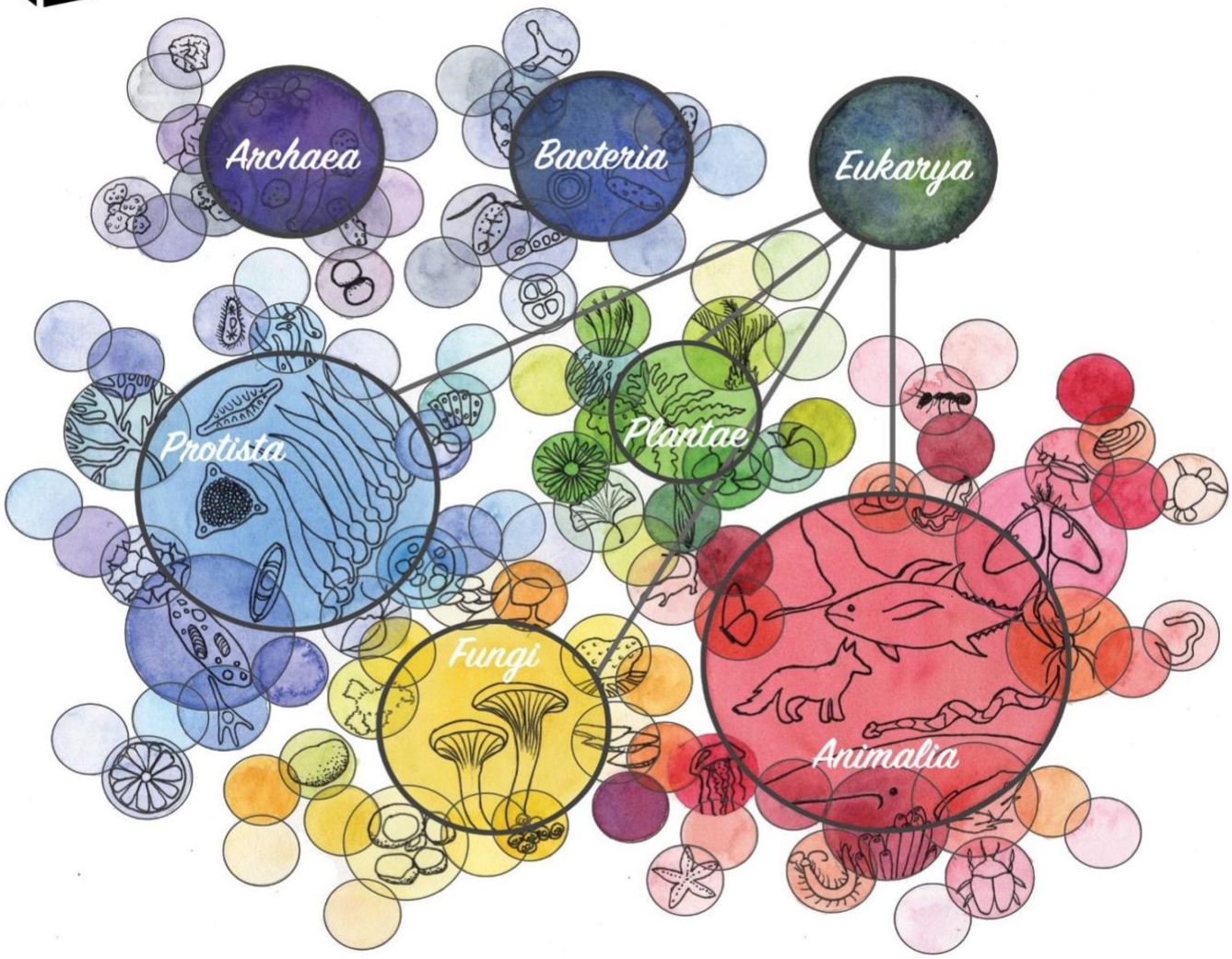
DISCOVERY TRUNKS

Hefner Museum



Science of Sorting

Hefner Museum of Natural History

SORTING AND CLASSIFICATION DISCOVERY TRUNK

Acknowledgments

We thank the following individuals and organizations for their work in "planting the seeds" for these lessons.

Ohio Environmental Education Fund for providing grant money from Sowing SEEDS: Science, Environmental Education, Discovery, and Synthesis, to produce these early childhood Discovery Trunk lessons

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Thoughts from the Artist-Cover Design

As humans, sorting, classifying, and delineating groups and boundaries helps us evaluate relationships of all sorts. We also understand nature is fluid. The artwork here representing species within three domains and four kingdoms shows one of the ways we can sort living organisms. You see distinct groups with their own color scheme, groups delineated by evaluating the characteristics of each organism and placing them based on similarities and differences. Also, you see some edges that touch and similar colors between groups. The artwork is not meant to convey specifics about any particular species, but instead to illustrate the overall diversity and fluidity that nature exhibits within and between our superimposed groupings.

Julia Ferguson

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Check-out and Care Guide

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Publications using the borrowed objects will acknowledge the University and Museum. Objects may not be reproduced in any form without written permission from the Museum. There is a charge for commercial use.

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A deposit fee of $25 will be collected at time of Trunk pickup. The fee will be returned upon complete return of the loan by the due date.

Tax deductible donation: If you wish to help defray the cost of shipping a Trunk to underserved schools in our area, you may

choose to leave the deposit as a donation or make an alternative donation. Donations will be recognized by Miami University with a letter for tax purposes. Checks should be made payable to the Hefner Museum of Natural History, memo, “trunk donation.”

Address any questions to Julia Robinson
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Trunk Purpose

Children possess an innate curiosity about the natural world. This trunk fulfills the educational outreach component of an NSF grant awarded to Miami University to purchase a Fluorescence Cell-Activated Sorter. The Fluorescence Cell-Activated Sorter (FACS) machine used in the MU Biology department sorts at the most basic level, the cell. This Trunk explores the topic of sorting, or classification, in the study of life science. Every grade level, K-8 in Ohio, includes the topic of classification.

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A Note to the Teacher

The guide is divided into several sections encompassing trunk contents, state standards, inquiry activities and accompanying literature. In addition to these core elements, we provide additional material to help prepare the user with adequate knowledge to carry out the inquiries. The guide also highlights important information to complete the inquiries. An **enlarged magnifying glass** positioned next to text indicates important information for that activity.

Teaching Philosophy – Inquiry

The Inquiry Lesson Format: Why the 5Es?

Hefner Museum Discovery Trunks, specimen-based educational kits, use museum collections and standardized curricula to catalyze critical thinking skills through inquiry learning. Inquiry learning empowers students in their own discovery of information through personal and group investigation. Students take the lead in guiding the direction of the activity. An investment in exploration, questioning, and discussion allows connections to form. The hallmark of inquiry includes making connections. Participants connect prior knowledge to new knowledge through engaging activities that encourage thorough exploration of a topic. The teacher acts as facilitator, guiding students throughout the engaged process.

Inquiry is based on the educational learning theory of Constructivism. In this method of teaching, participants construct their knowledge of the world as they manipulate, observe, analyze, and reflect on key concepts explored. All of the activities presented in the Hefner Museum Discovery Trunks are written in the 5Es format allowing students to build the framework of their knowledge. The 5Es include Engagement, Exploration, Explanation, Elaboration, and Evaluation. Each component of the 5Es inquiry lesson prompts these fundamental connections. The activities are student-driven, student-centered, and provide multiple opportunities for connecting prior knowledge with new learning.

The order of the inquiry matters, in that, the educator starts with Engagement and the opportunity to hone observation skills using the senses through directed Exploration, developing questions that lead to more in-depth Elaborations of the topic, and finally, Evaluation. An inquiry lesson often serves as the catalyst for new inquiries and informative discoveries.

A brief explanation of each component of the 5Es follows:

Engagement

How will you encourage your students to be engaged from the beginning in the learning? This could be through a variety of methods, such as an activity or game, graphic organizer, guiding questions, or a read-aloud.

Exploration

How will exploration take place? Exploration includes observing specimens, generating questions, and developing hypotheses. Through exploration, students make connections, bridging what they already know to new concepts. Student-generated questions and thoughtful communication guide the student learning throughout the inquiry.

A Note about Generating Questions

When we give children opportunities to develop their own questions, we want to spend time discussing what a thoughtful question looks like. Thoughtful questions...

1. *are testable.*
2. *will generate useful information.*
3. *are based on observations.*
4. *can be investigated, such as finding out what occurs when variables change.*
5. *require evidence to answer.*
6. *can determine relationships between variables.*
7. *will help to clarify what is needed.*
8. *may challenge another's argument.*

Explanation

What is the Big Idea of the inquiry? The curiosity of the student often sparks the insatiable need for more information. Here the facilitator directs the participants to verbalize the connections taking place and identifies key concepts explored in the inquiry.

Elaboration

How will you elaborate on the topic? The facilitator structures the content of the lesson using the observations and questions that students develop. They tell the "whole narrative." They answer questions created by the students and weave the objectives into an informative lesson using materials that elaborate on the topic.

Evaluation

How will you evaluate your students' learning? Care should be taken to develop evaluations that focus on the topic explored. Evaluations may take the form of written communication, observation, visuals and other modes.

Benefits of Inquiry Method

Inquiry through the 5Es is relevant to teaching in the 21st century. It can be used with any discipline and any age group to expand a student's knowledge base. Inquiry fosters communication skills and for the early childhood learner, expands language development. For the more mature learner, the answers to any inquiry are not always evident or clear. The process encourages thorough exploration and formulation of thoughtful, direct questions. For all learners, inquiry activities nurture and cultivate passions and curiosities. Along with developing research skills, learners practice the use of respectful language and behavior, especially when encountering diverse opinions. Inquiry seeks to answer questions, often leading to more questions. As a result, endless quests for new learning arise from one inquiry. Inquiry cultivates life-long learning opportunities.

Ohio Science Standards

Suggested Grade Levels: K, 1, 2, 3, 6

Kindergarten

Physical Science
Topic: Properties of Everyday Objects and Materials
Content Statement
K.PS.1: Objects and materials can be sorted and described by their properties.

Life Science
Topic: Physical and Behavioral Traits of Living Things
Content Statement
K.LS.1: Living things have specific characteristics and traits.
K.LS.2: Living things have physical traits and behaviors, which influence their survival.

Grade 1

Life Science
Topic: Basic Needs of Living Things
Content Statement
1.LS.1: Living things have basic needs, which are met by obtaining materials from the physical environment.
1.LS.2: Living things survive only in environments that meet their needs.

Grade 2

Life Science
Topic: Interactions Within Habitats
Content Statement
2.LS.2: All organisms alive today result from their ancestors, some of which may be extinct. Not all kinds of organisms that lived in the past are represented by living organisms today.

Grade 3

Life Science
Topic: Behavior, Growth and Changes

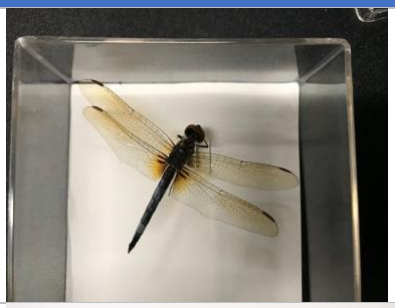
Content Statement
3.LS.1: Offspring resemble their parents and each other.
3.LS.2: Individuals of the same kind of organism differ in their inherited traits. These differences give some individuals an advantage in surviving and/or reproducing.

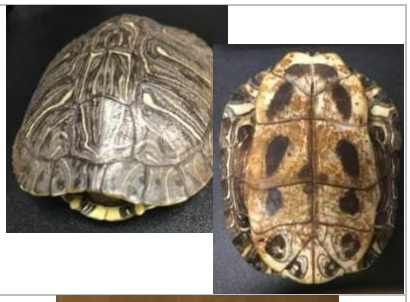
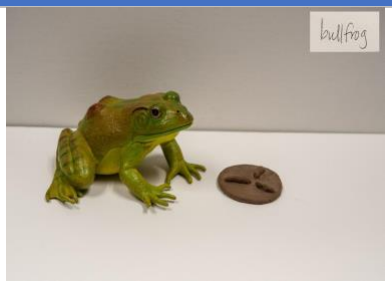
Grade 6

Life Science
Topic: Cellular to Multicellular
Content Statement
6.LS.4: Living systems at all levels of organization demonstrate the complementary nature of structure and function.

What's Inside

Visual Index of Trunk Contents

Specimens			
Blue Dasher Dragonfly *(Pachydiplax longipennis)*		Bess Beetle *(Passalidae)*	
Raccoon pelt (small piece) *(Procyon lotor)*		Skunk pelt (small piece) *(Mephitis mephitis)*	
Feathers Turkey *(Meleagris gallopavo)*		Feathers Peacock *(Pavo cristatus)*	
Tree wafers		Eastern Box Turtle *(Terrapene carolina carolina)*	
Antlers White-tailed Deer *(Odocoileus virginianus)*		Black Rat Snake *(Pantherophis obsoletus)*	

Assorted marine shells (6 sets)		Red-eared Slider *(Trachemys scripta elegans)*	
Additional Insects Ex: Tobacco Hornworm and Bumble Bee	May Vary	Japanese Beetle *(Popillia japonica)*	
Models			
American Bullfrog *(Lithobates catesbeianus)*		Fungus-Yellow Morel *(Morchella esculenta)* 3D printed	
Clownfish *(Amphiprioninae)*		Boa Constrictor *(Boidae)*	
Lizards (6 bags)			
Miscellaneous			
Are you a spider? by Judy Allen and Tudor Humphries			
Natural History: The Ultimate Visual Guide to Everything on Earth (Smithsonian) by DK			
Seashells by the seashore by Marianne Berkes			

Sorting by Henry Pluckrose
Sorting through spring: math in nature by Lizann Flatt
What is an Amphibian? by Angela Royston
What is a Bird? by Angela Royston
What is a Fish? by Angela Royston
What is an Invertebrate? by Angela Royston
What is a Mammal? by Angela Royston
What is a Reptile? by Angela Royston
Animal brochure
Evaluation pictures (Lesson 4)
Lizard Field Guide
Organism name tags-37
Sorting mats-8

Background

Ohio Science Standards emphasize the concept of classification throughout the grade levels from grades K-12. Each grade level covers its own content related to classification, but the concept of **classification** as a way of **sorting** through defined properties is evident in all areas.

Some of these topics include:

●Living and nonliving things have specific physical properties that can be used to sort and classify.

●Classify types of changes that objects or materials can go through to change observable properties (freezing, melting, tearing, wetting).

●Classify fossils based on anatomical characteristics and infer behavior patterns and habitats.

●Classify planets by exploring current scientific discussions.

●Classify motion as constant speed, speeding up, slowing down, based on distance traveled per unit of time.

●Classify organisms as producers, consumers or decomposers.

●Classify and identify different types of rocks, minerals and soil to decode the past environment in which they were formed.

●Classify types of energy as kinetic, potential or a combination of the two.

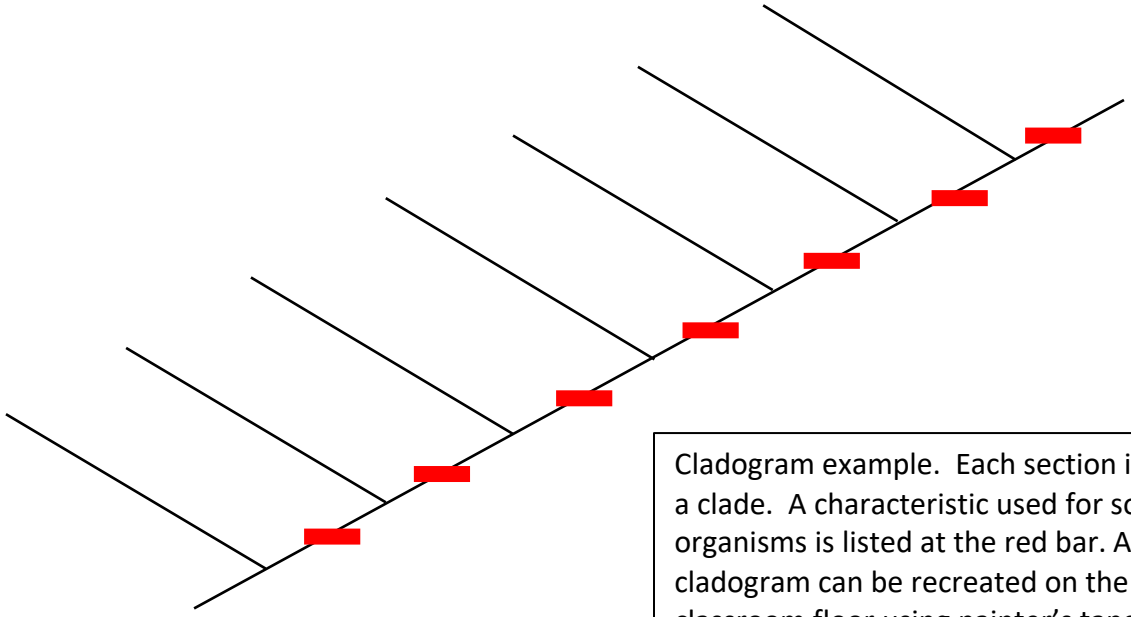
●Organisms have diverse body plans, symmetry and internal structures. General distinctions among organisms (e.g., internal structures, body systems, body plans, and symmetry) that support classifying them into a scientifically based system (a distinction of this grade level from Pre-K to 5) are explored. Organisms sorted into groups share similarities in external structures, internal structures and processes.

In life science, we focus on **taxonomy** as a way of classifying all living organisms. Carolus Linnaeus, known as the father of

Taxonomy, developed a system for ranking and classifying organisms in the world. We still use a form of his classification system today. In the following inquiry activities, we can use a cladogram or other methods of sorting.

What is a cladogram?

The **cladogram** is a visual graphic of living things that exhibit similar characteristics. This representation leads us to observe and organize common characteristics exhibited within a species. **Species** are living organisms that share common characteristics, can interbreed and produce fertile offspring. Cladograms, while simple in construction, allow taxonomists to visually sort organisms across different species and within a species.



Cladogram example. Each section is called a clade. A characteristic used for sorting organisms is listed at the red bar. A simple cladogram can be recreated on the classroom floor using painter's tape.

Using some of the specimens located in the Sorting in Science Discovery Trunk, we can create a cladogram to sort the organisms.

These are visuals of some of the specimens used in this example from the Trunk:





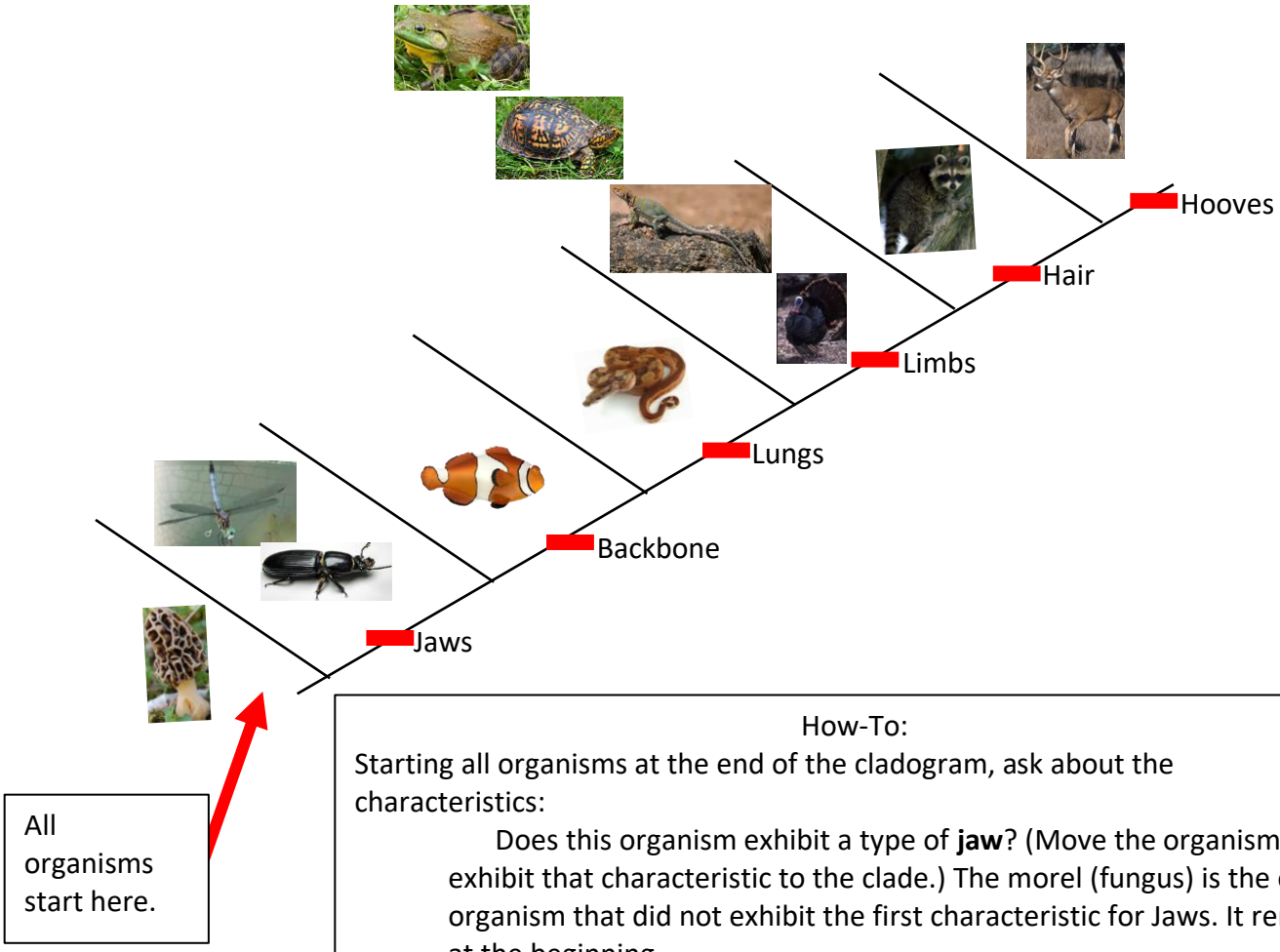






If we sort these organisms on a cladogram where each clade contains a characteristic, we could sort the organisms as is shown in the following diagram. Notice, all organisms start at the first clade. Only those organisms that exhibit that characteristic move onto the next clade. An organism remains at the clade where it last exhibited the characteristic.

Cladogram



How-To:

Starting all organisms at the end of the cladogram, ask about the characteristics:

Does this organism exhibit a type of **jaw**? (Move the organisms that exhibit that characteristic to the clade.) The morel (fungus) is the only organism that did not exhibit the first characteristic for Jaws. It remains at the beginning.

A **backbone**? (Move the organisms that exhibit that characteristic to the clade.) The Bess Beetle and Dragonfly do not exhibit a backbone. They remain at the first characteristic.

A type of **lung**? (Move the organisms that exhibit that characteristic to the clade.)

Any **limbs**? (Move the organisms that exhibit that characteristic to the clade.)

Continue along each clade determining whether or not the remaining organisms exhibit the characteristic identifies in the red box.

Essentially, we answer yes or no to the characteristic question. Does the organism display the characteristic? If yes, then move onto the next characteristic. If not, the organism remains. Cladograms offer a simple way to organize organisms based on certain traits identified.

Now Let's Talk Taxonomy

Taxonomy reflects relationships between all living things on earth. Taxonomy used to rely only on the observance of shared characteristics. Charles Darwin changed that realm of thinking by incorporating unobservable lineage with **phenotypic** traits. His theory of evolution states that populations of species arise and develop through natural selection. In natural selection, individual organisms that are better adapted to an environment survive to reproduce. Through reproduction, beneficial traits are passed on within the species. As the environment changes, traits within a species become beneficial, harmful, or neutral. These traits positively or negatively affect the survival and reproduction of individual organisms within the species population. *Individual organisms cannot change their genetic makeup to meet environmental shifts. It's their specific traits that allow them to outcompete others and successfully reproduce.*

In taxonomy, the most general classification group is the Domain. There are three domains of life: Bacteria, Archaea, and Eukarya. All living things on earth can be classified into one of three Domains. The contents of this trunk focus on Eukarya. Within the Eukarya domain, there are four kingdoms of life named Animalia, Plantae, Fungi and Protista. The most specific classification group is a species. There are eight classification groups from most general to most specific. This order of groups from least specific to most specific includes the following:

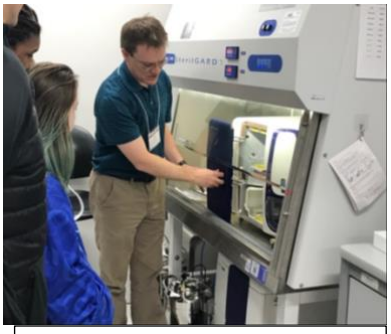
Domain (Bacteria, Archaea, Eukaryote)
  Kingdom (Animalia, Plantae, Fungi, Protista)
    Phylum
      Class
        Order
          Family
            Genus
              Species

For example, we can classify the Tiger Wolf spider, commonly found in Ohio, as follows:

Domain: Eukaryote
  Kingdom: Animalia
    Phylum: Arthropoda
      Class: Arachnida
        Order: Araneae

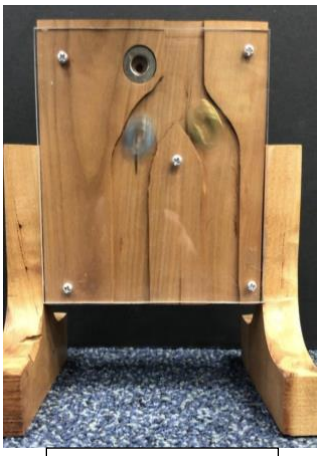
Family: Lycosidae
Genus: *Tigrosa*
Species: *aspersa*

All groups are written in Latin. When taxonomy was universally established by Linnaeus, Latin was a universal language. Many people around the world spoke Latin, which allowed scientists from different countries to communicate clearly. Today, Latin is no longer a spoken native language of any community, but it still used within science. To describe a specific species by its scientific name, write the genus and species in italics with the first letter of the genus name capitalized. Both words are enclosed within parentheses. Therefore, the Tiger Wolf spider's scientific name is written *(Tigrosa aspersa).*



Tim Wilson demonstrates the FACS to high School students.

The Science of Sorting Discovery Trunk was created as an educational component to the NSF grant *MRI: Acquisition of a Fluorescence Activated Cell Sorting System to Expand Synergistic Research and Educational Opportunities* at Miami University. Understanding the concept of sorting at its most basic level—sorting cells—and at a micro scale can be difficult for students to grasp. Machines, such as the Fluorescence Activated Cell Sorter (FACS) purchased through the grant, utilize color and magnetism to sort cells into distinct categories. More information on the FACS machine is offered at the end of the guide. To help students make a connection with this concept, we have provided a Koller Washer Sorter System. Created by Don Koller, this system works at a very simplified level compared to the Cell Sorter by sorting two different washers based on color and magnetism. The large titanium magnet in the top left corner of the Washer Sorter attracts the silver colored washers (steel) to the left side and allows the gold colored (brass) washers to travel to the right side. Students can observe that the washers are sorting by color and/or magnetism. This is available to use as an engagement or extension activity within any of the six lessons in this trunk.



Koller Washer Sorter

Lesson 1
"Shells, shells, shells"

Purpose

Things found in nature can be described by their **attributes** or characteristics such as size, shape, color or texture. Learners will compare and sort objects according to characteristics, determine an organism's needs within its habitat, and see that offspring resemble their parents and each other.

Materials for This Lesson

Specimens			
Assorted marine shells (6 sets)			
Seashells by the seashore by Marianne Berkes			
Laminated Sorting mats-8			

Standards Met by Lesson

Ohio Department of Education Standards for Lesson1

Kindergarten

K.PS.1: Objects and materials can be sorted and described by their properties
K.LS.1: Living things have specific characteristics and traits
K.LS.2: Living things have physical traits and behaviors, which influence their survival.

Grade 1

1.LS.1: Living things have basic needs, which are met by obtaining materials from the physical environment.
1.LS.2: Living things survive only in environments that meet their needs.

Grade 3

3.LS.1: Offspring resemble their parents and each other.

Lesson 1 "Shells, shells, shells"

Engagement

Ask the children if they have ever been to the seashore and collected seashells. Then read *Seashells by the Seashore* by Marianne Berkes.

Exploration

Divide the students into six groups. Give each group a set of shells. Ask the students to observe the various shells. How are they alike? How are they different? What are their characteristics or attributes? Give each group a sorting mat. Each student takes a turn sorting the shells into two groups. Students need to explain what attributes they used to sort the shells. This could include sorting by color, shape, size, and texture. Next, students sort the shells from largest to smallest.

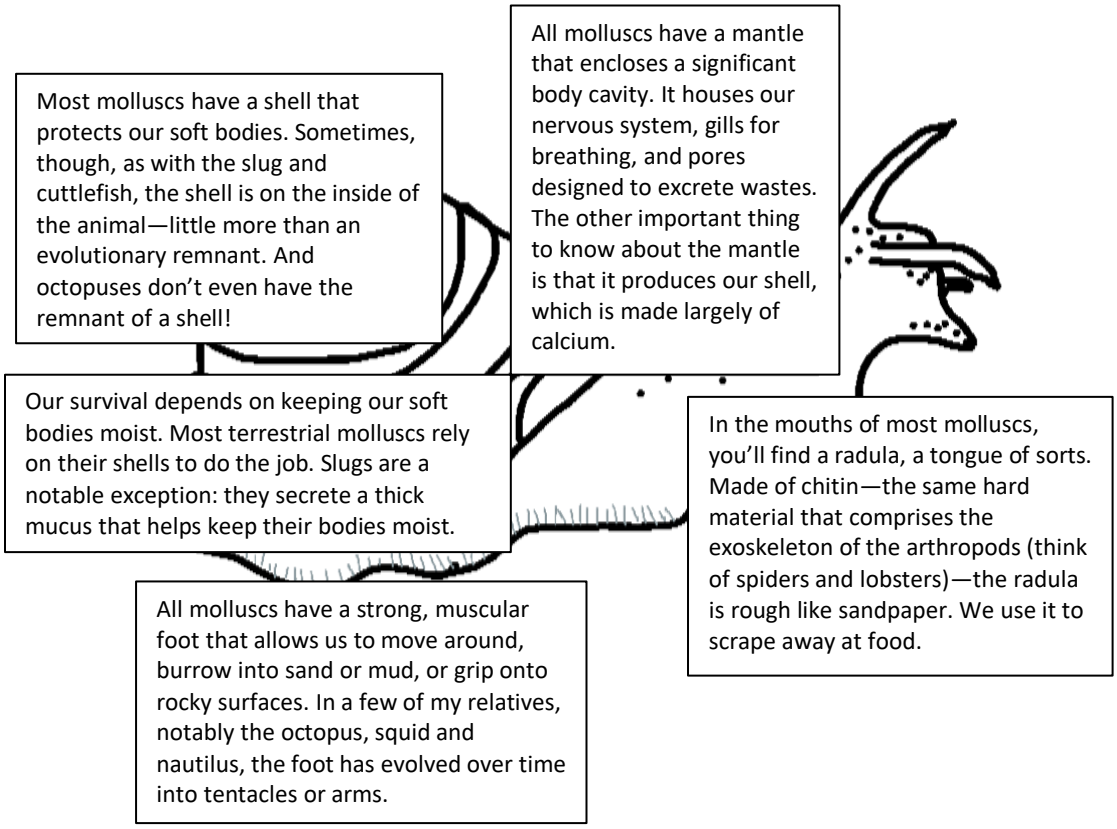
Explanation

We just learned that shells can be sorted according to their attributes. Attributes are observable traits or characteristics scientists use to identify organisms. When sorting the shells, students utilized sight and touch to observe each organism. Scientists also sort according to other properties, such as weight, length, composition, type of habitat, and so on.

Elaboration

The shells we find at the beach are actually the homes of small, soft -bodied animals called **molluscs**. Shells can be found in all different colors, shapes, and sizes. Clams, oysters, scallops, mussels, and conchs are common shells found on the beach. As the organism grows throughout its life, it secretes a calcium carbonate substance that forms its shell. This hard covering helps to protect the animal's soft body.

Shells are the outer protective layer of molluscs, a large group of marine, freshwater or land animals. As soon as the immature mollusc hatches from its egg, it begins to build its shell. The mollusc uses minerals, such as calcium carbonate and protein from its own body to build the shell. Your body uses collagen (protein) and calcium to make bones. Shells are excreted from the outer surface of the mollusc called the **mantle**. If a shell is damaged, it may repair itself. Molluscs grow shells in shapes that help them to best survive in their environment, whether it be for protection from predators or to help them to find food. The shell's colors come primarily from the type of food the mollusc eats. Upon the death of the mollusc, the shell can still be used by other animals. Hermit crabs inhabit shells of other dead marine molluscs. Shorebirds also use shells to build their nests. Mice and shrew eat shells of terrestrial snails to obtain calcium. When comparing young molluscs to parents, molluscs resemble the parents and other offspring. The parents and their offspring exhibit the same characteristics as described below.



Evaluation

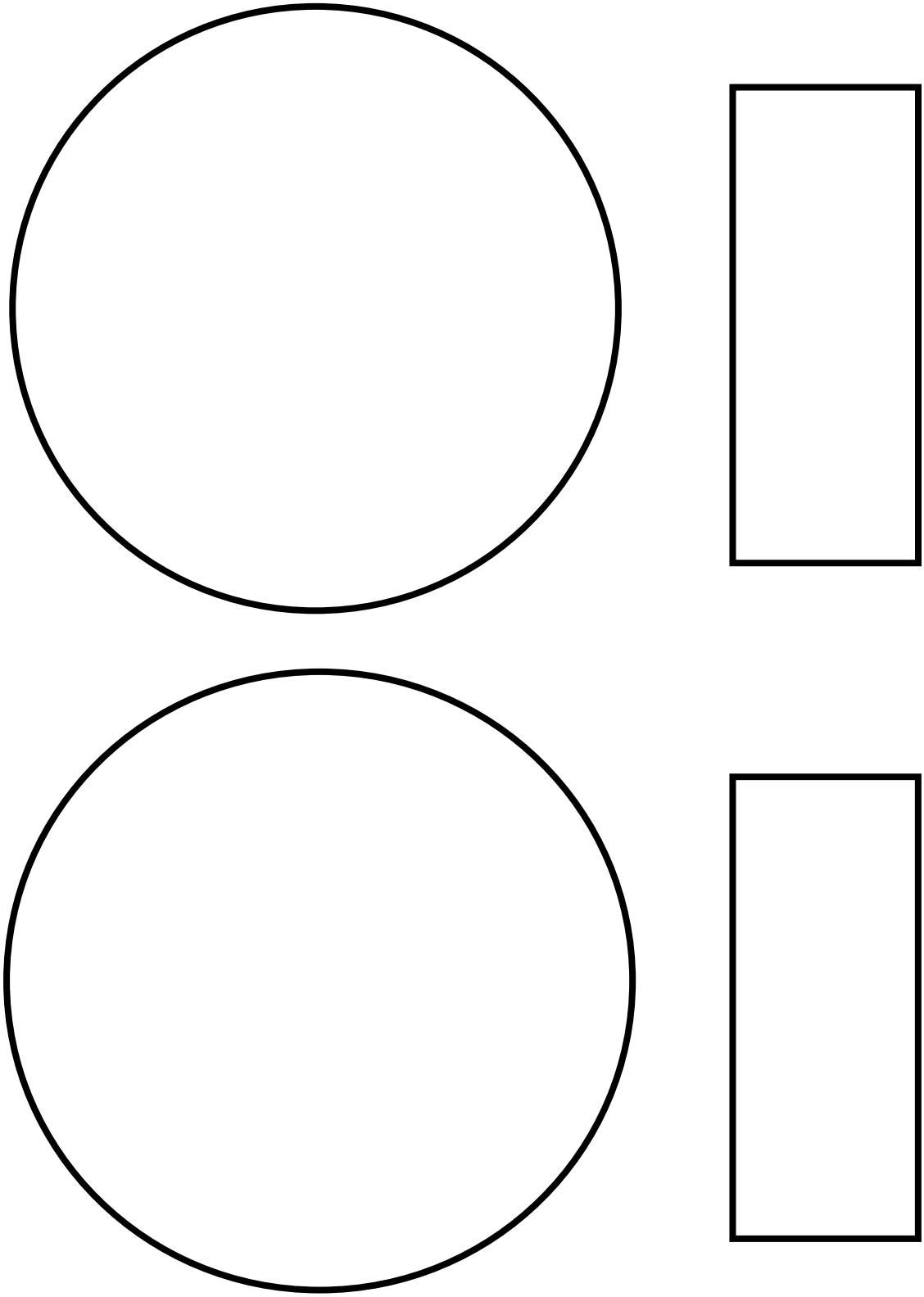
- Give students a set of shells and ask them to sort the shells into two groups. What attributes did they use to sort the shells? Then ask the students to tell you two things they learned about shells.
- Older students can research and label the parts of the mollusc body, as would be found in the parent and offspring.

Extension Activity Options

Koller Washer Sorter

Grade 1 Focus

In pairs, students will challenge each other to organize the shells by length. Student 1 picks three shells for student 2 to organize from largest to smallest. Student 1 will add a fourth a fourth shell for student 2 to add to the existing group. How did they decide where to put the fourth shell?



Sorting Mat

Lesson 2 "I got your back… bone."

Purpose

All animals can be divided into two groups – **invertebrates** (no backbone) and **vertebrates** (backbone). Each of these categories can be divided further. This lesson can be used as an introduction to classification or as a preparatory activity for an outing, such as a field trip to the zoo

Materials for This Lesson

Specimens			
Blue Dasher Dragonfly *(Pachydiplax longipennis)*		Bess Beetle *(Passalidae)*	
Raccoon *(Procyon lotor)* (small piece)		Skunk *(Mephitis mephitis)* (small piece)	

Feathers Turkey *(Meleagris gallopavo)*		Feathers Peacock *(Pavo cristatus)*	
Antlers White-tailed Deer *(Odocoileus virginianus)*		Eastern Box Turtle *(Terrapene carolina carolina)*	
Additional Insects Ex: Tobacco Hornworm and Bumble Bee	May Vary	Black Rat Snake *(Pantherophis obsoletus)*	
Red-eared Slider *(Trachemys scripta elegans)*			
Models			
American Bullfrog *(Lithobates catesbeianus)*		Boa Constrictor *(Boidae)*	
Clownfish *(Amphiprioninae)*			

Standards Met by Lesson

Ohio Department of Education Standards for
Lesson 2

Kindergarten
K.LS.2: Living things have physical traits and behaviors, which influence their survival.

Grade 1
1.LS.2: Living things survive only in environments that meet their needs.

Grade 3
3.LS.2: Individuals of the same kind of organism differ in their inherited traits. These differences give some individuals an advantage in surviving and/or reproducing.

Grade 6
6.LS.4: Living systems at all levels of organization demonstrate the complementary nature of structure and function.

Lesson 2

“I got your back… bone.

Engagement

Arrange the class into 5 groups. Distribute animal models and specimens from the Trunk, as needed, to each group. Make sure there are vertebrates and invertebrates in each group. Encourage students to identify their organisms. What do they observe about the organisms?

Exploration

Tell students that their mission is to sort the organisms into two groups. After this step, discuss how they sorted their specimens. What two attributes did you use to sort your specimens? Encourage students to share their observations and questions from earlier.

Explanation

Explain that all animals can be divided into two main groups based on whether or not they have a backbone. Can the children find their own backbones?

Address any outstanding questions students may have. Write the terms **vertebrate** (backbone) and **invertebrate** (no backbone) on the board. Encourage students to generate a definition for each.

Here’s the how-to

Create large labels of the two words, vertebrate and invertebrate, and place them at a central location where all can reach. Groups then place their organisms under the appropriate label to create a class graphic organizer based on these two properties.

Create a list of animals that have backbones and others that do not have backbones. Keep this up for a reference in the classroom. Have students think about why a backbone would help an organism to survive. Are there similarities between vertebrates and invertebrates? Compare one invertebrate to one vertebrate, such as a beetle and a raccoon, as a class discussion. Steer the learners to look at all aspects from possible weight, to length and mobility.

Elaboration

In science, we divide all living things according to their characteristics. Some traits or characteristics we can see and some we cannot. A **characteristic** is a feature or quality that we use to identify an object. What are the characteristics of a bird? What are the characteristics of a raccoon? Go through other items located in the trunk and ask students to describe their attributes or characteristics.

An organism can only survive in an environment that meets its needs such as food, shelter and space. It also needs to have the physical traits necessary to survive in this environment. A backbone is an example of this. The purpose of a backbone allows an animal to grow larger at a faster rate and provides them with a larger range of movement. The beetle, with no backbone, exhibits a more limited range of movement compared to a raccoon with a backbone. Animals that survive to reproduction will have offspring that exhibit these same traits. Other examples of body structures that enable an animal to survive could include a prehensile tail, a long beak, webbed feet, or an opposable thumb. Use the vertebrate and invertebrate organisms discussed previously for more examples.

Let's Find Out
Grade 1 Focus

Students use the provided animal brochure to research each organism's **habitat** and **food source** and record their findings on the provided inquiry sheet located in the Reproducibles section following this lesson (habitat, food source, fun fact). As a class discussion, ask how the environment provides for the needs of the organism.

Grade 3 Focus

Provide students with the "Parent and Offspring Match" activity located in the Reproducibles section following this lesson. Students cut apart game pieces and match **offspring** to the **parent**.
Introduce the idea that not all offspring look exactly like the parent until they reach **maturity**.

Grade 6 Focus

Students research the natural histories of each organism. A **natural history** provides information about an organism's environment, food source, description of body structure, how and when it reproduces and any cultural connections. Students use this information to understand the function that relates to many different body structures.

Evaluation

Kindergarten

Choose an organism from the Discovery Trunk. As a class, list characteristics of the organism and where the organism might live based on these traits. For example, a frog characteristic is webbed feet, this organism might live in or near a pond. Repeat this process with other organisms until each student has an opportunity to respond.

Grade 1, 3

Have students fold paper lengthwise. Draw a T chart on the paper. Label one side Vertebrate the other side Invertebrate. Select two organisms and compare and contrast their traits and their environments. Students in grade 1 should focus on how the organism's needs are met by the environment. Students in grade 3 should focus on how the offspring resembles its parent. (Use the red eared slider turtle mature and immature specimens to show a physical example.) As students discuss the type of birth, what similarities do they find among all invertebrates? Is it the same for vertebrates?

Grade 6

Students research an ecosystem and identify three organisms that live in the ecosystem. What makes these organisms specially adapted to live in that ecosystem? Students list three structures on each organism and explain the functionality of each structure. For

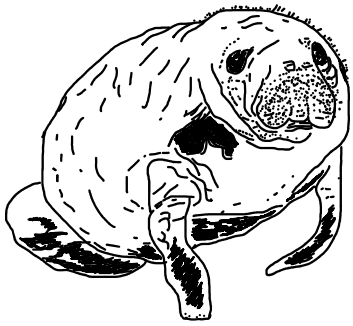
example, a sea otter is able to perform fine motor skills using the dexterity of its paws.

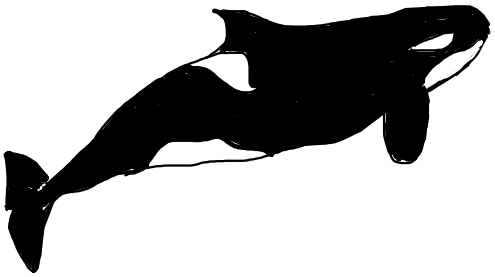
Extension Activity Options

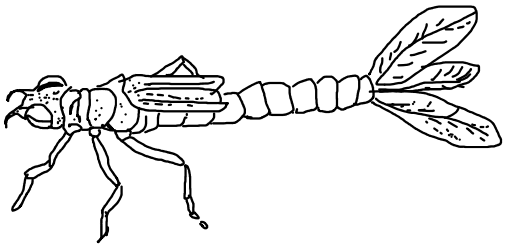
Koller Washer Sorter

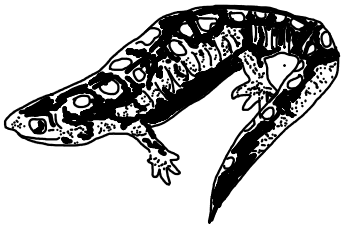
Parent Offspring Match

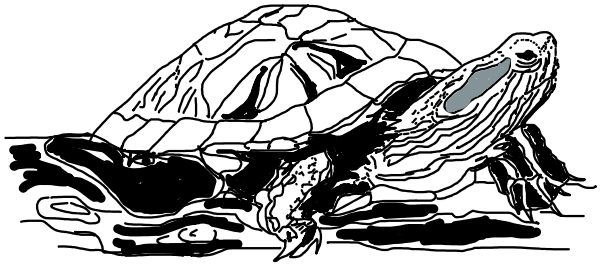
Match the parent with the offspring. What characteristics do they share?





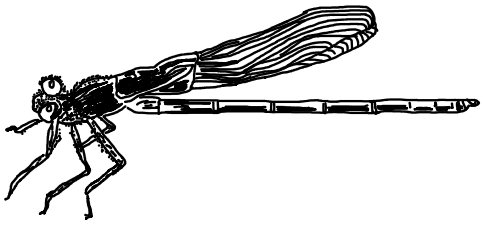


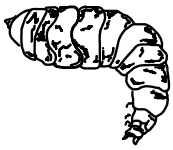


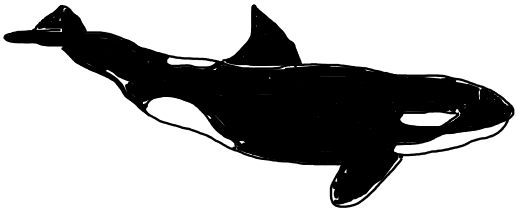


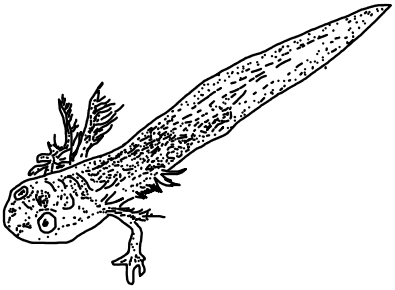
Parent Offspring Match

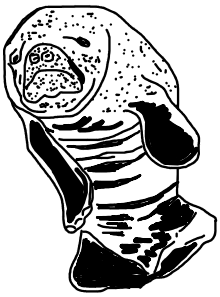
Match the parent with the offspring. What characteristics do they share?

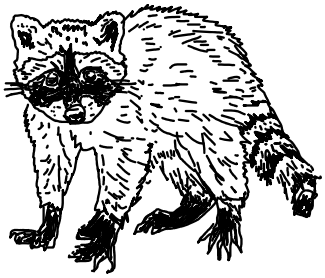


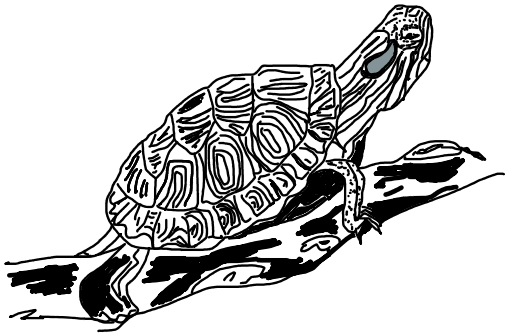


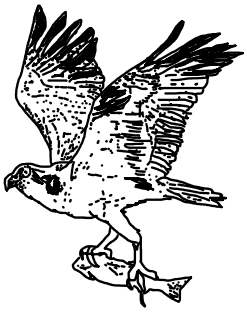




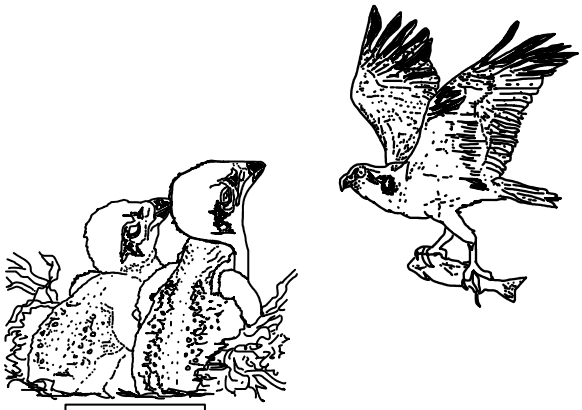




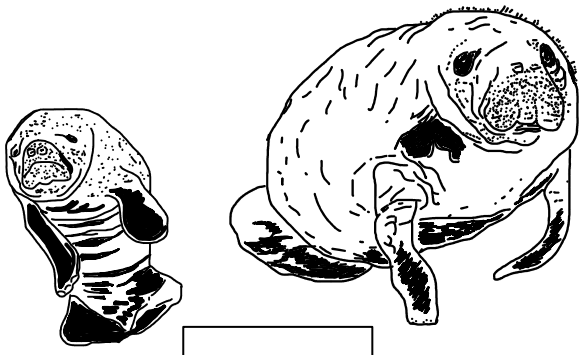




Answer Key



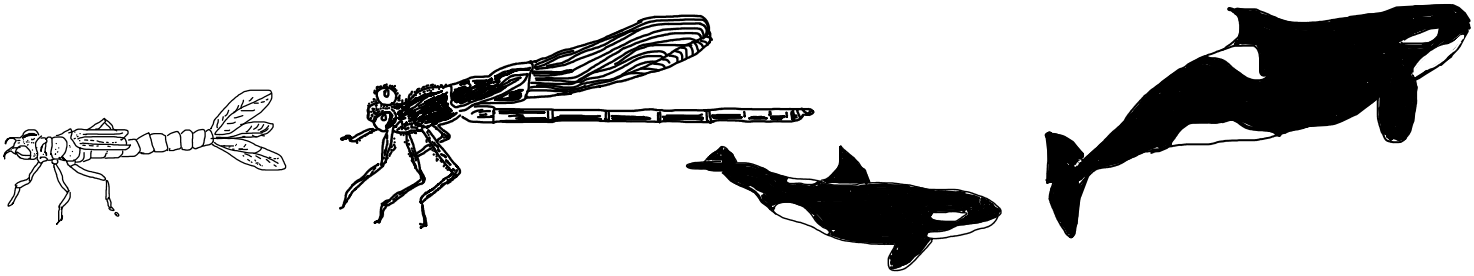
Osprey



Manatee

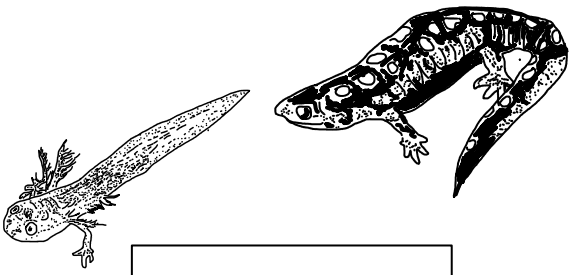
American Burying Beetle

Raccoon

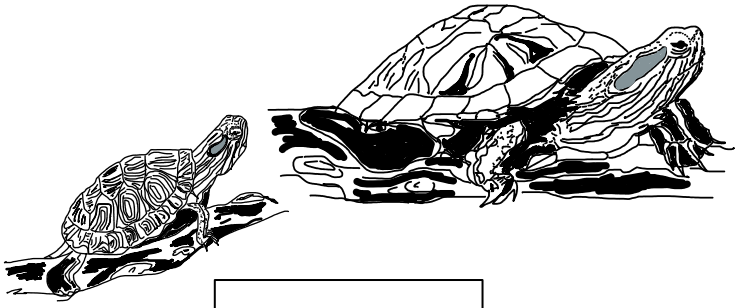


Damsel fly

Orca



Spotted Salamander



Red-eared Slider

Grade 1

	Vertebrate	Invertebrate
Habitat		
Food Source		
Fun Fact		

Grade 6

Natural History Notes

Body Structure

Body Function

Invertebrate

Vertebrate

Lesson 3
"Creepin' crawlies"

Purpose

Students classify invertebrates as **spiders** or **insects** according to body parts. This lesson is a great follow up to Lesson 2 on vertebrates and invertebrates.

Materials for This Lesson

Specimens			
Blue Dasher Dragonfly *(Pachydiplax longipennis)*		Bess Beetle *(Passalidae)*	
Additional Insects Ex: Tobacco Hornworm and Bumble Bee	May Vary	Japanese Beetle *(Popillia japonica)*	
Miscellaneous			
Are you a spider? Judy Allen and Tudor Humphries			
What is an Invertebrate? by Angela Royston			
Animal brochure			

Standards Met by Lesson

Ohio Department of Education Standards for
Lesson 3

Kindergarten
K.LS.2: Living things have physical traits and behaviors, which influence their survival.

Grade 3
3.LS.2: Individuals of the same kind of organism differ in their inherited traits. These differences give some individuals an advantage in surviving and/or reproducing.

Lesson 3
"Creepin' crawlies"

Engagement

Read and discuss *Are You a Spider* by Judy Allen and Tudor Humphries with the students.

Exploration

Students make observations of an insect using a picture, model or specimen (ex. Dragonfly, Bumble bee, Tobacco hornworm, Bess beetle, Japanese beetle, etc.) on the inquiry sheet. Discuss observations. (Complete this as a whole group activity with kindergarten students.)

Cut apart the spider identification sheet, located in the *Reproducibles* section of this lesson, and provide each pair of students with one spider picture. Students make observations on a second inquiry sheet. Discuss observations. (Complete this as a whole group activity with kindergarten students.)

Explanation

Compile student observations about insects and spiders from inquiry sheets on a large Venn diagram as a class. Lead students to the conclusion that these organisms are alike because they do not have bones. They are both **invertebrates**. How are they different? **Spiders** have 8 legs and 2 body parts (cephalothorax containing the head and thoracic region and legs and the abdomen containing the spinnerets and genital opening), and **insects** have 6 legs and 3 body parts (head, thorax and abdomen).

Elaboration

Insects and spiders are **arthropods**. As arthropods, they share the following characteristics:

1. They are invertebrates.
2. They are covered by an **exoskeleton** made of **chitin**.
3. As insects and spiders grow into adults, their exoskeletons cannot grow with them, so they **molt** the exoskeleton.
4. They exhibit segmented body parts.
5. They also exhibit segmented legs.

Although insects and spiders are both arthropods, their body parts differ from each other. Provide students with the "Parts of Arthropods" sheet located in the Reproducibles section following this lesson. Discuss differences.

Let's Find Out

Grade 3 Focus

There are many other examples of invertebrates. Today we looked at insects and arachnids (spiders), but we can also name others. What other animals in the world are invertebrates? It may be helpful to guide children to generate other invertebrates by making a chart with the headings: Ocean, Freshwater, Soil.

Name an invertebrate that lives in the ocean. Examples for ocean: **crustaceans** (lobster, crab, shrimp), **molluscs** (gastropods-snails, bivalves, squids, octopi), **cnidarians** (jellyfish, sea anemones, corals)

Name an invertebrate that lives in freshwater. Examples for freshwater: **crustaceans (**fairy shrimp) **molluscs (**freshwater mussels), and **annelids (**leeches)

Name an invertebrate that lives in soil: Examples for soil: **molluscs** (snails), **annelids** (leeches and earthworms), **coleoptera** (beetles)

Evaluation

Kindergarten

Encourage students to name insects or spiders with which they are familiar. Review body parts and differences between spiders and insects. Allow children to build a spider or an insect with playdoh. Individually, record student dialogue explaining what they created.

Grade 3

Assign each student a number 1 or 2. Those with a 1 will research a spider (8 legs and 2 body parts). Those with a 2 will research an insect (6 legs and 3 body parts). Students will identify the environment their organism inhabits and name two traits that allow them to survive in their environment.

Extension Activity

Using play dough, encourage students to design a new type of spider (8 legs and 2 body parts) or insect (6 legs and 3 body parts). Label the body parts that are characteristic of a spider or insect. Students will name the new spider or insect, identify its environment and traits that allow it to survive in that environment and share it with the class.

Inquiry Sheet

Write 3 observations about your object.

- _____
- _____
- _____

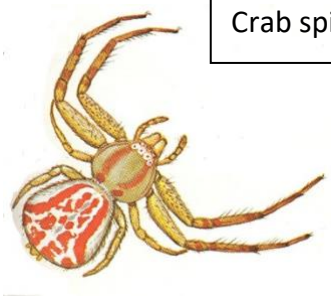
Write 3 questions you have about your object.

- _____
- _____
- _____

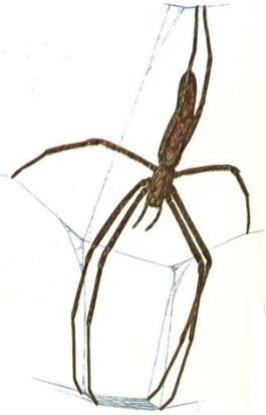
What is your hypothesis?

Spider Identification Sheet

Crab spider

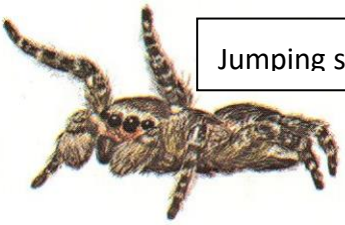


Gnaphosia



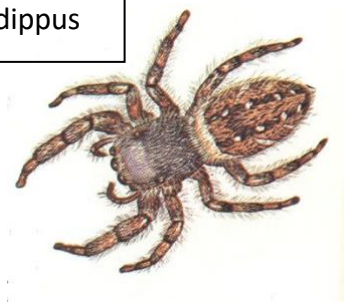
Ogre-faced spider

Orb weaver

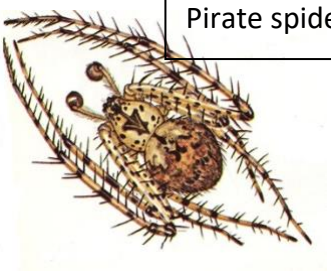


Jumping spider

Phidippus

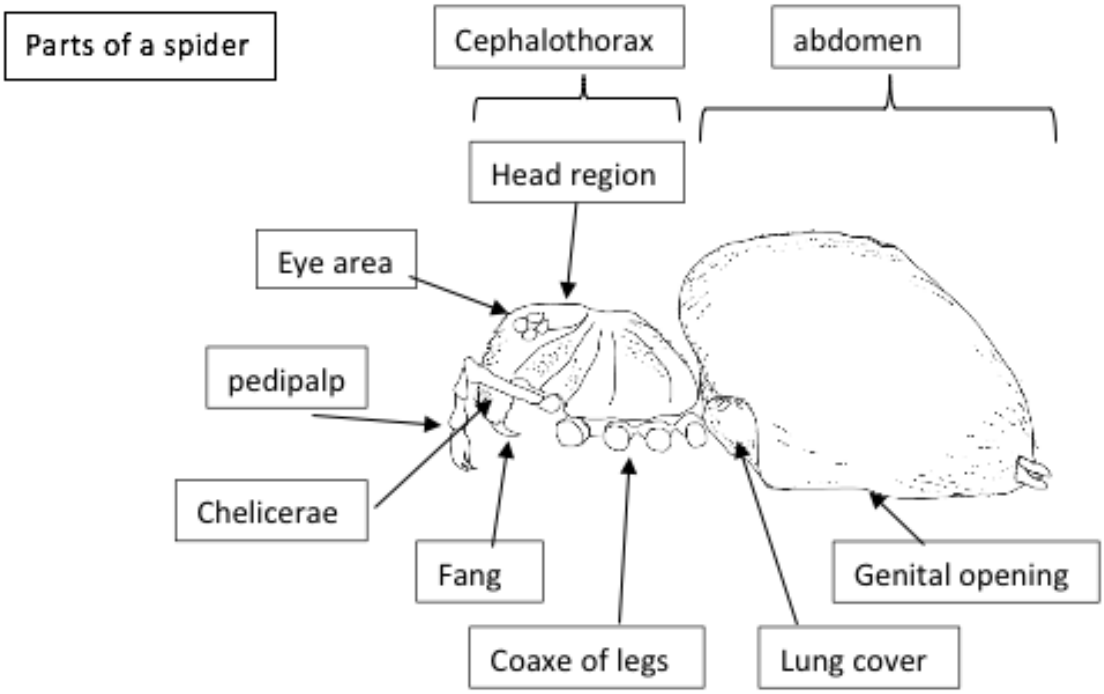


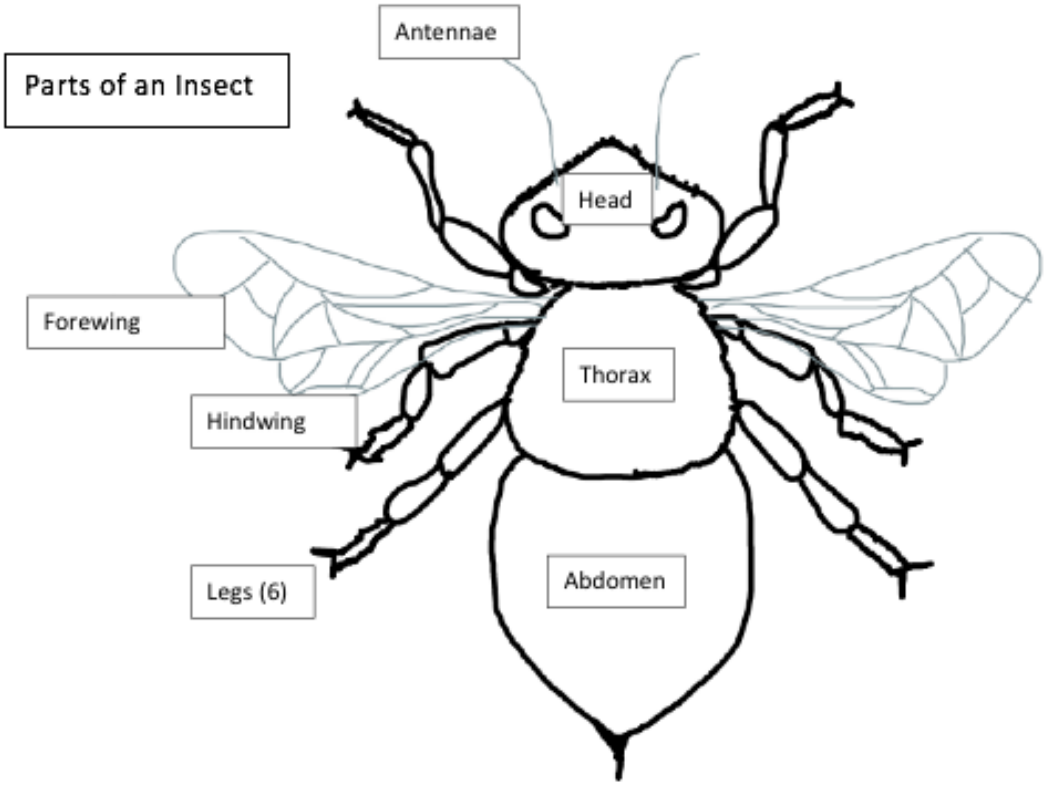
Pirate spider

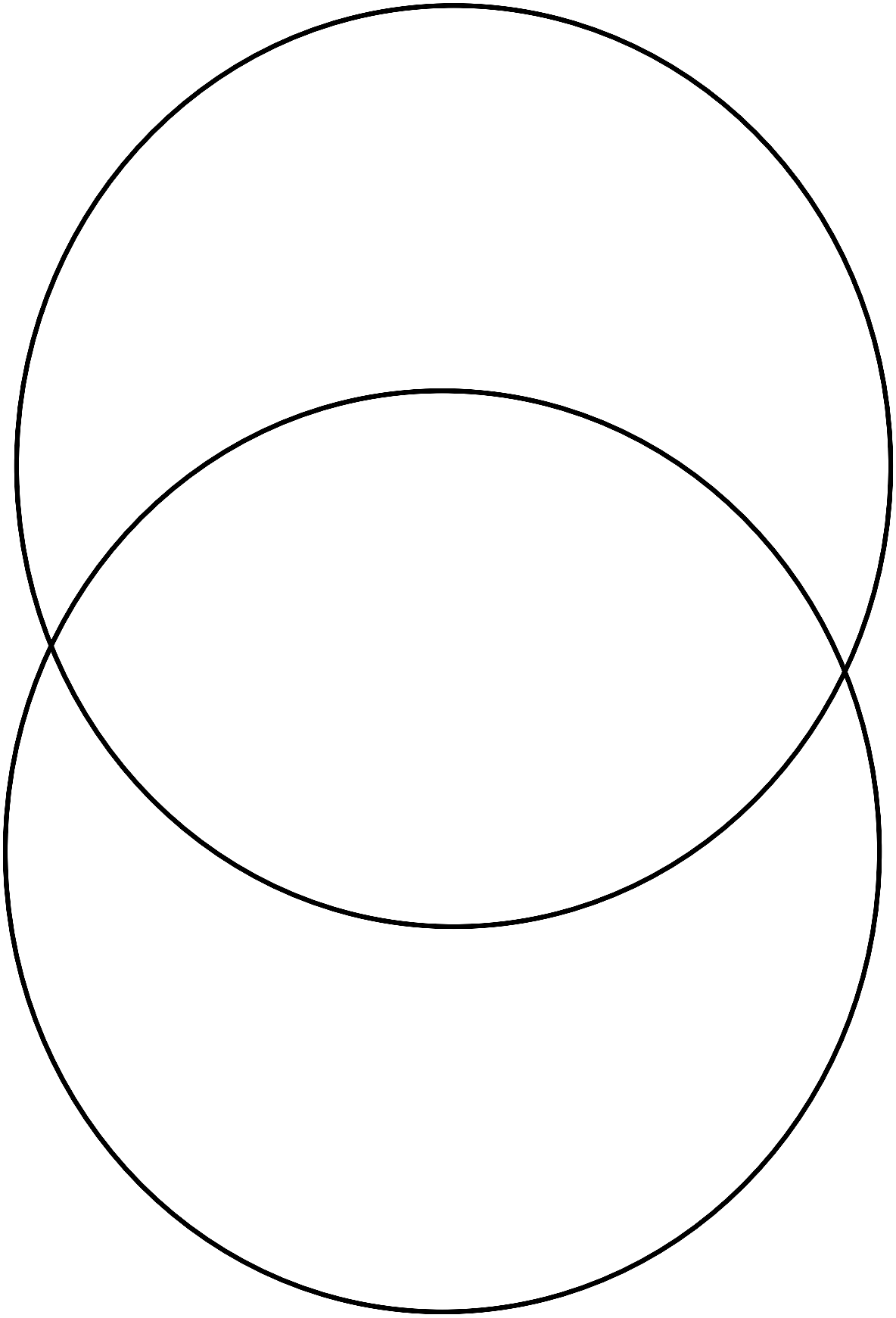


Source:
Levi, H. W. and Levi, L.R. (1987)
Spiders and Their Kin: A Golden Guide.
New York: Golden Press

Parts of Arthropods







Venn Diagram

Lesson 4 "All things great and small"

Purpose

In this lesson, students will classify vertebrates as **mammals, birds, fish, reptiles,** and **amphibians.**

Materials for This Lesson

Specimens			
Raccoon pelt (small piece) *(Procyon lotor)*		Skunk pelt (small piece) *(Mephitis mephitis)*	
Feathers Turkey *(Meleagris gallopavo)*		Feathers Peacock *(Pavo cristatus)*	
Antlers White-tailed Deer *(Odocoileus virginianus)*		Eastern Box Turtle *(Terrapene carolina carolina)*	

Assorted marine shells (6 sets)		Black Rat Snake *(Pantherophis obsoletus)*	
Additional Insects Ex: Tobacco Hornworm and Bumble Bee	May Vary	Red-eared Slider *(Trachemys scripta elegans)*	

Models

American Bullfrog *(Lithobates catesbeianus)*		Lizards (1 bag)	
Clownfish *(Amphiprioninae)*		Boa Constrictor *(Boidae)*	

Miscellaneous

Natural History: The Ultimate Visual Guide to Everything on Earth (Smithsonian) by DK
What is an Amphibian? by Angela Royston
What is a Bird? by Angela Royston
What is a Fish? by Angela Royston
What is a Mammal? by Angela Royston
What is a Reptile? by Angela Royston
Evaluation pictures-5

Standards Met by Lesson

Ohio Department of Education Standards for
Lesson 4

Kindergarten

K.LS.2: Living things have physical traits and behaviors, which influence their survival.
K.PS.1: Objects and materials can be sorted and described by their properties.

Grade 3

3.LS.2: Individuals of the same kind of organism differ in their inherited traits. These differences give some individuals an advantage in surviving and/or reproducing.

Lesson 4
"All things great and small"

For class preparation, divide the specimens and models in the trunk into six different groups: mammals, birds, reptiles, amphibians and fish. Place the groups in different containers, such as bowls or plates that will be easy to transport during the lesson.

Engagement

Students think of their favorite animals. What are characteristics of their favorite animals? (A characteristic is a feature that can be used to identify an organism.) What color is it? Does it have a backbone, legs, fur, feathers? Does it lay eggs?

Exploration

Arrange the class into five groups and provide students with an inquiry sheet (for Grade 3). Students explore the objects in front of them and record observations and questions about the organisms in their container. What makes these things similar? What makes them different? Each group then shares their findings with the class. (This may be done as a whole group activity with Kindergarten students.)

Explanation

We call many organisms "animals" but that is a general term. As we have found through our observations, animals display many different characteristics some of which include an ability to move, use of sensory organs, ability to reproduce, ability to breathe in oxygen and release carbon dioxide, and have a life cycle.
Discuss similarities and differences of each container as a class. What did organisms in each container have in common? The similarities help us to put animals into groups such as mammals, birds, reptiles, amphibians, fish, or insects. On a table, lay out the headings: mammal, bird, reptile, fish, amphibian, insect. Provide students with natural history sheets, *Natural History: The Ultimate Visual Guide to Everything on Earth (Smithsonian) by DK* and other non-fiction books located in the trunk, for their organisms and encourage them to look at the photos of each animal. Ask students to place their container under the heading identifying the group to which it belongs.

Elaboration

Reveal to students that the containers were organized by types of vertebrates (animals with backbones and internal skeletons). More specifically, mammals, birds, reptiles, amphibians, fish.

Let's review characteristics about each type of animal group.

Mammals: live on land or in water, exhibit hair, typically give live birth of young (**viviparous**), exhibit four limbs and are warm-blooded

Birds: typically live on land, display feathers, produce eggs (**oviparous**), display four limbs (two wings, two legs) and are warm-blooded

Reptiles: live on land or near water, have scales or scutes that cover their body, produce eggs and are oviparous (although some can give birth to live young because the eggs develop and hatch in mother's body, which is called **ovoviviparous**), have variable limbs and are cold blooded

Amphibians: live on land near water or in water, have moist skin with no scales, produce eggs (oviparous), exhibit variable limbs and are cold-blooded

Fish: live in the water, have scales and gills, produce eggs (oviparous), have some cartilaginous vertebrae and are cold-blooded

Certain characteristics help organisms to survive in specific environments. Within populations of one species, individuals could have different characteristics. For example, dogs are all one species, *Canis lupus*, yet they have extremely variable characteristics.

Grade 3 Focus

When a characteristic varies in a population, such as fur color, that does or does not match the environment, it provides one animal with a better chance to survive over another. If an organism survives to reproduce, it is able to pass on its genes to the next generation. This process of surviving and reproducing to pass on advantageous genes to the next generation facilitates **natural selection**.

Evaluation

Kindergarten

Allow each student to select one animal from the evaluation pictures provided. The student identifies the group it belongs to, its environment, and names two characteristics of the animal that enables it to survive in its environment. This activity can be completed as a class discussion, in small groups, or one-on-one with the teacher.

Grade 3

Make a flipbook of an animal native to Ohio. Research the animal's physical appearance, distinguishing traits that enable it to survive in its habitat, diet, reproduction and a fun fact about the animal.

Extension Activity Options

Koller Washer Sorter

Kindergarten Inquiry Sheet (use as a guide)

Write 3 observations about your object.

- _____
- _____
- _____

Write 3 questions you have about your object.

- _____
- _____
- _____

Grade 3 Inquiry Sheet

Write 3 observations about your object.

- _____
- _____
- _____

Write 3 questions you have about your object.

- _____
- _____
- _____

What's your hypothesis?

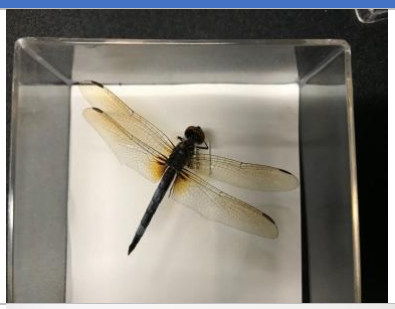
_____

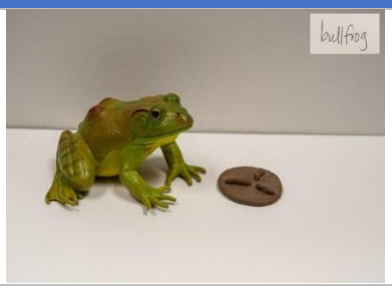
Lesson 5 "Taxonomy and classification"

Purpose

This lesson covers topics such as identifying properties, creating different classification schemes based upon shared internal and external characteristics of organisms, and pinpointing the form and function of such characteristics. Students will sort organisms into the six kingdoms of life and into a **cladogram**.

Materials for This Lesson

Specimens			
Blue Dasher Dragonfly *(Pachydiplax longipennis)*		Bess Beetle *(Passalidae)*	
Raccoon pelt (small piece) *(Procyon lotor)*		Skunk pelt (small piece) *(Mephitis mephitis)*	
Feathers Turkey *(Meleagris gallopavo)*		Feathers Peacock *(Pavo cristatus)*	

Tree wafers		Eastern Box Turtle *(Terrapene carolina carolina)*	
Antlers White-tailed Deer *(Odocoileus virginianus)*		Black Rat Snake *(Pantherophis obsoletus)*	
Assorted marine shells (6 sets)		Red-eared Slider *(Trachemys scripta elegans)*	
Additional Insects Ex: Tobacco Hornworm and Bumble Bee	May Vary		
Models			
American Bullfrog *(Lithobates catesbeianus)*		Fungus-Yellow Morel *(Morchella esculenta)* 3D printed	
Clownfish *(Amphiprioninae)*		Boa Constrictor *(Boidae)*	
Miscellaneous			
Organism name tags-37			

Standards Met by Lesson

Ohio Department of Education Standards for Lesson 5

Kindergarten

K.PS.1: Objects and materials can be sorted and described by their properties.

K.LS.2: Living things have physical traits and behaviors, which influence their survival.

Grade 2

2.LS.2: All organisms alive today result from their ancestors, some of which may be extinct. Not all kinds of organisms that lived in the past are represented by living organisms today.

Grade 6

6.LS.4: Living systems at all levels of organization demonstrate the complementary nature of structure and function.

Lesson 5 "Taxonomy and classification"

Pre-activity setup

Using painters' tape, create a cladogram on the floor large enough that the students can all stand next to. (See illustration in Reproducibles section) Distribute the natural objects in the Discovery Trunk onto a table. Keep the laminated photos, these will be used during the Explanation section of this lesson.

Engagement

Ask students if they ever had to clean up their room. How did they do it? Some words that may come up: organized, sorted, put away. If they found a bath towel, ball, and bat on the floor, what would they do with those objects? Take answers. Things were put away based on the physical, external features of those objects. We could call those characteristics or traits. Scientists organize organisms in the natural world according to characteristics and traits.

Exploration

Divide the students into pairs. Send one partner up to the table to collect a natural object. Encourage the students to tell each other all the parts of that natural object, its colors, when they have seen them, etc. If students are confused as to what their object is, add clarification and give an example of where it can be found in nature.

Grade 6 Focus

Sorting according to properties, characteristics or traits

Next, encourage the students as a whole group to divide their organisms into two groups. What will they use to determine their two groups? Was it based on **internal** (not visible to the eye) or **external** (visible to the eye) traits? Come back as a whole group and see if they can divide their organisms into three groups. What are the common features within each group? Eventually, help them to divide into: Animals, Plants, Fungus.

Teacher Tip

A fungus is not a plant. Plants produce their own food through photosynthesis and fungi rely on other organisms to make their

own food – when the organism dies, the fungus absorbs the decaying organic matter left over.

Explanation

Kindergarten Focus

Scientists divide all living things into categories according to their similar characteristics or traits. All animals are either vertebrates, having a backbone, or invertebrates, no backbone. Do you have a backbone? Animals also get their food from other organisms. Plants, or Plantae, make their own food. Fungus absorb their food from organisms that died. Help the students to determine which group their organism belongs to.

Grade 2 Focus

When we look at the phylogeny of organisms, we can infer ancestral relationships. All organisms alive today, result from their ancestors. Some of which may be extinct. Some kinds of organisms become extinct when their basic needs are no longer met or the environment changes.

Grade 6 Focus

In science, we divide all living things according to their traits. Some we can see and some we cannot. This classification system used to sort all living things is called **taxonomy**. Scientists divide all **eukaryotic** life, or organisms whose cells have a nucleus within a membrane, into 4 categories called Kingdoms. List each kingdom as noted below. Have students identify what Kingdom their organisms belong to.

Kingdoms of Life

1. Animalia: mammals, insects, reptiles, birds, amphibians, etc.
2. Plantae: mosses, ferns, conifers, flowering plants
3. Fungus: a common name used for mushrooms
4. Protista: examples are green algae or slime mold. These are unicellular organisms, but they can be found in clusters of many cells, with a definite cell membrane around the nucleus and no cell wall.

Let's take a closer look at animals.

Now, instruct all that hold a plant or fungus to trade in for an animal. Students then stand in a circle and identify each animal the students are holding. The next task is to discuss how we use traits to differentiate between different species.

`

Elaboration (Please refer to Background.)

A cladogram is a useful tool for sorting and classification that shows how items are related to each other. Explain to students that they will use a cladogram to help them sort or classify animals based on specific properties or characteristics.

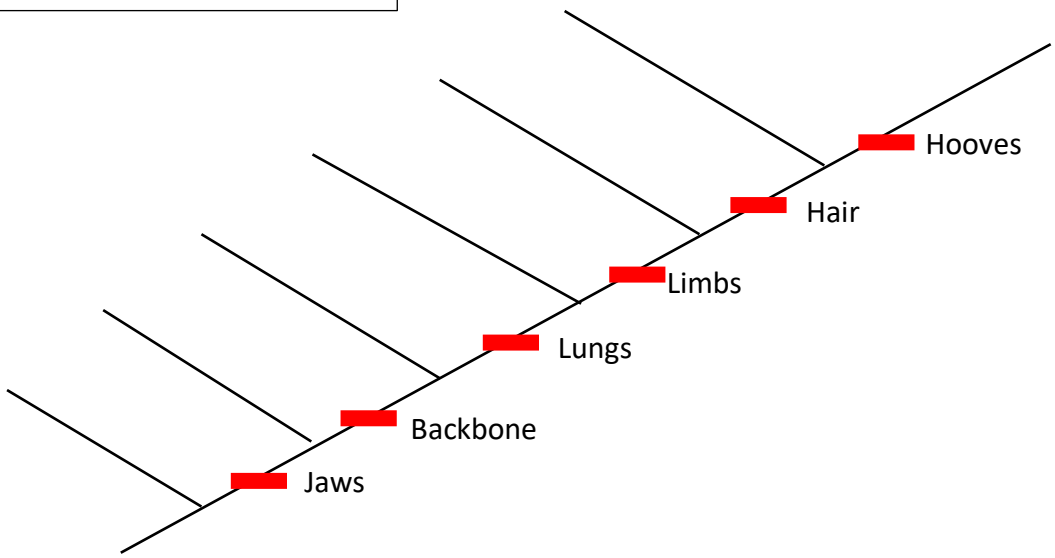
Kindergarten Focus

The teacher selects 5 animal specimens from the Trunk. The teacher will walk along the cladogram asking students at each clade if the animal exhibits that trait. They will stop when they reach a characteristic the animal does not exhibit. Do this with each animal.

Grade 6 Focus

Students progress along the cladogram starting at, "Jaws," and continue through each trait their animal exhibits. They will stop when they reach a characteristic their animal does not exhibit.

Cladogram for floor exploration



Students must remain in place at that level, known as a clade, on the cladogram. What do they notice as they progress through the different properties? (Those that have similar traits wind up grouped together at the same **clade**.)

What is taxonomy?

Grade 6 Focus

Cladograms provide a visual representation of living things that exhibit similar characteristics. This visual representation leads us to observe common characteristics exhibited within a species.

Species are living organisms that share common characteristics, , can interbreed to create fertile offspring. Cladograms, allow **taxonomists,** scientists that group organisms into categories**,** to visually sort organisms across different species and within a species. Taxonomy reflects relationships that are within the natural world of all living things on Earth. Taxonomy used to rely just on the similar characteristics observed. Charles Darwin changed that realm of thinking with his theory of evolution that species arise and develop through natural selection. In natural selection, organisms that are better adapted to the environment and its changes usually survive to reproduce. Their offspring will exhibit some of those same characteristics to allow them to survive to reproduce.

Evaluation

Kindergarten

Have an informal discussion with students about the kingdoms of life. Place the kingdom names of Animalia, Plantae, and Fungi on separate pieces of paper and scatter them throughout the room. Provide each student with an organism nametag and allow them to place it on the correct kingdom. This activity can be completed with the whole class, small groups, or one-on-one with the teacher.

Grade 6

Students create their own cladogram using at least ten organisms of their choice not included in the Trunk and six clades. They can use the lesson cladogram as an example, but they should have two characteristics that are not used in the lesson. Collect the cladograms and review them to check for understanding.

Extension Activity Options

Koller Washer Sorter

Grade 6

Students research the phylogeny of their favorite animal and give a presentation on the animal's closest living relatives, fossil connections, and modern characteristics.

Lesson 6 “Leapin’ lizards”

Purpose

Students are introduced to the use of a **dichotomous key.** Older audiences learn how to construct a dichotomous key.

Materials for This Lesson

Models			
Lizards (6 bags)		Sets of shells-6 sets	
Miscellaneous			
Lizard Field Guide			
Organism name tags-37			

Standards Met by Lesson

Ohio Department of Education Standards for Lesson 6

Kindergarten

K.LS.1 Living things have specific characteristics and traits.
K.PS.1 Objects and materials can be sorted and described by their properties.

Grade 3

3.LS.1: Offspring resemble their parents and each other.

Grade 6

6.LS.4: Living systems at all levels of organization demonstrate the complementary nature of structure and function.

Lesson 6

"Leapin' lizards"

Engagement

Discuss ways they sort things in their daily lives-laundry, trash/recycling, library books. What are some reasons we sort things?

Provide students with an organism name tag. Instruct the students to divide themselves into two groups. How did they divide themselves? (Example: plants and animals) Students then come back together and divide themselves into three groups using a new method. For younger students, the teacher can suggest traits with which to sort.

Exploration

Divide the class into six groups and give each group a bag of lizards. Allow the students an opportunity to explore the different lizards provided in their bag. Encourage them to create observations and questions they have about the lizards. As part of their observations they should compare the different lizards to each other (color, length, body features).

Model using a **dichotomous key** by choosing a lizard and going through each step to final identification. Give each group a *Dichotomous Key for Lizards*. Now have students pick one lizard from the set to identify. When the group thinks they have identified the lizard, they can use the Field Guide to verify their answer. They can then choose a different lizard to identify. For non-reading students, this can be done as a whole group activity with the teacher reading the key and the students making choices.

Explanation

The world is filled with millions upon millions of different living and non-living things. In order for scientists to study them, there needed to be a way to sort or organize them into groups. One way would be to sort them into groups of plants, animals, or minerals. But scientists needed a way to organize them further. A Swedish scientist named Carolus Linnaeus saw a need to bring order to the cataloging of the natural world. So in 1735, he used the anatomy and physiology of creatures to build a classification system which he called *Systema Naturae*. It divided the natural world into three

kingdoms, Animal, Vegetable, and Mineral. Since that time, the system has evolved and become more detailed. However, it is the way living things are classified by scientists worldwide.

Elaboration

Imagine walking into a library and looking for a book. The shelves are in disarray, and there are several piles of books on the floor. You ask the librarian for help; he says that the book you are looking for is there, but he is not sure where. Without a catalogue system, it is nearly impossible to find your book.

The same goes for the natural world—to help us understand it, we need to have a way to catalog living and nonliving things. This trunk focuses on four kingdoms of life, namely *Protista, Fungi, Plantae,* and *Animalia.* These kingdoms are further broken into successively smaller groups called phylum, class, order, family, genus, and species. The smaller the group, the more closely related its members. Offspring resemble their parents often sharing traits such as eye color or body structure. Interestingly, our system of classification is being refined further by DNA testing that reveals more information about the relatedness of organisms.

How do we name organisms?

Carolus Linnaeus, known as the father of Taxonomy, developed a system for ranking and classifying organisms in the world. We still use a form of his classification system today, known as **binomial nomenclature. Binomial nomenclature** is the use of the genus and species to identify a particular organism; this nomenclature specifies the organism's scientific name. For example, *Puma concolor* is the scientific name of the mountain lion: *Puma* refers to the lion's genus and *concolor* to the species. The terms used in scientific naming usually are derived from Latin or Ancient Greek. The terms sometimes may include Latinized versions of names of persons whom the organism is named in honor of. No two species of organisms have the same scientific name, though they may share a common name. This one name for one species ensures that there is no mistaking of an organism regardless of where it is found.

What is the connection between classification, taxonomy, dichotomous keys and binomial nomenclature? At the most fundamental level, they all look at basic traits shared by organisms, such as living and nonliving. Taxonomy further classifies organisms by naming, describing, and classifying an organism and its relatedness to other organisms, such as animal, plant, mineral. It

brings organization, as the Dewey Decimal System does for the librarian, to the natural world. It is an integral part of life science. To further classify organisms, scientists use dichotomous keys. A dichotomous key is a series of paired choices that divides a large group into smaller and smaller groups until the correct identification is determined. This ultimately leads to an organism's scientific name or binomial nomenclature.

We can look at the commonality of life when we observe the characteristics, body plans and external/internal structures of living organisms. We look for general distinctions to sort organisms by studying their external structures (ex. adaptations, appendages, facial features, coat color), internal structures (ex. skeletal, muscle, organs, symmetry) and the processes occurring (ex. nervous, circulatory, respiration, transpiration).

Evaluation

Kindergarten

Give each student a set of shells. Ask them to sort them into 2, 3, and 4 groups. Ask them to name the attribute of each group.

Grade 3

Have each student find or bring in a group of 8-10 similar objects such as Legos, Hot Wheels, fossils, seed pods, etc. Students will use the visible characteristics, such as length, of the items to create a dichotomous key. They should begin by placing all of the objects into a single group on a sheet of paper. Then find a single characteristic of the objects that could split up the group into roughly half. Place these two new groups into separate piles and record the characteristic that was used on the paper. Continue this practice for every subgroup. The idea is to further isolate each and every object into its own location based on the specimen's unique characteristics. Have students explain their key to the class.

Grade 6

Students create a dichotomous key using the shells. Most characteristics should relate back to function; for example, a shell color could relate to the function of camouflage. Students should also include measurement characteristics when applicable. They should begin by placing all of the shells into a single group on a sheet of paper. Then find a single characteristic of the shells that could split up the group into roughly half. Place these two new groups into separate piles and record the characteristic that was used on the paper. Continue this practice for every subgroup. The idea is to further isolate each and every shell into its own location based on the specimen's unique characteristics. Have students exchange their dichotomous key with that of another group. Ask

students to evaluate the ease of use and accuracy of the key. Discuss what characteristics were used in making the keys and what other characteristics could be used that were not? Were some characteristics better than others?

Extension Activity Options

Koller Washer Sorter

Grade 3, 6

Johnny's Wise Use of a Dichotomous Key

Divide students into six groups. Give each group a copy of *Johnny's Wise Use of a Dichotomous Key*. Students read the story and make identification selections. When students have identified the spider, have them verify their answer with the spider key.

Kindergarten

Professor Hoot and What is a Scientist? (Use this simple script and the owl puppet to discuss what a scientist does with the very young.)

Simple Script

Professor "Hoot":
Boys and girls, today, we are going to be scientists. "Whoooo" can help me learn about scientists?

"Whoooo" can finish the sentence? A scientist is someone who _____. (ex. learns about our world)
"Woo-hoooo," that's great!
Generate conversation with the younger audience. Here are some sample ideas to use.

"Whoooo" knows what a scientist does?

- A scientist looks at the world around them.
- A scientist asks questions.
- A scientist looks for answers.
- A scientist <u>always</u> thinks, "Safety First!"
- A scientist <u>always</u> respects nature.
- A scientist <u>always</u> respects other scientists.
- A scientist <u>always</u> respects tools and materials.
- A scientist tells what he or she learned to create a community of learners.

Johnny's Wise Use of a Dichotomous Key

Johnny was sleeping fitfully one night. In his science class earlier that day, they had spent their entire lab looking at, yuck, spiders! Johnny did not like spiders and just about passed out when the teacher brought in several trays of the little beasts. The students had to use a dichotomous key to sort the spiders according to several characteristics. This key allowed them to identify which spider from their area could inflict a painful bite. Johnny had fallen asleep thinking of these spiders, and they infiltrated his dreams….

Johnny awoke, and things seemed different this morning. He felt somehow small. That's when, to his terror, he discovered that he *was* small—only one inch tall. A scream came out of his mouth, but it was so weak that no one heard it. He decided to go to his parents' room and get their help. After a slow trek to the floor from his bed, Johnny began his perilous journey. Just as he started walking, he heard a noise. He lifted his eyes and froze in his tracks—it was a spider! Johnny knew from yesterday's discussions that any spider would be able to kill him at this size rather easily. This spider was acting as if it were looking for something. Was it him? His heart beat as if it were the drums of long ago Africa carrying messages to distant tribes. Would the spider hear this?

The spider kept its distance. Johnny was wishing he knew what kind it was and some of its habits. Something stiff in his jeans pocket jabbed into his side. He reached in and there it was, his key from yesterday! Now all he had to do was to go through some choices to determine which spider this was. The spider had a slightly flattened, blackish abdomen, with a reddish cephalothorax. In spiders, the head and thorax are joined together, making a cephalothorax. This observation narrowed the choice down to either the *Gnaphosid* or a crab spider. Which one?

You choose the identity!

1. A small (0.6 inch), blackish-brown, red spider with few markings…Gnaphosid

2. A small (0.3 inch), colorful spider, often with ornaments attached. It holds its legs off to the side and walks like a crab…Crab Spider

Source: Levi, H. W. and Levi, L.R. (1987) *Spiders and Their Kin: A Golden Guide*. New York: Golden Press, p. 86.

Your choice is

_____

Johnny watched intently. Well, the spider did not hold its body like a crab and it did not have ornaments, so that made it a type of *Gnaphosid*. "That's great!" Johnny thought. It is a nocturnal hunter and is just looking for a hiding place; just at that moment the *Gnaphosid*

slid into a small crevice between the baseboard and wall. Johnny was safe to continue his journey.

Johnny traveled from his room into the hallway without further encounters, except for the toy soldier that gave him a scare when he turned the corner around his bookcase. It was dark in the hall. There were no windows to let in light. Just down the hall was Mom and Dad's door, slightly ajar. Great! Light was streaming through the crack as Johnny approached, and that is when he saw two gleaming eyes looking right at him. He stopped and stared at the eyes—they belonged to another spider, oh no! What kind can this one be? He slowly brought out his key again.

The large eyes gave Johnny several choices: jumping spider, ogre-faced spider, or a *Phidippus*. It was also colorful, and it had a small abdomen.

You choose the identity!

Source: Levi, H. W. and Levi, L.R. (1987) *Spiders and Their Kin: A Golden Guide*. New York: Golden Press, p. 99.

1a A medium (0.8 inch) brown spider with legs as long as its body and an elongated abdomen…Ogre-faced Spider

1b A small to medium (0.3 to 0.5 inch) spider that is somewhat colorful. The abdomen and cephalothorax are about the same size…Go to 2

2a A medium (0.5 inch) spider with large eyes.

The cephalothorax and abdomen are different colors…*Phidippus*

2b A small (0.3 inch) spider with large eyes. The body is uniformly brown with striping…Jumping Spider

Your choice is

____

Johnny recalled the spider's characteristics: large eyes, colorful, with a small abdomen. That meant it was not an ogre-faced spider, which is rather brown and has an elongated abdomen. That was a plus, since ogre-faced spiders throw their webs at their prey, entangling it so that they can move in and sink their fangs into the body of their victim,

paralyzing it. “I don’t have to worry about a web flying at me, but which is it? It is less than a half-inch in size, so that removes the *Phidippus* from the choices—that’s good, since it is very active and has a voracious appetite. So, it must be a jumping spider!”

Now for the bad news: To catch their prey, jumping spiders may jump several centimeters and land on it. In addition, they have great eyesight—they can see up to 8 inches away. “Wait! They can only recognize things closer than eight inches; I’ll just stay a foot or more away.” Johnny slowly inched his way across the floor, being sure he stayed at least one foot away. The spider started to walk down the hall in the other direction. Johnny breathed easier and bolted to the door.

Johnny now saw the bed; Mom and Dad were both asleep. He yelled, but no one heard him. There! There is a small rope; he could easily climb up to the top of the bed where he could yell in Mom’s ear. He started his climb, but the rope was getting sticky. “How strange,” Johnny thought—that is when it hit him—there should not be a rope from the bed, and no rope would ever be this sticky.

NOOOOOOO!!! This is a spider’s silken thread! Johnny tried to let go, but his hands were stuck and he saw a huge gold and black spider coming towards him. He wanted to know what to do, but his hands were stuck, and he could not get his key. The spider came in close and then turned around. Maybe it was going back…but no. “It’s throwing silk on me!”

Source: Levi, H. W. and Levi, L. R. (1987) Spiders and Their Kin: A Golden Guide New York: Golden Press, p. 62

You choose the spider!

1. A small (0.2 inch) spider that catches its prey in a web made of sticky silk. It has poor vision and depends upon web movement to alert itself of prey. Once the prey is detected, the spider runs towards it, turns around and “throws” silk onto the animal, causing it to become more entangled…Orb Weaver

2. A small (0.2 inch) spider that creates a funnel-shaped web. The web is not sticky, and the spider, after sensing movement, runs out and bites its victim, paralyzing it…Funnel Weaver

“It’s an orb weaver. I’m becoming entwined with no hope of escape!” More silk was coming his way when it abruptly stopped. The web was shaking violently. It shook so hard that Johnny fell to the ground. When he looked up, he saw two spiders fighting. The stalkier, bristly one was winning.

One last choice.

A large (1.0 inch) spider that appears to be very hairy. It lives under stones or in holes in the soil…Wolf Spider

Source: Levi, H. W. and Levi, L. R. (1987)
Spiders and Their Kin: A Golden Guide
New York: Golden Press, p. 50

1. A small (0.3 inch) spider that appears "bristly." It hunts other spiders…Pirate Spider

Your choice is _____

The new spider sunk its fangs into the orb weaver, quickly paralyzing it. The orb weaver's struggle ceased and the predator was now the prey.

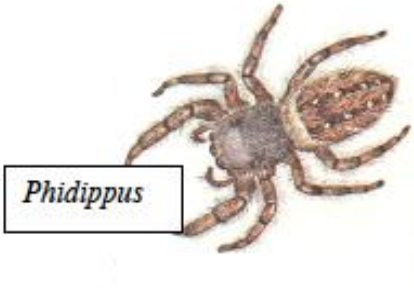
Johnny struggled and struggled to get loose of the threads, but he couldn't. Would he die tied up like an insect? He fought and wiggled until…

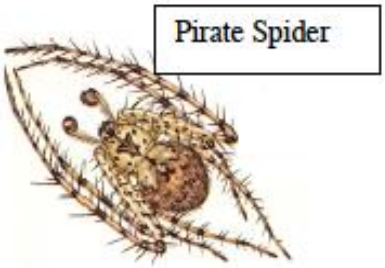
He fell out of bed still entwined in his covers. The fall woke him from his sleep. WOW! What a dream! He stood up and felt a poke from his pants; his hand reached in and there it was, his spider key, just as it was in the dream. As he started to walk into the hall, a movement on the floor caught his eye—a small spider dashing towards the safety of a small crack in the baseboard. Weird! In the hall he saw another small creature scurry away from him—it was a colorful, jumping spider. "Was it just a dream?" he wondered. He knocked and went into Mom and Dad's room. He explained the whole dream to his parents. There! Between the floor and bed frame were two spiders, one dead and the other eating.

Johnny bent down to have a closer look. "Yes, that one is an orb weaver. Look, Mom and Dad." As they came closer, they could see what Johnny was saying was true. "But why would one spider eat another?" Mom asked. Johnny was already trying to identify his protector. He noticed that it was covered with bristles and was slow-moving. After going through his key, he discovered it was a pirate spider that saved him.

Dad was getting ready to crush the pirate spider when Johnny stopped him. "That spider saved my life. I am going to place him outside." With that, Johnny caught the spider in a jar and took him outside, along with his key. He was off on a new, safer adventure, looking for more spiders to identify.

Johnny's Wise Use of a Dichotomous Key Spiders





Source:
Levi, H. W. and Levi, L.R. (1987)
Spiders and Their Kin: A Golden Guide.
New York: Golden Press

Miami University Sorts the Minute

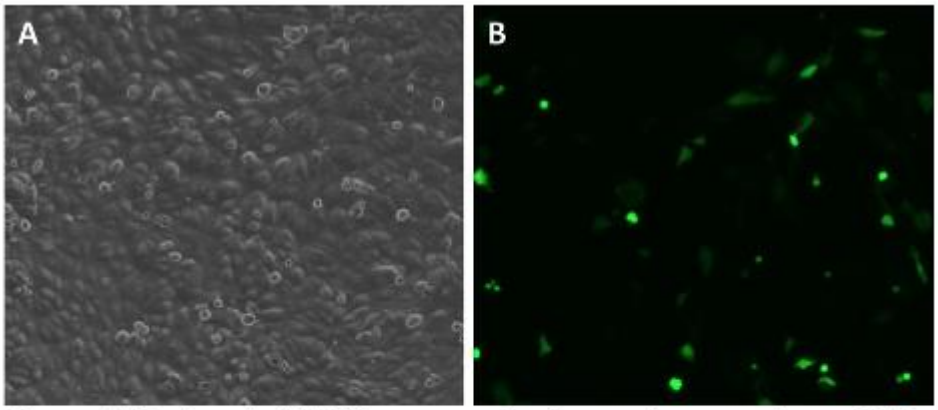
Let's see how Miami University scientists sort the very small using the FACS.

The Paul James lab is trying to understand the roles that a family of related proteins play in male fertility. There are thirteen proteins in this family, seven of which are expressed in the male reproductive cell, the sperm. We are interested in how the different members of this protein family each support the normal activity of the sperm. To do this, the James lab creates mice and rats that are missing one (or more) of these proteins – these are called knockout animals because we "knockout" the production of a specific protein by mutating, or changing, the gene that encodes that protein. Once we have a knockout animal, we can begin to understand the role that that missing protein normally plays in how the sperm works (physiology) by examining the abnormalities in the function of the sperm from the knockout mice (For example, can the knockout sperm still fertilize eggs?).

Paul James, MU Associate Professor

The Mice and rats have almost all of the same genes as humans and therefore we use these rodents as models to understand human male fertility. We knockout the genes encoding these proteins in single-cell mouse and rat embryos and then implant these embryos into the reproductive system of female rats and mice. Some of the offspring that are subsequently born are our knockout animals. Our genes of interest are mutated using the revolutionary gene editing technology called CRISPR/Cas9. The CRISPR/Cas9 genome editing technology has two components: 1) a protein that cuts DNA – this protein is called Cas9 and 2) a molecule that guides Cas9 to the exact site in the gene we are interested in mutating (this is called a guide RNA or gRNA for short). Cas9 is used for every gene that is mutated but each gRNA is different, as each is specific to the particular gene being mutated. The gRNA guides Cas9 to the specific site in the gene to be mutated, Cas9 cuts the DNA at that site, and when the cell repairs the break in the DNA it often makes mistakes resulting in mutations.

Before we use our gRNAs in mouse or rat embryos, we make sure they will work by testing them in mouse or rat cells that are grown in a culture dish. These cells do not have the ability to generate a whole rat or mouse but they do contain the exact same genes as the mice and rats we will use to make our knockout animals. We generate DNA constructs that instruct the cell to make our gRNAs, Cas9, and a protein called green fluorescent protein (GFP) and add them to the cultured cells. Even under optimal conditions, only a small subset of the cells take up the DNA constructs and therefore most of the cells in the resulting population cannot produce our gRNA, Cas9, and GFP. This is where the fluorescence activated cell sorter (FACS) comes in. When GFP is exposed to light of the proper wavelength it emits a green fluorescence and the cells that contain it glow green. We use the FACS to sort out the small population of cells containing GFP from the much larger population of cells that don't. We can then determine the sequence of the gene we are interested in to see if it has been mutated. If mutations are found, the gRNA works and we use it to generate knockout animals. If mutations are not found, we try different gRNAs that target the same gene but at a different site in the sequence.



Mouse cells incubated with DNA constructs that instruct them to make our gRNAs, Cas9, and green fluorescent protein (GFP). Panel A. A picture taken through light microscope of a continuous layer of mouse cells (each of the small bumps is an individual cell) on the bottom of a culture dish. This shows that the entire field is covered in cells. **Panel B.** A picture taken using a fluorescent microscope of the same cells. In this panel, cells that make GFP "glow" green. These are the few cells in the population that have taken up our DNA constructs and that we must sort out using the FACS. Cells that have GFP will also have the gRNAs and Cas9 as the instructions for all are on the same piece of DNA.

Michael Robinson, MU Professor

My laboratory studies retina regeneration. The retina is a thin layer of tissue lining the back of the eye, close to the optic nerve. Without a retina, you cannot see. A retina contains cells that are light-sensitive and nerve cells that carry information to the optic nerve through neural signals. These neural signals are like football players running to transport the football to the other end of the field. The optic nerve transports these signals to the brain. Then the brain processes the neural signal into an image. Think about this. Every time you open your eyes, your retina is converting light into information that nerve cells carry to the brain. The retina works nonstop.

So what is retina regeneration? When the retina becomes damaged, either through trauma to the eye or disease, blindness or vision loss sets in. In humans, retina damage is irreversible. In contrast, newts can regenerate (regrow) a new retina to replace damaged retinal tissue. The source for this new retina is the retina pigmented epithelium (RPE), a thin layer of cells behind the retina in both newts and humans. Our goal is to unlock the ability of human RPE cells to regenerate damaged retina tissue in order to restore sight to people whose retina has been damaged by injury or disease. Unfortunately, human RPE cells do not spontaneously replace damaged retina tissue. My laboratory seeks to discover ways to achieve retina regeneration from human RPE. My laboratory used genetic engineering (using technology to change or alter the genetic makeup of an organism) to create human stem cells that will produce fluorescent proteins (showing as different colors) only if they transform (differentiate) into neural retina cells. Descendants of these stem cells will turn on specific colors: a blue fluorescent protein if they differentiate into neural retina-specific stem cells, a green fluorescent protein if they differentiate into retinal ganglion cells, or a red fluorescent protein if they differentiate into a cell that can detect light (rods or cones). We differentiate these genetically engineered stem cells into human RPE and then treat the RPE with growth factors and other chemicals in order to induce or start neural retina cell production. After treating the RPE, we use **Fluorescence Activated Cell Sorting (FACS)** to count and isolate cells that have turned on the fluorescent proteins that we engineered (the blue, green or red proteins). We then test these sorted cells to look for other evidence of retina cell development and function. FACS allows us to evaluate just how efficient our test compounds are at inducing human retina regeneration from RPE. We hope that this research will lead to a treatment to restore sight to those blinded by retina damage.

Tim Wilson picks up the collection tubes containing the sorted cells.

Glossary

Amphibians
Small, ectothermic (cold-blooded) vertebrates that live part of their life on land and part in water. They exhibit an aquatic gill breathing larval stage and a terrestrial lung breathing stage. They include frogs, toads, salamanders and newts.

Animalia
A kingdom of life that includes all animals

Annelids
A segmented worm in the *Annelida* phylum and includes animals such as earthworms and leeches

Archaea
Single-celled prokaryotic organisms that often inhabit extreme environments and are distinct from bacteria forming one of the three domains of life

Arthropods
An invertebrate animal exhibiting an exoskeleton, a segmented body and paired jointed appendages, such as an insect, spider, or crustacean

Attribute
A characteristic feature or quality of something or someone

Bacteria
Single-celled prokaryotic organisms, distinct from archaea, forming one of the three domains of life

Bird
A warm-blooded vertebrate descended from reptiles that has feathers, wings, beak and lays eggs

Cephalothorax
The fused head and thorax of spiders and other arthropods

Characteristics
A feature that helps to identify something or someone

Chitin
A hard and fibrous substance that forms the exoskeleton of arthropods

Clade
A distinct group that includes a common ancestor and all of its descendants

Cladogram
A diagram used to show the relationship between species

Classification
A set of features or qualities used to identify an organism

Cnidarians
Aquatic invertebrate animals exhibiting radial symmetry

Coleoptera
Beetles

Crustaceans
An arthropod taxon that includes crabs, lobsters, crayfish, shrimp, etc.

Dichotomous Key
A tool used by scientists to determine the identity of organisms using a series of choices

Eukaryote
Single or multi-celled organisms comprised of cells, including a nucleus and membrane-bound organelles; one of the three domains of life

Exoskeleton
A rigid, exterior skeleton or covering that provides support and protection for an organism, particularly arthropods

External Traits
Characteristics that can be seen on the outside of the organism's body

Fish
An aquatic, cold-blooded animal without limbs that breathes through gills

Food Source
How an organism obtains energy to survive

Fungi
spore-producing, eukaryotic organisms that absorb organic matter, including yeasts, molds, mushrooms, etc.

Gills
Respiratory organs found in fish and some amphibians that allow them to get oxygen from water

Habitat
The natural home or environment where an animal lives

Insect
An arthropod that has a separate head, thorax, abdomen, and three pairs of legs, a pair of antenna and usually one or two pair(s) of wings

Internal Traits
Traits that an organism possesses that cannot be seen on the outside of the organism

Invertebrate
An animal without a backbone

Limb
Arm or leg of a person or animal

Lung
A sac-like organ used in respiration that allows oxygen to be taken into the body and carbon dioxide removed from the body

Mammal
A warm-blooded vertebrate that has hair and produces milk for its young

Mantle
The dorsal body wall of a mollusc that protects its organs and secretes calcium carbonate and conchiolin to help make its shell

Maturity
The process of growth and development from a zygote to an adult

Molluscs
An invertebrate, soft-bodied animal that has a foot and mantle; most exhibit an external shell

Natural History
A summary of an organism's description, habitat, behavior, food source, geographic region, and cultural connections

Natural Selection
The process by which organisms whom are better adapted for their environment tend to survive and produce more offspring

Offspring
The product of animal or plant reproduction

Oviparous
An animal that gives birth to undeveloped eggs, and the eggs develop outside of the mother's body

Ovoviviparous
An animal that gives birth to live offspring; but their offspring developed in an egg within the mother's body

Parent
An organism whose gamete resulted in an offspring

Phenotype
Observable characteristics

Phylogeny
The history of the evolution of a species.

Plantae
A kingdom of life typified by organisms that fix carbon dioxide through photosynthesis

Property
Distinctive attribute of an organism

Protista
A kingdom of life that includes single-celled eukaryotic organisms

Reptile
An ectothermic (cold-blooded) vertebrate that typically has dry, scaly skin and lays soft-shelled eggs on land, including, snakes, turtles, tortoises, crocodiles, and lizards

Sorting
Arranging or separating according to a particular characteristic or attribute

Species
A group of similar organisms that are able to interbreed to produce fertile offspring

Spider
A predatory arachnid with a short-unsegmented body (including a head, abdomen, thorax) and eight legs

Taxonomy
Classification of living things

Theory of Evolution
The process by which organisms change over time as a result of changes in heritable physical or behavioral traits; via natural selection

Ungulate
A mammal with hooves

Vertebrate
An animal with a backbone

Viviparous
An animal that gives birth to live offspring