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News

Charlie Ellington FRS retires

In 1973, a young student from Duke University arrived at the Department of Zoology in the University of Cambridge to begin his PhD with Torkel Weis-Fogh. The young student was Charlie Ellington, and he was destined to 'rewrite the book' on insect flight aerodynamics. Charlie recalls his arrival in Cambridge and says, 'Torkel asked me, "What would you like to study?" and I replied, "I'd like to work on fish swimming," and he answered, "Ja, you will work on insect flight".' With these words, Weis-Fogh launched the career of one of the most influential biomechanists of the past 40 years.

Charlie's career began as a pre-med undergraduate at Duke University, but within a matter of weeks he realised that medicine was not for him. He was soon spellbound by Steven Vogel, a new young lecturer at Duke. 'Vogel had the introductory biology course and it was the most interesting and stimulating course I have ever had,' remembers Charlie, who took the chance to join Vogel's group as an undergraduate researcher working on ventilation in prairie dog burrows. With publications under his belt before he graduated, Charlie was recommended to apply to work with Weis-Fogh at Cambridge. 'At the time that I joined the lab, Weis-Fogh had just published his big JEB article "Quick estimates of flight fitness in hovering animals, including novel mechanisms for lift production," and I was to apply a modified propeller theory to the flapping wings,' he remembers.

Charlie Ellington retires from the University of Cambridge Zoology Department after 37 years. Photograph by Stefan Maria Rother.

According to Charlie, Weis-Fogh left him alone to get on with it, so he began working with Weis-Fogh's photographic technician, Gordon Runnalls, to film flying insects, ranging from hover flies and ladybirds to bumble bees and honey bees, with a high-speed camera to try to understand how they stay aloft. 'The great thing about it was that there was no rush or deadline,' says Charlie, but 2 years later he found himself without a supervisor when, tragically, Weis-Fogh committed suicide. Inheriting Weis-Fogh's camera, Charlie joined Ken Machin's lab to finish his work. 'We came up with estimates of the lift coefficient needed for these things to hover, and for most insects the lift coefficients weren't much more than you might expect by cutting off wings and sticking them in the wind tunnel'. However, for some insects the lift coefficients were too high, and Weis-Fogh's theory, which treated airflow over the wings as if it flowed smoothly across the wings like a propeller – flowing from the leading edge to the trailing edge and hugging the wing surface – didn't work because it couldn't explain how insects generated sufficient lift to remain aloft. These insects beat their wings just like other insects, so Charlie concluded that the theory probably failed for the other insects as well.

Graduating in 1981, Ellington was appointed as a lecturer by the University of Cambridge, at which point he could finally begin recruiting graduate students to collect more evidence to show that conventional propeller aerodynamics could not explain insect flight. He also submitted his entire PhD thesis to *Philosophical Transactions* of The Royal Society, which the journal published *verbatim* in six (now classic) single-authored papers in February 1983.

Even before Charlie submitted his PhD thesis, John Treherne, the then Editor-in-Chief, invited him to join the Editorial Board of *The Journal of Experimental Biology*. Charlie was an active member of the board until Treherne's unexpected death in 1989, when Simon Maddrell (the Treasurer of The Company of Biologists) took him aside and asked him if he would be interested in being the Editor-in-Chief. 'It was totally out of the blue,' he recalls. Accepting the offer, Charlie was Editor-in-Chief from 1989 to 1994, single-handedly overseeing the peer review of hundreds of papers each year. 'I took advantage of the expertise of others enormously,' he recollects, and describes faxing abstracts to Editorial Board members, who recommended referees and adjudicated on papers. Charlie also modernised the journal's infrastructure, finally doing away with secretary Jean Wallis's 'steam driven' typewriter in favour of a computer. Eventually, Charlie recruited Bob Boutillier as a co-Editor to help with the ever-increasing burden of peer review, before finally stepping down as Editor-in-Chief in 1994.

In addition to his responsibilities at the journal, by the early 1990s it was clear that something was very wrong with conventional propeller theory. 'At that stage I adopted the heretical view that propeller theory wasn't working and we needed to see what was going on "literally",' remembers Charlie. Teaming up with Sandy Willmot, Coen van den Berg and Adrian Thomas, he decided to visualise the airflows over an insect wing by blowing smoke over it. Filming a flying hawkmoth in a smoke trail with a pair of cameras, Charlie was amazed to see something that could never be predicted by conventional aerodynamic theory. 'It showed some really weird stuff, like the smoke going over the leading edge of the wing, rolling up into a nice vortex, touching down on the upper wing surface and shooting out towards the wing tip, turning through 90 degrees in something like the radius of a millimetre,' Charlie recalls, and adds, 'Once I could see the

vortices, their geometry and position, it was obvious what was going on.'

But he was not satisfied just to publish this discovery. With instrument-maker Dick Holder, he built a flapping robot that reproduced the insect's wing motion once every 3 s and finally verified the presence of the now famous 'spiral leading edge vortex'.

Nature published the discovery in a Letter in December 1996 and Charlie remembers the reaction to the news. Television crews from all of the major US TV networks queued in the corridor outside his Cambridge lab to interview him about the discovery. And, as if that wasn't enough, shortly after the press frenzy, the US Defense Advanced Research Project Agency (DARPA) announced millions of dollars of funding for engineers to build a Micro Air Vehicle. Charlie remembers that while he was being interviewed for the television, one of the journalists asked if his discovery could help design air vehicles: 'Put these two together and the phone was busy. All the engineers were chasing the cash,' laughs Charlie.

What is even more miraculous is that Charlie was alive to witness the success of his research. 'Around the time we were developing the flapper I had four heart attacks and a triple bypass. That kind of interrupted things,' he remembers understatedly. Since then Charlie's health has deteriorated markedly, resulting in his early retirement.

Despite his ill health, Charlie's achievements have not gone un-noted. In 1998, he was elected as a Fellow of the Royal Society and shortly after received his personal Chair from the University of Cambridge. To mark his retirement, Graham Taylor, Alan Wilson and Simon Maddrell organised a symposium, held at Clare College Cambridge on 20–21 September 2010. Delegates from across the world came to discuss the aerodynamics of flight and Charlie's other passion, flight muscle. Contributors included past and present students, postdocs and collaborators. 'When Graham Taylor first started talking about it I didn't think people would come all this way for a day or two,' Charlie says humbly. But they did and he clearly relished every moment of the meeting.

Although Charlie has retired from his administrative and teaching responsibilities at the Department of Zoology, he still has an active lab with four students and one postdoc. However, he is not recruiting new members to his team and hopes that a current lecturer, Walter Federle, will continue the tradition of biomechanics in Cambridge that Charlie has upheld so strongly for the last 4 decades.

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