Inside JEB, formerly known as 'In this issue', 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

BEE'S KNEE TREMBLING TALES

Although a returning forager bee looks drunk on nectar as she trembles on the honeycomb, Corrina Thom explains that the ungainly dance is far from neurotic; it's part of the complex communication system that keeps the hive running smoothly. But what provokes the bees' staggering movements wasn't quite clear. Were they trembling to catch the attention of receiver bees to help them unload their nectar cargo, or were they reporting on conditions at a profitable food source? To find out what set the bees trembling, Thom lured them to a spacious feeder, and suddenly shrank it to a fraction of the original size to see how the bees reacted. Timing how the laden bees behaved upon their return to the hive, Thom realised that instead of calling for help from receiver bees, the trembling foragers seemed to be reporting the overcrowded conditions at the feeder (p. 2111).

During their brief lives, a honeybee's role alters as it ages. After serving the hive as a cleaner and attendant to the Queen, a middle aged bee becomes a 'nectar receiver', aiding returning foragers, before finally taking to the wing and foraging. But for the hive to thrive, foragers and receivers must communicate, to ensure that they work together efficiently and minimise delays. So a returning forager that's struck lucky dances, waggling their bodies, to direct other foragers to rich supplies of nectar. But what message are trembling bees communicating, and who is their message aimed at? Thom knew that overcrowding at the feeder provoked returning foragers to tremble. Were the bees commenting on conditions at the feeder, or signalling for back-up from the receivers?

Working with a team of student helpers, Thom began testing the returning insects' reactions to a congested source of nectar. First she trained foragers to feed at an artificial nectar source by slowly moving the feeder away from the hive. 'If they're in a good mood they'll follow' says Thom, 'but some colonies find other sources, such as flowers'; it can take days to train them. But once the hive was reliably returning to feed, Thom was ready to monitor how the bees responded to overcrowding. She replaced the spacious tray of nectar with a smaller, more congested feeder, and watched how the bees reacted.

Back at the hive, Thom timed how long the foragers waited for a receiver bee to appear, after the forager had returned from the cramped feeder. She was surprised that the bees waited no longer than if they had filled up at the spacious feeder; so overcrowding hadn't caused a backlog and delays for the returning foragers. But were waiting bees trembling to attract more receivers to help them unload? Thom timed how long it took foragers to begin performing, and found that some of the insects began trembling at the same time that other bees waggled, and most surprisingly, it didn't seem to matter whether receivers were even there to watch the performance. The ungainly dance didn't seem to be aimed at the receivers at all!

Thom believes that the foragers weren't trembling to recruit more receiver bees, she thinks that the message was aimed at other forager bees, adding extra information about the feeder's cramped conditions to the waggle dance's directions.

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Thom, C. (2003). The tremble dance of honey bees can be caused by hive-external foraging experience. *J. Exp. Biol.* **206**, 2111-2116.

CHICK'S FAST GROWTH TAKES NO EFFORT FOR PETREL PARENTS

Growing up is never easy, but for newly hatched Antarctic fulmarine petrel chicks, the pressure's really on. With little more than three months before the temperatures plummet and winter returns, the chicks must develop and take to their wings before the weather closes in. But these remarkable chicks rise to the challenge, growing at twice the rate of petrel chicks from temperate zones, even though it 'takes far more energy to make 1 g of chick at subzero temperatures' explains Wes Weathers. How the birds sustain these rapid growth rates wasn't clear, and Weathers and Peter Hodum wondered if the youngsters' parents had to put in more effort than their temperate cousins to sustain their chicks' spectacular growth rates. Hodum headed south to the Rauer Islands in East Antarctica to measure both chick and adult metabolic rates in four

Antarctic fulmarine petrel species, and was amazed to find that although all of the youngsters fledged within two months of hatching, their parents worked no harder than if they were feeding chicks that developed at half the rate (p. 2125)!

Hodum explains that he has always been fascinated by petrels, because of their beauty and the 'mystery of their lives'; very little is known about their biology. And Hodum adds that the Rauer Islands are probably the best place in the world to study the birds; four fulmarine petrel species gather there to nest. So he travelled south, during three consecutive field seasons, for the unique opportunity to measure the bird's metabolic rates as the chicks developed.

After injecting both chicks and adults from all four species of fulmarine petrel with naturally occurring isotopes of oxygen and hydrogen, Hodum collected tiny blood samples from the birds, so that he could compare the amounts of each isotope remaining in their bodies to calculate their energy expenditures. He remembers that collecting samples from the chicks was quite straightforward: 'they never move from the nest'. But the adults were another matter. Parent fulmarine petrels leave for days on end to forage in the oceans, often returning at night to feed their young, which is a problem during the southern hemisphere's summer; there is no night, so the birds can return at any time of day. Hodum and a team of helpers set up 24-hour watch, ready to intercept the returning adults.

And having chosen to work with the deuterium isotope of hydrogen instead of tritium, Hodum faced another complication. The carefully collected samples had to be sent to a specialised facility in the Netherlands for isotope analysis. After returning to his base in Australia, Hodum faced a frustrating two-year wait before he knew whether his efforts had been in vain.

With the isotope data finally in hand, Hodum was amazed; the adult Antarctic petrels only worked as hard as petrel-parents in more temperate zones, even though the youngsters were growing twice as fast as other species' chicks. Weathers and Hodum were also surprised that the chicks seemed to match their growth rate to the time available. All of the chicks fledged during Antarctica's three-month summer, even though some species' chicks were twice the size of others.

So how do the chicks sustain their accelerated growth rate if the parents aren't over exerting themselves? Hodum and Weathers suspect that the bird's phenomenal growth rate is down to the abundance of top quality food in the Antarctic oceans.

10.1242/jeb.00439

Hodum, P. J. and Weathers, W. W. (2003). Energetics of nestling growth and parental effort in Antarctic fulmarine petrels. *J. Exp. Biol.* **206**, 2125-2133.

NO LOUNGING FOR LIZARDS

The nickname 'lounge lizards' is more appropriate than you might think for some reptiles, given that certain lizards seem to avoid activity as they have difficulties getting air into their lungs when they move. While it might be acceptable for some species to sit and wait for dinner to pass by, limited respiration poses a challenge for livelier reptiles that actively forage for their food. One such lizard is the South American tegu, which caught the interest of Wilfried Klein and Steven Perry. They found that tegus have a primitive diaphragm, the post hepatic septum, which divides their body cavity in two, separating the lungs and liver from the rest of their internal organs. Smaller or lazier lizards lack this membrane, which made Klein wonder whether the post hepatic septum might help tegus to breathe during activity. So Klein left his laboratory in Bonn and travelled to the pleasanter climes of Brazil to work with Augusto Abe's colony of tegu lizards, where he could measure the animals' respiration while they walked (p. 2135).

The experiments were simple in principle. Klein monitored the breathing of groups of animals that either had an intact post hepatic septum or had the septum surgically removed, as they walked slowly on a treadmill.

However, they had not bargained on the tegus' lack of cooperation on the treadmill. According to Klein, tegus are very intelligent animals. 'If they are handled regularly most of them will be tame after a short while and they cooperate easily. However, some animals display a very strong character… and always have to be handled with great care as they have very sharp teeth!' To add to the team's frustrations, tegus hibernate during the winter; so the race was on to get the data before the animals became dormant. But having come to terms with the lizard's recalcitrance, Klein was able to measure the animals' respiratory rates and volumes, as well as their endurance as they walked at speeds up to $0.28\,m\,s^{-1}$.

Klein and his colleagues found that while the animals with a post hepatic septum were exercising, they breathed deeper and faster then when they were resting. However the tegus that lacked a post hepatic septum took much smaller breaths as they walked, although they made up for this smaller tidal volume by breathing faster. The team also noticed that the tidal volume of the tegus that had been operated on only increased immediately after exercise, not during, and then returned to resting levels. Klein explains that during exercise, the lizards' internal organs had shifted, effectively 'squashing' the lungs. So by restraining the animal's internal organs as it moves, the tegu's proto-diaphragm gives it the extra lung space it needs to chase its next meal.

Klein explains that this is extremely interesting given the active lifestyle of the animal, as its lungs are more like those of lazier lizard relatives, which are relatively stiff and requiring a lot of work to operate them. Tegu lungs therefore seem to be better equipped for life as a 'sit and wait' predator, so they must have developed their post hepatic septum to cope with this limitation. This finding may also have important evolutionary implications, as the true diaphragm in mammals is the main muscle, which supports breathing. Perhaps the mammalian diaphragm also started out as a membrane similar to the post hepatic septum, but evolved from an assisting role, to become respiration's major muscle.

10.1242/jeb.00440

Klein, W., Andrade, D. V., Abe, A. S. and Perry, S. F. (2003). Role of the post-hepatic septum on breathing during locomotion in *Tupinambis merianae* (Reptilia: Teiidae). *J. Exp. Biol.* **206**, 2135-2143.

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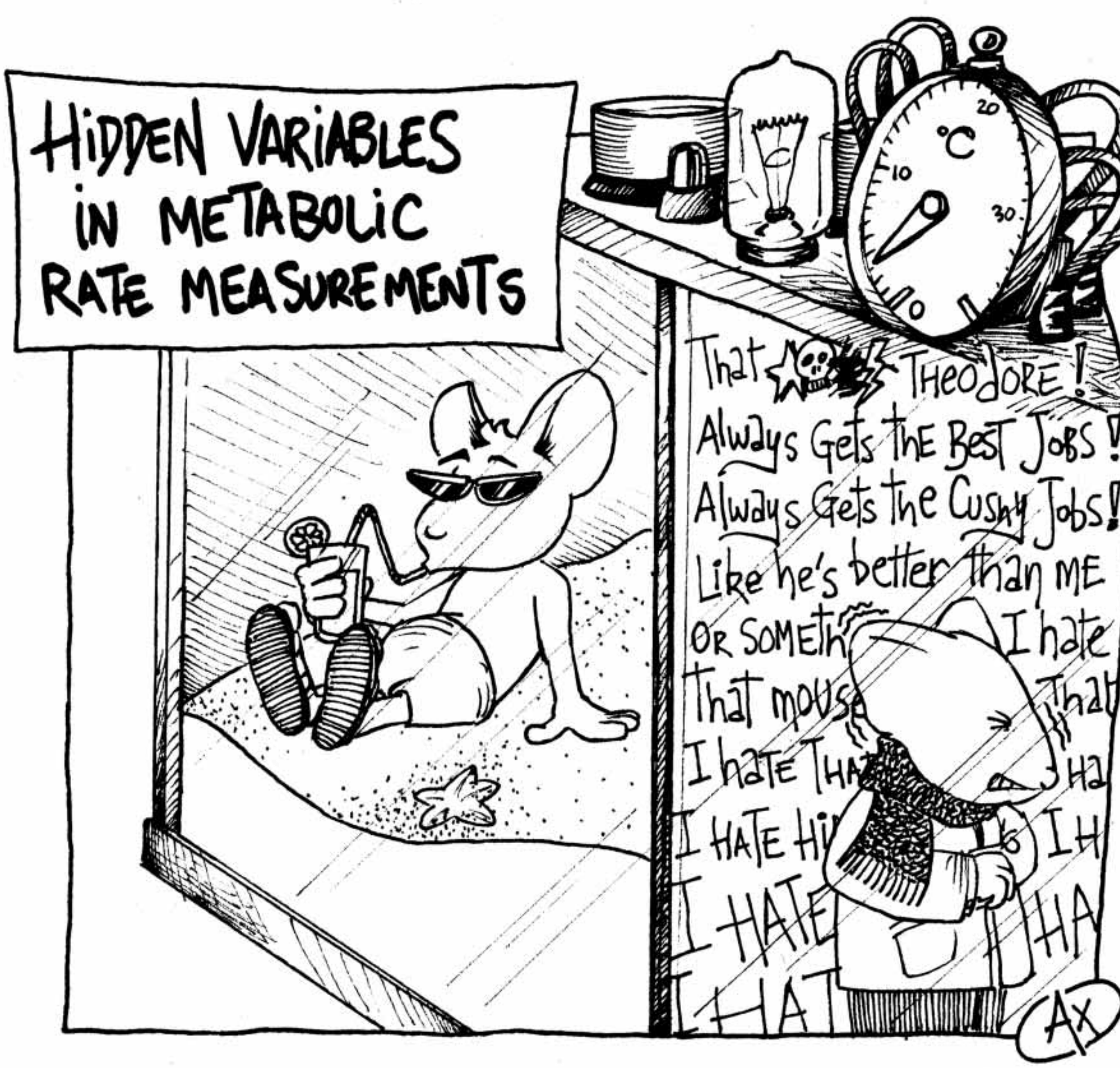
METABOLIC MAYHEM



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Measuring a mammal's metabolic rate is technically fairly straightforward these days. But as Roberto Nespolo explains, an animal that has been reared in clement conditions might have a very different metabolic rate then an animal that has been shivering in the cold. How much of an effect acclimation has on an animal's metabolic rate wasn't clear, until Nespolo measured the metabolic rates of tiny leaf-eared mice in the lab that had been acclimatised to either 30°C or 12°C. The animals' metabolic rates varied enormously, depending on the conditions the rodents had experienced. Which could mean that metabolic measurements made on animals in the wild could be unreliable, and strongly affected by the environmental conditions the animal has experienced (p. 2145).

Knowing that metabolic rate is highly correlated with body size, Nespolo also tested how well several physical characteristics that are often taken as good indicators of body size, correlate with the rodent's metabolic rates. In each case he found a correlation, but each characteristic was related to metabolic rate in a different way, so they couldn't be taken as a reliable indicator of body size. Nespolo decided to develop a more accurate way of defining the rodent's body size. He used a statistical analysis known as 'structural equation modelling' on three easily measured physical parameters, and found that of the statistical analysis was a much truer way of defining the animal's body size.

10.1242/jeb.00441

Nespolo, R. F., Arim, M. and Bozinovic, F. (2003). Body size as a latent variable in a structural equation model: thermal acclimation and energetics of the leaf-eared mouse. *J. Exp. Biol.* **206**, 2145-2157.

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