Interview with an Octopus

by

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ABSTRACT

Octopuses are extraordinary creatures: Despite their numerous biological divergences from humans, they display impressive intelligence. Aquarists and scientists alike have noted instances of octopuses having what appear to be personalities, and some (Roland Anderson and Jennifer Mather) have gone so far as to propose that octopuses are just as capable of having personalities as humans. There has been significant push-back from ethologists (Roger Hanlon and David Sinn) who instead say that this is the result of projection, and that animal behavior science ought to take a more quantitative and experimental approach to studies of behavior.

The case of the octopus is a valuable opportunity to consider how we as humans go about observing animal behavior. The contentious debate over whether to apply human terms like personality to animals may ultimately tell us more about the nature of humans as observers than the animals themselves. Octopuses provide a philosophical mirror by which we can consider our propensity to look at the world through a decidedly human lens.

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Peering over the edge of a tank, I have a hard time making out much past the ripples of the water and the dark reflections off the rocks in the giant Pacific octopus exhibit. The Monterey Bay Aquarium has two separate tanks to house their giant Pacific octopuses, kept separate to avoid fighting and mating, both of which can shorten the lives of an octopus. Given how large their arms can span at full reach—up to eight feet in captivity, even larger in the wild—the tanks at first glance seem small. But Steve Brorsen, the chief aquarist working with the octopuses, reassures me that octopuses spend nearly three quarters of their lives, and most of each day, hidden away in cramped dens. They seem content in their tanks, which just allow them to stretch their arms while providing plenty of nooks and crannies in which to hide from the prying public's eyes.

Brorsen leans far over the Astroturf-lined edge—one of the few surfaces the octopuses' deft suckers can't grab hold of and use to clamber out of the tanks. Octopuses are masters of camouflage, since every inch of their skin is covered by chromatophores: colored cells that expand and contract to mimic the colors around them. They can also wrinkle their skin, creating intricate textures that blend them seamlessly into rocks or coral. It only takes Brorsen a second to find our female, but he is well practiced at scoping them out of their hiding spots.

She is far away from us with her arms pulled into a little ball, sporting the same coloring as the rock she's sitting on. Brorsen is tall and quiet, with a stature well suited to the constant reaching across long tanks that his job requires. He takes out a long plastic stick and skewers a shrimp on one end. He reaches all the way across the tank to offer her the treat. For a moment, no one moves. Then slowly, the octopus begins to uncurl one timid arm to reach for the shrimp. Brorsen pulls on the stick, drawing her closer to us as she gobbles up her prize.

Her attention is clearly focused on the shrimp at hand, but the moment she sees Brorsen, her color starts to pulse white, then red, then white again. She is excited to see him. She rolls over onto her back, arms splayed out like an eight-pointed star, exposing her bright white suckers. Her body is somewhere between the size of a basketball and a beach ball, slightly deflated and stretched oblong. Brorsen offers her one of his hands, and she wraps two arms around his wrist, pulling him closer and teasing his fingers with the sand-dollar size suckers nearest her mouth. She wriggles as she explores, tasting and toying with him.

It is as magical as anything I have ever witnessed. And then Brorsen asks me if I'd like to touch her.

I dip a few fingers into the water. It is cold, but given this octopus came from just off the shore of Vancouver, B.C., I'm not sure why I had expected a tropical temperature. (Other species do live in warmer climates, and in fact, octopuses are some of the most diversely located marine species. An albino octopus species was recently discovered taking up residence near hydrothermal vents.)

My fingertips find the very end of one of her arms, tapered into a fine point, her suckers here only small dots. She does not recognize my taste and recoils. But I am insistent, touching her a bit more boldly this time. Her skin is far from slimy—more like wet velvet than the sticky surface I imagined. She is a creature divided, paying rapt attention to Brorsen with half her arms while deciding what to do with me with the others. She clearly is not thrilled to have to deal with me, but tolerates my touch, more or less.

Then, a lucky move: Brorsen fumbles one of the shrimp he has been feeding her. I pick it up and put it in her suckers a little further towards her center. While she sometimes feeds herself by moving her arm to put the shrimp closest to her mouth where all eight arms meet, this time she chooses to shuffle the shrimp up her arm, passing it sucker to sucker. This little offering seems to have earned me some trust, and when I go to put my hand near her larger suckers this time, she greets me with enthusiasm, sucking on my fingers and winding her arm up around my wrist.

By now I have collapsed into total giddiness, and I'm sure Brorsen is worried I will have a fit from all the excitement. I only notice that I have been entranced and cooing at our octopus after several minutes, when my hands have begun to go a bit numb from the cold water.

My personal reaction may have fallen into an extreme category, but I am not alone in my emotional connection with an octopus. Brorsen has fostered close relationships with other octopuses in the past, and this year-old female is far from the first one to fall in love with him. In fact, the reason I am here visiting Brorsen is because of something extraordinary that happened to him a few years ago.

As an aquarist at Monterey, Brorsen rotates exhibits once a year. During one rotation with the octopuses several years ago, Brorsen became particularly attached to one male octopus. They routinely played games around feeding time, including "catch the water": a game of Brorsen's invention which involved using his hand to squirt water in the air for the octopus to catch in its suckers. When Brorsen was rotated away to another exhibit, he grudgingly passed on the care of his octopuses to new aquarist.

But a few weeks later, Brorsen found he missed his octopuses and returned to the exhibit to say a quick hello. He dipped his hand into the familiar tank, and the young male reached up an arm to touch Brorsen's hand. Octopuses are skilled at recognition, able to identify people by sight but even more easily by tasting with their suckers.

The moment the octopus' sucker touched Brorsen's hand, the octopus launched itself out of the tank. All eight arms flew towards unsuspecting Brorsen, wrapping around his neck and chest. Brorsen had to gently pry the enthusiastic, and sticky, octopus off his body, placing it back in its tank.

I have a difficult time imagining exactly how I would react to a 65 pound giant octopus flinging itself at my face. But as Brorsen recounts the story, he smiles. He knew the gesture was not at all aggressive. If anything, he says, "It was like a hug." A wet, sticky, eight-legged hug.

But even as Brorsen tells the story with obvious delight, he holds back. He hesitates to characterize what happened as anything more than "*like* a hug." To call it an actual hug would be projecting, he says, and he hesitates to make assumptions.

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Scientists who study animal behavior are deeply and vocally divided about using terms like hug, emotion or personality when it comes to nonhuman animals. Many animal lovers and pet owners readily testify to the extraordinary qualities that separate the animals to whom they are close from all others of their kind: intelligence, friendliness, maliciousness, the emotional insight that allows them to tick just the right nerve in their human companions.

But a hunch hardly a science makes, and many scientists have fought against the inclination to project human emotional states onto animals. Jack Block, renowned for his work in developmental psychology at Berkeley, remarked to the *New York Times* in 2006 that, "Personality ratings have been done with chimps where you can see in them intimations of human characteristics." Block maintained that the most these actions could be were just that—imitations—let alone in animals other than chimps. "Even with chimps, it is a big extrapolation from them to us," he said. "But personality in fruit flies or octopi? Heck, no. All living organisms do react to pain and seek what they have developed to want in terms of food or mating. But they cannot manifest the complexity of responses that human beings can."

Except, of course, for those cases like Brorsen's story when it appears they do.

It is one thing to have a back-and-forth about whether a dog or a chimp has a personality. It is another all together to consider the octopus: an animal so radically different from us that aside from multi-cellularity and a basic proclivity towards life, we share strikingly few characteristics. Some differences are more obvious than others. What octopuses lack in a spine they make up for with eight appendages instead of our four. The differences only become more dramatic as the biology unfolds. In contrast with our brain and spinal cord, which contain 99 percent of our neurons, fully sixty percent of an octopus' neurons are divided among its eight arms, which must serve as not just arms, but also legs, lips, fingers, tongue, and sex organ for males. Their short lives are a mere blip in time compared to ours—three or four years if they are large and lucky.

As kinship is concerned, humans and octopuses probably shared an ancestor for only the briefest of evolutionary moments, splitting branches at least 555 million years ago. In 2009, scientists discovered a 95 million year old fossil embedded in limestone deposits just off the coast of Lebanon. The exceptionally well-preserved octopus even included its suckers and ink sac. More notable than the state of the fossil, though, was the fact that the 95 million year old octopus looked virtually identical to modern ones. Evolution tends to tinker and make gradual changes over time, but the octopus may in fact represent an evolutionary pinnacle, one that was reached over 94 million years before *Homo sapiens* was even a twinkle in its father's eye.

And yet, despite our obvious and persistent differences, there is something compelling about an animal willing to jump out of its tank to greet a handler to whom it has become rather obviously attached. Is it possible that an animal as radically different from humans as an octopus could have a personality?

As interesting as this question seems on the surface, there is actually a far more fascinating quandary hidden below. In order to answer the question of whether octopuses have personalities, we first have to give some serious thought to what we mean when we say "personality." Definitions for this kind of abstract human term are elusive, leaving even the

most assiduous scientists grasping for a concrete solution. Oftentimes, all we can say is that we know personality when we see it.

Applying human terms to nonhuman animals could have two quite different effects. On the one hand, playing fast and loose with our language could be a valuable way to open our eyes to the richness of animal behavior otherwise obscured by more technical and dismissive terminology. Or it could backfire, resulting in us demanding that animals that look nothing like humans conform to uniquely human standards of behavior.

The fact that octopuses are so different from us only brings the importance of this problem into sharper relief. How we choose to study an animal whose way of living is so profoundly removed from our own could shed as much, if not more, light on the nature of human observation than about the animals themselves. And our struggle to categorize and process our observations highlights just how very difficult it is to know about any species other than our own.

Instead of seeing them for what they are, we continually attempt to push octopus-shaped pegs through human-shaped holes. And it is this philosophical mirror that makes studying octopuses so important, and so valuable. More than whether they have personalities, we must ask: What can the octopus teach us about ourselves and how we view the world?

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Roland Anderson is a biologist recently retired from the Seattle Aquarium. In his many years working with and studying the octopuses there, he observed such diverse personalities among them that he and other staff members started to name them.

"There was Emily Dickinson," he recalls, "who decided to hide behind her backdrop in a space about three inches thick. And this was a 25 pound animal, so she was very two dimensional behind the backdrop away from the public. She was shy."

"Then we had Leisure Suit Larry, a male octopus, named after a video game of the time back in the 80s and 90s. Leisure Suit Larry the octopus would have been cited for sexual harassment because his arms were all over you, especially the female volunteers."

And the most diabolical octopus Anderson has ever met was Ursula. "She was just evil. Not only did she squirt water at you all the time whenever you opened her tank, or tried to pull you into her tank, presumably to taste you, but she also tore up her tank." Anderson came into the exhibit one day to find his carefully designed exhibit ripped to shreds, chewed up bits of nylon cables floating above the decimated under-gravel grate.

"At the aquarium there were only three species they found in which the individuals were so different that they gave them names," says Jennifer Mather, a psychologist at the University of Lethbridge who teamed up with Anderson to study animal personalities. "One of them was the octopuses, one of them was the seals, and one of them was the sea otters." The octopus stands out starkly against the others in the group: the only non-mammal, and more than that, the only one without a spine.

Anderson's observations were matched by other octopus handlers in aquariums all over the country. In addition to being on the receiving end of octopus embraces, Brorsen also has been privy to diverse octopus temperaments. Some, like an older male octopus currently in his care, don't seem especially interested in interacting with people. Others enjoy playing games, while still others are endless troublemakers. One morning while making rounds, Brorsen was unable to spot a younger male in its exhibit—an unusual event for Brorsen, who is an expert at spying camouflaged octopuses. Rushing backstage, he found that the octopus had managed to grab onto a supporting PVC bar on the far side of the Astroturf barrier, using it to fling itself out of the tank and onto the floor. Brorsen returned the octopus to its tank before mopping up the wet flop marks left on the floor during the octopus' brave escape attempt.

Anderson was intrigued by such stories, and decided to construct a study to examine whether personality was a trait that would hold up scientifically.

Mather became an eager collaborator in Anderson's study. "It's funny because I'd been doing science for decades at that point," she recalls, "and I found that it completely turned our assumptions upside down." Anderson and Mather's decision to study individual animals represented a shift from how many scientists look at animal behavior. Leaving the world of statistical generalizations behind, they wanted to look at one animal at a time, examining its behavior across a range of situations: an octopus ethnography.

"Instead of saying, the population or the group does X," Mather describes, "and the differences amongst them are just noise that gets in the way of our general conclusions, we had to say, Wait a minute, we want to study the noise."

Though most of the stories Anderson had heard were of giant Pacific octopuses, there were not enough of them in captivity to provide a satisfyingly large sample. Their rarity and size make them difficult to stock in bulk. Instead, Anderson and Mather studied the red octopus: a smaller species also found in Puget Sound, but only about a foot long arm to arm. They could keep 44 of these smaller animals in a handful of ten gallon tanks left over from another experiment.

Anderson started by sticking his head as close as he could to the opening of each tank, letting the octopus inside get a good view of him. A short while later, he poked the octopuses with bristly test tube brushes, taking note of their reactions to being irritated. Then after another pause, Anderson dropped a shore crab—one of the octopus' favorite foods—into the tank. He recorded whether the octopus grabbed the crab immediately, quietly reached out an arm to secret it away, or waited until the next day to eat.

It turned out that individual octopuses were consistent in their reactions to the various situations Anderson put them in. An octopus who was bold in approaching Anderson's head would also grab at the test tube brush and pounce on the crab. Another octopus would be consistently shy, hiding from the experimenter, brush, and crab, while still another would ink in response to offending objects.

The statistics showed what Anderson had predicted: Certain kinds of behaviors tended to group together, forming consistent "temperaments," such as active, reactive, or avoidant. Members of the same species could differ dramatically from one another, and the profiles of

their reactions were consistent over multiple situations. If they had run their statistics in the more conventional way, most of these individual differences would have been swept under the carpet. Focusing on octopuses one at a time allowed their individuality to shine through.

Anderson and Mather published their paper in 1993 in the *Journal of Comparative Psychology*. Their title, "Personalities of Octopuses," was the first time in scientific literature that the word "personality" had been applied to an octopus—or any animal without a spine.

Though we take human personalities for granted, the observation that individual octopuses can differ from one another in consistent ways has led to a more probing evolutionary question: Why would octopuses need personalities? Anderson offers one potential explanation. Just as not all environments are created equal, neither are octopuses. A variety of personality traits may be a simple indication of the fact that animals like octopuses find themselves in a comparable diversity of environments and situations—some of which are better suited for one personality type or another. "A shy animal might hide under a rock, but maybe it won't be able to find enough food," he explains. "Whereas an aggressive, bold animal will be out able to catch food, to go off and find that crab, but it might get eaten by another fish or another octopus."

"Different personalities survive better in different places," Anderson says. "Everything points to survivability one way or another."

But to find personalities in an animal like an octopus is far more surprising than in an animal that at least vaguely fits the mold of an intelligent animal. Compared to most mammals, octopuses have remarkably short lives. Chimpanzees can rack up 30 or 40 years, while elephants and whales have been known to celebrate fiftieth birthdays. Humans, of course, live significantly longer than any of these. Octopuses pose a stark contrast: In captivity, the giant Pacific octopuses only live about three years, but they don't fare much better in the wild, only occasionally making it to four or five years of age. Most other octopus species live for a year or less.

Intelligent animals also tend to be social—another convention that octopuses defy. Elephant herds trek the African savannahs together, while baboon troops are so cohesive that their social hierarchies persist for generations. But octopuses avoid each other's company as much as possible. Aquarists have learned the hard way to keep octopuses individually in separate tanks, since they are far more liable to kill one another than foster positive intra-octopus relations.

These qualities of sociability and lifespan may not be the actual determinants of intelligence, Mather says. Instead, she says, we need to consider the animal's ability to learn. And as it turns out, "octopuses—and other cephalopods too—are learning machines."

But Mather acknowledges that the short lifespan combined with their extraordinary learning ability make octopuses something of a puzzle. In the past, many scientists have explained an animal's propensity for learning by saying that their long lives meant they would have many opportunities to use what they had learned. "It's one of the paradoxes of the area," she says. "Why are they so dependent on learning when they don't live for very long to use it?"

Mather suggests that one answer to that question may lie in the evolutionary history of the octopus. Though they look nothing like clams or snails, octopuses are mollusks. More specifically, they are cephalopods: a group of animals that includes squid, cuttlefish, and nautiluses. The nautilus is the most ancient of cephalopods—sometimes referred to as "living fossils" by scientists. Unlike octopuses, nautiluses are known for their ornate and beautiful shells, which they carry with them at all times. From the nautilus emerged the cuttlefish which, instead of a large outer shell, has a smaller cuttlebone that sits just inside the mantle and helps it stay buoyant. The most recent relatives of the octopus are their squid cousins, which have ten appendages: eight arms like their octopus brethren, plus two longer specialized feeding tentacles.

Over the course of this evolutionary story, protective shells began to slowly disappear. The nautilus carries its home with it wherever it goes, and can quickly retreat whenever a situation becomes dicey. Cuttlefish have a smaller protective advantage, while squid and octopuses have virtually none at all. In order to compensate for this vulnerability, Mather says, octopuses may have gained intelligence and the ability to learn quickly. "My theory is that they evolved in a quickly changing environment," she says. "And the pressure was extraordinary to develop intelligence to cope with it." It is plausible, she continues, that "the more heavily dependent you are on learning, the more different things you might be able to learn, and therefore the more different you might be from other individuals of your species."

In response to the notion that octopuses don't live long enough to make use of their intelligence, Anderson points out that lifespan is a relative measure. Instead of just comparing the octopus lifespan to other conventionally intelligent animals, Anderson says, we have to put them in context of the entire animal population. "They don't really have a short lifespan," he says. "A mayfly may live only a day as an adult, but they live long enough to reproduce." Compared to animals like chimps and dogs, octopuses do seem short-lived. But putting them in the spectrum that includes insects—of which there are over 900,000 species and more than a billion times the number of individuals as humans—and other animals makes their lives seem both long and prosperous.

"So my point," Anderson says, "is that personalities are evidenced on an individual level, not a population level, and not the species as a whole." And whether looking at the behaviors of humans or octopuses, individuals will always be slightly different from one another.

"It turns out," Anderson says, "that no octopus is a population."

Still, there is discomfort that accompanies describing what Mather and Anderson have observed as "personality." Mather acknowledges that the word makes a lot of people uneasy, but attributes much of that discomfort to a common misconception about evolution. Though evolutionary science would not emerge until more than two millennia later, the idea of the Great Chain of Being was proposed by Aristotle in the fourth century B.C. Aristotle imagined a universe in which all creatures were ordered on a ladder of life. The lowest life forms were the most primitive, with humans perched on top of the chain. On each rung of this ladder could be only one creature, creating a perfectly scaled hierarchy.

Though many of Aristotle's ideas were thoroughly trumped by Darwin and other subsequent evolutionary biologists—Aristotle, for instance, did not believe animals could

change or evolve from their current state—other ideas have lingered in cultural memory, if not that of science. To many, the word "evolution" conjures a feeling of progress, of the steady march towards the creation of a more superior species. But this is not how it works. Mather worries about how this persistent Aristotelian idea translates into a feeling that "evolution rises from the dumb stupid invertebrates and the closer and closer you get to humans the more you find intelligence and capabilities and all this kind of stuff. And we're just the peak of it." She describes how more current models of evolutionary history eschew the common tree model in favor of a web, beginning with one species in the middle and expanding outward in all directions.

Insisting on putting humans at the top of the evolutionary hierarchy as Aristotle did makes the study of animals all the more difficult, say Anderson and Mather, since it makes it far more difficult to see our place in the evolutionary web. Applying terms like personality to animals is one tool to confront our bias towards ourselves, and to help us see the profound complexity and depth of animal behavior without casting a condescending or pejorative light. If we choose to take a more open perspective and look at animal behavior objectively, who is to say that an octopus is less entitled to a personality than a person?

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Anderson and Mather have a pedagogic ally in the king of evolutionary theory: Charles Darwin himself. Before Darwin's arrival on the scientific scene, humans and animals were absolutely distinct, since animals were beasts while humans were endowed with a special something extra: a soul. But Darwin's insistence that humans and animals were subject to the same evolutionary pressures—and even shared common ancestors—forced his contemporaries to view the supposed differences between people and creatures with new eyes. Though he did not deny that humans had more "mental power" than apes, in *The Descent of Man and Selection in Relation to Sex*, published in 1871, Darwin proposed that there was "no fundamental difference between man and the higher mammals in their mental faculties."

Darwin was so emphatic about the similarities in the mental lives of humans and animals that in 1872 he published an entire book on the subject, entitled, *The Expression of Emotions in Man and Animals*. Though he favored primates, his understanding of animal emotion extended through the entire kingdom. "All have the same senses, intuitions, and sensations," he wrote, "similar passions, affections, and emotions, even the more complex ones, such as jealously, suspicion, emulation, gratitude, and magnanimity; they practice deceit and are revengeful; they are sometimes susceptible to ridicule, and even have a sense of humor; they feel wonder and curiosity; they possess the same faculties of imitation, attention, deliberation, choice, memory, imagination, the association of ideas, and reason, though in very different degrees."

The only difference between humans and other animals that Darwin seemed willing to concede was that only man "is capable of incomparably greater and more rapid improvement than is any other animal... and this is mainly due to his power of speaking and handing down his acquired knowledge." But in response to claims that no other animal is self-conscious,

uses language, has a sense of beauty, or believes in God, Darwin argued that hints of all of these could be found in animal behaviors. According to Darwin, if we could not see signs of an emotional life in animals, we were simply not looking hard enough.

But Darwin's generous assessment of the mental and emotional lives of animals did not remain in vogue for long. John Watson struck the first blow in 1913 with the publication of his article "Psychology as the behaviorist views it." Watson claimed that attempts to "*construct* the conscious content of the animal whose behavior we have been studying" could only cause problems, since it meant that results would be "interpretable only in the narrow realm of (really human) consciousness." Rather than spend time speculating about inner lives, Watson and other behaviorists focused their attentions on the external actions of both people and animals. This far more objective realm, they felt, was the only place to gain insight about either human or animal nature.

If the behaviorists pushed anthropomorphism to the edge of what was acceptable, the new science of ethology banished it completely. Led by Niko Tinbergen and Konrad Lorenz in the mid-20th century, ethologists renounced psychology entirely. Instead, they opted to study the behaviors of animals in their natural habitats, as far away from psychology labs as possible.

Tinbergen was determined to transform the study of animals. Rather than brushing aside animal instincts as inexplicable and mysterious behaviors, he set out a concrete way in which ethologists could ask and answer questions about what caused behavior.

He divided the questions we could conceivably ask about animal behavior into four categories. Looking deep into evolutionary history, Tinbergen said we could inquire both about the function of a behavior—why it helped the species survive—and about how the behavior was passed around the evolutionary web. Behaviors also have more immediate causes, which made up the second two of Tinbergen's four categories. Developmental questions look at how behaviors arise over the lifespan of an individual, while causal questions examine the specific hormones, brain areas or environmental triggers that make a behavior take place. Each of these four aspects of a behavior need to be studied independently. Only later, once all the data has been collected, can they be taken together to provide a complete picture of why a particular behavior exists.

Tinbergen's work was so revelatory that he, Lorenz and their colleague Karl von Frisch were awarded the Nobel Prize in 1973 for their profound contributions in transforming the study of animals into a rigorous science, replacing the guesswork-laden field that came before them.

As for anthropomorphizing non-human mental life, Tinbergen's response was simple: "Because subjective phenomena cannot be observed objectively in animals, it is idle either to claim or to deny their existence."

Roger Hanlon, a biologist whose work focuses on octopus camouflage, is one of Tinbergen's heirs. And as such, he has concerns that Anderson and Mather's science is operating under a framework that has become notably outdated.

Hanlon is an avid diver and underwater photographer, and he puts those skills to good use in his research. He has studied octopuses all over the globe, following them in their

natural environments and recording their activities in excruciating detail. And, for all his research acumen, he is best known—to the public—for one short piece of video he captured in the Cayman Islands in 1997.

The scene emerged in the middle of a study of octopus camouflage. In that investigation, he took octopuses out one by one in the wild and let them get used to his presence. As each individual animal got comfortable and began slowly searching for food, Hanlon attacked the animals with the camera. He rushed up to them as fast as he could, jamming his camera towards them, trying to startle them into camouflaging.

But with the sixteenth octopus, he took a slightly different approach. He had tried to startle the animal four separate times when he shifted tactics as he watched it swim behind a rock. Rather than darting up to it, Hanlon took his time, creeping towards where he was sure the octopus was hidden. Hanlon's camera was almost touching the octopus' body when it suddenly transformed. In about two seconds, the brown and bumpy side of a rock—seamlessly blended into the background—went shockingly white. The octopus jetted off the side of the rock, inking Hanlon and his camera, before setting down a few yards away and desperately trying to camouflage itself again on the sea floor. The video tape elicits gasps of surprise even from those who are familiar with the rapid camouflage changes of which octopuses are capable.

Hanlon has been catapulted into a kind of public fame thanks to that video, but most of his research takes place back in the laboratories at the Woods Hole Oceanographic Institute just outside of Boston. He has spent over 30 years raising more than 20 different species of octopus in his lab—tens of thousands of animals all together.

Following the model of ethology set out by Tinbergen, Hanlon's studies include field work with large groups of animals, even across several species. In one 2008 study of Indonesian octopus mimicry and foraging, Hanlon recruited seven volunteer divers to help him and another scientist track three different species of octopus over five days. All told, they collected nearly 500 episodes of foraging, which they then painstakingly analyzed in a search for the kinds of concrete factors that would make an octopus camouflage in one particular way or another.

And each micro behavior he observes is excruciatingly defined. Indonesian octopuses, for instance, even needed to have "crawling" spelled out. (For the curious, crawling apparently consists of "the continuous slow movement of the mantle from one physical location to another when the arms were in contact with the substrate.")

Why bother to define crawling, a behavior most humans surely know by sight? We may know what crawling looks like when a human does it, but unsurprisingly, octopuses move very differently from humans. In order to ensure that they observe what is actually there, rather than what resembles human behavior, Hanlon and other ethologists feature stacks of painstakingly specific definitions in their work.

Deciding which of Tinbergen's four questions a study can answer is the first step in Hanlon's work—or in that of any of the modern ethologists. That choice leads to months of preparation, planning, and scrutinizing the experimental model. Addressing each of the four questions has a different approach and a different set of methodologies that, if conflated, can

muddle the results of a study. Compared to the more qualitative work of Anderson and Mather, Hanlon studies fewer behaviors, incorporates larger samples, and observes animals in their natural habitats—a combination of techniques which he and other ethologists feel is a more concrete and robust way of learning about how animals actually behave.

This, to Hanlon, is the real contribution that Tinbergen and other pioneers of ethology made: liberating animal science from the muddled observations of comparative psychology, turning it into a real, quantifiable science.

"You've got to measure X number of animals," Hanlon describes, "you've got to have a statistical design, you've got to sort your question or hypothesis out to whether it's causation, development, function or evolution. These are things that the card-carrying leaders of ethology do, and the two authors we're talking about have just never gotten into that field."

By contrast, Anderson and Mather's research falls into what Hanlon describes as alpha-level behavior studies. Instead of focusing on just one aspect of animal behavior, they study a relatively small number of animals and observe as much as they can about them. Their landmark 1993 study, for example, followed just 44 animals across multiple situations: interacting with a human, being aggravated by a brush, and receiving food.

Hanlon is respectful in his acknowledgments of the contributions that Anderson and Mather have made to studying octopuses, but worries that in an effort to raise provocative ideas, they are pushing the little data they have. Alpha-level descriptions are useful for setting up experimental questions in the future, but extrapolating solely out of observation without doing the rigorous experimental science can get risky. "It's not a criticism," Hanlon insists, "but it's the extrapolations that you make out of that initial level where folks can get in trouble."

Pushing an interesting idea without accumulating more data is hardly an isolated problem. Hanlon describes the case of a 1991 study in Italy that claimed to demonstrate that octopuses are capable of observational learning: that is, learning how to do something simply by watching another animal of their species, in the same way humans and other primates do. The study was not particularly well constructed, relying on color targets even though octopuses are colorblind. Even though no one has been able to replicate the results of the study since it was published over 20 years ago, the authors have continued to promote the idea anyway. "We think octopuses might be able to watch other species and perhaps learn from that observation," Hanlon says, "but the 1991 study is not a convincing case of observational learning *sensu stricto*."

"It's the slightly more subjective side of science that we like to think doesn't exist," Hanlon says.

Anderson and Mather's work could fall prey to that same tendency. Their studies are small, under tight budgets, with few animals and less rigorous experimental design. It is perhaps not appropriate, Hanlon points out, to draw conclusions as large as attributing personality to animals from such observational rather than experimental studies.

Moreover, Hanlon dislikes using words like "personality" to describe the behaviors that he and other scientists observe. In the struggle for objectivity, ethologists strive to get rid of as much baggage that comes with language as possible. Hanlon describes how dedicated

ethologists even avoid using terms like "aggressive display," since what we think of as aggression may not apply at all to the animal's real behavior in context.

Lest we think Hanlon is being overly stingy with his terms, it is worth noting that this kind of mistaken projection is startlingly easy. Octopuses and their squid cousins are often dragged out of the sea—by scientists on purpose and fishermen by accident. Squid and octopuses share their remarkable color changing ability, and the moment they are dragged onto a ship's decks, they turn a bright fiery red. A giant animal turning a flashy color is a nearly unmistakable sign of aggression: a threat to anyone who might mess with it.

Or not. In deep blue water, it turns out, red absorbs more light than any other color. An animal that turns red is doing the exact opposite of displaying aggression or trying to start a fight. It is trying to hide.

Whether using the term aggression or personality, Hanlon worries that the baggage that comes along with using a human term can take the conversation about animal behavior in the wrong direction. Instead of focusing on the objective behavior itself, we then spend our energy comparing what the animal does to what humans do when they are aggressive or displaying a particular personality trait. More than any other word, personality poses a vexing problem—it's got the word "person" right up front.

"I think Jennifer [Mather] did the right thing by bringing the subject up," Hanlon says. "I think she did the wrong thing by continuing to use the term personality, because it evokes expectations that cannot be met with scientific data."

As unglamorous scientific tasks go, writing definitions ranks pretty high. Coming up with a seamless definition of what an experiment is studying and measuring is of vital importance, and often a far from simple task. In the behavioral sciences, this struggle is ever present. Eventually, definitions come to plague just about every scientist who studies complex behavior.

Even in humans, there are many behaviors for which we have no real definitions. A classic example is that of play. Studies peppering fields from child development to comparative psychology throw out related words and ideas that get at the general gist of what play feels like, but with no actual consensus. It certainly seems that play is somehow related to good feelings, and maybe to social interaction, but beyond those broad concepts, play is tough to pin down.

More than other behaviors, play is especially problematic because its function is hazy at best. Many behaviors are defined in part by the purpose they serve: aiding cognitive development in the case of humans, for instance, or helping an animal forage. But play has no concrete role that we know of. Some scientists have gone so far as to try to define play by that very lack of function, but these attempts generally earn skeptical nose wrinkles and discontented sighs from the rest of the scientific community.

Play often comes down to that most disdained of pseudo-definitions: We know it when we see it. Watching a playground full of children tossing balls and building sand castles, giggling and shoving each other, we seem to know—or at least feel—that play is taking place.

And if we know it when we see it in human children, it certainly feels as though we see it in octopuses.

As the aquarist in charge of the octopus exhibit, Brorsen's mornings begin before the visitors are allowed in, as he makes a survey of the visitor's side. There are a handful of other fish in the tanks with the octopuses, largely for effect. Since the octopuses are so well fed, they mostly leave the fish alone. But occasionally Brorsen will notice a fish that's been attacked overnight—sometimes still swimming around with a big bite taken out of it—and will promptly remove it before the visitors arrive.

After the morning survey, Brorsen heads behind the exhibit. Right now, all the extra tanks on the ground are empty. Part of Brorsen's job as the aquarist in charge of the octopus exhibit is to acquire new exhibit animals, who will go in these tanks when they arrive. Though giant Pacific octopuses do live in the Monterey Bay, Brorsen has found that the most reliable source of good display animals is a couple of fishermen in Vancouver, B.C., who send their catches to Brorsen via UPS in giant wooden barrels. When the octopuses arrive at Brorsen's tanks, they are around 5 pounds. Within six months, they will grow to 65 pounds or more.

The two display tanks are up a small set of slip-proof stairs, and removable Astroturf walls barricade the tanks themselves. Brorsen spends the rest of his morning checking up on his charges, ensuring their tanks are clean and that they have not found some way to burrow impossibly behind a narrow crevice in the rock wall. Every other day, he feeds them a large meal of about 10 shrimp or pieces of fish, with a smaller snack on off days.

Feeding the animals and cleaning tanks are standard issue tasks within the aquarium. But there is one activity that sets the octopus exhibit apart from others: these aquarists must play games with the octopuses.

Brorsen pulls out a box from underneath the stairs leading to the giant octopuses, filled with colorful plastic toys in many different shapes. The theme of the toys is fairly consistent. They present a challenging puzzle to the octopus, the reward for which is the food hidden inside.

Brorsen chooses an oblong red toy with a few holes scattered around its surface. He rubs a shrimp all over it to entice the octopus to play, and then puts a few more shrimp on the inside of the ball. He climbs back up the stairs and holds the toy just above the female octopus' head. She is once again camouflaged and nearly impossible to tell apart from her rocky surroundings. Still disguised in rock colors, she gingerly reaches out an arm to grab the toy from Brorsen's hand.

She pulls it tightly into her body, burying two arms into the narrow holes to make a grasp at the shrimp inside. She wrestles with the ball for a while, turning it over and plunging arms in and out. Watching her struggle for her prize, I am struck again at the constant movement. With eight arms and a head, something is always wriggling. She almost appears to be wringing herself out, corralling her arms together, trying eight different ways at once to accomplish her goal.

Octopuses are easily bored, so they need to have play dates almost every day. The octopuses' need to be stimulated is so widely recognized, in fact, that it is required and regulated by the American Zoological Association. But there are also purely practical reasons the aquarists give the octopuses toys: Sometimes the animals need to be distracted long enough to allow an aquarist to fish something out of the tank without being latched onto by an eagerly exploring arm or several. The octopuses also seem more content in their tanks when they are played with regularly, and they live longer lives.

Toys are just one of several options to keep an octopus interested. Brorsen frequently invents games to play with them, and sometimes trades notes with the handlers on the sea otter exhibit (where he lends a hand from time to time) who have to come up with new games and puzzles for the otters on a nearly daily basis.

Roland Anderson has also witnessed some pretty extraordinary moments of octopuses entertaining themselves. He once peered over a tank to find a giant octopus taking a ball in its arms and tossing it to the far side of the tank. The current on the surface of the water generated by the filter brought the ball slowly back into its arms. The octopus picked up the ball and tossed it again, over and over. Anderson immediately got Jennifer Mather on the phone. "He's playing catch!" he exclaimed.

But ethologists like Hanlon take issue with Anderson and Mather calling what they saw "play." However much it might resemble a game of catch between two people (or really, a person and a wall of water), our lack of a concrete definition makes it impossible to say whether the octopuses are actually playing. What definitions there are of play in humans dance around ideas of entertainment, social growth and practicing behaviors that will be important later in life. With animals, the definitions are even less concrete. To an octopus, play could be purely functionless behavior, or maybe it lends some adaptive advantages. No one has a real handle on what constitutes cephalopod play, let alone how to define or quantify it.

Our definition of play faces even bigger challenges if we want it to span both human and octopus behaviors. Tossing a ball may be an overlapping activity, but what about all those behaviors that are exclusive to two-armed creatures with spines versus invertebrate eight-legged animals? Or the other way around?

"I think it's a terrible idea that humans always try to relate everything to humans," Hanlon says. "It's nonsense. You can't understand how an animal's body plan, brain, and behavior work unless you understand where it lives and how it operates."

And though Hanlon's methods differ quite dramatically from Mather and Anderson's, this is one point on which everyone agrees. It would be impossible to draw any meaningful conclusions about octopus activities and what their significance might be without spending some substantial time learning about what an octopus' life actually looks like—and especially how that life differs from a typical human life story.

An octopus' short existence is fraught with risk and improbability. As soon as a female octopus watches the last of her 50,000 eggs hatch, she concedes defeat to her shrunken and starved body, the care of which she has entirely abandoned in order to most diligently nurture her brood. Each of her children is less than the size of a grain of rice at the moment of

hatching, though by the time they reach adulthood a mere couple of years later, their arms can reach up to twelve feet in diameter.

The 50,000 tiny, transparent hatchlings make their way to the surface of the water where they hide and feed in plankton beds. They drift through a proverbial adolescence among the plankton, utterly defenseless, spending all their energy on growing. The tiny octopuses have innumerable predators, including fish, marine mammals feeding on the plankton, and even other larger octopuses who find the hatchlings a tasty snack. "Everyone always asks me how many survive," says Anderson, "and I always say, on average: two." Two surviving octopus hatchlings are just enough to propagate the species, and most of the other 49,998 will die in this first short and cruel chapter of life.

As hatchlings, octopuses are all head with only stubs for arms. As they develop, the hatchlings take on more features of an adult octopus. Their arms start to grow dramatically and they sprout numerous suckers. At a certain point, the octopus outgrows the relative safety of the plankton bed, too visible now to hide effectively, and it drops onto the ocean floor, where it will spend its adulthood.

Even during their time huddled together in the plankton beds, octopuses are deeply solitary creatures. As adults, they prefer to live as far away from one another as possible. On occasions when octopuses do take up residence close by—perhaps in different sections of a sunken shipwreck, as they have been known to do—they are awkward roommates, avoiding interaction as much as they can. For the most part, octopuses make their dens in secluded spots with hard walls: a hole in a rock wall, beneath a large boulder, or inside a coral. Octopuses have little concern for the size of the doors to their homes, since their flexible bodies can squeeze through tiny openings limited only by the size of their beaks.

An octopus spends the overwhelming majority of its days hiding from predators, and the small remainder is spent hunting. Octopuses are generalists—especially since they can use both their arms and some implements to crack the shells of tougher prey—though they are unabashed carnivores. After a hunting expedition, an octopus can sometimes be seen scuttling along the ocean floor, crab in eager grasp, secreting back to its den so it can eat without fear of being hunted itself.

The only moment in an octopus' life cycle during which it willingly interacts with another member of its own species comes towards the end. Spurred by a sudden chemical shift, an octopus will begin to seek out a mate. A male may briefly court a female and then, if she is willing, the copulation will begin. The event is brief. From the first moment of meeting to the post-coital departure, maybe four hours will elapse.

And even for such an intimate act, octopuses are capable of maintaining impressive distance. The male octopus' third right arm is specially equipped to deliver packets of sperm to the female, which he places inside her mantle. Though this is often done with the male sitting on top of the female, the female is sometimes not interested in leaving her den. In these cases, the male tries to assess whether the female is receptive, and if he gets the go-ahead, will simply pass the sperm packet to her through a small opening in her den wall.

Sex and death are intricately intertwined in the life cycle of the octopus. Almost immediately after mating, male octopuses goes into a state called "senescence" which eerily

resembles human dementia. Mather sometimes chides Anderson for using "Alzheimer's" to describe this state, "but it's not Alzheimer's," he admits. "It's not a disease; they all go through it." They stop eating, abandon their dens, and float listlessly in the water. They don't bother avoiding dangerous obstacles, running into stinging sea anemones and allowing themselves to be caught by larger predators without a fight. Their skin sometimes develops lesions, and they lose coordination of their arms. Some octopuses go so far as to throw themselves onto nearby beaches, where they wait for the sun to fry them to a crispy death.

Females manage to hold it together long enough to lay their eggs in the safety of their dens, though like their former partners, they also stop eating—even refusing food offered by curious and concerned human divers. As soon as the last hatchling leaves the nest, the mother octopus allows herself to die. "Octopuses reproduce, and then they die," says Anderson. "I like to say there's no such thing as safe sex for the octopus."

So what happens when we try to compare the behavior of this animal to humans? According to Hanlon, nothing good. "They're soft-bodied, everything's trying to eat them, and they do have a wide range of behavior and skin-patterning capabilities that allow them to compete in the highest circles," he says. "I think that is elegant! But everyone wants to know if an octopus is smarter than their dog. And it's such a ridiculous question—you can't make those comparisons. A dog would look totally stupid in the area where an octopus lives. An octopus would look totally stupid to most humans who see what it does. It's the wrong question."

David Sinn seeks to bridge between Hanlon's views and those more sympathetic to the idea that other species possess discernable inner lives. Sinn is a biologist who studies squid at the University of Tasmania. Even though he is a professed student of animal personality, he agrees with much of what Hanlon has to say. He uses the word personality with trepidation—in fact, in many of his published studies, he uses the more formal "behavioral syndrome" to avoid the kind of baggage that both he and Hanlon want to circumvent.

But Sinn does not want to throw the baby out with the bathwater. Simply because the term personality comes with a lot of unfortunate baggage is not a good reason to discard studying individual animals and their different responses to stimuli. In order to really understand the behavior of a whole species, he says, we need to spend time learning about why the individuals in that group behave the way they do. The more we know about individuals, the more we can put together a picture of the mechanics of how a group of those individuals behaves.

Even more than the baggage that accompanies the terminology of studying animal personality, Sinn has found a surprising challenge in his field. More than once, he says, scientists turn out to choose the wrong behavior to study all together.

Honeybees, like octopuses, have been a frequent target of individual-level personality studies. Sinn is particularly interested in one study that attempted to measure the personality differences among bees when it came to experiencing a new environment. The scientists responsible for the study put bees in locations they'd never seen before, and tried to measure the bees' individual responses. They found nothing of significance—the bees appeared to change their response at random on different days.

But then they looked closer at the data. "It turns out some honeybees tend to take a slower time investigating different food sources," Sinn says, "and they're actually more accurate in choosing food sources that are good for themselves." In contrast to these deliberate bees, other individuals investigate their environments less, and tend to make more mistakes while foraging. They gain some advantage in their speed, but the tradeoff is their lack of efficiency. And this kind of tradeoff, speed versus efficiency, turned out to be a perfectly consistent personality trait on an individual basis.

Sinn finds these kinds of mistakes fascinating. Looking at the life cycle of the species can sometimes help scientists choose which behaviors tend to vary among individuals, but realistically, it is a struggle, and not always a successful one.

More than telling us how much we know about animals and their behavior, the kinds of actions we observe may say more about the psychological lens humans use to view the world. "We know as humans that we can prime humans to perceive different things," Sinn says. "I reckon next time you look at a honeybee you might pay more attention to the speed that it's traveling and see if you can pick out individuals that are slower and spending more time to investigate things than others."

Sinn has mixed feelings about using the word "personality" to describe what he studies, and in conversation he often goes back and forth between the softer term and its harder scientific replacement "behavioral syndrome." Even though he clearly recognizes that what he studies is not the same thing as human personality, he sees some advantages in using the word.

"Certainly in the lay community, we forget that we're actually animals," he says. "To me, using similar terms to describe us and other animals, and finding out that other animals actually have similar neurotransmitters and neuro-synaptic circuits, and they react to things on a biological level in a very similar way to humans, I think that's essentially confronting for a lot of people."

"It's all my own personal opinion," he offers, "but I think we as a human society think of ourselves quite differently from animals. And I think there's some truth in that, but it's confronting as well to think about the similarities that occur."

So where does this investigation leave us? Do octopuses have personalities, or not?

Researchers like Hanlon and Mather come from radically different backgrounds and bring different skill sets to the table. Mather's comparative psychology background makes her something of a dreamer, a provocateur, throwing out interesting ideas that challenge how we feel about humans' proprietary hold on traits like personality. Hanlon is in some ways a better scientist: more objective, careful, and experimental.

But in spite of their differences, below the surface, they share a fundamental accord. Everyone agrees that animal studies are important, and that differences between individuals of a species can be extraordinarily telling. Delving deeply into individual behaviors, focusing on

the noise of an experiment rather than the mean, provides fascinating insight into how behavior arises. But can we—should we—call this personality?

Hanlon and Mather represent two camps that, despite their opposition, share the same goal. In order to avoid pejoratively describing animal behaviors in contrast to humans, Mather tries to spread around human labels as widely as possible. And in order to avoid pigeon-holing animals into human expectations, Hanlon strives to avoid the terms all together.

In the end, our feelings about whether personality is appropriately applied to octopuses tell us less about the octopus' behavior, and more about us. We are only human, and as such, tend to view the world through a human lens. It is simple for us to identify each other as shy or outgoing, personable or aggressive, because we know how to identify each of those types of people at a cocktail party. So when we see hints of those traits in creatures that are not human, we rush to relate to them in the best way we know how: by identifying and categorizing them with human terms. It is in some ways sweet, and in others tragic, that the only way we know how to make animal behavior intelligible is to take it out of the realm of animals, and bring it into that of humans.

Whether octopuses have personalities may well be the wrong question, misguided by an addiction to human terminology. It is better, perhaps, to ask: What does the octopus do? And what can we learn about the beauty of diversity of creatures by observing its fascinating and decidedly non-human behaviors?

The day I visit the aquarium is Brorsen's last day in the octopus rotation. His day does not look much different from the others: feeding and playing with the octopuses in the morning, making rounds and checking in on other exhibits in the afternoon. Except these days, he has also been training his replacement, a younger woman who is very eager to get her hands into the octopus tanks.

After today, Brorsen will take over care of the shale exhibit, where he will help design the jewel cases that house tiny fish and plants. Aesthetically speaking, it's not a bad job, but Brorsen's voice is soft and low as he describes his transition. Given the staff lottery and the overwhelming popularity of the octopus exhibit, it is unlikely he'll ever be placed on this exhibit again.

I have watched an animal as alien-looking as one I will ever have the chance to see up close roll over onto her back for Brorsen, like a dog asking for a belly scratch. Her arms curled naturally around his fingers, wrapping around his wrists gingerly and sucking eagerly.

Who knows what I felt that day at the aquarium—perhaps just a bond with a fellow animal, perhaps a projection of my wonderment. But the argument about whether this animal has a personality or not, whatever that means, cannot take away the profound beauty of this strange creature. Brorsen will miss his octopuses. So will I.

NOTES

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