The Cornell Lab of Ornithology

Evolution in Paradise

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

The *Evolution in Paradise* lesson series is part of BirdSleuth K-12 suite of educational 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 Birdsleuth K-12 curriculum, please contact us.
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BirdSleuth website: **www.birdsleuth.org**

For additional background information, useful resources, and direct links to the videos described within this unit, please visit www.birdsleuth.org/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 BirdSleuth!

BirdSleuth 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.birdsleuth.org 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.birdsleuth.net/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.

TheCornellLab of Ornithology
BirdSleuth K–12

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.birdsleuth.org/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"):

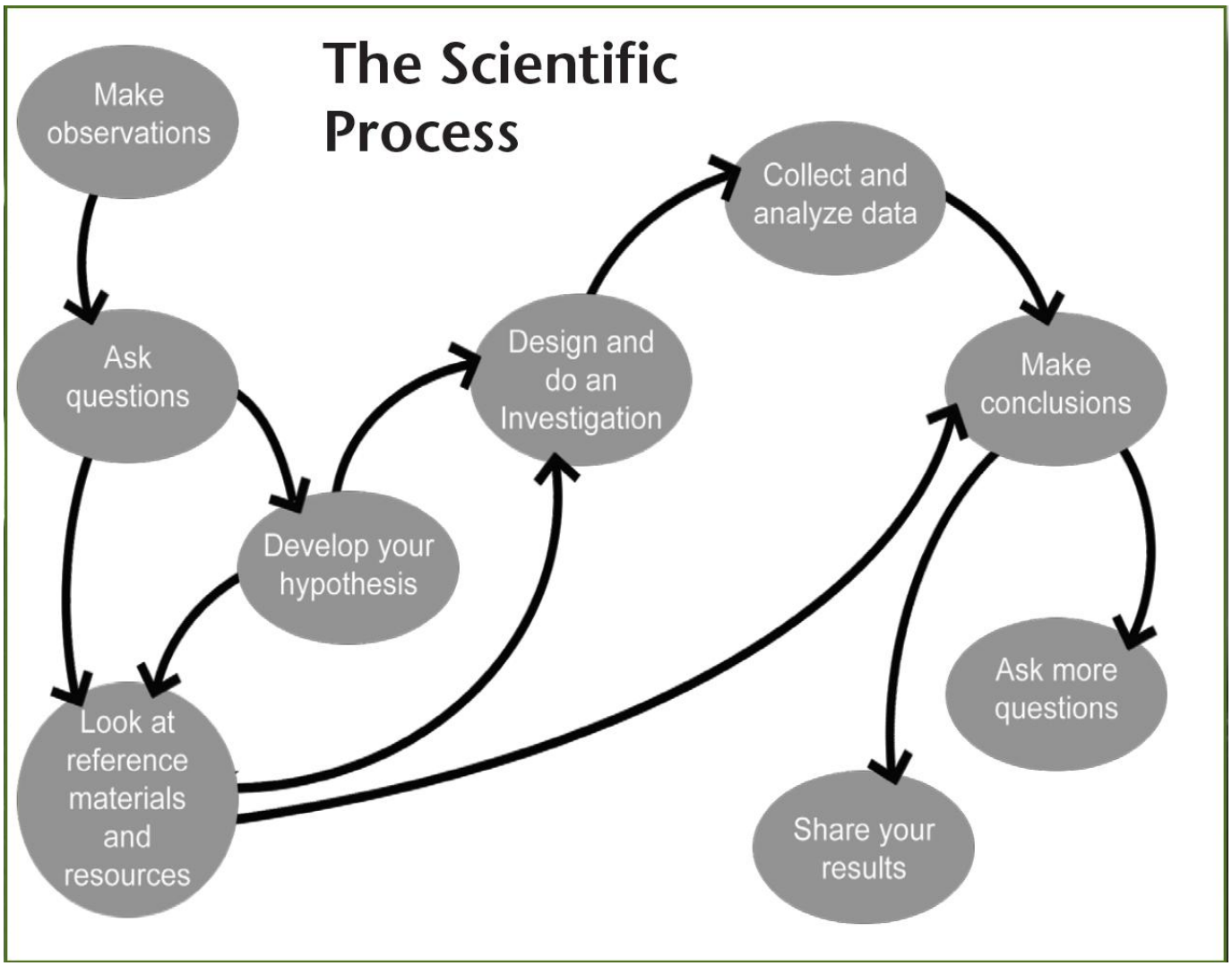
- Observe the natural world and look for patterns or things that surprise or puzzle you.
- Generate questions to investigate based on these observations.
- Develop a hypothesis to test.
- Collect and analyze information (data) to test the hypotheses.
- Look at the results and draw conclusions.
- Share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

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.