
# E-Dialogs on New Sciences

## *Science of Networks*

**November 8, 2012;  via  Webex**

## Fascinating evolution in new Knowledge acquisition through 'New' Sciences

## Innovation for half a century

- **Systems theory**

  **Systems Dynamics  CoR-Report  *The limits to growth (1972)***

- **Cybernetics**

  **Together produced  *Autopoiesis , Complexity & Networks***

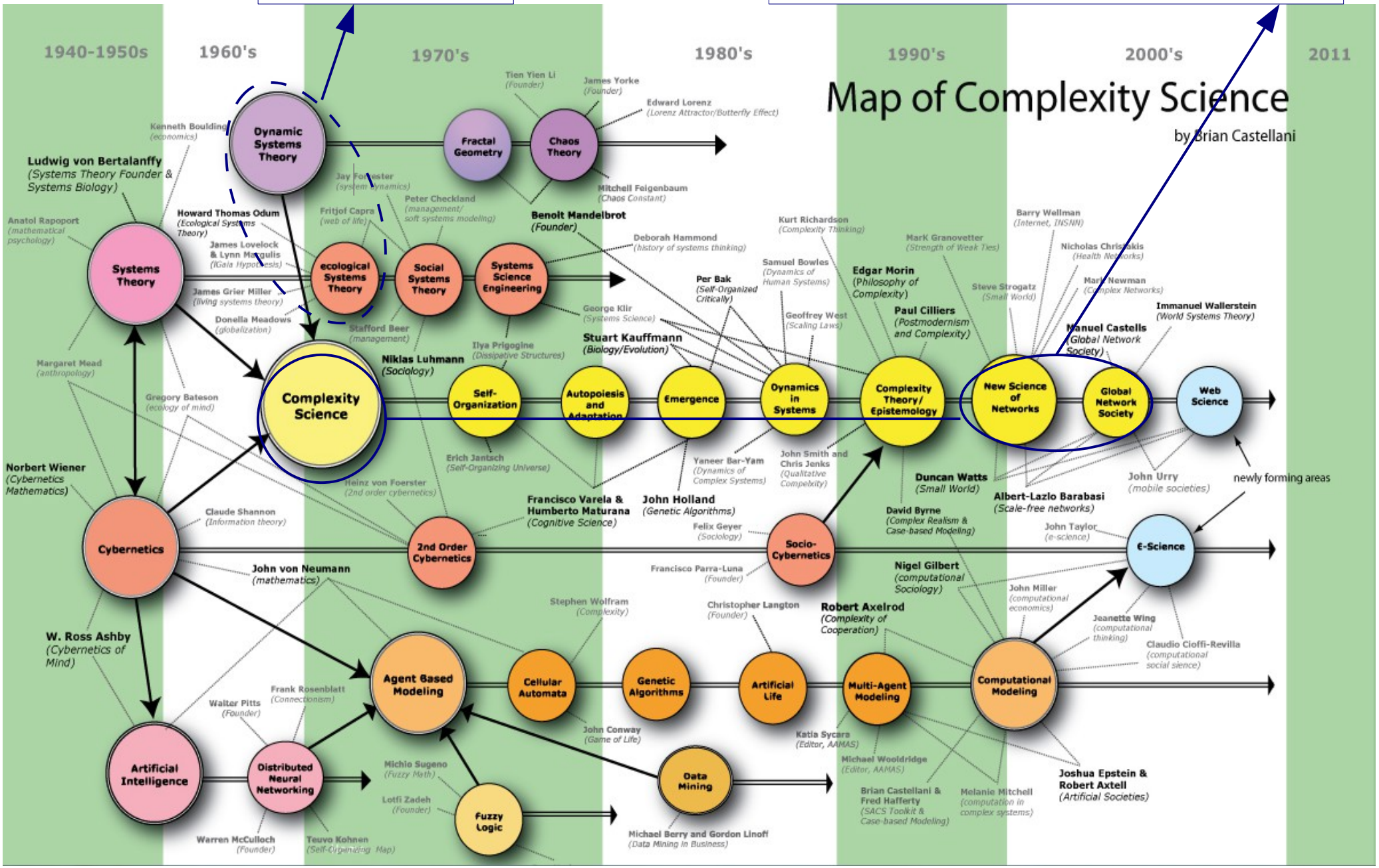
- **Artificial Intelligence**

  - **Agent based Modeling,  a.o.**

**RW  03.11.2012**

1972 Limits to Growth

2012 Towards Grand Unified Theory for Sustainability




http://wikipedia.org/wiki/Complexity

RW. Blue lines are add-ons

## Fascinating evolution in Knowledge acquisition through 'New' Sciences

## Innovation for half a century

**- Systems theory**

**Systems Dynamics CoR-Report *The limits to growth (1972)***

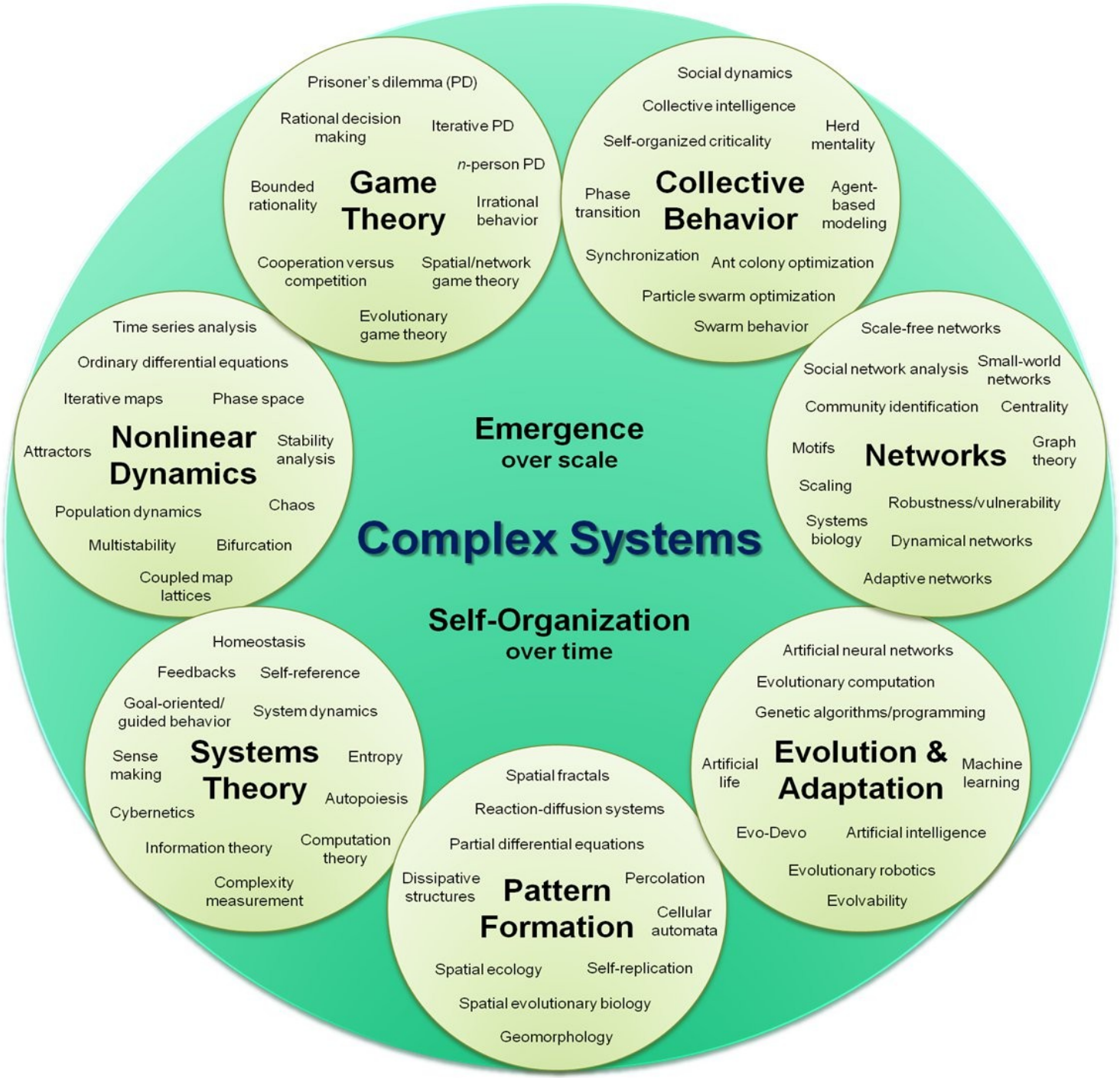
**- Cybernetics**

**Together produced *Autopoiesis , Complexity & Networks***

**- Artificial Intelligence**

**- Agent based Modeling, a.o.**

**RW 03.11.2012**




http://en.wikipedia.org/wiki/Complexity

## *New knowledge* acquired about most diverse domains :

- System dynamics
- Complexity in Society, technology, ….
- Networks in metabolism
- Autopoiesis & Self-organization :
  philosophical implications
- Modeling

**Common & new to all:**

- knowledge based on quantifiable information

[networks do exist since long time, but not in the sense of an 'exact' science]

## *Expectation* of possible new application domains ??

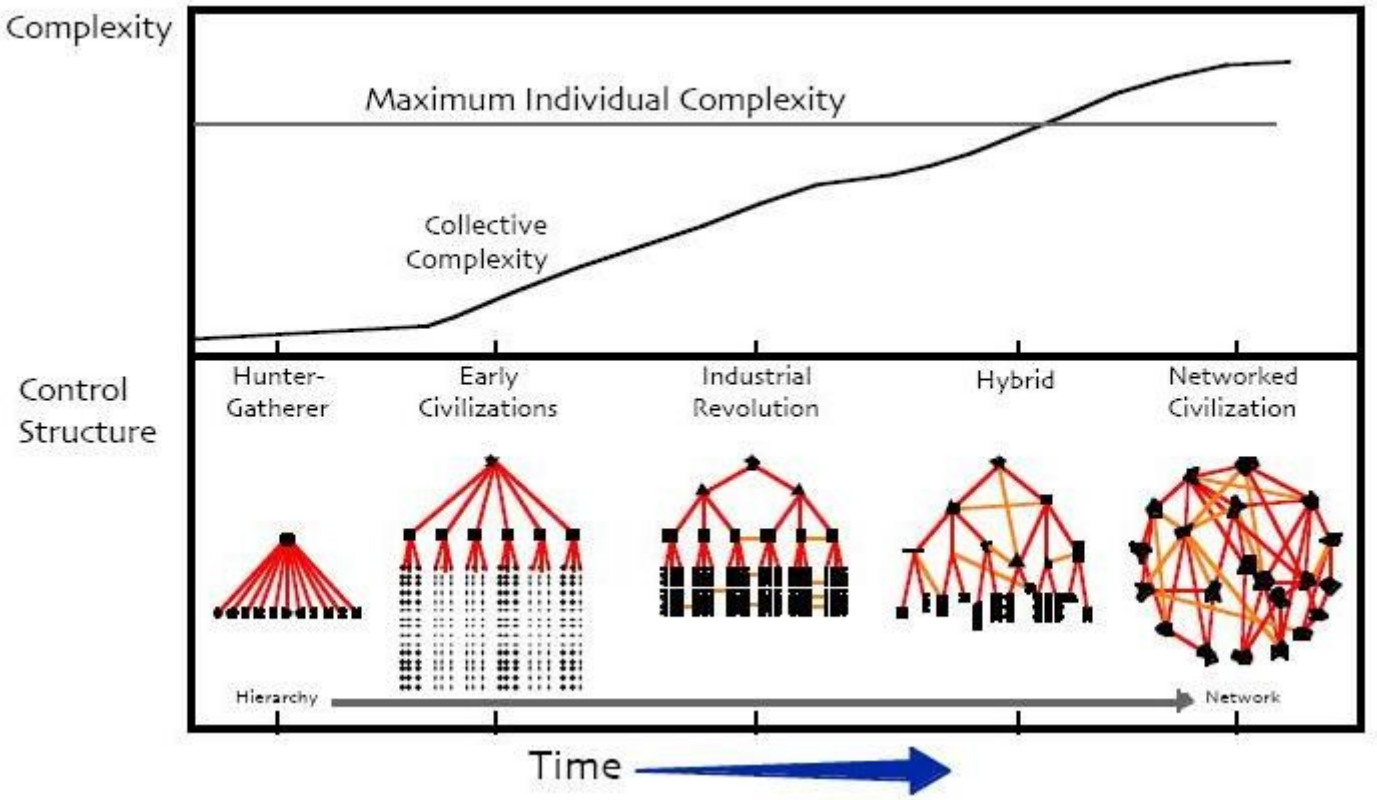
- **Finance & monetary systems/networks**

- **Governance large organizations UN**
  **Businesses multinationals**

- **Planetary Resilience /Sustainability issues**

- **Planetary food analyses :**
  **weather, water, soil, gmo**

# Positioning of Network Science in Civilization : quite recent!!



# *Kinds of Networks*

- **Technological networks**
  - **Internet**
  - **Telephone network**
  - **Power grid**
  - **Transportation networks**

- **Social networks**
  - **Person relationships**
  - **Ego-centered networks**
  - **'Small world' networks**

- **Networks of information**
  - **WWW**
  - **Citation networks [academic, biography, patents]**

- **Biological networks**
  - **Biochemical networks : Metabolic**
    **Protein-protein interaction**
    **Genetic regulatory networks**
  - **Neural networks**
  - **Ecological networks : Food webs**

# *Network Models*

**- Random networks**

**Random Poisson distribution [bell shape]**

**Paul Erdös & Alfréd Rényi (1959)**

**Illustration : US highway system**

**- Pareto's Law**

**Distribution : the 80/20 rule**

**- Scale free networks :**

**Power law : $P(k) \sim k^{-n}$**

***P(k) distribution of the links over k nodes***

**in a *log-log diagram n~2-3***

**A.-L. Barabåsi et al (1998)**

**Illustration : US Airway system**

## *Structure related properties*

**- In Scale-free networks : highly robust/resilient**

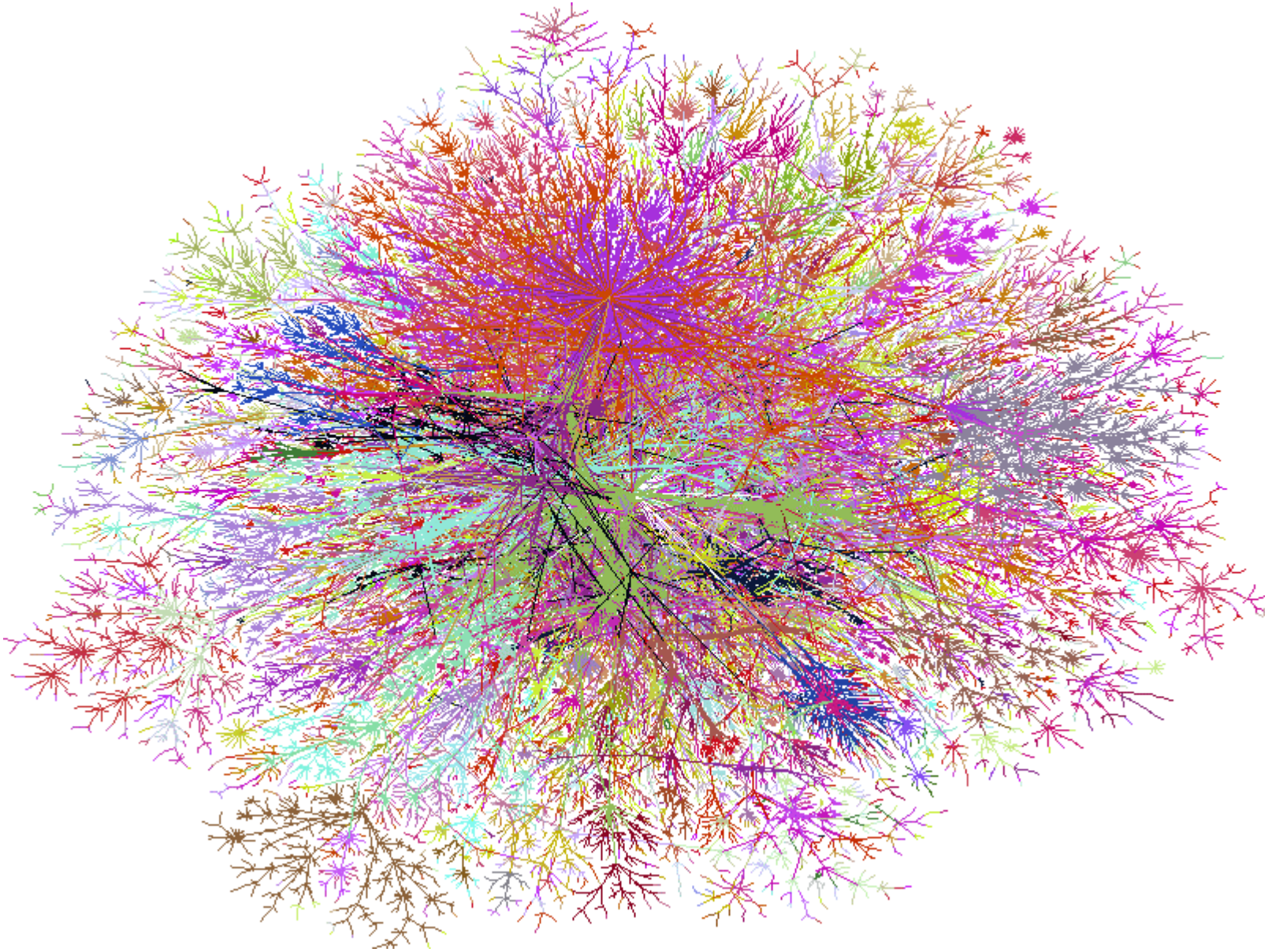
**- Internet is highly resilient against accidental (random) failures**

**- Living systems : resilient against failures at cellular level**

**- Elimination of small nodes -more numerous- will not disrupt the network topology significantly, because they contain few links.**

**- In Random networks**

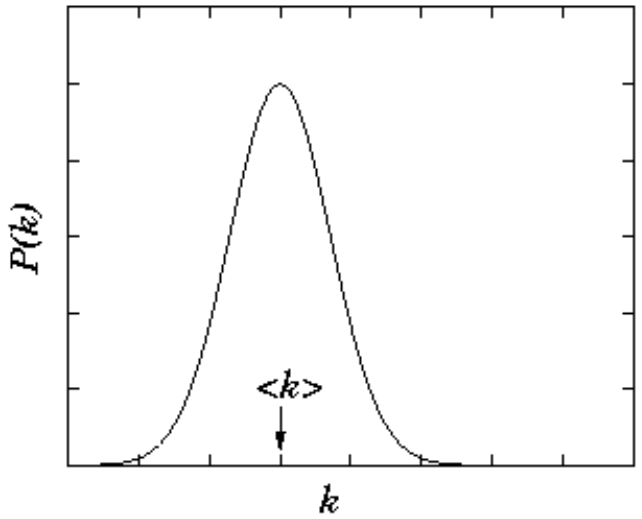
**- Breakdowns of substantial # of nodes leads to the 'inevitable' network's fragmentation**



https://www.google.be/search?q=communication+networks&hl=en&client=firefox-a&hs=uK0&rls=org.mozilla:nl:official&prmd=imvnsb&tbm=isch&tbo=u&s

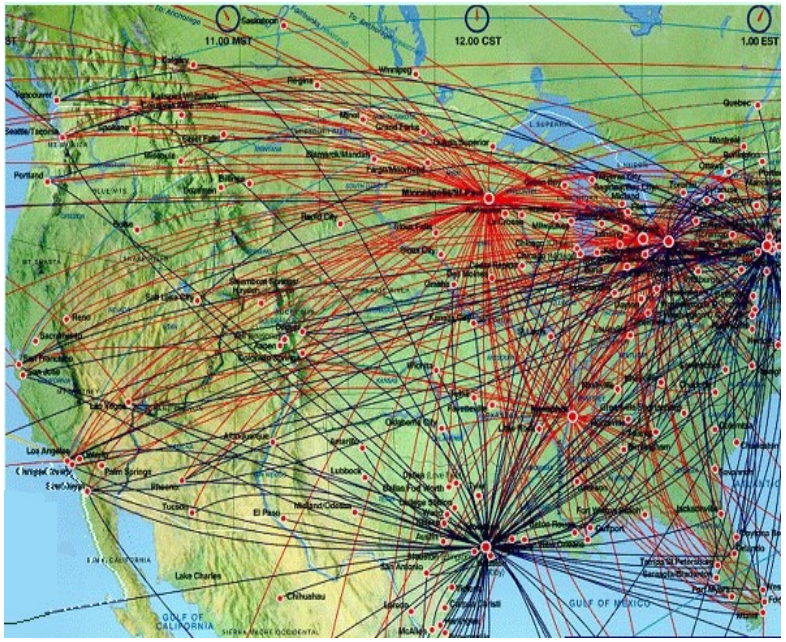
# World Wide Web

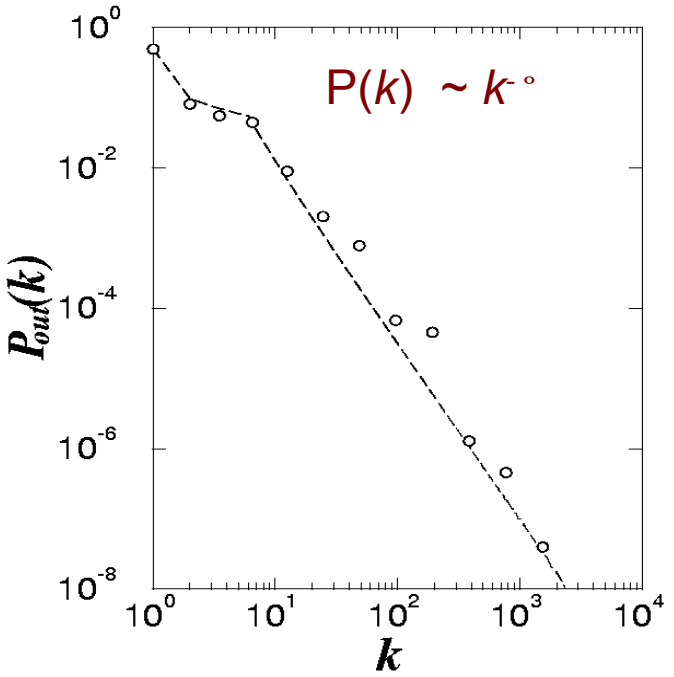
**Exponential Network**


Expected

**Scale-free Network**

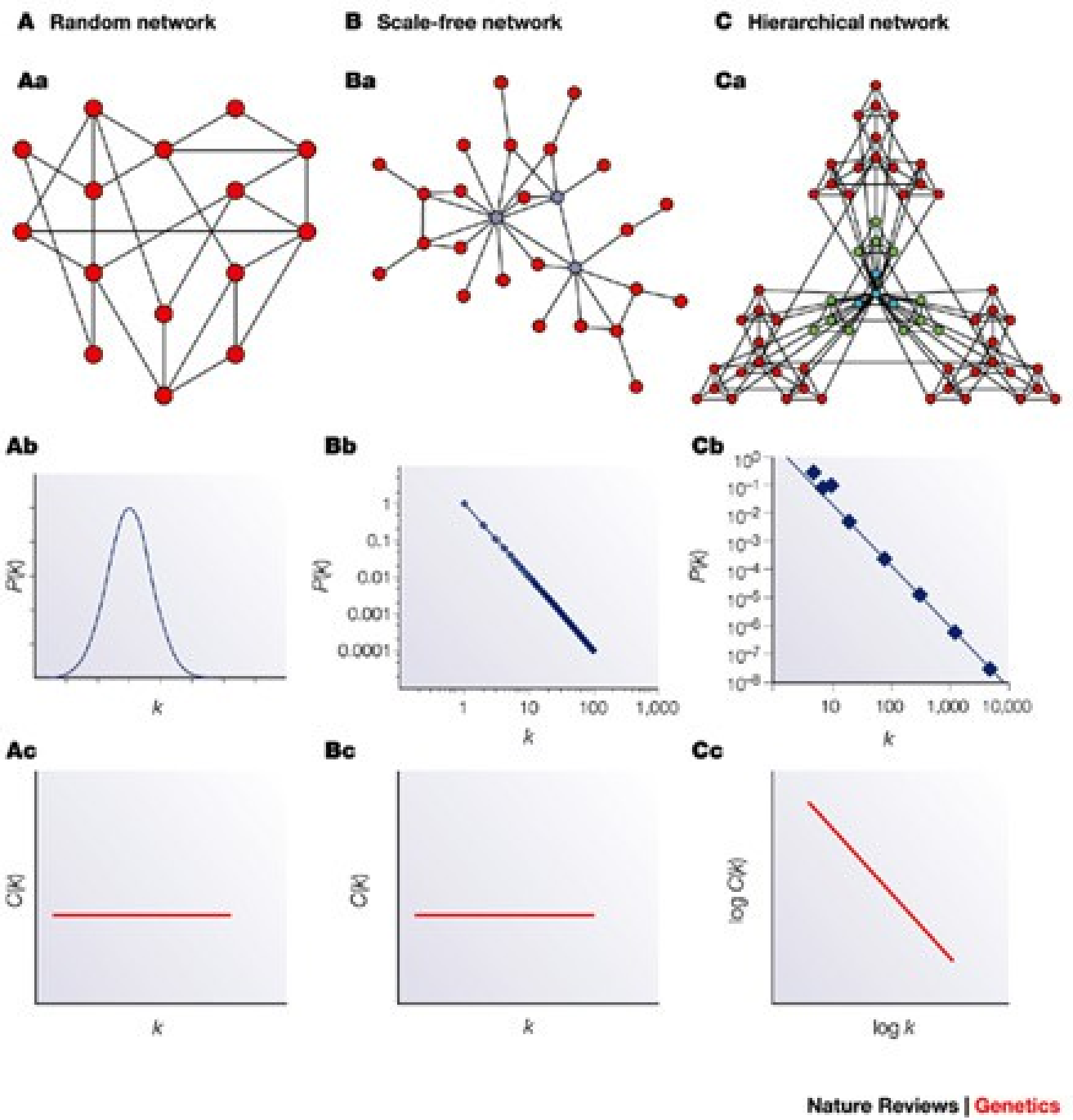





Found

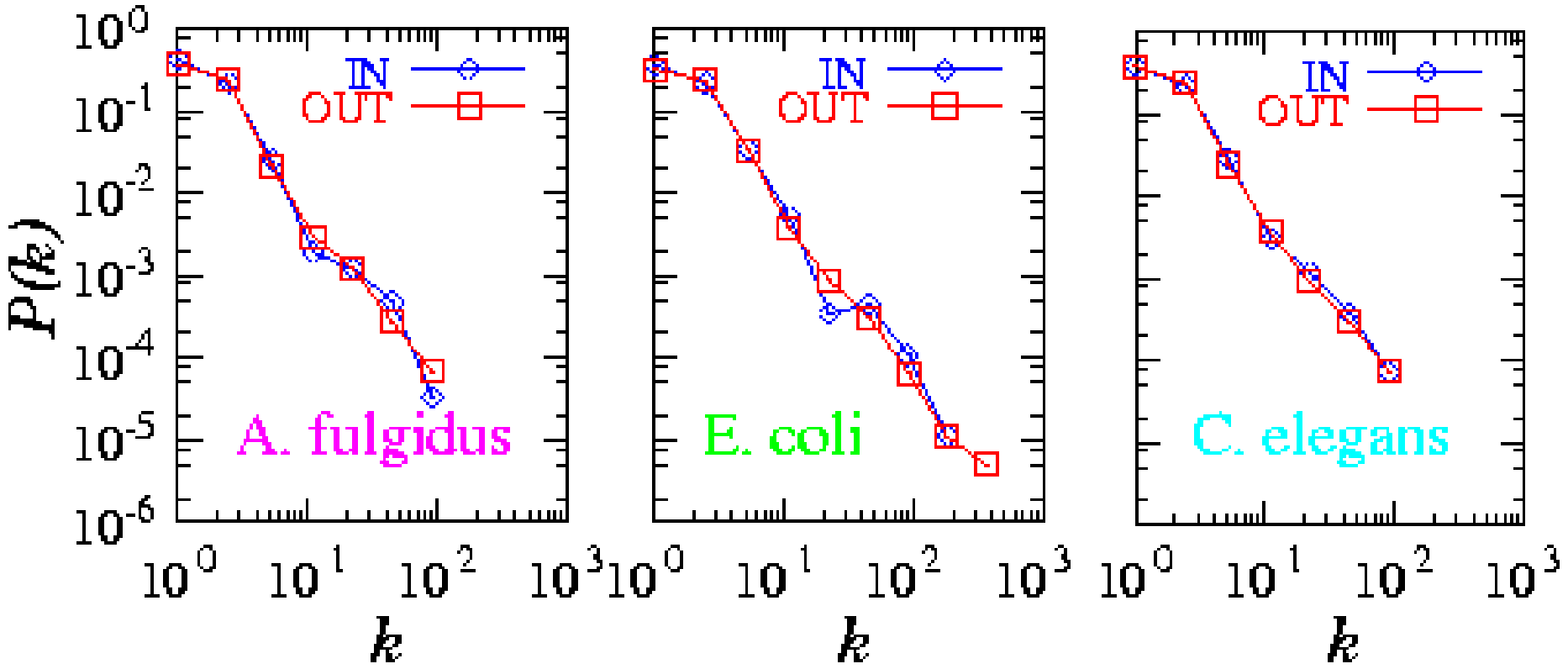
R. Albert, H. Jeong, A-L Barabasi, *Nature*, **401** 130 (1999).

# Global network properties



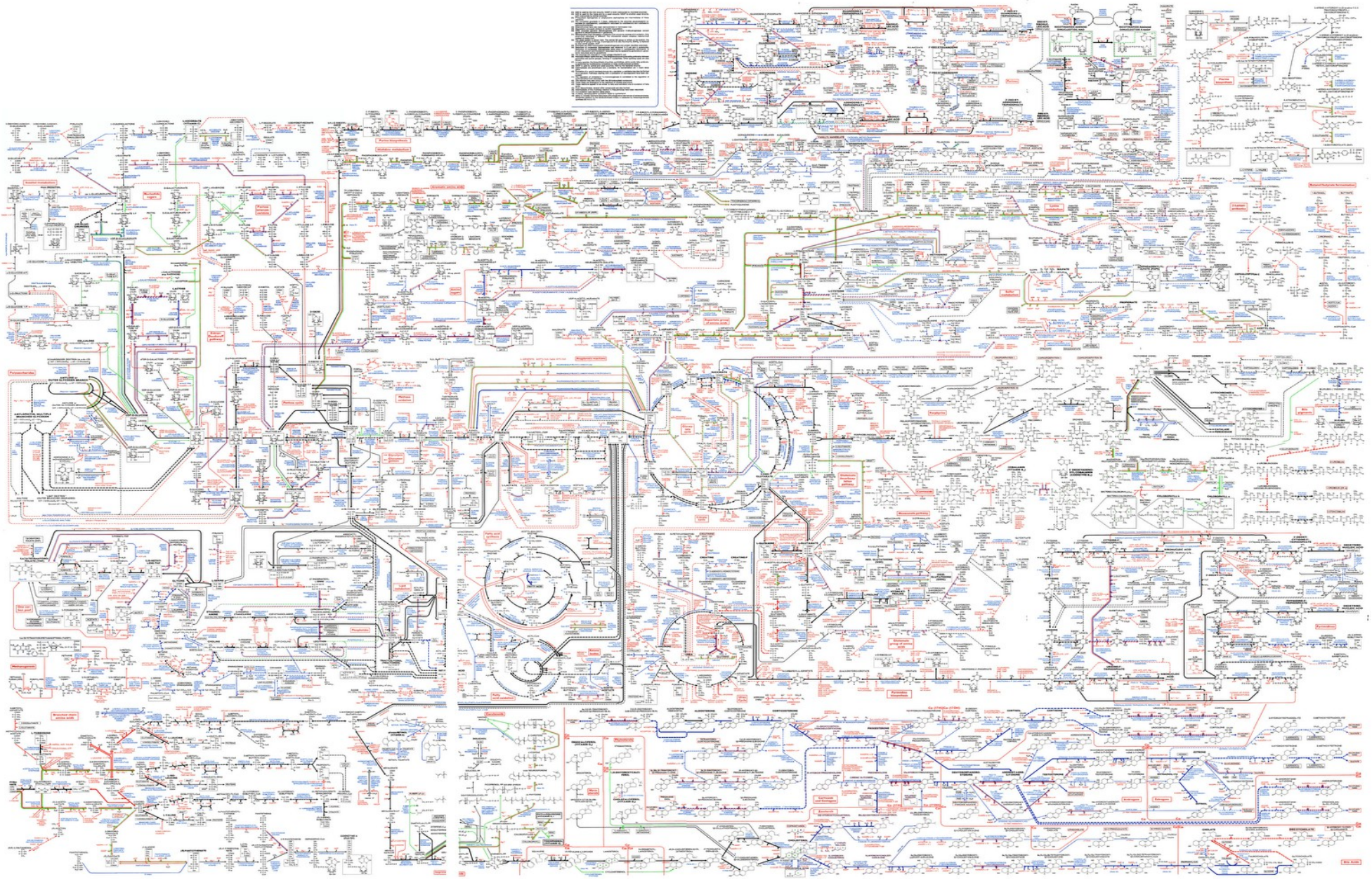

A.-L. B. and Z.N. Oltvai, Nat. Rev. Gen.(2004)

# Metabolic network

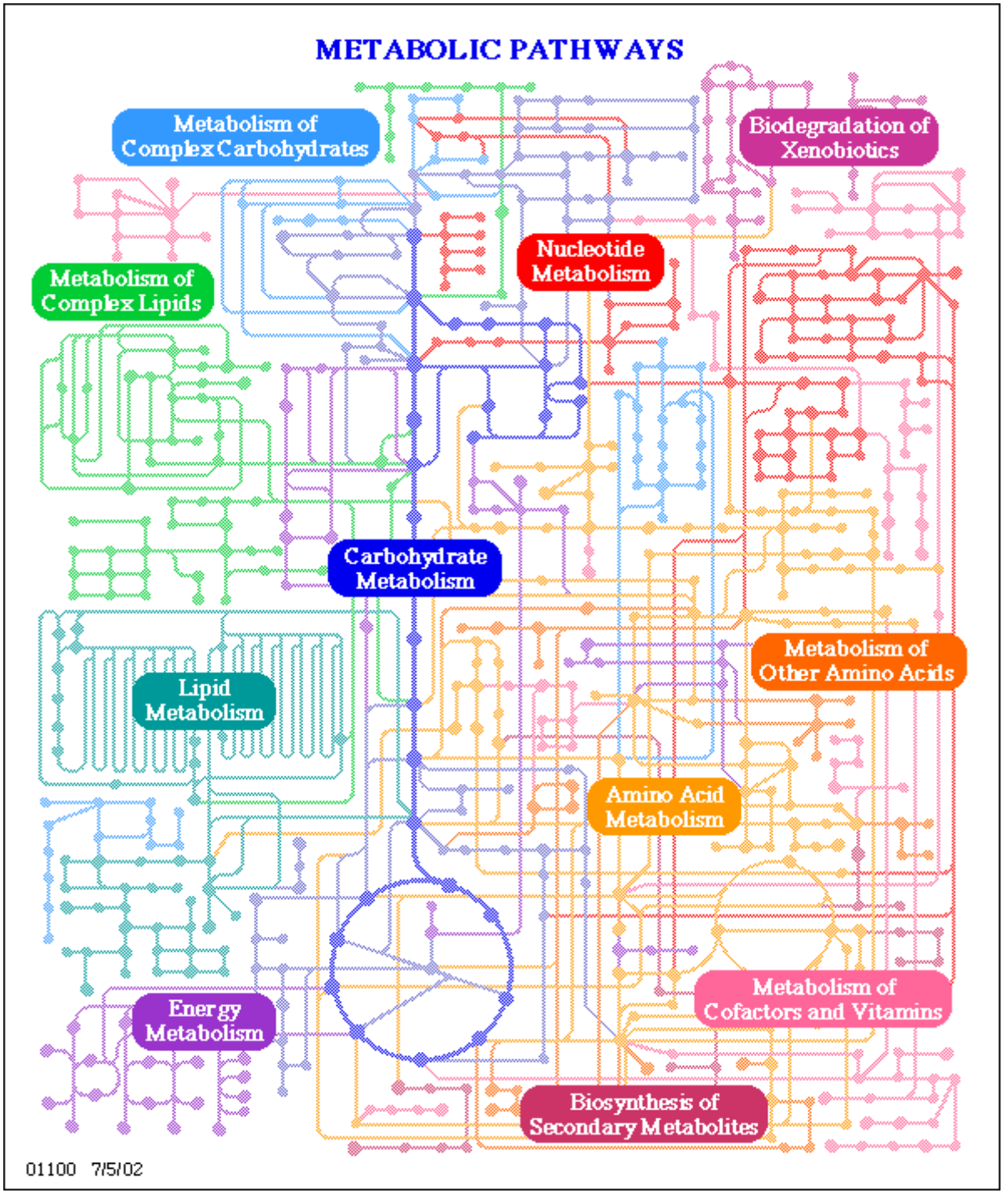



Organisms from all three domains of life are **scale-free** networks!

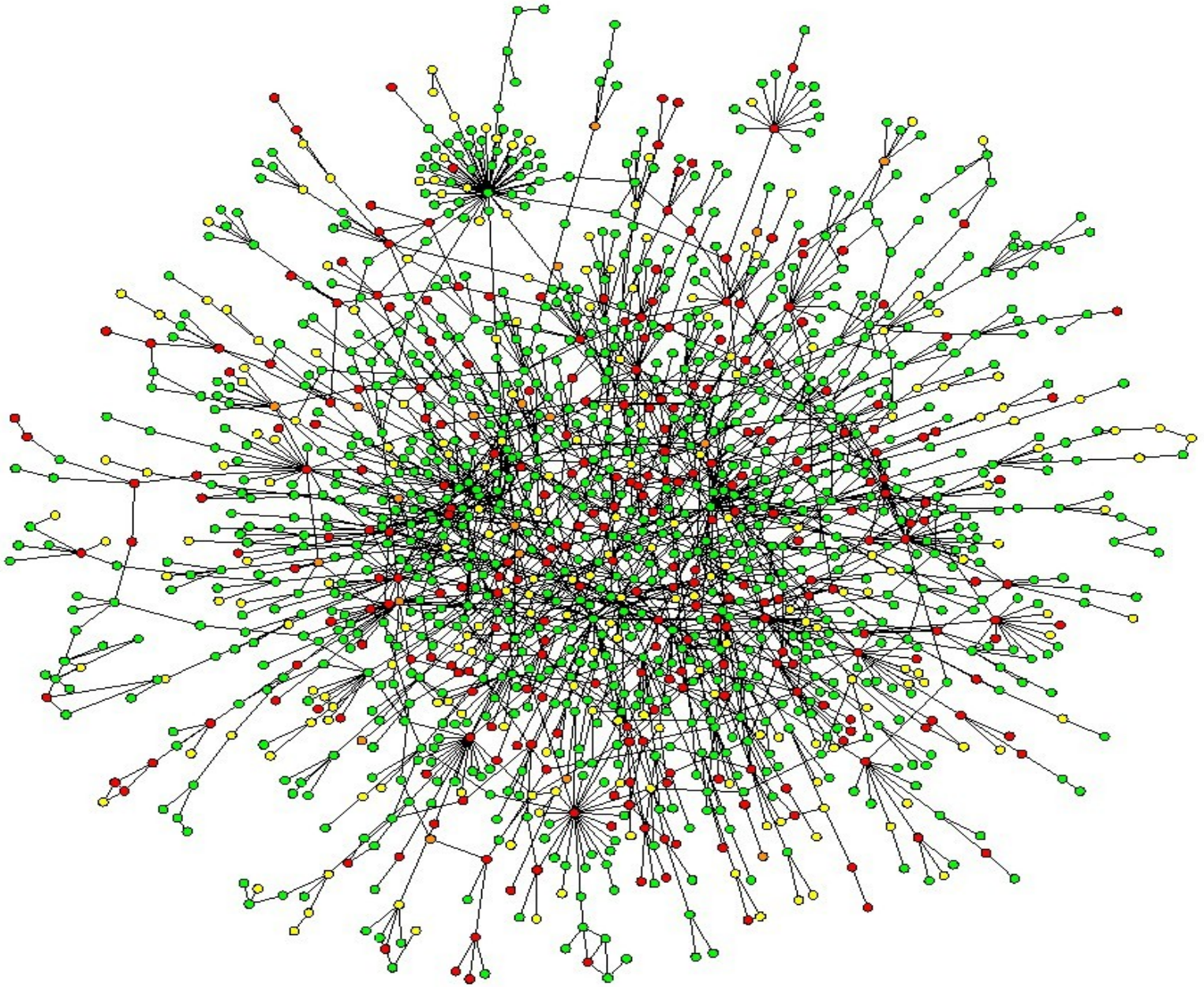
H. Jeong, B. Tombor, R. Albert, Z.N. Oltvai, and A.L. Barabasi, *Nature*, 407 651 (2000)



http://biochemicalpathwayswallchart.blogspot.be/2010/10/roche-biochemical-pathways-wall-chart.html




http://www.cs.cmu.edu/~blmt/Seminar/SeminarMaterials/IntroMolBasDisease.html



The scale-free nature of protein interaction networks is a generic feature of all organisms

**http://www.bordalierinstitute.com/target1.html#bio-chemistry**

## *Some application domains*

| | | |
|---|---|---|
| **- WWW** | **scale free** | **Information network** |
| **- e-mail** | **id** | **Social network** |
| **- business** | **id** | **alliances networks in US biotechnology industry** |
| **- cellular metabolism** | **id** | |
| **- protein interaction networks of cells** | **id** | |

**Topics to discuss eventually in this e-workshop**

- **Progress in mathematics of networks**

- **Examples in domain of governance**

    - **UN**
    - **Financial & Banking systems**
    - **Environmental sciences, climate change**
    - **Sustainability issues**
    - **other**

- **Experiences with software packages resp. development**

**RW 03.11.2012**

## *Some perspectives/conclusions :*

***The phenomena of Networks is almost omnipresence in affairs of human society : do we look upon a bright future?***

***Should WAAS take into consideration to get involved in some of these 'knowledge' domains shown here? WAAS being involved could mean :***

- ***either joining in projects of some research institutions; or***
- ***reflecting on applications of the science of networks in the domain of social sciences as sociology, governance, peace initiatives, a.o.***

***This workshop will be followed by two others on Complexity and on Autopoiesis (next year).***

***Proceedings should come out of these events, obviously with your assistance!***

**RW 03.11.2012**