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.

FINGERPRINTS DON'T INCREASE FRICTION

Peter Warman

Fingerprints mark us out as individuals and leave telltale signs of our presence on every object that we touch, but what are fingerprints really for? According to Roland Ennos, from the University of Manchester, other primates and tree-climbing koalas have fingerprints and some South American monkeys have ridged pads on their tree-gripping tails, so everyone presumed that fingerprints are there to help us hang onto objects that we grasp. The theory that fingerprints increase friction between the skin and whatever we grab onto has been around for over 100 years, but no one had directly tested the idea. Having already figured out why we have fingernails, Ennos was keen to find out whether fingerprints improve our grip, so he recruited Manchester undergraduate Peter Warman to test out fingerprint friction (p. 2016).

Because the friction between two solid materials is usually related to the force of one of the materials pressing against the other, Ennos and Warman had to find a way of pushing a piece of acrylic glass (Perspex®) against Warman's finger before pulling the Perspex® along the student's finger and measuring the amount of friction between the two. Ennos designed a system that could produce forces ranging from a gentle touch to a tight grip that squashed the entire fingerpad against the surface, and then Warman strapped his index finger into the machine to begin measuring his fingerprint's friction.

But after days of dragging the Perspex® along Warman's fingers and thumbs, it was clear that something wasn't quite right. Instead of the friction between each finger and the Perspex® increasing in proportion to the amount that the Perspex® pushed against Warman's fingers, it increased by a smaller fraction than Ennos had expected. Ennos realised that instead of behaving like a normal solid, the skin was behaving like rubber, where the friction is proportional to the contact area between the two surfaces.

To check that skin behaves more like rubber than a normal solid, the duo varied the area of each fingerpad that came into contact with the surface by dragging narrow and wide strips of Perspex® along Warman's fingerpads. They found that the friction did increase as more of the fingerprint came in contact with the surface, so the skin was behaving just like rubber.

Finally, the friction issue was clinched when Warman measured his fingerprints' surface area. The area of skin in contact with the Perspex® was always 33% less than if the fingerpads were smooth resulting in the maximum contact area. Fingerprints definitely don't improve a grip's friction because they reduce our skin's contact with objects that we hold, and even seem to loosen our grip in some circumstances.

So if fingerprints don't tighten our grasp on smooth surfaces, what are they for? Ennos explains that our fingerprints may function in other ways. They might have evolved to grip onto rough surfaces, like tree bark; the ridges may allow our skin to stretch and deform more easily, protecting it from damage; or they may allow water trapped between our finger pads and the surface to drain away and improve surface contact in wet conditions. Other researchers have suggested that the ridges could increase our fingerpads' touch sensitivity. Whatever our fingerprints are for, it seems that the idea that they provide friction for grip may be just another urban myth.

10.1242/jeb.033977

Warman, P. H. and Ennos, A. R. (2009). Fingerprints are unlikely to increase the friction of primate fingerpads. *J. Exp. Biol.* **212**, 2016-2022.

MANATEES LOCATE SOUND SOURCES

The world is a perilous place for the endangered manatee. While the mammals are at risk from natural threats, human activity also poses a great danger to manatee numbers. Debborah Colbert, from the Association of Zoos and Aquariums, explains that many manatees die and are seriously injured in collisions with boats every year. However, little is known about how manatees perceive their environment. Whether they can localise sounds, and specifically whether they can tell which direction a boat is approaching from, are crucial factors in the development of manatee protection programmes. Colbert and her colleagues decided to test whether the mammals can pinpoint sound sources (p. 2105).

Working at the Mote Marine Laboratory and Aquarium in Florida, Colbert was able to work with two male manatees, Hugh and Buffett, when she initiated a research programme to find out more about these enigmatic creatures. Born in captivity, the young males had already surprised people who had thought that manatees were 'not intelligent enough to train' says Colbert. Both young males had been trained to participate in a series of sensory studies, so Colbert, Joseph Gaspard 3rd, Gordon Bauer and Roger Reep patiently trained the animals to swim to a specific stationing platform in their enclosure where they could listen to sounds played from one of four speakers arranged around their heads.

Knowing that the manatees' hearing was most sensitive to sounds ranging from 10 to 20 kHz, while the animals' calls range from 2.5 to 6 kHz, Colbert and David Mann designed three sounds ranging from 0.2 to 20 kHz, 6 to 20 kHz and 0.2 to 2 kHz to play to the animals. The team also selected two single frequency (tonal) sounds at 4 kHz and 16 kHz to test how the manatees responded to less complex sounds. Having trained the manatees to swim to the speaker that they thought the sound came from, the team then played the broadband sounds, of 0.2, 0.5, 1 to 3 s, from each speaker at random while monitoring the animals' responses.

Yet again the manatees impressed their supporters. Buffett successfully identified the source of the broadband sounds with almost 90% accuracy, while Hugh did slightly less well. The team was also surprised that the manatees were able to locate the sources of both the 4 kHz and 16 kHz tones, although they only tested the animals with the longest of the two tonal notes, as the manatees had shown signs of frustration when they heard these sounds.

So how are the animals able to localise sounds? Colbert explains that many terrestrial animals use the time difference between a sound arriving at their two ears to find the source. However, this time difference is probably extremely short in aquatic animals, as sounds travel five times faster in water than in air. Animals also use the intensity difference as the sound arrives at each ear, which is more pronounced in high-pitched noises, to pinpoint the source. Colbert suspects that the manatees use combinations of these and other cues to help them localise sounds, as they were able to locate the sources of high- and low-pitched sounds equally well.

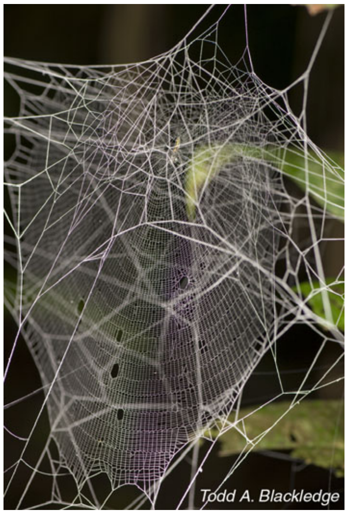
Crucially, the animals can probably hear approaching speed boats and tell which direction they are coming from, which is an essential piece of information for conservation organisations as they battle to save this gentle giant.

10.1242/jeb.033985

Colbert, D. E., Gaspard, J. C., 3rd, Reep, R., Mann, D. A. and Bauer, G. B. (2009). Four-choice sound localization abilities of two Florida manatees, *Trichechus manatus latirostris*. *J. Exp. Biol.* **212**, 2105-2122.

SPIDER SILK CONTRACTS LIKE MUSCLE

Todd Blackledge is fascinated by spiders and their webs. 'They are an incredible tool for exploring spider behaviour,' Blackledge explains and adds, 'they capture the behavioural decisions that spiders make in response to natural selection in the environment'. But to understand how spider webs function, you have to understand the mechanical properties of the silk itself and how it is affected by environmental conditions. Blackledge and his colleagues, from the University of Akron, decided to focus on the effects of humidity on one of the web's major structural components; dragline silk. According to Blackledge, some spider silks contract dramatically when they get very wet and it wasn't clear why. He decided to focus on the effects of humidity on dragline silk produced by the golden silk orbweaver and made the amazing discovery that tiny humidity changes cause the silk to contract and relax, just like a muscle fibre (p. 1981, p. 1990).



However, Blackledge was initially interested in understanding how spider silks behave when exposed to dramatic increases in humidity. Curious to know what happens to dragline silks when they become wet and supercontract, Blackledge and Ingi Agnarsson carefully mounted samples of the silk in a tensile tester equipped with an environmental chamber and slowly increased the silk's humidity in 10% intervals while measuring the tension on the thread (p. 1981). Not expecting to see any change in the silk's length until they reached higher humidities, the duo were surprised to find that the silk relaxed as they increased the humidity, and contracted as the air in the environmental chamber dried. By cyclically raising and lowering the humidity in 10% steps, Blackledge and Agnarsson were able to make the silk extend and contract repeatedly, like a muscle. However, when they increased the humidity further, the pair saw the silk contract dramatically and irreversibly when the humidity reached 70%.

Wondering why the silk was able to contract and relax reversibly at low and high humidities, yet supercontract irreversibly at 70% humidity, Blackledge and Agnarsson monitored the amount of water lost and gained from the silk fibres as the humidity changed. They found that the fibre's water levels rose as the humidity increased, allowing the fibre to relax as it became softer and regions of the silk protein molecules became more mobile. However, when the humidity fell, the reverse happened; the fibre dried forcing mobile regions of the silk proteins to collapse together as the fibre contracted.

Curious to find out why the silk supercontracted irreversibly, Blackledge teamed up with Cecilia Boutry, Shing-Chung Wong and Avinash Baji to look at the silk's thermal stability and found that the silk was permanently changed after the supercontraction. Water molecules had been incorporated into the silk protein's structure. Blackledge suspects that at very high humidities, a glycine rich region of the silk protein becomes extremely mobile, breaking free of the bonds holding the region down. This allows another region of the protein to collapse together in the fibre, supercontracting the silk and trapping water molecules in the silk's structure.

Having figured out why the silk relaxes under some conditions and supercontracts under others, Blackledge was curious to know more about the silk's remarkable muscle-like behaviour (p. 1990). Teaming up with Ali Dhinojwala and Vasav Sahni, Blackledge and Agnarsson decided to measure the stresses generated by the contracting silk and to find out how much weight a contracting fibre could lift.

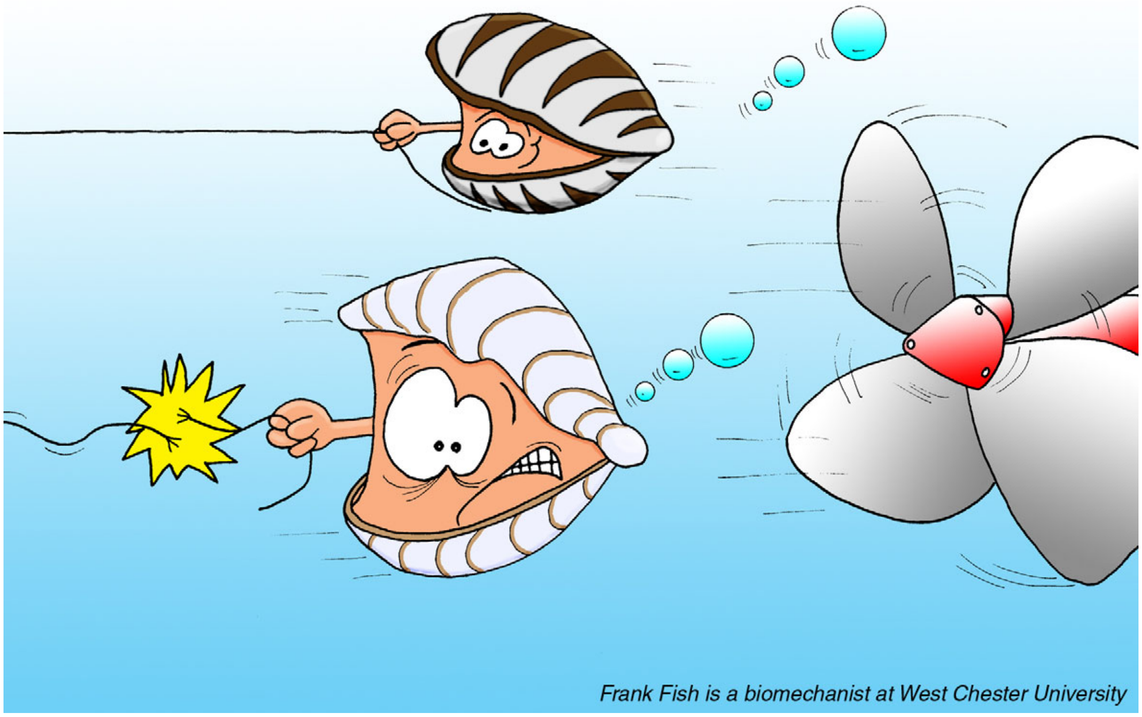
Drying a 5 μm thick fibre to force it to contract, the team measured stresses ranging from 20 mPa in moist conditions to 140 mPa when the air was almost dry. And the thread had no problem lifting weights up to 100 mg, which might not sound like much, but when Blackledge compared the silk's weightlifting prowess with that of a single human muscle fibre, the spider silk did as well as, and by some measures better than, the muscle fibre. What is more, the silk never tired and relaxed, unlike human muscle, which requires a constant energy supply to sustain a contraction.

Having realised that spider dragline silk can contract and relax rapidly as the humidity changes, Blackledge is keen to look at other species' silks. 'There are over 40,000 spider species,' says Blackledge, 'so we need to investigate cyclic contraction in other silks because there could be one that performs better.' And while Blackledge thinks it unlikely that spider silk muscles will ever power prosthetic limbs, he is optimistic that the silk's muscle-like behaviour could find applications in a wide range of new technologies, such as micro-mechanical systems and 21st century drug delivery systems.

10.1242/jeb.034009

Blackledge, T. A., Boutry, C., Wong, S.-C., Baji, A., Dhinojwala, A., Sahni, V. and Agnarsson, I. (2009). How super is supercontraction? Persistent *versus* cyclic responses to humidity in spider dragline silk. *J. Exp. Biol.* **212**, 1981-1989.
Agnarsson, I., Dhinojwala, A., Sahni, V. and Blackledge, T. A. (2009). Spider silk as a novel high performance biomimetic muscle driven by humidity. *J. Exp. Biol.* **212**, 1990-1994.

ZEBRA MUSSELS HOLD ON TIGHTER THAN QUAGGA MUSSELS



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Love them or hate them, zebra mussels are having a big effect on the ecosystems that they invade. While the bivalves clarify freshwater lakes and rivers, they also smother surfaces, clog pipes and wipe out indigenous mussel populations. But the invaders are themselves coming under threat from the quagga mussel. Concerns about both mussels' relentless occupation of territory have led Suzanne Peyer, Alice McCarthy and Carol Lee from the University of Wisconsin to find out more about the byssal threads that mussels use to secure themselves to a surface (p. 2027).

Exposing the mussels to still and fast flowing water, the team measured how fast the animals synthesised their byssal threads and how tightly they held on. They found that the zebra mussel not only grows byssal threads at a faster rate but also hangs on better in fast flowing water, giving it the edge over the quagga muscle in fast flowing waters.

However, the zebra mussel's investment in its attachments system may not go entirely in its favour. The team explain that growing more byssal threads might be energetically costly for the tenacious mussel, potentially limiting their growth and reproduction, while the easily dislodged quagga mussel is known to grow faster and larger which may allow it to begin reproducing sooner to out compete its rival. Lee and her team suspect that the quagga's greater size could prove to be advantageous for them in calm waters, while zebra mussels should thrive better in fast flows. But the team adds that a third of quagga mussels successfully held on even in the fastest flowing waters ($180\,\mathrm{cm\,s^{-1}}$). Lee and her colleagues suggest that the quagga mussel may be able to adapt to fast flowing environments, which would allow it to encroach on zebra mussel safe holds, leaving the smaller invader with fewer places to hide from its rival.

10.1242/jeb.033993

Peyer, S. M., McCarthy, A. J. and Lee, C. E. (2009). Zebra mussels anchor byssal threads faster and tighter than quagga mussels in flow. *J. Exp. Biol.* 2027-2036.

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