STUDY GUIDE

Lydia Daniels and Laurel Bridges Roberts

BIOLOGY

A GUIDE TO THE NATURAL WORLD

Third Edition

David Krogh

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Lydia Daniels & Laurel Bridges Roberts
University of Pittsburgh

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PREFACE

Welcome to the Study Guide

Welcome to the *Study Guide*, a companion for David Krogh's *Biology: A Guide to the Natural World*. Biology is the study of the world around us: how organisms live, eat, move, reproduce, and change over time. Biological knowledge is increasing at a dizzying pace, and that pace shows no indication of slowing down. Biological issues —including cloning, drug design, environmental management, and evolutionary processes—influence both political and sociological issues. This situation makes biologic literacy a critical component of good citizenship in our nation and our world. Understanding biology will help you understand the world around you and your place within it.

We are sure you want to be as successful as possible in your study of biology. Luckily, there are plenty of resources for you. In addition to your instructor, your lecture notes, your textbook, and your classmates, we have assembled this study guide for you. Remember that this guide is only one possible resource. It is not meant to replace your lecture notes or your textbook. Use this guide to reinforce and test your understanding of the concepts and details presented in class.

Our study guide is designed to help you identify and learn the important concepts presented in your textbook. Every *Study Guide* chapter has a similar format:

- A summary of the chapter's three or four **Basic Concepts**
- A bulleted list of the **key ideas** related to each of the Basic Concepts
  This list should help you identify the big ideas that you need to understand thoroughly to master the information in each chapter
- **Think About It** – a list of questions to test how well you've grasped the basic concepts.
- A **Cool Facts** essay presenting current research or real-life applications of the material presented in the chapter
- A **Vocabulary Review** for the entire chapter
- Suggested terms for **Web building** and **Flow charting**
- A **Practice Test**
- A practice essay question, called **But, What's It all About**, that challenges you to use the information you have learned not only in the current chapter but also in previous chapters to solve a problem or defend a position.

You can read and take notes on your text and then use the Basic Concepts and bulleted lists to double check your grasp of the major ideas in each chapter. To test your comprehension of the factual content, you can work through the Think About It exercises in the *Study Guide* as you finish reading the relevant section of the textbook chapter. Building the suggested webs and flowcharts will help you see how the factual information presented in the textbook defines the Basic Concepts of the chapter. When you are familiar with the material, you can count on the vocabulary review and practice test at the end of the chapter to assess your strengths and identify your weaknesses. You can also use the vocabulary review, practice test, and But, What's It All About question to prepare for your exams. The But, What's It All About question is structured to teach you how to collect evidence from multiple sources and use it to write a clear and detailed answer to a question – an important skill in any discipline. Even if your instructor doesn't use essay questions on tests, this practice essay will teach you how to integrate your knowledge of the factual content of biology and develop a deep and long-lasting understanding of the material.

We hope you will learn to love biology as much as we do! The understanding you gain from your studies will bring you a lifelong appreciation for the diversity and beauty of our world. We would like to acknowledge the work of our friend and colleague, Dr. Michele Shuster, whose creative energy and good humor contributed immeasurably to this *Study Guide*. Finally, we would like to thank our mentors for guiding us to become better scientists, our students for guiding us to become better teachers, and our families for guiding us to become kinder (and calmer) human beings.

Lydia Daniels

Laurel Roberts

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CHAPTER 1

Science as a Way of Learning: A Guide to the Natural World

Hello! We (the authors of this *Study Guide*) know who you are.

Well, we have a pretty good idea about who you are. You are enrolled in a biology class somewhere that is using David Krogh's *Biology: A Guide to the Natural World* as a textbook. Maybe you are enrolled in the class because you have to fill a distribution requirement for a natural science, and biology seemed less threatening than chemistry or physics. Maybe you want to learn some basic biology because it would help you understand the latest developments in the field of law, business, education, or communications. Maybe it's been a long time since you studied biology and you're curious about the science behind vitamins, global warming, and evolution. Whatever your reasons for learning about biology, we thought you'd like to know what your instructor will expect you to learn.

We have a pretty good idea about who your instructor is, too. Probably someone like us, who loves studying the natural world and enjoys sharing their knowledge of biology with other people. They may also do biological research and have specialized knowledge about some aspect of biology (Laurel is an ecologist; Lydia is a biochemist). But your instructor knows that biology isn't your primary field of interest. This is one of many courses you may be enrolled in, and it may not even be your favorite. So what does he or she expect you to learn?

We can't answer that question specifically, because every instructor's expectations are unique. But we can show you some learning tools that will help you deal with a variety of teaching and testing styles. In the first chapter of the text, David Krogh eloquently describes why you should learn biology; we want to use this chapter to show you how to learn biology—or any other complex subject, for that matter. We'll be introducing the techniques of concept mapping (also called webbing), summary, flowcharting, and grouping. These techniques will help you figure out the basic *concepts* in biology (webbing, summary), the *process* by which we understand these concepts (summary, flowcharting), and how to *apply* specific information to demonstrate these processes (flowcharting, grouping). Using this sequence of concept-process-application will help you learn and remember specific facts, as well as how these facts relate to each other and define biological theories. This is what we expect our students to learn, and we suspect your instructor does too.

Whatever your reasons for learning biology, we hope you'll also spend some time with us in learning how to learn. These techniques not only help you get the greatest value from this biology course but also transfer readily to any discipline, and they'll help you be more successful in learning history, economics, or physics. The knowledge you gain will be uniquely yours—and that's something you can't lose, even if you lose your notes and sell your textbook. So, let's begin.

WHAT IS SCIENCE?

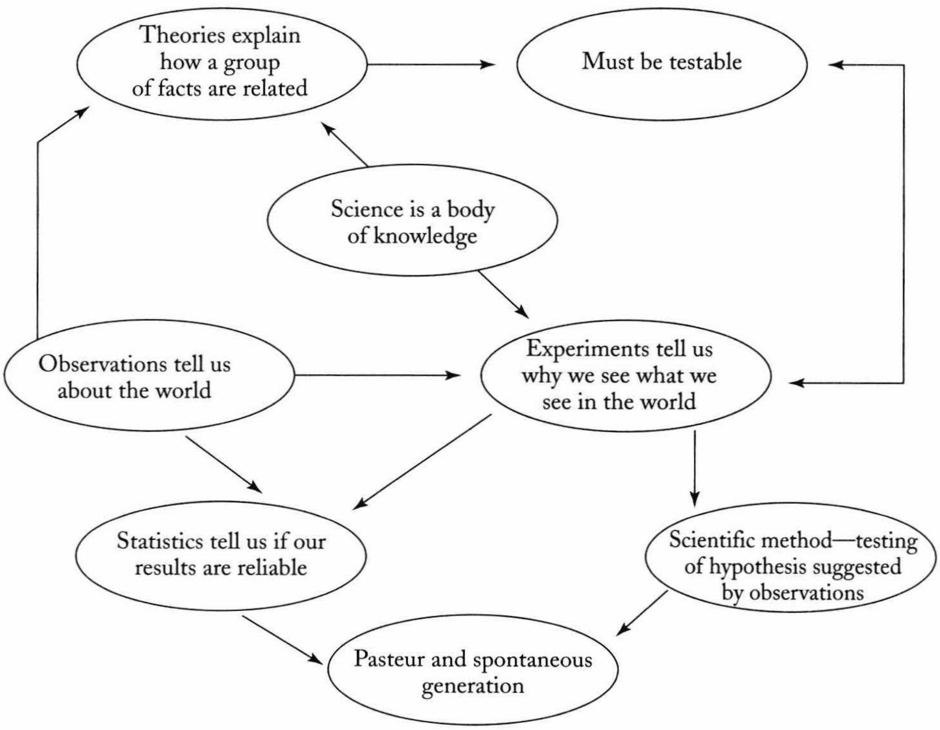
This part of the chapter describes some basic information about how to gather information in science and defines a group of terms commonly used by scientists. Let's begin with a summary outline to record the main idea of this section and summarize the major related concepts.

Science is both a body of knowledge and a method to gain that knowledge.

- Theories are statements of general principles about the natural world supported by evidence.
- Scientific evidence consists of observations and the results of experiments done to account for the observations.
- Experiments proceed using the scientific method, a process that involves testing the validity of a proposed explanation (hypothesis) in a controlled manner.
- No hypothesis or theory is ever proven absolutely in science, but if we fail to disprove theories often enough, we believe them to be true.

Notice that this summary doesn't just copy phrases from the textbook. Each idea has been expressed in terms that make sense to us; that's an important part of making knowledge your own. In this *Study Guide*, you'll see that we often use this summary outline technique to help you find key ideas. Notice also that this summary is rather "bare-bones"—there are no detailed examples of these concepts and no connection between these ideas; it's just a list. To make sense of the details and connections, we need a few other study techniques.

Let's now use a web to establish how these ideas are related and to practice using this new vocabulary.



One benefit of using a web is to see how ideas are related; for example, you can see that "theories" are part of the body of knowledge that we call science, and that experiments make up part of that body of knowledge but are also a key part of the process of science (testing theories). Now it's your turn. Use the following list of terms (or make up one of your own) to practice building a concept web.

> **Create a web:** zoo, peanuts, popcorn, elephants, kids, jelly, cartoons, Dumbo, Africa

Webs are particularly useful for showing connections between concepts and processes, but they don't give us any information about the sequence of these connections. For that information, we need to use flowcharts.

Figures 1.5 and 1.6 in the text are examples of *flowcharts*. A flowchart shows the physical or temporal relationships among ideas of things, so it is a good method when you need to remember the order of specific facts. Let's use a flowchart diagram like the one in Figure 1.5 to trace the specifics of Pasteur's experiment in spontaneous generation.

Using the flowchart lets us map the specifics of the Pasteur experiment, an *application* of the scientific method, to the steps of the *process.*

Microbes, living organisms, seem to appear spontaneously in sterile solutions. (Observation)

↓

Do these microbes arise from chemicals in the solutions, or must there already be microbes present? (Question)

↓

Microbes are present in the air, so a sterile solution open to the air will grow microbes; but a solution that microbes cannot enter will not. (Hypothesis)

↓

Broth in swan-necked flasks remains sterile until the neck is broken before the bend, and then microbial life appears in the flask. (Experiment)

↓

Microbial life appears only when something in the air, but not air alone, can reach the broth. That something must be microbes carried on dust. (Conclusion)

We've demonstrated summary outline, webbing, and flowcharting. Now you can apply these techniques, with our guidance, to the next section, Biology. We'll also introduce you to the last study technique, grouping, using this section. Let's start with a summary outline:

Biology

- Biology is the study of highly organized, living things.
- Living things can be differentiated from nonliving things by a suite of characteristics—there is no single factor that differentiates living from nonliving.
- Living things are highly organized, and this organization occurs in a hierarchy such that relatively simple and small components become integrated to make larger, more complex components.

One general concept mentioned in the outline concerns distinguishing living and nonliving things—what is the process we use to do this? If you read the subsection entitled "What Is Life?" on page 12 of the text, you'll learn some of the processes that characterize living things, but can some of these processes also characterize nonliving things? Here's where you can use *grouping* to help you compare and contrast living and nonliving things.

Grouping allows you to see which characteristics are shared by living and nonliving things and which are unique to living things.

Living Things	Nonliving Things
Movement	Movement (wind, sand dunes)
Growth	Growth (fire, crystals)
Highly organized	Highly organized (crystals, building)
Assimilate and use energy	Use energy (cars)
Respond to the environment	
Maintain internal homeostasis	
Uses an internal information base to function	Uses an internal information base to function (computers)
Can reproduce using internal information base	
Composed of cells	
Evolves from other living things	

The summary outline also indicates that living things are "highly organized." Organized how? In a hierarchy, but a hierarchy of what—and in what order? Sounds like a flowchart is in order. Read the section entitled "Life Is Highly Organized, in a Hierarchical Manner" on page 13, and create a flowchart that shows the components of living things at each level of complexity.

Summary outlines, webs, flowcharts, and groupings are ways to extract information from a text. These techniques give you the ability to explore connections between concepts, the processes by which we know a concept, and the specific details that show the application of a process to a concept. But these techniques are only learning tools, learning occurs when you can use the information the tools have helped you find to explain things. So we present our final study technique, answering questions. You'll see this technique throughout the study guide in sections called "Think about It."

THINK ABOUT IT

1. What kinds of policy issues have you heard about that require a basic knowledge of biology?

2. What is a scientific theory?

3. What are three characteristics of living organisms?

   Are these three characteristics sufficient to define something as living?

4. What is the unifying thread of biology?

Compare and Contrast

For each of the following paired terms, use a sentence of comparison ("Both . . . ") and a sentence of contrast ("However, . . . ").
organelle/organ

cell/organisms

population/community

atoms/molecules

If your instructor has assigned Chapter 1 in the text, you'll want to try the following practice test. Each of the upcoming Study Guide chapters uses a similar formula to help you to prepare for exams.

TESTING, TESTING

After reading Chapter 1 of the text and completing the exercises in Chapter 1 of this Study Guide, try the review exercises and practice test that follow.

Vocabulary Review

Group the following terms in the appropriate columns of the table. Some terms may be used in more than one column.

atom	evolution	molecular biology	scientific method
cell	homeostasis	organ	theory
community	hypothesis	physiology	variable

Hierarchy of Life	Practice of Science	Biology

PRACTICE TEST

After you have reviewed this chapter, close your books, grab a pencil, and spend the next 15 to 20 minutes completing this practice test.

Matching

Match the following terms with their description. Each choice may be used once, more than once, or not at all.

a. the basic unit of matter
b. unified set of principles explaining something about the natural world
c. building block of life
d. gradual change and separation of populations into new species over time

___Evolution
___Theory
___Cell
___Atom

Short Answer

1. What is the relationship between a hypothesis and a theory?

2. Why must a hypothesis be falsifiable?

3. Why is it necessary to define life by a list of criteria instead of a single attribute?

4. How did the study of biology change between the years 1800 and 1900?

Multiple Choice

1. What is the possible explanation for a series of observations?

   a. guess
   b. theory
   c. law
   d. hypothesis
   e. hunch

2. _____ is the unifying principle of biology.

   a. Molecular biology
   b. Evolution
   c. Physics
   d. Physiology
   e. Homeostasis

3. Which of the following represents a series ranked from smallest to largest?

   a. population → community → biosphere
   b. atom → molecule → cell
   c. tissue → organ → organism
   d. cell → organelle → organ
   e. a, b, and c

4. Which of the following is/are shared by all living organisms?

   a. the ability to assimilate energy
   b. the ability to transmit genetic information
   c. made up of building blocks called organs
   d. all of the above
   e. a and b only

5. Your spaceship crashes on Planet 2X-Alpha. While waiting for help, you try to discover as much as possible about your temporary home. To uncover facts about your new "natural world," you would first:

   a. Design theories to fit facts into.
   b. Do experiments.
   c. Draw conclusions.
   d. Make observations.
   e. Set up the grill and invite the residents over for dinner.

6. What's the second thing you should do to uncover facts about Planet 2X-Alpha?
   a. Design theories to fit facts into.
   b. Do experiments.
   c. Draw conclusions.
   d. Make observations.
   e. Offer to baby-sit the alien kids.

7. Which of the following is an example of a testable (falsifiable) hypothesis?
   a. Plants grow best on days when the temperature rises above 40 degrees.
   b. The best flowers are pink.
   c. Apples are nice.
   d. Many things happen, not all can be explained, but some can be experienced.
   e. Forty-two (42).

8. Your answer for the previous question was the best choice because
   a. it had the most words.
   b. it had numbers.
   c. it used inductive reasoning to generate universal laws.
   d. it was most likely to generate a controlled test.

BUT, WHAT'S IT ALL ABOUT?

Professors love to use essay questions on exams to determine if you can pull together the information you've been reading to answer a big picture question. These questions may ask you to solve a problem – practical application of knowledge. Sometimes a question will ask you to defend a model or justify a concept – construct an argument. So how do you provide the answer the professor wants? We'll show you.

At the end of each chapter, following the practice exam, we'll give you a sample essay question. In the first 10 chapters, we'll outline for you an approach to answering these "big picture" questions (beginning with chapter 11, you're on your own). What your professor wants, more often than not, is to see that you can supply specific evidence (facts and examples) that supports a more general claim made by a question. By working through these questions, you'll get some practice at organizing your information so that you can write a clear, concise answer supported by specific examples. And even if your professor never uses an essay exam, working with these questions is a good test of your understanding of the material. Let's begin.

Question: How does the fact that living organisms have a hierarchical organization impact the process of biological research?

1. **What is this question asking me to do?**
   Always stop first and figure out what the answer should look like. Is it a compare/contrast question? That means you need to provide some specific examples of similarities and differences. Does it ask you to defend a statement? Those questions require you to provide the experimental findings that support the claim made in the question. A more open-ended form of this type of question asks you to support or refute the statement. Again, you need to muster your factual evidence to defend your position. Does the question ask you to describe or document

the effect of one thing upon another, as this question does? In this case, we need to collect the information that describes the theory and describe how each part affects some other process, in this case, biological research.

2. **Collect the evidence.**
Our first step is to define, in detail, what is meant by a "hierarchical organization" and the "process" of biological research. We start by looking for information in the textbook.

Hierarchial Organization	Process of research
Living things highly organized	Research starts with an observation that produces a question
Lower levels of organization integrated to **create** higher ones (so higher levels don't exist without lower levels)	Questions lead to proposing possible assertions that can be experimentally tested and possibly found to be false (hypotheses)
Levels = atom, molecule, organelles, cells, tissues, organs, organism, population, community, biosphere	Theory = description of general principles that fits with all of the available factual evidence. Has power to explain things but is also provisional
Levels define "building blocks"	

Collect all the information that you can even if you probably won't use all of it in your final answer.

3. **Pull it together.**
Since we are trying to understand the impact on the process of research, let's start by asking how each part of the research process is affected by the hierarchy of life.

Starts with an observation

- Can make observations on any level of the hierarchy.
- Observations made on a given level for any one organism should be the same or very similar to that found for that same level in other organisms. For example, the properties of a specific molecule found in a fish should be very similar to the properties of the same molecule when found in a mouse.

Questions lead to hypotheses

- Hypotheses can be tested in different organisms as long as we consider the same level of organization – i.e., Questions about a specific molecule can be tested using molecules isolated from worms, mice, or people.
- Testing in different organisms and collecting reproducible results in each increases our certainty in our findings.

Evidence used to produce a theory

- Little tricky to see how the hierarchical organizations can help us make general theories. Seems that if our research is limited to one level, the best we could do is suggest theories about one level of organization.

Did any insights occur to you as you organized this information? What about the fact that the levels of the hierarchy are integrated? Does this imply that if we define some new property of the cell that we can then suggest a new property for the tissue? Likewise, does a newly identified cellular property imply that there must be new molecules (or old molecules with previously unidentified functions) involved? We can apply what we know about the hierarchy of life to the "problem" of research method and develop the new idea that research at any one level of the hierarchy can lead to new hypotheses about function at other levels of the hierarchy.

So let's write.

The hierarchical organization of living organisms presents well-defined systems to observe and ask questions about. For example, if we are observing an organism eating, we can develop hypotheses about why it chooses that food (organism level), how easy or difficult it is to find that food (community level), how it digests that food (organ level), or how it extracts energy from that food (cellular level). So one observation can be explored on many different levels. Because all of these levels are integrated, our findings on any one level can lead us to make suggestions about function at higher or lower levels of organization. The result is that by collecting the results of research done at the molecular, cellular, tissue, organ and community levels of organization we can produce a general theory of how and why that organism chooses that particular food.

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CHAPTER 2

The Fundamental Building Blocks: Chemistry and Life

Basic Concepts

- The fundamental building block of matter is the atom, an elemental particle composed of protons, neutrons, and electrons.
- The complex molecules of life are created from atoms through covalent, ionic, and hydrogen bonding.
- Chemical bonds define a molecule's physical, chemical, and biological properties.

Fundamental Building Blocks of Matter

- The basic forms of matter are the elements, 92 pure substances that cannot be reduced to simpler components. A single, elemental particle is called an atom.
- Atoms contain protons, neutrons, and electrons. Protons and neutrons occupy the nucleus of an atom and account for its mass. Electrons are essentially massless particles that occupy the space around the nucleus.
- Atoms are electrically neutral because, although protons are positively charged and electrons are negatively charged, the number of protons equals the number of electrons, assuring no net charge.

THINK ABOUT IT

1. **Create a web** that defines matter using the terms introduced in section 2.1.

2. Fill in the following table with the three subatomic particles and their properties.

Particle Name	Location in Atom	Charge	Mass Contribution