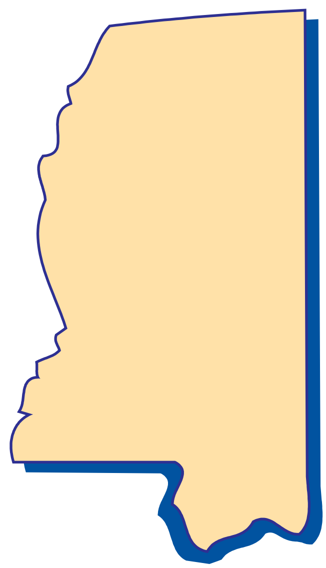
Student Review Guide

SATP 2

Biology I

Revised Edition



Mississippi
2010 Science Framework

Mississippi SATP2 Biology I
Student Review Guide

Authors:
Kelly D. Berg
Cecilia L. Boles

2010 Mississippi Science Framework

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Mississippi SATP2 Biology I Student Review Guide
based on the Mississippi 2010 Science Framework

by
Kelly D. Berg
Cecilia L. Boles

Kelly D. Berg
Project Coordinator and Executive Editor

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Table of Contents

The Authors/Acknowledgments 5
Preface/How to Use This Book 6

Pre-test 7
Pre-test Evaluation Chart 30

Section 1
Equipment, Procedures, and Safety
1.1 Length and Measurement 31
1.2 Temperature 34
1.3 Liquid Measurement and Handling 36
1.4 Mass and Weight Measurements 39
1.5 Microscopes 42
1.6 Equipment Used for Heating 47
1.7 Laboratory Safety and Protective Equipment 50
Section 1 Review 56

Section 2
Scientific Experiments
2.1 Using the Scientific Method 59
2.2 Setting Up Experiments 64
2.3 Using Tables to Organize and Interpret Data 70
2.4 Determining Validity of Experiments 73
Section 2 Review 77

Section 3
Analyzing Scientific Experiments
3.1 Using Line Graphs to Organize and Interpret Data 81
3.2 Using Bar Graphs to Organize and Interpret Data 88
3.3 Using Pie Graphs to Organize and Interpret Data 91
3.4 Using Diagrams to Organize and Interpret Data 93
Section 3 Review 95

Section 4
Biochemical Concepts
4.1 Characteristics of Living Things 99
4.2 The Atom 100
4.3 Elements and the Periodic Table 102
4.4 Reactivity 105
4.5 Covalent and Ionic Bonding 108
4.6 The Chemistry of Water 111
4.7 Ions and pH 115
Section 4 Review 120

Section 5
The Components of Life
5.1 Organic Chemistry 123
5.2 Carbohydrates 126
5.3 Lipids 129
5.4 Proteins 133
5.5 Nucleic Acids 135
5.6 Enzymes 137
5.7 Macronutrient Review 140
Section 5 Review 142

Section 6
Cell Structure and Function
6.1 Prokaryotic and Eukaryotic Cells 145
6.2 Cell Organelles 148
6.3 Plant and Animal Cells 152
6.4 Cellular Organization 155
Section 6 Review 159

Section 7
Cellular Transport
7.1 Introduction to Homeostasis and Cellular Transport 163
7.2 Passive Transport: Diffusion 165
7.3 Passive Transport: Osmosis 167
7.4 Active Transport, Endocytosis, and Exocytosis 172
Section 7 Review 175

Section 8
Cellular Energy
8.1 ATP 177
8.2 Aerobic and Anaerobic Cellular Respiration 180
8.3 Photosynthesis 184
8.4 Relationship Between Cellular Respiration and Photosynthesis 187
Section 8 Review 189

Section 9
Cellular Reproduction
9.1 The Cell Cycle and Mitosis 193
9.2 Sexual Reproduction and Meiosis 197
9.3 Gamete Production 202
9.4 Asexual Reproduction 203
9.5 Sexual Reproduction 206
Section 9 Review 208

Section 10
Basic Genetics
10.1 Introduction to Mendelian Genetics 213
10.2 Monohybrid Crosses 217
10.3 Human Autosomal Genetic Diseases 223
Section 10 Review 227

Section 11
Applied Genetics
11.1 Dihybrid Crosses 229
11.2 Incomplete Dominance and Codominance 232
11.3 Linked and Sex-Linked Genes 236
11.4 Pedigrees 240
Section 11 Review 244

Section 12
Molecular Genetics and Technology
12.1 DNA, Genes, and Chromosomes 249
12.2 DNA Replication 251
12.3 Transcription and Translation 253
12.4 Genetic Mutations 259
12.5 DNA Technology 264
Section 12 Review 269

Section 13
Evolutionary Theory
13.1 Spontaneous Generation and Biogenesis 273
13.2 The Theory of Evolution 276
13.3 Ideas on the Origin of Life 281
13.4 The Evolution of Cells 284
13.5 Classification 287
Section 13 Review 291

Section 14
Evidence of Change
14.1 Review of Natural Selection 295
14.2 Diversity in Gene Pools 299
14.3 Speciation 304
14.4 Evidences of Evolution 306
14.5 Patterns of Evolution 310
Section 14 Review 312

Section 15
Kingdom Classification
15.1 The Six Kingdom System 315
15.2 Kingdoms of Archaebacteria and Eubacteria 318
15.3 Kingdom Protista 322
15.4 Kingdom Fungi 326
Section 15 Review 329

Section 16
Kingdom Plantae
16.1 Overview of Plants 333
16.2 Non-Vascular Plants (Bryophytes) 336
16.3 Seedless Vascular Plants 339
16.4 Gymnosperms 342
16.5 Angiosperms 345
16.6 Plant Cells and Tissues 348
16.7 Plant Adaptations 352
Section 16 Review 356

Section 17
Kingdom Animalia
17.1 Overview of Animals 359
17.2 Sponges and Cnidarians 363
17.3 Worms 365
17.4 Mollusks and Echinoderms 367
17.5 Arthropods 369
17.6 Invertebrate Review 371
17.7 Chordates and Vertebrates 373
17.8 Animal Adaptations 377
Section 17 Review 382

Section 18
Biogeochemical Cycles
18.1 The Water Cycle 385
18.2 The Carbon Cycle 387
18.3 The Oxygen Cycle 390
18.4 The Nitrogen Cycle 391
Section 18 Review 393

Section 19
Environmental Interdependence
19.1 Introduction to Ecology 395
19.2 Ecological Relationships 397
19.3 The Flow of Energy in Ecosystems 400
19.4 Food Chains, Food Webs, and Energy Pyramids 403
Section 19 Review 408

Section 20
Biomes
20.1 Tundra and Desert Biomes 411
20.2 Forest Biomes 414
20.3 Grassland Biome 417
20.4 Terrestrial Biome Review 419
20.5 Aquatic Biomes 420
Section 20 Review 423

Section 21
Changes in Ecosystems
21.1 Population Factors 425
21.2 Population Interdependence 428
21.3 Ecological Succession 431
21.4 Human Impact on Ecosystems 433
Section 21 Review 437

Appendix: Periodic Table A-1

Index A-2

Practice Test A **separate booklet**
(with evaluation chart)

Practice Test B **separate booklet**
(with evaluation chart)

Preface

The ***Mississippi SATP2 Biology I Student Review Guide*** is written to help students review the skills needed to pass the Biology I end-of-course test in Mississippi. This comprehensive guide is based on the 2010 Mississippi Biology I Framework Competencies as correlated by the Mississippi State Department of Education.

How To Use This Book

Students:
The Biology I end-of-course test is required for graduation. You must pass the state end-of-course test, which contains a total of 70 multiple-choice questions (60 scorable and 10 field-test). This book is a review for the Biology I end-of-course test.

① Take the pre-test at the front of this book. The pre-test gauges your knowledge of Biology I content that will be tested on the end-of-course test. The pre-test is designed to identify areas that you need to review.

② Score the pre-test. Using the pre-test evaluation chart, circle the questions that you answered incorrectly.

③ For each question that you missed on the pre-test, review the corresponding sections in the book. Read the instructional material, do the practice exercises, and take the section review tests at the end of each section.

④ After reviewing the material, take the two practice tests (provided as separate booklets). These practice tests are written to look similar to the actual Biology I end-of-course test, so they will give you practice in taking the test.

⑤ After taking Practice Test 1 and/or Practice Test 2, use the practice test evaluation charts, which are found directly after each practice test, to identify areas for further review and practice. The practice test evaluation charts can be used in the same way as the pre-test evaluation chart.

Teachers:
This review guide is also intended to save you, the teacher, time in the classroom. It can be used for classroom instruction or for individual student review. Since this student guide offers review for ALL of the Mississippi Curriculum Framework for the Biology I course, you, the teacher, have one consolidated resource of materials to help your students prepare for the end-of-course test.

① When teaching or tutoring individual students, use the strategy outlined above for students. By taking the pre-test, students can identify areas that need improvement. The pre-test evaluation chart directs the student to the sections they need to review for instruction and additional practice.

② For classroom study, use this guide to supplement lesson plans and to give additional review for skills required by the Biology I Framework Competencies. Purchase a class set of guides for use in the classroom or assign guides to students for out-of-classroom work.

③ Assign the practice tests (provided in separate booklets) as comprehensive review tests. Score the tests according to the scoring directions given on pages PT1-1 and PT2-1 of the testing booklets to approximate the scoring potential for the actual SATP2 test.

④ Use the practice test evaluation charts found after each practice test to identify areas needing further review.

⑤ To establish benchmarks, you may want to use one of the practice tests (provided in separate booklets) as a pre-test. Score the practice test according to the practice test scoring directions given on pages PT1-1 and PT2-1 of the testing booklets. Then after the students have completed all the exercises in this review guide, use the second practice test to gauge progress. You should see marked improvement between the initial and final benchmarks.

⑥ Please **DO NOT** photocopy materials from this guide or the practice test booklets. These materials are intended to be used as student workbooks, and individual pages should not be duplicated by any means without permission from the copyright holder. To purchase additional or specialized copies of sections in this book, please contact the publisher at 1-800-745-4706.

Biology I Pre-Test
Introduction

Introduction
The pre-test that follows is designed to identify areas where you can improve your skills before or after taking the Biology I end-of-course test. This pre-test will be similar in format to the Mississippi SATP2 end-of-course test for Biology I.

Directions
Read the directions on the following page. These directions should be similar to what you will see on the actual SATP2 end-of-course test for Biology I. Once you have completed this pre-test, circle the questions you answered incorrectly on the pre-test evaluation chart on page 30. For each question that you missed on the pre-test, review the corresponding sections in the book as given in the evaluation chart. Read the instructional material, do the practice exercises, and take the section review tests at the end of each section.

Scoring the Pre-Test
The following pre-test can be used as practice for the SATP2 Biology I test, but it is primarily a diagnostic tool to help you identify which skills you can improve in order to prepare better for the actual test. Any pre-test question answered incorrectly may identify a skill needing improvement or mastery. Review the corresponding skill(s) indicated in the Pre-Test Evaluation Chart by reading the instructional material on the given pages and completing the practice exercises and reviews. By reviewing each skill, you will improve mastery of the material to be tested on the SATP2 Biology I test and potentially increase the score you receive on that test. (The practice tests, which are given in separate booklets, are provided to give you additional practice taking tests similar to the actual SATP2 Biology I test.)

1 The bottle of a chemical used in a biology laboratory is labeled with the following symbol.

What does this laboratory safety symbol indicate about the chemical?

A It should be heated first before it is used.
B It evaporates easily and should be used only under a vent hood.
C It is corrosive and should not be allowed to contact the skin.
D It is flammable and should not be used around open flames.

Ⓐ Ⓑ Ⓒ Ⓓ

2 Which of the following is NOT found in a carbohydrate?

F Carbon
G Hydrogen
H Nitrogen
J Oxygen

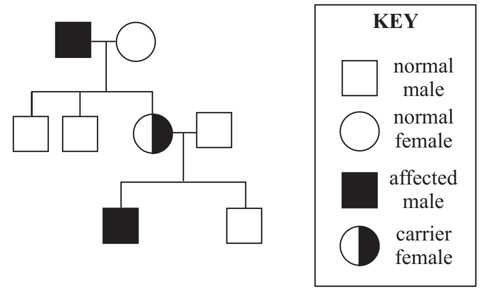
Ⓕ Ⓖ Ⓗ Ⓙ

3 In which circumstance would a high rate of mutation in a population be beneficial to the population?

A Only if the environment is very stable
B Only if the environment is changing rapidly
C Only if the environment is changing very slowly over a long period of time
D In any environment regardless of its stability

Ⓐ Ⓑ Ⓒ Ⓓ

4 Look at the pedigree graphic below.



This pedigree shows that only males are affected by a certain disorder. What type of inheritance is indicated by the pedigree?

F recessive
G dominant
H incomplete
J sex-linked

Ⓕ Ⓖ Ⓗ Ⓙ

5 Which two processes cycle carbon and oxygen between living organisms?

A Oxidation and combustion
B Transpiration and condensation
C Pollination and fertilization
D Cellular respiration and photosynthesis

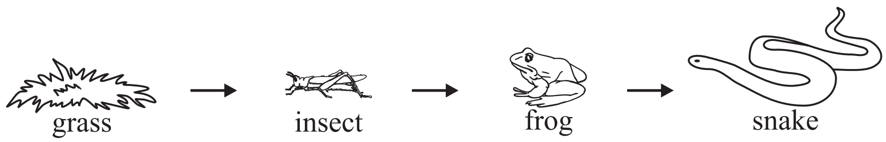
Ⓐ Ⓑ Ⓒ Ⓓ

6 Millions of acres of rainforests are destroyed each year. Which of the following is a negative result of this human activity?

F A decrease in atmospheric carbon dioxide
G A decrease in biodiversity
H An increase in atmospheric oxygen
J An increase in precipitation

Ⓕ Ⓖ Ⓗ Ⓙ

30 **A diagram of a food web is shown below.**

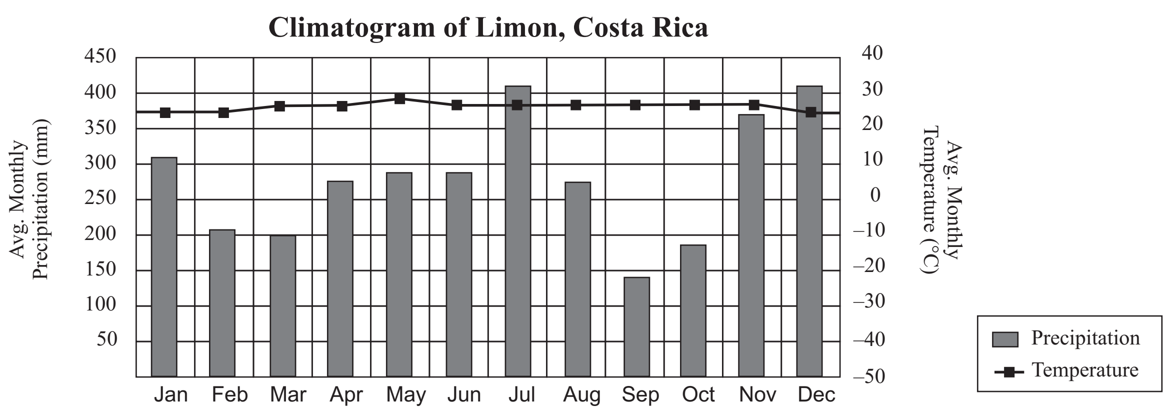


Which of the following organisms gets the MOST energy directly from the sun?

F frog
G grass
H insect
J snake

Ⓕ Ⓖ Ⓗ Ⓙ

31 **The graph below is a climatogram of Limon, Costa Rica.**



Which behavioral adaptation would be seen in animals in this biome?

A Likely to hibernate during winter months
B Prefer to live in trees to escape predators
C Dig deep underground tunnels to get to water
D Likely to migrate during dry months

Ⓐ Ⓑ Ⓒ Ⓓ

Biology I Pre-Test

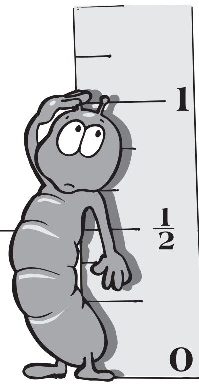
Evaluation Chart

Circle the questions you answered incorrectly on the chart below, and review the corresponding sections in the book. Read the instructional material, do the practice exercises, and take the section review tests at the end of each section.

If you missed question #:	Go to section(s):	If you missed question #:	Go to section(s):	If you missed question #:	Go to section(s):
1	1.7	31	17.8, 20.1, 20.2	61	12.1
2	5.2	32	12.3	62	11.3, 11.4
3	14.1, 14.2	33	6.2, 6.3, 8.2, 8.3	63	9.1
4	10.1, 10.2, 10.3, 11.3, 11.4	34	1.6, 1.7	64	6.4, 16.6
5	8.2, 8.3, 8.4, 18.2, 18.3	35	9.1	65	14.4, 14.5
6	21.4	36	13.4	66	10.1, 10.2, 11.2
7	2.1	37	9.1	67	13.2
8	5.6	38	3.1	68	2.3
9	14.2	39	16.7, 20.1	69	10.1, 10.2, 11.1
10	19.2, 19.3, 19.4	40	9.2	70	15.2, 15.4, 19.3
11	15.1, 15.2, 15.3, 16.1	41	2.3, 2.4	71	10.1, 10.2, 10.3, 11.4
12	4.2, 4.3, 4.4, 4.5, 4.6, 5.1	42	17.8, 20.3	72	18.4
13	6.2, 6.3	43	4.7	73	12.5
14	17.7	44	13.2	74	19.2
15	10.1, 10.2, 11.3	45	9.2, 12.4	75	12.5, 13.5
16	14.1, 14.2	46	6.2	76	7.3
17	10.1, 10.2, 10.3	47	14.2, 14.3, 14.4	77	13.1
18	16.6	48	4.7	78	12.2, 12.4
19	21.4	49	8.1, 8.2, 8.3	79	6.4
20	3.1	50	12.3	80	13.4
21	14.1, 14.2	51	5.4	81	9.1, 9.2, 9.3
22	13.3	52	17.7, 17.8, 20.1, 20.2, 20.3	82	15.1
23	16.1, 16.2, 16.3	53	17.8, 20.2	83	16.6
24	4.6	54	1.1, 1.3	84	6.4
25	17.1, 17.2, 17.3, 17.4, 17.5, 17.6	55	10.1, 10.2	85	14.1, 14.2
26	10.1, 10.2	56	1.5		
27	4.7, 5.6	57	9.4		
28	12.1, 12.2	58	21.1, 21.4		
29	7.2	59	2.1, 2.2, 2.3		
30	19.3, 19.4	60	6.1		

Equipment, Procedures, and Safety

Section 1.1
Length and Measurement



Pre-View 1.1

- **Ruler** or **meter stick** – equipment used in the laboratory to measure length in millimeters, centimeters, or meters
- **Meter** – metric unit for length
- **Accuracy** – the correctness of a measurement or how close the measurement is to the actual value
- **Precision** – the exactness of a measurement in terms of how many decimal places are used; determined by the smallness of the increments used in the measurement; can also be a measure of how reproducible or repeatable the data is

In general, biology is the scientific study of living things. Various types of equipment are used when studying biology, especially when conducting laboratory experiments. Biologists often use this equipment to make measurements. In your study of biology, it is important to know the names of some basic equipment and glassware and to understand when and how they are used. It is also important for you to know how to make meaningful measurements.

Measuring Length in a Laboratory

One of the most basic laboratory measurements is length. Just about everyone knows how to use a ruler to measure the length of an object, but scientists must measure length using metric units instead of feet and inches. A **ruler** or **meter stick** with metric units usually has several types of marks. The smallest marks indicate millimeters (mm). By the way, these marks are also called graduation marks or graduations. Graduation marks are found on many types of scientific equipment, so you will see this term again.

The centimeter ruler shown in figure 1-1 is drawn to scale. There are 1000 mm in one **meter**. The longer marks that are numbered show centimeters — 10 mm = 1 cm, and there are 100 cm in one meter. A man who is six feet tall is around 1.8 meters tall (or 1 meter, 80 centimeters). The ".8" means eight-tenths, and eight-tenths of a meter is 80 centimeters.

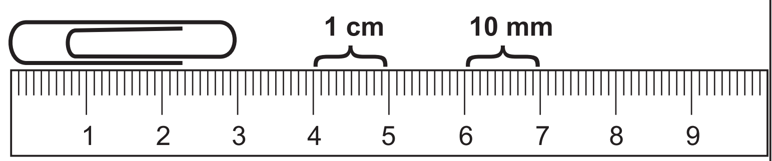


Fig. 1-1 Centimeter Ruler (To Scale)
A large paperclip is approximately 3 cm long.

Much longer lengths or distances are measured in kilometers (km), which are 1000 meters. One mile is about 1.6 kilometers.

Some scientific equipment is digital and gives a number on a readout. Other pieces of equipment, like rulers and meter sticks, require you to determine the measurement by manually reading a scale. In the real world, measurements rarely fall exactly at a graduation mark. Most of the time, the reading falls between two graduation marks. To get the reading, you simply estimate between the marks. Look at an example.

Performing Scientific Experiments

Section 2.2
Setting Up Experiments

Pre-View 2.2

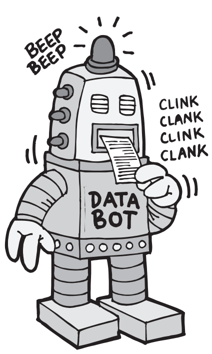
- **Experiment** – a set of steps used to test a hypothesis
- **Data** – observations, measurements, and other information gathered in an experiment
- **Quantitative data** – measured data; data associated with numbers or specific amounts
- **Qualitative data** – descriptive data; data not associated with numbers or amounts
- **Control group** – the group that is used for comparison; it does not receive the tested element
- **Experimental group** – a group that receives one element being tested
- **Bias** – a belief or opinion that may affect experimental results
- **Unbiased** – having no opinion or being impartial
- **Placebo** – a substance given to a control group that has no effect on the experiment but is used to eliminate bias
- **Constants** – factors that remain the same for all groups during an experiment
- **Variable** – a factor that is changed during an experiment in order to test its effect
- **Independent variable** – the variable used to produce an effect
- **Dependent variable** – the measurable change that occurs because of the independent variable

An **experiment** is a set of steps that are performed to collect data. The data can then be used either to prove or to disprove the hypothesis. The experiment must be designed carefully so that the data collected gives meaningful information. The following questions should be considered when designing an experiment.

Designing an Experiment

- What data should be collected and how?
- How many groups will be used?
- How many subjects per group should be used?
- What will be the control group?
- Will there be a placebo used?
- What are the important constants?
- What is the independent variable?
- What is the dependent variable?

Data

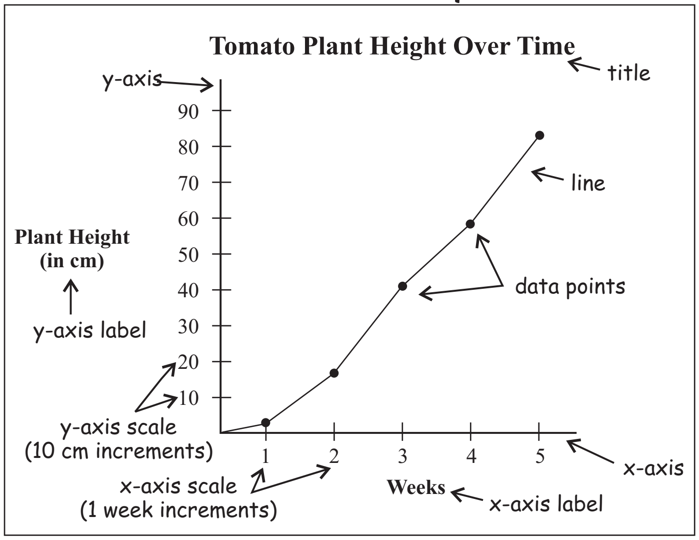


Data is any information gathered during an experiment. Measured data, such as length, mass, pH, temperature, or time of day is called **quantitative data**. Remember, a quantity is an amount of something, so quantitative data deals with numbers or amounts. The data recorded in most experiments is quantitative. Descriptive data, on the other hand, is called **qualitative data**. Color, odor, taste, feel, or any other described quality is considered qualitative data.

Many kinds of information can be recorded during an experiment. However, the only data that should be collected in an experiment is the information that can be used to prove or disprove the hypothesis. The scientist must decide which information is important to record and which isn't.

Section 3.1, continued
Using Line Graphs to Organize and Interpret Data

Well-Constructed Graph



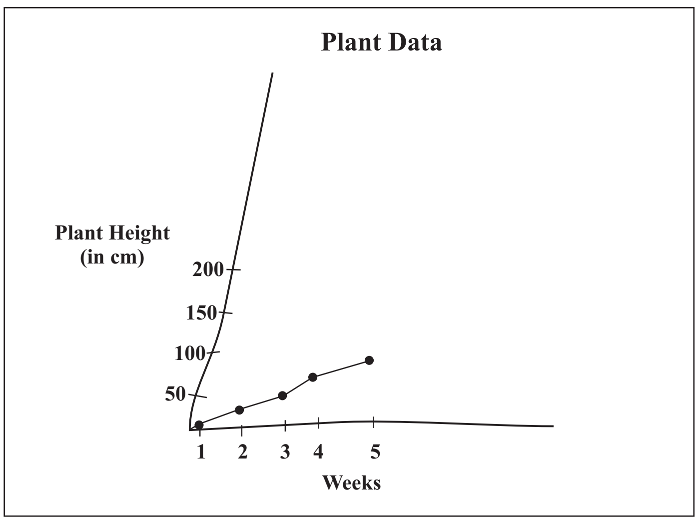
The graph on the left is a good example of how a line graph should be drawn.

Title: The title of a graph should give a general explanation of the data shown by the graph. In this example, the title is "Tomato Plant Height Over Time."

Axes and Labels: The x and y axes should be labeled to show what kind of data is being given. In this case, the x-axis represents "weeks" and the y-axis represents "plant height in centimeters."

Scale: The scale is shown by the numbers that are labeled on the x and y axes. In this example, the x-axis has a scale of one week per increment. The y-axis has a scale that is marked in 10-centimeter increments.

Poorly-Constructed Graph



Do you recognize all the reasons this graph is poorly constructed?

Title: Although this graph does have a title, it is not very descriptive of the data represented. For example, it doesn't tell what kind of plant.

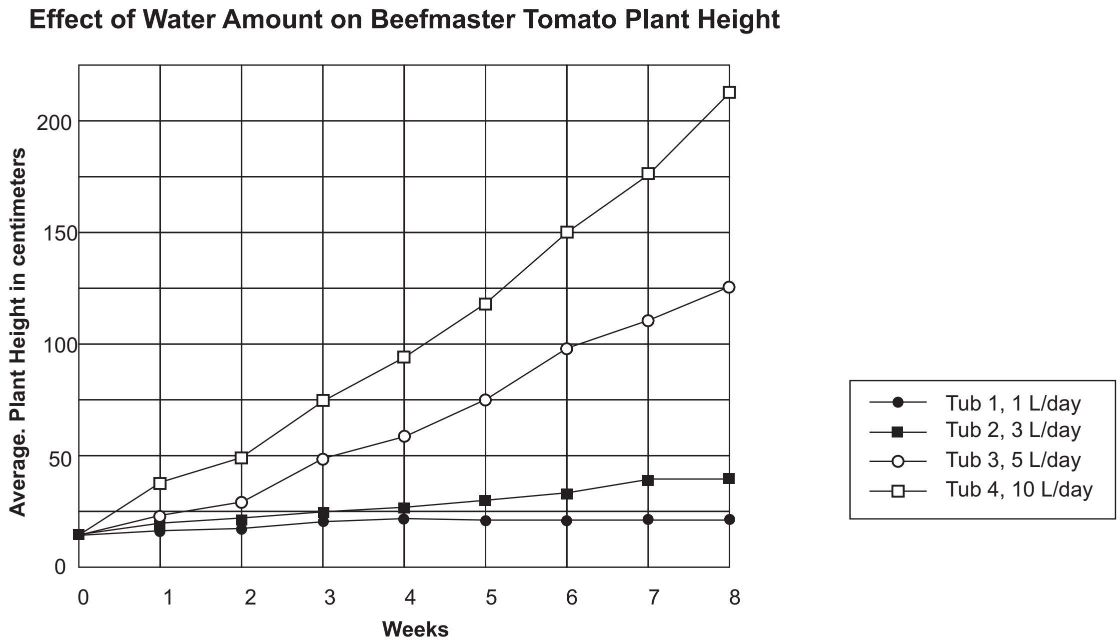
Axes and Labels: The x-axis and the y-axis are correctly labeled, but they are crooked. Be sure that you use a straight edge when drawing graphs by hand, and you will probably want to use graph paper as well.

Scale: When constructing a graph, choose a scale so that your data fills the space. In this example, the poorly chosen scale causes the data to fill only a small corner of the graph. Also, increments should be equally spaced. Notice that the spacing between the weeks is not equal.

When constructing line graphs, remember the following: Use a descriptive title that explains the data. Label the x and y axes and give the units. In the examples above, labeling the y-axis as "Plant Height" is useless unless you also give the units. Likewise, labeling the x-axis as "Time" would not be an appropriate label. No one would know what the 1, 2, 3, 4, or 5 represented — days, weeks, months, etc. Use an appropriate scale so that your data is spread out over the length and width of the graph. And of course, be very neat by drawing straight lines to represent your axes.

Read about the following experiment, study the graph, and answer the questions that follow.

The Beefmaster tomato plant is a variety that produces large tomatoes ideal for slicing and using on sandwiches. An experiment is performed to determine how the amount of rain, or watering, affects the height of Beefmaster tomato plants. Seedlings of equal height were planted in four large tubs. Each tub contained three plants, and all plants received the same amount of sunlight and fertilizer. The only difference was the amount of water that each tub received. The data from the experiment is summarized in the graph below.



6. Which of the following conclusions is supported by the graph?

F Rain helps tomato plants produce healthy, firm tomatoes.
G Beefmaster tomato plants grow taller than other varieties.
H Beefmaster tomato plants die when they are over-watered.
J Beefmaster tomato plants grow taller when they receive more water.

Ⓕ Ⓖ Ⓗ Ⓙ

7. Based on the graphed data, which of the following would be a logical prediction?

A Beefmaster tomato plants will thrive in gardens that are consistently watered.
B Beefmaster tomato plants will grow taller when they are planted in tubs.
C Beefmaster tomato plants will need more sunlight and fertilizer when planted in a garden.
D Beefmaster tomato plants will grow well during a drought.

Ⓐ Ⓑ Ⓒ Ⓓ

Biochemical Concepts

Section 4.6
The Chemistry of Water

Pre-View 4.6

- **Polar molecule** – a molecule that has a partial positive charge on one end and a partial negative charge on the other end
- **Hydrogen bond** – in the case of water molecules, the weak bond that occurs when the hydrogen in one water molecule is attracted to the oxygen in another water molecule
- **Cohesion** – the attraction between molecules of the same kind
- **Surface tension** – the film-like quality on the surface of a liquid that is caused by the attraction of the liquid molecules to themselves
- **Adhesion** – the attraction of one type of molecule to a different type of molecule
- **Capillary action –** the tendency of a liquid to draw up into a narrow tube due to the liquid's properties of cohesion and adhesion
- **Specific heat –** the amount of heat needed to raise the temperature of one gram of a substance one degree Celsius
- **Solvent –** a substance that dissolves another

Water — good old H_2O — is the most abundant compound in most living organisms, but it's made of only two elements, hydrogen and oxygen. What makes it so special?

Water has many qualities that make it important to living things:

- It is transparent, so it lets sunlight pass through it to reach organisms that live underwater.
- It can form positively or negatively charged particles called ions.
- It is a universal solvent that can dissolve many substances easily so that they can be transported by the blood or other body fluids.
- It is found inside our cells and around our cells.
- It exists as a liquid at room temperature, and its frozen state floats and does not sink.

A Covalent Polar Molecule

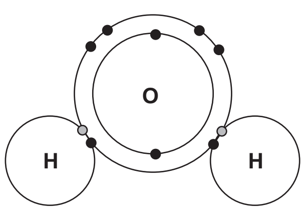
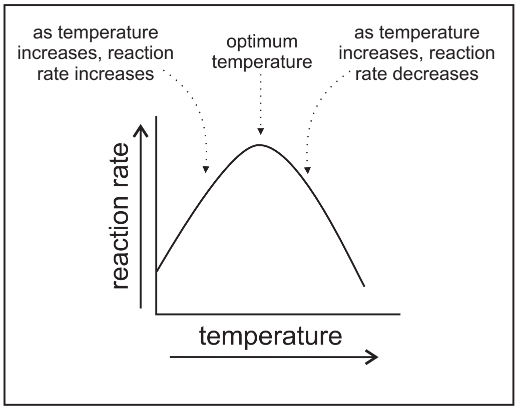


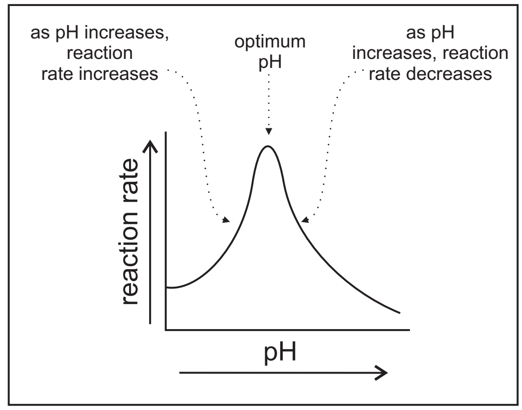
Fig. 4-9
Water Molecule

In a water molecule, covalent bonds hold the oxygen and hydrogen atoms to each other. Remember, a covalent bond is a bond formed by the *sharing* of electrons.

In a water molecule, however, the electrons are not shared equally. Since an oxygen atom has 8 protons (with 8 positive charges) and the two hydrogen atoms have one proton each (one positive charge each), the oxygen atom in a water molecule attracts electrons more strongly than the hydrogen atoms. The oxygen has more positive charge to attract the negative charge of the electrons. The unshared electrons in the oxygen atom push the hydrogen atoms down at an angle, so the water molecule ends up looking like the diagram in figure 4-9.

Both temperature and pH will change the shape of an enzyme. Since the shape of the enzyme affects how well it works on a substrate, enzymes work best at an optimum temperature and pH. Look at the graphs below that show how temperature and pH generally affect reaction rate.





Although the shapes of the curves are a little different, they both show the same trend. They simply show that as temperature or pH increases, reaction rate increases until it gets to an optimum temperature or pH. Then the reaction rate decreases when temperature or pH gets any higher. What point on the graphs represents the optimum temperature and optimum pH? The optimum is represented by the highest peak on the curve. Generally, enzymes work well in a narrower pH range than temperature range, so the "hill" of the curve is narrower and steeper on the pH graph.

Types of Enzymes

Humans produce two types of enzymes: metabolic enzymes and digestive enzymes. Humans also obtain and use a third kind of enzyme, food enzymes, from eating raw foods. Remember, enzymes are needed to speed up the rate of reaction. Reactions that could take days to complete can be completed in minutes or hours when enzymes are used.

Metabolic enzymes enable cells to perform cellular reactions. These reactions allow cells to make energy, repair tissues, and eliminate or neutralize wastes and toxic substances.

Digestive enzymes are ones that may be more familiar to you. The name of a digestive enzyme usually ends in *-ase*, and the first part of the name often indicates what it helps to digest (or break down into smaller components). Look at the chart on the right for common digestive enzymes and the substances they digest. For example, lactase is an enzyme that breaks down lactose, the sugar found in milk, into the monosaccharides of galactose and glucose. These are only a few of many. As you can see in the chart, digestive enzymes help to digest the different types of macronutrients. They allow the body to break down food in hours instead of days.

Common Digestive Enzymes

Enzyme	Breaks down —	Into products of —
amylase	carbohydrates	Disaccharides, monosaccharides
lactase	lactose (milk sugar)	galactose and glucose
sucrase	sucrose (table sugar)	glucose and fructose
protease	proteins	polypeptides, amino acids
lipase	fats	glycerol and fatty acids

Food enzymes also help to break down the foods we eat. Since food enzymes are destroyed at high temperatures, they are only found in uncooked (raw) foods or from supplements. Consuming food enzymes from raw foods helps the body to digest the foods without causing as much strain on the body to produce additional digestive enzymes.

Plant and Animal Cells

Figure 6-5 below shows a labeled diagram of a typical plant and animal cell.

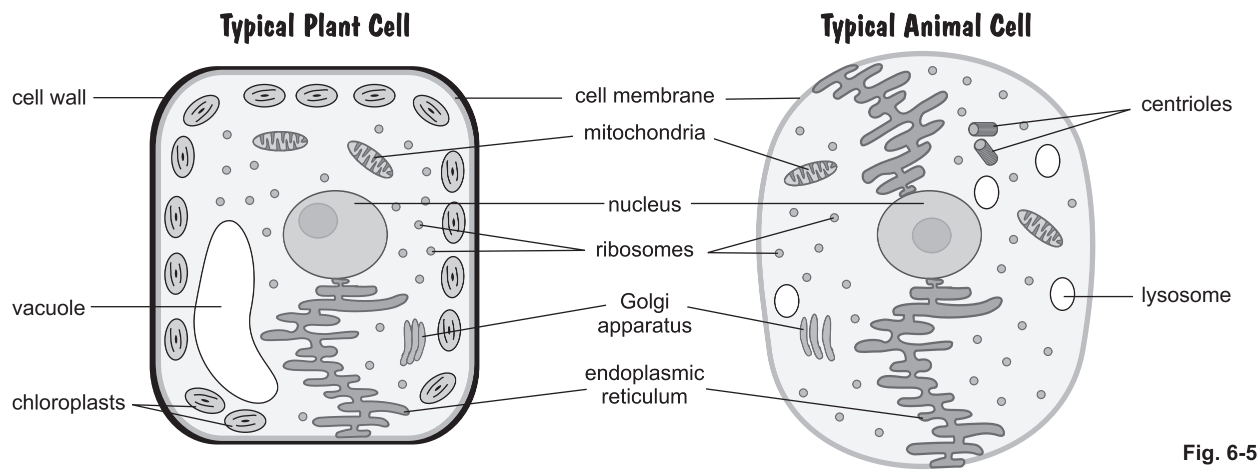


Fig. 6-5

Both plant and animal cells can reproduce, but the way that they divide into new cells is different. Both have some cell processes such as **cellular respiration** that are similar. In cellular respiration, cells use oxygen to help break down glucose to release energy and carbon dioxide. You'll see more about this process in Section 8.

Special Animal Organelles

Animal cells contain centrioles and lysosomes, neither of which are found in plant cells. Remember, centrioles play an important role in cell division, and lysosomes store enzymes that keep the cell free from debris.

Special Plant Organelles

From the chart on the previous page and the diagrams above, can you summarize a few things that are different between plant cells and animal cells? Hopefully, you see that the presence of a cell wall, the size of vacuoles, and the presence of chloroplasts make plant cells different. Let's take a closer look at each of these.

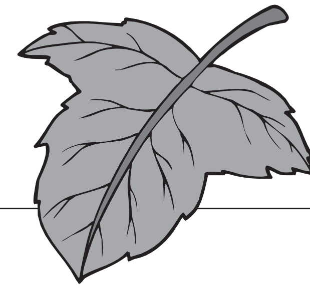
The Cell Wall
Plant cells have cell walls, but animal cells do not. The cell wall in a plant cell is made of **cellulose**, a material unique to plant cells. Similar to starch, cellulose is a type of carbohydrate. (Cellulose is also known as "fiber," an important part of a human diet.) The cell wall gives support and extra protection to the plant cell.

Vacuoles
Many plant cells have one large vacuole that is filled with water. The vacuole may take up 50% or more of the space inside the cell. Vacuoles are used to store water, salts, sugars, wastes, etc. In plants, they can help provide support for the cell. Most animal cells do not contain vacuoles, and when found in cells other than plant cells, the vacuoles are small. Single-celled organisms such as paramecium contain contractile vacuoles that help control fluid balance.

Chloroplasts
Only plant cells (and some types of algae) have chloroplasts, so they can go through a special process called **photosynthesis**. In photosynthesis plant cells use light energy, carbon dioxide, and water to produce oxygen and glucose. Remember that glucose is a monosaccharide carbohydrate, or in other words, a simple sugar. Also remember that glucose and other carbohydrates store energy. (See Section 5.2 if you need more review on carbohydrates.) Glucose molecules "link" together to form starch molecules, which are stored in plant cells for future use.

Cellular Energy

Section 8.3
Photosynthesis



Pre-View 8.3

- **Heterotrophs** (also called ***consumers***) – organisms, such as animals, that obtain energy by consuming plants and other animals
- **Autotrophs** (also called ***producers***) – organisms, such as plants, that usually use energy directly from the sun to produce glucose and other carbohydrates
- **Carbon fixation** – the process of converting the inorganic carbon found in carbon dioxide to organic carbon in glucose
- **Photosynthesis** – process used by autotrophs that uses the sun's energy to convert water and carbon dioxide to glucose (simple sugar) and oxygen
- **Chlorophyll** – the green pigment found in the chloroplasts of plant cells that absorbs energy from the sun and uses that energy in the first stage of photosynthesis
- **Calvin cycle** – the stage of photosynthesis that does not require light

You know that all living things need energy, but where does that energy come from? In Sections 8.1 and 8.2, we discussed how energy comes from converting glucose (or simple sugar) into ATP, but where does the glucose come from? The sun is actually the main source of energy for living organisms although many organisms can't use that energy in its original form. All living organisms live by releasing energy found in chemical compounds such as glucose, but some can also use energy directly from the sun to make glucose.

Living organisms can be divided into two main groups: autotrophs and heterotrophs. **Heterotrophs** are organisms, such as animals, that get energy from the sun indirectly by consuming foods that have energy stored in them. Heterotrophs are also called ***consumers*** since they must consume food for energy. **Autotrophs** are organisms, such as plants, that can directly use the sun's energy to produce energy-containing chemical compounds such as glucose and other carbohydrates. Autotrophs are also called ***producers*** since they can produce their own food.

Through the process of **photosynthesis**, most autotrophs use the energy in sunlight to change water and carbon dioxide (CO_2) into glucose and oxygen. The net equation for photosynthesis is shown in figure 8-10 below:

Photosynthesis

$$6CO_2 + 6H_2O \xrightarrow[\text{enzymes and chlorophyll}]{\text{light energy}} C_6H_{12}O_6 + 6O_2$$

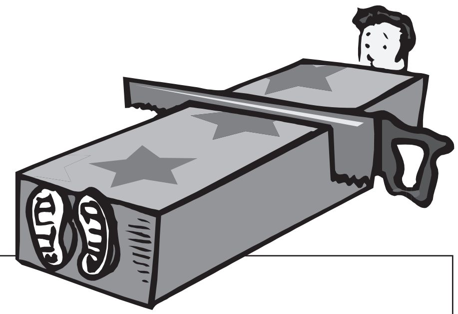
carbon dioxide — water — glucose (simple sugar) — oxygen

Fig. 8-10

Do you remember the difference between organic and inorganic compounds that you saw in Section 4.1? You may remember that carbon dioxide is an inorganic compound even though it contains carbon. Glucose, on the other hand, is an organic compound. So photosynthesis converts carbon from an inorganic compound into an organic one. This conversion is called **carbon fixation**. (Hint: Carbon dioxide cannot be used as food for us as humans. Once plants convert it into glucose, it is "fixed" into food that we can eat. The glucose made by photosynthesis helps to make up the potatoes, apples, lettuce, wheat, etc. that we eat.)

Cellular Reproduction

Section 9.2
Sexual Reproduction and Meiosis



Pre-View 9.2

- **Somatic cells** – all cells except sex cells; for example: blood cells, liver cells, skin cells
- **Sex cells (**or **gametes)** – the cells other than somatic cells that are formed through a process called meiosis
- **Meiosis** – the process that forms the sex cells called gametes (ova and sperm cells)
- **Haploid cells** – sex cells produced through the process of meiosis that contain half the number of chromosomes for that organism; have an n number of chromosomes
- **Diploid cells** – somatic cells produced through the process of mitosis that contain the full number of chromosomes for that organism; have a $2n$ number of chromosomes
- **Homologous chromosomes (**or **homologues)** – the two chromosomes that make up each pair of human somatic cells (23 pairs for a total of 46 chromosomes in humans)
- **Sex chromosomes** – the pair of chromosomes that determines gender (male or female)
- **Autosomes** – the pairs of chromosomes that do not include the one pair of sex chromosomes and that do not determine gender
- **Tetrad** – homologous chromosomes paired together side by side during meiosis
- **Crossing over** – the exchange of DNA between paired homologous chromosomes during meiosis

Gametes (Sex Cells)

Organisms that reproduce sexually have two types of cells. As we reviewed in Section 9.1, the cells that make up the body of the organism are called **somatic cells,** and they reproduce through the process of mitosis. The other cells are called **sex cells** or **gametes,** and they are formed using a process called **meiosis**.

Meiosis occurs only in reproductive cells to form egg cells and sperm cells. Unlike mitosis, meiosis does *not* produce two new genetically identical cells. Instead, the cells produced by meiosis are called **haploid cells**. Haploid cells have only half the usual number of chromosomes that other cells have. These cells are said to have an n number of chromosomes. Somatic cells are said to be **diploid** and contain the full number of chromosomes for any given organism. Somatic cells are said to have a $2n$ number of chromosomes. For example, human somatic cells have 23 pairs of chromosomes for a total of 46 chromosomes. The diploid number of chromosomes for humans is 46.

Human egg and sperm cells are haploid, which means they have only 23 chromosomes, not 23 pairs. When one egg with 23 chromosomes is fertilized by one sperm with 23 chromosomes, the offspring will have 46 chromosomes (23 pairs), the correct number for humans. If gametes were produced by mitosis, then each gamete would have 46 chromosomes, and the first set of offspring would have 92 chromosomes — twice as many as normal!

Somatic cells in an organism contain pairs of chromosomes that carry similar genetic information. The two chromosomes that make up each pair are called **homologous chromosomes** or **homologues**. One chromosome from each pair came from the mother's egg cell, and the other chromosome for each pair came from the father's sperm cell. Each pair of homologues contains similar information. For example, one pair of homologues will contain genes that determine eye color. One of the chromosomes may have information for blue eyes from the mother, and the other may have information for brown eyes from the father.

Applied Genetics

Section 11.1
Dihybrid Crosses

Pre-View 11.1

- **Dihybrid cross** – studying two traits crossed from parent organisms
- **Law of Independent Assortment** – a natural law that explains how traits are inherited independently of other traits

So far we have looked at monohybrid crosses, which only study one trait at a time. Many times scientists study two or more traits at a time. Studying two traits at a time is called a **dihybrid cross**.

When at least two traits at a time are studied, they illustrate the **Law of Independent Assortment**, which means that inheriting one trait doesn't affect the inheritance of another trait. For instance, having brown eyes has nothing to do with having freckles. The genes are inherited independently of each other. Again, Mendel was the first to make these observations, so this law is often called *Mendel's Law of Independent Assortment*. (You'll see later how this "law" isn't always true.)

To show a dihybrid cross, let's pick two different traits, such as handedness and freckles. Being right-handed (R) is dominant over being left-handed (r), and having freckles (F) is dominant over not having freckles (f).

Let's say that both the mother and the father are heterozygous for both traits. We can create a Punnett square of this dihybrid cross to analyze how these traits might appear in their children. The Punnett square is bigger and looks more complicated, but it really isn't difficult to do. Just follow these steps.

Step 1: First, pick a parent. The mother is heterozygous for both traits, (RrFf), so she has a dominant R gene and a recessive r gene. She also has a dominant F gene and a recessive f gene. She can pass on each of these traits independently to her children. What are the four possible combinations of these traits? They are RF, Rf, rF, and rf.

1 **RrFf = RF**
2 **RrFf = Rf**
3 **RrFf = rF**
4 **RrFf = rf**

Step 2: Next, consider the father. He is also heterozygous for both traits, so the combinations of traits are the same: RF, Rf, rF, and rf.

Step 3: Now fill in a Punnet square with these combinations. Since there are four combinations for each parent, the square is 4 × 4 instead of 2 × 2. But you fill it in the same way.

		Mother			
		RF	**Rf**	**rF**	**rf**
Father	**RF**	RRFF	RRFf	RrFF	RrFf
	Rf	RRFf	RRff	RrFf	Rrff
	rF	RrFF	RrFf	rrFF	rrFf
	rf	RrFf	Rrff	rrFf	rrff

Genetic Mutations

Remember, amino acids make up polypeptide chains, polypeptide chains make up proteins, and proteins are a vital component of living materials and carry out vital cellular processes. Remember also that genes in the DNA are made up of nucleotide sequences that are "read" in groups of threes similar to the three-word sentences shown on the previous page. The sequence of the letters in the mRNA determines the amino acid that is added to the polypeptide chain. If one or more amino acids added to that polypeptide chain are wrong, the organism will not be able to build proteins with the correct structure. Look at figure 12-7 to review the different types of gene mutations and how they affect protein production. Notice that the amino acids that make up the protein can change when different gene mutations occur. Gene mutations are sometimes called **point mutations** because the mutation occurs at only one point in the DNA. Insertions or deletions of a single nucleotide are also called **frameshift mutations** because they shift how the codons are read and can result in different amino acids being added to the protein. (Note: Since some nucleotide sequences "code" for the same amino acid, not all gene mutations result in a different amino acid.) Both point mutations and frameshift mutations may also create a stop codon, which will stop protein synthesis. The resulting protein will be shorter than it is supposed to be.

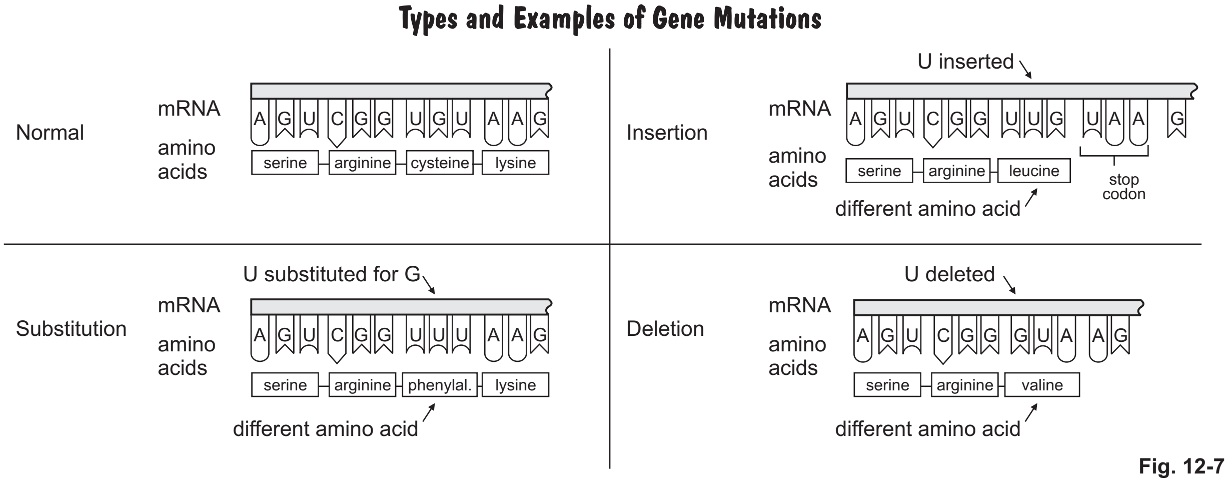


Fig. 12-7

Chromosome Mutations

The other type of mutation is a **chromosomal mutation**, where the structure or numbers of chromosomes change. The structure of a chromosome can change if a part of a chromosome is broken off or lost during the processes of mitosis or meiosis. The following types of chromosomal mutations can occur by a change in chromosome structure.

- A broken part can sometimes reattach to a sister chromatid and cause **duplication** of genetic information in one chromatid and **deletion** of genetic information in the other.
- If the broken part reattaches backwards, it is called an **inversion**.
- The broken part may also attach to another chromosome and is called **translocation**.

In any of these cases, the genes on the broken portion of the chromosome are now in the wrong place. Figure 12-8 shows the different types of chromosomal mutations.

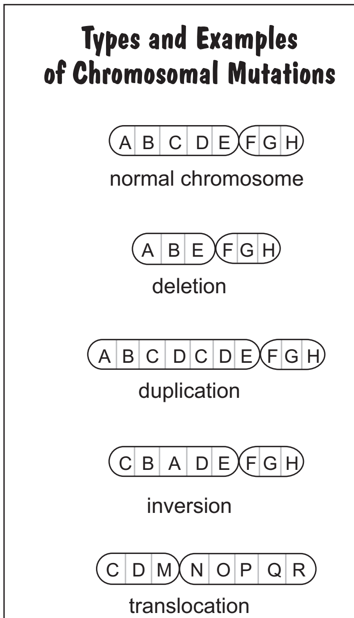


Fig. 12-8

John Needham and Lazzaro Spallanzani

Francesco Redi's experiment proved to most that large living organisms, like flies, did not come from nonliving things. But about 100 years after Redi, the question over spontaneous generation was still debated, especially when it came to organisms that could now be observed with a microscope.

In 1745, **John Needham** attempted to prove spontaneous generation does occur with microscopic organisms. At the time, it was known that heat kills living organisms. In an experiment, Needham heated chicken broth in a flask to kill all living microscopic organisms. He then let the flask and broth cool and sit. After some time, the broth became cloudy with microorganisms. This experiment gave Needham "proof" that microorganisms were created by the broth.

Another scientist, **Lazzaro Spallanzani**, repeated Needham's experiment, but Spallanzani suspected that the microorganisms were coming from the air. Spallanzani's experiment removed the air from the flask by creating a partial vacuum after the broth had been heated. In Spallanzani's experiment, no microorganisms grew, so he believed his experiment disproved spontaneous generation of microorganisms.

Spallanzani's experiment did not convince everyone because many believed that air was necessary for spontaneous generation to occur. Some believed that all Spallanzani proved was that spontaneous generation could not occur without air.

Louis Pasteur

Another hundred years passed by before **Louis Pasteur** finally designed an experiment that disproved spontaneous generation once and for all. In the late 1850s, Pasteur performed a variation of Needham's and Spallanzani's experiments. Pasteur sterilized broth by heating it, but he designed and used a special flask. See figure 13-2. The swan-like neck of the flask allowed air to enter, but it trapped microorganisms and other contaminants so that they could not reach the broth. Using this specially-designed flask, Pasteur was able to show that microorganisms lived in the air, but they were not formed by the air. He proved that microorganisms come from other microorganisms, not broth and air.

Pasteur's Swan-necked Flask

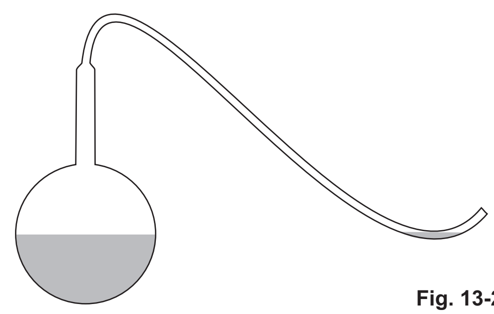


Fig. 13-2

Disproving the idea of spontaneous generation was just one of Pasteur's contributions to science. He is considered the father of microbiology and of immunology. Pasteur was the first to determine that yeast were responsible for fermentation, an important process in the making of beer and wine. He also developed the germ theory, the idea that diseases are caused by microorganisms, and he created vaccines for rabies and anthrax. Pasteur created the process of pasteurization, the heating of milk or other liquids to kill harmful bacteria. His discoveries in microbiology led to antiseptic techniques still used by doctors and nurses today to prevent the spreading of diseases.

Biogenesis

Pasteur's broth experiment led to the widely-accepted belief that living organisms come only from other living organisms. This belief became known as the law of **biogenesis**, a law that has been firmly established. A scientific law is a general fact of nature. Gravity, for example, is another scientific law.

Comparative Anatomy

Another way that scientists look for evidence of change in species is by looking at similarities in living organisms.

Homologous and Analogous structures: Homologous structures develop from the same tissues as embryos and have similar internal structures. They may look different on the outside, and they may have different functions. For example, if you looked at the forelimb of a bat, a human, a crocodile, and a bird, you would see that they all have the same skeletal structures — humerus, ulna, carpals, and radius — although they have different functions. See figure 14-1. These similarities suggest that they may have had a common ancestor long ago.

Homologous structures should not be confused with **analogous structures**, structures that have similar functions but are not believed to have evolved from a common ancestor. A bird's wing and a butterfly's wing are analogous structures. Both have the same function, to enable flight, but these two types of wings are structurally very different.

Homologous Structures

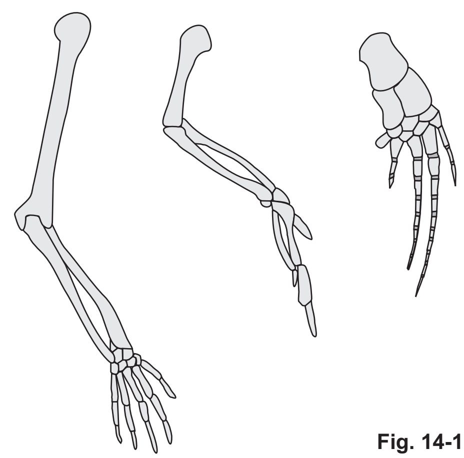


Fig. 14-1

Vestigial structures: Sometimes an animal has structures that seem to have no useful purpose now although they resemble structures that are useful in other species. These structures are called **vestigial structures**. The flightless wings of the ostrich, the sightless eyes of the cave salamander, and the pelvis bone found in some whales are considered examples of vestigial structures.

Embryology: Embryos of many vertebrates look very similar, especially in the earliest stages of development. These physical similarities suggest that the organisms have genetic similarities as well. By looking at the similarities in embryological development, scientists can determine if two very different species might have had a common ancestor.

Biogeography

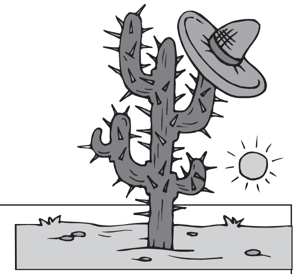
Plate tectonics theory explains that the surface or "crust" of the earth is divided into large plates that float on a semi-molten layer underneath the earth's surface. According to this theory, these plates continually move, and this movement explains earthquake and volcanic activity as well as continental drift. Continental drift is the movement of continents. Scientists believe that all land mass was once consolidated together in a single continent called *Pangaea*. Over time, the different continents have been formed as the plates of the earth drifted apart.

Biogeography is the study of how plants and animals are distributed around the world. This distribution depends on the migration ability of a particular species and how plants and animals have been separated from one another over time by continental drift.

Scientists use this distribution of organisms to figure out how and when species may have evolved. For example, some species are isolated to specific continents. Apes, including all fossils of apes, are found only in Africa and Asia. Marsupials, mammals with pouches, are found only in Australia. These species must have been separated from a common ancestor early in their history and then evolved differently. In other cases, species on a nearby island are similar but not exactly the same as those on the nearest mainland. Darwin made many of these observations about species on the Galapagos Islands. The explanation of how these different species may have evolved differently is explained by speciation, which you saw in Section 14.3.

Kingdom Plantae

Section 16.7
Plant Adaptations



Pre-View 16.7

- **Adaptations** – characteristics that help an organism to survive in its environment
- **Adventitious roots** – roots that grow in unusual places, such as on the stem of a plant
- **Prop roots** – roots that grow partially in the air and partially in the ground

Adaptations are physical, chemical, or behavioral characteristics that help an organism to survive in its environment. Let's think about plants a little more. Plants live in all different types of environments, from the hot and dry desert to the cold tundra and everywhere in between. Since most plants live out their lives in one specific place, what adaptations do they have that allow them to survive extreme temperatures, live in very dry areas, live in either salt water or fresh water, or keep them from being consumed by predators? How are they able to reproduce and spread to new areas? These adaptations can be found in their leaves, stems, seeds, flowers, fruits, and roots.

Leaf Adaptations

Leaves are specialized according to where the plant lives. The different sizes, shapes, and structures of leaves allow plants to survive in specific environments. Let's review a few basics about leaves. You should remember these points from previous sub-sections:

Leaf Review

- The primary purpose of a leaf is to absorb light and carry out photosynthesis to make food for the plant.
- For photosynthesis, the leaf must be able to take in carbon dioxide and release oxygen.
- The plant loses water through its leaves during transpiration.
- The stomata allow leaves to take in carbon dioxide and release oxygen, and they control the amount of water that is lost through transpiration.

Many times, the shape and size of the leaves, the number and location of stomata, and the type of cuticle will indicate the type of climate in which a plant can grow. Most plants have stomata on the underside of the leaves where they are protected from the drying effects of wind and sun. Let's consider some specific examples.

Plants that live in habitats where water is scarce may conserve water by having smaller leaves, leaves coated with a thick waxy cuticle, fewer stomata, or stomata that are deep in the leaves. Most cacti growing in deserts have no true leaves. Chloroplasts and stomata are found on their stems, and the stomata are closed during the day and open at night when it is cooler. The spines of a cactus are modified leaves that have no chloroplasts and contain no stomata, so they reduce water loss to the plant. The spines also protect the cactus from herbivores, provide some shade to the plant, and help to channel rain water to the base of the plant.

For conifers, the thin leaves with their waxy coating are an adaptation that helps the plants to conserve water. Many conifers can live in fairly dry climates. They also tolerate colder temperatures. By keeping most of their leaves, these plants can begin photosynthesis very early in the spring when plants without leaves are still dormant. Since they don't have to produce an entire set of new leaves every year, they can grow in habitats where nutrients are not as available.

Adaptations for Obtaining and Eating Food

Many adaptations help animals get food. These adaptations can include the ability to hunt or graze, a keen sense of sight or smell, or even the different types of beaks that allow birds of different species to have very different diets. Some specific examples are given below.

- Rattlesnakes and other snakes called **pit vipers** have special sense organs on each side of the head that alert the snakes to mice or other warm-blooded prey that are nearby.
- Birds have a number of special adaptations that help them obtain and eat food. The keen eyesight of hawks and eagles allow them to spot their prey. Sharp claws called **talons** allow them to grasp their prey, and sharp beaks allow them to tear apart and eat their prey. On the other hand, birds like the finches have short, strong beaks for cracking and eating seeds. Pelicans have large beaks designed to catch and eat fish. Woodpeckers have long, sharp beaks best suited for finding and eating insects. Some of these beak adaptations can be seen in figure 17-3 below.
- Some animals **migrate** in the fall to warmer climates with more plentiful food supplies. They migrate back to their original climates once weather and food conditions improve in the spring. Many different types of animals migrate, including birds, bats, fish, whales, elk, and butterflies. Even underground animals, such as termites and earthworms, "migrate" farther under the soil to find more favorable living conditions.
- Baleen whales are filter feeders and have special structures to strain their food out of the water as they swim.
- Herbivores, animals such as cows that eat only plants, have specially designed teeth to grind grasses and grains and special stomachs to digest them.
- Carnivores, animals like those in the cat family that eat other animals, usually have sharp claws and teeth to catch and eat their prey. They may also have special coloration that camouflages them as they hunt.
- Some animals use **aggressive mimicry** to lure prey to them. For example, the body of the angler fish resembles a rock. It uses a part of its spine as a lure, which looks like a much smaller fish, to lure prey to itself. Other animals may use scent or other signals to lure prey.
- Animals may be **nocturnal**, active at night and asleep during the day, or **diurnal**, active during the day and asleep at night. Since most people are diurnal, we are usually more familiar with diurnal animals, the ones that are awake when we are. But, you probably know some nocturnal animals as well. Many nocturnal animals have extra large eyes to allow them to see their prey at night. They may also have a very keen sense of smell to help them locate food when it is dark.

Examples of Bird Beak Adaptations

short, strong beak for cracking seeds — long, sharp beak for spearing fish — sharp, hooked beak for tearing flesh

Fig. 17-3

Environmental Interdependence

Section 19.4
Food Chains, Food Webs, and Energy Pyramids

Pre-View 19.4

- **Food chain** – a simple representation of how energy is passed from a producer to consumers
- **Food web** – a more complex representation of how energy is passed from producers to consumers in an ecosystem
- **Trophic level** – each "step" in a food chain that represents how many times energy has been transferred from one organism to the next
- **Energy pyramid** – a representation in the shape of a pyramid that shows how energy is passed from one trophic level to the next
- **Top consumer** (or **top predator**) – animal at the top of a food chain; usually a carnivore that has no natural predators

Food Chains

The simple explanation for the flow of energy from autotrophs to heterotrophs is called a **food chain**. A simple example of a food chain is shown in figure 19-2.

Example of a Food Chain

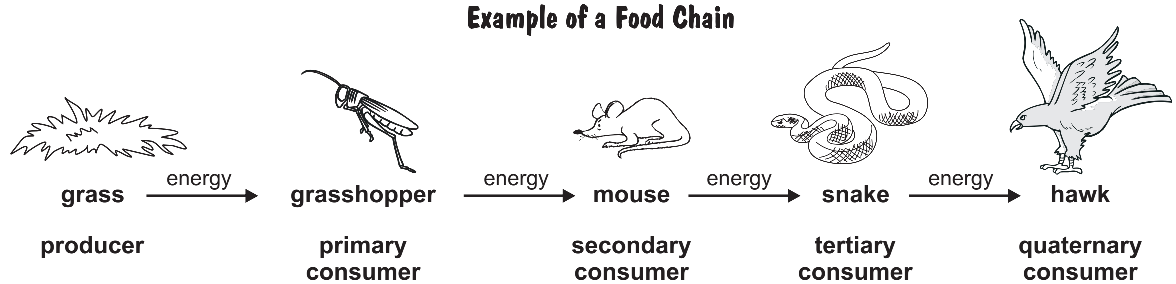


Fig. 19-2

In the food chain shown in figure 19-2, the grass is the producer. The grasshopper eats the grass, so it is the primary consumer. The grass gives energy to the grasshopper. The mouse eats the grasshopper, so the mouse is the secondary consumer. The mouse gets its energy from the grasshopper. The snake then eats the mouse. The snake is the tertiary consumer, which simply means "third level" consumer. The snake is then eaten by the hawk. The hawk is the quaternary consumer, or "fourth level" consumer. So you can see how a food chain represents how energy is passed from one organism to the next.

Note: Don't let the terms "tertiary" and "quaternary" scare you. "Tertiary" is another word for "third." Quaternary is another word for "fourth."

Example 1: In the food chain given in figure 19-2, which organisms are predators? Which are prey?

The mouse, the snake, and the hawk are all predators. The grasshopper is prey for the mouse, the mouse is prey for the snake, and the snake is prey for the hawk.

Changes in Ecosystems

Section 21.1
Population Factors

Pre-View 21.1

- **Carrying capacity** – the largest number of organisms that can be supported to live in an ecosystem
- **Logistic growth** – natural population growth the follows an S-shapped pattern
- **Limiting factors** – things that limit how many organisms can live in a population
- **Immigration** – the movement of organisms into an area
- **Emigration** – the movement of organisms out of an area
- **Density dependent factors** – limiting factors that depend on the number of organisms in a population; examples: available food, water, and suitable habitats
- **Density independent factors** – limiting factors that do not depend on the number of organisms in a population; examples: natural disasters or human activities
- **Exponential growth** – unrestricted population growth that follows a J-shaped pattern

Limiting Factors of Populations

Initially, all populations in an ecosystem tend to increase in number. In a population that is new to an ecosystem, the population may grow slowly at first and then more quickly since the population will initially have unlimited resources. After a while, the rate of population growth slows down until it stops or levels off. It levels off when the environment has reached its **carrying capacity**, which is the largest number of organisms of a species that can be supported by the environment. Natural populations have a pattern of growth that follows an S-shaped curve as shown in figure 21-1. This S-shaped pattern is called **logistic growth**.

Natural Population Growth (Logistic Growth)

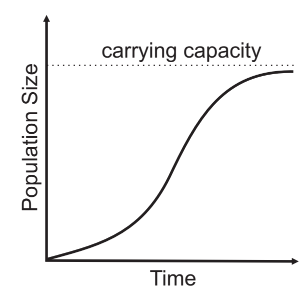
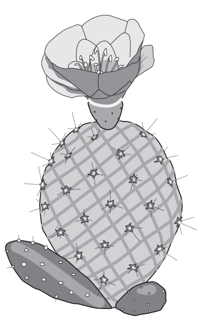


Fig. 21-1

The population growth is limited by several main factors: the birth/death rate of organisms in the population, the number of organisms entering and leaving the population, and the amount of available resources. These factors are called **limiting factors** because they limit how large a population can grow. If the birth and death rates are about even, and the immigration and emigration rates are even, then availability of resources becomes the main limiting factor. (**Immigration** is the movement of organisms into an area, and **emigration** is the movement of organisms out of an area.) Limiting factors can be biotic or abiotic. A biotic factor for animals could be competition for or the availability of food. For plants, these factors might be abiotic, such as sunlight, water, soil, and nutrients.



Example: Cacti grow in desert areas, but they are often well-spaced. Which of the following is the most likely limiting factor for cacti in a desert: sunlight, water, soil, or consumption by herbivores?

In a desert climate, the most common limiting factor for plants is the availability of water. Desert plants get plenty of sunlight and have lots of space and sand to grow. Consumption by herbivores is probably not a main limiting factor. Instead, the number of herbivores that can survive in the desert is most likely determined by the number of plants that can grow to feed them.