

Systems Biology-An Overview

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ARTICLE ID: 036

Introduction

The term “systems biology” has recently been coined to describe the cutting edge of cross-disciplinary research in the life sciences. It's been nearly a decade, systems biology was established in language of modern biology (Ideker *et al.*, 2001). Systems biology is a relatively new branch of biology that aims to understand biological systems at the system level. This means systems biology identifies and understands complete biological systems by elucidating, modeling, and predicting the behaviour of all components and interactions with respect to external perturbations.

Approaches in systems biology

At present, three system-based approaches for decoding the complexity of biological system are applied,

-  Top down
-  Bottom-up
-  Middle-out

1. Top down: which entails the use of high-throughput omics technologies to gain a holistic understanding to biological systems (Ideker *et al.*, 2001)

2. Bottom-up: which starts with molecular properties and leads to derivation of models to be tested and validated (Hartwell *et al.*, 1999)

3. Middle-out: which is based on the principle to start somewhere in between the top and bottom levels, then work out toward a hierarchy of models (Noble, 2002).

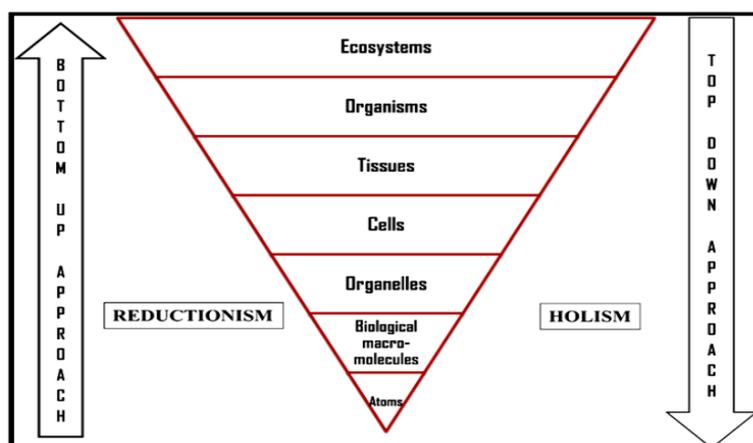


Fig. 1: Approaches in systems biology

Need for systems biology

Individual cellular components, their chemical composition, and often their biological functions were studied as individual components during the latter half of the twentieth century using a reductionist approach. However, as time has passed, the reductionist molecular approach's limitations have become more apparent. It became clear that biological systems cannot be understood solely on a genetic basis. Instead, they should be viewed as complex systems that result from dynamic interactions between various components at various levels, each of which functions as a whole to control the phenotype. Complex systems can be found at all levels of biological organization, from subatomic particles to individual organisms to entire populations and beyond. As a result, an integrative framework was required to provide a holistic understanding of the biological systems. This new science, in the post reductionist era, is called systems biology.

Networks in systems biology

The term "Network" is crucial in systems biology. Networks organize the complexity of biological systems as components (nodes) and interactions (edges) between them. Protein-protein interaction, gene regulatory, and metabolic networks are all examples of biological processes that are often represented as networks. Such research efforts in which novel biological networks are designed from a model will eventually converge and couple with efforts to study existing biological systems.

Systems Biology process

Model simulations could be used to rigorously evaluate a variety of potential modifications, which could then be verified directly in the biological system. The first step in

a systems-based approach is to identify all of the components involved in the system's functionalities (e.g., genomics, transcripts, proteome, and metabolites), then perturb the system and monitor its response in defined conditions. The information gathered can then be incorporated into system function models (Gutierrez *et al.*, 2005). New hypothesis generated by these models can be tested experimentally, which may lead to revised models and novel testable hypotheses.

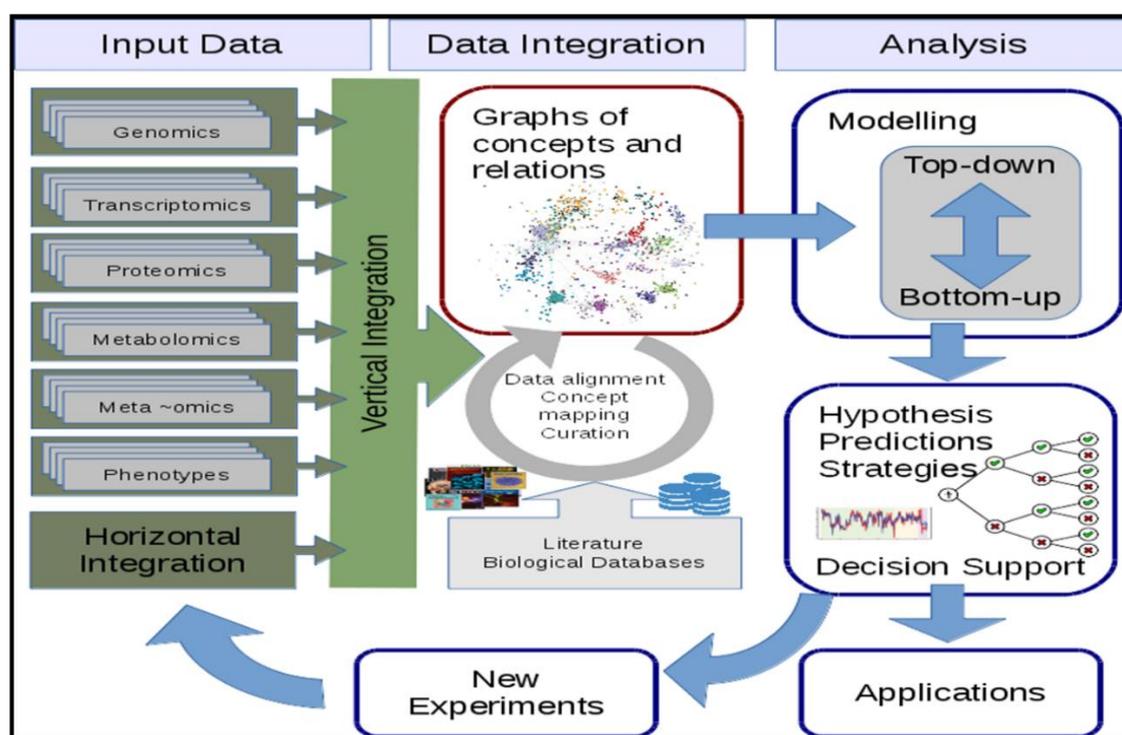


Fig.2: systems biology-an overview

Applications of system biology

a. Crop improvement

- ✚ Systems biology provides great potential for sustainable agriculture by understanding the complexity of multiple traits bridging the genotype–phenotype gap.
- ✚ It can be used to model and analyse multigenic traits such as plant architecture, nitrogen use efficiency, water use efficiency, and abiotic and biotic stress tolerance that are linked to agricultural productivity.
- ✚ Because of recent advances in high-throughput experimental analysis and computational power, it is now possible to combine multiple disciplines to explain any given complex trait.



- ✚ Development of comprehensive models by integrating multiomics data with high throughput and precise phenotyping will ensure efficient breeding programs to improve agronomically important and complex traits in the future.

b. Medicine

- ✚ Investigate complex processes involved in the development of diseases.
- ✚ Identify therapeutic targets and drugs.
- ✚ Understanding complex situations such as cancer and developmental neurotoxicology.
- ✚ Determine the relevance of specific molecule or pathway for the overall behaviour of the system or in the pathogenesis of a disease.

Conclusion

Today, there is a growing need of systems biology for successful identification and introduction of the desirable traits such as disease resistance, insect resistance, herbicide tolerance, chilling tolerance, delayed fruit ripening, as well as prolonged shelf-life for the development of smart crops with national and international importance.

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