networks *motivation*

advanced topics in *network science* (*ants*)

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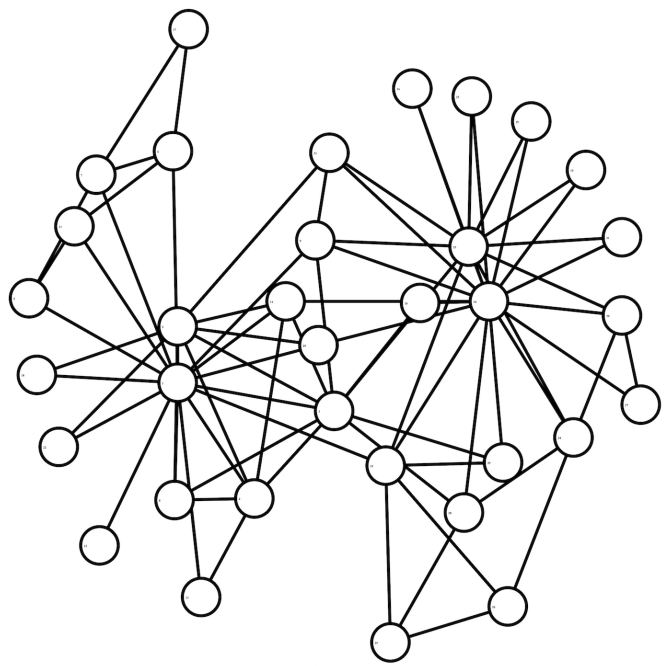
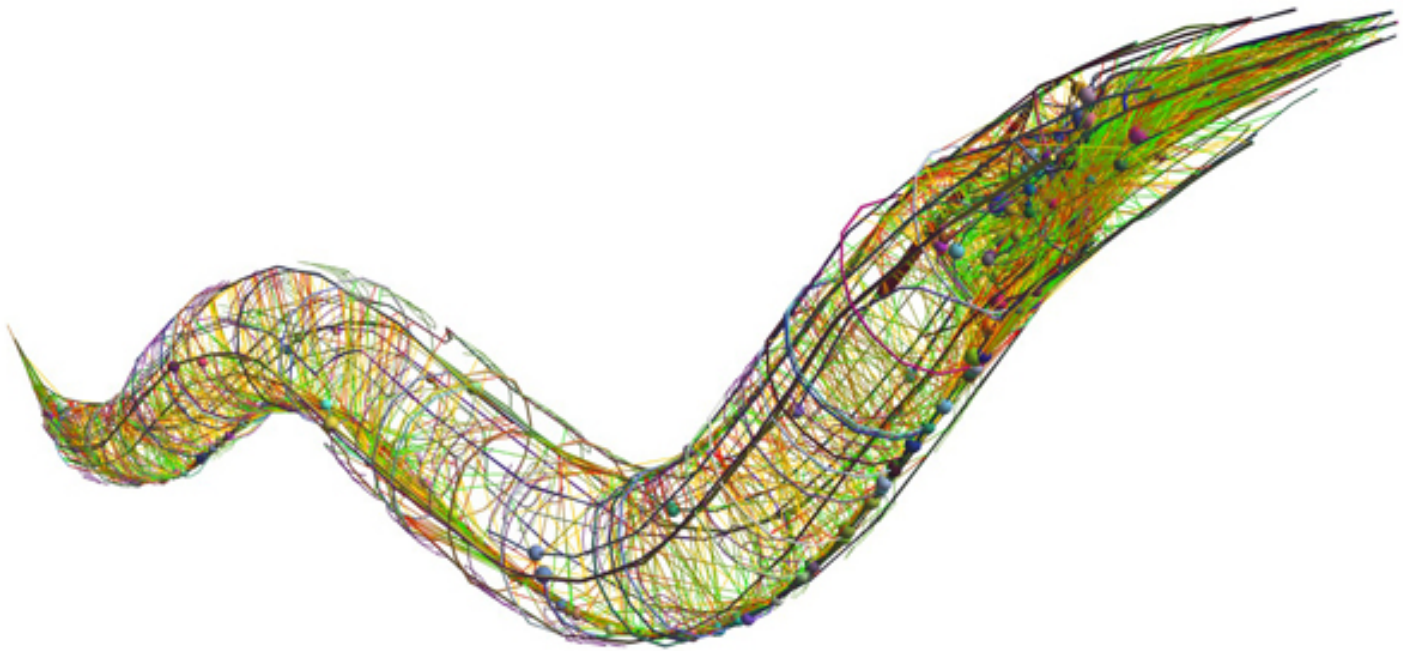
motivation *network*

- *network/graph* wiring diagram
- points called *nodes/vertices*
- connected by *links/edges*



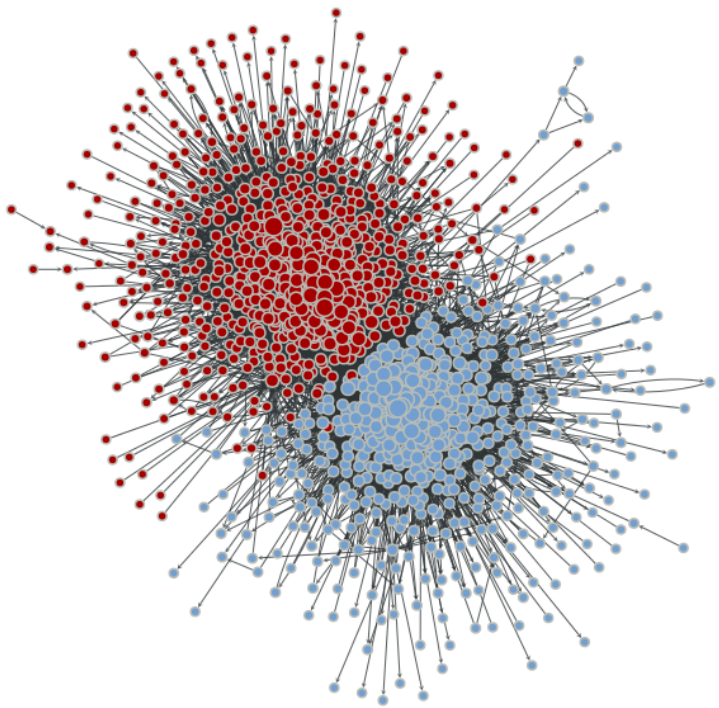
motivation *neural wiring*

- *human brain* $\approx 10^{11}$ neurons
- nodes are *C. elegans neurons*
- links are *synapses*



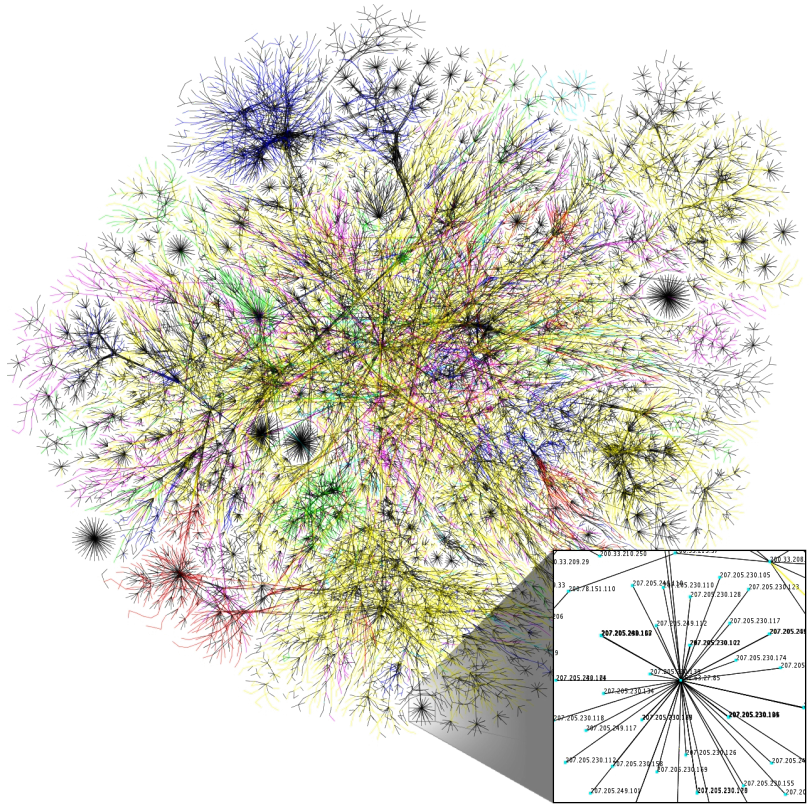
motivation *Web*

- *Web graph* $> 10^{12}$ pages
- nodes are *web pages*
- links are *hyperlinks*



motivation *Internet*

- Internet *overlay map*
- nodes are *class C subnets*
- links are *packet routes*

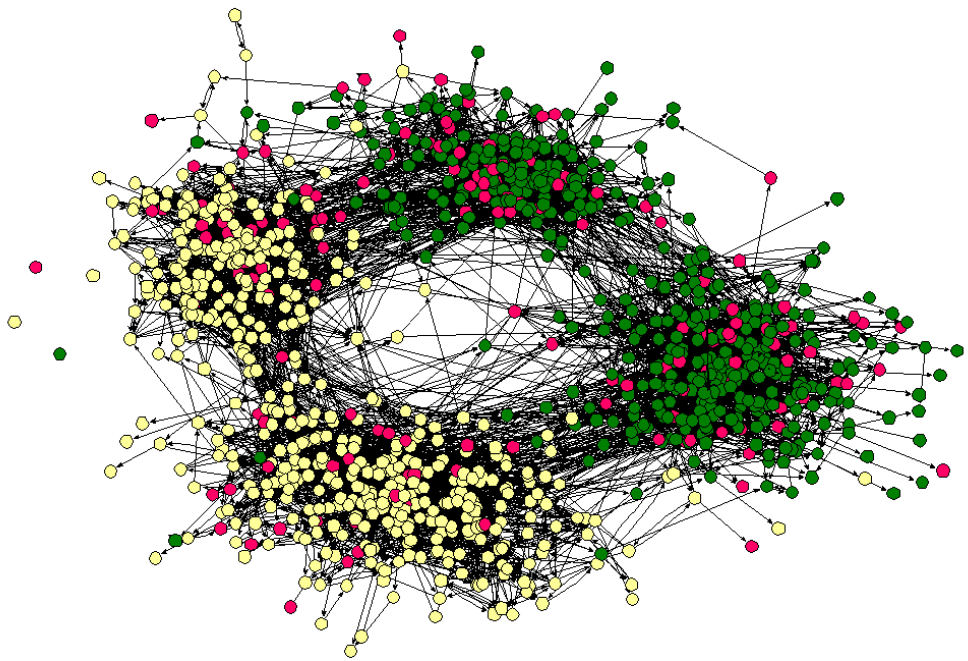


motivation *Facebook*

- *online social* network $> 10^9$ users
- nodes are *Facebook users*
- links are *social connections*

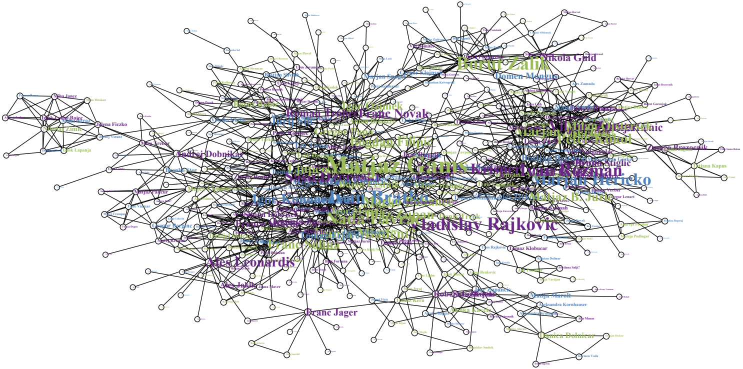
motivation *society*

- *offline social* network
- nodes are *school children*
- links are *friendship ties*



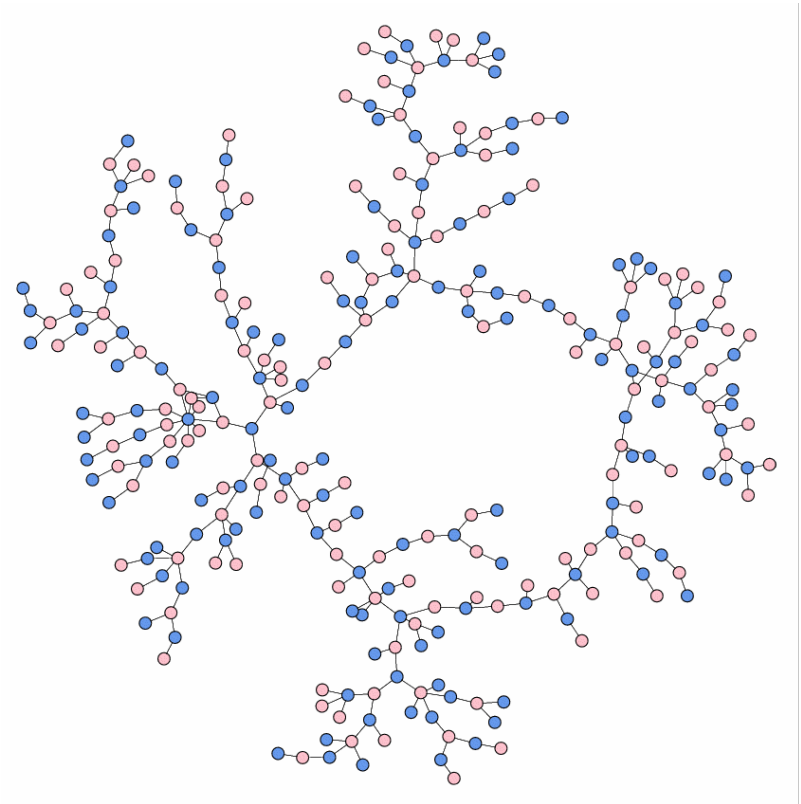
motivation *collaboration*

- *author collaboration* network
- nodes are *Slovenian computer scientists*
- links are *paper coauthorships* ≤ 2000



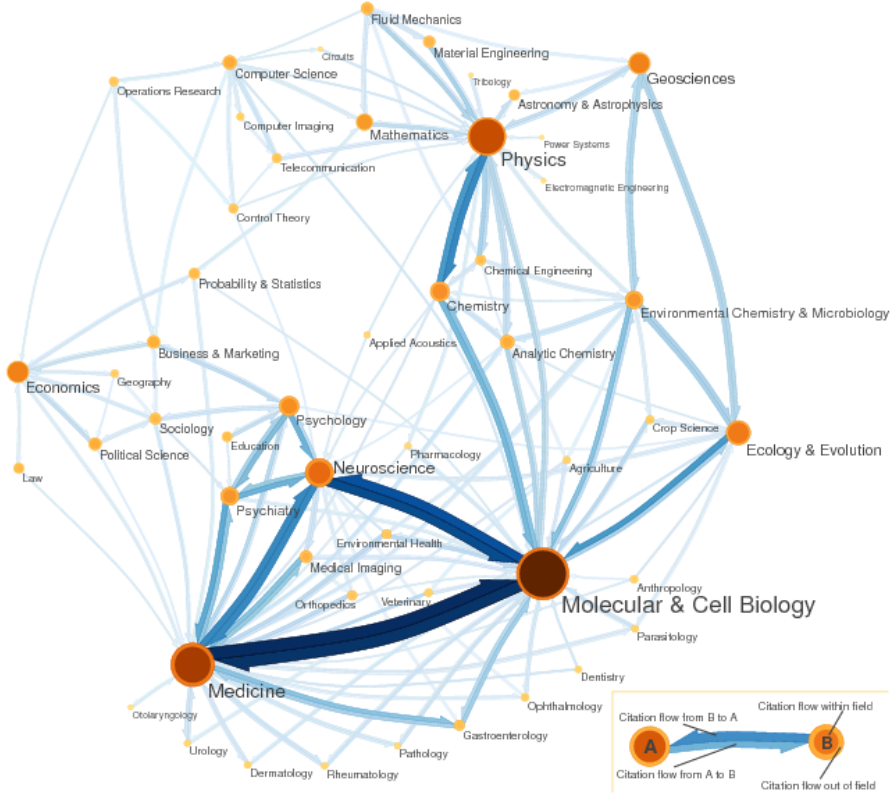
motivation *sex*

- *sexual* network
- nodes are *men/women*
- links are *sexual contacts*



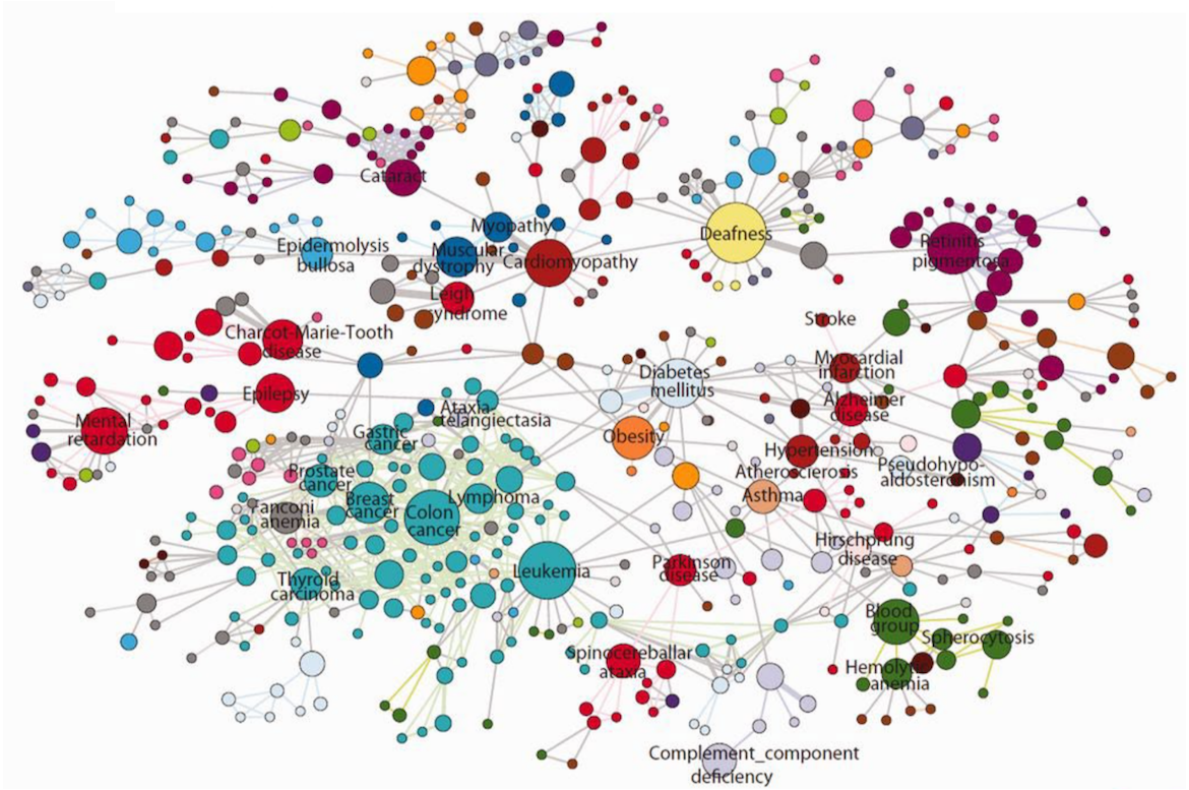
motivation *science*

- *map of science* network
- nodes are *scientific fields*
- links are *journal citations*



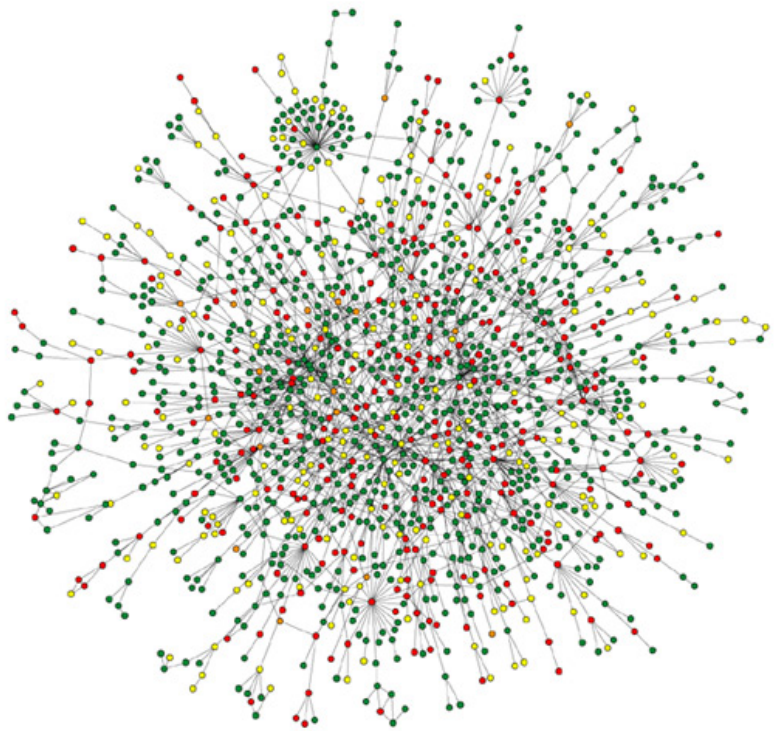
motivation *medicine*

- *human diseaseome* network
- nodes are *human diseases*
- links are *shared genes*



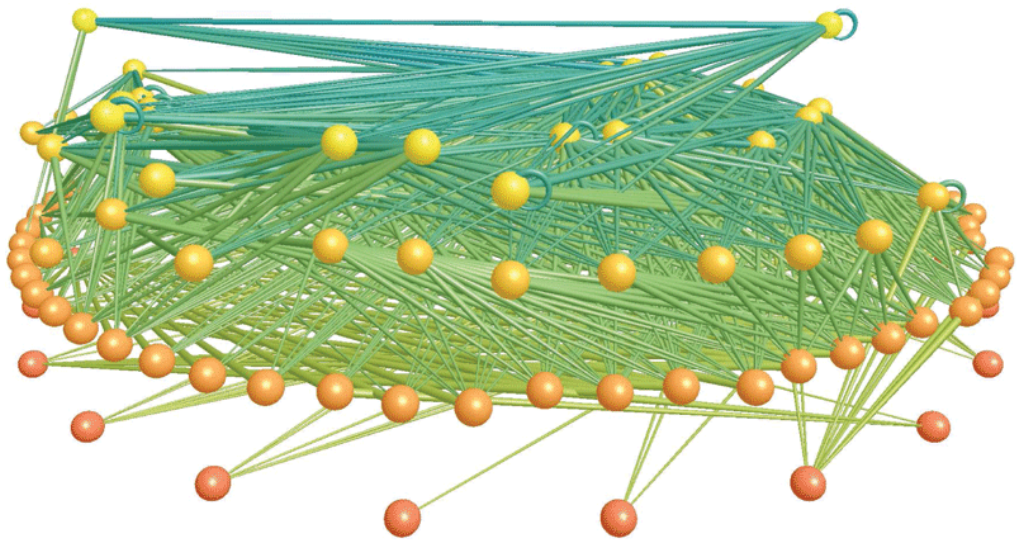
motivation *biology*

- *protein interaction* network
- nodes are *S. cerevisiae proteins*
- links are *physical interactions*



motivation *ecology*

- ecosystem *food web*
- nodes are *lake species*
- links are *predatory interactions*

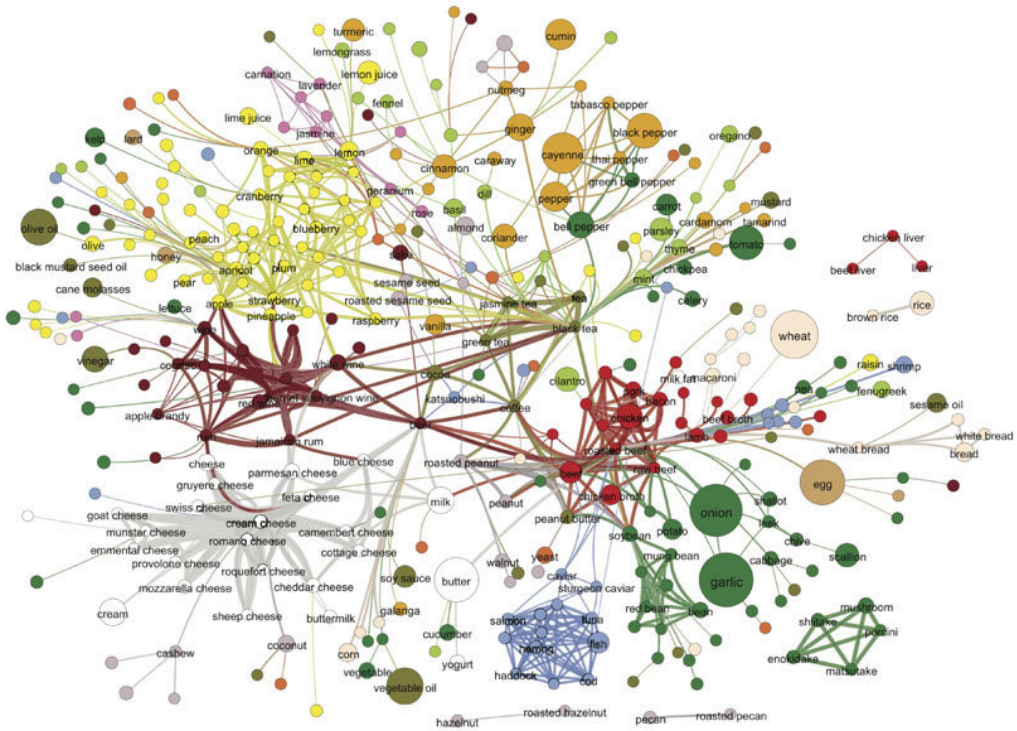


motivation *transport*

- *air transportation* network
- nodes are *world airports*
- links are *passenger flux*

motivation *gastronomy*

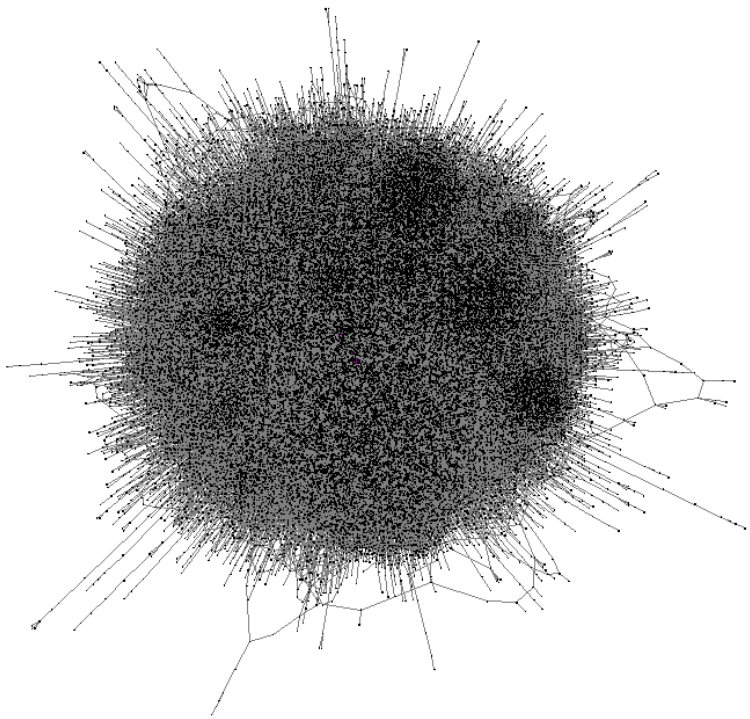
- *ingredient/flavor* network
- nodes are *recipe ingredients*
- links are *flavor compounds*



motivation *hairballs*

- most networks are *large/dense/complex*
- visualizations look like *ridiculograms*

  visually stunning but scientifically worthless

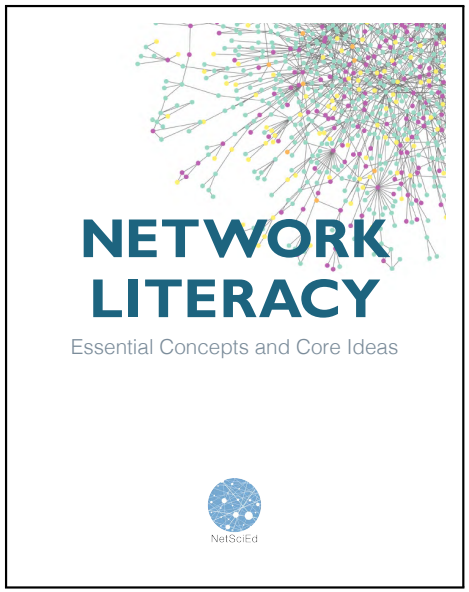


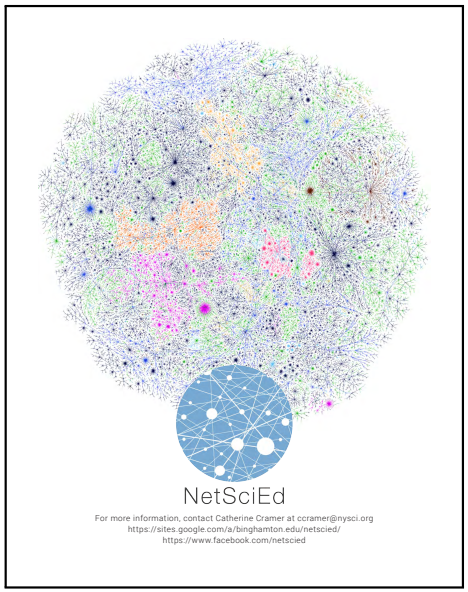
motivation *networks*

— must *study networks* to *understand real systems*

— how to see what is too complex to visualize?

— through *structure*, *evolution* and *dynamics*





motivation *documentary*

connected

the power of six degrees

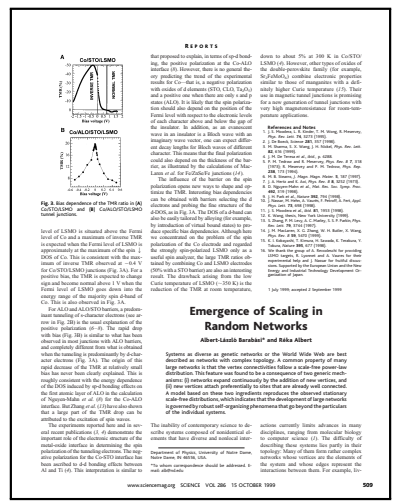
documentary on small-world and scale-free networks

letters to nature

Collective dynamics of 'small-world' networks

Duncan J. Watts* & Steven H. Strogatz

Networks of coupled dynamical systems have been used to model biological oscillators[1–3], Josephson junction arrays[4], excitable media[5], neural networks[6–8], spatial games[9], genetic control networks[10] and many other self-organizing systems. Ordinarily, the connection topology is assumed to be either completely regular or completely random. But many biological, technological and social networks lie somewhere between these two extremes. Here we explore simple models of networks that can be tuned through this middle ground: regular networks 'rewired' to introduce increasing amounts of disorder. We find that these systems can be highly clustered, like regular lattices, yet have small characteristic path lengths, like random graphs. We call them 'small-world' networks, by analogy with the small-world phenomenon[11,12] (popularly known as six degrees of separation[13]). The annual network of the worm Caenorhabditis elegans, the power grid of the western United States, and the collaboration graph of film actors are shown to be small-world networks. Models of dynamical systems with small-world coupling display enhanced signal-propagation speed, computational power, and synchronizability. In particular, infectious diseases spread more easily in small-world networks than in regular lattices.



REPORTS

Emergence of Scaling in Random Networks

Albert-László Barabási* and Réka Albert

Systems as diverse as genetic networks or the World Wide Web are best described as networks with complex topology. A common property of many large networks is that the vertex connectivities follow a scale-free power-law distribution. This feature was found to be a consequence of two generic mechanisms: (i) networks expand continuously by the addition of new vertices, and (ii) new vertices attach preferentially to sites that are already well connected. A model based on these two ingredients reproduces the observed stationary scale-free distributions, which indicates that the development of large networks is governed by robust self-organizing phenomena that go beyond the particulars of the individual systems.

letters to nature

Error and attack tolerance of complex networks

Réka Albert, Hawoong Jeong & Albert-László Barabási

[WS98]

[BA99]

[AJB00]

motivation *references*

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