Biology
The Study of Life
Coursebook

Oak Meadow

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Introduction

> *Science is a way of thinking much more than it is a body of knowledge.*
>
> **Carl Sagan**

Have you ever heard something described as "more an art than a science"? This common phrase makes it seem like science is a rigid set of rules and facts, with no room for wonder or imagination. This couldn't be further from the truth.

Consider science as a verb, not a noun, as an active exploration rather than a static body of previously discovered knowledge. Science is questioning, wondering, examining, and imagining: What would happen if. . . ? Why does. . . ? How can. . . ? Science is observing and measuring, guessing what might happen, and then watching and recording what does happen. Science is always attempting to answer questions about our world.

Have you ever wondered what you have in common with the butterfly in your garden, the mold that's used to make your cheese, the bacteria that gave you strep throat, or the houseplant over in the corner of the room? You are more connected to all other life-forms in the world than you might realize. In fact, all life-forms are made of the same stuff, and the molecules that make up your body might have been part of a plant, fish, bug, or bacteria (or maybe even all of them) at some point in the past.

Welcome to Oak Meadow *Biology*! In this course, you will be immersed in the study of the living things that surround you. You'll be learning how *life* is defined and how you fit into the whole picture. Biology is the study of life. That's a big subject, and part of the reason you have such a large textbook. In fact, every lesson opens the door to entire fields of study and possible careers!

The word *biology* comes from the Greek words *bio*, which means "life," and *logos*, which means "knowledge" or "to study."

To give you an idea of what to expect, take a few minutes to watch this quick video:

Introduction to Biology (Gregorio, *YouTube*)

https://www.youtube.com/watch?v=7L7x0BAqWis

Biology for the Next Generation

This course puts into practice a major shift in science education. Historically, scientists have often been isolated. The public was usually unaware of what the scientists were doing, and scientists did not attempt to communicate their work. Times are changing! Communication and collaboration are becoming more and more important, as scientific advancement has increasingly global implications. How does this affect you? Well, science is no longer a bunch of facts to learn. Information is widely available. You will not be tested on the names of the bones in the body or the orders of insects. Instead, we will focus on an understanding of broader concepts and how they are interconnected.

In this course, you will be *doing* science, *writing about* science, *talking about* science, *asking questions* about science, and *thinking* about science.

Integral to the study of biology or any other scientific discipline is the concept of *scientific inquiry.* In scientific inquiry, you are not only observing, inferring, and experimenting, but you are also encouraged to ask questions, form explanations, compare your explanations with current scientific knowledge, and communicate your ideas. We will be focusing on developing critical thinking and scientific reasoning skills, and using these skills to advance your understanding of science. Throughout the course, you will be encouraged to dig more deeply into the material. Every question or crazy idea is welcomed because it is by thinking "outside the box" that true scientific discoveries are made.

Now that you have an idea of what's ahead, here are some details that will help you get the most out of this course. Please take the time to read this entire introduction before you begin lesson 1.

Course Materials

This coursebook contains complete instructions for the wide variety of assignments, activities, and labs you'll be doing in this course. This course was designed to incorporate the Next Generation Science Standards (NGSS), a new framework for science education created by science teachers and organizations to prepare students for the new directions toward which science is heading. In addition to this coursebook, the following materials are used in this course:

- *Holt McDougal Biology: Student Edition 2015* by Stephen Nowicki (Houghton Mifflin Harcourt)
- Oak Meadow Biology lab kit

You will find a full materials list (sorted according to lesson) and lab kit list in the appendix of this coursebook. It's important to plan ahead so that you have the necessary materials on hand when you are ready to do your labs and activities.

About Your Textbook

The textbook we are using for this course, *Holt McDougal Biology: Student Edition 2012*, is a comprehensive volume that is extremely well organized. Please use it fully! Consult your textbook to answer

questions rather than looking up information on the internet. This is extremely important. You will be referred to great online resources throughout the course, and looking up information online can be helpful if you need further explanation on a topic. However, constantly looking for answers online as your primary source does you a great disservice because it takes the information out of context. Essential connections to the big picture are lost when you do this.

Take some time to get familiar with the layout of your textbook before you start the course. There is a great student resource section in the back with lots of useful information that can help you out as you go through the course. Look it over, bookmark parts, and don't forget that this resource exists!

How to Read Your Textbook

A science textbook is not a novel, and it takes a different kind of reading. Here are some tips:

- Pay attention to the key concepts, section headings, and main ideas.
- The highlighted words in the text are important, but the most important words to focus on are the ones you don't understand! You might already know the meaning of some highlighted words. Highlight any additional words you are unfamiliar with.
- Pay special attention to the images! This cannot be emphasized enough. The diagrams and illustrations are often easier to understand than the text, and often provide information in a way that your brain can make sense of more easily. Use the text for additional information to augment the diagrams.
- Learn how to take good notes. There is a whole section on note-taking in the student resources at the back of the book. Find a way that works for you.
- Use your notes! Taking notes is helpful in its own right, but referring to them for study is much more helpful.
- Mark up the textbook. Add notes in the margins, highlight sections, and make it work for you.
- Reading a chapter straight through once is not the best approach. You will need to skip around, going back and forth between sections, reading some parts two or three times. Skim some parts, and read other parts in depth.

How the Course Is Set Up

In this course, there are 28 lessons. Below you will find a suggested timetable to help you plan how much time will be needed for each lesson. Most of the questions in these lessons are short answer questions. Try to be concise, yet answer the question completely using full sentences. If you are expected to write more than one or two sentences, it will be specified in the assignment. Sometimes, if you are simply naming something, full sentences are not required. Usually the way the question is worded will give you a clue about how to answer. When in doubt, write in full sentences.

In some of the lessons, you will be offered a choice of activities, some of which will be creative projects. Even if you don't think you're very creative, you will be expected to try these occasionally. You will not be marked down for "bad" artwork or poetry. Practice expressing yourself while at the same time demonstrating your scientific awareness.

You are required to complete all activities and labs *unless* it is specifically mentioned that there is a choice. Extensions are also required for the labs unless specified as optional.

You may wonder why there are no dissections in this course. At Oak Meadow, we have chosen not to use dissections for a few reasons. We feel that, although taking apart an animal in a hands-on way is a great learning experience, it is not necessary to destroy a living animal to understand its basic anatomy. Even in medical schools, models are used more and more often these days. When working with living things, we would like to do so with the utmost respect, recognizing that we don't own nature; we are a part of it. Oak Meadow's philosophy is to approach education in environmentally conscious and sustainable ways. However, if you feel that a dissection is in line with your interests and want to pursue it on your own, there are many dissection kits available online, and your work can be incorporated into the course.

In each lesson, you will find sections to guide your studies and deepen your understanding of the material:

- **Lesson Objectives** outline the main goals of the lesson and give you an idea of what to expect.
- **Think About It** gives you an opportunity to discuss with someone in your family or community your thoughts and opinions about what you are learning. This section will help you consider alternate viewpoints, clarify your views, and practice logical argumentation. Please pay attention to the "Think About It" sections! They enrich the course greatly and will help you get much more out of the course.
- **Reading** tells you the reading assignment for the lesson. It is very important that you focus on the reading suggestions that are specified for each lesson, as they highlight the especially useful parts of the reading, and let you know which parts you can skim.
- **Comprehension Questions** are designed to help you solidify key concepts and knowledge.
- **Critical Thinking** questions encourage you to think deeper about the material and make important connections by applying your knowledge and your best scientific-reasoning skills.
- **Activities** provide a wide range of hands-on ways to explore the topics you are studying.
- **Labs** give you a way to explore, experiment, and discover how the concepts you are learning play out in real life. Some labs have labeled data tables, some have blank data tables, and some have no data tables (you'll be creating your own). Some have lines for answers; others don't. This allows you to gain practice in multiple ways of recording your data and formulating your response.
- An **Assignment Summary** is included at the beginning of each lesson so you can see at a glance what is required. It will make it easy for you to check off assignments as you complete each one. Assignments are fully explained in the lesson.

- **For Enrolled Students** is found at the end of most lessons. This section provides reminders and information for students who are enrolled in Oak Meadow School and are submitting work to their Oak Meadow teacher.

The **appendix** contains important material that you will be expected to read and incorporate into your work throughout the year. Take some time to familiarize yourself with the information in the appendix. In this appendix, you will find Oak Meadow's academic expectations, original-work guidelines, information about how to avoid accidental plagiarism, and details on citing sources and images. You will also find a list of citizen science opportunities, a comprehensive works cited page that lists the dozens of excellent resources mentioned in this course, a materials list, and enough graph paper to complete the labs and assignments that require graphs or diagrams.

In this coursebook, you will occasionally find references to "your teacher" that apply to all students, whether enrolled in Oak Meadow School or using this course independently. It is assumed that you will be working with an adult who assesses and supports your learning. This teacher—who may be a parent, tutor, or Oak Meadow teacher—is the one to whom these notes refer.

Online Resources

This course makes good use of technology and the vast resources found online. You'll have plenty of opportunities to do online activities and labs. For instance, one of the best ways to learn is to get involved. It's fun to see videos and films that show biology in action, like this one:

- "Lord of the Ants" (PBS: https://www.youtube.com/watch?v=5HKl8Luuotw)

Here are some other excellent resources for you to use throughout the course:

- *EOL: Encyclopedia of Life* (http://eol.org/)
- *Understanding Science: how science* really *works* (http://undsci.berkeley.edu/)

If you are interested in taking an active role in an ongoing research project, you can find an astounding array of citizen science opportunities at this website:

- *Zooniverse*—a "master list" of citizen science projects (https://www.zooniverse.org/)

For more great citizen science ideas, check out the detailed list in the appendix.

If you don't have internet service at home, you are encouraged to do the online activities at your local library. If you are unable to use the internet, please talk to your teacher about alternative assignments.

Academic Expectations for Enrolled Students

If you are enrolled in Oak Meadow School, you'll find a reminder at the end of every other lesson that instructs you to submit your work to your Oak Meadow teacher. Continue working on your next lesson while you are waiting for your teacher to send lesson comments. After you have submitted the first

semester of work, you will receive a semester evaluation and grade. At the end of the course, you will receive a final evaluation and grade.

Please follow the assignments in order and whenever possible place your responses to the assignments in the Google Drive course doc provided by your teacher. Your teacher will give you feedback on your work in this shared Google doc, so the more work that can be put there, the better. Some labs and activities have blank spaces or data tables for you to fill in. If possible, scan these pages and attach them to the shared doc so that all your work stays in one place. Details about how to do this can be found on the Google Drive help page.

You are expected to meet your work with integrity and engagement. Your work should be original and give an authentic sense of your thoughts and opinions, rather than what you think the teacher reviewing your work wants to hear. When you use other sources, you are required to cite them accurately. Plagiarism, whether accidental or intentional, is a serious matter.

The appendix of this coursebook includes complete details on Oak Meadow's academic expectations and original work guidelines. It is your responsibility to make sure you understand these academic expectations and abide by them.

Please remember to stay in touch with your Oak Meadow teacher and share your comments, ideas, questions, and challenges. Your teacher is eager to help you!

The Journey Ahead

Biology is a constantly changing field of study, as new discoveries are made in every area. Scientists are constantly finding that the more we learn about nature, the more we learn about ourselves and the consequences and effects of our actions on the rest of the world. This makes the study of biology a deeply personal journey. As you go through the course, be aware of this. Pay attention to the media, and learn about new discoveries as well as the controversies that often surround them. The more you learn about biology, the more you will be able to understand and relate to what you see and hear all around you. Enjoy!

Suggested Lesson Timetable (based on 36 weeks of study)

Unit 1: Introducing Biology (2 weeks total)

- Lesson 1: 1 week
- Lesson 2: 1 week

Unit 2: Cells (4 weeks total)

- Lesson 3: 1.5 weeks
- Lesson 4: 1.5 weeks
- Lesson 5: 1 week

Unit 3: Genetics (5.5 weeks total)

- Lesson 6: 1.5 weeks
- Lesson 7: 1.5 weeks
- Lesson 8: 1.5 weeks
- Lesson 9: 1 week

Unit 4: Evolution (4 weeks total)

- Lesson 10: 1 week
- Lesson 11: 1.5 weeks
- Lesson 12: 1.5 weeks

Unit 5: Ecology (5 weeks)

- Lesson 13: 1 week
- Lesson 14: 1.5 weeks

[end of semester 1]

- Lesson 15: 1 week
- Lesson 16: 1.5 weeks

Unit 6: Classification and Diversity (3.5 weeks total)

- Lesson 17: 1 week
- Lesson 18: 1 week
- Lesson 19: 1.5 weeks

Unit 7: Plants (4 weeks total)

- Lesson 20: 1.5 weeks
- Lesson 21: 1.5 weeks
- Lesson 22: 1 week

Unit 8: Animals (7 weeks total)

- Lesson 23: 2 weeks
- Lesson 24: 2 weeks
- Lesson 25: 1 week
- Lesson 26: 1 week
- Lesson 27: 1 week

Final Wrap-Up (1 week total)

- Lesson 28: Final Essay and Reflection

Lesson

1

What Is Biology?

Integral to the study of biology or any other scientific discipline is the concept of ***scientific inquiry***. In scientific inquiry, you not only will be observing, inferring, and experimenting, but you will be encouraged to ask questions, form explanations, compare your explanations with current scientific knowledge, and communicate your ideas. We will be focusing on developing critical-thinking and scientific-reasoning skills, and using these skills to advance your understanding of science. Throughout the course, you will be encouraged to question. Please remember: in science, there is no such thing as a stupid question!

When you see a word or term highlighted, such as scientific inquiry, that's a key term you should know. You'll find the word defined in your textbook.

Plan to spend one week on this lesson.

ASSIGNMENT SUMMARY

- ☐ Read chapter 1, Biology in the 21st Century (2–27).
- ☐ Answer eight Comprehension questions.
- ☐ Complete four Critical Thinking questions.
- ☐ Activity: Medical Imaging Technology
- ☐ Activity: Data Analysis Lab
- ☐ Activity: Experiment Design
- ☐ Lesson 1 Lab: Walking Crooked!

Lesson Objectives

- Define biology and become familiar with the themes of biology and the properties of life
- Review and practice the scientific process and the concept of scientific inquiry
- Explore examples of modern technology and its uses in biology

Assignments

Reading

Read chapter 1, Biology in the 21st Century (2–27), in your textbook.

Additional Reading Assignment for the Course

For this biology course, you will be reading one additional book. Below you will see a list of four books to choose from. They are all fascinating books so you may have a hard time choosing. Feel free to read them all! Any one of these books will help you see science in a different light.

You have the entire year to complete this additional reading assignment (or the entire semester if you are only taking one semester of biology). You may submit your review of the book (details on this are below) at any point during either semester, and it will be graded with the semester grade. You will see reminders throughout the course about this; try not to leave it until the end. If you are going on a family trip or taking a vacation, that would be a good time to pick up one of these books.

• *A Planet of Viruses* by Carl Zimmer

Viruses are involved in almost every important function on Earth. With the increase in bacterial resistance to antibiotics, viruses might be the future in treating infectious disease. Every liter of seawater is estimated to contain up to one hundred *billion* viruses! Carl Zimmer states, "Viruses are the smallest living things known to science, and yet they hold the entire planet in their sway." Viruses even blur the line between life and nonlife. In describing the intriguing life history of several viruses in short chapters, Zimmer makes science truly fascinating and accessible to anyone.

Writing assignment: As you read through this book, keep notes for each chapter. Write down at least three facts from each chapter that you find especially interesting or surprising. After you complete the book, write an essay about the effect the book had on you. Was it worth your time, and do you feel it fits well with the biology course? In the textbook, we learn that viruses aren't officially living things, as they are not made of cells. What are your thoughts on that, after reading this book? Submit your essay and the three interesting facts from each chapter to your teacher when you complete the book.

• *Flight Behavior* by Barbara Kingsolver

In this excellent work of fiction, Kingsolver weaves together real life and science as climate change, environmental sustainability, and discoveries made in the natural world reflect and influence what is going on in the life of a young woman. Monarch butterflies migrating through the Appalachian Mountains provide a rich backdrop for the story.

Writing assignment: After you read the book, write an essay addressing some of the following questions:

a. How can different people look at one event and see it so very differently? Some felt that the butterflies were a miracle, and others felt their presence was a disastrous

result of climate change. What does this say about human behavior and how people decide what to believe?

b. What do you think about Kingsolver using fiction to spark the conversation about climate change? Is this effective?

c. Comment on the process of science as it is introduced in this book. What did you learn about how science is done? Consider the sampling methods, data collection, and the concept of causation versus correlation that is addressed in the book. Did you end up with the feeling that science is accessible even to those who don't think they have a scientific mind?

d. Scientists express things with caution. Rarely are data expressed with certainty, as that would imply 100% certainty, from a scientific perspective. We are accustomed to certainty, and may prefer not to believe an issue if it is only 98% certain. Comment on the idea of certainty and how it relates to the climate change issue.

- ***The Immortal Life of Henrietta Lacks* by Rebecca Skloot**

Henrietta Lacks was a poor black tobacco farmer who, in 1951, was diagnosed with cervical cancer. Her cells were taken from her tumor, without her knowledge or consent, and became one of the most important tools in medicine. The *HeLa* cell line became very important in the development of the polio vaccine, cloning, gene mapping, cancer research, and more. *HeLa* cells have been, and continue to be, reproduced in labs throughout the world. Henrietta died as a result of her cancer. Meanwhile, her cell line lived on, and all of this happened without her family having any idea of what was going on. This book is like a detective story combined with a heart-wrenching novel. At times it is hard to believe it is all true. *The Immortal Life of Henrietta Lacks* brings the subject of bioethics to the forefront.

Writing assignment: After you read the book, choose **three** of the following topics to discuss in an essay.

a. Review pages 60–62 of your textbook, on the topic of bioethics. How does this book fit into the discussion of bioethics as it is seen today? Do you feel that the discussion should have started many years ago, when Henrietta Lacks's cells were taken?

b. Deborah shares her mother's medical records with the author, Rebecca Skloot, but was adamant that she not copy everything. Deborah says, "Everybody in the world got her cells, only thing we got of our mother is just them records and her Bible." If you were in Deborah's situation, how would you react to someone wanting to look into your mother's medical records?

c. Rebecca Skloot was very careful not to take sides when she reported this story. Since we always bring our own perspectives and experiences into whatever we read, do you

feel that Skloot was unbiased, or do you think that she took a side (scientist or family)? Did you take any particular side while reading the book, or are you in the middle? Explain.

d. Review the consent form that Henrietta signed (31). Based on this statement, do you believe TeLinde and Gey had the right to obtain a sample of her cervix to use in research? What information would they have had to give Henrietta for her to give *informed* consent? Do you think she would have agreed for her tissue to be used in research if she'd had all the information?

e. Do you feel the Lacks family should be financially compensated for the *HeLa* cells, all these years later? If so, where do you think the money should come from?

f. Review the case of John Moore (199–201). How does that make you feel? How do you feel about the Supreme Court of California's ruling that states when tissues are removed from your body, with or without consent, any claim you might have had to owning them vanishes?

g. Review chapter 32 (259–267), when Deborah and Zakariyya got to see the *HeLa* cells for the first time. How do you feel about the way Christoph Lengauer handled the situation? Relate this experience to the importance of informed consent. How could simple knowledge about the situation have prevented so much anger and misunderstanding?

- ***Stiff: The Curious Lives of Human Cadavers* by Mary Roach**

Medical students often practice surgery on cadavers. Before anatomy was understood, "body snatching" (the stealing of bodies from graves) for medical schools was a big business and the money earned from this practice fed many families. Today, criminal forensics is a very important and cutting-edge field, and understanding the process of human decay is necessary. And although it sounds horrible, the use of cadavers is far superior to the use of crash test dummies for auto safety research. While such a book may seem gruesome, Mary Roach is a master at making science, even *this* science, funny. If you are at all interested in medicine or forensics, this is a great read. No matter your interests, this book will open your eyes to fields of study you never knew existed.

Writing assignment: For this course, you are asked to read only the first six chapters (about 150 pages, half the book). As you read through each chapter of this book, keep notes. Write down at least three facts from each chapter that you find especially interesting or surprising, and any other notes you want to jot down. After you complete the book, write a report and critique of the book. Did it have any particular effect on you? How do you think it relates to the biology course? Do you find forensics to be an interesting biology topic? Submit your essay and the three interesting facts from each chapter when you complete the book.

Think About It

Can all questions be answered by using scientific methods? If you are testing a hypothesis and your results don't support your hypothesis, is your investigation a failure? Take some time to consider these two questions and then discuss your thoughts with a friend, sibling, or parent. Express yourself clearly and check that your discussion partner understands the points you are making. You might have to explain some of the scientific concepts or methods upon which your answers are based. Being able to "talk science" is an important skill, and you'll be practicing this throughout the course.

Comprehension

1. Given the definition of biodiversity found on page 5 of your textbook, how would you define ***species diversity***? How about ***genetic diversity*** and ***ecosystem diversity***? Based on your understanding of the meaning of diversity, explain what you think these terms mean. (We will be exploring each of these concepts later in the course.)
2. If you were to determine if an organism is alive, what characteristics would you look for?
3. Homeostasis is an important biological theme. Explain what homeostasis is, and give an example.
4. How does natural selection lead to adaptation?
5. What is the importance of peer review in science?
6. Differentiate between an independent variable and a dependent variable, and explain the purpose of a control group in a scientific experiment.
7. If you needed detailed images of the internal structure of a bacterium, what type of microscope would you select for the task? Explain your answer.
8. Describe two potential benefits and two potential risks of biotechnology.

Critical Thinking

1. Describe a system that is part of your everyday life. It does not have to be related to biology.
2. Look at the picture of the polar bear hair on page 9 of your textbook, think about its structure, and consider the following additional information: polar bears have black skin. Their hair is transparent, and only appears white because it reflects visible light in the same way snow does. How do the characteristics of the hair and skin contribute to homeostasis in the polar bear?

3. Based on the definitions of theory discussed on page 16 of your textbook, give an example of a theory that you have come up with in your life that would not be considered a scientific theory. Explain why it is not a scientific theory.
4. Answer question #2 on the Standards Based Assessment on page 31 of your textbook.

Activities

Complete all three of the following activities.

A. Medical Imaging Technology

Do some investigation and make a list of the medical imaging technology that you and your family have benefited from or used. Even if you rarely go to the doctor, it is likely that images were taken of you before you were even born! Think broadly, discuss with your family, and come up with as comprehensive a list as you can. This is a general question: respect the privacy of others and please don't share without consent any names or details about the reasons for the imaging.

B. Data Analysis Lab

Complete the Data Analysis Lab on page 12 of your textbook. In addition to the two questions in the lab, please answer the following question, and label it #3: Consider the qualitative data examples about the dolphins as observations that need further investigation. Choose one of these observations and describe how it might be investigated in a quantitative way.

C. Experiment Design

Design a controlled experiment about one of the topics listed below (you will not be carrying out this experiment). As mentioned in lab 1 below, there are variations in the way scientific investigations are carried out. However, section 1.3 in the textbook explains the general format. An *observation* of something usually leads to *questions*, from which a *hypothesis* is generated and tested.

Experiment topics:

- What causes leaves to change color and fall off trees in autumn? Is it temperature, light, or both?
- You have a new drug that has potential for being a cure for the common cold. Design an experiment to test the drug's effectiveness.
- Does hot water freeze faster than cold water? (Feel free to actually carry out this experiment!)
- Is acid rain causing a decline in the population of amphibians (frogs and salamanders)?

Explain the following steps of your experiment:

1. Identify the situation or problem based on your observation.
2. What are the questions that come up about the problem?
3. Consider an explanation for the situation, and put it in the form of a testable hypothesis.
4. Predict what will happen if your hypothesis is correct.
5. Design an experiment to test your hypothesis. Remember to include a control group. Identify the independent and dependent variables. Explain each step clearly.

Lab

Perform Lesson 1 Lab: Walking Crooked! Turn to the lab for detailed instructions (each lab is found directly following the lesson assignments).

FOR ENROLLED STUDENTS

For the discussion assignment in "Think About It," you can connect with a classmate via Skype or Google Hangout to discuss your thoughts, or talk to a friend or parent.

Begin using your Google course doc for all your written work (contact your teacher if you haven't received a link to your course doc yet). If you will be using an alternate submission method for your lessons, please consult with your teacher. Handwritten data tables or other work can be scanned and attached to your course doc or sent to your teacher via email or postal mail. You will send all your work from this lesson to your teacher after you complete lesson 2.

Name _____

LAB

1

Walking Crooked!

This Lab uses your own body to practice scientific inquiry. The step-by-step scientific method that you learned in this chapter is one example of how scientific investigations take place. There are variations. For example, you may simply have a question and you develop a way to test it, or your hypothesis is just something you've heard. Is this still scientific inquiry? Yes! You are controlling the variables, setting up an investigation, and looking for an answer.

The Guiding Question

Can a blindfolded person walk in a straight line?

Materials

- measuring tape or string, 10 meters long
- 5 to 10 markers to imitate "bread crumbs" to mark your path, such as popcorn, small plastic toys such as Legos, dry beans (if they are easy to see), etc.
- blindfold

You will also need a large or outdoor space that is flat, with even terrain, and a partner.

Procedure

1. Using the tape measure or string, mark a straight line 10 meters long. Leave it on the ground.
2. Stand at one end of the string facing in the direction the string goes, and have your partner blindfold you. If there is noise coming from a certain direction, you may need to control for this.
3. When your partner says, "Go," start walking slowly toward what you think is the other end of the marked area. Your partner will quietly walk behind you, dropping the "bread crumbs" to mark your path of travel. When you get toward the end of the 10 meters (or if it becomes unsafe), your partner will say, "Stop." Take off the blindfold and observe the results.
4. Measure how far you've strayed from the far end of the 10-meter path. Record your results in the data table below. Be sure to note whether you have strayed to the right or left. You might also want to note if there was a continuous curve to the path you took.

Biology—Lesson 1 Lab: Walking Crooked!

Data Table: Measuring Deviations from a Straight Line When Blindfolded

Person	Distance strayed	Right or left	Notes

5. Pick up the bread crumbs, switch places with your partner, and repeat the test. If you have more people available, it is fun to do this with as many people as you can. Record all data.

Analyze and Conclude

Describe your results. Answer the guiding question, using your results as evidence to support your conclusion.

Name _____

Biology—Lesson 1 Lab: Walking Crooked!

Extension: Making Connections

A test like this often results in more questions than you started with. Here are a few samples:

- Why don't people walk straight?
- Will one person always go the same direction?
- Is there a pattern if you are left or right handed?
- Would this translate to different activities, such as paddling a kayak?

Now it's your turn to come up with more questions about this experiment that could be tested. Think broadly: you might consider anatomy, gender, terrain, etc. You might have questions about why this happens, or you may want to look for patterns. Write down at least three questions. There are no wrong answers!

Lesson

2

The Chemistry of Life

Take a look at the picture in your textbook of the Venus flytrap consuming a frog (33). It is truly astounding that life exists in so many unique forms. Throughout this course, we will be studying the innumerable types of life on our planet, including our own amazing bodies. Despite the variety, all life on Earth consists of the same basic ingredients. Take cellulose, for example, that makes up the cell walls of plants. Did you know that plants produce 100 billion tons of cellulose a year? It is the most abundant organic molecule on Earth, and yet we can't even digest it. The only animals that can are those that are able to enlist the help of microorganisms that contain the right enzymes! In this lesson, we will learn about the building blocks of life: the special properties of the atoms, elements, and molecules that make up every living cell, and the chemical reactions that keep us going.

Plan to spend one week on this lesson.

ASSIGNMENT SUMMARY

- ☐ Read chapter 2, Chemistry of Life (32–56).
- ☐ Complete eight Comprehension questions.
- ☐ Answer three Critical Thinking questions.
- ☐ Choose one:
  - Activity: Importance of Water
  - Activity: Enzyme Deficiencies
- ☐ Lesson 2 Lab: Determining the pH of Common Substances

Lesson Objectives

- Become familiar with atoms, elements, and molecules, and how they join in ionic and covalent bonds
- Explore the properties of water and how water supports life
- Learn about the four types of carbon-based molecules in living things
- Become familiar with the basics of the chemical reactions that take place in living things, and the importance of enzymes

Assignments

Reading

Read chapter 2, Chemistry of Life (32–56), in your textbook.

You may skim section 2.1, taking note of the headings, diagrams, and highlighted terms. Read the other sections in more depth.

Think About It

The names of most enzymes end in the suffix *-ase*. Whenever you see a word with this suffix, you know you are reading about an enzyme. Read the list below of common enzymes in living things. Can you identify what substrate each enzyme acts on? If you can, discuss this list with a family member or friend. Make your best guess, and then check the end of this lesson for answers. How did you do?

- protease
- lipase
- lactase
- amylase (tricky one!)
- cellulase
- polymerase

Extra challenge! Which of the enzymes in the above list is *not* found in our bodies? (If you need a hint, read the introduction to this lesson again.)

Comprehension

Refer to your textbook as necessary to answer the following comprehension questions.

1. ***Mnemonic devices*** are often used in biology as a memory tool. "ROY G BIV" is a well known mnemonic device for remembering the colors of the rainbow (red, orange, yellow, green, blue, indigo, violet). Often a catchy phrase is created where the first letter of each word corresponds to the first letter of each term you are trying to remember. Come up with a mnemonic to remember the four elements that make up 96% of the human body. (We will be discussing these elements a lot in the next few chapters.)
2. Describe the difference between an ionic bond and a covalent bond, and give an example of each.
3. Explain two ways in which the polarity and hydrogen bonding properties of water molecules are essential for life to exist.
4. Why doesn't oil dissolve in water?
5. What special bonding properties of carbon make it the "building block of life"?

6. Answer the following questions.
   a. What monomer building blocks make up proteins? Nucleic acids?
   b. Is starch a monomer or a polymer?
7. Describe the functions of carbohydrates and lipids in living things.
8. What is activation energy? How do enzymes increase the speed of chemical reactions?

Critical Thinking

1. The pH scale is a negative logarithm. That means that there is a tenfold difference in H+ ion concentration between one pH value and the next. Given this information, answer the following two questions:
   a. What is the difference in H+ ion concentration between a substance with a pH of 2 and a substance with a pH of 4?
   b. Why is it so very important that the pH of human blood remain in a very narrow range? (Hint: there is more information about internal pH in section 2.5 of your textbook.)
2. Explain how proteins and nucleic acids are related.
3. What does it mean when a chemical reaction has arrows going in both directions? How does this make it hard to determine which are the reactants and which are the products?

Activities

Choose one of the following activities to complete.

A. Importance of Water

Get creative! Either write a poem or a song to a familiar tune (humorous or serious), or create an illustration that includes most or all of the following concepts. The idea is to illustrate how important water is to life on Earth. Include the following:

- the properties of water
- how the structure of the water molecule gives water these unique properties (i.e., how hydrogen bonds are responsible for specific heat, adhesion, and cohesion)
- how solutions are formed when substances dissolve in water
- how these solutions are often acids or bases
- examples of cellular processes that depend on water

B. Enzyme Deficiencies

You have learned about the importance of enzymes. Research one of the following enzyme deficiencies and write a brief (one page) report. Note that many enzyme disorders are a result of a mutation in a gene that gives instructions for the making of certain enzymes. (Remember,

enzymes are proteins, and genes code for the building of proteins.) In your report, describe the enzyme and its function, the effects a deficiency of the particular enzyme has on a person's health, how the deficiency is diagnosed, and what the most likely treatments would be. Be sure to include your sources.

- phenylketonuria (enzyme phenylalanine hydroxylase)
- galactosemia (affects enzymes that break down galactose)
- lactose intolerance (deficiency of lactase)

Lab

Complete Lesson 2 Lab: Determining the pH of Common Substances. In this lab, you will investigate the pH of common household substances using pH indicator paper, which changes color depending on the pH of the solution being tested.

FOR ENROLLED STUDENTS

If you connected with a classmate to discuss the ideas in "Think About It" for lesson 1, try to connect with the same classmate again for the discussion in this lesson.

Complete all your assignments and add them to your Google course doc, making sure to number each assignment and place it under the correct lesson header. If you scan your lab pages, you can attach them to your course doc. (Remember to clearly label each attached file.) When your first two lessons are ready for review, notify your teacher using the "Email collaborators" command in the File menu. If you prefer another submission method or have questions, contact your teacher.

Think About It: Discussion Points

How did you do?

- protease: proteins
- lipase: lipids
- lactase: lactose
- amylase: amylose (a component of starches)
- cellulase: cellulose
- polymerase: polymers (DNA or RNA polymerase catalyzes the synthesis of DNA or RNA—we'll be covering that later)

Extra challenge: Cellulase is not found in the human body. We don't have the capacity (or the microorganisms with the capacity) to digest cellulose.

Name _____

LAB

2

Determining the pH of Common Substances

The Guiding Question

What is the pH of common household substances?

Materials

- wide-range pH indicator paper
- 6 common household substances (you may choose from this list):
  - lemon juice
  - window cleaner
  - coffee
  - vinegar
  - bleach (wear gloves to avoid contact with bleach)
  - mouthwash
  - cola or other type of soda
  - milk
  - baking soda dissolved in water
  - orange juice or other fruit juice
  - tea
  - dish detergent
- water (this will be your control—label it #7)

Biology—Lesson 2 Lab:
Determining the pH of Common Substances

Procedure

1. Label the data table below with columns for solution, predicted pH, and measured pH.

Data Table: pH of Common Substances

1.		
2.		
3.		
4.		
5.		
6.		
7.		

2. Predict the pH of each solution you will be testing, as well as the water. Record your predictions on the data table.
3. Test each solution with the pH paper and record your results in your data table. To test a solution, dip one end of the paper *very briefly* into the solution. If you hold it in there too long, it will wash out the indicator. Give it just a quick dip, and then pull it out and compare that end to the color chart to read the pH.
4. Draw a pH scale similar to the one in the textbook on page 41 of your textbook, with a range of 0 to 14 (acidic to basic). Label the pH scale with your solutions.

Name _____

Biology—Lesson 2 Lab:
Determining the pH of Common Substances

Analyze and Conclude

1. Summarize your findings. Were your results very different from your predictions?

2. What is the pH range of the solutions you tested? What do your results tell you about how acidic or basic most household solutions are?

3. Which of your substances has the highest hydrogen (H+) ion concentration? Which has the lowest?

4. Apply your pH knowledge: Why can't you measure the pH of cooking oil?

Lesson

6

Meiosis and Introduction to Mendelian Genetics

Stop for a second and think about this question: "How did I become the way I am?" Although some of it has to do with the food you eat, your family and surroundings, and the people you hang out with, a lot of it arrived with you when you were born. You might be thinking, "I'm tall like my mother, but have freckles and blue eyes like my father." Or you might think, "I have no idea why I'm so short when both of my parents are above average height." Or, "My sister and I are both blond, but our parents have dark hair." How do we get these unexpected combinations of physical traits?

In this lesson and the next few, we will focus on those easily observable traits that have a clear genetic basis; in other words, we aren't going to explore why one person is shy and another outgoing. These are more complex, and are likely a combination of nature (genetics) and nurture (environment). We will be exploring the basics of genetics, which is what makes us sort of like, but sort of unlike, our parents.

ASSIGNMENT SUMMARY

- ☐ Read chapter 6, Meiosis and Mendel (157–182).
- ☐ Answer ten Comprehension questions.
- ☐ Complete six Critical Thinking questions.
- ☐ Activity: Coin Toss Genetics
- ☐ Lesson 6 Lab: Modeling Meiosis

Before that, though, we need to start at the beginning, learning about the tiny gametes, the sperm and the egg, that create us (or our dog, our spider plant, our resident house flies, etc.). Welcome to meiosis! As you read about meiosis, you will see that it is not a quick process. Human egg cells take years to develop (from birth to fertilization), and human sperm cells take 24 days. The duration of meiosis is highly variable, as different species will go through periods of inactivity. Even in the male reproductive organs of a lily plant, meiosis takes 7 days!

Plan to spend about one and a half weeks on this lesson.

Lesson Objectives

- Differentiate between the processes of mitosis and meiosis, and identify the factors involved in producing genetic variation
- Become familiar with the work of Mendel and the foundations of heredity

- Understand how genes and alleles determine genetic traits
- Investigate and experiment with the role of probability in the inheritance of traits

Assignments

Reading

Read chapter 6, Meiosis and Mendel (157–182).

Think About It

To learn, read; to know, write; to master, teach.

Hindu proverb

In this lesson, you will be learning many terms. In order to succeed with many of the questions here and in subsequent lessons, it is essential that you understand the meaning of these terms. We're leaving it up to you to learn the following terms in the way that works for you. You may be good at writing definitions, drawing pictures, creating flash cards—it's your choice. One of the best ways to learn is by teaching. Use this opportunity to teach family members about the basics of genetics. Formulating good explanations for others is a very useful learning tool, and this topic in particular is something that people may take an interest in if it is explained well.

Asking good questions is also very important, so feel free to ask your teacher or home tutor if you are stumped. However, rather than say, "I don't understand this," try being more specific. Explain what you do understand, and try to refine your question. In other words, be proactive in your learning! The following terms will be important to know:

allele	genome	recessive
gene	genotype	probability
homozygous	phenotype	genetic linkage
heterozygous	dominant	crossing over

You won't be asked the definition of these terms in this lesson, but it will become apparent soon enough if you don't take the time to learn them.

Comprehension

When answering comprehension questions, full sentences are not required when you are simply asked to name something, or identify genotypes or phenotypes.

1. Describe the difference between homologous chromosomes and sister chromatids.
2. The Y chromosome has the smallest number of genes. Do you have that chromosome?
3. Examine the steps of meiosis and answer the following questions. You might want to do this assignment *after* you complete the lab.
   a. Name the stage of meiosis during which sister chromatids are separated to opposite poles of the cell.
   b. In what ways are the chromosomes in telophase I of meiosis different from those in telophase of mitosis?
   c. In which division of meiosis do the cells become haploid?
4. Who was Gregor Mendel? (Write no more than two sentences.)
5. Why were pea plants a good choice for Mendel's experiments?
6. Apply the terms ***homozygous***, ***heterozygous***, ***dominant***, or ***recessive*** to describe plants with the genotypes PP and Pp.
7. Identify the phenotypes of rabbits with the genotypes Bb and bb, where B = black fur and b = brown fur.
8. Draw a Punnett square to show the offspring of two individuals who are heterozygous for freckles (Ff). Using it, predict both the phenotypic and genotypic ratios of the offspring. Please submit both the Punnett square and your answers to your teacher. (Be sure to review how a ratio is written, as explained on pages 169 and 175 of your textbook, if necessary.)
9. Let's say you have a pea plant with round seeds. Round seeds are dominant, but you don't know if the genotype is RR or Rr. Explain how you would use a testcross to determine what the unknown parent genotype is. Use two Punnett squares to illustrate your results and help demonstrate your answer.
10. Define the law of independent assortment.

Critical Thinking

1. Do you think the Y chromosome contains genes that are critical to an organism's survival? Explain your reasoning.
2. Refer to the analysis questions in the "Modeling and Recognizing the Stages of Mitosis" lab from lesson 5. What is the diploid number of chromosomes in a human? (Express this as $2n =$ ___.) What is the haploid number in human gametes? ($n =$ ___) What is the diploid and haploid number in a dog?

3. Why is it important that gametes are haploid cells?
4. When Mendel performed his experiments, he had no understanding of DNA as genetic material. One thing he excelled at was careful observation. Review the scientific process of observation, forming hypotheses, testing hypotheses, and analyzing data. Use examples from Mendel's work to show how his work fits this pattern.
5. On figure 4.1 (171), you see that polydactyly is a dominant trait. What are the possible genotypes for someone to have this trait? (Use the letters D and d.) Knowing that there are few people who have this trait, what do you think that tells you about the relationship between dominance and commonality of a trait?
6. If crossing over were to happen on sister chromatids during meiosis, would it increase genetic diversity? Explain your response.

Activity

Complete the following activity.

Coin Toss Genetics

In this activity (full instructions are below), you will demonstrate how independent assortment works, and how the probability of a particular outcome of meiosis can be predicted.

The way genes behave during meiosis and fertilization can be simulated using two-sided coins, where heads represent the dominant allele (**A**) that results in normal skin and hair color, and tails represent the recessive allele (**a**) that results in albinism. Suppose a parent is heterozygous (Aa). Then, tossing a coin and checking whether it lands tails up or heads up represents the 50-50 chance that an egg or sperm produced by meiosis will include an **a** allele or an **A** allele.

To simulate reproduction between two heterozygous (**Aa**) parents, you and a friend will each toss a coin and the result of the pair of coin tosses will indicate the pair of alleles contributed to a baby by an egg and a sperm.

Before You Begin

Construct a Punnett square to predict the probability of each outcome. Review page 177, where probability is described, and be sure you understand how probability is expressed (as a fraction or percent), compared with how a ratio is expressed. Enter your predicted probabilities, as both a fraction and a percentage, in the last row of the data table below. Also, put the predicted number in a family of four children. The first column is filled out for you.

Procedure

You can do this with a partner, or by yourself, creating a fictitious person to be your partner. Each person has one coin.

1. Each of you will toss your coin, and this pair of coin tosses will indicate the pair of alleles in the first child produced by a mating of two heterozygous (**Aa**) parents. Make three more pairs of coin tosses to determine the genotypes for the remainder of the children in this family of four children. Record how many of these four children had each of the three possible genotypes (**AA**, **Aa**, or **aa**) in the row labeled "first family of 4 children" in the data table below.
2. Now make four more pairs of coin tosses to indicate the alleles in a second family of 4 children. Record these genotypes in the second row in the table.
3. Do this two more times and record the results in the third and fourth rows of the table.
4. Add up your results to determine the total number of children from your coin tosses who had **AA**, **Aa**, and **aa** genotypes.
5. Using your totals in each column, calculate the percentage of each genotype in your population of 16. Record this in the data table.
6. For each family of 4 children produced by your coin toss matings, compare the results with the predictions from the Punnett square. Do the same for the totals. Next to each row, indicate the following:
    - Put a checkmark for any family that has the expected number of albino (**aa**) children.
    - Mark an arrow for any family that has no albino children.
    - Put an asterisk for any family that has two or more albino children.

Data Table: Genotypes of "Coin Toss" Children Produced by Two Heterozygous (Aa) Parents

	AA	Aa	aa
first family of 4 children			
second family of 4 children			
third family of 4 children			
fourth family of 4 children			
Totals			
Results (as a percent)			
Predictions based on Punnett square (fraction and percent)	$\frac{1}{4} = 25\%$ 1 child		

Analysis

1. For each family of 4 children produced by your coin toss matings, compare the results with the predictions from the Punnett square. Do the same for the totals. Present your answer as a written description.

2. Can you explain any differences between your results and the predictions? How does this lab relate to independent assortment in meiosis?

3. You have two sample sizes here: your samples of 4 children in each family, and your total of 16 children. Which one more accurately matches the predictions based on the Punnett square? How do you think your results would compare to the predictions if you had a group of 100 children?

Lab

Complete Lesson 6 Lab: Modeling Meiosis. This lab expands upon the modeling you did in the previous lesson.

FOR ENROLLED STUDENTS

Notify your teacher when lessons 5 and 6 are ready for review. If you have any questions, please let your teacher know.

Name _____

LAB

6

Modeling Meiosis

In this lab, you will use the same materials that you used for the Mitosis Modeling lab in the previous lesson, but you will increase the number of chromosomes you are working with to represent homologous chromosomes.

The Guiding Question

How can we create a model to demonstrate meiosis?

Materials

- pipe cleaners, 2 each of four different colors
- yarn
- wooden beads

If you used food items in the last lab, you certainly may use them again, but you need to come up with two more pairs of sister chromatids that are distinguished somehow from the others. They can be different sizes, as before.

Before You Begin

Review the stages of meiosis as illustrated on pages 164–165 of your textbook. Note that you will also be modeling crossing over, so review how that works.

Procedure

1. Take each pair of chromatids, and connect them at the centromere as before. You will have four pairs of chromatids, each pair being a different color.
2. Decide which two colors are chromosomes from the father, and which are from the mother. Make a note of this.
3. As you model prophase I and the homologous chromosomes pair up, be sure each pair of homologous chromosomes has one from the father and one from the mother.

4. During prophase I, crossing over happens. You need to model this. There are several ways to do this. Note: Be sure that your sister chromatids are in every way identical before crossing over starts!
    - You can cut a segment of pipe cleaner and exchange with a segment on the homologous chromosome.
    - You can have the end of each sister chromatid marked by wrapping with colored yarn. You then exchange some of the yarn pieces with those on the homologous chromosome.
    - The end of each sister chromatid should be marked with a labeled piece of paper (A, B, etc.). You can then exchange these labels with those on some of the homologous chromosomes.
5. Now continue with your model, demonstrating each phase of meiosis. You have two options for showing each phase in your lab write-up:
    - Draw and label each phase you model.
    - Photograph each phase, being sure to add labels either on the model when you take the pictures, or as captions on the photos.

Analyze and Conclude

1. How does the chromosome number of each of the four daughter cells compare to the original chromosome number?

2. Will all the gametes produced by one parent be identical?

3. When an egg and sperm fuse during sexual reproduction, the resulting cell is called a zygote. How many copies of each chromosome and each gene will be found in a zygote?

Biology—Lesson 6 Lab: Modeling Meiosis

4. The pairing of the homologous chromosomes at the start of meiosis I is called ***synapsis***. How would the outcome of meiosis differ if synapsis did not occur? (It might be helpful to model this.)

Extension: Making Connections

Usually, when a scientist finishes a set of observations, many new questions come up. Think about meiosis and all of its phases, and come up with at least two questions that you could ask that could be explored with a model like yours. One way to think about it is with "what if" questions: What if this happened, or this didn't happen, or this happened differently, etc. Consider crossing over, independent assortment, and the infinite possibilities of genetic variation. Or you might consider a change in one of the phases. There are no wrong answers here, as long as it is something that you can test with your model. (A question like "How long does meiosis take?" is not testable with this model.)

Lesson

17

Taxonomy

Taxonomy (the science of classification) is often undervalued as a glorified form of filing—with each species in its folder, like a stamp in its prescribed place in an album; but taxonomy is a fundamental and dynamic science, dedicated to exploring the causes of relationships and similarities among organisms. Classifications are theories about the basis of natural order, not dull catalogues compiled only to avoid chaos.

Stephen Jay Gould, *Wonderful Life: The Burgess Shale and the Nature of History*

ASSIGNMENT SUMMARY

- ☐ Read chapter 17, The Tree of Life (485–505).
- ☐ Answer four Comprehension questions.
- ☐ Complete four Critical Thinking questions.
- ☐ Choose one:
  - Activity: Library Taxonomy!
  - Activity: Taxonomy of Mythical Creatures
- ☐ Activity: Construct a Cladogram
- ☐ Lesson 17 Lab: Bioinformatics

This quotation says a lot and gives due credit to the sometimes tedious science of classification. It is often perceived as boring and, as mentioned above, dull. But let's look at it in a new light! We are now embarking on a new unit, which will guide us into our study that will take up the rest of the course: all the forms of life that exist on Earth. In order to make sense of the complex diversity of life, scientists have devised a system of classification to categorize it all. This topic builds on our study of evolution, and just as with evolution study, as new discoveries are made, the taxonomic system flexes and changes. Consider it like the fluid mosaic model that you learned about when studying cell membranes (78). There is nothing rigid in taxonomy; it is a fluid model that changes with each new input.

As you will recall, to study the relationships between species, biologists study anatomical and molecular features, among others, and organize them into categories, showing how they evolved through time. If you review the concept map you made about the evidence for evolution in lesson 10, you will see the same features that you will now read about in this chapter—the criteria used to classify organisms.

Plan to spend one week on this lesson.

Lesson Objectives

- Learn the Linnaean system of classification, and how it has been augmented and changed with new evolutionary analysis methods
- Practice using cladistics as a classification tool
- Use an online database to investigate evolutionary relationships using bioinformatics

Assignments

Reading

Read chapter 17, The Tree of Life (485–505), in your textbook.

Think About It

The father of the system of classification we use today is Carolus Linnaeus. He was so passionate about his work that he even changed his name from Carl to Carolus to make it into a Latin name. He even classified his private letters into groups and subgroups! Linnaeus at first didn't think that we really needed the species descriptor in addition to the genus, but later decided that it was very helpful. He had some groupings that now seem odd, such as placing the rhinoceros among the rodents. He also bravely suggested the relationship between humans and apes. This was a radical move in the 18th century.

Think about Linnaeus's contribution. Consider how such a "mistake" as the rhino/rodent grouping would add to the general understanding of the natural world. Somebody had to come along later, look at it with a skeptical eye, puzzle over it, collect new evidence, and reclassify the rhinoceros. This is science at work, and this is the fluid nature of the system described above. Can you think of anything you classify in your life and how your classification system changes as your knowledge and perspective change? Perhaps you classify people in a certain way, and perhaps you have a friend who sees them another way. What are your reasons for your system? Give this some thought and discuss it with your family, friends, or fellow students.

Comprehension

1. Come up with a mnemonic device to help you remember the seven levels of Linnaean classification, from kingdom to species. You can find many online, such as "Keeping Precious Creatures Organized For Grumpy Scientists," or "Keep Pond Clean Or Froggy Gets Sick." Check out some of these if you like, but then come up with one of your own that you will remember. If you like, you can include domains as well, for the total of eight modern levels of classification.
2. Describe the rules used in binomial nomenclature.

3. Choose a species that is not in the textbook, and list the eight levels of classification for that species, using proper nomenclature.
4. Describe the contribution of genetic research in reorganizing the classification structure of kingdoms, and the creation of domains.

Optional Extra Credit

What is cladistics? Describe how derived characters are used to determine evolutionary relationships.

Critical Thinking

1. How is cladistics similar to the Linnaean system of classification? How are they different? Which system allows more room for revision as we learn more research techniques?
2. Which type of molecular clock would be most useful to examine the relationship between different species of the dog genus, *Canis*? Explain your choice.
3. Given the traditional definition of species according to the biological species concept, explain why it is difficult to classify members of Bacteria and Archaea at the species level. Look up the traditional definition of species in your glossary if you are not perfectly familiar with it, and review section 5.4 (140) before you form your response.
4. List some of the extreme environments that Archaea inhabit. It is thought that Archaea were some of the first life-forms on Earth. Explain how the first part of the question supports this theory.

Activities

Complete both of the activities, A and B.

A. Choose one of the following:

    1. Library Taxonomy!

        Go to the places in your home where you keep books. It is likely they are in some type of order so that a particular book can be found if need be. Look to see how they are categorized. For example, the books in your home might be divided into rooms (yours, your parents' room, the family room, etc.). In each location they might be grouped by subject (which ones are where?) or author. They might be grouped by size, which member of the family owns them, or any other type of classification. Describe the method used to categorize the books. Give an example of a particular book and tell how it came to be classified and placed where it is. (You may even want to use this as an opportunity to create order where there is none!)

    2. Taxonomy of Mythical Creatures

        For this activity, you will practice classifying organisms based on their characteristics. Use the following list of mythological organisms to complete the analysis (found below).

- **Pegasus** stands six feet tall, has a horse's body, a horse's head, four legs, and two wings.
- **Centaur** stands six feet tall, has a horse's body with a human torso, a male human head, and four legs.
- **Griffin** stands four to six feet tall, has a lion's body, an eagle's head, four legs, two wings, fur on its body, and feathers on its head and wings.
- **Dragon** can grow to several hundred feet, has a snakelike body, from one to three reptile-like heads, fur on its body and head, scales, and has the ability to breathe fire.
- **Chimera** stands six feet tall, has a goat's body, snake's tail, four legs, a lion's head, fur on its body and head, scales on its tail, and has the ability to breathe fire.
- **Hydra** is several hundred feet long, has a long body with four legs and a spiked tail, 100 snake heads, scales, and is poisonous.

Analysis:

1. Identify the characteristics that you think are the most useful for grouping the organisms into separate groups.
2. Classify the organisms into at least three groups based on the characteristics that you think are most important. Each creature should belong to only one group.
3. Review the biological species concept again. Explain whether this can be used to classify these mythical organisms.
4. Look up these other ways of defining species: ecological species concept, morphological species concept, and phylogenetic species concept. Which one did you use in this exercise? Would any of the others be useful with the information you have?

B. Construct a Cladogram

After reviewing figure 2.2 (495), complete the "Construct a Cladogram" quick lab (493). Draw the cladogram, and answer all three "Analyze and Conclude" questions. Include the cladogram with your lesson submission.

Lab

Perform Lesson 17 Lab: Bioinformatics. In this lab, you will be using bioinformatics to analyze the mtDNA of several land mammals, using the online database from the Dolan DNA Learning Center at the Cold Spring Harbor Laboratory in New York.

Name _____

LAB

17

Bioinformatics

In lesson 9, you learned about bioinformatics. Bioinformatics is the use of computer databases to store, organize, and analyze biological data. By comparing DNA sequences of different organisms, we can estimate how closely related they are. The more closely two organisms are related, the more similar their DNA sequences are. As you learned in this lesson, different types of DNA are used in comparisons. Mitochondrial DNA (mtDNA) changes at a faster pace than nuclear DNA, and is used to study relationships between closely related species. Nuclear DNA tends to degrade much faster than mtDNA. For that reason, forensic scientists have used mtDNA from hair, teeth, nails, and bone samples to solve many older cases.

The Guiding Question

How can bioinformatics be used to examine relatedness between species?

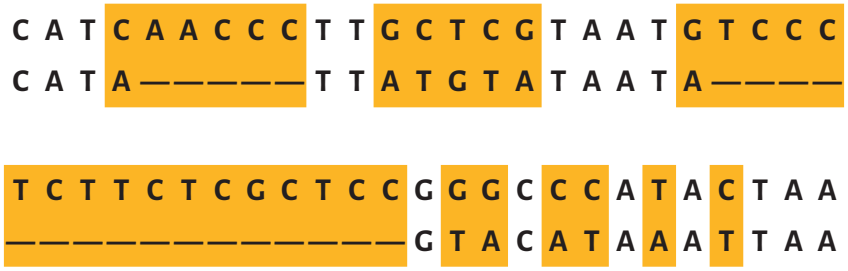
Hypothesize/Predict

Look at the data table below. Based on what you know about animal body structure, which was used in the past to determine species' relatedness, predict which pair of species in the data table you think are most closely related.

Procedure

1. Go to the Dolan DNA Learning Center website: http://www.dnalc.org/. Under "Websites" choose "Lab and Bioinformatics Sites," and then click on "BioServers." You can also go directly to the website here http://www.bioservers.org/bioserver/, but taking the roundabout route allows you to see the many other neat features of this resource.
2. Once you are on the BioServer website, click "Enter" under "Sequence server." Click on "Manage groups." This will open another window with some class data on it. Ignore that, go to the drop down menu at the top right, and choose "Non-human mtDNA." From there, select "Land mammal mtDNA" by checking the little box on the left, and click "OK" (not "View").

3. Now you will choose the four species that are in the data table below. You can get them all ready to compare by choosing each species in one of the drop down menus that come up each time you enter a species. Once you have all of them ready, select only two at a time to compare, as indicated by the data table. Once you select two, click "Compare" (not "Open").
4. A new window will open with the two sets of mtDNA sequences aligned for comparison. Change the number so it shows 1,000 per page ("Show ____ per page"). Then, select "Trimmed" and click on "Redraw."
5. You are now ready for counting! Where the mtDNA nucleotides do not match, they will be highlighted in yellow. There are also dashes where a nucleotide is not present in that position. If there is more than one dash in a row, count the entire run of dashes as a single difference. Count all the mismatches in this way, and write the total in the data table. Here is a sample set to make sure you are counting correctly.



There are 15 differences in these two lines. If you don't get 15 when you count them, reread the instructions and try again. Notice that the second line is a continuation of the first line, so the dashes in the first line continue right into the second, and should not be counted again (there are a total of only two differences due to missing nucleotides—dashes—in this sequence, one in the first line, and one in the first that continues to the second).

6. Record the number of base pairs shown for each comparison in the second column of the data table. This is the number that you see in bold print immediately above the data set: "Showing ____, starting from ____ and ending at ____."
7. Calculate the percentages of differences for each two species, and record that number in the table.

Percentage difference = (number of differences/number of base pairs) × 100

Name _____

Biology—Lesson 17 Lab: Bioinformatics

Data Table: mtDNA Comparisons

mtDNA types compared	Number of differences	Number of base pairs	Percentage
Dog #1 and European brown hare #1			
Dog #1 and Sika deer #1			
Lipizzan horse #1 and European brown hare #1			
Lipizzan horse #1 and Sika deer #1			

Analyze and Conclude

1. Which two species in the table share the most recent common ancestor, based on these data? Do your data match your prediction?

2. Which two species are the most distantly related, based on these data?

3. Notice that both of the above questions have the caveat "based on these data." Mitochondrial DNA is very useful in determining evolutionary relationships, but it is not the only type of molecular evidence. Describe two other types of molecular evidence that can be used to investigate evolution.

4. If you were to compare the mtDNA of the Lippizan horse and a dog, you would find only a 16% difference. Infer what this means about using mtDNA evidence alone when determining species relationships.

Extension: Making Connections

Choose some other species to compare or different organisms within the same species (there is room in the data table for two more). Human mtDNA is interesting. Spend five to ten minutes looking at a few more comparisons, and summarize what you find.

Lesson

23 Invertebrate Diversity

Nature has worked for a long, long time to make a leech, and we do not have something we've invented as scientists, engineers or doctors that has done better than what nature has done.

Dr. Stephen Sullivan, plastic surgeon at Rhode Island Hospital (Pappas, "Woman's Ear Reattached with Help of Leeches")

You're probably wondering what in the world the above quote is all about. It is about the amazing leech! Leeches—those disgusting, slimy things that get on you when you're wading in water and suck your blood and make you freak out because you can't get them off—are a tool that has been used for centuries in medicine. In the last century, practitioners of modern medicine thought they could do better, relying on antibiotics and other medicines, and the leech faded into obscurity. Recently it has been rediscovered as a surgical tool, mostly for microsurgery and reconstructive surgery. Very often in these situations, there is no way for the blood to drain from a wound until new blood vessels grow. Enter the leech! They use amazing precision to clean wounds of congested deoxygenated blood until the wounds heal and new blood vessels grow. So the next time a leech attaches to your ankle when you are wading in the local stream, thank it for the good work it does (and remember that salt is the best way to get it off)!

This lesson starts with an introduction to animals, including the evolutionary history of animals, and then goes into the simpler forms of invertebrates, including leeches. We learn about seven of the major phyla of animals in this lesson (including leeches, of course).

Plan to spend two weeks on this lesson.

You will want to begin Activity A right away because you need two weeks to complete it.

ASSIGNMENT SUMMARY

- ☐ Read Chapter 23, Invertebrate Diversity (651–678)
- ☐ Answer three Comprehension questions.
- ☐ Complete three Critical Thinking questions.
- ☐ Activity: Invertebrates
- ☐ Activity: Scatterplots
- ☐ Activity: Computer Modeling
- ☐ Activity: Major Phyla (work in progress)
- ☐ Choose one:
  - Lesson 23 Quick Lab A: External Anatomy of a Live Worm
  - Lesson 23 Quick Lab B: Virtual Earthworm Anatomy

Lesson Objectives

- Gain an overview of the general characteristics of animals and animal diversity
- Learn about the new molecular evidence that is changing our understanding of animal phylogeny
- Explore the characteristics of several phyla of invertebrates through reading and hands-on dissection
- Practice with organizing complex information in chart form

Assignments

Reading

First, scan the layout of Chapters 23–26, to get a sense of what types of animals are discussed in each chapter. Read chapter 23, Invertebrate Diversity (651–678), in your textbook.

As you read, pay special attention to sections 1 and 2, which describe the basic characteristics of animals, and the newer research methods that have improved and changed our understanding of animals. Also pay attention to the diagrams (something you should always be doing!). Figure 2.4 (659) sums up most of the information in section 2, so be sure to look at it closely. You might even want to bookmark it, in order to refer to it later when you are figuring out where an animal fits into the big picture.

Think About It

Note that the phylogeny in figure 2.4 mentioned above is entirely new within the last couple of decades, thanks to molecular evidence from ribosomal DNA and *Hox* genes. If you have an old biology textbook lying around, or want to look up "animal phylogenetic tree" online, you can compare and see the changes that have been made. Do you think it will change this much again in the next two decades?

Comprehension Questions

Read and study all of these questions, and respond to three questions of your choice. (Remember to begin Activity A right away as you need two weeks to complete it.)

1. Describe the derived characters that all animals share.
2. Why is it that radial animals cannot have complex organ systems?
3. What is the function of a gastrovascular cavity in jellyfish?
4. Contrast the way planarians and tapeworms feed.

5. What is the advantage of having a complete digestive tract (which started in mollusks) as opposed to the gastrovascular cavity found in cnidarians or the simple gut tube in some flatworms?
6. What characteristics make cephalopods unique among mollusks?
7. Classify the following as roundworms, segmented worms, or flatworms:
   a. leeches
   b. tapeworms
   c. earthworms
   d. pinworms
8. Describe how sea stars move.

Critical Thinking

1. How does the structure of animal cells allow animals to move?
2. Explain how *Hox* genes likely led to the diversity of animals and resulting speciation and evolution.
3. How might a community prevent *Schistosoma* infections?

Activities

Complete the activities below.

A. Invertebrates

For the next two weeks, take note of all the invertebrates that you have contact with in your daily activities. Discuss this with your family, and keep a list. See how long you can make your list, and remember, this is only the invertebrates that you can see! At the end of two weeks, name what phylum each invertebrate belongs to.

B. Scatterplots

Review the "Analyzing Scatterplots" data analysis exercise on page 677. There are no assignments due for this, but be sure you understand what a scatterplot is, and how to interpret data on them. For example, in graph 3, notice that the curve levels out as the shell diameter of the snails gets larger. This could be due to the fact that there is a limit to heart size in snails. These are the kinds of things to look for in a scatterplot. Could you draw a straight line through the plotted data, or a curve, or neither?

C. Computer Modeling

As you've learned during this course, in scientific research and analysis, computers have found an indispensable niche, both for data analysis and modeling. We can use models to predict

something local, such as the effects of introducing a new species to an area, or huge things such as climate change and the origin of the universe.

Your assignment is to visit *NetLogo* from the Center for Connected Learning (CCL) and Computer-Based Modeling (Northwestern University) at the following website: http://ccl.northwestern.edu/netlogo/index.shtml

NetLogo was first created in 1999 by Uri Wilensky at the Center for Connected Learning and Computer-Based Modeling, then at Tufts University. Since then, the CCL has moved to Northwestern University, and the program has been updated several times. Now it is used widely for education as well as research.

Read about the program, check the FAQs, and then download the program. From your downloaded version, you can find the library of sample models. These are also visible online, but you will want to access and run the models from your applications folder.

Explore the "Bug Hunt Camouflage" model and all its features. When you click on the model, you will see a menu bar at the top, and one of the tabs is "Info." Be sure you read this to get familiar with the purpose of the model and how to use it. Then spend some time with the model, trying out the different environments and settings. Recognize that this is a model, not a game (though it can be fun!). You can try to catch as many bugs as fast as you can, and this results in a scenario that we are all too familiar with, something we've seen with overhunting or overfishing. The prey then need time to recover. In this case, they are bugs, with a short generation time. Mutations and natural selection happen relatively quickly.

After you are very familiar with "Bug Hunt Camouflage," choose two more models to try out. These do not have to be related to biology—it is your choice! Give them the same thorough investigation as you did the first one. These take a little getting used to, so be patient with yourself as you learn the ropes.

Finally, write a summary of your experience. Which models did you try? Were any easier or harder to use? Do you see the usefulness of these models for education? For research?

You have now set yourself up for an easy transition when we return to this in the next lesson, when we will be exploring "Bug Hunt Camouflage" to practice scientific argumentation and peer review.

D. Major Phyla

Continue working on your unit-long project described in the unit introduction. (If you haven't started yet, refer to the unit introduction preceding this lesson for details.)

Lab

Complete one of the following quick labs:

- Quick Lab A: External Anatomy of a Live Worm
- Quick Lab B: Virtual Earthworm Anatomy

In this lab, you will be taking a close look at an earthworm. There are two choices for this lab: A) looking at a live earthworm that you dig up (preferred), or B) doing a virtual lab. If at all possible, try to find a real worm—it's fun playing with worms! (You may need to put this off until the weather warms up.)

FOR ENROLLED STUDENTS

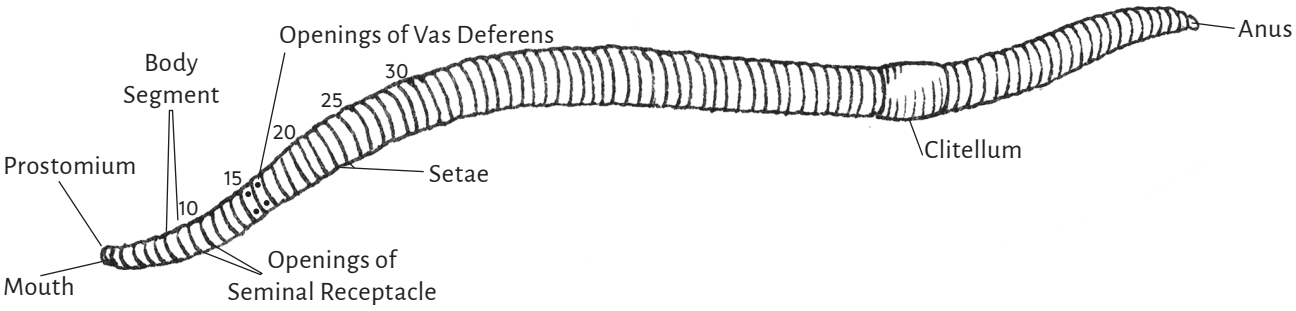
If you choose Quick Lab A for this lesson, External Anatomy of a Live Worm, and need to postpone it until the weather warms up, just let your teacher know.

Name _____

LAB

23

Quick Lab A: External Anatomy of a Live Worm



Materials

- an earthworm (the fatter the better)
- a shallow pie pan
- a pencil with an eraser
- hand lens

Procedure

1. Find a nice fat earthworm. Place it in a shallow pie pan while you study it.
2. Examine the earthworm with your hand lens. Locate the segments, mouth, anus, and clitellum (what does that do?). See if you can locate the setae or seminal openings as well. Use the eraser end of your pencil to prod the worm gently and keep it from crawling away.
3. Draw a sketch of your worm, labeling all the parts you can identify.
4. Observe its crawling motion. Describe how it moves.
5. Release your worm and clean up.
6. Submit your labeled diagram and description with your work for this lesson.

Biology—Lesson 23 Quick Lab:
A: External Anatomy of a Live Worm

Optional Extension (extra credit!)

Choose one of the following to research, and write up your findings in a one-half to one-page report. Note: You may use this for your unit project option.

1. Did you know that earthworms are not native to many parts of the United States? They were wiped out in the northern United States with the last ice age, and the northern forests have evolved without them. With the arrival of the Europeans, however, nightcrawlers and many other worm species have been introduced. Fisherman toss their extra worms in the soil, thinking they are doing good. However, these worms are actually quite harmful to northern forest soils. Do a little research on the effects of these invasive species on the forest soils, and report what you find.
2. Earthworms have quite an advanced system of locomotion. They don't need to wiggle back and forth as snakes do, and this is for a couple of reasons: they have no backbone, and they have segments. The segments are an integral part of what allows earthworms to move. Research the mechanism behind earthworm movement. Feel free to include an illustration to help you explain the process. If you have access to a live worm, watch closely as it moves to see this advanced locomotive system in action.

Enrolled students: If you are interested in these topics but are unsure if you have the time, please discuss options for flexibility with your teacher.

Name _____

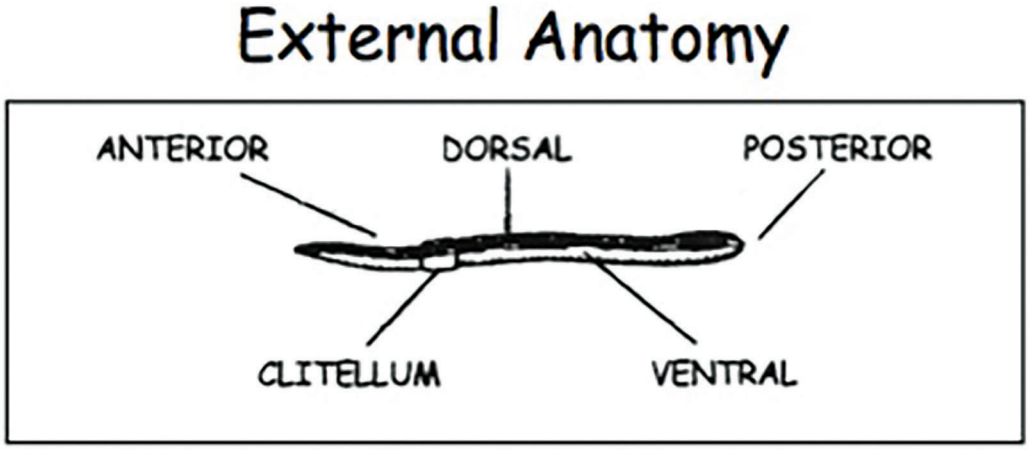
LAB

23

Quick Lab B: Virtual Earthworm Anatomy

Earthworms (*phylum Annelida*) show some of the important advancements in animal evolution that you are learning about. They have a *complete digestive tract* for efficient digestion, *segmentation* that allows efficient movement, and a *hydrostatic skeleton*. You will see all of these up close in this lab as we explore (virtually) both the internal and external anatomy of a worm.

1. Take a look at the external anatomy of an earthworm that is shown in the labeled diagram in Quick Lab A in your coursebook so you can be familiar with these structures. Also understand the anatomical terms in the following diagram, as you will hear these throughout the videos.



(Image credit: luzierscience.weebly.com)

View this video* of an earthworm dissection:

"Dissection 101: Detailed Earthworm Dissection"

https://opb.pbslearningmedia.org/resource/41b655c3-2791-4b66-89df-04fa972f0563/detailed-earthworm-dissection-video/

Biology—Lesson 23 Quick Lab:
B: Virtual Earthworm Anatomy

2. Here is another good video* that is highly recommended. It includes diagrams to help you see some of the more challenging structures in the earthworm.

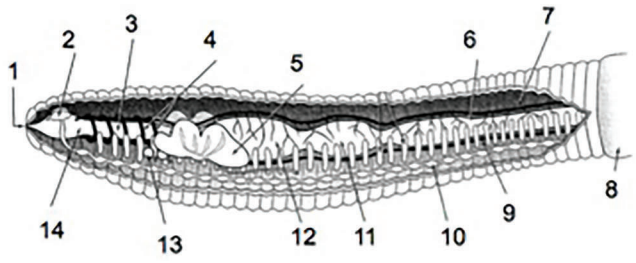
   "Biology Lab: Earthworm Dissection"

   https://www.youtube.com/watch?v=aCnwF6vtE2g&ab_channel=aceconnect

3. When you are ready, see if you can identify the anatomical structures in the earthworm diagram below. As needed, go back to the videos for assistance.

Match the letter appearing in front of each word in the word bank with the number of the structure.

a. Mouth
b. Pharynx
c. Esophagus
d. Crop
e. Gizzard
f. Intestine
g. Aortic Arches (Hearts)
h. Dorsal Blood Vessel
i. Ventral Blood Vessel
j. Clitellum
k. Seminal Vesicles
l. Seminal Receptacles
m. Ventral Nerve Cord
n. Brain



(Image credit: luzierscience.weebly.com)

When you are done, compare your answers with the answer key at the end of this lab. How did you do? Did you need to make any corrections?

Optional Extra Credit (answer any or all)

a. What are the two sets of muscles that help an earthworm move? Describe what they each do.

b. What is the advantage of segmentation?

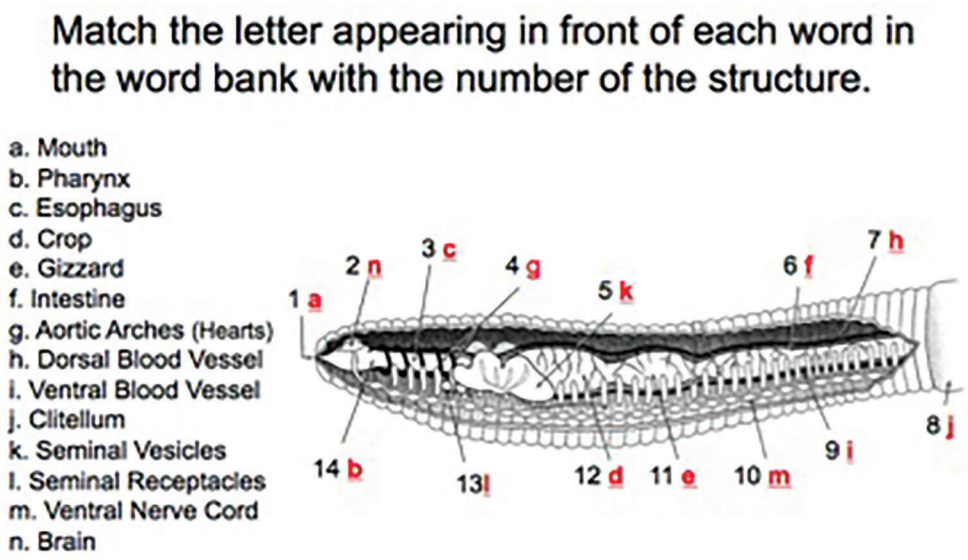
c. What does the hydrostatic skeleton do for the earthworm?

d. Earthworms are hermaphrodites. What does that mean?

*__Ecological note:__ Did you notice that in both of the videos earthworms are described as being very good for the soil ecology? This is true—sometimes—but not in the forests of the northern United States, where they are not a native species and are destroying the soil food web. See the lab extension options to learn more.

Name _____

Biology—Lesson 23 Quick Lab: B: Virtual Earthworm Anatomy



(Image credit: luzierscience.weebly.com)

Optional Extension (extra credit!)

Choose one of the following to research, and write up your findings in a one-half to one-page report. Note: You may use this for your unit project option.

1. Did you know that earthworms are not native to many parts of the United States? They were wiped out in the northern United States with the last ice age, and the northern forests have evolved without them. With the arrival of the Europeans, however, nightcrawlers and many other worm species have been introduced. Fisherman toss their extra worms in the soil, thinking they are doing good. However, these worms are actually quite harmful to northern forest soils. Do a little research on the effects of these invasive species on the forest soils, and report what you find.
2. Earthworms have quite an advanced system of locomotion. They don't need to wiggle back and forth as snakes do, and this is for a couple of reasons: they have no backbone, and they have segments. The segments are an integral part of what allows earthworms to move. Research the mechanism behind earthworm movement. Feel free to include an illustration to help you explain the process.

Enrolled students: If you are interested in these topics but are unsure if you have the time, please discuss options for flexibility with your teacher.

Name _____

Second Semester Test

1. State whether each of the following organisms are in the domain Bacteria, Archaea, or Eukarya.
   a. bread mold
   b. slime mold
   c. *Streptococcus mutans* (causes tooth decay)
   d. wood fern
2. For each of the above species, name the kingdom it belongs to.

_____

_____

_____

_____

Multiple Choice

3. In the past 150 years, the classification of life has changed through the addition and restructuring of kingdoms and domains. This system is always changing because . . .
   a. scientific study keeps producing more data.
   b. evolution keeps producing new organisms.
   c. extinctions change evolutionary relationships.
   d. humans increase the rate of speciation.

4. Humans are multicellular organisms, and we have about 3.4 billion base pairs in our genome. Yeasts are single-celled organisms with about 13 million base pairs in their genome. Both of these groups are classified as eukaryotes because they . . .

   a. can reproduce sexually.

   b. have over one million base pairs.

   c. utilize aerobic respiration.

   d. have a similar basic cellular structure.

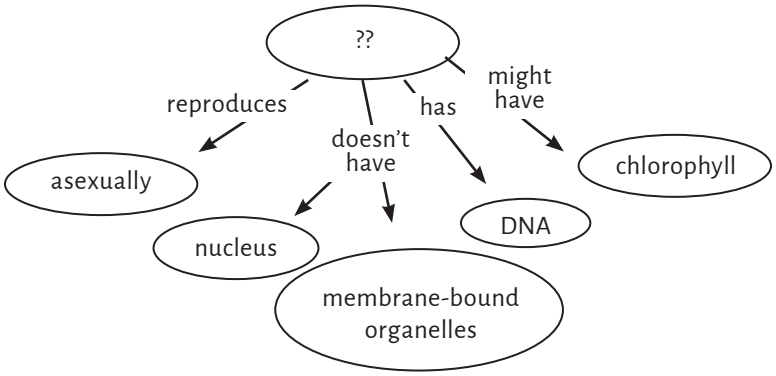
5. Which of the following is *not* true about viruses?

   a. They can reproduce on their own.

   b. They have genes.

   c. They are not made of cells.

   d. They do not contain a nucleus.



6. Which of the following fills in the blank in the concept map above?

   a. animal cell

   b. bacterium

   c. plant cell

   d. virus

Second Semester Test

7. What type of infection is described by the following? A pathogen enters a host cell, takes over the host's DNA to copy its own genes, and then bursts and destroys the host cell.
   a. single cell
   b. lysogenic
   c. bacterial
   d. lytic
8. How do fungi affect other organisms in the community?
   a. They keep other populations under control by preying on weak organisms.
   b. They make stored nutrients available to other organisms.
   c. They compete with plants for sunlight.
   d. They compete with plants for soil nutrients.
9. If an organism undergoes asexual reproduction, it does *not* undergo which process during reproduction?
   a. budding
   b. mitosis
   c. meiosis
   d. fission
10. The fossil record from the Cretaceous period contains the fossils of a variety of dinosaurs and seedless plants. The fossil record after the end of this period includes the fossils of many flowering plants and small animals, but no dinosaurs. Which of the following statements is supported by this evidence?
    a. Dinosaurs had begun to die out during the Cretaceous.
    b. The Cretaceous environment was less favorable to seedless plants than to flowering plants.
    c. A mass extinction at the end of the Cretaceous period made new niches available for flowering plants.
    d. Dinosaurs evolved around the end of the Cretaceous.

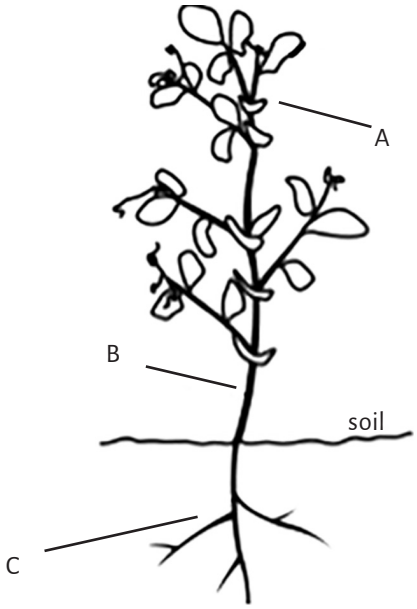
11. Which choice describes the way sugars are most commonly transported through the vascular system in the plant to the right?

    a. A to B only

    b. A to C only

    c. A to B to C

    d. C to B to A



12. Which leaf adaptation occurs in both deserts and cold dry climates to minimize water loss in plants?

    a. plump leaves that store water

    b. large and broad leaves

    c. compound and double compound leaves

    d. needles and spines

13. Cutting off the growing tip of a plant reduces auxin in the primary stem and encourages growth . . .

    a. toward light.

    b. of side branches.

    c. in the fruit harvest.

    d. beyond normal size.

14. Phyla of animals are defined by . . .

    a. structural and functional characteristics.

    b. whether they are used for food or energy.

    c. sexual or asexual reproduction.

    d. colors, behaviors, and movement patterns.

Second Semester Test

15. The surface of an arthropod's body is covered by a protective . . .

    a. coating.

    b. exoskeleton.

    c. appendage.

    d. endoskeleton.

16. Yellow fever is caused by a virus that is transmitted by mosquitoes. There is a vaccination for yellow fever. It contains small doses of the virus that . . .

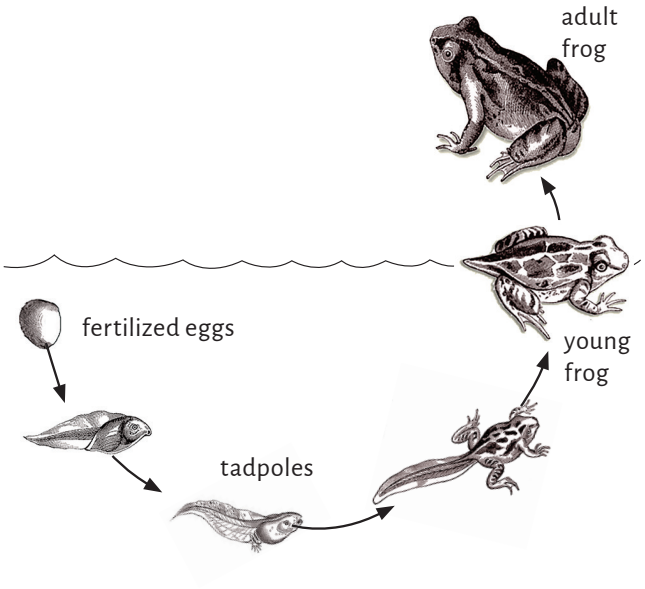
    a. kill any mosquitoes that bite the person.

    b. mutate in the person's bloodstream.

    c. allow the person to build up an immunity.

    d. kill all the viruses in the person's bloodstream.

17. This illustration shows the metamorphosis of a frog. Which of the following statements is true?



    a. Tadpoles can live on land or in water.

    b. Some amphibians lay eggs in the water.

    c. Frogs live only on dry land.

    d. Adult frogs can't survive out of water.

18. Fossils found in New Zealand suggest that as many as 2,000 frog species lived there in the past. Today, there are fewer than 300 frog species. What conclusion can you draw from this information?

    a. The climate conditions of New Zealand have changed over time.

    b. The species alive today are more specialized to particular niches than species in the past.

    c. Biological diversity of frogs in New Zealand has decreased.

    d. There are fewer frog species today because a mass extinction occurred.

19. As shown in this diagram, which feature of a bird's wing do airplane wings copy?

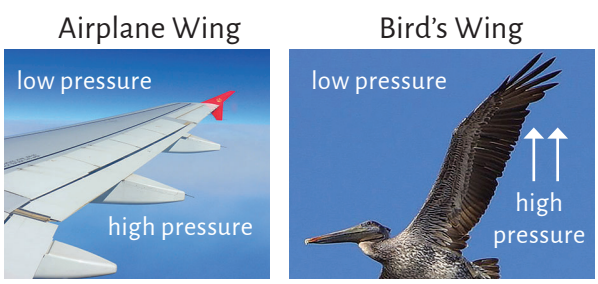
    a. strut system

    b. pressurized design

    c. convex bottom

    d. airfoil design

Cross section of



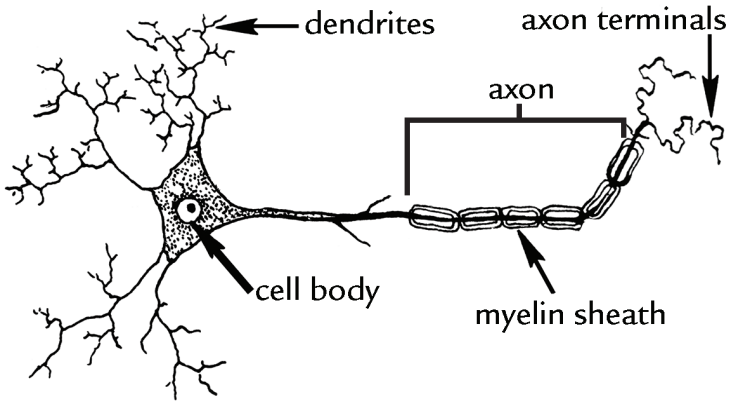
20. Which part of this neuron carries messages to the cell body?

    a. dendrites

    b. axon

    c. terminals

    d. myelin sheath



True/False

21. **True** **False** An increasing problem with viruses is that they are becoming resistant to antibiotics.

22. **True** **False** Bioremediation is a process that uses microbes and other living things to break down pollutants.

23. **True** **False** Fungi can be either heterotrophs or autotrophs.

24. **True** **False** Colorful petals would not be an advantage to a wind-pollinated flower.

25. **True** **False** Ethylene is a plant hormone that causes a plant to bend toward the light.

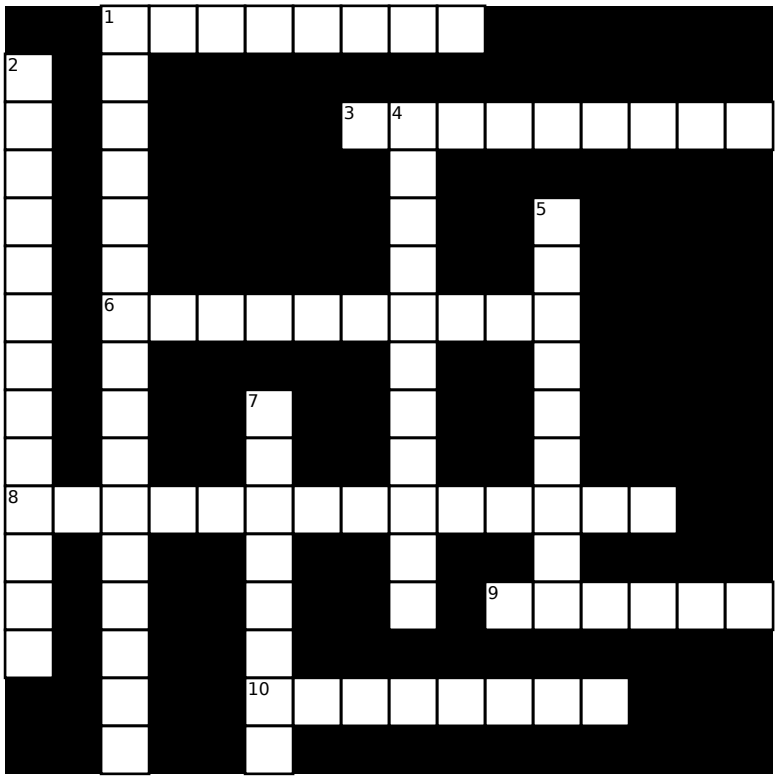
26. **True** **False** An octopus is a free-swimming vertebrate that lives in the ocean.

27. **True** **False** The embryo of a eutherian mammal receives oxygen and nutrients through the placenta.

Second Semester Test

28. Complete the following animal behavior crossword puzzle. If an answer is two words, leave a blank space between the words.

Animal Behavior Crossword Puzzle



Across

1 A type of behavior that is taught from one generation to another in a population

3 A chemical released by an animal that affects the behavior of another of the same species

6 An irreversible learning process by which a newborn animal quickly learns to recognize another animal, such as its parent

8 A behavior pattern in which an organism controls and defends a certain area

9 A behavior that is performed correctly the first time, not learned through experience

10 A type of information that elicits a response in an organism

Down

1 A daily cycle of activity over a 24-hour period that is controlled by the biological clock

2 When natural selection acts on alleles that favor the survival of close relatives

4 The process of an animal's behavioral response decreasing due to repeated stimulus

5 An "energy expensive" type of behavior where an animal travels a long distance for better living conditions

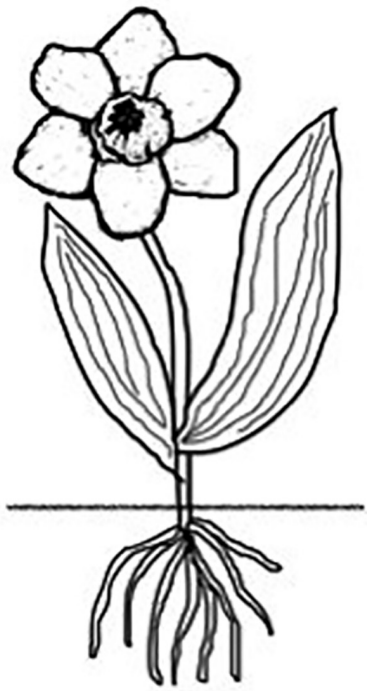
7 A type of behavior in which the animal reduces its own fitness to help other members of its social group

Second Semester Test

Short Answer

29. Why do both seedless vascular plants and amphibians need to live in moist environments?

30. Is this plant a monocot or dicot? Explain why.



31. Use these words to fill in the blanks in the following paragraph. (Note: there are more words than you will need!)

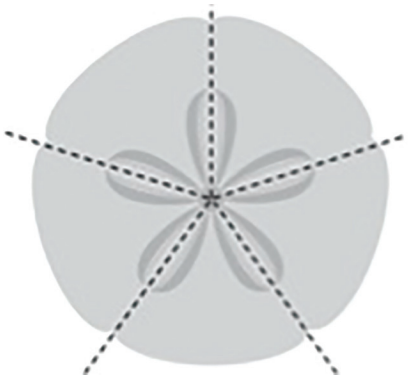
mesophyll	stomata
vascular	root hairs
phloem	xylem
transpiration	meristem

The system of _____ tissue transports water and nutrients throughout a plant. It consists of two different types of tissue, _____ and _____. Water is lost from plants in a process called _____, which can only happen when the _____ are open.

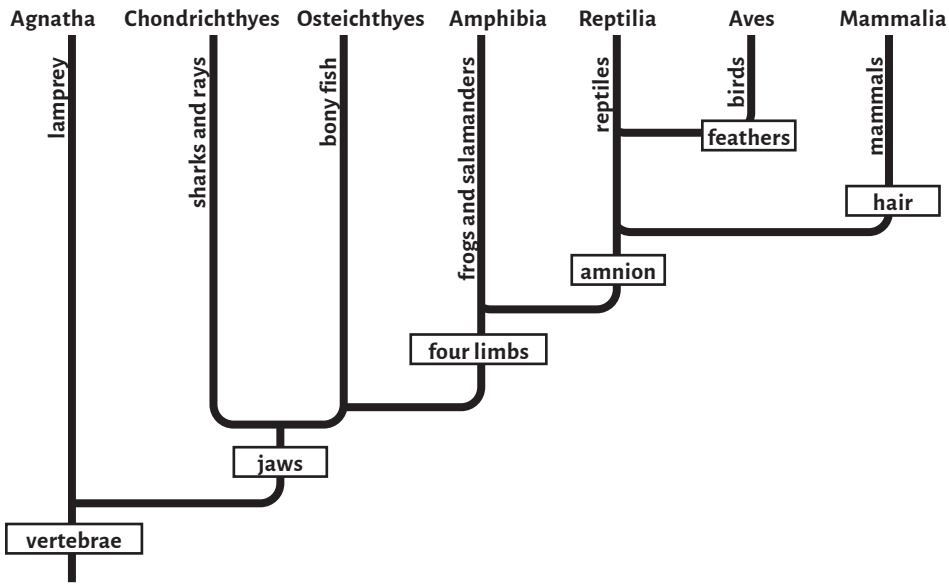
Name _____

Second Semester Test

32. What type of symmetry does this animal have?



Vertebrate Phylogenetic Tree



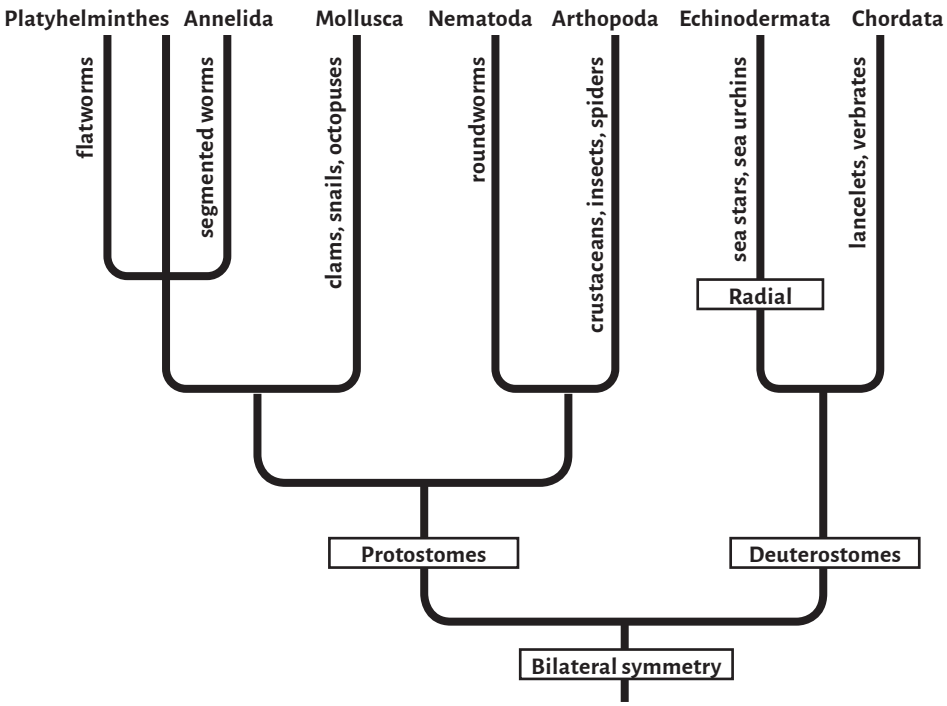
33. Use the partial phylogenetic tree above to answer the following questions:

    a. What do the smallest branches of this tree represent? _____

    b. Which phylum is most closely related to annelids? _____

    c. What do protostomes and deuterostomes have in common? _____

34. How did the evolution of jointed appendages lead to the wide variety of arthropods that exist today?



35. Use the vertebrate phylogenetic tree above to answer the following questions:

    a. What do the branches of this tree represent?

    b. According to the tree, what do reptiles, birds, and mammals have in common?

Second Semester Test

c. What fundamental characteristic do frogs and birds share?

_____

_____

36. Pressure increases with depth underwater. How does swimming deep in the ocean affect a fish's swim bladder?

_____

_____

_____

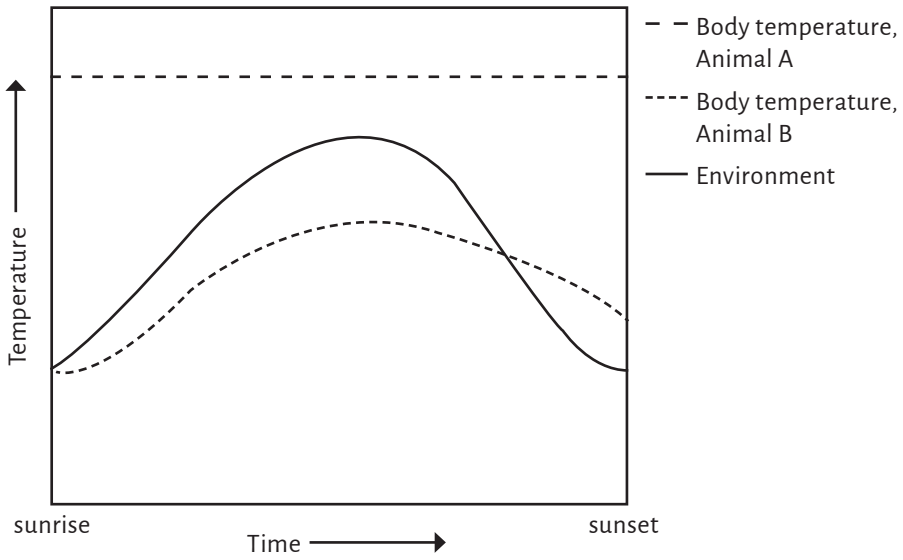
37. A sea turtle may lay up to 200 eggs in a nest, then return to the ocean. The young turtles must fend for themselves when they hatch. How do mammals differ in the number of offspring produced and in the amount of parental care?

_____

_____

_____

38. Using the diagram to the right, answer the following questions:



a. Which animal, A or B, is most likely to be an endotherm?

_____

b. Which animal, A or B, is most likely to be an ectotherm?

_____

c. Which animal needs to eat more food?

_____

d. Which animal might be observed to be shivering or sweating? _____

Second Semester Test

39. The white-fronted bee eater is a bird species that lives in family groups consisting of a breeding pair and some nonbreeding pairs. All adults help in the raising of the young. Since natural selection favors traits that enable an individual to pass on its own genes, how is this situation advantageous to the nonbreeding adults in this regard?

40. State whether each of the following is an example of positive feedback or negative feedback:

    a. thermoregulation, in which an animal maintains a constant body temperature

    b. A crew on a sailing ship works together to keep the ship on course despite changes in the wind and sea conditions. The lookouts see rocks ahead and alert the captain. The captain gives orders to the crew to change course. The sailors adjust the rudder and the sails to avoid the rocks. Once the impending disaster is averted, the captain receives the "all clear ahead" notice from the lookouts, and gives orders to restore the original course.

Bonus Question: What did the fungus say to the alga?

Appendix

Biology Materials List and Lab Kit

Below you will find all of the materials required for the lab activities in this course. Most of the items should be commonly available, and you may even have them around the house already. The first table is sorted by lesson and lab, so items that are used in several labs (such as a calculator or dish detergent) will be repeated. In the first table, items in red are those that are included in the Oak Meadow Biology Lab Kit, which is available from the Oak Meadow bookstore. The complete lab kit contents are listed below.

The second table shows the same list of materials, sorted alphabetically by item. The list includes only those items that you will have to procure yourself (the lab kit items are not in this list since it is assumed you will already have the lab kit). Both tables show the same information; they are simply arranged differently so that you can plan your labs in the way that works best for you.

Before you purchase or gather your materials, please read through the entire lab so you have a better idea of what you need (and why). Some lessons have a choice of labs and some labs have a choice of materials, so you may not need everything listed here.

Contents of Oak Meadow Lab Kit

QTY	
4	Beads
1	beaker, glass, 250 mL
1	digital scale
1	envelope containing strips of Picture A or Picture B
1	eyedropper
1	funnel
1	graduated cylinder, 100 mL
1	magnifier, folding (double large)
2	microscope slides
1	pH indicator paper
12	pipe cleaners
1	ruler, metric
1	safety goggles
1	screen, 3" circle
1	test tube
1	thermometer
1	tweezers

Materials List (sorted by lesson)

You can assume that paper and pencil will be needed for most labs, and often water. Sometimes people are needed for your lab as well, but they are not listed as materials.

Lesson	Lab Title	Materials (items in red are included in the Oak Meadow lab kit)
1	**Walking Crooked!**	• measuring tape or string, 10 meters long • 5–10 markers to imitate "bread crumbs" to mark your path, such as popcorn, Legos, dry beans, etc. • blindfold
2	**Determining the pH of Common Substances**	• wide-range pH indicator paper • 6 common household substances (choose from this list): lemon juice window cleaner coffee vinegar bleach mouthwash cola or other type of soda milk baking soda dissolved in water orange juice or other fruit juice tea dish detergent
3	**Observing Osmosis in an Egg Cell**	• 3 raw eggs • white vinegar • corn syrup • 3 clear glasses • digital scale • rubber gloves, optional

Lesson	Lab Title	Materials (items in red are included in the Oak Meadow lab kit)
4	**Examining the Effect of Light Intensity on Photosynthesis**	• test tube • beaker, 250 mL • liquid measuring cup • funnel • 2–3 sprigs of *Elodea* • sodium bicarbonate solution ($NaHCO_3$) (2 teaspoons baking soda in 500 mL of water) • source of bright light • watch or clock • metric ruler
5	**Modeling and Recognizing the Stages of Mitosis**	• pipe cleaners, 2 each of two different colors • Twizzlers, 2 longer pieces and 2 shorter pieces • yarn • shoestring licorice • 2 beads • 2 marshmallows
6	**Modeling Meiosis**	• pipe cleaners, 2 each of four different colors • yarn • beads
8	**Demonstration Lab: DNA Extraction**	• strawberry • isopropyl alcohol (10 mL) • dish soap (10 mL) • salt ($\frac{1}{4}$ tsp) • heavy duty zipper-lock bag • screen, 3 inch circle • graduated cylinder for measuring • beaker, 250 mL • small clear glass • tweezers • spoon
10	**Piecing Together Evidence**	• envelope with strips of "Picture A" or "Picture B"
11	**Practicing with Histograms and Distribution Curves**	• graph paper • colored pencils

Lesson	Lab Title	Materials (items in red are included in the Oak Meadow lab kit)
13	**Random Quadrat Sampling in the Field**	• quadrat about 1 meter square (see instructions in lesson 13 for how to construct a quadrat)
	Simulated Random Quadrat Sampling	• 2 small containers • scissors
14	**Analyzing Predator-Prey Interactions**	• graph paper • colored pencils (optional)
	Modeling Succession	• 1 quart glass jar with a lid • $\frac{1}{2}$ quart of milk (2 cups) • pH strips • small picnic cooler
16	**Modeling the Effects of Habitat Fragmentation**	• two 8 x 11 grids • calculator • colored pencils • black pen
18	**Make Your Own Yogurt**	• $\frac{1}{4}$ cup of plain yogurt with active cultures • 1 quart milk • thermometer • stainless steel or ceramic saucepan • wire whisk • large bowl • ice cubes and water • one quart glass jar • a small picnic cooler (preferred) or oven
19	**Quantifying Mold Growth**	• 1 or 2 slices of bread • eyedropper • sealable plastic lunch bags • digital scale
21	**Inquiry Lab: Transpiration Rate**	• 2–3 bunches of celery with leaves attached • jars • red food coloring and water • metric ruler

Lesson	Lab Title	Materials (items in red are included in the Oak Meadow lab kit)
22	**Flower Dissection**	• monocot flower • dicot flower • tweezers • magnifier • tape
	Observing the Effects of Ethylene on Ripening Fruit	• 6 green bananas • 1 apple • 2 paper bags or plastic grocery bags
23	**Quick Lab: External Anatomy of a Live Worm**	• an earthworm (the fatter the better) • a shallow pie pan • a pencil with an eraser • magnifier
25	**Quick Lab: Modeling the Action of a Swim Bladder**	• 250 mL beaker or small glass • cold, clear, carbonated soft drink or seltzer • 2 dry raisins
	Exploring External Fish Anatomy (see alternate materials below)	• live goldfish or other aquarium fish • 250 mL beaker
	Exploring External Fish Anatomy (alternate materials)	• a whole fish bought from the grocery store • shallow baking dish or plate • magnifier • tweezers • 2 microscope slides • dish detergent • small glass
26	**Comparing Bone Density**	• boiled fish bone • boiled chicken bone • small boiled beef bone • 100 mL graduated cylinder • digital scale • screwdriver • hammer • safety goggles • magnifier

Lesson	Lab Title	Materials (items in red are included in the Oak Meadow lab kit)
27	**Using an Ethogram to Describe Animal Behavior**	• an animal (a pet, farm animal, or zoo animal) • watch • calculator
	Observing Nonverbal Human Communication	• watch • calculator

Alphabetical List of Materials Not Included in Lab Kit

You will not necessarily need all the items on this list; some are optional items and some lessons provide a choice of lab.

ITEM	LESSON/LAB
animal (pet, farm animal, zoo animal, for observation)	Lesson 27 Lab: Using an Ethogram to Describe Animal Behavior
apple	Lesson 22 Lab: Observing the Effects of Ethylene on Ripening Fruit
baking soda	Lesson 2 Lab: Determining the pH of Common Substances Lesson 4 Lab: Examining the Effect of Light Intensity on Photosynthesis
bananas, 6 green	Lesson 22 Lab: Observing the Effects of Ethylene on Ripening Fruit
black pen	Lesson 16 Lab: Modeling the Effects of Habitat Fragmentation
bleach	Lesson 2 Lab: Determining the pH of Common Substances
blindfold	Lesson 1 Lab: Walking Crooked!
bone, boiled fish bone	Lesson 26 Lab: Comparing Bone Density
bone, boiled chicken bone	Lesson 26 Lab: Comparing Bone Density
bone, boiled beef (piece)	Lesson 26 Lab: Comparing Bone Density
bowl, large	Lesson 18 Lab: Make Your Own Yogurt
bread	Lesson 19 Lab: Quantifying Mold Growth
calculator	Lesson 16 Lab: Modeling the Effects of Habitat Fragmentation
candy thermometer	Lesson 18 Lab: Make Your Own Yogurt
carbonated cola or other type of soda	Lesson 2 Lab: Determining the pH of Common Substances
carbonated soft drink or seltzer, clear	Lesson 25 Activity: Modeling the Action of a Swim Bladder
celery with leaves attached	Lesson 21 Lab: Transpiration Rate
coffee	Lesson 2 Lab: Determining the pH of Common Substances
colored pencils	Lesson 11 Lab: Practicing with Histograms and Distribution Curves Lesson 14 Lab: Analyzing Predator-Prey Interactions Lesson 16 Lab: Modeling the Effects of Habitat Fragmentation
containers, 2 small	Lesson 13 Lab: Simulated Random Quadrat Sampling
corn syrup	Lesson 3 Lab: Observing Osmosis in an Egg Cell
dish detergent	Lesson 2 Lab: Determining the pH of Common Substances Lesson 8 Lab: Demonstration Lab: DNA Extraction Lesson 25 Lab: Exploring External Fish Anatomy
earthworm	Lesson 23 Lab: External Anatomy of a Live Worm
eggs, 3 raw	Lesson 3 Lab: Observing Osmosis in an Egg Cell

ITEM	LESSON/LAB
Elodea, 2–3 sprigs	Lesson 4 Lab: Examining the Effect of Light Intensity on Photosynthesis
fish, whole (dead, from grocery store)	Lesson 25 Lab: Exploring External Fish Anatomy
fish, live, goldfish or other live aquarium fish	Lesson 25 Lab: Exploring External Fish Anatomy
flower, dicot	Lesson 22 Lab: Flower Dissection
flower, monocot	Lesson 22 Lab: Flower Dissection
glass jar, 1 quart	Lesson 14 Lab: Modeling Succession Lesson 18 Lab: Make Your Own Yogurt
glasses, 1–8 small	Lesson 3 Lab: Observing Osmosis in an Egg Cell Lesson 8 Lab: Demonstration Lab: DNA Extraction Lesson 25 Lab: Exploring External Fish Anatomy
hammer	Lesson 26 Lab: Comparing Bone Density
ice cubes	Lesson 18 Lab: Make Your Own Yogurt
isopropyl alcohol	Lesson 8 Lab: Demonstration Lab: DNA Extraction
jars	Lesson 21 Lab: Transpiration Rate
lemon juice	Lesson 2 Lab: Determining the pH of Common Substances
licorice, shoestring type	Lesson 5 Lab: Modeling and Recognizing the Stages of Mitosis
liquid measuring cup	Lesson 4 Lab: Examining the Effect of Light Intensity on Photosynthesis
marshmallows	Lesson 5 Lab: Modeling and Recognizing the Stages of Mitosis
measuring tape or string	Lesson 1 Lab: Walking Crooked!
milk	Lesson 2 Lab: Determining the pH of Common Substances Lesson 14 Lab: Modeling Succession Lesson 18 Lab: Make Your Own Yogurt
mouthwash	Lesson 2 Lab: Determining the pH of Common Substances
orange juice or other fruit juice	Lesson 2 Lab: Determining the pH of Common Substances
paper bags or plastic grocery bags, 2	Lesson 22 Lab: Observing the Effects of Ethylene on Ripening Fruit
pencil with an eraser	Lesson 23 Lab: External Anatomy of a Live Worm
picnic cooler, small	Lesson 14 Lab: Modeling Succession Lesson 18 Lab: Make Your Own Yogurt
plastic bag, heavy duty zipper lock	Lesson 8 Lab: Demonstration Lab: DNA Extraction
plastic lunch bags, sealable	Lesson 19 Lab: Quantifying Mold Growth
quadrat (see lesson 13 for how to build)	Lesson 13 Lab: Random Quadrat Sampling in the Field

ITEM	LESSON/LAB
raisins, 2 dry	Lesson 25 Activity: Modeling the Action of a Swim Bladder
red food coloring and water	Lesson 21 Lab: Transpiration Rate
rubber gloves, optional	Lesson 3 Lab: Observing Osmosis in an Egg Cell
salt	Lesson 8 Lab: Demonstration Lab: DNA Extraction
saucepan, stainless steel or ceramic	Lesson 18 Lab: Make Your Own Yogurt
scissors	Lesson 13 Lab: Simulated Random Quadrat Sampling
screwdriver	Lesson 26 Lab: Comparing Bone Density
shallow pie pan	Lesson 23 Lab: External Anatomy of a Live Worm Lesson 25 Lab: Exploring External Fish Anatomy
spoon	Lesson 8 Lab: Demonstration Lab: DNA Extraction
strawberry	Lesson 8 Lab: Demonstration Lab: DNA Extraction
tape	Lesson 22 Lab: Flower Dissection
tea	Lesson 2 Lab: Determining the pH of Common Substances
Twizzlers	Lesson 5 Lab: Modeling and Recognizing the Stages of Mitosis
vinegar, white	Lesson 2 Lab: Determining the pH of Common Substances Lesson 3 Lab: Observing Osmosis in an Egg Cell
watch or clock	Lesson 4 Lab: Examining the Effect of Light Intensity on Photosynthesis Lesson 27 Lab: Using an Ethogram to Describe Animal Behavior Lesson 27 Lab: Observing Nonverbal Human Communication
window cleaner	Lesson 2 Lab: Determining the pH of Common Substances
wire whisk	Lesson 18 Lab: Make Your Own Yogurt
yarn	Lesson 5 Lab: Modeling and Recognizing the Stages of Mitosis Lesson 6 Lab: Modeling Meiosis
yogurt, plain with active cultures	Lesson 18 Lab: Make Your Own Yogurt