

## There is so much for us to learn from Nature: The octopuses

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Humans have learned from Nature in many discoveries to enrich the multifaceted aspects of our lives. There is, however, one eight-armed cephalopod (octopod) mollusk of the order *Octopoda* and the genus *Octopus* that much has to be discovered and leaned: the octopus. Octopuses vary greatly in size: from the smallest (*O. arborescens*) of about 5 cm to as large as 5.4 m in length (an armspan of ca. 9 m). The typical octopus has a saccular body: the head with a pair of large and complex eyes is demarcated from the body, which has eight contractile arms. Each arm bears two rows of fleshy suckers capable of great holding power, taste, tactile and other sensations. The arms are joined at their bases by web-like tissues (or the skirt), and where the mouth is located at the basal center. The mouth has a pair of sharp, horny beaks with a file-like radula for drilling shells and rasping away flesh. Octopuses takes water into its mantle and expels the water after respiration through a short funnel or siphon, and move around by crawling along the bottom with their arms and suckers. When alarmed, they may mobilize swiftly backward by ejecting a jet of water from the siphon. Additionally, when endangered, they eject an ink-like substance as a screen for escape; the substance produced by some species paralyzes the sensory organs of predators. They can also change color and shape for camouflage during escape and may serve as a threatening sign to predators. The best-known octopus is the common octopus, *O. vulgaris*, a medium-sized animal that is widely distributed in tropical and temperate seas throughout the world. It lives in holes or crevices along the rocky bottom and is secretive by nature. It feeds mainly on crabs, lobsters, and other crustaceans, although some are plankton feeders; however, they are fed upon by a number of marine fishes such as sharks, skates and rays. The *O. vulgaris* species, thought to be the most intelligent of all invertebrate animals, has highly developed pigment-bearing cells and can change its skin colors momentarily to extensive myriad patterns of colors for camouflage or for preying and escape. Each pigment-bearing cell (chromatophore) is individually innervated from the brain. Another species, the veined octopus (*Amphioctopus marginatus*), is also known for its intelligence. In 2009, biologists reported having observed the animals excavating coconut half-shells from the ocean floor, and carrying them for use as portable shelters: a first documented example of the tool use by an invertebrate. A recently discovered species with pink and appealing eyes is so cute that it has known as “adorable” in Latin, or *Opisthoteuthis adorabilis*. Octopuses have separate sexes, and the male has a specially modified arm (or hectocotylus) through which it

inserts spermatophores (sperm packets) directly into the female’s mantle cavity. *O. vulgaris* mates during the winter, and the eggs (ca. 3-mm length and  $>1 \times 10^5$  in count) are laid under rocks or in holes. A period of 4-8 weeks is required for the larvae to hatch. The female guards the eggs, cleaning them with her suckers while consistently fanning them with water. Upon hatching, the tiny octopods, which closely resemble their parents, spend several weeks drifting as planktons before taking refuge to grow on the shallow bottoms of shifting seas.

According to ‘The Soul of an Octopus: A surprising Exploration into the Wonder of

Consciousness’ by Sy Montgomery, there are many things that the octopus can teach us. The hitherto most mysterious nature of oozing a 46-kg body through an opening smaller than an orange is just awe-inspiring; it is indeed difficult to find another animal more alien than an octopus in the world of science. The octopus possesses uncanny intelligence, distinct personality and superpowers humans can barely dream of. The recently identified octopus genome reveals that many genes are active in the octopus brain, color-changing skin, and sensation-orientated suckers.

Octopuses are the most remarkably intelligent mollusks, which includes the brainless clams. Invertebrate octopuses learn to recognize individual humans fast. They can also solve puzzles. In studies at the New England Aquarium, the octopus was required to open three plexiglass boxes, each nested inside the other, and each with a different lock, in order to retrieve a crab from the innermost cube. Every single octopus tested with the cubes figured them out. Octopuses can also open jars – and sometimes screw the lids back on – and they enjoy assembling and disassembling Mr. Potato Head and Legos. Current robots may need more time to catch up with octopuses in tasking.

They can lift lids (a single sucker can lift up to 13.6 kg) and gel through tiny cracks in relocation or escape. At a number of aquariums, octopuses have been known to sneak out of one tank and to sneak in another and to devour its rightful occupants. They are simply curious creatures that learn to survive.

A giant Pacific octopus, Athena, with an armspan of ca. 3-m length and a smaller octopus, Kali, at New England Aquarium respond to human sighting and touch. They stretch their arms and ‘feel’ their keepers and their ‘visitors’ with their suckers. On frequent visits, an octopus may ‘recognize’ his/her ‘friend’. The skull-free octopus brain wraps around its throat, and most of its neurons are

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in its arms and skin, which raises the possibility of diffuse consciousness or even multiple selves.

Octopuses show us alternate paths of thinking and wildly different ways of being. They stretch our minds in directions far more productive than fear. We have much to learn from them. They can offer humans as models for developing versatile gelation robots unconstrained by joints. Yes, as author Sy Montgomery says: Perhaps even more valuable; by demonstrating that intelligence is more varied and emotions more universal than humans can imagine, the octopus stretches our moral universe.