modify the most precious thing on earth – human life. Power and money can take greed to unbelievably high levels of satiation. Worldwide protests are on the rise regarding the penetration of GMOs through multinational corporations (MNCs). In Europe, there is an increasing fear that these 'Frunkenfood', a term coined by critics for GM food are nothing but MNC strategies; after all they control most hi-tech labs. Their concern is more with increase of their own revenues and greater market control than with the damage they may be doing to public health and the environment. Hence there are legal and ethical battles regarding MNC food products all over the world.

Are we heading towards a bioengineered disaster? Or are we heading towards a bolder, brave new world where hunger, disease and physical deformities will be a thing of the past? Evolution, as they say 'is a forced random process' and risk is imperative to evolution. But from the days of cave painting to the creation of 'Dolly', without risk man would not have achieved anything. GMOs are speeding the evolution process.

MADHUSUDAN DEY*
SAYANDEB CHOWDHURY

School of Life Sciences,
Jawaharlal Nehru University,
New Delhi 110 067, India
**For correspondence.*
(e-mail: deymadhu@hotmail.com)

Sequencing of the human genome: Then what?

France hosted *Biovision*, the World Life Sciences Forum (7–10 February 2001) in its beautiful World Heritage City, Lyon. The timing could not have been better, just preceding the announcement of the sequencing of the Human Genome by rival research groups in journals *Nature* and *Science*. Almost every discussion in that International Conference had something to do with the consequences of sequencing, or the controversy surrounding the project.

It is surprising to me how quickly history is forgotten. Not long ago, people believed that Newtonian Physics was all that was left to be discovered. Einstein opened a new chapter in our understanding of the physical world and reduced Newton's framework as a special case of quantum mechanics. Post-Einstein, scientists are zeroing in on Unified Field Theory and String Theory. Each time a greater level of understanding was achieved, there was a sense of complacency and self-congratulation following it. The same might hold true for biology – after all, people believed for many centuries that women had fewer teeth than men because Aristotle said so! Today we may wonder why no one checked his baseless theory by asking Mrs Aristotle to open her mouth, but the chances are that scientific discussions are often steered by 'big names' and it is easy to be carried away. The high point of Biovision Forum was the dinner debate 'Sequencing of the Human Genome: Then What?', which had Craig Venter of Celera Genomics as one of the panellists. The Panel interpreted 'Then What?' in a rather mundane way, and discussed the real meaning of patents, accessibility of information, contribution of Celera, bioethics, discrimination of people with defective genes, what other organisms will be sequenced, etc. No wonder the Nobel Laureate Jean-Marie Lehn was unimpressed and asked the panel to move beyond 'Shopkeepers' discussion'.

Our improved understanding of life sciences, initially at the cellular level and now at the genomic level, is analogous to milestones such as Newton's Law and Quantum Physics, or Dalton's Atomic Theory and Sub-atomic Chemistry. Interestingly, well before Dalton came up with his concept of indivisible atom, the 9th century Tamil poet Kambar wrote: 'If an atom is split into a hundred [sub-atomic] particles, called Kones, God is in each of them' [*Or aNuvai(ch) chatha(k)kooRitta kOnilum uLan*]. It may be premature to assume that biology has answered all the questions by sequencing the Genome. Genetics may one day become a special case of a much more fundamental and detailed understanding of biology, and we need look no further than Venter's remarks to the BBC to guess this: 'Most of us thought that there were somewhere between 50,000 to 100,000 genes, but we were stunned that we only have between 26,000 and 30,000'. That human beings perhaps have only a few hundred more genes than a mouse has renewed the 'Nature vs Nature' debate, but there could be more to Nature itself.

In my opinion, Celera claims too high rewards for its efforts. For one, they started eight years after their rivals, the publicly-funded Human Genome Project (HGP), when computers were much faster and more powerful. Secondly, there are arguments that Celera could not have put its sequence together without the public HGP's data, and that the quality of information is not as superior as vaunted by the company. For example, HGP repeated the squencing four to five times instead of Celera's three. But even HGP's 99.9% accuracy is not enough, because the error is comparable to the 0.1% difference in DNA between human beings. However, a more worrying aspect of allowing industry-sponsored research into basic science lies in Venter's decision not to deposit his data in the public computer archive, *Genbank*. Although Celera has promised full access to its own database, it has set restrictions on distribution of its data. Public sector scientists say this could hinder the free flow of information, and lead to slow progress to developing cures for diseases. Some argue that it is akin to charging people to look at the periodic table! After the Panel Discussion, I asked Venter to give an order of magnitude estimate of the total cost of Human Genome Project, and Celera's expenses on sequencing. He said the total cost is about 2–3 billion USD, of which Celera spent about 60 million! With less than

5% contribution financially, Celera's claims to sequencing can only be justified by their unshakeable belief in the innovative use of supercomputers to sequence faster.

There are also important issues that were not very well debated in the conference because of disproportionate representation. Notwithstanding the hype about a Biotech boom in India, the country's delegation was limited to two Professors, and a couple of executives from a Hyderabad-based company. In contrast, the Chinese contingent made an impact with its English-speaking delegates that included a Minister and a Dean of Science who raised several issues on behalf of Asia and the Developing World. It is not clear if the diseases of the Third World are on the list of the Western priorities when it comes to potential benefits of gene sequencing to healthcare. K. P. Gopinathan of the Indian Institute of Science, Bangalore, delivered a speech on the promises of Biotechnology for India's future, and rightly pointed out the adverse effects of misplaced priorities of the Indian Government and 'militarisation' of Indian Science at the expense of other important sectors. However, unlike the Chinese delegation that had a minister, or the hosts who included President Chirac, there was nobody from the Indian political establishment to make a note of Gopinathan's points.

Related internet links:

- *Nature* Genome Gateway http://www.nature.com/genomics/
- *Science* Genome 2001 http://www.sciencemag.org/genome2001/
- Biovision website http://www.biovision.org/
- Human Genome Project Information http://www.nhgri.nih.gov/HGP/
- Sanger Centre http://www.sanger.ac.uk/HGP/
- Celera Genomics http://www.celera.com/

S. S. VASAN

Trinity College, Oxford
OX1 3BH, UK
vasan.seshadri@ox.ac.uk

NEWS

World Academies join hands – A new voice for global science concerns

Globalization has prompted new linkages that would strengthen existing knowledge systems. Such linkages are possible today with the help of modern communication networks. Through Academies, scientists worldwide are to cross-link for spreading knowledge. The Academies, would jointly function as a formal advisory body funded on a project-to-project basis for international bodies such as the United Nations, and would address common concerns of science and society with a unified voice. New science melodies are being fine-tuned with the birth of the 'Inter Academy Panel' (IAP) and the 'Inter Academy Council' (IAC).

S. Ramaseshan, Editor, *Current Science* had in 1994, written in this journal referring to a possible (but today still elusive) unified Academy of Sciences in India, as 'an apex body with representatives from all the academies which will increase coordination and cooperation in Indian science, advise Government and serve as a unified voice of scientists on issues of national importance'. These words ring true as well for the global basket made up of several world Academies going to operate in unison. Academies of Science around the world reflect the 'pick' of the best scientists. There is an increased necessity and pressure on scientists all over the world, to speak out their views, helping their respective nations and the public to understand the implications of science and for setting sound policy frameworks.

The President of the US National Academy of Sciences, Bruce Alberts was in India recently on a quest to promote 'activist' academies. He delivered two lectures in New Delhi, one on the 'Role of science in modern societies and the role of international scientific collaborations' at the Jawaharlal Nehru University and the other, the 5th Jawaharlal Nehru Birth Centenary Memorial Lecture, 'Spreading science through society: A new opportunity for all the world's scientists', at the Indian National Science Academy (INSA).

Alberts, a biochemist, is known for his work on protein complexes and has co-authored *The Molecular Biology of the Cell* and his most recent text is *Essential Cell Biology*. He holds improvement in science education close to his heart. He has helped to create, a programme called 'City Science' aimed to better the quality of teaching in elementary schools in San Francisco, USA.

In his lectures Alberts highlighted the role of science academies, that have a 'special status in the eyes of its own nation', but whose 'opportunities for national service' have been underutilized so far in several academies around the world. The US National Academy of Sciences is an exception, whose outlay is in its charter of 1863 which states that 'The Academy shall, whenever called upon by any department of the government, investigate, examine,... and report upon any subject of science or art,...'. The National Research Council (NRC), the operating