Networks and stability

Part 3A. – Examples for networks

Peter Csermely

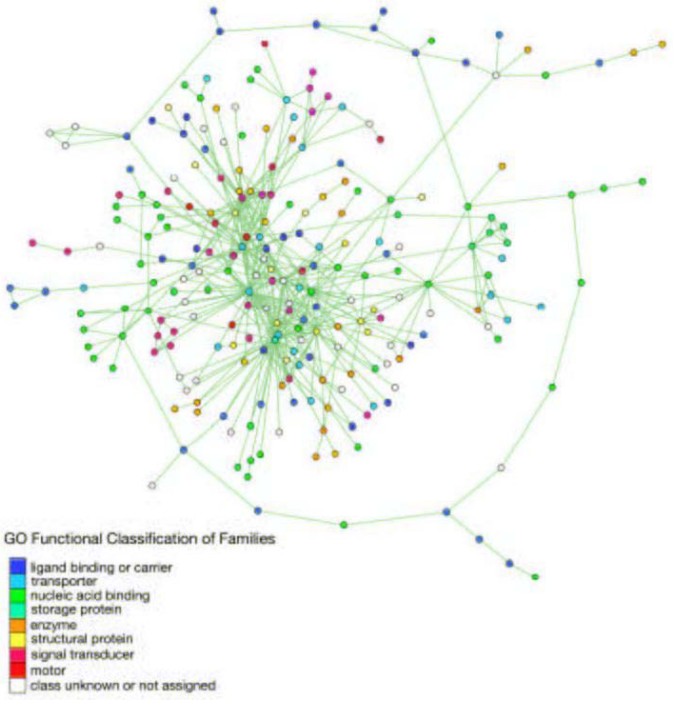
www.weaklink.sote.hu

1. network topology (II.20-27.)
2. network dynamics (III.6.-13.)
(III.20.-27. no lectures)
3. **examples for networks (IV.3.-10.)**
(IV.17. Easter)
4. synthesis (IV.24., V.1. holiday, V.8.)
(V.13. consultation)

Examples for networks

- **molecules**
- networks in the cells
- networks from cells
- social networks
- cultural networks
- ecosystems

The protein universe

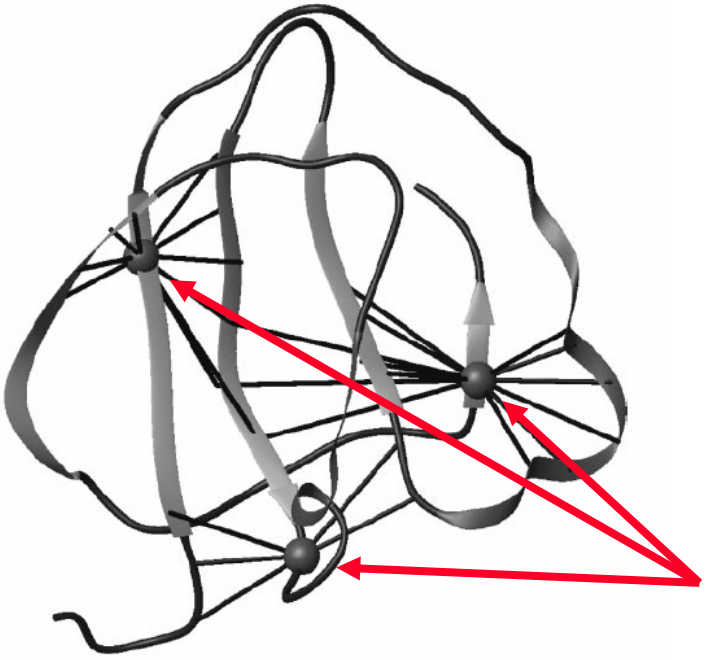


PNAS 102, 5641

protein sequences: $10^{400} \rightarrow 10^{10}$
protein folds/functions: 10,000

Atomic-networks

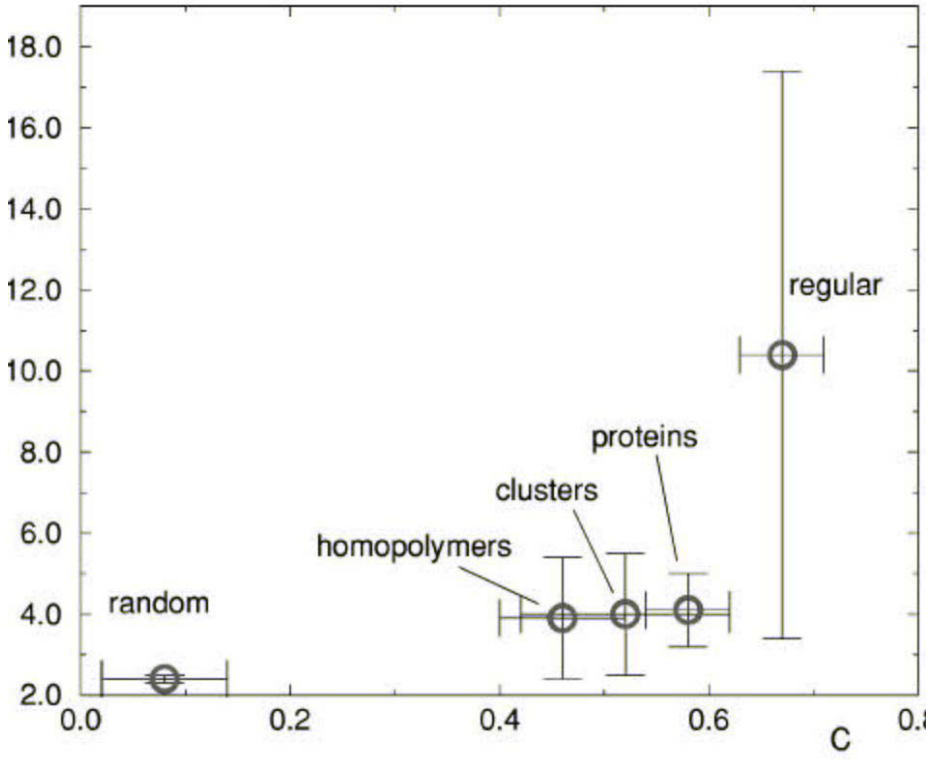
Vendruscolo et al:
Phys. Rev. E. 65:061910



key atomic residues
for protein folding

key atomic residues correspond to
central elements of the residue network
in transition state

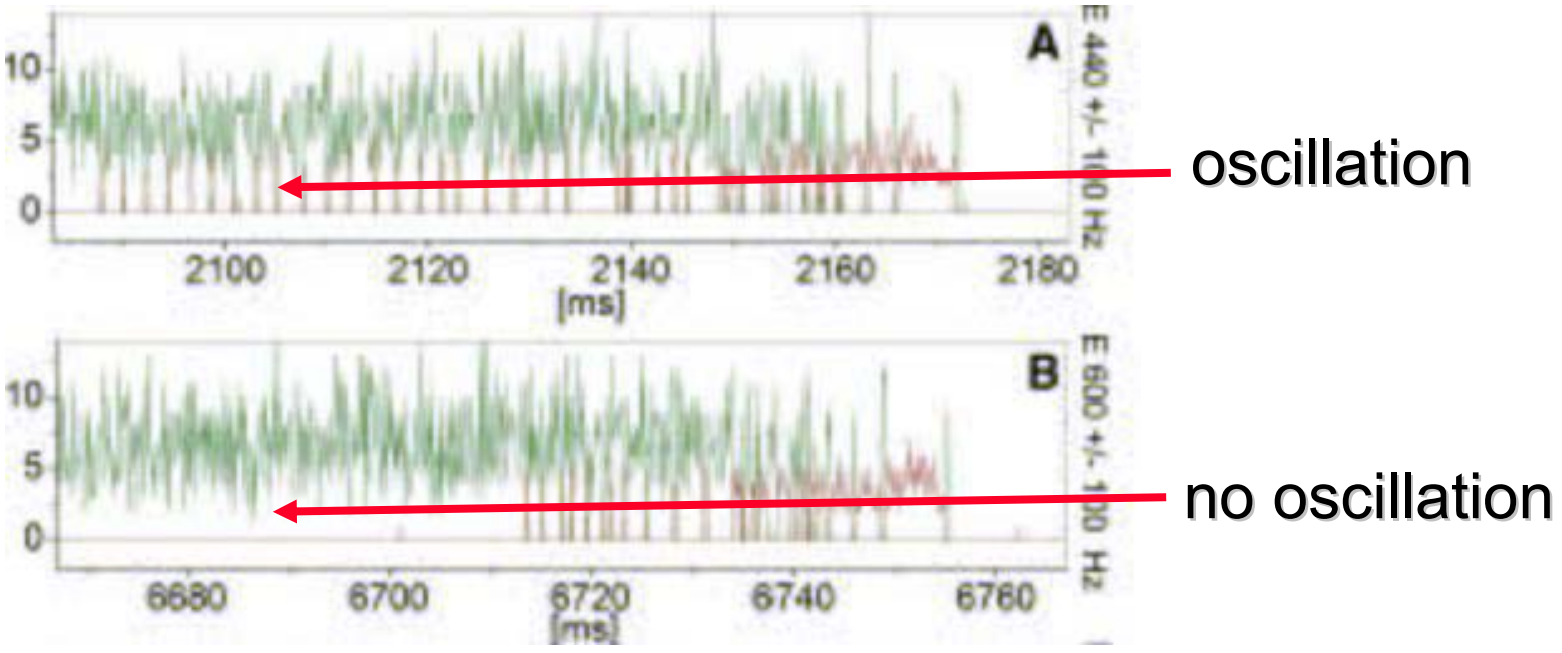
Atomic-networks



small world

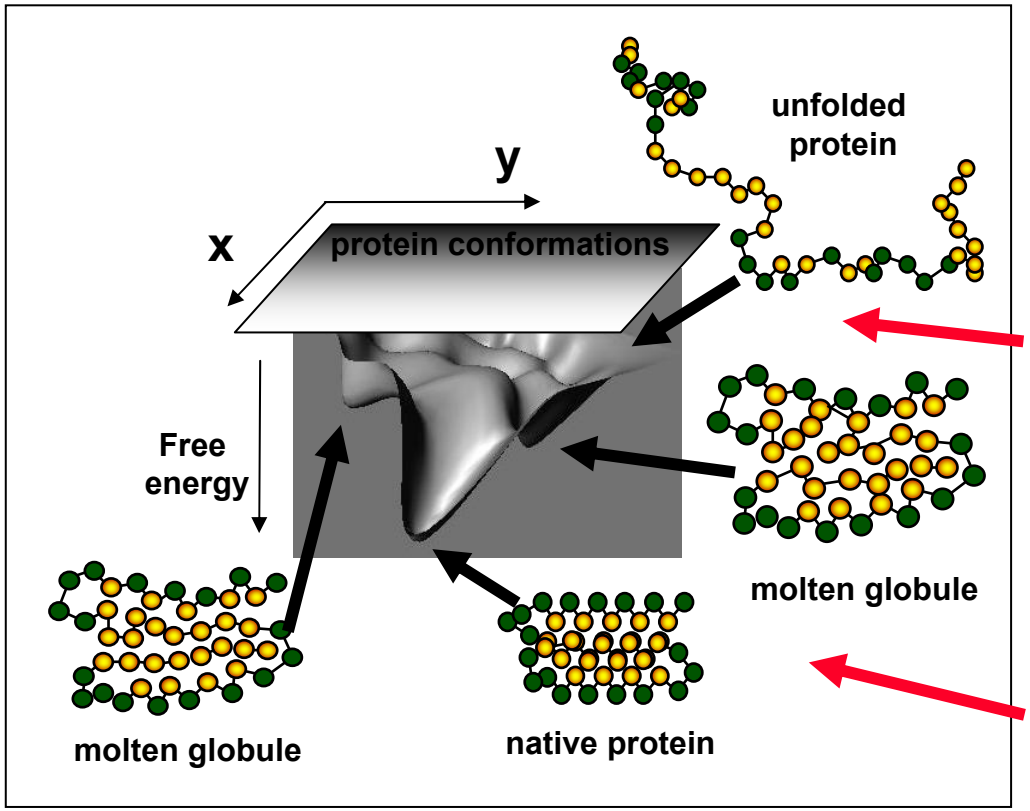
Vendruscolo et al:
Phys. Rev. E. 65:061910

Protein oscillation and unfolding can be triggered by noise

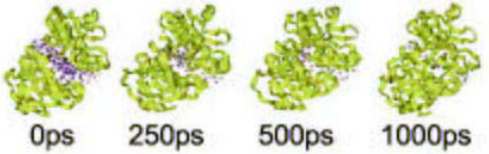


Science 309, 1096

Energy landscapes and folding



Science 305, 1605



fast hydrophobic collapse

slow rearrangement

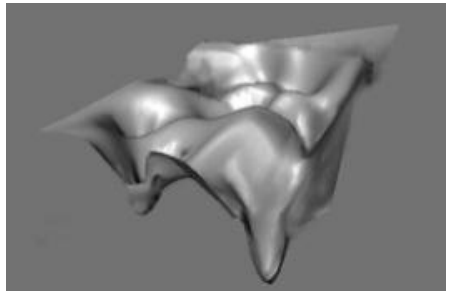
Energy-landscapes

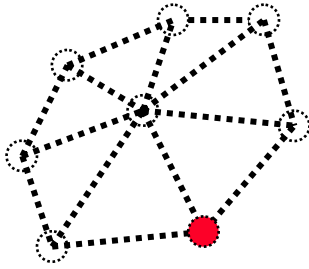
after Doye Phys. Rev. Lett. 88:238701
Csermely, TiBS 29:331

folding-traps

all-weak

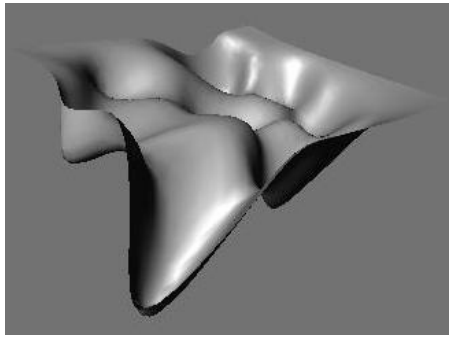
water & chaperones

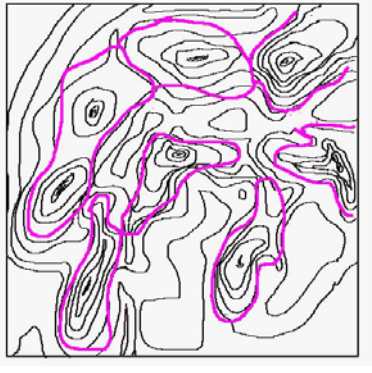


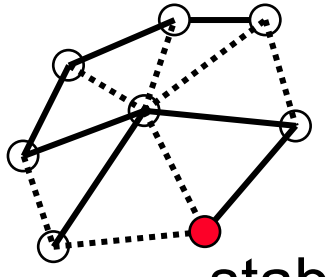


medium

water & chaperones



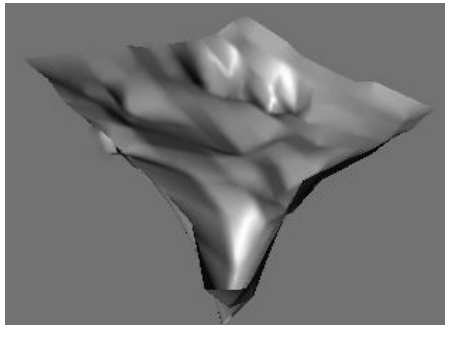


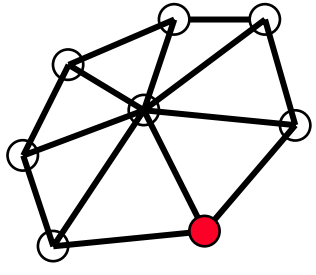


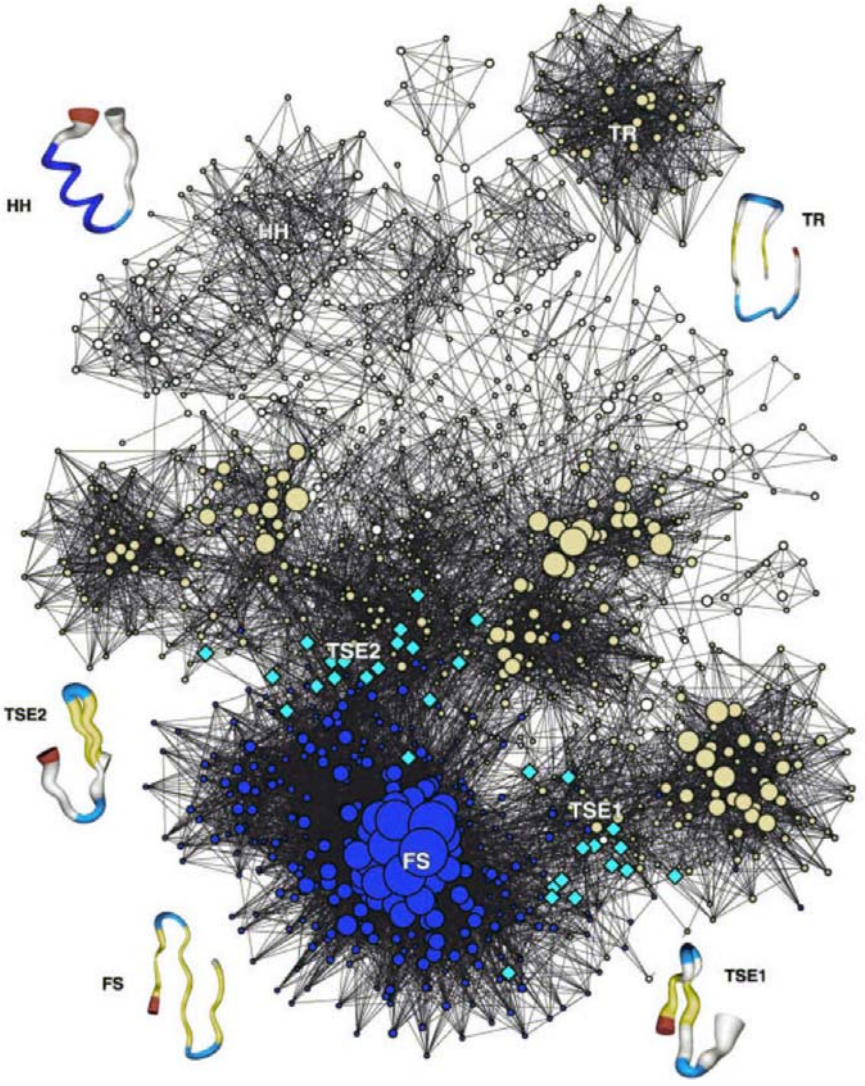
stabl

all-strong

folding-efficient





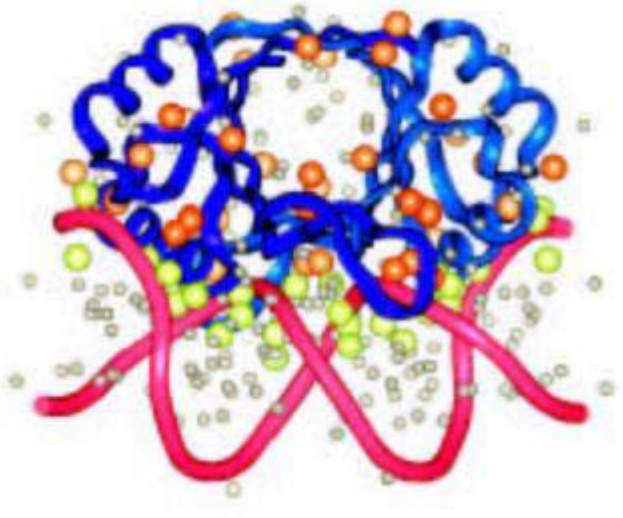


Folding networks

20 AA peptide
nodes: conformations
links: transitions

JMB 342, 299

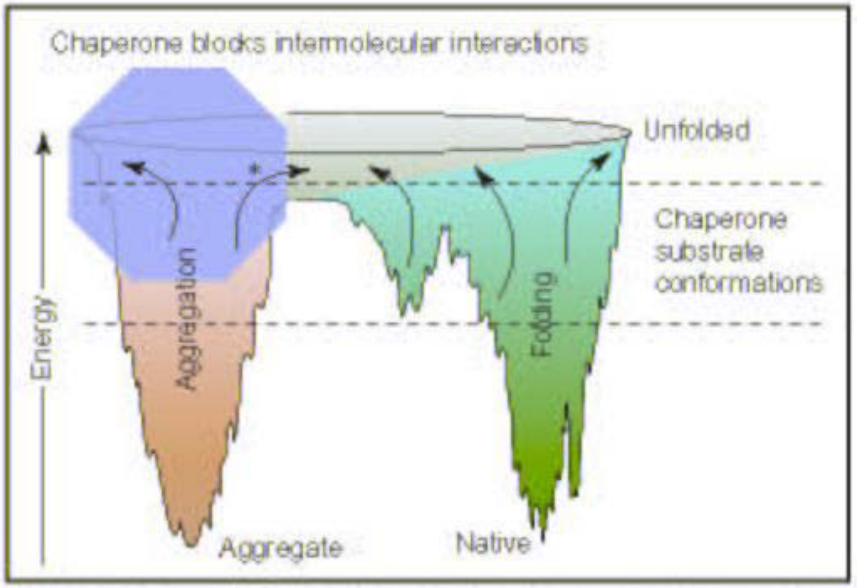
Role of water: lubricant



protein + DNA interfaces

PNAS 101, 3325

The full energy landscape and role of chaperones



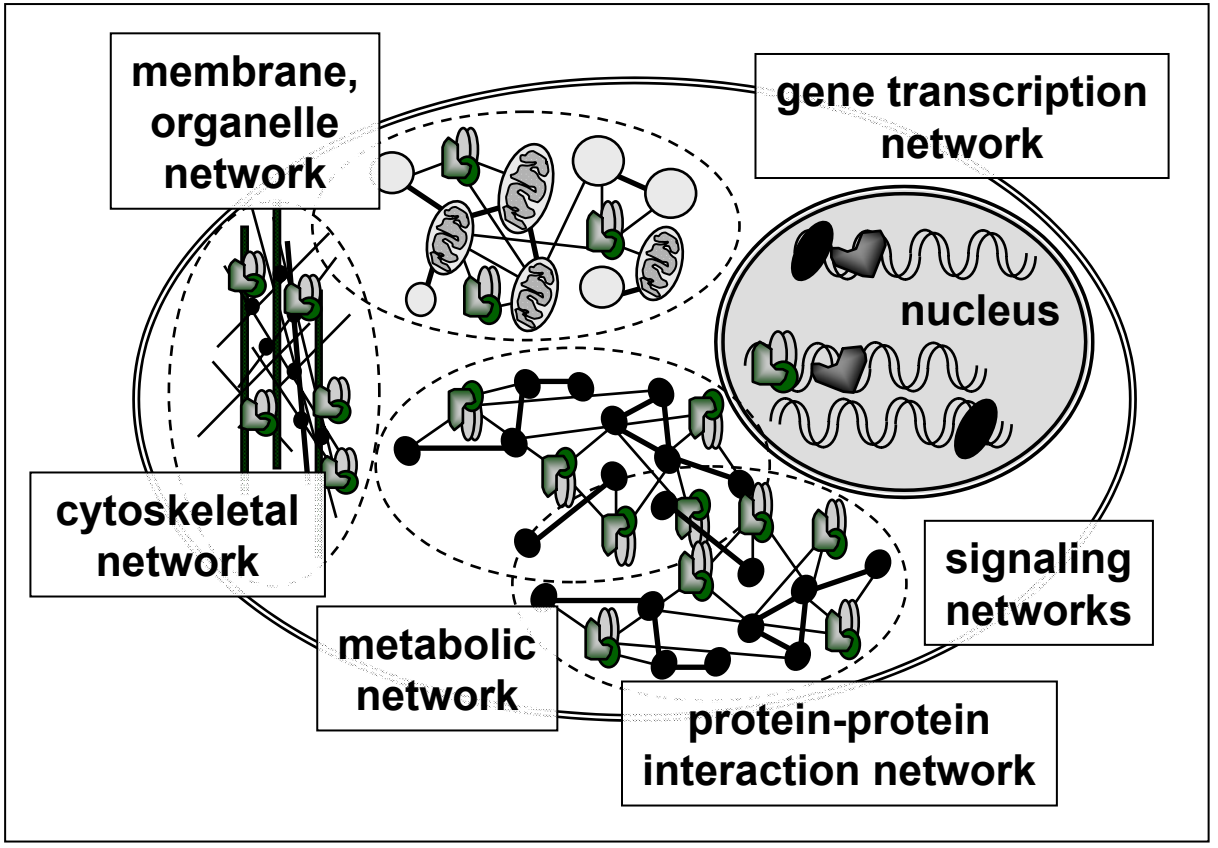
blocked aggregation
+ smoothing

TiBS 29, 527

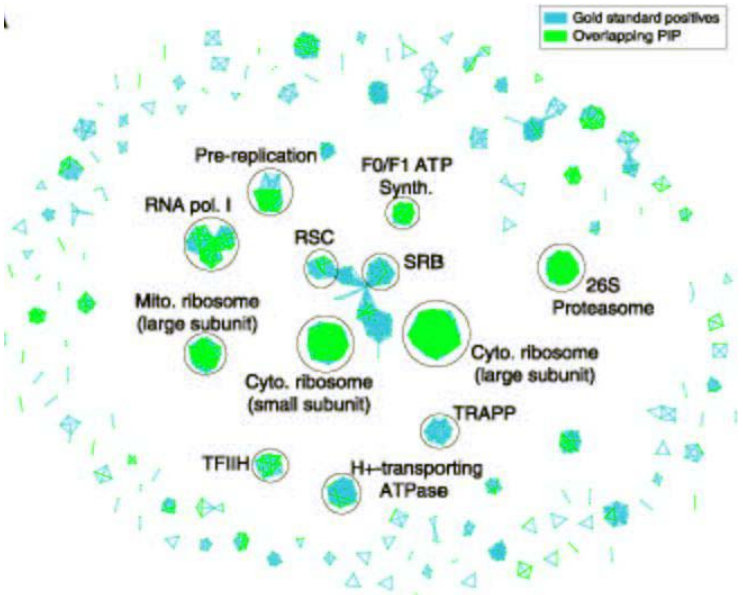
Examples for networks

- molecules
- **networks in the cells**
- networks from cells
- social networks
- cultural networks
- ecosystems

Cellular networks

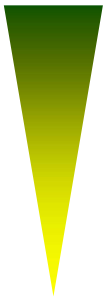


Protein interaction networks



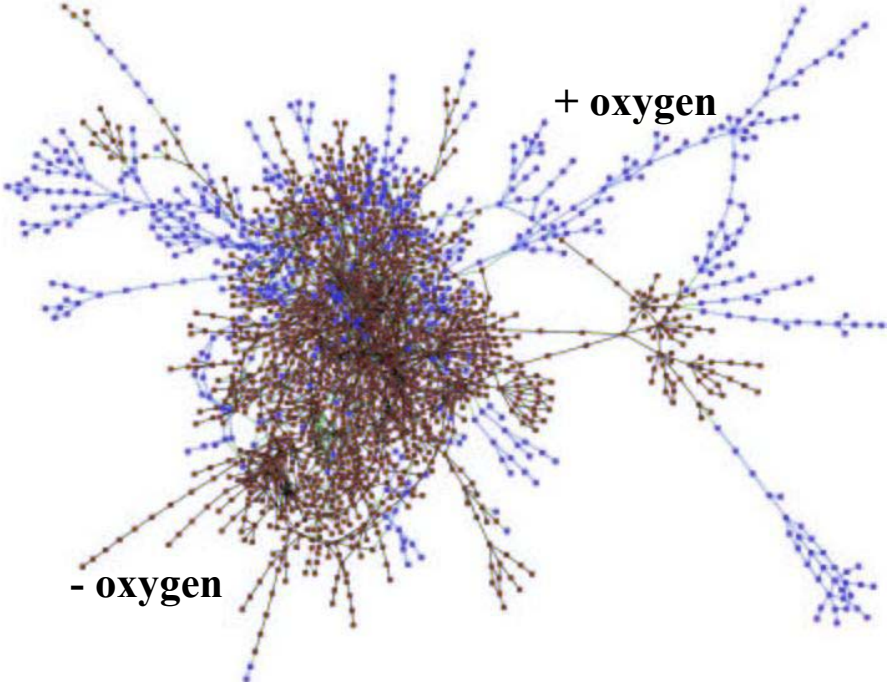
Science 302, 449

yeast
C. elegans
Drosophila
human



- small-world, scale-free (sampling, core)
- lethality: hubs, high betweenness
- modules, herpes, etc.

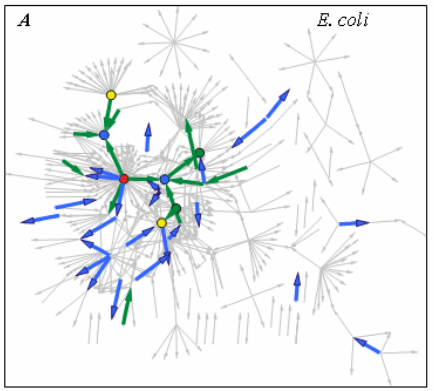
Metabolic networks

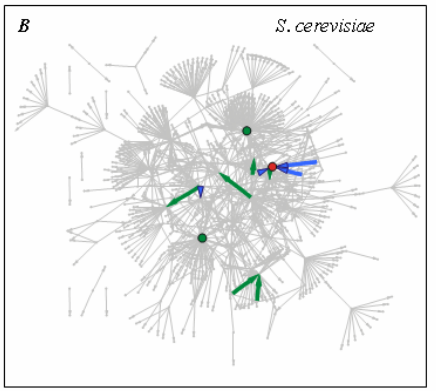


Science 311, 1764

- metabolites (nodes)
  + enzymes (links)
- small-world (?), scale-free (?)
- lethality: depends on reaction, high betweenness
- symbionts

Gene transcription networks



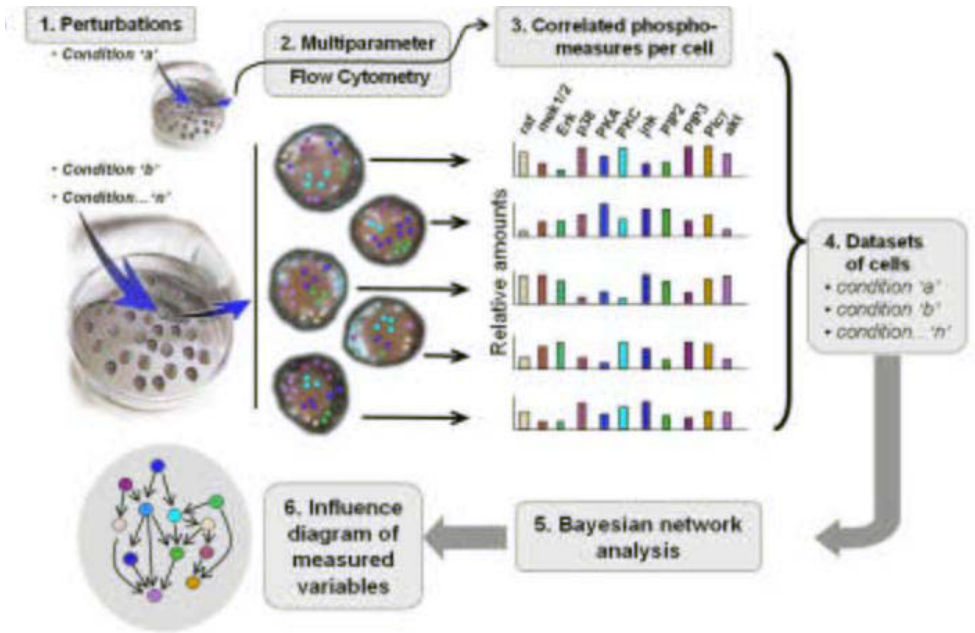


- genes (nodes)
  + transcription factors (links)
- derived from expression profile sets
- similar expression profile: interacting proteins

E. coli and *S. cerevisiae* networks
Agoston et al. Phys Rev. E 71, 051909

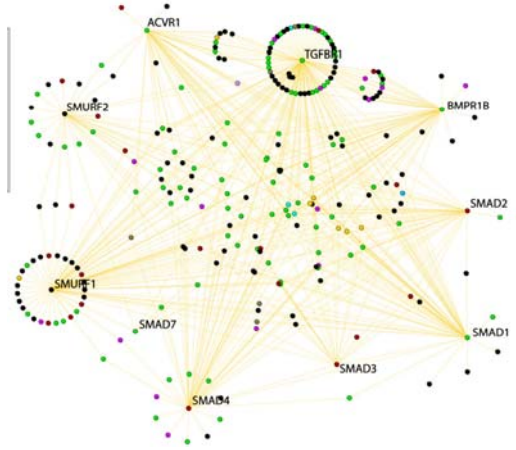
yeast	4% trfactor
C. elegans	5
human	8

Signal transduction networks



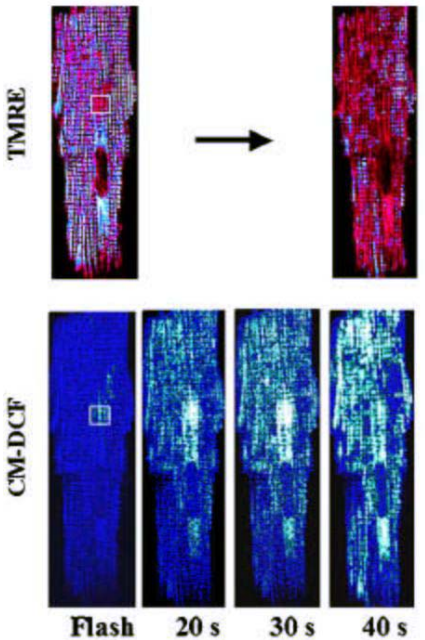
Science 308, 523

- signaling proteins (nodes) + regulation (links)
- partial maps: kinome (kinases)



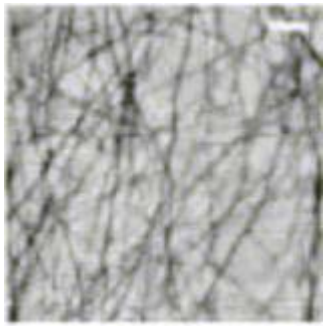
TGF-beta net, Science 307, 1621

Cell organelle networks



- mitochondrial net (cardiomyocyte)
- chaperone-coupling (decoupling in stress)

BBA 1762, 232



Actin-net, PNAS 101, 9636

Examples for networks

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- **networks from cells**
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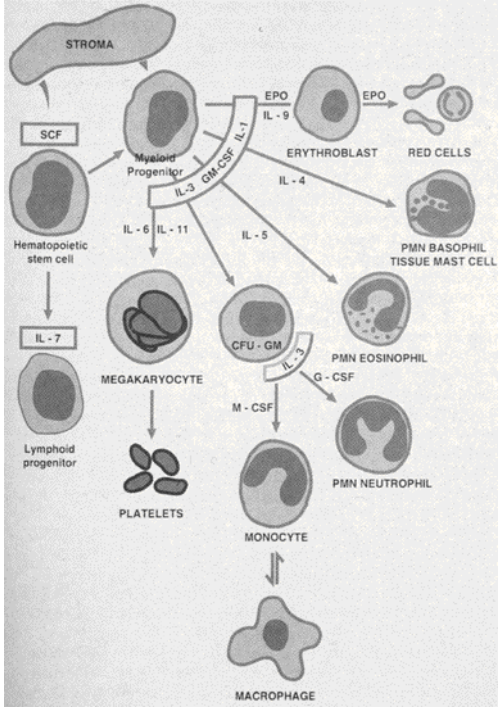
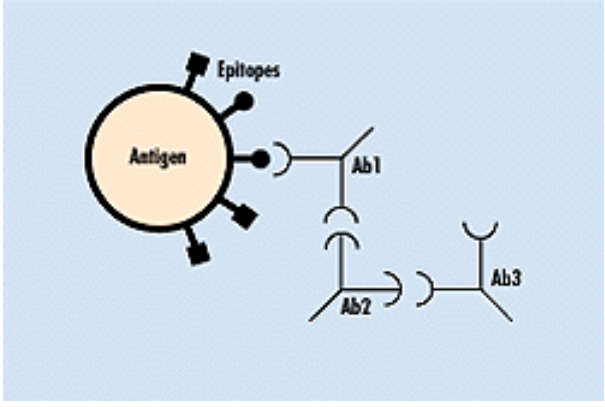
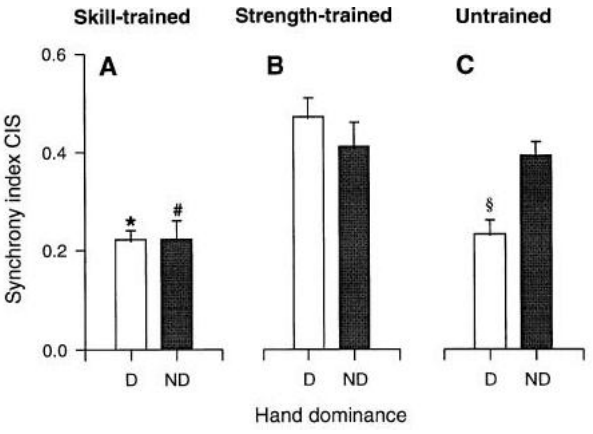
Immune nets





- cellular networks
- cytokine networks
- idiotype networks (Jerne, 1974)

Muscle unit nets

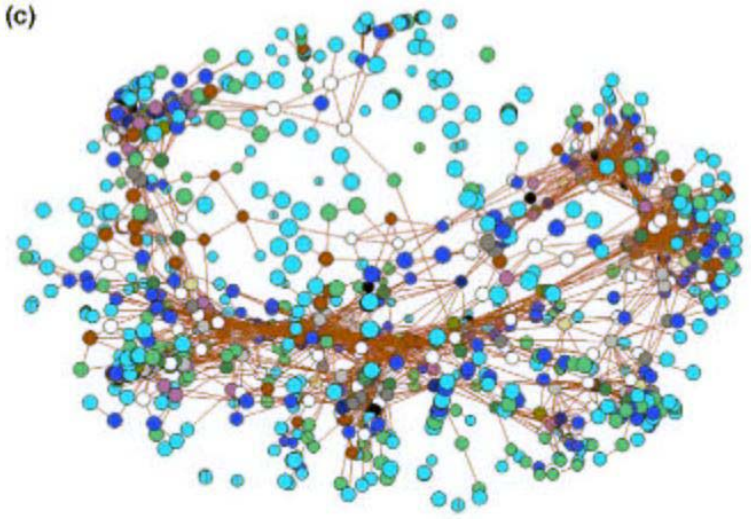


Exp. Brain Res. 119, 27

- piano player: two right hands
- weightlifter: two left hands

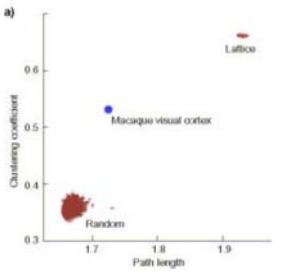
bone network
arxiv.q-bio.TO/0506019

Neural networks

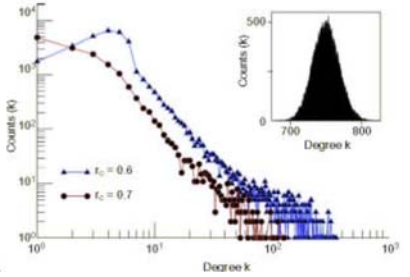


Trends Cogn. Sci. 8, 418

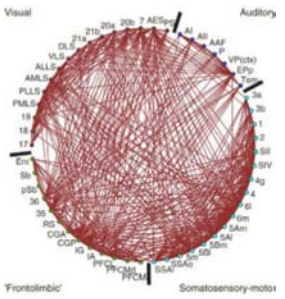
- cat brain net: neurons
- human brain billion neurons
- sync



small world



scale-free



modular