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Cephalopods: Aliens of the Deep

A WORD FROM THE FILMMAKER

Tales of nature's resilience offer hope. The current fate of cephalopods is one of them.

By getting close to the lives of octopus, squids, and cuttlefish, I wanted to show that these intelligent but short-lived molluscs have benefited from human greed: As we have overfished their predators like tuna, billfish, and sharks, we have created a unique opportunity for them to proliferate.

My goal was to film in a variety of places and depths and to show this success story unfolding from the abyss to the tropical lagoons. In the Philippines, I actually found more biodiversity than I expected. This bonus gave me countless filming opportunities and the chance to witness rare, unexpected, or never-before-filmed behavior.

At the end of the day, I hope viewers will share my endless fascination for these small creatures that have attained a form of intelligence via an unusual evolutionary path. Witnessing in full detail the intimate lives of such critters is my invitation to celebrate their intelligence and diversity!

Bertrand Loyer

Bertrand Loyer is a world-renowned wildlife film author, cameraman, producer, and director. Since founding Saint Thomas Productions in 1995, he has produced or directed more than 100 wildlife, science, and environmental films for all major broadcasters. He has developed countless underwater films. Cephalopods have often appeared in his award-winning films, such as ***Sperm Whales: Dealing with the Unexpected*** (Discovery, Canal+) or ***Whales of the Deep*** (both for Arte and National Geographic Channels International).

FILM SYNOPSIS

Cephalopods are an invertebrate group that includes squid, octopus, and cuttlefish. Unlike most marine species, their populations are booming. Through various examples, from the abyss to the tropical shallows, ***Cephalopods: Aliens of the Deep*** shows that the group is highly efficient at adapting to changes in their environment, enabling them to overcome the disturbances that have contributed to the depletion of other species. Although they only live for one to two years, they produce many offspring, with relatively low mortality rates, which allows them to adapt rapidly to environmental changes. In addition, as humans reduce the population of cephalopod predators by overfishing, we create a gap in the food chain for this adaptable species to fill.

Shot over three years across the globe using deep-sea submersibles and specialized underwater filming equipment, ***Cephalopods: Aliens of the Deep*** presents an intimate portrait of this fascinating family of molluscs. Through stunning cinematography, it reveals unexpected or spectacular behavior of little-known species in remote locations. In particular, the use of an array of macro lenses enables the viewer to plunge into the personal lives of small species and the larvae of large ones…and discover their unique physiology.

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EDUCATORS' INTRODUCTION

This educators' guide is designed to enrich your students' viewing of ***Cephalopods: Aliens of the Deep***. Designed for use with elementary and middle school students as a supplement to science, STEM, and STEAM curricula, the guide is divided into specific learning activities for grades K-2, 3-5, and 6-8 that align with Next Generation Science Standards and U.S. National Science Standards.

Following are general suggestions for using the guide, including ideas for pre/post-viewing discussion. Suggestions for using the accompanying classroom activities can be found in the Teaching Notes for each grade level. You can modify and adapt these activities to meet the specific needs of your classroom.

EDUCATIONAL OBJECTIVES

- To educate students about cephalopods and their unique traits and habitats
- To educate students about the current rise of cephalopods in the world's oceans
- To engage students' curiosity and develop science skills of observation and inference
- To help students develop and practice STEM skills

PRE-VIEWING TOPICS

Create a KWL graphic organizer on the chalkboard/whiteboard, with columns labeled, "What I KNOW," "What I WANT to Find Out," and "What I LEARNED." Fill in the first column by asking students what they already know about cephalopods, the class of animals that includes squids, octopus, and cuttlefish. Ask students who have watched other documentaries or have seen marine life at aquariums what they remember. Then fill in the second column of the organizer by asking students what they want to find out about this remarkable species. Lead this discussion with questions such as:

- What is a cephalopod?
- How many different cephalopod species are there?
- What kind of habitat do cephalopods need?
- What kind of predator/prey relationships do cephalopods have?
- Are cephalopods an endangered species?
- How do scientists study cephalopods?
- What predictions do you have about the film based on its title, ***Cephalopods: Aliens of the Deep***?

Grades K-2: Keep the graphic organizer visible in a central location. Return to it to discuss and complete the remaining column with students after viewing the film.

Grades 3-8: Conclude by having students copy the organizer so they can fill in the remaining column after they have seen the film.

POST-VIEWING TOPICS

Return to the KWL graphic organizer on the chalkboard/whiteboard to fill in the "What I LEARNED" column. Have students contribute facts and insights from the film viewing. Prompt student thinking with these discussion questions:

- What traits and special characteristics distinguish cephalopods as a species?
- How are cephalopod species alike and different from one another?
- What is the cause/effect of overfishing on the world's population of cephalopods?
- How do cephalopods' unique traits play a role in helping them to survive?
- What kinds of tools do scientists use to study cephalopods?

Grades K-2: Fill in the remaining columns using student comments and observations from the film.

Grades 3-8: Have students complete the remaining "What I LEARNED" column on their own.

Finally, create a new chart called "Wonder." Encourage students to share new questions the film may have raised about cephalopods to include on this chart. You may wish to use student ideas as the basis for new research projects. Remind students that the scientific process involves constant questioning and curiosity and that scientists often wind up pursuing new questions with research as they add to our knowledge and understanding of the natural world.

BACKGROUND INFORMATION FOR ALL GRADES

Cephalopods are a class of invertebrate animals within the Mollusca phylum that includes octopus, squid, and cuttlefish. Cephalopods get their name from the Greek words "ceph," which means head, and "pod," which means foot. That's because their heads literally connect to their multiple tentacles. Octopus have eight tentacles (arms) lined with suckers. Squid and cuttlefish also have eight arms with suckers but, in addition, have two tentacles that extend further than their arms and are used for catching prey. This trait influences their ability to feel and move. They have blue blood, as well as three hearts.

Cephalopods have well-developed brains which are relatively large in proportion to their bodies. Two-thirds of their brain are taken up by lobes that deal with vision. Such a complex brain is needed to process the sensory information taken in by all those arms and suckers, as well as to activate the millions of special skin cells called *chromatophores* that help cephalopods change skin color and textures and execute behaviors and reactions meant to camouflage or communicate. In addition, scientists have determined that cephalopods have a form of consciousness, and are sensitive to pain, and possibly to emotional stress as well.

Cephalopods are also known for the large size of their two eyes in proportion to their bodies. The squid has the largest eye-to-body ratio of all the cephalopods. Other interesting eye characteristics include different pupil shapes. Octopus have rectangular-shaped pupils, squids have a circular shape, and the cuttlefish pupil is w-shaped. With large eyes and jet propulsion capabilities in their movement, cephalopods are well adapted to hunting.

Cephalopods evolved from shelled animals resembling other moluscs, and some still have an internal shell. The cuttlefish, for example, has a small, hard internal shell that forces it to switch quickly between floating and ambling along the seabed. The octopus, on the other hand, has lost its shell altogether through adaptation and evolution.

The earliest ancestors of today's cephalopods appear in the fossil record around 530 million years ago, and they have continued to evolve over time. Due to their remarkable chameleon-like abilities to adapt to human-induced changes in their environment, such as the depletion of their predators due to overfishing, cephalopods have managed to thrive in large numbers.

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NEXT GENERATION SCIENCE STANDARDS*

Grades K-2	
K-LS1-1 **From Molecules to Organisms: Structures and Processes**	Use observations to describe patterns of what plants and animals (including humans) need to survive.
K-ESS2-2 **Earth's Systems**	Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.
K-ESS3-1 **Earth and Human Activity**	Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live.
1-LS1-2 **From Molecules to Organisms: Structures and Processes**	Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.
2-LS4-1 **Biological Evolution: Unity and Diversity**	Make observations of plants and animals to compare the diversity of life in different habitats.
K-2-ETS1-2 **Engineering Design**	Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
Grades 3-5	
3-LS3-1 **Heredity: Inheritance and Variation of Traits**	Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variations of these traits exists in a group of similar organisms.
3-LS3-2 **Heredity: Inheritance and Variation of Traits**	Use evidence to support the explanation that traits can be influenced by the environment.
3-LS4-2 **Biological Evolution: Unity and Diversity**	Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.
3-LS4-3 **Biological Evolution: Unity and Diversity**	Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
3-LS4-4 **Biological Evolution: Unity and Diversity**	Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
4-LS1-1 **From Molecules to Organisms: Structures and Processes**	Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
4-LS1-2 **From Molecules to Organisms: Structures and Processes**	Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
3-5-ETS1-1 **Engineering Design**	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
Grades 6-8	
MS-LS1-3 **From Molecules to Organisms: Structures and Processes**	Use an argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
MS-LS1-4 **From Molecules to Organisms: Structures and Processes**	Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
MS-LS1-5 **From Molecules to Organisms: Structures and Processes**	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
MS-LS1-8 **From Molecules to Organisms: Structures and Processes**	Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
MS-LS2-1 **Ecosystems: Interactions, Energy, and Dynamics**	Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-2 **Ecosystems: Interactions, Energy, and Dynamics**	Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
MS-LS2-4 **Ecosystems: Interactions, Energy, and Dynamics**	Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-LS4-2 **Biological Evolution: Unity and Diversity**	Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
MS-LS4-4 **Biological Evolution: Unity and Diversity**	Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
MS-ESS3-4 **Earth and Human Activity**	Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
MS-ETS1-1 **Engineering Design**	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2 **Engineering Design**	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

NATIONAL SCIENCE STANDARDS**

Grades K-4	
Science as Inquiry	• Abilities necessary to do scientific inquiry • Understanding about scientific inquiry
Life Science	• Characteristics of organisms • Life cycles of organisms • Organisms and environments
Science and Technology	• Abilities to distinguish between natural objects and objects made by humans • Abilities of technological design
Science in Personal and Social Perspectives	• Characteristics and changes in populations • Types of resources • Changes in environments
History and Nature of Science	• Science as a human endeavor

NATIONAL SCIENCE STANDARDS**

Grades 5-8	
Science as Inquiry	• Abilities necessary to do scientific inquiry • Understanding about scientific inquiry
Life Science	• Structure and function in living systems • Reproduction and heredity • Regulation and behavior • Populations and ecosystems • Diversity and adaptation of organisms
Science and Technology	• Abilities of technological design • Understanding about science and technology
Science in Personal and Social Perspectives	• Populations, resources, and environments • Risks and benefits
History and Nature of Science	• Science as a human endeavor • Nature of science • History of science

COMMON CORE STATE STANDARDS – ENGLISH LANGUAGE ARTS***

Grades K-2	
Grade K, Reading: Informational Text **Key Ideas and Details** **CCSS.ELA-LITERACY.RI.K.1**	With prompting and support, ask and answer questions about key details in a text.
Grade K, Reading: Informational Text **Integration of Knowledge and Ideas** **CCSS.ELA-LITERACY.RI.K.7**	With prompting and support, describe the relationship between illustrations and the text in which they appear (e.g., what person, place, thing, or idea in the text an illustration depicts).
Grade K, Writing **Text Types and Purposes** **CCSS.ELA-LITERACY.W.K.2**	Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic.
Grade 1, Reading: Informational Text **Key Ideas and Details** **CCSS.ELA-LITERACY.RI.1.1**	Ask and answer questions about key details in a text.
Grade 1, Reading: Informational Text **Integration of Knowledge and Ideas** **CCSS.ELA-LITERACY.RI.1.7**	Use the illustrations and details in a text to describe its key ideas.
Grade 1, Writing **Research to Build and Present Knowledge** **CCSS.ELA-LITERACY.W.1.8**	With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.
Grade 2, Reading: Informational Text **Key Ideas and Details** **CCSS.ELA-LITERACY.RI.2.1**	Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text.
Grade 2, Reading: Informational Text **Integration of Knowledge and Ideas** **CCSS.ELA-LITERACY.RI.2.7**	Explain how specific images contribute to and clarify a text.
Grade 2, Writing **Research to Build and Present Knowledge** **CCSS.ELA-LITERACY.W.2.7**	Recall information from experiences or gather information from provided sources to answer a question.
Grades 3-5	
Grade 3, Reading: Informational Text **Integration of Knowledge and Ideas** **CCSS.ELA-LITERACY.RI.3.7**	Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur).
Grade 3, Writing **Production and Distribution of Writing** **CCSS.ELA-LITERACY.W.3.4**	With guidance and support from adults, produce writing in which the development and organization are appropriate to task and purpose.
Grade 3, Writing **Research to Build and Present Knowledge** **CCSS.ELA-LITERACY.W.3.7**	Conduct short research projects that build knowledge about a topic.
Grade 4, Reading Informational Text **Integration of Knowledge and Ideas** **CCSS.ELA-LITERACY.RI.4.7**	Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, timelines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.
Grade 4, Writing **Text Types and Purposes** **CCSS.ELA-LITERACY.W.4.2**	Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
Grade 4, Writing **Production and Distribution of Writing** **CCSS.ELA-LITERACY.W.4.4**	Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
Grade 4, Writing **Research to Build and Present Knowledge** **CCSS.ELA-LITERACY.W.4.7**	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
Grade 5, Reading Informational Text **Integration of Knowledge and Ideas** **CCSS.ELA-LITERACY.RI.5.7**	Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.
Grade 5, Writing **Text Types and Purposes** **CCSS.ELA-LITERACY.W.5.2**	Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
Grade 5, Writing **Production and Distribution of Writing** **CCSS.ELA-LITERACY.W.5.4**	Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
Grade 5, Writing **Research to Build and Present Knowledge** **CCSS.ELA-LITERACY.W.5.7**	Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
Grades 6-8	
Grades 6-8, Science and Technical Subjects Key Ideas and Details **CCSS.ELA-LITERACY.RST.6-8.2**	Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
Grades 6-8, Science and Technical Subjects Integration of Knowledge and Ideas **CCSS.ELA-LITERACY.RST.6-8.9**	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

*NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States.* Washington, DC: The National Academies Press
**National Science Education Standards: Observe, Interact, Change, Learn. Washington, DC: National Academy Press, 1996.
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TEACHING NOTES FOR GRADES K-2

PART 1

Distribute the activity sheets and read this background to the class:

Have you seen pictures of an octopus or a squid? Scientists have a special name for animals like these. That name is "cephalopod" (ceph-a-lo-pod). Cephalopods have arms (called tentacles) attached to their heads! In the film, ***Cephalopods: Aliens of the Deep****, you see many different kinds of cephalopods, including fast-moving squids hunting prey, an octopus that can change its skin color and hide in the sand, and a cuttlefish that can walk on two of its tentacles. Cephalopods can change the color and shape of their skin. This tricks predators that hunt them, and it tricks prey that the cephalopods hunt to eat. They don't see the cephalopods coming. Changing color also helps cephalopods communicate with one another. The number of cephalopods living in ocean habitats around the world is increasing. This is because humans are catching so many of the fish that eat cephalopods. This makes it safer for the cephalopods so they can continue to grow.*

Remind students that scientists use careful observation to classify animals according to their characteristics. Have students examine the photos on the activity sheet and record their observations on the board or across three different paper charts labeled "See," "Think," and "Wonder." Encourage students to share what they "see" about each cephalopod, including its body features and behaviors. For "think," have them state what they think might be happening in each image. Finally, ask them to share "wonder" statements about the images. For example, "I wonder how the animal stays safe," or "I wonder what their habitat is like."

Next, help students read the cephalopod descriptions on the activity sheet and match each to the correct species. Use the background information on each cephalopod species at right to review student answers.

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BACKGROUND ON FEATURED CEPHALOPODS

BLACK-EYED SQUID

- Fast-moving predator (or hunter) with enormous round eyes that detect changes in light, even in deep ocean waters
- Has eight arms and two feeding tentacles with suckers and a hook-like feature at the tip that help these squids catch and eat fish larger than themselves, such as owlfish and lanternfish
- Soft internal shell
- Spends most of its life in shallow waters in the Northern Pacific Ocean from Japan to California
- Females instinctively move to deep ocean waters to carry and hold 2,000 to 3,000 eggs in their tentacles for nine months

COCONUT OCTOPUS

- Carries and uses clam shells, coconut shells, and other ocean trash to hide from predators and prey alike; the only marine invertebrate known to use tools, which scientists identify as a sign of intelligence
- Has eight arms lined with two rows of suckers; can use any two arms to walk
- Uses special skin cells (chromatophores) to quickly change color and texture for hiding from predators and prey; octopus have millions of chromatophores
- Feeds on crabs, shrimp, and small fish
- Lives in muddy bottom waters along the coast of the Pacific and Indian Oceans

FLAMBOYANT CUTTLEFISH

- Has a dark brown base color; puts on a moving light show of different skin colors when threatened to mesmerize prey and warn predators that the flamboyant cuttlefish is venomous
- Has eight arms and two tentacles that catch prey; walks on the seabed using two arms, moving slowly compared to the jet-like propulsion capabilities of squid and octopus
- Small in size (around three inches long) with small, hard, internal shell
- Feeds on small crustaceans like crabs, shrimp, and sometimes fish
- Lives on the sandy seafloor in the Pacific Ocean, from Indonesia to Papua New Guinea to Australia

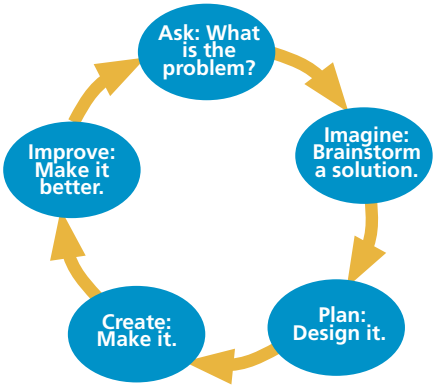
Answers: Black-eyed Squid (#1), Coconut Octopus (#2), Flamboyant Cuttlefish (#3)

PART 2

Project the cephalopod portfolio PDF found at **ymiclassroom.com/cephalopods**. Use it as a visual to guide students as they practice scientific observation and vocabulary skills. Help students describe what they see in the physical shapes and body parts of each animal, as well as their different skin colors and textures. Use the "See-Think-Wonder" strategy to record student observations, posting them for reference.

Help students read the directions to draw their favorite cephalopod in its habitat. Students may then use their drawing to follow the steps of the design process (shown below) to create a model of their chosen cephalopod exhibiting its camouflage or color-changing technique in its habitat. Depending on students' ages and abilities, they may write a brief description to explain their choice of cephalopod, as well as the model they created.

STEM DESIGN PROCESS



FOLLOW-UP

- Help students create a wall chart that categorizes the main differences between squids, octopus, and cuttlefish. Use and expand on the "See-Think-Wonder" charts created in class discussions together with the visual projection. Have students practice the cross-cutting concept of compare/contrast as they consider the diversity found within the range of cephalopod species presented in the film.
- Ask students to describe how they determined their favorite cephalopod in the activity. Help them name some of the characteristics it uses for hiding, camouflage, and communication and have students share which of these traits they wish they could possess and why.
- Have students use the information from the activity and the visual projection to categorize the "Physical Features," "Behaviors," and "Habitat" for each cephalopod. Find each of the oceans noted on a map.

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SURVIVAL STRATEGIES

PART 1 Three species of cephalopods that we see in the film ***Cephalopods: Aliens of the Deep*** are shown below. They live in the ocean, which is their habitat. Look at the pictures. Then write the correct number of the cephalopod in the box next to its picture.

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☐ **Coconut Octopus**

Cephalopod #1

- Has 2 huge eyes that help give it its name
- Has 8 arms with 2 tentacles to catch prey
- Has a soft internal shell
- Lives in shallow waters

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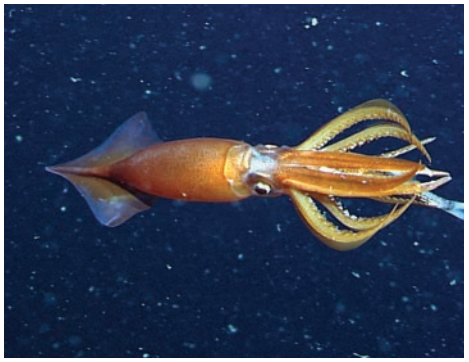
☐ **Flamboyant Cuttlefish**

Cephalopod #2

- Uses seashells and empty coconuts to hide in
- Has 8 arms with suckers
- Shares its name with a fruit
- Lives in muddy bottom along the ocean shore



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☐ **Black-eyed Squid**

Cephalopod #3

- Flashes colors like purple or pink when threatened
- Has 8 arms with 2 tentacles to catch prey
- Can walk along the seabed on two of its arms
- Lives on the sandy seafloor

PART 2 Draw your favorite cephalopod in its habitat. Don't forget its ability to change colors!

Cephalopod Name: _____

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TEACHING NOTES FOR GRADES 3-5

PART 1

Distribute the activity sheets and have students label the True/False statements with a T or an F. Share the information below as you review answers with the class.

Answers:

1. **False.** The Mimic Octopus can mimic the appearance of as many as 15 species.
2. **True.** Cephalopods have millions of chromatophores, or specialized pigment cells, in their skin that allow them to take on many camouflaging behaviors and communicate with one another, particularly in mating.
3. **True.** The Coconut Octopus is the only marine invertebrate known to use tools, including coconut shells thrown into the water by humans, for armor against predators and for camouflage before ambushing prey.
4. **False.** The Flamboyant Cuttlefish can camouflage itself to hunt prey or flash a pattern of pink, red, yellow, and purple to ward off predators with a color-warning that it is poisonous.
5. **True.** Black-eyed Squid live in shallow waters for hunting and mating, but a female will descend to depths of 4,000 feet or more to have babies, remaining there for nine months and holding a clutch of 2,000 to 3,000 eggs in her tentacles, then dying shortly after the eggs hatch.
6. **True.** The Flamboyant Cuttlefish is dependent on its internal shell in order to float, but the shell is so small that the cuttlefish most often walks on the seabed using two of its arms as legs. This characteristic, known as ambling, a behavior typically ignored as an oddity in the natural world, allows it to hunt in the middle of the day.
7. **True.** The Australian Giant Cuttlefish is the largest cuttlefish in the world, growing up to half a meter (1.6 feet) long and weighing more than 10 kilograms (22 pounds). Cuttlefish generally range from 15 to 25 cm (6 to 10 inches) in length.
8. **True.** Male Bigfin Reef Squid can change color several times per second when attracting a female during mating and can even make himself transparent.
9. **False.** While all cephalopods have two eyes, the eyes are, in fact, relatively large in proportion to the rest of their bodies. In addition, the pupils of each of the three featured species are shaped differently. Octopus have rectangular-shaped pupils, squids have a circular pupil, and the cuttlefish pupil is w-shaped. Scientists believe this may be the secret to how these amazing animals can detect shades of color since cephalopods have just one photoreceptor that would otherwise allow them to perceive only shades of light.
10. **False.** The Black-eyed Squid and Flamboyant Cuttlefish have eight legs and two tentacles, but the Coconut Octopus has eight legs and no tentacles.

Next, have students use the information and images provided by the True/False quiz and answers to group characteristics of the six cephalopods into a chart with two categories: anatomy and behavior. For additional images of these cephalopods that students can use for reference, project the cephalopod portfolio found at **ymiclassroom.com/cephalopods** onto a screen or whiteboard. Charts may include the following details.

COCONUT OCTOPUS

Anatomy
- Has rectangular-shaped pupils; can detect shades of color
- Has eight legs

Behavior
- Uses tools to hide from prey and predators
- Can change its skin color and texture to protect itself from predators and surprise prey

MIMIC OCTOPUS

Anatomy
- Has rectangular-shaped pupils; can detect shades of color

Behavior
- Can change its skin color and texture to protect itself from predators and surprise prey
- Can mimic as many as 15 species

FLAMBOYANT CUTTLEFISH

Anatomy
- Has a small internal shell so it walks on two arms
- Has w-shaped pupil; can detect shades of color
- Has eight legs and two tentacles

Behavior
- Can change its skin color and texture to protect itself from predators (and warn that it is poisonous) and surprise prey

AUSTRALIAN GIANT CUTTLEFISH

Anatomy
- Largest cuttlefish; grows up to half a meter (1.6 feet) long and more than 10 kilograms (22 pounds) in weight
- Has w-shaped pupil; can detect shades of color

Behavior
- Can change its skin color and texture to protect itself from predators and surprise prey

BIGFIN REEF SQUID

Anatomy
- Has a circular pupil; can detect shades of color

Behavior
- Can change its skin color and texture to protect itself from predators and surprise prey
- Males can change color several times per second and can make themselves transparent

BLACK-EYED SQUID

Anatomy
- Has a circular pupil; can detect shades of color
- Has eight legs and two tentacles

Behavior
- Can change its skin color and texture to protect itself from predators and surprise prey
- Females move to deep ocean waters to have babies; carry and hold 2,000 to 3,000 eggs; die after eggs hatch

PART 2

Students should select the empty tin can as the most likely hiding place or shield for the Coconut Octopus. Working in teams and following the engineering design process steps listed on the sheet, have them create a model of a hiding place or shield for a Coconut Octopus using recycled materials. Have students write out the steps they will take at each stage of the process and draw a representation of their model before they begin to execute their design. Plan a special class session for students to make improvements on their first design, then ask students to share their completed work along with the highlighted features of their design process.

Follow-Up
- Have students research ocean pollution to learn more about this issue and what is being done – or could be done – to combat it.
- Prompt students to identify which is their favorite cephalopod and why. Then ask them to share which features for hiding, camouflage, communication, etc., they wish *they* could have and why.

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SURVIVAL STRATEGIES

PART 1

In the film, ***Cephalopods: Aliens of the Deep***, you see the tiny Flamboyant Cuttlefish walking along the seafloor. You see the Bigfin Reef Squid showing off its ability to change colors several times a second. You even see the Mimic Octopus digging into the sand while copying the skin patterning of a sea snake. These are *cephalopods*. Their name comes from the Greek word "ceph," meaning head, and "pod," meaning foot. Their heads are attached to their tentacles, which they sometimes use like feet but mostly use as arms to capture their prey.

©Marta Sostres, Saint Thomas Productions

Coconut Octopus

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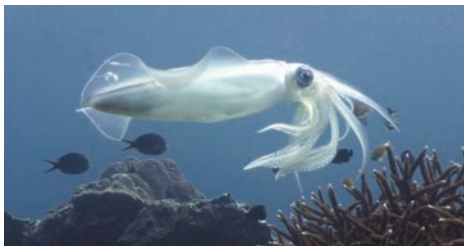
Flamboyant Cuttlefish



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Bigfin Reef Squid

©Marta Sostres, Saint Thomas Productions

Mimic Octopus

©Bertrand Loyer, Saint Thomas Productions

Australian Giant Cuttlefish

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Black-eyed Squid

Test yourself on what you learned about the cephalopods shown here by marking these statements with a T or an F for True or False.

_____ **1.** The Mimic Octopus gets its name from its ability to make sounds like other sea creatures.

_____ **2.** Cephalopods have millions of skin cells called *chromatophores* that allow them to change the color and texture of their skin to protect themselves from predators.

_____ **3.** The Coconut Octopus uses seashells and sometimes ocean trash to hide from predators and surprise its prey.

_____ **4.** The small Flamboyant Cuttlefish only changes its skin color to hide from predators.

_____ **5.** Black-eyed Squid take their clutch of eggs to the ocean's depths to keep their young away from predators.

_____ **6.** The Flamboyant Cuttlefish walks on the seabed and has few predators.

_____ **7.** The Australian Giant Cuttlefish is the largest cuttlefish in the world, growing up to half a meter long and weighing more than 10 kilograms.

_____ **8.** In the mating season, the male Bigfin Reef Squid can change color several times per second to attract females.

9. Octopus, squids, and cuttlefish all have two eyes that are small in proportion to their bodies.

_____ **10.** The Coconut Octopus, the Black-eyed Squid, and the Flamboyant Cuttlefish all have eight legs and two tentacles.

PART 2 STEM Challenge!

First, circle the image of the item you think the Coconut Octopus would most likely use as a hiding place or shield. Then use the steps in the engineering design process at right to create and improve on a model hiding place for this species.

Engineering Design Process
1. Ask: What is the problem? Define it.
2. Imagine: Brainstorm. Choose a solution.
3. Plan: Draw it. List materials needed.
4. Create: Make it. Try it out.
5. Improve: Make it better.

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TEACHING NOTES FOR GRADES 6-8

PART 1

Distribute the activity sheets and review the directions. Project images from the film found at **ymiclassroom.com/cephalopods** onto a screen or whiteboard. Use the images as a guide to help students match cephalopod species to their traits. Depending on student ages and abilities, students may work independently or with a partner to complete their work. Encourage students to use inference skills together with what they learned from the film to determine trait benefits. Students can research facts as needed to complete the charts.

Answers:

HUMBOLDT SQUID

Trait	Trait Benefit
1. Enormous eyes with round pupils	Advantage in hunting; can detect variations in light; pupil shape may help see color
5. Communicate by flashing colors at one another	Used in mating and defense
6. Hunts anything that moves	Enables dependable food source

COCONUT OCTOPUS

Trait	Trait Benefit
2. Burrows in sand	Camouflage in predator/prey situations
7. Large rectangle-shaped eyes	Advantage in hunting; can detect variations in light; pupil shape may help see color
9. Only marine invertebrate in the world known to use tools	Survival advantage

FLAMBOYANT CUTTLEFISH

Trait	Trait Benefit
3. Ambles on seafloor on two of its eight legs	Inconspicuous movement
4. Highly developed eyes with w-shaped pupils	Advantage in hunting, can see variations of light; pupil shape may help to see in color
8. Naturally camouflaged in habitat but can display flashing color changes	Warning to predators that it may be toxic; communication in mating

Traits shared by cephalopods may include large, highly developed brains, two-thirds of which are taken up with lobes that deal with vision; ability to change skin color and texture through specialized cells called *chromatophores*; multiple arms lined with suckers; well adapted to hunting; young born mature from birth; mollusc traits such as having a soft, unsegmented body and ability to adapt quickly to human-induced changes in their environments.

PART 2

Provide the resource list on page 10 for students to review. Have them select one of these research topics (anatomy, behavior, habitat, or evolution) and record an interesting fact about the topic they chose. Depending on their skills and abilities, have them create posters as a group or independently. Students may also create cephalopod models to include with their poster presentation.

Follow-Up

- Have students research and write an explanation of the phenomenon of overfishing giving rise to today's cephalopod "era" using the lens of one of the following NGSS Cross-Cutting Concepts: cause/effect, systems and systems models, or stability and change.
- Have students review details found at **https://www.scoop.it/topic/biomimicry/?&tag=Squid**, to research the term "biomimicry," along with how scientists are using technology to mimic cephalopods' physiology for such things as camouflage, self-healing fabrics, and soft robotics (like squids) for space exploration.
- Cephalopod ancestors are among the most ancient life on Earth. Students can research the connection between today's survivors and their origins and create a timeline based on their evolutionary progression, supporting the cross-cutting concepts found at **https://www.nextgenscience.org/dci-arrangement/ms-ls4-biological-evolution-unity-and-diversity**.

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SURVIVAL STRATEGIES

PART 1

The film, ***Cephalopods: Aliens of the Deep***, features one of the most unique classes of animals on Earth. From the tool-using Coconut Octopus, to the quick-change artistry of the plucky Flamboyant Cuttlefish, to the devastatingly effective hunting skills of the Black-eyed Squid, you see the many wonders of these remarkable marine creatures.

Their name cephalopod comes from the Greek word "ceph," meaning head, and "pod," meaning foot. Their heads are attached to their tentacles, which they sometimes use like feet but mostly use as arms to capture their prey. Octopus have eight arms lined with suckers. Squid and cuttlefish also have eight arms with suckers as well as two tentacles that extend further than their arms and add to their ability to capture prey. All cephalopods have highly sophisticated brains which influence their ability to feel and move.

Cephalopods have existed for about 530 million years and continue to evolve. Due to their remarkable abilities to adapt to human-induced changes in their environments, such as the impact of overfishing, cephalopods have managed to thrive in large numbers.

Here are three species featured in ***Cephalopods: Aliens of the Deep***. Use the traits list and the charts below to profile each species. Write the numbers of the three traits that belong to each species in the left column of the chart. Use the right column to describe the benefit each trait provides.

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Humboldt Squid

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Coconut Octopus

©Marta Sostres, Saint Thomas Productions

Flamboyant Cuttlefish

TRAITS

1. Enormous eyes with round pupils
2. Burrows in sand
3. Ambles on seafloor on two of its eight legs
4. Highly developed eyes with w-shaped pupils
5. Communicate by flashing colors at one another
6. Hunts anything that moves
7. Large rectangle-shaped eyes
8. Naturally camouflaged in habitat but can display flashing color changes
9. Only marine invertebrate in the world known to use tools

Traits	HUMBOLDT SQUID

Traits	COCONUT OCTOPUS

Traits	FLAMBOYANT CUTTLEFISH

PART 2

Use the links your teacher will give you to learn more about cephalopods. Select one of the research topics below and record the fact you find most interesting about that topic on a separate sheet of paper. Use your research to create a cephalopod poster in print or digital format.

• Anatomy • Behavior • Habitat • Evolution

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RESOURCES FOR GRADES 6-8

Anatomy and Behavior

- **Cephalopod, New World Encyclopedia:** https://www.newworldencyclopedia.org/entry/Cephalopod
- **Cephalopoda, Tree of Life Web Project:** http://tolweb.org/Cephalopoda
- **Cephalopods, Smithsonian Ocean:** https://ocean.si.edu/ocean-life/invertebrates/cephalopods
- **Get to Know the Four Types of Cephalopods, Birch Aquarium:** https://aquarium.ucsd.edu/blog/get-to-know-the-four-types-of-cephalopods/
- **Jet-Setting Cephalopods, Science Friday:** https://www.sciencefriday.com/educational-resources/jet-setting-cephalopods/
- **Phylum Mollusca:** http://bio.rutgers.edu/~gb102/lab_2/307am-mollusca.html
- **Secrets of Cephalopod Camouflage, Science Friday:** https://www.sciencefriday.com/articles/secrets-of-cephalopod-camouflage/
- **So You Think You're Smarter Than a Cephalopod?, Smithsonian Ocean:** https://ocean.si.edu/ocean-life/invertebrates/so-you-think-youre-smarter-cephalopod
- **The ABCs of Cephalopods with Conservation Biologist Samantha Cheng, American Museum of Natural History video:** https://www.amnh.org/explore/videos/kid-science/abcs-cephalopods-conservation-biologist-samantha-cheng
- **The Cephalopoda, University of California Museum of Paleontology:** https://ucmp.berkeley.edu/taxa/inverts/mollusca/cephalopoda.php

Evolution and Climate Change

- **Cephalopods and Climate Change, Shape of Life:** https://www.shapeoflife.org/news/featured-creature/2018/09/11/cephalopods-and-climate-change
- **Curiouser and Curiouser – Octopus's Evolution Is Even Stranger Than Thought, Scientific American:** https://www.scientificamerican.com/article/curiouser-and-curiouser-octopuss-evolution-is-even-stranger-than-thought/
- **Global Patterns of Species Richness in Coastal Cephalopods, Frontiers in Marine Science:** https://www.frontiersin.org/articles/10.3389/fmars.2019.00469/full
- **The "Head Foot" Sea Monsters that Ruled Before the Dinosaurs, Shape of Life:** https://www.shapeoflife.org/blog/"head-foot"-sea-monsters-ruled-dinosaurs

Habitat

- **Aquatic Species Distribution Map Viewer, Food and Agriculture Organization of the United Nations:** http://www.fao.org/figis/geoserver/factsheets/species.html
- **Deep-Sea Cephalopods, The Octopus News Magazine Online:** https://tonmo.com/articles/deep-sea-cephalopods-an-introduction-and-overview.19/
- **Octopus Facts, National Geographic Kids:** https://www.natgeokids.com/uk/discover/animals/sea-life/octopus-facts/
- **Total Cephalopod Distribution Worldwide, Research Gate (habitat map):** https://www.researchgate.net/figure/Total-Cephalopod-Distribution-Worldwide_fig1_45257399

ADDITIONAL RESOURCES

Cuttlefish

- **Cuttlefish, Britannica:** https://www.britannica.com/animal/cuttlefish
- **Meet the Common Cuttlefish, Monterey Bay Aquarium:** https://www.montereybayaquarium.org/animals/animals-a-to-z/common-cuttlefish
- **Model the Texture-Changing Structures of Cuttlefish Skin: Papillae, Science Friday:** https://www.sciencefriday.com/educational-resources/model-the-shape-changing-structures-of-cuttlefish-skin-papillae/

Octopus

- **Octopus, Britannica:** https://www.britannica.com/animal/octopus-mollusk
- **Octopus Mystery: How Do They See Color?, Carnegie Museum of Natural History:** https://carnegiemnh.org/octopus-mystery-how-do-they-see-color/
- **The Distributed Mind – Octopus Neurology, Science Friday:** https://www.sciencefriday.com/videos/the-distributed-mind-octopus-neurology/
- **The Mind of an Octopus, Scientific American:** https://www.scientificamerican.com/article/the-mind-of-an-octopus/
- **Weird Pupils Let Octopuses See Their Colorful Gardens, Berkeley News:** https://news.berkeley.edu/2016/07/05/weird-pupils-let-octopuses-see-their-colorful-gardens/

Squids

- **A Brief Profile on Squids, Tree of Life Web Project:** http://tolweb.org/treehouses/?treehouse_id=4225
- **Creepy Cannibals: Squid Have No Qualms About Eating Their Own Kind, Live Science:** https://www.livescience.com/56211-squid-cannibalism.html
- **Squid, Britannica:** https://www.britannica.com/animal/squid
- **What's the Difference? Octopus vs. Squid, National Marine Sanctuary Foundation:** https://marinesanctuary.org/blog/what-is-the-difference-between-octopus-and-squid/

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Tales of nature's resilience offer hope. The current fate of cephalopods is one of them. Shot over three years across the globe using deep-sea submersibles and specialized underwater filming equipment, ***Cephalopods: Aliens of the Deep*** presents an intimate portrait of this fascinating family of molluscs.

Through stunning cinematography, it reveals unexpected or spectacular behavior of little-known species in remote locations. In particular, the use of an array of macro lenses enables the viewer to plunge into the personal lives of small species and the larvae of large ones…and discover their unique physiology.

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For additional educational resources and online activities, please visit **ymiclassroom.com/cephalopods**

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NORTH/SOUTH AMERICAN SALES

Janine S Baker
+1 818-565-1101
jbaker@nwave.com

INTERNATIONAL

Goedele Gillis
+32 2 347-63-19
ggillis@nwave.com

info@nWave.com | nWave.com | /nWavePicturesDistribution | /nWave | /nWavePictures | /nWavepicturesdistribution

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