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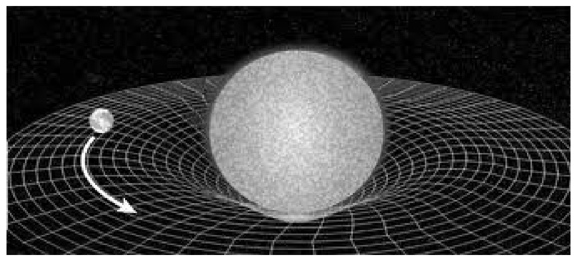
100 Years of Einstein's General Theory of Relativity

George Joseph*

In November 1915, Albert Einstein published his path-breaking discovery of the General Theory of Relativity that completely changed the way we look at the Universe. For most people, including many among the scientific community, the outcome of his theory was then something resembling science fiction. Even today it continues to be something esoteric. But it is no longer fiction because the theory has been tested again and again in the last hundred years.

What is the theory of relativity? In 1905, sitting in the patent office in Bern, Einstein formulated his Special Theory of Relativity (STR) which abolished the absolute and independent characters of space and time. From the premise that the velocity of light is a constant, he formulated the equations that characterise the relativity of space and time with reference to uniform motion. The conclusion is that matter exists in a four dimensional space-time continuum, three dimensions in space and the fourth one in time. The STR was related to uniform motion at constant speed. But in nature things are not in uniform motion, but undergo acceleration. How the space-time would look under the influence of acceleration or gravity was an uphill task. Einstein grappled with it for ten long years before he came up with the General Theory of Relativity (GTR) that describes gravity as the geometry of space time or in other words



the curvature of space time. For example the Earth goes around the sun because the mass of sun curves the space-time around it (see illustration above).

The theory and its corollaries may appear weird, but it has been proved again and again. The first time it was successfully tested was during the total solar eclipse of 1919. According to the theory, when light travels past a massive object like the sun, it should bend as per the curvature of space-time around sun. During total solar eclipse the apparent shift in the positions of stars behind the sun was measured and they agreed well with the predictions of the GTR. The latest proof of the GTR is the accuracy of the GPS system in the smart phones and other devices that people use nowadays. If the relativistic corrections are not made for the time measurements on the satellites, your GPS position would be off by several miles.

The world celebrates the centenary of this great achievement this year through numerous seminars and events worldwide.

*George Joseph is the Convenor, Tamil Nadu Chapter of *Breakthrough Science Society* .

Drastic fund cuts for our scientific Institutions

Uma Ramachandran*

End of October 2015, major daily newspapers carried the alarming announcement of our Ministry of Science and Technology headed by Dr. Harsh Vardhan, that funds for our scientific research institutes administered by the Council of Scientific and Industrial Research (CSIR) will be cut by more than fifty percent.

Among the developing countries, India could boast of a large body of scientific personnel. Its apex body, the Council of Scientific and Industrial Research has 38 national research laboratories spread all across our country. It is a deemed university and is the major funding agency for academic-based research projects. Over the years, it has successfully developed many technologies and trained a lot of scientists. By funding most of the research grants run under university based settings, it has played a crucial role in maintaining some standard in our higher education. Cutting its fund will be a great blow for our aspirations to see scientifically well trained citizens who can spread scientific temper in their community as well as help in developing new cutting-edge technologies.

CSIR has seen a lot of ups and downs; unfortunately more of downs of late. The quality of research has steady fallen. Many of the institutes under it (almost one-third of them at one point) were without a permanent head or director for long periods of time. CSIR itself is currently having an ad-hoc director. Many are still functioning with just in-charges who need to only do some 'fire-fighting' activities. Besides, many top posts have remained unfilled. We seem to lack the political-will to see that these premier institutes get permanent and competent leaders who can put them back on track and get them functioning efficiently with proper focus. Instead, we see that the Government has incapacitated them further by cutting its funds.

In June of this year, the 'Dehradun Declaration' stated that CSIR Laboratories have to work towards self-financing their research activities. It also asked them to invest their revenues to develop new technologies to support Modi's national missions like Swachh Bharath, Swasth Bharath, Skill India, Smart Cities, Digital India, Namami Ganga, etc. They have been asked to work in a business-like manner and develop industry-driven technologies.

What happens to the on-going projects? Many are to be wound up or reformulated due to inadequate funds. Most of the 'planned funds' (almost 60%) will go towards paying salaries of the staff and the electricity bills of all the institutes leaving very less for research activities. What about basic research? Who will fund it? Surely not the industries; they are looking for quick results and workable technology transfers. Most may not be willing to wait for an incubation time of over 3 years. The atmosphere for innovation is negatively impacted. Ironically the current mission statement of CSIR stresses on Innovation!

*Dr. Ramachandran is former Professor, National Institute of Pharmaceutical Education and Research (NIPER), Mohali

Commentary

Many wise countries set aside a significant portion of their GDP for basic research and for health care research.

This decision of our Government to slash funds for research organizations like CSIR, DST, DBT and ICMR comes at the time when other grave issues are surfacing. Many tall claims have been voiced by our political leaders including our Prime Minister on the so called scientific 'discoveries' made during the Vedic period. For the first time a whole session of the Indian Science Congress was hijacked by pseudo-scientists who claimed that during the Vedic period we had interplanetary flight vehicles among other things. Many rational voices of dissent are being muzzled; some prominent rationalists have been killed in broad daylight. Protesting against the growing climate of intolerance, many prominent scientists have stood up. Some have returned their national awards as a mark of their protest.

Globally, all these are highly embarrassing to our country's image especially to our scientists. The respected scientific journal *Nature* has slammed the Modi Government for poor performance in Science and Technology. In a special issue on India, it highlighted various problems plaguing Indian science of late: inadequate funding, leadership vacancies in research laboratories and curbing dissenting voices. Mr. Narendra Modi promised to cut red tape in the area of science administration but there has been no change at the ground level. In fact, it states that 'bureaucratic morass is impeding research and innovation.' It further goes on to observe the Government's move to silence dissent particularly critics of its policies on energy, climate and human rights.

The impact on healthcare sector has been even more damaging. For the first time, India's prime research grant agencies, including the Department of Biotechnology (DBT) and the Indian Council of Medical Research (ICMR) have either cut financial assistance by half or have stopped funding for want of money. According to sources, various projects (like the anti-HIV project to name one) which were already approved in the 12th five year plan, are now left in the lurch. As for its research commitments, hopes of millions waiting for breakthroughs in fields like drug resistant TB and age-related macular degeneration, among others may be dashed. Research in the field of public health has also been severely affected by cuts in working grants. There is already a huge shortage of quality primary healthcare centres. The good work done by our scientists in eradicating polio, in stemming the tide of some infective diseases and in manufacturing drugs efficiently to make them the cheapest in the world will all be reversed.

In conclusion it seems that science is being treated as a stepchild by the government. It seems that the present political leadership of the country is not interested in promoting science. Hence CSIR will have little to celebrate when it will be observing its Platinum Jubilee in September 2016.

Statements by Scientists and Historians

In the past couple of months the country has seen an outrage against growing communal intolerance as reflected in the writers, artistes and scientists returning their awards. Leading scientists and historians have also issued collective statements against the growth of communal frenzy and the propagation of unscientific views and superstitions. Here we publish a few such statements and petitions.

Statement by the Inter Academy Panel on Ethics in Science [1]

27 October 2015: When we became an independent republic, our founding fathers adopted the Constitution of India which demands that its citizens abide by and uphold reason and scientific temper. Scientific temper encompasses rationality, rights and responsibility in equal measure.

It crystallizes what Tagore wanted India to be, namely, a nation

Where knowledge is free;
Where the world has not been broken up into fragments by narrow domestic walls;
Where words come out from the depth of truth;
Where tireless striving stretches its arms towards perfection;
Where the clear stream of reason has not lost its way into the dreary desert sand of dead habit;
Where the mind is led forward by thee into ever-widening thought and action;
Into that heaven of freedom
Let my country awake.

Yet, we note with sadness and growing anxiety several of statements and actions which run counter to this constitutional requirement of every citizen of India. It is important that exemplary punishment be given to such trespassers of reason and rights. We also appeal to all sections of Indian society to raise their voices against such violated acts, so that they are nipped in the bud.

[1] This panel is constituted jointly by three science academies, namely, Indian National Science Academy, Indian Academy of Sciences and National Academy of Sciences, India

Two Statements by Scientists

Statement-1

The scientific community is deeply concerned with the climate of intolerance, and the ways in which science and reason are being eroded in the country.

It is the same climate of intolerance, and rejection of reason that has led to the lynching in Dadri of Mohammad Akhlaq Saifi and the assassinations of Prof. Kalburgi, Dr. Narendra Dabholkar and Shri Govind Pansare. All three fought against superstition and obscurantism to build a scientific temper in our society. Prof. Kalburgi was a renowned scholar and an authority on the Vachana literature associated with the 12th-century reformer Basava, who opposed institutionalised religion, caste and gender discrimination. Similarly, Dr. Dabholkar and Shri Pansare promoted scientific temper through their fight against superstition and blind faith.

The Indian Constitution in Article 51 A (h) demands, as a part of the fundamental duties of the citizens, that we '··· develop the scientific temper, humanism and the spirit of inquiry and reform'. Unfortunately, what we are witnessing instead is the active promotion of irrational and sectarian thought by important functionaries of the government. The Indian civilization is a truly plural one. We have always had many practices and communities that have allowed space for each other; we celebrate the festivals and anniversaries of all faiths. This unity and peace has now been disturbed by a rash of bigoted acts, attacks on minorities and Dalits, which show no signs of abating.

The writers have shown the way with their protests. We scientists now join our voices to theirs, to assert that the Indian people will not accept such attacks on reason, science and our plural culture. We reject the destructive narrow view of India that seeks to dictate what people will wear, think, eat and who they will love.

We appeal to all other sections of society to raise their voice against the assault on reason and scientific temper we are witnessing in India today. This signature campaign is on behalf of Indian scientists. The institutional affiliations given here is only for information as the scientists have signed in their individual capacity.

Statement-2

Stop the spread of communal hatred and polarization in the society

Indian civilisation is a truly plural one which unifies faiths and distils the wisdom of many streams of thought. There have been many practices and communities that have allowed space for each other and have lived together in peace and harmony for centuries. We celebrate the festivals and anniversaries of all faiths. This unifying threading of social and cultural fibre brings to bear the greatest civilisation strength and stability. It is this which is being threatened by a rash of sectarian and bigoted acts that have recently escalated.

A highly polarised community is like a nuclear bomb close to criticality. It can explode any time and drive the nation to utter chaos. This is a highly unstable atmosphere and we should do everything in our hands to defuse the disparity, and enlighten society in scientific spirit.

The literature fraternity is the first to act and return their awards in protest against the current events. The scientific community however seems to remain passive. But scientists are also part of society and it is times like this that call upon them to be conscientious citizens and voice their concern. This is to start a campaign for Scientists in India to wake up and and make a statement. This may be followed by stronger actions akin to the award winners of Sahitya Akademi.

In a fractured world, we have to keep the plural faith that defines our civilisation. As true adherents of science and its method, it is also our duty to help people at large to take informed and rational decisions, and particularly so in these volatile times. This is an ethical issue of great concern and import—a dharma—as enunciated by Buddha and Gandhi, and the question is how well we measure up to it. On the 100th anniversary of Einstein's General Relativity—one of the greatest feats of human thought, let's also pay fitting tribute to the exceptional man who stood for ethical and societal values and peace by speaking out for peace and harmony.

This is an appeal to the government to act swiftly to stop this mayhem which is victimising innocent people for eating beef, sensible people for being against superstition, RTI activists or whistle blowers and many more innocent people with human values. It is not just victimising innocent and enlightened people but killing them.

This is totally unacceptable. The strictest action must be taken against any such anti-human, anti-civilisational acts and any-one even suggesting such actions must be severely dealt with punishment beyond that reserved for anti-national activity as this is truly worse than that.

We strongly condemn the atrocities and join the protest of litterateurs in awakening people and the central and state governments to the dangers of not acting.

Statement by historians

October 26, 2015: Concerned about the highly vitiated atmosphere prevailing in the country, characterised by various forms of intolerance, we, as academic historians and as responsible citizens of a democracy that has greatly valued its inherited traditions of tolerance, wish to express our anguish and protest about the prevailing condition.

Differences of opinion are being sought to be settled by using physical violence. Arguments are met not with counterarguments but with bullets. When a poor man is suspected to have kept a food item that certain sections do not approve of, his fate is nothing short of death by lynching. At the launch of a book whose author happens to be from a country disapproved of by certain groups, the organiser is disfigured with ink thrown on his face. And when it is hoped that the Head of Government will make a statement about improving the prevailing conditions, he chooses to speak only about general poverty; and it takes the Head of the State to make the required reassuring statement, not once but twice. When writer after writer is returning their award of recognition in protest, no comment is made about the conditions that caused the protest; instead the Ministers call it a paper revolution and advise the writers to stop writing. This is as good as saying that intellectuals will be silenced if they protest.

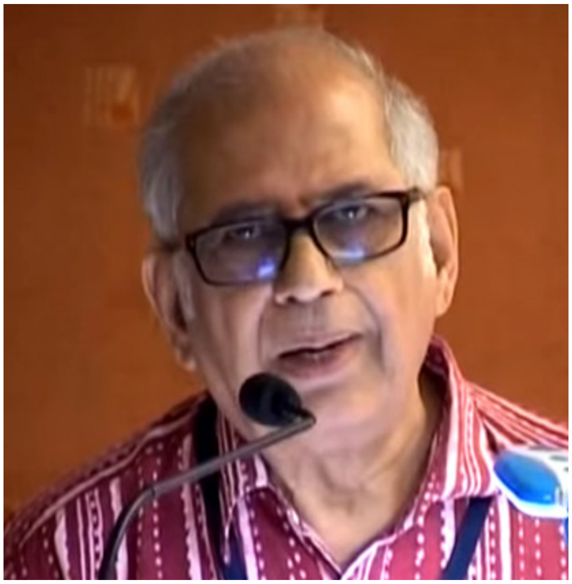
This is particularly worrying for us as historians as we have already experienced attempts to ban our books and expunge statements of history despite the fact that they are supported by sources and the interpretation is transparent. What the regime seems to want is a kind of legislated history, a manufactured image of the past, glorifying certain aspects of it and denigrating others, without any regard for chronology, sources or methods of enquiry that are the building blocks of the edifice of history.

We would, therefore, urge the state to ensure an atmosphere that is conducive to free and fearless expression, security for all sections of society and the safeguarding of the values and traditions of plurality that India had always cherished in the past.

It is easy to trample them down, but it is important to remember that it will take too long and will be beyond the capacity of those who are currently at the helm of affairs to rebuild it once it is destroyed.

Open letter to Indian authorities from historians and social scientists of India at academic institutions overseas

November 8, 2015: On October 26, a group of distinguished Indian historians issued a statement of concern about the damage being done in the current political climate to the traditions of tolerance, and freedom of speech, belief and practices, for which India was long applauded. We — historians and social scientists engaged in researching and teaching about the richness of Indian history and society in different locations overseas — write to express our solidarity with their statement. We share the deep concern over recent happenings in



Noted scientist and the founder of the Centre for Cellular and Molecular Biology in Hyderabad, Prof. Pushpa M. Bhargava, has returned his Padma Bhushan Award received in 1986 to protest against the growing intolerance in the nation and curtailment of freedom of the citizens. He decided to return the award to protest against “the government’s attack on rationalism, reasoning and science” and hoped that scientists, especially young ones, “too will will raise their voice.”

India, which are affecting freedom of artistic expression and historical and social science inquiry, and serving to produce a dangerously pervasive atmosphere of narrowness, intolerance and bigotry.

Currently reigning political attitudes and actions have seriously harmed the tradition of critical inquiry into the condition of India’s past and present that undergirded the country’s reputation of tolerance and democracy. Irresponsible statements by political leaders, declaring that India is finally free from eight hundred or one thousand years of slavery, and that the glory of the Hindu nation will shine anew, are creating a sense of fear among millions of citizens now being defined as outsiders. What the present regime seems to be promoting, as our colleagues in India note, is a legislated account of the past, glorifying a homogenized and inflexible “Hindu” tradition. This denies the very inheritance that made the tradition exceptional: ongoing debate, a remarkable range of accepted beliefs and practices, and the necessity of change over time. Such a monolithic and flattened view of India’s history is not supported by the sources, or by any serious historical inquiry.

It is a sad commentary on proclaimed traditions of tolerance and democracy that a family or individual can be lynched or burnt alive for an alleged social transgression (whether this be the eating of particular kinds of meat, or the forging of social relations across certain caste barriers) — without any formal charges being brought, let alone a trial being held in court. And that well-known and respected scholars can be killed for their intellectual opinions, research and writing because these do not fit with a particular political groups view of the“real” history or condition of India.

What makes the situation worse is that the Prime Minister and leaders of government have not felt it necessary to speak out promptly and strongly against these acts of criminal violence. With our colleagues in India, we urge the President, Prime Minister and central government, the Governors and Ministers of different state governments, and the Chief Justice and other Justices of the Supreme Court and High Courts, to uphold the law and the constitution, allowing free and fearless expression of views, ensuring security for all sections of society, and safeguarding the values and traditions of plurality that India has long cherished.

Letter from Prof. J. V. Narlikar to the President of India

Hon'ble Shri Mukherjee

You have been getting letters and petitions from various intellectual groups, scientists, literary persons, etc. reflecting their anguish at the present state of intolerance of freedom of expression. I beg to add my own concern to the issues involved.

At the time of independence, India opted to be a secular democracy which was the right decision in view of its long history of tolerance of different ideas, sectarian views, religious differences, etc. While there have been glitches in the past on some occasions, the overall impression of 'unity amongst diversity' held sway. Some of the recent events have, however, raised deep concerns as to whether the spirit of tolerance is under threat.

Some intellectuals have responded by returning their awards to express their dismay at the lack of action by the Government of India. I have not taken that extreme action and my rationale (which appeared in a few newspapers) is given in the attached sheet for your ready reference. Nevertheless I do share the general concern mentioned above and hope that a statement at the highest level accompanied by reassuring action will come before long.

With kind regards,
Yours sincerely,
Jayant Narlikar

Statement by BSS Karnataka Chapter

4 October 2015: It is shocking to read that Sri K. V. Dhananjay, legal counsel, Karnataka Unaided Schools Management Association (KUSMA) has stated that Darwin's theory of evolution is unscientific and that the association will move the Union and State Governments to remove it from school text books.

The scientific validity of Darwin's theory of evolution is an established fact that has withstood the critical scrutiny of biologists and scientists across the world for over a century. The world has moved ahead since the time of Darwin and evolutionary biologists are providing further evidence for evolution enriching the theory.

Sri K.V. Dhananjaya has not offered any contrary evidence to demonstrate that Darwin's theory of evolution is unscientific. Breakthrough Science Society (BSS) strongly condemns this statement and the alleged efforts by KUSMA which are detrimental to the cause of science and a healthy society. We would earnestly urge the parents — who send their children to unaided schools overwhelmingly — that their children's conceptual capabilities would be at risk if such reckless utterances by a person of the stature of the legal counsel of KUSMA are not met with the resistance that it truly deserves. It is also not clear how the teaching of the theory of evolution violates the constitutional rights of students as unlike many other disciplines, science thrives on criticism and argument and therefore any theory can be challenged if one can substantiate the criticism with facts. On the contrary to the contention of Mr. Dhananjay, the teaching of evolution therefore is very much within the framework of the constitution.

We would strive to evolve a strong public opinion in defense of Darwin's theory of evolution involving the scientific community, teachers, professionals, students and science-loving people. At the same time, we demand KUSMA to offer an explanation over this imbroglio that has been needlessly created and clarify whether or not KUSMA distances itself from and condemns this statement.

Satish. K. G., Convenor, State Unit, BSS

Materialist Philosophy in Ancient India – Part II

Subrata Gouri *

The Samkhya System

The *Samkhya* ideas were very old and their influence quite extensive. It is believed to be as old as the *Vedas*, may be even older than them. The epic *Mahabharata*, the medical treatise *Charaka-Samhita*, the law-book *Manusmriti* and the mythological Puranas, in so far as they touched upon philosophical topics at all, were as Garbe says, 'saturated with the doctrines of the *Samkhya*' [1]. Like *Lokayata* the original treatise of the *Adi Samkhya* is believed to be lost. For example, a certain ancient treatise on the system called the *Sasthitantra* is believed to have once existed. We have found reference of this treatise in *Isvarkrisna's Samkhya Karika*. But it is lost to us.

Tradition attributed it to *Kapila*, but made the case quite confounding by also attributing to him a wide range of conflicting myths. Nevertheless this system is often termed as *Kapila's darsana*. As I have already mentioned, the older version of it is not available now. What we are concretely left with are only two treatises claiming to expound the *Samkhya* views. These are the *Samkhya Karika* and *Samkhya Sutra*. The former was attributed to a certain *Isvarkrishna* who Garbe thinks probably lived around 500 AD. The latter was spuriously attributed to Kapila himself, because the actual date of this work is considered to be somewhere around AD 1400. Yet the *Samkhya* as we have just said must have been very old. It was declared by the *Mahabharata* itself to be eternal. Garbe and H.P. Sastri argue that it must have been before Buddha [2,3]. But it is doubtful how far the philosophy was preserved in its original form in the *Samkhya-Sutra* and even in *Samkhya karika*. In the *Samkhya-Sutra* as Garbe rightly points out, 'The *Samkhya* doctrine no longer appeared in its original unadulterated form; for they (i.e., the *Sutras*) seek to explain away the discrepancy between themselves on the one hand and the teachings of *Upanishads* and the Vedanta on the other.' [4] The writers of the later period made it an idealist philosophy.

But deeper study of the fragmentary materials available on *Samkhya* and the information brought out from '*Purvapaksha*' by other schools of philosophy clearly showed that originally it was a consistently materialist philosophy.

We may begin with some idea of the philosophy. It not only rejected the *Brahman* (the consciousness), the only valid truth according to the Vedanta, but emphatically denied the existence of God. The method of study was quite rationalistic. As the *karika* said, the cause of the world was to be inferred from the nature of the effect. Accordingly an effort was made to understand the nature of causality and make it the starting point of the philosophy. This view of causality was called the *Satkarya-vada* or *Parinama-vada* i.e., the doctrine that the effect was only a modification of the cause. What was found in the effect was contained

*The author is a member of the all-India Secretariat of *Breakthrough Science Society* and one of the Vice-Presidents of the West Bengal Chapter.

in the cause. Such a view of causality was argued evidently on the basis of everyday observations. If the effect was something entirely new and not what was already contained in the cause, then anything could be produced from anything—e.g., the *Sali* crop could be produced from the *Vrihi*-seeds and the *Vrihi*-crops from the *Sali*-seeds. But since the *Sali* seeds can produce only the *Sali* crops it had to be admitted that these were already contained in the *Sali* seeds. Besides if the effect was really non-existent before being produced, then it could never have arisen at all, for how could the non-existent ever come to being? Of course, as pre-existing in the cause, the effect was only potential, nevertheless the two were essentially the same in the sense of being the implicit and explicit states of the same thing.

It followed therefore that the essential character of the effect contained the clue to the essential character of the cause. What then was the essential character of the world, whose cause was sought to be established? Since, argued the *Samkhya* philosophers, the world was essentially material, its cause too must have been so. The cause thus inferred was called *Prakriti* or *Pradhana*, the primeval matter. It was not matter in its gross or explicit forms, i.e., the form in which the world was perceived. But it was matter in its subtle and potential form which, because of its subtlety, could not be directly perceived, but the essential materiality of which was clearly inferred. The *Samkhya* terminology for this primeval matter in its original state, i.e., in the state prior to its being evolved into the visible material world, was *avyakta* or the un-manifest, conceived as formless and undifferentiated, limitless and ubiquitous.

How was the composition of this primeval matter to be understood? The *Samkhya* answer was that it was to be understood exactly in the manner in which its existence had been inferred. In the *Samkhya* view everything in the material world was an unstable composition of three kinds of substances or reals, technically called the *gunas*, though in the composition of the different objects of the world, one or other of the *gunas* predominated. These three were called (1) *Sattva*, exhibiting qualities of lightness, illumination and joy, (2) *rajas*, exhibiting qualities of movement, excitation and pain and (3) *tamas*, exhibiting qualities of heaviness, obstruction and sloth. The primeval matter was accordingly conceived as composed of these three constituents. This conception of three *gunas* may not definitely conform to our modern ideas. This much is certain, however, that as constituents of primeval matter these were essentially material. *Sattva* was that aspect of the primeval matter which contained the potential for intelligence, *rajas* for energy and *tamas* for mass or inertia. In the *avyakta* state of the *Prakriti*, these formed a stable equilibrium. A loss of this equilibrium was somehow conceived as the starting point of the evolution of the world from the *avyakta*; but it is not quite clear how exactly the cause of this loss of equilibrium was conceived. As a result of disturbance of this condition of equilibrium the material universe is evolved. We had, at any rate, in the *Samkhya* a systematic effort to understand this process of evolution. 'This system', says the eminent 18th century scholar Brajendra Nath Seal, 'possesses a unique interest in the history of thought as embodying the earliest clear and comprehensive account of the process of cosmic evolution.' [5]

In the *Samkhya* terminology the process of evolution was as follows: From the disturbed equilibrium of the *avyakta* first arose the *mahat* or *buddhi*. *Mahat* meant the great, *buddhi*, the intelligence. From that, the *mahatahamkara*—the sense of the ego. From *ahamkara* arose (1) the *manas* or mind, (2) the five *jnanendriyas* or sense organs, (3) the five *karmendriyas* or motor-organs, and (4) the five *tanmatras* or subtle elements which, in the *Samkhya* view, were conceived as ultimately giving rise to the five well known gross elements or *mahabhutas*, namely earth, water, fire, air, and *akasa* or the empty space.

The detailed description of the process of evolution had created some confusion and controversies. It appears to be particularly odd that *ahamkara*, ordinarily understood as the ego-consciousness, should be given such a position in this scheme of evolution. One naturally feels like asking, did it actually mean the same thing in the original *Samkhya* as it does today? Some of the modern scholars give us the impression of quietly accepting the entire scheme without raising any question about the details; others discover in the details outstanding contributions to scientific thought. Whatever may be the decisive importance of *Samkhya* was the conception of matter in eternal motion. Upholding the materialist explanation of evolution by *Samkhya,* the famous Russian Indologist Stcherbatsky said, “the idea of an eternal Matter which is never at rest, always evolving from one form to another, is a very strong point of the system and it does credit to the philosophers of that school, that they at so early a date in the history of human thought so clearly formulated an idea of eternal Matter which is never at rest.” [6] “This Matter”, says Stcherbarsky, “embraces not only the human body, but all our mental state as well, they are given a materialistic origin and essence.” [6] The *Samkhya* also made *sattva* or the intelligence potential as one of the constituents of the *prakriti* and conceived *buddhi, manas* and the *ahamkara* as the products of this primeval matter. Here we have found a concept, which makes matter primary and spirit secondary. Understood from this point of view, the *Samkhya* contained serious potential for a materialistic philosophy. It was no wonder therefore that *Samkara*, one of the main proponents of idealism in our country, persistently characterized it as but *achetankarana-vada*, the doctrine of unconscious first cause; and looked upon it as his main philosophical rival, the *pradhana-malla*.

At the same time, there is a difficulty related to this philosophy. At least from the *Samkhya-karika* onwards, the philosophy admitted over and above the *Prakriti*, a multiplicity or what were called the *purusas*, generally understood as the souls. This made it vulnerable to easy criticism, i.e., here lies a scope for slipping to idealism. But a critical study of the earlier version of this philosophy shows that this concept was incorporated at a later period. Not only that the concept of *Purusas*, as it is understood today clearly shows that its role is secondary, i.e., *apradhana*. The main (i.e., *pradhana*) cause is *Prakriti*. So the *Brahma-Sutra* understood *Samkhya* as *pradhana-vada* or as *pradhana-karan-vada* i.e., the doctrine of the principal matter being the first cause. Many writers believe that the concept of *Purusas* was not present in the ancient version of *Samkhya*. As Prof. Dasgupta pointed out the concept of *Samkhya* present in *Charaka-Samhita* represents the older version, which tells that the Purusas were originated from the prakriti itself i.e., the conscious matter originated from the unconscious matter. [7]

Lastly, let us see how did idealists view *Samkhya*. There is no doubt that the earliest of our idealists viewed the *Samkhya* as being the strongest of their philosophical rivals and they did this clearly because they were apprehensive of its materialist implications. The first systematic expression of this was made in the *Brahma-sutras*. No less than sixty aphorisms in it were clearly designed to refute the *Samkhya*, whereas forty three in all were directed against the other rival philosophies. After elaborately refuting the *Samkhya* doctrine, the author claimed that therefore all other rival theories were virtually refuted. Shankara explained it thus: 'that by the conquest of the most dangerous adversary (*Pradhanamalla*, literally, the chief opposing wrestler) the conquest of the minor enemies is already virtually accomplished.' But why did the *Brahma-sutra* look upon the *Samkhya* as the most important challenge to the *Vedanta*? The answer is clear. It understood the Samkhya as *Pradhan-vada* or *pradhana-karan-vada*, i.e., the doctrine of the primeval matter being the first cause, while the Vedanta was *brahma-vada* or *brahma-karan-vada* i.e., the doctrine of *Brahman*, as something essentially conscious, being the first cause. It was thus, above all, a controversy between *acetana-karan-vada* and *Cetan-karan-vada* i.e., between the doctrine of the first cause being the unconscious matter and the doctrine of the first cause being the unconscious matter and the doctrine of the first cause being spirit or consciousness. That was why, after explaining in the first four *sutras* certain fundamental points about the nature of the *Brahman* and that of the *Vedanta* texts, the author of the *Brahma-sutra* immediately hastened to explain in course of the next seven *sutras* that this *Brahman* was a principle of consciousness or an intelligent principle and as such was to be clearly distinguished from the *pradhana* of the *Samkhya*, which, being unconscious or material, could not be the cause of the world.

Judging from the evidences cited above can there be any doubt of the materialist leaning of the older version of *Samkhya*? However, under the influence of the Vedantic Philosophy, the Vedantic commentators of the *Samkhya* like Goudapada and Vacaspati Misra had tried to make it spiritualistic in the later period.

The Nyaya-Vaisesika

From their earliest phases, the *Nyaya* and *Vaisesika* systems were closely related and in course of time the two were actually amalgamated. Hence the two are usually treated under the joint name of *Nyaya-Vaisesika*.

The source books of these systems, viz. the *Nyaya-Sutra* and the *Vaisesika-Sutra* were attributed to Gotama (Goutama) and Kanada respectively. Nothing historical is known of either and the periods of writing of these *Sutras* are conjectural. According to the Indologist Jacobi, these could have been redacted between 200 A.D. and 400 A.D. But unlike the *Samkhya* and *Mimamsa*, the actual origin of these two philosophies need not be traced to any great antiquity, for there is no tradition like that. On the contrary, the distinctive features of these two systems were quite new in the Indian philosophical tradition and presumably both took shape sometime around 300 or 200 B.C.

The system starts with the postulate that all knowledge by its very nature points to an object beyond it and independent of it. In defence of this position the *Nyaya-Vaisesikas*, beginning with Gotama, had to wage a relentless war against philosophical idealism. Moreover, since, the idealist's position amounted to the assertion that all knowledge—or at any rate, all empirical knowledge—was inherently false, the *Nyaya-Vaisesikas*, along with the *Mimamsakas* had to take a determined stand against this position. Already, the *Nyaya-Sutra* refuted the view that valid knowledge (*prama*) was an impossibility and the later exponents of the system took up the task of building up a positive theory of validity and invalidity of knowledge. They developed the theory of extrinsic validity and extrinsic invalidity (*paratahpramanya* and *paratahapramanya*). According to this, knowledge by itself is neither true or false; both its validity and invalidity depend upon and are determined by conditions different from those that produced the knowledge itself. Thus, a knowledge became valid not because of the conditions that produced the knowledge itself, but because of the additional condition called 'excellence' or *gunas*. Similarly, it could be invalid because of the additional condition called defect or *dosha*. How far these positions could be maintained with regard to all forms of knowledge was of course a different question. With regard to the knowledge derived from verbal testimony the position was quiet clear, because the validity of such a knowledge could be dependent upon the additional factor called the trustworthiness of such a person. But that the same was not so obviously true with regard to the perceptual and inferential knowledge could not be so easily pointed out. In spite of this difficulty, however, there is no doubt that the *Nyaya-Vaisesikas* developed a really revolutionary theory with regard to the question of the assertion, i.e., the criterion of determining the truth or falsity of a knowledge.

How was one to get knowledge? How was one to know that a particular knowledge was true or false? What was the test of the truth? The *Nyaya-Vaisesikas* answered that there was only one such test and that was practice. A knowledge could be ascertained to be true or false only after putting it to the test of practical life. If in practice it led to a successful result, it was to be accepted as true. If, on the other hand, it failed to lead a practical success, it was to be discarded as false. Thus, e.g., the knowledge of water in a mirage was false because it could not lead one to quench thirst; the knowledge of water in a pool was true because it could actually lead to the quenching of thirst. This was one of the most significant ideas developed in our philosophy and it closely resembled the modern scientific idea of practice being the criterion of truth.

With their fundamental postulate of the essentially objective and real existence of the world, the *Nyaya-Vaisesikas* proceeded to develop a rational explanation of it. This led them to their theory of *padarthas*. A padartha was defined as a knowable or valid and cognizable thing. The scheme of the *padarthas* thus represented an effort to arrive at a satisfactory classification of all knowable and namable things. Kanada himself mentioned six *padarthas* or broad categories under which everything known could be classified. These were (1) substance (*dravya*), (2) quality (*guna*), (3) activity (*karma*), (4) universal (*samanya*), (5) particularity (*visesa*), (6) the relation of inherence (*samavaya*). Later the *Nyaya-Vaisesikas*, however, added a seventh to this list and called it *abhava*, or non-existence.

Of these the most important was substance or *dravya*. Substances were conceived as nine in number, viz. (1) earth (*prithvi*), (2) water (*ap*), (3) fire (*teja*), (4) air (*vayu*), (5) sky (*akasa*), (6) time (*kala*), (7) space (*dik*), (8) self (*atman*), (9) mind (*manas*). The first five were called *bhutas*, i.e., substances having some specific quality that could be perceived by one or other of the external senses. These sensory qualities were odour, flavour, colour, touch and sound. It was further maintained that of these qualities the earth possessed the first four, water the second, third and fourth; fire the third and fourth; air the fourth only; akasa only the fifth. But the first four of these *bhutas* differed from the fifth in an important respect. We may understand this better if we begin with the conception of *akasa*. It was arrived at by trying to solve the problem of sound. Sound is neither a substance nor an action. As such it was a quality. But if it was a quality, it had to be the quality of some substance. This substance was *akasa*. It was partless and all pervasive. But the first four *bhutas* i.e., earth etc., were conceived in two varieties, called eternal and non-eternal. By the eternal variety of earth etc. was meant their atoms while by the non-eternal variety the products of these atoms. Thus in the Nyaya-Vaisesika view all the atoms were not homogenous in quality: the earth atoms were qualitatively different from water atom, etc., the water atom from earth atoms, etc., and so on.

Thus the *Nyaya-Vaisesikas* believed in the theory of atomism. Concretely, the conception was as follows. The mote in the sunbeam, i.e., the smallest among the perceptible-sized particles was called the *tryanuka*, i.e., the triad. It was so called because it was conceived to be made of three parts, each of which was called a *dvanuka* or dyad. The *dvanuka* were conceived as two and each of these called a *paramanu* or atom. But a *dvanuka* itself was not perceptible; therefore its component parts, i.e., the *paramanus*, were not conceived as made of parts.

Somehow or other, the *Nyaya-Vaisesikas* understood the production of an effect only in terms of the combination of parts. Therefore, the *paramanus* which were not made of parts could not be produced. Again, only things that were produced were conceived to have an end. But the *paramanus*, which were not produced, did not have any end. In short, the atoms were eternal, i.e., both beginningless and endless.

Here, we should mention the difference between the atomism of the *Nyaya-Vaisesikas* and that of Democritus. The most serious of this was connected with the movement of the atoms. What was reason for the atoms to take on the multiform combinations and produce the wealth of the organic and the inorganic worlds? Democritus finds it in the nature of the atoms themselves, to which the vacuum affords rooms for their alternate conjunctions and disjunctions. The atoms variously heavy, and afloat in empty space, impinge on each other. There arises thus a wider and wider expanding movement throughout the general mass and in consequence of this movement, there takes place the various complexions, like shaped atoms grouping themselves with like shaped. These complexions, however, by very nature, always resolve themselves again; and hence the transitoriness of worldly things. But this explanation of the formation of the world explains in effect nothing: it exhibits only the quite abstract idea of an infinite causal series, but no sufficient ground for all the phenomena of becoming and mutation. As the last ground there remained only absolute predestination or necessity (*ananke*), which is in contrast to the final causes of Anexagoras, who is said to have named it *tyche*, chance.

It is true that this conception of *ananke* had a mythological pre-history. In the system of Democritus, however, 'The idea of *ananke* has shaken off its mythical associations and became an abstract idea like the modern scientific concept of natural law.' [8]

The atomism of Democritus led him to a deterministic view of the universe in which there was no place for the God or the Creator or Destroyer. He had completely relied upon the combination of atoms for production of everything. The *Nyaya-Vaisesika* atomism, however developed in a somewhat opposite direction.

The fatal weakness of the *Nyaya-Vaisesika* atomism was its failure to conceive the atoms as either anti-dynamic or being moved by the natural laws. Although Kanada himself did not mention God, and in all presumption he was an atheist, the later philosophers of the system not only believed in god, but even became the foremost advocates of the proofs for his existence. Why did atomism fall to this peculiar fate in this philosophy? Due to the inherent weakness mentioned above it suffered this setback. The production of the composite objects was conceived as essentially a matter of joining; then there must be a joiner. This was how God came into the system to fill up the gap of the atomistic hypothesis.

Buddhism

Buddha himself saw all the miseries of his time, which was the result of the transformation of pre-class society into class-society. But what was to be done? He was too realistic to believe in God, prayers and sacrifices which could not, he knew, bring any effective remedy to the miseries he saw all around. He did not ask people to pray and sacrifice. He asked his disciples to turn away from 'opinions concerning the beginning and hereafter of things.' [9] For it was no use behaving like a fool who, with an arrow plunged into his flank, wasted time speculating on the origin, maker etc., of the arrow instead pulling it off outright. Therefore, when asked metaphysical questions that he considered being unprofitable, he simply remained silent. In short, the problem that oppressed him most was essentially a practical one. It was the bewildering mass of sufferings he saw around. And he wanted to have an essentially practical solution for this. But how, under the condition in which he lived, such a solution could at all be evolved?

There was no question, of course, of really removing the real miseries from this world. That meant skipping over stages of historical development. This is because the transformation from pre-class society to class society, which resulted in miseries and blood-shed, was a natural historical process. It was not possible for anybody to alter this process of development. So he had tried to take refuge in the class-less society. But it was not possible to create such a situation in the then existing society. So he developed the *Sanghas* on the basis of the principles of classless society. He asked people to take the *prabbajja* and *upasampada* ordinations, i.e., to 'go out' of the actual society and 'to arrive at' the life of the *sanghas*, or the order of the monks. For within the sanghas, things were different. Modelled consciously on the recollections of tribal society—without private property and with full equality among the brethren—these alone could offer the real scope to practice the 'simple moral grandeur or the ancient gentile society', [10] for which Buddha was really pleading. Thus the *sanghas*, as classless societies within the bosom of the class-society, could become the heart of a heartless world, the spirit of a spiritless situation.

In search of the cause of the suffering, early Buddhism started with a general theory of natural causation, known as the doctrine of *Pratitya-samutpada*. It meant, 'that being present, this becomes', from the arising of that, this arises. Physical corollaries of real importance were drawn in early Buddhism from this doctrine of *pratitya-samutpada*. These were the doctrines of universal impermanence and of the denial of the soul as a substance. The exact reason with which these corollaries were drawn from the doctrine of *pratitya-samutpada* is not quite clear. But it is clear the doctrines of universal impermanence and of the denial of the permanent soul were somehow or other connected in early Buddhism with the doctrine of *pratitya-samutpada* and there is no doubt that these doctrines were of real philosophical significance.

Both these doctrines arose as reactions against the *Upanishadic* thought according to which the soul was a pure substance that transcended all changes. This soul being the ultimate reality, all the concrete mental states were after all unreal. With early Buddhism it was just the reverse. The transient sensations and thoughts, along with the physical frame with which these were associated, are real and the idea of any soul over and above these was just a superstition. The personality was thus viewed as just an aggregate (*samghata*) of the mental states and the body.

'The aggregate is sometimes described as *nama-rupa*, utilizing an old Upanisadic phrase, though its meaning is here very much modified. By the first term *nama*, is meant not 'name' as in the *upanisads*, but the physical factors constituting the aggregate, and by the second, *rupa*, the physical body so that the compound signifies the psycho-physical organism and may be taken as roughly equivalent to 'mind and body'. That is, Buddha took as the reality the very things that were explained away as not ultimate in the *Upanishad* and denied the substratum which alone according to them is truly real.

A more detailed description of the personality in early Buddhism was that it consisted of five *skandhas* or factors, *vizrupa*, *vijnana, vedana, sainjna* and *samaskaras*, of which the *rupaskandha* meant the physical the other *skandhas* being psychical.

Material things, too, like the self, were considered as just aggregates of the quality perceived, and according to early Buddhism, none of the aggregates could persist even in two successive moments.

'Two symbols are generally used to illustrate this conception—the stream of water and 'the self producing and self consuming' flame. It will be seen thus that everyone of our so called things is only a series (*vithi*)—a succession of similar things or happenings, and the notions of fixity which we have of them is wholly fictitious'.

Philosophically speaking, this conception of everything having its being only in an eternal flux was by far the most significant contribution of early Buddhism and it is not a little surprising to note that precisely the same view, along with the same illustration of the fire, was proclaimed about a couple of generations later by Heraclitus in ancient Greece, and further, is being reinstated, though of course with an incomparably richer content, by modern science.

What Heraclitus or early Greek Philosophy did was also done by the Buddhists or early Indian Philosophy. It was all the more significant that this conception of change of becoming was presumably arrived at by synthesis of the conceptions of being and non-being. 'This world', said the Buddha, 'generally proceeds on a duality, of the 'it is' and 'it is not'. [11] We had here perhaps the first instance of dialectical thinking in Indian Philosophy.

Later Schools of Buddhism

The later schools of Buddhism, however, reflected an extravagant world-denying idealist outlook that proved inimical to science and sympathetic only to sundry superstitions. In the context of Buddha's own opinion against metaphysical speculations and his pronounced atheism, this line of subsequent development of the Buddhist philosophy may appear somewhat strange. However the clue to it is to be found in the withdrawal of the philosophical-monks from the labour of production. Subsisting wholly on the gifts of the merchants and kings, they were of course relieved of the worries of their own material existence.

This created conditions for a kind of philosophical specialization—the possibility of being exclusively concerned with learning and thinking, the discourse and debate—the conditions, in short for raising Indian philosophy to a new level of development. This explains the positive aspects of their contribution to philosophy. At the same time, their exclusive concern for theory or mental labour—i.e., their aloofness from material or manual labour—deprived them of a living contact with the world and the spirit of interrogating nature to gain a better insight into natural laws. This gradually led to the development of a sense of delusional omnipotence of thought itself, so much so, that it came to be believed that thought dictated terms to reality and as such was the only reality. The physical world, consequently, became only a phantom of imagination, dream or a fabrication of ignorance. In short, the development of idealism among the later Buddhists was no more a mystery than the birth of idealism.

Outside Buddhism among the *Upanishadic* or *Vedantic* philosophers, basically the same process of development took place and they were led to evolve substantially the same idealistic outlook. As such, there is little to wonder at the free exchange of philosophical ideas between the Vedantists and the later Buddhists, notwithstanding all their mutual religious animosities.

With this background in mind, we may now turn to the history of later schools of the Buddhist philosophy. It is perhaps best introduced with the story of Buddhist councils. Immediately after the death of Buddha, a council of the Buddhist monks was convened at Rajagriha to draw out the canonical texts and creed in its purity. This was the First Council and it main achievement was to settle the *Dharma* and the *Vinaya*. There was as yet no mention of *Abhidharma*. This is significant, for the *Abhidharma* mainly embodies the metaphysical speculations of the later Buddhists, while the *Dharma* and particularly *Vinaya* were chiefly concerned with the codes of conduct. Apparently the monks at the First Council were still too close to the Master to have drifted far away from his original emphasis.

However, some kind of resistance to the codes of conduct was not long to grow among the monks. We hear that after about a century a Second Council had to be convened at Vaisali specifically to consider the question. A large number of monks regarded some of the orthodox codes of conduct to be no more useful and demanded their relaxation. This happened due to the impact of the society which was built on the basis of the private property. Although Buddha had tried to build up his *Sanghas* in seclusion and in strict pursuance of the ethics of classless society, the situation had gradually changed after his death. However, the Second Council decided against any such relaxation as was demanded by a section of monks. But these monks refused to surrender. So they were thrown out or expelled. These monks convened a separate Council of their own, in which ten thousand were said to have congregated. 'Indeed, it was a great congregation of monks (*maha-samgiti*) from which they were called the *Mahasanghikas*, as distinguished from the orthodox monks, the *Thera-vadins* (*Sthavira-vadins*).

The *Mahasamghikas* modified the rules of conduct, redrafted the canonical literature and introduced certain ideological innovations into the Buddhistic standpoints. Two of these innovations deserve special mention. First, the *Mahasamghikas* originated the theory of *Lokattara* Buddha. The Buddha was no longer conceived as ordinary human being, who, moved by the miseries of his fellow beings, preached the doctrine of the cessation of sufferings; he was viewed as a supernatural or super mundane being, a veritable deity. This theory was developed further by the later *Mahayana* Buddhists in whose view the Buddha became virtually the god receiving a highly ceremonial form of worship from the devotees. We have moreover faint glimpses of some metaphysical assertions of the *Mahasamghikas* that may be taken as foreshadowing the idealistic philosophy of later *Mahayana*.

Thus a philosophy, which was started with a strong atheist stand transformed itself into an idealist one. And it was an irony that a philosophy which was developed by opposing *Upanisadic* tradition, gave shelter to that very *Upanisadic* idealism.

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A Brief History of Science
Part 11: Philosophy transcends mechanical materialism and metaphysics

Soumitro Banerjee*

The major developments in science in mid-19th century

In the last issue we focused on the most important advance in science in the mid-19th century: Darwin's theory of biological evolution. While the development of the theory of evolution has far-reaching consequences on our understanding of the material world, there were many other outstanding advances in other fields that occurred around the same time.

We have earlier seen that the first person to observe the cell was Robert Hooke. But at that time the importance of the cell in organizing organic life was not understood. In 1838-1839, M. J. Schleiden (1804-1881), T. Schwann (1810-1882), and R. Virchow (1821-1902) showed that the cell is the basic building block of all living organisms. They proposed the three postulates of cell theory:

1. All living organisms are composed of one or more cells;
2. The cell is the most basic unit of life;
3. All cells arise only from pre-existing cells.

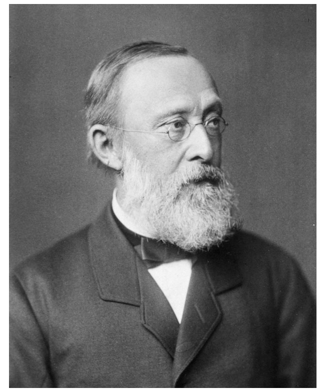
Thus they established a common feature of the animal and the plant kingdoms in terms of structure of these bodies. It was found that the cells in an organism's body are born, go through their lives, and die—as a continuous process running through the course of the organism's life.

Man's understanding about electricity and magnetism also advanced in leaps and bounds during this period. In 1820, Hans Christian Oersted (1757-1851) discovered that electric current could deflect a compass needle. Following the lead, Joseph Henry (1799-1878), Andre-Marie Ampere (1775-1836), Carl Friedrich Gauss (1777-1855), and Georg Simon Ohm (1787-1854) investigated the mutual interaction between electric current and magnetic field. This line of development was crowned by the outstanding experimentalist Michael Faraday's discovery of magnetic induction. He showed that the interaction between electric charge and magnetism was dynamic and not static: only a moving electric charge can induce magnetism and only a moving magnet can induce movement of charge. This established the equivalence between electricity and magnetism. Then the great theorist James Clerk Maxwell (1831-1879) used these results of experimental investigation to establish the theory of electromagnetism as a set of four equations relating electrical and magnetic quantities.

It was the period of the Industrial Revolution, and there was great demand for

*Dr. Banerjee is a Professor at the Indian Institute of Science Education & Research, and General Secretary of *Breakthrough Science Society* .





The originators of cell theory (L-R): Matthias Jacob Schleiden, Theodor Schwann, and Rudolf Ludwig Carl Virchow

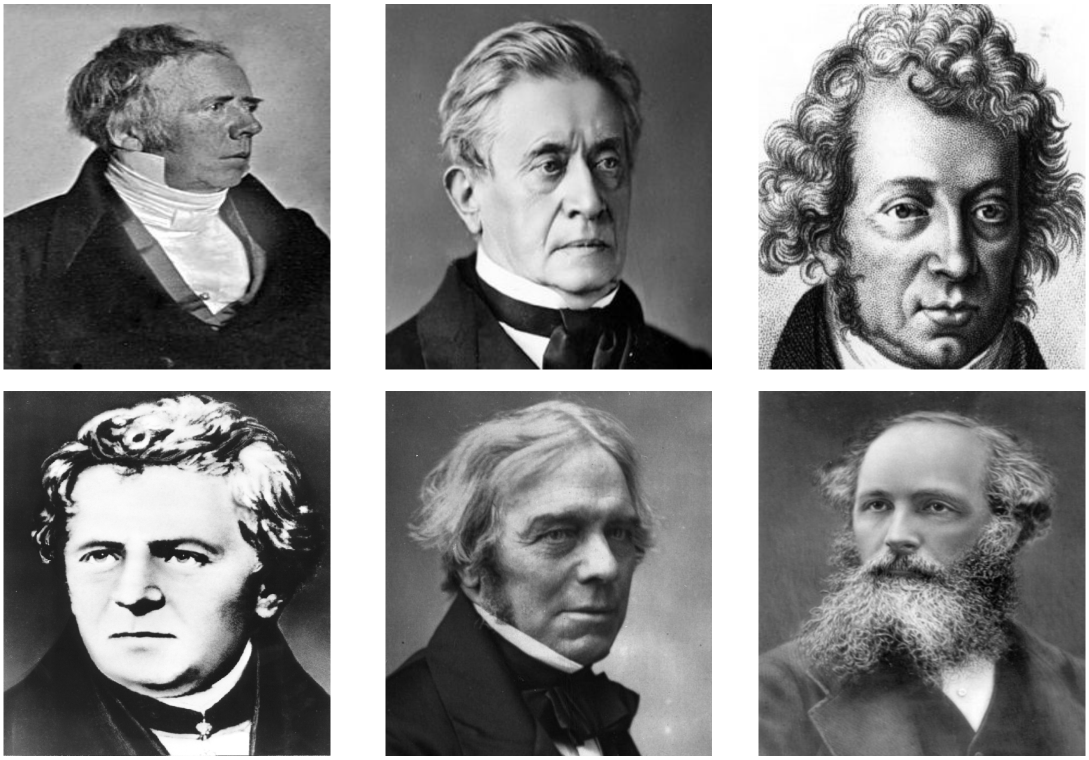
finding ways of powering industry. Many people tried, in various ways, to invent a "perpetual motion machine" with no success. Between 1842 and 1847, scientists like J. R. Mayer, J. P. Joule, H. Helmholtz, etc., established that the different forms of energy could be transformed from one to the other and that the quantity of energy is always conserved in such transformations. Thus, energy cannot be produced out of nothing. Earlier in 1824, Nicolas Leonard Sadi Carnot studied the nature of heat engines carefully and had showed that when heat energy is converted into mechanical energy of the rotation of a shaft, some heat is always lost to the environment, and thus such engines can never be 100% efficient—even in theory. These developments lay the ground for an integrated knowledge about energy—the first and the second laws of thermodynamics.

Shortcomings of mechanical materialism comes to light

These developments in science made it apparent that the prevailing philosophical currents were inadequate to guide further advancement in science. As we have seen earlier, the prevailing philosophical currents could be divided broadly into two categories: the idealistic and the materialistic. While materialism held that matter and the material world exist independent of our consciousness, idealism maintained that matter is not primary; it is spirit that creates matter and the material world. While various shades of idealism were doing their rounds in religious circles, scientists proceeded in their pursuit from the standpoint of materialism.

But scientists of that era saw the world from the point of view of mechanical materialism. Metaphysical way of thinking was still prevalent among a section of scientists. And in logical reasoning, their tool was Aristotelian formal logic. In order to understand why the advancement of science in the early 19th century made these three aspects inadequate, let us first recapitulate what their specific features were.

Formal logic had provided the guiding principles of understanding and analysing things as they are: viewing things as static, stable, and unchanging. But the developments in different branches of science showed that there is nothing really static and unchanging. So it became necessary to study the material world in the process of



Those who developed the understanding of electricity and magnetism, top row (L-R): Hans Christian Oersted, Joseph Henry, Andre-Marie Ampere, Bottom row (L-R): Georg Simon Ohm, Michael Faraday, and James Clerk Maxwell.

change and development. This demanded a system of logic that transcends formal logic and can account for change and development.

Now, it is not true that the ancient philosophers did not see change. Night changes into day and day into night. Each animal is born, goes through growth and maturity, and finally dies. These changes in day-to-day life were of course seen. But the idealist way of thinking linked all changes to some idea or intention. For the idealist, all changes were, in the last analysis, brought about by something outside matter—an idea which is unchanging. For the idealist, all change happens with a purpose. Mechanical materialism, on the other hand, sought the cause for change in the material processes or phenomena. They saw the world being composed of hard impenetrable particles and sought the reason for all change in the motion of these particles and their interaction. In general they tried to understand any change in terms of interaction among the component parts of the entity undergoing change.

What was the nature of the interactions? The mechanical materialists saw each component part of an entity (or particles at a fundamental level) as having separate and distinct existence. To them, the totality of the interactions gave the totality of what can happen to that entity. In the big picture, the totality of the interactions among particles in the universe, in their view, constituted the totality of everything that happens in the universe (recall Laplace's assertion that he can compute everything that will happen in the future, if he is provided with the information about the initial state of each particle in the universe, and enough computing power to solve the equations governing their motion). Crucially, they saw these interactions to be strictly of mechanical type, in the sense that they consist only of the external influence of one particle on another. This is like viewing the whole world as a complex piece of machinery. They sought answers to all questions about the material world in the working of this machinery, in its mechanism.

All mechanisms have a few characteristic features. First, they have component parts that fit together; second, they require a motive force to set them going; and third, the parts interact following laws that can be exactly stated. How would you find out the mechanism of typical machinery like a watch? You would break it up into parts, would find how the parts fit together and what laws the parts obey when interacting with each other, and how these interactions give rise to the working of the watch as a whole. This is how the scientists of the time tried to understand nature: they would divide nature into small pieces, and would study a piece at a time. To study each such piece, they would find out what the component parts were, how they fitted together, and what were their laws of working. This approach worked fine in many cases, but proved inadequate in dealing with the challenges faced by science in the mid-19th century.

Any piece of machinery keeps on working in the same way over the course of its life, eternally repeating the same cycle of mechanical processes. So the mechanical materialists looked for something that does not change, something that is permanent, within the observed processes. They took it that the material world is basically unchanging, all changes that we see are governed by mechanistic laws. Mechanical materialists saw changes everywhere, but viewed these as mere repetitive cycles of the same process. This viewpoint failed to analyse nature in its course of development, in the emergence of new qualities—like the appearance of a new species or a seed sprouting into a sapling.

Yet, by the mid-19th century it was clear that there were small quantitative changes as well as great qualitative changes in nature. The development in chemistry showed that all chemical reactions led to qualitative changes in the constituents; the development in thermodynamics showed that any form of energy can be qualitatively transformed into another; and exploration of the process of biological evolution showed that the course included speciation events—qualitative transformations that led to the emergence of new species. Discovery of these processes threw new challenges that the mechanical materialist viewpoint was philosophically unable to cope with. It was increasingly being revealed that the processes of nature did not merely involve infinite repetitions of the same cycles of mechanical interactions. In reality natural processes involved continual development and evolution, producing new forms of existence.

Finally, a problem with the approach of mechanical materialists was that they could not remain materialistic consistently. As any piece of machinery requires a motive force to set it going, when they faced the question about the motive force driving the machinery of the universe, they sought recourse in the idea of an extra-material 'prime mover'. This opened the door to idealism, what they intended to oppose.

Those who established the science of transformation of energy. Top row (L-R): Julius Robert Mayer (1814-1878), James Prescott Joule (1818-1889), Herman von Helmholtz (1821-1894). Bottom row (L-R): Nicolas Leonard Sadi Carnot (1796-1832), Rudolf Julius Emanuel Clausius (1822-1888), William Thomson (Lord Kelvin) (1824-1907)

The problems with metaphysical way of thinking

The metaphysical way of thinking, developed in ancient times, persisted in course of the scientific development of the 17th and 18th centuries. This style of thinking implies thinking in abstraction, divorced from reality. Scientific developments clearly established that each material entity exists in specific conditions of existence and its character depends on that. Now, if one talks about some inherent quality of a material substance without reference to its conditions of existence (for example, iron being hard without reference to its temperature), treating that quality abstractly as if it is independent of its condition of existence, then that reflects a metaphysical way of thinking.

Secondly, the metaphysical way of thinking would study things assuming its characters as given, fixed, and stable, without any change and development. For example in the study of psychology, a metaphysical way of thinking would consider a person as essentially good or bad, intelligent or dull—without reference to the conditions of his/her life that gave rise to these characteristics, and without considering the fact that these characters change as the person evolves in his/her life. The whole idea of measuring a child's IQ reflects a metaphysical way of thinking as it considers intelligence as something fixed, intrinsic to an individual, independent of the person's life-struggle.

Metaphysics presupposes that each thing has its own fixed nature, its own fixed properties, and considers each thing by itself, as isolated from all other things. It views the properties of each thing as a given, separate object of investigation, without considering things in their interconnection and in their change and development. It follows the dictum of Aristotelian formal logic "each thing is what it is and is distinctly different from all other things". It follows an "either-or" logic: an animal is either a reptile (lays eggs) or a mammal (delivers babies and suckles its young). This logic again ran aground when scientists first encountered the platypus—an animal that lays eggs and suckles its babies. This logic ran into trouble when scientists considered evolution—where a species changes into another. It became clear that a better approach was needed when doing science in the 19th century.

However, the classification of things into separate "bins" arose out of necessity. For a biologist, it was not possible to think clearly without classifying the biological world into kingdom, phylum, order, family, genus, and species. For a chemist, it was necessary to classify things into bins like metals, non-metals, acids, alkali, sugars, etc. Yet, it was becoming clearer with each passing year that the distinctions were not as hard-and-fast as they were first thought to be. If you try to put a thing either in category A or in category B, you are in trouble if you find a thing that has some characters of A and some of B. You run into trouble when you find that in some situations it behaves as A and in some other situations it behaves as B. You run into trouble if you find that A can, in some circumstances, change into B. These contradictions were in fact encountered in 19th century science, which called for development of a proper approach that could guide the further advancement of science.

It is important to note that metaphysical way of thinking is not be equated with thinking in abstraction. All human thought contains abstraction in some form or other. The problem with metaphysics is that in the process of abstraction things are considered in separation from one another, ignoring their interconnections; it considers things as fixed and unchanging and ignores the process of development and evolution, and it considers things in isolation, separated from their condition of existence.

Further development of materialism

So, in view of the tumultuous developments in various areas of science over the 18th and 19th centuries, mankind faced the question: What should be the correct scientific approach in looking at and perceiving nature? In what ways should we direct our investigation to further unravel the mysteries of nature?

Faced with these questions, science firmly took the side of materialism as against idealism. Science starts with the premise that the world exists independent of our consciousness. Now that we understood that man also came into being through a process of evolution, a natural corollary was that nature existed even before man emerged on this planet. It will continue to exist even if there is no intelligent being to do the perceiving. As intelligent beings our job is to understand nature, how it works, and the laws governing the existence, motion, and evolution of everything in this material world. While idealism held that matter is a product of idea, science upheld materialism in demonstrating that idea is always formed in a human brain—a material entity, and ideas are generated through interaction of the human brain with the surrounding physical world and society. Thus, matter is primary, idea is secondary.

But what is matter? The materialists' idea is that everything in this material world is matter. But that needs to be defined properly. Apples, bananas and oranges are "things" with specific characteristics, and when you leave out their individual characters and focus on the general property, you come to the idea of "fruit". Similarly, there are millions of different "things" in this material world, and when you leave out their individual characters and abstract out the general property—that of existing independent of our consciousness—then you come to the idea of "matter". It is therefore a philosophical category, and everything existing independent of our consciousness is matter; this concept of matter is reached through the process of generalization and abstraction.

How do you know that each piece of matter really exists? We know that because they leave some impression on our sense organs. I know that the table exists because I can see it. I know that the food is being cooked in the kitchen because I can smell it. Likewise, I can feel by touch, hear the sound and feel the taste of material substances. That is how I know that they really exist. Some things may not be so palpable as to directly influence our senses. For example, we cannot see the distant galaxies or minute molecules, but can still perceive their existence using appropriate instruments which in effect work as extension of our sense organs. Since the ability, sensitivity, and reach of our instruments are increasing with each passing year, things that were not perceptible 50 years back are being perceptible now. And in the infinite universe there will always remain very distant objects whose existence will be revealed only when our instruments develop adequately. The proper understanding of matter should take these aspects into account. Thus the idea developed that matter is that which has the quality of being perceptible to our senses, either directly or with the aid of instruments. This implies that something that is in principle not perceptible is not matter, and therefore science would not be concerned with it. Secondly, matter is not just what has mass (the way most science textbooks define it); light and other forms of electromagnetic radiations are also matter, because they also exist independent of our consciousness and are perceptible to our senses either directly or with the aid of instruments.

Developments in science till the 19th century made it clear that the world is not a collection of readymade things, with fixed properties. Everything in the material world is going through change and evolution. From this came the realization that the task of science is not to study things as fixed and static, but as things in change and evolution. Not only that, things are continuously coming into being and going out of being. Stars form, go through their lives, and finally meet explosive ends. Cells in the animal bodies are born from other cells, live for a time, and die. Each animal is born, goes through life, and finally dies. Each species, likewise, is born, has a period of existence, and finally goes extinct. In some physical process and chemical reactions, specific things are created and in other physical processes they may be annihilated. Thus the idea emerged that things come into existence and go out of existence. Therefore the task of science should be to study matter in its change and development, it has to understand how things come into being and go out of being. These ideas crystallized in the new materialist philosophy, which demanded the study of objects and phenomena in a state of flux, in a process of development and change. The new philosophy stressed that science should focus not on studying things; rather it should focus on studying processes. We should not view the material world as a complex of things; we should view it as a complex of processes in which things are continuously undergoing changes, continuously coming into being and going out of being. Metaphysics studies "things as they are"; now science should focus on understanding the process of change and development of matter.

The new philosophy insisted that science should not study things in isolation; rather it should study things in their interconnections. It should recognize that things are connected with, dependent on, and determined by each other. Science should not abstract properties of things divorced from their conditions of existence. Rather it should study how the properties of things change as the conditions of existence change.

What about the mechanical materialist programme of understanding all change in terms of interaction of particles constituting each body? Can this approach succeed in understanding change, evolution, development, and things coming into being and going out of being? It was clear that this approach was not successful in addressing the issues confronted by 19th century science. But what exactly was the problem?

It was realized that the main problem was that mechanical materialism treated matter as inert mass, to which motion has to be imparted from outside. The development of thermodynamics showed that the different forms of energy were nothing but different forms of motion of matter. Sound was one form of motion of matter while heat was another form, electricity was yet another. When one form of energy is transformed into another, actually one form of motion is transformed into another. But motion always remains. Following Galileo, it was realized that when a body appears to be at rest, it is actually at rest with respect to the observer; and both are moving with the motion of the Earth, that of the solar system, and so on. Therefore the general concept was proposed: matter cannot exist without motion, and motion is meaningless without reference to matter. Hence the correct understanding is to say that motion is the mode of existence of matter. With this viewpoint, it was no longer plausible to conceive matter as inert mass, to which motion had to be imparted from outside. Motion was now conceived as an inherent attribute of matter.

The other assumptions of mechanical materialism also did not stand ground in the background of the development of science in the 19th century. One tacit assumption was that each thing or particle, whose interaction constituted all change in the material world, had a fixed nature independent of everything else. Each thing was considered as an independent unit, existing in separation from other things. With the further development of materialism it was understood that this assumption was wrong: each body or particle also undergoes change and exists in interaction with other bodies or particles. Unless we take that into account, our study of dynamic nature will invariably be misled.

Another erroneous assumption was that the totality of all change observed in the universe was nothing but sum total of the interactions among the particles—separate units entering into external relation with other things. If this were true, it follows that the whole of a body is nothing but sum total of the parts. Cell theory amply demonstrated the error in this assumption: the cell is composed of millions of molecules, but its character is not a simple sum total of the motion and external interactions between the molecules. The cell as a unit has characteristics distinctly different from those of its parts, and can perform specific tasks. Likewise, a man is also composed of many different molecules, but the character of the man cannot be understood simply as a sum total of the motion of the molecules. At a particular level of aggregation and interaction of the constituent parts, a particular new character emerges. The same is true for each organism, each species, each planet, each star, and each galaxy. The properties and laws of development of the whole cannot be fully understood by simply breaking things apart and studying the properties of its parts.

The gigantic task of assimilating the essence of the discoveries of different fields of science, of pointing out the lacunae of prevalent lines of thought, and of showing the correct direction of thinking—in short, of developing a new world outlook based on science—was done almost singlehandedly by two men: Karl Marx (1818-1883) and Frederick Engels (1820-1895). All the arguments outlined in this section that freed science of the hangovers of mechanical materialism and metaphysics are their contribution.

They especially stressed on the ever-changing nature of matter and the material world, and the need to understand the process behind the change, evolution, and progress observed in nature. Different fields of science had shown that the process of change in each thing was in some ways different from others, but there was always some commonness. If we leave aside the differences, what remains are the common features of all change and evolution observed in nature. The first common feature is that there are opposing tendencies or forces in each thing, and the basic cause of change is the interaction between these opposing tendencies. The exact nature of these opposing tendencies differ from one body to another, but, in any process of change, one can always identify the opposing tendencies, each trying to change the object in opposing directions, one trying to change the object and the other resisting change. The second common feature is that change or evolution does not proceed linearly; there is continuity as well as breaks—while undergoing slow and quantitative process of change a nodal point is reached when one observes a qualitative transformation. When this happens in the process of development—here comes the third general feature—a new thing appears negating the earlier existence, assuming a different identity. This new emergent thing would also be subject to contradictory tendencies whose interaction would lead to small quantitative changes, and when a nodal point is again reached, would undergo a qualitative transformation, negating its earlier existence. Thus, again a newer thing would be born. This is the internal process responsible for change and development observed in nature. Thus, the general principles governing change and development were identified as : 1. The unity of opposites; 2. From quantitative change to qualitative change and vice versa; and 3. Negation of the negation.

If one recognizes these general principles, the directions of studying change and development in nature becomes clearer: In every particular process a scientist would have to identify the opposing tendencies. When stability prevails, one would be able to write equations by equating these opposing tendencies, and when a quantitative change occurs one would be able to write differential equations governing the process by writing the opposing tendencies in quantitative terms. When a nodal point reaches and a qualitative change occurs, it negates the earlier existence and hence the opposing tendencies also change. Now these have to be freshly identified and the process of its change has to be freshly worked out.

In developing this theory, Marx and Engels adopted Hegel's dialectical logic (see the last instalment of this article). In the early part of the 19th century Hegel formulated the basic laws and categories of dialectics which was undoubtedly one of the great achievements of human thought. But Hegel was an idealist who considered that the basis of nature and society was the absolute idea or 'world spirit' that exists eternally, independent of man and nature. But, while Hegel saw these merely as rules of logic that operate in the realm of ideas, Marx and Engels pointed out that they work because these are the general features of all changes and evolution seen in the natural world.

Thus they combined dialectics with a consistent materialist world view to create a truly scientific materialist world outlook. Since the emergent scientific materialism was based on this dialectical logic, the new philosophy is called dialectical materialism.

However, unlike other philosophers, Marx and Engels did not stop at telling people how to interpret nature and society. They went further and said that, if we really understand the laws governing change in nature and society, we should be able to change things for the better. We cannot change the laws of nature, but by understanding the laws we can utilize them to improve human life. Similarly, we cannot change the laws of development of society, but by understanding them we can change society for the better.

That a scientific philosophy could be applied to society so as to change it became an inconvenient truth for those who stood to gain by maintaining the system, and who would spare no effort to maintain it and who would resist tooth and nail any attempt to change the status quo. That is why their views on science were never publicized or propagated. The ideas of dialectical materialism were never taught in the academic system. Those being trained to become scientists of the future were deprived of the opportunity of absorbing a correct scientific worldview to guide their pursuit.

Yet, science has, in the main, adopted the guiding principles they had put forward. Any practising scientist today will agree that these are the principles followed in science today; yet most of them do not know who originated these ideas as a scientific philosophy. Their names may have been blocked out, but science cannot help but adopt their ideas, because these are true. You cannot successfully do science without adopting the correct scientific viewpoint and method. So we see a peculiar dichotomy today: scientists adhere to these guiding principles in their scientific pursuit, and yet, outside the laboratory many scientists believe and conduct their lives following ideas of idealism and metaphysics.

There have also been attacks on this scientific materialist philosophy, which has slowed down the advancement of science in the period following the great advancements mentioned earlier. A strong philosophical current called positivism developed as a challenge to scientific materialism, by which many scientists of the later part of the 19th and early 20th centuries were influenced. We'll talk about that in the next instalment of this essay.

Nobel Prizes – 2015
(Physics, Chemistry and Medicine)

Rajani K. S.*

Every year, the Nobel Prizes are given to distinguished people and institutions around the world for the study of science and for world peace. The prize is given out in five categories — Literature, Physics, Chemistry, Physiology or Medicine, and Peace. The Nobel Prize was started by Alfred Nobel, who donated the necessary fund through his 1895 testament (or will). The Nobel Foundation now controls the money. The Foundation asks different committees or academies to nominate people, who they feel deserve the honour for their contribution to the respective fields.

The Royal Swedish Academy of Sciences awards the Nobel Prize in Physics, the Nobel Prize in Chemistry, and the Nobel Memorial Prize in Economic Sciences; the Nobel Assembly at Karolinska Institutet awards the Nobel Prize in Physiology or Medicine; the Swedish Academy grants the Nobel Prize in Literature; and the Nobel Peace Prize is awarded not by a Swedish organisation but by the Norwegian Nobel Committee.

The various Prizes are awarded yearly. Each recipient, or laureate, receives a gold medal, a diploma and a sum of money, which is decided by the Nobel Foundation. The Prize is not awarded posthumously; however, if a person is awarded a Prize and dies before receiving it, the Prize may still be presented. Though the average number of laureates per Prize increased substantially during the 20th century, a Prize may not be shared among more than three people. The awards are presented in Stockholm, Sweden, in a ceremony on December 10. This day is the anniversary of Nobel's death.

Let us now see the scenario in 2015.

Physiology or Medicine

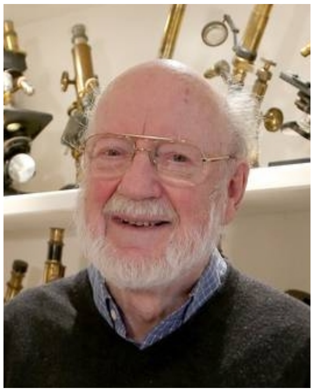
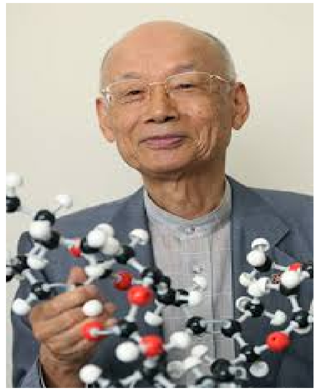
The Nobel Prize 2015 in Physiology or Medicine jointly went to William C. Campbell, Satoshi Omura, and Youyou Tu.

Mr. Campbell and Mr. Omura won it for "their discoveries concerning a novel therapy against infections caused by roundworm parasites". Their new drug, Avermectin and its derivatives have lowered the incidence of River Blindness and Lymphatic Filariasis. while Ms. Youyou Tu won it for "her discoveries concerning a novel therapy for malaria." She discovered Artemisinin, a drug that has significantly reduced the mortality rates for patients suffering from Malaria.

"The two discoveries have provided humankind with powerful new means to combat these debilitating diseases that affect hundreds of millions of people annually," the committee said. "The consequences in terms of improved human health and reduced suffering are immensurable."

Campbell is a research fellow emeritus at Drew University in Madison, New Jersey. Omura, 80, is a professor emeritus at Kitasato University in Japan and is from the central prefecture of Yamanashi. Tu

*Rajani is the Convenor, *Breakthrough Science Society* Bangalore City Chapter.


Nobel prize in physiology or medicine (L-R): William C. Campbell, Satoshi Omura, and Youyou Tu

is Chief Professor at the China Academy of Traditional Chinese Medicine.

The medicine award was the first Nobel Prize to be announced. The winners will share the 8 million Swedish kronor (about $960,000) prize money with one half going to Campbell and Omura, and the other to Tu. Last year's medicine award went to three scientists who discovered the brain's inner navigation system.

Physics

The Nobel Prize in Physics, 2015, was awarded jointly to Takaaki Kajita (Super-Kamiokande University of Tokyo, Kashiwa, Japan) and Arthur B. McDonald (Sudbury Neutrino Observatory Collaboration Queen's University, Kingston, Canada) "for the discovery of neutrino oscillations, which shows that neutrinos have mass." The discovery has changed our understanding of the innermost workings of matter and can prove crucial to our view of the universe.

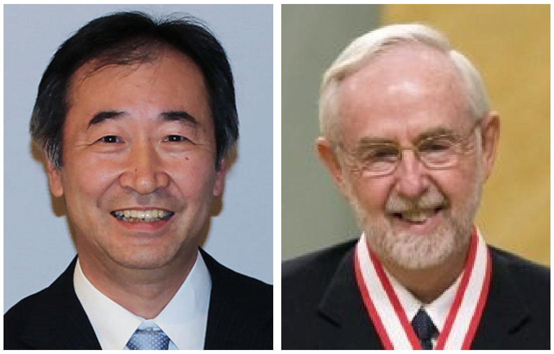
Around the turn of the millennium, Takaaki Kajita presented the discovery that neutrinos from the atmosphere switch between two identities on their way to the Super-Kamiokande detector in Japan. Meanwhile, the research group in Canada led by Arthur B. McDonald could demonstrate that the neutrinos from the Sun were not disappearing on their way to Earth. Instead they were captured with a different identity when arriving to the Sudbury Neutrino Observatory.

A neutrino puzzle that physicists had wrestled with for decades had been resolved. Compared to theoretical calculations of the number of neutrinos, up to two thirds of the neutrinos were missing in measurements performed on Earth. Now, the two experiments discovered that the neutrinos had changed identities.

The discovery led to the far-reaching conclusion that neutrinos, which for a long time were considered massless, must have some mass, however small.

For particle physics this was a historic discovery. Its Standard Model of the innermost workings of matter had been incredibly successful, having resisted all experimental challenges for more than twenty years. However, as it requires neutrinos to be massless, the new observations had clearly showed that the Standard Model cannot be the complete theory of the fundamental constituents of the universe.

The discovery rewarded with this year's Nobel Prize in Physics have yielded crucial insights into the all but hidden world of



Nobel prize in physics (L-R): Takaaki Kajita and Arthur B. McDonald

neutrinos. After photons, the particles of light, neutrinos are the most numerous in the entire cosmos. The Earth is constantly bombarded by them.

Many neutrinos are created in reactions between cosmic radiation and the Earth's atmosphere. Others are produced in nuclear reactions inside the Sun. Thousands of billions of neutrinos are streaming through our bodies each second. Yet, we do not feel them because they practically do not interact with anything. That is why neutrinos are nature's most elusive elementary particles.

Now the experiments continue and intense activity is underway worldwide in order to capture neutrinos and examine their properties. New discoveries about their deepest secrets are expected to change our current understanding of the history, structure and future fate of the universe.

Chemistry

The Nobel Prize in Chemistry for 2015 was awarded to Tomas Lindahl (Francis Crick Institute and Clare Hall Laboratory, Hertfordshire, UK), Paul Modrich (Howard Hughes Medical Institute and Duke University School of Medicine, Durham, NC, USA) and Aziz Sancar (University of North Carolina, Chapel Hill, NC, USA) "for mechanistic studies of DNA repair." They mapped, at a molecular level, how cells repair damaged DNA and safeguard the genetic information. Their work has provided fundamental knowledge of how a living cell functions and is, for instance, used for the development of new cancer treatments.

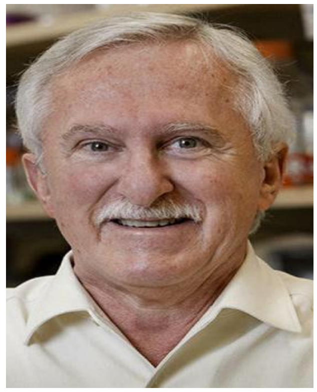
Each day the DNA molecules in each cell of our body are damaged by UV radiation, free radicals and other carcinogenic substances, but even without such external attacks, a DNA molecule is inherently unstable. Thousands of spontaneous changes to a cell's genome occur on a daily basis. Furthermore, defects can also arise when DNA is copied during cell division, a process that occurs several million times every day in the human body.

The reason our genetic material does not disintegrate into complete chemical chaos is that a host of molecular systems continuously monitor and repair DNA. The Nobel Prize in Chemistry 2015 awards three pioneering scientists who have shown how several of these repair systems function at a detailed molecular level.

In the early 1970s, scientists believed that DNA was an extremely stable molecule, but Tomas Lindahl demonstrated that DNA decays at a rate that ought to have made the development of life on Earth impossible. This insight led him to discover a molecular machinery, base excision repair, which constantly counteracts the collapse of our DNA.

Aziz Sancar has mapped nucleotide excision repair, the mechanism that cells use to repair UV damage to DNA. People born with defects in this repair system will develop skin cancer if they are exposed to sunlight. The cell also utilises nucleotide excision repair to correct defects caused by mutagenic substances, among other things.

Paul Modrich has demonstrated how the cell corrects errors that occur when DNA is replicated during cell division. This

Nobel prize in chemistry (L-R): Tomas Lindahl, Paul Modrich and Aziz Sancar

mechanism, mismatch repair, reduces the error frequency during DNA replication by about a thousandfold. Congenital defects in mismatch repair are known, for example, to cause a hereditary variant of colon cancer. The Nobel Laureates in Chemistry 2015 have provided fundamental insights into how cells function, knowledge that can be used, for instance, in the development of new cancer treatments.

Some interesting facts about the Nobel prize

The Nobel Prize in Economics was not a part of Nobel's will. It was started in 1969 by Sveriges Riksbank, the Bank of Sweden. The bank donated money to the Nobel Foundation for the Economics Prize in 1968. The Economics Studies Prize is in the memory of Alfred Nobel. It is awarded each year with the other Nobel prizes.

Some people have received more than one Nobel Prize.

Marie Curie – in Physics 1903, for the discovery of radioactivity; and in Chemistry 1911, for the isolation of pure radium.

Linus Pauling – in Chemistry 1954, for his research into the nature of the chemical bond and its application to the elucidation of the structure of complex substances; and for Peace 1962, for nuclear test-ban treaty activism. Pauling is the only person to receive two unshared Nobel Prizes.

John Bardeen – in Physics 1956, for invention of the transistor; and Physics 1972, for the theory of superconductivity.

Frederick Sanger – in Chemistry 1958, for structure of the insulin molecule; and in Chemistry 1980, for virus nucleotide sequencing.

Sometimes the members of a single family have won the Prize. Some examples are:

- Marie Curie – for Physics in 1903 and for Chemistry in 1911. Her husband Pierre Curie – for Physics in 1903. Their daughter Irène Joliot-Curie – for Chemistry in 1935. Their son-in-law Frederic Joliot-Curie – for Chemistry in 1935. Also, Henry Labouisse, the husband of the Curies' second daughter Eve, was the director of UNICEF when it won the Nobel Peace Prize in 1965.
- Gunnar Myrdal – for Economics in 1974 and his wife Alva Myrdal –for Peace in 1982

(Continued on page 39)

What is wrong with our teaching and research institutions today?

K. SAMPATH *

Introduction

Acquisition of factual knowledge as taught in schools and colleges does not necessarily prepare one to function as a scientist. Yes, that knowledge may enable one to be technically competent and skilled, but not necessarily a creative scientist.

Why are some individuals more creative in a specific field of research than others? The phenomenon of scientific creativity is rarely nurtured and examined in educational institutions. Yet it plays the most important role in making one function as a successful scientist.

The Early Research

Let us start from the 17th century—the age of empiricism. When we examine the history of science before 17th century, it appears that very few philosophers were contributing to science; and there were few organised science societies. Those philosophers were all independent thinkers, but any new idea developed has to be accepted or rejected by peers on the basis of its merits and demerits. Scientists worked in isolation and communication among them was limited, resulting in slow progress of scientific knowledge. Also the scientific methods were not developed as today.

Sir Francis Bacon of Britain introduced the inductive method and sought to reduce it to a set of recommendations; while Rene Descartes of France glorified the discipline of mathematics as queen of sciences and advocated for deductive method and philosophical mode of reasoning. Pure empiricism was an important part of almost every experimental procedure at that time.

The 18th century is identified as the age of reason. Importance was given to reason and individual thinking rather than tradition. It promoted scientific thought, scepticism, and intellectual exchange. Rational thought began with clearly stated principles, the use of correct logic to arrive at conclusions; testing the conclusions against evidence, and then revising the principles in the light of the evidence.

In the 19th century, humankind saw some of the most revolutionary ideas in human history. These ideas completely changed the way we view ourselves and the world around us. Significant new ideas appeared in the areas of science, philosophy, religion, and psychology.

Charles Darwin's theory of evolution had major implications on the scientific thinking. His theory postulated that all life, we see today, can be traced back to a common ancestor. The theory of evolution not only challenged the existing concepts on the origin of man, but also the age of the earth as well.

Path-breaking ideas also arose in the discipline of mathematics in the 19th century. However, few mathematicians of the time

*Mr. K. Sampath is a retired scientist, DRDO. Email: skasturi41@gmail.com

have achieved as much as Carl Friedrich Gauss. His work in mathematics and science created a foundation upon which advancements across several fields of study could flourish.

The 19th century was a time of great advancement of science. Throughout the 19th century, many different aspects of science were found, expanded upon, and pursued.

In the 20th century, the ideas of 19th-century science gave birth to new kinds of theories that have much greater explanatory, predictive, and controlling power. The development took place in the fields of plate tectonics, genetic engineering, space probes, nanotechnology, cosmology, electronic computers, nuclear energy, artificial intelligence etc. In this century we saw the birth of theory of relativity and the theory of sub-atomic particles.

The 20th-century science is in many senses evolutionary, because it built on the crucial 19th-century concepts such as energy, natural selection, atoms, fields, and waves.

Vision

The twentieth century was also the century of visionaries. The Russian mathematician Constandian Vilkavaski sowed the seed of an idea 40 years ahead, that man can land on Moon. Neil Armstrong became the first human to step onto the surface of the Moon, at 02:56 UTC on 21 July 1969. An estimated 500 million people worldwide watched this event, the largest television audience for a live broadcast at that time.

The idea of geostationary satellite was originally proposed in 1928; but in 1945, Sir Arthur Charles Clarke was the first to suggest that geostationary orbits would be ideal for establishing worldwide telecommunication relays. He lived in Ceylon for five decades and died in 2008, at the age of 90. Geostationary satellites form the backbone of communication today.

Both the examples show the importance of vision. Present day students may know the meaning of the word “vision”, but are they ever taught the effect of it — that great changes may be brought by ideas of visionaries?

A glimpse of the 20th century’s developments emphasise that the scope of science is as vast as the universe. These facts are to be brought to the notice of students to inculcate scientific temper in them.

Present Educational Environment in India

In schools and colleges science education is delivered as per syllabus; beyond that there is not much scope for learning. Case study is not discussed; problems are not posed for classroom discussions. Students are prepared for examinations only, not for gaining knowledge. Students are taught mathematics but are not told that mathematical systems deal with abstract ideas; manipulation of these ideas through logical process of reasoning gives rise to vast array of tools which are useful in connecting experimental observations. Students do experiments, can sometimes draw generalisations, but they are not told that generalisations themselves may point the way to further experimentations; that experiments can also at times be quite misleading—unless done with the clear notion of which idea is being tested.

Nowadays there is very little scope for isolated compartmentalized efforts in any field of science. Physics needs mathematics; there is no chemistry without physics and so on. Every branch of science depends on the other. This fact needs to be communicated to the students. Text books do not reveal all these points.

Explicit awareness about the significance of research tools such as hypothesis, observation, experimentation, theory, law, analysis and synthesis, analogy, symmetry, induction and deduction, mathematics, logic and reasoning, imagination, intuition and classification, etc., are absent in the curriculum. The above mentioned aspects are like the grammar of science; the significance of each should be taught.

Research does not depend on any single tool; it needs a number of tools. The meaning and the role of research tools are neither taught nor taken seriously in schools and colleges. Entering into research area or organisation without having the knowledge of the research tools is like writing essays without knowing grammar.

The present environment in R&D

Scientists are often so preoccupied with technical, scientific, development and administrative assignments, and project discussion, that they find little time left for reflection on nature, methods and goals of the scientific enterprise. As a result even some scientists are unable to comprehend the importance of scientific procedures such as, chance or accidental or serendipity discovery, insight or intuition or sudden flash of ideas, and building-up methods.

The quality and the tone of R&D organisations are highly influenced by their orientation: basic research or applied research. The R&D organisations across our country are engaged mainly in development work — their activities are result or goal oriented and not much stress is given to fundamental research. This is not the correct process of scientific progress, and research and development should progress side by side.

The role of research is to keep the thinking clear, to reduce ad-hoc practices, and to infuse development activity with scientific methods and to explore new lines or fields of research. Research alone can generate science (knowledge) and technology on which the present and the future developments rest. All development projects have grey areas where research is needed for further progress. Otherwise ad-hoc decisions are taken which influence or impede further development.

After leaving college, students are recruited directly in R&D organisations after written examinations and interviews. They do not have research experience leaving some exceptions. It is like pushing one in a pool hoping he learns to float on his own.

Tradesmen to teachers, administrators, soldiers, doctors, chartered accountants, lawyers and various other professionals are trained in their respective fields. However, except for the handful Ph.Ds churned out by universities, no systematic training is imparted to those employed in R&D organizations to do research. Orientation courses are conducted which are limited to the organisational charter. However, orientation courses alone are not self sufficient to be a scientist. Scientists need broader knowledge, understanding scientific thinking and extensive training. Theoretical background clubbed with proper training can mould one to be an effective and creative scientist.

What is the solution?

The development and output of an R&D organisation depend on the capability and the training parted to scientific staff of the organisation. The scientific society has the duty of creating awareness of the research methods, research tools and scientific creativity, in the minds of young scientists. This will bring positive result in the manner of scientific thinking and handling of Research and Development projects.

History of science and the life-struggle of scientists give us clues and tips to follow. There is no need to reinvent the wheel. The work and experiences of great scientists should be taught, to inspire and to inculcate scientific temper for the excellence in scientific research.

Enough literature is available on this subject and what is needed is to select, organise and propagate the ideas, concepts and methods of approaching scientific problems. We have to introduce these in the under-graduate or graduate level curriculum.

To my knowledge, no attempt has been made in India in this direction so far. (The UGC has introduced a subject called "Research Methodology" as a compulsory course for Ph.D. students, but in most universities and institutions basically the tools and techniques of research in specific fields are taught in the name of research methodology—not the history and philosophy of science or the life and work of great scientists.) It is an unexplored subject. If such a measure is taken, it will be a great contribution to research and development and for the development of science and technology as a whole. It will be of great help to the generations to come; and service to the entire scientific community.

How to implement? To frame such pedagogic material, institutional level, organisational level, and national level seminars, symposiums, and workshops should be organised involving eminent scientists, professors, and research professionals. Such events should discuss, among other things, the importance of learning the method of science, the history of science, the lessons to be learned from the lives of great scientists, etc. Accordingly, courses should be framed, and should be introduced at appropriate levels of the educative process.

(Continued from page 35: Nobel Prize)

- J. J. Thomson – for Physics in 1906. He was the father of George Paget Thomson who received the prize for Physics in 1937.

- William Henry Bragg shared the Prize for Physics in 1915 with his son, William Lawrence Bragg.

- Niels Bohr received the Prize for Physics in 1922. His son Aage Bohr received the Prize for Physics in 1975.

- Manne Siegbahn received the Prize for Physics in 1924. He was the father of Kai Siegbahn who shared the Prize for Physics in 1981.

- Hans von Euler-Chelpin shared the Prize in Chemistry in 1929 with Arthur Harden. Euler-Chelpin's son, Ulf von Euler, received the Prize for Physiology or Medicine in 1970.

- C.V. Raman received the Prize for Physics in 1930. He was the uncle of Subrahmanyan Chandrasekhar who received the Prize for Physics in 1983.

- Arthur Kornberg shared the Prize with Severo Ochoa for Physiology or Medicine in 1959. Kornberg's son, Roger, received the Prize for Chemistry in 2006.

Sources:
www.nobeleprize.org
www.wikipedia.org
www.thehindu.com

Organizational News

Madya Pradesh

The Madya Pradesh State Chapter organised Science Seminars at different places in the state from Sept 6 to 11, 2015, on the subject "Science in Ancient India: Myth versus reality". Shri. Chanchal Ghosh, all India Secretariat Member of BSS, was the main speaker in the chain of seminars. It was held in Guna on 6 September, in Ashoknagar on 8 Sept., in Indore on 9 Sept., in Bhopal on 10 Sept. and in Gwalior on 11 Sept.

Andhra Pradesh and Telengana

Mokshagundam Visweswaraiah Birth anniversary – Engineer's Day was observed on 15-09-15 at the Stanley College of Engineering and Technology for Women, Hyderabad.

Iswar Chandra Vidyasagar's 196th Birth anniversary was observed on 26-09-15 at Hyderabad. An essay writing competition was conducted in Government Polytechnic College, Hyderabad and a Memorial meeting was conducted in the college hostel.

The Kurnool District Chapter of BSS organized a miracle busting program on Sept 15, 2015 in Kalvabugga Boys Residential High School.

Breakthrough Science Society, All India Save Education Committee (AISEC), All India Secular Forum and Child Rights Protection Forum jointly organised an Educational Convention on "New Education Policy-2015 & Rewriting of Science and History" at Hyderabad on Nov 10, 2015.

Prof. P. L. Vishweswar Rao (President AISEC, Telangana) presided. Sri.Babu Gogineni (Renowned Rationalist), Sri S Govindarajulu (Secretary, AISEC), Sri Md Zaheeruddin (Managing Editor, Siasat Urdu daily), Sri G Sudhakar Goud (Former Director, British library), Dr G Nagarjuna (Former HOD, Printing Technology) and Mr R Gangadhar (Convener, BSS) participated as speakers. Nearly 200 delegates actively participated in the convention.

Karnataka

Science Study Camp: Sept 19-20, 2015 — BSS state unit organized a two day state level science study camp for its members across all districts where BSS is active, at Vidyasagar Pragathipara Adhyayana Kendra, Maralakunte, Bangalore Rural district.

Popular Science Lecture Series: As part of the Monthly Popular Science Lecture Series, an expert talk on 'Search for Extra-Terrestrial Intelligence (SETI)' was organized on 17 Oct, 2015 at MES Teachers' College auditorium, Bangalore. Prof. S. Jayanth Murthy, (Senior Professor, Indian Institute of Astrophysics, IIA, Bangalore) delivered the talk.

Save Jogimatti movement in Chitradurga: Nearly 600 wind energy mills are installed in Chitradurga district. Chitradurga is a dry land area and the forest area is very limited. The Forest Department permitted a wind energy company to establish 20 windmills within the thick forest area named Jogamatti.

The people of Chitradurga were against permitting the company to install wind mills inside the forest area. BSS volunteers took up the movement, demanded the concerned officers to stop the process immediately and declare the forest as a sanctuary. BSS also invited and involved other progressive organizations for the protest. A Save Jogamatti Forum was formed. Members of BSS conducted a massive signature campaign, spread awareness and mobilized public opinion in favor of preserving the forest. Finally the state Government conceded to the demands of the people of Chitradurga and declared the forest as wildlife sanctuary.

Workshop on Science and Society, Gulbarga: BSS Gulbarga unit and VG degree college for women jointly organized a workshop on Science and Society on 17 Oct 2015. The workshop was inaugurated by Dr. Ashok Jivanagi, Principal, VG College for Women, Kalaburagi. A session on 'Science in ancient India' was conducted by Mr Niranjan, BSS Karnataka state unit member. A workshop on food adulteration detection was conducted by Ms. Gauramma Patil, Vice President, BSS Gulbarga unit. A session on 'Crisis in society today: Can scientific temper show the way?' was conducted by Sri. G Satish Kumar, Convenor, BSS State unit.

Kerala

Sept 12, 2015: Presentation and discussion on "Ancient India's contributions in Science", at JPS Office, Mulanthuruthy, Ernakulam. Shri. P. P. Sajeevkumar made the presentation.

Oct 9, 2015: A workshop was organized in association with Kerala State Science and Technology Museum (KSSTM) for science teachers of schools in Thiruvananthapuram on the occasion of 'World Space Week'. Mr. Arul Jerald Prakash, Director, KSSTM inaugurated the workshop. Mr. P.Radhakrishnan, former Deputy Director, LPSC, ISRO, Mr. Sheeju Chandran, Scientist, VSSC, ISRO and Dr. Anand Narayanan, faculty, Indian Institute of Space Science and Technology delivered lectures. This was followed by a demonstration of ‘Water rocket’. More than 100 teachers from different schools of Thiruvananthapuram district participated in the workshop.

Oct.10, 2015: The Astronomy club, Kottayam, organized a Talk on International Space Week by Dr. Jason Cherian Issac, Professor, Dept. of Mechanical Engg, St. Gits College of Engineering, Kottayam. A space quiz was conducted by Sreelakshmi of RIT, Kottayam.

Oct 31, 2015: BSS Thiruvananthapuram chapter in association with KSSTM organized a seminar on ‘Science in Thinking’ at Priyadarshini Planetarium, Thiruvananthapuram. Mr.G.S.Padmakumar, President, BSS, Kerala chapter was the main speaker.

Nov 10, 2015: As a part of the observation of ‘World Science Day’ and ‘International Year of Light–2015’, BSS Thiruvananthapuram chapter in association with KSSTM and International Society for Optics and Photonics (SPIE), organized a lecture on the topic: ‘Photonic Ear for Remote Detection of Diseases and Eye for Super Resolved Imaging’ by Dr. Zeev Zalevsky, Professor, Bar-Ilan University, Israel, at the Kerala State Science and Technology Museum, PMG Junction, Thiruvananthapuram.

November 14, 2015: Talk on “Nobel Prize in Chemistry 2015: Prospects of finding cure for cancer” at CHILD, Thrippunithura by Dr. C M Joy, faculty in Botany at Sacred Heart College Thevara, Ernakulam.

Nov.14 , 2015: Astronomy club, Kottayam organized Talk on International Year of light by Prof P.Rajagopal, HoD, Dept. of Physics, CMS College, Kottayam.