Featuring Chapters from:

Student Textbook
Laboratory Notebook
Teacher's Manual
Lesson Plan
Study Notebook
Quizzes
Graphics Package

Focus On Middle School Biology

3rd Edition

Preview Booklet

Rebecca W. Keller, PhD

Real Science 4 Kids

Introduction

Welcome to the ***Focus On Middle School Biology 3rd Edition Preview Booklet*** where you can take our one semester unit study program for a test run!

The materials sampled in this book are taken from a full semester course, with two chapters from each part of the curriculum:

- The ***Focus On Middle School Biology Student Textbook–3rd Edition*** provides foundational science concepts presented in a way that makes it easy for students to read and understand. The many colorful illustrations make each chapter fun to look at and reinforce concepts presented.
- With two science experiments for each chapter, the ***Laboratory Notebook*** helps young students learn how to make good observations, an important part of doing science. Open-ended questions help students think about what they are learning, and information is provided to assist students with understanding what they observed while performing their experiments.
- The ***Teacher's Manual*** includes instructions for helping students conduct the experiments, as well as questions for guiding open inquiry. The commonly available, inexpensive materials used for all the experiments can be seen in the complete materials lists included in this booklet.
- Using the ***Lesson Plan*** makes it easy to keep track of daily teaching tasks. A page for each chapter in the ***Student Textbook*** has the objectives of the lesson and questions for further study that connect science with other areas of knowledge, such as history; philosophy; art, music, and math; technology; and language. Forms are included for students to use to do a review of material they've learned and to make up their own test for the chapter. Also included are icons that can be copied onto sticker sheets and used to help plan each day of the week.
- With the ***Study Notebook*** students learn to use critical and creative thinking while exploring their ideas about science. Thought questions are provided, and students are invited to take ownership of their learning by coming up with more questions and by doing research into their areas of interest.
- The one final and two midterm ***Quizzes*** are self-explanatory. For those who are not fans of quizzes, students can use the self-test at the end of the ***Lesson Plan*** instead.
- Another type of teaching aid is provided in the ***Graphics Package,*** which has two full-color images from each chapter of the ***Student Textbook.*** These graphics can be used to create additional teaching aids, such as flash cards, wall posters, PowerPoint lectures, or overhead projections.

Focus On

Grades 5-8

Middle School Biology

3rd Edition

Rebecca W. Keller, PhD

Real Science 4 Kids

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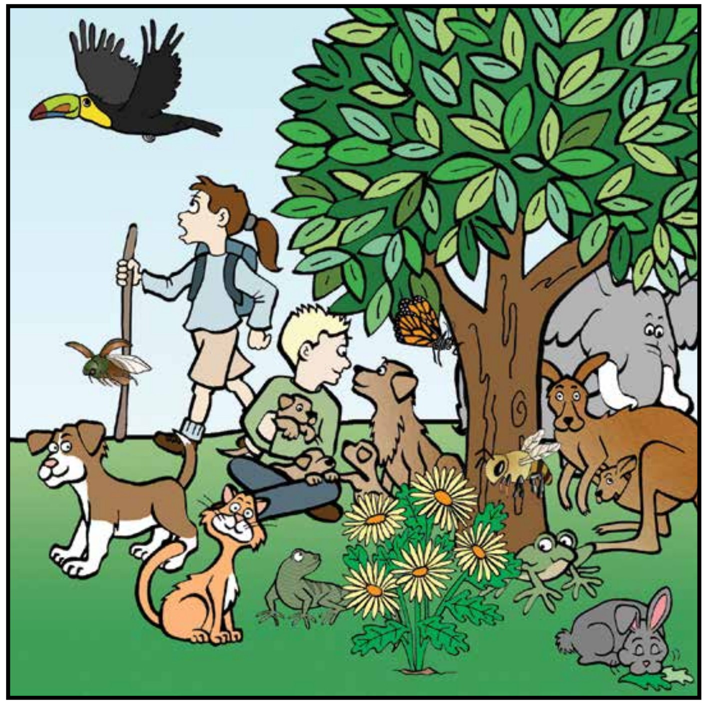
1.1 Introduction



Biology is the study of life. The word biology comes from the Greek words *bios*, which means "life," and *logos*, which means "description." Biology is the field of science that "describes life." Biology is concerned with all living things and how they interact with one another.

Living creatures come in many different sizes, shapes, and colors. Some are big and some are very small. Some are green, some are red, some are black, and some are white. Some see with two eyes, some see with eight eyes, and some have no eyes at all! Some fly, some walk, some swim, and some crawl.

There are many different kinds of living things, but they all have one thing in common. They all are alive. But what does it mean for something to be alive?

Both living things and nonliving things are made of the same material—atoms! But if living things and nonliving things are all made of atoms, why are they so different? Why can a butterfly land on a rock, but a rock cannot fly away to find food?

1.2 What Is Life?

It seems that defining life should be easy. Even a young child knows the difference between living things and nonliving things. But finding a definition for life is actually very difficult!

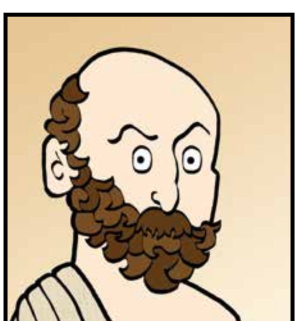
One way to define life is to list the properties that are unique to living things. For example, living things have the ability to grow, the ability to reproduce, and the ability to adapt to the environment. However, a computer program can be designed to grow, reproduce, and adapt to the environment, yet we wouldn't say a computer program is alive. There must be something missing from this list of properties. So what else is needed to define life?

ARISTOTLE
384-322 B.C.E.

The struggle to define life goes back many centuries. The Greek philosophers thought a lot about life and how to define life. Aristotle, a Greek philosopher (384-322 B.C.E.), believed that living things have a moving principle, which he defined as a force that causes an object to become itself.

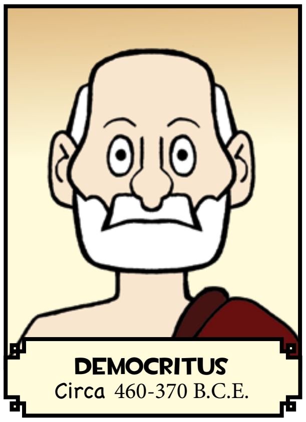
GALEN
circa 129-circa 199 C.E.

Galen (circa 129-circa 199 C.E.), a Greek physician who studied anatomy, agreed with Aristotle and further developed the idea of life having a moving principle. He referred to the moving principle as the vital spirit.



HIPPOCRATES
circa 460-circa 377 B.C.E.

Not all of the Greek philosophers agreed with the idea of a moving principle or a vital spirit. Hippocrates (circa 460-circa 377 B.C.E.), an early Greek physician, disagreed with Aristotle. He said that life is not caused by a moving principle, but by the ether, which he said was a type of fire that always existed and is present in air and in other matter.



Other Greek philosophers, called atomists, believed that life is simply the result of movements and combinations of small invisible, indestructible particles. Probably the most famous atomist was Democritus (circa 460-370 B.C.E.). Democritus proposed that all matter is composed of indivisible particles called atoms.

Many new ideas about life developed in the 16th and 17th centuries. These ideas usually combined some sort of mechanical theory (the idea that living things function like machines) with some explanation of purpose (why the living things exist).

Rene Descartes (1596-1650 C.E.) was a French philosopher who thought about how atoms form molecules. He also developed a "mechanical philosophy," or the idea of mechanism. He believed that all living creatures are like machines and their behaviors are controlled solely by forces pushing the organs of the body.

During the 1800s as we learned much more about the cell, it became much easier to explain life in terms of chemical reactions. By the end of the 20th century, a completely non-vitalist philosophy had emerged. This idea is called materialism. According to materialism, everything is made of matter only, so all life can be explained solely by the laws of chemistry and physics.

A particular facet of materialism is called reductionism. Reductionism is the belief that because life can be explained by the laws of chemistry and physics (materialism) you can completely understand something by studying its parts. For example, if you don't know what a bicycle is, then you can take it apart, and by understanding the tires, the spokes, and the gears, you can understand a bicycle.

Reductionism and materialism have played a very important role in shaping scientific understanding, but not everything can be explained by looking only at the individual parts. Systems biology, for example, involves examining the interactive system, not only the parts that make up the system. As more information about life is discovered, new ways of thinking about and studying life are sure to emerge.

1.3 Philosophical Maps Help Us Interpret Science

All of these "-isms" are particular ways to interpret the world. Vitalism, materialism, mechanism, and reductionism are philosophical maps that help us get a clearer picture of the world around us. Just like physical maps help us navigate directions in cities, philosophical maps help us interpret and understand scientific data.

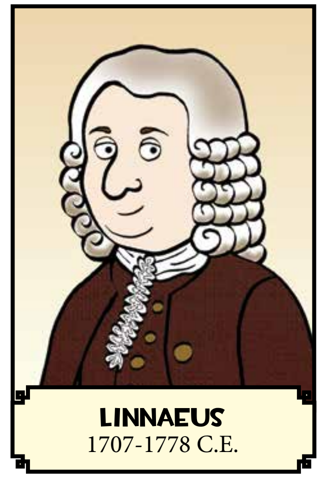
However, it's important that we don't confuse the map with reality. A map is just a map, and although it is useful, it does not always give the most accurate picture of reality. Also, the best way to navigate any territory is to use more than one map.

Often scientists disagree about which map is "right" for understanding science. However, there is not one "right" map for all questions. Materialism and reductionism can be useful in answering some questions, and vitalism and mechanism can be useful for answering other questions. The scientist who understands and can use multiple maps has a better chance of seeing the world more clearly than the scientist who only uses one map. Also, the scientist who uses many maps will find more opportunities to make new discoveries.

1.4 Organizing Life

Taxonomy

One way to understand living things is to organize or classify them. By organizing the different types of living things into groups, scientists can better study both their similarities and their differences.



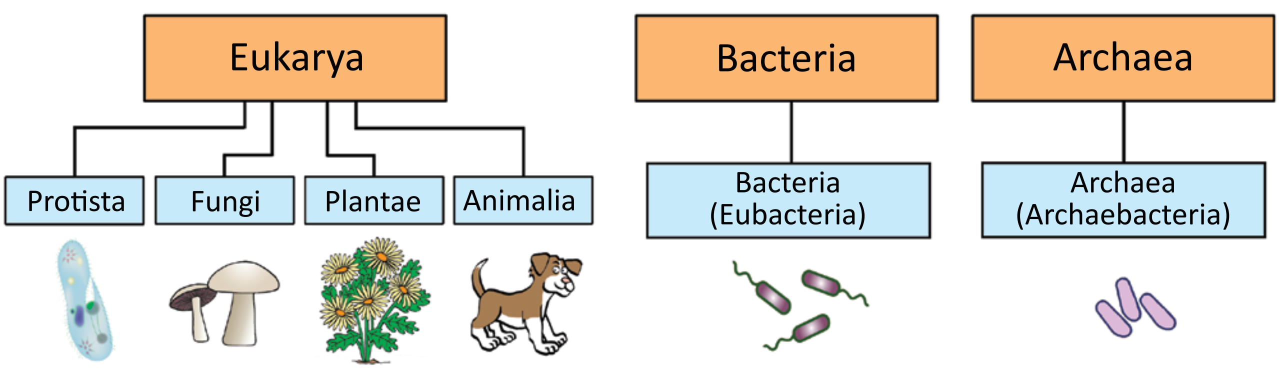
The branch of biology concerned with naming and classifying the many different types of living things is called taxonomy. Carolus Linnaeus (1707-1778 C.E.), a Swedish physician, was the founder of taxonomy. Linnaeus viewed science as a way to understand how the world is organized. He began to carefully study all the living things he could find. Whenever he found animals that were similar, like dogs and wolves or bees and wasps, he grouped them together. Grouping things together is what is meant by classifying. A new creature is classified in a group depending on which creatures it has the most in common with. Sometimes it is very hard to decide which group a creature fits into.

Domains and Kingdoms

Because there are so many different kinds of living creatures, it has been hard for scientists to figure out exactly how to organize them. Several different approaches are currently in use. Until recently, the most commonly used approach divided all living things into five kingdoms.

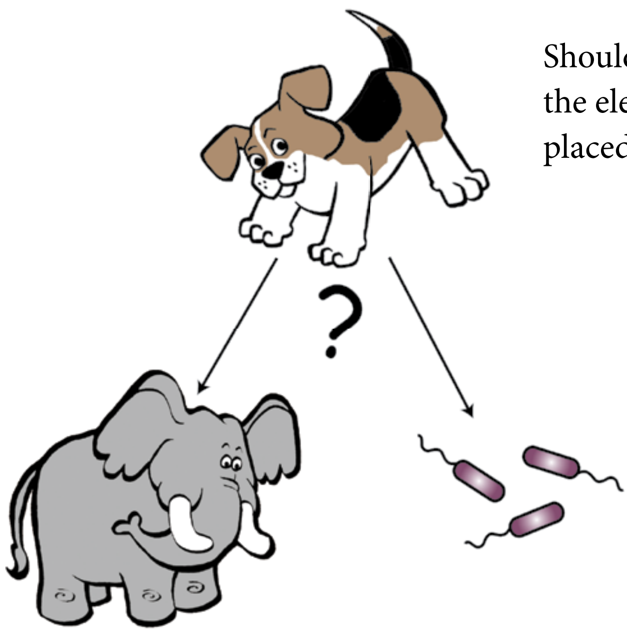
However, modern taxonomy is beginning to use a system introduced in 1990 by Carl Woese. In this system, living things are divided into three domains which are then further divided into six kingdoms. The three domains are called Eukarya, Bacteria, and Archaea.

The kingdoms in those domains are Protista, Plantae, Fungi, Animalia, Bacteria (also called Eubacteria), and Archaea (also called Archaebacteria).

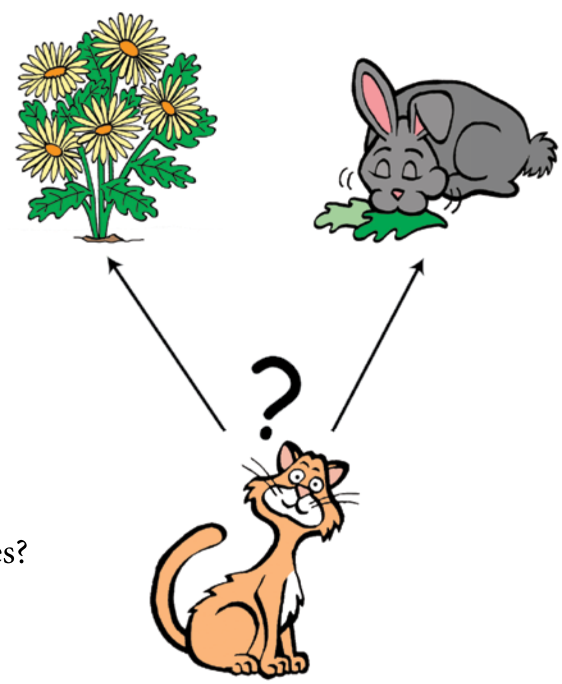


Taxonomy is continuing to change as scientists make new discoveries about living things, and scientists may use different taxonomic systems according to what they are trying to find out about living things.

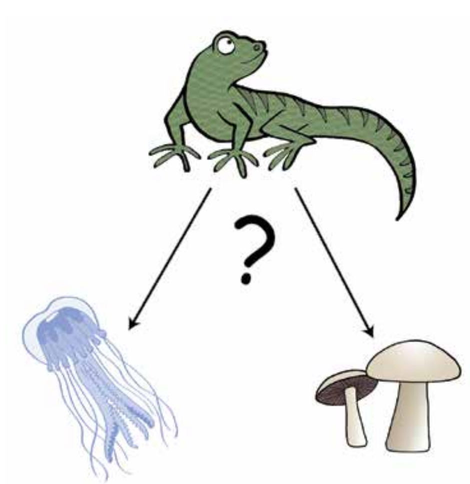
How do we decide in which domain and which kingdom a living thing should be placed?



Should a dog be grouped with the elephants, or should it be placed with the bacteria?



Should a house cat be grouped with the house plants or with the bunnies?



What about a lizard? Is it like a mushroom or like a jellyfish?

Before placing a living thing into a particular kingdom, it must first be placed in a domain. It is primarily the difference in the structure of the cells that ultimately determines the domain in which an organism is placed.

Dog cells are more like elephant cells than they are like bacteria, so dogs are grouped with elephants in the domain Eukarya. Cat cells are more like bunny cells than archaeal cells, so cats are grouped with bunnies in the domain Eukarya. Lizards and jellyfish, although very different from each other, have similar cells, so lizards are grouped with jellyfish in the domain Eukarya and not grouped with bacteria or archaea.

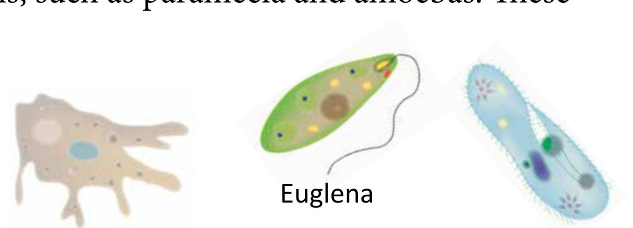
Once an organism is placed into a domain, it is further categorized and placed in a kingdom. The animal kingdom, Animalia, includes ALL of the animals: dogs, cats, frogs, sea urchins, bees, birds, snakes, jellyfish, bunnies, and even us!

The animal kingdom has a wide variety of living creatures in it. Some are similar to each other, like dogs and wolves, and some are not so similar, like bees and snails, but ALL animals in the kingdom Animalia have animal cells. (See Chapter 5.) This distinguishes them from other living things.

The plant kingdom, Plantae, includes all plants: trees, grass, flowers, ferns, dandelions, and even asparagus! Again, some plants are similar to each other and some plants are very, very different, but ALL plants have plant cells. (See Chapter 5.)

The fungus kingdom, Fungi, includes mushrooms, toadstools, truffles, and even athlete's foot! The fungi were once grouped with plants, but they have many unique features and are now placed in a kingdom of their own.

The last three kingdoms, Protista, Bacteria (Eubacteria), and Archaea (Archaebacteria), include most of the microscopic organisms, such as paramecia and amoebas. These organisms cannot be seen with the unaided eye and were unknown before microscopes were invented.

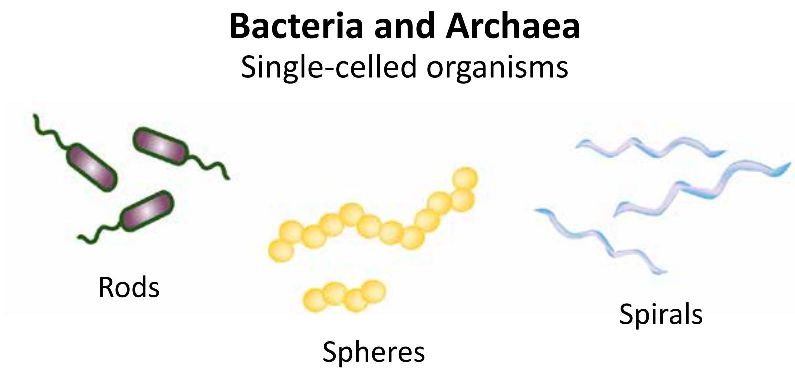


Protista

Single and multicellular organisms like algae and paramecia

The kingdom Protista is in the domain Eukarya because protists have cells similar to other Eukarya. In the kingdom Protista, there are creatures that have both plant-like and animal-like features. Some, like euglena, are green and can use the Sun's energy to make food, like plants do. Others, like amoebas, catch and eat prey like animals do.

Bacteria and Archaea have cells that are different from each other and also from Eukarya; therefore, they have their own domains. Most of the organisms in the kingdoms Bacteria (Eubacteria) and Archaea (Archaebacteria) are unicellular. That is, they have only one cell. These organisms have a variety of shapes. The three most common shapes are spheres, rods, and spirals.



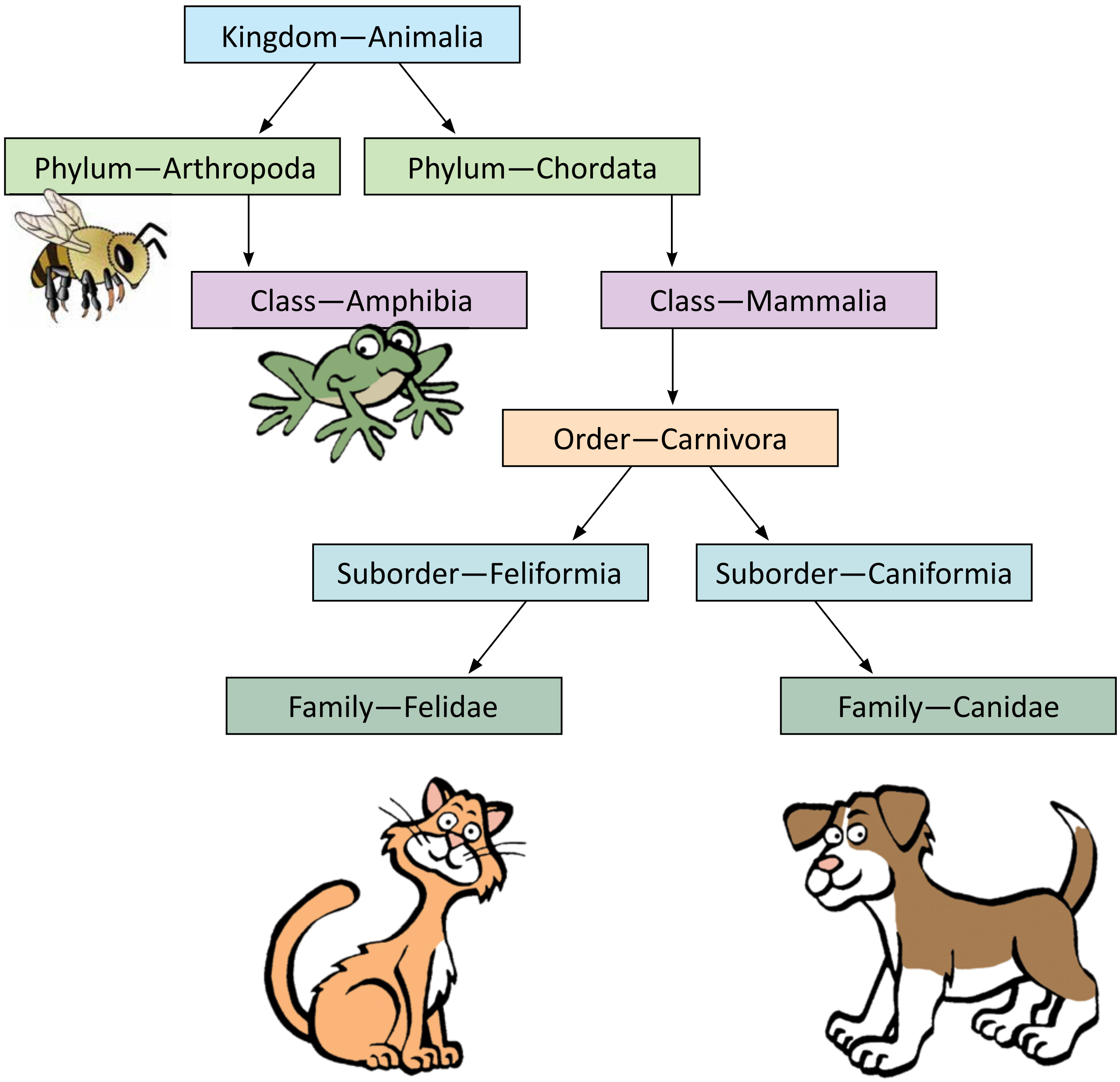
Further Classification

Once a living thing has been placed in a kingdom, the classification continues. Living things are further organized by being placed in additional categories that depend on a variety of criteria, like whether or not they have a backbone or whether or not they lay eggs. For example, although all animals are in the kingdom Animalia, it seems obvious that dogs and bees and snakes should be in different groups.

Kingdoms are divided into smaller groups called phyla. Dogs, frogs, and cats are members of the phylum Chordata because they all have backbones, and bees are in the phylum Arthropoda because they have "jointed feet (legs)."

In the same way, the phyla are divided into smaller groups called classes. Dogs and cats are all in the class Mammalia because they nurse their young, and frogs are in the class Amphibia because they live both in water and on land.

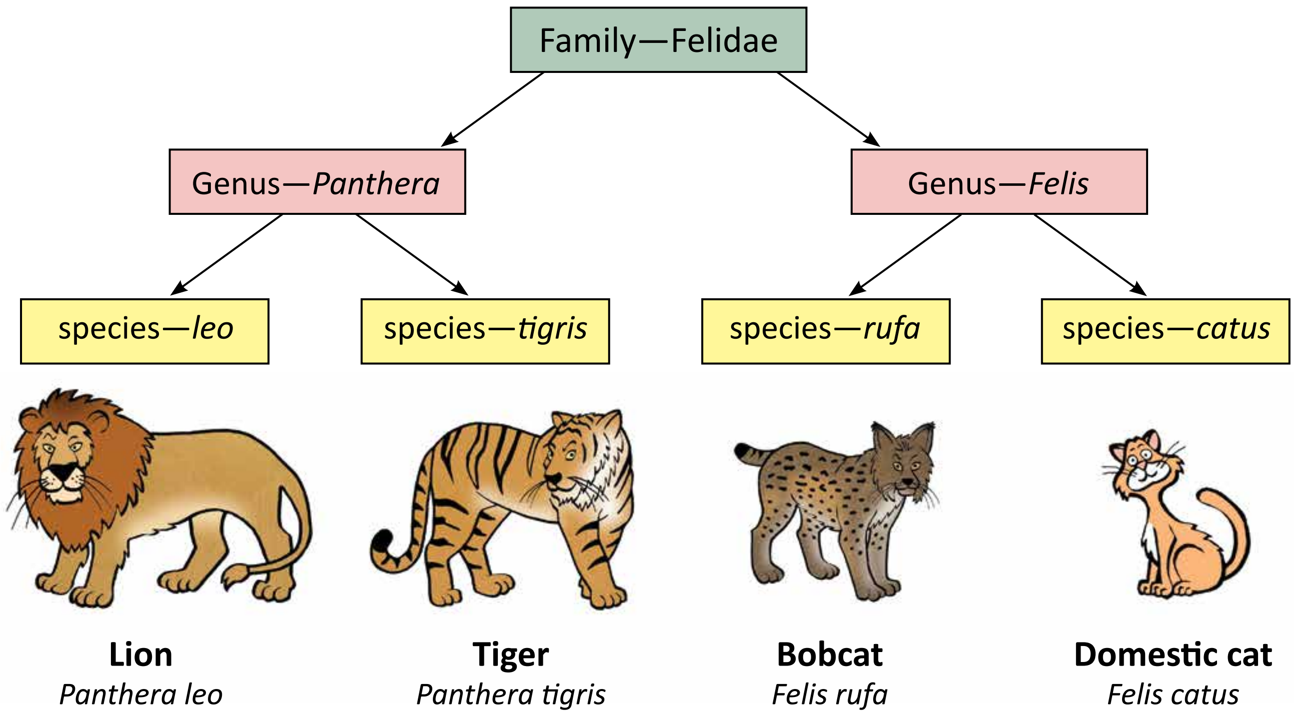
Classes are further divided into orders. Both cats and dogs are in the order Carnivora because they eat meat. Sometimes orders are divided into suborders. The order Carnivora is divided into the suborder Feliformia for cat-like animals and the suborder Caniformia for dog-like animals. The suborders are then divided into families. Cats are in the family Felidae, and dogs are in the family Canidae.



Naming Living Things

Finally, families are further divided into the genus, and the genus is divided into the species. The genus is the last group in which a living creature is placed, and the species identifies each creature placed in the genus, so each different type of living thing has a unique genus and species name. For example, both a bobcat and a house cat are in the genus *Felis*. A bobcat has the species name *rufa,* and a house cat has the species name *catus*. So a house cat is a *Felis catus* and a bobcat is a *Felis rufa*.

A tiger is a kind of cat, but it is different from both bobcats and house cats. It is in the genus *Panthera* and has a species name *tigris*. So, a tiger is called a *Panthera tigris*. A lion is like a tiger and is also in the genus *Panthera,* but it has a species name *leo*, so a lion is a *Panthera leo*.

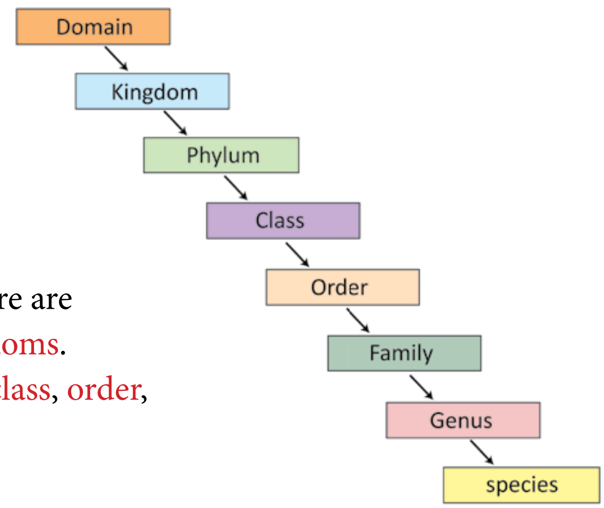


All living things have a particular genus and species name. The name for household dogs is *Canis familiaris,* and for humans it is *Homo sapiens* from the Latin words meaning "man wise." Note that the genus and species are written in italics, and the genus is capitalized.

1.5 Summary

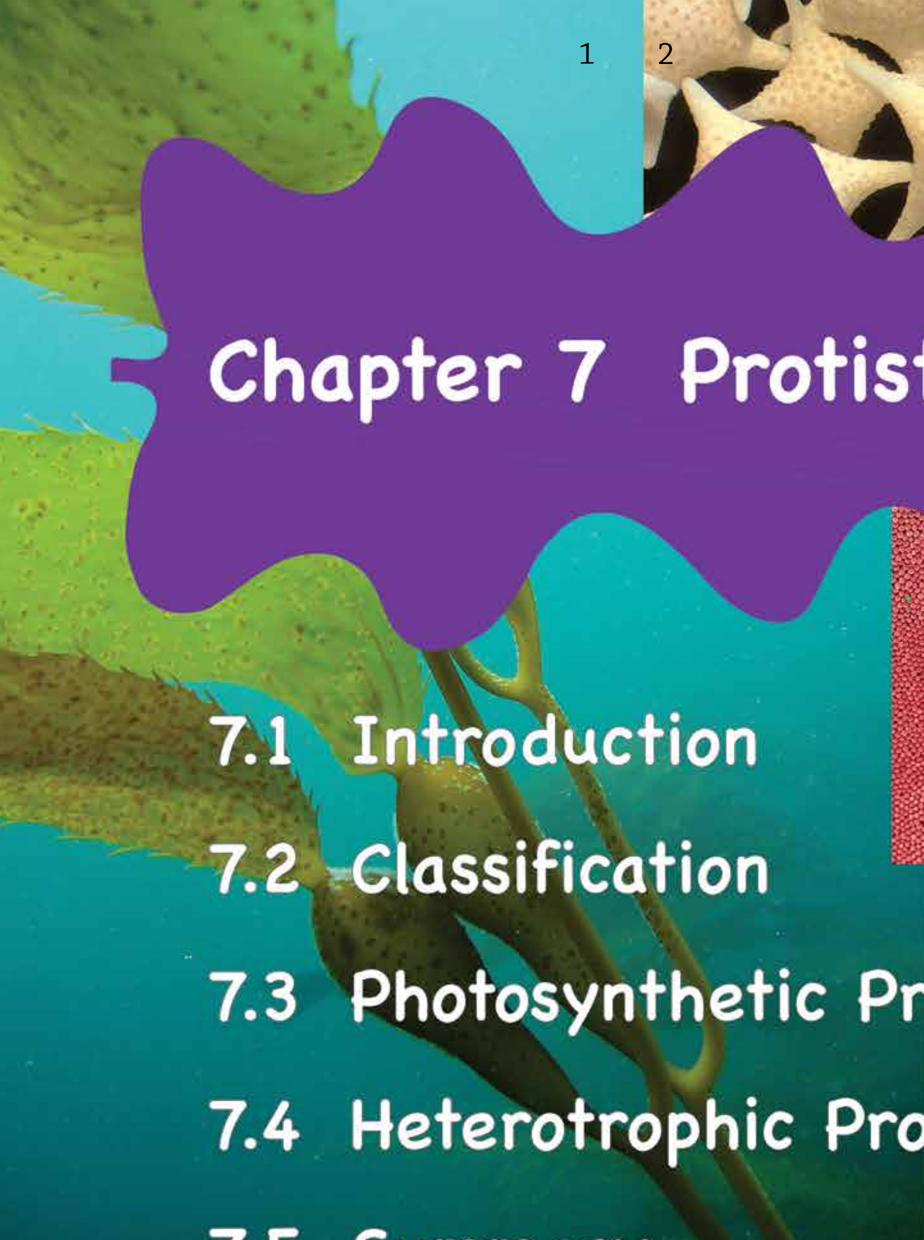
- Providing an exact definition of life is difficult, and both scientists and philosophers have contributed.
- Greek philosophers such as Aristotle, Galen, Hippocrates, and Democritus had different ideas about what causes living things to be alive.
- Vitalism, materialism, mechanism, and reductionism are philosophical maps that help us explore the world around us.
- Taxonomy is the branch of biology that classifies living things.

- Living things are grouped into categories so scientists can learn more about how they are the same and how they are different. Also, if a new creature is discovered, for instance, on the deep ocean floor, placing it into a group of known creatures will help scientists better understand how it lives.
- Living things are placed in a group depending on many characteristics, including what kind of cells they have, whether they have hair or scales, and whether or not they lay eggs.
- Several different systems of taxonomy are in use today, and taxonomy continues to change as new discoveries are made.
- All living things are classified into different groups. The largest group is the domain. There are three domains that are divided into six kingdoms. Kingdoms are further divided into phylum, class, order, family, genus, and species.



1.6 Some Things to Think About

- Make two lists, one of living things and one of nonliving things. Review your lists. What is different about the things that are living and those that are not alive?
- Review the different ways of defining life that are presented in this section. Do you think the way we define life will continue to change as new discoveries are made? Why or why not?
- How would you define life?
- What are some philosophical maps that you think you have used?
  Do you think these philosophical maps are helpful to you? Why or why not?
- Which kingdom would you most like to study? Why do you think this kingdom would be the most interesting one?



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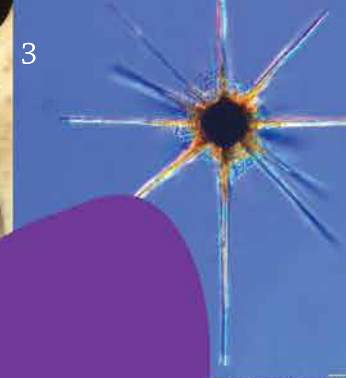

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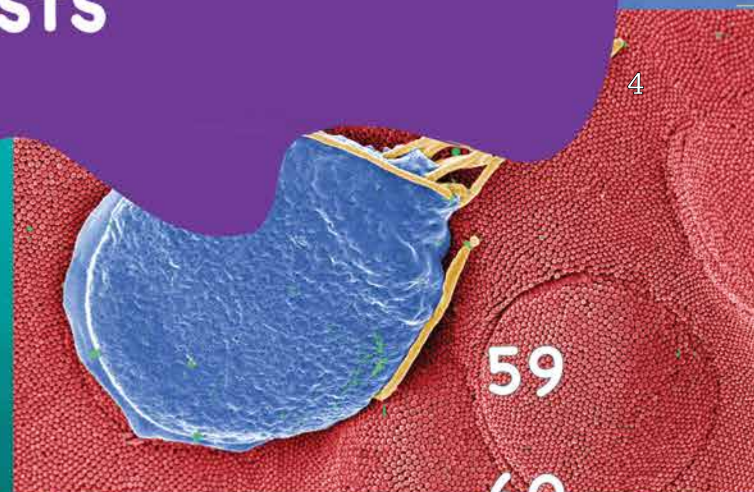
Chapter 7 Protists



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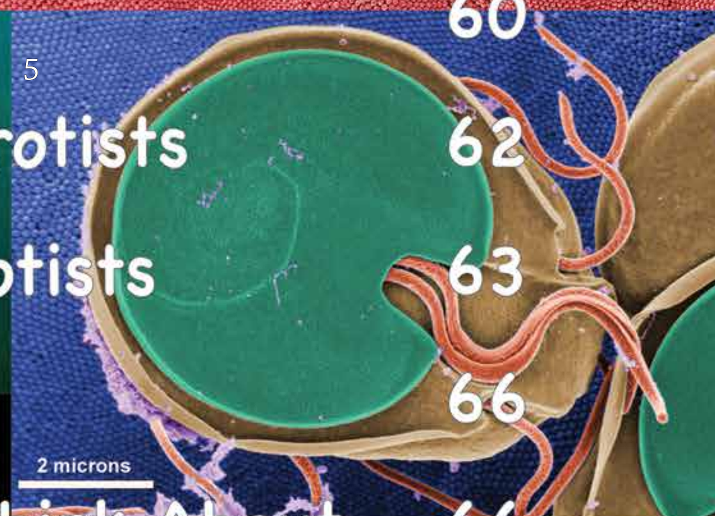

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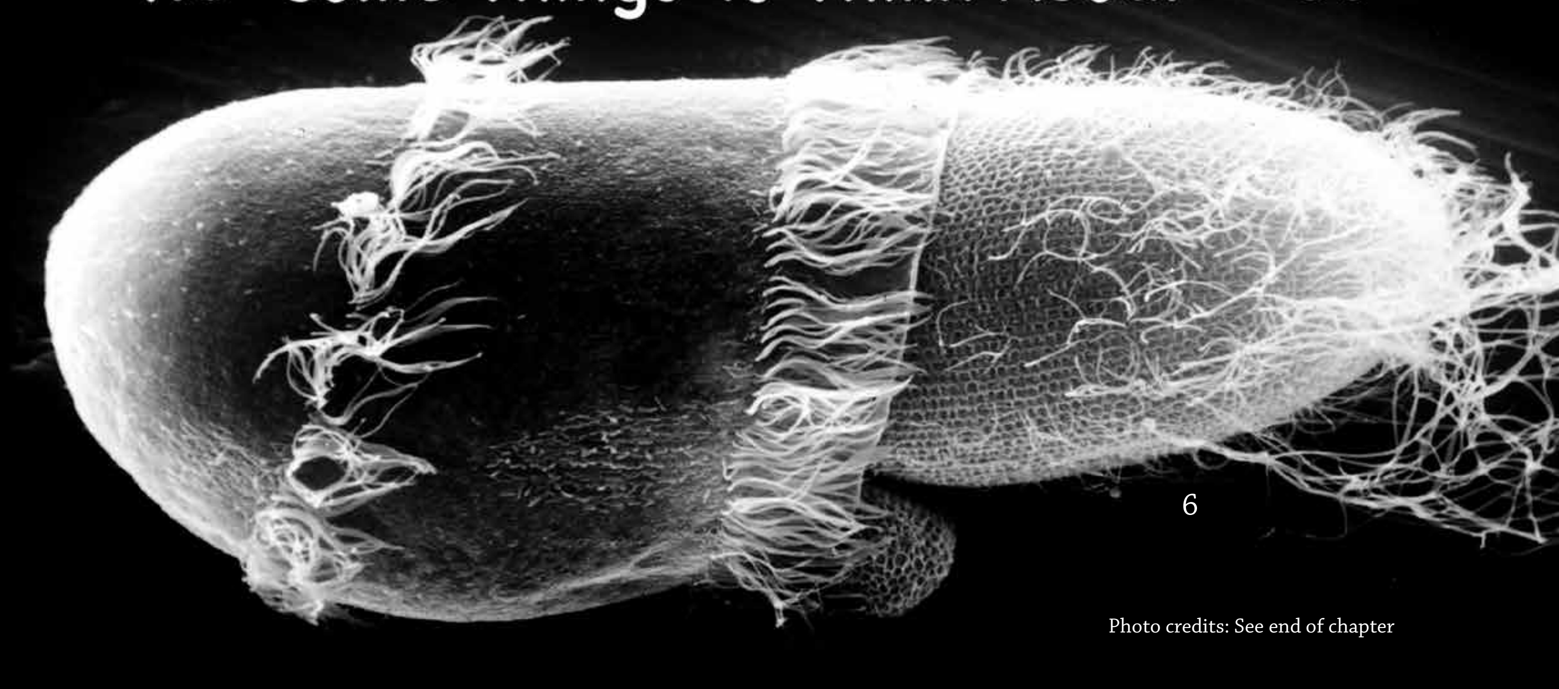

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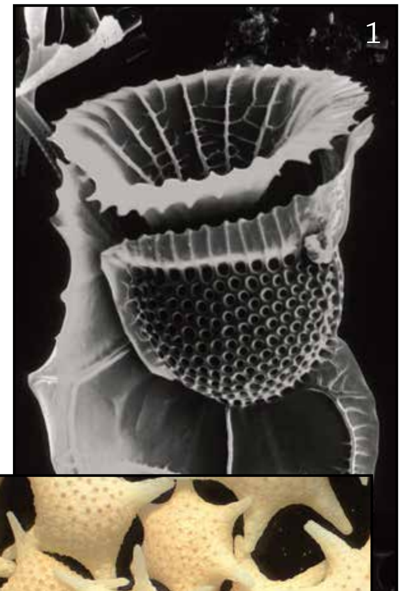
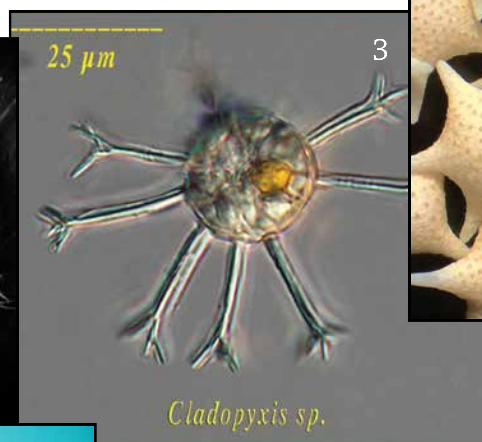
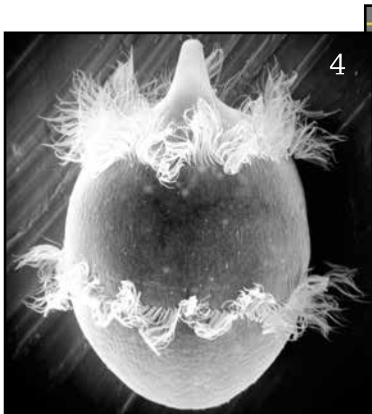
7.1 Introduction



Protists, sometimes called protozoa, are organisms that are like both plants and animals. Protists are in the domain Eukarya and have their own kingdom called Protista. The word Protista comes from the Greek *protos* which means "first." Although it is not likely that protists were among the very first life forms to appear on the planet, they are some of the oldest organisms that have been found in the fossil records.



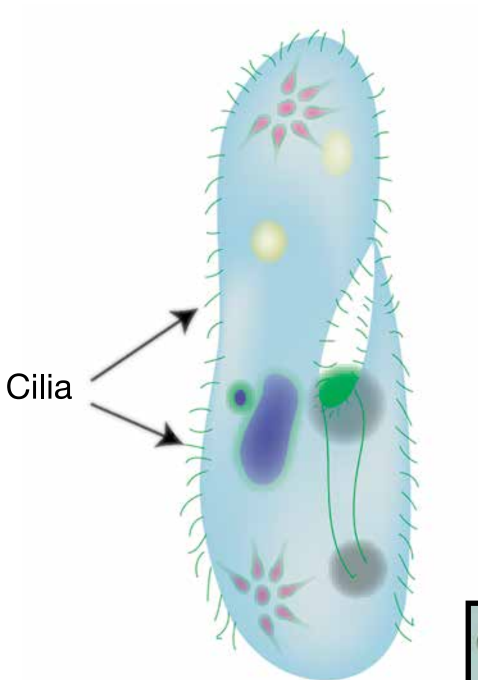


Protists come in a variety of shapes and sizes. Most protists are too small to see with the naked eye. Many protists are made of only one cell, but some protists, like kelp and seaweed, group together into large colonies. For most of human history nobody knew protists existed. However, when the first microscopes were invented in the middle of the 17th century, an entirely new world of microscopic organisms, including protists, was found. Protists live almost everywhere, including soil, freshwater ponds, and saltwater oceans.

1. Dinoflagellate, Courtesy of CSIRO; 2. Formanifora, Courtesy of Psammophile (CC BY SA 3.0); 3. Dinoflagellate, Courtesy of Dr. John R. Dolan, Laboratoire d'Oceanographique de Villefranche; Observatoire Oceanologique de Villefrance-sur-Mer; 4. *Didinium nasutum*, Courtesy of Gregory Anitpa, San Francisco State University; 5. Giant kelp, Courtesy of Claire Fackler, CINMS/ NOAA

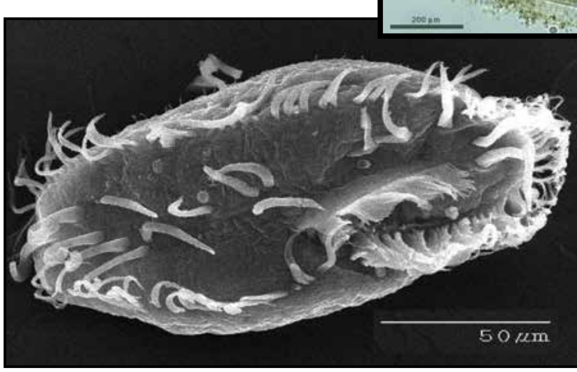
7.2 Classification

It is unknown how many species of protists exist, but estimates range from 36,000 to 200,000, many of which have not yet been discovered. Although protists are classified in the single kingdom, Protista, they vary in structure and function more than any other group of organisms. Because this group is so diverse, there are several different classification systems for protists. In this text we will focus on four main groups depending mostly on how they move. These group are the ciliates, the flagellates, the amoebae, and the spore-forming protists.



A ciliate

The ciliates are in the phylum Ciliophora. Ciliophora swim by using cilia, which are very small hair-like projections on their bodies. The cilia beat very rapidly to propel the organism through the water like a little submarine. The ciliates include *Paramecium*, *Didinium*, *Hypocoma*, and *Stentor*.

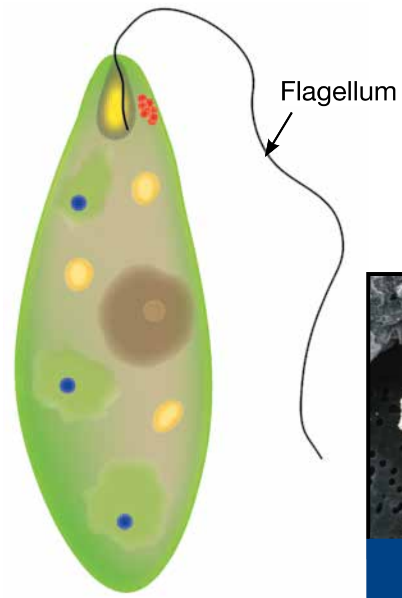


Ciliates

Top: *Paramecium caudatum*
Courtesy of Deuterostome (CC BY-SA 3.0)

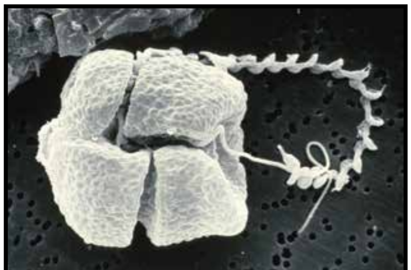
Middle: *Stentor roeseli*

Left: *Oxytricha trifallax*



A Flagellate

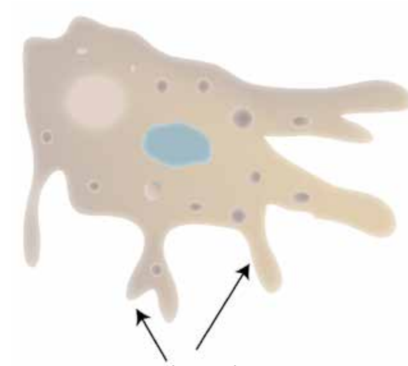
There are several different phyla for the flagellates including Trichozoa, Euglenozoa, Dinozoa, Choanozoa, and Metamonada. Flagellates also swim, but instead of many short, hair-like projections, flagellates have one or more long whip-like flagella that extend from one end of their body. These whips propel the flagellates through the water much like the tail of a fish. Many flagellates have a thin outer covering called a pellicle. Flagellates can exist as single organisms or in colonies. Many flagellates are parasitic, living inside other organisms.

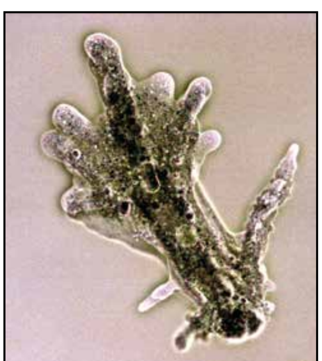


A dinoflagellate
Micrograph courtesy of CSIRO

Amoebae move very differently than the ciliates and flagellates. Amoebae do not swim or use flagella or cilia but instead crawl along surfaces by extending and bulging the edges of their membranes. The portions of their membranes that stick out are called pseudopodia. *Pseudo* is Greek and means "false" and *podia* means "feet," so pseudopodia are "false feet." Once the pseudopodia are extended, the rest of the amoeba flows into them, pulling the amoeba forward. The process then begins again.

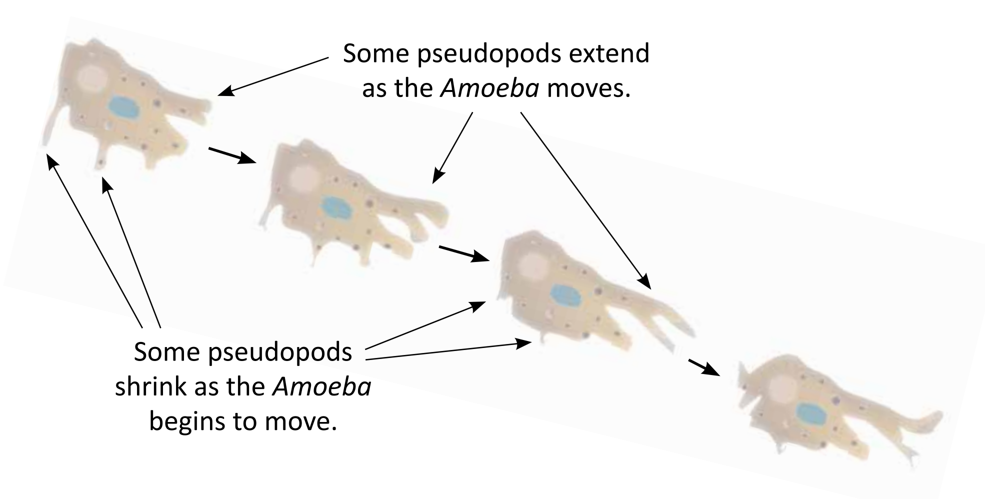
Amoeba

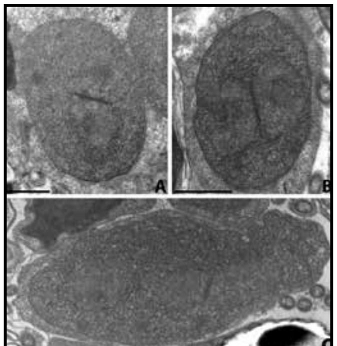




Amoeba
Amoeba proteus, courtesy of Cymothoa exigua, CC BY SA 3.0

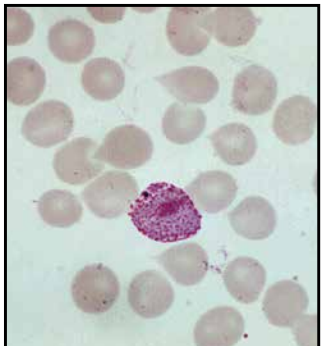
In a microscope, the movement of an amoeba along the surface of a glass slide looks something like the following illustration.





Nosema podocotyloidis (Microspora)

Courtesy of Bhen Sikina Toguebaye, Yann Quilichini, Papa Mbagnick Diagne and Bernard Marchand (CC BY 2.0)



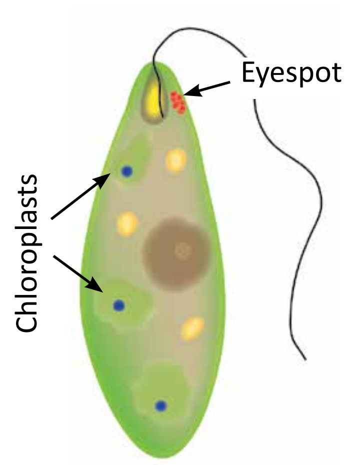
Trypanosoma (Megatrypanum) lainsoni in red blood cells

Courtesy of CDC/Mae Melvin

Sporozoa, or spore-forming protists, include three major phyla — Apicomplexa, Microspora, and Myxosporidia (Myxospora). Sporozoans live as parasites within cells or organs of almost every kind of animal. Sporozoans do not have flagella, cilia, pseudopodia, or any other locomotion process. A sporozoan spends much of its life cycle unable to move by itself and passes from host to host in a protective capsule called a spore.

7.3 Photosynthetic Protists

Because most protists are single-celled organisms, they do not have the advantage of using tissues and organs to process food. Instead, they must gather food, digest nutrients, and eliminate wastes, all within a single cell. As a result, protists are much more complicated than cells of other eukaryotic organisms.



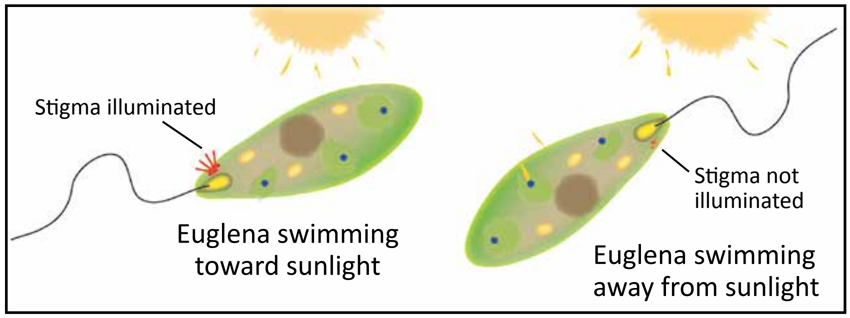
Euglena viridis

Some protists contain chloroplasts and use carbon dioxide, water, and the Sun's energy to make food by photosynthesis, just like plants do. Organisms that make their own food are called autotrophs. Autotroph comes from the Greek words *auto* which means "self" and *trophe* which means "food or nourishment," so an autotroph is an organism that is fed by itself.

Euglena sp. (species)

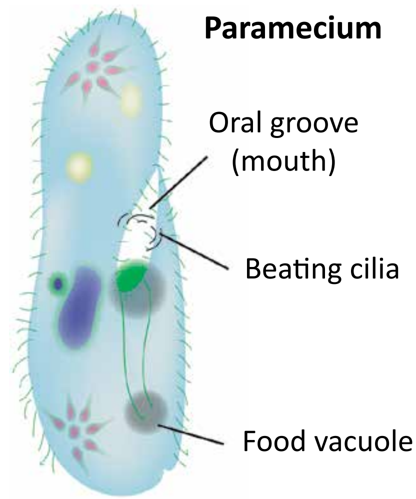
Courtesy of Deuterostome (CC by SA 3.0)

Euglena viridis is an example of a photosynthetic protist. Euglena are found in freshwater streams and ponds, sometimes being so numerous that the water turns green. Because euglena depend on photosynthesis for food, it is important for them to be able to detect the sunny areas in a pond or stream. To detect light, Euglena have a small red spot toward the



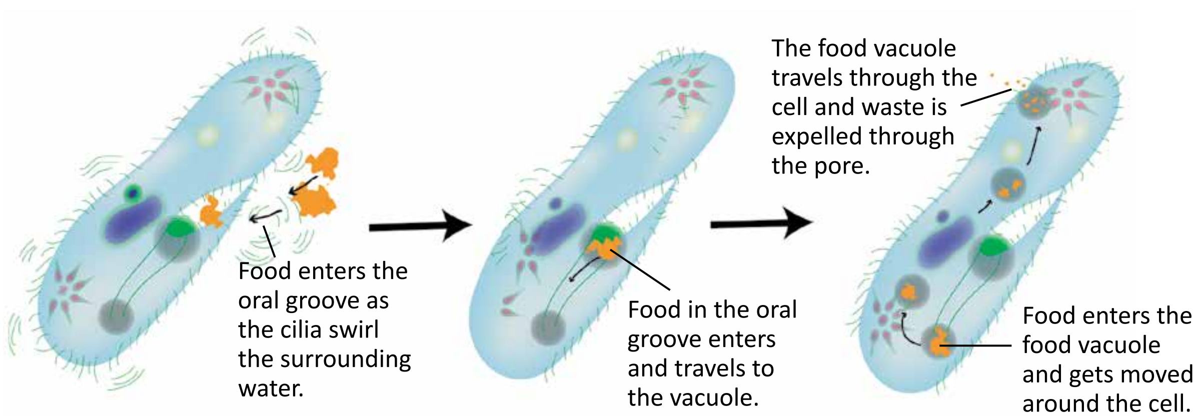
end of their body near the flagellum. This spot is called the eyespot or stigma. The stigma is a light sensitive area shaped like a shallow cup. This shape allows the euglena to detect sunlight only from a particular direction. When the euglena is traveling toward the light, a small part in the base of the stigma is illuminated. When the euglena swims away from the light, the spot is no longer illuminated, and the euglena knows that it is no longer in the path of the sunlight. Using the stigma as a detector, the euglena can find the sunlight needed for photosynthesis.

7.4 Heterotrophic Protists

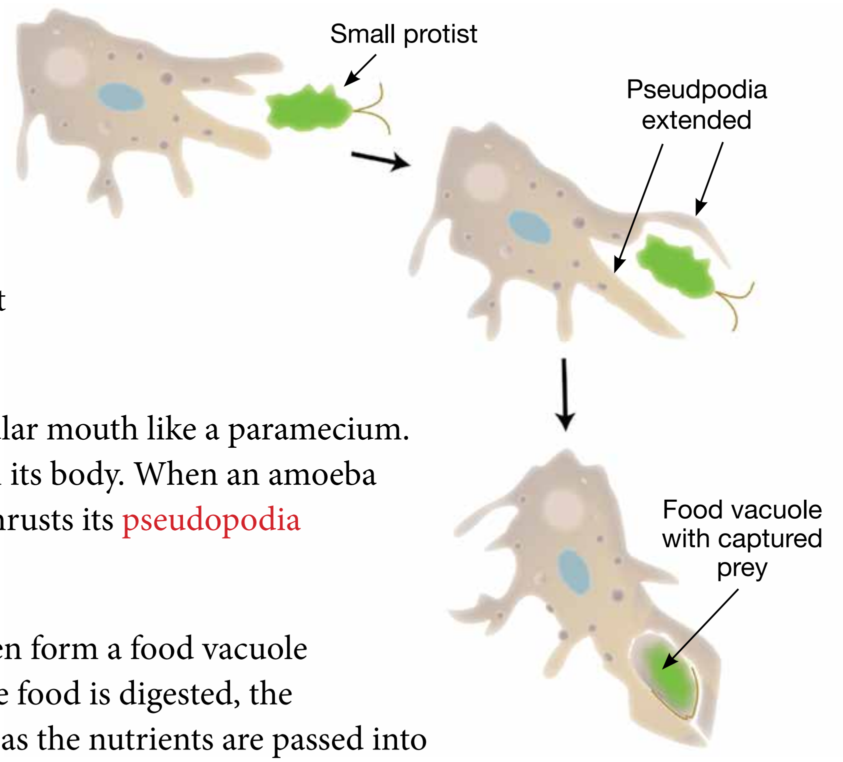


Many protists do not have the ability to make their own food through photosynthesis. They need to eat, just like we do. Organisms that cannot make their own food are called heterotrophs. Heterotroph comes from the Greek words *hetero* which means "other or different" and *trophe* which means "food or nourishment," so heterotrophs need to find food from sources other than themselves.

Paramecia, for example, live on bacteria, algae, and other small organisms. They have an oral groove that acts just like a big mouth. They gather their food by rapidly beating the cilia near the oral groove and creating water currents that sweep the food into the opening. The food travels into a food vacuole, which is like a tiny stomach for the paramecium. Once food is inside, the vacuole



circulates around the cell as the food is being digested. Any undigested food left in the food vacuole is ejected through a small pore.



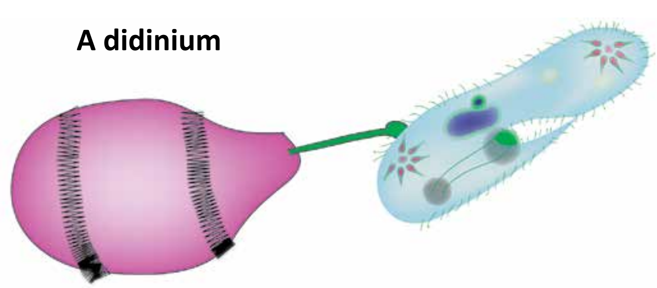
Amoebae are another type of protist that cannot make their own food. Amoebae are hunters; they feed on algae, other protozoa, and even other amoebae. However, an amoeba won't eat everything that comes its way. It is a picky eater.

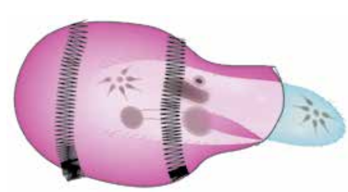
An amoeba does not have a cellular mouth like a paramecium. It can swallow food anywhere on its body. When an amoeba encounters something tasty, it thrusts its pseudopodia outward to surround the prey.

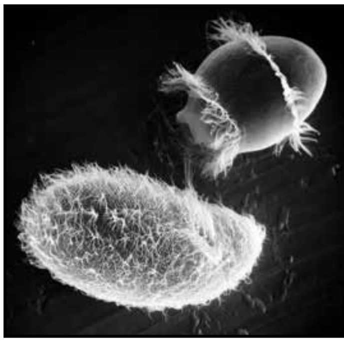
The surrounding membranes then form a food vacuole where the prey is digested. As the food is digested, the food vacuole gets smaller in size as the nutrients are passed into the cytoplasm. Once all of the food has been digested, the food vacuole shrinks and the waste is eliminated through the body surface.

Phagocytosis is the process of eating food by surrounding it and is used by both paramecia and amoebae. Phago comes from the Greek word *phagein* which means "to eat." Cyto comes from the Greek *kytos* which means a receptacle or container. The word-forming element cyt- is used by biologists to refer to a cell, so phagocyte is "a cell that eats."

There are still other protists that use entirely different methods for capturing and consuming food. A didinium, for example, has a single small tentacle called a toxicyst which contains a substance that is poisonous to paramecia. A didinium pierces a paramecium with the toxicyst to paralyze it and then swallows the paramecium





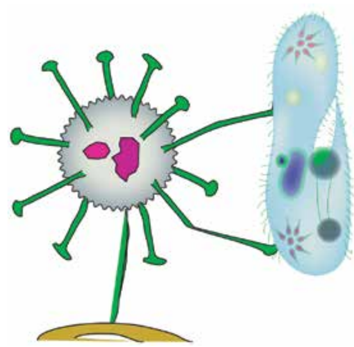


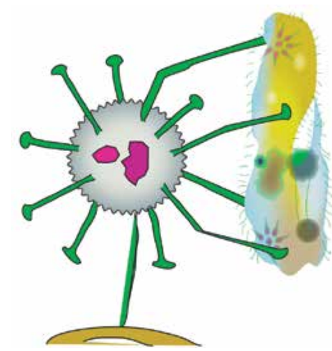
A didinium uses a toxicyst to capture a paramecium

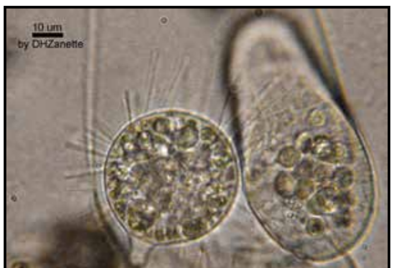
Courtesy of Gregory Antipa (San Francisco State University)

whole. Didinia are barrel shaped and have bands of cilia around their body, allowing them to swim fast and move in different directions.

Podophrya, on the other hand, have many tentacles with knobbed ends. A podophrya begins its life as a free-swimming ciliate. When it matures, it loses its cilia, grows tentacles, and uses a stalk to attach itself to a surface. When a protist is swimming past, the podophrya bends and moves to try to capture the prey. If the passing protist touches a tentacle, it sticks to the tentacle and becomes paralyzed. The podophrya then uses its tentacle to put enzymes into the captured protozoa to break it down into molecules that can be absorbed by the podophrya for food.



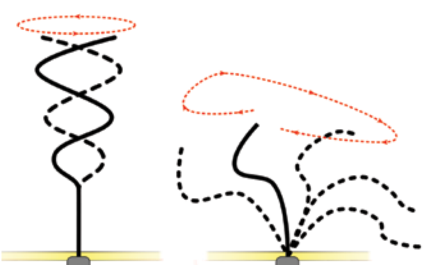




Podophrya-like protist (left) feeding on another protist

Courtesy of D. H. Zanette

Protists are truly remarkable creatures that accomplish an amazing variety of tasks — all within a single cell!

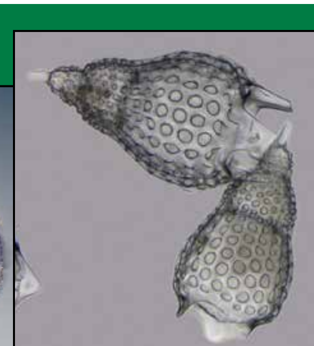


Left: A flagellum moves in a circular motion

Right: A cilium moves back and forth

Courtesy of Kohidai, L. and Urutseg, CC BY SA 3.0

Protists



Blepharisma japonicum A radiolarian

Micrographs by Frank Fox, www.mikro-foto.de, CC BY SA 3.0 Germany

7.5 Summary

- Protists are microscopic, one-celled organisms that have both plant-like and animal-like qualities.
- There are four main types of protists that are classified primarily on how they move. These are ciliates, flagellates, amoebae, and sporozoans.
- Ciliates move with tiny hair-like projections called cilia.
- Flagellates move with one or more long whip-like structures called flagella.
- Amoebae move by crawling with pseudopodia, or "false feet."
- Photosynthetic protists (autotrophs) , such as euglena, use the Sun's energy to make food.
- Heterotrophic protists, including paramecia, amoebae, didinia, and podophrya capture other organisms for food by using cilia, pseudopods, or tentacles.

7.6 Some Things to Think About

- Study the protist examples in this chapter. What features can you observe that make the organisms different from each other?
  Is it surprising that each of these organisms is made of only one cell (with the exception of the kelp colony) ? Why or why not?
- How would you describe the four ways that protists move that are used for classification?
- How do you think a euglena is helped by having a flagellum and a stigma?
- How would you compare different parts of a protist to different parts of the human body?
- How do you think protists can perform so many different functions when they are made of only one cell?
- What do you think are the advantages of organisms that have many cells compared to organisms that have only one cell?

Image credits for chapter title page:
1. Giant kelp, Courtesy of Claire Fackler, CINMS/ NOAA; 2. Formanifora, Courtesy of Psammophile (CC BY SA 3.0); 3. Star Radiolarian, Courtesy of Dr. John R. Dolan, Laboratoire d'Oceanographique de Villefranche; Observatoire Oceanologique de Villefrance-sur-Mer; 4. Giardia on intestinal cell, Courtesy of CDC/Dr. Stan Erlandsen; 5. Giardia, Courtesy of CDC/Dr. Stan Erlandsen; 6. *Didinium nasutum* eating a paramecium, Courtesy of Gregory Antipa (San Francisco State University) and H. S. Wessenberg (San Francisco State University)

Focus On

Grades 5-8

Middle School Biology

Laboratory Notebook

3rd Edition

Rebecca W. Keller, PhD

Real Science 4 Kids

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Illustrations: Janet Moneymake

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Keeping a Laboratory Notebook

A laboratory notebook is essential for the experimental scientist. In this type of notebook, the results of all the experiments are kept together along with comments and any additional information that is gathered. For this curriculum, you should use this workbook as your laboratory notebook and record your experimental observations and conclusions directly on its pages, just as a real scientist would.

The experimental section for each chapter is pre-written. The exact format of a notebook may vary among scientists, but all experiments written in a laboratory notebook have certain essential parts. For each experiment, a descriptive but short *Title* is written at the top of the page along with the *Date* the experiment is performed. Below the title, an *Objective* and a *Hypothesis* are written. The objective is a short statement that tells something about why you are doing the experiment, and the hypothesis is the predicted outcome. Next, a *Materials List* is written. The materials should be gathered before the experiment is started.

Following the *Materials List,* the *Experiment* is written. The sequence of steps for the experiment is written beforehand, and any changes should be noted during the experiment. All of the details of the experiment are written in this section. All information that might be of some importance is included. For example, if you are to measure 236 ml (1 cup) of water for an experiment, but you actually measured 300 ml (1 1/4 cup), this should be recorded. It is hard sometimes to predict the way in which even small variations in an experiment will affect the outcome, and it is easier to track down a problem if all of the information is recorded.

The next section is the *Results* section. Here you will record your experimental observations. It is extremely important that you be honest about what is observed. For example, if the experimental instructions say that a solution will turn yellow, but your solution turned blue, you must record blue. You may have done the experiment incorrectly, or you might have discovered a new and interesting result, but either way, it is very important that your observations be honestly recorded.

Finally, the *Conclusions* should be written. Here you will explain what the observations may mean. You should try to write only valid conclusions. It is important to learn to think about what the data actually show and what cannot be concluded from the experiment.

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Experiment 1

Putting Things in Order

Introduction

Explore sorting objects by putting them in categories.

I. Think About It

❶ What are some groups, or categories, of foods that you can think of?

❷ What are some groups, or categories, of toys that you can think of?

❸ In what other ways could you group foods or toys?

❹ Do you think it is helpful to you to put objects into different groups? Why or why not?

❺ In what ways might it be helpful for scientists to put objects into different groups?

❻ What do you think would happen if biologists tried to study each living thing by itself instead of placing it in a group?

II. Experiment 1: Putting Things in Order

Date ___________

Objective ____

____

Hypothesis ____

____

____

Materials

pencil and eraser

Collect a variety of objects. Some suggestions are:

- rubber ball
- cotton ball
- orange
- banana
- apple
- paper
- sticks
- leaves
- rocks
- grass
- Legos
- building blocks
- other objects

EXPERIMENT

❶ Spread all the objects out on a table. Carefully look at each object and note some of its characteristics. For example, some objects may be smooth, some fuzzy; some may be edible, others not; some may be large, some small, etc.

❷ In the following chart, record your observations for each item.

Item	Characteristics

❸ Now try to define "categories" for the objects. For example, some objects may be "hard," so one category could be called "Hard." Some objects may be "round," so another category could be "Round." Try to think of at least 4 or 5 different categories for your objects. Write the categories along the top of the following table.

❹ List the objects in the category that describes them. Take note of those objects that fit into more than one category. Write these objects down more than once, placing them in all of the categories that describe them.

❺ Next, take a look at each of the categories and each of the objects in those categories. Can you make "subcategories?" For example, some objects may all be the same color, so "Red" could be a subcategory. Some may be food items so "Food" could be a subcategory. Pick three categories and try to list two subcategories for each of these main categories.

❻ List the objects according to their category and subcategory. See if you can fit all the objects into a category and subcategory. You can rename your categories and subcategories as needed.

Categories						

Categories						
Sub-categories						

III. Conclusions

What conclusions can you draw from your observations?

IV. Why?

As you discovered in this experiment, it can be difficult to sort objects into exact groups because the objects have so many different features. Some of the objects you looked at could fit into two or more groups depending on their features and the way you defined the groups. It can take some time to figure out how to define groups in order to accommodate all the items being categorized. Once the main categories have been determined, objects that all fit into one of the main categories can then be placed into smaller subcategories according to additional features.

The same is true when scientists are putting living things into groups. There are so many different types of living things with so many different characteristics that it can be difficult to determine which organisms should be grouped together. When classifying living things, scientists first divide them into several very large groups. In the classification system used in this chapter of the *Student Textbook,* organisms are first grouped into domains according to the type of cell they are made of. Then each domain is divided into one or more kingdoms, then kingdoms into phyla. Each group is further divided until the level of genus and species is reached, which defines the particular type of organism. As you can see, taxonomic classification starts out with groups that contain very large numbers of organisms, and the number of organisms in a group gets smaller as more characteristics are considered.

These taxonomic categories can change or become outdated. New classification systems are developed as scientists make new discoveries and as they need to categorize organisms in ways that are more suited to what is being studied.

V. Just For Fun

On the next page write down the names of 15 or more living things you can see without a microscope or magnifying glass.

Make up your own taxonomic system. Put the living things you've written down into main categories and then as many sub-categories as you can according to their different features. Give your taxonomic system a name and name your categories and sub-categories. Record your taxonomic chart on the following page. Use additional paper if needed.

Living things: ____

____

____

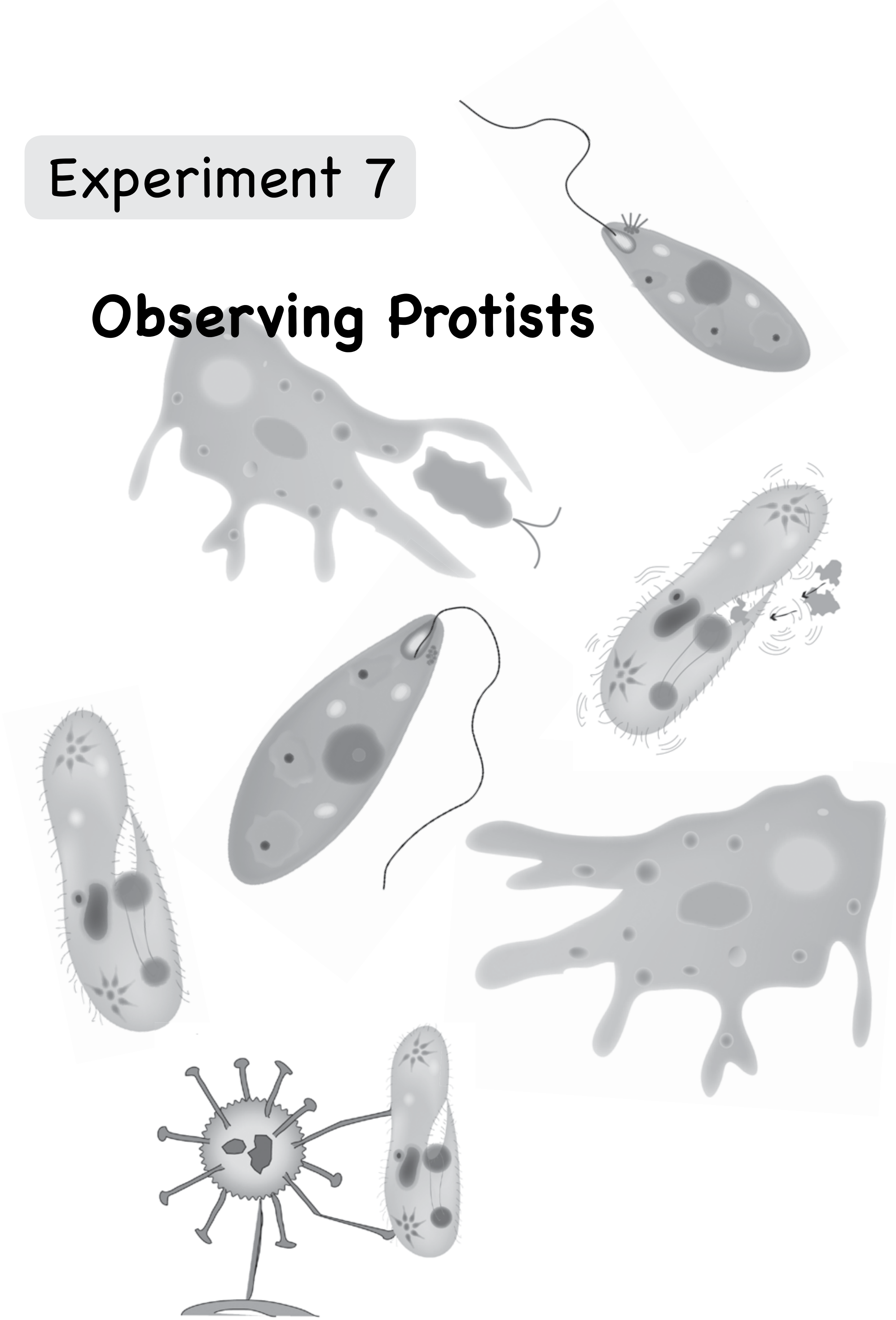
____

____

____

Experiment 7

Observing Protists



Introduction

Look through a microscope to see some amazing protists!

I. Think About It

❶ How do you think protists move? Do they all move in the same way? Why or why not?

❷ Would you rather be able to move like an amoeba or a paramecium? Why?

❸ What do you think it would be like to have to eat like an amoeba does?

❹ What would be the differences between moving with cilia and moving with a flagellum? Why?

____

____

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____

____

❺ Do you think it would be easier for a euglena to eat than for a paramecium to eat? Why or why not?

____

____

____

____

____

❻ In what ways do you think protists are like plants and how are they like animals?

____

____

____

____

____

II. Experiment 7: Observing Protists—How Do They Move?

Date ___________

Objective ______________________________

____

Hypothesis ______________________________

____

____

Materials

microscope with a 10X objective
microscope depression slides
5 eyedroppers
fresh pond water or water mixed with soil
protist study set
methyl cellulose

EXPERIMENT—Part A

❶ Take one of the samples from the protist set and use an eyedropper to place a small droplet of solution onto a glass slide that has been correctly positioned in the microscope.

❷ Observe the movement of the protists. If the organisms move too quickly, apply a droplet of methyl cellulose into the protist solution on the slide.

❸ Patiently observe the movement of one type of protist. In the *Results — Part A* section, note the type of protist you are observing. Draw the protist and describe how it moves, writing down as many observations as you can.

❹ Repeat Steps ❶-❸ with two other protist types. Use a new eyedropper for each sample.

Results—Part A

Type of protist ______________________________

Observations of movement:

____

____

____

____

____

____

____

Drawing of the protist

Type of protist ______________________________

Observations of movement:

____

____

____

____

____

____

____

Drawing of the protist

Type of protist ______________________

Observations of movement:

____

____

____

____

____

____

____

Drawing of the protist

EXPERIMENT—Part B

Take a droplet of fresh pond water (or water mixed with soil) and place it on a slide in the microscope. Based on how the organisms move, try to determine the types of protists you are observing. Write and draw your observations in the *Results — Part B* section.

Results—Part B

Types of protists seen and observations about them

Drawings of the protists labeled with type of protist

More protist observations

III. Conclusions

What conclusions can you draw from your observations?

IV. Why?

Protists are members of the kingdom Protista, and they are found wherever there is water, including saltwater, freshwater, and soil. Protists have been difficult to classify because they are eukaryotes and can have both plant-like and animal-like qualities. Protist is an “umbrella term” that fits those organisms that cannot be easily placed in any other kingdom.

The euglena moves by whipping back and forth an appendage called a flagellum, and the paramecium uses hair-like projections called cilia that it beats to move itself around. Although they have a simple appearance in a microscope, cilia and flagella are actually very sophisticated machines. Each whip contains long strands of molecules called microtubules. As the microtubules slide past each other, the flagellum or cilium changes orientation. When the microtubules next slide past each other going the opposite way, the whip again changes orientation. These successive changes cause the cilia or flagella to beat or whip causing the protist to move.

Having one flagellum makes a euglena tend to move in a single direction, and it may hover under a light source as it gathers light for photosynthesis. Having many cilia allows a paramecium to move all over the place. It can roll, move forward and backward, and spin. Amoebae move the most slowly, as they expand and contract their pseudopods to crawl along.

Protists are uniquely designed and are amazing tiny single-celled creatures.

V. Just for Fun: How Do They Eat?

Date: ___________

Do another experiment, this time observing how protists eat.

Objective ____

____

Hypothesis ____

____

Materials

microscope with a 10X objective
microscope depression slides
5 eyedroppers, measuring cup and measuring spoons
protist study kit
baker's yeast
distilled water
Eosin Y stain

EXPERIMENT

❶ Color the yeast with Eosin Y stain as follows:

Add 5 milliliters (one teaspoon) of dried yeast to 120 milliliters (1/2 cup) of distilled water. Allow it to dissolve.

Add one droplet of Eosin Y stain to one droplet of yeast mixture on a slide. Look at the mixture under the microscope. You should be able to see individual yeast cells that are stained red.

❷ Get the amoeba sample and place a small droplet of the solution onto a glass slide that has been correctly positioned in the microscope.

❸ Take a small droplet of the yeast stained with Eosin Y and place it into the droplet of protist solution that is on the slide.

❹ Looking through the microscope, patiently observe the protists, and note the red-colored yeast. Look for a protist eating and try to describe how it eats. In the *Results* section write down as many observations as you can. Draw one of the protists eating.

❹ Repeat steps 2-4 using the paramecium sample.

Results

Observations of an amoeba eating

Drawing of how an amoeba eats

Observations of a paramecium eating

Drawing of how a paramecium eats

Conclusions

What conclusions can you draw from your observations?

Focus On

Grades 5-8

MIDDLE SCHOOL

Biology

Teacher's Manual

3rd Edition

Rebecca W. Keller, PhD

Real Science-4-Kids

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Opening page: David Keller, PhD

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A Note from the Author

This curriculum is designed to engage middle school level students in further exploration of the scientific discipline of biology. The *Focus On Middle School Biology Student Textbook—3rd Edition* and the accompanying *Laboratory Notebook* together provide students with basic science concepts needed for developing a solid framework for real science investigation into biology.

The *Laboratory Notebook* contains 44 experiments—two experiments for each chapter of the *Student Textbook*. These experiments allow students to expand on concepts presented in the *Student Textbook* and develop the skills needed for using the scientific method. This *Teacher's Manual* will help you guide students through the laboratory experiments.

There are several sections in each chapter of the *Laboratory Notebook*. The section called *Think About It* provides questions to help students develop critical thinking skills and spark their imagination. The *Experiment* section provides students with a framework to explore concepts presented in the *Student Textbook*. In the *Conclusions* section students draw conclusions from the observations they have made during the experiment. A section called *Why?* provides a short explanation of what students may or may not have observed. And finally, in each chapter an additional experiment is presented in *Just For Fun*.

The experiments take up to 1 hour. Materials needed for each experiment are listed on the following pages and also at the beginning of each experiment.

Enjoy!

Rebecca W. Keller, PhD

Materials at a Glance

Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
pencil and eraser Objects chosen by students, such as: rubber ball cotton ball orange banana apple paper sticks leaves rocks grass Legos building blocks other objects **Optional** several sheets of paper	plastic petri dishes[1] dehydrated agar powder[2] distilled water K-12 safe E. coli bacterial culture[3] inoculation loop[4] candle or gas flame cooking pot mixing spoon oven mitt or pot holder measuring spoons measuring cup black permanent marker red marker rubber gloves, 2 pairs	microscope with 4X, 10X, and 40X objective lenses; 100X objective lens recommended but not required. (See beginning of chapter for purchasing info.) glass microscope slides[5] glass microscope cover slips[6] immersion oil (if using 100X objective lens)[7] Samples: piece of paper with lettering strands of hair droplet of blood insect wing	tincture of iodine [VERY POISONOUS—DO NOT ALLOW STUDENTS TO EAT any food items that have iodine on them] bread, 1 slice timer wax paper marking pen cup refrigerator a green vegetable one or more other vegetables or fruits	pencil colored pencils/crayons student-selected materials for model cell **Experiment 6** dehydrated agar [2] distilled water cooking pot measuring spoons measuring cup cup plastic petri dishes (20)[1] cotton swabs permanent marker oven mitt or pot holder

Experiment 7	Experiment 8	Experiment 9	Experiment 10	Experiment 11
microscope with a 10X objective microscope depression slides [8] 10 or more eyedroppers fresh pond water or water mixed with soil protozoa study kit [9] (must be used within 1-2 days of arrival) methyl cellulose [10] measuring cup and measuring spoons baker's yeast distilled water Eosin Y stain [11]	agar powder[2] distilled water cooking pot measuring spoons measuring cup plastic petri dishes[1] permanent marker oven mitt or pot holder jar with lid (big enough to hold 235 ml (about 1 cup) liquid 1 slice of bread, preferably preservative free small clear plastic bag white vinegar bleach borax mold or mildew cleaner 1-2 pairs rubber gloves	colored pencils handheld magnifying glass field notebook (blank or faintly lined pages) backpack, water, snacks 2 plant pots potting soil and water corn seeds, 8 or more with packet bean seeds, 8 or more with packet **Optional** field guide to the plants book iPad, camera, or smartphone with camera plant identification app: do some online research to find the best app to use with a specific mobile device	plant with at least 6 flat, green leaves (a tree may be used) lightweight cardboard or construction paper—enough to cut out 6 pieces that are bigger than a leaf scissors tape 2 small jars marking pen 4 or more plant pots potting soil bean seeds (12 or more)	microscope with 4X, 10X, and 40X objective lenses; a 100X objective lens is recommended glass microscope slides (plain)[5] glass coverslips[6] immersion oil (if using 100X objective lens)[7] water eyedropper sharp knife toothpick colored pencils Samples: raw celery stalk with leaves raw carrot a large leaf other plant parts: students' choice 3 or more small jars several fresh white carnation flowers food coloring

As of this writing the following materials are available from http://www.hometrainingtools.com/

1. A stack of 20 petri dishes: petri-dishes-plastic-20-pk/p/BE-PETRI20/
2. Nutrient-agar-8-g-dehydrated/p/CH-AGARN08/
3. Escherichia-coli-bacteria/p/LD-ESCHCOL/
4. Inoculating-needle-looped-end/p/BE-INOCUL/
5 Glass microscope slides: MS-SLIDP72 or MS-SLIDEPL
6 Glass microscope cover slip: MS-SLIDCV
7. Immersion oil: MI-IMMOIL
8. Glass Depression Slides, MS-SLIDC72 or MS-SLIDC12
9. Basic Protozoa Set, LD-PROBASC
10. Methyl Cellulose, CH-METHCEL
11. Eosin Y, CH-EOSIN
(Or search by the name of the item needed)

Experiment 12	Experiment 13	Experiment 14	Experiment 15	Experiment 16
several fresh vegetable scraps such as: carrot top, lettuce leaves or the root end of a head of lettuce, red beet top, turnip top, garlic bulb, onion bulb, scallions, either or both ends of a zucchini squash or cucumber, basil leaves with stem, potato (piece or peeling with eyes), or other vegetables of students' choice knife toothpicks several small glass jars or small drinking glasses colored pencils or pens several plant pots potting soil water **Optional** existing or new field notebook garden trowel or spoon	toothpicks or cotton swabs glass microscope slides[1] plastic pipette or eyedropper[1] methylene blue solution (0.5% to 1%)[1] (iodine can be used instead—follow the same safety precautions) plastic cover slip[1] paper towels or tissues thin rubber, vinyl, or latex gloves that are a tight fit goggles or other eye protection[1] microscope misc. household materials to make microscope dyes **Optional** immersion oil[1]	**14A** preserved specimens: clam, crayfish, sea star, and earthworm, (non-injected or injected)[2] dissection guide for each organism[2] safety goggles lab apron gloves dissection tray dissection pins dissecting probe forceps scissors scalpel hand lens or magnifying glass paper towels water **14B** food items: sugar cube small piece of animal protein (chunk of turkey, ham, roast beef, etc.) cheese apple bread oil or butter choice chamber, homemade: shallow pan, shallow cardboard box, short jar, or plastic Petri dish cardboard or paper cut into strips choice chamber, purchased: available from Home Science Tools; search on "choice chamber."[1]	**15A** preserved specimens: frog, shark, and perch (Specimens don't need to be injected.) dissection guide for each organism safety goggles lab apron gloves dissection tray dissection pins dissecting probe forceps scissors scalpel hand lens or magnifying glass paper towels water **15B** ebird.org app (free) Merlin Bird ID app (free) or other bird ID app and/or a print book field guide to the birds, such as *The Young Birder's Guide to North America* smartphone or iPad with internet access and camera; or desktop or laptop computer and digital camera, if available an email address field notebook (existing or new) pen, pencil, colored pencils **Optional** binoculars	**16A** preserved fetal pig (doesn't need to be injected) dissection guide safety goggles lab apron gloves dissection tray dissection pins dissecting probe forceps scissors scalpel hand lens or magnifying glass paper towels water **16B** smartphone, iPad, or computer with internet access and camera; or desktop or laptop computer and digital camera, if available an email address field notebook (an existing one or start a new one for citizen science projects) **Or** Local library, zoo, or natural history museum field notebook (an existing one or start a new one for citizen science projects)

1. Available from Home Science Tools: https://www.homesciencetools.com/
Type the name of the item needed in the website search bar.

Experiments 14-16

Most of the supplies are available from Home Science Tools. Type the name of the item needed in the website search bar.

For preserved organisms and dissection guides search on the Home Science Tools website for "dissection specimen" and "dissection guide." Choose the organisms listed for each experiment. (At the time of this writing, Home Science Tools offers an "Animal Specimen Set of 9 with Pig" that has most of the specimens needed for Experiments 14-16) Dissection tools are also available from Home Science Tools. Search for individual tools or a dissection kit. Look for other supplies too.

https://www.homesciencetools.com/

Materials

Quantities Needed for All Experiments

Equipment

backpack
choice chamber, homemade:
shallow pan, shallow cardboard box, short jar, or plastic Petri dish, and cardboard or paper cut into strips
choice chamber, purchased: available from Home Science Tools; search on “choice chamber” *
cooking pot
cup
cup, measuring
dissecting probe *
dissection pins *
dissection tray *
forceps *
goggles, safety, or other eye protection *
hand lens or magnifying glass *
inoculation loop [4]
jar with lid (big enough to hold 235 ml liquid (about 1 cup)
jars, 5 or more small
jars, small glass or small drinking glasses (several)
knife, sharp
lab apron *
microscope with 4X, 10X, and 40X objective lenses; a 100X objective lens is recommended (see Chapter 3 for selection info & advice)
oven mitt or pot holder
plant pots (6 or more)
refrigerator
scalpel *
scissors
smartphone or iPad with internet access and camera; or desktop or laptop computer and digital camera, if available
spoon, mixing
spoons, measuring
timer

Optional

binoculars
field guide to plants print book/field guide to birds
iPad, camera, or smartphone with camera
library, zoo, or natural history museum in your area
plant identification app (do some online research to find the best app to use with a specific mobile device)
trowel, garden, or spoon

Materials

agar, dehydrated powder [2]
bleach
borax
candle (or gas stove flame)
cardboard, lightweight, or construction paper
carnation flowers, several fresh white
cleaner, mold or mildew
cotton swabs
E. coli bacterial culture, K-12 safe [3]
Eosin Y stain [11]
eraser
eyedroppers (11 or more) *
food coloring
gloves, rubber, 3-4 pairs
gloves, thin rubber, vinyl, or latex, that are a tight fit (several pairs)
immersion oil (if using 100X objective lens) [7]
iodine, tincture of [VERY POISONOUS—DO NOT ALLOW STUDENTS TO INGEST] *
leaf, large
marker, black permanent
marker, red permanent
methyl cellulose [10]
methylene blue solution (0.5% to 1%) [1] (iodine can be used instead—follow the same safety precautions) *
microscope cover slips, glass [6]
microscope cover slips, plastic *
microscope slides , depression [8]
microscope slides, plain, glass [5]
notebook, for field notebook, existing or new (1 or more), unlined or faint lines works best
paper
paper towels or tissues
pencil
pencils, colored, or crayons
petri dishes, plastic (50-60) [1]
pipette, plastic, or eyedropper *

Materials

plant with at least 6 flat, green leaves (a tree may be used)
plastic bag, small clear
potting soil
protozoa study kit [9] (must be used within 1-2 days of arrival)
seeds, bean 20 or more with packet
seeds, corn, 8 or more with packet
tape
toothpicks
vinegar, white
water, distilled
water, fresh pond or water mixed with soil
wax paper

Materials, Misc.

materials, household (misc.) to make microscope dyes (students’ choice)
materials, student-selected, to make a model cell
objects chosen by students, such as:
rubber ball
cotton ball
orange
banana
apple
paper
sticks
leaves
rocks
grass
Legos
building blocks
other objects
plant parts, misc., students’ choice
samples for microscopy:
blood, droplet
hair, a few strands
insect wing
paper, piece with lettering

Other	Preserved Specimens *	Foods
ebird.org app (free) email address Merlin Bird ID app (free) or other bird ID app and/or a print book field guide to the birds, such as *The Young Birder's Guide to North America*	[can use either non-injected or injected specimens] clam crayfish earthworm fetal pig frog perch sea star shark dissection guide for each organism *	animal protein (chunk of turkey, ham, roast beef, etc.), small piece apple bread, any, 1-2 slices bread, 1 slice, preferably preservative free carrot, raw celery stalk with leaves, raw cheese oil or butter snacks sugar cube vegetable, green (student's choice) vegetables or fruits (misc.), one or more vegetable scraps, several fresh, such as: carrot top, lettuce leaves or the root end of a head of lettuce, red beet top, turnip top, garlic bulb, onion bulb, scallions, either or both ends of a zucchini squash or cucumber, basil leaves with stem, potato (piece or peeling with eyes), or other vegetables of students' choice yeast, baker's

As of this writing the following materials are available from http://www.hometrainingtools.com/

1. A stack of 20 petri dishes: petri-dishes-plastic-20-pk/p/BE-PETRI20/
2. Nutrient-agar-8-g-dehydrated/p/CH-AGARN08/
3. Escherichia-coli-bacteria/p/LD-ESCHCOL/
4. Inoculating-needle-looped-end/p/BE-INOCUL/
5. Glass microscope slides: MS-SLIDP72 or MS-SLIDEPL
6. Glass microscope cover slip: MS-SLIDCV
7. Immersion oil: MI-IMMOIL
8. Glass Depression Slides, MS-SLIDC72 or MS-SLIDC12
9. Basic Protozoa Set, LD-PROBASC
10. Methyl Cellulose, CH-METHCEL
11. Eosin Y, CH-EOSIN

(Or search by the name of the item needed)

* Available from Home Science Tools: https://www.homesciencetools.com/
Type the name of the item needed in the website search bar.

For preserved organisms and dissection guides search on the Home Science Tools website for "dissection specimen" and "dissection guide." Choose the organisms listed for each experiment. (At the time of this writing, Home Science Tools offers an "Animal Specimen Set of 9 with Pig" that has most of the specimens needed for Experiments 14-16) Dissection tools are also available from Home Science Tools. Search for individual tools or a dissection kit. Look for other supplies too.

https://www.homesciencetools.com/

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Experiment 1

Putting Things in Order

Materials Needed

- pencil and eraser

Objects chosen by students, such as:

- rubber ball
- cotton ball
- orange
- banana
- apple
- paper
- sticks
- leaves
- rocks
- grass
- Legos
- building blocks
- other objects

Optional

- several sheets of paper

Objectives

In this experiment students explore categorizing objects by their features.

The objectives of this lesson are for students to:

- Explore how objects can be categorized in different ways and how to chart their data.
- Observe the difficulties of categorizing objects.

Experiment

I. Think About It

Read this section of the *Laboratory Notebook* with your students.

Ask questions such as the following to guide open inquiry.

- *What are some groups of objects you can think of?*
- *How would you decide which objects should go in each group?*
- *Do you think it can be helpful to you to put objects into groups? Why or why not?*
- *Do you think some objects can go into more than one group? Why or why not?*
- *Do you think it is easy or difficult to put objects in groups? Why?*
- *How do you use groups in your day-to-day life?*

II. Experiment 1: Putting Things in Order

In this experiment, students will try to organize different objects according to their characteristics, such as shape, color, or texture. There are no "right" answers for this experiment, and the categories the students choose will vary.

Have the students read the entire experiment.

Help them collect a wide variety of objects of their choice that they will categorize.

Objective: Have the students write an objective. Some examples:

- *To put objects into different categories.*
- *To use categories and subcategories.*

Hypothesis: Have the students write a hypothesis. Some examples:

- *It will be easy to put objects in categories.*
- *Some objects will go into more than one category.*

EXPERIMENT

❶ Have the students place the collected objects on a table and then make careful observations. Guide them to notice some features of the objects, such as color, shape, and texture. Also, discuss any common uses, for example, those used as toys or those used as writing instruments.

❷ Have the students fill in the chart provided, listing each object and a few of its characteristics. Help them to be as descriptive as possible. For example, oranges can be described as round, orange, sweet, food, living, etc. Tennis balls are round, fuzzy, yellow or green (or another color). It is not necessary for them to fill in all the lines on the chart.

❸ Next, have the students determine some overall categories into which the objects can be placed. For example, marbles, cotton balls, and oranges are round, so "Round" could be a category. Basketballs, baseballs, and footballs are all balls, so another category could be "Types of Balls." Have the students write a category at the top of each column using a PENCIL so they are able to change the categories as more items are being written down.

❹ Students will list objects in the category that describes them according to their characteristics. Some items may fit into more than one category. Basketballs can fit into both the category "Round" and the category "Types of Balls." In the chart provided, have the students write down each item in all of the categories where it fits.

❺ Have the students look at each category separately and then choose three categories to further divide into subcategories. Guide them in thinking about what the subcategories might be, trying to choose categories that allow all of the items to ultimately be listed. If necessary, they can rename some of the main categories to better fit the items listed. The names of the categories and subcategories can be adjusted as needed so that each item is listed in a category and subcategory, but it's possible that not all of the items can be placed in a category and a subcategory. This can be quite challenging. The point of this exercise is to illustrate the difficulty of trying to find a suitable organizational scheme for things with different characteristics.

III. Conclusions

Have the students review the results they recorded for the experiment. Help them write valid conclusions based on the data they have collected. For example:

- Both oranges and cotton balls are round.
- Both cotton balls and marshmallows are white.
- Tennis balls and cotton balls are both fuzzy.

Examples of conclusions that are not valid:

- Both cotton balls and marshmallows are white. Marshmallows are sweet so cotton balls are sweet.
- Tennis balls and cotton balls are both fuzzy. Tennis balls are bouncy so cotton balls must be bouncy.

It is important to use only the data that has been collected and not make statements about the items that are not backed up by the data. It is obvious that marshmallows and cotton balls are both white, but it is not true that cotton balls are sweet. Because two or more items have one or two things in common does not mean that all things are common between them. Discuss this observation with the students.

Discuss the difference between valid and invalid conclusions. A valid conclusion is a statement that generalizes the results of the experiment, but draws only from the data collected. It does not go beyond the results of the data to include things that haven't been observed and does not connect results that should not be connected. An invalid conclusion is a statement that has not been proven by the data, or a statement that connects the data in ways that are not valid. The example given is that marshmallows are sweet and white, but although cotton balls are also white, it is invalid to say they are sweet like marshmallows.

IV. Why?

Read this section of the *Laboratory Notebook* with your students.
Discuss any questions that might come up.

V. Just For Fun

Students are to list 15 or more living things that can be seen without a microscope or magnifying glass. Then they will create their own taxonomic system to categorize them. There are no "right" answers.

Have them record their chart. They may want to use more paper.

Experiment 7

Observing Protists

Materials Needed

- microscope with a 10X objective
- microscope depression slides [1]
- 10 or more eyedroppers
- fresh pond water or water mixed with soil
- protozoa study kit [2] (must be used within 1-2 days of arrival)
- methyl cellulose [3]
- measuring cup and measuring spoons
- baker's yeast
- distilled water
- Eosin Y stain [4]

As of this writing, the following materials are available from Home Science Tools: www.hometrainingtools.com:

1. Glass Depression Slides, MS-SLIDC72 or MS-SLIDC12
2. Basic Protozoa Set, LD-PROBASC
3. Methyl Cellulose, CH-METHCEL
4. Eosin Y, CH-EOSIN

(Product availability or item numbers may change.)

Objectives

In this experiment students will be introduced to the microscopic organisms known as protists.

The objectives of this lesson are for students to:

- Observe how protists move and eat.
- Use a microscope to make observations.

Experiment

I. Think About It

Read this section of the *Laboratory Notebook* with your students.

Ask questions such as the following to guide open inquiry.

- *How many different ways do you think protists move?*
- *Do you think a paramecium moves more like a euglena or an amoeba? Why?*
- *How many different methods can you think of that protists use to eat?*
- *Do you think using cilia, a flagellum, or pseudopodia is the most efficient way for a protist to move? Why?*
- *Do you think it is easier for a paramecium to get around than for an amoeba? Why or why not?*

II. Experiment 7: Observing Protists—How Do They Move?

In this experiment students will examine the three different types of protists discussed in this chapter of the *Student Textbook*. They will then examine pond water or water mixed with soil to identify individual protists based on their method of movement.

It may take some time for younger students to align their eye directly into the lens so that the sample is visible. Also, viewing tiny organisms through the small eyepiece of a microscope can be difficult and requires some patience. These organisms can swim rapidly through the field of view, and it is easy to get frustrated trying to observe them. Methyl cellulose will help slow the organisms down without killing them. Patience with this experiment is a must.

Because students will be using slides with a concavity for the sample, they will not need to use cover slips.

Have the students read the entire experiment before writing an objective and a hypothesis.

Objective: Have the students write an objective. For example:

- *In this experiment, three types of protists will be observed. We will see how they move in different ways.*

Hypothesis: Have the students write a hypothesis. Some examples:

- *We can tell the difference between ciliates, flagellates, and amoebae.*
- *We can tell the difference between ciliates, flagellates, and amoebae in pond water by how they move.*

EXPERIMENT—Part A

Have the students set up the microscope.

❶ Have the students position a slide in the microscope and use an eyedropper to put a droplet of one of the protist samples on the slide.

❷ Have the students observe how the protists move. A droplet of methyl cellulose can be added to the protist sample on the slide to slow the movement of the protists.

A euglena will tend to move in a single direction, or it may not move at all but "hover" just under the light.

A paramecium will move all over the place. It will roll, move forward and backward, and spin. There are usually other things in the water with the paramecium. Have the students note what happens when the paramecium "bumps" into other objects or other paramecia.

The amoebae move very slowly, and it can be difficult to observe them. They are usually on the bottom of the container. Allow the container to sit for 30 minutes, and then have the students remove some solution from the very bottom, placing it on a slide. The amoebae should be visible but may be difficult to see since they are clear.

❸ Have the students draw the protist they are observing and write their observations. Boxes are provided in the *Results* section.

❹ Have the students repeat Steps ❶-❸ using the remaining two protist samples. Have them use a new eyedropper for each sample.

Results—Part A

Boxes are provided for students to record their results.

EXPERIMENT—Part B

Have the students repeat the experiment, this time looking for protists in pond water or water mixed with soil. Have them use a new eyedropper to place a droplet of fresh pond water (or water mixed with soil) on a slide in the microscope. Have them look for protists and try to determine the types of protists they observe based on how the organisms move. Have the students refer to the notes they made in *Part A* for comparison. Space is provided in the *Results — Part B* section for writing and drawing their observations. Have them record information for as many different organisms as they can find.

III. Conclusions

Have the students review the results they recorded for the experiment. Have them draw conclusions based on the data they collected. If the experiment did not work, this should be written as a conclusion.

IV. Why?

Read this section of the *Laboratory Notebook* with your students.
Discuss any questions that might come up.

V. Just For Fun: How Do They Eat?

Students will perform another experiment to observe how two different protists eat. Eosin Y stained baker's yeast will be used as food to be ingested by the protists. It may take some time for this observation. Once ingested by a protozoan, the red stained yeast will turn blue.

Have the students read the entire experiment. Have the students predict whether or not the protists will eat the yeast. Then have them write the objective and hypothesis.

❶ Have the students follow the directions to color the yeast with Eosin Y stain:

Add 5 milliliters (one teaspoon) of dried yeast to 120 milliliters (1/2 cup) of distilled water. Allow it to dissolve.

Add one droplet of Eosin Y stain to one droplet of yeast mixture. Look at the mixture under the microscope. You should be able to see individual yeast cells that are stained red.

❷ Have the students place a droplet of the amoeba sample on a glass slide that has been correctly positioned in the microscope. (For the amoebae, remind the students to gather the sample from the bottom of the container it comes in.)

❸ Have the students add a small droplet of the yeast stained with Eosin Y to the droplet of protist solution that is on the slide.

❹ Have the students observe the protists through the microscope, noting the red-colored yeast. Have them describe how the protist eats, writing down as many observations as they can and drawing one of the protists eating. It may take some patience to find protists eating.

❺ Have the students repeat steps 2-4, this time using the paramecium sample.

Focus On

Grades 5-8

Middle School Biology

Lesson Plan

3rd Edition

Rebecca W. Keller, PhD

Real Science 4 Kids

Real Science-4-Kids

Focus On Middle School Biology Lesson Plan—3rd Edition

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LESSON PLAN INSTRUCTIONS

This *Lesson Plan* accompanies the *Focus On Middle School Biology Student Textbook*, *Laboratory Notebook,* and *Teacher's Manual—3rd Edition*. It is designed to be flexible to accommodate a varying schedule as you go through the year's study. And it makes it easy to chart weekly study sessions and create a portfolio of your student's yearlong performance. The PDF format allows you to print pages as you need them.

This Lesson Plan file includes:

- Weekly Sheets
- Self-Review Sheet
- Self-Test Sheet
- Sticker Templates

Materials recommended but not included:

- 3-ring binder
- Indexing dividers (3)
- Labels—24 per sheet,1.5" x 1.5" (Avery 22805)

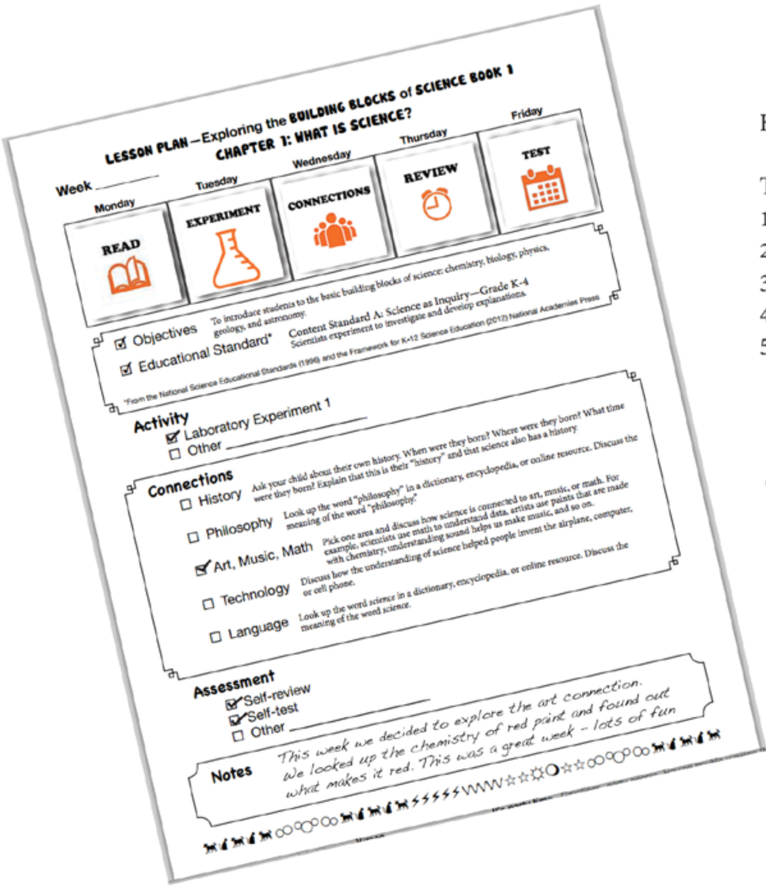
Use the Weekly Sheets to map out daily activities and keep track of student progress. For each week you decide when to read the text, do the experiment, explore the optional connections, review the text, and administer tests. For those families and schools needing to provide records of student performance and show compliance to standards, there is a section on the Weekly Sheets that shows how the content aligns to the National Science Standards.

To use this Lesson Plan:

- Print the Weekly Sheets
- Print Self-Review Sheets
- Print Self-Test Sheets
- Print the stickers on 1.5" x 1.5" labels
- Place all the printed sheets in a three-ring binder separated by index dividers

At the beginning of each week, use the squares under each weekday to plan your daily activities. You can attach printed stickers to the appropriate boxes or write in the daily activities. At the end of the week, use the *Notes* section to record student progress and performance for that week.

WEEKLY LESSON PLAN SAMPLES



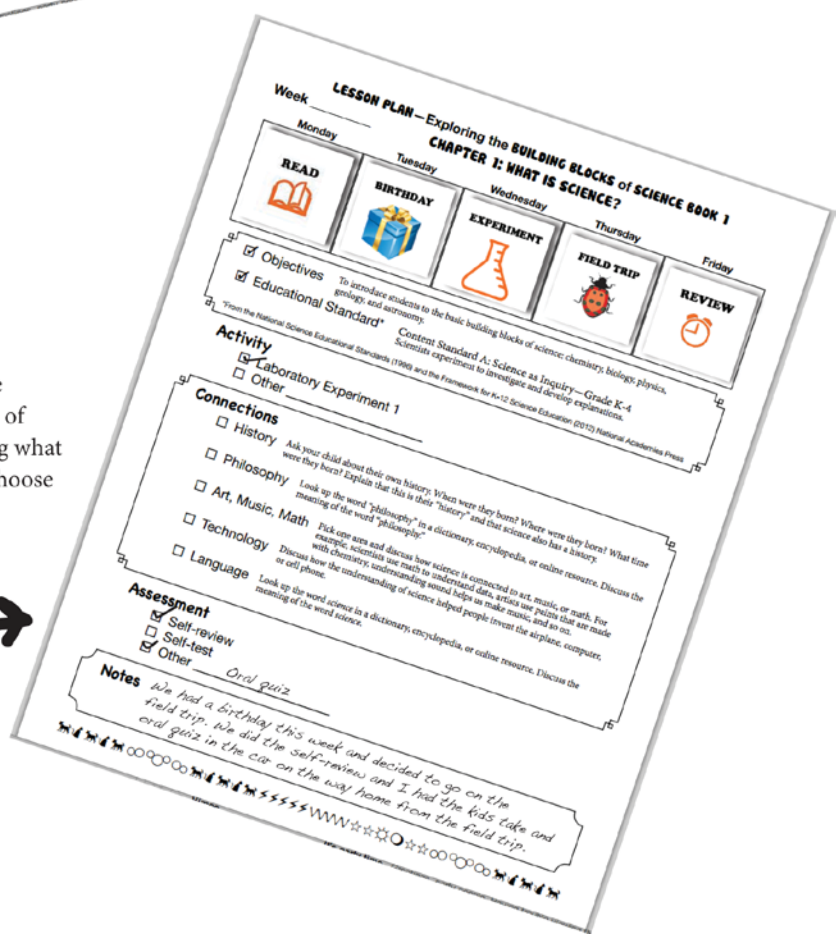
Here is a sample of a normal week.

The recommended sequence is
1 - Read the student textbook on the first day.
2 - Do the laboratory experiment on the second day.
3 - Pick one or more connections to explore on the third day.
4 - Do the self-review sheet on the fourth day.
5 - Administer the self-test or another exam on the fifth day.

Here is a sample of a week with other activities

1- Find at least one day to READ the text.
2 - Find a day to perform the EXPERIMENT.
3 - Find a day to do the REVIEW or TEST.

Any activity that is missed can be rescheduled for the following week. However, keep to the main sequence of reading the text, doing the experiment, and reviewing what has been covered. If an activity needs to be missed, choose the CONNECTIONS or SELF-TEST.



Week __________

CHAPTER 1: WHAT IS BIOLOGY?

Monday	Tuesday	Wednesday	Thursday	Friday

☑ Objectives To introduce students to the ideas surrounding the definition of life.

☑ Educational Standard* Connections to Nature of Science
Science assumes consistent patterns in natural systems.
(Content standard 5-PS1-2)

*Next Generation Science Standards National Academies Press

Activity

- ☐ Laboratory Experiment 1
- ☐ Other ______________________

Connections

- ☐ History Look up both Galen and Hippocrates and explore how their ideas contributed to what we know about life.
- ☐ Philosophy Discuss how philosophy, religion, and worldview maps influence ideas about how to define life.
- ☐ Art, Music, Math Discuss how the definition of art has changed throughout different times and cultures.
- ☐ Technology Explore how modern technology has helped us define life.
- ☐ Language Look up the word *biology* in a dictionary, encyclopedia, or online resource and discuss its meaning.

Assessment

- ☐ Self-review
- ☐ Self-test
- ☐ Other ______________________

Notes

Week ________

CHAPTER 7: PROTISTS

Monday	Tuesday	Wednesday	Thursday	Friday

☑ Objectives To learn about the kingdom Protista.

☑ Educational Standard* Disciplinary Core Ideas
LS1.C: Organization for Matter & Energy Flow in Organisms—Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food). (MS-LS1-6)

*Next Generation Science Standards National Academies Press

Activity

☐ Laboratory Experiment 7
☐ Other ____________________

Connections

☐ History Look up the taxonomy for protists and discuss how and why protists were initially classified with plants and animals.

☐ Philosophy Discuss whether or not philosophy shaped the classification of protists.

☐ Art, Music, Math Look at the metric scale and discuss how measurements are determined for tiny organisms.

☐ Technology Discuss how the microscope is used to visualize protists.

☐ Language Look up the word *amoeba* in a dictionary, encyclopedia, or online resource and discuss its meaning.

Assessment

☐ Self-review
☐ Self-test
☐ Other ____________________

Notes

SELF-REVIEW

Think about all of the ideas, concepts, and facts you read about in this chapter. In the space below, write down everything you've learned.

Date ________________ Chapter ____

SELF-TEST

Imagine you are the teacher and you are giving your students an exam. In the space below, write 5 questions you would ask a student based on the information you learned in this chapter.

Date ________________ Chapter ____

READ READ READ READ

REVIEW REVIEW REVIEW REVIEW

EXPERIMENT EXPERIMENT EXPERIMENT EXPERIMENT

CONNECTIONS CONNECTIONS CONNECTIONS CONNECTIONS

TEST TEST TEST TEST

READ READ READ READ

HOLIDAY

HOLIDAY

HOLIDAY

HOLIDAY

FIELD TRIP

FIELD TRIP

FIELD TRIP

FIELD TRIP

BIRTHDAY

BIRTHDAY

BIRTHDAY

BIRTHDAY

REST DAY

REST DAY

REST DAY

REST DAY

REST DAY

REST DAY

REST DAY

REST DAY

SICK DAY

SICK DAY

SICK DAY

SICK DAY

FOCUS ON

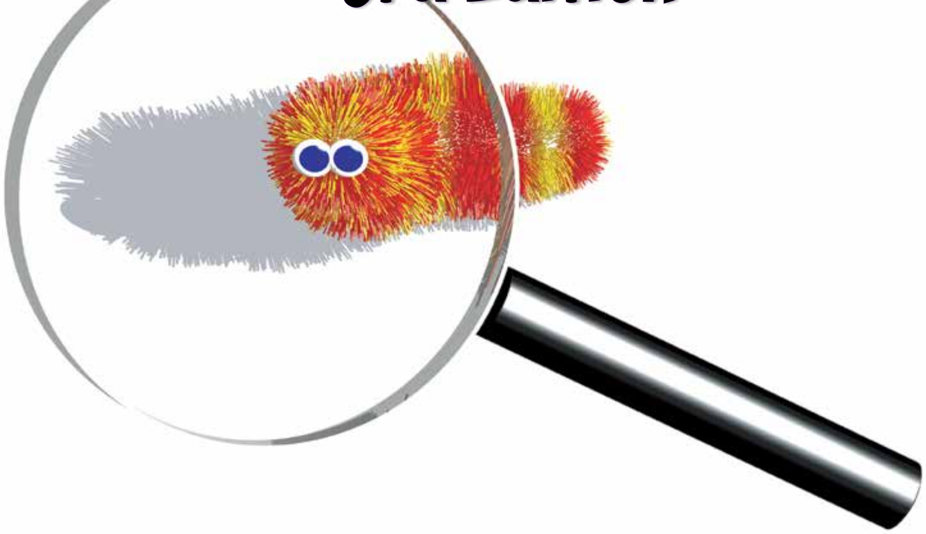
Grades 5-8

MIDDLE SCHOOL

Biology

Study Notebook

3rd Edition



Rebecca W. Keller, PhD

REAL SCIENCE 4 Kids

Illustrations: K. Keller

Focus On Middle School Biology Study Notebook

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Focus On Middle School Biology

STUDY NOTEBOOK

Welcome to your study notebook

This notebook is your place to record anything you want as you learn about biology and cells, plants, protists, viruses nd bacteris, fungi, animls,the chemistry of biology, and all the other amazing facts and concepts we call biology.

There are questions and suggestions. Some are serious and some are whimsical. If you don't like them, cross them out and create your own.

Just explore what you think about all the topics you are learning and try not to get too worried about writing down the "right" answers. This is an opportunity for you to explore what YOU like.

There are places in this notebook that are unscripted and have little instruction. There are also questions that just dangle on the edges of the page. That's OK. Just record, draw, or paste images that you think apply. Add extra pages as you like. Answer the questions and suggestions in a way that makes the most sense to you. Most of real science is unscripted and making discoveries has no set of instructions. Just play with it. You'll be fine and you might find out something unexpected and amazing.

This notebook is not meant to be graded. So parents and teachers, just let it go. Don't grade this notebook or make your student "turn it in." If your student wants to share all they are learning, great! If not, let that be OK too.

day month year

CHAPTER 1

If you had to create a machine that could sing any song, what would you need?

1.

2.

Anything else

Do you think your machine would work? What would it sound like?

Look up ‘reductionism’.

Reductionism:

BONUS!

Look up ‘holism’.

Holism:

Research Galen, the Greek physician, and his thoughts about the 'vital spirit'.

Compare this to 'atomism' and the ideas of Democritus.

Do you have a **Vital Spirit?**

Draw pictures of Democritus and Galen in Greece!

Use this page to design your singing machine from this chapter.

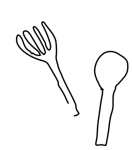
day month year

CHAPTER VII

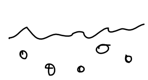
Draw an amoeba. (Or a herd of amoebas.)

Draw an amoeba eating.

What's with the feet?



Which would you rather be — an amoeba, a paramecium, a euglena, or a podophrya? Or maybe a Didinium?



Name ______________________________________ Date ____________________

Focus On Middle School Biology 3rd Edition - Midterm 1
Chapters 1-8, 24 questions, 10 points each, 240 points total
(Sample questions, Chapters 1 & 7)

1. Match the term with its definition.

____ Moving principle
____ Vital spirit
____ Ether
____ Reductionism
____ Materialism

a) A type of fire that always existed and is present in air and in other matter.
b) Everything is made of matter only, so all life can be explained solely by the laws of chemistry and physics.
c) An idea derived from the moving principle.
d) A force that causes an object to become itself.
e) Because life can be explained by the laws of chemistry and physics, you can completely understand something by studying its parts.

2. A philosophical map...
   - O Provides the one right way to interpret scientific data.
   - O Uses only the ideas of materialism and reductionism.
   - O Shows where the Greek philosophers lived.
   - O Helps us interpret and understand scientific data.
   - O Comes in only one form.

3. In taxonomy the three domains are Bacteria, Archaea, and Animalia.
   - O True
   - O False

19. Match the protist with how it moves.

____ Euglena	a) Uses cilia
____ Amoeba	b) Uses a flagellum
____ Paramecium	c) Uses pseudopodia

20. Match the protist with how it eats.

____ Euglena	a) Uses photosynthesis
____ Amoeba	b) Engulfs its food with pseudopodia
____ Paramecium	c) Uses cilia to swirl food into its oral groove

21. Because protists only have one cell, they can't perform a variety of tasks.
   - O True
   - O False

Answer Sheet

Focus On Middle School Biology 3rd Edition - Midterm 1
Chapters 1-8, 24 questions, 10 points each, 240 points total
(Sample questions, Chapters 1 & 7)

1. d, c, a, e, b
2. Helps us interpret and understand scientific data
3. False

19. b, c, a
20. a, b, c
21. False

Name ______________________________________ Date ____________________

Focus On Middle School Biology 3rd Edition - Final
Chapters 1-16, 32 questions, 10 points each, 320 points total
(Sample questions, Chapters 1 & 7)

1. Check the statements that are true for philosophical maps.
   - ☐ It is best for a scientist to use only one philosophical map or it could be confusing.
   - ☐ Scientists who use many philosophical maps to gather ideas will find more opportunities to make new discoveries.
   - ☐ Scientists often disagree about which philosophical map is the correct one.
   - ☐ Philosophical maps are always correct, so all scientists are in agreement with each of them.
   - ☐ Philosophical maps are ways of interpreting the world, and they help us get a clearer picture of the world around us.
   - ☐ Philosophical maps help us interpret and understand scientific data.

2. Check the statements that are true for taxonomy.
   - ☐ It is the branch of biology concerned with naming and classifying the many different types of living things.
   - ☐ One current system of taxonomy includes domains, kingdoms, phlya, and further classifications.
   - ☐ Taxonomy was founded by Carolus Linnaeus who began sorting living things into groups according to similar features.
   - ☐ It is always easy to determine which group a creature fits into because there are so many categories.

13. A paramecium and an amoeba both... (Check all that apply.)
    - ☐ Make food using photosyntheses.
    - ☐ Are protists.
    - ☐ Are single-celled organisms.
    - ☐ Have cells.
    - ☐ Do not have to eat.

14. An amoeba... (Check all that apply.)
    - ☐ Uses tentacles to eat food.
    - ☐ Swims rapidly by waving its pseudopods.
    - ☐ Moves using pseudopods.
    - ☐ Eats lots of potato chips.
    - ☐ Eats by surrounding its food with pseudopods.

Answer Sheet

Focus On Middle School Biology 3rd Edition - Final
Chapters 1-16, 32 questions, 10 points each, 320 points total
(Sample questions, Chapters 1 & 7)

1. Scientists who use many philosophical maps to gather ideas will find more opportunities to make new discoveries; Scientists often disagree about which philosophical map is the correct one; Philosophical maps are ways of interpreting the world, and they help us get a clearer picture of the world around us; Philosophical maps help us interpret and understand scientific data.
2. It is the branch of biology concerned with naming and classifying the many different types of living things; One current system of taxonomy includes domains, kingdoms, phlya, and further classifications; Taxonomy was founded by Carolus Linnaeus who began sorting living things into groups according to similar features.

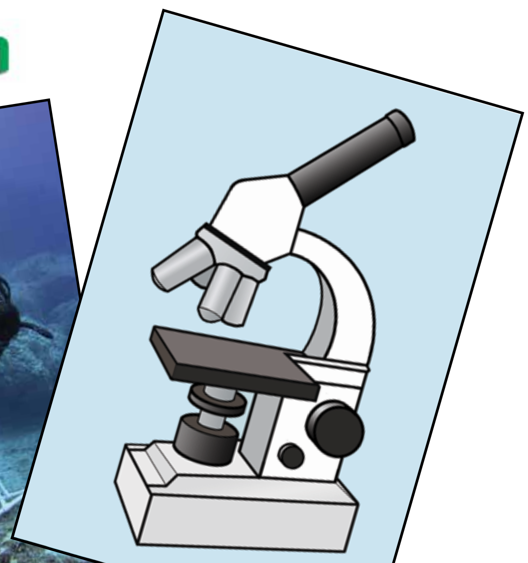
13. Are protists; Are single-celled organisms.
14. Moves using pseudopods; Eats by surrounding its food with pseudopods.

Focus On

Grades 5–8

Middle School Biology Graphics

3rd Edition



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Illustrations: Janet Moneymaker

Focus On Middle School Biology Graphics Package— 3rd Edition

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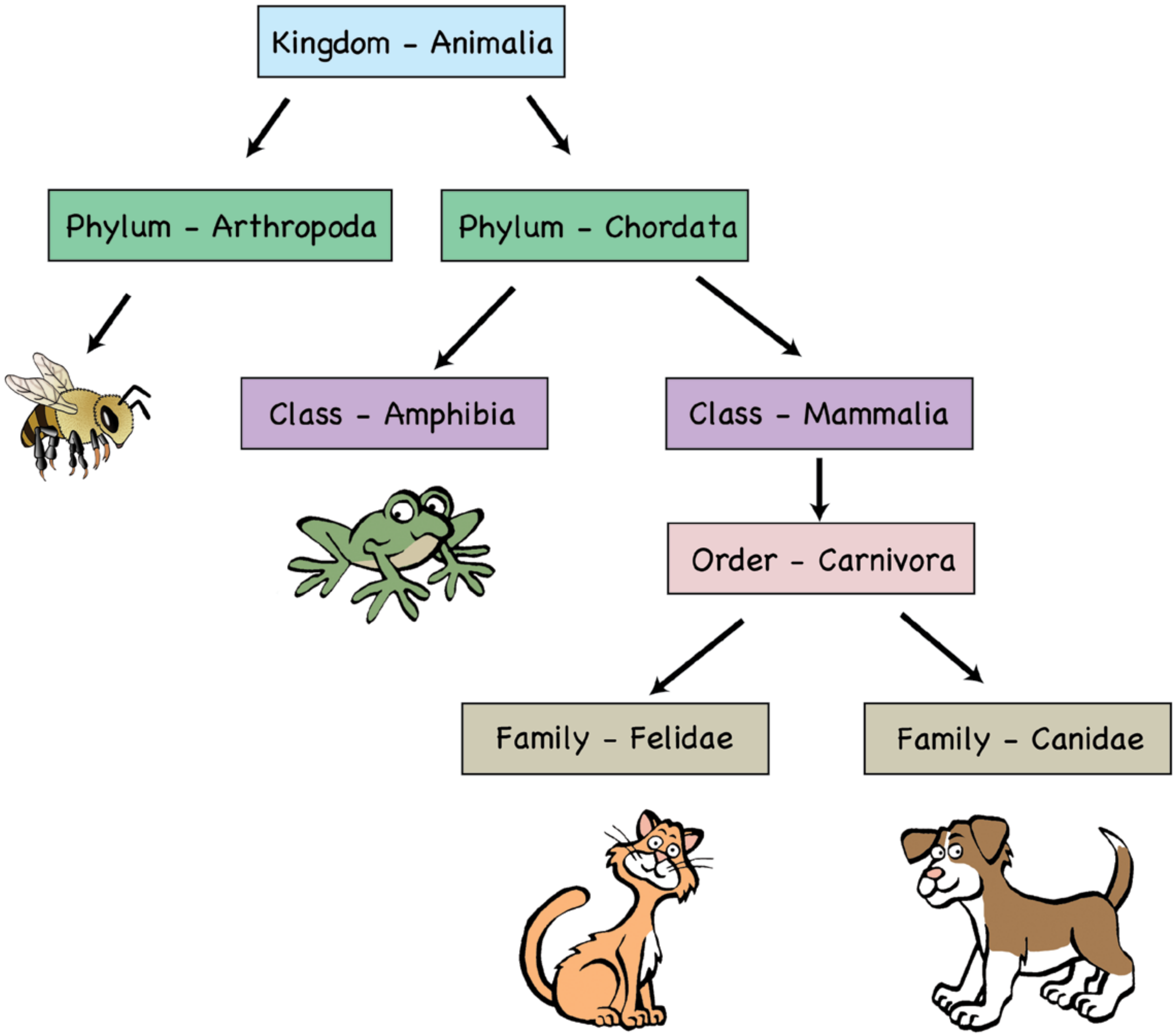
I THINK WE NEED TO GO THIS WAY.


Kingdom - Animalia
Phylum - Arthropoda
Phylum - Chordata
Class - Amphibia
Class - Mammalia
Order - Carnivora
Family - Felidae
Family - Canidae

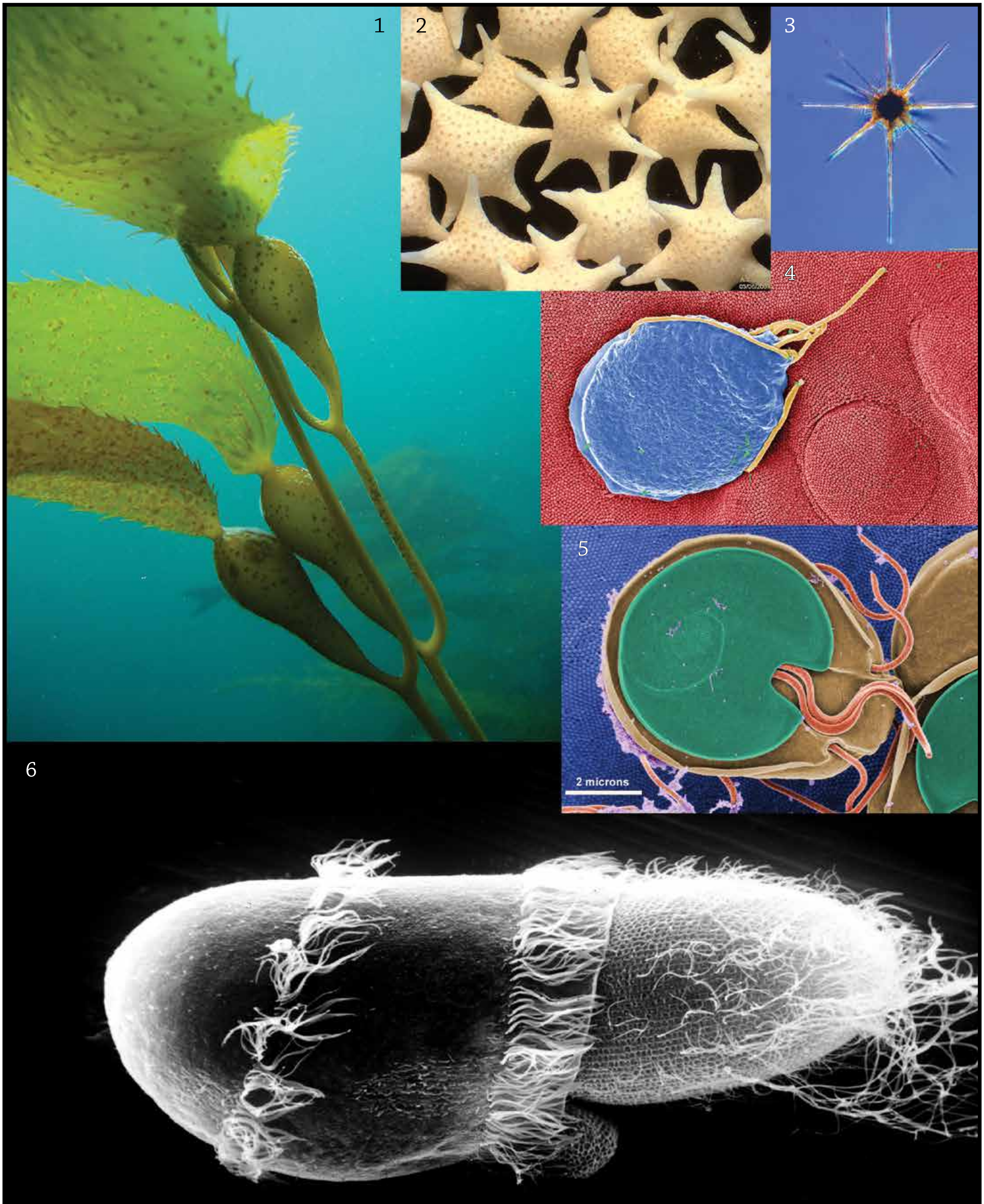
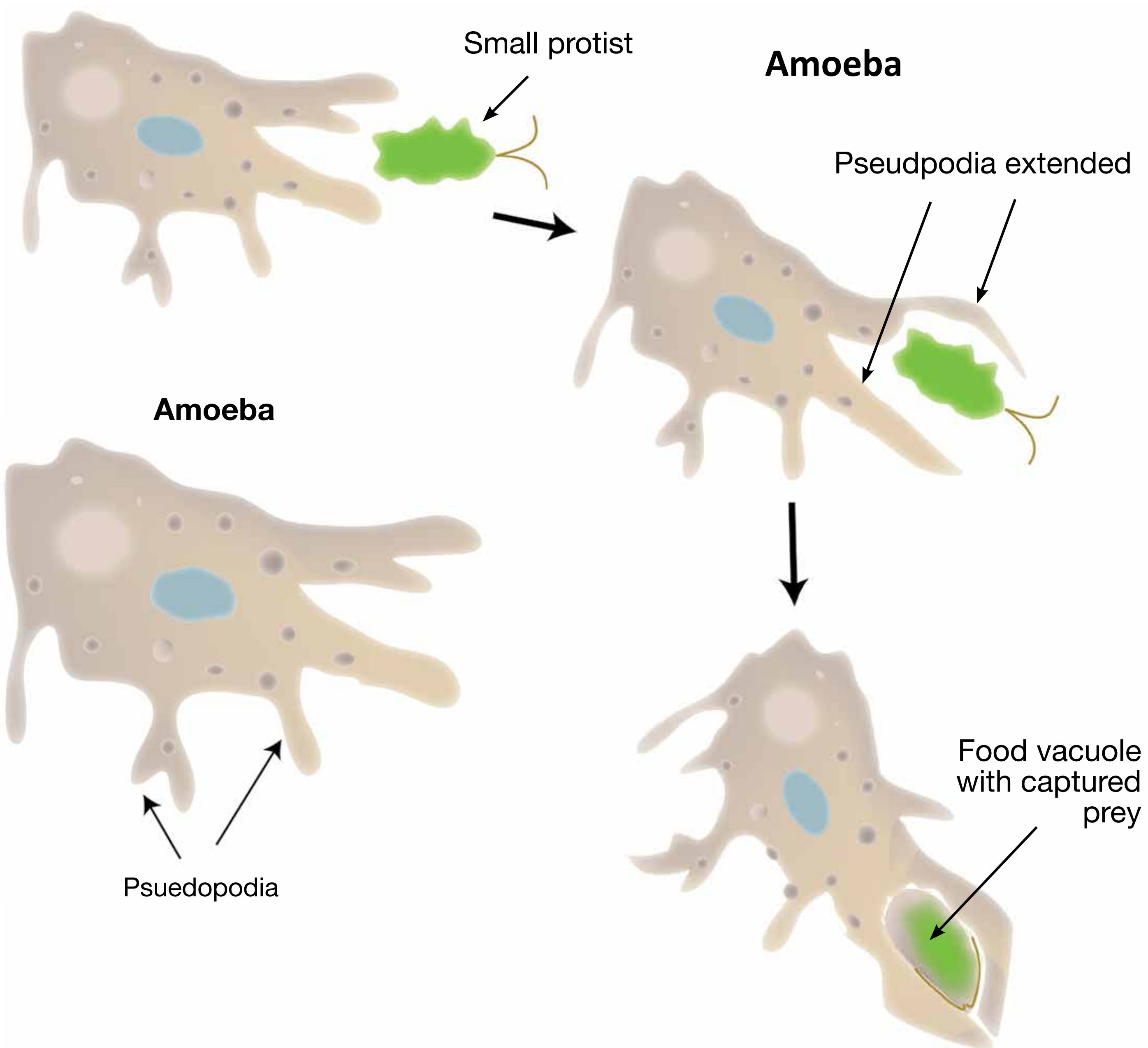
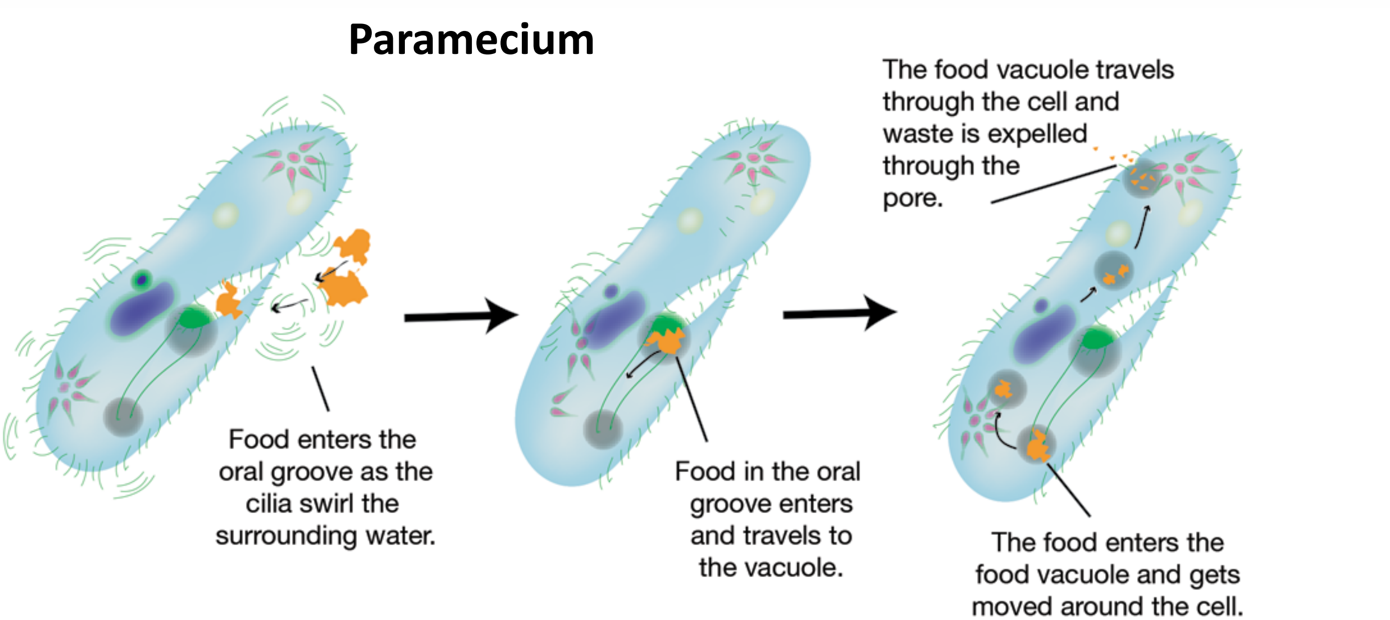


Image credits: 1. Giant kelp, Courtesy of Claire Fackler, CINMS/ NOAA; 2. Formanifora, Courtesy of Psammophile (CC BY SA 3.0); 3. Star Radiolarian, Courtesy of Dr. John R. Dolan, Laboratoire d'Oceanographique de Villefranche; Observatoire Oceanologique de Villefrance-sur-Mer; 4. *Giardia* on intestinal cell, Courtesy of CDC/Dr. Stan Erlandsen; 5. *Giardia,* Courtesy of CDC/Dr. Stan Erlandsen; 6. *Didinium nasutum* eating a *Paramecium*, Courtesy of Gregory Antipa (San Francisco State University) and H. S. Wessenberg (San Francisco State University)


Small protist
Amoeba
Pseudpodia extended
Amoeba
Food vacuole with captured prey
Psuedopodia


Paramecium
The food vacuole travels through the cell and waste is expelled through the pore.
Food enters the oral groove as the cilia swirl the surrounding water.
Food in the oral groove enters and travels to the vacuole.
The food enters the food vacuole and gets moved around the cell.