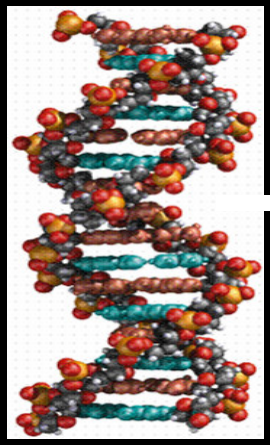
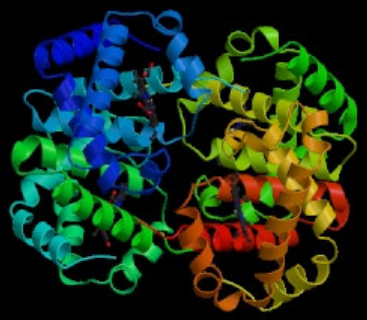
Systems Biology: from molecules to populations

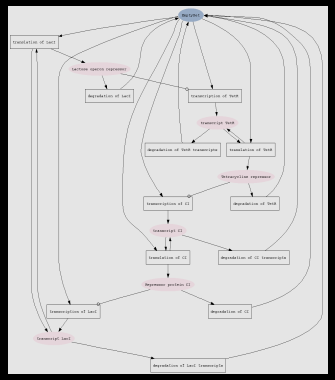
An (Unorthodox) View



DNA/RNA



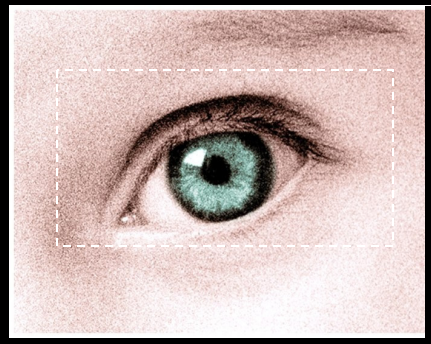
Proteins



Regulatory Networks

Cells

Cell colony



Organ

Individual

After 50 years of steady progress biologists now understand partially many of the subsystems underlying “Life”

Conventional bioinformatics enabled the gathering of massive data bases of DNA/RNA/Protein molecules and other metabolites.

The data mining of high throughput data still remains a bottle neck but steady progress has been made.

However: this has not led to a better understanding of how the *integrated* subsystems give rise to characteristic system behavior.

Behavior comes from complex & complicated chains of interactions between components

The *Pragmalogical* Problem of systems biology

- Systems biology bring to the fore the ubiquitous *philosophical* questions in complex systems, that of emergent behavior and the tension between reductionism and holistic approaches to science.

- Systems biology has, however, a very *pragmatic* agenda: the engineering and control of biological systems

- The pragmalogical problem: If each subcomponent of a living system (and reactions therein) are understood… Can we say that the *system* is understood? That is, can we assume that the system = ∑parts ?

And more importantly: can we control that biosystem?

"Although the road ahead is long and winding, it leads to a future where biology and medicine are transformed into precision engineering." - Hiroaki Kitano.

Systems biology promises more than integrated understanding: it promises systematic control of biological systems.

This required new approaches and fresh views as to try to understand "the system":

1. From an experimental viewpoint: Improve data acquisition
2. From a bioinformatics viewpoint: Improve data mining and analysis tools
3. From a conceptual viewpoint: move from a science of mass-action/energy-conversion to a science of information processing through multiple heterogeneous medium

Nobody argues about points 1 & 2, but what about point 3?

- Should Systems Biology be more about *information processing* rather than (basic) chemical reactions, energy-matter transformations, etc?

This is a great opportunity for Computer Scientist to make an enormous contribution

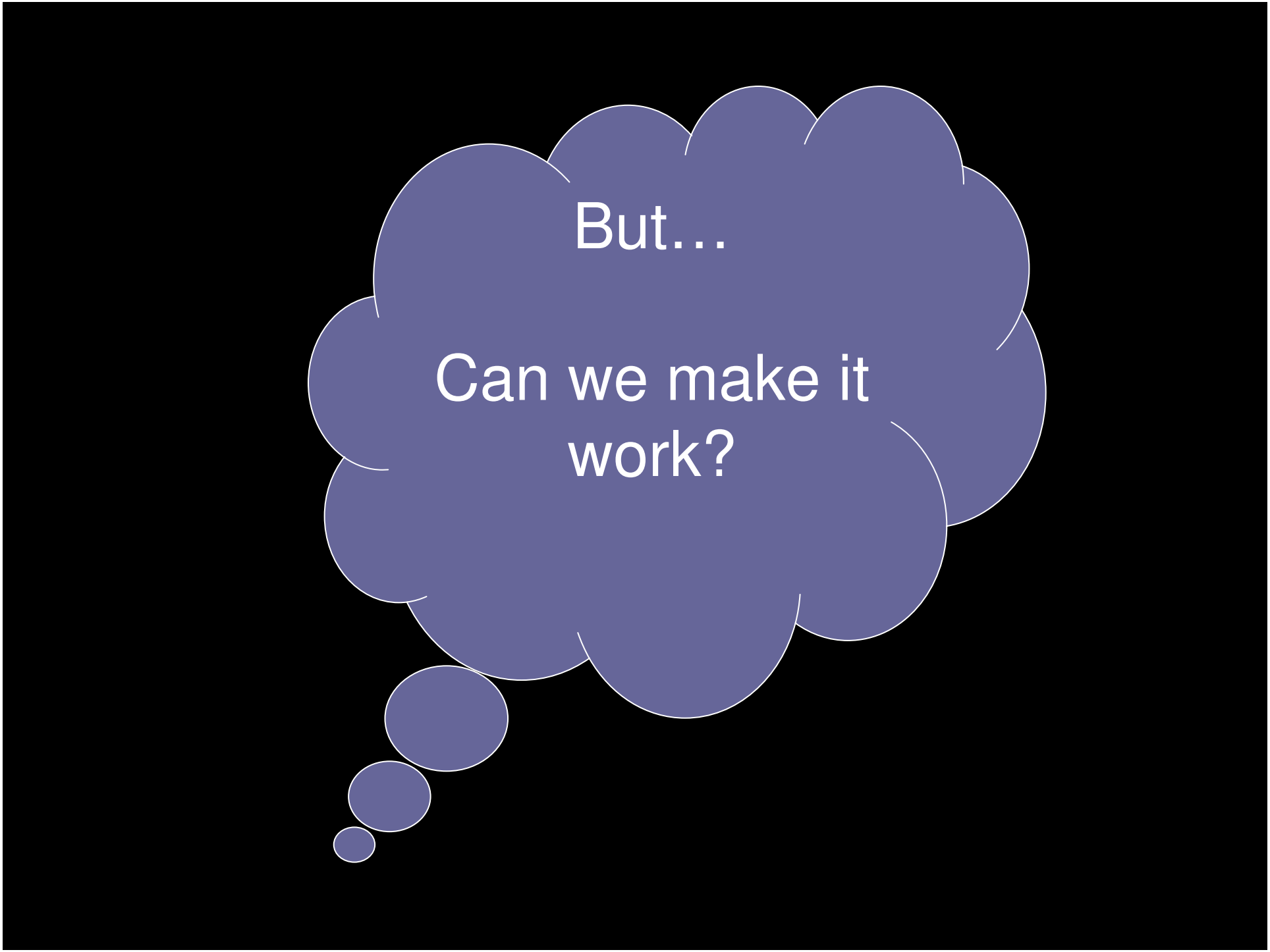
- If information processing is put center stage then computer science methodologies should (and will) have a preponderant role.

There are good reasons to think that information processing is (one of) the keys to successful Systems Biology:

• Information processing capability relies on a medium for storing/transporting/processing information

• However it is not the medium per se, e.g., looking at the atomic composition of a piece of fiber optic will tell us nothing about the “phone conversations” conveyed through the fiber optic.

- Life as we know is coded in discrete units (DNA,RNA, Proteins)
- Life as we know is combinatorial (DNA-RNA, DNA-Proteins,RNA-Proteins , etc) interactions
- Through the combinatorial interactions of discrete units Life emerges.
- In living systems information is transported in time (evolution/natural selection & heredity, neural memory, immune system memory) and transported in space (molecular transport processes, channels, pumps, etc)
- Transport in time = storage/memory (a computational process)
- Transport in space = communication (a computational process)
- Signal Transduction = procesing (a computational process)


But…
Can we make it work?

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