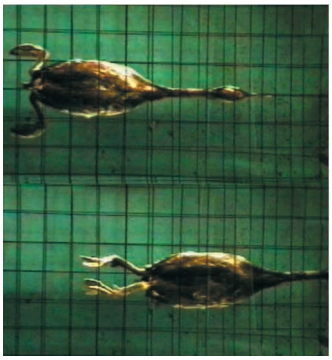
IN THIS ISSUE



Funny Feet (pp. 1687–1696)

Grebes have strange feet, even by the standards of most birds. In fact, they are so strange that the grebe has abandoned the land and opted for an aquatic life, only leaving the water for floating nests to reproduce. Christoffer Johansson noticed their odd shape while wandering around the Natural History Museum in Gothenberg, and decided to set about answering the question: why do grebes have such weird feet?

His first problem was to find a trusty subject, so Johansson teamed up with Glufse the Grebe, and together they began to solve the problem of why grebe's toes are the way they are.

Glufse was trained to swim through a 2 m long tunnel that was 0.4 m high and 0.6 m wide. Johansson filmed him from above and the side collecting over 170 swimming sequences. He rejected the more erratic trajectories, and finally selected the thirteen sequences where Glufse used his best technique for digital analysis. Johansson followed the motion of six points on Glufse's body while he swam: the tip of his tail, two points on his leg and the tips of three toes. Having established the motions of the six body points during each swimming cycle, Johansson used force/vector analyses to draw the conclusion that grebes use lift, rather than drag, for forward propulsion.

How does Glufse achieve this feat? Well, his toes behave as hydrofoils. They act as multiple slots, which generate a lift force, and push the bird forward, in the way that primary flight feathers perform in birds. The multiple slots in the wings increase the lift to drag ratio by reducing the drag of the wings, and the gaps between Glufse's toes produce the same effect.

The asymmetric shape of the toes also reminded Johansson of primary flight feathers, which can be rotated individually to maintain the greatest lift coefficient. If this could be achieved by the toes swivelling passively, so that they were always in the best orientation to generate the least drag, this would maximise the lift to drag ratio and make this an extremely efficient way of swimming. Of course, Glufse does this with no effort at all.

Grebes have no living close relatives and probably haven't evolved much over the last 2 million years. The fact that grebes evolved little over that period of time suggests that they have found an evolutionary pinnacle, but that doesn't mean that other swimming strokes aren't equally as efficient, just different.

So, that's why grebes have strangely shaped feet. And where is the star of Johansson's swimming movies? He has retired to his own private lake in the Universeum, Gothenberg, to paddle out peacefully the rest of his days.

New Tricks for Old Models (pp. 1757–1764)

In 1974, Sydney Brenner wrote his classic paper on mutagenesis of *Caenorhabditis elegans*, and the rest is history. With a single publication, he elevated the tiny worm (1 mm long) to a hallowed place in science's Hall of Fame. Despite its diminutive stature, it has been dissected and scrutinised to ever-increasing resolution, culminating last year in 1998 in the determination of the DNA sequence of its entire genome.

A great deal is known about the way the worm's nervous system regulates the elegant sinusoidal path it leads through life, thanks to members of the species that are less coordinated. However, very little little is understood about the way that these animals respond to external stimuli, and even less about their ability to learn. Yuichi Iino explains that learning can be defined as 'a phenomenon where the behaviour of an animal changes depending on its previous experience'. So how do you test a worm's ability to learn? Sounds like a tricky test. Over the years some of the worm's behavioural traits have formed the bases of 'learning' assays, and now Iino and his team have come up with another reliable method based on two strong incentives: starvation and salt.

Most of us will recognise the craving for a certain salty flavour, and *C. elegans* isn't much different. Under most circumstances, worms placed on a Petri dish covered in nourishing E.coli will migrate up a salt gradient, attracted by the salty source. However, when the worms are starved in the presence of salt, they adapt their behaviour so that a fresh salt gradient holds no attraction, and the worms move randomly across the plate. In other words, the worm has learned. Iino points out that the worms need both stimuli to 'learn' this response, and he believes that this is a form of associative learning. Armed with this knowledge, the team of three(?) set out to design a chemotaxis assay that can be used to sort out A-grade students from their less adaptable classmates.

In the first stage of the assay, well-fed adult hermaphrodite worms are transferred to a training plate, where they are conditioned with NaCl under starvation conditions for 4 h. After training, the animal's reaction to a fresh salt gradient is tested, and the worms that have adapted show no interest in the tempting salty spot. They then test how the trained worms respond to volatile chemoattractants. In this case, the worms don't alter their response, finding isoamylalcohol equally tempting before and after training. In other words, the behaviour is specific.

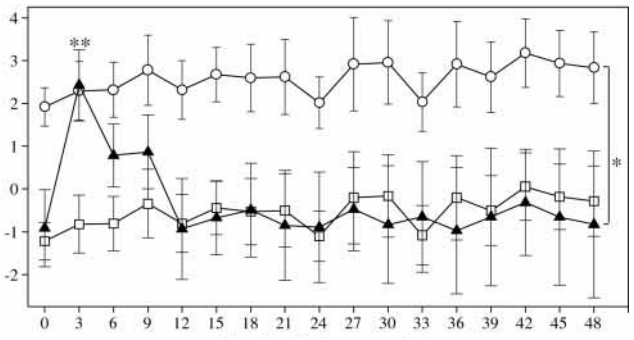
Having established that the new assay worked, they decided to use it to screen mutagenized worms with the hope of identifying individuals that didn't catch on as quickly as their classmates. And they did: in fact they isolated three mutants that failed to learn and continued to migrate along a salt gradient, despite starvation training.

In the same way that the genome has opened up many new avenues of research, Iino's new simple learning system has expanded the range of techniques available to anyone interested in adaptive behaviour in worms. The next challenges are to expand the screen to identify more mutants with a learning deficit, and to begin unravelling the complex relationships between inputs that lead the starving worms to learn. Ultimately, Iino would like to clone and characterise the mutated genes and delve into the mechanisms of learning at the molecular level. Who knows, we might even be using a few of those learning genes ourselves, but that's a lesson for another day.

Weight is a Mouse Issue Too! (pp. 1729–1734)

Losing weight isn't easy, and it doesn't look as if there are going to be any breakthroughs for humans in the near future. However, in a study published in this issue of *J. Exp. Biol*., Chris Adams describes an intriguing observation that indicates that some organisms integrate neural mechanisms with better-understood endocrine factors, to stay trim and keep the weight down.

During a completely unrelated study, Andrew Korytko noticed that mice who had been implanted with an interperitoneal thermometer lost weight. Chris Adams thought this was intriguing, so he began a systematic study to see how mice adjusted their body mass in response to inert implants, even if their mass was increased by a sizeable amount. He then took the question a stage further and wondered whether the mice could readjust their mass after that extra weight was later removed.



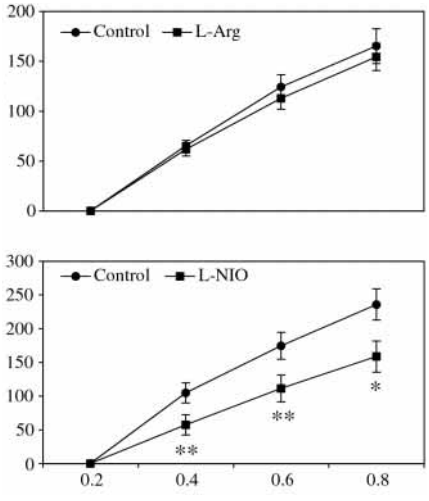
Adams decided to look at two effects: the modification of total body mass in response to the implants, and the effect on body composition. In the first group, 50 adult mice were chosen and their normal food intake and body mass levels monitored. The mice were then divided into five groups, three of

which were implanted with weights of 1, 2 and 3 g respectively. The other two groups were used as controls, and had either an empty implant or a sham operation. Each animal's weight was monitored daily for a total of five weeks. At the end of this period, half of the animals in the 1, 2 and 3 g groups were operated on and their implants removed, after which they recovered and were studied for a further 45 days. In the second study, another 50 mice were tested with implants. These mice were sacrificed after 5 weeks to see if there was any variation in their body composition.

Even though some of the mice had gained as much as 10 % mass during the implant operation, they all reduced their body mass within a few days to compensate for the extra grams they'd gained, and maintained the lower weight through the rest of the five week period. A few days after the implants were removed, Adams found that the mice had suffered a surprising weight gain, their body masses shooting up by as much as the weight they'd just been relieved of. However, they lost this extra body mass within a few days of having put it on. The interesting point was that instead of returning to the weight they'd had before the experiment began, it returned to the new lower value that they'd achieved, while carrying the weighty implant. They'd reset their body weight set point, thanks to the unconventional mouse slimming aid!

If the mice were losing weight, were they eating less too? The animals with the largest implants had definitely cut down, which suggested that they were partly regulating their weight by changing their energy intake. However, when Adams looked at the animal's body composition, this hadn't changed in response to the weight loss. The animals hadn't shed fat or muscle, they'd remained physiologically unchanged, and yet they'd lost weight. This led Adams and his colleagues to draw the conclusion that the animals are responding to a change in the load on the musculoskeletal system, and that this is transduced by a novel neural pathway.

In short, this may be great news if you're a deer mouse that's a touch on the heavy side, but species that tip the scales further will just have to keep on using more conventional alternatives. We'll still be counting the calories for a few more years to come.



NO Heart Beat (pp. 1719–1727)

Nitric oxide (NO) has proved to be **the** regulatory molecule of the last decade. Since its identification as the Endothelium Derived Relaxation Factor our love affair with NO has continued with intensity, the number of citations rocketing from a lowly 120 in 1987, to over 5500 last year!

NO is a key modulator of mammalian heart function. It mediates its function through a variety of molecular mechanisms, including regulating cGMP production, by targeting guanylyl cyclase. NO is produced in tissue by nitric oxide synthase (NOS), which uses arginine and oxygen to produce NO. Tinkering with NOS is a good way to find out where NO is regulating a response.

One of the main sources of NO in myocardial tissue is the endocardial endothelium. Fish have a larger ventricle surface area to volume ratio than homeothermic hearts. So, the endocardial endothelium is a potentially rich source of NO for the fish heart. Sandra Imbrogno and colleagues at the University of Calabria decided to investigate whether NO regulation of myocardial function might also be significant in fish, and added the eel *Anguilla anguilla* to the list of august organisms that have 'lost their hearts' to NO.

Imbrogno took isolated eel hearts and tested the response to NO under three sets of conditions. Firstly, she looked at the heart under basal conditions and established that NO altered the heart beat under a variety of conditions that inhibited either nitric oxide synthesis or guanylyl cyclase, and conditions which damaged the endocardial endothelium. Then she looked at the effect of NO on the cholinergic response. This time she found that the heart beat with more force, and that NO from the endocardium endothelium was essential for the effect.

In the last set of experiments, Imbrigno and co-workers looked at the effect of NO on the Frank-Starling response, where an increase in venous filling pressure causes the heart to pump harder. By activating and inhibiting NOS, she found that NO does affect the Frank-Starling response, giving the fish a stronger heart beat in response to physical activity.

So the answer to the question is a resounding YES. NO does modulate fish heart function, in much the same way it does in mammals and amphibians. The difference is that mammals can modulate their heart rate to a much greater extent than fish. Which means that this form of Frank-Starling response regulation is probably more significant to fish than mammals and that NO is definitely the way to a fish's heart.