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Other Minds: The Octopus and the Evolution of Intelligent Life
by Peter Godfrey-Smith

In 1815, fifteen years before he made his most famous print, *The Great Wave*, Hokusai published three volumes of erotic art. One of these volumes contains the woodcut print known in English as 'The Dream of the Fisherman's Wife' and more simply in Japanese as *Tako no ama*, 'Octopus and Shell Diver'. It depicts a naked woman lying on her back, legs spread and eyes closed, while a huge red octopus performs cunnilingus on her. The octopus's slit eyes bulge between the woman's legs and its suckered limbs wrap around her writhing body. A second, smaller octopus inserts its beak in to the woman's mouth while curling the thin tip of an arm around her left nipple. Early European critics saw Hokusai's print as a scene of rape. It would have helped had they read Japanese. Around the three entwined bodies are the words of their shared ecstasy. 'You hateful octopus!' the shell diver exclaims, 'Your sucking at the mouth of my womb makes me gasp for breath! Ah! Yes…it's…there! With the sucker, the sucker!...There, there!...Until now it was I that men called an octopus! An octopus!...How are you able?...Oh! Boundaries and borders gone! I've vanished!'

The octopus threatens boundaries in more ways than one. Its body, a boneless mass of soft tissue, has no fixed shape. Even large octopuses – the largest species, the Giant Pacific, has an arm span over four metres, and weighs 100 pounds – can fit through an opening an inch wide, or about the size of its eye. This, combined with their considerable strength (a mature male Giant Pacific can lift 30 pounds with each of its 1600 suckers) makes octopuses notoriously difficult to keep in captivity. Many aquarium octopuses escape their tanks through small holes or by lifting their lids, making their way, sometimes across stretches of dry floor, to a neighbouring tank for a snack, or to the nearest drain, and occasionally back home to the sea. Octopuses also lack any stable colour or texture, changing both at will to match their surroundings: a camouflaged octopus can be totally invisible from just a few feet away. While octopuses, like us, have centralised nervous systems, they lack a clear distinction between their brains and bodies. Most of an octopus' neurons are dispersed through its body, allowing its eight individual arms to act intelligently all on their own, grasping, manipulating and hunting. (Octopuses have arms, not

tentacles: tentacles have suckers only at their tips. Squid and cuttlefish have a combination of arms and tentacles.) Perhaps most strikingly, octopuses are highly intelligent when, in a sense, they have no right to be. The last common ancestor between octopuses on one hand, and humans and other intelligent animals (monkeys, dolphins, dogs, crows) on the other, was probably a primitive, blind worm-like creature that existed 600 million years ago. Other creatures that evolutionarily distant from us – lobsters, snails, slugs, clams – rate pretty low on the cognitive scales. But octopuses (and to some extent, their cephalopod cousins, cuttlefish) frustrate the neat evolutionary division between clever vertebrates and simple-minded invertebrates, exhibiting sophisticated capacities for problem-solving, learning, tool-use, mimicry, deception and perhaps even humour. Just how sophisticated these capacities are is a matter of scientific controversy: their very strangeness makes octopuses hard to study. What we do know is that octopuses represent a form of intelligence at once like ours and utterly unlike ours. Octopuses are the closest we can come, on earth, to knowing what it might be like to encounter intelligent aliens.

Peter Godfrey-Smith is a philosopher and diver who has been studying octopuses and other cephalopods in the wild, mostly off the coast of his native Sydney, for years. For Godfrey-Smith, the alienness of octopuses offers us an opportunity to reflect on the nature of cognition and consciousness without simply projecting from our own, vertebrate case. Because of their evolutionary distance from us, Godfrey-Smith writes, octopuses are an 'independent experiment in the evolution of large brains and complex behaviour' (9). Insofar as we are able to make intelligent contact with them – to understand octopuses and have them understand us – it is 'not because of a shared history, not because of kinship, but because evolution built minds twice over' (9). The worry, of course, is that the evolutionary chasm between the octopus and us is too great to make such mutual intelligibility possible. If so, the octopus will have something to teach us about the hard limits of our own understanding.

An octopus is an eight-armed, soft-bodied mollusc. Its arms are covered in suckers and arranged radially around a sharp-beaked mouth; an octopus eats by catching prey with one of its arms and moving it through a conveyer belt of its undulating suckers to its mouth. Thus an octopus' arms can alternatively, if somewhat abjectly,

be thought of as its lips. Resting on top of its arms is the octopus' head, which contains the animal's brain and features two large eyes with horizontal, dash-shaped pupils, like a cat's eyes turned on their side. At the back of the head is the octopus' mantle, a large bulbous structure that contains the vital organs, including three hearts that pump blue-green blood. A tubular siphon is attached to the mantle, which the octopus variously uses for jet propulsion, respiration, excretion and inking predators. A full-grown octopus can range in size from the Giant Pacific and its four metre arm span, to the 2.5 centimetre long *Octopus wolfi*, which weighs in at less than a gram.

Octopuses, especially of the larger variety, are perhaps unsurprising objects of fear. Linnaeus called the octopus *singulare monstrum*, 'a unique monster'. In his *Natural History of Norway* (1752), Erik Pontoppidan, bishop of Bergen, described the Kraken, a giant octopus-like sea monster capable of dragging down 'the largest man of war' in its arms, or sucking it down in the whirlpool of its wake. A similar creature, the Akkorokamui, with huge eyes and the ability to amputate and regenerate its limbs, is found in Ainu folklore, and is worshipped in Shinto shrines throughout Japan. Victor Hugo's *Toilers of the Sea* includes a long description of the octopus or 'devil-fish':

> If terror were the object of…creation, nothing could be imagined more perfect than the devil-fish……This irregular mass advances slowly towards you. Suddenly it opens, and eight radii issue abruptly from around a face with two eyes. These radii are alive: their undulation is like lambent flames… A terrible expansion!...Its folds strangle, its contact paralyses. It has an aspect like gangrened or scabrous flesh. It is a monstrous embodiment of disease...Underneath each of [its] feelers range two rows of pustules, decreasing in size...They are cartilaginous substances, cylindrical, horny, and livid…A glutinous mass, endowed with a malignant will, what can be more horrible?

Octopuses are indeed glutinous; according to Sy Montgomery, author of the splendid *Soul of an Octopus*, octopus slime feels like a cross between drool and snot. But the octopus' will is far from malignant, at least when it comes to humans. Octopuses very occasionally attack people, giving a venomous nip or stealing an

underwater camera when threatened or annoyed. In general, however, they are gentle, inquisitive creatures. (Meanwhile, fishermen often kill octopuses by biting out their brains or bashing them against rocks, and in many countries they are eaten alive.) Divers who encounter wild octopuses will frequently be met with a probing arm or two, and sometimes be led by the hand on a tour of the octopus' neighbourhood. Aristotle, mistaking curiosity for a lack of intelligence, called the octopus 'a stupid creature' because of its tendency to approach an extended human hand. Octopuses can recognise individual humans, and will respond differently to different people, greeting some with a caress of the arms, and spraying others with their siphons. This is particularly striking behaviour in an animal whose natural life cycle is deeply antisocial. Octopuses live solitary lives in single dens and die soon after their young hatch. Many male octopuses, to avoid being eaten during mating, will keep their bodies as far away as possible from the female, extending a single arm with a sperm packet towards her siphon, a manoeuvre known as 'the reach'.

Just how clever are octopuses? An octopus has half a billion neurons, about as many as a dog. (For comparison, a human has 100 billion neurons.) Octopuses also have a high ratio of brain to body size, a sign of the 'investment' the animal makes in its own cognition. These metrics are a very rough guide to animal intelligence, since the number and complexity of synaptic connections between neurons can produce different amounts of brainpower. (Crows and parrots have small brains, but have been recently shown to be highly intelligent.) And the brain-to-body ratio measurement – on which the octopus scores high – does not take into account the two-thirds of the octopus' neurons that exist outside its brain. Moreover, a detailed understanding of the octopus' brain founders on the fact that its structure is completely distinct from that of our own. Thanks to our common vertebrate ancestry, the parts of even a bird or fish's brain exhibit a one-to-one correspondence with the parts of a human brain. But the octopus brain is built on a different model entirely; our brains prove no guide to theirs.

Scientists are thus left looking to the octopus' behaviour as the best indicator of its cognitive power. But here researchers are often frustrated by what Godfrey-Smith describes as a 'mismatch' between experimental studies on octopus intelligence on one hand, and anecdotal reports on the other. In the lab, octopuses do fairly well, navigating mazes, drawing on their memory to solve simple puzzles, and

unscrewing jars and child-proof bottles to get food. (Octopuses have also been filmed opening jars from the inside.) And yet it can take octopuses a surprisingly long time to be trained into new behaviours, which some researchers have taken as a sign of their cognitive limitations. Much of the early work on octopus intelligence was done at the Naples Zoological Station. In 1959, Peter Dews, a Harvard scientist, trained three octopuses there to pull a lever to obtain a piece of sardine. Two of the octopuses, Albert and Bertram, pulled the lever in a 'reasonably consistent' manner. But the third octopus, Charles, would anchor his arms on the side of the tank and apply great force to the lever, eventually breaking it and leading to the premature termination of the experiment. Dews also reported that Charles repeatedly pulled a lamp into his tank, and that he 'had a high tendency to direct jets of water out of the tank; specifically…in the direction of the experimenter'. 'This behaviour,' wrote Dews, 'interfered materially with the smooth conduct of the experiments, and is…clearly incompatible with lever-pulling'. Dews concluded his experiment a partial failure. Godfrey-Smith says this 'encapsulates much of the story with octopus behaviour'. Octopuses have a high curiosity drive, and a knack for repurposing the things around them for their own particular ends. Perhaps there are tasks that octopuses have difficulty learning. Or perhaps they just have better things to do.

Captive octopuses appear to be aware of their captivity, at once adapting to and resisting it. When octopuses try to escape, which is often, they tend to pick the one moment they are not being watched. They deliberately plug valves in their tanks with their arms, sometimes flooding the lab. At the University of Otago, an octopus short-circuited the electricity supply by shooting jets of water at the aquarium bulbs so many times that it had to be released back into the wild. Jean Boal, a cephalopod researcher at Millersville University in Pennsylvania, reported feeding octopuses in a row of tanks with thawed squid, a food not naturally loved by octopuses. When Boal got back to the first tank, the octopus had not eaten the squid, but was instead holding it out in its arm; watching Boal, the octopus slowly made its way across the tank, and shoved the squid down the drain. The third century Roman rhetorician Claudius Aelianus, a more sympathetic observer than Aristotle, identified the octopus' main characteristic as 'mischief and craft'.

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What does it feel like to be an octopus? Does it feel like anything at all – or are octopuses, as Godfrey-Smith puts it, 'just biochemical machines for which all is dark inside?' This form of question – does it feel like something to be a given creature – is philosophical shorthand for asking whether that creature is conscious. Many philosophers think consciousness is an all-or-nothing thing: you either have it or you don't. Humans have it, as do perhaps chimps and dolphins. Mice, ants and amoebas presumably do not. Part of the motivation for the all-or-nothing view is that it is hard to imagine consciousness coming in degrees. Other cognitive attributes – like memory, linguistic capacity, problem-solving ability – are the sorts of things that can and do vary in strength from creature to creature, and species to species. But it is harder to see how consciousness itself can so vary. As Godfrey-Smith puts it, '[h]ow can an animal be halfway to having it feel like something to be that animal?' And yet, if consciousness is itself a natural thing, something that evolved over time, then it seems unlikely that it just popped up at some point in evolutionary history, fully formed.

Godfrey-Smith's proposal is to begin with the conviction that consciousness is an evolved thing, and embrace the conclusion that it has more primitive precursors: that it comes in degrees after all. Consciousness – the possession of an 'inner' model of the 'outer' world, or the sense of having an integrated, subjective perspective on the world – is just, on his view, a highly evolved form of what he calls 'subjective experience'. Many animals, Godfrey-Smith thinks, have some degree of subjective experience, even if not full-blown consciousness. His argument appeals to what the physiologist Derek Denton named the 'primordial emotions': thirst, lack of air, physical pain. When we experience them, these sensations intrude violently on our more complex mental processes, refusing to be dismissed. They hark back to a more rudimentary form of experiencing the world – a form of experience, Godfrey-Smith thinks, that does not require a sophisticated inner model of the world. 'Do you think' he asks, that pain, thirst and shortness of breath '*only feel like something* because of sophisticated cognitive processing in mammals that has arisen late in evolution? I doubt it' (91).

The case of animal pain underscores his point. Simple animals respond to physical harm with what appears to be distress, and there is experimental evidence that

suggests that they feel pain: that physical harm feels bad for them. Zebrafish, injected with what is presumably a painful chemical, will prefer an otherwise less desirable environment that has a painkiller dissolved in its water. Similarly, chickens will choose a feed that they do not normally prefer, laced with painkiller, when they have injured legs. While insects do not appear to feel pain – carrying on as usual even after major injuries – shrimp and crabs groom their injured parts, and will lessen their grooming when given anaesthetic. Of course, none of this is dispositive evidence that animals feel pain. But then it is not clear what would be. As Godfrey-Smith says, 'you can still doubt that these animals feel anything, yes. But you can doubt that about your next-door neighbour.' (95). If even simple animals have rudimentary forms of consciousness or subjective experience, what might that feel like? What does it feel like to be an injured crab? Here Godfrey-Smith reaches for a metaphor proposed by evolutionary theorists Simona Ginsburgh and Eva Jablonka: white noise. Primitive consciousness, he writes, might be like 'a crackle of metabolic electricity', an 'inchoate buzz' that grows, with evolutionary time, in complexity and clarity.

If consciousness comes in degrees, then how far along on the spectrum is the octopus? Octopuses almost certainly feel pain. They nurse and protect injured body parts, and show a preference not to be touched near wounds. (Until recently, researchers operated on octopuses without anaesthetic, and much early work on octopuses involved electric shocks. A 2010 EU directive on animal testing classifies cephalopods together with vertebrates because of their 'ability to experience pain, suffering, distress and lasting harm'.) In addition to feeling pain, octopuses also have sophisticated sensory capacities: excellent eyesight, and acute sensitivity to taste and smell. This, together with their large nervous systems and complex behaviour makes it all but certain, in Godfrey-Smith's view, that octopuses have a rich subjective experience. But they might have even more than this. According to some theorists, most notably Stanislas Dehaene, a certain kind of mental processing, the sort that involves completing novel tasks extended over time, goes hand-in-hand with human consciousness, and helps explain why we humans are conscious. The octopus' curiosity and adaptability to novel circumstances – at work when an octopus protests its squid-diet, say, or decides to take a scuba diver on an underwater tour – are, Godfrey-Smith suggests, 'reminiscent' of these

paradigmatically human forms of cognition. If so, then being an octopus might be more like being a human than we have thought.

The question of what subjective experience might be like for an octopus is complicated by the odd relationship between its brain and body. An octopus' arms have twice as many neurons as its brain, about 10,000 neurons per sucker, and the octopus' arms can taste, smell and exhibit short-term memory. An individual arm can act with considerable independence from the brain; even a surgically detached arm can perform actions like reaching and grasping, avoiding painful stimuli, and changing colour. (In *The Soul of an Octopus*, Sy Montgomery imagines an octopus testing human intelligence by seeing how many colour patterns our severed arms can produce in one second.) And yet an octopus' brain can also exert executive control, 'pulling itself together' when it needs to, for example when an octopus sends out only a single inquisitive arm to inspect a stranger. Godfrey-Smith suggests that the octopus is, phenomenologically speaking, in a kind of hybrid situation, where the octopus' arms are partly self, and partly other. Because of this, the octopus is sometimes taken as a mascot for the 'embodied cognition' movement in psychology, which stresses the way in which the physical body, by constraining and making possible certain actions, is itself 'intelligent'. The human ability to walk, for example, is not simply a matter of top-down brain-control, but also a function of the angles of our joints; in this sense, our bodies encode information vital for intelligent action. There is little doubt that an octopus' embodiment is radically different from our own, and that understanding an octopus' mind requires us to grasp its particular form of embodiment. But thinking about the octopus in terms of embodied cognition might undersell its strangeness. While our own bodies can be thought of in terms of the constraints and opportunities they afford, the octopus' body, as Godfrey-Smith says, is 'protean, all possibility'. Even asking how much the body contributes to intelligent action presupposes a division between brain and body that seems not to apply to the octopus. For the octopus' body is pervaded by nervousness. It is not a thing controlled by the animal's thinking part, but itself a thinking thing.

A further oddity in thinking about octopus experience has to do with the creature's relationship to colour. An octopus' skin is a layered screen of pixel-like sacs of colour called chromatophores, which allows an octopus to change its colour at will to match its surroundings or threaten an aggressor. The so-called mimic octopus can

impersonate more than fifteen different animals, including flounder, lionfish and sea snakes, by changing its colour and shape. An octopus' colour also seems to indicate its mood – some octopuses will go white after being caressed for a long time by humans, as well as after mating. The chromatic displays produced by octopuses can be arresting, including elaborate patterns of stripes and spots, flashing rings, and waves of rippling colour. And yet, octopuses (like most cephalopods) appear to be colour-blind. Their eyes lack the variety of photoreceptors required to see colour, and octopuses are unable to distinguish between differently coloured objects in experimental tests. How is this possible? Scientists are unsure, though researchers have recently discovered that octopuses have photoreceptors not only in their eyes but also in their skin. This suggests that octopus skin can not only taste and smell, but also see, either by sending the visual information it receives to the octopus' brain, or by processing the information itself. Both options are weird: either the skin as a whole becomes an eye, or the octopus' body sees independently of the octopus' brain. But even this is not the whole story, since the photoreceptors found in octopus skin are, like those in the octopus' eyes, insufficient to detect colour. The best going hypothesis is that some complex interaction between the skin's photoreceptors and chromatophores allows the octopus to turn colours it cannot see.

In the main octopuses use their colour displays for camouflage and signalling. But they also engage in elaborate colour displays for no apparent reason, in the absence of predators or other octopuses. Godfrey-Smith calls these purposeless displays 'chromatic chatter', suggesting they might just be an involuntary, metabolic effect. But one wonders if it is not something more intentionally expressive. Do octopuses talk to themselves? The problem with this tempting thought is that octopuses appear not to have language at all, and so presumably can no more talk to themselves than to others. (Wittgenstein famously argued for the conceptual impossibility of a 'purely private language', a language meaningful only to one person. Whether or not a private language is conceptually possible, it is evolutionarily unlikely, since the ability to talk to oneself appears to be a later internalisation of the ability to talk to others.) The megapixel screen of an octopus' body means that it could theoretically telegraph information of almost indefinite complexity – the sort of expressive bandwidth of which a chimp or baboon can only dream. And yet most of the chromatic signals produced by an octopus appear not to

have any reliable effects on other octopuses, suggesting that they are signs without meaning, words with no sense.

Most species of octopus live one or two years; the Giant Pacific, the octopus with the greatest longevity, lives for four years at the outside. Both female and male octopuses mate only once, and enter a swift and sudden decline into senescence soon after, developing white lesions on their skin, losing interest in food, and becoming uncoordinated and confused. Females die from starvation while they tend their eggs, and males are typically preyed on as they wander the ocean aimlessly. Most highly intelligent animals live significantly longer than octopuses, as do some other molluscs. Why the compression of the octopus' life? Aging in general is explained by evolutionary theorists by what is known as the Medawar effect: while natural selection tends to weed out mutations whose harmful effects appear early on in an animal's life, it is less likely to weed out mutations whose harmful effects only manifest later on. This is because most animals will succumb to death by predation, disease or accident before they reach the age where these late-acting mutations could manifest. Thus late-acting mutations will accumulate in a given animal population, eventually producing the appearance of a pre-programmed lifespan. In the octopus, the Medawar effect, coupled with an uncommon body plan, has resulted in an uncommonly early death. In its early evolutionary history, the octopus gave up its protective, molluscan shell in order to embrace a life of unboundaried potentiality. But this was bought at the cost of an increased vulnerability to toothy and bony predators. An animal with a soft body and no shell cannot expect to live long, and so harmful mutations that start showing their effects only a couple of years after the animal's birth will soon spread through the population. The result is a life that is experientially rich but conspicuously brief.

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Last month, on a drive from San Francisco to Los Angeles, I went to go see the octopuses at Monterey Bay Aquarium. At the time Monterey's permanent octopus exhibit housed two Giant Pacifics, though there were more octopuses in its temporary 'Tentacles' exhibit, the largest ever exhibit of cephalopods. This was my second encounter with a live octopus. (I have had more dinner table encounters with dead octopuses than I would like to recall. They sadly make for excellent carpaccio.

Never again.) My first encounter was just off a beach in Mykonos where I was snorkelling. There was not much on the sea floor, just small crustaceans and darting silver fish, until I saw a red mass a few feet away, about the size of a cat, watching me with a single eye. I stayed still, watching it back. The octopus made small, unhurried movements, curling and uncurling its arms, snuffling along the floor. Eventually it crawled to a sunken rope some feet away and wrapped itself around it. Its body became a brown, barnacled coil, and then there was only a single white eye with a black dash of pupil. The eye closed, and the octopus vanished.

At Monterey the octopuses were plainly in sight, with only remote possibilities of escape. The two Giant Pacifics were in side-by-side tanks a few metres wide. The first octopus was energetic, unfurling its huge body and then compressing it, uncoiling its arms and pushing its suckers against the tank walls, boiling and jetting its way back and forth through the water. Tourists took flash photographs despite the sign that warned that octopuses dislike bright lights. Children expressed admiration and disgust. When you're looking at an octopus, your attention naturally goes to its rows of suckers, coiling arms, bulging sac body. Its eyes, meanwhile, can look sleepy, half-closed. You have to know what you're looking for to see that they are open, and looking straight at you. I looked the octopus in the eyes and found it looking back at me, fixedly, as its body ballooned and hollowed behind it. The second octopus was quieter, bundled up at the top of her tank. A few thin strands of translucent, pearl-shaped eggs – laid and then painstakingly braided together with the thin tips of her arms – hung nearby, remnants of the clutch that had been removed by the aquarium keepers. Her skin was dull and white.

The logic of aquariums, like that of zoos, is the logic of conservation: individual animals must sacrifice their freedom so that the species as a whole can be protected. (As the philosopher Robert Nozick put it, 'utilitarianism for animals, Kantianism for humans'.) The conservationist logic is at its most compelling at an aquarium like Monterey, with its state of the art research centre, environmental policy unit, and public education programmes. Plenty of its creatures seem perfectly delighted to be there, as far as one can tell, and others seem perfectly unaware of where they are. No doubt many of these animals live longer and healthier lives than they would in the ocean. And yet there might be particular ethical questions raised by creatures, like the octopus, who so clearly yearn for freedom. Perhaps though the life of a wild

octopus is, from our perspective, already a tragic thing: sociality without society, speaking without being heard, a life-world without longevity. We could add to this list the octopus' alienness. If only the octopus were more like us, we might be better at leaving it alone.