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Slashing of Government Fund — Scientific Research in India in Peril

'*Robust funding for scientific research*' was one of the main demands of the 'March for Science' undertaken by around 1.3 million people in 600 cities around the world on April 22, 2017, highlighting some core issues science is facing in the contemporary world. "De-funding and hiring freezes in the sciences are against any country's best interests." "We believe that the federal budget should reflect the powerful and vital role that science plays in supporting our democracy." "We advocate federal funding in support of research, scientific hiring, and agency application of science to management. This funding cannot be limited to a few fields or specific demographics — scientific support must be inclusive of diverse disciplines and communities" — said the website of the 'March for Science' movement.

The demand for robust funding for scientific research came in the wake of the situation where cuts in federal research funding are severely affecting the progress of scientific research in the United States. A report from the Massachusetts Institute of Technology (MIT) titled "The Future Postponed: Why Declining Investment in Basic Research Threatens a U.S. Innovation Deficit" rightly points out that none of the recent landmark scientific achievements like the first spacecraft landing on a comet and the discovery of a new fundamental particle — the Higgs boson, etc., were US-led achievements. This report cites 15 research areas in which the US leadership is diminishing or is going extinct and attributes this bleak situation to the declining public funding of basic research.

If slashing of government funding for research can push a country like the USA which was in the forefront of scientific achievements to this situation, the future of scientific research in a relatively backward country like India, where a similar cut in government funding for research is being imposed, is in real danger. It was declared by the Prime Minister at the Indian science congress held at Tirupati last year that, by 2022, India would be a major global scientific power. Naturally one would expect an increase in government funding for scientific research to achieve this goal. But in contrast we see a slashing of government funding for research. Our budgetary allocation for research remains at around 0.8% of GDP against the long standing demand for allocation of at least 3% of GDP for scientific research.

Last few years witnessed slashing of financial support to even premier institutions like IITs, NITs, and IISERs. IITs and NITs have been asked to raise their running expenditures from students' fees. Inadequate allocation of funds has severely affected the building of basic infrastructure in new IITs and IISERs. Funding for IISERs, established for promoting research in basic sciences, has been reduced significantly in spite of the fact that an additional IISER has been sanctioned at Behrampur and many of the existing IISERs have not yet established their campuses. Research funding agencies like Department of Science and Technology (DST), Department of Biotechnology (DBT) and Council of Scientific and Industrial Research (CSIR) are facing severe shortage of funds to support research. It is reported that the CSIR which normally allocates Rs.1200-1400 crores to its laboratories for research will be able to provide only 360 crores this year for research. Scientists in government laboratories are being asked to generate a part of their salary by selling their inventions and from other sources. Most of the universities and other institutions of higher education are not given funds for setting up of research facilities.

"India's largest R&D organisation CSIR has declared financial emergency" screamed the newspapers on 5th June 2017. "India's 38 premier scientific laboratories are in a budgetary pinch." wrote an article in the leading scientific journal *Science*. "A jump in expenditures on salaries, pensions, and perks for government employees, recommended by an advisory commission, is leaving little money for new research in the budget of the Council of Scientific & Industrial Research (CSIR), based in New Delhi, which oversees the labs and their 4600 scientists. The increase in personnel expenses comes on top of a 2015 call by the government for CSIR to raise 30% to 50% of its total budget itself by commercializing its technologies. The stark reality is that "we will be left with no funds to support new research projects," CSIR Director General Girish Sahni wrote in an email to CSIR lab directors obtained by *Science*." While the focus was on commercialization of technologies, the fund crunch forced the CSIR even to close down a firm that was created precisely for that purpose. "CSIR Pvt. Tech Ltd. (CSIR-Tech), a company affiliated to the Council of Scientific and Industrial Research (CSIR), and primarily formed to commercialise technology developed by the 75-year-old organisation's 37 labs, has been shut down" reported The Hindu on 8 March 2017.

On the research front the successive government's thrust was on setting up of few centres of excellence for education and research. Even these elite institutions are now being forced to look for alternative sources in order to generate funds. As per the Dehradun declaration of 2015 the CSIR has to generate about 50% of its budget through external sources. Thus, the research-funding agencies as well as the scientific institutions are being forced to seek industry sponsored projects.

There are two problems in this. Firstly, as a consequence of this approach, research in basic science is being discouraged as it is not of any immediate use to the industry. Since the government is not providing adequate budgetary allocation, it is increasingly becoming difficult to get financial support for research in basic sciences.

Secondly, those who are going out to seek industry funding are finding that the Indian industry is not really interested in supporting scientific and technological research. Indian industry is happy buying technology from the West. Foreign consulting firms are routinely given the jobs of solving industrial problems that could easily be solved by Indian scientists if research on those problems could be supported for a few years. But Indian industries want readymade solutions and are not inclined to invest money in building up the expertise. The only motive force of production is to fetch maximum profit, and if that can be achived by importing outdated technology from the West, a majority of Indian industry will happily follow that path.

Just look at the massive mobile phone industry as an example. In this sector, the revenues are so high that even scams go into the order of Rs. 12,000 crores. How much of that money is invested in Indian academia in order to generate the technology in-house? Does the telecom industry use any technology developed in India? Does Reliance, Airtel, Idea, Bharti or BSNL even try to develop technology by utilizing the knowledge available in India? No. Each of their gadgets is imported. They are happy with that, because it generates maximum profit. Though there are a few laudable exceptions, this attitude is true for almost all sectors of industry. Indian industry lacks the vision of European or American industrial houses who often sponsor research with a view to getting dividend one or two decades later. As a result, the chance of Indian academia getting substantial sponsorship from Indian industry is very meagre.

There is another aspect to it. Industry sponsored research taken up with a narrow objective of developing or improving some products will not lead to any path-breaking discovery. This was beautifully explained by the famous scientist J.J. Thomson, the discoverer of electron: "By research in pure science I mean research made without any idea of application to industrial matters but solely with the view of extending our knowledge of the Laws of Nature. I will give just one example of the 'utility' of this kind of research, one that has been brought into great prominence by the War — I mean the use of X-rays in surgery ··· Now how was this method discovered? It was not the result of a research in applied science starting to find an improved method of locating bullet wounds. This might have led to improved probes, but we cannot imagine it leading to the discovery of the X-rays. No, this method is due to an investigation in pure science, made with the object of discovering what is the nature of Electricity." He further added: "research in applied science leads to reforms, research in pure science leads to revolutions, and revolutions, whether political or industrial, are exceedingly profitable things if you are on the winning side."

Yet, the thrust is on research in the areas of technology required for the industry. The successive governments were eager to invite industry participation in research. The Science, Technology and Innovation (STI) Policy – 2013 explicitly states its objectives with regard to the private investment in research, as follows: "Global investment in Science, Technology and Innovation are estimated at $1.2 trillion as of 2009. India's R&D investment is less than 2.5% of this and is currently under 1% of the GDP. Increasing Gross Expenditure in Research and Development (GERD) to 2% of the GDP has been a national goal for some time. Achieving this in the next five years is realizable if the private sector raises its R&D investment to at least match with the public sector R&D investment from the current ratio of 1:3". That means the government is not going to increase its funding for research and researchers will be forced to take up industrial projects if they have to get funds. Can we expect the Indian industry reeling under recession to provide enough sponsored projects?

Even if the answer is 'yes', the situation is going to seriously affect the quality of the scientific research in our country. To satisfy the needs of business, only a limited quantum of science and technology is sufficient. The business houses require technology to the extent it is necessary to decrease the cost of production and selling of commodities with increased profit. They require science to the extent it is necessary to develop that technology. Naturally, research in basic sciences which does not lead to any immediate benefit will be neglected.

But parallel to these, we see some alarming initiatives from some other quarters. Liberal funding is being provided by some government agencies for 'research' on some apparently unscientific ideas. One of such recent initiatives reported in the press is that the Uttarakhand government has began a state sponsored hunt for the mythical herb '*Sanjeevani Booti*', which according to Ramayana, Hanuman brought from Himalayas to Lanka to treat Lakshmana. It is one thing to research the medicinal values of herbs, but it is another thing if the intention is to establish the veracity of a poetic image in an epic. This incident is probably the latest in the interpretation of mythological stories as scientific achievements of the past, a disturbing trend prevailing in our country inimical to the development of scientific temper.

Thus the scientific research in India is facing a deep crisis. Development in scientific research is essential for advancement of the society and human civilization. It is our historic task to save scientific research from this crisis. 'India March for Science' called by the scientists on 9th August 2017 is a movement in this direction. One of the main demands of this movement is allocation of at least 3% of GDP to scientific and technological research and 10% towards education.□

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Commentary

Scientists' Appeal for
INDIA MARCH FOR SCIENCE

Eminent scientists of India have given a call to organize March for Science in all important cities of India on 9th August. Following is the text of their appeal.

Dear Friends,

We are delighted to note that, on 22nd April this year, more than a million people undertook a March for Science in 600 cities across the globe, demanding robust funding for science and demanding that governmental policies be guided by scientific evidence.

We are planning to complement and supplement this global effort in India as we feel it is very relevant in the current juncture. On the one hand, scientists from India have played a commendable role in the discovery of gravitational waves and of Higgs Boson, in the interplanetary mission through Mangalyaan and in reducing foreign dependence through the development of indigenous satellite launching capability. But, on the other, science in India is facing the danger of being eclipsed by a rising wave of unscientific beliefs and religious bigotry, and scientific research is suffering serious setback due to dwindling governmental support.

We note with deep concern that financial support to even premier institutions like IITs, NITs, and IISERs has been slashed. Universities are facing shortage of funds to adequately support scientific research. Research funding agencies like DST, DBT and CSIR are reportedly impacted by reduced governmental support. Scientists in government laboratories are being asked to generate a part of their salary by selling their inventions and from other sources.

While we can justly be inspired by the great achievements in science and technology in ancient India, we see that non-scientific ideas lacking in evidence are being propagated as science by persons in high positions, fueling a confrontational chauvinism in lieu of true patriotism that we cherish. Promoting scientific bent of mind can certainly help improve the social health of our country where incidents of witch hunting, honour killing and mob lynching are reported regularly.

We feel that the situation demands the members of scientific community to stand in defence of science and scientific attitude in an open and visible manner as done by scientists and science enthusiasts worldwide. We appeal to scientists, researchers, teachers, students, as well as all concerned citizens to organize 'India March for Science' events throughout the country, particularly in the state capitals, on 9th August 2017, with the following demands:

1. Allocate at least 3% of GDP to scientific and technological research and 10% towards education

2. Stop propagation of unscientific, obscurantist ideas and religious intolerance, and develop scientific temper, human values and spirit of inquiry in conformance with Article 51A of the Constitution.

3. Ensure that the education system imparts only ideas that are supported by scientific evidence.

4. Enact policies based on evidence-based science.

The names of the eminent scientists who have made this appeal can be found in the webpage:
www.breakthrough-india.org/imfs2017/

March for Science, March for Progress

Ashish Mahabal*

'Ice has no agenda – it just melts' read a sign held by a young lady. 'I can't believe I am marching for facts', said another large cardboard held high. In the past one could have been pardoned for thinking that the signs were at some march in some desolate, illiterate country ruled by a dictator. No, this was in Washington DC, the capital of US, the country one would look up to for education, science, and development. And these were not a few isolated signs that a few disgruntled folks were carrying either, or a hundred years ago, but in 2017. These and thousands such signs, large and small, with and without pictures, held by men and women from eight to eighty descended on all major US cities, and hundreds of other places as well, united for 'March for Science' on April 22 usually celebrated as Earth day. In California alone there were 44 such marches.

During the primaries of the 2016 elections, the divide between Republicans and Democrats seemed more stark. The candidates that the former – supposedly the Grand Old Party (GOP) – fielded were blatantly anti-science. Trump was no exception. When it became obvious that he is to be the next president, many people realized the necessity to become activists. The Women's (solidarity/rights) March started through social media quickly garnered momentum and one day after Trump took over as president, on 21 January 2017, the

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peaceful marches boasted as many as five million participants across the US.

Some groups had already been thinking about the incredulous position we were in – having to lobby for science and facts. It is the women's march that brought a greater backing for the march for science, to take the cause of science research and its outcomes to the public, making them aware that the fruits they reap are from a well planned process, and if it is in danger, all our future development will be too. No, it already is! Some scientists while not opposed to such a march, were wary of marching as they thought that such an activity will allow the people on the other side of the fence to say things like 'Oh, these scientists are just a bunch of liberals' and oppose science even more. Others thought that if they do not stand up now, there may not be another time. A little militant activism is needed, more for the people on the fence, to convert them. Not only do I trust science, but why you should too.

Cover Article

I grew up in India, and only after my PhD did I come to the US. For close to two decades now I have observed closely the changes happening here in the US, in India, as well as the rest of the world. Science is opening wonderful new avenues, and making available technology undreamt of. You do not have to understand the innards of a cell-phone to be able to call someone else half the world away. The same device can be used to detonate a bomb. This situation is akin to the school day essays one writes: 'is science a boon or curse?'. We all know that science is a boon and not a curse. Or do we all? You just have to look around you to see the benefits of science: vaccination has all but eradicated many diseases, and yet there are people who do not want their children to be vaccinated. But for genetically modified (GMO) food, many children in the SouthEast will not be getting their proteins today, yet people fight GM rather than the laws that make GM corporations strong. People just cling to many beliefs, make them their truths and are adamant about them.

Donald Trump, who has had no public office experience whatsoever, and one who was ridiculed even during the Republican primaries, had found resonance with a large fraction of people through his sugar-coated slogans like 'Let us make America great again' which were not backed with any realistic plans whatsoever. The slogans and short tweets appealed especially to those who are unquestioning, self-centered, and those who crave instant gratification needing no details. Through a series of intricate and complex set of events, where the Democrats have to take a healthy share of blame too, Trump won the electoral vote (number of seats), the only thing that counts in the current US system. This despite the fact that his rule would mean major setbacks to healthcare in America, the environment of the entire planet, and several other things involving and contrary to established science. Perhaps a bit too late and almost certainly not in enough numbers, but more people were waking up to the possible horrors about to be let loose on the American society.

I had never participated in public protests, happy to be in my bubble, and staying away from trouble. There had been occasions that disturbing events had happened, but in a different country where I could not do anything. (That is never true, by the way). But here I was feeling restless. People fueled just by rhetoric and not ready to look beyond their noses, and not caring for anyone but limited interests, had elected a big mouth to lead them. In January as the Women's March came up, I decided it is high-time I participated personally – take responsibility for my future and that of generations to follow. I will not be truthful if I say that I was not afraid of the thought of participating in a public protest. Growing up in places like India one has that strange fear of people whose job is to protect you. In the US it seems a bit 'safer' to protest – one hopes that even the police will be sensible and not use force. I quickly found myself asking what if they did (use force)? And the answer came swiftly enough in the form of a rhetoric song that I like: '*Mi morcha nela nahi*' i.e. 'I have never gone on a protest march' by the Marathi poet Sandeep Khare. We have to act, and face the music if need be. As fresh US citizens (and having recently seen the presidential part of our

first votes going down the drain), Anu (my wife) and I were ready to exercise our first amendment rights to protest. I knew my parents in India would be anxious, so we told them how it is safe here, but even if something happens, it is our duty to do what we were. Our son was immersed for four years in the free-speech start-up of (University of California) Berkeley, where protests are regular. I suddenly found myself not being anxious about his participating in peaceful protests for what he feels is a just cause.

Being at the Women's March was a great experience. Everything was peaceful. Peaceful but loud. I had an observing run at the 5-meter telescope of the Palomar Observatory on the night of April 21st. That meant I could not be in Pasadena or Los Angeles on the morning of the 22nd. Science runs by principles. One simple rule of these large observatories is that if you are on the schedule of the telescope, you should be there. So not going to do my science duty and protest instead would have defeated the purpose. The Pasadena march was to start from Caltech of course. Caltech is a private university and the officials try to be politically correct. But the current storm is so damaging that there have been multiple

messages from the president supporting just causes, and Caltech's pro stand on science. I talked to two graduate students in astronomy, Lee Rosenthal and Dillon Dong, just starting their science careers, who went to the march. Caltech students, postdocs, staff and faculty were joined by citizens of Pasadena. There were a couple of short, to the point, but impassioned speeches. People marched peacefully, placards held high, along the sidewalks (footpaths) making sure that the normal flow of traffic is not obstructed. They went to the city hall where more people had gathered.

Lee highlighted discussions on how nonpartisan and unambiguous science gets twisted in the hands of politicians. He had joined the march in support of the National Science foundation (NSF) and the National Institute of Health (NIH) and to protest the cut in funding to fundamental sciences. He said science benefits everybody, be they progressive or conservative.

Dillon thinks that we should not pretend science, the collecting and cataloging of facts and knowledge, can be done independently of society. Trump, by garnering help from antiscience elements has shown that we cannot stay in our shells and believe that problems outside academia will resolve themselves. He went to the march in Los Angeles because he hoped to vote on his feet, be vocal, and be able to persuade those on the sidelines about why advocacy is important.

Often, going on such a march is a feel-good thing. You think you are doing something important, and you are. But that is not the end. If anything, it is just the beginning. Steadfastness and continuity is imperative, as is coming up with plans to take the ideas across. Many suggestions have come forward. One is for scientists to carry placards on public transport stating things like 'I am a scientist – ask me about astronomy' – or physics, or climate etc. depending on their speciality and start a dialogue with more people. Describe to them how science is deep-rooted, everywhere around us, and in fact, indispensable. Another is called 314action (http://www.314action.org/). It is a non-profit organization (equivalent to NGO) formed by STEM (Science, Technology, Engineering, Mathematics) supporters, and for encouraging scientists to run for public office so that policies can be fact-based. Continuing to write to current senators about what you think is important and is necessary too. Outreach through blogs, internet, and print media continues to make an impact and should not be neglected.

Such external initiatives are fine, but most revolutions start at home. Or they should. Many times we are great orators when it comes to big topics that have to do with the country but apparently not with us (though indirectly they always do). We talk about sports, and weather, and movies, in a casual manner, but not enough about what *we* can do (need to do!) here and now. Inspecting one's own surroundings for parallel topics would be one way. We generally do not veer out of our comfort zone. We need to question that. Often

under tradition many practices are continued. In the US, conferences start without fanfare, directly jumping into the topic. Education has sufficiently been separated from religion at some level. But that is being rolled back! Intelligent design and anti-evolution as well as other religious bits which have no basis except for appearing in some book are taken as facts by many, and trying to make their way into primary education. That is dangerous at best.

The situation is not unique to the US. Each country likely has pockets – hopefully smaller – where similar situations play out. Can parallel cases and situations be identified in India? Can proactive measures be taken against them? Can the feeling of fear for the police and politicians be removed?

In India, barring a few elite institutes of higher learning, many meetings still start with Saraswati poojan (and coconut breaking). At a school function I was presiding in India, the officials saw no irony in staging a play showing national integration through a story on how Hindus, Christians, Muslims, and Sikhs unite, and then performing the traditional rites of just one of those religions on stage. Passed as harmless traditions, these harbour a deep divide in our thinking, showing a lack of clarity. It is easy to pass on non-facts (called alternate facts thanks to Trump's tweets) to the populace. In India there is a more dangerous trend of seasoning these with (of all things) science-speak. One sign at one of the marches was very telling. It said: 'What do we want? Evidence based science. When do we want it? After peer review'. Indeed, we want evidence to back statements, and we want the research to be reproducible. Not something that someone allegedly said a few thousand years ago, and definitely not something that you received just now through a WhatsApp message.

How frequently do you accept rubbish without questioning? How does social peer pressure come into play? How is your attitude towards the politicians? Do you excuse them when you should not? What about excusing stars (movies and sports)? Answers to questions above may provide some insight as to why so many people voted for Trump (and his political clones elsewhere). I cannot believe that all of them are as morally rotten as he is, but the very small fraction that are, are emboldened by his victory, his loud-mouthedness and the support others provide unwittingly to it.

What next? Like any big movement there were hurdles and differences. The pulling out of the Paris Accord by the US has indicated that the regress will not stop on its own. Unless we continue to build momentum, the movement will fizzle. Wearing the science hat everywhere, not being shy about science is a pledge we all need to take. Change is slow, and it needs drivers. People making it a mission, and many more contributing a bit regularly and creating a resistance when required. Reinhold Niebuhr's prayer requests serenity to accept things that cannot be changed. One placard summed up the current movement for me differently: 'I will have the perseverance to change things that I cannot accept'. Let us look at the person in the mirror and be the change. □

A Brief History of Science, Part 15
Rebirth of Science in India

Soumitro Banerjee*

Introduction

We have seen earlier that India had a great scientific tradition, created mainly in the Siddhantic period (around 6th century BC to 11th century AD). Indian contribution to science was focused on astronomy, medical science, metallurgy, and branches of mathematics like arithmetic, algebra, number theory, and trigonometry. We have dealt in details with these contributions in an earlier issue (Vol. 17, No. 3, February 2015).

We have also seen that, starting from about 9th century AD science in India declined, and after 12th century AD, practically nothing was left (except for the Kerala School of Mathematics, which flourished in the 14th-16th centuries). India lapsed into a "dark age". The cultural conditions prevailing during this medieval period has striking similarity with that during the Dark Ages in Europe. Beliefs and superstitions ruled the Indian mind. There was blind faith in the scriptures, and answers to all questions were sought in the writings of ancient sages. Casteism was practised in a virulent form, which relegated a considerable section of Indian people — the lower castes — into the wretched life of untouchable community. The oppressive casteism in the Hindu society induced a large section of the lower caste people to embrace Islam. But by then, Islam also had lost its character of patronage for science and was on the way to becoming another bastion of blind faith and superstition. Thus, India lost touch with the science created on its own soil.

In the 17th century, the Europeans — Portuguese, Dutch, French, and British — set foot on Indian soil as traders. Out of these, the British slowly gained ground by utilizing the internal contradictions between the Indian rulers, and the British East India Company occupied vast stretches of land by defeating the Mughals. The other European powers became limited to a few pockets like Pondicherry, Goa, Daman, Diu, Chandannagore, etc. Even though the East India Company was a private enterprise, it represented British colonial interest in the subcontinent. In order to perpetuate its rule, the Company installed a postal system, railways, roadways, courts, tax collection departments and other arms of administrative machinery.

By 1818, the revenues from India rose to about one third of the total revenues of the British government. Such exploitation of the wealth of India required a large manpower, but the British citizens stationed in India were a mere handful in number. Thus, the East India Company had to install an education system to train some Indians to serve the British in various capacities of the administrative machinery.

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Statue of Raja Rammohan Roy in Bristol, where he spent the last 3 years of his life in an effort to influence the British parliamentarians to support his reform movement.

One would have expected that they would install an education system similar to that in Britain, where science is given due importance. But, no. Their intention was not really to enlighten the Indian people. The British rulers' outlook towards education was to train up a sufficient number of clerks and lower level administrators who would help a smooth running of the Government machinery. They carefully avoided dissemination of the modern ideas born through the European renaissance. For this, the existing model of education — the learning of ancient texts through the medium of Sanskrit — suited them fine. By promoting Indian beliefs and social practices, British rulers actually tried to foster traditionalism.

Raja Ram Mohan Roy

But through the British, the English language entered India, which opened a window to the ideas born in the European enlightenment. One of the first Indians to absorb these ideas and to appreciate their importance was Raja Ram Mohan Roy (1772-1833). He was an extraordinary scholar, well versed in many languages, and exposed to the highest traditions of the Hindu, Muslim and European literature. He realized that the way forward was to usher in the ideas of European enlightenment. But that was not what was in the minds of the rulers. So he engaged in a struggle with the British, making a strong case for a modern scientific education system.

We get a glimpse of his opinions from a letter he wrote in 1823 to Lord Amherst, the then Governor General of India. Ram Mohan expresses his utter dismay that instead of installing an education system based on modern science, "we now find that the Government are establishing a Sangscrit school under Hindoo Pundits to impart such knowledge as is already current in India. This Seminary (similar in character to those which existed in Europe before the time of Lord Bacon) can only be expected to load the minds of youth with grammatical niceties and metaphysical distinctions of little or no practicable use to the possessors or to society. The pupils will there acquire what was known two thousand years ago, with the addition of vain and empty subtleties since produced by speculative men, such as is already commonly taught in all parts of India."

"If it had been intended to keep the British nation in ignorance of real knowledge, the Baconian philosophy would not have been allowed to displace the system of the schoolmen, which was the best calculated to perpetuate ignorance. In the same manner the Sangscrit system of education would be the best calculated to keep this country in darkness, if such had been the policy of the British Legislature." He urged the government to "promote a more liberal and enlightened system of instruction, embracing mathematics, natural philosophy, chemistry and anatomy, with other useful sciences which may be accomplished with the sum proposed by employing a few gentlemen of talents and learning educated in Europe, and providing a college furnished with the necessary books, instruments and other apparatus."

It is to be noted that Ram Mohan was well aware of the various shades of philosophy current in Western thought at that time. Out of these, he wanted the introduction of a particular line of thinking, based on Baconian philosophy (for an exposition, see Part 5 of this series in Vol.16, No. 4, January 2014) which was, at that time, recognized as the philosophical grounding behind the development of science.

We are fortunate that Ram Mohan succeeded in persuading the British to accept his views, at least partially. But what was installed was a mixture of Sanskrit scripture based oriental education and a bit of English literature and arts.

However, Ram Mohan tried to bring in social reform through a religious reform, by trying to make the practices of the Hindu religion more humane and rational. To achieve that, he preached a monotheistic form of religion, called Brahmo Dharma, based on *Vedanta*. In this we see an apparent contradiction: while Baconian philosophy urged people to observe the material world intently and to derive its laws by applying inductive logic, Vedanta considered the material world as *maya* or illusion, and urged people to look away from it. Ram Mohan was aware of this contradiction, but somehow lived with it.

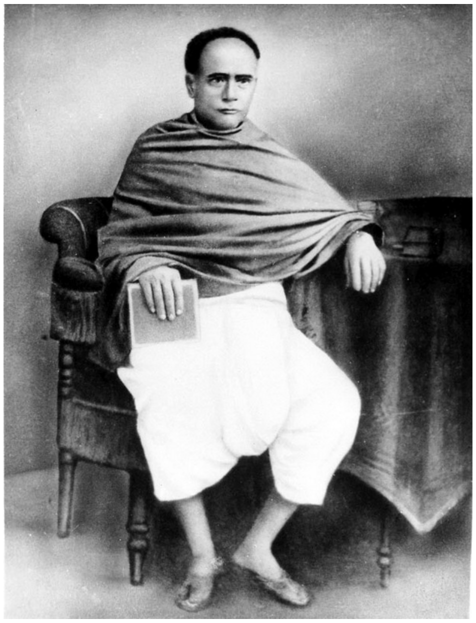
Ishwar Chandra Vidyasagar

In the next stage, the fight was taken up by Ishwar Chandra Vidyasagar (1820-1891). He was an erudite scholar in Sanskrit grammar and literature who earned fame (and the title Vidyasagar — ocean of knowledge) at a very young age. He was also well versed in English, science, and familiar with various schools of philosophical thought of the West. Most importantly, he was completely free of the prejudices of his time and was the first representative of secular humanism on Indian soil.

Vidyasagar joined the Sanskrit College in Calcutta in 1846 as Assistant Secretary, at the age of 26. At that time the curriculum comprised mainly Sanskrit grammar and specialized in the scholarship of Indian tradition, philosophy and religion. He immediately proceeded to prepare a blue-print for drastic reform of the curriculum, proposing to introduce science and mathematics as developed in the West, and to make English compulsory. The proposal received a hostile response from the then Secretary of the College, Rasomoy Dutta, who refused to forward it to the Government's education department. Vidyasagar resigned from the College, and took up writing and publishing independently.

What did he write on? One of his books, *Jeevan Charit*, focused on the life struggles of scientists like Copernicus, Galileo, Herschel, Newton, Linnaeus, etc., in simple, elegant Bengali language. Another one, *Bodhodaya*, discussed the basics of zoology, physiology, botany, mathematics, physics, chemistry, geography, etc. These books were an instant success, as they introduced the Bengali readership to the highest products of the European renaissance and enlightenment. He also wrote books like *Varna Parichay* as a primary level textbook for learning reading and writing Bengali.

Meanwhile, a small number of Englishmen who understood the value of this man prevailed upon the Education Department, and Vidyasagar was brought back to the Sanskrit College as Secretary. He immediately proceeded to implement his plan of



Ishwar Chandra Vidyasagar (1820-1891)

curricular reform. The majority of British functionaries of the education department were alarmed. They ordered a review of the proposed reform by Mr J R Ballantyne, Principal of the Sanskrit College at Benaras, and a prominent oriental scholar.

Mr. Ballantyne visited the Sanskrit College, Calcutta, reviewed the new curriculum, and submitted a report to the Education Department. While he greatly appreciated the erudition of Vidyasagar, he did not agree with most of the recommendations. In reply, Vidyasagar sent a long rejoinder on 7 September 1853, countering Ballantyne's arguments one by one. This has gone down in history as the famous 'Vidyasagar-Ballantyne debate'.

Ballentyne felt that Vidyasagar was putting undue importance to the work of John Stuart Mill. Mill had to be taught, but one could do with an abridged version of his work, he felt. Vidyasagar did not buy the argument and steadfastly stuck to his point that the students should be exposed to the great thinker's work in its original.

Ballantyne had argued that along with the work of other philosophers, the idealist philosopher Bishop Berkeley's writings should also be a part of the curriculum. Vidyasagar's remark on this point deserves special attention: "With regard to Bishop Berkeley's Inquiry, I beg to remark that the introduction of it as a class-book would beget more mischief than advantage. For certain reasons, which it is needless to state here, we are obliged to continue the teaching of the *Vedanta* and *Sankhya* in the Sanscrit College. That the *Vedanta* and *Sankhya* are false systems of philosophy is no more a matter of dispute. These systems, false as they are, command unbound reverence from the Hindus. Whilst teaching these in the Sanscrit course, we should oppose them by sound philosophy in the English course to counteract their influence. Bishop Berkeley's *Inquiry*, which has arrived at similar or identical conclusions with the *Vedanta* or *Sankhya*, and which is no more considered in Europe as a sound system of philosophy, will not serve the purpose. On the contrary, when, by the perusal of that book, the Hindu students of Sanscrit will find that the theories advanced by the *Vedanta* and *Sankhya* systems are corroborated by a philosopher of Europe, their reverence to these two systems may increase instead of being diminished. Under these circumstances, I regret that I cannot agree with Dr. Ballantyne in recommending the adoption of Bishop Berkeley's work as a class-book."

Vidyasagar's proposal to counter the influence of wrong and obscurantist philosophies by sound and modern philosophies in the English course also met with opposition from Ballantyne, who felt that two different philosophies taught in different courses may induce the students to believe that "truth is double". Vidyasagar retorts:

"Truth is truth if properly perceived. To believe that "truth is double" is but the effect of an imperfect perception of truth itself — an effect which I am sure to see removed by the improved courses of studies we have adopted at this institution."

Thus countering Ballantyne, Vidyasagar proceeded to state clearly his vision regarding education. "What we require is to extend the benefit of education to the mass of people. Let us establish a number of vernacular schools, let us prepare a series of vernacular class-books on useful and instructive subjects, let us raise up a band of men qualified to undertake the responsible duty of teachers, and the object is accomplished."

What did he mean by 'a band of qualified men'? He says, "They should be perfect masters of their own language, possess a considerable amount of useful information and be free from the prejudices of their country." ··· "To raise up such a useful class of men is the object I have proposed to myself and to the accomplishment of which the whole energy of our Sanscrit College should be directed. That the students of our Sanscrit College, when they shall have finished their college course will prove themselves men of this stamp we have every reason to hope."

Thus we see that he had clearly set out the task before himself, and defended his right to proceed along this line. And in this, he succeeded.

Apart from the drastic change in the curriculum, he brought many other far-reaching changes. At that time, only upper caste Hindus from well-to-do families were admitted to the Sanskrit College. He changed the rules to allow students from all sections of the society to join the college.

He also took lead in another direction. He travelled, mostly on foot, to far-flung villages of Bengal, and established hundreds of schools. He also took the first initiative to start schools for girls. These schools would impart education through the mother tongue: "Vernacular Education on an extensive scale, and on an efficient footing, is highly desirable, for it is by this means alone that the condition of mass of the people can be ameliorated." He also had very concrete opinion regarding what should be taught in these schools: "Mere reading and writing, and a little arithmetic should not comprise the whole of this education; Geography, History, Biography, Arithmetic, Geometry, Natural Philosophy, Moral Philosophy, Political Economy and Physiology should be taught to render it complete."

In those days mathematics used to be taught using Bhaskaracharya's *Lilavati* (for arithmetic and mensuration) and *Vijaganita* for algebra. These books were not written as textbooks that demand systematic exposition. In fact, *Lilavati* was written as a collection of mathematical puzzles. Vidyasagar demanded introduction of modern mathematics with modern pedagogical techniques: "These two works are very meagre. ··· The examples are very few. The study of mathematics in Sanscrit should be discontinued. It is not to be understood from this that I undervalue a knowledge of Mathematics as an essential element of a complete education. Far from it. I wish to substitute the pursuit of it in English, whence in less than half the time now given to it an intelligent student will acquire more than double the amount of sound information that he could obtain by the most perfect acquaintance of all that exists in Sanscrit language in the subject."

Thus he ensured, firstly, that education reaches the common people, and secondly, that the students who come up to college level get a truly modern and scientific education. Other schools and colleges around

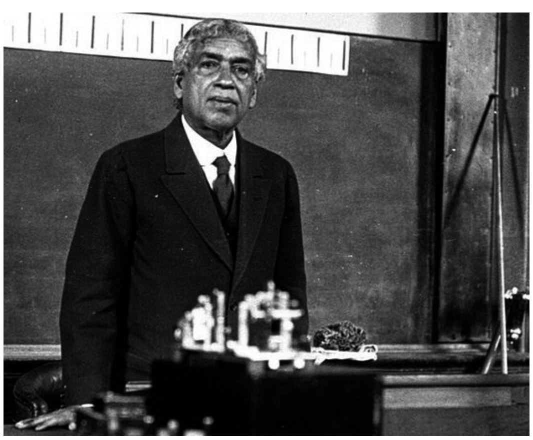
India soon emulated the example, and the 'Vidyasagar model' took root in the Indian education system much to the displeasure of the colonial rulers.

The results flowed surprisingly fast.

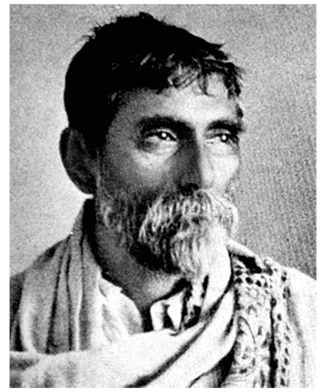
The decade of 1860-1869 saw the birth of a band of people who would shape the Indian cultural and political scenario in the later years. This includes Rabindranath Tagore, Madan Mohan Malaviya, Swami Vivekananda, Motilal Nehru, Ashutosh Mukherjee, Lala Lajpat Rai, V S Srinivasa Shastri, Mohandas Karamchand Gandhi, Jagadish Chandra Bose, and Prafulla Chandra Ray. They could become what they were because of the modern education they received in the 1870s and 1880s, which exposed them to the ideas of democracy, freedom, and science. *That* was the vision of Vidyasagar.

The upsurge in science

Two young friends, Jagadish Chandra Bose and Prafulla Chandra Ray, joined the Presidency College, Calcutta, in the late 1880s. At that time there was no facility or environment for scientific research in any college in India. The two friends took upon themselves the task of initiating scientific research — J C Bose in physics, and P C Ray in chemistry — despite the lack of funding and equipment, and indifferent attitude of the English administrators.



Jagadish Chandra Bose delivering a lecture at the Royal Society, London.



Acharya P C Ray (1861-1944)

By then Maxwell had shown that electromagnetic waves are possible, and Hertz had experimentally demonstrated the existence of such waves. Bose started research in this area, and soon developed a method to produce waves of much smaller wavelength than what Hertz had produced (about 5 mm, which we now know to be microwaves). Then he developed a technique to detect these waves at a distance from the emitter — in fact he was the first to use semiconductor material in the detector. He gave a public demonstration at the Calcutta Town Hall in 1895, in which he ignited gunpowder from a distance. All this work was of path-breaking importance in the development of wireless telegraphy. He refused to patent his inventions and made his discoveries public. The Italian inventor Marconi took advantage of this knowledge and developed the world's first commercially usable wireless telegraphy.

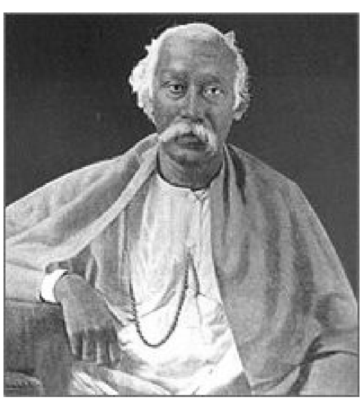
Bose later turned his attention to botany, and used local expertise to build extremely sensitive instruments for measuring growth of plants and their response to stimuli.

He was truly a pioneer in scientific instrumentation. He also built an institute for scientific research, now called the Bose Institute.

P C Ray started working in inorganic chemistry, particularly on synthesizing compounds of mercury. Soon he made an unexpected discovery — that of mercurious nitrite $Hg_2(NO_3)_2$. With the rudimentary equipment at his disposal, he characterized the new substance, which has turned out to be correct in the light of modern crystallographic techniques. This earned him accolades from around the world. He continued to work on other nitrites and on coordination chemistry, published in leading scientific journals including Nature and the journal of Royal Society of Chemistry.

He trained a band of students who spread all over India and built the edifice of chemistry research in the nation. They included Jnan Chandra Ghosh (Director of IISc Bangalore and the founding Director of IIT Kharagpur); Panchanan Niyogi (founding Principal of the Raja Manindra Chandra College, Calcutta); Nil Ratan Dhar (who started physical chemistry research in Allahabad University); Priyada Ranjan Ray (Calcutta University); and Biresh Chandra Guha (Founder of biochemical research in India). The eminent indologist Sylvain Levy said "his laboratory was the nursery from which issue forth the chemists of new India".

C V Raman (1888-1970)

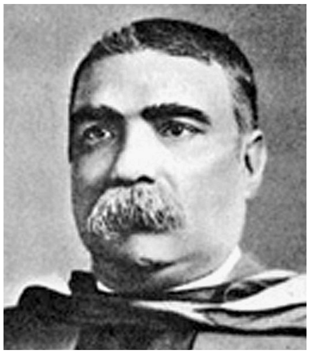


Mahendralal Sarkar (1833–1904)

Mahendralal Sarkar, a doctor by profession, realized early on that an important component on India's emancipation should be scientific research. But at that time there was no place to conduct scientific research in the country. So he singlehandedly founded a small scientific institution called the 'Indian Association for the Cultivation of Science' in 1876 that was funded, run, and managed solely by Indians. Individuals could join the IACS and could use its very meagre facilities to conduct scientific research. It also organized public lectures on scientific topics to disseminate scientific ideas among the people.

In 1907, a young South Indian man named C V Raman, then working as a civil servant in Calcutta, noticing the IACS signboard on a building on Bowbazar Street, simply went in and asked if he could work there during his free time. The rest is history. He discovered the celebrated Raman Effect in 1928 while working at the IACS, and received the Nobel Prize for it in 1930. He worked there from 1907 to 1933.

The University of Calcutta had been founded in 1857, but was initially administered by the British. The progress



Sir Ashutosh Mukherjee (1864-1924)

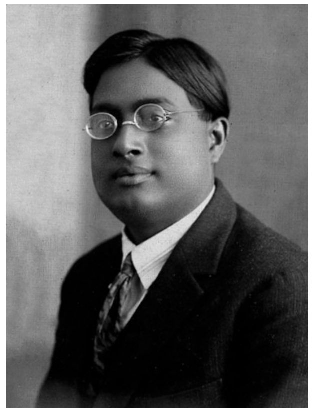
was slow, with teaching confined to a few arts subjects. Its fortune changed when the mathematician and lawyer Sir Ashutosh Mukherjee took charge as the Vice-Chancellor in 1906. During his tenure the British educational administration lost grip on the university and threatened to stop its funding. Ashutosh accepted the challenge, and appealed to the people to support the University so that it can satisfy the educational aspirations of the nation. He received generous support from Indian donors, and proceeded to create science departments, envisioning these to become cradles of advanced scientific research and teaching.

Ashutosh Mukherjee had a keen eye for spotting talent. He realized the potential of C V Raman at least 12 years before the discovery of the Raman Effect, and felt that his employment in the Indian Finance Department was a sheer waste of scientific talent. So he invited Raman to join the University College of Science. Raman joined the University in 1917, and continued his scientific research at the IACS, where he made his key discovery.

Two classmates, Satyendra Nath Bose and Maghnad Saha (both students of J C Bose and P C Ray), did their master's degrees from the Presidency College in Applied Mathematics in 1915. At that time Ashutosh Mukherjee was contemplating starting master's degree in physics. He spotted their talents and invited both of them in 1916 to join Calcutta University as lecturers in the subject of physics. They took up the challenge, learned the new advancements in physics (relativity and quantum mechanics) that was happening at that time, and started teaching these at the university. At that time most of the scientific literature was in German. So they had to learn German and had to read the original papers in German. In fact, the two young friends were the first in the world to translate Einstein's epoch-making paper on General Theory of Relativity, and the English version was published by the Calcutta University in 1920.

Soon they started creating their own footprints. While teaching Planck's derivation of the black-body radiation curve, Bose managed to derive it in an entirely different way, showing that light emitted by a black body would not follow the Maxwell-Boltzmann distribution because light quanta are indistinguishable from each other. He wrote up the new derivation and sent it to Einstein. Einstein realized

Srinivasa Ramanujan (1887–1920)


The three famous class-mates: Meghnad Saha, Satyendra Nath Bose, and Prashanta Chandra Mahalanobis.

the importance of the approach, translated it into German, and got it published. In addition, Einstein worked out the statistics to be followed by any particle that have similar properties. These particles are now called bosons, and the statistics they follow is called Bose-Einstein statistics.

Meghnad Saha, on the other hand, started working on ionization of gases at high temperatures that exist in the stars, and derived an equation that is followed in thermal ionization. The equation is now called the Saha equation.

Another classmate of theirs, Prashanta Chandra Mahalanobis, joined the Presidency College and started research on statistics. He later founded the Indian Statistical Institute, which is a premier institution for teaching and research on mathematics and statistics even today.

Srinivasa Ramanujan, with very little formal training in pure mathematics, started working in isolation on areas such as number theory, analysis, infinite series, continued fractions, etc., and soon obtained results that later startled mathematicians. In 1913 he started writing to the English mathematician G H Hardy. Upon realizing his extraordinary talent, Hardy arranged for Ramanujan to travel to Cambridge. There he produced important results such as the Ramanujan Prime, Ramanujan theta function, mock theta functions, etc. These opened entirely new areas of work and inspired a vast amount of further research.

Thus an age of science was dawning on India. There was excitement in the air, and India was making its presence felt in the world of science. The dreams of Rammohan and Vidyasagar were coming true.

Struggle between science and belief systems

Space for science cannot be created anywhere without launching a struggle against unscientific beliefs and practices. The doyens of Indian science did engage in this struggle, and tried hard to dispel the miasma. Rammohan and Vidyasagar had to fight against orthodox Hindu fanaticism. While Vidyasagar worked to spread a scientific education system, people like Akshay Kumar Dutta (1820-1886), and Rajendralal Mitra (1824-1891) stood by him by spreading scientific thought through numerous writings.

Acharya P C Ray waged an uncompromising struggle against casteism and the superstitious behaviour and beliefs prevailing in the society. Even in the chemistry classes he would try to dispel unscientific notions prevailing in his students. For example, he would burn a piece of bone in bunsen burner, and then would drop it in his mouth. Some students would shudder: being a Hindu, which animal's bone did he consume? Prafulla Chandra would then explain: After it is burnt what remains are just inorganic compounds calcium carbonate and calcium phosphate! Thus he would not only teach chemistry; he would also inculcate a scientific bent of mind.

He was mostly successful, but not always. In one of his writings he lamented, "I have been teaching for half a century, and in that period I have told thousands of students that eclipses do not happen because demons called *Rahu* and *Ketu* devour the sun and the moon, and that eclipses do not end when the demons, satisfied by the worship of the earthlings, release the heavenly bodies. These are just myths, products of pure imagination. When I tell these with scientific explanation, my students understand and accept. But on the day of the eclipse, when people come out to the streets chanting *mantras* to please the demons, these truth-seekers also join them, and throw away their food."

Meghnad Saha was also very active in propagating a scientific bent of mind, and waged a polemical battle with the protagonists of orthodox Hinduism. In 1938 he gave a lecture at Shantiniketan with the title 'A new philosophy of life' in which he criticized various Hindu beliefs and customs. After it was published, there was a deluge of protests from people belonging to devout religious circles, who argued that all ideas of modern science can be found in the Vedas. Saha then read the Vedas in original Sanskrit, and showed, quoting the shlokas, that this is not true.

Thus we see that most scientists and social reformers of that era engaged in public dissemination of scientific ideas and in fighting unscientific beliefs. As long as and to the extent this outlook prevailed and guided the scientific community, science advanced in rapid strides.

Unfortunately this phase did not last long and did not embrace all spheres of life. Towards the close of the 19th century, a revivalist trend of thought arose and took shape in various forms of Hindu religious movements that sought to establish an ideal and purified Hinduism as the guiding ideology in all spheres of life including science. Indian nationalism grew in such an environment in the last quarter of the 19th century and at the beginning of the 20th century, which was based on religious sentiments and a sense of pride in an imaginary glorious past. Even though leaders like Netaji Subhas Chandra Bose and Bhagat Singh opposed it ardently, the dominant trend in the nationalist movement remained national pride based on Hinduism. As a result, the nationalist movement failed to achieve unity of different religious communities, and was beset with caste and communal prejudices. Even in meetings of the Indian National Congress there were separate kitchens for each community, a practice severely criticized by Acharya Prafulla Chandra.

As science's struggle for a foothold in the social psyche waned, the Indian renaissance started losing ground to different faith systems. But by then the age of science and technology had arrived. So science could not be ignored. Thus science education and research continued, but its revolutionary core, the scientific way of thinking began to be left behind. Science became reduced to being a mere gateway to a career.

During the days of freedom struggle a

sense of idealism — fighting against the British, taking the country forward — fired the young community. The scientists of that time also viewed science that way. They wanted to serve the country through science. They wanted to show the world that India can also make her mark in modern science. After independence, that nationalistic fervour in doing science disappeared. The value system that once propelled advancements in science became ineffective and was reduced to an instrument for privilege for a few.

While the number of scientific institutions have multiplied after independence, while a far larger number of scientists are working in these organizations, while the research facilities have significantly improved compared to the pre-independence era, still we are unable to produce scientists of eminence comparable to J C Bose, P C Ray, C V Raman, M N Saha, S N Bose, S Ramanujan, etc. We have been unable to produce a single Nobel Laureate since independence.

The flame lit by the doyens of the Indian renaissance has begun to dim. The task before the science movement today is to rekindle it and to make it burn brighter so that it lights up the whole nation freeing the society of unscientific beliefs and encouraging people to practice science as a way of thinking and a way of life. We now need to release a new current of struggle to build a society free of oppression of man by man, where the pursuit of science will be motivated solely by an urge to unravel the laws of nature and to serve the society. □

(*End of the series*)

Was there a creation for the universe?

Moncy V. John*

From time immemorial, people might have wondered about secrets behind the star-studded sky during pitch black nights, from time immemorial. The universe consists of the earth and everything on it, moon, planets, stars, galaxies, and all else that exists. When our everyday experience is that phenomena occurring on earth have beginnings and ends, it is only natural that they thought about a beginning for the universe also. Most religious texts speak about a beginning for the universe. A scientific study of the entire universe, which is a branch of physics and astronomy, is called cosmology. Some cosmologists who are working in this field also think that there was a beginning for the universe. Their model, in which the universe is expanding at present, is called the Big Bang model. Is it just a coincidence that modern cosmology reaches the same conclusion—that there was a moment of creation for the universe—as mentioned in sacred books?

It is well-known that in contrast to divinations, science must follow certain methods, such as experiments and observations, before reaching any conclusion. Are such methods strictly followed by cosmologists in making the above conclusion regarding the creation of our universe? Here we shall address this legitimate question that may arise in the minds of every student who attempts to study cosmology.

To understand the methods adopted by cosmologists, we must first think of the enormity of the distance to various celestial objects. The moon is very close to us, at a relatively small distance,from which light can travel to earth in approximately 1 second of time. When compared to this, the Sun is very far off. Light takes approximately 8 minutes to reach us on earth from the Sun. Our nearest star, other than the Sun, is Proxima Centauri and is at a huge distance of 4.22 light years. This means that light will take 4.22 years to reach us from that star. Astronomers measure such large distances with another unit, called parsec. (1 parsec = 3.26 light years.) Those stars we see at night with naked eyes belong to our Milky Way galaxy. They are several parsecs or even kiloparsecs away. In fact, the diameter of our Milky Way galaxy, which contains 10^{11} (1 followed by 11 zeroes) stars such as the sun, is 30 kiloparsecs ($= 30,000$ parsecs).

But in the universe, the Milky Way is not the only galaxy. Our nearest galaxy, which is almost similar to that of Milky Way in size and other features, is the Andromeda galaxy. It is at a distance of about 700 kiloparsecs from us. Earlier, it was estimated that the total number of observable galaxies in the universe is around 200 billion. However, a recent study showed that the total number of observable galaxies in the universe is a lot more than this, around two trillion. Also we now estimate that the maximum observable part of our universe is spread in a region with radius approximately equal to 3000 megaparsecs (=3,000,000,000 parsecs). There are a

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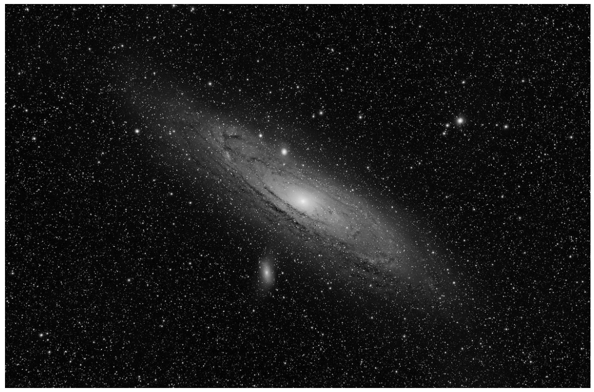


The Andromeda galaxy

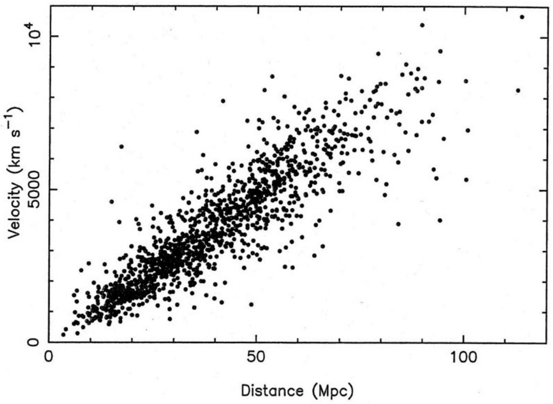
large number of astronomers, spending their time in lonely observatories around the globe, constantly watching the entire universe with powerful telescopes.

A crucial point to be noted from the above discussion is that we can directly see 'our own past', i.e., the past of our universe, using these telescopes. For instance, when we see the sun now, it does not appear to us as it is at present. We see it as it was 8 minutes ago. When we see the Proxima Centauri, it appears to us as it existed 4.22 years ago. Now, what about the Andromeda galaxy[1]? It appears to us as it existed about 25 lakh years ago. A person situated in the Andromeda galaxy can see the earth as it existed in the same period. This was a period before human beings came into existence on earth. Then what can one say about the light that reaches us from the farthest part of the observable universe? If the universe had an origin, then the light we see from the farthest regions must have started at around the beginning of the universe itself!

However, the above discussion does not give us any clear evidence for a creation of the universe. Then why do people say that the light coming from the farthest observed part shows us a picture of the beginning of the universe? One reason is that beyond a certain region,there are no galaxies observed. Was it a time before the formation of galaxies? If galaxies too had an initial time of formation, the absence of galaxies beyond 3000 megaparsecs can be indicated as providing evidence for a period when they were not born. Another reason is that this distance corresponds to a time interval roughly equal to 10 billion years, which is the age of the oldest objects, such as radioactive substances found on earth, oldest stars in the universe, etc. These are valid reasons. However, there are some stronger evidences for believing that we are seeing the beginning of our own universe at these distances.

These latter reasons are related to the discovery that our universe is expanding. This most important discovery, that laid the foundations of modern cosmology, was made in 1929 by Edwin Hubble. He observed that all galaxies recede from us, with the speed of recession proportional to their distance from us. The farther the galaxy, the more is the speed with which it moves away from us. By studying this

[1]We can barely see it with naked eyes during very dark nights, as a patch of light, in the neighbourhood of the Andromeda constellation. Hence the name Andromeda galaxy.



A plot of recession velocity versus estimated distance for a set of 1355 galaxies. The straight line fit implies Hubble's law.

relation between the recession speed and distance of galaxies from us, he came to the conclusion that our universe is expanding. If it is expanding now, earlier it must have been in a more compact state. All the matter in the universe must have been in a denser and hotter state at earlier times. We know that when anything expands, it becomes less dense. If it expands without exchanging heat with the outside (the universe has no "outside", hence there is no question of exchanging anything with its outside!), it will cool down. Therefore the very early universe must have been very dense and very hot.

Note that if a Big Bang had occurred, the temperature and pressure of the universe at the initial time $t = 0$ must be infinite. The state of the universe at this moment is called a singularity. One cannot start a theory from such a singularity, where all laws of physics break down. If we start from the present time and go backward in time, one can use the general theory of relativity to find the time at which the singularity eventually reached and that may be taken as $t = 0$. We may also note that if general relativity and other theories of physics are not valid at any time in between, for instance at the earliest epochs, our evaluation will also give wrong results.

Again, if we just think of going back in time from the present, then in an early epoch, the universe must have been very hot such that even atoms cannot withstand the heat (This is a temperature above 3000 Kelvin or so). All electrons in these atoms would fall apart, so that we have only a hot fully ionized 'plasma' in the early universe. If we make such extrapolation backwards in time with the presently measured expansion rates, it is possible to understand that this had occurred at a time close to 13 billion years to the past.

But we must note that light cannot travel freely through such plasma. The universe was opaque at such times. Then it is not possible for one to see something that existed during that period. Only when the universe cooled down to a temperature below 3000 Kelvin, light could start to travel freely. In cosmology, this period of time is called the epoch of decoupling radiation from matter. The entire universe became transparent at that point of time.

However, an observer situated at any given point at that time will not be able to see clearly the other parts of the universe. This is because light takes some finite time to travel. Hence she will first see only things in her immediate vicinity during the initial moments. She can see more and more parts as time goes on. Thus the sphere of her vicinity will expand with time and what she can see at the farthest observable part will be a surface of the primordial plasma. This is true even today. (This is not because plasma exists there at present; instead, it is just an illusion caused by the finite speed of travel for light.) The observer cannot see beyond that surface at any time of making the observation. But as time goes on, more parts will appear clear and transparent. This is the maximum limit of our 'observable universe' at any particular instant. It was George Gamow who first postulated that there must be such a sight waiting for us to see at the extreme outer boundary of our observation. That was in the year 1946.

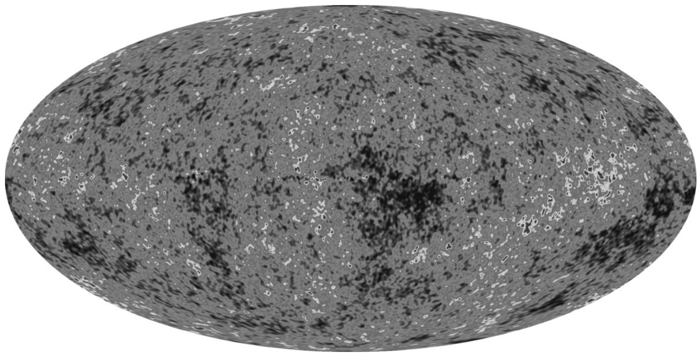
In 1964, two engineers Arno Penzias and Robert Wilson, who were unaware of this prediction by Gamow, accidentally discovered this plasma surface at the outer edge of our observable universe. This 'last scattering surface' is called Cosmic Microwave Background (CMB). The light coming from it has cooled down, so that it reaches us as electromagnetic waves with wavelength the same as that of microwaves, used in our communication systems. In 1978, Penzias and Wilson were awarded the Nobel Prize for their discovery of CMB. This was a conclusive evidence that the universe had a very hot early phase. Most cosmologists believe only in a limited version of the Big Bang theory. As stated above, they call the model as a 'hot early universe model'.

Beyond the distance of about 3000 megaparsecs, one cannot make direct observations with telescopes. (This is because, as mentioned already, the universe was opaque during that time.) Hence we cannot directly see what happened before the time of emission of that light, which we see today as CMB. Any kind of electromagnetic wave, such as visible light, X-rays, etc., will not help us in this regard. Perhaps the recently discovered gravitational waves may be eventually helpful, but the technology for any such observation is far beyond our reach at the present time. Hence direct detection of any creation event for our universe, as envisaged by the Big Bang model, is not possible at present.

What one can do instead is to look for indirect evidences. One such thing is the theoretical prediction of the presence of various light elements, such as helium, lithium etc., in the universe and the comparison of the calculated values of the relative abundance of these elements with the actual measured values of the corresponding quantities. The measurements are made by analysing the spectrum of light emitted by stars, galaxies, etc. The theoretical predictions of these relative abundances need numerous assumptions and hence this exercise cannot be considered as providing ultimate, foolproof evidence. The theory that explains this is called Big Bang Nucleosynthesis (BBN).

The formation of elements starts when the temperature in the expanding universe is approximately 10^{10} Kelvin. If a big bang had really occurred, 10^{10} Kelvin will be the temperature in the universe at about 1 second after the event of creation. (Thus in this description of BBN, one assumes that a creation event, or the big bang, has occurred at time $t = 0$, but this is just for a convenient description.) The universe was expanding very fast at this time and was filled with a sea of neutrons, protons, electrons, anti-electrons (positrons), photons and neutrinos. As the universe cooled, the neutrons either decayed into protons and electrons or combined with protons to make deuterons. The deuteron is the nucleus of deuterium, which is the heavy form of hydrogen (^2H).

During the first three minutes of the universe, most of these combined to make helium nuclei. Trace amounts of lithium were also produced at this time. A general consensus is that the predicted and actual observed values are in agreement. The predicted abundance of deuterium, helium and lithium depends on the density of ordinary matter in the early universe. It is generally expected that about 24% of ordinary matter in the universe produced during BBN is helium. However, the success of BBN



All-sky map of cosmic microwave background radiation.

cannot be taken as a proof for the creation of the universe. Instead, it only says that the story of the formation of light elements, starting from a high temperature as large as 10^{10} Kelvin, is valid.

Going further backward in time, what happened during the time prior to the start of BBN, is a lot more speculative. Extending the known laws of physics to this period helps to explain the formation of hadrons from the so called quarks, which are among the most fundamental particles. This period is called the hadron epoch, which extends from 10^{-6} seconds to approximately 1 s after the big bang moment. The period before the hadron epoch is the quark epoch, which starts from a time 10^{-12}. Before this, we have the electroweak epoch. This is preceded by the inflationary epoch and the grand unification epoch. The earliest epoch in the big bang cosmology is called the quantum cosmology epoch or the Planck epoch. We must by now realise that these are all speculations based on the presently known laws of physics and it is not certain that the same laws are valid in all these epochs, down to the moment of big bang. One cannot expect those theories to have any direct observational evidence. As mentioned above, they are speculations based on the presently known laws of physics.

We thus see there is considerable uncertainty regarding the very early universe. One does not know whether there really occurred a creation of the universe. It may be that before the beginning of the present stage of expansion, the universe was in a contracting state. After reaching a minimum size, it may now be bouncing back to the present large size. This kind of bouncing cosmological models are also being seriously discussed by some cosmologists. Another possibility is the oscillating model, where the universe keeps on expanding and contracting periodically. The quasi-steady state model proposed by the famous Indian cosmologist Prof. Jayant Narlikar is another possible model for our universe.

In spite of these confusions regarding the real history and real fate of the universe, a lot of facts regarding it is now known for certain. The known facts are that the universe is expanding now and that it had a very hot early history. It is highly probable that the relic of this hot past is what appears to us as the CMB. The study of CMB is a very active and exciting field of research. With dedicated work, mankind can hope to extend such understanding to the early universe too. But as of now, there is no definite answer to whether a creation event actually occurred. □

Story of an Experiment in Physiological Research

K Sampath *

Observation is an exploration in the act of discovering something unknown; testing an idea and identifying the nature of the problem for the formulation of hypothesis or theory. Some observations lead to discovery as well.

An experiment is an investigation in which an idea, hypothesis or theory is tested or the independent variable is manipulated in order to find the effect on the dependent variable. Through an experiment we interrogate nature. An experiment is also a procedure carried out to support, refute, or validate a hypothesis. It allows us to objectively study the character of the material world, and possesses the most conclusive power. In an experiment we try to set up conditions that are meant to clarify how nature behaves, how it works. Considering this view, experiments are nature's interpreters. An experiment can also be designed to explore the possibilities of finding something unknown in a new territory. Such an experiment sometimes can lead to unexpected new discoveries.

The late Richard Feynman, one of the leading theoretical physicists of the twentieth century, wrote: The principle of science, the definition, almost, is the following: The test of all knowledge is experiment. Experiment is the sole judge of scientific 'truth' [1].

The aim of observations and experiments is meant to explain the facts. They certainly are not two different things in kind; both may be considered as complementary – two sides of the same coin. Only experiments can unveil the hidden phenomenon or event; therefore experiments are a special kind of observation.

Observation and experiment are the fundamental activities of research. In fact both observations and experiments are the reality checks.

Claude Bernard[1], of great repute, was the founder of modern experimental physiology (the first scientist whom France honoured with a public funeral). He opined that various circumstances may serve as the starting point of an experimental research, yet they fall mostly under two types namely; observation and a hypothesis or a theory.

Let us examine the starting point for experimental research as an observation.

The example below describes one of the classic examples of a researcher proposing a hypothesis on the basis of observation, followed by deep logical thought process, connecting the hypothesis step by step to an experiment and finally verifying the hypothesis. Sometimes during the course of an experiment, a new fruitful observation itself becomes the subject for further experiment.

Some rabbits that were brought and kept

*The author is a retired scientist, DRDO

[1]It was said of Claude Bernard, "He is not merely a physiologist, he is physiology". His book on "Introduction to the Study of Experimental Medicine", first published in 1865, has remained a classic which is still read.

in the laboratory had urinated on the tables. This was accidently noticed by Claude Bernard. He found that the urine was clear and acidic. Generally the urine of a herbivore was then known to be turbid and alkaline while that of a carnivore, acidic and clear.

Research mostly proceeds on the basis of existing knowledge — research firmly based upon one or more past scientific achievement — within the existing paradigm. It was a surprise for Bernard as the nature of the rabbit's urine was contrary to then known science. Scientists never allow any oddity or contrary observation to go unchecked. Therefore, Bernard immediately started thinking what could be the cause and continued further research — the way scientists work and reap rewards.

The rules of thumb for scientific thinking are finding empirical evidence, logical reasoning and possessing a skeptical attitude in all research work.

The observation of acidity in the rabbits' urine struck Bernard to think that these rabbits must be in the nutritional conditions of carnivores, as urine of carnivores alone can be clear and acidic. This observation had led Claude Bernard further to assume that the rabbits may not have eaten for a long time and their fasting made them behave like carnivores. Logical reasoning on that first observation about the urine gave birth to a hypothesis that the nutritional conditions made them to behave like carnivores and that they sustained by living off their own blood.

Now the task before Bernard was to prove his hypothesis that rabbits were living off their own blood, so he fed grass to the rabbits; and a few hours later, their urine turned turbid and alkaline. He performed the experiment by keeping them under fast for a day or two, and found that their urine turned clear and acidic. When he fed them grass, the urine turned turbid and alkaline again. By repeating the experiment a few times he obtained empirical evidence that indicated a general rule.

Claude Bernard was not satisfied with the experiment on rabbit alone and repeated the same experiment on horses, and other herbivores. He found that under fasting conditions the urine of the horses turned acidic and clear, with an increase in urea which at times spontaneously crystallized when cooled. He thus built inductive reasoning.

To prove that the fasting rabbits were truly carnivores, he felt a counterproof was necessary. For the sake of counterproof, rabbits were fed with cold boiled beef, which they ate (when nothing else was given). On testing, the urine was found to be clear and acid as long as the rabbits were fed with beef.

To complete the experiment he made an autopsy on the animals to see if the meat was digested in the same way in the rabbits as in a carnivore. He found all the phenomena of excellent digestion in their intestinal reactions just like that in a carnivore. He thus satisfied his skeptical attitude.

In the course of the autopsy, white and milky lymphatics were visible in the small intestine in the lower part of the duodenum about thirty centimetres below pylorus. But in the case of dogs, white and milky lymphatics are visible much higher in the duodenum just below the pylorus. This new observation attracted his attention to probe further. On careful examination it was also found that the position of pancreatic duct coincided with the exact spot where the lymphatic began to contain a chyle made white and milky by emulsion of fatty nutritive materials.

The closeness of pancreatic duct and where the lymphatics began to contain a

Claude Bernard (1813-1878)

chyle made white and milky, led him to think that it is the pancreatic juice that makes the emulsion of fat to form white chyle. Now this idea had to be confirmed or falsified by a suitable experiment.

To verify, the best way was to mix the pancreatic juice directly with neutral fats outside the body (in a laboratory) and to examine its reaction. The secretory organ is deep in the abdominal cavity; and pancreatic juice does not flow outside the body like saliva, milk, urine or any other excretion. To solve this problem the pancreatic fluid was collected from various living animals like dogs, rabbits in a suitable physiological condition and then was mixed with oil or melted fat. It was found that they always instantly emulsified and later they turned into fatty acids, glycerine, etc., by specific ferment. This experiment proved his supposition that pancreatic juice makes the emulsion of fat and forms the white chyle in the intestine of rabbits.

To sum up: The chance observation of an incident of urine of rabbits being clear and acidic gave birth to a hypothesis about the probable cause of the phenomenon observed. The hypothesis was tested with clearly conceived experiments that resulted in a firm conclusion.

The experiment on pancreatic juice played a double role. It first judged and confirmed the provisions of the reasoning. It also popped up a fresh observation (about the chyle and its location).

The moral of this example is that all the aspects of an experiment, the ones related to the hypothesis as well as the ones apparently unrelated with it, must be observed. If we see only facts connected with our hypothesis it may restrict our ability to make new discoveries.

In a philosophical sense, observation shows and experiment teaches.

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Analysis of the Real: Part III

Sarosh Ali *

1. Derivatives

We have seen a property of functions that is a condition on the two limits as we approach the given point from both sides —its continuity. If the limiting value of a function over a continuum doesn't match from both sides, then the function is discontinuous at that point. There are many more such properties that tell us about the behaviour of the function at a given point or approximately in an arbitrarily small neighbourhood of the point. One such property measures the rate at which a function increases or decreases in an arbitrarily small neighbourhood of a point. This is called its derivative at the point x_0 and is defined as $\lim_{x\to x_0}\frac{f(x)-f(x_0)}{x-x_0}$. The process of calculating a formula for derivatives at a point in the domain is called differentiation. If we plot $y = f(x)$ vs. x then the derivative measures how fast the value moves on the y-axis in comparison with the way its projection moves on the x-axis. The symbol used for the derivative is $\frac{dy}{dx} = \frac{df(x)}{dx}$

Consider the function $y = f(x) = c$ where c is a constant and the domain is the whole real line. Let us calculate its derivative at x_0,

$$\frac{dy}{dx}|_{x_0} = \lim_{x\to x_0}\frac{f(x)-f(x_0)}{x-x_0} = \lim_{x\to x_0}\frac{c-c}{x-x_0} = 0 \tag{1}$$

The derivative of the constant function is 0. This is quite understandable as y remains the same for all values of x. Next, comes the general straight line $y = mx + c$ where m is a constant slope and c is the constant y-intercept.

$$\begin{aligned}\frac{dy}{dx}|_{x_0} &= \lim_{x\to x_0}\frac{f(x)-f(x_0)}{x-x_0}\\ &= \lim_{x\to x_0}\frac{(mx+c)-(mx_0+c)}{x-x_0}\\ &= \lim_{x\to x_0}\frac{m(x-x_0)}{x-x_0} = m\end{aligned}$$

Thus, the derivative of a straight line is its slope which is a constant. This is because on a straight line for the same increment of x, the y increases by the same amount everywhere. This gives us an insight as to how the derivative at a point describes the function's rate of increment. Let us try to understand this for an arbitrary function.

Consider two points on a curve $f(x)$ vs. x. The derivative for this curve is given by $\frac{dy}{dx} = \lim_{x\to x_0}\frac{f(x)-f(x_0)}{x-x_0}$. As $x \to x_0$, $f(x) \to f(x_0)$ and the derivative is the slope of the tangent at the point x_0. This suggests that the function is constituted by small segments of straight lines the sizes of which goes to 0. The derivative is the slope of this tiny straight line segments in the limit of the two points on the segment becoming arbitrarily closer. Thus, it is the slope of the tangent at x_0. Thus, the function is an idealization of the limit of straight segments that keep getting smaller as well as denser. We should also remember that nature also has cutoffs at very small, where things are granular like atoms, molecules, etc. Given the slopes at all points, one can construct the function by the envelope of the the set

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of tangents upto a vertical shift.

Derivatives are very important property of a given function. It is the $\tan$ of the angle between the tangent and the x-axis. Tangents with angle θ and $\pi + \theta$ are the same straight line. So it is fine if we restrict ourselves to the range $-\frac{\pi}{2} < \theta < \frac{\pi}{2}$.

If the function is increasing at a point then the angle lies between 0 and $\frac{\pi}{2}$ and the derivative is positive. If the function is decreasing then the angle lies between $-\frac{\pi}{2}$ and 0 and the derivative is negative. And if the function is stationary (neither increasing or decreasing) then the angle is 0 and the derivative is also 0. Knowing all the stationary points of a function tells us the behavior of the function such that, the nature of the function between two consecutive stationary point is monotonic.

For a given function points can be stationary in three ways. If the derivative of a function decreases from a positive value, becomes 0 and then it starts to decrease to negative values, then we have a 'maxima' where the derivative is 0. At the maxima, the function neither increases nor decreases and so in the region between its previous stationary point and the next stationary point, the function attains a maximum value, and is called a local maxima. The highest of all maximas for a bounded function (from above) is called a global maxima. Between the previous and the next stationary point of a maxima, the derivative (rate of change) of the function decreases monotonically. Similarly, if we replace increasing by decreasing and decreasing by increasing in the previous line of argument, then we get a 'minima', and between the preceding and next stationary point the rate of change (derivative) of the function is monotonically increasing.

Finally, there's a third type of stationary point in which the function starts with positive (negative) rate of change (derivative), the derivative becomes 0 and then it starts increasing (decreasing) again to positive (negative) values. Thus, the derivative of a function has a minima (maxima) at this stationary point, which implies that the derivative of the derivative (second derivative) is 0 at this point. Such a point, where the second derivative vanishes(not necessarily the first derivative) is called a 'point of inflection'.

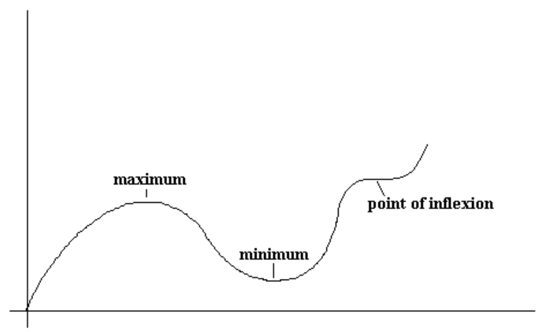


Figure 1: Stationary points

These special points are certain important properties of the function with which we can understand the behavior of the function in the neighbourhood of these points. In fact, at any point, if we know the value of the function, it's derivative, the derivative of it's derivative ad infinitum, then it is possible to construct the function at all points in its domain for which the function is continuous. To see this let us consider the value of the first derivative at a point,

$$f'(x_0) = \lim_{h \to 0} \frac{f(x_0 + h) - f(x_0)}{h} \quad (2)$$

Which can be inverted to obtain the value of the function at a neighbouring point as,

$$f(x_0 + h) = f(x_0) + hf'(x_0) \quad (3)$$

where we have considered the h so small that there is no structure of the function at a smaller level and it can be considered to be a straight line segment without any further loss of accuracy in its value.

Next, let us consider the second derivative of the function,

$$\begin{aligned} f''(x_0) &= \lim_{h\to 0} \frac{f'(x_0+h)-f'(x_0)}{h} \\ &= \lim_{h\to 0} \frac{f(x_0+2h)-2f(x_0+h)+f(x_0)}{h^2} \end{aligned}$$

Keeping in mind the smallness of h, this relationship can be inverted as,

$$\begin{aligned} f(x_0+2h) &= 2f(x_0+h)-f(x_0)+h^2f''(x_0) \\ &= f(x_0)+2hf'(x_0)+h^2f''(x_0) \end{aligned}$$

Thus we have increased the size of neighbourhood in which we have full knowledge of the function to h by using the first derivative and from h to $2h$ by using the second derivative. Let us see what we can achieve by the third derivative.

$$f^{(3)}(x_0) = \lim_{h\to 0} \frac{f''(x_0+h)-f''(x_0)}{h}$$

$$= \lim_{h\to 0} \frac{f'(x_0+2h)-2f'(x_0+h)+f'(x_0)}{h^2}$$

$$= \lim_{h\to 0} \frac{f(x_0+3h)-3f(x_0+2h)+3f(x_0+h)-f(x_0)}{h^3}$$

This can be inverted to increase our interval of knowledge further.

$$\begin{aligned} f(x_0+3h) &= 3f(x_0+2h)-3f(x_0+h) \\ &\quad +f(x_0)+h^3f^{(3)}(x_0) \\ &= f(x_0)+3hf'(x_0) \\ &\quad +3h^2f''(x_0)+h^3f^{(3)}(x_0) \end{aligned}$$

Thus we see that if we know a function and all its derivatives at a given point, then we can expand our domain of knowledge of the function arbitrarily. This suggests that given a ”well behaved function” (smooth at all length scales), the local behaviour, in all its details, determines the global nature of the function in the continuum of the real line. With the help of sufficient data about a particular function, we have learned to analyze all its intricacies in a small neighbourhood around a point. But if we know the local behavior, can we go from there to determine some global properties of the relation.

2. Integration

One global property that is interesting is the length of threads fixed at both ends and show some irregular zig-zag shape in between. If it were stretched into a straight line it would be easy to just use a foot-rule to measure its length. But any other shapes pose a technical difficulty. The best we can probably do is to break the interval between the two endpoints in tiny equidistant spaces, use a straight measure, and keep adding values along the thread starting from one fixed point and ending at another. If the number of steps are N and each step be labelled by an index i then the length,

$$\begin{aligned} l &= dl_1+dl_2+dl_3+\cdots+dl_N \\ &= \sum_{i=1}^{N} dl_i \end{aligned} \tag{4}$$

Notice the relation to the concept of series previously discussed. The new ”sigma-symbol” is just a notation of writing the sum of a series in a compact way. It only means we are adding values of a sequence labelled by integers where they vary from 1 to N. The length of each small part of the thread is preceded by a ”d” because it is a tiny increment of the total length as we proceed from one fixed point towards the other. The tinier the increment at each step the more accurate the result for the total length.

Now let us algebraize the whole process of measurement of length. First let us place the thread on a two dimensional orthogonal coordinate plane. Let the dependent axis be called y-axis and the independent one be called the x-axis. The thread would then represent a function $y = f(x)$ between the two endpoints a and b. We can break up the thread into equi-spaced intervals of x each separated by dx. The length of the thread may now be measured by the formula

$$\begin{aligned} l &= \sum_{a}^{b} dl(x) \\ &= \sum_{x_a}^{x_b} \frac{dl}{dx} dx \end{aligned} \quad (5)$$

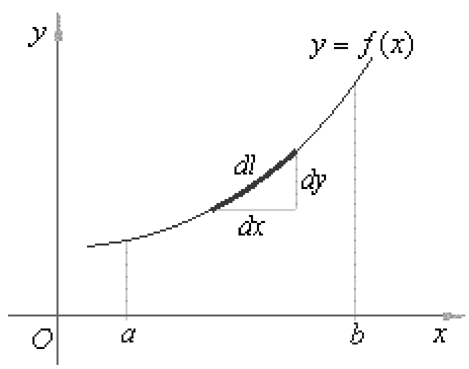


Figure 2: Measuring length through integration

So what is it that we have done. We have found a function $l(x)$ that depends on the independent variable x and if we add up tiny increment of the variable $l(x)$ in a dx-sized interval for each value of x starting at point a and ending at point b, we get the total length of the thread. Are there any errors in this measurement? Well there would be if we were to approximate a small arc with a small straight line, but it is always agreed that any increment of a quantity which is preceded by a "d" is assumed to be tending to zero. And, for any well behaved function, at such tiny levels the small segment is tending to a straight line. For curves such as 'fractals' this may not work and the length becomes infinite, as there is always more curvi-ness even at the tiniest of scales. But for most of the simpler cases in nature our calculus works. A more popular notation which incorporates the fact that the size of the tiny interval is infinitesimal is expressed as,

$$l = \int_{x_a}^{x_b} \frac{dl}{dx} dx \quad (6)$$

The new symbol "$\int$" is just a stretched "S" denoting summation and is called the 'integral', and the process 'integration'. In general, we can ask what be the length of the thread starting from the value of x at a upto the arbitrary value x. This can easily be seen to be,

$$l(x) = \int_{x_a}^{x} \frac{dl}{dx} dx \quad (7)$$

We recollect that given the function $f(x)$ we can obtain its slope at point x by the derivative $\frac{df}{dx}$. Similarly, given the derivative $\frac{df}{dx}$ one can obtain the original function $f(x)$ by the method of integration. Thus, differentiation and integration are inverse operations on a function. The 'integral' at one time was also called the 'anti-derivative'.

As an example it would be good to illustrate how, given a curve expressed by the function $y = f(x)$, we can evaluate its length between two points a and b. The two axes being orthogonal to each other, we can use Pythagoras theorem between the tiny increments dx, dy and dl as the hypotenuse.

$$dl^2 = dx^2 + dy^2 \quad (8)$$

which gives,

$$\frac{dl}{dx} = \sqrt{1 + \left(\frac{dy}{dx}\right)^2} \quad (9)$$

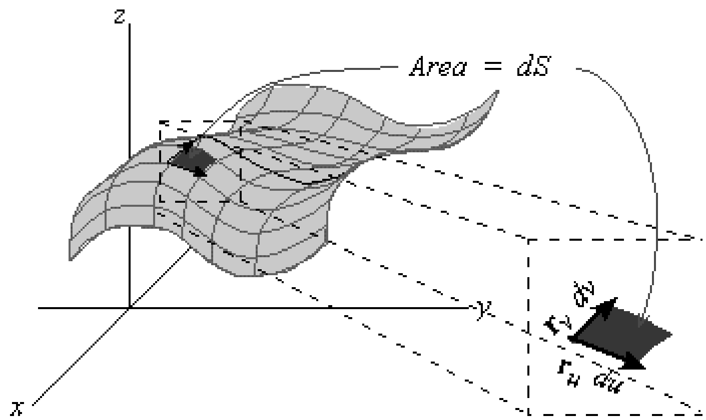


Figure 3: Measurement of Area

Thus, the length may be evaluated as,

$$l = \int_a^b \sqrt{1 + \left(\frac{dy}{dx}\right)^2}\, dx \qquad (10)$$

Finally, a note on the utility of the method of integration on obtaining various global results for mathematical objects. As we found the length of a curve by breaking it into tiny segments and adding it all up, it is possible to obtain area within a 2-d region by breaking it into tiny rectangles or the volume of a 3-d region by breaking it into tiny parallelepiped. Further, science is full of quantities that are the sum of many local fields. For example the 'Work' done by 'Force', 'Flux' of 'Electric and Magnetic Fields', 'Action' of a given 'Lagrangian' and many more. In fact, for every fundamental law of a classical system, there is, in so many cases, integral forms of the same law. It is just a manifestation of the fact that the local behaviour of fields completely determine the global behaviour and vice-versa.

3. Conclusion

New phenomena in nature are usually understood in connection with something that is already known to us. In a lot of cases there is a repetition or universality in there patterns, which appear to be so simple after their discovery. However, prior to it, these phenomena are not at all obvious or trivial. Many a times these discoveries are facilitated by introduction of new mathematics.

Analysis evolved with the need of mathematical precision of various terrestrial and universal phenomenon. However, ever since it's discovery in the 17^{th} century, analysis has not lost its relevance even now. From the simple case of relation between two quantities, it has evolved to include cases or dependence on more than one quantity, quantities embedded in higher dimension spaces, quantities embedded in non-euclidean curved spaces and many more generalizations that reality posed in front of it. However, the basic technique of breaking the problem in to smaller parts and putting it all together still remains the bedrock of analysis. And that is why it is probably the first thing that a mature student learns before embarking on the adventurous journey of science. □

(*End of the series*)

Organizational News

Kerala

Office of the Kerala chapter of Breakthrough Science Society started functioning at Iswara Chandra Vidyasagar Samskarika Kendram, Thiruvananthapuram. This office is expected to emerge as a centre for spearheading the new science movement initiated by Breakthrough Science Society throughout the state with the motto: 'Science for Society, Science for Man, Science in Thinking.

Dr. Soumitro Banerjee, General Secretary, Breakthrough Science Society, formally inaugurated the office on 29th April 2017. Mr. G S Padmakumar, President, BSS, Kerala Chapter, presided over the function. Prof. C P Aravindakshan and Dr.V.Venugopal, both advisors of BSS Kerala chapter, were the other speakers. Prof. Francis K, Vice President, BSS Kerala chapter welcomed the gathering. Dr. T K Shajahan and Mr. P S Gopakumar, both members of state executive committee, also spoke at the function. Dr. Soumitro Banerjee delivered a lecture on 'Science and Scientific Outlook' at the inaugural function.

10 May: One-day science camp and sky observation was organized by *Breakthrough Science Society* at the SNGM Central School, Valamangalam, Turavoor, Cherthala. Sri C Ramachandran, retired Senior Scientist of ISRO, delivered the inaugural address. In the skywatching programme, students viewed the sun and other celestial objects through a Newtonian telescope.

The office inauguration programme on Thiruvananthapuram, Kerala

Madyapradesh

A miracle bursting workshop for volunteers was organized at Christ School, Guna on May 10, 2017 and a miracle bursting program was conducted on May 11 in the school. Shri H N Jatav conducted a discussion on the need to free people from superstitious beliefs.

A state-level workshop was organized on 17-18 June at Gwalior. Dr. Soumitro Banerjee, General Secretary of BSS, was

The Madam Curie memorial programme at NBT Government High school, Hyderabad.

the main speaker. The topics of discussion included different aspects of science, scientific outlook, and the role of science activists in the development of science movement. Around a hundred people from different parts of the state attended the workshop.

Karnataka

The *Breakthrough Science Society* Bangalore city chapter organized an 'Astronomy Day' on May 6. Around 100 people participated.

Andhra Pradesh and Telengana

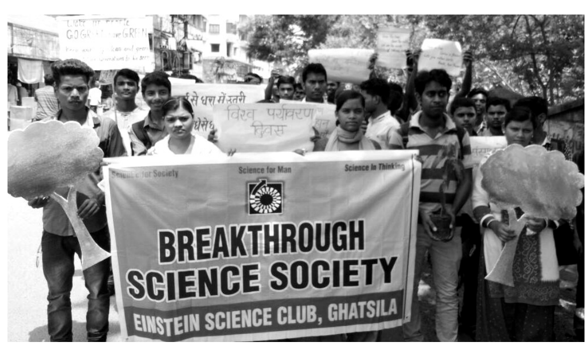
July 1: On the 83rd death anniversary of Madam Curie, a seminar was organized at NBT Government High school at Banjara hills. Addressing the students, Mr P Teja explained about the life struggle and humanism of Madam Curie. School Head Master, Mr D Upender presided.

July 4: Madam Curie Science Club organized a seminar at Indira Priyadarshini College for Girls. The main speaker Ch. Preemela explained about the life and work of Madam Curie. Principal, Dr. P. Durga presided.

July 4 : As part of observance of Madam Curie Day a meeting was held at the free tuition centre in a slum area in Hyderabad. Mr Gangaji and Mr Sathyanarayana Prathibha spoke. About 50 students attended the program.

Jharkhand

June 5: World environment Day was observed at Ghatsila by organising a rally to create awareness about the need to protect environment by taking steps against



The environmental awareness rally at Ghatsila, Jharkhand.

A part of the audience at the Kolkata district workshop.

various kinds of pollution including that caused by excessive use of plastics.

July 4: Madam Curie Day was observed by Einstein Club, Ghatsila, by organizing a seminar.

Tamilnadu

July 4: Madam Curie Day was observed at Aryasamaj Middle School, Vyasarpadi, Chennai. Ms Sugubala S, Member, BSS State Committee presented a lucid description of the life and greatness of Madam Curie. Head Mistress Mrs Amudha presided. A photo-quotation exhibition on the life of Madam Curie was also arranged.

West Bengal

On the 150th birth anniversary of great scientist and humanist Madam Curie, Kolkata District Chapter of *Breakthrough Science Society* organized a Science Workshop on 25th June, 2017 at Maharani Kasiswari College, on ‘Learning Science through Experiment’. The workshop was inaugurated by Prof. Pulak Sengupta, recipient of S S Bhatnagar Award, Professor of Geology Dept., Jadavpur University and was presided by Prof. Dhrubajyoti Mukherjee, INSA scientist, and President of BSS.

The workshop was attended by the more than 200 young learners from different schools. The programme of the workshop included science experiments, exhibition, anti-superstition shows and food adulteration tests. In the evening session Dr. Nilesh Maiti and Sri Subrata Gouri discussed on Madam Curie’s life, and Science and Scientific Outlook. A new Kolkata district committee of BSS was formed with Prof. Debabrata Bera as President and Dr Nirmal Duari and Subhra Prakash Kajli as joint Secretaries.

10 May: A science camp was organised at Howrah Jogesh Chandra Girls High School on the occassion of 150th birth anniversary of Madame Curie. More than hundred students participated in the model exhibition and in learning science through experiments.

5 June: Numerous programmes were organised on the occassion of World Environment Day in different parts of West Bengal. In view of the government’s move to build a nuclear power plant at Haripur in East Midnapur district, BSS West Bengal

State Committee gave a call to observe this day as anti-nuclear day throughout the state by organising seminars, marches and demostrations. At Kanthi a huge cycle rally was organised in protest of the proposed nuclear power plant. A seminar was also organised to educate the people of the areas close to Haripur about the problems of nuclear power plants. In the Kanthi locality, situated close to Haripur, a massive signature campaign has been initiated to build consensus against the proposed nuclear power plant. At Sabang, Tamluk and Behala Chowrasta science rallies were organised on 5 June. At many places plantation programme were initiated by local science clubs. A seminar on “Effects of pesticides and chemicals in agriculture” was organised at Midnapore town.

26 June: The “Chetana Bigyan Sangstha” of the Balurghat town organised a science competition and seminar on the occassion of 150th anniversary of Madame Curie. More than 200 students participated in the day-long programme.

Statement against introduction of Vastu in curriculum:

In a workshop recently organized in Kolkata with the theme ‘Vastu in Global Perspective, it was announced that IIT Kharagpur is going to introduce vastushastra in the undergraduate and postgraduate programs in Architecture. Topics like sacred diagrams, 9 circuit placements or the nabagraha mandal, sacred altars, etc., will be taught, and the students will be asked to do projects and assignments on these topics.

The recent issue of a journal published by the ‘Ranbir and Chitra Gupta School of Infrastructure Design and Management’, IIT Kharagpur, advised people to follow vastu practices in day to day life—like keeping idols of ‘Hanuman’ and ‘Ganesha’ in front of the house. An article titled "A to Z of Vastu Vidya" by Prof. Joy Sen claims that these idols can protect us from "evil powers"!

Professor Amitabha Datta, President of Breakthrough Science Society West Bengal Chapter issued a statement in response to the news item published in newspapers.

"We believe that the curricula in all academic institutions should contain only those material which have been arrived at through thorough investigation, and are well tested following scientific procedures" he said. "Through which research work have the utility of 'sacred diagrams', 'sacred altars', or 'nabagraha mandal' been tested, and the character of 'evil powers' identified?" he demanded. "It is highly objectionable to introduce untested beliefs into academic curricula because the students will be marked on the basis of their adherence to these beliefs."

The statement further said "In science it is an established practice to publish articles only after a thorough 'peer review' process in which other scientists check if the content of a paper have been obtained through proper scientific investigation. It is clear that this journal has violated this practice and has published articles that are based on untested beliefs. We strongly protest against such attempts to propagate unscientific beliefs and superstitions through a journal published by a prestigious Institute, and demand that the journal should immediately be withdrawn from circulation. This is not an isolated incident. We are now witnessing a concerted effort to infuse unscientific, mythical beliefs into the common peoples' minds in the name of science. We appeal to the science-loving people of the country and particularly the members of the IIT community to protest against the move and to stop the introduction vastu in the syllabus."