

## Energy concepts for the 21st century\*

A one-day discussion meeting on the emerging new energy concepts for the 21st century was held at the National Institute of Advanced Studies (NIAS), Bangalore. B. V. Sreekantan and S. Ranganathan (NIAS) and M. Srinivasan (formerly of Bhabha Atomic Research Centre (BARC), Mumbai) served as co-conveners for this meeting. There were about 40 participants at the meeting, majority of whom had a scientific background. Two of the participants represented an Indian venture capitalist firm.

Ever since the two electrochemists, Martin Fleischmann and Stanley Pons, University of Utah, announced in March 1989 that they had discovered a simple table-top device wherein nuclear fusion reactions take place at room temperature producing significant 'excess heat', the subject of what came to be known initially as 'cold fusion', but now more commonly referred to as 'low energy nuclear reactions' (LENR) has been embroiled in controversy. Majority of the scientific community had dismissed the initial claims of Fleischmann and Pons as unlikely. The main criticisms were: (a) non-reproducibility of the phenomenon, (b) non-observation of telltale signatures of the occurrence of nuclear reactions in the form of nuclear radiation or particles and (c) most importantly, there did not seem to be any valid explanation or theory as to how the Coulomb barrier can be overcome in these experimental configurations for nuclear reactions to happen at low temperatures.

While most of the groups worldwide who attempted to replicate the original experiments failed, a minority has been observing anomalous 'excess heat' not attributable to faulty calorimetry or any hidden chemical reactions. Other groups, through careful experimentation, have since reported emission of neutrons,

X-rays or charged particles and/or production of tritium, helium and nuclear transmutation products. Over the last 19 years, the sophistication of the experiments has significantly improved and considerable evidence accumulated, indicating the occurrence of nuclear reactions in these devices. A large variety of experimental configurations have been studied, besides electrolytic cells. However, reproducibility is still a problem, although there are now a few recipes which are reported to give a reasonable degree of reproducibility. As for the fundamental objection of the nuclear physics community regarding overcoming the Coulomb barrier at low temperature, it would seem that on the surface (or in the near-surface region) of a metal such as palladium, the physics of nuclear reactions is very different from that in a hydrogenous plasma.

During the last 19 years, 13 international conferences in the ICCF series have taken place and several meetings at the national level. Most of the papers published to date are available in the website [www.lenr.org](http://www.lenr.org). A professional society named 'International Society for Condensed Matter Nuclear Science' (ISCMNS) was formed in 2002 ([www.iscmns.org](http://www.iscmns.org)), which publishes an electronic journal of CMNS. Although there is still reluctance on the part of some mainstream physics and chemistry journals to publish papers pertaining to this field, a few prestigious journals have started publishing LENR-related papers, as can be seen from the above website. It is noteworthy that both the American Physical Society and American Chemical Society have been convening special sessions on LENR since the last few years during their annual meetings. The American Chemical Society is currently bringing out a comprehensive *Sourcebook on Low Energy Nuclear Reactions*, which is under publication by Oxford University Press (2008).

During this one-day meeting, three researchers and one science editor who have been closely associated with the field of condensed matter nuclear science shared their first-hand experience in this emerging area of science, and led the discussions. Michael McKubre, an experimentalist with electrochemical back-

ground, who has been working in this field from the beginning (March 1989) has significantly contributed to throwing light on why the electrolysis results are difficult to reproduce, one of the main criticisms of the non-believers and skeptics. His talk titled 'Cold fusion: Past, present and future' carried the participants through the various surprises and breakthroughs that have characterized the unfolding of the science of LENR. The main conclusion of his research may be summarized as follows: The primary 'ash' of the LENR in Fleischmann-Pons-type electrochemical cells is He-4 gas. McKubre has found that for the nuclear reactions responsible for excess heat generation to be switched on, there are at least three necessary conditions to be satisfied: (i) The deuterium to palladium loading ratio needs to cross a threshold value of 0.93; (ii) the current density needs to exceed 0.60 A per sq. cm, and (iii) there needs to be an adequate deuterium flux across the cathode surface. McKubre's path-breaking research has now fully dispelled the mystery of why most people who tried to replicate the Fleischmann-Pons experiment failed! Unfortunately even with the significant level of understanding, he was not able to demonstrate excess heat with certainty when the source of the palladium metal (the supplier) is changed, indicating that there are still some missing bits of the puzzle which are not yet understood.

Steven Krivit, Editor, *New Energy Times* ([www.newenergytimes.com](http://www.newenergytimes.com)) is a science journalist who has interviewed almost every major investigator involved in LENR research in the world and has authored a book titled *Rebirth of Cold Fusion* (2004). Krivit gave a global overview of the status of the field. A brief summary of his talk also appears in the present issue of *Current Science*.

Edmund Storms, is a retired scientist from Los Alamos Scientific Laboratory, who has recently authored the book, *The Science of Low Energy Nuclear Reaction* (World Scientific). His prerecorded talk titled 'What is cold fusion and why should you care?', was screened at the meeting. [Edmund Storms, 'How to Cause Low Energy Nuclear Reactions (LENR)', re-

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corded December 2007. See: [http://www.youtube.com/view\\_play\\_list?p=3B79262131CA1BCF](http://www.youtube.com/view_play_list?p=3B79262131CA1BCF).] Storms points out that LENRs seem to be occurring in special localized sites on the surface of deuterium-loaded materials, which he has characterized as constituting a novel 'nuclear active environment' (NAE). The LENR community is currently involved with unravelling the unique nature of the NAE.

M. Srinivasan, who was also involved in cold fusion research from day one at BARC, reviewed the experimental evidence published even prior to the Fleischmann-Pons announcement of 1989, which indicates that LENR is in fact not a new concept and that elemental transmutation seems to be occurring in nature more commonly than generally believed. The pre-cold fusion era transmutation reports are found to be in full consonance with the observations of nuclear transmutation reactions involving the host metal atoms reported by a large number of LENR

workers in recent years. (The BARC cold fusion results of 1989–90, played a key historic role in the early development of the field, by providing a positive picture at a time when doubts were being cast on the reality of the nuclear origin of the phenomenon. The website [www.lenr.org](http://www.lenr.org) carries a brief account of the early BARC work. Unfortunately, interest in the subject died at BARC in the nineties.)

It thus appears that the field of LENR/CMNS has matured sufficiently to claim recognition as a valid new branch of science, even though some of the questions raised in the early years still remain. If all that is claimed by the LENR community is validated, then one has to concede that we are witnessing a significant paradigm shift in nuclear science. It is therefore timely that the Indian scientific community took stock of the status of the field with an open mind, in view of its importance and the prospects of being developed into a 'third alternative option' for generating nuclear energy in the

21st century, besides fission and thermonuclear fusion.

The meeting concluded with a stimulating panel discussion in which the panelists M. R. Srinivasan (former Chairman, Atomic Energy Commission), S. K. Rangarajan (former Director, Central Electro-Chemical Research Institute, Karaikudi), Bikas Sinha (Director, Variable Energy Cyclotron Centre, Kolkata), besides the three speakers unanimously endorsed the view that LENR research should be strongly supported in the country. To quote M. R. Srinivasan '*...There is some science here that needs to be understood. We should set some people to investigate these experiments. There is much to be commended for the progress in the work. The neglect should come to an end.*'

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**M. Srinivasan**, 25/15, Rukmani Road, Kalakshetra Colony, Besant Nagar, Chennai 600 090, India.  
e-mail: [chino37@gmail.com](mailto:chino37@gmail.com)

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## MEETING REPORT

### BioMalaysia 2007\*

Many countries around the world are showing great interest in biotechnology now than ever before, and Malaysia is no exception to this. In fact, Malaysia's aim to become a regional biotechnology hub is to make sure that the country will get its slice of the lucrative market. Investments by both foreign and local investors in the biotech sector are encouraging and the biotech sector is well on the track to meet its target of contributing 2.5% of the country's gross domestic product (GDP).

BioMalaysia is an annual premier biotech event of Malaysia that brings biotech experts, industry players and all stakeholders together. BioMalaysia 2007

was held recently and the objectives were to provide partnering opportunities for the biotechnology industry to meet and forge relationships, to provide a unique opportunity for biotechnology companies and research institutions to learn from and share their experiences with experts, to be the platform for governmental agencies, regulators and private sectors to exchange views for working towards achieving greater heights in biotechnology development in the region, and to be the platform for recognition of outstanding performance of scientists and researchers in the area of biotechnology. The theme of the conference was 'Innovation for the Quality of Life'.

In the three-day conference, there were two keynote sessions, three plenary sessions, one single-track super session and six concurrent sessions, namely agriculture biotechnology, healthcare biotechnology, industrial biotechnology, finance, growth and strategic challenges. More than 1000 conference participants, 200 companies/

organizations for exhibition and 10,500 participants from over 30 countries participated in this three-day event. Selected papers, which give the flavour of the conference are mentioned here.

In the keynote address, a systematic review of bionanotechnology was presented by Tony Cass (ICL, UK). He highlighted the importance of standardization, miniaturization, acceptability, responsiveness, timeliness of the medicine, increasing healthcare costs, personalizing therapies, nanoscale techniques for DNA analysis, and advances in bionanotechnology and nanomedicine. Cass claimed that the excitement of working at disciplinary interfaces, engagement of biology/engineering/physical sciences, available funding, desire to generate new values (intellectual property (IP), services and products), and insatiable demand for healthcare are the drivers of bionanotechnology. By summarizing initiatives in the countries from European Union (EU), the USA, India, Japan, Korea,

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