The Cornell Lab of Ornithology

Evolution in Paradise

Engaging science lessons for middle and high school brought to you by The Cornell Lab K-12 and the most extravagant birds in the world!

TheCornellLab
K-12 Education

The *Evolution in Paradise* lesson series is part of K-12 Education suite of resources from the Cornell Lab of Ornithology.

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This educational unit was inspired by Ed Scholes and Tim Laman's work on the Birds-of-paradise.
Thank you to the Cornell Lab of Ornithology Multimedia and Communications groups for developing an amazing website that is so valuable for teachers.
We thank the artists and photographers who provided drawings and photos, particularly Tim Laman for providing photographs not otherwise credited.

If you have questions about the K-12 Education curriculum, please contact us.

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For additional background information, useful resources, and direct links to the videos described within this unit, please visit www.Birds.Cornell.edu/K12/Paradise.
The Birds-of-Paradise project website is: www.BirdsofParadiseProject.org.

The Cornell Lab of Ornithology is a nonprofit membership institution whose mission is to interpret and conserve the earth's biological diversity through research, education, and citizen science focused on birds.

Welcome to The Cornell Lab K12!

The Cornell Lab K12 is a growing series of inquiry-based, interdisciplinary science modules for K-12 students developed at the Cornell Lab of Ornithology. Our curriculum kits and free resources focus on learning to identify birds, participating in the Lab's Citizen Science projects, getting outdoors, and doing real science investigations. Through these activities, we hope to motivate students and encourage interest in science.

New Guinea's birds-of-paradise, with their dazzling colors, bizarre feathers, and outlandish calls, seem to turn imagination into reality. These magnificent birds may be half a world away, but our goal is to harness the excitement and curiosity that these birds stir as we point youth toward the many natural wonders that can be found in their own neighborhoods. We hope that this curriculum will inspire you and the young people you work with to connect with birds!

Please visit www.Birds.Cornell.edu/K12 to learn more about our K-12 resources, connect with us via our social networks and access our free downloads and easy-to-use curriculum kits.

Introduction to the Birds-of-Paradise Project

Within the immense rainforests of the tropical islands of Papua New Guinea live some of the most stunning and exotic birds ever known—the birds-of-paradise. Until recently, seeing more than a just few teasing images or videos of these extraordinary birds required traveling all the way there and attempting to find the birds firsthand. Now, thanks to the incredible work of evolutionary biologist Ed Scholes and wildlife photographer Tim Laman, access to the staggering beauty and wonder of all 39 species of the birds-of-paradise is right at our fingertips. The birds-of-paradise website, www.BirdsofParadiseProject.org, gives us a guided tour of the spectacular photos and videos captured during Ed and Tim's eight-year journey, which included 18 expeditions to 51 unique field sites.

While the shocking forms and dazzling beauty of the birds-of-paradise are easy to focus on, they have much more to offer us: these birds are essentially living textbooks on the biological phenomena of adaptation through sexual selection. It is these phenomena that have produced the colors, forms, and ornaments that make the birds-of-paradise so spectacular.

Birds-of-paradise Lesson Summary

Lesson Title	Key skills and content
1. Science in Paradise	Scientific process, the nature of science
2. Sexual Selection	Evolution by natural and sexual selection
3. Heritable Behaviors	Behavioral adaptations, heritability

- Visit www.Birds.Cornell.edu/K12/Paradise to download the complete *Evolution in Paradise* unit and find useful links and associated resources.

Meeting the Science Standards

A Framework for K-12 Science Education (NRC, 2012) lays out the vision that students will learn about science by integrating content knowledge with experience in the practices of scientific inquiry. Students should be engaged with fundamental questions about the natural world and how scientists investigate and seek answers to these questions. The Framework identifies eight science practices and seven crosscutting concepts for the K-12 science classroom, which are mapped to the *Evolution in Paradise* lessons in the tables below. This lesson series also addresses these Life Science Disciplinary core ideas: *LS3: Heredity* and *LS4: Biological Evolution*.

Lessons mapped to *A Framework for K-12 Science Education***

Scientific Practices	Lesson 1 Science in Paradise	Lesson 2 Sexual Selection	Lesson 3 Heritable Behaviors
Asking questions and defining problems	●		●
Developing and using models			
Planning and carrying out investigations	●		●
Analyzing and interpreting data			●
Using mathematics and computational thinking			●
Constructing explanations and designing solutions	●	●	
Engaging in argument from evidence		●	
Obtaining, evaluating, and communicating information	●		

Crosscutting Concepts	Lesson 1 Science in Paradise	Lesson 2 Sexual Selection	Lesson 3 Heritable Behaviors
Patterns		●	
Cause and effect	●	●	
Scale, proportion, and quantity			●
Systems and systems models	●		
Energy and matter			●
Structure and function	●	●	●
Stability and change		●	●

* National Research Council (NRC). 2012. *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press.

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Lesson 1: Science in Paradise

Big Idea: Scientists utilize the scientific process to generate and answer questions.

Overview

Through videos and discussion, students will become familiar with the bird-of-paradise expeditions and the scientists involved, learn how the scientists applied the scientific processes while studying the birds, and understand why the birds-of-paradise are a topic of interest to evolutionary biologists.

Learning Objectives

Students will be able to…

- Analyze scientific investigations to determine the questions investigated, the data/information collected and the methodologies, and the conclusions that the investigator made.
- Describe, in their own words, the features of a scientific investigation.
- Identify key aspects of the nature of science.

Time and Location: 60 minutes, indoors

Resources Needed

- ☐ Computer with Internet access and projector
  OR computer lab with Internet access
- ☐ Chalkboard or whiteboard
- ☐ Journal pages ("What is a Scientist?" and "Science Expedition")

Getting Ready

Preview and prepare to show these Birds-of-Paradise Project videos (direct links also available at www.Birds.Cornell.edu/K12/Paradise):

- ☐ Introduction video *(5:38)*
- ☐ Ed Scholes: Evolutionary Biologist *(6:04)*
- ☐ Multi-cams, Revealing the Female Perspective *(5:23)*

Background Information

Scientists can study a diverse range of topics, but all scientists have particular qualities in common. Collaboration, creativity, and curiosity are integral to being a scientist, as well as to the nature of science itself.

Two of the most exciting aspects of teaching science are conveying how science is done and engaging students in this process of discovery themselves. Science is a particular way of understanding the natural world, and is built on curiosity. It is based on asking questions and making observations. We use our senses, and extensions of those senses (instruments) to give us information about the world around us. Scientists investigate things over time, they collect and analyze data, and sometimes they do experiments. They base their explanations or conclusions on evidence, and have to stay open to new ideas and be willing to change or discard their ideas when new or more reliable evidence is found.

Science is...

- creative and driven by curiosity
- based on observation and asking questions
- collaborative
- revised with new evidence

Teachers and students might simplify the basic process that scientists use to try to find answers as a series of steps (often called the "scientific method"):

- Observe the natural world and look for patterns or things that surprise or puzzle you.
- Generate questions to investigate based on these observations.
- Develop a hypothesis to test.
- Collect and analyze information (data) to test the hypotheses.
- Look at the results and draw conclusions.
- Share the results.
- Ask more questions based on these observations.

However, doing science is not as simple as a linear progression, and it doesn't always mean "doing experiments." This concept map of the scientific process shows this complexity and better models the many different paths that can be taken during scientific inquiry:

TEACHER TIP: Expanding views of evolutionary biology

Many students, especially those who have not yet been taught about evolutionary biology, may think that scientists in this field all study fossils. While fossils are undoubtedly useful to many evolutionary biologists, they are not necessary (or even possible) to use in all studies of evolutionary biology. Genetic analysis, for example, has become an integral tool in evolutionary biology.

Be sure to point out, especially if you notice that your students have a narrow concept of what evolutionary biology is, that this is a very broad field that is investigated in a variety of ways using many different tools.

Conducting the Activity

1. **Discuss: What is a Scientist?**

   Ask students to think about what a scientist is and what scientists do. Give students about 5-10 minutes to draw or describe a scientist on the "What is a scientist?" journal page.

   Discuss with the class what they drew or pictured in their heads when thinking of a scientist. *(Are their scientists male or female? Are they wearing lab coats? Are they working inside or outside? Who drew a "mad scientist?" Why? What are some stereotypes of scientists and are they true? Is the scientist doing something that you'd like to do?)*

   Ask students to form pairs or triads and come up with three key things that make a scientist. Come back together for a class discussion of these features and write them on the board. *(For example: A scientist asks questions that can be investigated, a scientist answers questions by observing or gathering data, a scientist shares their work or findings.)*
   Ask:

- What is evolutionary biology? *(Evolutionary biology is the study of how species change and diverge over time, how organisms adapt to environmental conditions.)*
- What do you think an evolutionary biologist does? *(An evolutionary biologist studies the evolutionary relationships between organisms, tries to understand what events or conditions shaped the evolution of an organism.)*

2. Watch videos that introduce the Birds-of-Paradise Project

Introduce the "Science Expedition" journal page to your students. Explain that as they watch the videos, their task is to write down any aspects of the scientific process that they see. These can be bulleted notes, and information from more than one video can go into the same section. For example the "Ask questions and develop hypotheses" section might include ideas such as: *How did the birds-of-paradise come to be? Why does the female Parotia watch courtship displays from above?*

Show your students each of the videos listed below, in order, encouraging them to add to their journals throughout the films.

- Introduction *(5:38)*
- Ed Scholes *(6:04)*
- Multi-Cams *(5:23)*

Review the journal pages as a class, compiling a complete list of ideas for each of the "science process" sections, a-d.

A male Wahnes's Parotia performing the "ballerina" dance

Discuss

- Did you realize before watching these videos that scientific investigation could take place outside of a laboratory, and even in a forest?
- Add any new "key features" to the list created earlier and talk about these features.

3. Draw a concept map of the scientific process

Illustrate the science process by constructing a concept map on the board with the class (see previous page for a sample diagram).

Reflect and Evaluate

1. What do you think is interesting about the birds-of-paradise?
2. Why might an evolutionary biologist be interested in studying these birds?
3. How did the collaboration between Ed and Tim help in scientific discovery? Could they have learned as much from working alone? Why or why not?

Extensions

- Learn more about these extensions and find helpful links at www.Birds.Cornell.edu/K12/Paradise.

1. Encourage students to write a "Meet the Scientist" report on any scientist they find interesting. After writing the reports, compare and contrast the different scientists that the students chose. *(How many students chose female scientists, and how many chose males? Did most choose indoor or outdoor scientists?)*

2. Use the *Investigating Evidence* unit (available as a free download) to help students develop and carry out their own investigations about birds. *(For example, previous studies have included: what kinds of feeders/seeds do our local birds prefer? Will we see more birds in the schoolyard in the morning or in the afternoon?)*

3. Invite a professional scientist to visit your class. You could find a scientist at your local college or university, ask a company or business, enlist a former student or a parent of a student, or contact your local nature center, state park or wildlife refuge. Invite them to talk about their work and invite students to ask questions.

4. Research opportunities for students to get involved with scientists and real science projects—such as citizen science, volunteering at local science organizations, science fair, programs for high school research-- and have the students share what they've found with the rest of the class.

Journal Page: What is a Scientist?

Think about scientists whom you've read about, seen on TV, or maybe even know personally. What do they have in common? What do they do that makes them scientists?

Draw or describe a scientist.

Journal Page: Science Expedition

As you watch this video, write down what Ed and Tim did for these parts of a scientific process:

a. Make observations and notice patterns

b. Ask questions and develop hypotheses

c. Collect and analyze data

d. Draw conclusions and share work

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Lesson 2: Sexual Selection

Big Idea: Sexual selection deals specifically with the component of natural selection that favors genes for traits that improve reproductive success.

Overview

Through videos and sorting exercises, this lesson delves into the fascinating process and products of sexual selection: the process by which traits become more or less common depending on an individual's ability to mate with more or better partners. Understanding sexual selection allows a deeper understanding of natural selection and evolution.

Learning Objectives

Students will be able to…

- Define sexual selection both generally and in terms of the birds-of-paradise.
- Describe how and why sexual selection leads to traits that improve an organism's chances of reproducing, but not necessarily of survival.
- Describe how both sexual selection and natural selection have shaped the appearance and behavior of the birds-of-paradise.
- Describe the connection between habitat and natural selection.

Time and Location: 70 minutes, indoors

Resources Needed

- ☐ Computer with Internet access and projector
- ☐ Selection Cards—one set of 16 cards for each group of 3 to 4 students
- ☐ Chalk board or white board

Getting Ready

- ☐ Review and prepare to show the Natural and Sexual Selection video *(8:28)*
  - ➢ *Visit www.Birds.Cornell.edu/K12/Paradise for a direct link to the video and to access additional background information and other resources.*
- ☐ Copy and cut apart the selection cards

Background Information

Natural selection is the evolutionary process by which genes for traits that improve survival and/or reproductive success are favored. Sexual selection essentially hones in on the reproductive aspect of natural selection. It occurs through the processes of female choice (in which females choose to mate with males with the traits they find most attractive) and male-male competition (in which males compete to protect a territory that is attractive to females). Because the birds-of-paradise experience relatively low levels of selection pressure due to factors such as food scarcity and predators, they are able to invest energy in courtship displays and draw attention to themselves with colorful plumage. There is a balance between the forces of natural selection and sexual selection.

TEACHER TIP: Look out for misconceptions!

Natural selection plays an important role in all biological systems, but it can be a difficult concept to comprehend and is all too often shrouded in misconception.

Common misconceptions:

- ☒ New variation arises in response to specific environmental conditions, or that an animal chooses to change or "adapt,"
  - ☺ rather than variation happening randomly within genes due to mutation.
- ☒ All individuals in a population change at once,
  - ☺ rather than change starting in one or a few individuals and gradually spreading over generations via natural selection.
- ☒ Only traits that improve survival are beneficial and spread through populations,
  - ☺ rather than both traits that improve survival and traits that improve reproductive success being favored by natural selection.

The "Natural and Sexual Selection" video attempts to clarify these concepts, but be mindful of student misconceptions as you discuss this topic. A strong understanding of natural selection is key to understanding sexual selection.

Your students might be confused about how sexual selection and natural selection are related, and may even think they are contradictory. Though sexual selection may seem counterintuitive, it is still a form of natural selection. Natural selection is as concerned with reproduction as it is with survival.

Conducting the Activity

1. **Familiarize the class with sexual dimorphism**

   Brainstorm with the class a list of animals that are sexually dimorphic—that is, species in which the males and females of the same species look different from one another. Write down the list on the board as you go along. *(For example: deer, lions, cardinals, peacocks.)*

   Ask the students what the differences are between the males and females of each species that they came up with earlier and add these to the board. *(For example: antlers, color, fancy tails, vocalizations.)*

   Ask if your students can think of any possible explanations for these differences between males and females. *(For example: male deer have antlers for fighting other males, male peacocks have fancy tails to attract females.)*

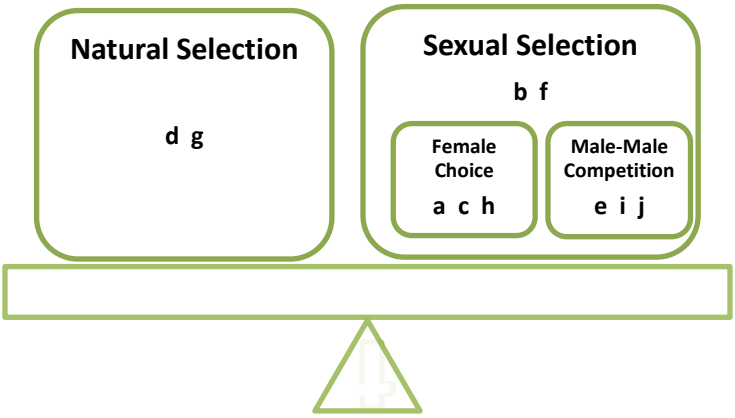
A male (black) and female (brown) Wahnes's Parotia perched side by side

   - What are the general differences between the male traits? Do the traits seem to fall into categories? *(There are two main categories: fancier/more ornamented males and males that have adaptations for fighting.)*

2. **Watch the "Natural and Sexual Selection" video** *(8:28)*

   Introduce the "Sexual Selection" journal page to your students. If they are not familiar with basic genetics or evolutionary biology, review the following terms from the glossary with them: trait, gene, population, recombination, mutation, heritability, fitness, evolutionary force.

   Show your students the Natural and Sexual Selection video on the Birds-of-paradise website and have them complete the "Sexual Selection" journal page as they watch. The video explains the processes of natural and sexual selection.



Answer key to "Sexual Selection" journal page

Connect the concepts of male-male-competition and female choice, explained in the video, with the two categories of differences that you came up with earlier. *(The "fancier" category corresponds to female choice and the "fighting" category corresponds to male-male competition.)*

3. **Selection Card Sort activity**

Divide your students into groups of three or four and hand out one set of 16 Selection Cards to each group. For each of the four "species," there are four cards: one showing the female, and three cards that each have a unique male. Each of the three different males corresponds to one of the evolutionary processes discussed in the video: natural selection, sexual selection by male-male competition, and sexual selection by female choice. Write these categories on the board.

A male King Bird-of-Paradise performing a courtship display.

The students' task is to figure out which male corresponds to which process, based on what they learned in the video about the evolutionary trends associated with each process.

Challenge each group to write their own definitions for natural selection, sexual selection, male-male competition, and female choice and brainstorm their own examples of each. Once the students have completed the activity, bring the groups back together for discussion.

Ask them which male they assigned to each category for each species, and why. If two or more groups have differing responses for any of the males, have each group defend their response using what they've learned. Discuss why the natural and sexual selection categories are drawn as a balance. *(Answer: Sexual selection acts to increase an organism's chances of reproductive success, but those traits don't typically increase an organism's chances of survival, as in natural selection. The two balance each other.)*

4. **Lead a class discussion emphasizing key points**
   Invite a few students from different groups to share their definitions and example. Make sure that each definition incorporates the key elements of each term, pointing out anything your students forgot or phrased incorrectly and explaining why these distinctions are important.

Reflect and Evaluate

1. Why don't all species don't undergo sexual selection? *[Hint: The birds-of-paradise have very few predators and plentiful food sources in their home of New Guinea.] (Answer: When other selective pressures that impact survival (such as finding food sources and escaping predators) are eased, sexual selection, which often produces traits that could make surviving in the midst of such selective pressures even more difficult, can occur without a survival cost that is too high to persist. In other words, if there are predators looking for you, you can't afford to attract attention to yourself with bright colors and huge ornaments.)*

2. Why don't deer antlers or peacock tails just keep getting larger? *(Answer: Natural selection is still at work, and at some point these adaptations for reproduction begin to significantly impede the organism's ability to survive.)*

3. Can sexual selection happen in females? If so, under what circumstances can this occur? (*In cases in which the male provides most/all of the parental care, and survival pressures are relatively low, it is possible that sexual selection will visibly act on females. This is best documented in several species of birds, such as jacanas in which the female defends a large territory which contains the smaller territories of her harem of males. The males build the nests, incubate the eggs and raise the young. Although the plumages of males and females are similar, the females are on average over one and a half times heavier than males.*)

Extensions

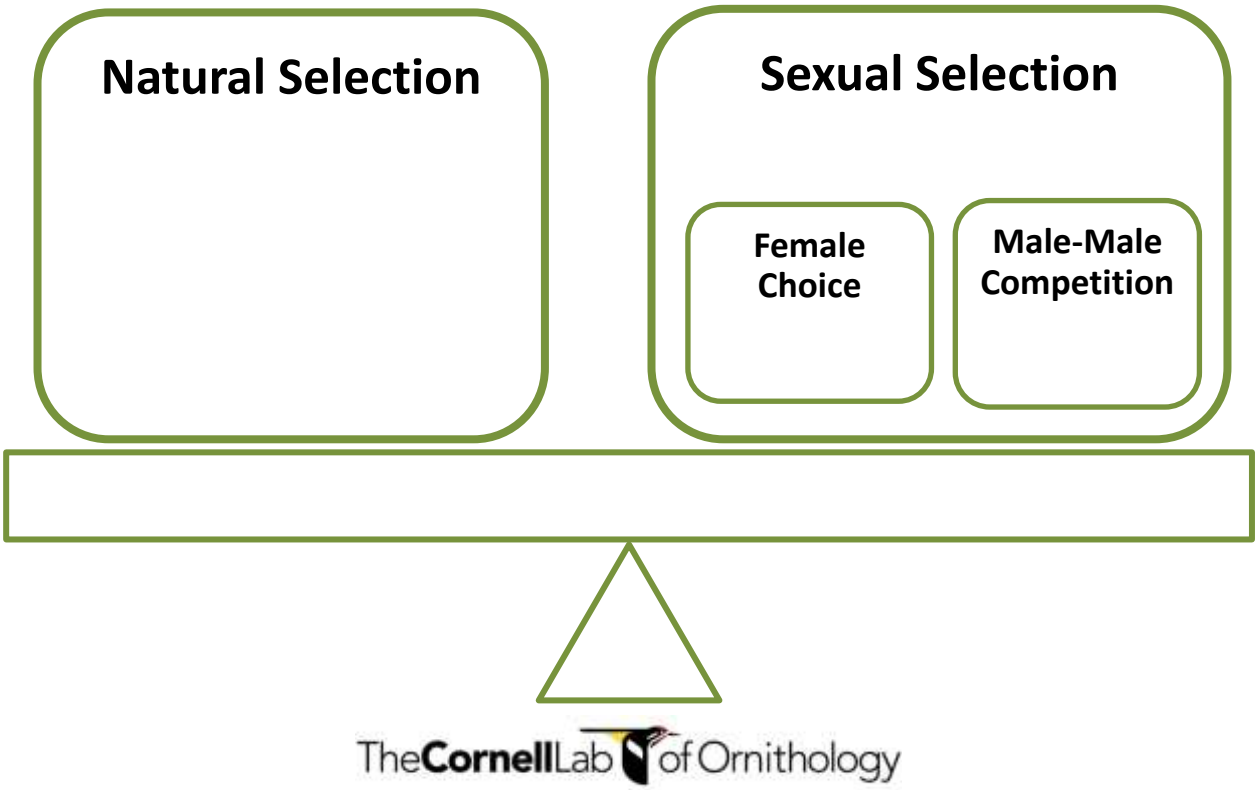
1. Challenge your students to take note of any species in your area which display signs of sexual selection and research and report on the conditions that may have allowed the species to undergo sexual selection.

2. Have your students create their own Selection Card Sort cards with drawings or photos, and use them to play the game with each other.

Journal Page: Sexual Selection

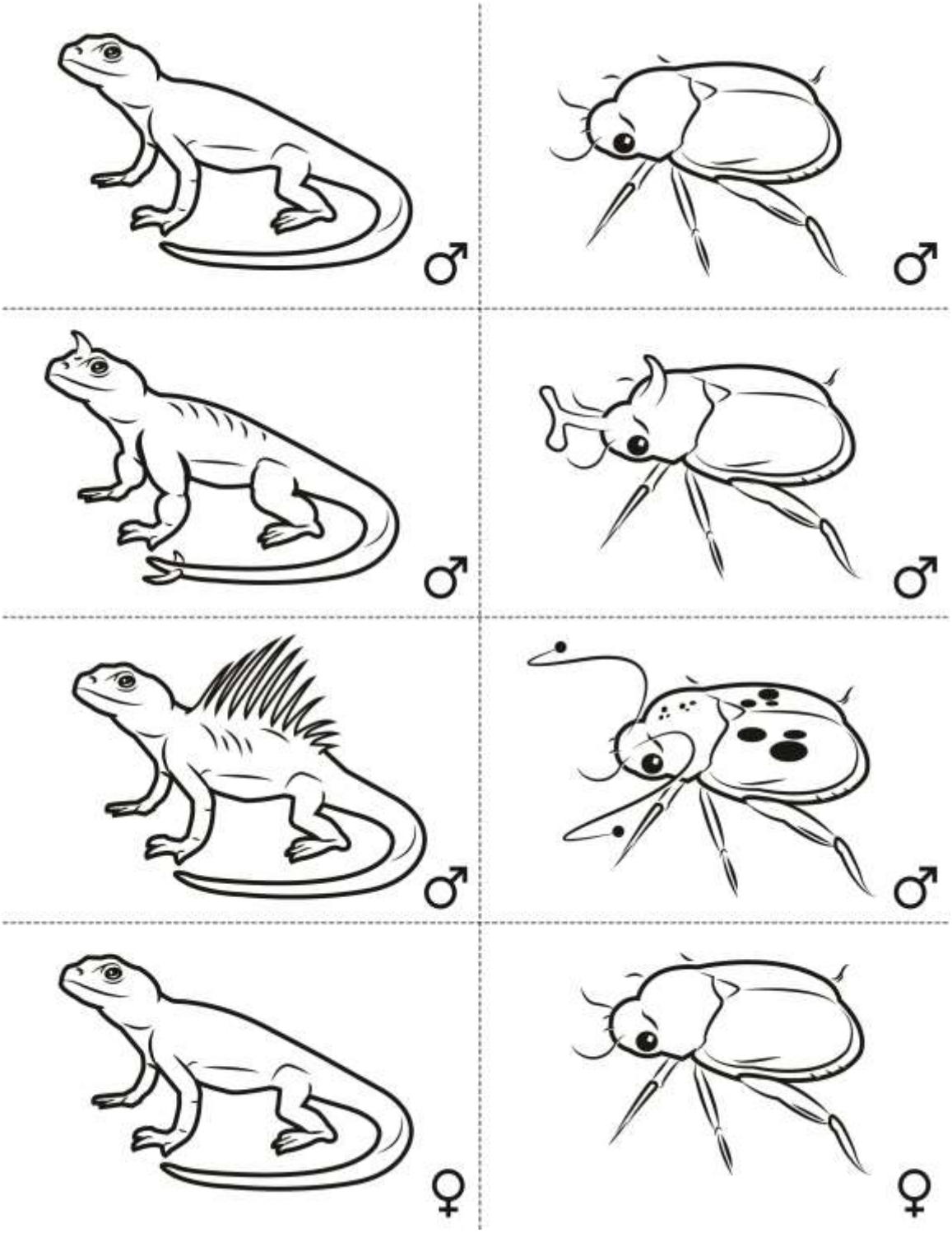
Each of the boxes below is labeled with a term from the "Natural and Sexual Selection" video. As you watch the video, place each lettered choice in its most appropriate box. If you think a choice **always** applies to more than one term/box, write the letter for that choice only once, in the largest of the boxes that you think it applies to.

- **a.** Occurs when food sources are dispersed
- **b.** The process by which traits become more or less common depending on an individual's ability to mate with more or better partners
- **c.** Males with ornaments that females find attractive are able to mate with more females and pass on their genes
- **d.** Produces females and males of the same species that look similar
- **e.** Occurs when food sources are clustered
- **f.** Produces females and males of the same species that look different
- **g.** The process by which traits become more or less common depending on an individual's ability to survive and gather resources
- **h.** Results in "fancy," extravagant males
- **i.** Males that are better able to defend their territory are able to mate with more females and pass on their genes
- **j.** Results in males that are better suited for fighting



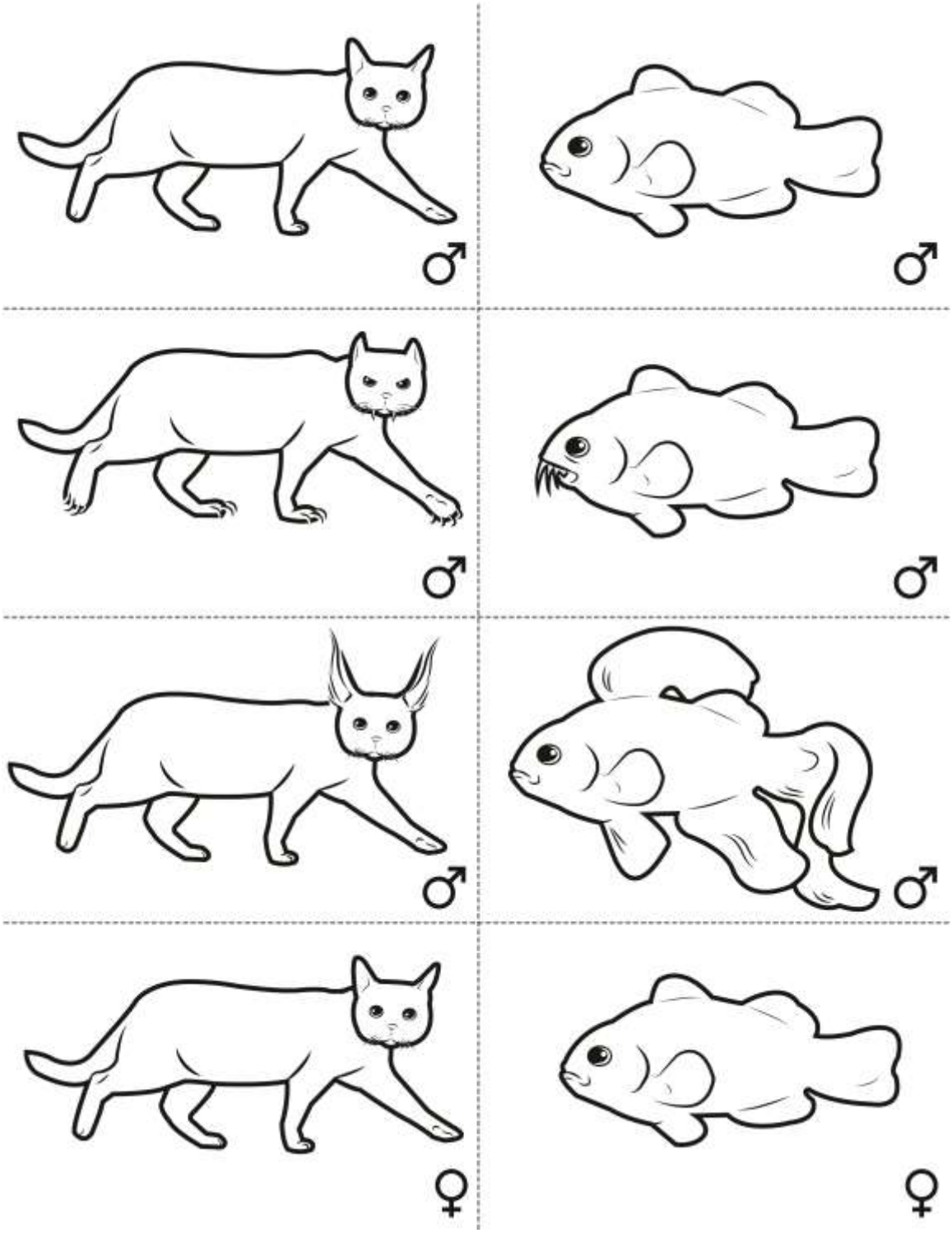
Selection Card Sort Cards

Images courtesy: Andrew Leach



Selection Card Sort Cards (continued)

Images courtesy: Andrew Leach



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Lesson 3: Heritable Behaviors

Big Idea: Behaviors can be determined by genes, learned, or a combination of both.

Overview

Many behaviors, including the mating displays of the birds-of-paradise, are genetically passed from one generation to the next. Environmental factors further influence the development of these traits. In this lesson, students explore their own heritable behaviors and watch videos of the birds-of-paradise practicing and performing courtship displays.

Learning Objectives

Students will be able to...

- Define the term "gene."
- Explain how both genetic and environmental factors influence traits.
- Give examples of the diversity of behavioral adaptations seen among the birds-of-paradise.

Time and Location: 80 minutes, indoors and outdoors

Resources Needed

- ☐ Computer with Internet access and projector
- ☐ Chalkboard or whiteboard
- ☐ Bird behavior handouts (Mallard, Rock Pigeon, and/or Red-winged Blackbird—one for each student or small group)
- ☐ "Local Bird Behavior" journal page (one per student or pair)

Getting Ready

- ☐ Review the videos connected to this lesson, and prepare to show them:

  Life's A Stage *(4:09)*

  Dance and the Birds-of-Paradise *(6:15)*

  - *Visit www.Birds.Cornell.edu/K12/Paradise for direct links to these videos, as well as additional background information and resources*

- ☐ Print bird the behavior handouts and journal pages

☐ Locate a place to watch birds (Note: courtship is highest in spring and early summer)

Background Information

Behaviors are commonly thought of as learned, rather than pre-determined by genes. While this is the case for some behaviors, there are other behaviors, such as the mating displays of the birds-of-paradise that have a genetic basis. Behaviors that are genetically based are heritable, meaning that they can be passed from one generation to the next. A young male bird-of-paradise can inherit the ability to do those dance steps from their fathers, then refine them through practice and watching adults.

The concept of heritable behaviors can be demonstrated if you think about raising two different baby animals, such as a puppy and a kitten, together, without an adult dog and cat to learn from. Even when raised under the same conditions, each will retain certain behaviors that are encoded in its species' genes. For example, the puppy will still perform behaviors such as sniffing and barking, while the kitten will pounce, hiss, and meow… even if they have not learned those behaviors from a conspecific.

A group of female (brown) Carola's Parotias watches a displaying male (black) from their perch above him, as another male looks on.

Conducting the Activity

1. **Watch the "Life's A Stage" video** *(4:09)*
   Show your students the "Life's a Stage" video from the Birds-of-Paradise website.

   Ask
   - Why do the birds do these dances? *(To attract and impress females.)*
   - How do you think that these "performers" know their dances? *(Answers might include: they learned it from their parents or other birds and that they were born knowing how to do it/it is instinctual.)*

2. **Watch the "Dance and the Birds-of-Paradise" video** *(6:15)*
   Ask
   - Have you heard the phrase "It's in your genes"? What does this phrase mean? What traits do you think are "in your genes?"
   - What is a gene? *(A gene is information encoded in DNA that determines a particular trait in an organism.)*

   Brainstorm a list of inherited traits with the class. These can be traits of humans, birds-of-paradise, or other animals. Divide the list into physical and behavioral traits.

A female Magnificent Bird-of-Paradise closely inspects a displaying male

Ask

- How could a behavioral trait be influenced by both genetic and environmental factors? Can you give an example? *(For example: Courtship behaviors are in the genes of the birds-of-paradise, but they then practice them on their own and with other birds and learn how to improve these genetically based behaviors.)*
- How could a physical trait be influenced by both genetic and environmental factors? Can you give an example? *(For example: A bird-of-paradise's genes may dictate that certain feathers are red, but environmental factors such as diet can change the shade of the feathers.)*

3. **Heritable behavioral traits activity**

Draw a chart on the board:

Tongue Curling		Ear Wiggling		Eyebrow Raising	
Yes	No	Yes	No	Yes	No

Mark the appropriate column with a tally for each student in each of the three categories as you go around the class and ask if the students can curl their tongues, wiggle their ears, or raise one eyebrow. These are all heritable behavioral traits. Evidence shows that these behaviors can also be learned, but an individual's genes can predispose him or her to having this ability.

Calculate statistics for each trait as a class. What percentage can curl their tongues? What percentage can wiggle their ears? What percentage can raise one eyebrow?

Ask the class if they can think of other statistics to calculate *(for example, compare boys vs. girls for each trait)*. If time allows, calculate these statistics as well.

4. **Take the class outside to watch local bird behavior**

Show images of three common bird species that do their own form of mating "dance." Refer to the Lab of Ornithology's website www.allaboutbirds.org and www.Birds.Cornell.edu/K12/Paradise for images, bird sounds, videos, and other information.

- Mallards—duck species commonly found in ponds, males have bright green heads, while females are mostly brown with small purple patches
- Rock pigeons—common city birds, mostly light and dark gray with some green and purple iridescence
- Red-winged blackbirds—a common bird found in parks and wetlands, jet-black males with red and yellow wing patches, females are brown

Ask:

- Have you seen any of these birds around here?
- Can you identify any of them?

Hand out the illustrated behavior handout for the species you wish to study to each student or small group. If none of these birds are commonly found in your area, research another local bird to determine courtship displays or other interesting behaviors to study. Go outside with the class to a place where you think that the species can be found. Bring copies of the journal page accompanying this activity for each student or pair to fill out during your trip.

Ask the following discussion questions after your bird behavior expedition:

- What behaviors did we observe?
- Do you think these behaviors will change seasonally?
- Do you think these behaviors are heritable? Influenced by the environment? Why or why not?
- What questions do we have about local birds and behavior? How can we investigate them?

Reflect and Evaluate

1. Identical twins (who have the same genes) do not behave the same way. Why?

2. How could we test what influence genes and the environment have on behaviors? *(Answers include: twin studies, studies of siblings raised in different environments.)*

Extensions

➢ Learn more about these extensions and find helpful links at www.Birds.Cornell.edu/K12/Paradise.

1. Have students research the behaviors of local birds, and create their own ethograms using their observations and background reading.

2. Your students can collect data about local birds that scientists can use! Participate in one of the Cornell Lab of Ornithology citizen science projects, such as the Great Backyard Bird Count, eBird, or Project FeederWatch.

3. Encourage your students to ask their family members if they can curl their tongues, wiggle their ears, or raise one eyebrow and record their responses. Calculate the statistics for each of these abilities among families, and compare it to the data you calculated for your class.

Mallard Courtship Ethogram

Images courtesy of Kevin J. McGowan, adapted from the Courtship and Rivalry Course, Cornell Lab of Ornithology

Head-Shake and Tail-Shake	 	Both males and females use this behavior, often right before going into other displays, as a way of getting attention. In a pre-display Head-Shake, the male lifts up without flapping his wings. These behaviors may occur one right after the other, or separately.
Grunt-Whistle		The male dips his bill into the water, then quickly arches his neck and raises his body upright. He makes a soft whistle as he throws a stream of water droplets over his shoulder, then settles back onto the water with a grunt.
Head-Up-Tail-Up		The male draws up his head and neck as if on a string, while lifting his rump and raising his wings.
Nod-Swimming		In this display, Mallards swim quickly for short distance with their heads and necks outstretched over the surface of the water.
Down-Up		The male tips forward and rapidly dips his bill into the water and then flips it up to create a small trail of water, while making a nasal *raeb-raeb* sound.
Inciting		The female swims alongside or just behind her mate, flicking her head to the side away from the male, pointing her bill (beak) downward, and making a drawn-out noise.
Head-Pumping		Rhythmic head-bobbing between a male and a female, which occurs before mating and may be repeated. It may increase in pace and end in mating, or break off with ducks going their separate ways.

Rock Pigeon Courtship Ethogram

Images courtesy of Julie Zickefoose, adapted from Celebrate Urban Birds, Cornell Lab of Ornithology

Bowing		A male puffs out his neck feathers, lowers his head, and turns around in circles.
Driving		A male pigeon runs closely behind a female.
Tail-dragging		A male spreads his tail and drags it while running after a female.
Billing		A female puts her beak (bill) inside a male's beak.
Mating		A male stands on top of a female and flaps his wings to keep his balance.
Clapping		After mating, a male pigeon may make a display flight. In this display, he "claps" his wings twice.

Red-winged Blackbird Displays

Images courtesy of Kevin J. McGowan and Ted Schroeder (high intensity songspread), adapted from the Courtship and Rivalry Course, Cornell Lab of Ornithology

Hidden Epaulets		When a male red-winged black bird is at ease and does not want confrontation, he keeps his bright right patches (epaulets) hidden.
(Low intensity) **Songspread** **(High intensity)**	 	Males perform songspreads as a threat display when they want to defend their territory, or possibly even attract females. Low intensity songspreads are less confrontational, and the male keeps his red epaulets more hidden. During high intensity songspreads, the male exposes his red epaulets and calls as part of an aggressive display when another blackbird is nearby.
Song Flight and Fluttering Flight		When performing song flight and fluttering flight, the male flies slowly around his territory, while calling and sticking up his feathers.

Journal Page: Local Bird Behavior

Fill in the bird behavior chart below with the types of behaviors you see, the number of times you see each behavior, and any other notes.

Species: _____
Location: _____
Date: _____

Behaviors	Tally of Behaviors Seen	Notes

Glossary

adaptation—a characteristic that allows a bird to survive and reproduce in the area in which it lives.

bird—a vertebrate that has wings, feathers, and a beak. They lay eggs and can usually fly.

birds-of-paradise—tropical birds of the taxonomic family *Paradisaeidae.*

breeding—mating and producing offspring.

breeding range—the geographic area where a bird species breeds and raises young. This is sometimes called the bird's "summer range." Birds that do not migrate have the same range year round.

citizen scientist—a person who collects data for use in scientific studies.

classification—how animals are grouped together according to their shared characteristics and evolutionary relationships.

common name—a bird's non-scientific name. For example, *Ceryle alcyon* is also known by its common name, Belted Kingfisher.

dimorphism—occurrence of something in two different forms.

distribution—the geographic locations where a species is found. Distributions are shown on maps as shaded areas.

eBird—an online citizen-science project that collects bird observations. The information is shared among scientists, educators, students, and bird watchers who want to know more about the distribution and movement of birds around the world. **www.ebird.org**

ecosystem—an area in which animals, plants, and other living things interact with each other and the non-living things around them. An ecosystem can contain many habitats.

ethogram—an inventory of all behaviors or actions exhibited by an animal**.**

evolution—an ongoing process in which species change over time. The diversity of life we see today is the result of the evolutionary process.

evolutionary force—any factor in an organism's environment that influences the survival and/or reproduction of that organism.

evolutionary biologist—a scientist who studies evolutionary processes as well as the evolutionary history of and relationships between organisms.

feather—light, flat growths on birds. Feathers are used for flight, insulation, and waterproofing and make up the bird's plumage.

female choice—a type of sexual selection that occurs when resources are dispersed and males become more ornamented and/or brightly colored in order to increase their chances of attracting and mating with females.

field guide—a book with illustrations and descriptions of various bird species. Most field guides group birds according to their taxonomic order, instead of alphabetically.

field marks—distinctive colors and patterns used to identify birds. Breast spots, wing bars (thin lines across the wings), and eye rings (circles around the eyes) are common field marks.

genus—a category of animals or plants. Members of a genus have a common origin and often share physical characteristics and/or behaviors. Western Bluebird *(Sialia mexicana)* and Eastern Bluebird *(Sialia sialis)* are in the genus *Sialia*. Both have blue plumage and red breast feathers, similar bills, and musical calls in flight.

gene—information encoded in DNA that determines a particular trait in an organism.

heritability—the ability of a trait to be passed from one generation to the next through genes.

hypothesis—a proposed answer to a question that has been posed for investigation.

inherit—to receive a gene from a parent.

male-male competition—a type of sexual selection that occurs when resources are clustered, and males become more and more suited for fighting in order to be able to defend a territory that gives them mating access to females.

mate—(noun) a breeding partner of the opposite gender. Together, two mates produce offspring; (verb) to breed and produce offspring.

mutation—a change to a gene.

natural selection—the process by which traits become more or less common depending on an individual's ability to survive and gather resources.

plumage—a bird's feather colors and patterns.

population—a group of organisms of the same species inhabiting a particular area.

recombination—the shuffling of genes due to the swapping of pieces of two strands of DNA.

scientific name—a bird's internationally standardized name, which has two parts—genus and species. It is written in Latin. The Belted Kingfisher's scientific name is *Ceryle alcyon*.

scientific process—refers to the principles and techniques involved in investigating scientific problems.

sexual dimorphism—describes species in which males and females look different from one another.r

sexual selection—the process by which traits become more or less common depending on an individual's ability to mate with more or better partners.

species—in taxonomy, this category is the most specific classification. Birds grouped in the same species can breed with each other and generally share common habitats, appearance, and behavior.

taxonomic order—the scientific hierarchy used to group living organisms: kingdom, phylum, class, order, family, genus, and species. "Kingdom" is the most general and "species" the most specific.

taxonomy—the system of assigning names and categories to living organisms based on their evolutionary relationships. "Order," "family," and "genus" are examples of taxonomic categories.

territory—an area that an animal or group defends from other animals of the same species.

trait—any feature of an organism, often determined by the organism's genes.

tropical rainforest—an especially diverse habitat found near the Earth's equator. Tropical rainforests have high rainfall and warm temperatures throughout the year.