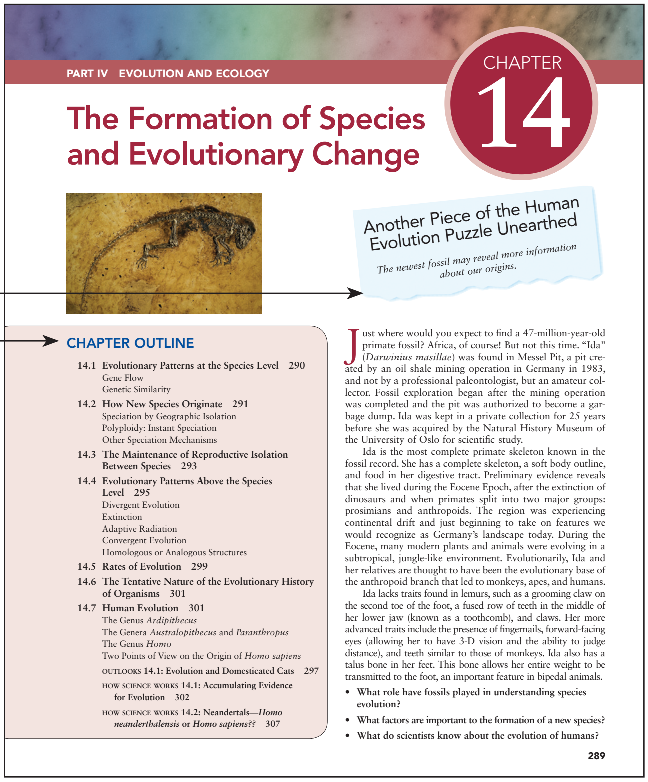
Features

Opening Vignette The vignette is designed to pique students' interest and help them recognize the application and relevance of the topics presented in each chapter. The fourteenth edition also introduces bulleted questions for further reflections.



PART IV EVOLUTION AND ECOLOGY

CHAPTER 14

The Formation of Species and Evolutionary Change

Another Piece of the Human Evolution Puzzle Unearthed

The newest fossil may reveal more information about our origins.

CHAPTER OUTLINE

14.1 Evolutionary Patterns at the Species Level 290
Gene Flow
Genetic Similarity
14.2 How New Species Originate 291
Speciation by Geographic Isolation
Polyploidy: Instant Speciation
Other Speciation Mechanisms
14.3 The Maintenance of Reproductive Isolation Between Species 293
14.4 Evolutionary Patterns Above the Species Level 295
Divergent Evolution
Extinction
Adaptive Radiation
Convergent Evolution
Homologous or Analogous Structures
14.5 Rates of Evolution 299
14.6 The Tentative Nature of the Evolutionary History of Organisms 301
14.7 Human Evolution 301
The Genus *Ardipithecus*
The Genera *Australopithecus* and *Paranthropus*
The Genus *Homo*
Two Points of View on the Origin of *Homo sapiens*
OUTLOOKS 14.1: Evolution and Domesticated Cats 297
HOW SCIENCE WORKS 14.1: Accumulating Evidence for Evolution 302
HOW SCIENCE WORKS 14.2: Neandertals—*Homo neanderthalensis* or *Homo sapiens*?? 307

Just where would you expect to find a 47-million-year-old primate fossil? Africa, of course! But not this time. "Ida" (*Darwinius masillae*) was found in Messel Pit, a pit created by an oil shale mining operation in Germany in 1983, and not by a professional paleontologist, but an amateur collector. Fossil exploration began after the mining operation was completed and the pit was authorized to become a garbage dump. Ida was kept in a private collection for 25 years before she was acquired by the Natural History Museum of the University of Oslo for scientific study.

Ida is the most complete primate skeleton known in the fossil record. She has a complete skeleton, a soft body outline, and food in her digestive tract. Preliminary evidence reveals that she lived during the Eocene Epoch, after the extinction of dinosaurs and when primates split into two major groups: prosimians and anthropoids. The region was experiencing continental drift and just beginning to take on features we would recognize as Germany's landscape today. During the Eocene, many modern plants and animals were evolving in a subtropical, jungle-like environment. Evolutionarily, Ida and her relatives are thought to have been the evolutionary base of the anthropoid branch that led to monkeys, apes, and humans.

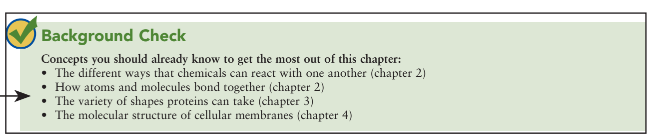
Ida lacks traits found in lemurs, such as a grooming claw on the second toe of the foot, a fused row of teeth in the middle of her lower jaw (known as a toothcomb), and claws. Her more advanced traits include the presence of fingernails, forward-facing eyes (allowing her to have 3-D vision and the ability to judge distance), and teeth similar to those of monkeys. Ida also has a talus bone in her feet. This bone allows her entire weight to be transmitted to the foot, an important feature in bipedal animals.

- **What role have fossils played in understanding species evolution?**
- **What factors are important to the formation of a new species?**
- **What do scientists know about the evolution of humans?**

289

Chapter Outline At the opening of each chapter, the outline lists the major headings in the chapter, as well as the boxed readings.

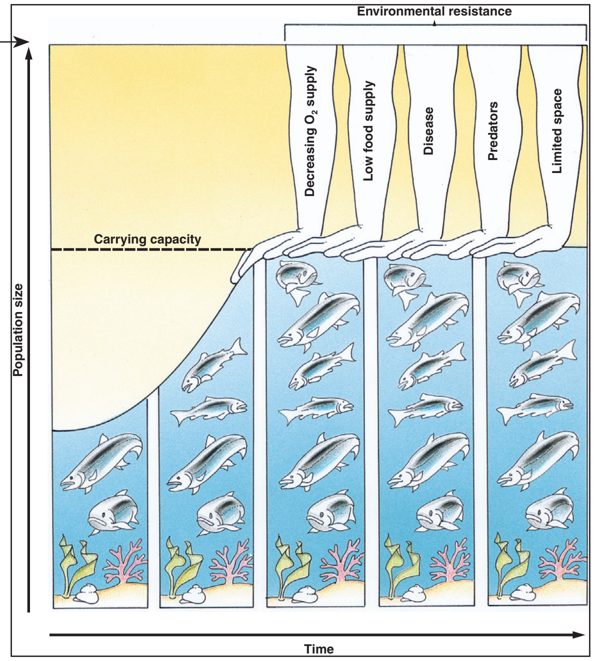
Background Check The Background Check lists the key concepts students should already understand to get the most out of the chapter. Chapter references are included for review purposes.



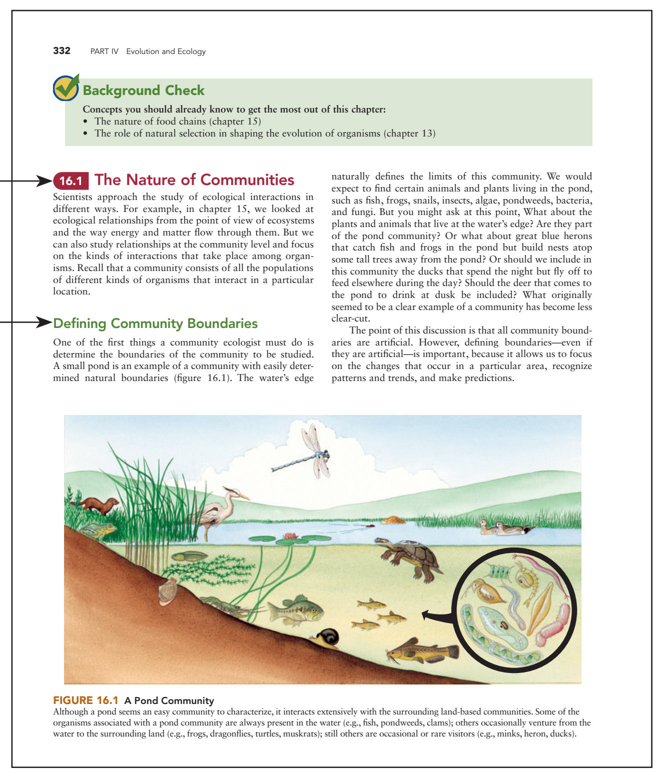
Background Check

Concepts you should already know to get the most out of this chapter:
- The different ways that chemicals can react with one another (chapter 2)
- How atoms and molecules bond together (chapter 2)
- The variety of shapes proteins can take (chapter 3)
- The molecular structure of cellular membranes (chapter 4)

Quality Visuals The line drawings and photographs illustrate concepts or associate new concepts with previously mastered information. Every illustration emphasizes a point or helps teach a concept.



Topical Headings Throughout each chapter, headings subdivide the material into meaningful sections that help readers recognize and organize information.



332 PART IV Evolution and Ecology

Background Check

Concepts you should already know to get the most out of this chapter:
- The nature of food chains (chapter 15)
- The role of natural selection in shaping the evolution of organisms (chapter 13)

16.1 The Nature of Communities

Scientists approach the study of ecological interactions in different ways. For example, in chapter 15, we looked at ecological relationships from the point of view of ecosystems and the way energy and matter flow through them. But we can also study relationships at the community level and focus on the kinds of interactions that take place among organisms. Recall that a community consists of all the populations of different kinds of organisms that interact in a particular location.

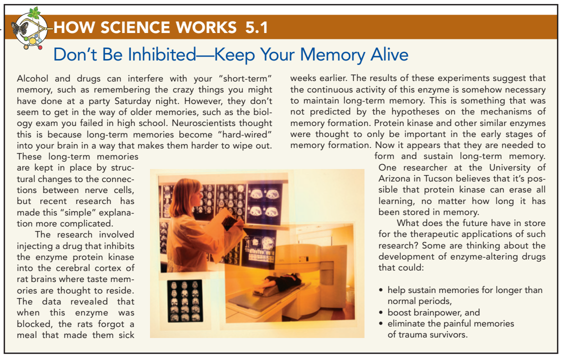
Defining Community Boundaries

One of the first things a community ecologist must do is determine the boundaries of the community to be studied. A small pond is an example of a community with easily determined natural boundaries (figure 16.1). The water's edge naturally defines the limits of this community. We would expect to find certain animals and plants living in the pond, such as fish, frogs, snails, insects, algae, pondweeds, bacteria, and fungi. But you might ask at this point, What about the plants and animals that live at the water's edge? Are they part of the pond community? Or what about great blue herons that catch fish and frogs in the pond but build nests atop some tall trees away from the pond? Or should we include in this community the ducks that spend the night but fly off to feed elsewhere during the day? Should the deer that comes to the pond to drink at dusk be included? What originally seemed to be a clear example of a community has become less clear-cut.

The point of this discussion is that all community boundaries are artificial. However, defining boundaries—even if they are artificial—is important, because it allows us to focus on the changes that occur in a particular area, recognize patterns and trends, and make predictions.

FIGURE 16.1 A Pond Community
Although a pond seems an easy community to characterize, it interacts extensively with the surrounding land-based communities. Some of the organisms associated with a pond community are always present in the water (e.g., fish, pondweeds, clams); others occasionally venture from the water to the surrounding land (e.g., frogs, dragonflies, turtles, muskrats); still others are occasional or rare visitors (e.g., minks, heron, ducks).

How Science Works and Outlooks Each of these boxed readings was designed to catch readers' interest by providing alternative views, historical perspectives, or interesting snippets of information related to the content of the chapter.


HOW SCIENCE WORKS 5.1

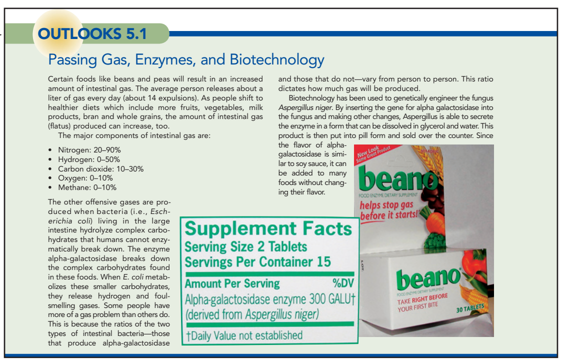
Don't Be Inhibited—Keep Your Memory Alive

Alcohol and drugs can interfere with your "short-term" memory, such as remembering the crazy things you might have done at a party Saturday night. However, they don't seem to get in the way of older memories, such as the biology exam you failed in high school. Neuroscientists thought this is because long-term memories become "hard-wired" into your brain in a way that makes them harder to wipe out. These long-term memories are kept in place by structural changes to the connections between nerve cells, but recent research has made this "simple" explanation more complicated.

The research involved injecting a drug that inhibits the enzyme protein kinase into the cerebral cortex of rat brains where taste memories are thought to reside. The data revealed that when this enzyme was blocked, the rats forgot a meal that made them sick weeks earlier. The results of these experiments suggest that the continuous activity of this enzyme is somehow necessary to maintain long-term memory. This is something that was not predicted by the hypotheses on the mechanisms of memory formation. Protein kinase and other similar enzymes were thought to only be important in the early stages of memory formation. Now it appears that they are needed to form and sustain long-term memory. One researcher at the University of Arizona in Tucson believes that it's possible that protein kinase can erase all learning, no matter how long it has been stored in memory.

What does the future have in store for the therapeutic applications of such research? Some are thinking about the development of enzyme-altering drugs that could:

- help sustain memories for longer than normal periods,
- boost brainpower, and
- eliminate the painful memories of trauma survivors.


OUTLOOKS 5.1

Passing Gas, Enzymes, and Biotechnology

Certain foods like beans and peas will result in an increased amount of intestinal gas. The average person releases about a liter of gas every day (about 14 expulsions). As people shift to healthier diets which include more fruits, vegetables, milk products, bran and whole grains, the amount of intestinal gas (flatus) produced can increase, too.

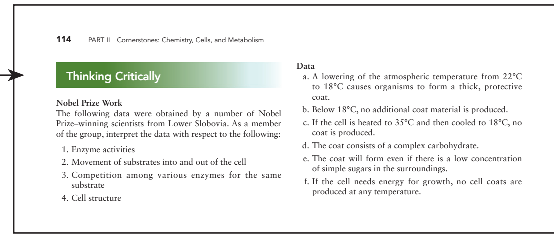
The major components of intestinal gas are:

- Nitrogen: 20–90%
- Hydrogen: 0–50%
- Carbon dioxide: 10–30%
- Oxygen: 0–10%
- Methane: 0–10%

The other offensive gases are produced when bacteria (i.e., *Escherichia coli*) living in the large intestine hydrolyze complex carbohydrates that humans cannot enzymatically break down. The enzyme alpha-galactosidase breaks down the complex carbohydrates found in these foods. When *E. coli* metabolizes these smaller carbohydrates, they release hydrogen and foul-smelling gases. Some people have more of a gas problem than others do. This is because the ratios of the two types of intestinal bacteria—those that produce alpha-galactosidase and those that do not—vary from person to person. This ratio dictates how much gas will be produced.

Biotechnology has been used to genetically engineer the fungus *Aspergillus niger*. By inserting the gene for alpha galactosidase into the fungus and making other changes, Aspergillus is able to secrete the enzyme in a form that can be dissolved in glycerol and water. This product is then put into pill form and sold over the counter. Since the flavor of alpha-galactosidase is similar to soy sauce, it can be added to many foods without changing their flavor.

Thinking Critically This feature gives students an opportunity to think through problems logically and arrive at conclusions based on the concepts presented in the chapters.


114 PART II Cornerstones: Chemistry, Cells, and Metabolism

Thinking Critically

Nobel Prize Work

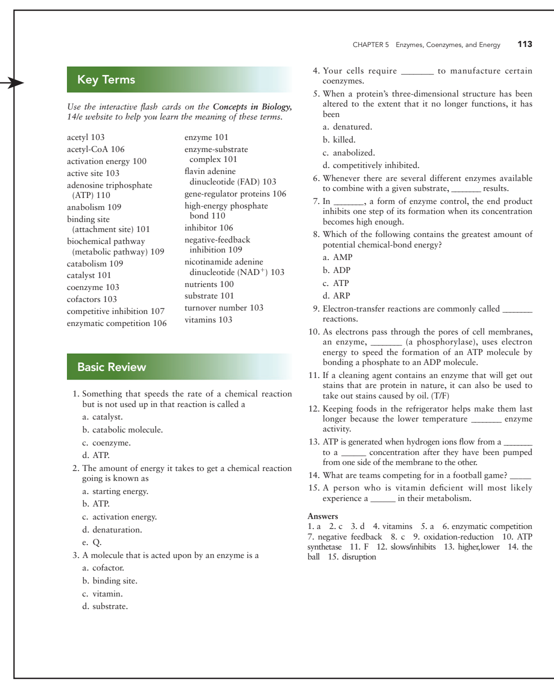
The following data were obtained by a number of Nobel Prize–winning scientists from Lower Slobovia. As a member of the group, interpret the data with respect to the following:

1. Enzyme activities
2. Movement of substrates into and out of the cell
3. Competition among various enzymes for the same substrate
4. Cell structure

Data

a. A lowering of the atmospheric temperature from 22°C to 18°C causes organisms to form a thick, protective coat.
b. Below 18°C, no additional coat material is produced.
c. If the cell is heated to 35°C and then cooled to 18°C, no coat is produced.
d. The coat consists of a complex carbohydrate.
e. The coat will form even if there is a low concentration of simple sugars in the surroundings.
f. If the cell needs energy for growth, no cell coats are produced at any temperature.

Page-Referenced Key Terms A list of page-referenced key terms in each chapter helps students identify the vocabulary they need to understand the concepts and ideas presented in the chapter. Definitions are found in the glossary at the end of the text. Students can practice learning key terms with interactive flash cards at www.mhhe.com/enger14e.


CHAPTER 5 Enzymes, Coenzymes, and Energy 113

Key Terms

Use the interactive flash cards on the ***Concepts in Biology****, 14/e website to help you learn the meaning of these terms.*

acetyl 103
acetyl-CoA 106
activation energy 100
active site 103
adenosine triphosphate (ATP) 110
anabolism 109
binding site (attachment site) 101
biochemical pathway (metabolic pathway) 109
catabolism 109
catalyst 101
coenzyme 103
cofactors 103
competitive inhibition 107
enzymatic competition 106
enzyme 101
enzyme-substrate complex 101
flavin adenine dinucleotide (FAD) 103
gene-regulator proteins 106
high-energy phosphate bond 110
inhibitor 106
negative-feedback inhibition 109
nicotinamide adenine dinucleotide (NAD^+) 103
nutrients 100
substrate 101
turnover number 103
vitamins 103

Basic Review

1. Something that speeds the rate of a chemical reaction but is not used up in that reaction is called a
a. catalyst.
b. catabolic molecule.
c. coenzyme.
d. ATP.
2. The amount of energy it takes to get a chemical reaction going is known as
a. starting energy.
b. ATP.
c. activation energy.
d. denaturation.
e. Q.
3. A molecule that is acted upon by an enzyme is a
a. cofactor.
b. binding site.
c. vitamin.
d. substrate.
4. Your cells require ______ to manufacture certain coenzymes.
5. When a protein's three-dimensional structure has been altered to the extent that it no longer functions, it has been
a. denatured.
b. killed.
c. anabolized.
d. competitively inhibited.
6. Whenever there are several different enzymes available to combine with a given substrate, ______ results.
7. In ______, a form of enzyme control, the end product inhibits one step of its formation when its concentration becomes high enough.
8. Which of the following contains the greatest amount of potential chemical-bond energy?
a. AMP
b. ADP
c. ATP
d. ARP
9. Electron-transfer reactions are commonly called ______ reactions.
10. As electrons pass through the pores of cell membranes, an enzyme, ______ (a phosphorylase), uses electron energy to speed the formation of an ATP molecule by bonding a phosphate to an ADP molecule.
11. If a cleaning agent contains an enzyme that will get out stains that are protein in nature, it can also be used to take out stains caused by oil. (T/F)
12. Keeping foods in the refrigerator helps make them last longer because the lower temperature ______ enzyme activity.
13. ATP is generated when hydrogen ions flow from a ______ to a ______ concentration after they have been pumped from one side of the membrane to the other.
14. What are teams competing for in a football game? ______
15. A person who is vitamin deficient will most likely experience a ______ in their metabolism.

Answers

1. a 2. c 3. d 4. vitamins 5. a 6. enzymatic competition 7. negative feedback 8. c 9. oxidation-reduction 10. ATP synthetase 11. F 12. slows/inhibits 13. higher,lower 14. the ball 15. disruption

Chapter Summary The summary at the end of each chapter clearly reviews the concepts presented.

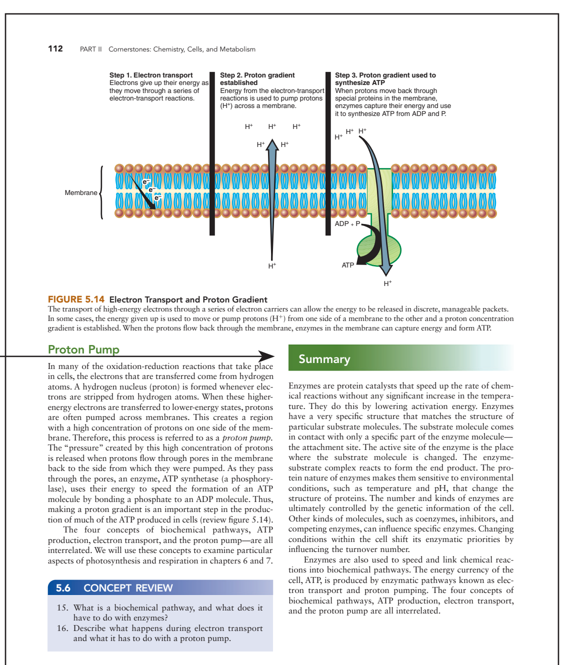

112 PART II Cornerstones: Chemistry, Cells, and Metabolism

FIGURE 5.14 Electron Transport and Proton Gradient

The transport of high-energy electrons through a series of electron carriers can allow the energy to be released in discrete, manageable packets. In some cases, the energy given up is used to move or pump protons (H^+) from one side of a membrane to the other and a proton concentration gradient is established. When the protons flow back through the membrane, enzymes in the membrane can capture energy and form ATP.

Proton Pump

In many of the oxidation-reduction reactions that take place in cells, the electrons that are transferred come from hydrogen atoms. A hydrogen nucleus (proton) is formed whenever electrons are stripped from hydrogen atoms. When these higher-energy electrons are transferred to lower-energy states, protons are often pumped across membranes. This creates a region with a high concentration of protons on one side of the membrane. Therefore, this process is referred to as a *proton pump*. The "pressure" created by this high concentration of protons is released when protons flow through pores in the membrane back to the side from which they were pumped. As they pass through the pores, an enzyme, ATP synthetase (a phosphorylase), uses their energy to speed the formation of an ATP molecule by bonding a phosphate to an ADP molecule. Thus, making a proton gradient is an important step in the production of much of the ATP produced in cells (review figure 5.14).

The four concepts of biochemical pathways, ATP production, electron transport, and the proton pump—are all interrelated. We will use these concepts to examine particular aspects of photosynthesis and respiration in chapters 6 and 7.

5.6 CONCEPT REVIEW

15. What is a biochemical pathway, and what does it have to do with enzymes?
16. Describe what happens during electron transport and what it has to do with a proton pump.

Summary

Enzymes are protein catalysts that speed up the rate of chemical reactions without any significant increase in the temperature. They do this by lowering activation energy. Enzymes have a very specific structure that matches the structure of particular substrate molecules. The substrate molecule comes in contact with only a specific part of the enzyme molecule—the attachment site. The active site of the enzyme is the place where the substrate molecule is changed. The enzyme-substrate complex reacts to form the end product. The protein nature of enzymes makes them sensitive to environmental conditions, such as temperature and pH, that change the structure of proteins. The number and kinds of enzymes are ultimately controlled by the genetic information of the cell. Other kinds of molecules, such as coenzymes, inhibitors, and competing enzymes, can influence specific enzymes. Changing conditions within the cell shift its enzymatic priorities by influencing the turnover number.

Enzymes are also used to speed and link chemical reactions into biochemical pathways. The energy currency of the cell, ATP, is produced by enzymatic pathways known as electron transport and proton pumping. The four concepts of biochemical pathways, ATP production, electron transport, and the proton pump are all interrelated.

Concept Review Questions At the end of each numbered section of the text there are review questions that help students assess their understanding of the material. Concept review questions are answered at www.mhhe.com/enger14e.

5.1 CONCEPT REVIEW

1. What is the difference between a catalyst and an enzyme?
2. How do enzymes increase the rate of a chemical reaction?

Basic Review Questions Students can assess their knowledge by answering the basic review questions. The answers to the basic review questions are given at the end of the question set so students can get immediate feedback.

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