SCIENTISTS IN THE FIELD

Where Science Meets Adventure

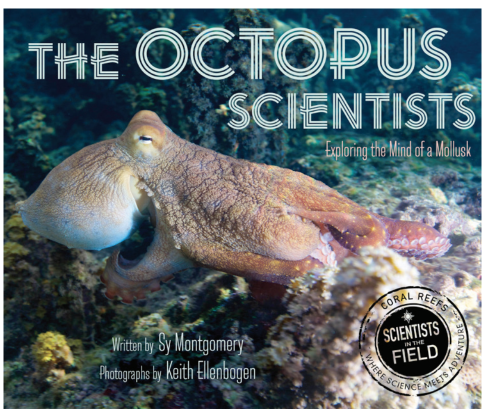
DISCUSSION AND ACTIVITY GUIDE

The Octopus Scientists: Exploring the Mind of a Mollusk

By Sy Montgomery   Photographs by Keith Ellenbogen

About the Series

The Octopus Scientists: Exploring the Mind of a Mollusk is part of the award-winning Scientists in the Field series, which began in 1999. This distinguished and innovative series examines the work of real-life scientists doing actual research. Young readers discover what it is like to be a working scientist, investigate an intriguing research project in action, and gain a wealth of knowledge about fascinating scientific topics. Outstanding writing and stellar photography are features of every book in the series. Reading levels vary, but the books will interest a wide range of readers.



The Octopus Scientists: Exploring the Mind of a Mollusk
by Sy Montgomery
Photography by Keith Ellenbogen
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About the Book

Can a creature related to a snail possess intelligence and personality? If so, does an octopus's personality play a role in what that octopus choses to eat? And what do those choices tell us about the health of the species? As air-breathing creatures, can human scientists accurately measure the intelligence or personality of a marine creature?

These are some of the questions at the heart of the new book from the veteran science writer Sy Montgomery as she introduces readers to a team of scientists researching big questions about intelligence and personality in one of the most fascinating creatures on earth.

About the Author

While researching some of her many books, Sy Montgomery has been bitten by a vampire bat, hugged by an octopus, and hunted by a tiger, and she has crawled into a pit with 18,000 snakes! She has written more than fifteen books for adults and children and has won many honors, including the Orbis Pictus Award, a Robert F. Sibert Award, the Henry Bergh Award for Nonfiction, and many more.

Besides writing books, she is a screenwriter for film and television and a popular speaker. She works with many organizations to preserve and protect nature. Montgomery lives on a farm in New Hampshire with her husband and many animals.

About the Photographer

Keith Ellenbogen's fascination with the marine world began when he began volunteering at the New England Aquarium as a teen. After receiving his MFA from the Parsons School of Design, Keith was awarded a Fulbright Scholarship to Malaysia, where he solidified his career choice of underwater photography and videography. He is committed to connecting science and the arts to education, and is passionate about marine conservation. When not on assignment, Keith lives in Brooklyn, New York and is a faculty member in the Photography program at the Parsons School of Design.

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Pre-Reading Activity

Think about very young children that you know. You may know more than these young children, but which of them may be more intelligent than you, and how would you go about proving whether it is true or not?

Many people depend a great deal on their vision. We use color and shape to describe all sorts of things, including animals. What would happen, however, if we could not use color or pattern or shape to recognize creatures? Practice describing various common animals without using any visual attributes.

Throughout history humans have used knowledge of animals to design new inventions, devise new medicines, plan safety procedures, and more. Brainstorm a list of possible inventions, medicines, games, safety tips, and other ways humans depend on animals every day.

Watch a group of people doing the same thing, such as watching a sporting event or eating or reading. What do all the people do that is the same? What are some of the most obvious differences? As you watch, are you able to determine whether some are better at watching or eating or reading? Explain why or why not. Now watch a group of ants and try to make similar evaluations about their actions. Watch a group of fish or other small animals. Is it possible to evaluate whether individual animals within a group are more capable than others? Can we pick out different personality types?

Discussion Questions

Is it possible to compare the intelligence of different species? Is it even possible to rank creatures by their intelligence when they are of the same species? Is it true that the bigger the brain is, the smarter the creature? Would this mean that males are smarter than females?

If we looked at any group of animals, could we determine whether some of those animals are better at being that animal than others? In other words, are some cats better at being a cat than other cats?

Humans use a wide variety of measures to describe people's personalities. We speak of introverts and extroverts, for example. Do animals have personalities to the same degree as humans? How would we go about proving this?

Is it possible to compare and contrast personalities of octopuses, dolphins, parrots, apes, and humans? Can we compare one species with another? What are the limitations, if this is possible?

An octopus is a mollusk. It is related to the garden snail. Do we typically think of intelligent snails? What happened in the evolution of the octopus that has many people speaking of it as "the most intelligent invertebrate?"

We can easily come up with standards for humans and their occupations or responsibilities, but can we come up with standards to suggest that some octopuses are better hunters than others? What about squirrels or sparrows or grasshoppers?

Since we do not live in the ocean, how can we be sure that our conclusions about the animal behavior of ocean animals are accurate? We have the ability, on land, to use binoculars and other tools. Our ability to see in the ocean is much more limited. How does the difference in visibility impact our understanding?

Applying and Extending Our Knowledge

The very first paragraph of this book begins with a most extraordinary claim: "*The ocean is the world's largest wilderness, covering 70 percent of the globe. But this vast blue territory is even bigger than it looks from land, or even from space. It's a three-dimensional realm that accounts for more than 95 percent of all livable space on the planet—and most of it is unexplored.*"

- Create a graph or chart that explains what the 5 percent is and where it is located.
- Compare the 5 percent with the 95 percent on an overlay to the graph or chart above.
- The use of the word "livable" suggests that there

may be unlivable spaces on Earth. What makes a space unlivable? Given the quote above, make a third overlay (or a new graph or chart) that shows 100 percent of the planet and both the 95 percent of livable space that is the ocean, the 5 percent of other livable space, and all of the unlivable space. What is the percentage of livable to unlivable space, if any? Explain what is meant by "livable" in all three graphs or charts.

Common Core Connections

CCSS.ELA-Literacy.RST.6-8.7
Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

The first chapter uses the word "weirdness" and later speaks of the intelligence of octopuses.

- Rewrite the sentences or the sections of the book that speak of weirdness and intelligence from the point of view of the octopus.
- On social media, top ten lists are ubiquitous. Would the octopus make your top ten list of weird animals? Create your top ten list of weird animals with a brief annotation for why you choose as you do. If the octopus is not on your list, how many more animals until you list the octopus? Explain your reasoning.
- Create a different top ten list. This time use "intelligence" as the attribute. Would the octopus make your top ten list of smart animals? Create your top ten list of intelligent animals with a brief annotation for why you choose as you do. If the octopus is not on your list, how many more animals until you list the octopus? Explain your reasoning.

Common Core Connections

CCSS.ELA-Literacy.RST.6-8.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
CCSS.ELA-Literacy.RI.6.4
Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings.
CCSS.ELA-Literacy.W.6.1.a
Introduce claim(s) and organize the reasons and evidence clearly.
CCSS.ELA-Literacy.SL.6.1.c
Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

On page 1 Montgomery writes, *"We're looking for octopus—the Pacific day octopus, to be exact, one of perhaps 250 octopus species on the planet. Pacific day octopuses grow to more than four feet long. They're not rare or endangered. Should be pretty easy to find, right?/'Pttttthhhth!'"*

- Bring in to the classroom some plush toy that is larger than twelve inches. Have different teams of students design a background for this plush toy that hides it in plain sight. Draw, paint, bring in fabric, bring in items, and use what is in the classroom to make this plush toy as difficult to spot as possible without putting it completely behind something. The goal should be to have the plush toy out in the open and still be difficult to spot.
- Bring in one of the Where's Waldo books or similar books. Using a document camera (with the projection initially turned off) find a page to share with the whole class on a projection screen. Create teams of students (three or four to a group). When all the groups are ready, turn on the projection. The first team to spot Waldo (and prove it) gets a point. Play until one team wins three or more times. Adjust the rules to match your students. After the game is over, examine what the illustrator has done to misdirect our eyes and make it difficult to spot Waldo. Make a list of artist techniques. Compare these techniques to what the octopus does to blend in. Create a Venn diagram to compare them.

Common Core Connections

CCSS.ELA-Literacy.SL.6.2
Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.
CCSS.ELA-Literacy.RST.6-8.7
Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

The "An Octet Of Octo Facts" sidebar on page 11 provides a small glimpse at the world of octopuses and mentions that there are more than 250 other species of octopus.

- Prepare an online presentation defining the words *mollusk* and *octopus*. Show viewers representatives of at least ten different species of octopus.
- In the presentation, make sure to explain the difference between various species in terms of size, coloration, range, diet, behavior, predators, threats to the specific octopus, and any other pertinent facts. Since the Pacific day octopus is the featured member of the octopus species, create a presentation (online or a poster) comparing other species to this one.
- Make a map showing where various types of octopuses live, including ranges.
- Make a set of trading cards showing the types of octopuses, their range, what they eat, threats to the various octopus species, and other interesting facts.
- Prepare a poster or an online presentation distinguishing octopuses from other mollusks.

On page 13 we read, *"'That's going to be fringing reef,' Yannick explained, mentioning one of the three main types of coral reefs scientists study. A fringing reef is found in shallow water close to shore. A barrier reef is separated from shore by deep water; another coral reef type is an atoll, shaped like a ring with water in the middle."*

- Research these three types of coral reefs to determine which type is the home for more octopus species (list them).
- Prepare a report that explains in more detail how these different reefs form. Which animals are most common in each of these types of reefs?
- Prepare an illustrated definition for some of the more common types of corals found on these reefs. Make sure to explain why corals are not in the plant family.

Common Core Connections

CCSS.ELA-Literacy.W.6.2.a
Introduce a topic; organize ideas, concepts, and information, using strategies such as definition, classification, comparison/contrast, and cause/effect; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.
CCSS.ELA-Literacy.RST.6-8.7
Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
CCSS.ELA-Literacy.RH.6-8.7
Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.
CCSS.ELA-Literacy.SL.6.5
Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.
CCSS.ELA-Literacy.W.7.2
Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-Literacy.WHST.6-8.7
Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
CCSS.ELA-Literacy.WHST.6-8.2
Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

The scientists in this book are located in French Polynesia at CRIOBE (Centre de Reasearches Insulaires et Observatoire de l'Environnement de Polynesie Francasie).

- Locate this group of islands on a map and plot the most direct route to Moorea from your school.
- Prepare two marketing brochures for the Society Islands designed to attract tourists. The first brochure is for humans. The second brochure is for octopuses.
- While French Polynesia has a small total land mass of just over 3,500 kilometers (convert this to miles), it is spread out over a much larger expanse of ocean. Make a map that shows your school. If you drove 3,500 kilometers, where would you be? Using a compass, place your town in the radius and trace a circle showing where you would be if you walked in any direction for 3,500 kilometers. Make sure to share the scale on the map to prove that the distance from your town to the circle is 3,500 kilometers.
- If you trace a line between the two islands of

French Polynesia that are the farthest apart, how large is that area? What happens if you use the total area of all the islands and the ocean to do the previous activity? How far would you walk? List some possible locations of where you could be.

Create a picture glossary of many of the more common organisms found in French Polynesia.

- Indicate which ones, if any, are also found outside of French Polynesia. Indicate whether an organism is a year-round resident or a transient species. If transient, how long do they stay?
- Include scientific name, common name, range, animal description, habitat description, diet, and any noteworthy facts (about behavior or endangered status, etc.).
- Group animals by families and then alphabetical by scientific name.

On pages 16–17, Montgomery writes: *"I was beginning to wonder how anyone could ever find octopuses anywhere. The octopus specializes in looking like anything but itself. It squeezes itself into a den so tight you might never see it there, hides or rests most of the time, and moves dens frequently. How do you find a hiding, invisible creature in a place you've never been before?"*

- Brainstorm with your students what kinds of organisms the class could observe in an outdoor area, such as a field or empty lot or wilderness area (whichever matches your school environment). Make predictions for what animals should be there. Make a list of ways you could prove that these animals are present in the environment even if you do not see them.
- While looking for the elusive octopus, the scientists observed many other creatures. Create a field book for animal observations, stressing the importance of dates, drawing, and description. The American Museum of Natural History has good information about field journals here: www.amnh.org/explore/curriculum-collections/biodiversity-counts/what-is-biodiversity/doing-science-researchers-and-exhibition-staff-talk-about-their-work.-keeping-a-field-journal-1. You may also use iPads, digital cameras, or other devices to create an electronic field journal.
- Divide the outdoor area using string or hula hoops or natural markers and assign students a specific section to monitor with a field journal. Make sure to map the site so the students are always observing the exact same location. For the next month (or longer), have students record their observations as regularly as time permits (ideally, on a daily basis). You may wish to have students record the GPS coordinates for their specific location.
- Divide the class into groups and have certain groups specialize in a specific organism (in addition to their field journal work) and have another group work on looking for animals that should be present in the area but have not yet been observed.
- Create a class booklet of the questions students have written. When appropriate, have these questions guide the next day's observations. Have other students use their own observations to formulate answers or theories concerning the questions. These activities, above, may also be used by students in outdoor areas of their own choosing (and assigned as homework or extra credit). Discuss with students whether a field journal could even be done in, say, the lunchroom.
- Compare the class predictions before starting with what the class observes monthly (and at the end of the time period). What new predictions and hypotheses do the students have?
- At what point should we give up looking for an animal that we have not been able to find? Write an argument for abandoning a search and write an argument for continuing to search. Your students may even enjoy debating this. Conduct a mock trial with lawyers, witnesses, a judge, and jury members over whether or not to continue a search. Use the discussion of the sea cucumber on page 14 to guide ways in which to present and use evidence.

Common Core Connections

CCSS.ELA-Literacy.SL.6.1
Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

CCSS.ELA-Literacy.SL.6.1.c
Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

CCSS.ELA-Literacy.SL.6.6
Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate. (See grade 6 Language standards 1 and 3 for specific expectations.)
CCSS.ELA-Literacy.WHST.6-8.7
Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
CCSS.ELA-Literacy.RST.6-8.7
Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
CCSS.ELA-Literacy.RH.6-8.7
Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.
CCSS.ELA-Literacy.SL.6.5
Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.
CCSS.ELA-Literacy.RST.6-8.3
Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
CCSS.ELA-Literacy.W.6.1
Write arguments to support claims with clear reasons and relevant evidence.
CCSS.ELA-Literacy.W.6.3
Write narratives to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences.
CCSS.ELA-Literacy.WHST.6-8.2
Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Montgomery is compelled to share information about the team. On pages 7–10, she provides information about each member of the team.

- Make a class book modeled after these descriptions forecasting what each class member would offer to a scientific team. This is a venture into speculative nonfiction—the goal is to honestly envision ourselves as scientists (regardless of whether or not that is our current career goal). List skills that we have or see ourselves developing that would be of use to the team.
- Encourage students who do have an existing science passion to adapt their biographical entry to fit a project related to their current interest.

In chapter 4, the science team reviews the protocol for data collection, *"First, check the den to see if the octopus is in. If so, administer the personality test. What does the octopus do as we approach it? Hide? Change color? Squirt ink? Or come out? Next, gently touch the octopus with a pencil. What does it do? Does it leave the burrow? Block the entry? Grab the pencil? And finally, collect the prey remains around the den. What does the octopus do then? Does it erect papillae? Blow a jet of water? Just watch? Or ignore us completely?"*

- Put on your octopus therapist's hat and write predictions for what the various behaviors may tell us about the octopus's personality. Justify your answers.
- Pick another common animal, such as a dog. Design one or two simple tests to gauge whether or not it is possible to conclude anything about canine personality. If possible, record observations of ten or more dogs responding to your tests. Obviously, safety of both people and animals is the highest priority. Use common sense and do not put yourself or the dogs in harm's way. Write an annotation of your experiment. Make sure to record the date, time, participants, and other data or procedures. Scientists evaluating your data should be able to verify your results and duplicate your procedures.

Common Core Connections

CCSS.ELA-Literacy.W.7.2
Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-Literacy.WHST.6-8.2
Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
CCSS.ELA-Literacy.RST.6-8.3
Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Further Reading

Courage, Katherine Harmon. *Octopus!* Penguin/Current, 2013.

Jango-Cohen, Judith. *Octopuses*. Benchmark, 2004.

Kessler, Colleen. *Octopuses.* ABDO, 2014.

Markle, Sandra. *Octopuses.* Lerner, 2007.

Montgomery, Sy. "Deep Intellect." *Orion Magazine,* Nov/Dec, 2011.
www.orionmagazine.org/index.php/articles/article/6474

Other Websites to Explore

Common Octopus — *National Geographic*.
animals.nationalgeographic.com/animals/invertebrates/common-octopus

Day Pacific Octopus — Monterey Bay Aquarium
www.montereybayaquarium.org/animal-guide/octopus-and-kin/day-octopus

Are Octopuses Smart? — *Scientific American*
www.scientificamerican.com/article/are-octopuses-smart

Guide created by Ed Spicer, curriculum consultant, and Lynn Rutan, retired middle school librarian, now reviewer and blogger at Bookends: the Booklist Youth Blog.