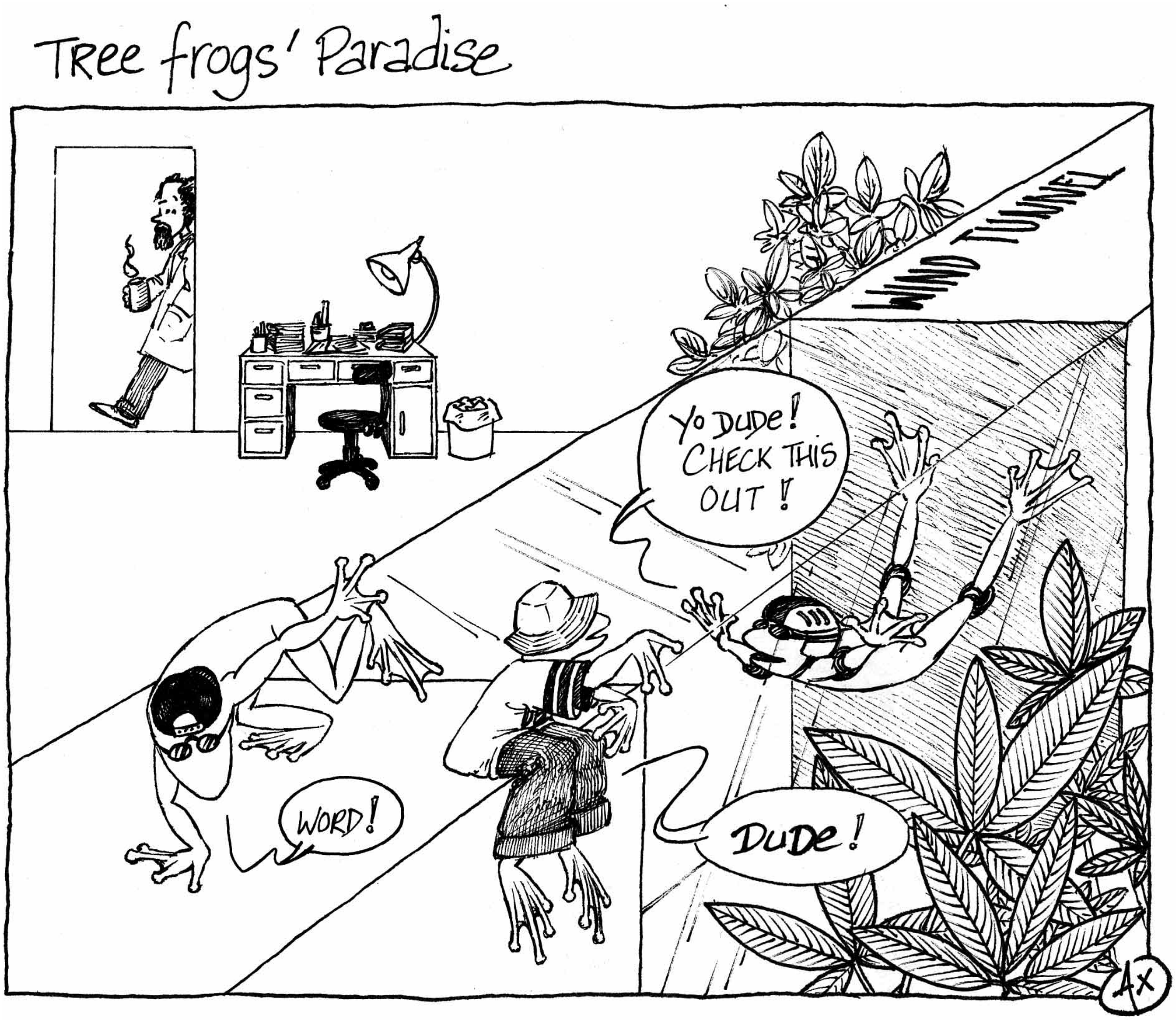
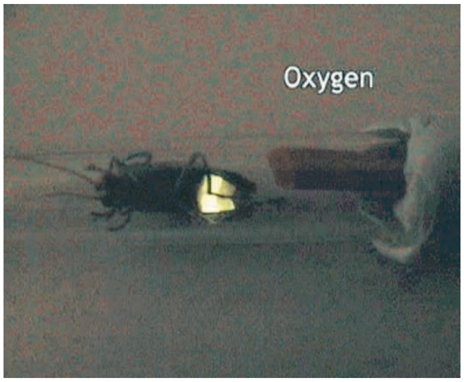


McCay, M. G. (2001). Aerodynamic stability and maneuverability of the gliding frog, *Polypedates dennysi*. *J. Exp. Biol.* **204**, 2817–2826.

Blinded by the Light (p. 2795)



If you've ever caught a firefly, cupped it in your hands and watched its tail glow, you'll know why Graham Timmins thinks that bioluminescence 'is cool'. It's a phenomenon that has fascinated people for centuries. Although the chemistry of the reaction is well understood, the real puzzle has been how the light is 'switched on'?

The light-emitting reaction is fuelled by oxygen. Maloeuf suggested, as long ago as the 1930s, that the switch was oxygen delivery to the photocytes, but no one had been able to provide convincing support for his idea. Interest in the switch mechanism has been re-ignited at the turn of this century by two competing theories that hinge on the oxygen source.

The mechanism proposed in *Science* magazine by Trimmer (Trimmer et al., 2001) proposes that oxygen levels in the photocytes are regulated by nitric oxide (NO). His model suggests that cytochrome c oxidase in the mitochondria is inhibited by NO, causing a transient increase in the photocyte oxygen levels to activate the flash of light. However, in this issue of *J. Exp. Biol.*, Timmins reports kinetic measurements, which indicate that oxygen delivery by the tracheoles provides the activating pulse of oxygen.

Oxygen is transported throughout the insect's body by a network of tubes called tracheoles. When the insect has relatively few energy demands, the system is suffused with tracheolar fluid, but when the insect is active, the fluid levels drop by osmosis, to deliver oxygen to organs that need energy. Maloeuf thought that the flash might be initiated by a pulse of oxygen carried by the tracheoles to the photocyte cells in the lantern. He suggested that as the reaction progressed and consumed the available oxygen, the flash would decay. His idea was that the tracheolar fluid 'gates' oxygen delivery to the photocyte cells. For this 'gate' to be the switch, the reaction kinetics would have to agree with those predicted by diffusion theory.

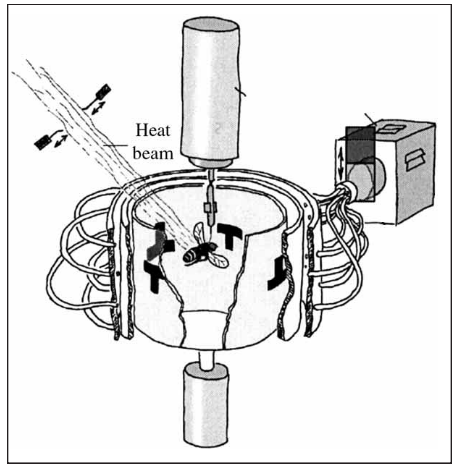
Timmins tested the flies under different atmospheric conditions. He found that the time between stimulation and flashing is consistent with an oxygen-gating trigger. This is the first time that anyone has provided strong evidence for Maloeuf's gating mechanism.

Timmins has suggested a sequence of events that spark a flash. He thinks that a nerve signal is sent to the lantern, which initiates an osmotic change in the tracheole cells that reduces the tracheolar fluid levels. Air then flows into the lantern's tracheoles and triggers the glowing reaction.

Both Trimmer's and Timmins' theories are plausible, yet neither have been proved beyond doubt. Woodward Hastings at Harvard University, who inspired Timmins to take up the challenge, thinks that he's not quite there yet but 'he has come a long way to answering the question'. With two competing models attracting significant attention the firefly has sparked new interest in an established scientific puzzle that Timmins hopes might be resolved in the near future.

Trimmer, B. A., Aprille, J. R., Dudzinski, D. M., Lagace, C. J., Lewis, S. M., Michel, T., Qazi, S. and Zayas, R. M. (2001). Nitric oxide and the control of firefly flashing. *Science* **292**, 2486–2488.

Fly With IQ (p. 2849)



Intellectual learning is a human luxury that most of us take for granted. But for many creatures, learning is the essence of survival. Interest in vertebrate learning behaviour has a well-documented history. Two major theories, that have stood the test of time, became established in the early 20th century. They are referred to as 'blocking' and 'sensory preconditioning'.

Blocking can be described as a labour saving device. If an animal learns about a situation using one stimulus, it blocks learning from any other associated stimuli. The second type of learning occurs when two stimuli frequently occur together. The animal associates them, and if it is stimulated by one of the stimuli alone it recalls the other. Vertebrates are known to use both strategies. However, the situation isn't so clear for invertebrates. Showing that a particular learning response doesn't occur in one context is not proof that it never happens.

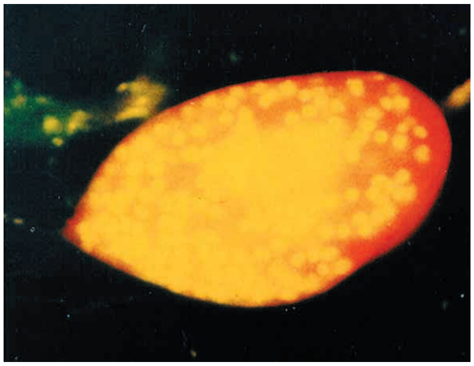
Martin Heisenberg and his student Björn Brembs have used a tiny flight simulator to look at the way *Drosophila* lay down memories. The flies are suspended inside the simulator so that they can flap their wings, but their heads and bodies are stationary. The simulator senses the tethered fly's intended movements and moves the visual world accordingly. First the flies are trained by using an unconditioned stimulus (heat), that forces them to fly so that they avoid the heat, while being shown two conditioning stimuli (colours and patterns) that they learn to associate with the avoidance flight pattern. After training, they are then shown the conditioning stimuli alone (e.g. colours and patterns), but they have learned to fly as if they were avoiding the heat, even though that stimulus has been removed. One question was whether the fly would be able to learn to respond to the visual stimuli (patterns and colours) independently if it had been trained with both together. They also wondered whether the fly would block learning with a second visual stimulus (colour) if it had already learned to avoid the heat with an earlier stimulus (pattern).

Heisenberg was pleased with the results. The flies learned from both stimuli, and didn't block learning with a second stimulus. They were also able to learn from, and then untangle, simultaneously presented stimuli, as humans would. Of course this doesn't mean that the flies don't block learning under other conditions, but they don't do it in this flight simulator.

The ability to untangle different training stimuli is quite sophisticated behaviour, suggesting that there are many similarities between learning in vertebrates and invertebrates. As Heisenberg puts it 'I wouldn't believe that a fly could read the New York Times, but they manage life as well as we do'.

Fitness and Fertility (p. 2773)

If you're bitten by an insect in the West, it's usually a minor irritation, but in parasite infested regions of the world, it can spell death. Hilary Hurd has been interested in the relationship between



parasites and their insect hosts (vectors) for most of her scientific life. She's been intrigued by the ways that parasites manipulate the vector's health. In some cases, the parasite can only progress to the next stage in its life cycle if the vector dies, but in others, a parasite will invest to keep a vector healthy.

One result of some parasitic infestations is a decrease in the vector's fertility shortly after infection. Some insects also suffer a loss of appetite around the same time, and this coincidence made it tempting to speculate that the decreased fertility was a result of the poorer diet. However, it turns out that not all infected vectors lose their appetite, and that some parasites trigger follicular resorption in the ovaries that decreases the insects' fertility.

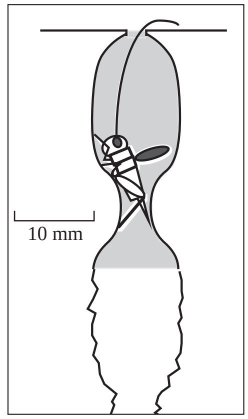
Hurd and her team wondered if the biggest human killer in the world, the malaria parasite, affected mosquitoes in the same way, and to test this turned to a lab-safe malaria parasite, *Plasmodium yoelii nigeriensis* that infects mice.

She collected mosquitoes after they'd fed on an infected mouse. Looking at the infected mosquito's ovaries, she found that ovarian follicles were being absorbed into the body. She could reverse this if she treated the cells with a cell death inhibitor, because the epithelial cells were undergoing apoptotic cell death

But what is the advantage to the parasite of reducing the host's fertility, especially if it might result in a smaller host population to carry future generations of parasites? The strong correlation between longevity and reproduction is a well-established fact. Organisms that reproduce less, are fitter and live longer. Of course the parasite wants a fit insect to transport it to its next vertebrate host. The best course for the parasite is to ensure the insect's fitness by reducing the insect's fertility and preventing it from 'wasting' energy on its own young.

At first sight, this may seem to be a counterintuitive measure. Surely a reduction in the insect population would affect the parasite too. Hurd points out that this isn't likely because the infected insect population is usually less than 20 % of the entire population at any one time. The uninfected insects can easily maintain population levels that will satisfy the parasite's demands.

Apoptosis seems to be a fundamental aspect of the malaria parasite's life, but little is known about apoptotic mechanisms in mosquitoes. At present the mosquito genome is far from complete, but she hopes that the identification of genes homologous to mammalian apoptotic genes could turn out to be a key step in the war against malaria.



The Well-tempered Burrow (p. 2827)

Henry Bennet-Clark has always been interested in the 'Gee-Whiz' of biology. Which is why he's spent much of the last 30 years listening to crickets: they're just too loud for their size. Throughout nature, loudness and frequency scale with size. Tiny creatures make weak highly pitched chirrups, while giants rumble away in the bass register. But crickets break the rules when it comes to volume and pitch, which is why he wondered how these tiny musicians sing fortissimo.

Over the years, Bennet-Clark has worked with a succession of people to investigate the qualities of different insect songs. Most crickets project their voice using well-established acoustics. For example, a cicada produces an incredibly loud sound by using its body as a soundbox. The noisy critter vibrates the timbal structures, which force the abdominal air sac and ear-drums to behave as a Helmoltz resonator.

But then Win Bailey introduced him to a tiny cricket that lives in the western Australian desert. The little beast lives in tubular burrows carved from the desert floor and cemented with saliva. What struck Bennet-Clark about this cricket was the purity of the clear, bell-like song, and the consistency of the pitch.

Bennet-Clark and Bailey set out into the desert to record the cricket's song. The recordings showed that the note was made from a single pure tone, more like the sound from a flute than the buzz from a violin. Because the insects had perfect pitch the two scientists realised that the insects must be using some other resonator system, so they turned their attention to the burrows.

The team noticed that the burrow's dimensions were almost as consistent as the songs the crickets sang. Back in the lab, Bennet-Clark built models based on the burrow-casts they had made in the desert. When he tested the models with an artificial sound source, he found he could produce sounds that were as pure as the cricket's songs.

Having proved that a weak chirrup can produce a pure tone he also noticed that the cricket might 'tune' the burrow by moving around and singing softly at different sites. But the burrow's acoustics were completely different from anything Bennet-Clark had seen before, so he recruited Neville Fletcher, to see if he could interpret the ringing tones.

Fletcher's model explains the cricket's unique acoustic system. No other creature uses a burrow in quite this way to sing to its neighbours. It's the burrow's design that helps the insect hit the note, by strongly coupling the cricket's voice with the acoustic properties of its home. Which is why, this cricket is the purest singer in the world.

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