in hydrogen-bonded clusters and aromatic clusters, in addition to explaining the effect of cation–π interaction on hydrogen-bonded clusters and π–π clusters. Avesh Tyagi (Bhabha Atomic Research Centre, Mumbai) spoke about functional materials, a new class of materials that are being developed that have wide applications. Inducing functionality and stabilizing these materials is a problem that researchers are now trying to address. He mentioned that using combustion method and vacuum heating in a reduced atmosphere, a range of materials like $CeCrO_3$ could be synthesized. $CeCrO_3$ is used to degrade rhodamine, a toxic dye.

Hormones play an important role in the regulation of reproduction and overall physiology. They are of interest to protein chemists, said Rajan Dighe (IISc). The antibodies against hormones and their receptors are pivotal to probe the mechanism of hormone action at both physiological and molecular levels. The receptor antibodies help in elucidating the mechanisms of activation of glycoprotein hormone receptors and can have applications in cancer immunotherapeutic. Souvik Maiti (Institute of Genomics and Integrative Biology, Delhi) explained the *in vitro* screening method using DNA-based molecular beacon to identify inhibitors of miR27 from a library of 14 aminoglycosides. Further, screening of the library revealed that streptomycin had the inhibitory capacity to silence miR-21 oncomir by structural perturbation of the dicing process, making it a potential anti-cancer agent. Debashis Mitra (National Centre for Cell Science, Pune) said that 30 years after the discovery of HIV, a vaccine is yet to be developed. His group has been able to identify and characterize few novel HIV-1 inhibitors that may functionally block the proteins inside the cell that enhance virus replication. The on-going study may take two years to complete. He said that these specific inhibitors may help solve the mystery of drug resistance in HIV patients. He said though 27 FDA-approved inhibitors exist, none has been developed further. These inhibitors can keep the virus away, but the virus tends to rebound once they are withdrawn.

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MEETING REPORT

Thermophiles–2013*

The 12th International Conference 'Thermophiles–2013' was organized by the Archaea Centre, Institute of Microbiology, University of Regensburg, Germany. During the inauguration Michael Thomm (Chairman, Organizing Committee) explained how the Archaea Centre originated and also about its activities. Karl Stetter gave an account of the expeditions to high-temperature geothermal environments in Iceland and oceanic thermal vents for collection of samples followed by isolation, characterization, identification and discovery of novel hyperthermophilic bacteria and archaea. Stetter and co-workers have described several new genera and species of thermophilic bacteria and archaea, and developed an excellent facility for the preservation of microbial cultures, studying their physiology, biochemistry and molecular characteristics, and unique facility for large-scale cultivation of hyperthermophiles in specially designed fermenters. The conference proceedings consisted of invited lectures, and oral and poster presentations.

R. K. Thauer (Max Planck Institute for Terrestrial Microbiology, Germany) spoke on the early evolution of C-1 metabolism. Flavin-based electron bifurcation has been shown as the mechanism of coupling endergonic and exergonic redox reactions in anaerobic archaea such as *Methanopyrus kandleri* and bacteria like *Moorella thermoacetica*. Van der Oost (Wageningen University, The Netherlands) presented the work on DNA-guided DNA interference by prokaryotic argonaute. Argonaute is a key enzyme of RNA-guided RNA interference pathway in eukaryotes. The argonaute in prokaryotes such as *Thermus thermophilus* functions as a host-defence system on DNA-guided DNA interference.

Jennifer Littlechild (University of Exeter, England) explained how they produced thermostable biocatalysts from thermophilic bacteria and archaea, and bacterial genomes and metagenomes for different industrial applications. Recombinant thermostable enzymes such as dehydrogenases, hydrolases and transferases, halogenases and dehalogenases have been produced and tested for various bioconversions. She further added that the current Framework 7 grant HOTZYME and ERA-1B grant THERMOGENE holders are now studying new hydrolase and transferase enzymes respectively. N. Morant (University of Bath, UK) reported the discovery of a unique DNA polymerase (Tin DNA pol I) from thermophilic marine anaerobic bacterium *Thermodesulfatator indicus*. The enzyme displays strand displacement at 65°C and thermostability up to 95°C for several minutes. The enzyme has been found to be useful in heat-denaturing loop-mediated isothermal DNA amplification (HD-LAMP) method for the rapid and on-site detection of nucleic acids.

G. Diemer and co-workers (Portland State University, USA) discovered RNA–DNA hybrid virus from metavirome of Boiling Springs Lake, a high-temperature acidic lake. This could be due to recombination between DNA and RNA viruses. Such a recombination was considered not to occur in nature. Lossouarn *et al.* (Bretagne Occidentale University, Plouzane, France) reported the discovery of bacteriophages that infect thermophilic bacteria of the order Thermotogales. The viruses belong to Siphoviridae. While Edmann *et al.* (University of Copenhagen, Denmark) observed complex CRISPR

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(Clustered Regularly Interspaced Short Palindromic Repeats) immune responses to the viruses of *Sulfolobus*.

P. Schonheit (University of Kiel, Germany) described the work on understanding the modified Embden–Meyerhof (EM) pathways for metabolizing glucose in hyperthermophiles such as *Thermotoga maritima*, *Pyrobaculum aerophilum* and others. His group resolved the crystal structure of pyruvate kinase from *P. aerophilum*. M. J. Danson (University of Bath, UK) explained the work being done by his group on 2-oxoacid dehydrogenase multienzyme complex. The group has been able to clone and express polypeptides and reconstitute functional multienzyme complex, which is a tough task.

D. Cowan (University of Pretoria, South Africa) presented extensive work on metabolic engineering of *Thermoanaerobium* and *Geobacillus* for ethanol production from lignocellulosics. He summarized recent developments on the molecular and physiological basis of redox responses, solvent tolerance, inhibitor resistance and other necessary characteristics for reliable commercial performance. Unfortunately, it has not been possible to attain higher than 8% ethanol despite extensive efforts. M. W. W. Adams (University of Georgia, Athens, USA) spoke about metabolic engineering of *Pyrococcus furiosus* for producing biofuel. The engineered *P. furiosus* is capable of utilizing H_2 and incorporate CO_2 into 3-hydroxypropionic acid, a major industrial building block. This was accomplished by cell-free extracts and whole cells at 70°C. Efforts are underway to develop a strain that contains complete carbon fixation cycle of *Metallosphaera sedula*. This involves 13 enzymes encoded by 16 genes that together generate acetyl coenzyme A. The goal is then to engineer *P. furiosus* to utilize acetyl coenzyme A for biofuel production.

E. Bonch-Osmolovskaya (Winogradsky Institute of Microbiology, Moscow) presented the work done in her laboratory for understanding methanogenic communities in Kamchatka springs. The predominant microbes found are uncultured representatives. From mesophilic habitats, cultured members of the novel order Methanoplasmatales have been recently obtained. These organisms are considered to play a pivotal role in methanogenesis in terrestrial hot springs.

J. Saw *et al.* (Uppsala University, Sweden) have been able to analyse single-cell-amplified genomes from two hot springs in Yellowstone National Park, USA. Preliminary analyses suggested the occurrence of novel representatives of archaea and bacteria lineages that facilitate a genomic glance into an unknown microbial world. The collection and analysis of large amounts of genomic data from uncultivated microbial lineages will allow revaluation of the evolutionary connections between branches of the 'tree of life' even at the domain level.

T. Satyanarayana (University of Delhi South Campus, New Delhi) reported retrieval of thermo-alkali-stable xylanase gene from the soil-compost metagenomic library. The DNA insert of 6.2 kb contained full-length gene, which was cloned and expressed in *Escherichia coli* and *Bacillus subtilis*. The metagenomic xylanase belonging to GH 11 family has been shown to be useful in generating xylooligosaccharides from agro-residues and pulp bleaching. W. Liebl (Munchen Technical University, Freising-Weihenstephan, Germany) reported the possibility of developing metagenomic libraries simultaneously in *E. coli* and *Thermus thermophilus*. New selection markers and the technology for introducing fosmid inserts and entire fosmid libraries into *T. thermophilus* have been established. A comparative screening of metagenomic DNA for cellulase, hemicellulase and other enzymatic activities in two hosts suggested substantial differences in functional gene retrieval.

B. Mukhopadhyay (Virginia Tech, USA) presented work on understanding the role of thioredoxin in methanogens. Thioredoxin occurs in all methanogens, and it has been found to assist in combating oxidative stress and synchronizing metabolic activities.

H. K. Kotlar (Statoil ASA, Norway) explained about reinjection of extremophilic microbes (derived from oil reservoirs or oil-contaminated sources) as *in situ* biocatalysts for the conversion of heavy oil. Experiments designed to mimic reservoir conditions have been conducted. A reduction in the viscosity of the heavy oil components was recorded. Two- to three-fold reduction in the viscosity was observed depending on the type of oil, which could be due to chelation of heavy metals and/or biosurfactant production.

Podar *et al.* (Oak Ridge National Laboratory, USA) reported isolation and sequencing of a Nanoarchaeote *Nanobsidianus stetteri* from Obsidian Pool in Yellowstone National Park. This Nanoarchaeote has a larger genome than *Nanoarchaeum equitans*.

Kim *et al.* (Korea Institute of Ocean Science and Technology, Ansan, South Korea) reported that *Thermococcus onnurineus* harbours CODH (carbon monoxide dehydrogenase)-mch cluster, which is essential for CO-dependent growth.

Moriya and Oshima (Kyowa Kaco Co Ltd, Tokyo, Japan) reported a novel polyamine *N*-aminopropylspermine in the extreme thermophile *Calditerricola satsumensis* isolated from high-temperature compost. This polyamine was not detected in the bacterium when grown at lower temperature such as 65°C. Ishino *et al.* (Kyushu University, Fukuoka, Japan) discovered the presence of single-strand-specific 3′–5′ exonuclease in Thermococci.

The 13th International Conference 'Thermophiles–2015' will be held at Santiago, Chile during 30 August–4 September 2015, while Thermophiles–2017 will be held at Pretoria, South Africa.

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