scientists and faculties of College of Horticulture and Forestry that they could conduct a meeting before every semester break and assign students work with proper training to explore TKs. The best contributing student should be rewarded and trained at the centre of excellence. Complementing this suggestion, Vipin Kumar (National Coordinator (S&D) of NIF, Ahmedabad) announced that five best students who would explore TKs and spread awareness among local communities about PIC, would be invited for learning and training at the Indian Institute of Management (IIM), Ahmedabad under the guidance of Anil K. Gupta.

Kumar also assured that, if a TKH or group of TKHs are willing to establish TK-based micro-enterprise, then NIF would be pleased to support such efforts technically and financially. NIF would also try to process in protection of IPR of TKH on unique knowledge explored through PIC and proved by scientific validation. Community members of Adi community of Berung, Miram, Yagrug and Sibut participating in workshops in February 2008 and March 2009 (94.18%) wanted to ensure implementation of PIC by institutionalizing it with Kebang (customary institution) and village panchayat. They also emphasized the need for rights to be given to these institutions for controlling and monitoring any activity or the access of genetic resources and related TK at the village level. On account of series of workshops and seminars, the following recommendations were made.

First of all, a massive awareness campaign about the PIC among the community members of northeast India is required. Series of meetings and seminars are required exclusively on the PIC implication in use and research on indigenous biodiversity and ensure the equitable benefit shares for the knowledge holders. The role of the panchayat should be defined in the implementation of PIC at the grassroot level. To ensure proper implementation, there is need for training programmes on PIC and plant/animal based TKs for the members of panchayats. Formal participation of customary chief of tribal communities, who still play a pivotal role in decision making at community level is necessary. The customary chief needs to be well trained in the use and implementation of PIC in proper coordination with village panchayat in the era of IPR and protection of biocultural knowledge systems. Use of PIC should be made mandatory to all scientists and related institutions as well as publications working on TK and biodiversity. The benefits (tangible and non-tangible) must be properly passed on the TKH. There is urgent need to devise a model of benefit sharing with the stakeholders of TK and conservators of biodiversity.

Ranjay K. Singh*, Department of Technology Evaluation and Transfer, Central Soil Salinity Research Institute (CSSRI), Karnal 132 001, India; R. C. Srivastava, Botanical Survey of India, Itanagar 791 111, India.
*e-mail: ranjay singh jbp@rediffmail.com

---

**MEETING REPORT**

**Engineering education in the 21st century***

‘I am an optimist ... so, in spite of the problems that I am going to talk about I believe the world’s getting better; larger number of people are being educated.’—this was the preliminary statement of Charles M. Vest (Massachusetts Institute of Technology (MIT) and National Academy of Engineering). He gave a public lecture on ‘Engineering education in the 21st century’ at the Indian Institute of Science (IISc), Bangalore. In his introduction of Vest, P. Balaram (Director, IISc) remarked that MIT became the envy of every other academic institution in the world when Vest had been its President (1990–2004).

Vest described a current project of the National Academy of Engineering namely ‘Grand challenges for engineering’. A Grand Challenges committee was formed, each member of which has a rich history of innovation, creativity and accomplishment. The chair was William Perry (Stanford University). The group wanted to execute four items on the agenda namely, challenge, inspire, educate and innovate.

‘Challenge’ to forge a better future. Fourteen 21st century challenges were chosen for possible solutions through engineering. These are (1) make solar energy economical, (2) provide energy from fusion, (3) develop carbon sequestration methods, (4) manage the nitrogen cycle, (5) provide access to clean water, (6) restore and improve urban infrastructure, (7) advance healthcare informatics, (8) engineer better medicines, (9) reverse-engineer the brain, (10) prevent nuclear terror, (11) secure cyberspace, (12) enhance virtual reality, (13) advance personalized learning and (14) engineer the tools of scientific discovery.

Basically, there are four grand challenges: (i) energy, environment, global warming, sustainability; (ii) improve medicine and healthcare delivery; (iii) reduce vulnerability to human and natural threats; (iv) expand and enhance human capability and joy. Meeting these challenges requires vision, science, imagination, boldness, priorities, policy, markets and perseverance. All this requires what Vest calls ‘serious engineering’.

‘Inspire’ ourselves and others to work at the frontiers of technology. Engineering frontiers can be grouped into tiny systems (bio, info, nano) and macro systems (energy, environment, health care, manufacturing, communications, logistics). The tiny systems are getting smaller, faster and more complex, while

---

*A report on the public lecture ‘Engineering Education in the 21st Century’ by Charles M. Vest. The lecture was organized by and held at the Indian Institute of Science, Bangalore on 19 January 2010.*

746 CURRENT SCIENCE, VOL. 98, NO. 6, 25 MARCH 2010
the macro systems are getting larger and more complex. The macro systems are of great societal importance but at least in the US there is not much work being done in these systems.

Vest pointed out that the differences between science and engineering are almost non-existent. There is a need to work as a team; synergies are required. These engineering systems need social science, management, art, humanities and communications; engineering education must recognize this. The problem is different in different parts of the world. Some institutes focus only on engineering or only on science; others have all disciplines in the same campus. The payoff will come from bridging the frontiers.

The 21st century engineering and science are interdisciplinary, interrelated and involve use-inspired research. An example of this interdisciplinary nature is in genomics research where there are inputs from biology, combinatorial mathematics, microfabrication, robotics and automation, and insights of doctors who have worked with real patients.

Science and technology have always been independent and this is even more important today. In brain research, imaging, microsensors, complex systems, computation and cell biology have all come together in understanding how the human brain and mind work. Most of these are two-way paths.

Research and development (R&D) is increasingly performed in ‘Pasteur’s Quadrant’ (Figure 1). Donald E. Stokes in his book Pasteur’s Quadrant – Basic Science and Technological Innovation (1997) questioned the purpose of research: Is it for pure understanding or for some use? In IISc and MIT, work is increasingly being done in use-inspired basic research.

Global R&D investments, both in the public and private sectors, are divided equally among North America, Europe and Asia. Regarding human capability – young professional workforce (college graduates with up to 7 years experience): China dominates in engineering, India in finance/accounting and the US in life sciences. There is an increasing number of engineering graduates in China, India and China are also building up infrastructure.

Vest indicated that everything is speeding up. He gave an example of the time it takes for innovative products to reach 25% of the US population: automobiles took ~55 years; cell phones took ~13 years; and the World Wide Web took ~8 years.

The nature of jobs is also changing. In 1800, 95% of the US population lived and worked on farms. In 1950, it was 10%. Now it appears to be heading towards 1%. Vest remarked that ‘Openness of US campuses and immigration have saved us from ourselves’. In the US, PhD students (science and engineering) are highly international and many are from Asian countries.

‘Educate’ to advance knowledge and enterprise. The role of universities is to create opportunity for students (training, skills, education) and for cities, states, regions and nations, not only through people but also through the knowledge and technology that we develop. Vest cited the following reasons for the strength of US higher education: institutional diversity, freedom of action of young faculty, weaving research and education, welcoming international students/faculty, federal government’s support of basic research, private philanthropy and competition (among schools to hire the best faculty, to get the best students, to get funds).

‘Innovate’ to advance societies and meet grand challenges. In the US innovation system, the federal government puts money in universities to do research. The government has programmes that anyone can apply for. The best research proposal gets support. The double duties of this government funding are to create new knowledge and technology, and to educate men and women. People and knowledge go into business and industry; and if the system works well, business and industry puts knowledge back into the system.

Vest said that some changes with respect to 21st century innovation would be in: globalization of R&D education workforce, a new enabling technology which would allow more and more people to do things worldwide, disruptive technologies for grand challenges, future of venture capital, macro systems especially energy, and life sciences and information technology. There would also be evolution of current innovation systems, discovery innovation institutes, new universities and educational organizations, virtual communities and induce-ment prizes. An example of a new educational organization is the Singularity University where NASA, Google and other thinkers tried to cross-train people from the bio, nano and info world to solve problems like grand challenges.

Vest humorously mentioned that previously there was ‘brain drain’ when many people may have come to the US.

<table>
<thead>
<tr>
<th>Consideration of use?</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quest for fundamental understanding?</td>
<td>Yes</td>
<td>Pure basic research (Bohr)</td>
</tr>
<tr>
<td>No</td>
<td>Pure applied research (Edison)</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1. Pasteur’s Quadrant.**

**Box 1.**

What is important in engineering education?

*Making universities and engineering schools exciting, creative, adventurous, rigorous, demanding, and empowering environments is more important than specifying curricular details. That’s what I learned at MIT by observation. (Charles M. Vest)*
NEWS

from countries that needed them. Now we are beginning to see a healthy ‘brain circulation’. The next step could be ‘brain integration’ where people work together beyond geographical boundaries. A core research question at the MIT Centre for Collective Intelligence is ‘How can people and computers be connected so that collectively they act more intelligently than any person, group, or computer has ever done before?’

Finally he observed that in the 21st century, we compete with each other, but we also have to cooperate. ‘How do we simultaneously compete and cooperate so that all can do better?’

Geethanjali Monto (S. Ramaseshan Fellow), D-215, D-type Apartments, Indian Institute of Science, Bangalore 560 012, India. e-mail: geethum@hotmail.com

MEETING REPORT

Hyperspectral remote sensing*

In an effort to give fillip to hyperspectral remote sensing technologies in the country, the Department of Earth Sciences, Indian Institute of Technology (IIT) Bombay organized a five-day course. Participants were drawn from various universities, research institutions, the Geological Survey of India and the National Technical Research Organization. The course was sponsored by the Department of Science and Technology, Government of India and was coordinated by D. Ramakrishnan (IIT Bombay).

The participants were exposed to the key components of hyperspectral remote sensing which included the basic concepts of imaging spectroscopy relevant to hyperspectral remote sensing, field and laboratory spectral signature acquisition techniques, spectral database management, pre-processing of spectral signatures of landcover materials, hyperspectral image analysis and classification, and also to some case studies.

The highlight of the course was a hands-on exercise in hyperspectral image processing wherein the participants had the occasion to follow the step-by-step procedure of hyperspectral data processing.

Present at the inaugural session, R. Siva Kumar (Natural Resource Data Management System, New Delhi) reiterated the great potential of hyperspectral data in evaluating and monitoring the terrain and management of earth resources. He urged the participants to get involved with developing new technologies and algorithms to extract more detailed and specific information from hyperspectral data which it is capable of yielding.


S. Farooq. Department of Geology, Aligarh Muslim University, Aligarh 202 002, India. e-mail: farooq.amu@gmail.com