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

WHY SOME CREATURES HAVE SLIT SHAPED PUPILS

Ronald Kröger from Lund University, Sweden, has been fascinated by eye optics ever since his PhD, but more recently he has begun investigating eyes that have an unexpected characteristic; their lenses have multiple focal points, each tuned to a different wavelength of light. Kröger explains that this remarkable characteristic compensates for the natural chromatic aberrations found in single focus lenses, producing a sharply focused colour image rather than the fuzzier images from conventional lenses. But on closer inspection, Kröger realised that round pupils could inadvertently block some colours from being sharply focused, while slit shaped pupils would not. Had creatures that evolved multifocal lenses also adopted slit pupils to make the most of their sharp vision? Curious to know how common multifocal lenses are in terrestrial animals and whether they are correlated with slit pupils, Kröger and his student Tim Malmström embarked on an eye testing odyssey (p. 18).

Fortunately, Malmström and Kröger didn't have to travel to the four corners of the earth to find the exotic creatures they wanted to test; most of the species they chose to investigate were available in local zoos, and the less exotic were often on their doorstep. Filming 14 species with slit pupils and 9 with round pupils using an infrared sensitive digital camera, the team was able to determine which animals had multifocal lenses and which did not. Fortunately the filming could be done from a distance of several metres when necessary, keeping the cameraman safe from the more carnivorous subjects. Malmström also took photographs of the animals' eyes during bright light conditions to get a clear view of the pupil's shape. 13 out of the 24 species that Malmström and Kröger investigated had mutlifocal lenses, and almost all of the creatures with multifocal lenses had slit pupils. 'Multifocal lenses aren't a freak solution for a few species' says Kröger, and they seem to explain why some creatures have opted for a slit pupil.

But the team are still puzzled by which came first, the slit pupil or the multifocal lens? Kröger explains that they deliberately chose to investigate groups of closely related animals, having slit and round pupils, with the hope of finding intermediate eyes that didn't fall into either category. Fortunately, their strategy worked. Malmström and Kröger found two species with multifocal lenses that still had round pupils, the common house mouse and the Taiwan beauty snake, suggesting that the multifocal lens might have evolved first in some species. But when Malmström investigated cats ranging in size from small domestic cats to the big predators, the team were surprised to see that the mid-sized lynx has an oval pupil and its lens is only slightly multifocal; everything is intermediate. Kröger suspects that there are several distinct evolutionary pathways to solve this problem, and cats and snakes may have taken different ones.

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Malmström, T. and Kröger, R. H. H. (2006). Pupil shapes and lens optics in the eyes of terrestrial vertebrates. *J. Exp. Biol.* **209**, 18-25.

CLEAR NIGHT SKY COOLS BIRDS

When birds feel the urge to migrate, nothing gets between them and their destination. Sustaining impressive metabolic outputs over lengthy periods of time, the birds cross seas, mountains and deserts while maintaining a 10 fold increase in their metabolic rate for days at a time. Even top human marathon runners clad in light running kit can only sustain an 8-9 fold increase for a matter of hours; well insulated birds on the other hand have to keep it up for much longer. How they dissipate the enormous amounts of heat generated by their muscles during migration puzzles Jacques Larochelle, and more precisely, how do they migrate across scorching deserts without succumbing to internal combustion? Intrigued by the animals' remarkable thermoregulation, Larochelle and student Jérôme Léger decided to test whether a migrating bird could shed much of its thermal load by radiative heat loss while traversing some of the world's hottest wildernesses (p. 103).

Surprisingly Larochelle's inspiration didn't come on a scorching summers' day. He realised radiative heat loss could have a significant cooling effect one clear autumn evening about thirty years ago; the roof of his car were covered in frost while the rest of the vehicle was ice free, even though the air temperature was a balmy 5°C. Larochelle recalls that at that time, 'everyone thought that birds avoided flapping flight in air above 20°C', so he didn't make the association. It was only later when colleagues recorded birds migrating across the Sahara at 20°C that he recalled the car's frosty top. The car was losing an enormous amount of heat by radiation to the clear night sky heat sink. Could radiative cooling stop birds from boiling over while migrating at night too?

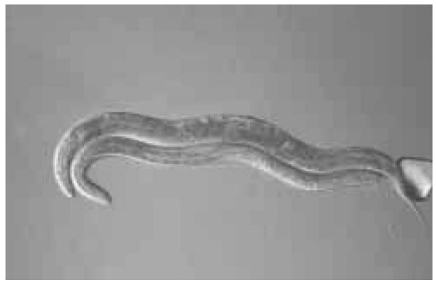
Testing his theory required some technical ingenuity. First Larochelle and Leger had to convince pigeons to lie in a flight position in a wind tunnel while they simulated the bird's exposure to mild flight winds. But how could they simulate the night sky's heat sink effect while generating a warm breeze in the small flight tunnel? Eventually the team decided to impregnate the wind tunnel's walls with combinations of ice, dry ice and methanol to plunge the walls to temperatures as low as a –78°C. Finally the team had to come up with a way of gently simulating the heat generated by the bird's labouring muscles. Knowing that physiotherapists use weak microwave radiation to gently warm damaged muscle, Larochelle carefully warmed the birds with weak microwaves to simulate the heat generated during a long flight. The team were ready to test whether the night sky was keeping the birds cool.

Monitoring the birds' wing feather temperatures with an infrared thermometer the team realised that the birds were much cooler than could be explained by convection. When the team dropped the wind tunnel walls' temperature 20°C below the ambient air temperature, it was clear that the birds could be losing as much as 50% of their heat by radiation alone. And when the team dropped the wall temperatures even lower, they realised that radiative cooling became so effective that the ambient air began warming the birds' outer feathers. So a clear night sky keeps birds cool when voyaging on sultry nights.

10.1242/jeb.02022

Léger, J. and Larochelle, J. (2006). On the importance of radiative heat exchange during nocturnal flight in birds. *J. Exp. Biol.* **209**, 103-113.

DECISIONS, DECISIONS



It's sometimes said that food is the way to a man's heart and *C. elegans* are no different; they love tucking into a plate of *E. coli.* But *C. elegans* rarely experience *E. coli* in the wild. Their natural foods of choice must be some of the hundreds of bacterial species cultivated in soil. Intrigued by the nematode's natural dining habits, Boris Shtonda and Leon Avery from the University of Texas Southwestern Medical Center decided to find out whether the worms fared better on some bacteria than others. Offering the nematodes a selection of 40 bacterial varieties gathered from local Dallas soils, the team soon realised that worms thrived on some species while barely growing on others. Recognising that all bacteria are not equal from a nematode's perspective, Shtonda and Avery decided to investigate whether the tiny worms were capable of making choices between nutritious and poor bacteria, and whether past experiences influenced their dining choice (p. 89).

Once Shtonda knew which bacteria the worms thrived on and which they grew less well on, he began offering the tiny worms a simple choice between two bacterial colonies of different nutritional qualities placed close together. At first, the worms distributed themselves evenly between the two dining options, but within several hours, Shtonda began noticing that the worms were expressing a preference. If offered a choice between a nourishing species and a less nutritious bug, most of the worms eventually ended up in the more nutritious of the two. The worms were making a choice between a good and bad diet.

Amazed that such a tiny creature could make the choice between fine dining and junk food, Shtonda decided to test whether the worms actively chose to eat a more nutritious diet, or were they deciding to abandon the poorer meal in search of something better. The team began filming the worms as they ate either nourishing or poor bacteria to see if they could identify particular behaviour patterns. Sure enough, Shtonda quickly realised that worms offered a poor diet had a much higher probability of leaving the dining spot than worms offered a better quality meal. *C. elegans* was making the decision by leaving behind poor food in the hope of finding something better.

Curious to know how sophisticated the worm's decision making process was, Shtonda decided to investigate whether earlier dining experiences had any affect on the nematode's later decisions. Having allowed the worms to feed on one of the bacterial strains for 2 hours, Shtonda then offered them a choice between good and poor bacteria to see if past experiences influenced their choice. As Shtonda suspected, worms that experienced a good diet at some time in their lives were more prepared to search for good meals than worms that had been treated to a mediocre diet; 'a good food experience makes them more motivated to seek better food later' says Shtonda.

Puzzled by what controls the tiny animal's ability to make a choice, Shtonda began screening a wide range of mutant worms to see which ones had the biggest problem making a decision and was surprised when a worm that had lost its ability to migrate towards a warm spot also proved incapable of choosing a good diet. Knowing which neuron was impaired in these mutant worms, Shtonda inactivated the neuron in wild-type worms, and they became less able to make a choice. Having found part of the circuit that controls the nematode's food seeking behaviour, Shtonda is keen to know how it regulates the worm's choice but suspects that it will be a long time before he knows the way to a worm's heart.

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Shtonda, B. B. and Avery, L. (2006). Dietary choice behavior in *Caenorhabditis elegans*. *J. Exp. Biol.* **209**, 89-102.

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