



# Do you speak cuttlefish?

Not content with being masters of camouflage, cuttlefish have a sophisticated system for talking to one another on the sly, reveals **Michael Brooks**

Confusing shrimp, wooing females and scaring off predators. It's all in a day's work for *Sepia latimanus*

EVOLUTION'S a bitch. There you are, a mollusc species floating through the ocean in a heavily armoured shell. You are safe from ravenous marine predators and feeling pretty good about yourself. Then some random genetic fluctuation turns you inside out. Now your species has a small internal skeleton, and – from the point of view of the marine reptiles that just happen to be experiencing a boom at this point in the Jurassic – you are a big tasty, packaging-free ready meal chock-full of protein.

To survive this turn of events required a pretty clever solution, and cuttlefish rose to the challenge in ways we are only just beginning to discover. We have known for a long time that these creatures have the world's best camouflage skills, but it seems this is just one of their many talents. Research published in the last few months shows cuttlefish can do things that are way beyond most molluscs and only rarely seen in mammals: their response to an approaching predator is tailor-made for the carnivore in question, for example. Not only that, they have also developed a secret communications system that could be the marine equivalent of invisible ink. You can almost imagine them sniggering at our primitive interactions from behind their eight arms.

That said, cuttlefish are not above acknowledging the presence of lesser species such as humans, as divers around the world will testify. When they come across cuttlefish, some divers offer a greeting, the two-fingered "peace" sign. In what is surely one of the few cross-species salutations in the natural world, the cuttlefish reciprocates by lifting two of its arms. This message of peace is actually quite the opposite – a startle response to what the cuttlefish perceives as a threat. Sticking two fingers up at divers or predators is a secondary level of defence which cuttlefish use on the rare occasions that their camouflage fails.

Cuttlefish and their fellow cephalopods – octopuses and squid – are masters of disguise, able to turn from completely invisible to totally obvious, and back, in about 2 seconds. They can use this trick to blend seamlessly into any natural background and will have a good stab at artificial ones too. While the skills of octopus and squid are not to be sniffed at, the cuttlefish is the king of cephalopod camouflage, according to Roger Hanlon of the Woods Hole Marine Biological Laboratory in Massachusetts. The fact that it achieves its disappearing tricks with a rigid cuttlebone, which means it cannot contort its body like an octopus, only makes it more impressive. Cephalopods have such remarkable

camouflage primarily because of their chromatophores – sacs of red, yellow or brown pigment in the skin made visible (or invisible) by muscles around their circumference. These muscles are under the direct control of neurons in the motor centres of the brain, which is why they can blend into the background so quickly. Another aid to camouflage is the changeable texture of cuttlefish skin, which contains papillae – bundles of muscles able to alter the surface of the animal from smooth to spiky. This comes in pretty useful if it needs to hide next to a barnacle-encrusted rock, for instance.

The final part of the cuttlefish's camouflage portfolio comes from leucophores and iridophores, essentially reflecting plates that sit underneath the chromatophores. Leucophores reflect light across a wide range of wavelengths so can reflect whatever light is available at the time – white light in shallow waters and blue light at depth, for example. Iridophores combine platelets of a protein called reflectin with layers of cytoplasm to produce iridescent reflections rather like those of butterfly wings. Iridophores in other species, like some fish and reptiles, produce optical interference effects that shift the light towards blue and green wavelengths. Cuttlefish can turn these reflectors on or off in seconds to minutes, controlling the spacing of the platelets to select the colour. They can also combine these iridescent hues with those of the chromatophores to make shimmering purples and oranges, for example.

## Talk to the fishes

All this paraphernalia is not just for disguise: it is also for sending signals. Hanlon has documented around 40 different cuttlefish body patternings, many of which are used to communicate with other cuttlefish (see lower Diagram, page 31). But they also send signals to other species. In a paper published in December last year, Keri Langridge at the University of Sussex in Brighton, UK, showed that cuttlefish are the only invertebrates known to give specific reactions to different kinds of predator (*Current Biology*, vol 17, p R1044). Just as we know to bop an attacking shark on the gills or run from an alligator, a threatened cuttlefish eyes up the predator and responds accordingly.

Langridge's work was based on cuttlefish kept in tanks at the Sea Life Centre aquarium in Brighton, where the University of Sussex has a research station. When she put a predator in a neighbouring tank and used an arrangement of mirrors designed to fool ▶

the cuttlefish into thinking it was in the same tank, the cuttlefish were remarkably perceptive.

Faced with a sea bass, a cuttlefish would flatten its body and extend its large frill-like fin to make itself look as big as possible, as well as displaying two, dark “eye” spots on its back. This startle or “deimatic” display is fairly common in the animal world, but it’s a risky strategy. “It’s purely a bluff and is very unlikely to fool all predators,” says Langridge.

Cuttlefish seem to know this too: they weren’t tempted to try a deimatic display when faced with dogfish or crabs. Crabs hunt by smell, tracking down prey by sensing chemicals in the water, while dogfish use electric fields to home in on their next meal. Since the cuttlefish has no defences against these lines of attack, the only reasonable response is to flee immediately. And that’s what the cuttlefish always did.

## Signal selection

This might not seem remarkable, but identifying and classifying the specifics of a threat is something very few animals do. “The most famous example is vervet monkeys,” Langridge says. “If [the threat is] a leopard they give a call that makes the others in the group look down or run into trees; if it’s an eagle, they give a call that makes them look up and run for cover.”

These signals, though, are directed at their social group, not at the threat. Selective signalling at a predator is very rare. Langridge is aware of only one example: last year, Aaron Rundus of the University of California, Davis, showed that ground squirrels pump hot blood into their tails to distract rattlesnakes, which hunt using infrared sensors. The squirrels don’t bother with this tactic when faced with gopher snakes, which cannot sense infrared (*Proceedings of the National Academy of*

**You won’t spot cuttlefish such as *Sepia latimanus* lurking around tropical corals, but they’ll spot you**



*Sepia latimanus* achieves its exotic look by the clever arrangement of iridescent cells in its skin

*Sciences*, vol 104, p 14372). As Langridge points out, most people would assume there is a big gulf in cognitive capacity between mammals and cuttlefish. “Discriminating between species and applying different tactics to different ones is pretty sophisticated for a mollusc,” she says.

It’s a level of sophistication that probably saw cuttlefish through the Jurassic period, which was the era of marine reptiles as well as a time when sharks and bony fish had come into their own. “The seas were full of visually oriented predators,” Langridge says.

Another unique trick probably helped. New research by Hanlon and his Woods Hole colleague Lydia Mäthger reveals that, by controlling their iridophores, cephalopods have access to a communication channel invisible to anything but other cephalopods, while to most other species they remain perfectly camouflaged.

The cephalopod’s secret mode of communication uses polarised light. Sunlight coming down into the ocean is polarised when it hits the water – it has some of its electric and magnetic fields filtered out so that the fields oscillate in only one plane. Cuttlefish can not only see polarisation patterns in light, but are also able to send polarised signals from their iridophores, controlling the polarisation by changing the spacing of their reflectors. As the polarisation passes through the pigments in the chromatophores unchanged, they can send secret messages while remaining fully camouflaged (*Biology Letters*, vol 2, p 494).

It’s a cunning trick, but in the context of the evolutionary arms race between predator and prey it is “not totally surprising,” say Mäthger and Hanlon. They point out that a major problem of being in a prey group is that if you spot a predator, you’re meant to warn everybody else. But that draws the predator’s attention to you, making you their first

target. What you want is a way of signalling that doesn’t single you out. With polarised light signals passing through the camouflage, that’s exactly what the cuttlefish has.

Hanlon is swift to point out that his group has not actually attempted to prove that cuttlefish use their polarisation signalling capabilities to communicate. That’s because identifying a response to a polarisation signal would be very hard to do. “The signal would most likely say, ‘there’s a predator nearby: don’t move,’” Hanlon says. “What response are you going to measure, exactly?”

Amazingly, the clarity of the signal doesn’t vary with the cuttlefish’s posture or movement: the iridophores are arranged and controlled so that even if the cuttlefish could perform a Mexican wave, the polarised light signal coming off it would vary only minimally. In other words, they can camouflage themselves, sway and send secret signals all at the same time if need be.

This is something they may well do. As well as changing their skin patterns and texture, cuttlefish also adopt certain postures or

# “Cuttlefish can send secret messages while remaining fully camouflaged”

movements in order to disappear into their environment. When hiding in sea grass, they lift their arms and wave them in time with the swaying grass around them. Hanlon has just completed the first studies of this physical posturing in his lab at Woods Hole. The results of presenting cuttlefish with vertical and horizontal stripes on the wall of their tank are amazing, he says. “If the stripes were vertical they would raise an arm. If the stripes were horizontal they would stretch their bodies out horizontally. How cool is that?”

What is interesting about this is that the cuttlefish does not use body patterning to exactly match the stripes. Adam Shohet and Chris Lawrence, who are looking into the possibility of copying cuttlefish camouflage for use in the military (see “Now you see us...”), suggest that this is because it is too

risky: even small errors in the alignment and spacing of camouflage stripes can make the creature stand out. Nevertheless, they can and do use stripes – to blend in with seagrass for example. But Hanlon points out that this is not because they are trying to perfectly match the background. Instead, they are using stripes as “disruptive” camouflage, where the aim is to break up the creature’s background, making it harder to see.

There are plenty of discoveries yet to be made about cuttlefish. No one knows exactly how they can tell when they have matched their background effectively. Experiments have shown that cuttlefish don’t look at their skin to check how well it matches the background, so how do they get it so right?

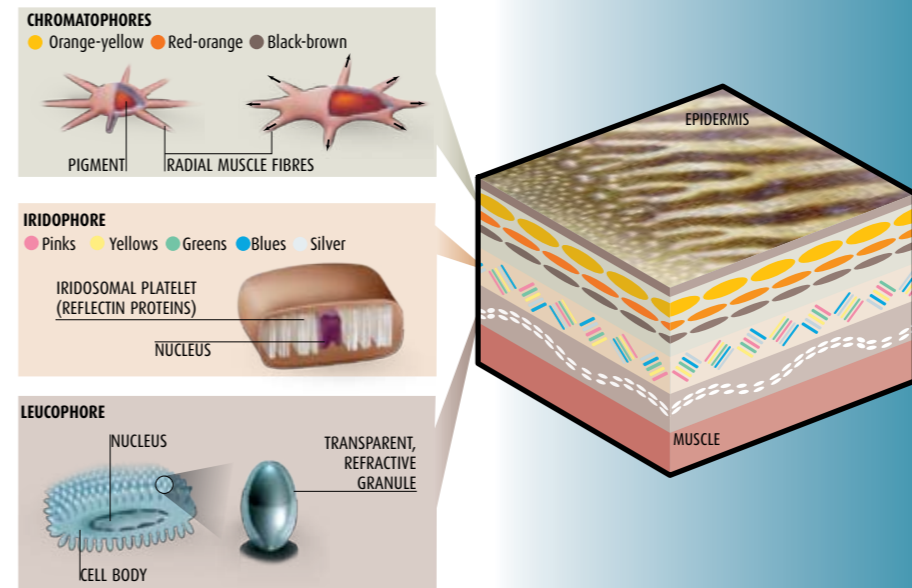
Another question is how they match coloured backgrounds so convincingly when a growing body of evidence suggests that they are colour-blind: they see in shades of green. Shohet thinks it might be to do with the fact that there are actually very few colours in most natural underwater scenes. The chromatophores match this natural palette and the brightness of the background, while the leucophores and iridophores do the rest. “It’s a conjuring trick without the smoke,” he says.

It’s an impressive one, nonetheless. Hanlon and his colleagues have recently found that the cuttlefish’s ability to camouflage is equally impressive at night (*American Naturalist*, vol 169, p 543). Obviously, facing predators with good night vision has made this necessary, but how do they do it when they only see green?

One clue seemed to emerge when an analysis of cuttlefish skin revealed it contains active genes that encode for opsin, a light-sensitive molecule. This might indicate that the skin is dotted with light sensors that help control the camouflage. “It makes sense to think there would be some distributed sensing in the skin,” Hanlon says. But the opsin in the skin is the same as that in the eye: if there is distributed light sensing, it’s still all in shades of green. So for now, the cuttlefish camouflage system, like their invisible communication channel, remains one of the many secrets of the world’s most inventive mollusc. ●

## HOW THE CUTTLEFISH GETS ITS SPOTS

Pigment sacs in the skin, called chromatophores, are under direct neural control and can open or close in the blink of an eye. Iridophores and leucophores both reflect ambient light, and iridophores can produce iridescent colours by changing the spacing between reflecting plates



## SPEAK THE LINGO



**DEIMATIC DISPLAY**  
“Go away/I’m too big to eat”



**ZEBRA DISPLAY**  
To all cuttlefish: “I’m a male”  
To males: “Let’s fight”



**PASSING CLOUD DISPLAY**  
To prey: “Watch this while I catch you”  
To predator: “Look, no cuttlefish here!”



**ARM-WAVING DISPLAY**  
To prey: “Watch this while I catch you”

## Now you see us...

Perhaps unsurprisingly, the extraordinary capabilities of the cuttlefish are attracting the attention of military researchers. In 2006 Adam Shohet and Chris Lawrence of the UK defence company Qinetiq published a paper on cuttlefish camouflage in the *Journal of Defence Science* (vol 10, p 252), declaring that research into how cuttlefish achieve their quick and convincing camouflage is “a subject with clear military interest”.

Dealing with the visual information of a given background is not the problem, says Shohet. Much more difficult is mimicking the

colour-matching abilities of the cuttlefish – something that it achieves with direct neural control over pigment sacs, combined with reflective cells in its skin – and its texture-matching ability, which utilises the muscles beneath it. “That skin is the driving force behind the camouflage. It’s highly unlikely that anyone could achieve that same level of camouflage,” he says.

And as Shohet and Lawrence point out, cuttlefish are able to do much more than just blend into a static background. They are also able to disorient a predator as they escape.

In a ploy that has been labelled the “passing cloud”, the cuttlefish makes a pattern of dark waves move across its body as it flees. Studies have shown just how effective this is: when a moving pattern appears on a moving body, it is very difficult to process the visual information. As a result, predators simply can’t tell where the cuttlefish is, how fast it is moving or even in which direction. Such “kinetic patterning” would clearly be extremely useful in military camouflage. For now, though, the invisible tank remains an elusive dream.