



Bird Brained?

Lesson Overview

GRADE LEVEL: 9-12

TIME ALLOTMENT: Three 45-minute class periods

OVERVIEW: The traditional view of animal behavior is that it is driven by inherited, innate instincts, but recent scientific research is revealing a larger role for complex cognitive processes among many species. The lesson will explore some of the more commonly accepted indicators of animal intelligence as demonstrated by the most brainy of all birds-the raven.

Students will first explore a series of science Web sites to compile a list of certain animal behaviors and abilities that indicate higher intelligence. They will then find and analyze examples of these behaviors and abilities as demonstrated by ravens in selected clips from the NATURE episode "Ravens." Based on what they learn, students will then work in groups to create a theoretical intelligence-challenging "obstacle course" for ravens.

This lesson could be used following (or in conjunction with) the lesson "Symbiotic Strategies" (<http://www.pbs.org/wnet/nature/lessons/symbiotic-strategies/overview/1494/>).

SUBJECT MATTER: Living Environment/Biology

LEARNING OBJECTIVES:

Students will be able to:

- Compare "classical" and "modern" views of bird brain anatomy and function, and compare bird brains to human brains;
- Describe various raven behaviors and abilities that indicate intelligence;
- Explain why many of these behaviors indicate cognitive intelligence rather than simple inherited instinct;
- Assemble a realistic sequence of intelligence-testing challenges for ravens.

STANDARDS AND CURRICULUM ALIGNMENT:

National Science Education Standards

<http://www.nsta.org/publications/nses.aspx>

CONTENT STANDARD C: As a result of their activities in grades 9-12, all students should develop understanding of:

THE INTERDEPENDENCE OF ORGANISMS



- Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.
- Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.

THE BEHAVIOR OF ORGANISMS

- Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.
- Like other aspects of an organism's biology, behaviors have evolved through natural selection. Behaviors often have an adaptive logic when viewed in terms of evolutionary principles.
- Behavioral biology has implications for humans, as it provides links to psychology, sociology, and anthropology.

CONTENT STANDARD G: As a result of activities in grades 9-12, all students should develop understanding of

NATURE OF SCIENTIFIC KNOWLEDGE

- Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.
- Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science such as the conservation of energy or the laws of motion have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested. In areas where data or understanding are incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest.



NEW YORK STATE CORE CURRICULUM ALIGNMENTS

Living Environment Core Curriculum

<http://www.emsc.nysed.gov/ciai/mst/pub/livingen.pdf>

Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing and creative process.

Performance Indicator 1.1: Hone ideas through reasoning, library research, and discussion with others, including experts.

1.2a Inquiry involves asking questions and locating, interpreting, and processing information from a variety of sources.

Standard 4: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 1: Living things are both similar to and different from each other and from nonliving things.

Performance Indicator 1.1 Explain how diversity of populations within ecosystems relates to the stability of ecosystems.

1.1a Populations can be categorized by the function they serve. Food webs identify the relationships among producers, consumers, and decomposers carrying out either autotrophic or heterotrophic nutrition.

1.1b An ecosystem is shaped by the nonliving environment as well as its interacting species. The world contains a wide diversity of physical conditions, which creates a variety of environments.

1.1c In all environments, organisms compete for vital resources. The linked and changing interactions of populations and the environment compose the total ecosystem.

Key Idea 6: Plants and animals depend on each other and their physical environment.

Performance Indicator 6.1 Explain factors that limit growth of individuals and populations.

6.1g Relationships between organisms may be negative, neutral, or positive. Some organisms may interact with one another in several ways.



They may be in a producer/consumer, predator/prey, or parasite/host relationship; or one organism may cause disease in, scavenge, or decompose another.

MEDIA COMPONENTS:

Video

NATURE: *Ravens*, selected segments:

Clip 1: "Raven Adaptability"

Ravens are the most intelligent birds in the crow family.

Clip 2: "Feeding Time"

Ravens' smarts can be observed in many situations.

Clip 3: "The Roost"

Why do ravens gather together?

Clip 4: "Testing Intelligence"

Scientific experiments test how ravens think.

Access the streaming and downloadable video segments for this lesson at the Video Segments Page (<http://www.pbs.org/wnet/nature/lessons/bird-brained/video-segments/1719/>).

Web Sites

Bird Brain

<http://www.pbs.org/wgbh/nova/sciencenow/3214/03-brain.html>

A site from PBS's NOVA exploring the most current understanding of bird brain physiology, revealing a less instinctive and more cognitive brain structure than has traditionally been thought.

Measuring Intelligence

<http://nationalzoo.si.edu/Animals/ThinkTank/MeasuringIntelligence/default.cfm>



A site from the Smithsonian National Zoological Park addressing some of the basic difficulties in determining bird intelligence.

The Animal Mind

<http://www.pbs.org/wnet/nature/episodes/inside-the-animal-mind/introduction/2081/>

A NATURE site from PBS describing the intelligent behavior of four different species.

Symbiosis

<http://www.cals.ncsu.edu/course/ent591k/symbiosis.html>

A site from North Carolina State University featuring descriptions of the different types of symbiotic relationships among animals.

Nutcrackers

<http://www.pbs.org/lifeofbirds/brain/index.html>

A PBS site exploring intelligent behavior in various bird species.

MATERIALS

For each student:

- “Raven Reason” Student Organizer
- Computer with Internet access

For the class:

- “Raven Reason” Student Organizer Answer Key
- Computer with Internet access and projection system for showing video clips
- Blackboard or whiteboard

PREP FOR TEACHERS:

Prior to teaching this lesson, you will need to:

Preview all of the video clips and Web sites used in the lesson.

Download the video clips used in the lesson to your classroom computer, or prepare to watch them using your classroom’s Internet connection.



Bookmark the Web sites used in the lesson on each computer in your classroom. Using a social bookmarking tools such as del.icio.us or diigo.com (or an online bookmarking utility such as portaportal.com) will allow you to organize all the links in a central location.

Gather the necessary materials listed above in advance of teaching the lesson. Download and print the “Raven Reason” student organizer and make copies for each student in your classroom.

Note that the computer requirements in the “Materials” section reflect an ideal arrangement. You may find it necessary to divide the class into a number of groups equal to the computers available, adjusting the lesson instructions accordingly.

INTRODUCTORY ACTIVITY

1. Ask students what they think of when they hear “bird brain.” (*Not very smart.*) Ask if they think birds live more by instinct than by thinking? (*Most students will likely answer “instinct.”*) Ask for a volunteer to define “instinct.” (*An inherited, natural tendency for animals to behave in ways which maximize their chances of survival and reproduction.*) Explain that up until very recently, the accepted view was that birds were almost robotic, with even their most complex behaviors governed by a genetically pre-programmed set of instincts. Recent scientific research, however, is revealing quite a different reality. Have students go to the “Bird Brain” Web site (<http://www.pbs.org/wgbh/nova/sciencenow/3214/03-brain.html>) and scroll to the diagrams at the bottom of the page. Provide a **FOCUS FOR MEDIA INTERACTION** by asking how the “classic view” of the songbird brain compares with the human brain? (*The bird brain is overwhelmingly instinctive compared to the more cognitive-that is, more thoughtful-human brain.*) What do the diagrams tell us about how the “modern” view of bird brains has changed from the “classic” view? (*Bird brains are now understood to be much more cognitive and less instinctive than once believed.*)
2. Explain that determining an animal’s cognitive intelligence can be very difficult. Write the following question on a blackboard or whiteboard: “What basic abilities or behaviors might indicate cognitive intelligence in a species?” Have students go to the “Measuring Intelligence” Web site (<http://nationalzoo.si.edu/Animals/ThinkTank/MeasuringIntelligence/default.cfm>). Allow them 5 minutes to read the page, providing them with a **FOCUS FOR MEDIA INTERACTION** by asking how this article answers the question on the board (i.e. how it defines a “thinking” animal). (*Thinking animals are those that can demonstrate flexibility when faced with new environments and challenges.*) Ask how this quality might be described in one word. (*Adaptability.*) Write this answer on the board beneath the question.
3. Have students go to “The Animal Mind” Web site (<http://www.pbs.org/wnet/nature/episodes/inside-the-animal-mind/introduction/2081/>) and click on the “Clever Creatures” link on right side of the page. Provide a **FOCUS FOR**



MEDIA INTERACTION by again asking the question written on the board: “What basic abilities or behaviors might indicate cognitive intelligence in a species?” Have students click on all four species pictured. After allowing 2 minutes for students to read about the intelligent behavior of the four species listed, review the focus question. Ask students to volunteer their responses as you write them on the board. (*Answers should include:*

- *Trial-and-error learning (exemplified in a dog’s learning of complex tasks)*
- *Communication (exemplified in the meerkat’s use of a complex “language”)*
- *Tool use (exemplified in the chimpanzees use of grass stems to fish for termites)*
- *Memory (exemplified in the Clark’s Nutcracker’s ability to remember where it buried seeds)*

4. Ask if anyone can think of any other general abilities or behaviors that might indicate cognitive intelligence in an animal? (*Accept all answers, but encourage the following:*

- *Counting*
- *Cooperation*
- *Social interaction*
- *Ability to solve complex problems*
- *Taking advantage of other animals’ abilities or behaviors*

5. Distribute copies of the “Raven Reason” student organizer. Explain that it lists some of the behaviors and abilities that tend to indicate high levels of cognitive intelligence in animals. (Note that certain answers given by students in the previous section might not be specifically mentioned here.) Tell students that the rest of this lesson will be spent examining video clips featuring the most intelligent of all birds-the raven-and that as their various abilities and behaviors are discussed, students should make note of them in the appropriate row of the organizer. For teacher use, an answer key is provided.

LEARNING ACTIVITIES

1. Tell students they will first be looking at a video clip describing ravens’ primary intelligence attribute: adaptability. Provide students with a FOCUS FOR MEDIA INTERACTION by asking why ravens need to be intelligent. Play Clip 1, “Raven Adapatability” (access the video segments for this lesson at the Video Segments Page, <http://www.pbs.org/wnet/nature/lessons/bird-brained/video-segments/1719/>). PAUSE clip after the narrator says “...but they prefer meat.” Review the focus question: Why do ravens need to be intelligent? (*To adapt to different environments and find food.*) Ask students what ravens eat. (*Preferably meat, but almost anything that’s available.*) What type of animal does this makes them? (*An omnivore.*) Explain that ravens don’t kill their own food, relying instead on finding animals that are already dead. Ask students what type of animals this makes them? (*Scavengers.*)

2. Tell students they will now be watching the rest of the clip. Provide them with a FOCUS FOR MEDIA INTERACTION by asking how coyotes help ravens get food. Play the clip through to the end. Review the focus question: How do coyotes help ravens get food? (*They rip open the tough hides of dead animals so ravens can eat the insides.*)



3. Explain that the manner in which ravens benefit from coyotes is an example of a symbiosis, which describes a close ecological relationship between different species. Ask students if they know which *type* of symbiosis this is. (*Accept all answers.*) Have students go to the “Symbiosis” Web site (<http://www.cals.ncsu.edu/course/ent591k/symbiosis.html>) and provide them with a FOCUS FOR MEDIA INTERACTION by asking which of the five types of symbiotic relationship exists between the raven and the coyote, based upon what they’ve just seen in the clip. (*Commensalism, in which one species benefits and the other is unaffected. In this case, the Raven benefits from the coyote’s teeth and jaws without doing the coyote any harm. Note that some students may answer “parasitism” because the ravens have taken some of the coyotes’ food; explain that this doesn’t actually do the coyotes any biological “harm.”*)
4. Tell students that ravens have been observed to act as airborne guides for coyotes, using their keen eyesight to lead their earthbound partners to carrion (dead animals), which the ravens need their help to tear open. Based on this new information, ask students how they might classify the symbiotic relationship between ravens and coyotes differently according to the five categories listed on the “Symbiosis” Web site? (*Mutualism, in which both species benefit.*) Explain that ravens’ ability to exploit and cooperate with other animals in symbiotic relationships is a sign of their high intelligence.
5. Remind students that adaptability is another hallmark of intelligence, and tell them that they will now be watching a clip in which ravens demonstrate this attribute by establishing a different symbiotic relationship to survive in harsh winter environments. Provide a FOCUS FOR MEDIA INTERACTION by asking what other intelligence attribute is being displayed by the raven in the clip. Play Clip 2, “Feeding Time” (access the video segments for this lesson at the Video Segments Page, <http://www.pbs.org/wnet/nature/lessons/bird-brained/video-segments/1719/>). PAUSE the clip after the narrator says “This raven knows it can only carry four hot dogs, so it counts them out.” Review the focus question: What other higher intelligence attribute is being displayed by the raven? (*Counting.*) What might have drawn ravens to garbage dumpsters in the winter? (*They’re always in the same place and are full of food even in winter, when food is hard to find in the wilderness.*) Ask students what type of symbiotic relationship exists between humans and ravens. (*Commensalism. The ravens benefit from humans’ activity without harming them-aside from maybe making a mess.*)
6. Tell students that they will now be continuing with the clip, providing them with a FOCUS FOR MEDIA INTERACTION by asking what other intelligence attributes these ravens demonstrate as they gather to feed. Resume playing Clip 2, PAUSING after the narrator says “Ravens have learned to use other creatures’ skills to their own advantage.” Review the focus question: What other intelligence attributes are these ravens demonstrating as they gather to feed? (*Communication-by both squawks and body language-and social interaction.*) Ask what types of body language the ravens use to communicate aggressiveness or formidability? (*They puff their head, throat, and leg feathers.*) Why might they adopt this posture? (*To indicate their territorialism or hierarchical status.*)



7. Remind students about the raven with the four hot dogs. Ask students if they think it will be able to eat all four of those hot dogs at once? (*Probably not.*) What do they think it will do with the extras? (*Accept all answers.*) Tell students they will now be watching a clip that will reveal the raven's strategy for keeping extra food. Provide a FOCUS FOR MEDIA INTERACTION by asking what this strategy is called. Resume playing Clip 2 through to the end. Review the focus question: What is the raven's strategy for keeping extra food called? (*Caching.*) What intelligence attribute is required for this task? (*Memory-to recall where food was hidden.*)

8. Explain that while the raven's act of caching-to say nothing of cache theft by other ravens-might seem to indicate an "every bird for itself" mentality within the species, as students will see in this next clip, there is actually ample evidence that within their own communities, young ravens in particular can be quite cooperative. Provide a FOCUS FOR MEDIA INTERACTION by asking students why a young raven, having found food, might call other young ravens to help eat it. Play Clip 3, "The Roost" (access the video segments for this lesson at the Video Segments Page, <http://www.pbs.org/wnet/nature/lessons/bird-brained/video-segments/1719/>). Review the focus question, asking why a young raven, having found food, might call other young ravens to help it eat. (*The younger ravens find safety in numbers from older ravens that might otherwise take the food for themselves.*) Explain that this ability to share and cooperate is another example of ravens' very practical intelligence, allowing them to survive as a collective where they might fail as individuals.

9. Explain that, as with most birds (and animals more generally), basic survival instincts like finding food have led ravens to develop quite intelligent behavior, but that some of their most impressive demonstrations of intelligence are found through experiments that test their cognitive capacity to solve more complex or abstract problems. Tell students that the last clip they will be watching will show a few of these experiments, conducted by zoologist and raven expert Berndt Heinrich. Explain that to guarantee the integrity of his results, Heinrich needed to ensure that his ravens had no prior experience with the challenges of his tests. Ask students how they think he might have accomplished this? (*Accept all answers.*) Provide a FOCUS FOR MEDIA INTERACTION by asking students how Heinrich ensures that his ravens have no prior experience with the test. Play Clip 4, "Testing Intelligence" (access the video segments for this lesson at the Video Segments Page, <http://www.pbs.org/wnet/nature/lessons/bird-brained/video-segments/1719/>). Review the focus question: How did Heinrich ensure that his ravens have no prior experience with the tests? (*He raised them himself.*) Ask students what about the ravens' performance in the tests they find impressive. (*Accept all answers, but encourage an appreciation that without any prior training or condition, they solved relatively complex spatial relation problems using coordinated movements of their feet and beak.*) Ask: Do all birds pass this test? (*No-even the raven's close cousin the crow fails.*) Explain that success in this test indicates that ravens possess not only complex instinctive knowledge, but also cognitive comprehension of more abstract spatial relations.

10. Explain that even crows-demonstrably less intelligent than their raven cousins-exhibit types of intelligent behavior once thought exclusive to mammals or even just humans. Have students log onto the "Nutcrackers" Web site



(<http://www.pbs.org/lifeofbirds/brain/index.html>) and have them read the first five paragraphs, providing a **FOCUS FOR MEDIA INTERACTION** by asking why crows can't crack open walnuts with the same technique they use for clams? (Because the walnut's soft outer shell doesn't break on rocks.) Ask students how they think crows might have figured out this nutcracking strategy. (*Accept all answers.*) Explain that the crow's complex nutcracking technique is probably based upon their synthesized comprehension of several simpler observations. Ask the class what these might be. (*Answers may vary, but should include:*

- *Cars can crack things open.*
- *Cars move and stop at particular places (i.e. intersections).*
- *Cars move and stop at particular intervals of time (i.e. traffic lights).*
- *People move across intersections when cars are stopped (i.e. "This is when it's safe to go place the walnuts").*

Explain that crows probably arrived at each of these understandings by a combination of observation, trial-and-error, and imitation of other crows who had already figured out the process.

11. Ask students if they think the crow's nutcracking technique is an example of tool use. (*Accept all answers. Explain that the answer depends on how strictly one defines a tool; despite the obvious work that the car's wheels are doing for the crow, the nutcracking crows aren't actually manipulating the car's wheels.*) Tell students that there are other types of crows that do use tools by even the strictest definition. Have them scroll down the "Nutcrackers" Web page until they get to the paragraph adjacent to the second photo, which starts "On the Pacific island of New Caledonia..." Tell students to read that and the following three paragraphs, providing a **FOCUS FOR MEDIA INTERACTION** by asking whether scientists know for sure whether tool making and use among crows is genetically inherited or cognitively learned. (*They do not.*)

12. Ask students if they think the walnut-cracking technique of the Japanese crows is genetically inherited or cognitively learned? (*Accept all answers, but encourage an understanding that the behavior has only been observed for the past 20 years or so in Japan-less in California-and cars themselves have only existed for about 100 years-too short a time for such complex behavior to have evolved genetically.*)

CULMINATING ACTIVITY

1. Divide the class into groups of four. Explain that each group will be designing a single theoretical intelligence-testing challenge (similar to those shown in the "Testing Intelligence" clip) for ravens based upon this bird's demonstrated intelligence attributes (i.e. the content of the "Raven Reason" student organizer). Each group should make drawings or diagrams to help explain and describe its challenge. Explain that each group's challenge will be "graded" by the other groups on a point scale according to the following criteria:

- "Originality" - 1-3 points awarded for the creativity and uniqueness of the challenge.



- “Motivation” - 1-3 points awarded for the likelihood that a raven would have sufficient motivation to complete the challenge.
- “Cognition” - 1-3 points awarded for the level of cognitive ability a raven would demonstrate by completing the challenge.
- “Realism” - 1-3 points awarded for the likelihood that a raven might encounter the challenge in the real world.

2. Allow at least a half hour for groups to complete this activity, carrying over into the next day’s class if necessary (with students brainstorming ideas as homework in between). Then have each group designate a speaker to present its challenge to the class. After each presentation, allow at least five minutes for the other groups to confer and determine the score they will award it. The scores assigned by each group should be kept secret until all groups have presented, at which time the scores will be revealed and tallied. Explain that these kinds of tests lead us new ideas that expand our understanding of behavior in living things.

CROSS-CURRICULAR EXTENSIONS

History

Ravens have traditionally been perceived as birds of ill-omen. Have students investigate why this is, and then have them explore more positive perceptions of ravens in three different cultural contexts: the Tower of London, traditional Native American folklore of the Pacific Northwest, and Norse mythology.

English/Language Arts

Have students read and critically analyze Edgar Allan Poe’s poem “The Raven,” asking them to consider which cultural perceptions of ravens it draws upon, and has itself perpetuated. An excellent interactive Web site about “The Raven” can be found at Maryland Public Television’s Knowing Poe (<http://knowingpoe.thinkport.org/writer/annotated.asp>).

COMMUNITY CONNECTIONS

Invite a local ornithologist, zoologist, or birdkeeper to bring a raven to class for a “show and tell.” Alternatively, visit a local zoo or aviary to see ravens in a more natural habitat.



NAME: _____

DATE: _____

“RAVEN REASON”

Type of Intelligent Behavior/Abilities	Example as Demonstrated by Ravens (or Crows)
Adaptability	
Taking advantage of other animals	
Counting	
Communication	
Memory	
Social interaction	
Cooperation	
Ability to solve complex problems	
Trial and error learning	
Tool use	
Other	



NAME: _____

DATE: _____

“RAVEN REASON”

Student Organizer Answer Key

Type of Intelligent Behavior/Abilities	Example as Demonstrated by Ravens (or Crows)
Adaptability	<i>Ravens' ability to find food in a wide variety of environments.</i>
Taking advantage of other animals	<i>Symbiotic relationship in which ravens lead coyotes to carrion, which the coyotes tear open so the ravens can eat it.</i>
Counting	<i>A raven counting out the exact number of hot dogs it knows it can fly away with.</i>
Communication	<i>Squawking and feather puffing to indicate territorial primacy or hierarchical status.</i>
Memory	<i>Being able to recall the location of cached food.</i>
Social interaction	<i>The dusk gathering of the roost, in which ravens who have found food share information with those that haven't.</i>
Cooperation	<i>Young ravens sticking together to resist attacks by older ravens.</i>
Ability to solve complex problems	<i>Ability to figure out Berndt Heinrich's "meat on string" tests of spatial reasoning.</i>
Trial and error learning	<i>Japanese crows' crosswalk nutcracking technique.</i>
Tool use	<i>New Caledonian crows' construction, use, and retention of tools for eating insects.</i>
Other	<i>Answers will vary</i>