

Preface

More than any other subject, science is full of change and surprise. Subjects often seem more and more mysterious as we learn more about them—then we find out one more thing, and suddenly all is clear. When atoms were discovered a century ago, they certainly seemed mysterious. They were thought to be made up only of protons and electrons, but their behavior in laboratory experiments didn't add up. Then Chadwick discovered the neutron in 1932 and suddenly everything made sense—so much sense that it only took another 13 years to build an atomic bomb.

Today biology is undergoing just this sort of explosion of understanding. For over fifty years our study of the living world has focused on the “central dogma”, the idea that the information that determines what we are like is found in DNA molecules, and that the information in DNA is used to guide the manufacture of proteins that do the work of living. Much of biology can be explained with this simple picture, but just as with the atom, some things didn't seem to add up.

Then over the last few years researchers uncovered treasure where none was expected, in the study of RNA. In the central dogma, the role of RNA is pretty much restricted to ferrying information back and forth between DNA and protein, no more important than a postman. Now RNA looks to be every bit as important as DNA and protein, and may in fact be the main regulator of what goes on inside a cell. Biologists have suddenly gone from thinking they

pretty much know what is going on in cells, to realizing they are just beginning to.

So it's a great time to be learning biology—and to be writing biology textbooks. With the fifth edition, *The Living World* took the important step of adding Professor Jonathan Losos of Harvard University to the author team. Working together, we have refined this new edition of *The Living World* to better teach the concepts of biology to undergraduate students like those we teach, students who will probably not become biology majors.

The challenge we faced in writing these new editions of *The Living World* was to present the key ideas of biology, the same principles taught in a majors course, to nonmajors in a clear and engaging way, without technical jargon or needless complication. With each passing year our students, and those of every biology instructor, are more impacted by biology, and this is true whether they major in science or English, art or business.

With this rush of change it has become increasingly clear to us that every student must have the opportunity to understand how science works, and how the many changes science is creating can be expected to affect their lives and the future of our planet. We believe deeply that an appreciation of science at work has become an essential element of every college student's education, of citizenship in a world for which today's college students will soon be responsible.



Key Features

Overview

- **New Advances in Science Presented**
- **Illustrations Integrated into Body of Text**
- **Chapters Reorganized**
- **Inquiry & Analysis Features Expanded to Full Pages**

The previous editions of *The Living World* featured a lean presentation of biology that focused on presenting the essential concepts in a clear and interesting way. That approach has not changed in the subsequent editions. *The Living World* remains first and foremost a teaching tool, devoted to explaining to nonmajors the key ideas of biology and how they relate to everyday life.

This sixth edition of *The Living World* is strengthened in two significant ways. First, there have been major advances in the biological sciences since the last edition, advances that affect biology in important ways. Second, the many instructors using *The Living World* have suggested several improvements in content and presentation, requesting new ways of relating what a student is reading to the illustrations that appear on the page, suggesting organizational changes in some chapters, and asking for better ways to convey the *process* of science to students.

New Advances in Science Presented. The primary purpose of any revision is to update the science, so that the text presents the current state of biology. A textbook is not a newspaper, and cannot incorporate new findings as soon as they are announced, lest errors creep in. Any scientist knows that results and ideas are in a constant state of flux, and that new findings suffer a harsh trial by fire after they are announced, tried, and tested in many other labs before being widely accepted. When new findings are verified, they can sometimes cause a sea change in how we think about a key idea or regard a particular theory. Sometimes whole new avenues of inquiry open, changing biology in fundamental and important ways. At least four such major advances have occurred recently in biology, each introduced briefly on the next page.

Illustrations Integrated into Body of Text. Many instructors tell us that their students are visual learners. The illustrations are key to helping them understand concepts, but all too often a text's illustrations seem peripheral to the discussions in the text. In response to these instructors, *The Living World* actively integrates illustrations into text discussions. The text includes a description of the figure that accompanies it, pointing out aspects that are key about the figure. A student reading the text can't help but follow through the figure with the description provided in the text. For complex ideas, there are numbered links between the text and the figure. The numbers clearly link the point under discussion in the text with the appropriate place in the figure, allowing a student to quickly refer to the area of the figure under discussion.

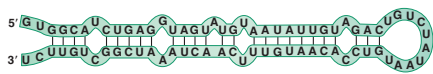
Topic Presentation Reorganized. Many instructors suggested ways to reorganize the topics within chapters to facilitate student understanding. In response, the order of key topics has been shifted in five chapters (8, 13, 20, 24, and 40) and many minor changes made in others. In over a dozen instances, topics were eliminated as unnecessary or too brief to be of benefit to students, and the space was used to expand explanations of the remaining topics.

Inquiry & Analysis Features Expanded to Full-page. Biology students, and in particular nonmajors, enter a biology course with little knowledge or skill in dealing with experimental data, so key to understanding biology. To help students become familiar with the challenge of analyzing and interpreting data, almost every chapter of the sixth edition of *The Living World* ends with an analysis of experimental data related to that chapter's content. These *Inquiry & Analysis* features are all full-page presentations. Each provides a short description of an actual experiment, a graph presenting data collected during that experiment, and then a series of questions to guide the students in interpreting the data. The questions help the student understand how the data set is presented, why it is presented in this way, and how the graph is best interpreted to draw the proper conclusions about the experimental outcome. Concepts that help a student interpret the data (for example what a log scale is and why it is used) are set off in color, so that the student can easily identify helpful information in the body of the text.

Advances in Science

Small RNAs Take a Lead Role in Molecular Research

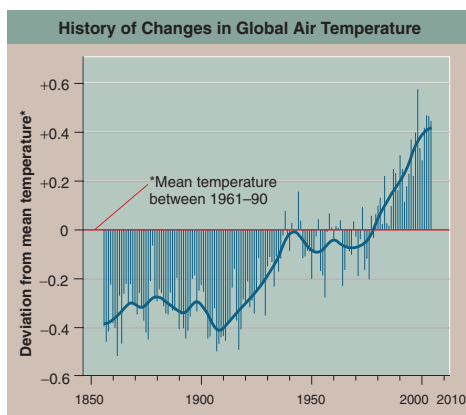
For decades, DNA has been the focus of molecular biology, but findings in the last few years have put RNA center stage. While biologists are accustomed to viewing RNA as a copy of DNA used to guide a cell's production of proteins, it comes as a great surprise that small RNA molecules like the one you see here are also active players in gene regulation. Apparently most animals and plants regulate the expression of their



genes at two levels: 1) Proteins act to promote or inhibit the “reading” of genes by the enzyme called RNA polymerase that produces the messenger RNA copy used to make proteins; 2) small “interfering” RNAs inhibit the use of particular messenger RNAs by binding to those that match the small RNA so that they cannot be read properly. The new “gene silencing” level of gene control appears very widespread, and its discovery has already led to major advances in gene technology and medical treatment. Using this form of regulation, researchers can shut off any gene whose sequence is known. Interfering RNAs that were discovered in 1998 are perhaps the most active research area in molecular biology, having snagged a Nobel Prize for their discoverers in 2006. Learn more on pages 245 and 247.

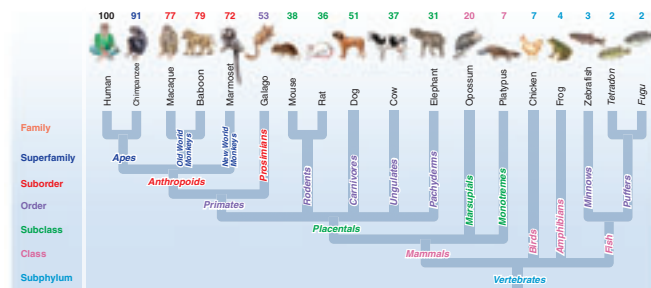
Global Warming Gets Real

Global warming has been a scientific reality for many years, researchers concluding that recent decades were the warmest in the last thousand years. Industry and government in the United States have been slow to accept this conclusion, however, attacking “hockey stick” graphs (like the one below showing little change in global temperatures for many centuries, followed by a rapid rise in the most recent century) as statistically flawed. This objection was put to rest for good in 2006 by a comprehensive study by the National Academy of Sciences. Temperature measurements, variation in ancient tree rings, and temperature measures in deep holes in the earth, all lead to the same conclusion—the warming in the last 25 years exceeds any peaks since 1600. Global warming is real, and demands our attention. Learn more on pages 794 to 795.



Evolution Under Fire

The teaching of evolution in America's public schools, long controversial, has been under sharp recent attack by proponents of “intelligent design” (the proposal that life is too complex to have resulted from evolution without intelligent help). The sequencing of the genomes (all the DNA of an organism) of many vertebrates in the last few years has finally allowed a direct test of Darwin's proposition—did vertebrates evolve or not? The numbers in the diagram below (or see page 314) are the percent of DNA that are the same as the human genome. As you can see, the longer ago a vertebrate diverged, the more differences that have accumulated between its DNA and the human sequence. This settles the issue once and for all—vertebrates evolved. Learn more on pages 314 to 315.



Embryonic Stem Cells without Embryos

In the ten years since human embryonic stem cells were first isolated, there has been controversy over their potential use as therapeutic agents to potentially replace damaged tissue. In mice, embryonic stem cells have been used to cure Parkinson's disease, type 1 diabetes, and spinal chord lesions. However, obtaining the embryonic stem cells destroys the early embryo in the process, and many people feel that destroying human embryos in this way is tantamount to murder. New experiments hint at a way out of this thorny ethical dilemma. Technology advances now allow researchers to challenge the human genome DNA with the RNA present in a cell, and so determine which genes are active in any given tissue. Comparing embryonic stem cells with differentiated skin cells, they were surprised to find that there were very few differences in which genes were turned *on* and *off*. In 2007 researchers successfully reprogrammed adult mouse skin cells into embryonic stem cells by introducing just four genes into the adult cells. The genes were so-called transcription factors, turning on key genes that acted to reverse the “shut off” changes that had occur during development of the adult cells. From proof-of-principle in mice to application in humans is still a leap, but the possibility is exciting. Learn more on page 296.

Updates and Additions

Every chapter of this new edition of *The Living World* has been carefully reworked to incorporate new research findings and to better integrate the illustrations with the text.

Chapter 3 A discussion of van der Waals interactions was added as these interactions exist in biological systems.

Chapter 4 An application on reading nutritional labels was added, as was a discussion on how a protein's structure determines its function. A discussion of artificially hydrogenated fats and trans fats was added, a topic in the news.

Chapter 7 A new 4-page introduction to photosynthesis was added that walks the student through the overall process more clearly. A new feature was added "Cold-Tolerant C₄ Photosynthesis".

Chapter 9 The mitosis figures were revised to more clearly reflect the process. A discussion of the deadliest cancers in the U.S. was added. The discussion on the actions of p53 was expanded and information added on a potential cancer treatment that targets the loss of p53 function.

Chapter 12 The section on DNA replication was expanded by adding a more detailed discussion about the 3' and 5' orientation of the DNA strands. A new feature, "Biology & Staying Healthy Protecting Your Genes" was added that discusses the health dangers of smoking and tanning beds.

Chapter 13 A new figure overviewing the processes of DNA replication, transcription, and translation was added and the discussion of gene expression expanded. The discussion of gene expression is now divided into two sections: gene expression in prokaryotes, with CAP explained in more detail, and gene expression in eukaryotes with expanded discussions of transcriptional control by chromosome structure, DNA methylation, histones, activators, and coactivators. A section on RNA-level control in eukaryotes was also added.

Chapter 16 The section on the ethics of stem cell research was updated with recent research results on using adult stem cells to produce pluripotent cells.

Chapter 17 The text has been revised and rewritten throughout the chapter, clarifying the discussions.

Chapter 19 The discussion of Bird Flu has been expanded including the conditions that trigger a pandemic and preparations by health officials.

Chapter 20 The last half of the chapter on classifying the protists has been completely revised following the new phylogeny now being widely adopted by taxonomists.

Chapter 21 A new section on edible and poisonous mushrooms was added.

Chapter 24 The section on sexual reproduction was rearranged so that the text follows the process with pollen formation being explained first, then egg formation, then pollination and fertilization.

Chapter 25 Phylogeny guideposts were added to the Phylum art summaries so students would know where a particular animal group fit in the phylogeny of the Animal kingdom. The discussion about insect size was expanded, including a limitation imposed by the respiratory system. A new feature was added, "A Closer Look: Diversity Is Only Skin Deep."

Chapter 26 A discussion of the evolution of the reptiles was added earlier in the chapter, where the invasion of land is discussed. A discussion of early world geography and climates was added, with new drawings of the periods of the Mesozoic. The discussions of sharks and bony fishes were expanded. The discussion of lobe-finned fishes and the evolution to land animals was updated and expanded. The discussion of reptiles was expanded to include the three lineages from reptiles. Phylogeny guideposts were added throughout the chapter so students would know where a particular group fit among the vertebrates. A new feature was added, "A Closer Look: Dinosaurs."

Chapter 28 The discussion of the matrix in bone was expanded and clarified. A discussion about the different types of joints in the human body was added..

Chapter 36 The discussion of spermatogenesis was expanded to include more information on sperm structure, semen production, and prostate health. The discussion of fertilization was expanded to include more detailed descriptions of the process. A new section was added on birth, describing the process. A new feature was added, "Biology & Staying Healthy Why Don't Men Get Breast Cancer?" A discussion of cervical cancer was added as a sexually transmitted disease.

Chapter 37 The logistic growth equation was simplified, replacing dN/dt with "G." A new feature was added, "Character Displacement Among Darwin's Finches."

Chapter 39 The section on Vertebrate Societies was expanded to include Insect Societies.

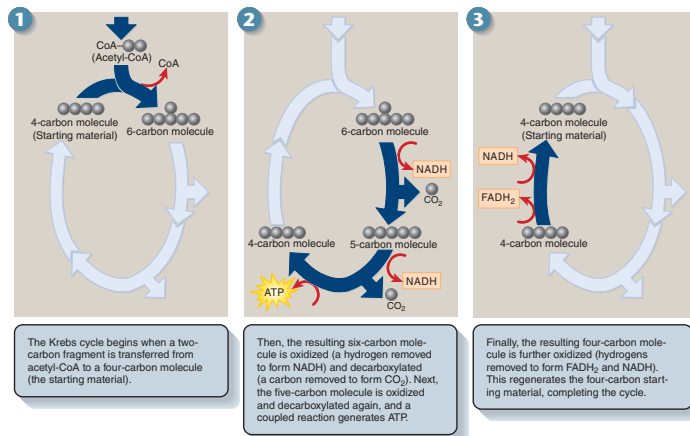
Chapter 40 The topic of global warming was expanded, updated, and a new figure added. The energy discussion was updated and expanded to include more information on renewable energy, especially ethanol. The discussion on human population was updated and revised.

Learning Tools

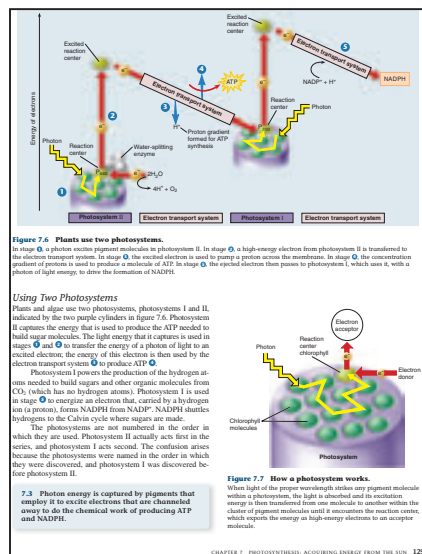
Focusing on the Essential Ideas of Biology

Biology is at its core a set of ideas, and if students can master these essential concepts, then the rest of biology comes more easily to them. *The Living World* was written to focus on concepts rather than terminology and technical information, to teach how things work and why things happen the way they do, rather than merely naming parts or giving unnecessary information. In this way we intended to make *The Living World* a more effective learning tool.

1. **Process Boxes.** However clearly it is written, there is no way a text can avoid the fact that some processes like photosynthesis and the Krebs cycle are complex. To aid in a student's learning of complex ideas, we have prepared special "This is how it works" Process Boxes for some four dozen essential processes that students encounter in introductory biology. Each of these process boxes walks the student through a complex process, one step at a time, so that the central idea is not lost in the details.



2. **Integration of Illustrations and Text.** The use of numbered steps in *The Living World* to link different aspects of an illustration to those parts of the text discussing them puts illustrations to work, actively integrating them into a student's reading. Increasingly, today's students are visual learners, and this linkage amplifies the effectiveness of a student's reading. For examples of this method of integrating illustrations into the text, see chapter 7, page 129 (left), in which the text discusses how two photosystems



interact during photosynthesis. The numbers link the points under discussion with the appropriate aspect of the illustration. As another example, chapter 5's pages 90-91 link the discussion of the operation of the cell's endomembrane system to aspects of the artwork presented on page 91. The student does not examine the figure as a separate activity, but rather as an active part of reading the discussion.

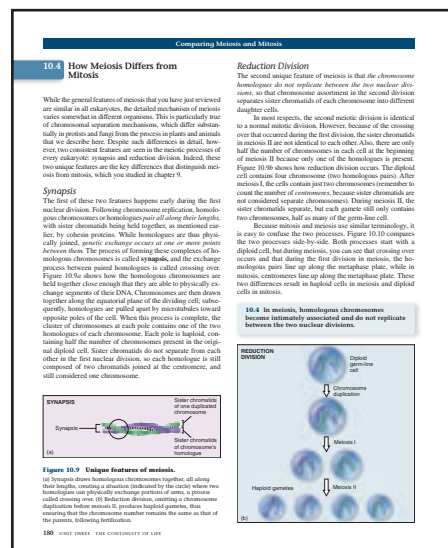
3. **Interactive Learning.** Perhaps the most difficult challenge facing nonmajors students taking a science course for the first time is assessment—although students don't yet understand a point, they may think that they do. To aid students in meeting this challenge, *The Living World* has placed on its website a series of interactive assessments. Students can take quizzes that probe what they understand, pinpointing any material that they have not yet mastered and pointing them to the appropriate learning module in each instance.

Arranging This Text for Effective Learning

This text is organized to teach the key ideas of biology effectively to today's nonmajors students. As college instructors ourselves, in *The Living World* we put to work what we have learned in a combined 40 years of teaching biology to freshmen—key strategies we found to be successful in our own classrooms.

1. **Connecting the Essential Concepts.** We have written *The Living World* as a series of learning modules presented on one or two pages. This format makes it easier for students to understand how the essential concepts within the chapter fit together conceptually. It also allows instructors to customize the text to their courses, as they can clearly point out which modules will be included in lecture.

2. **Relating Essential Concepts to Evolution.** It is no accident that *The Living World* begins with a chapter on evolution and ecology. These ideas, central to biology, provide the student a framework within which to explore the world of the cell and gene function, which occupy the initial third of the text. Students learn about cells and genes much more readily when they are presented in an evolutionary context, as



biology rather than as molecular machinery. The fact that within each mitochondrion is a tiny circle of DNA makes perfect sense when mitochondria are understood as relics descended from a bacterium engulfed long ago by an ancient eukaryotic cell.

Because of evolution's central role in biology, it is important that students be prepared to deal with the long-standing controversy over the teaching of evolution in public schools. Chapter 17 presents the student with a detailed overview of the controversy, evaluating the arguments advanced against evolution objectively on their scientific merit.

3. Relating Essential Concepts to Everyday Life.

One of the principal roles of nonmajors biology courses is to create educated citizens. In writing *The Living World* we have endeavored to relate what the student is learning to the biology each student ought to know to live as an informed citizen in the twenty-first century. Students also engage much more actively in the course when they can see how what they are studying relates to their own everyday lives.

Throughout the text, *The Living World* presents full-page boxed readings written by the authors that make connections between a chapter's contents and the everyday world: Today's Biology essays examine important new advances; The Scientific Process essays focus on how scientific analysis is carried out; A Closer Look essays allow a more detailed examination of interesting points; Biology and Staying Healthy essays discuss health issues; and Author's Corner essays take a more personal view (the author's) of how science relates to our everyday lives.

Much of the current impact of biology on everyday life centers on progress in DNA research and cell biology. This "new biology" is only beginning to impact nonmajors courses, but it is of great interest to students. Genetically modified foods, cloning of genetically identical animals, the potential of using stem cells to repair damaged tissues—all these topics appear in the news daily, and students need a way to link what they are learning in biology to them. Chapters 14, 15, and 16 provide a brief roadmap.

Helping Students Learn the Process of Science

A principal goal of a nonmajors biology course is to educate students about science—what science is, and how it is done. In every chapter of *The Living World*, the student sees science in action. Hypotheses are advanced and their predictions tested. Two features in this edition help students learn how science is done.

1. **Data Analysis and Presentation.** Many students taking a course in nonmajors biology have little or no background in the sciences. Much of the difficulty they have with the course in many cases simply reflects a lack of experience with handling

How Scientists Analyze and Present Experimental Results

After a scientist conducts research, he or she must then analyze and present the results so that others can interpret them. To do this, the scientist becomes carefully on what is measured in an experiment, and how the data are evaluated.

Variables are the tools of research. They are manipulated and measured in an experiment as a means of answering questions and testing hypotheses. There are two types of variables in any experiment. An **independent variable** is one that a researcher is able to control—for example, the concentration of a chemical in a solution or the timing of when a measurement is taken. The independent variable is selected by the investigator based on the question he or she is trying to answer. A **dependent variable**, by contrast, is not predetermined by the investigator; it is the response that is measured by the investigator in the experiment.

Some research involves examining correlations between sets of variables, rather than the deliberate manipulation of a variable. For example, a researcher who measures both blood pressure and cholesterol level is actually comparing two dependent variables. While such a comparison can reveal correlations and so suggest potential relationships, correlation does not prove causation. What is happening in one variable may actually have nothing to do with what happens in the other variable. Only by manipulating a variable (making it an independent variable) can you test for causality. Just because people with high blood pressure might also have high cholesterol does not establish that high blood pressure causes high cholesterol. The "Vital Under-standings" question 1 at the end of this chapter shows how an incorrect conclusion can be reached when comparing two dependent variables.

How to Present the Results in a Graph

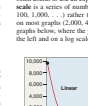
You will encounter a lot of graphs in this text and to interpret them, it is important to realize that all graphs are presented in a certain way. The independent variable is always presented and labeled across the bottom, called the **x-axis**. The dependent variable is always presented and labeled along the side (usually the left side), called the **y-axis**.

In some situations, two sets of data may be presented in the same graph using the same independent variable—for example, a control experiment and a testing experiment. In this case, the two sets of data are presented as two different lines on the graph. On a graph, you can compare two different experiments (two different dependent variables) with the same independent variable. In this situation, a graph might have two y-axes, one on the left and one on the right, defined against the same x-axis.

Using the Appropriate Scale and Units to Present Data

A key aspect of presenting data in a graph is the selection of proper scale. Data presented in a table can often, many


scales, from seconds to centuries, with no problems. A graph, however, typically has a single scale on the x-axis and a single scale on the y-axis, which might consist of molecular units (for example, nanometers, micrometers, milligrams) or macroscopic units (for example, feet, inches, liters, days, milligrams). In each instance, a scale must be chosen that fits what is being measured. Changes in continuous variables are best obvious on a graph scaled in units. If a variable changes a little over the course of the experiment, it is often useful to use an even smaller scale. For example, a graph showing the distance of a car from 1000 to 10000... () rather than on more graph (20000...) where the left end on a big scale.



You can see that the changes in the dependent values of the independent and 4). Notice that the y-axis is not linear either—the itself subdivided on a 10 mark between 10 and 15 than to 10.

Individual graphs on each chosen to best depict needed conversion units, a system of units specific, weight is expressed on a diagram, and weights are represented as a contour in a hand-drawn diagram of a graph. The English system uses metric, decimal-based and very straightforward.

Other types of data represent proportions of a whole data set, for example, the different types of trees in the park as a




percentage of all the trees. This type of data is often presented in a pie chart, as shown here.

Putting Graphs to Work

The same graphs we have encountered here are used frequently by scientists in analyzing and presenting their experimental results. As an example, consider research on the ozone hole, discussed earlier in this chapter.

A line graph can be used to present data on how the size of the ozone hole changes over time. The data points might include a very consistent pattern, or they might not.


Consider the data in this graph:



The data points on the left are changing in a very consistent way, with little variation from what a straight line shows in reality would predict. The graph in the middle shows more experimental variation, but a straight line still does a good job of showing the overall pattern of how the data are changing. Such a straight "best-fit line" is called a **regression line** and is calculated by estimating the distance of each point to the line, adding the values, and dividing the total by the number of data points. The data points on the graph on the right, unlike the other two, are randomly distributed above and below the line, indicating that there is no relationship between the dependent and the independent variables.

Other Graphical Presentations of Data

Sometimes the independent variable for a data set is not continuous but rather represents discrete sets of data. A line graph, with its assumption of continuity, cannot accurately represent the variation occurring in discrete sets of data, where the data sets are being compared with one another. The preferred presentation is that of a **histogram**, a kind of bar graph. For example, if you were comparing the heights of your team in a park, you might group their heights (the independent variable) into discrete



"bins" such as 5 to 10 meters tall, 10 to 15 meters tall, and so on. These categories are placed on the x-axis. You would then count the number of trees in each category and present that dependent variable on the y-axis.

Other types of data represent proportions of a whole data set, for example, the different types of trees in the park as a

numbers. Data are at the heart of science, and no student can navigate a biology course successfully without being able to read a graph. To aid such students, we have included in chapter 1 (pages 12–13) a quick overview of how scientists analyze and present experimental results.

2. Inquiry & Analysis Features.

Perhaps the most important thing a student can learn about how science is done has little to do with equipment and laboratories. Science at its heart is a process of objectively asking and answering questions. To aid students in gaining some appreciation of this, most chapters of *The Living World* end with a full-page feature *Inquiry & Analysis* that poses a particular scientific hypothesis and sorts out how to evaluate it with an experiment, creating real data. The student is then challenged to analyze the data and reach a conclusion about the validity of the hypothesis. This process is the nuts-and-bolts of the process of science, and by mastering it a student goes a long way toward learning how a scientist thinks. The answers to *Inquiry & Analysis* questions are available to the instructor on the website.

INQUIRY & ANALYSIS

Do Vertebrate Genomes Evolve as Darwin Predicted?

The genetic comparisons presented in Figure 15.5 establish clearly that the genomes of four vertebrates are more similar than those of their closest nonvertebrate relatives. However, as the analysis in the figure says nothing about how rapidly genetic mutations accumulate, we can compare the genomes of vertebrates in different orders. And if we don't know about such evolutionary rates, how can we see how much the differences in genetic information contained in Figure 15.5 imply about the ongoing accumulation of evolutionary change? Why do they amount to the result of some unimagined delay in how we measure evolutionary change?

Fortunately, it is not difficult to see. The independently dated fossil record shows that the vertebrate lineage branched off from the invertebrate lineage during the Cambrian period, about 540 million years ago (see Figure 15.1). It is possible to reconstruct the analysis of Figure 15.5 in the time of the Cambrian period, and to see how the differences in genetic information accumulated in the vertebrate lineage over longer periods of time, as Darwin's theory predicts.

For each of the 17 vertebrate vertebrates in Figure 15.5, the graph in the upper right plots the percentage of the genome that is homologous to the human genome. The percentage of the genome that is homologous to the human genome is the same for all vertebrates, and it is the same for all vertebrates. This is the case because the percentage of the genome that is homologous to the human genome is the same for all vertebrates, and it is the same for all vertebrates. This is the case because the percentage of the genome that is homologous to the human genome is the same for all vertebrates, and it is the same for all vertebrates.

1. Applying Concepts

a. Vertebrates. In the graph, which is the dependent variable?

b. Comparing Concepts. Of the 17 kinds of vertebrates included in the study, which has the greatest amount of genetic information? Which has the least? How do you think the amount of genetic information in vertebrates has changed over time, and why? How do you think the amount of genetic information in invertebrates has changed over time, and why?

2. Interpreting Data

a. What general conclusion can be made regarding the relationship between the % alignment with the human genome and the time since divergence from the human genome? In the graph, are members of the same family (family) clustered together in the graph? Are vertebrates with similar genomes more closely aligned with the human genome than are invertebrates? Do vertebrates with similar genomes more closely align with the human genome than do invertebrates? In the graph, are members of the same family (family) clustered together in the graph? Are vertebrates with similar genomes more closely aligned with the human genome than are invertebrates? Do vertebrates with similar genomes more closely align with the human genome than do invertebrates?

3. Making Inferences

a. In general, which of the vertebrates most closely resemble a vertebrate genome in the human case? (The percentage of the genome that is homologous to the human genome is a continuous variable.)

b. What is the significance of the fact that the relationship in the graph is a straight line with a positive slope?

4. Drawing Conclusions

a. How do you think the amount of genetic information accumulated over time in vertebrates? How do you think the amount of genetic information accumulated over time in invertebrates? How do you think the amount of genetic information accumulated over time in vertebrates? How do you think the amount of genetic information accumulated over time in invertebrates?

b. Further Analysis. This analysis involves only 17 kinds of vertebrates and invertebrates. Do you think the amount of genetic information in vertebrates has changed over time, and why? How do you think the amount of genetic information in invertebrates has changed over time, and why?