RAZZLE DAZZLE 'EM

To blend in, you've got to stand out

TO BECOME invisible, first make yourself conspicuous. It sounds absurd, especially once you learn that this concept was the brainchild of an eccentric American artist. Now, more than a century after it was put forward, the idea is finally being tested. The findings have revealed surprising insights into how camouflage fools – or fails to fool – the eye of the beholder.

In 1909, the prevailing belief was that animals hid themselves by matching their surroundings. Then the painter and naturalist Abbott Handerson Thayer suggested a different mechanism was at work: highly conspicuous markings, such as the zebra's stripes and the oystercatcher's black-and-white plumage, are actually disguises. Predators, he reasoned, locate their prey by looking for their outlines, so animals with high-contrast markings that disrupt telltale edges and create false ones can evade detection.

With this and other ideas about animal markings, Thayer earned himself the title "father of camouflage". But although disruptive camouflage was cited in countless textbooks, it remained largely untested until 2005, when Innes Cuthill, Martin Stevens and their colleagues at the University of Bristol, UK, devised an experiment using fake moths made from paper triangles. By pinning them to oak trees, the researchers found that "moths" with black markings on their edges were less likely to be attacked by birds than those with central markings or uniform colours. "It showed that disruption was indeed a very good way of being hidden," says Stevens, now at the University of Exeter, UK. Using a similar approach, he and Cuthill later discovered that high-contrast markings become less effective once their contrast exceeds that in the creatures' natural environment. One way to avoid this is for some parts of the body to blend in while others stand out.

TECHNICOLOUR DREAM CLOAK

How to stage the ultimate disappearing act

The most cunning paint job may be no use as camouflage. It won't do much to hide you from the prying eye of a thermal camera, or silence an inadvertent sneeze. Even something as subtle as a shadow can give your presence away. To win in the ultimate game of hide-and-seek, what you need is an invisibility cloak that goes way beyond simply not being visible.

That might seem a tall order, yet researchers are racing to perfect the technology. So could their devices make you disappear completely? This is where the future of concealment begins to look hazy.

First, consider what it would take to make you vanish. If you could wear something that bends light rays from the wall behind you smoothly around your body – like water flowing around a rock – then steer them towards someone looking in your direction, they would see nothing but the wall: no outline, no shadow.

This trick is not too difficult to accomplish. Last year a team led by Hongsheng Chen from Zhejiang University in Hangzhou, China, used special optics to diffract light around a cat, making it vanish from view. Unfortunately, the effect only works at certain viewing angles. And the system isn't portable – it uses a large and very heavy glass prism. Less cloak, more bunker.

Rather more practical would be clothes made of synthetic metamaterials – assemblies of many small components that work together to warp light in unusual ways. The first metamaterial invisibility cloak was unveiled in 2006. Constructed from an array of concentric metal rings, it successfully hid a small metal object – but only from a beam of microwave radiation.

Now, researchers are devising cloaks that work with visible light. Last year a team from Stanford University in California designed a metamaterial made from an array of tiny metal rings shaped like crescent moons. Their calculations suggest this high-tech "chain mail" could bend parts of the visible spectrum, hiding you completely in blue or green light, say. Don it in daylight and you would fade to a sort of ghostly, reddish hue.

A material that bends light at all visible wavelengths is required if this monochrome spectre isn't to betray you. But we have yet to find a

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An invisible man needs to be more than just unseen

JIM RICHARDSON/NATIONAL GEOGRAPHIC CREATIVE

The best-hidden creatures wear high-vis outfits

metamaterial that curves all wavelengths the same amount. In theory, there's no reason why it couldn't work across the visual spectrum, says Tie Jun Cui, a metamaterials expert at Southeast University in Nanjing, China, but most researchers believe it can't be done.

Certainly you will have more luck stifling the noise of a cough or sneeze. Sound waves zip faster through a light, stiff material than through air and, according to Steven Cummer, an engineer at Duke University in Durham, North Carolina, that makes an acoustic cloak entirely feasible. Constructed from stacks of thin materials with the right compressibility and density, this wrap will effectively soundproof your presence.

A similar idea will help keep your thermal signature to yourself. Sebastien Guenneau and colleagues at the Fresnel Institute in Marseille, France, have used a two-dimensional metamaterial shield, made from a metal sheet patterned with rings, to divert heat around an object. If such a cloak can match the temperature of its outside edge to that of the surroundings, it should help keep even the hottest body out of sight.

Lest you imagine that complete invisibility is within our grasp, think again. For now, there's no way to combine technologies to simultaneously block visible light, heat and sound. The problem is that the materials to manipulate each of these waves work in different ways, and if you swathed yourself in a thick coat of cloaks stacked one on another, only the outer layer would perform as planned. For now, it might be better to stick with an old-fashioned cloak of paint. ■

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Cuthill and Stevens revived interest in disruptive camouflage, but the first real insights into just how it works came only last year. Richard Webster at Carleton University in Ottawa, Canada, asked volunteers to search for virtual moths on a computer screen while an eye-tracker monitored their gaze. "We could almost get inside people's eyes," he says. He found that the more patches moths had on their edges, the more often volunteers failed to notice them, and they needed to fixate their gaze on them for longer to have any chance of spotting them. The eye-tracking vindicated Thayer again: by breaking up an animal's outline, disruptive camouflage does impair a predator's ability to spot its prey.

Although instructive, the experiment had an obvious shortcoming: humans do not prey on moths, let alone computer-generated ones. To test whether disruptive colouring fools its intended audience, Stevens has started field trials. In Zambia and South Africa, his team is studying ground-nesting birds that rely on disruptive camouflage, including nightjars and plovers. His team measures the patterns on the birds' feathers to quantify how well hidden they are in their environment. They also track the birds' survival to determine how effectively they evade predators.

Nightjars and plovers are difficult to spot in the first place, so the researchers have employed sharp-sighted local guides to help find them. This raises the question of whether predators, like the guides, might be less easily fooled by disruptive markings as they become more familiar with them. Last year, Stevens and his team found that people do gradually get better at spotting virtual moths, especially if they see several at the same time. He suspects that the volunteers learn to stop the futile search for outlines, and instead start scanning for the high-contrast markings.

Whether non-human predators adopt the same tactic is hard to say. They may not even see camouflage markings in the same way that we do. But if predators can learn to see through disruptive camouflage, it would suggest that this concealment strategy is more likely to evolve in ›