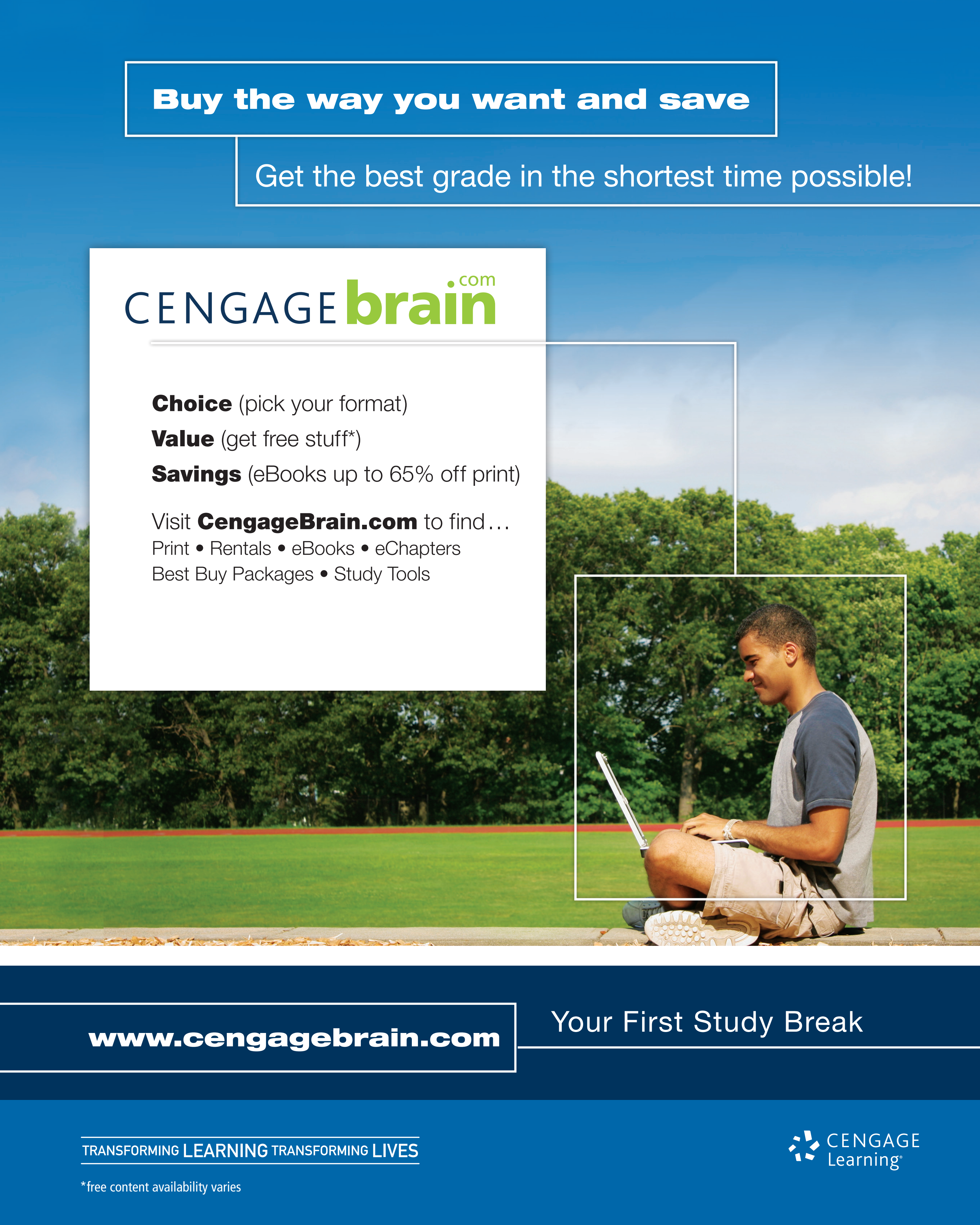
SEVENTH EDITION

Learning and Behavior

PAUL CHANCE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Preface

A textbook is like a city: It is never finished. Go into any city and you see old buildings being torn down and new ones being built, trees being planted in vacant lots, jackhammers tearing up streets to install phone lines underground. The same is true of textbooks: Some topics are dropped, new ones added, chapters or sections moved from here to there. Here are some of the changes you'll see in *Learning and Behavior,* 7th edition:

- Updated content. The reference list includes over 100 items dated 2011 or later.
- New topics, including evaluative conditioning, asocial observational learning, computer-based VRET, progressive schedules, and constraint-induced movement therapy, among others.
- More studies are cited to document findings, especially those that are counterintuitive or controversial, such as that learning sometimes occurs without awareness of the contingencies involved.
- New applications, including the use of Pavlovian and operant procedures for diagnosis, assessment, and treatment of medical disorders.
- The Miller–Dollard theory of observational learning has been replaced with a generic operant learning model.
- Increased emphasis on the role of context in forgetting, and the idea that forgetting may be largely a matter of stimulus control, a view taken by increasing numbers of psychologists.
- Footnotes are replaced by brief marginal notes that students are more likely to read.
- An increased emphasis in the recommended reading lists on items students are likely to read, such as Hal Markowitz's *Enriching Animal Lives,* Susan Schneider's *The Science of Consequences,* and articles in *The New Yorker* and other popular periodicals.
- An increase in the number and variety of illustrations, including photographs and sketches.
- Increased coverage of research by evolutionary biologists, primatologists, ethologists, rehabilitation psychologists, developmental psychologists, and cognitive psychologists.

- An increase in coverage of research done outside the United States.
- Researcher affiliations are sometimes provided, mostly involving recent studies, to convey to students that not all noteworthy learning research comes out of Ivy League schools.
- A brief section near the end of each chapter called "A Final Word." My hope is that these will prompt the students to think about and discuss the implications of their reading.
- To make room for new material, I have deleted the workbook (students will find a study guide online); reduced chapter review questions from 20 to 10; shortened the discussion of memory; removed Edwin Twitmyer, the discussion of semantic conditioning, self-control, self-awareness, and mnemonic systems. Some of this material will be available on the book's website.

Although cities are constantly being "revised," some things remain the same for decades. The same is true of texts. The following key features of *Learning and Behavior* remain essentially unchanged:

- A readable style and a cordial tone that help make reading the text a welcome activity rather than a tedious chore, so that students get more out of their class sessions.
- Certain themes continue to run through the text: that learning is a biological mechanism (I call it evolved modifiability) by which individuals cope with change; that changes in behavior are the products of biological and environmental events; and that the natural science approach is the best way to study behavior.
- An abundance of examples and applications to help students "get" the principles, not merely memorize them.
- Though many of the experiments involve animal subjects, the emphasis is on what that research tells us about *human* behavior.
- Chapter 2 reviews the basic research methods used to study learning, including the single-subject designs that are unfamiliar to many students.
- Queries appear at irregular intervals to help keep students alert and help them monitor their progress.
- A practice quiz and review questions appear at the end of each chapter *without* answers. I believe the absence of answers prompts students to think about and discuss the questions and may result in interesting class discussions.
- Data graphs that represent findings in an easy-to-grasp form.

I hope you will find that this is the best edition yet of *Learning and Behavior,* but I'm already making notes for the next edition. As I said, textbooks, like cities, are never really finished.

Acknowledgments

As always, many people contributed to the "renovation" of this book. Several instructors reviewed the 6th edition and suggested changes that were, as always, a great help. My thanks to:

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I am also grateful to my editor, Ken King, who provided moral support and editing comments as I drafted the revision. I also want to thank Vernon Boes of Cengage Learning and Brenda Carmichael of PremediaGlobal and others who had a hand in producing what must be one of the best cover designs ever seen on a learning text. I also thank Gunjan Chandola and others at PreMediaGlobal for turning out the most aesthetically pleasing edition yet of *Learning and Behavior.*

Finally, I want to thank the students who emailed me with comments, mostly positive but always helpful, about the 6th edition. I cannot list them all, but Michael Allison, a student at San Diego Community College, and Kim Katsaros, a student at the University of Massachusetts in Lowell, seem representative. Michael thanked me for the occasional humor in the book and added, "I'm glad I don't have to read a stuffy and boring learning text." Kim also praised the book but criticized a passage she found offensive (and which, as a result, I deleted). When I hear from students, I often reply, "You made my day!" That is no exaggeration. Thank you, Michael and Kim, and thanks to all the students who took the time to share their thoughts, positive or negative, about *Learning and Behavior.*

As you can see, I am indebted to a lot of people, and I'm sure there are still more who deserve to be on my list. My apologies to you if you are among them. All of you, named and unnamed, have contributed in one way or another to *Learning and Behavior,* 7th edition. Any flaws in the text are my responsibility. Write to me about them at pc@paulchance.net.

Paul Chance

Note to the Student: How to Get the Most from this Book

As always, I've done what I can to make this book interesting and easy to understand, but you've still got your work cut out for you: There's a lot to learn about learning. Here are some suggestions on how to get the most from this book:

- First, turn to Chapter 12 and study the section called "Learning to Remember." This information will help you learn any course content.
- Second, be sure to read the "Preview" and "In This Chapter . . ." sections at the start of each chapter. This material will help you see where the chapter is headed.
- Third, as you are reading through the text, answer the queries that appear. Write your answer on a slip of paper or say it aloud, then check your answer by reviewing the text above the query or by flipping to the query answers at the end of the chapter.
- Fourth, after you've read a chapter, read the review questions and consider how you would answer them if you were asked those questions in class or on an exam. This is a great thing to do in a study group, since many of these questions can be answered in various ways.
- Fifth, take the practice quiz provided at the end of the chapter. Be sure to *write* your answers as you would if you were taking a quiz in class, or say them to a study partner. These quizzes will help you learn the content *and* give you a rough idea of how well you have mastered it.
- Sixth, take a look at the book's Cengage website. The study guide there should help you master chapter content.

If you really want to get the most from a text or a course, you have to be an active learner. If you want to get the most out of a class, you can't just sit back and listen to the instructor. You have to be actively involved—ask questions, make comments, take notes. The same thing is true when learning from a text: Ask questions, answer queries, make notes, think about the implications and applications of what you read, discuss what you read with other students, and review, review, review. If you are an active learner, you will not only have a far better chance of acing the exams, you will be able to put more of what you learn to practical use for years to come.

If you have read the Preface, you know that I am eager to get feedback about the book from students as well as instructors. If you have thoughts about the book you'd like to share, email me at pc@paulchance.net.

CHAPTER

1 Introduction: Learning to Change

IN THIS CHAPTER . . .

Change is the only constant.

—Lucretius

PREVIEW

This chapter raises basic questions about the adaptation of humans and other living things to a changing environment. It looks at the adaptation of both species and individuals. The chapter devotes a good deal of space to topics usually covered in biology texts. The reason is that learning is a biological mechanism. Learning did not evolve so that you could learn to solve algebra word problems or program a computer. It is first and foremost a survival mechanism, a means of meeting the challenges that threaten our survival. One question I hope you will consider as your read this book is whether human learning ability is up to the challenges that threaten our survival today.

THE CONSTANCY OF CHANGE

Keiko, a woman in her sixties, was walking in the underground boarding area in Shinjuku train station, one of the largest train stations in Tokyo, on a spring afternoon. Suddenly she felt very dizzy, so much so that she leaned on a nearby wall to keep from falling. When she looked around, she saw that other people were doing the same thing. It was not dizziness, then, but what was it? There were a few seconds of silence, then a woman nearby shouted, "Jishin da!" (Earthquake!). With that a couple of teenage girls standing nearby screamed.

Earthquakes are a common occurrence in Japan, so after a moment during which there were no signs the building was about to collapse, people continued on their way. Keiko boarded her train, but it did not move; instead there was an announcement: "All train traffic in Tokyo has been suspended."

No trains meant no subways. Keiko's apartment was miles away; how was she to get home? As she emerged from the station, another earthquake struck and someone shouted, "Mite!" ("Look!") and pointed toward the top of a skyscraper. Keiko looked up at Cocoon Tower, a building with a structure that fits its name, and saw it swaying back and forth, like the inverted pendulum of an old-fashioned clock. She wondered how it could sway so far without the upper part breaking off.

The area outside the station was packed with people, so Keiko knew there was little chance of getting a cab. Perhaps a bus? She got into a long line at a bus stop and waited. When a bus came, those at the front of the line boarded, but the bus went nowhere. Finally someone announced that bus transportation


samxmeg/iStockphoto.com

Cocoon Tower in Tokyo, Japan. The tower swayed back and forth during the March 11, 2011, earthquake, though it was 150 miles from the quake's epicenter.

was suspended. The only way for Keiko to get home was to walk, but it was a long way from Shinjuku station and she had no map. She knew the way to her sister's home and it was closer, but there was no way to know what she might encounter along the way. Another quake might bring down buildings along her route. Her options were limited, however, so she set off on foot. It took her three hours, but she made it safely. Keiko had been lucky.

To see a video of skyscrapers swaying during the Japan earthquake of 2011, go to youtube.com *and search "Japan earthquake." If you think earthquakes are uncommon events, Google, "U. S. Geological Survey earthquake maps."*

Many of the people who lived 150 miles to the northeast, nearer the earthquake's epicenter, were not so lucky. The Great East Japan Earthquake of March 11, 2011, at magnitude 9.0, was the strongest earthquake ever known to have hit Japan and one of the five most powerful earthquakes worldwide since 1900. The earthquake moved the northern part of Honshu, Japan's largest island, about *eight feet* to the east. A tsunami followed the quake, and a wall of water, in some places well over 100 feet high, crashed into the coast, washing away cars and trucks like leaves in a stream, destroying over 300,000 homes, schools, and factories, and killing over 15,000 people. The tsunami also inflicted severe damage on nuclear power plants, resulting in the release of radioactive material that poisoned dairy products, crops, and farmland within a 50-mile radius of the plants, and adding the threat of disease throughout much of Japan for weeks afterward.

The earth's crust is constantly moving. To see a brief video on how whole continents have moved over millions of years, go to youtube.com *and search "650 million years in under 2 minutes."*

Earthquakes, tsunamis, and other natural disasters are a part of life, but we tend to regard them as an aberration, a brief disruption in a normally constant world. When a great volcano erupts, as Mt. St. Helens in Washington State did in 1980, knocking over thousands of trees and covering the ground for miles around with a blanket of volcanic ash; when a gigantic tsunami hits land, as happened in the Indian Ocean in December 2004, killing over 200,000 people and destroying thousands of homes; when a heat wave kills over 50,000 people, as in Europe in the summer of 2003; when a drought rages across a continent, destroying crops and wiping out herds of sheep and cattle, as in Australia from 2006 until 2011, we think how strange it is that nature should misbehave so. It is, we tell ourselves, a momentary lapse, a kind of geological tantrum; soon our old planet will regain its composure, its constancy. But the truth is, as the Roman philosopher Lucretius said 2,000 years ago, "Change is the only constant." We live in a world that is ever-changing, like the varicolored patterns of a steadily rotating kaleidoscope.

Change is not the exception to the rule, it *is* the rule. Throughout nature, the struggle to survive is an effort to cope with change: The climate changes, prey animals become harder to see, predators become faster, diseases strike without warning, population increases put added stresses on the availability of food, water, habitable space, and other resources. Some changes, such as the movement of continents, take place over eons; others, such as the advance or retreat of glaciers, normally take hundreds or thousands of years; some, such as the changes in climate we are now seeing due to human use of fossil fuels, take decades; still others, such as the rise and fall of the sun or the abrupt lane change of an aggressive driver, occur on a daily basis. The one constant in our lives is change. Any individual or species must be able to cope with change if it is to survive. But how? By what mechanisms can we and other animals deal with such a fickle world? Charles Darwin offers one answer.

CAPSULE **REVIEW** The world in which we live is not a stagnant place. It is constantly changing. Mountains rise and fall, forests become deserts, new diseases appear, countries rise and fall, famine is followed by abundance and visa versa. The history of humanity, and your own personal history, is about coping with change. One way species cope with change is through natural selection.

NATURAL SELECTION

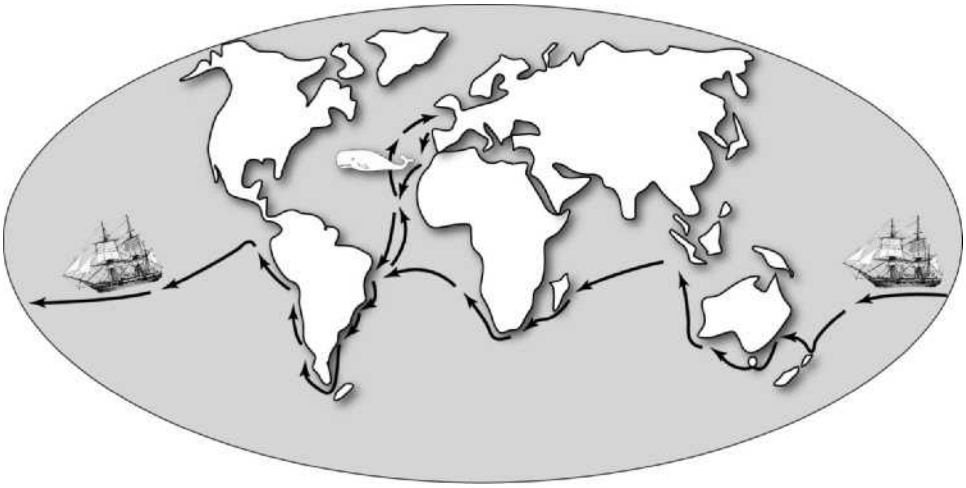
Charles Darwin was born in England in 1809. The son of a physician, he went to the University of Edinburgh in 1825 to study medicine. His heart was not in it, however, and when the blood and screams of a patient undergoing surgery without anesthesia sent him scurrying to the exit, he decided to pursue a degree in theology at Cambridge University. His heart wasn't in that field, either, and he spent much of his time pursuing his true love, natural history.

Shortly after graduating, Darwin accepted an offer to join an expedition on the British naval vessel HMS *Beagle* as the ship's naturalist. The *Beagle* was under the leadership of Captain Robert FitzRoy, a 23-year-old aristocrat who wanted a naturalist who would also serve as a suitable dinner companion. The chief purpose of the voyage was to map the shorelines of land areas around the world. It was a great success in this endeavor, but it is now remembered only because it gave Darwin the opportunity to gather hundreds of specimens of plants and animals in his effort to understand "that mystery of mysteries," the origin of species.

Darwin took a copy of Charles Lyell's *Principles of Geology* with him on the *Beagle*. Lyell, considered by many the father of geology, got many things wrong (he rejected the idea of ice ages, for example), but his view that the earth

Tomsich Tomsich/Getty Images

Portrait of Charles Darwin in the late 1830s when he was about 30 years old.



The course of HMS Beagle. *The* Beagle *left Plymouth, England, on December 27, 1831, and returned on October 2, 1836.*

changes gradually over eons gave Darwin a new perspective on where species came from. If the earth had been around for millions of years and changed slowly, as Lyell argued, there was no reason to think that the vast variety of life forms had appeared overnight in their current form.

Once back in England, Darwin focused attention on animal breeding as a source of insights into the variations in living things. He was himself a breeder of doves, and knew that breeders had long changed the characteristics of cows, horses, pigs, sheep, chickens, dogs, cats, and other domestic animals by selectively cross-breeding individuals with desirable characteristics. Such breeding seemed to provide a model for changes in species in the wild, but breeding was the result of deliberate, thoughtful intervention by the breeder. Who was nature's breeder?

Work on selective breeding in foxes over a period of 40 years shows that behavioral characteristics can be selectively bred so that the descendants behave more like a different species than like their own ancestors. See Kukekova and Trut (2007); Trut (1999); also see Goldman (2010) for a nontechnical summary.

The answer occurred to Darwin when he read a book by a fellow Englishman, Thomas Malthus (1798), called *An Essay on the Principle of Population*. Malthus was a clergyman who did not accept the then-popular idea that human population growth was the path to utopia. On the contrary, Malthus argued that it was the road to ruin. Resources are limited, and eventually an expanding population spells disaster. There are limits to all resources, and as populations increase, these resources prove inadequate to supply all individuals. "The power of population," he wrote, "is indefinitely greater than the power in the earth to produce subsistence for man."

Malthus focused on the effects of human population growth, but Darwin realized that all species of animals and plants produce far more offspring than the environment can possibly support, which inevitably leads to competition for resources. Some survive, but most do not. What determines which individuals and species will win out? Clearly the winners must have features that give them an advantage. Those of their offspring that share their parents' advantage will also tend to survive and reproduce. Over generations, these advantages, some of them very subtle, may accumulate and result in very different species. Darwin saw that the mechanism for change was analogous to the breeder's practice of selectively mating animals with desirable characteristics. The difference is that in the wild, *nature is the breeder:*

> Owing to this struggle for life, any variation, however slight and from whatever cause proceeding, if it be in any degree profitable to an individual of any species, . . . will tend to the preservation of that individual, and will generally be inherited by its offspring. The offspring, also, will thus have a better chance of surviving. . . . I have called this principle, by which each slight variation, if useful, is preserved, by the term of Natural Selection, in order to mark its relation to man's power of selection.

In writing "its relation to man's power of selection," Darwin is drawing attention to the analogy of **natural selection** to the *artificial* selection of breeders. "There is no obvious reason," he wrote, "why the principles which have acted so efficiently under domestication should not have acted under nature."

In Darwin's day, little was known about how characteristics were transmitted from one generation to the next. As Darwin noted, "The laws governing inheritance are quite unknown. . . ." The Austrian friar and founder of genetics, Gregor Mendel, did not publish his work on inheritance in peas until 1866, and it did not become widely known among scientists until the early 1900s. Nevertheless, it was clear that characteristics were somehow passed from one generation to another, and these characteristics were beneficial, detrimental, or of no significance in a particular environment.

It is important to note that natural selection depends on variations among the members of a species. If all members of a species were genetically identical, natural selection would be impossible. As Darwin wrote, "unless profitable variations do occur, natural selection can do nothing."

Very few biologists question natural selection today, and it is widely accepted throughout Europe and Asia, but a Gallup poll found that four in ten Americans still believe that God created all forms of life in their present form about 10,000 years ago (Newport, 2010).

Darwin's critics have often said that even with variation, natural selection cannot possibly account for the sudden appearance of complex organs such as the human eye. You may be surprised to learn that Darwin agreed. But Darwin went on to say that complex organs do not normally appear suddenly. Far from it.

Evidence suggests that the human eye, for example, had its origin millions of years ago with the appearance of a few light-sensitive cells on the skin of some primitive animals. These light-sensitive cells would have proved helpful since anything that cast a shadow on them could, for example, warn of an approaching predator. Through additional variations and natural selection, more light cells appeared, and the light-detecting organ became more and more complicated until it gradually reached the sophisticated light-sensitive organ found in higher animals, including humans (Lamb, 2011; Schwab, 2011).

To see how the increasing complexity of the eye improves vision, go to youtube.com *and search "Dawkins eye."*

This may seem to be pure speculation, since we have no videotape of the evolution of the eye, but it is based on evidence suggesting increasing sophistication of organs, including the eye, as we go through the animal kingdom from the simplest to the more complex species. Consider, for example, the trematode *cercaria,* a parasitic flatworm that invades fish brains (Lafferty & Morris, 1996). Cercaria has two spots that, though they may look a bit like eyes, are nothing at all like any mammal's eye (see Figure 1-1). There is no

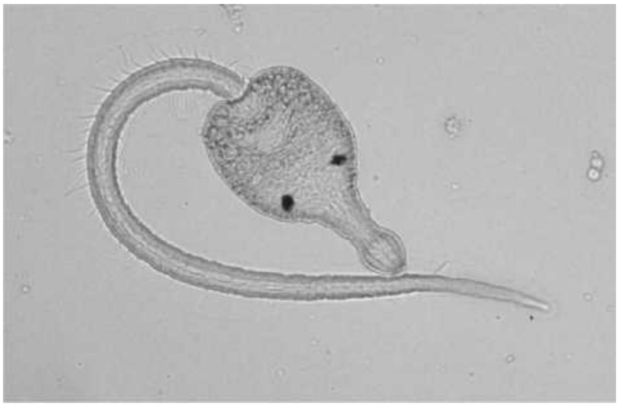


Figure 1-1 *The flatworm cercaria with two light-sensitive eye spots. (Image courtesy of Todd C.Huspeni, Curator of Parasites, Department of Biology and Museum of Natural History, University of Wisconsin—Stevens Point.)*

iris, no retina, no vitreous humor, nothing, really, except light-sensitive cells. (Light-sensitive cells form the retina of your more sophisticated eyes.) The cercaria's eyespots help it to find its way to a higher water level where it is more likely to encounter the killifish on which it depends. Go up the evolutionary scale and you see increasingly complex visual equipment. The eye of a reindeer, for example, not only sees more or less what you see, it also responds to ultraviolet light, which helps it to identify both predators and food in snow-covered areas (Hogg et al., 2011).

The human brain is another complex organ that did not appear overnight. The jellyfish has a simple network of neurons, but this primitive nervous system, which serves to coordinate its swimming movements, has no brain at all. The first true brains appear in worms. The brain of the earthworm is about the size of a mustard seed, but it is an advance over the jellyfish. Generally, the further up the evolutionary scale you go, the more complicated the brain and the greater its capacity for dealing with environmental changes.

The devices resulting from natural selection are rarely, if ever, as simple and efficient as they could be, but they generally work (Marcus, 2009; Olshansky, 2009). What natural selection demands is not perfection, but devices that are good enough to aid survival. Natural selection is a crude, inefficient mechanism, so it typically takes countless generations to develop sophisticated tools. You might compare it to carving the sculptures of Mt. Rushmore with a hammer and chisel while blindfolded. Nevertheless, it helps species meet the challenges of a changing environment.

All kinds of changes in the environment can affect the characteristics of a species. Climate change is perhaps the most important of these environmental changes, a point made by Darwin (1859). The west coast of Scotland is famous for its cold winters and its warm wool. Until recently the Soay sheep that produced that wool tended to be large, since smaller sheep often succumbed to the cold before reaching reproductive age. Over the past 25 years, however, the sheep of this area have been getting smaller and lighter (Ozgul et al., 2009; Maloney, Fuller, & Mitchell, 2010). This reduction in size parallels a change in climate due to global warming: Winters in Scotland have gotten shorter and milder in recent decades, so smaller sheep now are more likely to survive and reproduce.

Changes in terrain (due to a change in the course of a river or volcanic eruption, for example) can also induce changes in species through natural selection. Evolutionary biologist Erica Rosenblum and her colleagues at the University of Idaho (Rosenblum et al., 2010), studied three species of lizards in White Sands, New Mexico. All three species have dark skins in other geographic areas, but those that live in White Sands, an area with dunes composed of white gypsum, have developed lighter skins (Figure 1-2). The lizards evolved in areas where their dark skin made them difficult for predators to see, but when they moved into the white dunes, those dark skins made them vulnerable to predators. Those with lighter skins were more likely to survive and reproduce, and this selection process continued over generations until the lizards in the dunes were far lighter than their ancestors.

Pollution provides another example of how changes in the environment affect species characteristics. The classic example is the peppered moth, one

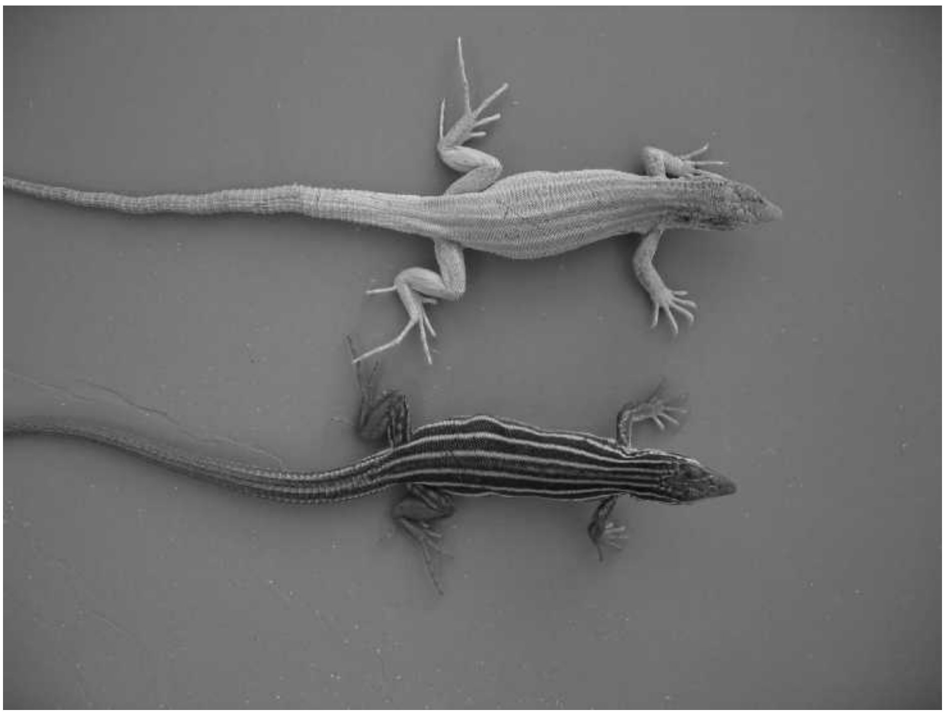


Figure 1-2 *The natural selection of skin color. Descendants of lizards that were dark-skinned elsewhere (bottom photo) became light in color when living among white sand dunes in New Mexico. (Photo courtesy of Erica Bree Rosenblum, Department of Biological Sciences, University of Idaho at Moscow.)*

of many large moths found in the British Isles. The peppered moth feeds at night and rests during the day on the trunks and limbs of trees. Its survival depends in large part on its ability to escape detection by the birds that find it an appetizing food. At one time, nearly all of these moths were a mottled light gray color, closely resembling the lichen-covered trees on which they rested. A rare black variation of the moth, first observed in 1848, stood out against this background like coal against snow, making it highly vulnerable. But when pollutants from burning coal killed the lichen and darkened the bark of trees, the light-colored moths increasingly fell prey to birds, whereas the dark moths tended to survive and reproduce. In forests near industrial centers, where pollution was common, the black moths increased in number, and the light-colored variety declined. In some areas, 90% of the moths were of the once-rare black variety (Kettlewell, 1959; see Figure 1-3). In recent years, improvement in local air quality has reversed this trend, so that the lighter variety of moth is once again dominant.

Predators are an important part of most animals' surroundings, and changes in predators play an important role in natural selection. Swanne Gordon of the University of California at Riverside and his colleagues (2009) did an experiment with guppies that demonstrates this. The researchers moved wild guppies in Trinidad from a stream that had no predators to a stream with guppy-eating fish. Eight years later Gordon transferred more guppies from the safer stream and compared the survival rate of their young with the young of guppies that had lived among the predators for many generations. The evolved guppies had a survival rate more than 50% higher than that of the newcomers.

Changes in the environment also affect human characteristics. Human skin color is largely due to the amount of melanin, a substance found in the

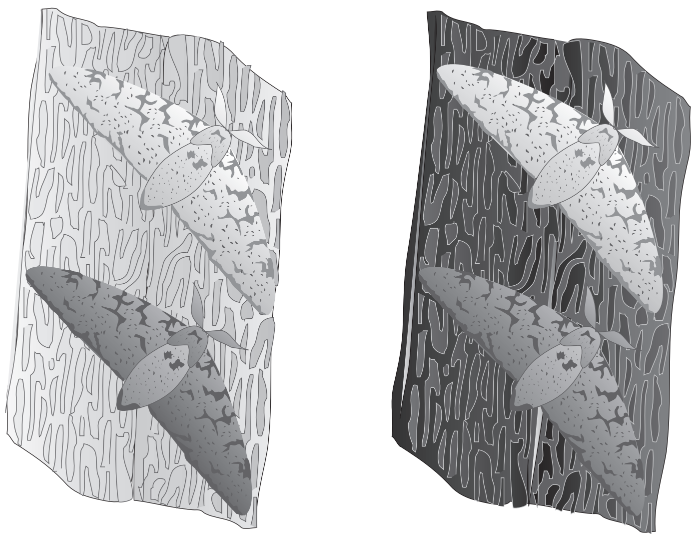


Figure 1-3 *The peppered moth and pollution. Prior to 1850, the gray peppered moth was hard to detect against the light trees on which it rested. After soot darkened the trees, the once-rare black variety became dominant. (Drawings by Diane Chance.)*