Inside JEB 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

FALSE KILLER WHALES FOCUS ECHOLOCATION CLICKS

Hunting in the ocean's murky depths, vision is of little use, so toothed whales and dolphins (odontocetes) rely on echolocation to locate tasty morsels with incredible precision. Laura Kloepper from the University of Hawaii, USA, explains that odontocetes produce their distinctive echolocation clicks in nasal structures in the forehead and broadcast them through a fat-filled acoustic lens, called the melon. 'Studies by other people showed odontocetes have the ability to control the shape of the echolocation beam and it has always been assumed that they are using the melon to focus sound', explains Kloepper. However, no one had ever tested this directly, so Kloepper and her PhD advisor, Paul Nachtigall, decided to tackle the question (p. 1306).

Fortunately, the duo is based at the Marine Mammal Research Program at the Univerity of Hawaii, which is home to Kina the false killer whale. Kloepper explains that Kina is extremely adept at working with marine biologists after decades of dedicated work by Marlee Breese and her training staff. On this occasion, Kina had been trained to recognise a 37.85-mm-wide cylinder with 6.35-mm-thick walls by echolocation, signalling that she had recognised the cylinder by touching a button in return for a fish reward. However, when Kina encountered other cylinders – with different wall thicknesses – she was trained to remain still before receiving her fishy prize. The team then selected two other cylinders to test her echolocation abilities: one with much thicker walls (7.163 mm) that Kina could detect with ease and another with only marginally thicker walls (6.553 mm) that Kina had more difficulty distinguishing from the 6.35 mm cylinder. Then, over a period of weeks, Nachtigall, Breese and Kloepper randomly presented the cylinders to Kina at distances ranging from 2.5 to 7 m, while noting her success rate and recording the cross-sectional area of her echolocation clicks with an array of hydrophones located between her and the cylinder.

But there was a problem: the width of an acoustic beam is determined by the frequency of the sound. So how could the team tell whether a change in beam width was due to Kina focusing the sound or simply due to the physics of acoustics? They turned to statistician Megan Donahue. 'Using statistics, we can account for the natural relationship that exists between beam area and frequency', says Kloepper, allowing them to correct for the frequency-related beam width variation. Plotting the adjusted beam area against the distance to the target, Kloepper discovered that Kina's echolocation beam became wider when she was having difficulties distinguishing between the 6.553 mm and 6.35 mm cylinders and when the cylinders were more distant. The false killer whale was effectively 'squinting' and adjusting the size of her echolocation beam in response to the more difficult tasks.

But was she actually focusing on the objects, because the beam width seemed to be getting wider rather than focusing in? Kloepper realised that the beam only appeared wider at the cluster of hydrophones because the array was close to Kina. When she plotted the path of the acoustic beams as they emerged from the animal's melon and passed through the hydrophone array, it was clear that the beams that appeared widest at the hydrophones were focused furthest away while the narrowest beams must be focused on the nearest objects.

'This is the first time that someone created a basic design to show that there is differential focusing of the beam under different target and echolocation conditions', says Kloepper, who is keen to find out whether other species use Kina's focusing strategy.

10.1242/jeb.072330

Kloepper, L. N., Nachtigall, P. E., Donahue, M. J. and Breese, M. (2012). Active echolocation beam focusing in the false killer whale, *Pseudorca crassidens*. *J. Exp. Biol.* **215**, 1306-1312.

Kathryn Knight

ENDOCANNABINOIDS MOTIVATED EXERCISE EVOLUTION

In the last century something unexpected happened: humans became sedentary. We traded in our active lifestyles for a more immobile existence. But these were not the conditions under which we evolved. David Raichlen from the University of Arizona, USA, explains that our hunter-gatherer predecessors were long-distance endurance athletes. 'Aerobic activity has played a role in the evolution of lots of different systems in the human body, which may explain why aerobic exercise seems to be so good for us', says Raichlen. However, he points out that testing the hypothesis that we evolved for high-endurance performance is problematic, because most other mammalian endurance athletes are quadrupedal. 'So we got interested in the brain as a way to look at whether evolution generated exercise behaviours in humans through motivation pathways', says Raichlen.

Explaining that most human athletes experience the infamous 'runner's high' after exertion, which is caused by endocannabinoid signalling in the so-called 'reward centres' of the brain, Raichlen adds that the reward system is also able to evolve, becoming more potent in mice that increase their exercise levels over generations. However, little was known about the role of endocannabinoids in the other aerobically active mammals, so Raichlen, Gregory Gerdeman and their colleagues decided to find out how exercise influenced the endocannabinoid levels of two mammalian natural athletes – humans and dogs – and a low activity species – ferrets (p. 1331).

Recruiting recreational runners and pet dogs from the local community, Raichlen and Adam Foster trained the participants to run and walk on a treadmill and collected blood samples from the participants before and after the exercise. Unfortunately, the ferrets were less cooperative, so the team collected the ferrets' blood samples after exercise and during rest.

Next, Andrea Giuffrida and Alexandre Seillier analysed the endocannabinoid levels in the blood samples and found that the concentration of one endocannabinoid – anandamide – rocketed in the blood of the dogs and humans after a brisk run. And when the team tested the human runners' state of mind, they found that they athletes were much happier after the exercise. However, when the team analysed the ferrets' blood samples, the animal's anandamide levels did not increase during exercise. They did not produce endocannabinoids in response to high-intensity exercise.

This leads Raichlen to suggest that natural selection used the endocannabinoid system to motivate endurance exercise in humans and other animals that walk and run over long distances. He says, 'These results suggest that natural selection may have been motivating higher rather than low-intensity activities in groups of mammals that evolved to engage in these types of aerobic activities.'

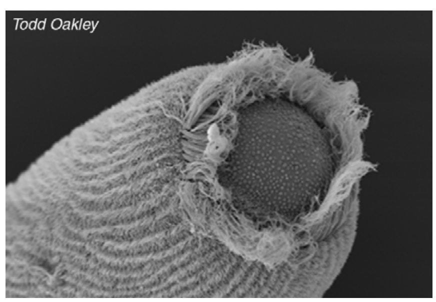
Having found that exercising mammals release pleasurable endocannabinoids in response to exercise, could these brain chemicals be the magic bullet that solves the obesity crisis? Sadly not, says Raichlen, who explains that couch potatoes are not about to leap suddenly out of their comfy chairs and experience the pleasurable effects of exercise, because they probably cannot produce enough endocannabinoids. He says, 'Inactive people may not be fit enough to hit the exercise intensity that leads to this sort of rewarding sensation.' However, he is optimistic that inactive individuals can be helped to build up their exercise tolerance until they cross the threshold where they become motivated to exercise by endocannabinoids. Raichlen also suggests that exercise could be a cheap solution to many medical conditions, improving our mental state through the endocannabinoids and our cardiovascular and pulmonary condition through good old-fashioned exertion.

10.1242/jeb.072348

Raichlen, D. A., Foster, A. D., Gerdeman, G. L., Seillier, A. and Giuffrida, A. (2012). Wired to run: exercise-induced endocannabinoid signaling in humans and cursorial mammals with implications for the 'runner's high'. *J. Exp. Biol.* **215**, 1331-1336.

Kathryn Knight

SPONGE LARVAE COULD BE GUIDED BY CRYPTOCHROME


Todd Oakley

From simple eyespots up to complex refractive and compound eyes, most animals are equipped with some form of visual structure that allows them to navigate the world; but not sponge larvae. Lacking conventional eye structures, rings of primitive light-sensitive cells guide larval sponges toward the blue light or shadow cues that indicate potential settlement sites. Todd Oakley and an international team of collaborators say, 'With pigment adjacent to photoreceptors, the sponge ring structure meets a minimal definition of an eye.' However, the *Amphimedon queenslandica* genome lacks one vital visual component: a gene for a light-sensitive opsin pigment – which is essential for vision in other animals – suggesting that the sponge's unique eyes might have evolved a completely novel light-detection mechanism. Curious to find out whether the sponge's simple eyes evolved independently of other eye structures, Oakley and his co-workers decided to try to identify components of the sponge's visual system (p. 1278).

Knowing that another group of light-sensitive proteins – known as cryptochromes – is produced by plants, insects and mammals, the team searched the sponge genome for evidence of the gene and discovered two examples. Next, the team made RNA probes to determine where the genes were expressed in the embryonic and larval sponges, and found that one of the two cryptochromes, *Aq-Cry2*, was produced near the sponge's simple eye cells. However, the team had to prove that the protein was cryptochrome and not a very similar protein, photolyase, which repairs damaged DNA in response to UV and blue light. So, the team expressed both genes – to produce the proteins that they encoded – and then tested whether the proteins could repair damaged DNA. Neither could. And when the team tested which wavelength of light the proteins absorbed, they found that Aq-Cry2 absorbed 450 nm light most strongly; the same wavelength that the larvae respond most strongly to.

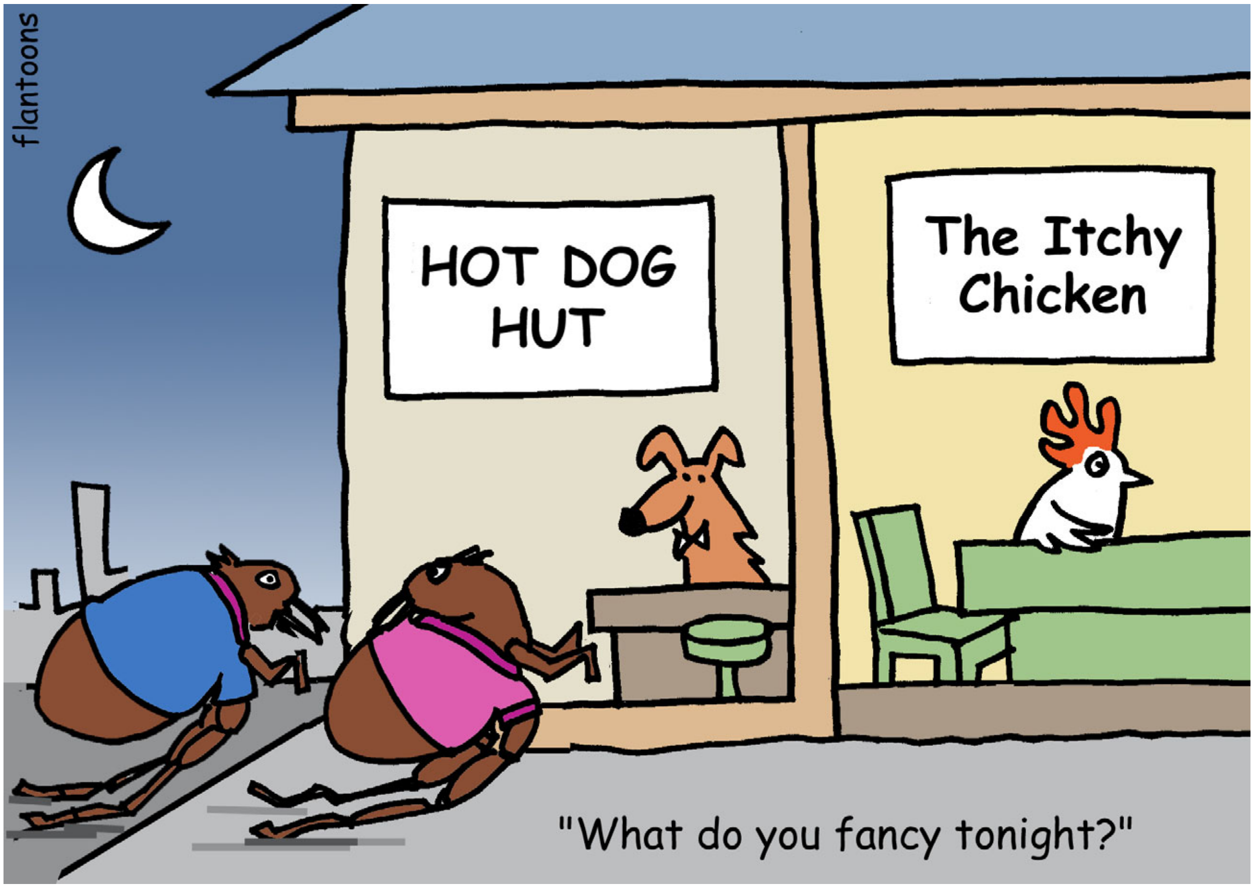
The team says, 'These results are consistent with a hypothesis that opsin-less sponge eyes utilize cryptochrome, along with other proteins, to direct or act in eye-mediated phototactic behaviour.' However, they also point out that although Aq-Cry2 cryptochrome has all of the necessary attributes for responding to blue light, it is not clear exactly how the protein functions to direct larvae to their settlement sites. Ultimately, the team is keen to determine how much sponge ring eyes share in common with other eye structures to learn whether sponges evolved their novel photodetection system completely independently or from other more conventional eye structures.

10.1242/jeb.072322

Rivera, A. S., Ozturk, N., Fahey, B., Plachetzki, D. C., Degnan, B. M., Sancar, A. and Oakley, T. H. (2012). Blue-light-receptive cryptochrome is expressed in a sponge eye lacking neurons and opsin. *J. Exp. Biol.* **215,** 1278-1286.

Kathryn Knight

PREFERRED HOSTS DON'T OFFER BEST DINING OPPORTUNITIES



We all have our favourite meals, and parasites are no different, preferring to dine and reside on one particular host – although they will infest and feed off others if their host of preference is not available. However, Boris Krasnov and colleagues from Israel and the USA explain that the more distant the evolutionary relationship between the principal host and second choice dining opportunities, the fewer parasites tend to take up residence. Intrigued by the relationship between parasites and their hosts, Krasnov and his team decided to find out whether the parasites preferences were affected by the dining opportunities presented by their host (p. 1259).

Suspecting that fleas would be more likely to dine, consume more and spend less energy digesting blood extracted from their preferred host than more distantly related hosts, the team collected newly hatched *Parapulex chephreis* and *Xenopsylla ramesis* fleas to infest rodents ranging from the fleas' preferred hosts to more distantly related species. Then, after allowing the fleas to feast, the team measured how many of the fleas had dined, how much they had consumed and their metabolic rate as they tackled digesting the meal, to find out if the relatedness of the hosts impacted the parasites' dining preferences.

The team was surprised to find that the fleas did not always do better when dining on their preferred host. Having expected that the fleas would consume most when sucking blood from their host of choice and spend the least energy digesting that meal, the team actually found the opposite: that fleas drank more from hosts that were only distantly related to their first choice and spent less energy digesting the meal. Also, *X. ramesis* fleas always consumed more than *P. chephreis* and used less energy processing the meal.

Analysing the unexpected consumption patterns, the team suspects that fleas used less energy digesting the blood of distantly related hosts because the victims rarely encounter the fleas; hence their immune response is weaker, making the blood easier to digest.

The team also suspects that *X. ramesis*' lifestyle could account for their efficient digestion. Explaining that *X. ramesis* only reside briefly on the bodies of their hosts, whereas *P. chephreis* remain in residence for lengthy periods, the team suggests that *X. ramesis* fleas are opportunists, consuming large meals and digesting them efficiently to make the most of their infrequent dining opportunities.

10.1242/jeb.072355

Khokhlova, I. S., Fielden, L. J., Degen, A. A. and Krasnov, B. R. (2012). Digesting blood of an auxiliary host in fleas: effect of phylogenetic distance from a principal host. *J. Exp. Biol.* **215**, 1259-1265.

Kathryn Knight
kathryn@biologists.com