Reinventing the university

S ANANTHANARAYANAN REPORTS ON HOW THIS INSTITUTION OF LEARNING IS CHANGING FROM THE INSIDE AS WELL AS THE OUTSIDE

Early universities, whether at Nalanda in India or the monasteries of 11th century Europe, were devoted exclusively to scholarship. It was only in the 1800s that these educational institutions followed the lead of England and Germany to give equal importance to scientific research. This change represented a stamp of approval of experiment and enquiry, till then an activity of tradesmen or mavericks whose discoveries entered universities only after they were regarded as classical learning.

"But in the past few decades," says a review in the journal *Nature*, "universities around the world have begun to take on further missions. Today, they are supposed to be not only centres of education and discovery but also engines of economic growth, beacons of social justice."

The review then examines changes and innovations in the USA, China, South Korea, the UK and South Africa, of partnering with industry or commercialising research, to changing methods of administration and motivation and also overturning methods of instruction and delivery.

Funding of research or related facilities by the industry has been a practice since some decades. Academics now routinely patent discoveries and universities formally connect faculty and students with companies though technology transfer, industrial partnerships, internships and mentoring. Going a step further, industry in the USA has started stationing its staff right within the research lab. This removes the physical separation between the market and academia and makes for a relationship where each inspires the other and promotes shared excitement in solving problems.

The necessity of taking the lead

The solution to the environmental crisis the earth faces lies in science and social dynamics, which are primarily studied in universities. The International Alliance of Research Universities has brought together the leaders in environmental science for a three-day Congress in Copenhagen. Academics got together to discuss what might be the most pressing problem of the day, to identify priorities for the UN Climate Change Conference in November/December 2015.

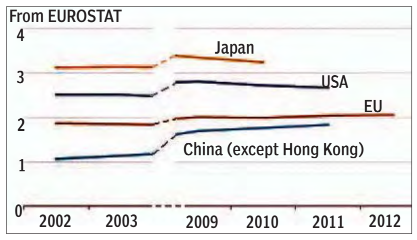
Co-location presents challenges, of course, say Jana J Watson-Capps and Thomas R Cech of Bio-c-Frontiers, a start-up at the University of Colorado, in Boulder. The first is the difference in motivation, academic or commercial. This demands that the rules be clear, that there are goals to be attained, but without impeding the course of research. Funding of the joint work needs to be from sources other than research funds, like rent from the co-located company or grants. Conflicts, including the ownership of IPR, need to be addressed and also evaluation of students by academic standards despite the proximity of other beneficiaries.

Co-location goes further than bring research and industry together, it connects the university to the community and involves the academic view in daily matters, as well as engages the lay public in matters academic, which people too often choose to ignore.


Jie Zhang


Tae Eog Lee


Mike Sharples



Chinese three-step

Jie Zhang, academician and associate of the Chinese and US National Academies of Sciences and president of Shanghai Jiao Tong University, describes China's concern to enable universities sustain the economic growth of the last few decades. Investment has increased and China's expenditure on research and development in 2012 was over $160 billion and over $100 billion on education. (the picture shows how China's R&D share, as a percentage of GDP, has grown faster than others', despite the huge rise in GDP). The R&D expenditure in India, in contrast, was $40 billion in 2012, rising to $44 billion 2014.The education budget was below $10 billion dollars in 2012.

The number of full-time researchers in China increased by 38 per cent from 2005 to 2012, of published articles by 54 per cent and the patents awarded increased eightfold in the same period. But the quality of research, Jie Zhang says, as judged by how often Chinese papers are cited, has not kept pace. In 2007, Shanghai Jiao Tong University hence embarked on an improvement drive, through high quality recruitment, recognition and incentives. World-class scientists were hired to work at the cutting edge and to set a high bar.

New junior researchers were competitively selected and their progress carefully evaluated. Attractive salary, incentive and career paths were devised and schools were given autonomy, finally arriving at a performance-based tenure regime similar to that of the leading US universities. And for existing academics who do not fit into the new system, there is a fair exit scheme, which makes the change acceptable.

The measures taken have brought the university within top ranks worldwide and both patent publications and citations are growing. The measures have prompted a shift in educational emphasis and a culture that values and rewards innovation has taken root, he says.

The German experience

Chemist Worfgang Hermann, president of the Technical University of Munich since 1995, has succeeded in changing the archaic, hidebound bureaucratic legacy since the 1960s and turning the university into a model of creativity, freedom and flexibility, writes Alison Abbott in the *Nature* review. Hermann replaced the control of the government education ministry with a board of trustees, she says, and restructured the institution on the lines of MIT in the USA. He brought in rigorous and uniform coursework for PhD candidates so that a graduate school could maintain a standard. The freedom to raise funds as an "entrepreneurial university" was a revolutionary change, in keeping with the changed role of modern universities.

While there was resistance to the changes, the results — soaring scholarly output and sumptuous funding — have put an end to all of it. "This new culture is now ingrained," says Hermann. "The next generation of leadership will continue in this vein."

Korea — flipped classroom

Tae Eog Lee, who heads the Centre for Excellence in Teaching and Learning at the Korean Advanced Institute of Science and Technology University at Daejeon, South Korea, has actually suspended the practice of teaching by lecture, says writer Mark Zastrow. In the "flipped classroom", as Lee describes his new method, students do not sit through lectures but watch on-line lessons at home and come to class to discuss concepts and work on problems in groups. Teaching staff supervise and support, but the learning is by the students themselves. Lee says this way encourages creativity, teamwork and curiosity, all of which is suppressed by a one-way lecture, or even, as many believe, by Korea's hierarchical society itself.

Other institutes in Korea have tried the concept before, but Lee, in just two years, has taken the lead in the movement and 60 classes are now "flipped" at Kaist. He hopes to raise the number to 800, or 30 per cent of all classes in the next three years. The bulk of the students exposed report a better understanding of subjects taught this way and also higher motivation and concentration. While there are doubters, Gerard Postiglione, who studies Asian higher education in Hong Kong, says universities in Asia are watching to see how the Kaist initiative, now the second best in Asia, progresses. Some have already followed suit, including the prestigious Seoul National University.

UK goes on-line

Elizabeth Gibney reports that Mike Sharples, at the Open University at Milton Keynes, UK, is overtaking the wave of Massive On-line Courses (Moocs), recorded lectures from US universities that thousands of students could follow on the Internet for free. Sharples follows the thinking of the late Gordon Pask, a British educational phychologist who believed that students built up knowledge through mutual interactions. He redesigned the Moocs with social engagement at the centre of the learning process. The courses allow discussion on every single element of the content, with the devices of "like" and "follow" of social networks, and learning can take the intensity of on-line games. "It seems obvious in retrospect that people would want to talk about their learning, but it wasn't obvious a year ago," says Sharples.

The new Moocs have better figures of the proportion of students who complete the courses they join. Although the enrollment is still less than that of Stanford and a provider at Cambridge, Massachusetts, the leaders grant that Sharples' method, which uses student feedback to improve the interaction in the platform, is "evolving at a torrid pace".

Social transformation

South Africa has changed how education is delivered to undo the effects of earlier practices like apartheid. Linda Nordling reports that the University of Cape Town programme helps disadvantaged children, mostly non-white, to acquire skills that their wealthier contemporaries take for granted. This includes help in language, counselling to develop better study habits, foundation courses in subject areas as well as field visits, like aquariums or the fossil park, science-related experiences that students may have missed while growing up.

To provide time for extra activities, the UCT has an optional four-year programme to complete the three-year Bachelor's degree programme. Students join all together, but opt, after six weeks, to join the normal three-year course or the extended four years. The progress is still slow, with the proportion of black children who join university or complete the course being well below that of white students. But there are successes, like Mokete Koago, who hopes to join for a Master's degree in oceanography next year. "When my parents came down for my graduation, it was the first time in their lives that they saw the sea," he says.

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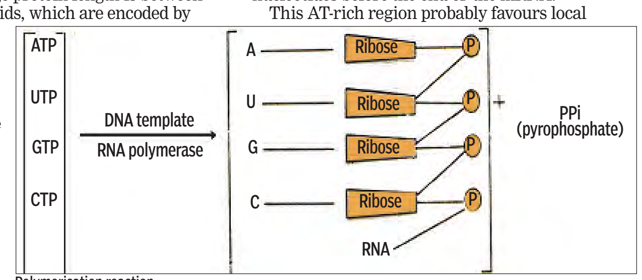
CODING FOR PROTEINS

TAPAN KUMAR MAITRA DESCRIBES TRANSCRIPTION IN PROKARYOTES

Messenger RNAs code for proteins. The average lifespan of mRANs in *E. coli* is about two minutes, after which the molecules are broken down by ribonucleases. Since prokaryotes do not have a nuclear membrane, the ribosomes are free to attach to the mRNA molecules as they are being synthesised. In other words, prokaryotic mRNAs are translated into protein at one end while the other end is still being transcribed. The half-life of these mRNAs is so brief that sometimes degradation starts even before synthesis is completed. In bacteria, therefore, any change in the rate of mRNA synthesis will be followed a few minutes later by a change in the synthesis of the corresponding protein.

The length of mRNA is heterogeneous, reflecting the length of the polypeptide chain for which it will code. The average protein length is between 300 and 500 amino acids, which are encoded by between 900-1,500 nucleotides. In bacteria, however, mRNAs frequently code for several proteins and in these cases (called *polycistronic mRNAs)* the molecules are very long. For example, the five enzymes involved in the metabolism of tryptophan are all encoded by a single mRNA molecule – the polycistronic mRNA molecule that codes for more than one protein.



Polymerisation reaction

In prokaryotes, all types of RNAs are transcribed by the same enzyme. Using DNA as the template, this RNA polymerase catalyses the formation of RNA from the four ribonucleoside triphosphates. The enzyme copies the base sequence of one of the DNA strands according to the Watson-Crick base-pairing rules. Since only one DNA strand is used as a template, transcription is said to be *asymmetrical*.

In addition to copying the nucleotide sequence of the DNA template precisely, RNA polymerase is able to recognise a variety of genetic signals on the chromosome, such as the signals for starting and stopping RNA synthesis at precise sites.

There are an estimated 3,000 genes in *E. coli* and they are all transcribed by the same enzyme. Considering these multiple functions, it is not surprising that RNA polymerase is a large and complex enzyme. A complete molecule or *holoenzyme* consists of several polypeptides: two *a* of 40,000 daltons, one b of 155,000, one *b* of 165,000, and one s of 90,000. The total molecular weight of the enzyme is therefore 490,000 daltons.

The sigma (s) factor is loosely bound to the rest of the enzyme and can be separated by physical means. The *bb'* a_2 enzyme (without sigma) is called the *core polymerase*. The sigma factor is required for the enzyme to recognise the correct start signals on the DNA. As soon as the RNA chain is started, the sigma factor is released from the core enzyme and can be used in the transcription of other RNA molecules.

The following stages are commonly distinguished in the transcription by RNA polymerase: (1) binding to promoters and chain initiation, (2) elongation, and (3) termination. The start signals on DNA are called *promoters* and represent the initial binding site for the RNA polymerase. This binding is a crucial step in the regulation of gene expression. All prokaryotic promoters have the common sequence, TATAATG (or slight variations of it), located some 10 nucleotides before the end of the mRNA.

This AT-rich region probably favours local separation of the DNA strands, a step required for RNA polymerase to gain access to the DNA bases. In addition to the TATAATG sequence, the enzyme also recognises a DNA region located about 35 bases before the start of the mRNA. Single-base changes in this region can inactivate promoters, but different promoters have no obvious common sequences in this region.

Individual variations between promoters are not surprising, since different genes are expressed with varying efficiencies; that is, some promoters are "stronger" than others.

E. coli has proteins called *repressors* that can bind to specific sequences of DNA (called *operators)*, turning off the expression of a gene or set of genes. Repressors work by binding to a DNA site that overlaps with the promoter, thereby preventing the binding of RNA polymerase.

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All-female Mars odyssey?

A WOMEN'S MISSION TO MARS MAY BE MORE THAN JUST PIE IN THE SKY, SAYS **KATE GREENE**

In February 1960, American magazine *Look* ran a cover story that asked, "Should a Girl Be First in Space?" That sensational headline represented an audacious idea at the time and, as we all know, the proposal fell short. In 1961, the National Aeronautics and Space Administration sent Alan Shepard above the stratosphere, followed by dozens of other astronauts over the next two decades.

Only in 1983 did Sally Ride become America's first female astronaut to launch. But why would anyone think a woman would be the first to space, anyway? Medical studies, for one thing. Some studies in the 1950s and 1960s suggested female bodies had stronger hearts and could better withstand vibrations and radiation exposure.

Moreover, psychological studies suggested that women coped better than men in isolation and when deprived of sensory inputs. Some of these investigations were limited in their design and sample sizes. But there was another, more compelling reason that women might outshine men as potential astronauts: basic economics. Thanks to their size, women are, on average, cheaper to launch and fly than men. As a Nasa guinea pig, I had the chance to verify this first-hand.

Last year, I took part in a Nasa-funded research project called the Hawaii Space Exploration Analog and Simulation. It required that I and five other crew members live as astronauts on the surface of Mars. We didn't leave rarth, obviously, but for four months we were cooped up in a geodesic dome on the side of the very red, very rocky, very Mars-like Mauna Loa volcano in Hawaii.

Our food, water, power, and communications were limited, and we were only allowed to exit the habitat if we wore mock spacesuits. This was the first Hi-Seas mission — a third is due this month — and it was designed mainly to study the types of food Mars explorers might eat. I was the crew writer, and since I had the scientific background, I conducted a sleep study, too.

One device we used to track sleep was a sensor armband, which also provides estimates of daily and weekly caloric expenditure. Over time, I noticed a trend. Week in, week out, the three female crew members expended less than half the calories of the three male crew members. We were all exercising roughly the same amount — at least 45 minutes a day for five consecutive days a week — but our metabolic furnaces were calibrated in radically different ways.

During one week, the most metabolically active male burned an average of 3,450 calories per day, while the least metabolically active female expended 1,475 calories per day.

The calorie requirements of an astronaut matter significantly when planning a mission. The more food she needs to maintain her weight on a long space journey, the more food should launch with her. The more food launched, the heavier the payload. The heavier the payload, the more fuel required to blast it into orbit and beyond. The more fuel required, the heavier the rocket becomes, which, it in turn, requires more fuel to launch. Every pound counts on the way to space. Nasa was keenly aware of this, and that's why, in the early 1960s, it nearly considered a female astronaut corps.

Of course, politics and culture have a pesky way of sneaking into engineering decisions, especially when a country's pride is on the line, according to Margaret A Weitekamp, author of *Right Stuff, Wrong Sex: America's First Women in Space Programme*. Despite extensive training and excellent performance, the women in the programme were dismissed. Some of the reasons included fears about public relations if female astronauts were killed, as well as Nasa's reliance on military pilots, who at the time were only male.


First woman: Valentina Tereshkova.

The first woman in space was cosmonaut Valentina Tereshkova of the Soviet Union, who flew 20 years before Sally Ride. Her flight bolstered the appearance of Communist egalitarianism during the Cold War. Russia hasn't kept up a female presence in orbit, though; it only just last month launched its first female cosmonaut in almost two decades, Elena Serova.

PLUS POINTS


Russell Edwards and Dr Jari Louhelainen with the shawl.

Jack the Ripper

It was supposed to have been the definitive piece of scientific evidence that finally exposed the true identify of Jack the Ripper after he'd brutally murdered at least five women on the streets of Whitechapel in the East End of London 126 years ago. A 23-year-old Polish immigrant barber called Aaron Kosminski was "definitely, categorically and absolutely" the man who carried out the atrocities in 1888, according to a detailed analysis of DNA extracted from a silk shawl allegedly found at the scene of one of his murders.

However, the scientist who carried out the analysis has apparently made a fundamental error that fatally undermines his case against Kosminski — and once again throws open the debate over who Ripper's identity. Jari Louhelainen is said to have made an "error of nomenclature" when using a DNA database to calculate the chances of a genetic match. If true, it would mean his calculations were wrong and that virtually anyone could have left the DNA he insisted came from the Ripper's victim.

The apparent error, first noticed by crime enthusiasts in Australia blogging on the casebook.org website, has been highlighted by four experts with intimate knowledge of DNA analysis — including Professor Sir Alec Jeffreys, the inventor of genetic fingerprinting, who found that Dr Louhelainen made a basic mistake in analysing the DNA extracted from a shawl supposedly found near the badly disfigured body of Ripper victim Catherine Eddowes.

They say the error means no DNA connection can be made between Kosminski and Eddowes. Any suggestion therefore that the Ripper and Kosminski are the same person appears to be based on conjecture and supposition — as it has been ever since the police first identified Kosminksi as a possible suspect more than a century ago.

The latest flurry of interest in Kosminski, who died in a lunatic asylum aged 53, stems from a book, *Naming Jack the Ripper*, published earlier this year by Russell Edwards, a businessman who bought the shawl in 2007 on the understanding that it was the same piece of cloth allegedly found next to Eddowes.

STEVE CONNOR/THE INDEPENDENT

Ancient sex

It is widely believed that external fertilisation — like frogs spawning in pools — is the ancestral mode of reproduction among jawed vertebrates, but the discovery of certain structures indicative of internal fertilisation in the 400 million-year-old fossils of *Microbrachius,* which were among the first jawed fish, shakes the very foundation of this claim. "It would not take a whole lot of evidence to reshape that tree to suggest a different history," said evolutionary biologist Martin Brazeau of Imperial College London, who was not involved in the study that was published on 19 October in *Nature*. "But I think that's part of what makes this a really exciting discovery. It's going to drive a lot of debate and I think it's one of the most important discoveries in this area of research in years."

Microbrachius is an "antiarch", a member of heavily armoured group of fish believed to be the most primitive subgroup among their kind (placoderms), dating to about 380-400 million years ago. Looking at new specimens from the Orkney Islands in Scotland, an international team of researchers concluded that solid bone structures on the backsides of males, once thought to be modified pelvic fins, are actually claspers that may have protected soft tissues used for transferring sperm into the female's cloaca.

"Claspers are very distinctive structures with a single function: to effect internal fertilization. These claspers, which have now been found in numerous specimens, are conclusive evidence that fertilisation was internal in *Microbrachius*," said coauthor Per Ahlberg of Uppsala University in Sweden.

SANDHYA SEKAR/SCIDEV.NET