elements and exploit them for technological applications. These superheavy elements are expected to have very different properties and behaviour than the presently known elements.

Similar advances are also being made in synthesizing new elements away from the line of beta stability which have unusual neutron to proton ratios. With the advent of new generation of accelerators providing radioactive nuclear beams, more of such elements, known as the exotic nuclei, are being synthesized at present. Several talks focused upon these areas. In particular, R. K. Gupta, Chandigarh, provided insights into the theoretical aspects of this new game and A. K. Sinha covered the experimental aspects of the field. R. Shyam (SINP, Calcutta) gave an account of our present understanding of the exotic elements. Y. K. Gambhir (IIT, Mumbai) and Arun Jain (BARC, Mumbai) considered the treatment of the exotic nuclei from a relativistic mean field theory which is being considered as a powerful tool to understand nuclear properties.

A special evening session was devoted to a panel discussion to arrive at a consensus on the Future National Experimental Facilities. The discussion was coordinated by B. K. Jain. Many possible scenarios of future experimental facilities were presented by A. K. Sinha (NSC) and R. Pillay (TIFR). S. N. Chintalpudi (IUC–DAEF) presented the progress and difficulties in setting up a National Gamma Ray Array. A consensus was reached among the scientists to set up a National Gamma Array and a Radioactive Ion Beam Facility. A suggestion was made by R. Shyam for having a National Document in the area of nuclear physics research for the next five to ten years. This suggestion was supported by I. M. Govil (Chandigarh), L. Chaturvedi (Banaras) and A. K. Jain (Roorkee), Convener of the Workshop. It was agreed that this idea is very useful and steps should be initiated to prepare such a document as soon as possible.

Talks by many younger scientists were presented on the new modes of quantum rotation like magnetic rotation (Amita), Giant Dipole Resonances (V. Nanal) and high-spin features of $A = 70$ and 100 nuclei (G. Mukherjee and P. Joshi). It is known that only deformed nuclei can exhibit quantum rotational spectra. Studies of deformed shapes and high spin states (very large rotation) have occupied the centre stage of nuclear physics research. Magnetic rotation is a new mode of rotation discovered only a couple of years ago; here nearly spherical nuclei display rotational spectra, something quite unexpected. An explanation in terms of a shear mechanism where the neutron and proton blades of angular momentum, initially perpendicular to each other, close in to generate high spins, has been proposed recently. Following this discovery, new modes of rotation like anti-magnetic rotation are also being talked about. Topics like super-deformation and hyper-deformation (N. Singh and V. Ramasubramanian) were also discussed. Both of these are also high spin phenomena and have resulted in the observation of many unusual features like identical bands which still remain unexplained.

State-of-the-art of the various nuclear models being used at present and complete spectroscopy was discussed at length by V. K. B. Kota (PRL), R. Sahu (Berhampur), P. K. Raina (IIT, Kharagpur) and R. C. Nayak (Orissa). S. S. Malik and A. K. Jain presented an application of the semi-classical methods to nuclear systems which highlighted the renewed interest in classical dynamical methods and their applications to quantum systems by introducing quantization. Twenty-six invited speakers from all over India made presentations on the current topics and the work carried out in the country. A significant number of these talks were presented by young scientists who have completed their Ph D or, are in the process of completing it. Intense discussion was the hall-mark of the workshop with sufficient time provided for it.

The meeting concluded with a summary of the workshop presented by C. V. K. Baba (Hyderabad). The proceedings of the workshop will be published soon.

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# Biogeochemistry of trace elements*

In the 5th meeting in a conference series started in 1990 the keynote lectures delivered by Leon Kochian (Cornell University) and by Iain Thornton (London) addressed complementary aspects, i.e. plant–soil interactions focusing on the rhizosphere and the food chain. Kochian provided a comprehensive review of the basic mechanisms and regulation of plant-based processes involved in the entry of toxic heavy metals into the food chain (via uptake into plants), the phytoremediation of metal contaminated soil and mechanisms of heavy metal tolerance by plant. Referring to the soil as a primary source of essential trace elements for plants, animals and therefore, for humans, Thornton pointed out that soil is also a source of heavy metals, though anthropogenic inputs of industrial and other emissions may greatly exceed natural geological sources.

The conference topics covered important aspects of fundamental research such as kinetics and mechanisms of the fate of trace elements, including radionuclides, in the soil and related ecosystems and methods of their assessment. The scientific programme comprised ten special symposia, emphasizing key areas in trace element research.

There were 298 oral presentations in 59 special symposia and technical sessions as also three poster sessions consisting of nearly 253 papers.

*A report of the International Conference on the Biogeochemistry of Trace Elements, held at the Technical University, Vienna, Austria during 11–15 July 1999.

Alan Baker (UK) described that specially selected plants, e.g. *Thlaspi* species, known as hyperaccumulators, can extract and accumulate exceptionally high levels of toxic metals from the soil. Phytoremediation is a new technology employed for removing excessive toxic metals and pollutants from the soil or contaminated aqueous medium. Louis Jean Morel (INRA, France) explained that human activities lead to the ineluctable increase of metal concentrations in the soil and are becoming a threat for the surrounding ecosystems and for food safety. Hyperaccumulators are a special class of plants which have acquired the ability to accumulate metals with higher than 1% concentration in the foliar dry matter. Steve P. McGrath (Rathamsted, UK) explained constraints to the growth and metal uptake by hyperaccumulator plants. Rufus L. Chaney (USDA-ARS-Environmental Chemistry Lab, USA) concluded that development of effective agronomic management practices and improved cultivars of hyperaccumulator species show promise for development of successful phytomining and phytoremediation technologies for Ni. Clayton L. Rugh and co-workers (University of Georgia, USA) demonstrated that transfer to bacterial mercury resistance genes to plants provide them the ability to grow on normally toxic Hg-containing substrates and has great potential as a method to remove hazardous bioavailable mercurials from contaminated environments.

S. Dushenkov (Ukraine) concluded that phytoremediation may be a valuable option for the soil with low level radionuclide contamination. High biomass plants are capable of removing substantial amount of radioactivity from the soil. T. Harren (Switzerland) opined that to achieve better results either in modelling of radionuclide soil-to-plant transfer or in phytoextraction further research in the soil chemical processes and in the plant uptake mechanism is needed. Hirofumi and Tsukada (Japan) suggested that the investigation of the root uptake of stable Cs and K in the rice plant could lead to a better understanding of the transfer of radiocesium in paddy fields. E. Lombi (UK), W. W. Wenzel (Austria), G. R. Gobran (Sweden) and D. C. Andriano (USA) reviewed the work on rhizosphere-contamination interaction and its role in phytoremediation and suggested that future research should be directed to establish the role of rhizosphere processes in the various phytoremediation technologies on a metal-specific basis.

N. T. Basta (Oklahoma State University, USA) and G. M. Pierzynski (Kansas State University) discussed the remediation technologies of As, Pb, Cd and Zn contaminated soils and explained that smelting of non-ferrous metal ores, pesticides, coal combustion, and Pb-based paint atmospheric deposition have resulted in contamination of the urban soil with these heavy metals. Chronic exposure to these contaminants can result in human health effects including kidney dysfunction from Cd, skin and internal organ cancers from As and impaired metal development from Pb. Excessive Zn and Cd in the soil causes phytotoxicity. B. D. Hill and R. Naidu (South Australia) provided a brief overview of issues of soil contamination within Australia, New Zealand and the South Pacific region and current assessment, management and remediation strategies that have been developed for addressing these issues. They reported that there are approximately 60,000 contaminated sites in Australia and over 50,000 in New Zealand and the South Pacific region. M. H. Wong (China) presented current approaches to managing and remediating metal-contaminated soil in China and M. G. Pirzynski in the United States. Similarly, K. M. Paknikar (India) discussed bioremediation of metal contaminated soil strategies for India and its neighbouring countries. Chakraborti (Jadavpur University, India) cautioned that the arsenic calamity of West Bengal, which is one of the biggest in the world, should not be neglected and similar situations should be avoided in other countries. A proper watershed management is the need of the day. S. M. Ullah (Dhaka University, Bangladesh) predicted that the entry of metals into the food chain through plant uptake might cause health hazards and also environmental problems. Mobilization of metals due to their complexation may play an important role in the soil after aforestation, in particular after agricultural application of organic fertilizers as concluded by A. Karczewska (Poland). G. Taylor (Canada) suggested that a more detailed analysis of the potential for interactions between metals in the environment may be required. Marigold is able to take chromium in quite large quantities as suggested by C. Bini (Italy) and could be suitable for phytoremediation of Cr-affected soil. Over 30 metallic elements and 20 non-metallic elements have been found in crude oils by S. L. Davydova from Russia who further predicted that heavy metals will be the main pollutants of the next century. Naidu revealed that electrokinetic remediation and soil washing process may be useful technologies for the removal of As from contaminated soils. Studies conducted by C. Michiel Laker (South Africa) suggest that Mn deficiency may increase the incidence of oesophogeal cancer and it is important to understand the interrelationship between the soil, crops and human health.

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