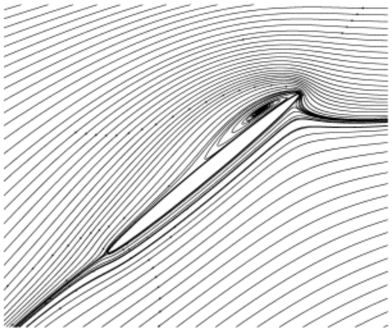
In this issue



Still Defying Gravity (p. 55)

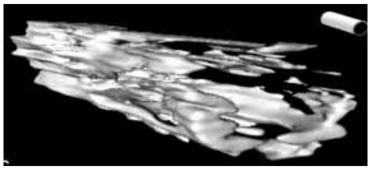
Until Mao Sun's students started quizzing him about animal flight, he was mainly interested in the aerodynamics of aircraft, but their questions caught his imagination and set him off along a biological train of thought. At first his interest in insect flight was entirely academic, but recent developments in micro-aviation have made Sun's calculations extremely relevant to modern aeronautic engineering.

Sun has solved the Navier-Stokes equations for fluid flowing around a flapping insect wing. These equations are the most complete mathematical description of the way a fluid moves around an object. But their complexity made it impossible to solve the equation analytically. The explosion of computational power at the end of the twentieth century, accompanied by the development of powerful algorithms, has allowed Sun and his colleagues at Beijing University of Aeronautics and Astronautics to solve these equations numerically.

Several labs have measured the total force at the wing-base exerted by the flapping wing, but this doesn't give the whole aerodynamic picture. Knowing how the air flows around the entire wing tells you where and how the lift is generated to keep the insect aloft. Instead of visualising this flow inside an oil filled tank, Sun has relocated his flapping Drosophila to the cyberworld. He has used the computational power of 5 PCs for hundreds of hours, to solve the equations of flow around the insect wing.

The lift on a flapping insect wing can be explained in terms of three lift mechanisms. The acceleration at the beginning of a wing-beat generates one type of lift force on the wing. The second mechanism, is referred to as dynamic stall. In the 1990s, Charlie Ellington found evidence of a vortex spiralling along the front of a mechanical moth's wing. He realised that when the moth's wing retained this vortex, it delayed the insect from stalling, but if this vortex was lost the lift would fail and the insect would stall. Ellington named it the leading edge vortex, and it is responsible for the dynamic stall effect. The third mechanism occurs when the wing rotates at the end of a stroke, producing a large lift similar to the force that pulls a jet fighter up. The insect's aerodynamic agility is a consequence of the way these effects are combined by the micro-aviator.

Michael Dickinson's Robofly is the mechanical equivalent of Sun's cyberfly. Sun's calculations agree well with the lift and drag values that Dickinson has found from his measurements on Robofly. But there are some differences between the two fly simulations. Michael Dickinson's mechanical simulation didn't find a leading edge vortex but Sun's calculations do. Ulrike Müller, a biomechanist in Cambridge says 'Sun's calculations bring the leading edge vortex back from the brink'. She believes that 'this is very interesting, the field [of insect flight] is wide open again'.



Hope for Spinal Injury (p. 1, p. 13)

In 1978, Richard Borgens won a prestigious postdoctoral award that would change the course of his research forever. The fellowship, granted by the National Paraplegic Foundation, took Borgens to the annual meeting of the Foundation. He recalls that in the early 1970s, 'you didn't see many people in wheel chairs', and he certainly had no idea what life was like for a spinal injury survivor. After meeting over 100 young people living with these severe disabilities, he returned to his lab in Yale with a new focus: to 'take the best biology and tweak it towards a therapy'. This goal has already resulted in two groundbreaking therapies, and his work on polyethylene glycol (PEG) may soon result in a third. In a pair of papers in this issue, Borgens shows that PEG applied to injured spinal tissue can produce a significant reduction in spinal damage, even if the treatment is administered eight hours after the trauma.

But what gave Borgens the idea to try PEG in the first place? Before the molecular biology revolution of the 1970s, the only way to get DNA into a cell was to fuse two cells together in a solution of PEG. Borgens remembered this old fashioned approach to cell biology and realised that it might be able to repair shattered nerve cells.

Working with his colleague Riyi Shi, they applied PEG solutions to severed individual spinal cord nerve fibres in the laboratory and succeeded in restoring electrical activity after fusion. But a successful result for a single fibre doesn't always spell success for complex nerve tissue. So they began to look at the healing effect of PEG on the spinal cords of small animals.

When they treated adult guinea pigs with PEG, the animals achieved a miraculous recovery of neuro-function that untreated animals never accomplished. The big surprise was that animals who were treated as much as eight hours after their injury, recovered as well as animals that were treated instantly (p. 1). Borgens is very excited that the treatment can be applied several hours later, because he knows that it's not uncommon for lengthy delays between an injury and the patient's arrival at the Emergency Room.

To get a true estimate of the therapy's effectiveness, Borgens needed to accurately reconstruct a three-dimensional view of the damaged tissue. He established a collaboration with Bradley Duerstock and Chandra Bajaj. Together they developed new image reconstruction algorithms based on very thin cross sections of the spinal cord, that allow Borgens to assess the treatment's effectiveness (p. 13).

These results have encouraged Borgens to apply this therapy to large animals in real life situations. He explains that the early experiments carried out on surgically severed spinal tissue don't reflect the real damage sustained from 'terrible mechanical contortions' during a violent impact. Working in a veterinary college, Borgens sees many dogs that have suffered spinal damage from car accidents. He has treated some of these canine victims with his innovative PEG therapy and successfully restored neurological function that they could not recover naturally.

His application of this treatment to large animals is a significant step along the way to gaining FDA approval before this therapy becomes available for human patients. Based on his current progress, Borgens hopes that he might be able to offer this treatment to human patients as soon as 2002.

Learning at a Snail's Pace (p. 131)

Some aquatic species haven't always lived underwater. The snail, *Lymnaea stagnalis*, was originally a terrestrial species. They now live in ponds, and have adapted to breath through their skin, leaving their lungs redundant. But they haven't lost the use of their lungs. They come in handy when oxygen levels drop and it gets difficult to breathe.

Ken Ludowiak, in Calgary, has capitalised on the snail's parallel breathing, to find out how good their memories are. When he puts the snails into hypoxic water, they react by extending a breathing tube (pneumostome) so they can breathe using the lung. But Ludowiak discovered that if he gently touched the snail, it eventually learned not to use its pneumostome when exposed to hypoxic water. Ludowiak realised that he could measure how good the snail's memory was by returning it to de-oxygenated water several hours later, and watching to see if it remembered to keep its pneumostome closed. If the memory had faded, the pneumostome came back out.

Memory can be divided into three types depending on how long the memory persists. Short and long term memories are at the two extremes, short-term memory lasting a matter of minutes and long-term for days and even weeks. The third category lies somewhere in between, and is called intermediate term memory (ITM), but it wasn't clear whether ITM had any affect on the snail's ability to lay down long-term memory. Ludowiak and his team set about gently prodding the snails to see how long they could remember to keep their pneumostomes closed.

By using two different types of training, Ludowiak directed the memory to the snail's intermediate memory or their long-term memory. Then he waited for different lengths of time before he gave snails that had an intermediate memory a 'top-up' with some long-term training.

Using the intermediate training regime, he could get the snails to remember to keep their pneumostomes closed for up to three hours, while the longer-term training sowed memories that lasted up to 48 hours. But snails that had had their memory topped-up within eight hours of their ITM training remembered the lesson more than three days later, even if their intermediate memories had already failed before the extra tuition! Snails that waited more than eight hours for the extra tuition, behaved as if their intermediate memories had never been primed.

Ludowiak interprets this in terms of mRNA translation and transcription in the nerve's cell body. He thinks that ITM uses rapid transcription of mRNAs that are already in the cell to make proteins that mark sites in the nerve cells where memories are laid down. If these sites have been tagged during earlier training, the long-term memories that are cemented by the second training session are reinforced and held for longer.

Which is a salutary lesson for all those students out there frantically cramming the night before a test. It's probably better to learn at a snail's pace, it'll stay with you longer.

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