Introduction to Biological Systems

BI2123

Aurnab Ghose; 200901

Introduction to Biological Systems

(Understanding complexity in Biology)

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Video lectures: either prerecorded or video made available

Live discussion sessions: typically on alternate Thursdays

Evaluations as per announcements

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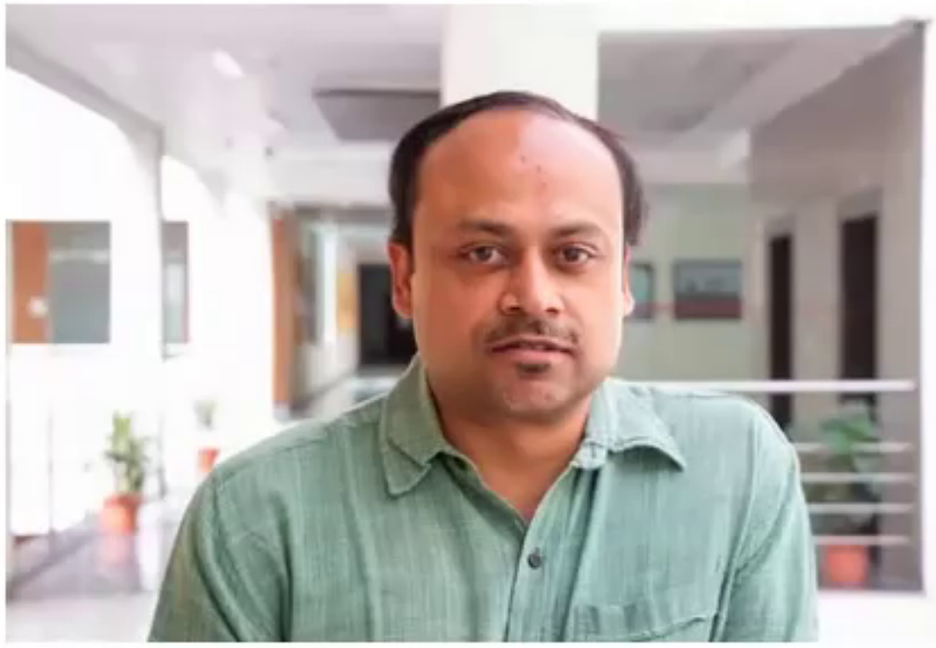

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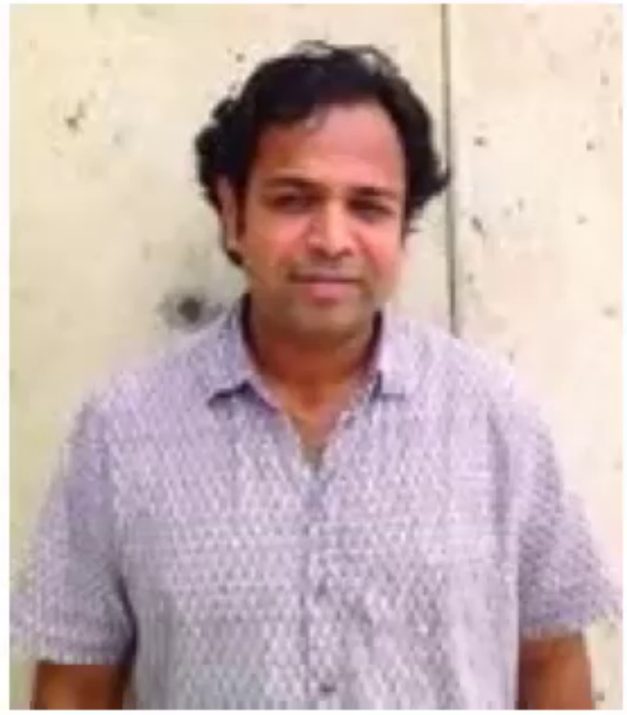

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Integrative Levels of Organisation in Biology

Biosphere

Ecosystem

Community

Population

Organism

Organ Systems

Tissue/Organs

Cell

Organelles

Molecule

Atom

Novikoff, 1945

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Novikoff, 1945

Highly organized across length and time scales

Spontaneous organization

Ability to perform low error functions and computation (in an environment of strong thermal fluctuations and in a dense confusing soup of molecules)

Optimized to efficiently achieve objectives

Shaped over evolution and is evolvable

Premise:

Biological systems can be understood from a perspective of unifying DESIGN PRINCIPLES (and can be represented in a mathematical framework).

DESIGN PRINCIPLES of biological systems

Optimized to efficiently achieve objectives

Robust
Specific
Sensitive

(Shaped over evolution and is evolvable)

What is a “Complex System”?

A complex system is a group of parts that come together, interacting and interdependent, to form a more complex whole unit.

None of the interacting parts posses the properties of the whole system, but when they come together they display special properties called Emergent Properties arising out of a multiplicity of relatively simple interactions

Irreducibility

Systems that have emergent properties are irreducible

They cannot be reduced to their individual parts or studied one part at a time, with the expectation of understanding the emergent properties of the system.

What is Systems Biology?

Systems biology is the study of an organism, viewed as an integrated and interacting network of genes, proteins, biochemical reactions and biophysical processes which give rise to life.

Rise of Systems Biology in the ~ 20 yrs:

- high throughput methodologies

- the genome project (and the other “-omes”)

- accumulation of critical mass of information

- application and development of analytical & computational methods

Associated Identification/Quantification Methodology

Transcriptomics: global measurement of gene expression

Proteomics: global protein expression patterns

Phosphoproteomics/Glycoproteomics: global analysis of post-translation protein modifications

Metabolomics: global analysis of metabolites

Glycomics: global identification of carbohydrates

Associated Analysis Platforms

Interactomics: Identifying and mapping interactions (mainly protein and genetic)

Fluxomics: Changes of molecule dynamics over time

Integration and organization in Cells
Gene regulation and gene regulatory networks
Signal transduction – representing the outside and communication

Integration and organization in Organisms
Early development and pattern formation
Themes in development

Integration and organization in Physiology
The immune system
The nervous system