This is obviously one effort which can be made in India with some advantage. There are other experiments which can be taken up in India. Realizing that one meteorite, Murchison, has transformed our concepts and provided a firm evidence of abiotic synthesis of complex molecules in the outer space, search and analysis of fresh meteorite falls may be an easy and effective way to pursue this problem. So far satellites have not been used to photograph meteor trails and such a programme can be taken up here using Indian satellites. Since about 10–20 meteorites fall on the Earth every year, there is a good chance of quick recovery of a meteorite in India provided its trail is determined photographically. It can be expected that some of them may turn out to be unique and may shed further light on problems related to the origin of life in our solar system.

In spite of the absence of any evidence so far for existence of life beyond Earth, the subject remains extremely fascinating. It is hoped that with improved technology, the coming century may provide an answer to the question whether we are alone in the universe or if there are some companions out there waiting for us to communicate.

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OPINION

New trends and fashions in science and apathy of funding authorities towards areas in classical science

D. D. Pant

The role of fashion in science has been dealt with in some detail by Erwin Chargaff in his essay 'Triviality in Science: a brief meditation on fashions'. Later in his autobiographical book *Heraclitean Fire*[2] Erwin Chargaff says 'The onset of molecular biology was accompanied by an orgy of model-building, much of it of a transparent stupidity. The journals were full of models no sooner published than discarded. Even then I counselled moderation, thus contributing to my reputation as a "controversial figure".' Another author Stephen Jay Gould[3] speaks of modern trends in science in his 1991 Science Book Prize winning work *Wonderful Life* where he points out, 'The sciences of historical complexity have been demoted in status and generally occupy a position of low esteem among professionals.... These distinctions have entered our language and our metaphors the "hard" versus the "soft" sciences the "rigorously experimental" versus the "merely descriptive". Several years ago Harvard University, in an uncharacteristic act of educational innovation broke conceptual ground by organizing the sciences according to procedural style rather than conventional discipline within the core curriculum. We did not make the usual two-fold division into physical versus biological but recognized the two styles just discussed, the experimental-predictive and the historical. We designated each category by a letter rather than a name. Guess which division became Science A and Science B? My course in the history of earth and life is called Science B-16.' In one of my earlier articles I too have dealt with this subject[4].

In my present article on this topic, I wish to deal with the new trends in science, particularly in Indian science with special reference to life sciences. In doing so, I must first outline the process of scientific investigation which is the study of nature and natural phenomena by observation through our sensory organs. In the modern age, we supplement our senses by different gadgets which augment our observations. However, our observations are only the beginning of science, these are followed by a process in the mind which classifies and reasons out our observations, draws conclusions and makes generalizations. The fall of an apple and Newton's law of gravitation is a familiar example. These generalizations then have to be tested by experiments wherever possible, by artificially creating the conditions and these generalizations are now called laws or theories. The phenomena and laws thus discovered are next utilized to perform difficult jobs or activities. Up to the discovery of the phenomena and making generalizations about them, the process is science but thereafter the skill in performing jobs with that scientific knowledge is technology, although it may be difficult at times to say where science ends and where technology begins. Citing examples from the field of biology, the persons who domesticated wheat or rice plants by creating conditions for their culture under cultivation were doing science but those who repeated the cultivation for ages by improving conditions of cultivation were doing technology but here again those who discovered better breeds in nature or bred new varieties by crossing or by other genetic processes were scientists. Taking another example from the field of medical science, when Ronald Ross found that bites of *Anopheles* mosquito were responsible for injecting malarial parasite in the blood stream in humans and these thereafter multiplied in the body and caused malarial fever in man, he was doing science, but the doctor who prescribes quinine or other drugs to cure malaria is only a technician, but once again a doctor who discovers a new drug or new treatment for malaria is a scientist.

And I must also mention here cases like those of James Lovelock, the author of 'Gaia'[5] whose invention of the electron capture detector helped other scientists in getting the Nobel Prize in Chemistry and for his being invited by NASA jet propulsion laboratory to find out if there was life on Mars or other planets. As a result of his work, he looked for a definition of life and came to the conclusion that it was a self-regulating system or object. He finally concluded that there was no prospect of life anywhere else in the planets around us and that our earth itself was a living organism. The salinity of its seas, the composition of its atmosphere and the temperature of the earth have been stable throughout the ages. He called his theory 'Gaia' after the name of Goddess Earth in Greek mythology. In recent years, biologists have not only started seeing the cell or the body of multicellular organisms as composite organisms but even ant, bee and termite colonies or the human society as organisms. Lovelock on the other hand, sees the Earth itself to be a living organism. It is a sad spectacle to find that Lovelock's theory was responsible for his exit from NASA. In our modern jargon Lovelock is holistic instead of being a reductionist. In his research laboratory at Launceston in London he has invented the microwave oven. He first discovered long range air pollution in 1966 and pointed out that chlorofluorocarbons (CFC) and nitrous oxide are depleting the ozone layer. As a result, his holiday cottage in Western Ireland became the centre of a global monitoring network. He continues to invent gadgets for scientific research but recently when his name was proposed for the Nobel Prize, the scientists of the Nobel Committee felt that he was not a scientist but only an inventor. However, he has received the Swedish Volvo Prize and the Japanese Blue Planet Prize.

Fashions in science and change of labels

The latest trends in science which have come after the fission of the atomic nucleus and also that of the cell have lately started new fashions in science which are leading to the neglect of many aspects of pure science while other areas are being boosted by enormous amounts of money available for fashionable areas like atomic research, energy research, ecodevelopment, microbiology or biotechnology. This tempts many of our scientists to indulge in politicking for funds and also to change their labels or signboards while they continue working in the areas of research that they were pursuing earlier. I may cite some examples to bring home the manner in which this is done. A scientist who is a plant physiologist gets a project of a crore of rupees to scan diverse plants for their photosynthetic capacity to fix solar energy for building carbohydrates in the plant body. The way he does it is to allow the plants to grow in the sunlight for sometime, thereafter he cuts them, dries them and determines their dry weight to decide which plant is more efficient in fixing solar energy. Reports are submitted to the funding authority where they remain in the files and are not used further. Another scientist obtains a project on microbiology without any previous work on the subject and without the knowledge of identifying the object he will study. Yet another scientist may continue squashing root tip cells for counting the number and observing the form of their chromosomes but he may change his signboard from cytology to genetic engineering to draw funds available for such research.

The result of this unbalanced distribution of funds is the production of third rate work in copiously-funded areas while good research in other areas is suffering. The proper method of encouraging and funding scientific research does not lie in identifying 'thrust areas' but in identifying capable and devoted scientists of any age and giving them facilities to work. Good science is done by capable scientists not by the labels they carry or by the costly gadgets they import. We need devotion, motivation and hard work for good science and not 'brain storming'. As Thomas Alva Edison has said, 'Genius is one percent inspiration and ninety nine percent perspiration'. My teacher the late Sahni used to define research in the same way by substituting research in place of genius. Gadgets may become important at a certain stage but the first prerequisite of good science is a devoted and capable scientific worker. The example of C. V. Raman should be enough to convince you about my advice. Asutosh Mookerji identified him when he was an accountant general by seeing his single-minded devotion to research at the Indian Association for Advancement of Science. Asutosh offered him the Palit Chair of Physics in Calcutta University and Raman brought the first Nobel Prize for India. On the contrary, we are today busy selecting persons on the basis of caste, relationships and other parochial considerations and expecting good science by unbalanced distribution of research funds and by looking at the fashionable labels of the scientists and not at their capability and devotion. Of late, things have deteriorated to such an extent that persons who are known to have indulged in fraudulent research remain firmly entrenched and go unpunished. At the same time persons who do not have even the basic training required for a subject are being placed in very specialized pure science institutions established by savants at the cost of their savings for the continuance of research in their fields which they feared may happen to lie unprotected outside the fashionable areas of science. In this manner square pegs are being fitted into round holes of pure science by selectors who are themselves square pegs of the same kind.

There was a time when universities were producing good researchers and teachers in diverse branches of science but why are we not able to do so now? My answer is bad recruitment of teachers and promotions by counting years of service without looking at the performance or reputation of the candidates in teaching and research. University teachers also start activities like coaching classes, etc. in order to earn more money. So they spend less time in teaching and research. Unless we stop these practices we cannot rejuvenate the universities and their science. Devoted research scholars, though capable, cannot find suitable jobs in science departments of universities or institutions. Scientists are produced by universities and therefore one has to improve the universities for better science in the country.

Universities themselves have gone down by the overhauling of their old liveral Acts based on those of Cambridge and Oxford, while the Acts of Cambridge and Oxford have remained the same as they were four or five hundred years ago. As a result of the changed Acts, semi-educated persons become elected as members of the University Executive Councils for indefinite tenures to pass judgement over university administration, standards and appointments, whereas university teachers get in by rotation for a limited term of one year instead of being elected by their colleagues. The Deans of Faculties are again appointed by rotation so that except two the remaining faculties remain unrepresented in the Council and the Deans too have a limited term of one year. Senior-most Lecturers and Readers who fail to secure the higher ranks, even by promotion become representatives of Readers and Lecturers, it is claimed to avoid electioneering. Above all, Vice-Chancellors are not elected but selected by a strange Committee which has one nominee of a political chancellor and only one of them elected by the Executive Council and the other nominated by the Chief Justice of the High Court and thereafter the Chancellor has a second and final choice of appointing the Vice-Chancellor. And mind you, a political Chancellor has supreme power over twenty or more universities. Unless we bring back our old Acts of Universities there is hardly any chance of improvement.

In spite of the extreme paucity of avenues of employment for graduates or postgraduates in science, our Universities are unable to control the mad rush for admissions in universities and colleges. No one even thinks of methods of controlling admissions in universities and colleges. Their numbers have been rising year after year without quality control. More universities and colleges are opened where quite a large number of students enter for training as 'netas' for later political life through student unions because this is the most easy course for a lucrative profession. Others join because there is nothing else they can do in the largely elusive hope of qualifying for some employment and also because the cost of graduate and postgraduate education is easily affordable, sometimes being cheaper than school education. I think it is late but not too late and we must plan our higher education particularly in science where the cost of education is relatively high. One of the methods of controlling the rush of students for higher education is to make it costly as they have done in Cambridge and Oxford. The fees in these universities are so high that only the best students who hold government scholarships for education or children of those who can afford such costly education can enroll there. Naturally when the toppers or the students whose parents pay such high amounts for their higher education enter the universities, they seldom waste their time and opportunity for learning. We must therefore make our primary education free and easily affordable but make our higher education particularly in science costly so that only our best and motivated students get in. Finally those students who choose scientific research must do so as an end in itself and not as a means to some other end.

1. Chargaff, E., *Prospect. Biol. Med.*, 1976, **19**, 324–333.
2. Chargaff, E., *Heraclitean Fire*, Rockefeller University Press, 1980, p. 171.
3. Gould, Stephen Jay, *Wonderful Life*, Penguin Books, 1991, p. 279.
4. Pant, D. D., Presidential Address, Botany Section, Indian Science Congress, Ahmedabad, 1978.
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SCIENTIFIC CORRESPONDENCE

Who is afraid of breeders?

We present here our comments on the article by Tongia and Arunachalam[1].

Who is afraid of breeders? Many are. The main basis for the fear is the concern for nuclear proliferation as the fast breeder reactor (FBR) breeds or produces more fissile material than it consumes. The fear has manifested itself in many forms.

One of the earlier manifestations was the argument against the closed U-Pu cycle initiated during the International Fuel Cycle Evaluation (INFCE)[2]. Fortunately and correctly, the conclusion from the INFCE studies was that 'No fuel cycle is free from proliferation'. Nevertheless, we witnessed the abandoning of the FBR programme in the UK, Germany and USA; the joint European FBR programme also has been disbanded all due to the fear. Then came the campaign that as there are abundant resources of energy (coal, oil, gas, uranium and the highly enriched uranium and plutonium from the dismantled weapons), there is no need to breed, we should only burn fissile material. So France is converting its breeders to burners, with inert matrix fuels, etc.[3] The Russian Federation, Japan and India are the only three countries that have announced plans to continue with the FBR on a commercial scale. (While China is now building a 65 MW test fast reactor, and South Korea a 50 MW test fast reactor, we started construction of our 40 MW Fast Breeder Test Reactor [FBTR] way back in the seventies.) Now come Tongia and Arunachalam with the advice to India that fast breeders do not breed fast enough and therefore 'India should consider entering into long-term agreements with other countries, with appropriate policy innovations for importing uranium'. Alas they have not told us which countries and what are the 'appropriate policy innovations'. It is interesting that in their paper under Methodology, in the subsection 'Plutonium from PHWRs' (p. 553), Tongia and Arunachalam state, 'The availability of uranium from other countries is not included in these calculations as there are restrictions imposed by the Nuclear Suppliers Group on the supply of nuclear materials to India'. So their advice is very