SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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National Science Education Standard—Life Science

Biological Evolution

Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification.

The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.

Teacher Materials

Learning Sequence Item:

1001

Organizing Principles of Plants and Animals

May 1996
Adapted by: Tom Hinojosa

Biological Classifications: Their Basis in Evolutionary Relationships. Students should examine the organization of body forms, from single-celled protists to colonial forms to complex multicellular organisms. They should organize the major divisions of plants and animals, showing phylogenetic similarities, and explore life-cycle concepts, including distinctions between the haploid and diploid conditions of plants and animals. (*Biology, A Framework for High School Science Education, p. 111.)*

Contents

This micro-unit was adapted by **Tom Hinojosa** (SS&C Center Coordinator, Santa Clara, Calif.)

1001
Learning Sequence

Biological Classifications: Their Basis in Evolutionary Relationships. Students should examine the organization of body forms, from single-celled protists to colonial forms to complex multicellular organisms. They should organize the major divisions of plants and animals, showing phylogenetic similarities, and explore life-cycle concepts, including distinctions between the haploid and diploid conditions of plants and animals. *(Biology, A Framework for High School Science Education, p. 111.)*

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
The Shape of My Kingdom **Activity 1** The Spice of Life **Activity 2** Microville **Activity 3** What's in a Name? **Assessment 1** My Kingdom, My Life **Assessment 2** Man's Best Friend? **Assessment 3** Family Trees, Bush, Branch, etc. **Assessment 4** Spicy Life **Assessment 5**			A Jungle Beneath Your Nose **Activity 4**

Suggested Sequence of Events

Event #1

Lab Activity

1. The Shape of My Kingdom (35 minutes)

Alternative or Additional Activities

2. The Spice of Life (40 minutes)

Event #2

Lab Activity

3. Microville (40 minutes)
   Advance preparation required

Event #3

Lab Activity

4. The Jungle Beneath Your Nose (90 minutes)
   Advance preparation required

Event #4

Readings from Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science

Suggested readings:

Aldhous, Peter, "Ecologists Draft Plan to Dig in the Dirt," *Science*, Vol. 265, Sept. 9, 1994, p. 1521.

Gould, Stephen Jay, "What is a Species?" *Discover* Magazine, Vol. 13, No. 12, December 1992, pp. 40–44.

Oliwenstein, Lori, "Life's Grand Explosion," *Discover* Magazine, Vol. 17, No. 1, January 1996, pp. 42–43.

Pennisi, Elizabeth, "Name That Fly," *Science News*, Vol. 145, No. 7, Feb. 12, 1994, pp. 108–109, 111.

Pennisi, Elizabeth, "Tending Nature's Garden," *Science News*, Vol. 146, No. 11, Sept. 10, 1994, pp. 170–171.

Assessment items are at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple-choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.

2. Open-ended questions asking for essay responses.

3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Teacher Sheet

Science as Inquiry

The Shape of My Kingdom

What characteristics would you use for purposes of classification?

Overview:

Students practice the process of classification by grouping simple objects by shape or other physical characteristics. This activity is intended to give students insight into the classification of living things using the categories of kingdom, phylum, and class. Safety consideration: Caution students to be careful when using scissors.

Materials:

Per lab group:

Sample Shapes I and II, 1 copy
scissors

Procedure:

Students carefully cut out the shapes from the Sample Shapes provided. They then group the various shapes—first into two kingdoms, then phylums, and finally classes. They may find that one or more shapes end up in a group by themselves. Students then assign descriptive names to the two kingdoms, to each separate phylum, and then to each member in each group.

Background:

A single class-set of the shapes can be prepared by the teacher in order to save class time. Mount the shapes on a sturdy background and store in plastic bags for each lab group.

Living things are commonly classified by kingdom, phylum, class, order, family, genus, and species. Here, they are listed in order from most generalized category to the most specific category. The number of divisions in each level is not always agreed upon by all scientists, but generally a modern taxonomic system recognizes five separate kingdoms, animalia, plantae, protista, monera, and fungi. The early two kingdom (animals and plants) classification systems were found to be inadequate as scientists learned more about the nature and variety of living things. The development of the light microscope and other technologies has further elucidated the characteristics and nature of living organisms, thus giving rise to recognized kingdoms which are more appropriate for certain specific kinds of living things.

Modern taxonomy and classification makes use of more than just structural similarities. Other evidence of relatedness may come from the way organisms develop during the early part of their lives, chromosome structure, DNA base sequences, reproduction, biochemical similarities, and embryology.

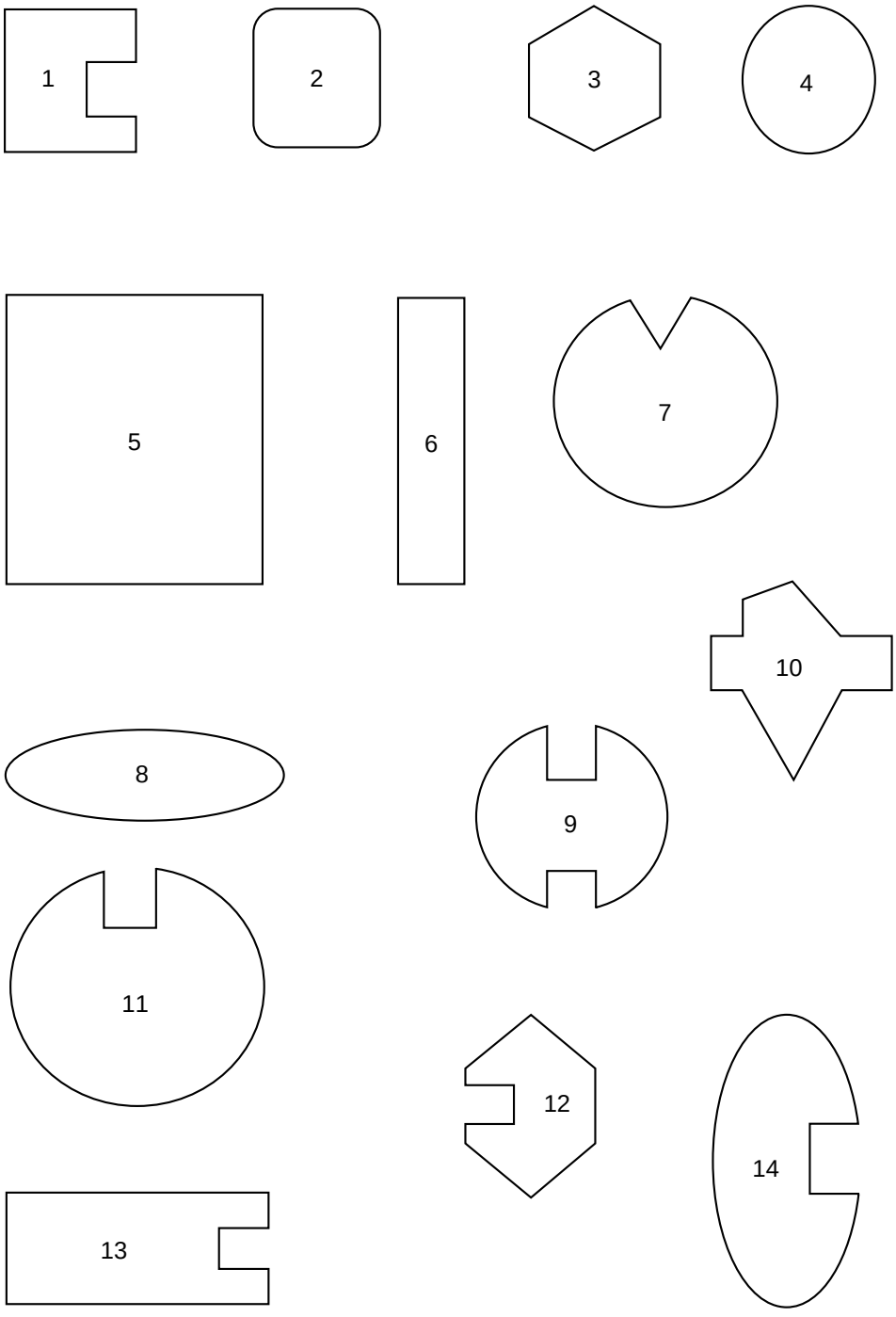
Variations:

You may wish to use a variety of physical objects rather than paper cutouts for the shapes in this activity. Also, more (different) shapes or different colors of these shapes can be added to increase the amount and length of the activity.

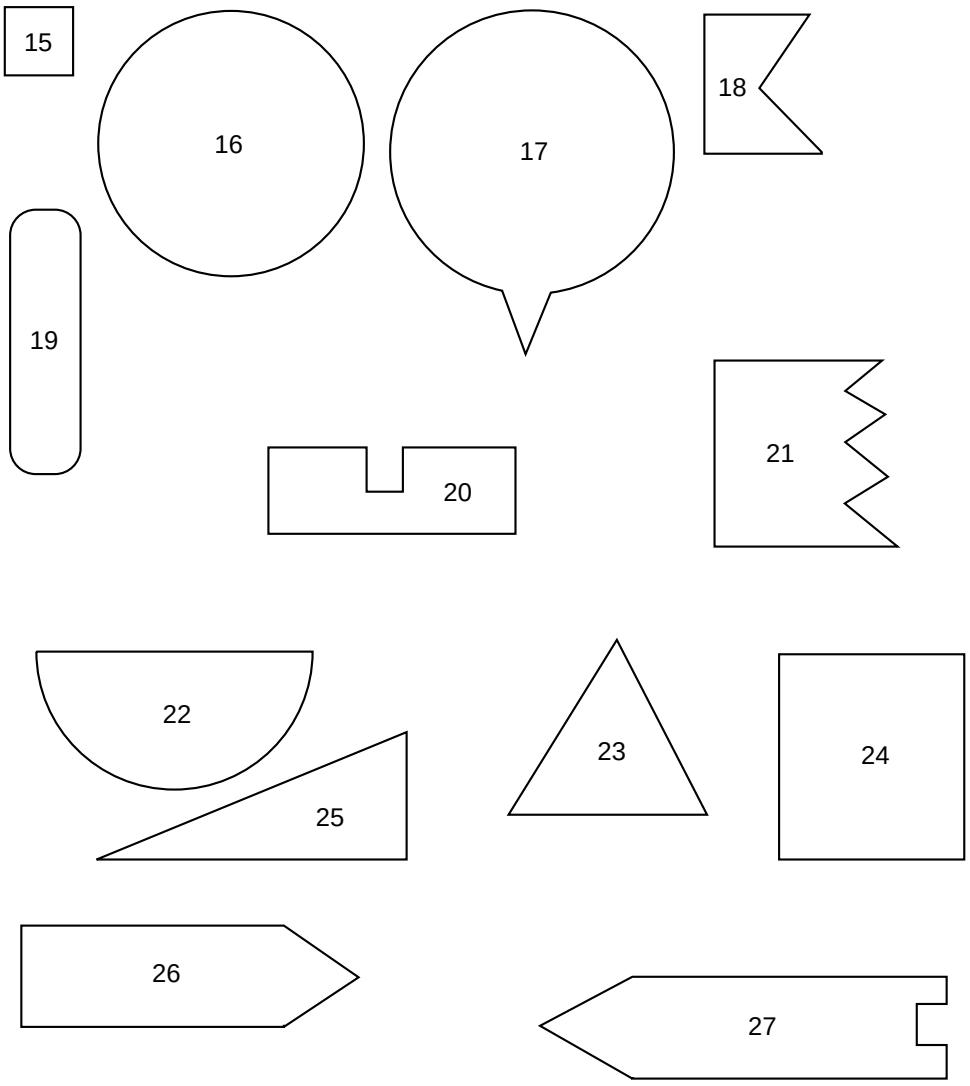
Another alternative is to hold back one or two unique shapes until after the students have derived their classification system(s) and challenge them to classify the new object(s) with a rationale for their decisions.

Adapted from:
Daniel, L., Merrill Life Science Laboratory Manual, Westerville, Ohio: Glencoe Div., Macmillan/ McGraw-Hill, 1993.

Sample Shapes I



Sample Shapes II



an alternative activity for Event 1

Teacher Sheet

Science as Inquiry

The Spice of Life

How can we organize the major divisions of plants and animals?

Overview:

Students are told they will be doing a short project about the diversity of living things. This first assignment is to take on the role of curator of a virtual bio-exhibit or zoo. They will classify their specimens based upon observed characteristics.

Materials:

Per lab group:

wildlife field guide

plant field guide which includes local flora

Procedure:

The students create (through class discussion) a list of living things that they have actually observed—i.e., pets, insects, and common plants—in their local area. To the degree possible, include in parentheses the scientific name for the common specimens (e.g., canis familiaris for dogs, Homo Sapiens for humans). Binomial nomenclature should have been introduced in 9th grade. If not, you will need to review it here.

Students work in small groups to expand their list using descriptive terms and classify each living thing while carefully developing a detailed description for each category. They write the common name for each organism followed by a binomial scientific name in parentheses. If the correct scientific name cannot be determined, students give the organism their own "scientific" name. (You should guide this part of the activity carefully.) The students also indicate which organisms seem to be closely related and justify their choices. The entire class then discusses the categories and descriptive criteria they came up with. Help students to come up with a scheme which uses at least two major categories (kingdoms) and several subcategories underneath the major ones. Students discuss the evolutionary relationships and implications of their classification systems.

Background:

Taxonomic classification is not a fact. That is, classification is always based upon interpretation of facts and is, therefore, variable. Species with many similar characteristics are grouped into the same larger category called genus. The genus names come from the Latin names, e.g., Latin for dog is canis; the second part is somewhat descriptive of the specific species. So, Grey Wolves are canis lupis and pet dogs are usually canis familiaris, while Coyotes are canis latrans. It is not important for the students to be overly concerned with the naming, but rather to understand the methods of classification. You should post a chart in the classroom which shows the seven levels of classification (kingdom, phylum, class, order, family, genus, species). But let the students work to discover the numbers of categories in each level, rather than just telling them that there are commonly five kingdoms in modern classification systems.

Caution students about mistaking dimorphism (multiple forms of the same species due to age and sex) for different species. This is quite common in many species, especially birds.

Modern taxonomy and classification makes use of more than just structural similarities. Other evidence of relatedness may come from the way organisms develop during the early part of their lives, chromosome structure, DNA base sequences, reproduction, biochemical similarities, and embryology.

Variations:

Students with artistic ability may be asked to illustrate their categorized specimens. This could be for inclusion in a portfolio.

Homework: Students find out the rules for the determination of scientific names for living things, i.e., How do things get their scientific names? Tell students to give themselves or their pet a scientific name and give a rationale for it.

Students do a mini-report on the life cycle of a plant of their choice, focusing on the difference between plants and all other kinds of living things.

A longer project may be assigned which requires students to create a flower collection of up to 50 different species. Students will need an appropriate field guide and should include the scientific name for each specimen.

Adapted from:

Haynes, N. L., Biological Science: An Ecological Approach, BSCS Green Version, 5th ed., Boston: Houghton Mifflin Co., 1982.

Goodman, H. D., L. E. Graham, T. C. Emmel, and Y. Schecter, Biology Today, Orlando, Fla.: Hold, Reinhart and Winston, Inc., 1991.

Teacher Sheet

Science as Inquiry

Microville

Are common microbes unique forms of life?

Overview:

This activity is intended to give students experience with unique life forms which constitute the kingdom, Monera. The students add these organisms to their list of living things and classify them along with the others previously classified.

Materials:

Per lab group:

beaker, 600 mL
microscope
cotton swabs, 2
petri dishes, 4
prepared slide with different types of bacteria
fork or tongs
potato, peeled, four or five 2-cm slices
hot plate, or other suitable heat source for boiling water
hot mitts
knife
soap
water

Procedure:

Students sterilize the potato slices in boiling water, then place individual slices in petri dishes. They use cotton swabs to inoculate separate potato slices with dust, the inside of the cheek, and the finger. Students establish a control dish, which should be covered immediately and left to sit for at least three days. They then observe the prepared slide(s) of bacteria under the microscope. They draw and record their observations in as much detail as possible and record their observations in a data table.

Students add these living organisms to their list of living things from Activity 2 and classify them in a suitable group (like they did for the other life forms), and modify their classification system if necessary. Students should conclude that in addition to the kingdoms of plants and animals, another kingdom is necessary to classify the bacteria. Help students identify specific characteristics and criteria for classification of moneran life forms and warn students about assuming that all microorganisms can be classified in a single category.

Background:

Since bacteria are very small, students should use oil immersion lenses if available. A magnification of 90x is necessary to see these bacteria. Some potato slices will not show results. Students should be able to explain why this result might occur.

Monerans are simple, single-celled organisms with no membrane-bound organelles. There are generally two groups, bacteria and cyanobacteria. They are prokaryotes, and their nuclear material consists of a single circular chromosome. Some have a few plantlike characteristics such as a cell wall and the presence of chlorophyll. These chlorophyll forms (cyanobacteria) use sunlight and carbon dioxide to produce their own energy supply, but most Monerans are heterotrophs and rely on other organisms to provide food.

Monerans help maintain balance in nature. One group, called saprophytes, digest dead organisms and recycle nutrients so that they are available for use by other organisms. The roots of plants such as peanuts and peas contain nitrogen-fixing bacteria in growths called nodules. These bacteria change nitrogen from the air into forms useful for plants and animals.

Some Monerans, called pathogens, cause disease. A common one many students have had experience with is strep throat. Other examples are anthrax in cattle, tetanus, and whooping cough. Bacterial diseases are effectively treated with antibiotics like penicillin. Point out to students the effect of high heat on bacteria. Because many bacteria are able to produce thick cell walls (called endospores) that are resistant to heat and drying, sterilization by boiling requires several minutes to effectively kill all living bacteria in the sample.

Many industries rely on bacteria. Biotechnology has put bacteria to use in making medicines, enzymes, cleansers, and a wide variety of other products. Other forms of useful bacteria are naturally found in the digestive tract and some are used in the production of cheese and yogurt. Remind students that not all bacteria are germs, and that bacteria of decay plays an important role in nature.

Variations:

Nutrient agar may be used instead of potato slices for a medium on which to grow bacteria. Agar is commonly available from scientific supply companies.

Soak white beans in water to get bacteria (do not wash the beans). They will smell horrible, but this works.

Adapted from:

Daniel, L., E. P. Ortleb, and A. Biggs, Merrill Life Science, Westerville, Ohio: Glencoe Div., Macmillan/McGraw-Hill, 1993.

Teacher Sheet

History and Nature of Science

A Jungle Beneath Your Nose

Will a simple classification system work for all living things?

Overview:

In this activity students gather data and make observations of a wide variety of living things, from single-celled organisms to colonial forms to possibly complex multicellular organisms. From their data/ observations they classify all the organisms, and should arrive at the conclusion that there are several (ideally, five) different major divisions or kingdoms necessary to encompass all known living things.

Students make the garden of microorganisms, and do an observational study to create a larger pool of organisms to add to their previous list or data table from Activity 1.

Students organize their list (collection) into major categories showing phylogenetic similarities.

Materials:

Per lab group:

fruit, very ripe (banana, apple, etc.), 2 slices
hay or dried grass, 2 g
beans, dried, 10
cream cheese, 2 oz.
bread, stale, 2 slices
cornstarch, 5 g
peppercorns, 10
soil, rich garden, 50 g (no commercial soil)
pond or river water (w/bottom materials), 50 mL
bowls, glass or plastic, 8 (dia: 10 cm, 4-cm high)
glass covers for bowls, 2 or 3
filter paper, 2 pieces
spatula
tap water source
hand lens, or stereo microscope
monocular microscope
forceps
dissecting needles, 2
microscope slide
medicine dropper
cover slip
glass-marking crayon

Procedure:

Students mark each of 8 finger bowls for their lab group for easy identification. They should be prepared ahead of time (at least 5 days). Each of the bowls contain the following ingredients:

Bowl 1. Fruit, cut to fit the bowl.

Bowl 2. Water from a pond or river, containing bottom materials.

Bowl 3. Enough hay to cover the bottom of the bowl and 200 mL tap water.

Bowl 4. Dried beans and tap water.

Bowl 5. Cream cheese, spread over the bottom of the bowl about 1 cm deep.

Bowl 6. Stale bread, moistened (not soaked!) with water. Expose to air for 24 hours, then cover.

Bowl 7. Place a piece of filter paper on the bottom of the bowl. Mix 5 g cornstarch with 50 g rich garden soil. While mixing soil and starch, add enough water to give the mixture a dough like consistency. Spread the mixture smoothly on the filter paper. Keep the soil mixture moist throughout the investigation.

Bowl 8. Peppercorns infused in tap water.

It is a good idea to set up teams or lab groups of 4 or 8 students to divide up the work of making observations of the 8 specimens. Otherwise, the process of observing and recording observations will be too time consuming.

Students make microscopic observations of the various cultures, concentrating on their respective assigned bowl(s), then sharing information/observations with their team members. They make detailed notes and drawings of living things they observe from the various cultures. As newly observed living organisms are found, students add these to their previous list of living things from Activity 2. These newly observed organisms are classified (like the others before them), with modifications made to the classification system as needed. Students group them and carefully develop a detailed description for each category that would help someone know which organisms should be classified in each category.

Students assign a scientific name to each new organism listed. If the correct scientific name cannot be determined, the organism should be named by the student who "discovered" it, using the scientific format.

Background:

Preparation time. If the bowls are set up on a Wednesday, they will likely be ready for microscopic study by the following Monday. It is recommended that one week's time be allowed between setting up the bowls and microscopic study.

Students can supply most of the materials for this activity. Peppercorns (Bowl 8) are recommended because of their historical significance with Leeuwenhoek's work.

Problems can develop if the tap water source has too much chlorine. If this is the case, distilled or deionized water is better.

Most of the organisms that appear in the cultures are protists, but others are plants and possibly even some animals. As such, be sure the students don't conclude that a single category is sufficient for all microorganisms. That is, microbe is not synonymous with protist!

The basic distinction between autotrophs (organisms that produce their own food) and heterotrophs (dependent on others for food) may be useful at this time. Microscopically, protists are eukaryotes (have nucleus) and have both autotrophic and heterotrophic forms—includes protozoa and algae; monerans are prokaryotes (no nucleus). Most protists are unicellular; animals and most plants are multicellular. While some protists and almost all plants contain chlorophyll, only plants possess chloroplasts. The lack of chloroplasts, but presence of green color due to chlorophyll is one important distinction of protists from plants as separate kingdoms.

Bread mold is a class of fungus called, terrestrial molds. Fungi are organisms that obtain food by decomposing organic matter and, unlike plants, lack chloroplasts and cannot carry out photosynthesis. Fungi also have few animal characteristics. Because of their unusual combination of traits, fungi are classified as a separate kingdom.

Monera is a separate kingdom characterized by simple organisms without nuclei (prokaryotes). They include bacteria and viruses. An engaging discussion of the classification of viruses (such as AIDS) and their impact/affect on the human population may naturally arise after or in association with this lab activity.

Variations:

There are many other choices of cultures that could be used for this activity. The teacher may choose to include additional cultures which favor the growth of bacteria, such as sterilized potato slices innoculated with dust or a swab of the inside of the cheek.

Adapted from:

Haynes, N. L., Biological Science: An Ecological Approach, BSCS Green Version, 5th ed., Boston: Houghton Mifflin Company, 1982.

Goodman, H. D., L. E. Graham, T. C. Emmel, and Y. Shechter, Biology Today, Orlando, Fla.: Holt, Rinehart and Winston, Inc., 1991.

Science as Inquiry

What's in a Name?

Item:

Sciurus griseus, Sciurus aberti, Sciurus carolinesis, Sciurus arizonensis. These are the scientific names for several small living things. Based upon their names, what can you reasonably conclude about all or any one of the organisms?

Answer:

Student should recognize these as scientific names. By definition, the names all refer to particular species of the same genus, Sciurus. (These are actually all tree squirrels, but it is not expected that students would know this.) Students may conclude that the names refer to colors of the species or their natural geographic territory. For example, Sciurus griseus is the Grey Squirrel; Sciurus carolines is the Eastern Grey Squirrel; Sciurus arizonensis is the Arizona Grey Squirrel. They may also speculate that the names are possible references to the person who first identified them as a separate species. Further, they may further comment on the likelihood of common ancestry and/or that they are likely the result of speciation to divergent evolution based upon geographic specific natural selection pressures.

Science as Inquiry

My Kingdom, My Life

Item:

Describe the major divisions or kingdoms of living things. Create a data table or chart which would help distinguish between each one with examples (names) in each category.

Answer:

Students should give at least 3 or 4 kingdoms which may include animals, plants, fungi, monera, and protists. A sample table is given below:

Kingdom	Characteristics	Example
animals	multicellular; heterotrophs; have nucleated cells	humans; dogs; fish
plants	multicellular; nucleated cells with cell walls; do photosynthesis with chloroplasts	pine trees; rose bush; grass
protists	nucleated cells; both autotrophic and heterotrophic forms; many are unicellular and therefore microscopic	protozoa; algae
fungi	multicellular heterotrophs; nucleated cells; absorb food through cell wall	bread mold; mushrooms
monera	simple organisms without nuclei or organelles; microscopic	bacteria; viruses

Science as Inquiry

Man's Best Friend?

Item:

Study the table below. Discuss the similarities and differences among the organisms. How are these similarities and differences reflected in their classification? What other animal(s) would have more categories in common with humans?

CATEGORY	HUMAN	DOG
phylum	chordata	chordata
class	mammalia	mammalia
order	primates	carnivora
family	hominidae	canidae
genus	homo	canis
species	sapiens	familiaris

Answer:

Answers will likely discuss the specific categories on the table. They may discuss the common characteristics of all mammals (hair, warmblooded, suckle their young, live birth, etc.) and/or chordates (having backbones and spinal cord). From there, many obvious difference may be cited. Students should discuss the fact that their common classification ends high in the system of classification thus reflecting only a modest phylogenic similarity and relationship. Students should cite chimps, gorillas, monkeys, etc. as animals which would have more categories in common with humans.

Science as Inquiry

Family Trees, Bush, Branch, etc.

Item:

Choose three very different living things you know very little about. Using appropriate resources find out the proper classification for each species including kingdom, phylum, class, order, family, genus, and species. Discuss the similarities and differences among the organisms. How are these similarities and differences reflected in their classification? Organize your answer in a table to allow for easy communication of your ideas.

Answer:

Student answers will vary depending on the organisms chosen, but they should all be able to determine a complete classification of the three species chosen.

Science as Inquiry

Spicy Life

Item:

At one time, scientists only used two kingdoms, plants and animals, to classify all life forms. Discuss the reasons why today, we commonly use five kingdoms.

Some people have proposed a seven-kingdom scheme of classification. Do you see a need for this? Justifiy your answer.

Answer:

Students should discuss the occurrence of life forms which do not fit well into either the animal or plant kingdoms because they may have characteristics of both or sometimes have only partial characteristics of one of these families. For example, some protists are able to synthesize food due to the presence of chlorophyll, but they lack chloroplasts like true plants. They should also refer to the invention of the microscope as a major technological event which brought to light the existence of many previously unknown or undescribed life forms.

Consumables

Item	Quantity (per lab group)	Activity
beans, dried	10	3
bread, stale	2 slices	3
beans, dried	10	4
bread, stale	2 slices	4
cheese, cream	2 oz	4
cornstarch	5 g	4
cotton swabs	2	3
cover Slips	2	4
grass, hay, dried	2 g	4
fruit, very ripe (banana, apple)	2 slices	4
paper sheet of drawn shapes	1	2*
peppercorns	10	4
pond water or river water	50 mL	4
potato	1	3
soap and water	—	3
soil, garden	50 g	4

Nonconsumables

Item	Quantity (per lab group)	Activity
beaker, 600 mL	1	3
bowls, finger	8	4
covers, glass, for bowls	2–3	4
crayon, glass marking	1	4
dish, petri	4	3
dropper	1	4
filter paper	2	4
forceps	1	4
fork or tongs	1	3
hot mitts	1	3
knife	1	3
hot plate or heat source	1	3
microscope,compound	1	3
microscope, monocular	1	4
needles, dissecting	2	4
plant field guide	1	2*
prepared slides of bacteria	1	3
scissors	1	1

(continued)

slide, microscope	1	4
spatula	1	4
wildlife field guide	1	2*

*indicates alternative or additional activity

Key:
1. The Shape of My Kingdom
2. The Spice of Life
3. Microville
4. The Jungle Beneath Your Nose

Activity Sources

Daniel, L., *Merrill Life Science Laboratory Manual*, Westerville, Ohio: Glencoe Division, Macmillan/ McGraw-Hill, 1993.

Daniel, L., E. P. Ortleb, A. Biggs, *Merrill Life Science,* Westerville, Ohio: Glencoe Division, Macmillan/ McGraw-Hill, 1993.

Goodman, H. D., L. E. Graham, T. C. Emmel, and Y. Shechter, *Biology Today,* Orlando, Fla.: Holt, Rinehart and Winston, Inc., 1991.

Haynes, N. L., *Biological Science: An Ecological Approach*, *BSCS Green Version,* 5th ed., Boston: Houghton Mifflin Co., 1982.