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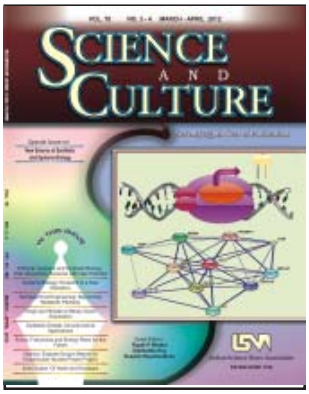
EDITORIAL

SYSTEMS AND SYNTHETIC BIOLOGY: INTER-DISCIPLINARY SCIENCES WITH VAST POTENTIAL



The first decade of the new millennium has witnessed the paradigm shift in almost all disciplines of life sciences. The current special issue of Science and Culture highlights two such cardinal conceptual advancements in biological sciences that will shape the future understanding of life processes as well as its applications for the benefit of mankind. These two are 'Systems Biology' and Synthetic Biology'. Both the areas integrate experimentalists, theorists, and computational biologists to design and re-design the biological systems.

Until recently, biologists were engaged in studying various biochemical reactions in a cell, one at a time. Over the years a large body of knowledge on the functioning of an organism has been accumulated using this reductionist approach. However, it is now clear that these biochemical reactions do not take place in isolation. Rather, they work in a highly interactive manner. Thus, to understand the complete working of life processes an integrated approach to decipher the complex interactions among each of these biochemical reactions in a cellular milieu is required.

Systems biology is an inter-disciplinary study field that focuses on the systematic study of complex interactions in biological systems. The goal of systems biology is to discover new emergent properties that may arise from the systemic view of these complex interactions in its entirety. Each of the functional attributes of cells is controlled by several groups of molecular interactions, termed interactomes. They shape the cells' signaling, metabolic and structural framework. These interactomes in turn have modular structures that form specific pathways governing a specific biochemical output. This systems level understanding of a cell is also being extended to tissue and organ level organization to obtain a complete view of the phenotypes of an organism. The initial inroads into the systems level understanding of a cell is made possible due to advancement in the capability of acquiring large amount of data on gene structure and function using various technologies that can obtain data in massively parallel fashion, termed the 'omics'. It has also been realized that both qualitative and quantitative measurements are necessary to comprehend the emergent property of any biochemical reaction network. Multivariate analysis of these datasets, using various algorithms and computer aided modeling, are shedding new light on cellular functions. This recent paradigm shift (from reductionist to integrative approach) in biological sciences is set to discover newer realistic views of the life processes. It is predicted that this new view of life processes will

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have long range applications in medical, agricultural and energy sector.

Another frontier area of modern biological sciences is **Synthetic biology.** The goal of synthetic biology is to design and construct new biological systems not found in nature. It applies the principles of engineering and fundamentals of biology to fabricate novel biological circuits. Synthetic biology is the ultimate expansion of genetic engineering. While in genetic engineering a small number of genes are moved between organisms, in synthetic biology large number of genes is moved to create a new circuit based on the information derived from other biological systems and the re-design and re-engineering is based on more quantitative approaches. In a way synthetic biology uses the knowledge generated in systems biology regarding the pathway structure for specific biochemical outputs. Synthetic biology uses standard parts such as genes, proteins, biomolecular structures *etc*. to build circuits of new biological functions in heterologous hosts using tools such as bioinformatics and computer simulation. Synthetic biology promises to synthesize large quantities of metabolites of biological importance by engineering hosts such as a bacteria and fungi. It also has tremendous potential to introduce agricultural revolution by adding nutritive values to common food as well as producing eco-friendly pesticides from plant sources. In a recent breakthrough discovery, synthetic biology principles were applied to initiate replication of cell after insertion of a genome of million bases in size assembled outside the cell. Some critiques dubbed synthetic biology as 'Extreme Genetic Engineering' because of its far reaching consequences on environment and society. However, it is believed that with tight regulatory guidelines synthetic biology will benefit mankind in an unprecedented manner. ❐

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Dr. Rupak K. Bhadra is a Senior Principal Scientist in the Division of Infectious Diseases and Immunology, CSIR-Indian Institute of Chemical Biology, Kolkata. His expertise is in the field of microbiology and bacterial gene regulation. He has contributed significantly in the understanding of the molecular basis of nutritional starvation related stringent response in *Vibrio cholerae*, the human cholera pathogen. He has also worked extensively on the role of diverse cholera toxin genes carrying phages, called CTXΦ, in the evolution of new pathogenic clones of *V. cholerae*. Currently he is the Nodal Scientist of the Synthetic Biology Network Program of CSIR, New Delhi.

Prof. Siddhartha Roy joined Bose Institute after completing his Ph.D. from University of Delaware and post-doctoral research at Brandeis University and National Institutes of Health. In Bose Institute, he initiated studies on gene regulatory circuits. Later he started work on peptide models of complex protein-protein and protein-nucleic acids interactions and peptide therapeutics. He is winner of Santi Swarup Bhatnagar Prize and elected Fellows of Indian National Science Academy and Indian Academy of Sciences. He is currently serving as the Director of CSIR-Indian Institute of Chemical Biology. He is currently the President of West Bengal Academy of Science and Technology. He has co-authored over 100 research articles in internationally reputed journals and edited a book. He is also the Co-ordinator on CSIR program on Synthetic and Systems Biology.

Dr. Susanta Roychoudhury obtained his PhD (Biochemistry) degree in 1985 from the Calcutta University, India. From 1985 to 1990 he did postdoctoral research on cell biology of growth factors and molecular biology of human hepatitis B virus at University of Pennsylvania, USA. Since 1991 he is working as a scientist at the CSIR-Indian institute of Chemical Biology, Kolkata, India. Dr. Roychoudhury was elected as the Fellow of the National Academy of Sciences, India in 2009. Dr. Roychoudhury is among the first few who initiated genomic research in India. He contributed significantly on the molecular understanding of the genomic instabilities in human cancer. His work generated new insights into the genetic underpinning of the oral cancer and *Helicobacter pylori* mediated gastroduodenal diseases in Indian population.

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