Understanding the Architecture and Dynamics of Living Systems

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1. Introduction

We intend understanding biology by reverse engineering control, making an aircraft analogy, but in biological systems modular control features are poorly known.

As far as our current knowledge and use of biology to improve our lives is concerned, we are still in a more-or-less preindustrial revolution phase

Human Genome Project: means a great achievement, but greatest insight is that it yields very limited information.

Reductionism, “Non-human animals can be reductively explained as automata” versus Holism, “The whole is more than the sum of its parts” and Emergence, “The way complicated systems and patterns arise out of many relatively simple subsystems”, are major issues.

2. Systems Biology

a. Basic aspects

All biological systems are made up of networks, underlying networks properties are similar, principles apply to all levels of aggregation and how to construct simple models for biological systems

b. Network as central concept in Systems Biology :

External input/output Autoregulation is a Central question, based on mutual, interactions, self-regulation and external inputs.

Network nodes &edges for the various environments:

- Genomics, nodes: genes, edges: indirect interactions via transcription factors
- Signal transduction networks, nodes: proteins, edges: direct chemical reactions
- Neuronal networks, nodes: neurons, edges: interactions via electric signals

Metabolic networks, genetic circuits, signalling pathways and cell-cell communication are fundamental network topics.

c. Working hypotheses:

Biological systems (e.g. human body) consist of structures of finely intertwined cellular and molecular networks. Common properties to physical systems are emergence, robustness and modularity, but they differ in that they constantly aim at variation and evolution

Disease perturbs network structures of a system through genetic perturbations and/or pathological environmental cues, such as infectious agents or chemical carcinogens

d. Top-down vs bottom-up in Systems Biology

Bottom-up: Start with 1000s of genes and proteins to fit them together in representation of virtual cell, organism or systems

Top-down: Start with major features of the system of interest and work out from top down to relevant subsystems genes, proteins, tissues, etc.

3. What is Synthetic Biology?

It is the design and fabrication of biological components and systems that do not already exist in the natural world, also the re-design and fabrication of existing biological systems.
Major Disciplines in Synthetic Biology are: Molecular Biology, Evolutionary genomics, Biotechnology, Organic chemistry, Origin of life, Artificial life, Orthogonal life, Engineering, Computing and Modelling
What is the difference between synthetic biology and systems biology?
Systems biology studies complex biological systems as integrated wholes, using tools of modelling, simulation, and comparison to experiment.
Synthetic biology studies how to build artificial biological systems for engineering applications, using many of the same tools and experimental techniques.