Hearts Divided

For most creatures, sitting down to digest a good meal isn't a time of pulse-racing physical exertion. But for pythons, digestion sends their pulse rate soaring as the reptile's three-chambered heart rises to the metabolic challenge. All reptile hearts have a single ventricle where oxygenated and deoxygenated bloods mix, reducing the amount of oxygen that can circulate around the reptile's body and limiting the creature's maximum metabolic rate. A muscular ridge partially divides all reptiles' ventricles, but never to the extent of developing two independent ventricle chambers. But Tobias Wang, Jordi Altimiras and Michael Axelsson knew that the muscular ridge in a python's heart is much larger than in many less active species. They wondered whether the size of the ventricle's ridge was in any way correlated with a reptile's metabolic demands. Working in Sweden, they tested how blood flows through a beating python heart, and were amazed when they found that the python's muscular ridge effectively divides its ventricle in two (p. 2715)!

Reptiles of all sizes and life styles have the same basic cardiac plan: two atria delivering blood to a single ventricle. On leaving the ventricle, the blood either returns to the lungs, where it is reoxygenated, or is shunted into the body when a sphincter muscle constricts around the pulmonary artery, temporarily isolating the heart from the lungs. Oxygenated blood in the ventricle is continually diluted by the deoxygenated blood returning from the reptile's body, naturally limiting the amount of oxygen that the reptile can deliver to meet its body's metabolic demands. For most reptiles, this state of affairs is not troubling, as their metabolic rates never rise too high. But some reptiles have active lifestyles. Would they need more oxygen than a single ventricle could deliver, or have they overcome the dilution problem to fuel their active lifestyles?

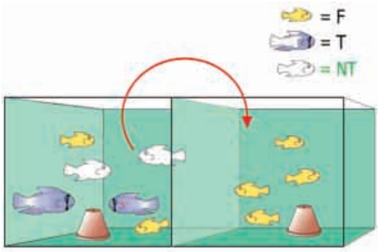
Although python's lives are not hectic, their heart and metabolic rates rocket during digestion, and they also have a well-developed ridge in their ventricle. What effect would that have on the way the ventricle delivers blood to the lungs and body?

The team fed saline solution into either the pulmonary or systemic veins. If the ventricle was undivided, saline would pump out of both of the ventricle's arteries, but if the ridge divided the ventricle in two, the heart would only pump saline out of the same side as the vein delivering saline to the heart. Wang explains that they were astonished when saline only pumped out of one artery. The python's ventricle was divided in two and behaving like a four-chambered mammalian heart!

Wang admits that this is a very controversial result for reptile cardiology, but he believes that the metabolic advantage the python gets from maximising oxygen delivery to its body could account for the creature's high metabolic rate during digestion. Of course, one data point 'does not a correlation make', but Wang is now looking to other families of Brazilian snakes to see if any other snakes have such clearly divided hearts.

Sex in Cichlid Society

Teenagers aren't the only species that suffer from social pressure. In fact some creatures even change sex when the social equilibrium shifts. Some male cichlid fish don't go that far, but their behaviour, appearance and fertility alter as the social hierarchy changes. Russell Fernald wondered whether a shift in social status was the trigger for the physiological changes that accompany well-established behavioural changes. Working with Stephanie White and Tuan Nguyen, he monitored male cichlid reproductive status after the fish were transferred to a new social environment. Tracking the fish as their dominance rose and fell, the scientists discovered that changing the fish's social status drove changes in the level of a key sex hormone that controls the fish's sexual maturity (p. 2567).



In the shore pools of Lake Tanganyika, only territorial, brightly coloured male cichlid fish are fertile. The remaining males, who haven't succeeded in winning a patch of pool, are dowdy and infertile until circumstances change and territory becomes available. An unaggressive male can then join the dominant group, changing both his behaviour and fertility while transferring his social status. Fernald and his team wondered whether changes in the fish's physiology and behaviour were influenced by the make up of the community around it.

White decided to test for evidence of changes in the fish's sexual maturity by following the sex hormone, gonadotropin-releasing hormone (GnRH). The peptide is expressed in neurons in the fish's hypothalamus, so White tracked levels of the hormone's mRNA template in the fish's brain. She also monitored gonad size as it changed in response to the fish's social context. Having figured out how to track the fish's physiology, she needed to persuade them to change social status.

The simplest way to make a fish 'top dog' is to place him, unchallenged, in the midst of a school of females. White transferred a non-territorial male into a tank of females. With no other males around, the newly transferred fish instantly switched to behaving aggressively, but it took several days before he matured sexually.

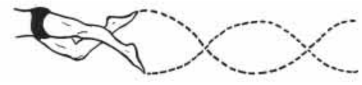
Although promoting a male cichlid into a harem might be every cichlid's dream, it's hardly a realistic social situation. White repeated the test with non-territorial males, transferring them to a tank where they dwarfed the resident dominant males. This time, the males were more cautious, waiting until they had matured completely before beginning to act boldly. However, when White reversed the situation and demoted a dominant male by transferring him to a tank where he was dwarfed, he switched instantly into a submissive role. This fish's GnRH mRNA levels didn't immediately reflect the male's new life style, falling slowly over a period of three weeks while the gonads shrank.

White explains that these different responses to situations where the males were either promoted or demoted show that 'the community make-up influences both the behavioural and the physiological changes'. She adds that although the time lag between the responses seems counterintuitive at first, White believes that it is probably geared to take advantage of the rare opportunities when territory becomes available.

White and her colleagues don't know what aspect of the fish's altered social status triggers the transcription of the hormone template, but they have evidence that social stress affects production of the all important gonadotropin-releasing hormone.

Dragging the Speed Down

Alberto Minetti is fascinated by machines that improve human physical performance. He describes the bicycle as a 'marvellous invention' which increased man's top terrestrial speed by approximately 300% at the energetic cost of a light jog. But the



story isn't so impressive in water. The only tools that humans have developed to boost swimming performance are fins. Bikes increase muscle efficiency by taking the legwork out of supporting our own body weight. But a swimmer's weight is already supported by the water, so how do the fins benefit their performance? Minetti and his team began scrutinising every detail of swimmer's leg strokes as they swam with and without fins (p. 2665) and discovered that the appendages increase the size of the propulsive jet of water that pushes a swimmer forwards with less wasted energy.

Compared with air, water is a dense and viscous medium. With every kick, a swimmer thrusts a propulsive jet of water backwards that overcomes the effect of drag. But some of the swimmer's energy is wasted simply displacing water sideways. Minetti needed to find out how efficient swimmers are before he could see how fins improve our performance.

Minetti teamed up with Dave Pendergast in Buffalo New York. Pendergast has a 60m long swimming channel where he monitors swimmers' metabolic and mechanical performances as they swim along the channel. Paola Zamparo, Minetti's student, travelled to Buffalo where she videoed elite swimmers' kicking action while measuring their oxygen consumption as they swam at different speeds with and without the fins.

Swimmers have to overcome drag, so the strength of their backwards propulsive jet must balance the amount of drag from the water. Because the strength of the propulsive jet is equal to the drag acting against the swimmer, she measured the amount of drag acting on each swimmer to find out how strong the propulsive jet was. She also calculated the amount of energy wasted by kicking water sideways based on the movements of the swimmers limbs. From these values, she could determine the efficiency of the swimmers as they performed with and without fins. By comparing the swimming efficiencies with and without fins, they realised that the swimmers with fins were able to push more water into their propulsive jet, increasing the efficiency from 61% to 70%.

Minetti and his team also realised that the fins slowed the swimmer's kick rate at a given speed. They realised that the finned swimmers were moving more efficiently because their kicks had been slowed to a speed where their muscles generated work more efficiently. So, each leg was moving more water at a lower physical cost to the swimmer, giving them spare energy to boost their speed.

Minetti accepts that other types of fin might offer bigger improvements in human aquatic performance, but he doesn't hold out much hope for future developments in small-fin technology. He believes that it's going to take a much more radical development before we see human swimmers keeping pace with the dolphins.

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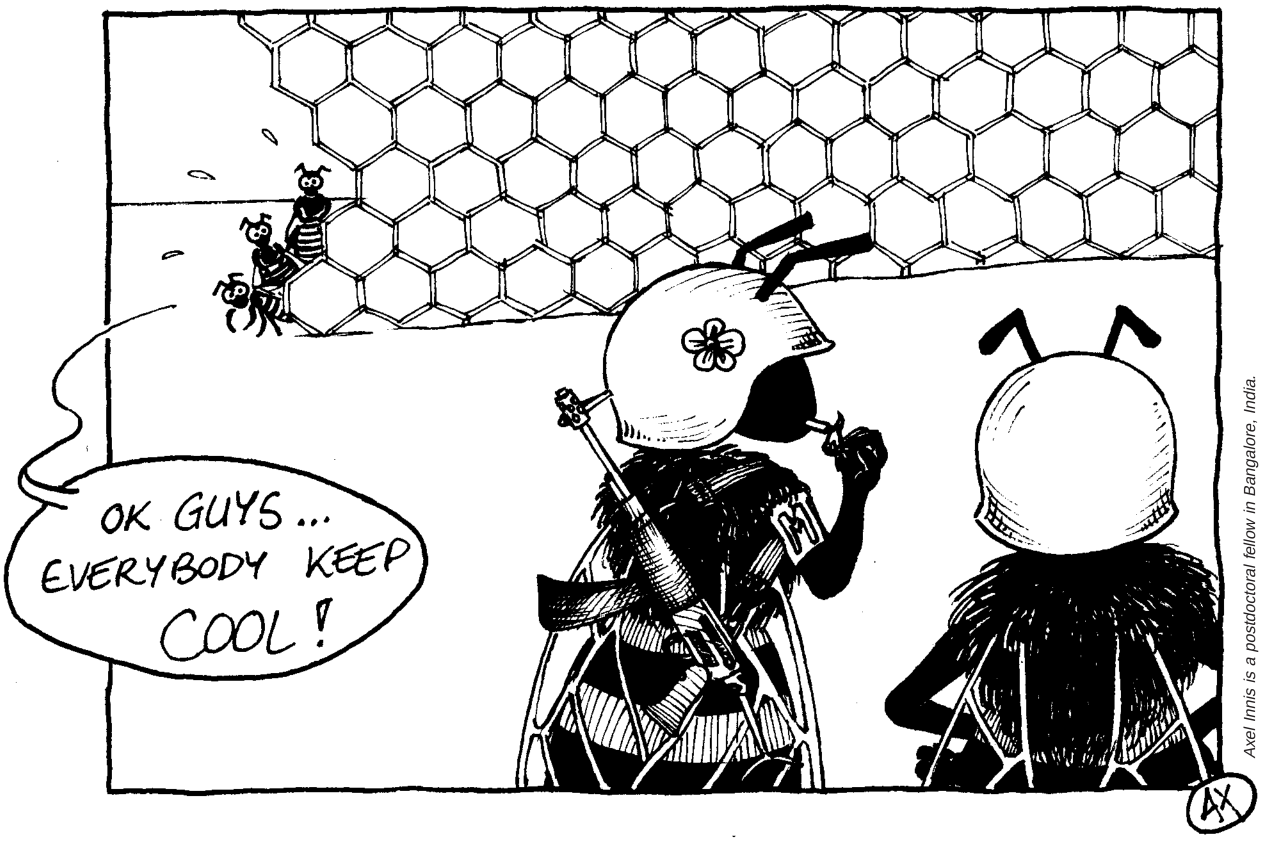

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OK Guys, Everybody Keep Cool!

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