has information about specific events within the context of other events in a person's lifetime, for example, the memory of learning to play soccer while in school. Semantic memory concerns facts, concepts, rules and meanings. It contains information necessary for perceptual recognition and complex motor skills, including speech or typing. The cerebral cortex is thought to subserve much of semantic memory. In contrast to the role of the cortex in semantic memory, the hippocampus and associated structures are thought to be primarily involved in episodic memory. Patients with damage/degeneration due to aging in these latter areas, quickly forget events in their daily lives; for instance, where they are or what they had for lunch. It must be remembered, however, that aging is a complex set of factors, intriguingly intertwined, by nature and nurture.

OPTIMA, the Oxford Project to Investigate Memory and Aging and the collaborative initial effort at the University of Calicut[3], focused on some of these apparently corollary factors, such as low blood levels of folate, vitamin B12 and higher level of homocysteine, which go hand in hand with the cognitive decline, i.e. dementia, generally after the age of 65.

Aging gracefully

It is not difficult to understand that cognitive decline in dementia, depending on its severity, can therefore threaten the dignity of the aged, besides having to live with physical infirmities. It is remarkable that the acquisition of language skills early in life somehow seems to protect our brains against problems of dementia in later life. David Snowdon, a neurologist based at the University of Kentucky, came out with epoch-making findings regarding this relationship. In his famous nun study[4], Snowdon analysed various factors of nature and nurture that might contribute to Alzheimer's disease in later life.

Examining 93 autobiographies which were hand-written in the first person by sisters who took their vows between 1931 and 1939, Snowdon separated these sisters into one group that had clinical symptoms of Alzheimer's and another that did not, their healthy cohorts. Assessing the monosyllabic, multisyllabic and rarely used words in the autobiographies, Snowdon and his associates had reason to think that the healthy sisters had a richer vocabulary in early life and may have read a more diverse selection of literature as children.

A third and more rigorous analysis involved measuring idea density and separately measured grammatical complexity, by psycholinguists and the analysis was blind to rule out bias and to ensure objectivity. While idea density reflects language processing ability, grammatical complexity on the other hand, is associated with working memory capacity.

In order to write a complex sentence, one has to keep many elements in play, until they are properly coordinated. There is always the risk of losing the train of thought before one reaches the end of the sentence, in case of poor working memory.

The level of idea density in the autobiographies was strongly associated with the scores from the cognitive test that the sisters were administered every year. Grammatical complexity was also associated, but to a relatively lesser degree. On average, the sisters were 22 years old when they wrote their autobiographies and 80 years old when Snowdon and his associates assessed their mental function. After 74 sisters with early life autobiographies had been autopsied, the power of idea density, in predicting Alzheimer's disease in late life was about 80%, an incredible level of accuracy.

Susan Kemper, the psycholinguist who collaborated with Snowdon thinks that the idea density may signify properties of the brain, such as those related to perception, encoding and memory retrieval. To put it simply, it is the sum total of our conscious experience.

Conclusion

Most of the brain's growth comes during our earliest years. An infant's brain grows exponentially after birth. During this period, we can do a lot to increase and direct the brain's capacity by learning and experiencing in order to preserve its cognitive capacity in later life and thus ensuring as much as is possible, a graceful aging.

1. Ramakrishna, T. (ed.), *The Human Brain: Essays on Awareness*, Publications Division, University of Calicut, 2001.
2. Ramakrishna, T., *Brain, Language and Memory*, Publications Division, University of Calicut, 2002.
3. de Jager, C. A. *et al.*, *Neurol. India*, 2008, **56**, 161–166.
4. Snowdon, D., Aging with Grace (*The Nun Study and the Science of Old Age. How We can All Live Longer, Healthier and More Vital Lives*), Fourth Estate, Harper Collin Publishers, London, 2001.

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Value of introducing the 'science, technology and society' perspective into Indian science

Rustum Roy

Preamble

Balaram's editorial[1], 'Images and Icons: Chemistry, Physics and the Garden of Mendeleev', is itself a wonderful garden of significant issues regarding the very fundamentals of the human activity we call 'science.' I start with just a short list of ideas that resonated with my thinking, and produced these comments and suggestions.

(a) Does not the actual practice of 'science' today match, as we shall show, more or less exactly what is usually also described by the term religion? And not only in its parallel in the use of icons and images?

(b) Does not the immutability of the empirically derived 'first law of chemistry' ('periodicity of the element's properties with atomic number,' the heart of the

periodic table) advance chemistry's case as the mother of the reliability of unchanging 'basic science' for the wider public?

(c) This fact also advances the greater reliability of the inductive method – based on solid, reproducible experimentation – as the superior general method of advancing innovations in our now mature science.

(d) Is not the omission of Mendeleev, by the Royal Swedish Academy of Sciences from the election to the equivalent of its foreign Membership (also referred to as 'Nobel laureates'), one more argument against the nearly absurd overweighting of this one metric as the unique indicator of scientific achievement? Unfortunately it provides further proof that science ultimately also worships (with the 'world') at the same shrine, of the 'golden calf' – money. It was simply the size of the prize-money that conferred a special measure of quality on the Nobel Prize for everyone, including most scientists. Is not the election of, say, an Indian scientist to be a foreign member of the US National Academy, or of the equivalent national bodies of the leading science-producing nations, of at least equal merit?

Icons and images

I turn next to the matter of our 'professions' versus our practices in science. In the entry hall of Pennsylvania State University's Materials Research Laboratory (PSU–MRL), is a quote from Einstein hardly ever cited by physicists[2]. It is also totally ignored in the quotes in the Einstein 'garden' which houses his statue in the US National Academy site in Washington. Einstein urges scientists on a daily basis to think of the impact of their work on their society. Einstein's deep involvement in the world around him is a vastly more significant and accurate descriptor of the person than the offhand, ubiquitous quote about 'dice-playing' by an undefined entity referred to as 'God'. Hardly a few physicists I have tested, have ever heard of this kind of Einstein's concern for and involvement in the world, in society or even in empirical science and engineering. Few knew that Einstein worked full time in the Swiss Patent Office while he churned out many of the magical year physics papers. (Some of which he wrote, in his own records, were illuminated by what he saw at his work, in the patent applications.) Even fewer know that he holds nearly a dozen patents (mainly on refrigerators based on the NH_3 expansion cycle). And when my acquaintance Stephen Brunauer told me (fifty years before Google!) that it was he as a Navy lieutenant who had, during the Second World War, got his Admiral to induce Einstein to work on improving US Navy torpedoes, I could well believe it. Einstein's interest in, and participation in the world of concrete reality was lifelong and genuine, and is, sadly, totally neglected by most of the scientists in academia that I know, even those that grant him 'icon' status. That is the loss that I am writing about. We, for our part, in the PSU–MRL, emphasized the very down-to-earth, non dice-playing, suggestions he made for scientists' conduct in society. By following Einstein's mottos on our walls, and learning from Bell Labs own 'theory', we focused on 'applications-driven basic research,' and apparently were not handicapped by it at all. Penn State's MRL was ranked, in 2003, by ISI as the #1 materials research laboratory in the world, based on the largest number of highly cited faculty.

Einstein was as remarkable as Gandhi (whom he venerated for decades, publicly) precisely because among scientists, in addition to his enormous scientific contributions, he was totally involved in the society around him. He was the quintessential interdisciplinary scientist. From $E = mc^2$ to special relativity, to Brownian motion, to gyroscopes, and refrigerators, to torpedoes to anti-war marches and banning the bomb campaigns in the political sphere.

The new imperative – interdisciplinarity

If applications-driven or connectedness to reality is the first necessary change for science, the second is surely the absolute need to embrace in real terms, interdisciplinarity. I was pleased with Balaram's tribute to Mendeleev's 'garden', since in my own office I, who has been trained as a chemist, have had for decades a 4 ft by 3 ft periodic table (in Russian). It features a tiny picture of Mendeleev, hanging on my wall – not as an icon – but a genuine resource, especially for non-chemist students (and colleagues) who have long since forgotten its contents!

This was one way in which we practised what we have preached for 50 years – the interdisciplinary imperative[3] – in every aspect of life and work. Physicists, chemists and engineers had to learn each other's language. Like other religions in decline, the implosion of science into less and less significance is more or less assured, if it continues on the path of reductionism by splintering into more sub-specialties, each with its own little territory and its own dialect. Are we going from 'nano,' to 'pico,' 'femto' and 'atto' disciplines? Learning more and more about less and less till we know everything about nothing?

Halo-words are not good science policy

Who can defend the nano (funding) craze? Does it not rather remind one of the religious debates on the number of angels standing on the point of a pin? The politics of public funding of science has encouraged a science conforming to politics with absurd marketing strategies of using magical, euphonious themes to attract big money – the 'SSC'; the high T_c superconductor craze; the myth of using 'ceramic engines'; 'CVD diamonds' and of course, 'nano'. Has there ever been a chemist who was not working at the nano level? What if few scientists stop to ask: Is this a good science policy for the country? Is it, in the long term, good for science?

Science : theology :: technology : religion

Attacks on fundamentalism (easily defined as the claim that one's truth is the truth, the only truth, the whole truth) must surely include *science fundamentalism*. Is this approach healthy for science? All scientists moan about the science illiteracy of the public. But one of the balancing absurdities is the societal illiteracy of scientists. At least in the West, and I keep testing it, most scientists know little about politics, even their country's own science policies that feed them. The tirades by a few – indeed, minor jihadis by some – against religions in society is simply bad politics and worse – equally bad science. Many of these extremists even insist on mixing up incommensurable quantities by setting up battles between 'science' and 'religion'. But 'science' is a scalar quantity, as is 'theology'. These two terms deal with theories, beliefs, abstract, abstruse terms. 'Technology' and 'religion' as a properly matched pair are commensurable: they are vectors, and

may be compared and contrasted. The debate can be about different theologies and versus different sciences. And surely no one, or no group, has ever been authorized to speak for 'science'. Yet, many arrogate this right to themselves and soon we have created delicious morsels for the voracious media on supposed conflicts between 'science vs religion'.

Technology is the embodied, concrete combination of science and group goals and resources. Religion is its analogue: it is the 'praxis', practice of one's values; transforming ideas, beliefs into actions, into lifestyles. *Ortho praxis* (religion) is very different from *orthodoxy* (theology). Technology and religion both add 'agraha' to 'satya'; putting 'force and persistence' behind truth. These two human activities, by no means inherently in conflict, are the most important vectors clamouring today for the hearts and minds of the world (the associated scalar terms – science and theology – are only of interest to the academics, the detail-persons, mainly because they are both small terms in the equation of real life for the masses).

Science, technology and society – The needed interdisciplinary organizing principle

I have been involved (for over 40 years) in the founding and development of the (academic) field of science, technology and society (STS), which now has modest outposts across leading institutions in the US from MIT to Stanford. One of the areas of research and serious inquiry, besides, say, science and policy and politics, is science, technology and religion hinted at in our title. When I was invited to give the 1979 Hibbert Lecture in London in this area of science and religion (sic), I was intimidated by the fact that the only previous Indian lecturers on this topic were Rabindranath Tagore and S. Radhakrishnan. The interaction of science with technology in, and with, society is an area scientists ignore at their peril. Yet I find that in India STS is indeed totally ignored. I hope that this commentary might ignite some interest in changing the culture of 'science' and engineering in Indian academica to much greater interdisciplinarity, and giving leadership to the emergence of teaching and research in STS.

As part of PSU's STS programme, started in 1973, we had regular university-wide lectures and discussions over a period of a few years in the 1980s, with a spectrum of many world-leaders, who had indeed thought about the real interactions among sciences, technology and all aspects of society. Representative discussants included persons such as C. F. von Weizsacker, Edward Teller, the poet W. H. Auden, Vassily Nalimov (Kolmogorov's handpicked STS mathematical genius in Moscow), E. F. (ritz) Schumacher, of *Small is Beautiful* fame, and Lord (C. P.) Snow, whose wisdom Balaram also quotes. Relevant in this context was Snow's response in the vigorous discussion; at that time of the height of the nuclear war threat, and the increasing sophistication of its MIRV-ing technologies, etc. to the question: 'What force is strong enough to contest with such advances of technology?' With no hesitation, Snow replied, 'Only religion.' He gave as his example to prove the case, China's *then* deeply enforced (if not held) beliefs, and Communist 'religious' practices which emphasized decentralization, including the notorious backyard steel furnaces. Snow must be turning in his grave today!, but his point is clearly valid. Technologies and religions are used, *practised*, for good or ill *by the masses*. Certainly, the strongly pro-science and technology, anti-theology and religion, nearly contemporary, national models of Nazi Germany and the USSR give us recent important data-points, or inconvenient truths, about the naively assumed uniform beneficence of science and technology. They also more than offset the facile references to the cruelties and absurdities of the 500–1000 yr-old Crusades and Inquisition, or Hindu–Muslim post-partition clashes, despicable as they appear to us now, as the usual products of religions.

As I write today, we are in the middle of the financial meltdown, after another 20-year cycle of very different but incredibly successful technological manipulation of 'human desire' – exploiting the innate worldwide attraction to the Golden Calf, i.e. money, against the currently weakened, balancing social forces of religions worldwide. Science-based technology seems to have suddenly met its match – again. The Buddha had rejected wealth. Moses was very hard on the golden calf worshippers. Jesus vigorously championed the poor and rallied against the rich. But the 'scientific' (??) theorists of the alternative theology of 'greed is good', from Ayn Rand and her disciple, Alan Greenspan, to the pulp atheist crowd of Richard Dawkins, Christopher Hitchens, Daniel Dennett, Sam Harris and their anti-religion crusades, are all worshippers and fervent believers in the God of 'science'. They surround themselves by vague references to science as the only guide, and drop names of all its 'icons' from Darwin, and Einstein, to the selected winners of the 'highest prize money' award. They sprinkle scientific terms from 'quantum mechanics, 'indeterminacy', and 'double helices' and 'DNA', and fearlessly equate the whole future, indeed the very survival of science to the acceptance (whatever that means) of Darwinian evolution as true (whatever that means to them). The fact is that even though most non-biologists (like me) take the general concept of evolution as pretty solid, they never *use* it. 'Evolution' is a tiny corner of, and hardly equal to, 'science'. It is *never* encountered in the entire world of physics, chemistry, all engineering disciplines, and is hardly used even in most biological research papers. These facts do not faze these non-scientist 'jihadists for science'. All of us workaday scientists seem to permit this illegitimate hijacking of the good name of science to be used to support the causes such as anti-religious jihadis, or for the God of unbridled capitalism or consumerism-uber-alles? Or do we enter the fray as citizens of our homelands and home planet, with one special type of knowledge to contribute within a STS framework, emulating both Einstein, and learning from Gandhi who listed among his 'seven deadly social sins': 'science without humanity?'

1. Balaram, P., *Curr. Sci.*, 2008, **95**, 145–146.
2. 'Concern for man himself and his fate must always form the chief interest of all technical endeavours, concern for the great unsolved problems of the organization of labor and the distribution of goods – in order that the creations of our mind shall be a blessing and not a curse to mankind. Never forget this in the midst of your diagrams and equations'. – Albert Einstein.
3. Roy, R. (ed.), *The Interdisciplinary Imperative: Interactive Research and Education, Still an Elusive Goal in Academia*, Writers Club Press, 2000.

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