Miscellaneous commentary

Popper refuted (*December 2001*)

In mid-Victorian times, William Thomson, 1st Baron Kelvin, peered down his nose at Charles Lyell's estimation of sedimentation rate from the historic silting of the port of King's Lynn, as a means to judge the vast time span represented by the stratigraphic column. His words were not kind; "…when you cannot measure [what you are speaking about], when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind". Geologists cringed, particularly when Lord Kelvin went on to reckon an age of 20 to 40 Ma for the Earth based on its cooling from a molten mass, using the physical laws of conduction and radiation. He turned out to be fundamentally wrong on most counts, partly because he knew nothing of radioactive heat generation or convective heat transfer. Sadly his corpse could not be revived to eat his mean-spirited words. Nonetheless, the gibe of Earth scientists' being "unscientific" has stuck. We rarely stick to the "scientific method", reputedly stemming from the Elizabethan philosopher, Francis Bacon, and his rationalization of the inductive method of reductionist experimentation. There are few universal "truths" in Earth history, and the interweaving of limitless processes with a vast spectrum of rates, scales and magnitudes renders reductionism absurd. Even more prone to *reductio ad absurdem* is the chemist Karl Popper's supposedly logical insight that "proper" science rigorously subjects hypotheses to a "risky test"; an experiment that should yield evidence of refutation if the notion is unsound. Popper's method of falsification consigns to the dustbin of research any hypothesis which fails the test, with the corollary that it is not "best practice" to seek confirmation for a hypothesis.

Carol Cleland of the University of Colorado (Cleland, C.E. 2001. Historical science, experimental science, and the scientific method. *Geology*, v. **29**, p. 987-990; doi: 10.1130/0091-7613(2002)030<0951:HSESAT>2.0.CO;2) demolishes the "recipe-book" approach to science, which has laid a dead hand on more than the Earth sciences, from the standpoint of philosophy and reality. She starts from the position of Thomas Kuhn, by pointing out that, for Popper, the whole of Newtonian celestial mechanics should have bitten the dust when 19th century astronomers discovered that the orbit of Uranus deviated from Newtonian prediction. A sustained search for reasons why concluded that there must be gravitational forces from planets beyond Uranus, and sure enough astronomers discovered Neptune.

There is an air of bullying about the "scientific method", which has warped investigations and dulled imagination and curiosity for centuries. It provides ammunition for those who carp and pontificate from the sidelines, and in many cases from positions of considerable power. Cleland does us all a service by discussing philosophical matters of science in the context of the realities that confront us all, in an accessible way. Her analogy is Holmesian detection (Sherlock was a deductionist, by the way, proceeding from the general to the particular), which discovers events and proceeds to trace their circumstances - the search, to my mind, for the artillery rather than a single "smoking gun" is far richer than the events themselves, because that deepens our sense of context for particular events, however dramatic they might seem to be.

Hogmanay comment: Sidelined by events? *(December 2001)*

2001 was the year of the human genome, stem cells and carnage in the USA (9/11) and Britain (the British foot and mouth epidemic) delivered by self-justifying fanatics and the agricultural wing of government respectively. It ends with serious inroads into basic freedoms of expression and privacy in the wake of violence. September 11th feature prominently in the authoritative end-year reviews by both *Science* (v. **294**, p. 2443; DOI: 10.1126/science.294.5551.2443a) and *Nature* (v. **414**, p. 836-837; doi: 10.1038/414836a). It is hardly surprising that Earth science, bar comments on climate change, has no entry to rank with downturns in science budgets, development of neural circuitry, high-temperature superconductivity, bio-molecular chips, the unending hunt for the neutrino, adventures with the Large Hadron Collider and the farce of NASA's Space Station . Nonetheless, our progress has been marked by the sublime and the ridiculous, to a satisfying degree, as *Earth Pages* tried summarise. No doubt its limitations have meant that some major advances have been missed, for which I apologise. I leave it to readers to judge from the archive what were the highlights of the year.

In Britain, the last month has been one for either celebration or sober reflection by university academics, on announcement of the results of the latest round of the Research Assessment Exercise by HEFCE. Science in general seems to have done rather too well over the last 5 years, for there is insufficient cash in the pot to suitably reward those departments whose rating has risen (Watson, A. 2001. Universities raise their game, but the money doesn't flow. *Science*, v. **294**, p. 2448-2449; DOI: 10.1126/science.294.5551.2448). The £1.3 billion kitty to boost research infrastructure falls about £150 million short of the improved departments' supposed expectations. The board of HECFE is to tinker with the goalposts to eke out the dosh. No doubt the well-endowed will benefit even further, the middle rankers getting less than their improvement ought to warrant, and then there are the also-rans. In Earth sciences a financial squeeze ought not to have such an inequitable outcome as in more lab-dependent disciplines, but the whole exercise seems destined to result in marginalization of research topics into a dwindling bunch regarded as world-ranking. That would be a recipe for a cut in diversity, that does not match the increasing need for breadth in getting to grips with processes in and history of the Earth System.

Returning, finally, to the events that have gripped the world for the last quarter of 2001, the central theme of most commentary is that the world changed on 11th September. I do not believe that it did. For two thirds of the world's population it is "business as usual" - an ever widening gap between hope for the future and expectation of any relief from poverty, disease and the fear of falling victim to natural and anthropogenic calamities that scientific advance might bring. Despicable as the perpetrators and those who motivated their actions were, the attacks on the USA arose from the growing powerlessness of hundreds of millions of dispossessed people to secure their livelihoods and lives. Global communications ensure that they are confronted daily by what they lack set against what is possible, leading to a deep sense of unfairness and perpetual victimhood Scientists, whose work is enmeshed with emergence of the possible, should dwell on how they might help close that growing human fault line, rather than raging at or cringing before the monstrosity that they have helped to nurture. Assisting the dispossessed to secure safe, dependable water supplies, to improve their agricultural yields, to rid themselves of endemic disease, to gain access to cheap energy and transportation, and above all to acquire knowledge and the ability to

solve their own problems is not a problem of cosmological or genomic proportions. It is a simple, human duty.