Real Science-4-Kids

Biology

Level I
Teacher's Manual

Rebecca W. Keller, Ph.D.

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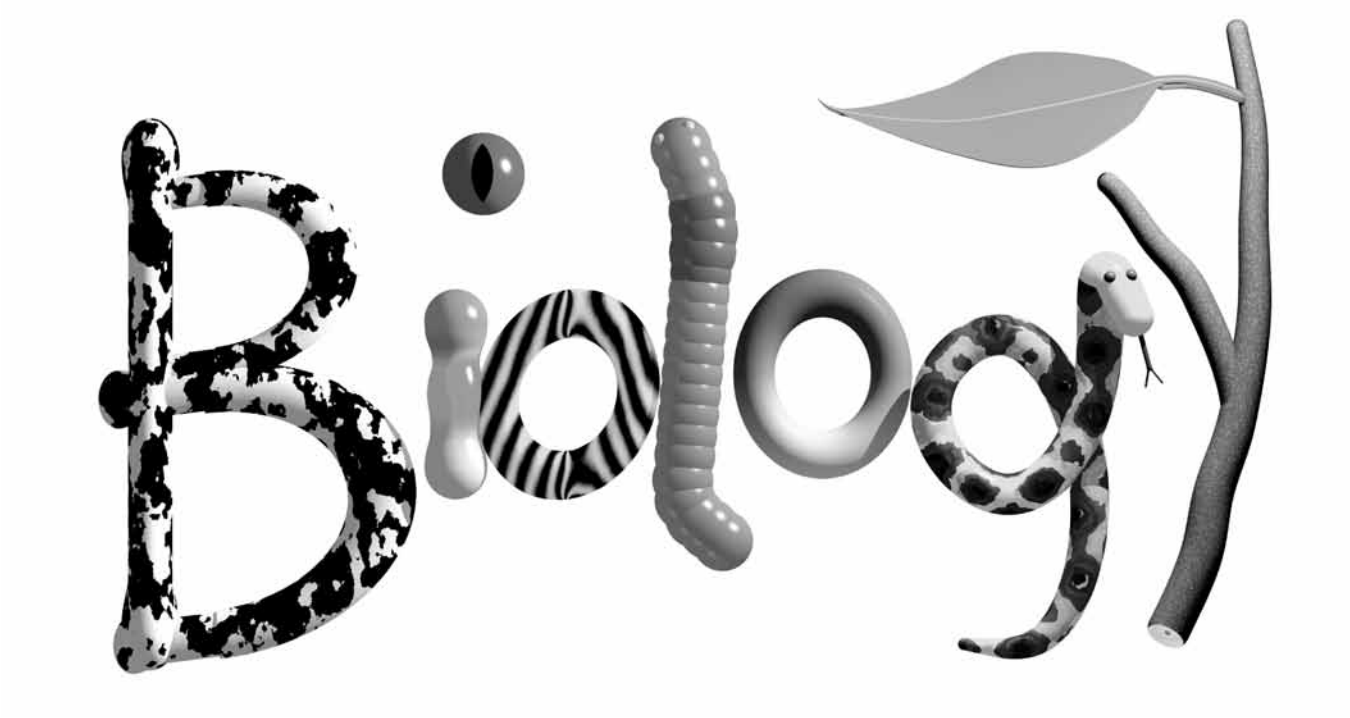

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Cover design: David Keller
Opening page: David Keller, Rebecca W. Keller, Ph.D.
Illustrations: Rebecca W. Keller, Ph.D.

Real Science-4-Kids: Biology Level I Teacher's Manual

ISBN 10: 0-9749149-9-1
ISBN 13: 9780974914992

Published by Gravitas Publications, Inc.
4116 Jackie Road SE, Suite 101
Rio Rancho, NM 87124
www.gravitaspublications.com

Printed in United States

A Note from the Author

This curriculum is designed to give students both solid science information and hands-on experimentation. Level I is geared toward fourth through sixth grades, but much of the information in the text is very different from what is taught at this grade level in other textbooks. I feel that students beginning with the fourth grade can grasp most of the concepts presented here. This is a *real* science text, so scientific terms are used throughout. It is not important at this time for the students to master the terminology, but it *is* important that they be exposed to the real terms used to describe science.

Each chapter has two parts: a reading part in the textbook and an experimental part in the laboratory workbook. In the teacher's manual, an estimate is given for the time needed to complete each chapter. It is not important that both the reading portion and the experimental portion be concluded in a single sitting. It may be better to split these into two separate days, depending on the interest level of the child, and the energy level of the teacher. Also, questions not addressed in the teacher's manual may arise, and extra time may be required to investigate these questions before proceeding with the experimental section.

Each experiment is a *real* science experiment and not just a demonstration. These are designed to engage the students in an actual scientific investigation. The experiments are simple, but they are written the way real scientists actually perform experiments in the laboratory. With this foundation, it is my hope that the students will eventually begin to think of their own experiments and test their own ideas scientifically.

Enjoy!

Rebecca W. Keller, Ph.D.

How to use this manual

The Biology Level I Teacher's Manual provides directions for the experiments in the Laboratory Workbook and answers to the questions asked in each experiment. Additional information for each chapter is provided as supplementary material in case questions arise while reading the text. It is not necessary for the students to learn this additional material as most of it is beyond the scope of this level. However, the teacher may find it useful for answering questions.

The laboratory section (or Experiments) together with the Review are found at the end of each chapter in this manual. All of the experiments have been tested, but it is not unusual for an experiment to fail. Usually repeating an experiment helps both student and teacher see where an error may have been made. However, not all repeated experiments work either. Do not worry if an experiment fails. Encourage the student to troubleshoot and investigate possible errors.

Getting started

The easiest way to follow this curriculum is to have all of the materials needed for each lesson ready before you begin. A small shelf or cupboard or even a plastic bin can be dedicated to holding most of the necessary chemicals and equipment. The following *Materials at a Glance* chart lists all of the materials needed for each experiment. A materials list is also provided at the beginning of each lesson.

Several experiments require living organism. Some of these can be found in the backyard or local environment, or they can be purchased from a local pet store. All of the living things required for these experiments can be purchased from internet sources.

Materials at a Glance

Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
Items such as: rubber balls cotton ball orange banana apple paper sticks leaves rocks grass Legos or building blocks, etc.	pencil or pen colored pencils or crayons	plant with at least 6 flat green leaves lightweight cardboard or construction paper tape 2 small jars marking pen	2 or more small jars 2 or more fresh white carnation flowers food coloring knife	2 small jars several pinto beans absorbent white paper plastic wrap clear tape 2 rubber bands marking pen knife

Experiment 6	Experiment 7	Experiment 8	Experiment 9	Experiment 10
microscope with a 10X objective[1] microscope slides[2] 3 eye droppers fresh pond water or water mixed with soil protozoa study kit[3] methyl cellulose[4]	microscope with a 10X objective[1] microscope slides[2] 3 eye droppers protozoa study kit from Experiment 6[3] baker's yeast distilled water Eosin Y stain[5]	caterpillars collected locally OR butterfly kit[6] small cage	tadpoles[7] tadpole food[7] small aquarium tap water conditioner and tap water OR distilled water	clear glass or plastic tank with a solid lid water plastic wrap soil small plants small bugs: worms small beetles ants, etc.

[1] Student Microscope, www.gravitaspublications.com, "Other Products" section, Gravitas Publications, Inc.
The following materials are available from Home Science Tools, www.hometrainingtools.com:
[2] Glass Depression Slides, MS-SLIDCON or MS-SLIDC12
[3] Basic Protozoa Set, LD-PROBASC
[4] Methyl Cellulose, CH-METHCEL
[5] Eosin Y stain, CH-EOSIN
[6] Butterfly Garden, LM-BFLYGAR
Butterfly Pupae, LM-BFLYCUL
[7] Grow-A-Frog Kit, LM-GROFROG

Most of the items from Home Science Tools are included in their Real Science-4-Kids Level 1 Science Kit, RS-KTLEV1

Laboratory safety

Most of these experiments use household items. However, some items are poisonous. Extra care should be taken while working with all chemicals in this series of experiments. The following are some general laboratory precautions that should be applied to the home laboratory:

- Never put things in your mouth unless the experiment tells you to. This means that food items should not be eaten unless tasting or eating is part of the experiment.
- Use safety glasses while using glass objects or strong chemicals such as bleach.
- Wash hands after handling all chemicals.
- Use adult supervision while working with iodine or glassware and while conducting any step requiring a stove.

Contents

Chapter 1: Living Creatures

Time Required

Text reading	1 hour
Experimental	30 minutes

Materials

Items such as:	paper
rubber ball	sticks
cotton ball	leaves
orange	rocks
banana	Legos or building
apple	blocks, etc.

Overall Objectives

This chapter introduces the field of science, called biology, that is concerned with the study of living things. In this chapter students will learn how living creatures are categorized. Because living creatures have unique features, the students will discover that it is often difficult to make exact categories for all living things, and often these categories are changed or become outdated. New classification schemes are constantly being tried and rejected.

1.1 The science of life

Point out to the students that living things differ from non-living things because they are "alive" and eventually cease to be alive, or die. Have the students think about what being "alive" means. Have them come up with their own definition of "living." Point out that non-living things do not reproduce themselves, are not independently mobile, do not consume food or water, and do not die.

Explain to the students that there are different disciplines of biology to deal with different aspects of living things. Some are:

- *Molecular Biology*: the study of the molecules, proteins, and DNA that make up living things
- *Cell Biology*: the study of the whole cells of living things
- *Physiology*: studies involving whole animal systems
- *Genetics*: studies that are concerned with the genetic information encoded in DNA
- *Ecology*: the study of living things and their interaction with the environment
- *Botany*: the study of plants
- *Zoology*: the study of animals

1.2 Taxonomy

Taxonomy is that branch of science concerned with classifying living things. The term comes from the Greek word taxis meaning "arrangement" and nomos meaning "law." Carolus Linnaeus, a Swedish physician, began the systematic organization of living things into what is now called taxonomy. His system had only two kingdoms: Plants and Animals.

Have a discussion with the students about some of the many different kinds of living things — some are similar, and some are very different. Have the students list some animals that are similar, like wolves and domestic dogs, and some animals that are different, like jellyfish and humans.

1.3 The kingdoms

Before discussing the various taxonomic divisions, ask the students how they would classify living things. Ask them to make up their own groups. Answers will vary.

Because of the diversity of living things and because new information about known species continues to be discovered, it has been difficult to establish an overall consensus about how to classify all living things. In 1959, Cornell University Professor R.H. Whittaker proposed a five-kingdom system that is still used today and is the system that is presented in the textbook. However, a four-kingdom system that only recognizes the kingdoms Animalia, Plantae, Monera, and Virus has also been proposed. There is a proposed eight-kingdom system that recognizes the kingdoms Bacteria, Archaea, Archaezoa, Protista, Chromista, Plantae, Fungi, and Animalia. Also, a three-domain system has been proposed that would include the domains Bacteria, Archaea, and Eukarya.

Originally, the field of taxonomy was created to organize living things as a useful way to separate the various types of life into distinct categories for further study. Today, taxonomy is often a branch of evolutionary biology where an evolutionary connection is sought between certain species. For example, the distinction between the two domains Bacteria and Archaea is centered around differences in the ribosomal RNA sequences of species in these domains.

The first task in classifying living things is to determine into which kingdom a given organism should be placed. Before the discovery of the microscope, all known living things were classified as either plants or animals. They were placed in these two categories based on their plant-like or animal-like characteristics. However, today an organism is placed into a given kingdom based primarily on the cell type of that organism. Cells are discussed in more detail in Chapter 2.

Although there are five kingdoms, there are not five different cell types. There are two basic cells types — prokaryotic and eukaryotic (see Chapter 2). However, there are two different types of eukaryotic cells: plant cells and animal cells. A diagram showing the division of kingdoms based on cell type follows.

Eukaryotic				**Prokaryotic**
Plantae	Animalia	Fungi	Protista	Monera
plant cells	animal cells	like plant cells with some differences	like both plant and animal cells	

In spite of all of the classification difficulties, two main kingdoms stay consistent throughout all of the proposed classification schemes. These are the kingdoms, *Animalia* and *Plantae* (animals and plants).

The animal kingdom includes all animals. The common feature of all animals is the type of cell they have — the animal cell — which is covered in detail in the next chapter. This is not to say that all animal cells are the same. In fact, animal cells have a wide variety of shapes, sizes, and functions, but these cells all have some similar features that place all animals in the animal kingdom.

Have the students think about what creatures might be included in the kingdom *Animalia*. Then have them write down the names of several of these creatures. If it is not immediately obvious that an organism is an animal, have the students eliminate it from the other kingdoms first.

For example: A student may say "shrimp," but maybe it's not clear that a shrimp is an animal.

- Is it a plant? (Plantae) *No*.
- Is it a bacteria? (Monera) *No*.
- Is it a single-celled organism or does it have both plant and animal like characteristics? (Protista) *No*.
- Is it a fungus? (Fungi) *No*
- Then it must be an animal in the kingdom Animalia.

The same is true for all plants that are in the plant kingdom. All plants have plant cells, and again, this is covered in detail in the next chapter. Also, not all plant cells are identical: plant cells vary widely in shape, size, and function, but they all have similar basic features. Repeat the exercise above for plants. This may be trickier since a fungus can also look like a plant. Mushrooms, for example, are fungi, not plants. Use an encyclopedia or other resources if necessary.

The fungi originally were placed in the plant kingdom because they are sedentary like plants. However, fungi differ from plants in that they do not use the sun's energy for photosynthesis (see Chapter 3), and they differ from plants structurally. They are, therefore, in a kingdom of their own.

The fungi acquire their nutrients by absorption. They have special enzymes on the outside of their bodies that they use to break down food which they then absorb. There are three basic classifications of fungi: decomposers, parasites, and symbionts. The decomposers live off non-living organic matter such as fallen logs and animal corpses. The parasites absorb nutrients from a living host but can kill the host, and the symbionts acquire their food from a living host but are beneficial to the host they use.

The kingdoms Protista and Monera make up almost all of the microscopic organisms.

The cell type of Protista has characteristics of both plant and animal cells, but because Protista do not fit entirely in either the plant or the animal kingdom, they are given their own kingdom. These organisms are explained in more detail in Chapters 6 and 7.

The creatures in the kingdom Monera all have a particular cell type called a prokaryotic cell (see Chapter 2). Their cell shapes are diverse, but the most common shapes are rods, spheres, and spirals. *E. coli* is a type of bacteria that is rod-shaped and is found in our intestines. Bacterial pneumonia is commonly caused by a sphere-shaped bacterium.

1.4 Further classification

To further classify all living things, six additional categories are used. These differentiate between the various living things within a given kingdom.

The phylum, class, order, family, genus, and species are the names for these additional categories.

The phylum subdivides the kingdom into different groups. For the kingdom Animalia some of the phylum divisions are:

- Phylum Chordata—those that have a backbone
- Phylum Mollusca — includes clams
- Phylum Arthropoda — insects

The class further divides each phylum of a given kingdom. Some of the classes for the order Chordata are:

- Class Amphibia — frogs, toads, and newts
- Class Aves — birds
- Class Mammalia — animals with mammary glands for nursing
- Class Pisces — bony fishes

Then, the order divides the class, and the family divides the order.

1.5 Naming living things

The family is further divided into the genus and the species. These final classifications give each different creature a unique "two name" designation. The first name is the genus name. "Genus" comes from the Latin word for birth or origin and is the generic name for a given organism. It is written with a capital letter and is in italics. The second name, the species, is the specific name for that particular creature, and it is written in lower case and in italics.

The example shown in the text illustrates the different names for four different types of cats. It is not important that the students remember all of these names, only that they understand how each animal is classified.

Point out that the scientific names of all living things are in either Latin or Greek that has been "Latinized" by the addition of Latin endings. Linnaeus, although he spoke Swedish, used Latin to name living things. Latin was the universal language of scientists in his day, and he wrote most of his scientific work in Latin to make it available to other scholars. In general, the Latin or Latinized Greek name of a living thing often describes some unique feature of that organism. The name for the bobcat is *Felis rufa* which refers to its reddish coat. *Felis* is the Latin word for cat, and *rufa* in Latin means red, or ruddy.

Not all names given to a specific organism reflect some scientific aspect of that creature. The scientist that discovers the organism has the right to name it. Some names reflect where the organism was found, and other names may be derived from Greek myths or in honor of a person.

1.6 Summary

Review the summary points of this chapter with the students.

- Biology is the study of living things Review the difference between a living and a non-living thing. Discuss that taxonomy is a branch of biology that deals with classifying living things.
- The classification of living things begins with dividing them into various groups. Review the diagram with the students and point out the different groups. The largest groups are the kingdoms. Each kingdom is divided into phyla, each phylum into classes, each class into orders, each order into families, and each family into genera (plural form of genus) and species. The classification of a creature into a certain group depends on many things, like its cell type, whether it lays eggs, whether or not it has a backbone, etc.
- Point out to the students why classifying living things is important. By knowing how organisms are different or how they are similar, scientists can better understand how they live. For example, by observing the balancing behavior of a domestic cat on the edge of a narrow ledge, an understanding of how the mountain lion navigates the terrain of the Rockies may be possible. Also, observing the enmity between the neighborhood cat and the family dog may help explain the lack of cooperation between the lioness and the jackal.

Experiment 1: Putting Things in Order Date: _____

Objective

In this experiment we will organize a variety of objects into categories.

Materials

Collect a variety of objects. Some suggestions are: rubber ball, cotton ball, orange, banana, apple, paper, sticks, leaves, rocks, grass, Legos or building blocks, etc.

Experiment

❶ Spread all of 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 Record your observations for each item in the Results section.

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 graph in the Results section.

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 several subcategories for each of these main categories.

❻ List the objects according to their category and subcategory.

In this experiment, the students will try to organize different objects according to some property like shape, color, or texture.

There are no "right" answers for this experiment, and the categories the students pick will vary.

Have the students collect a variety of objects, place the 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.

Have the students make some notes about the objects they have collected, briefly describe each object and list a few of its characteristics.

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." Some items may fit into more than one category. Basketballs can fit into both the category "Round" and the category "Types of Balls." Have the students write down each item in all of the categories where it fits.

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.

The students will now record the characteristics of the various items. 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).

Help the students describe, in detail, several different items. Some examples are listed.

Results

(Answers will vary.)

Item	Characteristics
orange	*round, orange, food, sweet*
grape	*oval, food, sweet, green*
tennis ball	*round, green, fuzzy*
marshmallow	*white, soft, sweet, shaped like a cylinder*
cotton ball	*round, white, fuzzy*

Categories					
white	*fuzzy*	*round*	*square*	*hard*	
marsh-mallow	*tennis ball*	*oranges*			
cotton ball	*cotton ball*	*tennis ball*			
		cotton ball			

Categories	*White*		*Fuzzy*			
Sub-categories	*round*	*food*	*round*	*toys*		
	cotton ball	*marsh-mallow*	*cotton ball*	*tennis ball*		

Have the students write the categories at the top of each column using a PENCIL, so they are able to change the categories as more items are being written down.

They will decide which items fit into which categories and then write those items in the column below the category name.

Next, they will pick one to three of the categories and divide them further into subcategories, 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.

Help the students write valid conclusions about 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

Conclusions

Review

What is taxonomy? *the branch of biology concerned with classifying living things*

List the five kingdoms.

Plantae
Animalia
Fungi
Monera
Protista

List the other six categories for classifying living things.

Phylum
Class
Order
Family
Genus
species

Which kingdom are dogs, cats, and frogs in? *Animalia*

Which phylum are dogs, cats, and frogs in? *Chordata*

Which class are frogs in? *Amphibia*

Which order are dogs in? *Carnivora*

Which family are cats in? *Felidae*

What is the Latin name given to humans and what does it mean?

Homo sapiens. This means "man wise."

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.