Inside JEB is a twice monthly feature, which highlights the key developments in the *Journal of Experimental Biology*. Written by science journalists, the short reports give the inside view of the science in JEB.

Inside JEB

GOOD VIBRATIONS

Blind mole rats finding their way around their underground tunnels appear to face a tough challenge. They can't use any of the sensory cues that surface-dwellers take for granted: they can't see, and sounds and smells don't carry far through soil. But blind mole rats are actually spectacular navigators and expertly burrow the most efficient detours around obstacles. Tali Kimchi and colleagues at Tel-Aviv University now suggest that mole rats accomplish these astonishing feats using a form of seismic 'echolocation' (p. 647).

'Mole rats need to live at a certain depth' says Kimchi, 'because the roots and tubers that they eat are mainly found 20-40 cm below the surface.' Emerging on the surface is suicide since these blind animals are helpless against predators, while digging too deep costs energy and brings the mole rat out of range of its food supply. So how do mole rats estimate their distance from the surface? Mole rats communicate with one another using seismic signals produced by drumming their heads against their tunnel roofs. Could they be using the reflected vibrations of their own head-drumming to estimate their distance from obstacles and from the surface?

If mole rats use seismic 'echolocation', they should head-drum more often during a complex than a simple spatial task. To record mole rat head-drumming, Kimchi dug ditches across mole rat tunnels in a field and placed small seismic earthquake detectors called geophones around the tunnels. She recalls that it was tricky getting recordings; the shy creatures ran away when they felt her approaching their tunnels. As she had expected, mole rats digging detours around her ditches head-drummed more often than mole rats navigating through straight tunnels, so mole rats do drum more often during complex tasks.

But to demonstrate that head-drumming provides information about the mole rats' surroundings, Kimchi needed to show that seismic waves are reflected in different ways depending on the obstacle. She took her recordings to Moshe Reshef, a geophysicist who produced a computer model that generated pulses exactly like those in Kimchi's recordings. The model showed that the amplitude, polarity and diffraction of reflected seismic waves provide information about the distance, density and size of obstacles. So reflected waves could help mole rats assess obstacles and probably also their digging depth.

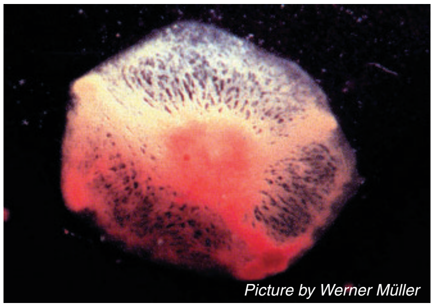
But how were the animals detecting these waves? Mole rats pick up head-drumming signals from others by pressing their jawbone against their tunnel wall. They couldn't possibly drum their head and then press their jaw against the tunnel fast enough to detect their own signal reflected from obstacles ahead, so Kimchi wondered if mole rats use their feet to pick up the signal. To test this, she designed a tunnel T-maze in which mole rats could only detect vibrations through their feet. Sure enough, mole rats sped towards a head-drumming mole rat located down one of the maze's arms, suggesting that they could detect vibrations through their feet. Kimchi then showed that mole rats can also detect reflected seismic signals from their own head-drumming; mole rats had no trouble finding a mechanical shaker sending out similar signals to her field recordings. As a final touch, Kimchi found unique mechanoreceptors in the skin of mole rats' paws, which might detect vibrations.

Kimchi admits that while all her results point in the same direction, she does not have concrete proof that mole rats use seismic 'echolocation'. She concludes: 'Further work is needed to prove the dual function of head-drumming. This is just the tip of the iceberg.'

10.1242/jeb.01461

Kimchi, T., Reshef, M. and Terkel, J. (2005). Evidence for the use of reflected self-generated seismic waves for spatial orientation in a blind subterranean mammal. *J. Exp. Biol.* **208**, 647-659.

SPONGES RELY ON SILICATE FOR SUPPORT



Picture by Werner Müller

Listening to Werner Müller talk about sponges, there's no doubt about his boundless enthusiasm for these primitive creatures. Sponges may look simple, but Müller explains that they are not amorphous blobs of cells; like other creatures, sponges have a 'Bauplan' or body design. Müller's team has now unravelled some of the intricacies of the sponge skeletal blueprint (p. 637).

'Sponge skeletons are made of pretty silicate-based shapes called spicules' says Müller, 'and they grow very fast.' But the skeleton's raw material, silicic acid, is not abundant in oceans. Sponges therefore probably expend a lot of energy to accumulate enough silicic acid to produce their spicules, and Müller wondered where this energy comes from. Arginine kinases are enzymes that buffer cells' ATP supplies and mediate energy transfer within cells. Since arginine kinase is an energy-transferring enzyme, Müller's team suspected that it might be involved in the energy-consuming process of sponge skeletal formation. The team already knew that silicic acid influences expression of the gene for silicatein, an enzyme that is responsible for the formation of silica in skeletal spicules. Could silicic acid also trigger expression of the sponges' arginine kinase gene?

To answer this question, Müller's team used an intriguing tool: primmorphs, tiny 3D sponge stem cell cultures. They grew one set of primmorphs in aquaria with very little silicic acid and another set supplemented with high levels of silicic acid, hoping that arginine kinase gene expression would be triggered in the supplemented primmorphs. Sure enough, primmorphs exposed to high silicic acid levels showed increased arginine kinase gene expression and enzyme activity, while primmorphs exposed to low silicic acid levels did not. But for really convincing evidence that silicic acid triggers induction of the arginine kinase gene, the team needed to show that sponge cells that can't take up silicic acid do not produce arginine kinase. The team exposed primmorphs to an inhibitor that prevents cells from taking up silicic acid, and were pleased to find that these primmorphs no longer showed an increase in arginine kinase gene expression and enzyme activity. So silicic acid really is an inorganic inducer of the sponge arginine kinase gene, leading to enhanced activity of this enzyme.

But can arginine kinase, triggered by silicic acid, influence the differentiation of sponge stem cells into spicules? The team reasoned that if arginine kinase plays a role in spicule formation, they should only find spicules growing in primmorph cells exposed to high levels of silicic acid, since only these cells have high levels of arginine kinase activity. As expected, when they examined primmorph cross-sections with an electron microscope, they only saw spicules forming in primmorph cells that had been exposed to high levels of silicic acid. The team concluded that silicic acid triggers a chain reaction, beginning with gene expression leading on to high levels of arginine kinase activity, which in turn helps the sponge accomplish the energy-consuming task of skeletal formation.

Müller explains that while most animals' body designs are genetically controlled, his team's results suggest that sponge blueprints may also be inorganically controlled. When sponges appeared on the scene some 800 million years ago, oceans were rich in silicate, so it made sense for them to use this inorganic substance to build their skeletons. Somewhere along the line, silicate apparently also began regulating enzymes involved in sponge skeletal formation. According to Müller, 'This is one of the first examples of an external element contributing to morphogenic processes in a multi-cellular animal.'

10.1242/jeb.01463

Perović-Ottstadt, S., Wiens, M., Schröder, H.-C., Batel, R., Giovine, M., Krasko, A., Müller, I. M. and Müller, W. E. G. (2005). Arginine kinase in the demosponge *Suberites domuncula*: regulation of its expression and catalytic activity by silicic acid. *J. Exp. Biol.* **208**, 637-646.

Outside JEB

Calling all aspiring
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If you'd like to write an Outside
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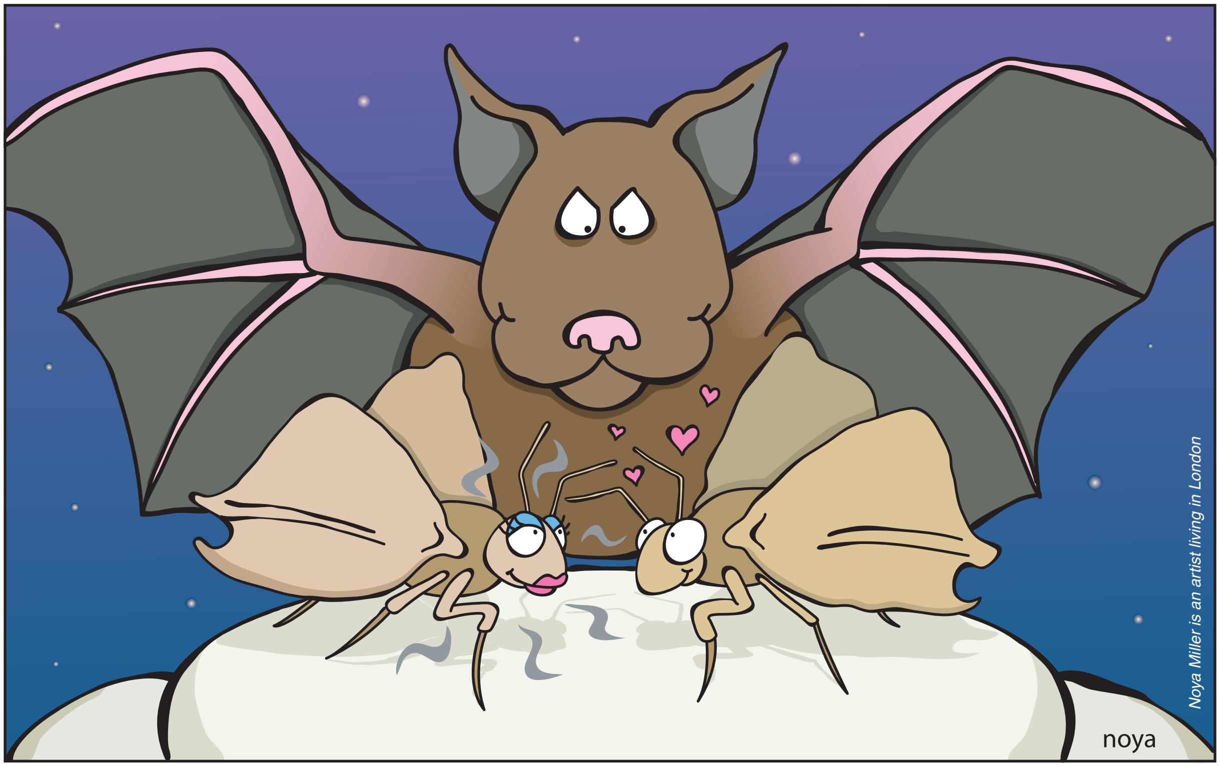
BATTLE OF THE SENSES



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Our senses are constantly bombarded with so many different signals that it can be hard to know what to pay attention to. If you're a male moth, the answer is simple: sex. Moths only live for two weeks, so it's unsurprising that males are preoccupied with sniffing out the fairer sex. But you can't mate if you're dead, so males should not ignore the sound of lurking danger. How male moths handle the trade-off between the sweet smell of their mate and the sound of impending doom depends on the relative intensity of these two sensory cues. Niels Skals and his colleagues have discovered that a whiff of female scent overpowers a male moth's sense of hearing, making the hapless male deaf to the sound of an approaching bat (p. 595).

To see how male moths cope with conflicting sensory information, Skals set up an air stream wafting a female moth's attractive scent across an open arena. He placed male moths at the downwind end of the arena and watched the males excitedly zigzag towards the odour source. When the male was halfway towards the object of his affections, Skals played bat ultrasound attack calls through a loudspeaker. Male moths sniffing synthetic pheromones froze when they heard bat calls, a typical predator evasion response. But as Skals increased pheromone quality and concentration, males became more reckless at the prospect of sex. When Skals used natural female pheromone gland extracts, the love-struck males completely ignored the bat calls and hurried on in hot pursuit of their female. Skals concludes that male moths have to weigh up the relative importance of smells and sounds; a high concentration of female scent could indicate that a potential mate is nearby and the male can't afford to lose his lady, even if that means an increased risk of becoming a bat's dinner.

10.1242/jeb.01462

Skals, N., Anderson, P., Kanneworff, M., Löfstedt, C. and Surlykke, A. (2005). Her odours make him deaf: crossmodal modulation of olfaction and hearing in a male moth. *J. Exp. Biol.* **208**, 595-601.

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