Visual Marvels

As there are many challenges to being a human being, if and when we are lucky enough to discover the existence of something that seriously beguiles us, it is cause for celebration. And, possibly the impetus for a Lansing Woman's Club research paper. Anything which can still inspire a sense of wonder in our beleaguered old world and jaundiced old sensibilities is a treasure.

Marine biologist, I am not, nor naturalist, nor scientist of any kind, but the appearance of what seems like magic in nature sometimes captures me and makes me wish I was all of those. These phenomena can present as fanciful, bizarre, beautiful, impossible occurrences like the Northern lights, a Morgan le Fay mirage, or the existence of Cephalopod Mollusks, the subject of my current paper.

If you have seen the film The Shape of Water, you are familiar with the strange, intelligent form of marine alien portrayed in the movie. The movie creature was anthropomorphic unlike the most shape-shifting of cephalopod, but there is, to me, some likeness in the strange beauty and intelligence of both.

Marine biologists frequently say that if a true alien could be said to exist in our time, cephalopods would fill the bill. One stated, "If superlatives of uniqueness were allowed cephalopods are the most unique of all." They are aquatic, intelligent, and mysterious, and, If you watch documentaries of them for very long you can become unable to tear yourself away from watching Octolab.

The classification cephalopod meaning head-foot partly references their appearance, but also the fact that some species have brains which extend into their limbs, and behave independently of the "central *brain". How "other" is that! Millions of years of evolution has produced invertebrates that are intelligent in ways that confound us. More frivolously, anyone who professes fondness for extravagant color in the world, presented with a magical sleight of hand might love them for that alone.

Cephalopods fall into 4 main classes: squids, nautilus and my personal favorites, octopuses, and cuttlefish. These later two are the dual subjects of my paper. Both are often referenced together, making it difficult to choose between them, so I didn't.

Cephalopods, except for the nautilus, long ago abandoned the exterior shell of a mollusk despite retaining the name. They are therefore classified separately from mollusks with shells, like snails for example. In fact, they are truly unlike anything else in the animal kingdom. Many species of octopuses and cuttlefish are capable of altering themselves instantaneously and with an almost infinite variation in color, size, and texture; in order to variously: Hide by mimicking their surroundings. Attract the opposite

wonderful to flow from one exterior to another as mood and circumstances fluctuate; variously hiding from, appealing to, or repelling the world. In cephalopods this range is described as "from conspicuousness to camouflage." And, if this variability weren't enough, some octopuses, will "dress" and then swim in coconut or conk shells in order to hide and move at the same time.

Cephalopod chromatophores enable them to look like seaweed on one side, rocks on the other in one instant and like one of their own enemies the next. Additionally, not just color and shape but their very texture changes. My own first awe-stricken introduction to their power was a documentary that showed a cuttlefish approximating the black and white checks of a checker board pattern that had been put in its tank. Since game boards do not occur in nature there could not have been practice affect.

Cuttlefish and octopuses are the fastest, most able assumers of new color and texture in all of biology, although colorblind themselves! People think of chameleons as talented color adapters and reference them to describe any human's frequent changes in appearance or behavior. They say, "That person is like a chameleon". Ha!

It takes one of these reptiles twenty seconds or more to change color, and this is actually done by altering how light reflects off of them. It takes certain species of cephalopod milliseconds and they can do it repetitively as their motivation and chromatophore selection change. How ironic that no one says of a changeable human, "They're like a cephalopod." They really should.

The patient scientists who count such things figure some cephalopod species perform an average of 177 color –texture changes per hour, as the priority of individual circumstance changes. Like Robin Williams in full swing, they must go from "I'm hungry, whoops there's a cute female, oh oh, another male, Eek there's a scary predator... each change requiring instant decision making.

Experts cite these practices as proof of intelligence, and why not? Cephalopods must make many spontaneous decisions based on a rapid consideration of their changing circumstance, rather like a Navy Seal in crisis mode. Both groups are good at evasion, deterrence, mimicry and distraction. Choosing between conflicting goals requires brains.

Another proof, recently noted is their ability to count like young humans, seeming to estimate the quantities of potential prey and choosing whichever most, despite relative similarity in numbers is. They'll consistently go for 5 shrimp not 4, or 7 crabs not 6. If the smaller bunch of edibles is bunched and the larger scattered, they still know which number is greater.

On the debit side of being a gifted cephalopod: it is a pity when almost everything wants to eat you. If able to avoid that outcome your miraculous intelligent life is still going to be very short. Cephalopods grow very fast after hatching fully developed. They

sex. Resemble an enemy so as to eat him or escape him. Communicate with each other (In the case of cuttlefish) and express emotion. Pretend to be female

Cephalopods are invertebrates of an advanced cognitive evolution, equal in stature to other intelligent vertebrate species, and far exceeding other invertebrates, with the largest "brain to body ratio" of that group. As smart as they are, they have none of the common evolutionary connections found in other intelligent species either vertebrate or invertebrate. They "came up" a different evolutionary path.

That alone would render them mysterious as does almost everything else about them. Even the evils of global warming seem to advantage the cephalopods of all subspecies, because warm water is their habitat of choice and the supply of that has increased. Huge numbers of them continue to be hatched, and they are currently on the Red List, which contains the world's least endangered animals.

Their advanced nervous systems don't" mesh" with ours. The closest ancestor humans share with the cephalopod is a rather ordinary worm that lived 600 to 800 million years ago and reflected rather poorly as an antecedent having only a primitive few neurons. This is unlike both people and cephalopods. Human beings are species-proud for good reason, but, cephalopods can sometimes both dazzle and befuddle us with their abilities, some yet unquantified.

The most obvious differences between octopuses and cuttlefish is in their exterior anatomy. An octopus has a round head and eight arms that radiate like spokes of a wheel. A cuttlefish has eight arms and two snatchy tentacles which project out the front, and it more closely resembles a squid. Both groups have hard beaks.

Other physical traits common to both cuttlefish and octopuses: both have 3 hearts, one for each gill, and one for the rest of the body. These pump copper infused bluish green blood. Both can jet propel themselves through water when speed is necessary.

But most marvelously, octopus and cuttlefish skin has been described as, "layered screens of millions of pixel-like sacs of color contained in chromatophores." There are 200 of these per millimeter. By flexing the associated muscles next to these chromatophores they can transform themselves ...over and over. These muscles change shape, texture and/or color; whatever is required and as fast as it is required.

This ability to alter their appearance so variously has been compared to the pushing of piano keys to play infinitely differing music. In some species of these cephalopods, for example, it enables the impersonation of more than 15 different animals, among them: flounder, lionfish, sea snakes or females of their own species that they want to sneak up on, but they can easily appear to transform into parts of their own backdrop.

This would be particularly enviable to anyone who has ever brooded over what to wear when faced with conflicting motivation and then despised their final decision. How

then sadly die young. This should be counter-indicated according to the rules of natural selection because most life forms with superior intelligence are longer lived. When they are not, part of the hardship in this means there is no possibility of passing on superior accrued wisdom and skill sets to another generation. How can your species expect to evolve? More on this later.

As early as the 3rd century AD cephalopods were observed by naturalists to be" mischievous and crafty", seeming to have personalities that vary like ours...in a way. For example cephalopods demonstrate personal preferences to certain human observers or caretakers.

One person who experimentally poked an octopus daily began to be automatically drenched with jets of water whenever he appeared and the octopus would display dark bands of color typifying anger. Sometimes they would squirt ink at the offender. Another, "nice" technician, about the same size and wearing the same kind of clothes was left dry.

Additionally, octopuses in captivity are often fond of raw chicken eggs, but if a rotten egg is inadvertently delivered, the octopus will quickly spit the nasty contents out, often into the face of the server, displaying the ability to hold a grudge.

Individual cephalopods of both species are known to behave in idiosyncratic ways, both in the wild and in laboratories. In labs, some cooperate with attempts to train them and some will have none of it; rather, they seem to enjoy sabotaging experiments. If an individual does permit itself to be taught it tends to hang on to the new skill indefinitely. Cuttlefish have been proven to have both short term memory (defined as an hour) and long term memory (defined as a year or more) based on repeated trials.

An octopus named Heidi began living in the home aquarium of David Shiel, a professor and cephalopod specialist in Alaska. Shiel remarked that, "He was recently divorced and as his wife took most of the furniture he was left with plenty of space." When Heidi first moved in her alarm and anxiety seemed obvious and she would change color almost non-stop, a sign of worry. After becoming used to the household and its rhythms she would pop up in the water at the same time each day to greet the teen-aged daughter returning from school. She clearly recognized her, grabbing onto her arm and changing an agreeable color. Heidi seemed to enjoy game playing with this young lady, catch in particular. The affection between the two was obvious. The girl had wanted a dog, but she got over it.

In fact, it is not uncommon for marine biologists and lab techs to develop a bond with one of their quirky test subjects, all the while knowing it wouldn't live very long. Cuttlefish are especially short-lived, at most a year and a half to two years. Octopuses can live from three to five years, but most cephalopods are doomed to die soon after mating.

The cuttlefish, of the order sepiidia, was so named because of the sepia color of their ink; a distinctive brownish red that artists are familiar with. It is another weapon in their arsenal. When squirted in bubbles covered in mucus it serves as a decoy, because it has a chemical which disguises smell and taste, providing temporary protection from predators. Cuttlefish ink has been used in dye and paints and as a natural medicine for centuries.

120 different subspecies have currently been discovered, some very recently and it is believed that more exist. They seem to cross breed creating more variations. Some are as small as a thumbnail (like a deadly poisonous flamboyant) or as long as an arm (the giant Australian).

Unlike others in their class, cuttlefish have a surfboard shaped bone which gives them buoyancy when living and are used in bird cages as a calcium carbonate food supplement when they are dead and buoyancy becomes irrelevant.

Cuttlefish mate around the ages of 6 months to 2 years, somewhat younger than octopuses, and in much the same fashion across their species. The male grabs a female and holding her in position face to face deposits encapsulated sperm in openings by her mouth. When this is accomplished the male will then keep watch protectively over this female repository of his future to avoid a subsequent male's deposit destroying his ...lineage? During the courtship rituals some males make themselves appear as much as 30% larger and more... babe magnetty?

While trying to optimize their courtship appearance males are often in near constant conflict with rivals, so clever smaller males, unable to compete in puffed up presentation will camouflage themselves as a female on the side visible to their rivals and as a male on the other, hoping to attract a female. In this fashion they can sneak up, pretending to be one of the "girls", have their wicked way and escape looking like something else. If the position of the other males changes, the female appearing side will alternate. This is called dual gender signaling and considered to be an act of great cleverness.

The resulting eggs, 100 to 500 of them, to me resemble translucent dime-sized cocktail onion, with visible yolk sacs and emergent chromospheres like polka dots. Their eyes can also be seen through the sacs. The eggs take 4 to 6 weeks to hatch no matter where they are stored and most are fertilized in May and June. Sometimes fertilized eggs are stuck on upright marine sticks and some are glued inside coconut shells. Certain subspecies use their own ink to dye their eggs brown or black for concealment purposes. In any case, dealing with egg placement wears out the females, mating wears out the males, and they both usually die soon after.

Developing cephalopods seem to start learning by watching from their egg sac! They have to begin early because both parents die shortly after the eggs are in position, and they themselves have so little time. After 30 to 90 days they hatch, fully developed but small. It is theorized that even this pre-natal time is spent planning attacks, because

when they hatch they quickly begin to prey on creatures they have been known to observe before they hatch. No time to waste.

Cuttlefish nervous systems are less evolved than that of octopuses, which have descended from them, but cuttlefish intelligence is still considered comparable by some, for reasons not entirely understood. Different references site cuttlefish or octopus variously as the superior species, dependent, perhaps, on the discipline and personal preference of the scientist author.

From the time they hatch cuttlefish appear more social than the usually solitary octopus, and are often seen traveling in schools in mostly shallow water. They apparently communicate with each other (being more social) by flashing in variable color patterns. This ability is also used by certain species of cuttlefish for more sinister purposes. They will stick two arms to the side, two overhead and radiate bands of color in order to hypnotize their prey, who" come hither" to investigate. Both cuttlefish and octopuses have been observed using their rapidly changing color for enticement and while sleeping. Scientists think they may be dreaming!

There are currently about 300 known species of octopus and, unlike cuttlefish, all have brains that extend through their 8 arms. These arm -brains are known to function both with the central brain and independent of it, which has been described as making the arms, "partly self and partly other." This ability exemplifies what is called, "embodied cognition." In fact biologists believe that with any octopus the mind/ body dichotomy is senseless. Rather, they appear to be all mind.

Octopuses can sense, taste, and problem solve with their arms. Octopus arms have thousands of suckers each with half a million neurons and ganglia all along these as well as a 65 million neuron brain. All these peripheral brains are attuned to each other and the master brain, and seem to work like the internet with" extensive local control, seeing skin and eight thinking arms".

Using these "smart arms "they can figure out childproof pill bottles requiring simultaneous pulling and twisting plus skill, intelligence and persistence some component of which some unnamed people lack. When put into screw top jars for demonstration purposes they quickly use the suckers on their arms to open the lids from within in less than a minute once they have worked out the problem.

Assisting the arms are their rectangular eyes which have far more photo receptors than humans, and can see in all directions.

If an opening in a container is purposefully made too small for even their famously elastic bodies to squeeze through, they seem to take note and quit trying. New openings will evince new effort. It has been noted that an octopus presented with a new problem will try the obvious solution, but if that fails it will seem to contemplate the issue for 5 minutes or more, then try something different.

This still, silent contemplation has been observed repeatedly and it often yields a solution.

One small octopus laboring mightily to retrieve a small fish from within a nippled baby bottle, got one arm in, tasted the bait, wanted it, and with a tremendous heave pulled the nipple out of its collar to gain entry. It was estimated that a human would be hard-pressed to do that.

In an attempt at comparison, embodied cognition in humans, if we can be said to have any would be in what we call motor memory. Scientists would probably say this analogy hugely undersells the octopus' intelligent strangeness. After all, our severed arms can't sense food, then crawl and pick it up!

Because their bodies are a boneless mass of soft tissue they have no fixed shape except for their beaks. Even the largest species, the Giant Pacific, which can have an arm span of more than seven yards and weighs a hundred pounds – can fit through an opening an inch wide, or about the size of its eye.

Therefore, it is an expensive, complicated procedure to keep octopuses in lab aquariums as they adeptly figure out escape routes. Captive octopuses appear to be aware of their captivity and some adapt to it. Some do not. One who was Not content kept squirting jets of water at the lightbulbs above him and repeatedly shorting out the electrical system. They had to let him go.

Some have lifted their tank lids, crawled across a dry floor and gone to another tank for a snack, or to the nearest drain and escaped. Others become fond of flooding labs by clogging up the drains in their tanks using their arms.

An octopus unhappy with a diet of thawed squid held it in his arms while waiting for the scientist observer to come, and while watching him watching, shoved the squid down a drain.

When they try to escape, which is often, they tend to wait for a moment they aren't being watched. Famously, a New Zealand aquarium lost an octopus known as Inky, through the drain pipes in his tank. He made it to the Pacific Ocean.

It used to be thought that the use of tools by an octopus was rather limited for a creature so smart but a short documentary of an octopus experimentally deprived of space in its barrel defies that idea. When scientists filled it with small cubes, "Arnold" devised a way to empty it using equipment it dragged from the other side of the aquarium; first one tool, then another. Other experiments have yielded similar results, and some researchers consider wearing a coconut shell like a coat is using it as a tool.

Human eyes are often described as the only anatomy with any similarity to cephalopods, but there are huge differences. One is the previously referenced difference in quantities of photo receptors. They have many more. We both have camera- like structures with lenses that focus images on a retina. Cephalopod eyes

however perceive light polarization, have no blind spot and can therefore see in front and behind. When you are plagued with predators this skill is very useful.

Octopus pupils are rectangular, while cuttlefish have w shaped pupils the form of which has been compared to what Charley Brown does with his mouth when Lucy moves the football...again! Recent experiments involving the use of 3D glasses on cuttlefish have established that they have depth perception, inciting great glee in the University of Minnesota scientists.

Both groups lack ocular photoreceptors for color, but as previously referenced other receptors in their skin seem to "sense" color, as well as taste and smell! It is thought that maybe the skin also operates like eyes, and their whole bodies "see" separate from the central brain. Some unknown anatomical part or parts of these animals can obviously translate color effortlessly.

And, one recent experiment testing color preference in an octopus found it to be consistently drawn to the colors orange and red, choosing to ignore or flinch from green, race to embrace purple, and undulate gracefully with blue. Another mystery.

An interesting disparity involves the differences in their delivery of toxins Octopuses and cuttlefish both possess deadly subspecies The small blue ringed octopus is so venomous that if you were pecked by its beak you would surely die. Their venom, a mix of saliva and symbiotic bacteria is more toxic than that of any land animals and there is no antidote for it. The difference between a "venomous" blue ringed octopus and a "poisonous" flamboyant cuttlefish is how the toxin is delivered. You would have to foolishly eat the later. And then you would surely die.

Of octopuses and their disparities with the more social cuttlefish it can be said that despite being considered loners, some species that live around the isle of Capri appear to have recently begun banding together in a community called Octopolis. Scientists think it is in response to too many divers in the area, and are anticipating they may begin learning from each other how to resolve the issue.

Another octopus community, Octlantis, was discovered in 2016 off the east coast of Australia in Jervis Bay. Multiple dens of Gloomy Octopuses, previously considered loners, have been observed living together, "foraging, mating and fighting" in close quarters full of "broken scallop shells, beer bottles, and lead fishing lures," junk which may stabilize octopus dens making them more permanent. Some Gloomy have been observed evicting others for reasons unknown.

Both cuttlefish and octopuses are often curious when encountering divers and will sometimes reach for their hands in a nonmenacing way. One diver described a game of peekaboo with an octopus. Another was robbed of his camera by an octopus who snapped a few shots. They clearly distinguish and seem to bond with the kinder lab personnel that they encounter daily.

Early on I referenced the fact that cephalopods are short lived and therefore not a good evolutionary investment. As the smartest invertebrate one might imagine they both deserved to live longer, and should have been designed to do so.

One theory explaining this conundrum is that cephalopods are the victims of late acting mutations. Natural selection is known to weed out early negative mutation, thereby slowing or stopping its continuation; enabling the "survival of the fittest".

With late appearing mutation the establishment of a negative trait, like a short life span, is already in the individual, seemingly preprogrammed. This is interestingly defined as a Medawar accumulation, based on the idea that random," germline mutations" occur that effect overall health and survival later in life and are responsible for the physical damage we associate with ageing.

A very exciting alternative theory explaining the absence of longevity addresses the fact that only cephalopods are known to be frequent editors of their own RNA; "a novel mechanism" to "neural sophistication." In essence they can alter their own nervous systems during their lifetimes, by altering the proteins produced by their neurons, sometimes as much as 60 percent of the time. The proteins affected are described as "key players in neural excitability and neuronal morphology. " They can change their own brains!

I should explain that I am interpreting this to mean (in as much as I can pretend to understand it) that they can choose to change the chemical functioning of their own brains under certain circumstances Scientists are currently trying to figure out what triggers them to do it. Might it entail changes in environment or experience? Does it help explain why some previously solitary octopuses now have communities, or why they were thought to not use tools, and have been observed doing just that? Other species, from fruit flies to people have demonstrated this practice "only in a fraction of 1 percent of their RNA".

Apparently the downside of another singular cephalopod practice is that it is done at the expense of their "genomic DNA", which means changing ones RNA in life uses up the same substances that might permit a longer lived mutation. This is the current extent of my understanding.

It is my belief that Edna St. Vincent Millay was thinking of cephalopod mollusks when she wrote:

"My candle burns at both ends
It will not last the night;
But ah, my foes, and oh, my friends -
It gives a lovely light.

Thank you for your kind attention