along the left and top sides of the square. The possible gene combinations of the F_2 offspring are filled into the boxes that make up the square.

Where You Will Learn It

Section 11–1, Section 11–2, Section 11–3, Section 14–1, Section 14–2

PRACTICE PROBLEM

For the flowers of a particular plant species, yellow (*Y*) is the dominant allele and white (*y*) is the recessive allele. Suppose that a yellow-flowered plant (*YY*) is crossed with a white-flowered plant (*yy*). Which statement best describes the phenotypes and genotypes of their offspring?

A* all yellow-flowered (*Yy*)
B all white-flowered (*yy*)
C half yellow-flowered (*YY* or *Yy*) and half white-flowered (*yy*)
D three-quarters yellow-flowered (*YY* or *Yy*) and one-quarter white-flowered (*yy*)

Standard Set 3. Genetics (Mendel's Laws)

3. A multicellular organism develops from a single zygote, and its phenotype depends on its genotype, which is established at fertilization. As a basis for understanding this concept:

3.a. *Students know* how to predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance (autosomal or X-linked, dominant or recessive).

3.b. *Students know* the genetic basis for Mendel's laws of segregation and independent assortment.

What It Means to You

The genotypes of offspring shown in a Punnett square can be used to determine the phenotypes of the offspring. X-linked alleles are carried on the X chromosome. A trait controlled by an X-linked recessive allele will be shown in males even if only one recessive allele is present. You will learn that Mendel's laws of segregation and independent assortment are a result of the segregation of alleles during gamete formation.

Where You Will Learn It

Section 11–1, Section 11–2, Section 11–3, Section 14–1, Section 14–2

PRACTICE PROBLEM

Colorblindness is a recessive, sex-linked trait. If a colorblind man has children with a woman who has only the dominant alleles for this trait, which of the following statements could be true?

A Their daughters may be colorblind.
B Their sons may be colorblind.
C* None of their children will be colorblind.
D All of their children will be colorblind.

***3.c.** *Students know* how to predict the probable mode of inheritance from a pedigree diagram showing phenotypes.

What It Means to You

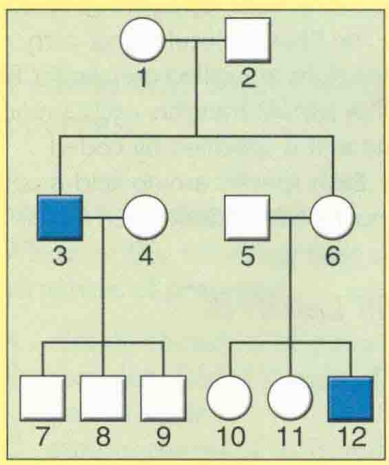
A pedigree is a diagram that can be used to predict genotypes. A pedigree shows the relationships within a family and which members express a particular trait. These phenotypes can be used to infer probable genotypes and the way alleles for traits are inherited within the family.

Where You Will Learn It

Section 14–1

PRACTICE PROBLEM

The blue squares on the diagram indicate a person with hemophilia, a sex-linked disorder.



Which person is a carrier of the disease?

A person 2
B person 5
C* person 6
D person 9

***3.d.** *Students know* how to use data on frequency of recombination at meiosis to estimate genetic distances between loci and to interpret genetic maps of chromosomes.

What It Means to You

You will learn that chromosomes, not genes, assort independently. The closer together that genes are on a chromosome, the less likely they are to be separated during crossing-over. You will also learn that rates of crossing-over can be used to construct gene maps.

Where You Will Learn It

Section 11–5

PRACTICE PROBLEM

Here are the locations and names of some genes on chromosome 2 of the fruit fly:

13.0	dumpy wing
51.0	reduced bristles
75.5	curved wing
104.5	brown eye

Which two genes would most likely be separated during crossing-over?

A dumpy wing and curved wing
B reduced bristles and curved wing
C* dumpy wing and brown eye
D brown eye and reduced bristles

Standard Set 4. Genetics (Molecular Biology)

4. Genes are a set of instructions encoded in the DNA sequence of each organism that specify the sequence of amino acids in proteins characteristic of that organism. As a basis for understanding this concept:

4.a. *Students know* the general pathway by which ribosomes synthesize proteins, using tRNA to translate genetic information in mRNA.

4.b. *Students know* how to apply the genetic coding rules to predict the sequence of amino acids from a sequence of codons in RNA.

What It Means to You

Most genes contain instructions for assembling amino acids into proteins. The RNA molecules that carry copies of these instructions are called messenger RNA (mRNA). Transfer RNA (tRNA) transfers each amino acid to the ribosome as it is specified by coded messages in mRNA. Each specific amino acid is coded by a specific three-nucleotide codon.

PRACTICE PROBLEM

In messenger RNA, each codon specifies a particular

A nucleotide.
B purine.
C pyrimidine.
D* amino acid.

Where You Will Learn It

Section 12–3

4.c. *Students know* how mutations in the DNA sequence of a gene may or may not affect the expression of the gene or the sequence of amino acids in the encoded protein.

What It Means to You

Mutations, or changes to the genetic code, can involve single nucleotides or whole chromosomes. Many mutations have little or no effect on an organism. Other mutations can cause dramatic changes in protein structure or gene activity and are harmful.

Where You Will Learn It

Section 12–4, Section 14–2, Section 40–1

PRACTICE PROBLEM

What is a mutation?

A any change that is harmful to an organism
B* any change in a gene or chromosome
C any change that is helpful to an organism
D any change in the phenotype of a cell

4.d. *Students know* specialization of cells in multicellular organisms is usually due to different patterns of gene expression rather than to differences of the genes themselves.

What It Means to You

Only a fraction of the genes in a cell are expressed at a given time. An expressed gene is a gene that is transcribed into RNA. Nearly all cells in an organism contain the same DNA, but each gene can be turned on or off and expressed in different ways. This results in different patterns of development in different organisms.

Where You Will Learn It

Section 12–5

PRACTICE PROBLEM

During the development of a multicellular organism, many different types of cells can arise from a single cell. Which process allows for this to occur?

A* cell specialization
B binary fission
C fertilization
D respiration

4.e. *Students know* proteins can differ from one another in the number and sequence of amino acids.

***4.f.** *Students know* why proteins having different amino acid sequences typically have different shapes and chemical properties.

What It Means to You

Proteins are polymers made up of long chains of amino acids. The chains can be folded in various ways and combined with other chains to determine the type of protein. There are more than 20 different amino acids, but they all have the same basic structure. The part of the amino acid that is different is called the R-group. The different R-groups give the different amino acids different chemical properties.

Where You Will Learn It

Section 2–3, Section 2–4

PRACTICE PROBLEM

Which of the following best describes the structure of proteins?

A simple chains of identical amino acids
B complex, folded chains of identical amino acids
C simple chains of different amino acids
D* complex, folded chains of different amino acids