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## In The News

### CSIR Celebrates its 71st Foundation Day



On the dais during the CSIR Foundation Day Function at IGIB, New Delhi (from left) are: Prof. Samir. K. Brahmachari, Director General, CSIR; Shri S. Jaipal Reddy Minister of Science & Technology and Earth Sciences and Vice President, CSIR; Prof. M.M. Sharma, Dr. Rajesh S. Gokhale, Director, IGIB

**T**HE Council of Scientific & Industrial Research (CSIR) celebrated its 71st Foundation Day on 26 September 2013. The function was held in the new campus of the CSIR-Institute for Genomics and Integrative Biology (IGIB) in New Delhi. While Union Minister of Science & Technology and Earth Sciences Shri S. Jaipal Reddy chaired the function, Prof. M.M. Sharma, world renowned scientist and the first Indian engineer to be elected as a Fellow of Royal Society of London, delivered the CSIR Foundation Day Lecture.

Several prestigious CSIR awards were also given away during the function. These include the CSIR Young Scientist Awards 2013, the CSIR Technology Awards 2013, the G.N. Ramachandran Award 2013, and the CSIR Innovation Award for School Children 2012. On the occasion, the names of the winners of the Shanti Swarup Bhatnagar Prizes 2013 were also announced by Prof. Samir Kumar Brahmachari, Director General, CSIR.

## Address of Shri S. Jaipal Reddy, Union Minister of Science & Technology and Earth Sciences and Vice President, CSIR

Shri S. Jaipal Reddy complimented the CSIR leadership and its scientists for maintaining CSIR's position in the first 100 organizations of the world – to be precise at the 81<sup>st</sup> position amongst 2740 institutions worldwide. He quoted a statistic according to which the scientific staff of CSIR constitute only about 3-4% of India's scientific manpower but contribute to 11% of India's scientific output.

He also emphasized on the role of “Responsible Innovation” in providing more enabling technologies, innovative products and services for people at the base of the economic pyramid, which was essential for the progress of the country. India still lives in villages. People at the base of the economic pyramid need our help to enhance their income and remove drudgery, and in this context the Minister was especially appreciative of the CSIR-800 programme.

Shri Reddy said as one of the leaders in innovation in the country, CSIR has greatly energized the National Innovation System through its contributions in the past seven decades. The spectrum of such contributions is quite wide – from import substitution to development of specific industry segments, from strategic capacity creation in some niche segments to marching towards global leadership. He expressed happiness that CSIR was increasingly carving out global Science & Technology niches and moving further in enabling the National Innovation System in a strategic manner. He said the setting up of the CSIR-Fourth Paradigm Institute (CSIR-4PI) is a testimony to that.

In the current Decade of Innovation, as declared by the Government, the Minister was especially happy that CSIR had pursued several innovative activities such as conceptualization of the eHealth Center (eHc) and making it operational. He felt proud to have launched the first eHealth Center in November 2012. Housed in an unused shipping container, it is a unique platform for pursuing the fourth paradigm of science, the data-intensive discovery, while also providing affordable healthcare services to people in need in rural settings, he added.

He also expressed happiness at CSIR setting up Innovation Complexes and its partnership with the National Innovation Council (NInC) to strengthen their MSME clusters – these steps had now started showing results.



Shri S. Jaipal Reddy  
Minister of Science &  
Technology and Earth  
Sciences and Vice President,  
CSIR addressing the gathering

The Minister also pointed out that CSIR is granted 90% of US patents granted to any Indian publicly-funded R&D organization and has a wide portfolio of patents in its armoury, of which 13.86% are licensed, a number which is above the global average.

He also appreciated that CSIR had won the prestigious National Intellectual Property Award 2013, as top R&D Institution in Patents. Also, the recognition of CSIR scientists by National Academies is of very high order. In the year 2013, two CSIR scientists received Infosys Foundation Award, out of the seven awarded, he said.

Emphasizing that real value in a knowledge economy could only be derived from invention and innovation, Shri Reddy called upon CSIR and its constituent laboratories to create an “Innovation System” in their own right. This would require building up of an ecosystem of researchers, entrepreneurs and enabling institutions. There was a need to invent and innovate more and more and also engage all the stakeholders in doing so.

**Shri Reddy said as one of the leaders in innovation in the country, CSIR has greatly energized the National Innovation System through its contributions in the past seven decades.**

The Union Minister later gave away CSIR Awards in various categories. Shri Reddy said he was happy to see future leaders of Indian science in the CSIR Young Scientist Awardees and called upon them to perform well in times to come and help the country achieve S&T leadership.

Prof. Samir K. Brahmachari,  
Director General, CSIR,  
presenting a shawl to the Minister  
Shri S. Jaipal Reddy



## Welcome Address by Prof. Samir K. Brahmachari Director General, CSIR

In his address to the gathering, Prof. Samir Kumar Brahmachari, Director General, CSIR said he was glad that the 71<sup>st</sup> CSIR Foundation Day function was being held for the first time in the new campus of CSIR-IGIB, which was inaugurated last year.

He said he had come to Delhi with a dream to put India on the global genomics map. When he joined a small unknown laboratory – the Centre for Biochemical Technology – he wondered whether at this laboratory genomics could be done. He soon realised that CSIR was a great organisation and was quite positive that it could be done. Prof. Brahmachari said that his dream came true when CSIR-CBT transformed into the CSIR-Institute of Genomics and Integrative Biology (IGIB).

“India today is a big player in genomics,” he said, “and this institute from which I formally stepped down six years back, has not only continued to do well, but has firmly put its footprint on the global arena and is today *the* institute of genomics in India.”

Prof. Brahmachari said that CSIR-IGIB was a testimony that if one dreams one could achieve it. “As a DG, I believe CSIR can unify and make a difference in the national context and I am glad to say in the last six years CSIR has undergone major transformation,” he said. “Today it is ‘One CSIR’ and is ready to deliver and is delivering for the people of India.”

The DG informed that during the last

year, CSIR had been able to raise one-fourth of the total budget internally. He was confident that CSIR would find innovative solutions to better utilise its intellectual workforce. He also said that CSIR had the potential to generate more revenue from the industry.



DG-CSIR, Prof. Samir K. Brahmachari delivering the Welcome Address



A view of the audience

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Prof. Samir K. Brahmachari

## Chemicals, Fuels and Petroleum Sectors: Opportunities in CSIR Laboratories

PROF. MAN MOHAN SHARMA

— A Report



Prof. M.M. Sharma delivering the CSIR Foundation Day Lecture

The CSIR Foundation Day 2013 lecture was delivered by Prof. Man Mohan Sharma, Emeritus Professor of Eminence, Institute of Chemical Technology, Mumbai on the topic *Chemicals, Fuels and Petroleum Sectors: Opportunities in CSIR Laboratories*.

Introducing Prof. M.M. Sharma to the gathered audience, Prof. Brahmachari said that Prof. Sharma was the first FRS from chemical engineering discipline in the country. He is a living legend and an example of a model guide, teacher, and mentor under whose tutorship students grew bigger. His students had single-author papers when Prof. Sharma was himself not well-established. There is no scientist who can claim as his students people like Dr. R.A. Mashelkar, who earned academic laurels and Mr. Mukesh Ambani, who became a corporate giant, said Prof. Brahmachari. He said it was a good opportunity to expose the students and scientists of CSIR to a model scientist and living legend on the 71<sup>st</sup> CSIR Foundation Day celebrations.

Prof. Sharma began by admitting that he had been an admirer of CSIR for long. He felt that the creation of the Academy was a landmark in the history of CSIR. CSIR has the incredible distinction of fathoming the ocean and tasting the rarefied air, he said. There is no organisation in the world that has a portfolio as wide, as deep and as rare.

During his hour-long lecture, Prof. Sharma came up with innovative and challenging opportunities and problems for CSIR laboratories to work on and emerge as world leaders.

He began with talking about renewable raw materials. One raw material that is available throughout the country and whose sourcing is not a problem is bagasse, because

we have a thriving sugar industry often crossing production of 25 million tonnes per annum, so one can imagine the quantity of bagasse that is available. He said that under the NMITLI programme of CSIR this work was taken up, but it progressed only to a certain stage. The problem is of such large magnitude that if we can take this bagasse and convert it to hydrate cellulose we can bring back the renewable-raw material based plastics; hemicelluloses can also be subjected to easy fermentation in the existing distillery and lignin should not to be treated as a fuel but valorised. During the last few years literature is flooded on valorisation of lignin. There is plenty of scope in India and CSIR labs can easily work on this problem of very large magnitude.

Prof. Sharma also pointed out that water was going to be a serious problem in the country. Sugarcane takes water for the entire year. However, the water utilisation in sugarcane and sugar refining leaves much to be desired. As of now all sugar refineries burn wet bagasse. So, lot of energy is wasted in vaporising water. He posed the question: Why can't we dry the bagasse with supercritical steam, which is already available in the cogen plants and harvest all this water? Engineering oriented labs can look at drying the bagasse with superheated steam, and harvest all the



Prof. Samir K. Brahmachari, Director General, CSIR, presenting a shawl to Prof. M.M. Sharma

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## Brief Biodata of Prof. Man Mohan Sharma

Prof. Man Mohan Sharma (born on 1 May 1937) was the first Indian engineer to be elected as a Fellow of Royal Society of London in 1990. He obtained B.Chem Engg and MSc (Tech) from Bombay University and PhD in Chemical Engineering from Cambridge University. He returned to India as Professor of Chemical Engineering and later became Director of UDCT (1989-97), now Institute of Chemical Technology (ICT), Mumbai – a deemed university.



Prof. Sharma is currently Emeritus Professor of Eminence, Institute of Chemical Technology, Mumbai; Kothari Research Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore; Member, Scientific Advisory Council to the Prime Minister; Chairman, Board of Governors, IIT Madras; Chairman, Standing Committee of IIT Council; Member, Advisory Board, IIT Bombay; Academy Professor, Academy of Scientific & Innovative Research (AcSIR).

Prof. Sharma has been conferred DSc (Honoris Causa) by a number of Universities and Institutes in India including several IITs. Among the several awards he has received are the Leverhulme Medal (1996); Padma Bhushan (1987); Padma Vibhushan (2001); Shanti Swarup Bhatnagar Prize in Engineering Sciences (1973); Moulton Medal of Institution of Chemical Engineers, UK (1971, 1977); FICCI Award in Science and Technology Engineering and Technology (1981); Om Prakash Bhasin Award, Engineering (1985); Danckwerts Memorial Lecture, Chemical Engineering Science/ Institute of Chemical Engineers, U.K. (1987); Shreve Distinguished Visiting Professor, Purdue University, USA (1989); P C Ray Memorial Award (1995); Millennium Award (2003), Indian Science Congress Association; H K Firodia Award for Excellence in Science and Technology (1999); G M Modi Science Award, Modi Foundation (1991); Life Time Contribution Award in Engineering, Indian National Academy of Engineering (2001); Life Time Achievement Award, Dr B P Godrej - IChE (2002); Life Time Achievement Gold Medal, Chemical Research Society of India (2003); Life Time Achievement Award, Indian Chemical Society (2004); LakshmiPat Singhania National Leadership Award in Science & Technology, IIM Lucknow (2011), to name a few.

He has been Fellow, Indian Academy of Sciences (1974); Fellow, Indian National Science Academy (1976), President, Indian National Science Academy (1989-90); Fellow, Third World Academy of Sciences (1990); International Fellow, The Royal Academy of Engineering (2005); Foreign Associate, U.S. National Academy of Engineering (2006); Honorary Fellow, National Academy of Sciences (1988); Director, Central Board of Directors, Reserve Bank of India (2006-2011).

Prof. Sharma has been Editor, *Chemical Engineering Science*, UK (1975-1986); Associate Editor, *Chemical Engineering Research and Design*, UK (1974-1986); Member, International Advisory Board, *Canadian Journal of Chemical Engineering* (1989-1993); Member, International Advisory Board, *Reactive and Functional Polymers* (1995- 2006); Editorial Board, *Separation and Purification Technology* (1997-1999); Editorial Board, *Green Chemistry* (1999-2000); Member, Editorial Board, *Clean Technologies and Environmental Policy* (2002- 2004).

Prof. Sharma has published 250 research papers in *Chemical Engineering Science*, *Industrial and Engineering Chemistry Research*, *Chemical Engineering Research and Design*, *Canadian Journal of Chemical Engineering*, *Reactive and Functional Polymers*, etc., published two books and also contributed several chapters in renowned books. He has supervised 71 Doctoral Thesis and 35 M. Chem Engg/MSc (Tech) Thesis and has been an active Consultant to Industry since 1964.

water. He said until now no work has been done in India on this challenging problem.

Next, Prof. Sharma moved on to generation of power. We are generating lot of power in India burning natural gas, which has the highest amount of hydrogen than

any other natural substance. He said, we can harvest a huge amount of water from the off-gases through novel technologies. It is a challenging problem how to recover water from the gas which is leaving at high temperature. One suggestion he gave was to



He posed the question: Why can't we dry the bagasse with supercritical steam, which is already available in the cogen plants and harvest all this water? Engineering oriented labs can look at drying the bagasse with superheated steam, and harvest all the water. He said until now no work has been done in India on this challenging problem.



**NGRI has done a lot of mapping of natural gas hydrates, often referred to as “fire on ice” or “frozen assets”. Shale gas has transformed United States and they have even started exporting gasoline. Prof. Sharma wanted CSIR’s chemical-oriented labs to look into recycling this water.**

develop a novel membrane separation technology for this purpose.

He also said that the new breakthroughs in availability of natural gas around the world are going to come through natural gas hydrates. NGRI has done a lot of mapping of natural gas hydrates, often referred to as “fire on ice” or “frozen assets”. Shale gas has transformed United States and they have even started exporting gasoline. Prof. Sharma wanted CSIR’s chemical-oriented labs to look into recycling this water. We also need to develop chemicals required for fracking, he said.

Plenty of carbon dioxide is available from several sources and globally there is considerable work going on in reforming methane with carbon dioxide, that way you will also do carbon capture. He suggested that we look for small-scale distributed Dimethyl ether (DME) plants.

There is a lot of talk about biodiesel. However, Prof. Sharma said that he was vociferously against biodiesel because there is no hope of being able to make any significant contribution for a very simple reason: the global requirement of diesel is 1.2 billion tonnes per annum; total production of non-edible plus edible oil is barely 70 million tonnes per annum. Even if 5% of biodiesel were to be blended with diesel, it would completely throw out of gear the edible oil industry. Ten million tonnes of edible oil, almost 60% of our requirement, is being imported in India. But what we can do from the non-edible oil is we can create biodegradable lubricants, he said. He said that the old classical process of refining of lube oils now required a relook.

Prof. Sharma pointed out another unusual thing – that India is going to burn a lot of petcoke, which comes from heavy crude oils. Many times these crude oils have sulphur as high as 2%, and petcoke ends up with 6-9% sulphur. But if you do IGCC all the sulphur is recovered and India has a very good appetite for sulphur because we need sulphuric and phosphoric acid for many industries. But when you process this heavy crude, the petcoke often contains 2000-3000 ppm of vanadium and nickel. We have no nickel source in India. This is a technology that nobody has developed today. It is a

challenge, he said, to recover vanadium and nickel from the ash that comes from petcoke IGCC as well as petcoke gasification. Petcoke gasification has already been undertaken. IGCC for petcoke will be on a grand scale in Jamnagar at levels of 60-70 million tonnes per annum. So huge amounts of vanadium and nickel can be recovered.

There is also a need to look at underground coal gasification far more intensely than we have been doing so far now. Prof. Sharma’s suggestion for coal and petroleum labs was to do coal carbonisation in series. This allows a significant part of volatile matter to be recovered as variable liquid fuels that can be upgraded.

The Fischer–Tropsch process is a key component of gas to liquids technology, which produces a synthetic lubrication oil and synthetic fuel, typically from coal, natural gas, or biomass. Prof. Sharma said that the Fischer–Tropsch synthesis could be linked to power generation. No matter which way you get your syngas – whether from coal or from hydrocarbons – since you generate them under pressure, when you generate power out of it, you have made good use of that pressure and instead of recycling the gas you take that gas to power generation. So there should be a link between petroleum refining petrochemicals and power generation. There is no reason why refineries cannot be exporters of power, he said. We need very intensified work in this area.

One of the challenges, he said, was novel catalyst development without cobalt. Do it in petrochemical mode so that you get olefins and alcohols from Fischer–Tropsch. When syngas comes from coal then you can consider making synthetic natural gas.

Prof. Sharma also mentioned the many novel applications of C6 to C18 and that nothing of this kind has been attempted. There are many opportunities with very large size cokers in India and also medium cokers. All of them are amenable to a variety of applications from etherification to esterification. Use of coker gas oil is another serious problem and needs to be considered, he said.

He posed the question: Why should we do thermal cracking of naphtha? Why shouldn’t we be doing cat-cracking where the yields of ethylene and propylene will be

much higher. Thermal cracking is not very efficient, he said.

Talking about the utilisation of C4 to C9 fractions of olefin, he said it was a pity that a lot of LPG in India is olefins. To use olefins as a fuel is technologically very bad, he said. This is happening on a grand scale in India and we are only partially valorising C4 to C9 fractions of olefin, particularly C4.

Prof. Sharma also called on chemical-oriented labs to take up telomerisation of butadiene to give 1-octanol as it was commercially viable.

Rare earths are becoming a political item throughout the world due to the Chinese embargo. Recovery of valuable rare earth metals is another challenge, said Prof. Sharma. Rare earths are absolutely essential for many things including a powerful magnet.

He also asked CSIR labs to focus on environment-friendly pigments, such as Cerium and Lanthanum based yellow and red pigments to replace hazardous Cadmium and Lead based pigments. Expertise in making pigments is lacking in India – even in the case of iron oxide pigments where the price varies from Rs 8 per kg to Rs 120 per kg. No one in India has the expertise to make this higher grade iron oxide pigment.

Even though our country is tropical the paint manufacturing companies are not selling anti-bacterial paint coatings. Imagine in our house if the coatings are insect repellent we will not need lots of sprays. Similarly we have high levels of dust in India. Exterior coatings require to be dust repellent. Powder coatings are also becoming very important. Prof. Sharma appealed to the coatings division of CSIR-IICT to look at these coatings.

Lithium is a very critical item; we have practically no source of lithium in India. There are no batteries possible today without lithium. Prof. Sharma said we need to locate new sources. One possible source could be recovery from used batteries and mobile phones. With 900 million mobiles and so many other devices using lithium, a technology to recover lithium could be wonderful. Also for storage the trend today is using Zinc Redox batteries. We need to work in this area, he said.

Fertilisers are a highly neglected area in India, said Prof. Sharma. For the last 13 years

we haven't had any new fertiliser. China is 40 million tonnes of nitrogen plus but we are struggling at 10 or 11. All potassium chloride is imported, almost 6.5-7 million tonnes per annum. There are only one or two countries that have the technology to convert potassium chloride to potassium nitrate or potassium phosphate. It is a big challenge, he said.

Prof. Sharma also emphatically said that there is a need for CSIR to create a centre for crystallisation. No drug production is possible without crystallisation. Medicines have turned out to be unsaleable because their crystallisation has not been done properly, he said. It is an area crying for intensification of efforts.

In view of large scale desalination we need high-flux separation membranes, said Prof. Sharma. Also nanofiltration membranes to withstand aggressive conditions like polar solvents, high concentration of sulphuric acid, high concentration of caustic soda, etc. This will aid manufacture of many drugs, agrochemicals and dyes.

Another area that Prof. Sharma talked about was cement, which is growing to more than 300 tonnes per annum. He said we need high performance concrete additives. There was a need to go in for polycarboxylic super plasticisers, which are also ecofriendly, particularly for high speed railways and expressways.

Among some other challenges he posed were production of Formic acid (which has many applications including silage – efficacy of silage goes up dramatically on treatment with formic acid); Macrocyclic synthetic musk to offset the smell of detergents (it is also environmentally good); and biotechnology products such as COQ10, Hyaluronic acid, L-cysteine, L-methionine, lycopene, and Heparin.

Prof. Sharma ended with a quote from Prof. Dr Uwe Krueffr, CEO of Atkins who says: "Shaping the future is better than trying to predict it. Take Leonardo da Vinci and his design for a helicopter 400 years before one flew." The utilitarian part of research invigorates fundamental research and it is here that CSIR plus Academy can really show the way how high science can be done, said Prof. Sharma.



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**Prof. M.M. Sharma**

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**Prof. M.M. Sharma**

## CSIR Young Scientist Awards 2013

Instituted in 1987, CSIR Young Scientist Awards seek to promote in-house excellence in various fields of science and technology. CSIR scientists, below 35 years of age, as reckoned on 26 September (CSIR Foundation Day) of the preceding year, are eligible for the Award. These awards are given annually in the following fields:

- Biological Sciences
- Chemical Sciences
- Earth, Atmosphere, Ocean & Planetary Sciences
- Engineering Sciences
- Physical Sciences (including instrumentation)

Each award consists of a citation, a cash prize of Rs 50,000/- (Rupees fifty thousand only) and a plaque. CSIR Young Scientist Awardees are also entitled to a research grant of Rs 5 lakhs (Rupees five lakh only) per annum for a period of five years and an honorarium of Rs 7,500/- (Rupees seven thousand and five hundred only) per month till the age of 45 years.

Till 2012, 157 scientists (including 17 women scientists) have received the CSIR Young Scientist Award and out of these 16 scientists have been conferred with the prestigious Shanti Swarup Bhatnagar Prize.

For the year 2013, Advisory Committee consisting of eminent scientists recommended the following six scientists for the CSIR Young Scientist Awards, which were given away by the Union Minister for Science & Technology and Earth Sciences Shri S. Jaipal Reddy.

### Biological Sciences

**Dr. Arun Kumar Trivedi** of CSIR-Central Drug Research Institute, Lucknow for his

outstanding contributions towards identification of novel targets of E3 ubiquitin ligases that regulate tumorigenesis.



The Union Minister for Science & Technology and Earth Sciences Shri S. Jaipal Reddy with the CSIR Young Scientist Awardees, at the 71st CSIR Foundation Day Celebrations in New Delhi on 26 September 2013. DG-CSIR, Prof. S.K. Brahmachari, Prof. Man Mohan Sharma and Dr. Rajesh Gokhale, Director, CSIR-IGIB can also be seen.



### Chemical Sciences

**Dr. Santoshkumar D. Bhat** of CSIR-Central Electrochemical Research Institute, Karaikudi, for his innovative contributions to the design and development of polymer electrolyte membranes in fuel cell applications.

**Dr. Yatendra Singh Chaudhary** of CSIR-Institute of Minerals and Materials Technology, Bhubaneswar, for developing novel functional nanostructured materials for solar-fuel generation and bio-implant scaffolds.

### Earth, Atmosphere, Ocean & Planetary Sciences

**Dr. Maheswar Ojha** of CSIR-National Geophysical Research Institute, Hyderabad, for his significant contributions in exploring gas hydrates using novel inversion and numerical tools.

### Engineering Sciences

**Dr. Parveen Saini** of CSIR-National Physical Laboratory, New Delhi for his significant contributions related to the development of conducting polymer based EMI shielding materials, antistatic coatings and anticorrosive paints as well as fundamental contributions in the area of conjugated polymers and polymer nanocomposites.

### Physical Sciences (including instrumentation)

**Dr. Sanjay Kumar Srivastava** of CSIR-National Physical Laboratory, New Delhi, for development of simple processes for large area fabrication of silicon nanowires and nano-scale textured silicon with very low surface reflectivity towards realization of efficient solar cells.

## CSIR Technology Awards 2013

Minister of Science & Technology and Earth Sciences and Vice President, CSIR, Shri S. Jaipal Reddy gave away the CSIR Technology Award 2013 on the occasion of the 71<sup>st</sup> CSIR Foundation Day celebrations.

Given annually, the CSIR Technology Awards were instituted in 1990 with a view to foster and encourage in-house multidisciplinary team efforts and external interaction for technology development, transfer, marketing and commercialization. Each award carries a cash prize of Rs. 2 lakh. Besides, a plaque and a citation are also given to the awardees.

This year the CSIR Technology Awards were given to the following laboratories:

### CSIR-North East Institute of Science & Technology (CSIR-NEIST), Jorhat

**CSIR-NEIST** has won the award for developing herbal drug for management of arthritis. The herbal formulation developed is non-toxic, non-invasive and is for topical application. It helps in managing the arthritic problem effectively. CSIR recognises the significant contribution of Prof. Samir Bhattacharya of Visva-Bharati University, Santiniketan.

### CSIR-Central Salt & Marine Chemicals Research Institute (CSIR-CSMCRI), Bhavnagar

**CSIR-CSMCRI** has won the award for developing technology for production of synthetic hydrotalcite using effluent streams from organic pigment industry. The technology is focused at achieving significant value addition to waste which was causing environmental hazard. The technology was licensed to M/s Heubach Colour Pvt. Ltd., Ankaleshwar. The company has installed a 1000 TPA plant to manufacture synthetic hydrotalcite. This

is the first plant to produce SHT in India and the first of its kind in the world to produce SHT using effluent streams from organic pigment industry and salt industry.

**CSIR-Central Mechanical Engineering Research Institute  
(CSIR-CMERI), Durgapur**

**CSIR-CMERI** has won the award for developing portable magnifying instrument useful for colposcopy. The innovation involves development of a portable optical instrument for early diagnosis of cervical cancer especially affordable to the poor patients residing in remote villages. CSIR recognizes the contribution of Late Dr. Gour Chandra Chatterjee, Gynaecologist of Sree Sree Mohanananda Cancer Hospital, Durgapur.

**CSIR-National Chemical Laboratory  
(CSIR-NCL), Pune**

**CSIR-NCL** for significantly enhancing the business and marketing of its knowledgebase. CSIR-NCL played a vital role in the quest of the country towards scientific and technological leadership and providing scientific solutions to the industries and adopted several new strategies and developed business models for smooth flow of technologies to industry.



The Union Minister for Science & Technology and Earth Sciences Shri S. Jaipal Reddy with the CSIR Technology Awardees, at the 71st CSIR Foundation Day Celebrations in New Delhi on 26 September 2013. DG-CSIR, Prof. S.K. Brahmachari, Prof. Man Mohan Sharma and

**CSIR Award for S&T Innovations for Rural Development (CAIRD)**

CSIR instituted the CSIR Award for S&T Innovations for Rural Development (CAIRD) in 2006 to recognize and honour those outstanding S&T innovations that have helped transform the lives of rural people or alleviated the drudgery of the rural people.

The award is given to an innovation

that has created a paradigm shift in standards of quality of life of the rural people or demonstrated competitive advantage and positive user response or helped in generation of rural employment in the country and shown a new way of conducting business to achieve social and economic transformation in the domain of

rural development. The award consists of a cash prize of Rs 10 lakh, a citation and a shield.

**CSIR Award for S&T Innovations for Rural Development (CAIRD) for the year 2012 was awarded to CSIR-**

**CSMCRI, Bhavnagar along with AquAgri Processing Pvt. Ltd., New Delhi for “Cultivation of red seaweed *Kappaphycus alvarezii* and co-production of bio-nutrients & Carrageenan from fresh seaweed”.**



## CSIR Diamond Jubilee Technology Award

CSIR instituted the CSIR Diamond Jubilee Technology Award in commemoration of its Diamond Jubilee from the year 2003. The award acknowledges the most outstanding technological innovation that has brought prestige to the nation.

The award is given to a technology that is developed in the country by Indian innovators and meets the highest global standards. Technologies leading to commercially successful products,

processes and services, which give India a sustainable competitive advantage, are considered for the award. The award consists of a cash prize of Rs 10 lakh, a citation and a shield.

**CSIR Diamond Jubilee Technology Award (CDJTA), for the year 2013, was conferred on Mahindra Reva Electric Vehicles Private Ltd., Bangalore for “Design and development of the electric car named e2o”.**

## CSIR Innovation Award for School Children 2012

In order to enhance creativity amongst school children, CSIR announced for the first time the Diamond Jubilee Invention Award for School Children on 26 April 2002 – the day celebrated as World Intellectual Property Day throughout the world. The objective of this competition is to capture the creativity and innovativeness amongst school children and create awareness about IPR. The competition continued till 2010 and in the year 2011 was renamed as the ‘CSIR Innovation Award for School Children’.

During the last eleven years, i.e. from 2002 to 2012, 4181 proposals were received for these Awards from various parts of the country and 66 inventions/innovations were selected for various prizes by a High Level Awards Selection Committee.

For the year 2012, only six innovations were selected out of 487 proposals received for the various categories of prizes, out of a total number of thirty prizes to be given. In the year 2012. The winner gets a cash prize, trophy and a certificate.

### FIRST PRIZE (₹ 1,00,000/-)

No. of prizes : Nil

### SECOND PRIZE (₹ 50,000/-)

**Srishti Jain, Vatsal Sharma, Yash Bansal** of Class 12<sup>th</sup> of DLF Public School, Ghaziabad, for the invention *ADIA-Cool (Air Conditioner)*.

This innovation utilizes the idea of cooling the air adiabatically by continuous expansion and accordingly has devised a model of air conditioner that does not use CFCs. The devised air conditioner is eco-friendly and cost effective.

### THIRD PRIZE (₹ 30,000/-)

**Master R.G. Janani** of Class 7<sup>th</sup> of Kendriya Vidyalaya, No.-2, Kalpakkam, Tamil Nadu for his invention *Universal Kitchen Machine*.

This innovation relates to motorized, portable, user friendly, economical, and a multi-utilitarian kitchen machine for utensil cleaning with extended kitchen applications like mixing, churning, battering, scraping.

This device will protect workers' hands from roughness, wet sores, nail infection and will reduce the drudgery of cleaning utensils. This device is cost effective and will replace the bulky, high energy consuming and expensive dish washer.

#### FOURTH PRIZE (₹20,000/-)

**Rohan Ch. Das** of Class 9<sup>th</sup> of Little Flowers' School, Nalbari, Assam for his invention *Conversion of Energy by Applying Playway Method in Schools*.

This innovation employs the optimization of mechanical energy of swings and cycle in the school and converting it to electrical energy which can be used to run fans and for charging the rechargeable batteries of mobiles, digital cameras, and remote control torch lights. This innovation is effective in remote villages without any electrification.

#### FIFTH PRIZE (₹10,000/-)

**Pritam Chhetri** of Class 12<sup>th</sup> of Birpara High School, Jalpaiguri, West Bengal for his invention *A Safety System for Gas*.

This innovation provides the design of a safety system for the detection of unexpected domestic gas leakage which works on the basis of Pascal's theory. The device consists of volt cell, piston, motor, speaker, LED, key & lock, copper and

aluminum plate, small iron rod and aluminum pipe which further consist of movable aluminum ball, connected with the gas regulator which becomes active only after the lock is open. The leakage of gas can be detected and prevents blast of gas cylinder.

**Nishant Rajesh Dugad** of Class 8<sup>th</sup> of L.V.H Academy, Nasik, Maharashtra for his invention *Magic Irrigation to Save Electricity, Manual Power and Energy*.

This innovation relates to a device for irrigation that can save electricity, manual power and energy. In this innovation, a hand pump is attached with the see-saw and then it is kept in a tub filled with water. When the see-saw goes down on one side the pump gets half dipped and air pressure brings the water into the pipe. Through these pipes water is supplied to the plants. There is also a ball valve near the water tank which is used in case plants do not need water.

**Anjaney Kumar and Abhishek Anand** of Class 11<sup>th</sup> of Jawahar Navodaya Vidyalaya, Saharsa, Bihar for his invention *Magnetic Goggles for Handicapped*.

This innovation provides a device magnetic spectacle useful for both arm amputated person for reading and turning the pages of a book. This spectacle comprises of simple attachable and detachable magnets at the side of the frame which will be attracted towards the iron foil pasted on the edge of the book.



The Union Minister for Science & Technology and Earth Sciences Shri S. Jaipal Reddy and DG-CSIR Prof. Samir K. Brahmachari with the winners of CSIR Innovation Award for School Children 2012

# Shanti Swarup Bhatnagar Prize for Science & Technology 2013



The Shanti Swarup Bhatnagar (SSB) Prize for Science and Technology are perhaps the most awaited scientific awards in the country. The names of the winners of the Shanti Swarup Bhatnagar Prizes 2013 were announced by Prof. Samir Kumar Brahmachari, Director General, CSIR during the 71<sup>st</sup> CSIR Foundation Day celebrations.

Instituted in the year 1957, in the memory of late Dr (Sir) Shanti Swarup Bhatnagar, FRS, the founder director of the Council of Scientific & Industrial Research (CSIR), the SSB Prize is awarded each year on the basis of conspicuously important and outstanding contributions to human knowledge and progress, made through work done primarily in India during the five years, preceding the year of the prize.

Any citizen of India engaged in research in any field of science and technology up to the age of 45 years is eligible to be nominated for the SSB Prize. Overseas Citizen of India (OCI) and Persons of Indian Origin (PIO) working in India are also eligible to be considered.

The SSB Prize, comprising a citation, a cash award of Rs. 5,00,000/- (Rupees five lakh only) and a plaque, is given to each person selected for the award in the following disciplines:

- Biological Sciences
- Chemical Sciences
- Earth, Atmosphere, Ocean & Planetary Sciences
- Engineering Sciences
- Mathematical Sciences
- Medical Sciences
- Physical Sciences.

## LIST OF RECIPIENTS OF SSB 2013

### Biological Sciences

**Dr. Sathees Chukkumbal Raghavan**  
Department of Biochemistry  
Indian Institute of Science (IISc)  
Bangalore 560 012

### Chemical Sciences

**Dr. Yamuna Krishnan**  
National Centre for Biological Sciences  
(TIFR) UAS-GKVK, Bellary Road  
Bangalore 560 065

### Earth, Atmosphere, Ocean & Planetary Sciences

No Award

### Engineering Sciences

**Dr. Bikramjit Basu**  
Materials Research Centre  
Indian Institute of Science (IISc)  
Bangalore 560 012

&

**Dr. Suman Chakraborty**  
Department of Mechanical Engineering  
Indian Institute of Technology (IITKgp)  
Kharagpur 721 302

### Mathematical Sciences

**Dr. Eknath Prabhakar Ghate**  
School of Mathematical Sciences  
Tata Institute of Fundamental Research  
(TIFR) Homi Bhabha Road, Colaba  
Mumbai 400 005

### Medical Sciences

**Dr. Pushkar Sharma**  
National Institute of Immunology (NII)  
Aruna Asaf Ali Marg, New Delhi 110 067

### Physical Sciences

**Dr. Amol Dighe**  
Department of Theoretical Physics  
Tata Institute of Fundamental  
Research (TIFR)  
Homi Bhabha Road, Colaba  
Mumbai 400 005

&

**Dr. Vijay Balakrishna Shenoy**  
Department of Physics  
Indian Institute of Science (IISc)  
Bangalore 560 012

## G.N. Ramachandran Gold Medal for Excellence in Biological Sciences & Technology 2013

CSIR instituted a Gold Medal in 2004 in the fond memory of Prof. G.N. Ramachandran, a pioneer of protein chemistry and the founding father of structural biology in India, for recognizing excellence in the interdisciplinary subject/field of Biological Sciences & Technology.

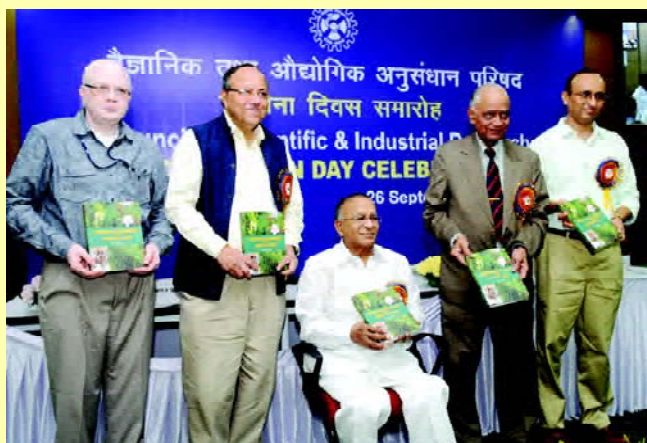
Till the year 2012, nine scientists have been bestowed with this prestigious award: Prof. M. Vijayan (2004), Prof. P. Balaram (2005), Prof. T.P. Singh (2006), Prof. C. Ramakrishnan (2007), Prof. M.R.N. Murthy (2008), Prof. R.V. Hosur (2009), Dr. Dinakar M. Salunke (2010), Prof. Jayant B. Udgaonkar (2011), and Prof. Dulal Panda (2012).

For the year 2013, the Advisory Committee recommended Prof. Raghavan Varadarajan of the Indian Institute of Science, Bangalore for the G.N. Ramachandran Gold Medal for Excellence in Biological Sciences and Technology. Prof. Varadarajan has used



The Award being presented by the Union Minister for Science & Technology and Earth Sciences Shri S. Jaipal Reddy to Prof. Raghavan Varadarajan of the Indian Institute of Science, Bangalore, in the presence of DG-CSIR Prof. Samir K. Brahmachari and Prof. M.M. Sharma

both computational and experimental methods to obtain a deeper understanding of the relation between protein fold and stability. He has done exemplary work on the design of proteins to carry out specific functions, especially on the design of immunogens that could be eventually used in an AIDS vaccine.



Shri S. Jaipal Reddy releasing a book "Appropriate Technologies for the Development of Northeast India", edited by Dr. U.S.N. Murty, Chief Scientist, CSIR-IIT at the Foundation Day 2013 celebrations



India's first Supercontinuum light source designed and developed by Vinvish Technologies in collaboration with CGCRI being released by Shri S. Jaipal Reddy on 26 September 2013



## DG-CSIR delivers the 56<sup>th</sup> Holland Memorial Lecture

Prof. Samir K. Brahmachari, Director General, CSIR delivered the 56<sup>th</sup> Holland Memorial Lecture organized by the Mining, Geological and Metallurgical Institute of India (MGMI), Kolkata at the Taj Bengal, Kolkata on 14 September 2013. The Lecture Series is named after Sir Thomas Henry Holland (1868–1947), a British geologist who in 1903 was appointed Director of the Geological Survey of India (GSI). Sir Holland founded the MGMI in 1906.

The DG made an impassioned presentation entitled *Open Innovation, Big data and Crowd Sourcing: The Next Frontier*. A copy of the formal oration was also circulated amongst the august audience. However, he frequently departed from the prepared text some of which has been summarized here.

Prof. Brahmachari began his presentation by making a clear distinction of his dual roles; the first as Secretary to the Government of India and the second as DG-CSIR, Head of India's largest innovation system. He said that he would not be addressing policy issues in this talk. He likened his job as DG-CSIR to that of a field soldier who carries out the task of implementation. He said, "Pandit Nehru and Sir Shanti Swarup Bhatnagar realized what had to be done and the chain of CSIR laboratories were built...I will talk about what has to be done but it is important to walk the talk; not just preach. Unless you walk the talk you cannot convince others."

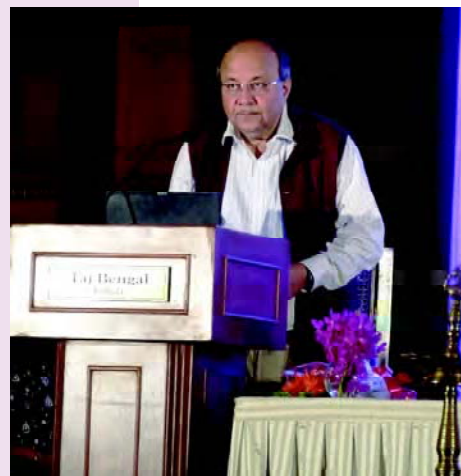
He said that it was amazing to realize that the GSI is the oldest institute that happened in Kolkata; this citadel of knowledge played such an important role in developing the minds of the modern Indian. He said it was a great privilege to have been educated in the great city of Calcutta and that the list of personalities who were living then was mind boggling and that he wished he had been born 50 years ago! He marvelled at how GSI managed to create maps without the aid of

satellites and said that it showed how ahead of its times the city was.

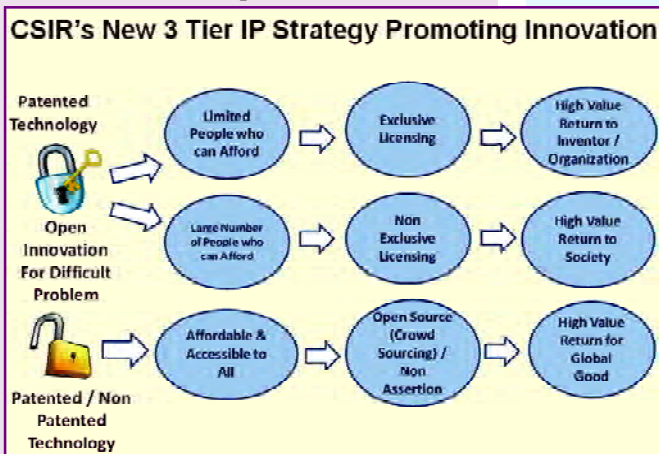
He then presented some statistics about CSIR in 1942 and compared it to similar statistics in recent times. He detailed CSIR's new 3-tier IP strategy saying that patented technology would give high return to Inventor/Organization and would be limited to people who could afford it, open innovation would be used to solve difficult problems and through non-exclusive licensing the solution could be made available to a large number of people for the benefit of society.

Prof. Brahmachari joked that his predecessor had been a champion of IPR; yet he, as the next DG-CSIR, was a great believer in Open Innovation. There was no contradiction, he asserted and said that CSIR's IP portfolio and patents were needed. It was akin to having an atomic arsenal before talking about nuclear non-proliferation, he said. In India it was possible to acquire the IPR that is best in the world and to out-compete other countries.

According to Prof. Brahmachari, innovation is the need of the hour and open innovation is the path in the future.



DG-CSIR, Prof. Samir. K. Brahmachari delivering the Lecture





One example of how big data could be generated and effectively analysed for societal welfare was the CSIR fully integrated, cloud-enabled e-health centre that has been recently created jointly by CSIR and Hewlett Packard. These e-healthcare centres can be set up to provide affordable and preliminary healthcare in remote areas.

Innovation must be promoted. Major issues that need innovative approaches include Energy. Solutions should be sought via the open source way because energy is needed for all.

He pointed out that times change and mindsets change too. For example, the seventies generation was an idealistic one imbued with the spirit that admired Che Guevara. In the nineties, competitive spirit had raised its head and many youngsters migrated abroad to create wealth in the Silicon Valley.

Currently the new generation has learnt to connect through innovative use of social networking sites such as Facebook and Twitter. He then spoke about computer networks as compared to people to people networks as enabling grids for E-science. In his words, “Thus from protected IP we move into open space innovation.”

Prof. Brahmachari then posed the question: “Can we make the next generation GSI map? Can we involve people to make it happen? I am confident that we can; innovation is in our blood.”

One way to ensure inclusiveness is to generate wealth at the grassroots level. This is where the micro, small and medium enterprises (MSMEs) come in. In terms of value, the MSME sector accounts for about 45% of the manufacturing output and around 40% of the total export of the country. It is against this backdrop that a huge MSME Business Conclave was being organized in Kolkata, he said.

The question was how wealth could be generated for those at the bottom of the economic pyramid. DG-CSIR said that innovation is inclusive when it is open. The Open Source Drug Discovery Programme (OSDD) is an example; it is a CSIR-led Team India project which has earned the appreciation of the world. The 2012 report of Nesta, which is the UK’s innovation foundation, focused on the policies, institutions and industries that are driving research and innovation in India. In this

report, special emphasis was given to frugal innovations that are present in the Indian system. One such initiative is the effort to crowd source drug discovery that is being driven by CSIR. With crowd sourcing we can connect the best minds, the DG said.

According to the report by Nesta, OSDD is considered a frugal innovation as it is leveraging human capital for science in new ways to radically reduce the cost of drug discovery by crowd sourcing resources. DG-CSIR pointed out that OSDD was launched in 2008, and that by happy chance it was on OSDD’s 5<sup>th</sup> Foundation Day that he was delivering the 56<sup>th</sup> Holland Memorial Lecture. OSDD, which is an attempt to provide affordable healthcare, is an example of the fourth paradigm of science in action, he said. “I had a dream,” he said “could we involve thousands of people and make drug discovery inexpensive; make drug discovery for neglected diseases. Five years down the road it is becoming a reality. OSDD is a fine example of a crowd sourced project. What gives me hope is that we have about 7600 members in 130 countries.”

When science first began it was empirical; based on direct or indirect observation and experience. Then it moved to the second stage which was largely theoretical. Then science evolved to the computational stage which involved simulations and modelling. Big data is the next frontier, he said. This is the fourth paradigm of science and it involves data-intensive scientific discovery.

We have a new opportunity here and CSIR has repositioned CSIR-CMMACS as the nucleus of CSIR-Fourth Paradigm Institute. It will work in the domain of computational, data intensive research and discovery. CSIR-Fourth Paradigm Institute has been designed to function in a hub-and-spoke model. The hub is in Bangalore and the spokes will be at Delhi, Chennai, Pune, Hyderabad, Kolkata, Nagpur and Chandigarh.

One example of how big data could be generated and effectively analysed for societal welfare was the CSIR fully integrated, cloud-enabled e-health centre

that has been recently created jointly by CSIR and Hewlett Packard. These e-healthcare centres can be set up to provide affordable and preliminary healthcare in remote areas. The solution integrates medical instruments that collect basic patient health data. It also enables medical diagnosis through remote consultation via video-conferencing. DG-CSIR said, “This shows that if you have imagination, persistence and conviction it is possible to implement.”

Science 2.0 is another area where data intensive projects are possible. The Mining, Geological & Metallurgical Institute of India is an ideal institution for Science 2.0. As an example, the DG explained in detail about the Connect to Decode (C2D) programme,

which created self-learning communities that communicated to re-annotate the genome of the Tuberculosis causing microbe. Such a pattern of learning was totally different from the traditional didactic system of learning. New ways of science communication, such as Science 2.0 use social media extensively. Thus blogs, micro-blogs or tweets can all be effective channels. It is more important to motivate which is a long-term perspective as against providing incentives which are short term measures.

He concluded by saying that in India, mining was facing a crisis and that innovation was needed as falling behind was not an option.

*Report by Dr. Sukanya Datta,  
Principal Scientist, CSIR-CGCRI,  
Kolkata*



The DG explained in detail about the Connect to Decode (C2D) programme, which created self-learning communities that communicated to re-annotate the genome of the Tuberculosis causing microbe. Such a pattern of learning was totally different from the traditional didactic system of learning.

### Full Text of the Lecture



I am extremely delighted to be here today, delivering the prestigious Sir T.H. Holland Memorial Lecture. It is indeed an honor for me to address such a distinguished audience, comprising eminent personalities and many bright young minds, who I believe, are set to offer innovative solutions to the many socio-economic issues, which matter to the people of this country today. And I thank the Mining, Geological and Metallurgical Institute of India for this opportunity.

I take this opportunity to pay my tribute to Sir Thomas Henry Holland, the Founder President of MGMI, in whose memory, this prestigious lecture has been organized. His significant contributions to Indian Geology, like the first scientific description of the charnockites near Kolkata, and the establishment of this institute here in India, are reflective of the fact that pursuit of

scientific excellence and intellectual contributions for betterment of mankind, transcend the boundaries of nationalities and cultures.

It is also significant that the lecture is being held here in Kolkata aptly called the ‘Citadel of Knowledge’. Having spent my childhood here, I am not unfamiliar with the city of Kolkata. Also two of CSIR’s prestigious institutes – CSIR-Indian Institute of Chemical Biology and the CSIR-Central Glass and Ceramic Research Institute – are located here. Needless to say, Kolkata has always been a centre of academic and creative excellence.

It was here, at the Indian Association for the Cultivation of Science, that Sir C.V. Raman made the phenomenal discovery on scattering of light in 1928, which bears his name and that brought many accolades



**The mining industry of India commands respectable antiquity, dating back to pre-Harappan times. And owing to the foresight of our great leaders, the scientific acumen of our researchers and persisting efforts of our ardent industrialists, we are today a major global player in the field of geology, minerals, metallurgy and mining technologies.**

including the Nobel Prize. It was here in Kolkata, that the Indian Science Congress Association made its modest beginning in 1914, with hundred and five members and which today stands as a strong scientific fraternity with more than twenty thousand members. And it is here that the Mining, Geological and Metallurgical Institute of India was established, way back in 1906 and which now has its branches across the country, and is playing a crucial role in promoting study of minerals and mining practices in India.

Stones, followed by minerals and metals, have been the earliest resources available to humankind. The journey of civilization from caves to skyscrapers undoubtedly has been collinear with the advent and evolution of mining and engineering technologies that helped man explore, discover, process and beneficially use these resources. Like the many other disciplines, Ayurveda, music etc., the mining industry of India commands respectable antiquity, dating back to pre-Harappan times. And owing to the foresight of our great leaders, the scientific acumen of our researchers and persisting efforts of our ardent industrialists, we are today a major global player in the field of geology, minerals, metallurgy and mining technologies.

I must admit that when I was asked to give this lecture, I was enormously hesitant. I, coming from a genomics background and addressing a gathering of geologists, metallurgists and mining technologists .....It was a little awkward. However, I realize that being DG, CSIR, one's position is like a coconut ..... (You are) needed for every Hindu festival.

Therefore, no wonder that my CSIR predecessors, physicists and chemical engineers, from Prof. Nayudamma and Dr. Varadarajan to Dr. A.P. Mitra and Dr. R.A. Mashelkar have delivered this prestigious lecture from this forum. I was awestruck to learn that Prof. Satyendra Nath Bose delivered this lecture from this very platform fifty three years back. However, from a look at the entire list of past speakers, I realized that I will be the first person from Biological Sciences to address this eminent group from geological, mining and metallurgical sciences. But I hope that my basic education as a

student of Chemistry from the city of Kolkata and my topic for today that spans all disciplines – be it life sciences or earth sciences – justifies my presence.

### **IPR for Global Good in Present Scenario**

It is interesting that 15 years back, Dr. Mashelkar talked about Intellectual Property Rights and future challenges from the same place. And today, another DG CSIR is going to talk to you about the power of Open Innovation in the era of Facebook and how new technologies are going to reshape the entire scenario of global S&T and their application to industrial growth.

Historically, Industrial Revolution in Europe and subsequently, USA, grew based on the strong protection of Intellectual Property Rights. India has accepted the Intellectual Property regime in the past two decades and has been keeping pace with the changing world. Today, CSIR-India holds a large IP portfolio with 90% of total US patents granted to any public funded institution in India. CSIR also has the ability to commercialize 14% of these patents through licensing...far above international average. This puts me in a position, as Head of CSIR to talk to you about the power of Open Source while holding large number of Intellectual Property Rights. Just as we all realize that to talk about non-proliferation, it is important that you are a nuclear power state.

The monopolization of knowledge as an individual property has always been a much debated issue, dating back to 1421, when the world's first patent was awarded for an improved method of transporting goods up and down the River Arno in Florence, Italy. Intellectual Property Rights is generally considered to be a reliable indicator of inventive activity and a driver of innovation. Today, not only has this idea been proved ineffective in many cases like that of healthcare, but has also posed serious threat to affordability and accessibility of technologies. With the emergence of open source as a trend in technological innovations, the possibility of coexistence of patent rights and open source innovations, which in turn can ensure affordability and accessibility, has opened up.

It is interesting that in the past 15 years, the world has changed. We have moved far ahead through telecommunication revolution, come a long way forward through computer revolution and we have converted this world into a connected world. So I have chosen to talk to you about the power of Open Innovation, Big Data and Crowd Sourcing, the next frontier of global S&T and their applications in industries.

### **What is Open Innovation?**

So, what is open innovation? We all are aware, about the development of World Wide Web (WWW), Wikipedia and powerful operating systems like LINUX. We all admire the historical achievement in life sciences – The Human Genome Project – which is transforming the healthcare sector. It is important to note that all these significant achievements in the history of human kind were based on a single novel concept – The Open Source.

There was a scenario...many decades ago when the idea of collaborative research was strictly limited to professor-student association. Exchange of data and knowledge was restricted within the laboratories of a research institution. Slowly, science progressed from the state of serendipitous discoveries to organized branches of study and then to transdisciplinary mode and the vital need of sharing of information and research was felt at large. Over the years, large scale scientific projects involving an intricate division of labor among various institutes and greater de-centralization of authority came into existence. The Human Genome Project is the finest example of this paradigm shift in research. Suddenly science started moving away from the echelons of the ivory tower to discussing innovation based on inclusiveness and collaboration to solve intriguing scientific challenges.

The IT revolution played a major role in promoting the concept of free sharing of technological information, and the world saw the formation of self-organizing communities of individuals who come together to produce a shared outcome. All the data was kept and shared in open and thus the idea of peer-production was introduced.

Let me explain this to you a little more, in the context of existing healthcare sector and discovery of new drugs for neglected tropical diseases like Tuberculosis and Malaria. As I mentioned previously, I come from a biological science background, and today represent an organization which has pioneered the first global scale, open source research project in India – the Open Source Drug Discovery, with the vision to provide affordable healthcare for all.

Needless to say, in the past few decades, we have made rapid strides in introducing new vaccines and medicines that have improved healthcare significantly. But our scientific understanding of causative elements of many of the infectious diseases is still far from satisfactory. The market-driven innovative models of pharma companies have developed drugs for diseases that have sales potential commanding a large market. Diseases that are predominant in countries like India, for example, TB and Malaria, and in which western countries have little or no interest, are still being treated with drugs created in the middle of the last century. Because of the closed door and profit based approach, innovation has stopped or has frozen in time for such diseases that affect our people, except few philanthropic institutions' efforts in recent years. The discovery pipeline of big pharma companies for these infectious diseases is dry and the costs of R&D have escalated ... thus increasing the cost of drugs. This, indeed is a very alarming situation and therefore you can't leave drug discovery in the hands of pharma alone ... it is too risky for humanity.

It is evident that there are not enough innovations, the ones that exist are too marginal and unaffordable. Therefore, it is clear that we cannot expect to solve our problems with the same thinking pattern we have been trained to use. As it is said, "Real innovation lies in innovating how we innovate: and the question is how we introduce that innovation element?"

So, what do we do? We do the same thing that pharmaceutical companies do; but we do it a little differently....This is where the concept of open innovation that can challenge the conventional drug discovery

**It is interesting that in the past 15 years, the world has changed. We have moved far ahead through telecommunication revolution, come a long way forward through computer revolution and we have converted this world into a connected world.**

**Diseases that are predominant in countries like India, for example, TB and Malaria, and in which western countries have little or no interest, are still being treated with drugs created in the middle of the last century. Because of the closed door and profit based approach, innovation has stopped or has frozen in time for such diseases that affect our people, except few philanthropic institutions' efforts in recent years.**

We remove the lock that restricts access to information in conventional drug discovery platforms. There is no password. All the data is accessible....



The Fourth Paradigm of Science is based on data-intensive discoveries. Scientific research is turning out data sets so large and complex that it becomes difficult to process them using traditional data processing applications.

approach comes in. We remove the lock that restricts access to information in conventional drug discovery platforms. There is no password. All the data is accessible....and the moment we do that, transformation takes place....and that is what Open Source Drug Discovery (OSDD) is all about. This is what Open Innovation is all about. And this is the need of the hour.

Inclusiveness, virtual collaborations, along with the adoption of open sharing of data have come to be regarded as some conspicuous facets of modern science clearly demarcating science of the 21<sup>st</sup> century from the exclusive, and insular approach of traditional science.

### The Fourth Paradigm and Big Data Mining

Let us now discuss what Big Data is .....

Today, we are actually witnessing the advent of what has been described by the pioneering computer scientist Jim Gray, as the '*Fourth Paradigm*' in Science. The Fourth Paradigm of Science is based on data-intensive discoveries. Scientific research is turning out data sets so large and complex that it becomes difficult to process them using traditional data processing applications. The capture, curation, storage, search, sharing, transfer, analysis and visualization of these large datasets are the challenges before us today.

The Fourth Paradigm of science has not happened overnight in a single jump. It is actually the result of the path that scientific discovery has taken over the ages.

If we were to trace the evolution of modern science, we would observe that this evolution has happened in distinct stages. From being curiosity-driven in ancient times, when scientific research was more of empirical nature, it graduated to becoming hypothesis–experimentation dependent and then moved on to a phase where modeling and simulation studies shared the spotlight. These distinct stages have been referred to as the First, the Second and the Third Paradigms of Science, respectively. Today scientific research is based on the unification of theory, experiment and simulation. Data analytics using data mining, machine learning, etc. is a common practice. This stage of

science is what is called as the Fourth Paradigm of Science.

Big Data Mining is not just about huge amounts of scientific data and the computational systems needed to handle it. It also calls for a transdisciplinary approach, cross-flow of technologies and collective effort of experts in different fields. It demands sophisticated tools, and platforms that integrate seamlessly.

Let me give you two well known examples to understand the significance of Big Data in research.

First is the Large Hadron Collider experiments. Considered one of the greatest engineering milestones of mankind, you would be surprised to know that it represents about 150 million sensors delivering data 40 million times per second. There are nearly 600 million collisions per second. After filtering and refraining from recording more than 99.999% of these streams, there are 100 collisions of interest per second.

Second are the Genome Sequencing projects in Biology. The Human Genome Project, considered the biggest feat in biological research, originally took 10 years to be completed. But with significant progress in the speed and accuracy of sequencing technologies we have moved from sequencing 10 Kilobases per day per machine to 100 million Kilobases per day per machine. The modern DNA sequencers have also reduced the sequencing cost by 100,000 fold in the last ten years – from 300 million dollars to 3000 dollars. With such technologies in hand, life scientists are rapidly coming up with massive amounts of genomic data along with various phenotype data, everyday, which when analyzed can help us gain a deeper understanding of life and diseases.

Thus, it is clear that technologies to effectively mine and analyze huge volumes of data are the need of the hour. The applications we develop need to be optimized to fulfill this objective. These data can fuel major discoveries of tomorrow. This is the science of the future. With the appropriate use of Big Data, the manner in which technologies are developed and applied to industries will be changed

profoundly and forever. Data-driven decision making will aid groups of respectable wise men making guidelines and every decision and every outcome will be data for the next decision.

The Fourth Paradigm of Science will transmute the way Science is being done. In turn, this has fuelled the need for a totally new generation of Scientists to address the burning issues of today; for example, healthcare to alternate energy; structural engineering solutions to traffic control on roads; water harvesting to flood management.

It will mean exploring innovative solutions such as Crowd Sourcing and cloud computing. It will involve global collaborations, at local levels, to provide services such as affordable healthcare and electricity to all.

CSIR aspires to partake in this Big Data driven science and our data intensive research focuses on multiple disciplines spanning from Biomedical and Engineering Informatics to Earth System Informatics, Chemical Sciences and Cyber Security. Realizing the importance of data intensive research, CSIR has established the CSIR-Fourth Paradigm Institute....the first of its kind in the world. This multi-location, national institute with a captive hub laboratory and a few regional centers aims to focus on data intensive scientific research and develop cutting edge technologies to capture, curate and analyze, Big Data.

CSIR-IGIB has come up with a successful cross flow of technology – The Micro Public Health Centre. The Micro PHC is the most modern eHealth Centre which includes health cloud computing managed through satellite and provides affordable primary care reaching directly to the rural people. Micro PHC's are designed to generate the required data for data-intensive discovery of future preventive and predictive health solutions.

### **Crowd Sourcing: The New Mantra**

In the Fourth Paradigm of science the new mantra is 'Crowd Sourcing'. It is diametrically different from the classical or traditional methods of collaboration. The conventional model of collaboration and cooperation

involves interacting with a person(s) whom you know. However, crowd sourcing takes the approach to an entirely new, almost counter-intuitive level by outsourcing collaborative tasks to an undefined group of people or community who share the required expertise and interest.

Crowd sourcing is a perfect model when it comes to massive goal driven efforts seeking solutions to complex problems through individuals in cyberspace willing to cooperate. The underlying principle is enabling participatory efforts of people who may not even be acquainted with each other. In crowd sourcing lies the future of Science education and research. This is Science 2.0. This is the way all science will be done in the future.

While crowd sourcing emerged as a buzz word that was coined in *Wired* magazine by author Jeff Howe in 2006, it is interesting to note that the process of crowd sourcing was invented as early as 1714, when the British Government conducted the first ever Crowd Sourcing activity. They launched an open contest to solve what was called 'The Longitude Problem' which made sailing difficult and dangerous. This first crowd sourcing endeavor resulted in an innovation — 'Marine Chronometer' – which was an accurate, vacuum sealed pocket watch and it established the fact that crowd sourcing can be a major driver of innovation and creativity.

This was followed by the Toyota logo designing contest in 1936. The Sydney Opera House, one of the most innovative landmarks of the world, is the outcome of a crowd sourced architectural contest that received 233 entries from 32 countries around the world in 1955. The period from 2001 to 2005 saw some of the largest crowd sourced initiatives so far, namely Wikipedia which is today's crowd sourced knowledge, YouTube – the crowd sourced entertainment, InnoCentive – the open innovation company which provided the first online platform for crowd sourcing and the American Idol Season-I, which kicked off a plethora of talent contests drawing individuals from the public.

The period between 2007 and 2013 has been a revolutionary period in the context



**CSIR aspires to partake in this Big Data driven science and our data intensive research focuses on multiple disciplines spanning from Biomedical and Engineering Informatics to Earth System Informatics, Chemical Sciences and Cyber Security.**



**Crowd sourcing takes the approach to an entirely new, almost counter-intuitive level by outsourcing collaborative tasks to an undefined group of people or community who share the required expertise and interest.**



**In 2007, CSIR launched the Open Source Drug Discovery which is a translational drug discovery platform, bringing together experts of various disciplines like informaticians, wet lab scientists, mathematicians, computer scientists, and chemists together to collaboratively aggregate the biological, genetic and chemical information available in order to use it to hasten the discovery of drugs.**

of crowd sourced research. In 2007, Zooniverse – the first citizen science web portal – was launched by the Citizen Science Alliance. Also, in 2007, CSIR launched the Open Source Drug Discovery which is a translational drug discovery platform, bringing together experts of various disciplines like informaticians, wet lab scientists, mathematicians, computer scientists, and chemists together to collaboratively aggregate the biological, genetic and chemical information available in order to use it to hasten the discovery of drugs. OSDD, a CSIR-led team India Initiative with global partnership is today an inclusive community with the participation of over 7600 researchers and students across 130 countries working in cyberspace through a collaborative portal called Sysborg 2.0 which facilitates open sharing of data. A community of 800 students manually re-annotated the entire genome of the pathogen *Mycobacterium tuberculosis* and identified novel drug targets in the same.

Then came, Foldit – the online puzzle video game – which encourages players to fold the structure of selected proteins, using various tools provided within the game. These structures are then analyzed by researchers. In 2011, players of Foldit helped to decipher the crystal structure of the Mason-Pfizer monkey virus retroviral protease an AIDS-causing monkey virus protein. The problem of how to configure the structure of this enzyme had been puzzling scientists for almost 15 years.

The BRAIN Initiative recently announced by the Obama administration with the goal of mapping the activity of every neuron in the human brain is the most recent addition to this line.

Hence, it is clear that crowd sourcing does not have to remain confined to specialized or niche areas of S&T. Crowd sourcing can be a powerful tool for commercial innovation too. It will definitely branch out from the Open Innovation Model exemplified by OSDD to another type more suited for Business models. The future of the global industry may well be shaped by crowd sourcing. Even today, it is obvious that the conventional model of manufacturing a product at a given location is poised to change dramatically. In the

future, conventional assembly lines may well be replaced by ‘virtual industries’. It will be possible to be an Industrialist without owning a single piece of land but owning just an assembly line. The entire manufacturing process can be carried out by identifying micro, small and medium enterprises or MSMEs and crowd sourcing those MSMEs. This has tremendous potential.

Just look at the statistics. According to the website of the Ministry of Micro, Small and Medium Enterprises, the 4th Census of MSME Sector shows that this sector employs an estimated 59.7 million persons spread over 26.1 million enterprises. It is estimated that in terms of value, MSME sector accounts for about 45% of the manufacturing output and around 40% of the total export of the country. Can you estimate just how rich the future of MSMEs can be when crowd sourcing takes off in a big way, involving students from engineering, business management, marketing etc?

The advantages that crowd sourcing can provide as compared to the conventional ways of collaboration are many. Those industries that can position themselves to optimally use this system will be the ones to take the lead in market’s future space. This tool will be applicable to all; even social scientists for formulating new policies, based on data intensive discovery. The future winners will be those who can innovatively tap into this emerging system.

OSDD is hence a good example of how distributed co-creation can eventually become mainstream research. OSDD has emerged as a large virtual organization, opening up the boundaries of conventional research and allowing individuals to offer their expertise in novel ways. The scale of collaboration OSDD has been able to achieve could not have been possible without the application of open innovation and crowd sourcing concepts. Yes, crowd sourcing is an extensive networking activity and it is facilitated by the modern computational technologies and internet connectivity. It becomes even more exciting when the data is so large that it cannot be handled just by few experts. As we rapidly stride forward, it becomes clearer that this approach can be extended towards the development of novel technologies like

smart power grids, control of traffic mobility, population migration models, and design of energy efficient buildings to achieve the goals of sustainability. This also can help us create novel business models which create value through interactions among multiple players and create “paying only for what you use” services thus helping consumers avoid large expenditures, as well as the hassles of buying and maintaining a product. The success of business models like OLX and Flipkart are examples of how networking using computational technologies is changing the world.

We have seen that innovation, especially inclusive innovation, happens at the bottom of the pyramid. And what better strategy than crowd sourcing to identify the innovators from the bottom of the pyramid? This is clear again from the experience of OSDD, which has successfully executed massive scale research projects drawing upon the talents of previously untrained graduate students. The National Innovation Foundation aims to identify and support grassroots innovators of the society in a similar fashion.

### **Crowd Funding**

Public good is most likely to be produced on the grid. This is the future we are looking into. But then the question is who will fund these activities? Will they always be funded by government or can funding also be crowd sourced? The answer is crowd funding. Crowd funding refers to the collective, networked effort of individuals to pool money, in order to support developmental efforts initiated by other people or organizations. This invariably follows the principle of “Public money for the public good”. This is an innovative financial model that will facilitate innovation through crowd sourcing without conventional controls. Crowd funding like Crowd Sourcing is expected to soon to become the new trend.

### **Big Data Mining: Role in Geology, Mining and Metallurgy**

The continuously expanding economies of the world have created an enormously increasing demand on resources. Securing metal and mineral resources is critical for

the development of industries. This also holds a strategic competitive advantage to build national security and at the same time poses the grand challenge of sustainability and inclusive growth. Similar is the case with geo-sciences which involves large scale monitoring and data analysis to understand the course of natural phenomena which are vital to human activities like agriculture, water management and so on. All this in turn demands technological innovations. Scientific and technological innovation systems that break the barriers of conventional R&D spanning discovery of unique applications of previous knowledge, novel processes and structures to enhance performance should be promoted. In this era of globalization and large scale social networking we need to leverage on the potentials of global networks, collaborations and consortia.

Geological studies, mining and metallurgical processes are international activities, much like many manufacturing enterprises like pharma and IT industries. So when IT and pharma industries are looking up to innovations in open mode, is it possible to seek innovative solutions to issues of eco-friendly mining technologies in an open source mode? Isn't it possible to generate quality simulation models for mining and metallurgy and minimize toxic wastes and energy consumption in an open source manner?

Why not? Some of the shining examples of open innovation have come from the field of mining. Take the famous example of the Goldcorp challenge. The international mining agency Goldcorp published their mine's map on the web to seek best methods and estimates of mining from experts across the world. This attracted the potential of more than 1,400 scientists, engineers, and geologists from 50 countries and the innovative solutions that emerged have resulted in massive increase in the productivity of the mine. So it is time we ask: Can we build an international collaborative platform seeking open innovations and solutions to issues persisting in the geology and mining sector? How do we use Big Data in context of geology, mining and metallurgy? Can we find alternate



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**The international mining agency Goldcorp published their mine's map on the web to seek best methods and estimates of mining from experts across the world.**



Can we source global brain for global good through open innovation and crowd sourcing? These endeavors will generate huge volumes of data which when analyzed will lead to breakthrough discoveries that may transform the world.

methods of mining which can avoid deforestation? Can we develop novel innovative methods to use low grade minerals to get high quality metals? Can we come up with an alternate metal that can replace steel?

Thus here I pose three grand challenges:

- Firstly, in the context of geo-sciences, remote sensing operations play a crucial role. How do we use sensors and smart GIS/GPRS based application systems to monitor and generate large volumes of integrated data to address the challenges of agriculture and water management? Can we use this Big Data to understand the genomic profile of soils and thus map soil productivity? How can we generate new knowledge that can be well utilized for the creation of agricultural wealth?
- Secondly, today the term 'Sustainable Mining' is fast catching on. Though it sounds like an oxymoron, we need to ask if sustainable mining can be achieved through open source and crowd sourcing principles. The grand challenges in this area include questions like development of novel technologies for horizontal mining that can be performed without disturbing or displacing indigenous tribal population and effecting ecological balance. Can

we engineer highly efficient, supreme quality mining explosive that is 100% soundless?

- Thirdly, how can we use crowd sourcing to develop innovative next generation technologies for metallurgy. How do we develop technologies that reduce the energy utilization during production of Aluminum?

### Conclusion

These challenges are vital questions that need to be solved and for which investment may not be possible. But, these solutions are for global good. So can we source global brain for global good through open innovation and crowd sourcing? These endeavors will generate huge volumes of data which when analyzed will lead to breakthrough discoveries that may transform the world, whether it is the integration of geo-spatial data along with soil properties, agriculture productivity or water levels in various places.

Earth Systems Science and its various branches are going to be the ones maximum influenced by Big Data. In this scenario, handling Big Data and making discoveries is the challenge. Hence it is crucial that Indian scientific community and a society like yours come forth, generate skilled individuals and partake in the Fourth Paradigm of Science. Let us be future ready. Together we can ...and we should!!! .

## Forthcoming Events

**International Conference on Advanced Functional Materials (ICAFM-2014):** 19-21 February 2014. Being organised by CSIR-National Institute for Interdisciplinary Science and Technology, Trivandrum in association with The Indian Institute of Metals, Materials Research Society of India and Indian Ceramic Society, Trivandrum Chapters. Email: [icafm2014@niist.res.in](mailto:icafm2014@niist.res.in).

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Phone: 25848702; Fax: 25847062; E-mail: [csirnews@niscair.res.in](mailto:csirnews@niscair.res.in); [hjk@niscair.res.in](mailto:hjk@niscair.res.in)

**Website:** <http://www.niscair.res.in>

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