Agharkar Research Institute, Pune

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Agharkar Research Institute, Pune has a mission of conducting basic and applied research in life sciences by harnessing the genetic diversity of microbes, plants and animals for a cleaner environment, sustainable agriculture and better health of the masses. To achieve this goal, it is making valuable contributions in the areas of biodiversity, bioenergy, bioprospecting, genetics and plant breeding, developmental biology, and nanobioscience.

Keywords: Bioenergy, bioprospecting, biodiversity and palaeobiology, genetics and plant breeding, nanobioscience.

AGHARKAR Research Institute (ARI), Pune is an autonomous research institution funded by the Department of Science and Technology (DST), New Delhi. Founded in 1946 as the Maharashtra Association for the Cultivation of Science Research Institute, it was renamed in 1992 as Agharkar Research Institute in the honour and memory of its founder Director, late Professor Shankar Purushottam Agharkar. It operates under the overall umbrella of the Maharashtra Association for the Cultivation of Science (MACS), a registered Society and a Public Trust. The Institute is committed to promotion of fundamental and application-oriented science for the benefit of human kind and the nation. Current research activities of the Institute focus on six thematic areas, viz. bioenergy, biodiversity, bioprospecting, developmental biology, genetics and plant breeding and nanobioscience. Some important highlights of the scientific work carried out under different thematic areas in 2014 are as follows.

Bioenergy

A methanogen, identified as a novel species of the genus *Methanoculleus*, was isolated from deep sub-seafloor sediment obtained from the Krishna–Godavari Basin off the eastern coast of India. This methanogen probably plays a major role in the formation of submarine methane hydrate deposits, which are an important future source of energy[1].

A consortium of four *Clostridium* strains growing optimally at 96°C was developed for the recovery of crude oil from depleted oil reservoirs with temperatures above 91°C. The consortium produces metabolites such as volatile fatty acids, organic acids, surfactants, exopolysaccharides and carbon dioxide, which reduce oil viscosity, favour its emulsification and increase reservoir pressure facilitating displacement of the emulsified oil. The consortium could enhance recovery of crude oil by 26.7% in sand pack trials[2].

Biodiversity and palaeobiology

In the area of biodiversity an entire gamut of organisms, viz. bacteria, bacteriophages, viruses, fungi, lichens, diatoms, plants and fossils is being studied.

Microbes from human gut are important for maintaining the health status of the host. Out of the several obligate anaerobic bacteria isolated by us from human faeces, *Megasphaera indica* sp. nov. was reported as a new species[3].

In another study the role of novel isolate from human gut, *Clostridium* sp. BL8 was investigated in detail using genome sequencing tool. It has several adaptive features, viz. bile resistance and presence of sensory/regulatory systems, oxidative stress managing systems, membrane transport systems, virulence factors, adhesion factors, proteases, Type IV secretion system and antibiotic resistance genes. These suggest that *Clostridium* sp. BL8 could be a potential human pathogen. Further *in vivo* studies are necessary to ascertain this possibility[4].

DST has established a National Facility for Culture Collection of Fungi (NFCCI) for Indian fungal germplasm collection, identification and conservation at ARI. As a part of these activities of national importance, NFCCI has identified several new species of fungi since its inception.

Based largely on the contributions made by ARI, a monograph on the flora of Bhagwan Mahavir (Molem) National Park, Goa has been recently published by the Botanical Survey of India[5].

As a part of our work in the area of palaeobiology, ichnological work on the Jurassic of Jaisalmer was carried out. This led to the discovery of the oldest wedge-footed bivalve complex trace fossil, *Hillichnus lobosensis*.

The coastline and other areas in the lowlands of south-western India supply sufficient evidence of tree trunks of wet evergreen forests getting buried during the Holocene under varying thickness of clay, silty-clay and sand sequences. Our recent study has shown that this preserved subfossil log assemblage forms an excellent proxy for

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eco-geomorphological and palaeoclimate appraisal reported hitherto from the Indian subcontinent, and complements the available palynological data. Thus, the subfossil logs of tropical evergreen forests constitute new indices of Asian palaeomonsoon[6].

Bioprospecting

A novel insulin-like protein (ILP) was purified from *Costus igneus* belonging to the family Costaceae from the Western Ghats of India. ILP showed a potent hypoglycemic activity in an *in vitro* assay and significant decrease in blood glucose levels was observed when administered orally in oral glucose tolerance test[7].

In a study on Cisplatin, a popular anti-cancer drug, we have shown that it inhibits copper-catalysed oxidation of amyloid β (Aβ) peptide. These findings may lead to the design of better platinum complexes to treat oxidative stress in Alzheimer's disease and other related disorders[8].

In yet another study related to neurodegenerative diseases, two ruthenium(II) polypyridyl complexes, [Ru(phen)3](2+) (1) and [Ru(phen)2(bxbg)](2+) (2) (where phen = 1,10 phenanthroline, bxbg = bis(o-xylene)bipyridine glycoluril), have been shown simultaneously to inhibit acetylcholinesterase (AChE) and Aβ peptide aggregation[9].

ARI has a long-standing experience in developing attractant and repellent formulations for insects based on natural products. We have now shown that an essential oil from the flower of *Swertia densifolia* (Gentianaceae) has a dose-dependent repellent activity towards Indian honey bees *Apis florea* F. The 19 constituent compounds of the essential oil have been identified. These results establish the previously unknown chemical constitution that may be used to improve bee management[10].

Genetics and plant breeding

ARI is probably the only centre outside the ICAR system that is part of the All-India Coordinated Projects. It has played a major role in developing a diverse range of improved breeding lines and parental lines of hybrids of wheat, soybean and grapes.

In our continuing efforts in this area, a new wheat variety, MACS 6478, has now been identified for timely sown irrigated conditions of the peninsular zone. This variety is highly resistant to both black and brown rusts under artificial and field conditions. It has bold and lustrous grains with highest 1000-grain weight recorded (49 g), high protein content (14%), better nutritional quality (zinc 44.1 ppm, iron 42.8 ppm), excellent chapatti quality (score 8.05) and good bread quality (score 6.93).

A high-yielding soybean variety, MACS 1188, was released and notified for its cultivation in the southern zone. This variety is resistant to major insect pests, diseases, and has pod-shattering habit. It has yield potential of 25–40 q/ha.

As a part of our extension activities, Wheat Choupal Pradarshan Khets were conducted in Karnataka during *rabi* 2013–2014 under the umbrella of ITC. About 1000 acre area was under cultivation of our variety, MACS 6222, which showed its superiority over other varieties and performed well even under three irrigations.

Developmental biology

We have isolated and characterized vascular endothelial growth factor (VEGF) and fibroblast growth factor (FGF) homologues from *Hydra vulgaris* Ind-Pune, a Cnidarian which exhibits an organized nervous system and primitive epithelio-muscular cells. Our findings on VEGF and FGF in hydra are significant since they could help in designing strategies for identifying the evolutionary ancient functions of these, and probably other growth factors[11].

Structural and sequence similarities of Hydra Xeroderma Pigmentosum A protein to human homologue suggest early evolution and conservation[12]. The principal players of nucleotide excision repair (NER) are the xeroderma pigmentosum (XP) group of proteins. One of the first members to come into play during NER is XP group A (XPA) protein. We report here the presence of *XPA* gene in hydra[15]. Hydra *XPA* shows a high degree of similarity to vertebrate homologues and clusters with deuterostomes in phylogenetic analysis. The protein most likely functions in hydra in the same manner as in other animals, indicating that it arose early in evolution and has been conserved across animal phyla.

One of the broad areas of our interest is understanding molecular mechanisms that regulate neural development in *Drosophila melanogaster* and particularly the role of glia in regulating some of these processes. Our work has identified mitochondria as an unexpected player in mediating Fog signalling. It would be interesting to test if this pathway is conserved in Fog responsive cells other than those undergoing gastrulation[13].

Nanobioscience

Previously we had shown that *Jasada bhasma* (zinc ash), an extensively used Ayurvedic medicine comprising 200–500 nm-sized zinc oxide particles exhibits moderate antidiabetic activity in streptozotocin-induced type 1 and 2 diabetic rats[14].

Encouraged by these results, the work has now been extended to zinc oxide nanoparticles. Oral administration of zinc oxide nanoparticles in streptozotocin-induced type 1 and 2 diabetic rats (dosage 1, 3 and 10 mg/kg) showed significant antidiabetic effects, i.e. improved glucose tolerance, higher serum insulin (70%), reduced blood glucose (29%), reduced nonesterified fatty acids (40%) and

reduced triglycerides (48%). Nanoparticles were systemically absorbed resulting in elevated zinc levels in the liver, adipose tissue and pancreas. Increased insulin secretion and superoxide dismutase activity were also seen in rat insulinoma (RIN-5F) cells. Nanoparticles were safe up to a 300 mg/kg dose in rats. Thus, zinc oxide nanoparticles are a promising new antidiabetic agent warranting further studies for possible use in modern medicine[15,16].

Fluorescent cadmium telluride quantum dots are an attractive option for bioimaging, but are known to display high cytotoxicity. A facile, green synthetic strategy has now been developed to embed green fluorescent cadmium telluride quantum dots in biocompatible chitosan nanoparticles to obtain a stable, luminescent, biocompatible preparation with favourable toxicity profile and better cellular uptake for use in bioimaging and targeted detection of cellular components[17].

Studying cells in 3D enables researchers to 'mimic' physiological conditions that exist *in vivo*. A microfluidics-based 3D cell culture chip has been fabricated by a novel method that enables simultaneous (one-step) fabrication of all the components, viz. a porous compartment supporting cell growth, connecting circular microchannels for supplying nutrients and removing metabolic waste[18].

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