Vision things

Philip Campbell

Science's unpredictability has not prevented a group of invited scientists from being farsighted about future possibilities in fundamental research and its applications.

Anticipation is one thing, vision quite another. Geneticists and others are relishing the prospect of the maps and inventories that are to come, and the inevitable insights into organismal development and function, relationships between species and between kingdoms, and the evolutionary past. But where's the new vision? And what sorts of visions are driving other parts of biology and other sciences towards new discoveries and technologies?

This *Nature* Insight provides a partial answer to those questions. The editors of *Nature* and of the ten Nature journals (including three new review journals), who usually thrive on mutual independence, have collaborated to select ten topics to help all of our readers peer into the future. In December 1999 such a survey anticipated the impacts, on research and on society, of foreseeable science. This time we look towards the unforeseeable, by focusing on what might take us there: cutting-edge basic science that might lead to unexpected technologies, and adventurous technologies that should lead to unpredictable, fundamental discoveries. Our authors have been given freedom to speculate, untrammelled by peer review. These, then, are personal visions, and can be considered to be somewhat courageous. After all, most readers should be around long enough to evaluate their prescience.

Nurturing foresight

The inherent dangers of scientific prediction were discussed in the previous survey[1]. But visions are surely to be encouraged. Perhaps the most forward-looking vision ever was that of J. D. Bernal in 1929 in his book *The World, the Flesh and the Devil: An Inquiry into the Three Enemies of the Rational Soul.* He anticipated life transforming itself into an ethereal intelligence dispersed between the stars. The physicist Freeman Dyson demonstrated[2] subsequently that this was not altogether incredible within known physical laws. This collection of articles falls short of that sort of reach. But it does include two aspects of mind: the scientific connection between life and artificial intelligence (see Rodney Brooks, page 409), and future technologies based on the ability to control mechanical objects using neural prosthetics (Miguel Nicolelis, page 403).

Physics' legendary successes have been based partly on its ability to establish principles and then develop predictions and elaborations. Biology, in contrast, is currently thriving on its cataloguing of the particular. Seeking principles is fine in principle but is way down the agenda of most molecular and cell biologists. But as our knowledge of the molecular circuitry of cells grows, so grows the opportunity to organize that knowledge conceptually and to depict and hypothesize about larger organizational patterns and even — possibly — principles. What is the most we might aspire to in cell biology? On page 387, Jack Szostak and colleagues imagine in some detail what it will take to synthesize a whole cell. On page 391, Drew Endy and Roger Brent elucidate the scale of the challenges to come in computational simulation of intracellular networks and even entire cells.

A place for chemistry

Molecular and cell biology also provide opportunities for chemists, whose insights will be ever more necessary in understanding the molecular dynamics of cells. But despite rumours to the contrary, chemistry itself still provides opportunities for chemists too. It is particularly appropriate now, 100 years after quantum mechanics was conceived, to focus on quantum chemistry. Over the past decade or so, chemists have been exploring not only the fundamentals of chemical reactions but also subtle ways of steering them by using photons to select quantum states as reactions proceed. Stuart Rice anticipates the potential technological applications of such fundamental chemistry on page 422.

Particle physics stands at a critical juncture. Just when the Large Electron–Positron Collider at CERN, in Geneva, spotted what might have been a few Higgs bosons — the long-sought particles that give other particles the property of mass — it was closed down to make way for the next generation of accelerator, the Large Hadron Collider. Fermilab's Tevatron near Chicago may establish the Higgs particle's existence conclusively in the next few years, but theorists also believe we are on the threshold of a world of new fundamental laws. To probe them will require new accelerator technologies, which may themselves have other technological spin-offs, as have past accelerators. One such scheme, at least two accelerator generations ahead, is described by John Ellis and Ian Wilson on page 431.

Star gazing

Like the high-energy physicists, astronomers too can look forward to technologies that will not only expand their horizons but also reveal new ones. Roger Angel is a highly creative developer of new telescopes for optical and infrared wavelengths. As he explains on page 427, technologies for large ground-based and space-based telescopes will extend enormously our capacity for unimagined discoveries, as well as our deeper appreciation of objects already identified.

In contrast, firmly embedded in the everyday world, there is a quite different sort of vision: that of technologies created around principles of structure and pattern established by nature itself. As Philip Ball describes on page 413, "proteins and elephants" can stimulate engineers of the future.

Wherever there is scientific vision, there is a danger of hubris — or at least perceived hubris. Dyson's cosmically eschatological visions of intelligence's future caused him to be criticized by philosophers for, as they perceived it, wanting to control the Universe. One vision that positively reeks of hubris is that of controlling our planet's surface conditions, on a global scale, to cope with the climatic and environmental changes arising from human activities. The possibilities deserve to be elucidated, and the concerns expressed. Enter Stephen Schneider, with David Keith, on page 417.

Another application of science, and one that has given rise to more than its fair share of social concern, is the genetic modification of crops. On page 397, George Blackburn views functional foods through the rather different lens of the physiology of undernourishment.

It is surely one of scientists' roles to look unflinchingly at feasible extrapolations of current knowledge, however unpopular that may make them. If in so doing they stimulate our readers — including authors' communities as well as funding agencies — to lift their sights as well, so much the better.

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1. Campbell, P. *Nature* **402** (Suppl.), C7–C9 (1999).
2. Dyson, F. *Infinite in All Directions* (Harper & Row, New York, 1988).