Systems Biology

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What is systems biology?

- The study of the mechanisms underlying complex biological processes as integrated systems of many interacting components.
- Systems biology involves

  (1) collection of large sets of experimental data

  (2) proposal of mathematical models that might account for at least some significant aspects of this data set,

  (3) accurate computer solution of the mathematical equations to obtain numerical predictions,

  (4) assessment of the quality of the model by comparing numerical simulations with the experimental data.

Why Systems Biology?

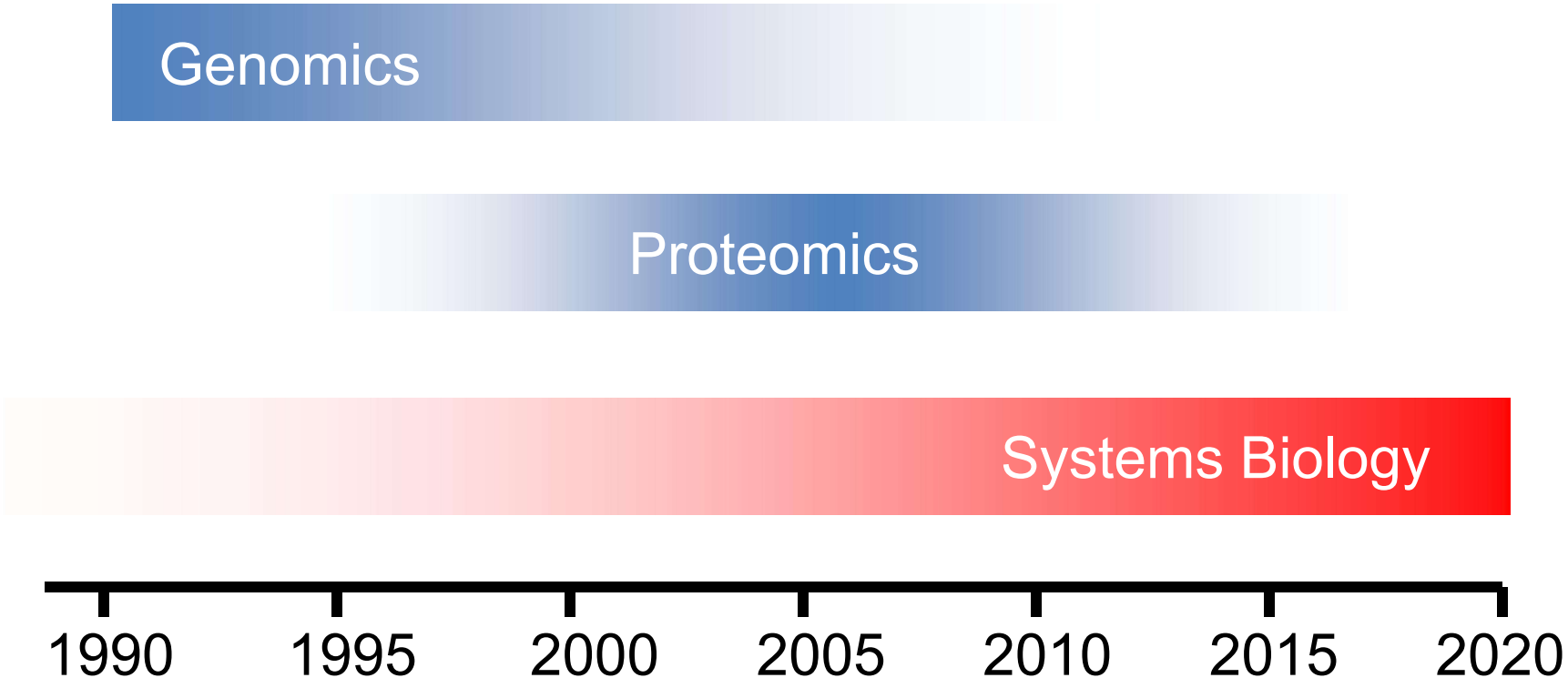
- On the technology side (PUSH): Capabilities for high-throughput data gathering that have made us aware that biological networks have many more components than we previously surmised.

- On the biology side (PULL): The realization that to the extent that we don't characterize biological systems quantitatively in their full complexity, the scope and accuracy of our understanding of those systems will be compromised. (in classical experimental terms, the uncontrolled variables in the system will undermine our confidence in the conclusions we draw from our experiments and observations)

Systems Biology vs. traditional cell and molecular biology

- Experimental techniques in systems biology are high throughput.
- Intensive computation is involved from the start in systems biology, in order to organize the data into usable computable databases.
- Exploration in traditional biology proceeds by successive cycles of hypothesis formation and testing; data accumulates during these cycles.
- *Systems biology initially gathers data without prior hypothesis formation*; hypothesis formation and testing comes during post-experiment data analysis and modeling.

Genomics, Proteomics & Systems Biology

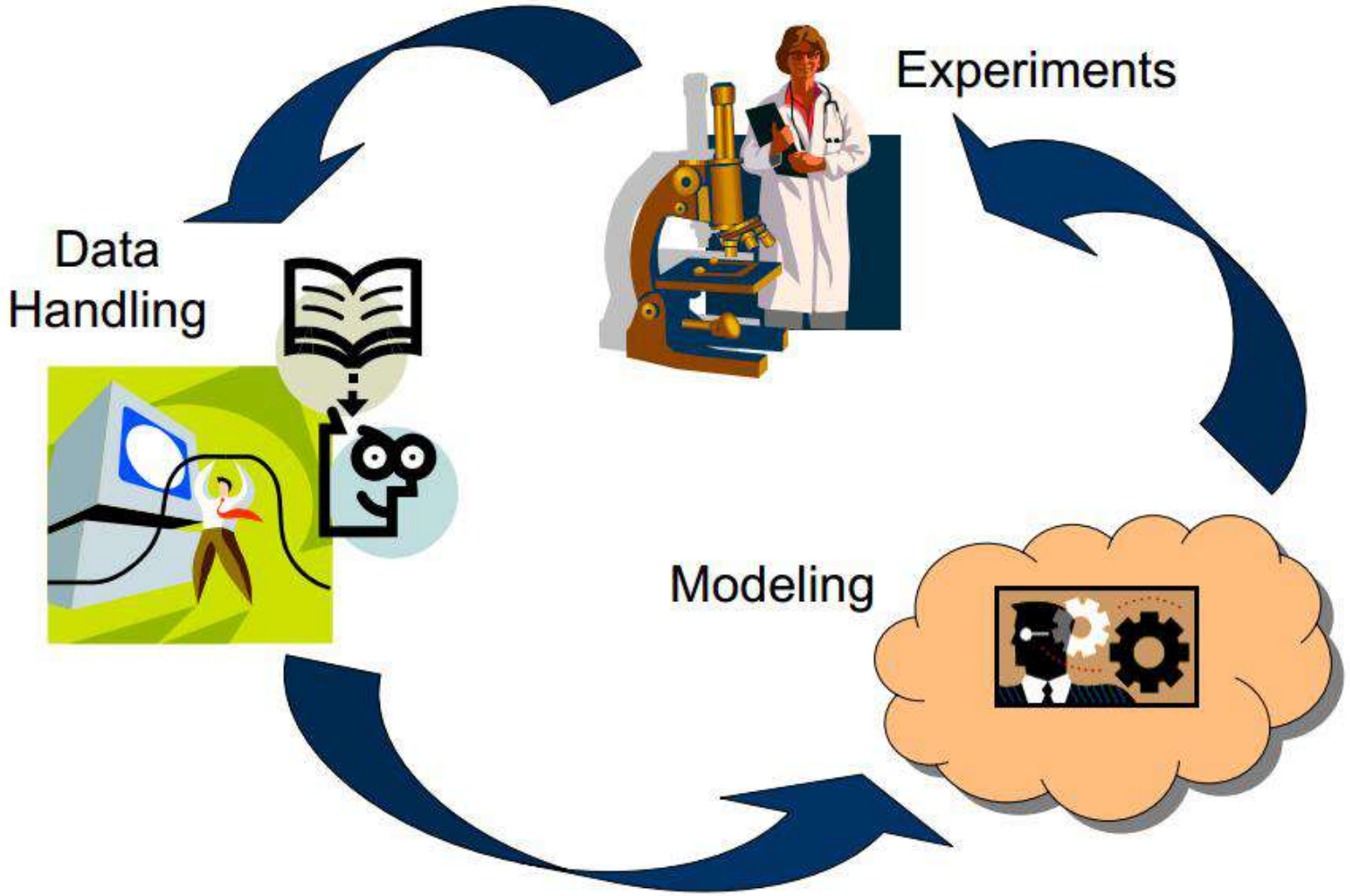


Systems Biology Approach

A systems biology approach means

- **Investigating the components of cellular networks and their interactions**
- **Applying experimental high-throughput and whole-genome techniques**
- **Integrating computational and theoretical methods with experimental efforts**

An Iterative Approach



Computational Systems Biology

From Systems Biology to Computational Biology

- **Biological Systems are complex, thus, a combination of experimental and computational approaches are needed.**

- **Linkages need to be made between molecula characteristics and systems biology results**

Databases and Tools

- **Languages**
  - Systems Biology Markup Language
  - CellML
  - Systems Biology Workbench
- **Databases**
  - Kyoto Encyclopedia of Genes and Genomes
  - Alliance for Cellular Signaling
  - Signal Transduction Knowledge Environment

Cancer Drugs

- Alkylating agents - interfere with cell division and affect the cancer cells in all phases of their life cycle. They confuse the DNA by directly reacting with it.
- Antimetabolites - interfere with the cell's ability for normal metabolism. They either give the cells wrong information or block the formation of "building block" chemical reactions one phase of the cell's life cycle.
- Vinca alkaloids - (plant alkaloids) are naturally-occurring chemicals that stop cell division in a specific phase.
- Taxanes - are derived from natural substances in yew trees. They disrupt a network inside cancer cells that is needed for the cells to divide and grow.

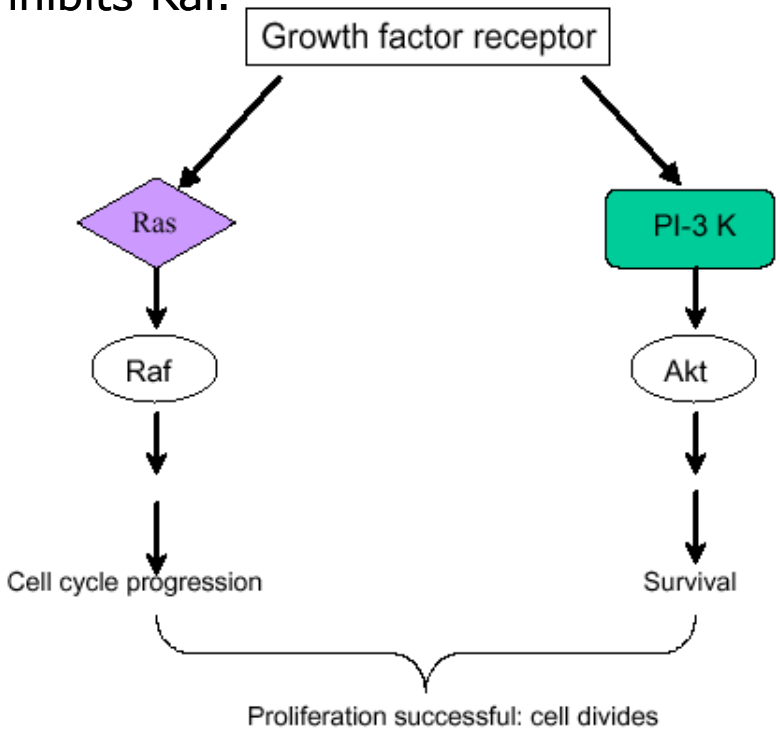
all inhibit the cell cycle

Advantages of Computational Systems Biology

- It is highly relevant in discovering more complex relationships involving multiple genes
- This may create new opportunities for drug discovery
- Better medical therapies for individual treatments

Concurrency in Biochemical Networks

Biochemical networks are also concurrent communicating systems. Pathways consist of sequences of interactions which sometimes affect other parallel pathways. As an example, consider two pathways involved in cell division. The Ras- Raf pathway which triggers the cell division and the PI- 3K- Akt pathway which keeps the cell alive are both triggered by the same growth factor. The sequences of interactions in both pathways run concurrently with some interaction i. e. Akt inhibits Raf.



Future

- Still a maturing field, lots of potential.
- While there had been an influx of data, most of that has been at the genomic level.
- The field compliments the development of other fields in the lower levels such as the “omics” and molecular biology. As these fields grow so will this.