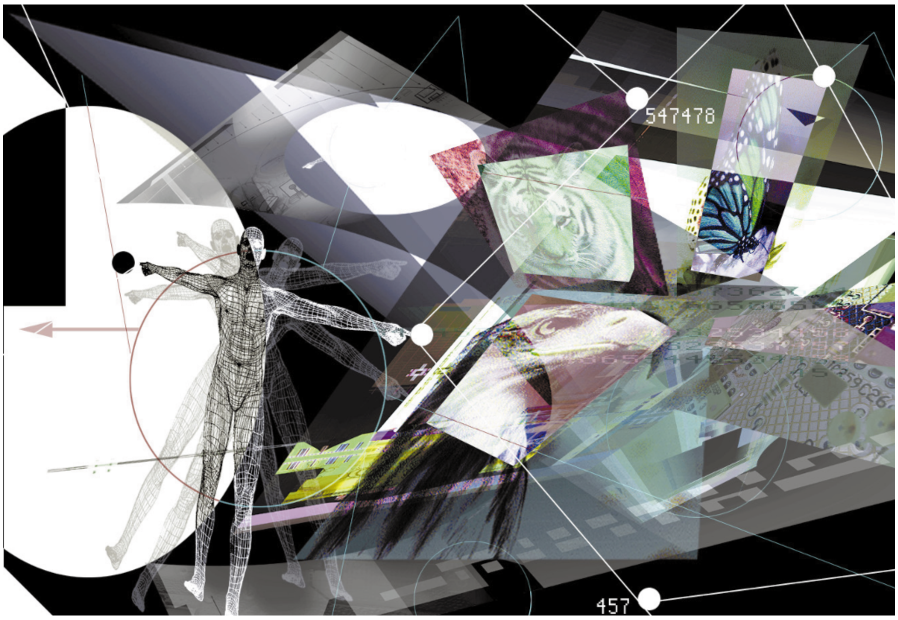
The new laureate speaks

The response of this year's Nobelist in full

Charles Sheffield



JACEY

It is customary, and almost mandatory, in accepting awards such as this to say that one's own efforts rest on the backs of the giants of earlier days. I would prefer, with all modesty, to say that my work and the work of my colleagues has depended on spinners; the spinners, in particular, of two great threads of scientific history.

My first thread concerns the mutability of species. For most of human history, the forms that inhabit Earth's lands and seas were regarded as unique, well-defined, and unchanging. The alternative view, first advanced over a thousand years ago by Charles Darwin and Alfred Russel Wallace, produced intellectual shock waves that have affected science and society everywhere (with the possible exception of Kansas, which holds out to this day.) Species can and do change, through natural selection, to produce new species. The timescale for such events is long, measured in millions of years, in contrast to the 'unnatural selection' that the farmers and breeders of the planet have used for ten or so millennia to produce preferred varieties of plants and animals. Evolution, however, is inevitable and continues to this day.

A second shock came less than a century later, when in 1953 Crick and Watson elucidated the molecular structure of DNA. As its central role in life became clear, so did human ability to map and modify its structure. Through the wholesale mix-and-match of genetic materials, almost any combination of physical characteristics became possible. Moreover, the timescale for development of these hybrids could be measured in years or months, not aeons. In consequence, today the idea of a biological 'species' is still a useful concept, but the present definition of the word would baffle Darwin's predecessors. In their day, the biological species resembled integers along the real number line, well defined and well separated. Now, between any pair of those original species, there exists a whole continuum of intermediate species created routinely by DNA manipulation. The single points have become a continuous line. I call this the life-line, upon which my own work has heavily depended.

The second thread derives from exactly the same period as Crick and Watson's work. Despite Charles Babbage's attempts to construct a mechanical analytical engine more than a century and a half earlier, the first successful computer awaited the development of reliable electronics. From humble beginnings in the 1940s, it rapidly became an astonishing success story that went from exotic rarity to ubiquitous presence in less than a human lifetime of the day.

We can liken the earliest computers, such as the ENIAC and EDSAC, to primitive life forms. Successive generations evolved fast and far in both hardware and software, so that within fifty years the sleek laptops and supercooled teraflop machines seemed as remote from the original ur-computers as an amoeba is different from an elephant. However, the amoeba and the elephant share strong family resemblances at the DNA level. At a similar deep level the logic was the same in all early computers, and the lineage of those first machines was clear (when our historians plumb the depths of Windows 98, they find within it the primitive reptilian brain of DOS).

The early computers offered an apparent choice among hundreds of models, but most of the variability was superficial. Discount the differences in speed, memory, and operating systems, and the enumeration of the distinct computer 'species' at the turn of that millennium needed no second digit in decimal notation. Like the biological species, those early computer designs formed isolated points along a line of their own. I term this the machine-line. And today our computers, unrecognizably different in size, speed, and capability from their distant ancestors, populate the full machine-line continuum of computational types and capabilities.

Now it is time to weave the two threads together. This interweaving of life-line and machine-line at first came slowly. The initial steps were primitive, in spoken inputs to computers, grammar and spelling checkers, on-line patient care clinics, and 'smart' pacemakers. The next steps followed within a couple of human generations: eye lenses changing focus as needed, or boosting contrast to an aging retina. They contained the so-called 'supercomputers' of their day, which it is all too easy for us to mock. There were similar hearing aids, with full directional sensitivity and selected frequency enhancement; and, of course, there was computer activity directed by built-in brain implants, permitting communication with people mentally 'locked in' through accident or disease, and in many ways the direct precursors to my own work.

In truth, what I and my colleagues did was simple. Indeed, to anyone with mathematical tendencies it is almost inevitable. Let us retain the life-line of the biological species as the real coordinate axis, and let us assign the machine-line of computer types to an imaginary coordinate axis. We now have a 'complex plane of organisms', any point of which represents some combination of organic and inorganic organized systems. Call each point a cyborg. It is for the creation of the 'theory of functions of a complex variable', appropriate to the description and analysis of all possible cyborgs, that I and my human companions feel honoured to be rewarded today.

Charles Sheffield's latest book is ***Borderlands of Science****. He also writes a weekly column.*