New frontiers of science

By Preethi Ann Thomas - CHENNAI | 24th June 2013 12:00 AM

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With rapid advancements in science, it has become pertinent to recognise new fields in the discipline — each more specialised and inter-related. Gone are the times when all you could study was physics, chemistry and biology. Edex features four new avenues to stir your scientific curiosit.

Enzymology

The word enzyme was coined by Wilhelm Kühne, a German physiologist, in 1877. It means 'in the yeast' in Greek, as yeast was considered to be a rich source of enzymes. According to Prof Arvind Kayastha, HoD, Banaras Hindu University (BHU), Varanasi, "Enzymes are biocatalysts, which participate in all biochemical reactions taking place in a living system." Over the last couple of decades, enzymology has been pursued vigorously to understand how enzymes interact and react. When a body is not capable of producing certain enzymes, they can be manufactured to suit evolutionary or individual needs. Researchers in this field can apply their knowledge in a number of ways, ranging from developing medications to new ways of using enzymes in manufacturing. Job opportunities are available in the fields of medicine, food science, textile and paper manufacturing, pharmaceuticals, chemistry, biology, nutrition and environmental remediation.

Enzymologists are now collaborating with nanotechnology to immobilise enzymes on nanomaterials like gold nanoparticles and graphene. The

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new technology has helped reduce the size of fabrications like biosensors for analytes (Eg: serum, glucose, lactose and cholesterol) present in our body. “Enzyme-based industries will thrive because of the obvious advantages of zero side effects and pollution-free products. More than 100 enzymes are presently used in industrial applications. Many of our students have been absorbed in Ranbaxy, Dr Reddy’s Lab, Dabur, and getting good remuneration. Students may pursue this under biological streams like biochemistry and biotechnology,” he says.

Enzymology training programme is being held at Rapture Biotech Agra, a biotechnology company. CSIR-Indian Institute of Chemical Biology, Indian Institute of Science, Bangalore, JNU Centre for Advanced Scientific Research, Bangalore, BHU and Netaji Subhash Institute of Technology, New Delhi, are pursuing research in enzymology.

Synthetic Biology

This is where biology meets engineering. In the words of Markus Schmidt (founder of Biofaction, which works on industrial and environmental applications of synthetic biology), synthetic biology is the design and construction of biological devices and systems. J Craig Venter, founder of Celera Genomics, The Institute for Genomic Research and the J Craig Venter Institute, and is now working at JCVI, USA, took a remarkable leap by creating the first cell with a synthetic genome in 2010. In his words, it is “the first self-replicating species we’ve had on the planet whose parent is a computer.” He constructed a full-length DNA and transferred to an existing cell. It took him 15 years and the project cost $40 million. While Venter received flak for not creating, but mimicking life, it does open up a world of possibilities. The field represents two key areas — design and production of new biological components, and redesign and production of existing systems and models.

Centre for Systems and Synthetic Biology (CSSB) under University of Kerala, Thiruvananthapuram, pursues research in this field. “Biological systems are noisy and unpredictable. To create well-behaved and predictable systems, one needs standards and rules of composition. Synthetic biology is an engineering-inspired approach to create novel and well-behaved parts, devices and circuits for implementing useful behaviours,” says Prof Pawan K Dhar, director, CSSB.

CSSB aims to design microbes for water purification, make genes from ‘junk’ DNA, construct a knowledge base of novel and functional intergenic parts, develop a bio CAD platform and an engineering-inspired language in biology. Dhar explains, “In the way biology has been practised, you reduce the system to genes and proteins. Synthetic biology works in the opposite way. You make a system like an engineer, starting from bricks (genes in the case of synthetic biology). Nobody knows how to make an organism from scratch. Constructing biological systems from scratch requires standards and rules for pathway like engineers refer to the IEEE standards.”

India acknowledged the field formally in 2010 through a meeting held in Thiruvananthapuram, which was followed up in 2012 at JNU, New Delhi. Currently, there’s no formal training programme in India but Prof Dhar is working with JNU, New Delhi, to offer a course and Symbiosis School of Biomedical Sciences, Pune, has incorporated a one-semester training module in their MSc biotechnology programme. It has some fascinating focus points in the areas of bio-fuel and medication/vaccines. Jay D Keasling, professor of chemical and bioengineering at University of California, Berkeley, has attempted to transfer an entire plant pathway from a rare African plant with anti-malarial properties. He did this in yeast, making it a precursor to the drug, which could be a lifesaver. There is hope in the revolutionary effects of synthetic biology. Visit www.biodesignindia.org and www. cssb.res.in for details.

Computational Social Science

Computational Social Science is an interdisciplinary science of complex social systems and the investigation of these systems through computational modelling and related techniques. This is where social science integrates with computer science. It covers the entire breadth of social sciences like sociology, political science, geography, history, linguistics and communication. The idea is to use computational

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simulation models and data from social media networks to investigate social phenomena. This science helps create virtual labs to introduce practical solutions for societal problems.

Animesh Mukherjee, assistant professor, Indian Institute of Technology-Kharagpur, explains, “Computational social science attempts to reveal new understanding about the properties that systems of people and computers together possess. A major thrust is to leverage on the ever-growing coupling of the users with the World Wide Web to design socially intelligent computing systems. The ‘wisdom of the crowd’ allows for precise quantitative answers to certain fundamental questions in the domain of cognitive and social sciences including anthropology, sociology, linguistics, fine arts and human culture as a whole.”

He says that research in this area in our country is less, but not insignificant. Presently, students can pursue a master’s or PhD. A minor in sociology and a major in computer science are required for research in this area. Complex Networks Research Group (www.cnerg.org) at the Department of Computer Science and Engineering, IIT-Kharagpur, provide opportunities to pursue this field at master’s and doctorate levels. Other institutes pursuing research in this area are IMSc-Chennai, SNBNCBS-Kolkata, CSSS-Kolkata, IISER-Kolkata, IIIT-Delhi, IISc, Bangalore, IIT-Madras and Delhi University.

Facebook, Twitter, Microsoft Research Labs, Google Research Labs and Yahoo Research Labs regularly hire doctorates from this area. There are excellent research opportunities in MPI, Germany, CNRS, France, CNR, Italy and universities including Oxford, Cambridge and ETH, Zurich. He continues, “Industries offer pay packages in the range of Rs 20-40 lakh per annum. A post-doctoral tenure would offer somewhere between €2,000-2,500 per month in Europe and $45,000 pa.”

Cliodynamics

The term cliodynamics comes from ‘Clio’, one of the nine Greek muses in history, and dynamics is the study of temporarily varying processes. As an interdisciplinary area of research, it seeks to explain historical dynamics using mathematical modelling. Simply put, it explains why certain empires rise and fall, economies dip and surge, some civilisations survive and others are wiped out, why wars are fought, won or lost using mathematics. Still in a nascent stage, cliodynamics, a term which was coined by Peter Turchin, (professor at Duke University, New York, specialising in population biology and cliodynamics) is yet to catch on in India.

If you’ve read Isaac Asimov’s Foundation, you would’ve come across the term, ‘psychohistory’, which draws on mathematical concepts to understand the past and predict the future. But now reality is drawing from science fiction. While economics, sociology and anthropology have been quantified over the ages, history relies more on accounts/evidences and is not predisposed to quantification. Turchin seeks to build a mathematical model with one data set and then test that against other historical data sets they’re unfamiliar with.

Generally, any social science/natural science discipline can serve as a good basis for your research. Turchin in his writing has some advice for those wishing to pursue this science. He believes one should first decide on a disciplinary home, and then build a career within it. Only after you have slugged it out, can you truly pursue cliodynamics. Basically, you have to think long-term. He picks anthropology, archaeology and sociology as his primary choices for study. He suggests undertaking a PhD project that is not entirely theoretical. Rather, it should be mostly empirical or experimental. Let’s not forget the basis — you need to have a strong foundation in mathematics, statistics and programming to pursue this field. For details, visit www.socialevolutionforum.com.

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