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National Conference on 'Integrating Science with Society'

A report

A two-day National Conference on 'Integrating Science with Society' was held at Jadavpur University, Kolkata on the 15th and 16th of December, 2018. The conference had sessions on the Philosophy of Science, Cultivation of Scientific Temper, Ethical Practice in Science, Reforming Science Education and a Panel Discussion on "The role of scientists in society". The conference concluded with an Open Session (for the public) addressed by the eminent astrophysicist Prof Jayant Vishnu Narlikar. Around 500 registered participants attended the delegate sessions and around 1000 people attended the open session.

The conference was inaugurated by Prof. Suranjan Das, Vice Chancellor, Jadavpur University at Gandhi Bhavan, Jadavpur University, Kolkata, on Dec 15. Prof Soumitro Banerjee, General Secretary of Breakthrough Science Society welcomed the gathering and Prof Dhruba Mukhopadhyay, former Professor of Geology, Calcutta University and President, Breakthrough Science Society, presided. In his inaugural address Prof Das said that the science movement led by Breakthrough Science Society is a timely step towards building scientific temperament in the society. He began with quotes from two leading scientists "Science begins where speculation ends" and "Science is nothing but the refinement of everyday thinking". He then asked the question 'After 70 years of independence have we been able to end speculations or superstitions?' He lamented that his colleagues from science stream were sometimes more superstitious than those from social science background. He stressed that education based on scientific reason can help the country to come out of the present crisis.

Session 1: History and Philosophy of Science

The session was chaired by Professor Dhruba Mukhopadhyay, President, Breakthrough Science Society

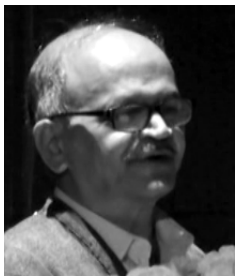
Prof S G Dani, former President, National Board of Higher Mathematics and Professor, Centre for Excellence in basic sciences, Mumbai

Title: *'On issues of scientific validation in everyday life'*

Over the last one century science has brought many benefits to society, but science is not just about benefits alone, it also provides a way of thinking. Prof Dani briefly outlined the development of knowledge and the method of science. Knowledge grows as a cumulative body through putting together experiences in a coherent form; forming hypotheses based on them; testing the hypotheses; identifying limitations of the hypotheses through multiple applications, modifying wherever appropriate etc. This is the essence of the scientific method.

There is a charge that reason based or evidence based thinking is of western import.

But that is not true; reason based tradition was there with the Arabs and so also in the Indian subcontinent. Prof Dani quoted from the 10th century Arab thinker Al-Haytham renowned for his works on optics, "The duty of the man who investigates the writings of scientists, if learning the truth is his goal, is to make himself an enemy of all that he reads, and ... attack it from every side. He should also suspect himself as he performs his critical examination of it, so that he may avoid falling into either prejudice or leniency."



Prof S G Dani

Ancient India also had substantial reason based philosophic traditions. The Mimamsa works of Sabara, Prabakara etc.; the Lokayata or Charvaka tradition; Samkya, Vaiseshika, Yogavasishtha etc.; the Buddhist tradition, were some of those. Kanada was an outstanding rationalist thinker.

Knowledge acquisition has two main components, inputs through sense perceptions coupled with experimentation and inference. In the 19th century excessive importance was given to the sense perception, the use of inference in conceiving reality was viewed with hostility. This trend gave birth to positivism or empirio-criticism. Under its impact most physicists did not accept anything that was not observable by the senses. Boltzmann was one of the major victims of this trend since his kinetic theory of gases required the presence of molecules which were not visible. Apart from senses we have the innate facility of arriving at inference through deductive and inductive reasoning. In the 20th century positivism was overcome mainly through the efforts of scientists like Einstein and scientific materialism got established. Through his work on the theory of viscosity, Einstein deduced that molecules are a physical reality. His work on Brownian motion further established the reality of molecules. His work on photoelectric effect showed the reality of the quanta of energy formulated by Max Plank.

Inference is also vulnerable to various corrupting factors. In parallel with our sensory abilities we have emotions, love/hate, pride, hostility, revulsion etc. At a collective level there are various vested interests like business interest, political interest, professional interest etc. favoring one or the other idea. One needs to counter these influences consciously for the effective use of inference in the process of acquisition of knowledge. In this context he referred to some of the pseudo-science claims in recent times like the medicinal effects of Gomutra and others that have been making headlines in the media. There are also other claims appearing in the media and social media. It is necessary to subject such claims to the scrutiny of scientific examination and verification, he said.

Prof G Nagarjuna, Professor, TIFR – Homi Bhabha Centre for Science Education, Mumbai

Title: *'Making as a Medium of Truth: A Constructionist View of STEM'*

Prof G Nagarjuna

Prof Nagarjuna congratulated BSS for organizing the conference at Kolkata where the Indian Association for Cultivation of Science a pioneering institution for the advancement of science had sown the seeds of the science movement in the country more than a century back. He enunciated the

concept of constructionism in the field of epistemology and philosophy. On the question why STEM (Science, Technology, Engineering, Mathematics), he said that this will provide an organic view point. Technology has so far been neglected in the study of philosophy of science. But technology has a big role in establishing falsifiability. Explaining with the help of building blocks such as atoms, numbers, elementary particles, cells, genes, etc., he demonstrated the constructionist approach in developing theoretical understanding in various branches of science.

Dr Liaquat Ali, Honorary Director, Pothikrit Centre for Health Studies and former Vice Chancellor, Bangladesh University of Health Sciences
Title: *'The Bengal Renaissance: an Epistemological Analysis'*


Prof Liaquat Ali

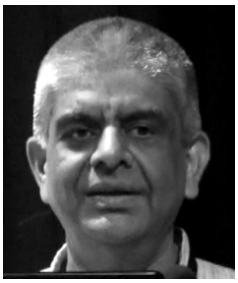
He presented a brief history of the renaissance in India, particularly the Bengal Renaissance led by stalwarts like Raja Rammohan Roy and Vidyasagar. He also spoke about the empiricist streams of thought in both eastern and western philosophies. He said that Ancient India had a rich tradition of empiricist philosophical thinkers whose contributions have not been properly understood or have been twisted in our history of thought. He cited the examples of the empirical elements in Vedas, the empiricist ideas in Charvak and Vaisheshika-Nyaya philosophies, and the pragmatist worldly approach of Buddhist philosophy. He concluded by discussing about the limitations of Bengal Renaissance and said that the present generation has the responsibility to pursue the unfinished tasks of Bengal Renaissance taking into consideration the experiences so far generated in the modern world.

Session 2: Cultivation of Scientific Temper

This session was chaired by Prof. Abhijit Majumder, Dept. of Chemical Engineering, IIT Bombay.

Dr Ajit M. Srivastava, Institute of Physics, Bhubaneswar
Title: *'Cultivation of Scientific Temper: Focus on Indian Science Community'*

In a lucid talk laced with humour he discussed ways of inculcating scientific bent of mind among the common people, and more particularly among the people who are 'trained in science'. He was of the opinion that on the question of scientific temper there is not much of a difference between the common people who are not trained in science and the people supposedly trained in science, e.g., those who have Ph.D. in science. The difference completely disappears when one focuses on scientific analysis of socio-economic phenomena.


Prof Ajit Srivastava

The main reason for this situation, he attributed to the intensely feudal family structure in our society where questioning is suppressed in general in all aspects of life and the same atmosphere continues in schools and colleges. He felt that we can attempt to improve the situation, though in limited ways, for example, by imparting an early training to children from schools about the importance of unconstrained questioning. For this he suggested organizing regular intense and completely

informal discussion sessions of scientists with school students where scientists do not appear as authorities of knowledge, rather facilitators of discussions on various topics.

Prof Palash Baran Pal, Popular science writer and former Professor, Saha Institute of Nuclear Physics
Title: *'Scientific Temper and the Education System'*


Prof Palash B Pal

Our education particularly at the school level does not teach the learners to think rationally and to act logically. The school syllabus is too heavy, which leaves very little time for the students to think. He discussed the ways rational and logical thought can be encouraged through education. He suggested the following points in this regard.

1. The importance of teaching in the mother tongue, which helps develop a student's imagination.
2. The importance of learning the science behind phenomena seen in everyday life, and a quantitative study of global environmental issues.
3. The importance of reading popular science books which tell students not only about the theories, but also how the ideas were conceived.

Prof Mangala Narlikar, Former Professor of Mathematics, University of Bombay and University of Pune
Title: *'Developing Scientific Temper'*

The most important aspect in cultivating scientific temper is to develop in students a questioning mind in schools. There are many facets of the question of developing scientific temper in our society. Is scientific temper against religion? Does scientific temper exclude belief in God? On this she said that scientific temper does not insist that you should not believe in god. There are two types of believers, reasonable believers who are open to reasonable logic and fanatic believers who are victims of superstitions and other unreasonable practices. What scientific temper is against is in holding as true what has already been proved to be false for example *rahu, ketu*, etc., and other superstitious beliefs. The important thing is to ask questions and try to find rational answers. The task before us is to complete the unfinished Renaissance of the whole country and to take science to the people patiently and tactfully.


Prof Mangala Narlikar

Prof Aniket Sule, TIFR-Homi Bhabha Centre for Science Education, Mumbai
Title: *'What do we learn from our recent brush-ins'*

In the recent past, the scientific community had to raise voice repeatedly against suppression of scientific thought in the country. In this context he felt that it was more appropriate to discuss about the events in the last 18 months. One of the important events was the March for Science organized in August 2017 and April 2018. Then in January 2018, a signature campaign was launched to protect evolutionary theories in school curriculum. Similarly, a couple of months back we had to raise our voice again on the issue of proposed inclusion of a book of poor quality containing unsubstantiated beliefs in the curricula of technical education. In his talk he mainly discussed

about the lessons learnt from these brush-ins so as to prepare ourselves in a better way in the future. From the feedbacks received from the scientific community and media people, he felt that when we prepare a write up explaining our stand on an issue we should make it very clear, focused and brief. The reason is that when press people go through the material to prepare a report they would not prefer a lengthy draft. The order of the demands also matter. In our write up on the March for Science the first demand was on funding and so the press mainly highlighted this demand. There was some criticism from some scientists that we have come not just for money alone. Another important observation he made was that more participation from senior scientists, women and students is needed. The nonpartisan way of writing the draft was appreciated by the scientific community as well as the media people. He also felt the need for a strong presence in the social media.

Prof Aniket Sule

Session 3: 'Ethical Practice in Science'

The session was chaired by Prof Naba Kumar Mandal, former Professor, TIFR.

Prof Dipankar Chatterji, former President, Indian Academy of Sciences and Honorary Professor, IISc, Bangalore
Title: *'Galileo's Children'*

Scientific temper and ethics are closely related; without ethics it is not possible to cultivate scientific temper. The challenges and many failures that a scientist has to encounter are strong temptations to take shorter routes to achieve success. Thus, an experimenter can generate desired results by massaging the raw data and bending the truth. However, such results have short lives. The inherent strength of science is reproducibility. Observations and conclusions which are rigorously tested and reproduced by others alone get written on granite stone. A research student faces such temptations from the very beginning of his/her career. Term papers, even lab note books, for example, are indeed well tested exercises in original thinking and writing. However, today's copy-paste technology offers such alluring short cuts that ultimately lead to plagiarism in scientific paper writing. It may be possible to survive by bending the truth, where success is judged by some bizarre metrics and not by the rigour behind the scientific output of an individual. He concluded by saying that what we urgently need is a self-correcting mechanism in place.

Prof Dipankar Chatterji

Dr C Prabhakara Reddy, Professor of Cardio-Thoracic and Vascular Surgery, Govt Medical College, Kurnool, Andhra Pradesh
Title: *'When will the fruits of medical research reach the common man in the present scenario of violated medical ethics?'*

Physicians are also part of the society and the ills of the society also influence them. A person who wants to become a doctor should be judged by his passion for the profession, but unfortunately our system selects medical students by entrance tests without judging his commitment to service. And because of the commercialization of the medical education system, the

commitment for service to the society has vanished. Even Governments are collecting huge amounts to start hospitals and are promoting corporate culture. Hospital is declared as an industry, and patient is considered as consumer. This has caused a lot of damage to the society. Medical profession has become a business and we are now facing its evil effects.

Manufacturing and pharmaceutical sectors are involved in similar business. Drugs fetching larger profit margins are marketed whereas essential drugs are not produced in adequate quantities. The issue of patent is another problem affecting the health sector. Companies who own patent for some drugs are selling those drugs at abnormal prices unaffordable by common people.

Dr C Prabhakar Reddy

There is a huge gap between what people need and what the governments are providing in the health-care sector. Primary Health care system is not at all strengthened. Secondary and Tertiary level hospital system is inadequate. In primary hospitals the number of doctors is insufficient and infrastructure and preventive measures are not addressed. As a result, people are forced to go to corporate hospitals. The knowledge of diseases and medicines has become a commodity and is being sold with huge margins. We have to change this situation; everybody should get the fruits of research, science and technology. The dream of health for all will be achieved when medicines and treatment are available to all rather than those who can afford. He also spoke about a very inspirational work he has undertaken in setting up a model cardio-thoracic centre in a government medical college hospital in Kurnool where state of art heart surgeries are conducted free of cost. In the last two years 300 heart surgeries were conducted in the Centre.

Soumitro Banerjee, Professor, IISER Kolkata

Title: *'A few issues in the ethics of science'*

Prof Soumitro Banerjee

Ethics are systematic norms of behavior that are conducive to the aims, objectives, and activities of a community, profession or organization. In the conduct of science, the practices conducive to collective enquiry into natural phenomena that have developed through ages constitute ethical practices in science. This includes the issues of objectivity and carefulness in planning and conducting experiments; honesty and integrity in reporting the results even when these contradict one's own beliefs; openness in disseminating the research results, etc.

Even though most of these practices that constitute ethics of science seem to be obvious, violation of these is becoming increasingly common. One main reason for this is that in our country science is considered just as a career. Many scientists no longer investigate nature for the excitement of it; they do it to fulfill well-defined career goals – promotions, awards, name and fame. Intense competition and the urge for quick results have opened the doors for various malpractices including fabrication, distortion, plagiarism, and various types of unethical publishing practices. He cited some of the classic cases of fraud such as the Piltdown man, the Japanese stem cell research, the Korean cloning experiment etc. He also talked about the role of mo-

tivated research funded by interest groups, the role of intellectual property rights, etc., in vitiating research ethics.

Play: 'The Uncertainty of Principles'

In the evening, a humorous play titled 'The Uncertainty of Principles' was staged by a group of professional scientists. The play was about an educated, middle class family which gets steeped in superstition and into the clutches of a 'Godman' due to a very tragic event in their lives. One of the two sons, who is a physicist and a passionate teacher of quantum physics and who shuns unscientific thinking and practices, counsels his family members and helps them to come out of their irrational shell. The play tries to give the message that uncertainties in life often makes people slip into irrational practices.

Session 4: Reforming Science Education

The session was chaired by Prof. Narayan Banerjee, Professor, IISER Kolkata.

Prof M C Arunan, CUBE Lab, Homi Bhabha Center for Science Education, TIFR, Mumbai
Title: *'Populating India with STEM Spectators: Gully Cricket Model of Spreading STEM Culture'*

In India, there is a serious dearth of spectators for science, unlike, say, in a game of cricket. A game like cricket is a rule-following activity where the players as well as the spectators are immersed in it. The idea was to see if Indian science can learn anything from Indian street cricket. With this aim a new model of Science, Technology, Engineering and Mathematics (STEM) education called CUBE (Collaborative Undergraduate Biology Education) was launched 6 years ago at the Homi Bhabha Center. STEM is taken as a set of games scientists, engineers and mathematicians play. The idea is to develop groups of people who understood some rules of the game and they would constitute the STEM spectators. For creating the STEM spectators, groups of students and teachers working in collaboration were encouraged to do experiments using the resources in their neighborhood on problems that they observe in their everyday life. Several such groups in undergraduate colleges and schools across the country were set up. Prof Arunan narrated examples of such experiments as the pea study, the Dafnia study, the flowering patterns of mangoes in different geographical locations etc. It was observed that some of these studies matured from curiosity to frontier science.


Prof M C Arunan

Prof Umesh Kadhane, Indian Institute of Space Science and Technology, Thiruvananthapuram
Title: *'Reforms in science education: conflict between deliverable and assessment'*

In an environment where quantitative assessment is at the highest priority, the teaching goals and deliverable get distorted. One of the reasons why our science education is in the present dire situation is the method of assessment of the students on the basis of their marks. This forces the system to teach concepts in terms of packets which can be asked as answers to students in examination and


Prof Umesh Kadhane

marks can be given. More rationalistic, objective and scientific teaching must focus more on the concept rather than definitions and derivations. A more modern but practical approach is needed urgently. He suggested that if courses are designed with more emphasis on hands on learning and experimentation, then transfer of concept and assessment both can be achieved with better efficiency.

Prof Mayank Vahia, Dean, School of Mathematical Sciences, Narsee Monjee Institute of Management Studies, Mumbai, & TIFR
Title: *'Teaching Science to Non-science Students'*

We are talking about science, but we never teach science to the students. We only teach the grammar of science. Is it possible to teach English language only through Wren & Martin without bothering about who is Shakespeare or what he wrote? Talking about physics education, he said that the students need to understand its logical elegance as one appreciates a good poem. That physics can be taught only through equations is counterproductive. Understanding the concept is more important. After a concept is understood, mathematics is necessary to generalize it. Taking the example of the pendulum, if the student is told that the pendulum obeys such and such equation it makes no sense for the student. First the student has to understand why it oscillates before going into the equation that it obeys. In the text book Newton's first law is stated as 'a body continues in its state of rest or of uniform motion unless it is acted upon by an external force'. But every child has the experience that a ball rolling stops after some distance. So there is a contradiction between the physics taught in the classroom and the physics experienced by the student. We need to make the student understand why Newton's law correct. It is friction, something not known earlier to the student which makes the difference between what is seen in the textbook and what he or she actually experiences.


Prof Mayank Vahia

Summarizing, he said that most of us are visual people and visualization is very important in the learning process. Getting science students to understand the complexities of real situations is another aspect. In our country the number of students in the non-science streams is much more than in the science stream. It is necessary to make the non-science students understand the beauty of the logical simplicity of science and that would make science versatile.

Prof R Ramanujam, Institute of Mathematical Sciences, Chennai
Title: *'Doing science in the science classroom'*

The central problems of our science education are little experimentation, little critical thinking, inadequate emphasis on modeling and quantification and little relation to technology. Apart from these, there are generic problems in education that afflict science education as well: excessive rote learning, inadequate teacher preparation and rigid modes of assessment and evaluation. All of these together end up privileging memory-based theoretical knowledge.


Prof R Ramanujam

The most critical problem is the entire lack of hands-on engagement in scientific activity by children in school. On the one

hand, this encourages children to perceive science only as a collection of (disjointed) facts, and experiments as demonstrations of already established facts. On the other hand, this also helps perpetuate social inequality, by respect for intellect and degradation of physical work.

Prof Ramanujam strongly recommended the need for reforms along the following lines: Shifting the focus of the science classroom from content knowledge towards critical scientific inquiry; Active engagement of all children in experimentation and working with physical material; using material to make/build things; Making connections between the areas of science as well as with other areas of study; Changing assessment models to reflect the methodology of science; Enriching teachers with a variety of scientific resources. Doing science in the classroom implies a commitment to the process of science; it is also the way to build scientific temper in society.

The Session 5: Panel Discussion "The role of scientists in society"

The session was chaired by Prof Amitava Datta, INSA Senior Scientist, Dept of Physics, Calcutta University. The panelists were Dr C M Nautiyal, Prof Pradipta Bandyopadhyaya, Prof Prajval Shastri, and Prof Guruprasad Kar.

Dr C. M. Nautiyal, Formerly Scientist-in-Charge, Radiocarbon Lab., BSIP, Lucknow. Now with Indian National Science Academy, New Delhi as Program Consultant (Science Communication)
Title: *'Scientists as Integral Part of Society'*

In olden days the popular term for those studying nature was 'philosopher'. We should think about the role of scientists in society in that light again. Usually scientists are viewed as thinkers who work in isolation, but if that were true not so many of the discoveries and inventions beneficial to mankind would have taken place. Those discoveries were the result of curiosity as well as the compassionate side of human mind. These humane traits have greatly benefited the society. So the role of scientist in society has also been of one who serves humanity.


Dr C M Nautiyal

He felt that if scientists visit teaching institutions and teachers spend some time in research institutes, it will greatly help to improve the education system. Scientists should also take time to interact with farmers and other strata of people. Through such interactions many problems in the farming and rural sector could be resolved. Scientists also have a big role in educating the masses about the natural phenomena and to free people from misconceptions and superstitions. He cited the remarkable example of the total solar eclipse in 1995, when scientists organized several outreach programs. In Diamond harbor, Kolkata, more than 600 children had come the previous night, listened to the discussions on eclipse and witnessed the eclipse the next day.

Prof Pradipta Bandyopadhyay, School of Computational and Integrative Sciences, Jawaharlal Nehru University, New Delhi
Title: *'The role of scientists in society'*

In India there is not much of a connect of science and scientists with society. The role of scientists in society has changed considerably over the last century. It is known that in the early and mid-twentieth century, a large number of scientists have been involved in shaping the thought process in society both in India and abroad. In

Prof Pradipta Bandyopadhyay

India both before and after independence, several scientists played significant roles in shaping the future of the country. For instance, Prof P C Mahalanobis was a member of the planning commission, and Prof M N Saha was a member of Parliament. However, it appears that there has been a steady decline of scientists who are strongly connected with society. One major reason for this could be because of the complete separation of humanities and science streams from an early stage of our education. Hence, one can practice science without knowing basic history, geography, political science etc. There could also be other reasons like the fact that scientists are generally recognized by their academic work, papers etc. rather than their commitment to society.

Dr Prajval Shastri, Indian Institute of Astrophysics, Bangalore
Title: *Beyond Bridging the Science Deficit: Scientists Role in Transiting to Public Ownership of Science*

In India today we are witnessing a deep disconnect between the public readily embracing the fruits of technology on the one hand but being skeptical of the scientific way of understanding the world around us on the other. It is also true that common people have been exploited by superstitious beliefs. Prof Shastri listed several reasons for the science deficit. The lack of science communication among the larger public is one important aspect. The hiring and promotion process in scientific institutions is weighed in favor of performance culture with very little importance for teaching and outreach activities and no innate commitment to the scientific method. In research institutions, open discussions on philosophical questions – such as what are the implications of the scientific method – are stifled so much so that practicing scientists and definitely the public forget that the scientific method is the best way to understand the world around us.

Prof Prajval Shastri

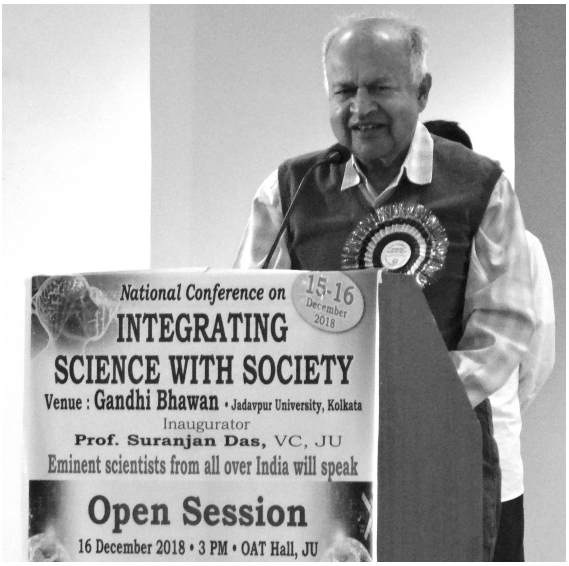
Issues of scientific method are often seen as direct opposition to religion. The task of persuading the public to accept the scientific method has not been carried out by the practicing scientists, but mainly by voluntary science organisations. She said that lack of funding is not a major reason for the disconnect. Freedom of expression for the academia, freedom to conduct open debates etc. should be constitutional right so that use of service rules to suppress dissent becomes illegal. The scientists should be concerned less about entitlements and more about responsibilities and move towards public ownership of science.

Prof. Guruprasad Kar, Indian Statistical Institute, Kolkata
Title: *'Correlation between present model of development and the propaganda of anti-science'*

In the last few years there had been a misinformation campaign regarding science and ancient history of India. The problem has been acute not just because some fringe groups are involved but some people occupying governmental position have also taken special initiative in this direction. It is to be noted that this misinformation campaign has intensified with the intensification of various neo-liberal economic policies. The neo-liberal globalization policy

Prof Guruprasad Kar

has been in vogue for more than two decades and it has created a few super rich at the cost of enormous misery for the common people. With the backing of clear statistics, Prof Kar showed the effect of globalization on various sectors. Agriculture is one of the most badly affected sectors, more than 2 lakh farmers committed suicide in the last 20 years. In the mine rich states like Chattisgarh, Jharkhand, etc., the percentage of people below poverty line has gone up drastically. People's discontent has been rising fast all over the country. In such a situation the pseudo-science propaganda is one of the tactics adopted by the ruling elites to create confusion among people so that their thinking and reasoning ability are impaired. In this context, scientists while exposing the non-scientific propaganda and abuse of science should also challenge the various policies adopted by the government that go against the interest of the common people.



Prof Jayant Vishnu Narlikar addressing the Open Session

Open session on Dec 16, 2018

The concluding session of the conference was an Open Session (for the public) at the Open air theatre of Jadavpur University. Prof Dhruba Mukhopadhyay, President, Breakthrough Science Society, presided. Prof Pradip Narayan Ghosh, Pro VC, Jadavpur University, addressing the large gathering of delegates, students and general public talked about the necessity of integrating science and technology for the benefit of the society.

The main speaker was the eminent astrophysicist **Prof Jayant V Narlikar**. He spoke on the problems facing the development of scientific culture in India. He began his speech with his deep concern about the mindset of a large section of our people. Even though we live in the 21st century and are enjoying the advantages of many technological developments of science, the mindset of a large population of our country is frozen in the 19th century. Laced with humour he cited examples of different types of superstitions prevalent in our country. Several years back, the so called miracle of an idol drinking milk had become sensational news in the country. But then the real miracle was that the news spread so fast – a miracle of modern technology.

He suggested that one method that may be of use in controlling the spread of superstitions is to develop suitable tests to check whether the predictions of these superstitions are correct. He cited the example of the experiment conducted by Bernie Silverman in the USA to see if there was any correlation between happily married couples and their horoscopes. A

similar experiment was conducted in Maharashtra where the birth charts of 200 students, out of which 100 were that of bright students and 100 were of mentally retarded students, were taken for the study. 40 charts were randomly picked and given to 51 astrologers and were asked to pick the bright students among those. The results showed a success rate marginally lower than that would be got by coin tossing.

Narrating interesting stories and anecdotes he explained the need to develop scientific temper in the society. But we must learn to be patient and tactful rather than aggressive or abrasive in tackling superstitions, he cautioned.

The chairpersons of different sessions of the conference presented brief summaries of each session. The conference ended with an emotional call by Prof Soumitro Banerjee, General Secretary, Breakthrough Science Society to take up earnestly the task to make India scientifically literate. He also thanked the speakers and the delegates.

Messages

Prof Ram Ramaswamy, President, Indian Academy of Sciences, former VC, Central University Hyderabad and Professor, IIT Delhi

Hands-on learning at an early stage

The main reform that is needed in science education in the country should be in our schools. Much of our education at the primary and secondary level at the present time relies on rote learning, with the classroom teaching mainly being 'one-way'. From an early age, students are encouraged to not ask questions, and the examination process rewards those who are best able to reproduce what has been delivered in the textbooks or in the classroom. Thus in most of our schools today, there is little scope for students to learn by doing, and in all but the more elite institutions, classroom or laboratory science experiments are not a part of the curriculum. Whatever is learned at an early stage is largely delivered wisdom.

If the scientific temper is to be imbibed at all, it has to be at this stage, and the necessity is for strengthening primary education. There is an urgent need to focus on learning skills. The future will increasingly belong to those who can teach themselves what they need; and the earlier that students learn how to learn, the more they will be able to apply these skills at a later stage. Intrinsic to the scientific temper is the ability to question, and without the freedom to question, this ability is rarely developed.

There have been many attempts to reform the primary educational system, and some of these have been in this direction. Mahatma Gandhi, who believed that one should "learn as if you will live forever", proposed the alternate schooling method, *Nai Taleem*. This places special emphasis on skill development and has apprenticeship as an integral component. Although Gandhiji's experiment is largely forgotten at the present time, there is an important aspect that is easy to redeem: there needs to be more hands-on experience at the primary and secondary levels: Our schools should be laboratories of learning, and this is an investment that will pay for itself many times over.

Debabrata Ghosh, Department of Physiology, All India Institute of Medical Sciences, Delhi

We live at a time when there are state-sponsored attempts towards the viciously privative employment of abstract constructs and characters, and the planned plantation of misplaced concreteness. These are some of the original sins of the rationalistic mind. However, I find a ray

of hope in the antithesis brought forward in this Conference by the Breakthrough Science Society to draw upon a few rational minds to ponder upon different facets of philosophy and history of science and to open up dialogue to integrating science with society. In the Conference, I had a task to present a paper on, "A scientist's view on the tenets of politicization of science" highlighting some of the principles and processes underlying the politicization of science. I thank the organizers and special thanks to Professor Soumitro Banerjee, the horse power of the effort. No doubt the effort is commendable, but true hope is due to the delegates as they will henceforth be delegated to carry the rational spirit into larger societal canvas. Please recall what was opined in Katha-Upanishad, "Wonderful is he who can teach ··· and wise is he who can be taught". Please note that there is no binaries, it is the process philosophy. Personally, I wished to witness this process, but it cannot be fructified now due to some personal issues. It is my loss and I apologise for this last moment change from my end and consequent inconveniences. I wish a grand success to the organizers of the Conference and hope that it triggers the outreach spread of progressive rational scientific spirit.

Dr Jayasree Sengupta, Chair of the Board of General Assembly-International Union of Physiological Sciences, Former Professor and Head, Physiology, All India Institute of Medical Sciences, New Delhi

In the play *Nathbati Anathbat*, the actress Shaoli Mitra portraying Draupadi, daughter of the Panchala Raja, Drupad, and wife of the five Pandava brothers, cries out in the court of King Dhritarashtra being called 'unchaste' by Karna when Yudhishthira loses her in a game of dice in Mahabharatam ~400 BCE. Now in the 21st century #MeToo Movement we find women still remain the subject of racial and gender inequity. In my article, 'Oral contraception: Science, ethics and policies' slated for discussion at the national conference in Kolkata, I have attempted to highlight how a group of scientists, medical fraternity and the industry misused their powers to delusion women to believing that use of oral contraception promised greater control over their bodies and fertility, failing to inform that this 'freedom' comes at an enormous cost to a woman's health.

Despite several generations of women having been used as guinea pigs, as more and more dangers of the birth control pills are still emerging we do not find its echo in the Indian scenario as found in the western world through blogs and group meetings. As a society we in India must focus upon such moral and ethical issues, and policy controversies on how science failed the ethics from the viewpoint of women's welfare to enlighten the public through conferences such as the current one, Integrating Science with Society, and through Outreach Programmes. Unfortunately due to certain commitments I am unable to join this meeting in person but I take this opportunity to wish the conference all success.

The talks at the conference are available in YouTube:
https://www.youtube.com/channel/UCUgvyHn9MV3rFl3XaHg1PAA

2nd All India Science Conference

A report

The 2nd All India Science Conference of *Breakthrough Science Society* was held at the University Institute Hall, Kolkata, on Dec 17, 2018. The conference began with the hoisting of the flag by Prof Dhruba Mukhopadhyay, President, Breakthrough Science Society, in front of the hall at 10 in the morning.

The conference proceedings started with Ms K S Rajani proposing a Presidium consisting of Prof Dhruba Mukhopadhyay, Mr Debasis Roy, Mr V P Nandakumar and Prof P N Thankachan. The proposal was seconded by Dr Nilesh Maiti.

The president requested the house to observe two minutes silence to pay homage to G S Padmakumar, who was a vice president of Breakthrough Science Society, All India Committee and Yogesh Dhakad who was the State coordinator, BSS, Madya Pradesh.

The president then called upon Prof Amitava Dutta, President, BSS, West Bengal to address the delegates. Prof Amitava Datta said that in the present situation in the country there is an urgent need to build up a science movement and there is much scope to do it. Generally scientists are shy of coming out in the open to take stand on issues, but after the two science marches more and more of the scientists are coming out. So the situation is quite encouraging. We also need to use the website and social media very effectively. The imposition of unscientific ideas through textbooks and educational curriculum is another dangerous thing that needs to be fought out, he said.

Prof Soumitro Banerjee, General Secretary, BSS,then presented the General Secretary's Report. He presented a brief outline of the history of the development of science movement in the country and the tasks before us. The main task before us is to carry out the unfinished task of the Indian Renaissance, he reminded. He also presented a brief history of the organization starting with the publication of the magazine Breakthrough in 1984, under the guidance of the leading scientist Prof Sushil Kumar Mukherjee, former Vice-Chancellor of the Kalyani University and the Calcutta University. He described how BSS was formally launched through an all-Bengal Science Conference held at the Presidency College, Kolkata, from 30th December 1994 to 1st January 1995. He touched upon the important programs that were organized, and the process leading to launching BSS as an all-India organization through an all-India Science Conference held in Bangalore from 17th to 19th October, 2014.

Against the propagation of anti-science ideas and fund cut for scientific research, the All-India Committee of BSS took a timely decision to spearhead a movement by giving a call for 'India March for Science' on August 9, 2017. The program was a grand success, as marches were organized in around 40 cities and towns all over India. The National Science Day (28 February) of 2018 was observed with the slogan "India against superstition and pseudo-science". On that occasion, a large number of programs were organized all over the country.

Conference Report

Prof. Dhrubajyoti Mukhopadhyay, President, Breakthrough Science Society, speaking at the Conference.

The 2nd 'March for Science' was organized all over India on 14 April. It was again a grand success.

Mr V P Nandakumar called upon the delegates to suggest amendments on the General Secretary's report. Several amendments / corrections were suggested by the delegates.

The afternoon session was conducted by Prof P N Thankachan.

Dr Vinay Kumar from Delhi placed the resolution on the proposed New Education Policy. It was seconded by Dr Siddharth Varadaraj, Odisha.

Biswajit Roy from West Bengal placed the resolution on Nuclear Power. It was seconded by K G Satish, Karnataka

Dr P P Rajeevan from Kerala, placed the resolution on Anti-Black Magic Act that was seconded by Dr Radhakanta Koner, West Bengal.

Abhishek Sahu from West Bengal placed the resolution on Funding for Scientific Research. It was seconded by by Dr R Venkatesan, Tamil Nadu

Dipajyoti Mandal placed the resolution on Medical Sector that was seconded by Dr Ansuman Mitra, West Bengal

All the resolutions were passed by the house unanimously after short discussions.

Delegates then placed their suggestions on future course of action to be taken.

The Office Secretary Mr Tapan Si placed the accounts for the four years since the 1st Conference in 2014.

The next item was the election of the new committee. A panel was placed by Mr Debasis Roy. It was seconded by Mr V P Nandakumar. The panel was unanimously approved by the house.

The conference concluded with the speech by the General Secretary, Prof Soumitro Banerjee.

The newly elected Committees are as follows.

President: Prof. Dhruba Mukhopadhyay
Vice Presidents: Mr. V. P. Nandakumar, Dr. P. Mishra, Mr. Biswabasu Das, Prof. Damodar Maity, Mr. Subrata Gouri, Mr. Debashis Roy
General Secretary:
Prof. Soumitro Banerjee

Conference Report

A section of the audience at the Conference.

Secretariat: Mr. Satish K. G., Mr. George Joseph, Prof. P. N. Thankachan, Prof. N Maity, Mrs Rajani K S, Dr P P Rajeevan, Dr R Konar, Prof R Gangadhar, Dr Manabendra Bera

Executive Committee: Prof. Francis Kalathunkal, Dr. R. Venkatesan, Dr. P S Babu, Prof. Siddhartha Bharadwaj, Prof. K. P. Saji, Dr T K Shajahan, Er. Jai Prakash Maurya, Mr. Kanai Barik, , Dr. Vinay Kumar, Mr. Gopal Sahu, Mr. Chanchal Ghosh, Mr. Dinesh Mohanta, Mr. Chandan Santra, Mr Pintu Debnath, Mr K Tabrez Khan, Mr Dilip Satashia, Mr Vikas Bansal, Ms Sadhna Jakre, Dr. Uma Ramachandran, Mr S Jani Basha, Mr Patit Pawan Kuila, Mr. Ganesh Behera, Dr. Nirmal Duari, Dr. Subhraprakash Kajli, Dr Sarifa Khatun, Dr. Debabrata Bera, Ms Deepti B

Treasurer: Mr Asish Samanta

Office Secretary: Dr Tapan Kumar Si

Editorial Board of Breakthrough: Prof. Dhrubajyoti Mukhopadhyay, Prof. Soumitro Banerjee, Mr V P Nandakumar, Ms. Rajani K. S., Prof. K. P. Saji, Mr. George Joseph, Dr T K Shajahan, Dr. Manabendra Bera, Prof. Ashoke Prasun Chattopadhyay, Prof. P. P. Rajeevan

General Council:
West Bengal: Prof. Kartik Ghanta, Prof. Bijoy Dolui, Dr. Safique Ul Alam, Mr. Biswajit Ray, Mr Pratyush Sikdar, Mr Avishek Sau, Mr Siddhartha Shankar Ghanta, Mr Swadeshpriyo Mahato, Surajit Saha, Sumanta Shee, Mrs Sunanda Banerjee, Dr Apurba Senapati
Karnataka: Mr Chandresh B V, Ms Laxmi B V, Anandraj E, Ms Abhaya D, Mr Amjad M Sayed, Ms Deepa
Kerala: Dr K Hariprasad, Mr K Sivankutti, K S Harikumar
Tamil Nadu: T Hilda Mary, S Sadashiv
Bihar: Mr. Kamal Kishore, Mr. Rupesh Roshan, Mr Ashutosh Kumar
Madhya Pradesh: Ms Asha Prajapati, Mr Gaurav Namdev
Chhatisgarh: Ms Pooja Sharma
Delhi: Ravi Kumar
Odhisha: Ms Kulamani Nayek, Ms Subhra Roy, Saptarshini Raul
Assam: Sabina Yasmin, Biplab Richong
Haryana: Mr. Harish Kumar
Andhra Pradesh: Mallick Duth Kumar, Viswanath Reddy
Telengana: Dr G Rajitha, Devarshi Gangaji
Jharkhand: Mr Vijay Kumar, Mr Sujay Bhattacharya
Tripura: Mr Raju Acharjee
Sikkim: Mr Shankar Sharma, Rahul Thapa, Raju Chettri

The Indian Science Congress 2019

Protest against propagation of unscientific views

The 106th Indian Science Congress was held at the Lovely Professional University, Punjab on 3-7 January, 2019. It had an impressive technical programme with the focal theme 'Future India: Science & Technology'.

However, on the third day of the Congress something completely out of tune with a scientific event happened. In the Childrens' Science Congress section, two speakers — Andhra University Vice Chancellor Prof G Nageshwara Rao and independent researcher Dr Kannan Jegathala Krishnan made outlandish and unscientific claims. Immediately the *Breakthrough Science Society* sprang into action, and on 6 January a Press Release was issued (text given below).

Press Statement by BSS

The All India Committee of Breakthrough Science Society (BSS) expresses its happiness at the commencement of the 106th Indian Science Congress at the Lovely Professional University, Punjab being held on 3-7 Jan, 2019. It is heartening to see that an impressive number of distinguished scientists from 60 countries including 3 Nobel Laureates are participating in the Congress and discussing on the focal theme Future India : Science & Technology (ref: http://isc2019.org/) with very relevant topics covering agriculture, forestry, veterinary & fishery sciences, anthropology, archaeology, psychology, chemical & material sciences, information & communication, medical & physical sciences, 'New Biology' etc. The Congress has also featured an interesting concept of a 'Time Capsule' – a collection of objects representing today's technology – buried 10 feet deep for posterity. In his inaugural address, Prime Minister Narendra Modi recalled the rich legacy of ISC due to its association with some of India's finest minds, including Acharya JC Bose, CV Raman, Meghnad Saha, and SN Bose. We wish the Congress a grand success.

At the same time, we are astounded and even, horrified at the following claims made at the Congress :

- Kauravas were born due to stem cell and test tube technologies.
- Lord Rama used 'astras' and 'shastras' while Lord Vishnu sent a Sudarshan Chakra to chase targets. This shows that the science of guided missiles was present in India thousands of years ago.
- Ravana didn't just have the Pushpak Vimana but had 24 types of aircraft and airports in Lanka.
- Theoretical physics – including the contributions of Newton and Einstein – is totally wrong. Gravitational waves will be renamed as 'Narendra Modi Waves' and gravitational lensing effect will be renamed as 'Hashvardhan Effect'.

It is absolutely distressing that these claims were made in the Children Science Congress section of ISC where the audience largely comprised teachers and young students. Indians can justifiably be proud

Demonstration in Bengaluru against propagation of unscientific ideas at the Indian Science Congress. Prof Jayant Murthy, Director of Indian Institute of Astrophysics, addressing the gathering.

of our varied and colourful cultural history spread over two millennia. Our contributions to philosophy, art, music, literature, astronomy, mathematics, and medicine are renowned the world over. The richness of our culture is the direct outcome of the openness with which our ancestors welcomed and assimilated the essence of other cultures. The result is a wonderful collage that we have come to recognise as our cultural legacy.

In fact, the past presidents of Indian Science Congresses – Acharya Prafulla Chandra Ray (1920), Sir Ram Nath Chopra (1948) and Prof. P Parija (1960) – dealt with Science in India in an objective and educative manner while giving due recognition to the achievements in science in ancient India.

Now, such a hallowed assembly of scientists has been misused to make false and chauvinistic claims about ancient India tarnishing the genuine contributions of the great science personalities of yore and that too, in front of young and impressionable minds.

The scientific enterprise is a self-correcting quest to understand and explain natural phenomena based on critical observation, experimental evidence, universal verification and constant advancement. Stem cell research, in vitro fertilisation, science of ballistics and guided missiles, theory of relativity, quantum mechanics, etc., have evolved in this process. It is important to note that no technological accomplishment can be made without the relevant scientific theoretical foundation. For instance, construction of guided missiles requires electricity, metallurgy, mechanics, projectile motion, radars, optics, motion sensors, wireless communication, etc., and there is no evidence for the existence of these underlying pillars of scientific knowledge in ancient India.

Puranic verses and epics are poetic, enjoyable, contain moral elements and are rich in imagination but not scientifically constructed or validated theories. Hence, it is wrong to mix mythology and science. To claim that such innovations already existed in ancient India citing these sources is not only false and unhistoric but an affront to the real achievements in science in ancient and medieval India. Further, such false facts are, as Darwin said, more dangerous than false views.

This is not the first time this blunder has happened. In ISC, 2015 at Mumbai, false claims on the existence of aircraft in ancient India were made but was rebuffed by the science community in an online petition signed by over 1000 science academics and communicators and submitted to the president of ISC. In ISC-2016 at Mysore, false claims about Lord Shiva being the first environmentalist and the use of tiger skin to reverse aging process were made and BSS staged a protest demonstration in front of the ISC venue which was lauded by large sections of science community. No wonder that Nobel Laureate Venki Ramakrishnan termed ISC a 'circus'.

We spare no words to condemn this unpardonable attempt to dilute the integrity of scientific process, to tarnish the genuine contributions of ancient India and the rich heritage of Indian Science Congress. But, ISC does not seem to be learning from the past mistakes. Hence, it is time that scientific community speaks up again and in a stronger voice.

Thanking You,

Yours' sincerely,
General Secretary,
BSS, All India Committee

Soon after, many eminent scientists openly condemned the claims made in the Congress and wrote a strongly worded letter to the General President of the Indian Science Congress Association. The letter was initially sent by email. But when no response was received from the ISC, volunteers of *Breakthrough Science Society* went to the ISC office in Kolkata and personally handed over the letter. The text of the letter is reproduced below.

Letter sent by eminent scientists

To,
The General President,
Indian Science Congress Association
14 Biresh Guha Street
Kolkata 700 017

Date: 9 January 2019

Subject: The unscientific claims made at the Indian Science Congress – 2019

Dear Sir,

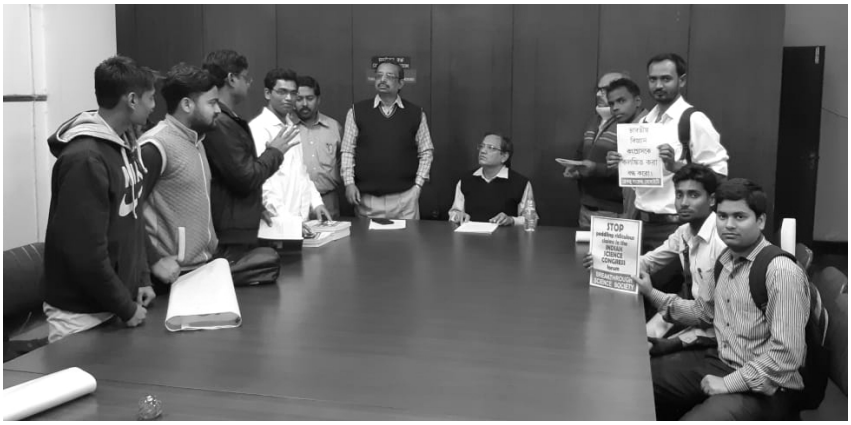
We are deeply shocked and disturbed that false claims, based on confusing episodes in mythology as science, have been made in the 106th Indian Science Congress, that too in scientific presentations made to the Children Science Congress. Such content in the ISC undermines the long scientific tradition of the ISC which, in the past, has been led by outstanding scientists such as Acharya Prafulla Chandra Ray, Sir Ram Nath Chopra and Prof. P. Parija. Such claims tarnish the image of Indian science globally, and also undermine the credibility of the genuine contributions of the great science personalities of yore, that too, in front of young and impressionable minds. Stories from our epics are poetic, enjoyable, rich in moral elements and in imagination but are not scientifically constructed or validated.

Furthermore, this is not the first time unscientific and false claims have been propagated in the ISC. In response to similar occurrences in the 2015 ISC, an online petition was signed by over 1000 science academics and communicators and was submitted to the president of ISC.

While we are happy to see press reports that some cognisance has been taken of the outcry against what happened in the ISC, we hope you will find out how the speakers were deemed fit to address the gatherings, and we hope stronger steps are planned to ensure that the ISCA actually promotes and advances the cause of science.

Thanking You,
Yours sincerely,

1. Jayant V Narlikar, former Director, IUCAA
2. Dipankar Chatterji, IISc Bengaluru
3. Dhrubajyoti Mukhopadhyay, Calcutta University
4. S Mahadevan, IISc Bengaluru
5. Soumitro Banerjee, IISER Kolkata
6. Naba Kumar Mondal, Saha Institute of Nuclear Physics, Kolkata
7. Aniket Sule, Homi Bhabha Centre for Science Education, Mumbai
8. Amitabha Datta, Calcutta University
9. Palash Baran Pal, Calcutta University
10. Ajit Srivastava, Institute of Physics, Bhuvaneswar
11. Prajval Shastry, Indian Institute of Astrophysics, Bengaluru



BSS volunteers delivering the letter written by eminent scientists to the General President of the Indian Science Congress Association

12. Abhijit Majumder, IIT Bombay
13. Arvind, IISER Mohali
14. G Nagarjuna, Homi Bhabha Centre for Science Education, Mumbai
15. Aurnab Ghose, IISER Pune
16. Guruprasad Kar, Indian Statistical Institute, Kolkata
17. S G Dani, Centre of Excellence in Basic Sciences, Mumbai
18. Dhruv Raina, Jawaharlal Nehru University
19. R Ramanujam, Institute of Mathematical Sciences, Chennai
20. M C Arunan, Homi Bhabha Centre for Science Education, Mumbai
21. Godfrey Louis, Former Pro-Vice-Chancellor, CUSAT, Cochin
22. Debshankar Ray, Indian Association for the Cultivation of Science, Kolkata
23. Debashis Mukherjee, S N Bose National Centre for Basic Sciences, Kolkata
24. Ajay Kumar Ray, IIT Kharagpur
25. Siddhartha Sen, IIT Kharagpur
26. Debabrata Ghosh, AIIMS Delhi
27. Jayashree Sengupta, AIIMS, Delhi
28. C S Menon, Retd from MG University, Kottayam
29. Moncy V John, Visiting Professor, SPAP, M G University, Kottayam
30. Babu Joseph, former VC, Cochin University of Science & Technology
31. K G Padmakumar, Director, International Center for Research & Training in Below Sea level Farming, Kuttanad, Allepey
32. Chetana Sachidanandan, CSIR-IGIB, Delhi
33. Prof K Aravindashan, former Principal, Maharaja's College Kochin
34. Shri C Ramachandran, retd. scientist, Rocket Propulsion Division VSSC Trivandrum
35. K Vijayakumar, HoD Mathematics Dept, CUSAT
36. A R Prasanna, PRL, Ahmedabad
37. Arvind Gupta, Science educator

Response from the ISC General President

Subject: Unscientific claims made at the Indian Science Congress-19

Dear All,

Kindly refer to your letter on the subject mentioned above dated the 9th Janaury 2019. I appreciate your concern, about the unscientific claims made at the Children's Science Congress the objectives of which

Demonstration in front of Calcutta University Rajabazar Science College. Famous particle physicist Prof Amitava Datta speaking to the Press.

is to motivate children to be attracted to science. We are also deeply shocked and condemned the incident as soon as we were made aware of this. I understand that during the deliberation of these unscientific claims, it was protested by the senior scientists present at the audience. I was disheartened that a Vice Chancellor of a state university discussed and raised these unscientific issues at "Meet the Children Programme" of Children's Science Congress. The ISCA is greatly concerned and will not tolerate in the future any unscientific claims at the session. It has been decided by the Executive Committee, Council, and General Body that from now on for the sessions like Meeting with Scientists at Children's Science Congress it will be mandatory for the scientists to submit a summary of their talk and scientists from ISCA will monitor their talk to block any unsubstantiated claims based on myths and heresy at such sessions. On behalf of ISCA I would like to thank you all for your concern to take the scientific activities of ISCA to a greater height.

I would like to take this opportunity to inform you briefly about the scinentific activities of 106th session of Indian Science Congress at Lovely Professional University (IPU). A large number of papers were presented at 14 different sections, such as Anthropological Sciences, Animal and Veterinary Sciences, Agricultural Sciences, Chemical Sciences, Information and Communication Sciences, Earth System Sciences, Medical Sciences including Physiology, Material Sciences, Physical Sciences, Plant Sciences, Environmental Sciences, Mathematical Sciences, New Biology including Biochemistry, Biophysics, Molecular Biology and Biotechnology. Fourteen Sectional Presidents were given responsibilities to organize the scientific activities of these sections. In each section several scientists from India and abroad delivered their lectures. Award lectures, endowment lectures, public lectures by eminent scientists were also organized. Besides these in 20 plenary sessions on contemporary issues a large number of national and international scientists which include President, International Society for Human and Animal Mycology, Chairman DRDO, Secretary DHR, and DG-ICMR, Secretary DST, Chancellor University of California, San Diego, Chairman AICTE, Vice Chairman, UGC, Chairman ASRB, etc., delivered their talk. One plenary was organized by Prof Dilip Kr Sinha, former VC Viswa Bharati University and past General President of ISCA to celebrate the 125th anniversary of Prof. P C Mahalanobis, Prof. Meghnad Saha, Prof S N Bose. Along with this session an exhibition was organized to commemorate the 125th anniversary of Prof. P C Mahalanobis, Prof. Meghnad Saha, and Prof S N Bose which was attended by a large number of students and delegates.

Along with these Children's Science Congress, Women Science Congress, Science Communicators' Meet were organized separately.

Three Nobel Laureates, Prof. M Duncan Haldane (NL, 2015 in Physics, Princeton University), Prof. Thomas Sudoph (NL, 2013 in Physiology or Medicine, Stanford University), Prof. Avram Hershko (NL in Chemistry, Technion Israel) attended 106th ISCA and delivered their talk. Around 30,000 attendees including around 15,000 delegates were present at the event. Each day 10,000 local school children along with their parents participated at the exhibition of children's science congress as well as the main exhibition (Pride of India) of ISCA. Scientists from different universities of India and abroad, ICMR, ICAR, CSIR, ISRO, DST, DBT, AIIMS, PGI, SGPGI, IITs, IISc, DRDO, Earth Sciences, IISER, BARC, NPCIL etc. attended the 106th session of the ISC. A session on Academia Industrial interface was also organized where speakers belonging to rich industrial background participated.

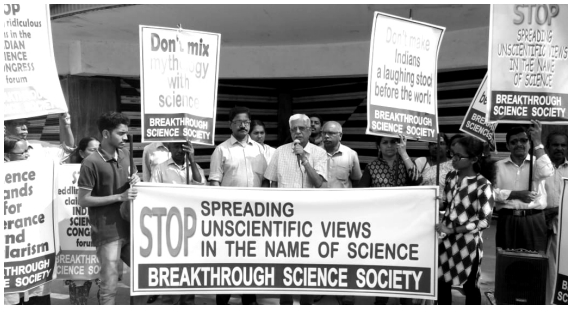
A time capsule with 100 items representing a cross section of today's technology and India's scientific prowess was buried by the Nobel laureates at LPU campus to be preserved for 100 years.

Despite having a myriad of scientifically sound, inspiring lectures by very well established scientists, we find it very painful that a part of media chose to focus on such lectures only which, as I have stated at first paragraph of my letter, was not the view of ISCA and which ISCA condemned. Moreover, it was protested by the senior scientists present at the session during deliberation.

This cynical approach of reporting only negative aspect of an event neglecting all the positivity that emitted from the conference, we feel is rather unfortunate, should also be addressed.

Thanking you, Sincerely,

Dr Manoj Kunar Chakrabarti
General President, ISCA



Demonstration in Ernakulam, Kerala

Our reply

Dear Prof. Chakrabarti

Thank you for your response on our concerns and anguish expressed regarding the unfortunate utterances at the Children's Science Section in the recently concluded ISC. It is heartening to know that expeditious steps have been taken by the EC and the General Body of ISCA towards preventing recurrence of such incidents in future, and we wish you success in the effort.

We are appreciative of the objectives of ISCA, and the multi-pronged activities and programs undertaken at the Congresses towards meeting them. Let us hope that with increased commitment towards maintaining quality the Congresses would begin to be taken more seriously by the scientific community and the media platforms in the country.

The media are approaching us about your response to our letter. We propose to share the contents of your letter for making them widely known. We trust that you would be supportive of this, as it would enable spread your message across. In case you have any caveats in this respect please let us know expeditiously.

Thank you.

Soumitro Banerjee
(On behalf of the group of scientists)

Protest Against Propagation of Unscientific Ideas

In the International Conference on 'Emerging Trends and Innovations in School Sciences'

Not much after the Indian Science Congress was disgraced when some people made outlandish claims in its dais and made the entire conference appear ridiculous in the eyes of the international scientific community, another conference followed suit. This time the conference organised by none other than National Council of Educational Research and Training (NCERT). The "International Conference on Emerging Trends and Innovations in School Sciences", was held at the Regional Institute of Education (RIE), Bhopal, from February 6 to 9, 2019.

One of the sessions in this conference was called "Ancient Scientific Knowledge in Recent Perspective". It was supposed to discuss, among other things, topics such as "Science and technology knowledge in ancient literature, monuments, scripture", "Indigenous scientific knowledge and its linkage with modern sciences", and "Traditional wisdom and scientific knowledge". According to media reports, various people discussed how saying 'Namaste' keeps diseases away, how Sindoor helps in balancing blood pressure, and how going around the Tulsi plant can have a cooling effect on the body. No doubt this has become an emerging trend in Indian scientific conferences, as many government functionaries themselves make such claims. The lesser officials, aiming at advancing their own careers, jump in and make even more outlandish claims in order to pursue this easy way to fame and official approval. Substantiating a claim with hard evidence takes time and effort. Understandably, no such attempts were made.

When the Indian Science Congress had made news for making similar claims, Prof. Vijayaraghavan, Principal Scientific Advisor to the Prime Minister, had called such claims "scientifically untenable". He also hoped that such scientists would feel the 'heat' from their community. What we see is that such individuals are still using scientific conferences to make themselves visible to people in power. The trend is clearly continuing.

Before the conference, a few scientists contacted the organizers and cautioned them about possible presentation of pseudo-scientific views in the session. But this went unheeded. After the apprehension turned out to be true, BSS activists tried to meet the director of RIE with a memorandum, but he refused to meet us. BSS organized a demonstration outside the venue. Such demonstrations were also organized in places like Gwalior and Guna in the state of Madhya Pradesh.

Scientific conferences are meant to discuss advances made in specific areas of science and technology. This is where scientists exchange new ideas, propose hypotheses, examine the evidences offered, and engage in debates and discussions. Personal beliefs that are not supported by evidence and serious research should have no place in scientific conferences. If such pseudo-scientific papers are allowed to be

The demonstration by *Breakthrough Science Society* in front of the Regional Institute of Education, Bhopal

presented in scientific conferences, that would, in the end, dilute the seriousness of scientific conferences and tarnish the image of the Indian scientific community. We request all science-loving people to raise their voice against using the floor of scientific conferences for unscientific ends.

Statement on Pseudo-scientific claims in a conference organised by R.I.E., Bhopal

Date: 6th February 2019

The Regional Institute of Education (RIE), Bhopal, is hosting an International Conference "Emerging Trends & Innovations in School Sciences" from 6 to 8 February 2019. The conference is attended by participants from different parts of India as well as a number of foreign participants. On the first day today, the conference had two parallel sessions on "Ancient Scientific Knowledge in Recent Perspectives". As per eyewitness account of these sessions and contemporaneous notes taken by persons in the audience, several speakers giving contributed presentations in these sessions made a number of questionable claims. We list some of the examples here:

- Doing 'pradakshina' of the tulsi plant gives a cooling effect to body and improve immune system
- Vedic knowledge does not need scientific scrutiny. It is correct because our grandparents have taught us that.
- Peepal tree uses maximum CO2
- Sindoor helps in balancing blood pressure and stress
- Gomutra is an antibiotic
- Sleeping with head towards south helps in blood circulation towards the brain
- Water falling towards the rising sun is good for the eyes
- In the 'namaste' way of wishing, the top of all fingers is pressed, which keeps transitive viruses and bacteria away

The demonstration by *Breakthrough Science Society* before RIE Bhuvaneswar

- By pricking of ears, blood circulation in the veins is controlled.
- When we apply 'teeka', acupressure point is pressed.

It is obvious that these claims are perfect examples of pseudo-science. Scientists who have held March for Science for the past two years precisely oppose such propagation of pseudo-scientific beliefs. Recently, Prof. K. Vijayraghavan, Principal Scientific Advisor to Government of India, wrote in an online article that propagation of such claims is certainly not warranted and it becomes duty of organisers and session Chairs to ensure that such claims are not presented from the dais. Unfortunately, it seems the organisers of this conference and the respective session Chairs have utterly failed in this case.

In fact, when we came across the conference schedule, we emailed the conference organisers as well as Principal of RIE, Bhopal and requested that they vet these sessions a priori as the titles looked suspicious enough. We also contacted some members personally to alert them about these suspicious talks. Sadly, all our warnings fell on deaf ears and organisers did not take any steps to stop these talks from happening. Even during the session, when several members of the audience questioned the claims, the session Chair and other guests tried to protect the speakers and made excuses for them.

We, the science educators and rational thinkers, reject all these claims and condemn them. We also condemn conference organisers for their selection of such pseudo-scientific abstracts for presentation and session chairs for their lack of intervention to stop such talks. We hope that organisers would take necessary action at least now and clearly denounce all these talks. We hope the organisers will not confer legitimacy to these claims through their appearance in the proceedings of a conference organised by an institute that is held in good regard by the education community.

Signed and endorsed by

Organisations:

1. Breakthrough Science Society

The demonstration by *Breakthrough Science Society* in Gwalior

2. All India People's Science Network (AIPSN)
3. Maharashtra Andhashraddha Nirmoolan Samiti
4. Federation of Indian Rationalist Associations

Individuals:

Dr. Aniket Sule, HBCSE(TIFR), Mumbai
Prof. Soumitro Banerjee, IISER, Kolkata
Mr. S. Krishnaswamy, All India People's Science Network, Chennai
Prof. Prajval Shastri, Indian Institute of Astrophysics (retd), Bengaluru
Prof. Priyadarshini Karve, Symbiosis School for Liberal Arts, Pune
Prof. T. Jayaraman, Tata Institute of Social Sciences, Mumbai
Prof. Tejal Kanitkar, Tata Institute of Social Sciences, Mumbai
Prof. S. G. Dani, UM-DAE CEBS, Mumbai
Prof. Arnab Bhattacharya, TIFR, Mumbai
Prof. Pradip Dasgupta, Nayi Talim Samiti, Sewagram
Dr. Rohini Karandikar, HBCSE (TIFR), Mumbai
Ms. Geeta Mahashabde, Navanirmiti Learning Foundation, Pune
Mr. Kedar Soni, Abhinav Vidyalaya, Dombivali
Dr. Manojendu Choudhury, IUCAA, Pune
Prof. Medha Rajadhyaksha, Sophia College, Mumbai
Ms. Sushama Bakshi, Kilbiliat, Mumbai
Prof. Sabyasachi Chatterjee, All India People's Science Network, Bengaluru
Dr. Shweta Naik, HBCSE(TIFR), Mumbai
Prof. Jyotsna Vijapurkar, HBCSE(TIFR)
Prof. S. Mahadevan, IISc, Bengaluru
Prof. Mayank Vahia, NMIMS, Mumbai
Dr. Vivek Monteiro, Navnirmiti
Prof. Jasjeet Singh Bagla, IISER (Mohali)
Mr. Vinod Sonawane, HBCSE (TIFR)
Prof. Palash Baran Pal, University of Kolkata
Prof. Naba Mondal, Saha Institute of Nuclear Physics, Kolkata
Prof. Ajit Mohan Srivastava, Institute of Physics, Bhubaneswar
Prof. Amol Dighe, TIFR, Mumbai
Prof. Arindam Bose, TISS, Mumbai
Prof. Abhijit Majumdar, IIT(B), Mumbai
Prof. Amitava Datta, Calcutta University
Prof. Dhruba Mukhopadhyay, Raman Centre for Applied and Interdisciplinary Sciences
Prof. G. Nagarjuna, HBCSE(TIFR), Mumbai

International Year of the Periodic Table 2019

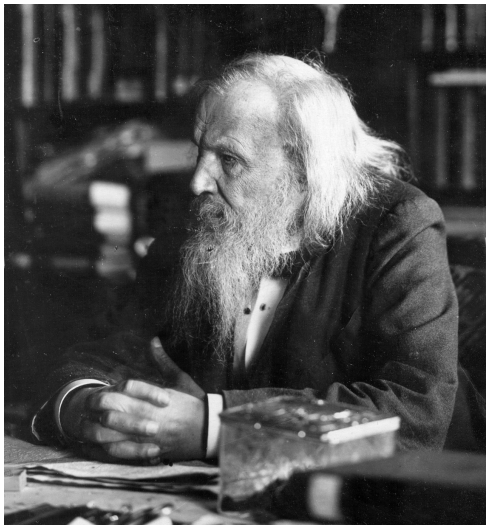
Uma Ramachandran*

The year 1869 is considered as the year of discovery of the Periodic Table of Chemical Elements by the scientist Dimitri Mendeleev. This year 2019 turns out to be the 150th anniversary of the Periodic Table and therefore been declared as International Year of the Periodic Table of Chemical Elements (IYPT2019) by the United Nations General Assembly and the UNESCO.

Introduction

Periodic table contains all the elements discovered so far in our material world. The Periodic Table is one of the most powerful tools that the chemist has. It is an invaluable and a very predictive tool; if you know where the element is in the periodic table you can predict its properties. Each element is represented by one or two letters with its atomic number in the top left hand corner and its atomic mass down below.

Most elements found in the periodic table on the left and centre are metals; they are shiny and good conductors of heat and electricity. The non-metals are found on the right side and also on the upper left side where we find hydrogen. There are a few metalloids which fall between metals and nonmetals. The elements are arranged in increasing order of atomic number from left to right, top to bottom. Each element has a unique atomic number which denotes the number of protons they have.



Dmitri Mendeleev in 1897

Why are the elements arranged in rows and columns? Why are we not putting them one after the other in a long list? It turns out that if you arrange the elements according to their increasing atomic number, a pattern emerges; there is a periodicity or a repeating of certain characteristics in the properties of the elements. For example, after an inert gas element appears, right next to it comes an element which reacts violently with water (alkali metal). Periodic repetition is called the periodic law and forms the basis of organizing the elements into rows according to the filling of their valence electrons.

There are several rows or groups of elements in the periodic table: each periodic row represents the different energy level occupied by the electrons. The two groups

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Periodic Table of Elements

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period																		
1	1 H 1.008																	2 He 4.003
2	3 Li 6.94	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.79
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.96	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	*	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.5	81 Tl 204.38	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	**	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (277)	109 Mt (278)	110 Ds (281)	111 Rg (282)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (289)	116 Lv (293)	117 Ts (294)	118 Og (294)

	Lanthanide Series*	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3		69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
	Actinide Series**	89 Ac (227)	90 Th 232	91 Pa 231	92 U 238	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)		101 Md (258)	102 No (259)	103 Lr (262)

on the left, that is, the alkali and alkaline earth metals where the s orbital electrons are being filled. On the right side are 6 columns which represent the filling up of p orbitals. On the furthermost right side, is the group of noble gases which are inert as their outermost valence orbital are duly filled with electrons. In the middle are 10 columns of transition metals where their outermost d orbitals are being filled from 1-10 by their valence electrons. In the last two rows you see an asterisk mark which represents two rows of 14 elements each. They are the inner transition metals; the Lanthanides and the Actinides.

History of the Periodic Table

The Periodic Table as we know it today, has 118 elements arranged in 18 columns (vertical) called groups or families and 7 rows (horizontal) called periods.

The elements in each group have the same number of electrons in the outer orbital. Those outer electrons are also called valence electrons. Members of the same group or family in the periodic table have similar properties.

The periods are numbered 1 through 7 on the left-hand side of the table. In each period or row, the atomic numbers increase from left to right. All elements in a period have the same number of atomic orbitals. For example, every element in the top row (the first period) has one orbital for its electrons. However, elements in the same period do not have similar chemical properties.

Fewer than 70 elements were known in the mid-1800s. Noble gases were yet to be discovered. There was no method known for listing the elements. If it were to be listed in the order of their discovery, it

would be quite useless as a predictive tool of the elements properties. This was the state of affairs till the Russian scientist Dmitri Mendeleev came up with his Periodic Table on February 17 in the year 1869.

He listed the elements in order of their increasing atomic mass. He, for the first time, grouped all the elements with similar chemical properties into vertical rows. All this was done 25 years before J.J. Thomson discovered electrons and the full structure of the atoms was even known! Around this time, Lothar Meyer of Germany also came up with a similar classification. However, it was Mendeleev who worked tirelessly on this Table and was responsible for its wide acceptance. He insisted on arranging the elements having similar properties in groups and was undeterred when he found certain 'holes' in his periodic table. He predicted that these places would be eventually filled when that element would be discovered and he even predicted their properties.

The life of Dimitri Mendeleev

Dimitri Mendeleev was born in Siberia, Russia, in the year 1934. He was the youngest of the 14 siblings and his mother struggled hard to ensure that he had a good college education at St. Petersburg. He finished his studies with flying colours in spite of being afflicted with tuberculosis during his late student days. As a young lecturer in the University of St. Petersburg, he felt a lack of quality textbooks in chemistry. He wrote the book 'Organic Chemistry' in 1861 and later in 1868, another popular book, 'Principles of Chemistry', which was translated into many languages. During the late 1860s, he worked on his periodic table for which he is well known worldwide and was honoured by the British Royal Society in 1889.

He was a great Russian educator of chemistry and travelled widely in and out of Russia. He was the co-founder of the Russian Chemical Society and a true modern scientist. He not only relied on his own research but facilitated the flow of data from scientists across Europe and the USA to enrich his research. Even after his retirement in 1890, he continued as a consultant and contributed immensely to the development of chemical, petroleum and allied industries in Russia. The element 101 is named Mendelevium in his honour.

The Periodic Table after Mendeleev

In 1913 an English physicist Henry Moseley made an important modification to the Periodic Table. He was working in Rutherford's laboratory and measuring the X-ray emissions of various metals. He found a mathematical relationship between the wavelength of the emitted ray and the atomic number of the elements in the Periodic Table which increased by 1. He suggested that the elements be rearranged in order of their atomic number rather than their increasing mass. He reorganized the pattern in the elements and he too left some 'holes' for yet to be discovered elements in the periodic table.

Many of the elements predicted by Mendeleev were discovered eventually. However the element technetium (43) was not discovered, but was finally man-made, as late as in 1920. This radioactive, short-lived element is used as a tracer element to study the circulatory systems of humans. In 1969, a hundred years after we had Mendeleev's periodic table, there were around 104 elements. At that time, many scientists, even those closely associated with the Periodic Table, felt that we have accounted for all the elements. They were proved wrong. Out of the listed 118 elements in our present day periodic

Reihen	Gruppo I. — R^1O	Gruppo II. — RO	Gruppo III. — R^2O^3	Gruppo IV. RH^4 RO^2	Gruppo V. RH^3 R^2O^5	Gruppo VI. RH^2 RO^3	Gruppo VII. RH R^2O^7	Gruppo VIII. — RO^4
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Su=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —

Mendeleev's 1871 periodic table with eight groups of elements. Dashes represented elements unknown in 1871

table, many of the heavy elements are made by nuclear bombardment in cyclotrons.

Many of the elements in the Periodic Table are known to us as we come across them in our everyday life. There is enough material on each of these elements detailing their discovery, properties and their varied uses. Of particular interest to me is the discovery of the radioactive Polonium and Radium, both by Madame Curie through a very painstaking process over more than four years. It involved the manual extraction of few milligrams of pure Radium out of a few tons of the Uranium ore, pitchblende. By now, a technique by which one could spectroscopically characterize each element by their unique scattered light, much like a coloured barcode, was known.

Scientists are still searching for new elements, especially heavier elements. Some of these artificially created elements were discovered after 2000. The element 118 named Oganesson was discovered in 2002, element 113 called Nihonium in 2003, Moscovium with atomic number 115 in 2003, element 116 called Livermorium in 2000, and element 117 called Tennessine was discovered in 2010. So periodic table is still in the process of evolution.

Origin of the elements

Our body is made of mostly water, which is H_2O. As carbon makes up most variety of molecules which are present in the organic and biological world, it is the third most abundant element found. But we do not take number of atoms into consideration; rather we take their weight. Hydrogen has atomic weight 1, oxygen has 16 and carbon has 12. By this criteria, oxygen is the most abundant element in our body. This is followed by carbon and then hydrogen. Oxygen is also found in silica, SiO_2, in the abundant sand around us.

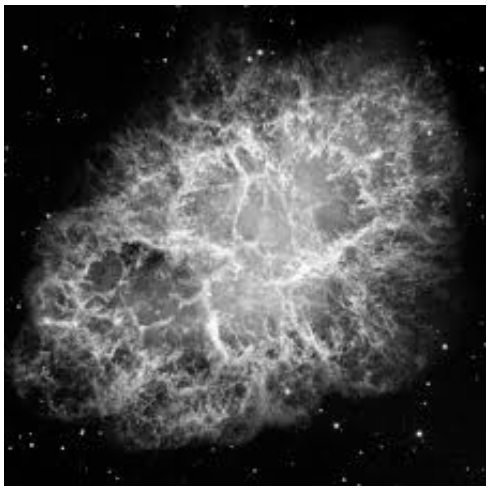
All naturally occurring elements, 92 of them, come from the cosmos. Hydrogen is the most abundant of all. It is the simplest

of all elements, made of one proton and an electron. It forms 90% of all elements in the cosmos. When four hydrogen atoms fuse together at the core of a star in a nuclear fusion reaction, you get helium which has two protons and two neutrons. The tremendous energy given off during the process fuel the great stars, our Sun included. It is over 15 million degrees Celsius at the core of the sun. Helium bombarded with a proton gives rise to lithium and so on.

Roughly 74% of the sun's body is made up of hydrogen, helium accounts for 25%, and rest of the elements put together constitute only 1% of its mass. When the hydrogen fuel of such a star depletes, the thermonuclear reaction cannot keep it stable against the intense gravity. The core of the star collapses and becomes very dense while the envelope expands to a large volume. This is called a red giant star.

At the core of such a red giant star, helium atoms fuse together, producing heavier elements like carbon, oxygen etc., all the way up to iron. This explains why in nature the elements which are even numbered are more abundantly found compared to those having odd atomic numbers. The fusion of three helium nuclei give rise to carbon, this will fuse with another helium to give oxygen etc. Iron has a very stable nucleus and absorbs energy when it has to undergo nuclear reaction.

In a red giant star, the helium fusion reaction creates heat, which offsets the immense gravity which tends to pull inwards. As the star gets older, iron accumulates at the core, and thermonuclear reaction slows down. Eventually gravity wins and the core collapses. This releases a large amount of energy which causes the old star to explode into a bright supernova, scattering all the elements and gases back into the space. In the last seconds, many heavier elements including silver, gold, mercury etc. are formed due to smaller elements fusing together under tremendous temperatures, gravitational pressure and density.



The Crab Nebula supernova remnant. Hubble Space Telescopemosaic image, assembled from 24 individual Wide Field and Planetary Camera 2exposures, taken in October 1999, January 2000, and December 2000.

And then, a new nebula starts condensing from the debris of the old exploded star, taking some of these elements into it. Or the debris may become a part of the dust particles thrown by the exploded star and the elements may then find themselves as part of a planet formed around a new star, as it condenses.

So we are all made up of elements coming from two or more stars which are millions of years old. And into some star we will eventually find our remains returning, when our Earth will someday be vaporized once our Sun becomes a supernova as it dies one day. □

Experimentation

K Sampath *

Experimentation has been practiced since the dawn of civilization. It is one of thetwo distinct scientific methods, and is also a mechanism for exploring the world around us. Experimentation is an act of testing an idea. Testing means to support, refute or validate. Experimentation is commonly and effectively used in physical and biological sciences. Experimental research is important tosociety and helps us improve our everyday lives. In sciences such as physics, chemistry and biology, the investigator sets up experimental arrangements so as to be able to test his/her hypotheses.

Aims of experimentation:

1. To test the validity or feasibility of concepts or solutions to problems
2. To quantify the magnitude of response of a variable
3. To find causal relationship between variables
4. To modify methods or techniques from other experiments or studies
5. To find suitable products for specific applications

When Homo sapiens set out from Africa and eventually reached and colonized all the continents (except Antarctica perhaps), they had to face new experiences for which they were not prepared. What saved the species is experimentation and ability to communicate the results to other clan members and to the next generation. They were already familiar with the local flora and fauna of Ethiopia, but encountered many different life forms, weather conditions, hazards in their journey to other parts of the world over several millennia. The acts of cultivating wheat from wild einkorn variety, or taming of cattle from the aurochs must be termed as experimentation, although of very primitive nature. Cross-breeding of cultivars or of domesticated pets must also count as experimentation, as is the act of producing yogurt from milk, one of the earliest biotechnological breakthroughs.

Experimentation is one of the two pillars of scientific research. Experiments form an empirical method that adjudicates between competing models or hypotheses. They have the final word on precision, reliability and conclusion of theories. In controlled experiments, we try to set up conditions that are meant to clarify how nature behaves. Experiments are thus nature's translators or interpreters.

Copernican Revolution and the period of Renaissance

Experimental physics, as a distinct field, was established in Europe, during what is known as the Copernican Revolution, by physicists like Galileo, Huygens, Kepler, Pascal and Newton. Galileo made extensive use of experimentation to validate physical theories. Later, experimentation was intro-

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It is now known that even very young children perform rudimentary experiments to learn about the surroundings world.

duced and practiced in most branches of science.

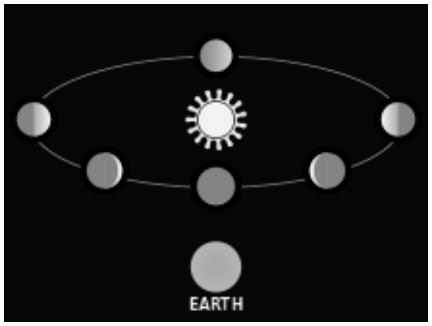
Theoretical physics is concerned with predicting and explaining the physical behavior of nature. Newton made a firm link between the experimental science of mechanics and observational astronomy by merit of his law of universal gravitation and his explanation of Kepler's laws of planetary motion.

A considerable amount of progress on the design and analysis of experiments occurred in the early 20th century, involving the newly established field of statistics. People like R. A. Fisher, J. Newman, O. Kempthorne, G. M. Cox, W. G. Cochran, among others left their mark. Methods of testing causality was developed into what is known as 'Rubin causal model', which formalizes earlier statistical approaches to the analysis of experiments.

Observational experiment

Astronomy, paleontology, geology, epidemiology, ecology, descriptive biology and most forms of clinical research in medicine are all observational sciences. In these observational sciences, the hypotheses are studied and tested by the collection of information from phenomena (which occur naturally) that lie outside the control of the researcher/observer. For example, a researcher who studies astronomy cannot change the movement, temperature or any other aspect of the sun, moon and stars. Therefore, studies are done through observations only, and recording the findings over a period of time. Here observations become the experiment – non-invasive in nature.

Consider Venus, for example. Based on its closeness to the Sun, it shows several phases. When it is between the Earth and the Sun, it cannot be seen as its illuminated side is facing away from the Earth. More of Venus gets illuminated as it moves in its orbit. This visible sunlit surface is called its phase. Venus becomes almost completely lit by the sun, and disappears due to the Sun's brightness. This happens when the sun lies between Venus and the Earth. During the second half of Venus' orbit



Phases of Venus, observed by Galileo in 1610

"The experiment serves two purposes, often independent one from the other: it allows the observation of new facts, hitherto either unsuspected, or not yet well defined; and it determines whether a working hypothesis fits the world of observable facts"

— René J. Dubos (1901-1982)

around the sun, illumination decreases.

Sociology and economics are considered to be purely observational sciences because no one can really control the members of society. It is also difficult to predict their reactions to certain situations and changes, and to form a pattern. In these subjects, only observations yield useful information.

Nature of Experimentation

Experiment is the foundation of the scientific method, which is a systematic means of exploring the world around us. Some experiments are conducted in laboratories; but experiments could be performed anywhere, at any time. It is problem based. Experiments in the scientific world should be done with an attitude of openness and accountability. It is crucial that any experiment involves detailed recordkeeping, in order to report the experimental results and prove the integrity of the testing procedure and also for extension, if required.

Hypotheses, theories, and postulates in turn have to get confirmation through experimental data. In addition, an experiment can be designed to explore the possibilities of finding something unknown in a new territory. Such an experiment sometimes leads to unexpected new discoveries.

Many scientific facts can be established and theory can also be verified sometimes without the use of experiments but simply by observing nature. The utility of experiments lies not in their repeatability alone, but certainly on their controlled approachability or manipulability. This artificial set of controllability or manipulability provides knowledge about cause and effect of the natural world. Experiments also allow us to get access to entities that we might not be able to see normally. For example in high energy physics, we observe and get a glimpse into realms that would normally be hidden from us.

Types of Scientific Experiment

Controlled Experiments

Normally laboratory experiments are controlled experiments, although a controlled experiment can be performed outside a laboratory setting as well. In a controlled experiment, results of an experimental group are compared with a control group. These two groups are identical except for one independent variable. The controlled experiment is one of the most important concepts in biological experimentation.

The experimentalgroupis given the experimental treatment and thecontrol groupis given either a standard treatment or a placebo. Thecontrol group is used in an experiment as a way to establish that the experiment actually works. Here we have freedom to interrogate/question nature.

Natural Experiments

A natural experiment involves gathering of data by observing a system and then forming a hypothesis. The variables are not controlled or manipulated in a natural experiment. It is an empirical or observational study. Natural experiments are used, for example, in astrophysics.

> "There remains simple experience; which, if taken as it comes, is called accident, if sought for, experiment. The true method of experience first lights the candle [hypothesis], and then by means of the candle shows the way [arranges and delimits the experiment]; commencing as it does with experience, duly ordered and digested, not bungling or erratic, and from it deducing axioms [theories], and from established axioms again new experiments."
>
> — Francis Bacon. *Novum Organum*. 1620.

Field Experiments

A field experiment may be either a natural experiment or a controlled experiment. It takes place in the real world, rather than under laboratory conditions. For example, an experiment involving an animal in its natural habitat would be a field experiment. Often, research in social sciences, e.g. marketing, economic analyses, education, commodity trading, storage of items and health may need field experiments. Such experiments have the advantage that outcomes are observed in a natural setting. Both natural experiments and field experiments suffer from the possibility of contamination. Experimental conditions can be controlled with more precision and with certainty in the laboratory.

Variables in an Experiment

There are three kinds of variables (terms) in an experiment: controlled variables, independent variables and dependent variables. Common examples of variables are: volume, pressure, temperature, duration of the experiment, composition of materials.

Controlled variables are variables that are kept constant or unchanging. For example, while performing an experiment on the effect of spraying plants with different chemicals, the pressure and volume of the spray may be maintained constant.

An independent variable is the factor that is changed. This makes measurements and interpretation of the data much easier. If raising the temperature of water allows dissolution of more sugar, then the independent variable is temperature. This is the variable which is purposefully varied.

The dependent variable is the variable that is observed, to see whether it is affected by the independent variable. In the experiment of heating the system where sugar is added to water, we may see if temperature affects the amount of sugar dissolved. Then the amount of sugar dissolved is a dependent variable.

Advantages of laboratory experiments

As generalisation cannot be done from the results of a single experiment, experiments need to be replicated. The larger the number of times the experiment is repeated, and if the same results are obtained, the more would be the confidence placed on the theory being tested. Repeatability is a hallmark of a good experiment.

Laboratory experiments allow for precise control of variables. The purpose of control is to isolate the one key variable which has been selected, in order to observe its effect on other variables.

Experiments are the only means by which cause and effect can be studied. Experiments enable us to find cause and effect by the deliberate manipulation of one variable, and keeping all other variables constant. As much as possible, outside influence is eliminated and close observation is maintained – thereby a better relationship between the

"With the spread of experimentation and improvement in methods of measurement, theoretical investigation has been forced in certain direction almost automatically"
— Max Planck

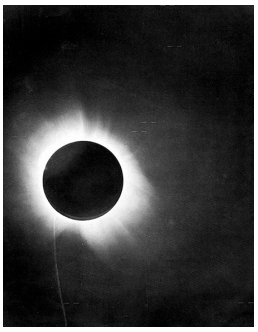
cause and the effect can be revealed.

An example of experimentation

According to one prediction of general relativity, light may not travel in a perfectly straight line, especially near massive celestial objects. Light, while traveling through space-time and nearing the warp induced by an object's gravitational field, should follow a curved trajectory.

During a total solar eclipse in 1919, Sir Arthur Eddington led the firstexperimental test of Einstein's general theory of relativity and confirmed the bending of light around sun. One form of such bending of light around massive objects may lead to gravitational lensing.

James B. Conant defines experimental science as an act that "can be thought of as an activity which increases the adequacy of the hypothesis and theory that are related to certain types of perception and which lead to certain types of activities. It is one extension of common sense."



Observation of solar eclipse in 1919

Limitations of experimentation

The strength of the experimental method lies in the amount of control which experimenters have over variables. It must also be noted that it is not possible to completely control all variables. There may be other variables at work which the experimenter is unaware of. In particular, it is impossible to completely control the mental world of people taking part in a study.

Experiments can also, at times, be quite misleading. The most common cause of error is a mistake in technique.

Often observations are restricted to limited ranges. This factor has to be taken into account during experimentation. Possible methodological limitations such as sample size, lack of available or reliable data and measure used to collect the data have to be taken care of. In biology, for example, experimental results are, strictly speaking, only valid for the precise conditions under which the experiments are conducted. Caution must be exercised while applying the result for a wider range. □

"Experiment is the sole judge of scientific truth." — Richard Feynman

"No amount of theoretical work can ever prove me right; a single experiment can prove me wrong" — Albert Einstein

National Science Day

Observed with the Slogan 'Make India Science Literate'

A week-long celebration of the National Science Day was organised all over the country on the theme 'Make India Science Literate'. Various programs like seminars, talks, debates, discussions, science experiments demonstrations, video shows and exhibitions were organised in schools, colleges and local science clubs. A brief report of the programs in different states is given below.

Delhi: Seminars were organized on "Science and Scientific Outlook" at The Vivekanand School, Narela, at Brahma Shakti Public School, Rohini, at New Age Public School, Uttam Nagar, and at Mayur Vihar Phase-1.

Sikkim: National Science Day was celebrated in Namchi Government College, Kamrang. The program consisted of an interactive discussion session and a quiz competition.

Madhya Pradesh: A seminar was held in Maharani Laxmibai college Bhopal on "Integrating science with society".

Gujarat: Programmes were conducted at L. D. Engineering College, and Republic High School, Laldarwaja, Ahmedabad. The programmes included a film show on "Galapagos and Darwin," a talk on 'Mathematics & Scientific Temperament', a photo exhibition on C. V. Raman & Raman effect and interactive experiments explaining the basic principles of Physics, Chemistry.

Jharkhand: various programmes were organized in Ramuna town in Garhwa district, in the Omega Coaching Centre, Chandil.

Tripura: Programmes were organized at Charipara Higher Secondary School and A.D. High Secondary School, Agartala.

Bihar: The National Science Day was observed through various programmes in Darbhanga, Patna, and Jamalpur. BSS Jamalpur organised a quiz on periodic table & biography of Mendeleev, and Cartoon making (on chemistry).

A teacher reading out the oath before students in the Belghoria Jatiya Vidya Niketan in West Bengal

The Oath, read at the programmes:
"On the National Science Day I take pledge to be guided by scientific outlook and social responsibility. I shall try to inspire others around me, relatives and friends to be free of unscientific beliefs and superstitions. I shall oppose the spread of pseudo-science, false claims and religious bigotry in all possible ways. I shall always uphold the banner of struggle of great renaissance personalities like Rammohan and Vidyasagar for spreading scientific temper and modern outlook based on truth."

The programme at BSNV PG College in Lucknow

Uttarakhand: The 'Students Science Forum' observed the National Science Day in HNB Garhwal Central University, Uttarakhand.

Uttar Pradesh: A seminar on 'Science & Scientific outlook' was organized at at Bappa Srinarain Vocational P G College in Lucknow. A discussion was conducted at Aminabad Mahila P G College, Lucknow.

Assam: Programmes were organised in Jorhat and Silchar.

Karnataka: National Science Day was observed at the Raman Institute, in which Prof Jayanth Murthy (Director, IIA) spoke on 'Scientific Temper and why do I care', and Mr Satish Kumar spoke on 'Making India Science Literate and Science minded'. Other programmes we organized in Mysore, Dharwad, Devengere, and Kengeri area of Bangalore.

AP and Telangana: Programmes were organized in Saraswathi Vidyamandir, School of planning and Architecture, JNAFA University, and the Stanley college in Hederabad. Dr. Chandana Chakravarty, Senior Scientist CCMB spoke on "Scientific temper and Rationality" at the programme in Stanley College. Various programs were also organised in Hyderabad, Narsing, Vizag, Anantapur and Hindupur.

Chattisgarh: Group discussions were held at Raypur, Koriya, Dhamtari, Bilaspur and Durg.

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Tamilnadu: Programs were organized in Boy's HSS, Saidapet, Sethu Bhaskara Matric Higher Secondary School, Ambattur, and Govt High School, Chinnasekkadu, Manali, Chennai. A programme in the American College, Madurai, included mime and skits on the life of Galileo and against superstition.

West Bengal:

NSD programs were organised in Contai Nayaput High School; Tajpur High School (East Medinipur); Belghoria Jatiya Vidyaniketan, Kolkata; Birati High School, Kolkata; Naktala High School, Kolkata; Vivekananda College, Kolkata; Ramnagar Rao School (East Medinipur); Durgapur City Centre; Coachbihar Govt Engg College; J. K. College, Purulia, Siuri, Birbhum and Belghoria Jatiyo Vidya Niketan, Kolkata. Students of Charu Chandra college, Alliah University, Jadavpur University, and Ballygunge science college campus (Calcutta University) observed the national science day with various programs. In Rajabazar Science College Campus (Calcutta University), Dr Amitava Dutta and Dr Palash B Pal addressed students.

Kerala: National Science Day was celebrated in different districts of Kerala with a variety of programs. Dr Anandmayee Tej gave a public lecture titled 'A journey to the stars' as part of National Science Day lecture series at Planetarium, Trivandrum. Dr Godfrey Louis, former Pro-VC CUSAT inaugurated the photo poster exhibition on the life & work of Madam Curie at SNGM college campus. Other programmes were held in Pattom GHSS, and Sai Krishna Public school, Chenkal, Trivandrum.

In the districts, programs were organised at Trissur; Trippunithura in Ernakulam; St.John's UP school, Ulanad and Madam Curie Science club in Pathanamthitta district, Kidangara in Alappuzha district, and at Erumely in Kottayam district.