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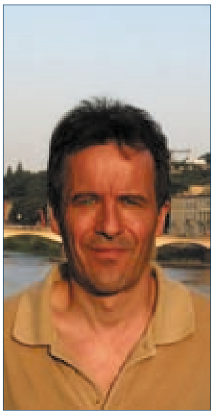
Changing the scientific paradigm

The era of the algorithm is upon us, says Bernard Chazelle, and it "promises to be the most disruptive scientific development since quantum mechanics". Chazelle is a Professor of Computer Science at the Ivy League Princeton University in New Jersey, USA, and made this claim in March during public lectures in Auckland, Wellington, Christchurch and Dunedin as part of the NZIMA Programme in Algorithmics. He talked with Jenny Rankine.

Bernard Chazelle advocates radical change. When asked how algorithmics can become not just a body but a *way* of thinking, he focuses first on maths and science. "Traditional maths focused on symmetries. You could write on one page math equations from physics that explain 99% of everything that happens around you in the physical world. The reason is that the natural world has so much symmetry."



"But the 21st century is looking very different; the problems are economic, technological, the behaviour of complex organisms, ecologies and social groups. The traditional tools of maths are not going to be as efficient to handle these new problems, because they don't hold the same symmetries."

An algorithmic way of thinking is pretty much the only candidate, he says. "If you squint hard enough, a network of autonomous agents interacting together will begin to look like a giant distributed algorithm in action." Algorithms may not be as successful as equations, but there is no plan B; "it's becoming the central scientific paradigm of the 21st century."

Then he focuses on education: "The way teaching is done in the USA and Europe, if I say the algorithmics toolkit is going to unleash a new world, it makes no sense. The curriculum will have to change."

University departments and curricula, and by implication those in secondary schools as well, are based on 19th century classifications, he says. "Algorithms and information science are becoming an integral part of how scientists think about their science. The biology part of the Human Genome Project was not the most important - the hard part was algorithmic, computer science."

He gives an integrated first-year biology course at Princeton as an example of how science and maths could be taught. He and another computer scientist taught the course with two biologists, a chemist and a physicist, aiming to show the relationships between the deepest concepts in these disciplines. "I talked about the algorithm behind Google, the chemist talked about the fundamental chemical process of diffusion; we taught together so students would understand that these are the same processes."

Chazelle's enthusiasm for integration may relate to his own abilities in multiple fields; he blogs regularly about politics and music, and draws cartoons.

Chazelle argues that the field of algorithmics has been limited by its use only as a problem solver; publications systems have discouraged exploratory and theoretical work. He gets quite literary. "There are simple, zinger-like algorithms; local rules that produce complex systems." An illustration is an algorithm about bird behaviour that models migrating geese as well as undirected flocking networks.

Then there are algorithmic novels, which allow multiple levels of abstraction. Chazelle gives the example of war, which at its most basic "is a soldier valiantly following combat rules on the battlefield. At a higher level of abstraction, it is a clash of warfare strategies." These epics of the algorithmic world "devote most of their energies to servicing their constituent parts via swarms of intricate data structures."

Chazelle looks forward to the time when the ability of maths to modify, combine, harmonise and generalise equations is applied to algorithms, enabling us to knead them like dough to form new algorithmic shapes.

See also

Chazelle's home page: www.cs.princeton.edu/~chazelle/