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The Role of Systems Biology and Bioinformatics

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Description

Particularly from the year 2000 onwards, the concept has been used widely in biology in a variety of contexts. It is a biology-based interdisciplinary field of study that focuses on complex interactions within biological systems, using a holistic approach (holism instead of the more traditional reductionism) to biological research. These typically involve metabolic networks or cell signalling networks.

The human genome project is an example of applied systems thinking in biology which has led to new, collaborative ways of working on problems in the biological field of genetics. One of the aims of systems biology is to model and discover emergent properties, properties of cells, tissues and organisms functioning as a system whose theoretical description is only possible using techniques of systems biology. Systems biology is the computational and mathematical analysis and modeling of complex biological systems. Systems biology can be considered from a number of different aspects. As a field of study, particularly, the study of the interactions between the components of biological systems, and how these interactions give rise to the function and behavior of that system (for example, the enzymes and metabolites in a metabolic pathway or the heart beats).

Systems Biology

The distinction between the two paradigms is referred to in these quotations: "The reductionist approach has successfully identified most of the components and many of the interactions but, unfortunately, offers no convincing concepts or methods to understand how system properties emerge the pluralism of causes and effects in biological networks is better addressed by observing, through quantitative measures, multiple components simultaneously and by rigorous data integration with mathematical models. As a series of operational protocols used for performing research, namely a cycle composed of theory, analytic or computational modelling to propose specific testable hypotheses about a biological system, experimental validation, and then using the newly acquired quantitative description of cells or cell processes to refine the computational model or theory. Systems biology is about putting together rather than taking apart, integration rather than reduction. It requires that we develop ways of thinking about integration that are as rigorous as our reductionist programmes, but different. It means changing our philosophy, in the full sense of the term."

As a paradigm, systems biology is usually defined in antithesis to the so-called reductionist paradigm (biological organisation), although it is consistent with the scientific method. Therefore, transcriptomics, metabolomics, proteomics and high-throughput techniques are used to collect quantitative data for the construction and validation of models. As the application of dynamical systems theory to molecular biology. Indeed, the focus on the dynamics of the studied systems is the main conceptual difference between systems biology and bioinformatics.

As a socio-scientific phenomenon defined by the strategy of pursuing integration of complex data about the interactions in biological systems from diverse experimental sources using interdisciplinary tools and personnel. Since the objective is a model of the interactions in a system, the experimental techniques that most suit systems biology are those that are system-wide and attempt to be as complete as possible. According to the interpretation of systems biology as using large data sets using interdisciplinary tools, a typical application is metabolomics, which is the complete set of all the metabolic products, metabolites, in the system at the organism, cell, or tissue level.

Items that may be a computer database include: Phenomics, organismal variation in phenotype as it changes during its life span; genomics, organismal Deoxyribonucleic Acid (DNA) sequence, including intra-organismal cell specific variation. Sub disciplines include phosphoproteomics, glycoproteomics and other methods to detect chemically modified proteins; glycomics, organismal, tissue, or cell-level measurements of carbohydrates; lipidomics, organismal, tissue, or cell level measurements of lipids.

The molecular interactions within the cell are also studied, this is called interactomics. A discipline in this field of study is protein-protein interactions, although interactomics includes the interactions of other molecules. Neuroelectrodynamics, where the computers or a brain's computing function as a dynamic system is studied along with its physical mechanisms; and fluxomics, measurements of the rates of metabolic reactions in a biological system (cell, tissue, or organism).

In approaching a systems biology problem there are two main approaches. These are the top down and bottom up approach. The top down approach takes as much of the system into account as possible and relies largely on experimental results. The RNA-Seq technique is an example of an experimental top down approach. Conversely, the bottom up approach is used to create detailed models while also incorporating experimental data. An example of the bottom up approach is the use of circuit models to describe a simple gene network.

Cancer Systems Biology

Various technologies utilized to capture dynamic changes in mRNA, proteins, and post-translational modifications. Mechanobiology, forces and physical properties at all scales, their interplay with other regulatory mechanisms; biosemiotics, analysis of the system of sign relations of an organism or other biosystems; Physiomics, a systematic study of physiome in biology.

Cancer systems biology is an example of the systems biology approach, which can be distinguished by the specific object of study (tumorigenesis and treatment of cancer). It works with the specific data (patient samples, high-throughput data with particular attention to characterizing cancer genome in patient tumour samples) and tools (immortalized cancer cell lines, mouse models of tumorigenesis, xenograft models, high-throughput sequencing methods, siRNA-based gene knocking down high-throughput screenings, computational modeling of the consequences of somatic mutations and genome instability). The long-term objective of the systems biology of cancer is ability to better diagnose cancer, classify it and better predict the outcome of a suggested treatment, which is a basis for personalized cancer medicine and virtual cancer patient in more distant prospective. Significant efforts in computational systems biology of cancer have been made in creating realistic multi-scale in silico models of various tumours.