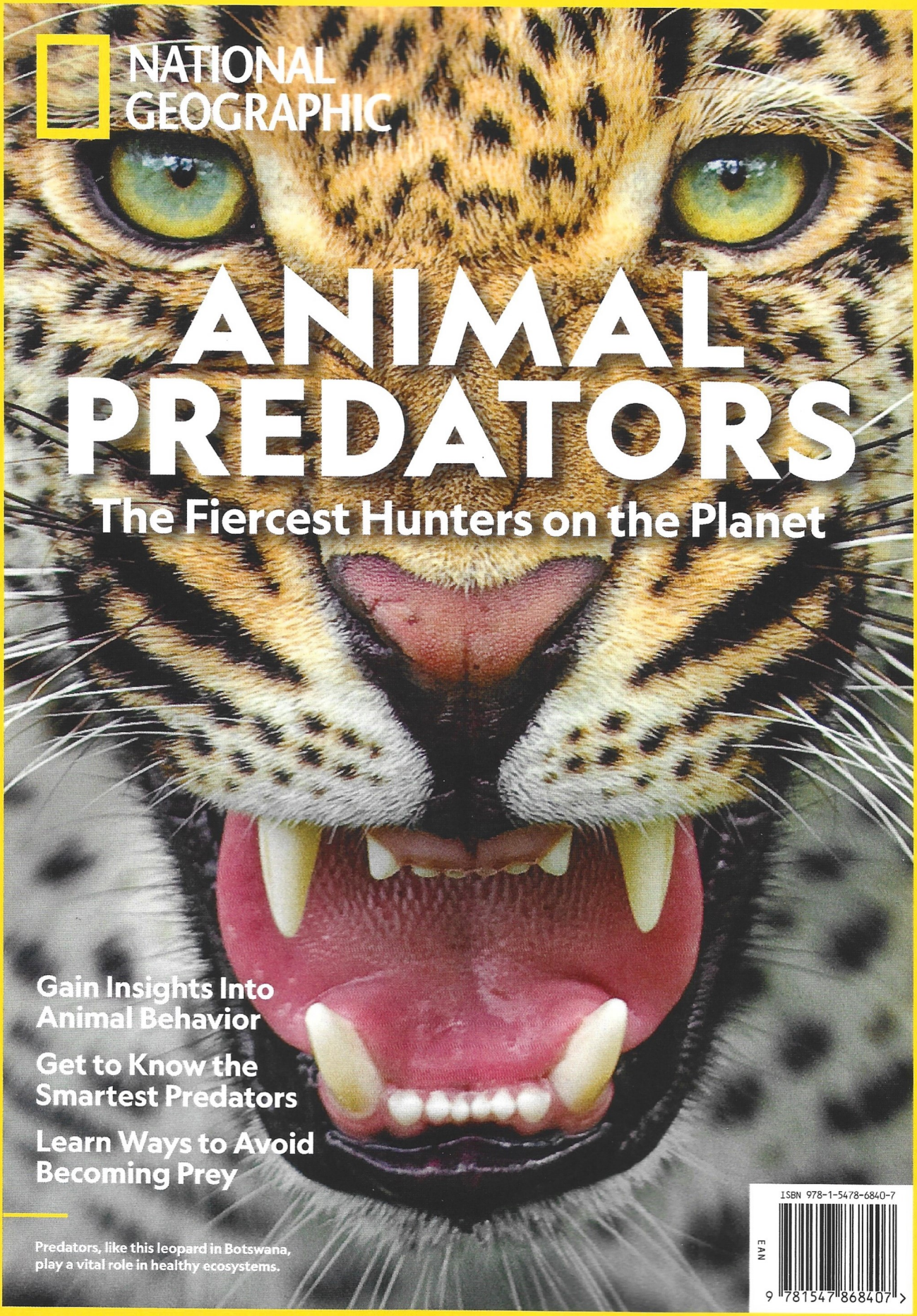

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JELLYFISH ARE MINDLESS MENACES OF THE SEA

Jellies are mostly water and lack a brain, yet these marine creatures have an array of superpowers helping the species survive hundreds of millions of years.

BY LIZ LANGLEY

WHEN WE THINK of dangerous animals, a bag of water without a brain may not seem like it should be on the list. But if ocean bathers hear "jellyfish," they'll stand at attention like meerkats, because jellies can pack a wallop.

Often gorgeous and often dangerous, jellyfish are slippery masses of contradictions. As increasingly warmer waters and deoxygenation enable their populations to grow, we take a look at their squishy superpowers.

Did you know some jellyfish are 95 to 98 percent water? Lucas Brotz, a Cnidaria scientist with Quantitative Aquatics, Inc., a non-profit based in the Philippines that provides data on marine life and conservation, says the main body of a jellyfish—its bell, that balloon-like structure that pulsates through the water—is made of two thin layers of cells with nonliving, watery material in between.

Brotz says this simple structure is a "neat evolutionary trick" that lets them grow big and eat more things without the cost of a high metabolism. Some jellyfish species can thrive in climate change conditions that other marine life cannot, including warming ocean temperatures and lower oxygen levels.

As a group, "they've survived every mass extinction," Brotz says. While most species have gone extinct, jellyfish are "bags of water that have somehow survived" for over 600 million years.

A jellyfish sting is "one of the fastest processes in biology," says Sean Colin, a marine biologist and professor at Roger Williams University in Rhode Island. It's also pretty complicated for a seemingly simple animal.

Jellyfish tentacles are lined with thousands of stinging cells called cnidocytes, a singular feature of jellies and their relatives, such as corals and sea anemones. Inside each cnidocyte is an organelle called

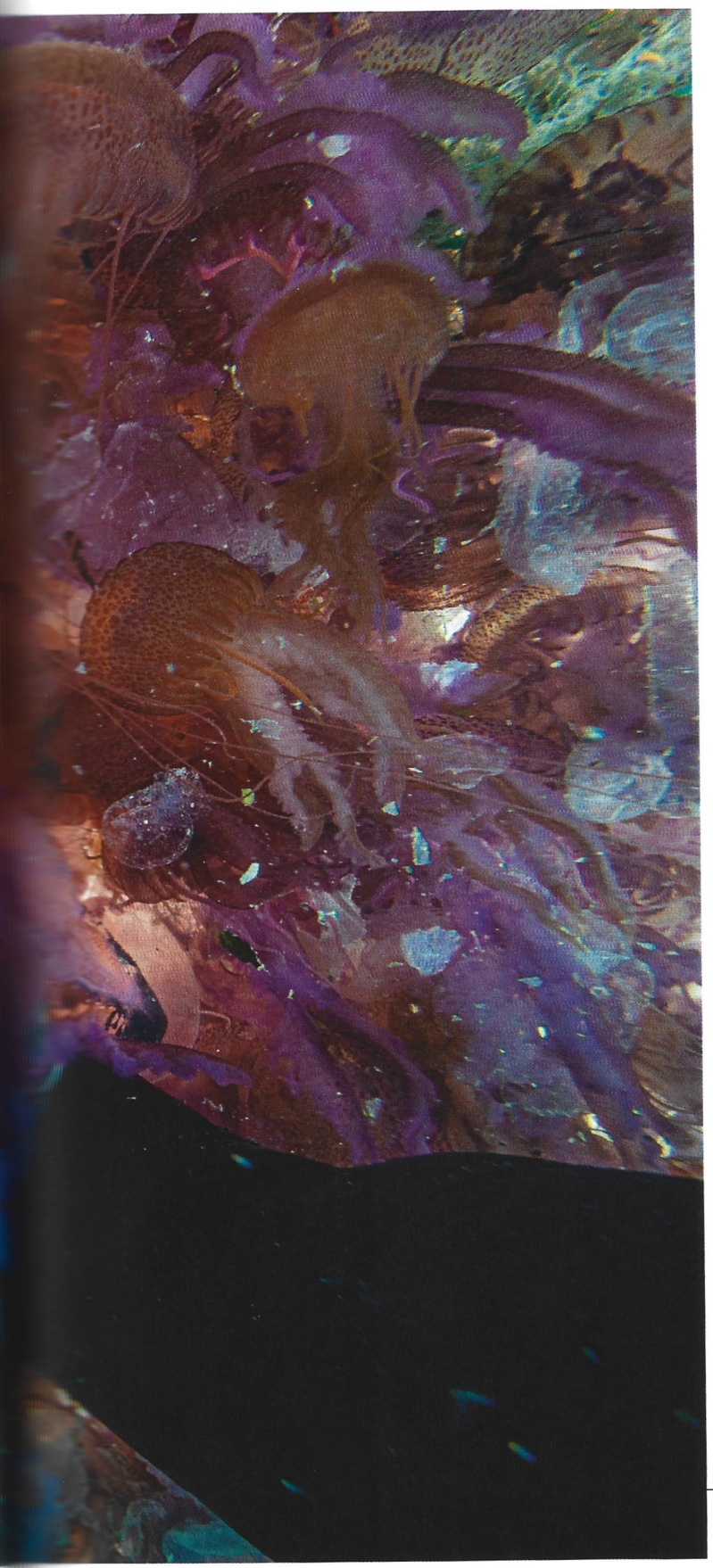
the nematocyst, a type of cnida, which contains what Colin describes as a capsule with little harpoons coiled up inside, filled with the venom that incapacitates their prey.

When triggered to strike, these spring-loaded nematocysts pop out. That pressure release makes for superfast jabs, lasting just 700 nanoseconds, with enough force to crack a crustacean shell at its weakest point.

That capsule deployment clocks in at "five million times the normal pull of gravity," according to the National Oceanic and Atmospheric Administration. Some jellyfish don't even need to touch you to sting you. "Stinging water" is a phenomenon created by upside-down jellyfish, a species that releases mucus containing stinging cells that can hang around for 10 days.

"The coiled up thread is actually hollow and everts as it blasts out. That's how the venom gets in," says Allen Collins, a zoologist with NOAA Fisheries and the Smithsonian Institution's National Museum of Natural History. Once a barb gets stuck in another animal or human, the jelly loses that barb and has to regrow it.

Japanese sea nettles have a striking sunburst pattern on their bells and very long oral arms. As carnivores, their diet consists of small crustaceans, zooplankton, and even other jellies.



And though jellies may seem to randomly sweep their tentacles over everything, like a death mop, that isn't the case. Jellies drift a lot, but "they have some control over whether they're going to fire" those tiny harpoons, says Collins.

In a 2020 study published in the journal *eLife*, researchers at the Bellono Lab at Harvard University studied the starlet sea anemone, a close predatory relative of jellyfish. They found that the anemone's nematocysts responded with a sting when two things occurred: the sensory cue of its tentacles brushing against something and the detection of chemical cues given off by potential prey or predators. In this anemone, only combining both cues prompts the barb to fire.

Other research on Cnidaria has revealed that one or both cues may be required depending on species, habitat, and feeding habits of the anemone. It turns out that jellies can also avoid wasting barbs on rocks or plants. Living things, though, don't get this lucky break.

ANIMALS STING FOR two reasons: to defend themselves and to catch prey. "Jellyfish are carnivores, and they use stinging cells to immobilize their prey," says Kelly Sutherland, a marine biologist at the University of Oregon. Still, "there's quite a bit of diversity in how they capture their prey."

Some jellyfish are ambush predators. They "lie in wait," Sutherland says, hanging motionless in the water, extending their long tentacles. The largest is the lion's mane jelly, which has tentacles that can reach 120 feet.

Photographer Angel Fitor is swarmed by *Pelagia noctiluca* off the coast of Alicante, Spain. Jellies can form large groups, or smacks, often scaring tourists.

HOW THEY FEED

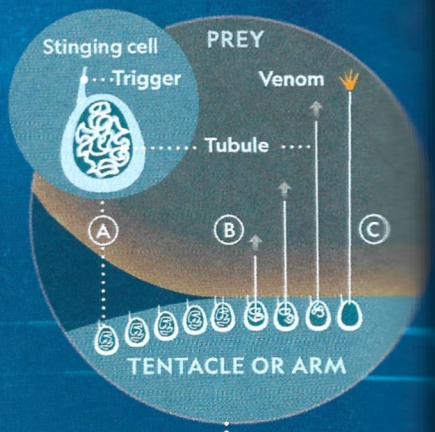
Atlantic bay nettles swim to find food. Currents bring them in contact with their prey: zooplankton, crustaceans, and even other jellies.

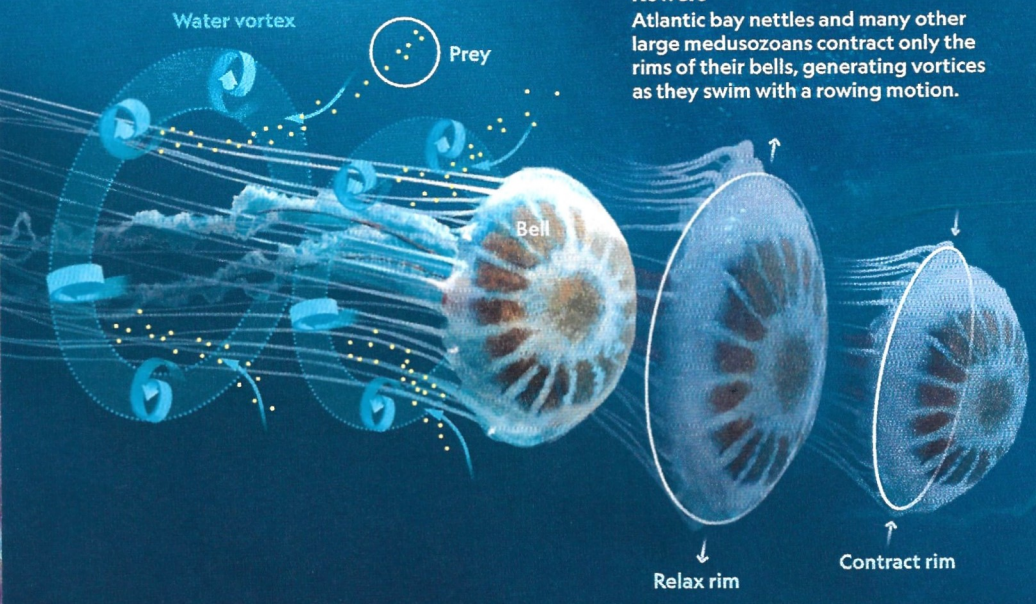
1 Swimming

Like most jellies, the Atlantic bay nettle hunts not by sight but by direct contact, spreading its oral arms and tentacles wide. Vortices help draw in prey.

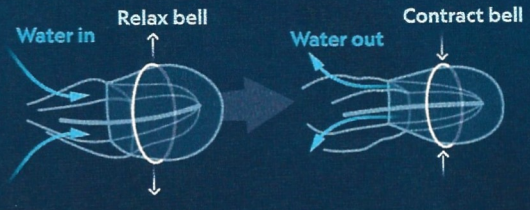
2 Stinging

Thousands of stinging cells (A) line each tentacle and arm. Some have coiled, barbed tubules that, when triggered, (B) uncoil with enough force to pierce shells or flesh to (C) inject venom.

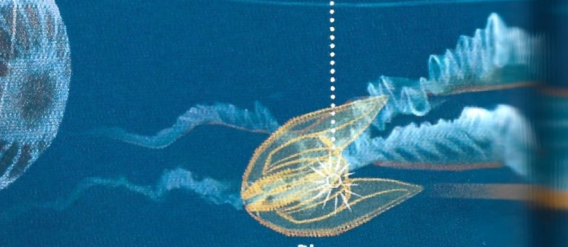




Rowers
Atlantic bay nettles and many other large medusozoans contract only the rims of their bells, generating vortices as they swim with a rowing motion.



Jetters
Many smaller medusozoans contract the entire bell, expelling a jet of water that propels them forward.



Big prey
Mnemiopsis comb jelly

Small prey
Zooplankton

BONELESS BEAUTIES

Being 95 percent water and gelatinous is a good strategy on an ocean planet, which is why jellyfish have survived for hundreds of millions of years. The term covers thousands of species in two barely related categories: the comb jellies and the medusozoans, such as the Atlantic bay nettle, featured here. It's a familiar menace to Chesapeake Bay swimmers.

3 Ingesting

Once prey is caught, hairlike cilia on the oral arms help convey it toward the mouth. If it fits, it's swallowed in minutes; larger prey can take hours to ingest.

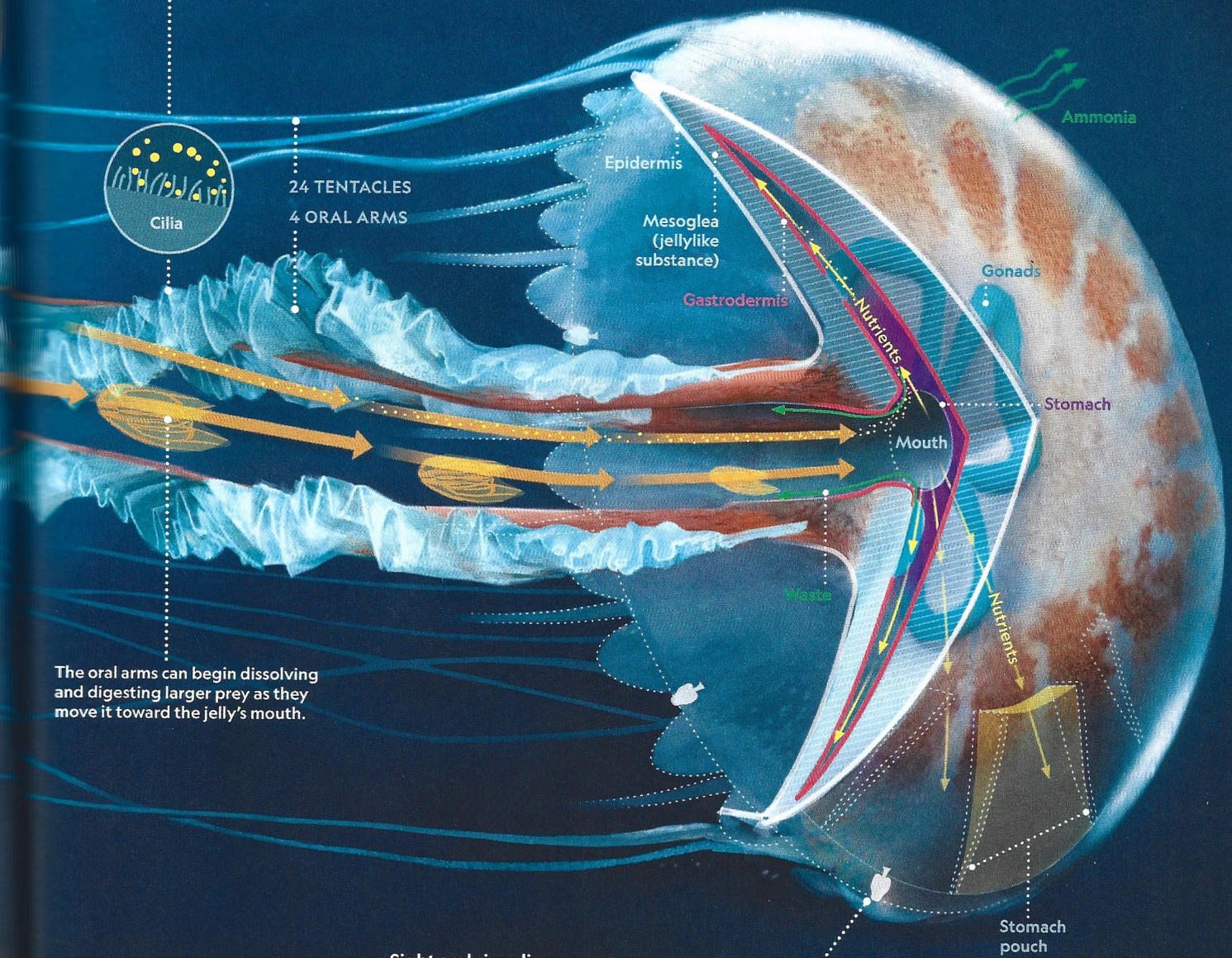
4 Digesting

A central cavity acts as both stomach and intestine to churn and break down food. Sixteen stomach pouches transport nutrients throughout the bell.

5 Removing waste

Waste (mostly ammonia) is secreted through tissue or excreted from the single orifice that serves the jelly as both mouth and anus.

Atlantic bay nettle
Chrysaora chesapeakei



The oral arms can begin dissolving and digesting larger prey as they move it toward the jelly's mouth.

Sight and signaling

Rhopalia, sensory structures that sense light and gravity, trade data with nerves on the bell. This exchange drives jellyfish behavior.

FERNANDO G. BAPTISTA, EVE CONANT, KATHERINE APPEL, AND ALISON HARFORD, NGM STAFF; LAWSON PARKER
SOURCES: KEITH BAYHA, REBECCA HELM, AND ALLEN COLLINS, SMITHSONIAN NATIONAL MUSEUM OF NATURAL HISTORY; JENNIE JANSSEN, NATIONAL AQUARIUM

JELLYFISH ACT FAST ON **THEIR STUNNED SEAFOOD.**

Some of these species, like Australia's tiny but terrifying Irukandji box jellyfish, twitch their tentacles to attract prey, like you might with a fishing lure. Whether they're twitching or just patiently waiting, when a little animal like a crustacean, copepod, or fish larvae touches that tentacle, the jellyfish act fast on their stunned seafood. "They move that prey item to their mouth," Sutherland says, and "in some species it looks almost like a long arm" or "a hand putting a french fry in the mouth. Pretty incredible." It's a fairly involved task for an animal that is, well, brainless.

"It'll never stop blowing my mind," Sutherland says, "because these are organisms that have no brain." They have nerves that can react to things but no "central command station" to process information and make decisions. "This really intricate set of coordinated behaviors that miraculously is achieved without a centralized nervous system, I find that to be supercool."

The other type of jellyfish are feeding-current feeders, which Collins calls "cruisers," constantly on the move. As they swim, Sutherland says, "they're moving water in and around themselves and pulling currents of water toward their tentacles," like their own private feeding current. "That mode of predation captures a different type of prey," Sutherland says, referring to slow-swimming or even nonswimming prey, like plankton, which drifts in the water.

"They'll be going through the water, forcing the water through their tentacles, or what we call mouth arms, and then capturing little prey and eating them, almost like a filter," Collins says.

ONCE THEY CAPTURE these morsels, how they eat them depends on the type of jellyfish they are and what feeding apparatus they have. Some species "capture prey using tentacles and possess a simple mouth called the manubrium," says Guilherme Morsch von Montfort, a Ph.D. candidate in Biological Oceanography at the Federal University of Rio Grande, Brazil. This mouth hangs from the central underside of the bell. Most jellies that eat fish this way are serious bigmouths. "They have just this really stretchy, stretchy mouth that goes all the way around the fish," Collins says.

The mouth, von Montfort notes, "opens directly into the stomach, or gastrovascular cavity," which is helpful for quick digestion. He explains that some have this mouth along with mouth arms, also called oral arms, which are "specialized feeding structures found only in two groups of jellyfish."

The Semaeostomeae, or flag-mouth jellies such as sea nettles, have "both the tentacles and the oral arms," which are "long and thin, in a veil shape, with a central mouth opening," von Montfort says. Unlike the longer, thinner tentacles, mouth arms have more body and look almost ruffled, like a scarf.

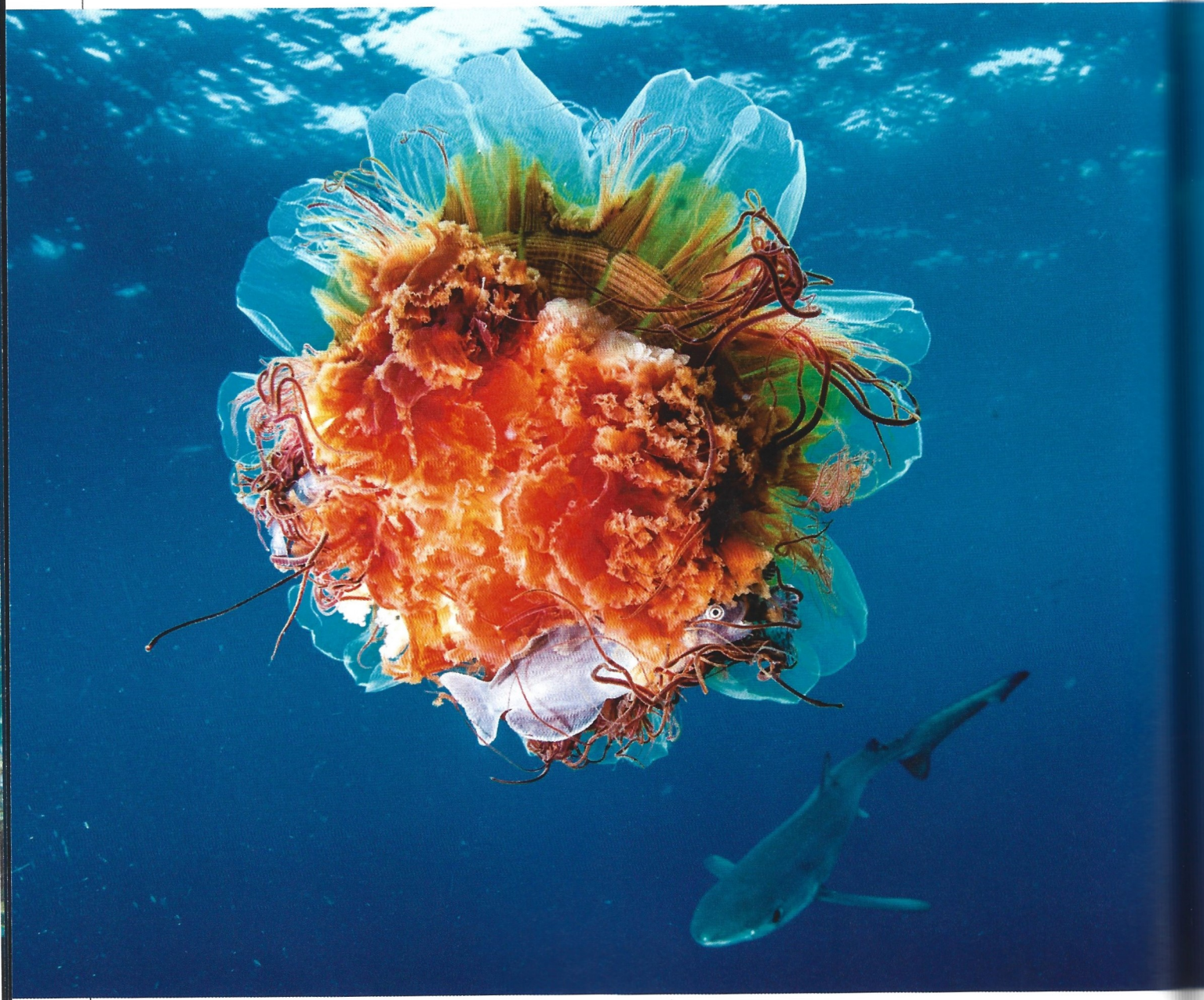
In contrast, von Montfort says, the Rhizostomae group, including cannonball

The light captured from this *Pelagia noctiluca* showcases its inner anatomy. *Noctiluca*, meaning "shines at night" in Latin, is an apt descriptor of its bioluminescence.

jellyfish and upside-down jellyfish, "lacks tentacles and their oral arms have evolved into highly specialized filtering structures with numerous mouth openings." This is similar to the cruisers pushing water and prey through multimouthed oral arms.

The golden jellyfish of Palau's Jellyfish Lake have "all the little frilly parts under them; those are mouth arms," Collins says. "When those guys are swimming through the water, their bell is pushing little, tiny prey through the mouth arm," capturing and eating them with those small mouths. Some species, like the blubber jelly, don't even bother having a mouth under their bell; they ingest all of their prey through their oral arms.

Once ingested, a jelly's food might as well already be digested. Any hard materials, like a crab shell, just go back out of the mouth, which is a multipurpose organ, taking in prey, expelling waste, and even releasing



A prowfish hides in the tentacles of a lion's mane jellyfish to evade a blue shark.

sperm from males and eggs from females.

Some deep-sea jellies, like the bloody-belly comb jelly, a ctenophore, "have dark red guts, really dark red," Collins says. Because red can't be seen in the light spectrum at that depth, they likely appear black. "They're eating bioluminescent prey, putting something in their bodies that could light up," but "the dark red pigment blocks that light so that they won't then become visible to a predator with eyes."

Being on the wrong end of a stinger can cause symptoms ranging from annoying to extremely painful, even deadly, depending on the species, severity, and susceptibility of the victim. The same can be said for jellyfish, but their sting is nothing personal. Those nematocysts are activated just by brushing against any organic matter, including humans.

Zooplankton, tiny animals that drift along with the current, are a favorite prey of jellyfish. They give off vibrations that trigger a jelly's capsules to open, releasing the toxin-filled microtubules with sharp tips that impale and envenomate prey. Jellyfish are nothing you want to tangle with, but at the same time, they certainly deserve respect, even awe.

Jellyfish stingers "are among the most sophisticated biological equipment ever evolved," says Juli Berwald, an oceanographer and author of *Spineless: The Science of Jellyfish and the Art of Growing a Backbone*. It's probably why they have remained the same for hundreds of millions of years. "When you are stung, you interact with half a billion years of evolution," she says.

Stings of some jellies, such as box jellyfish of northern Australia and the Indo-Pacific, can be lethal, while others have nematocysts that don't penetrate human skin. Jellyfish do not, however, sting each other or themselves. Brotz says chemical cues likely guard against that.

Jellyfish can be dangerous even after they are dead. Stinging nematocysts just don't quit. You can get stung by a detached tentacle or even by a dead jelly. Marine biologist Colin says if you eat a squid that ate a jelly but didn't fully digest it, that jelly could sting you too. Did anyone else just become a vegetarian?

NOT ALL JELLYFISH float with their bells on top. Upside-down jellies flip over and live on the seafloor in tropical waters of the Indo-Pacific, Florida, the Caribbean, and Hawaii. These jellies lie with their bell on the ocean floor like a sunbather catching some rays—which is exactly what they're doing. They keep microscopic algae in their tissues and "hold them up to the sun to give them a place to grow," Brotz says, then use them as a source of nutrition. The golden jellies in Palau's Jellyfish Lake also farm algae, following the sun as it travels from one side of the lake to the other during the day and fertilizing their crop at night, Brotz says.

Many of the about 4,383 accepted species of jellies discovered so far, Brotz notes, are bioluminescent, meaning that they can make their own light. An important part of this trick used by one species, the crystal jellyfish, is a gene called green fluorescent protein or GFP, says Brotz.

When used by scientists as a biomarker, this protein literally sheds light on the inner workings of the body, tracking processes from insulin production to HIV infection to muscle structure. The researchers who developed this technology won the Nobel Prize in Chemistry in 2008—riding the tentacles of a jelly.