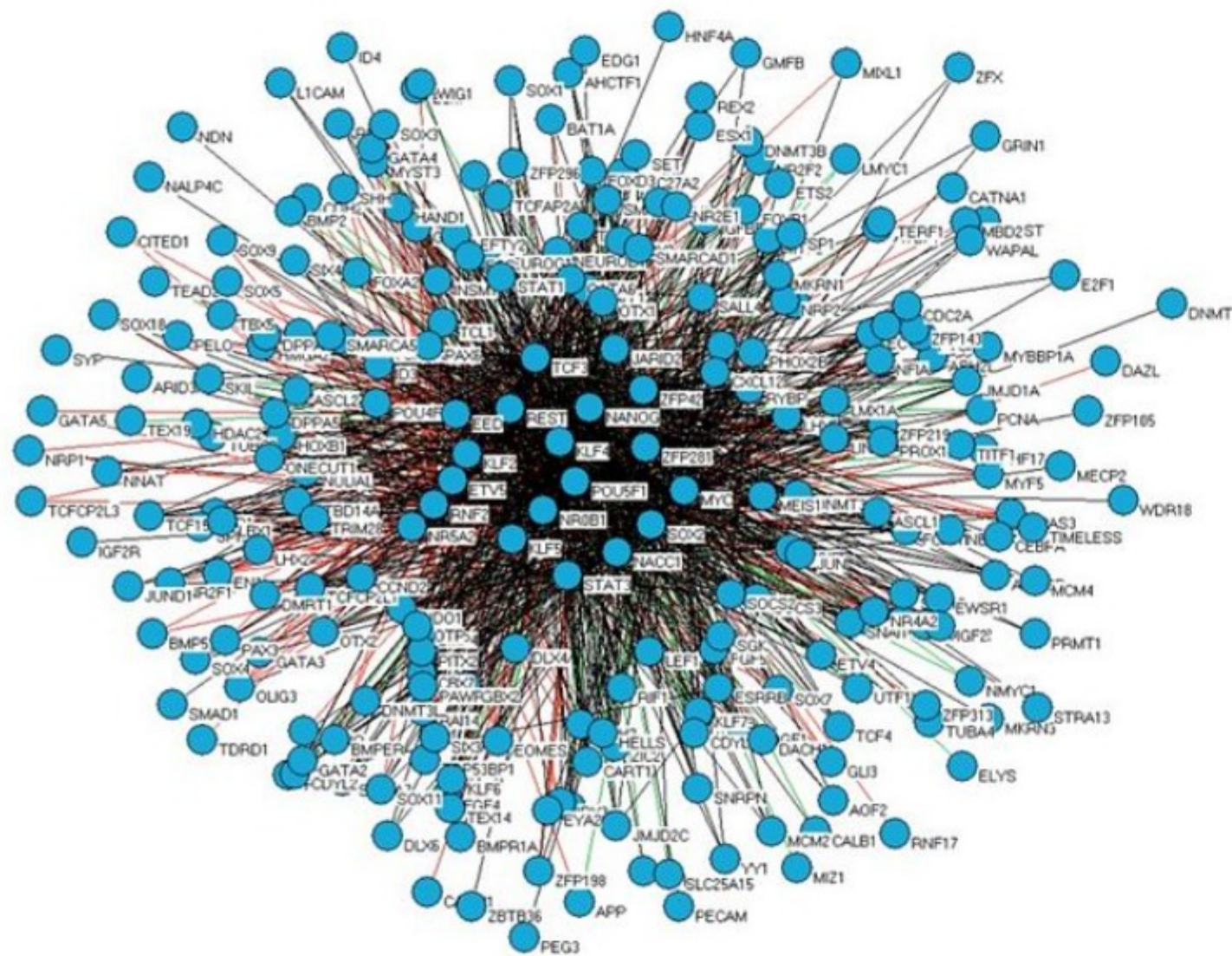


Systems & Network Biology Networks

Jordi Garcia Ojalvo
Keith Kennedy

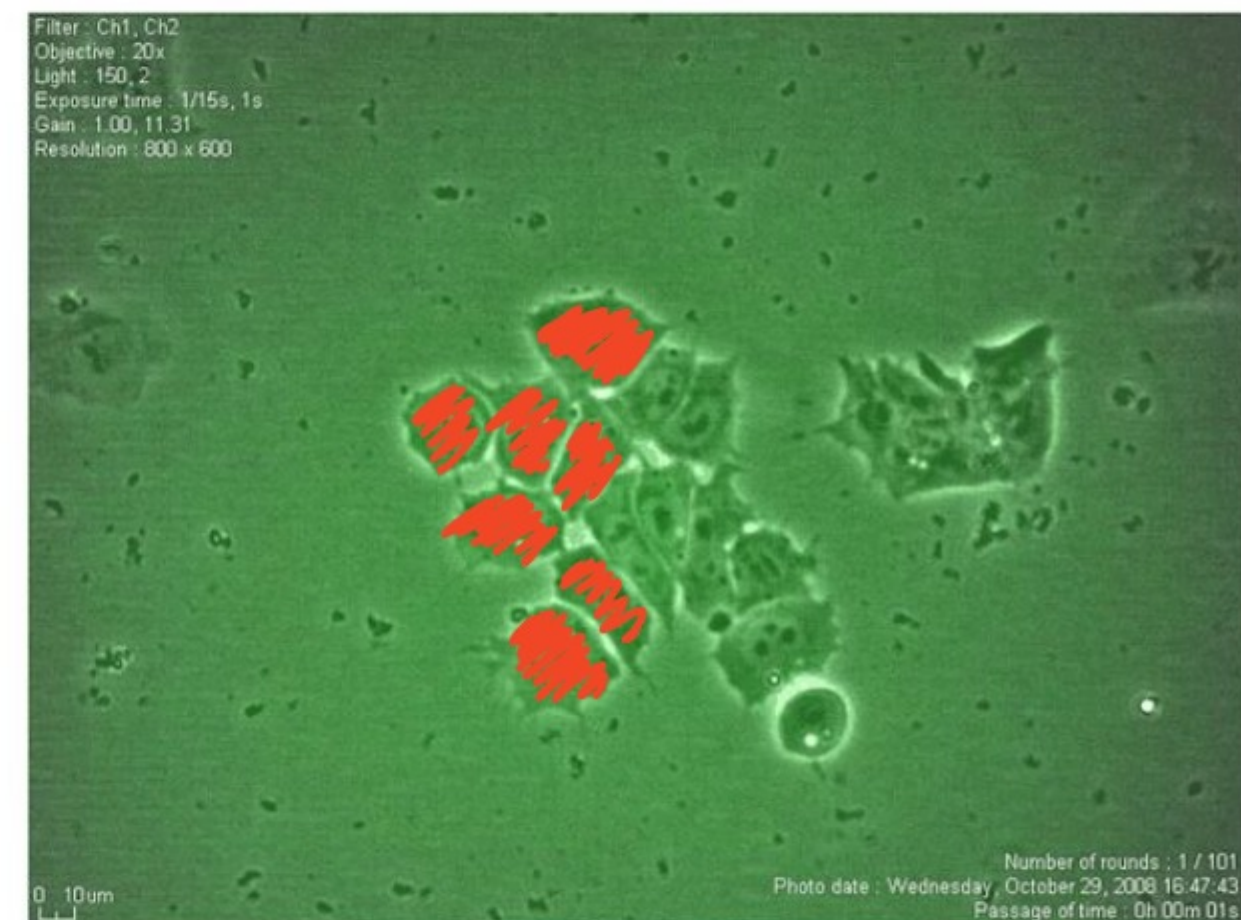
Department of Experimental and Health Sciences
Universitat Pompeu Fabra

Understanding life



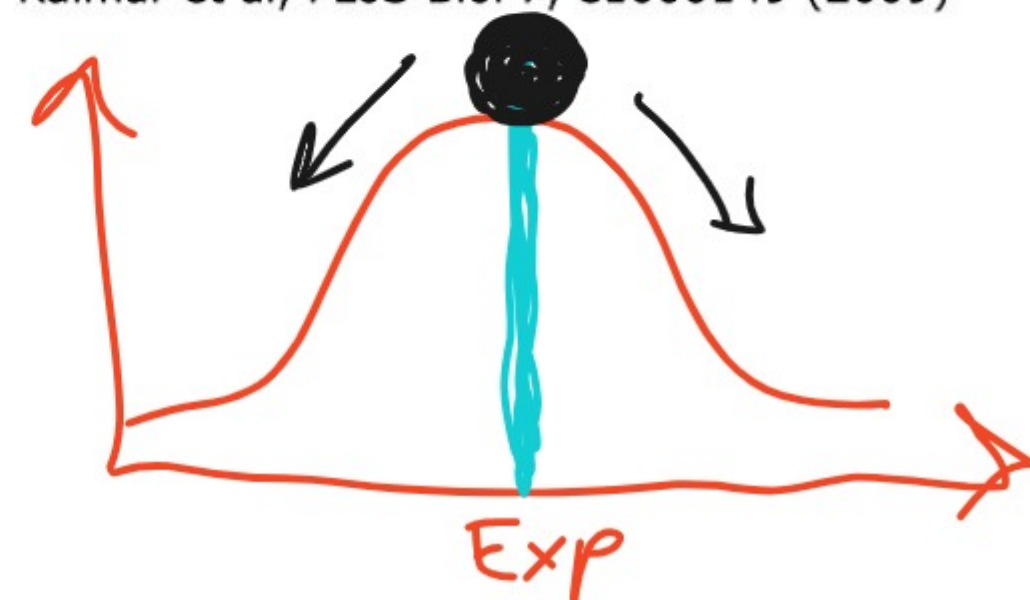
Gene Regulatory Network of pluripotency

[Integrated Stem Cell Molecular Interaction Database]

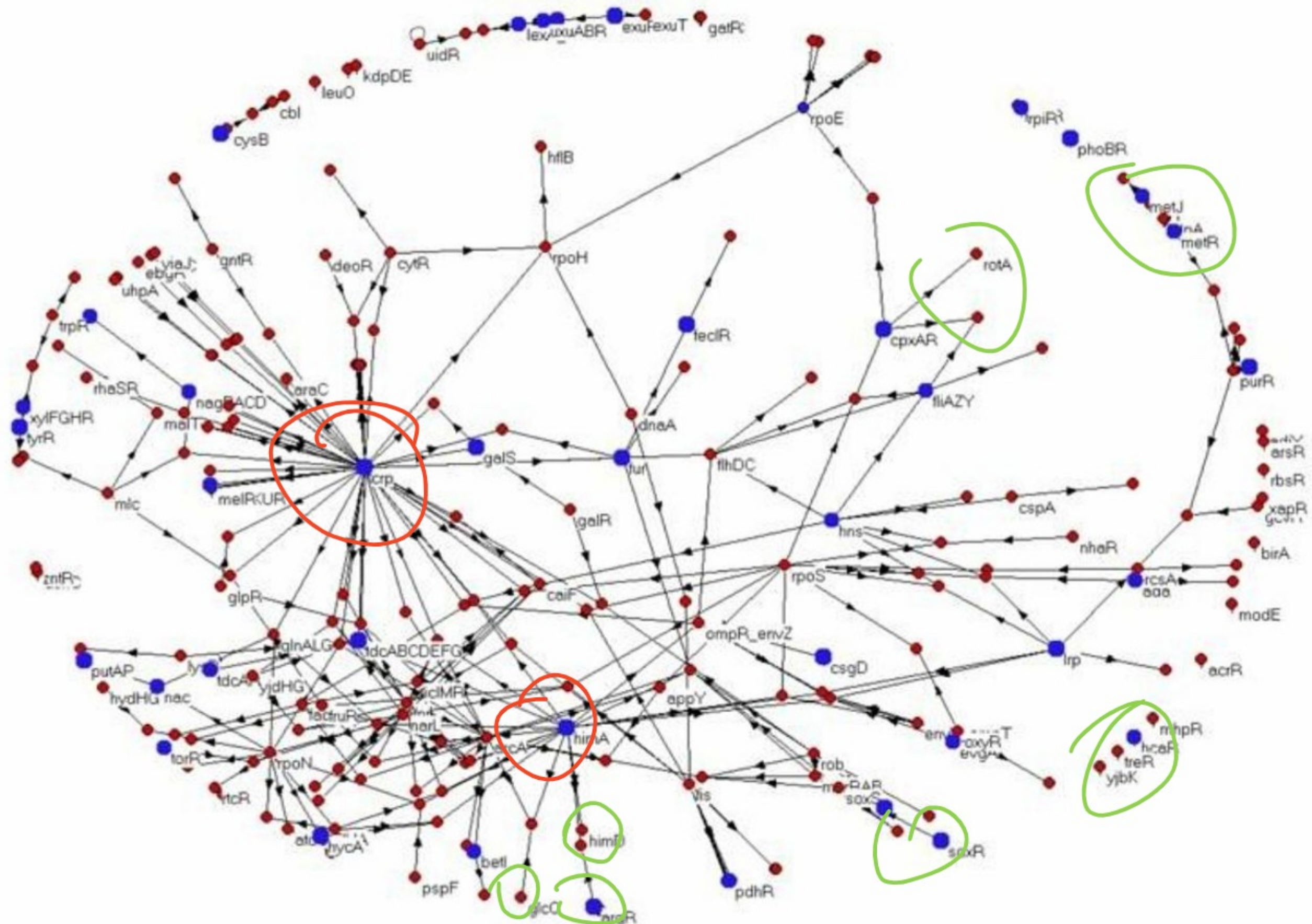


Dynamics of Nanog in **embryonic stem cells**

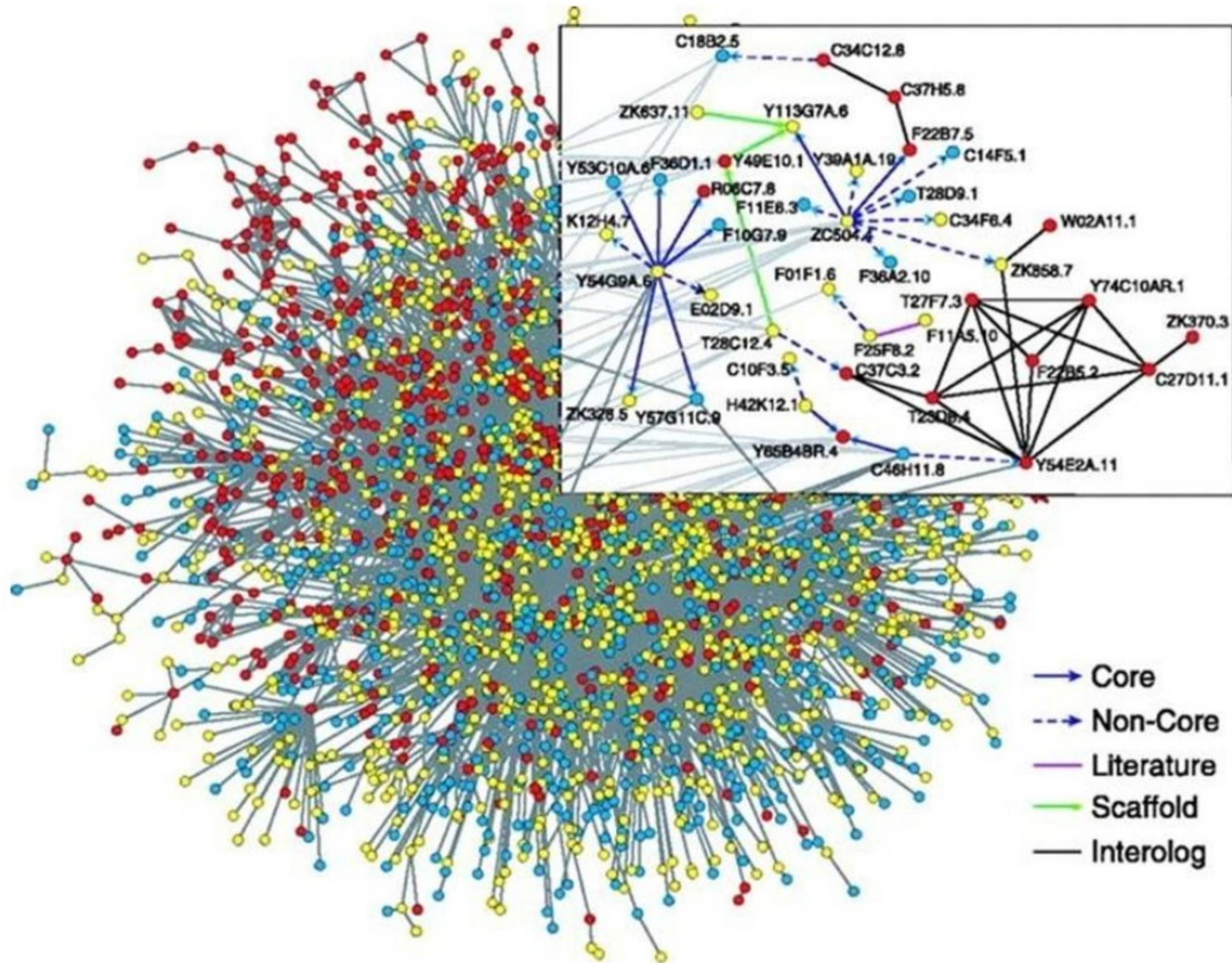
Kalmar et al, PLoS Biol 7, e1000149 (2009)



Degree Distribution



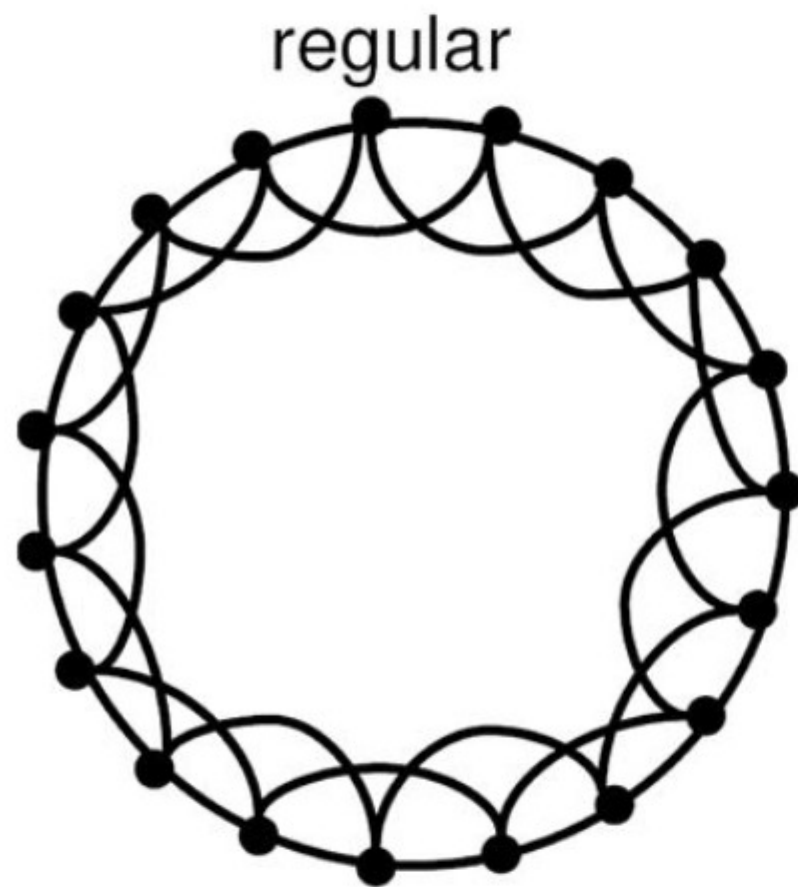
Protein-protein interaction network of *C. elegans*



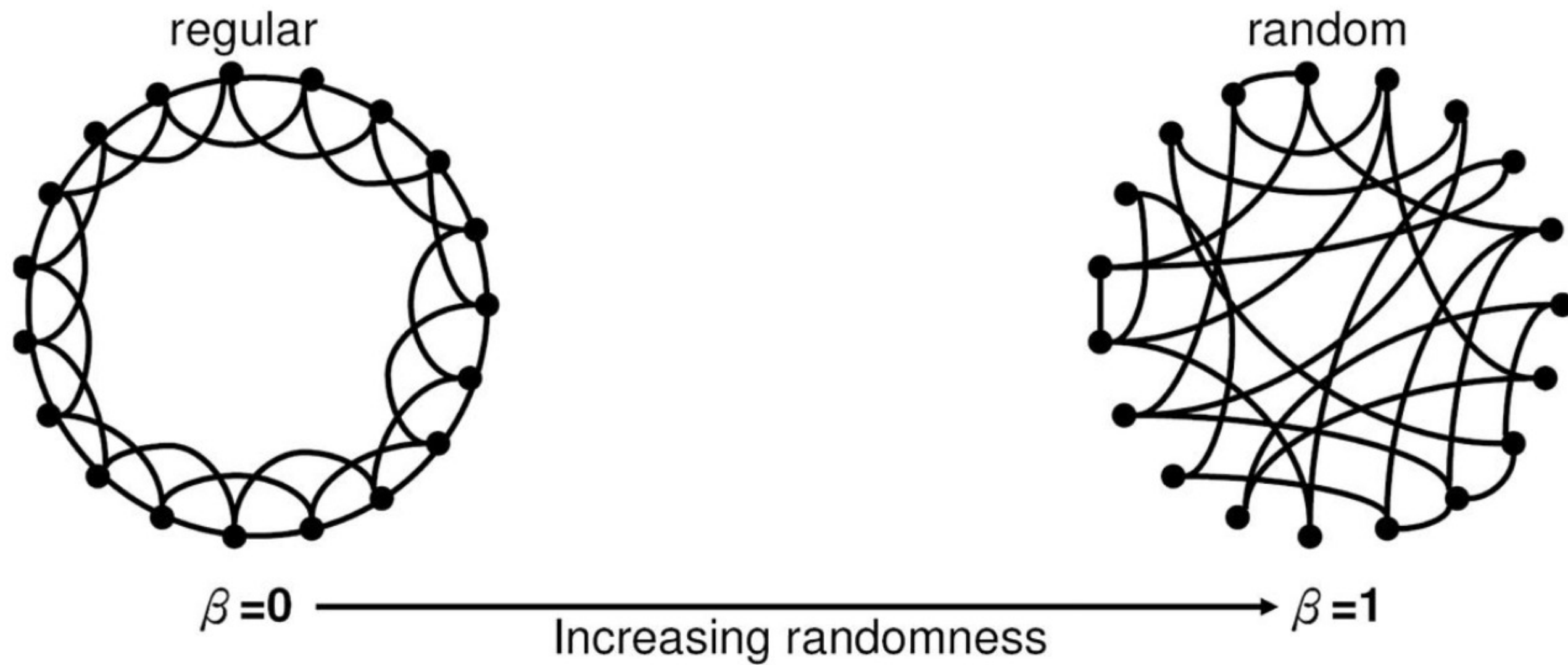
A Map of the Interactome Network of the Metazoan *C. elegans*

Siming Li et al, Science 23 January 2004: **303** (5657), 540-543

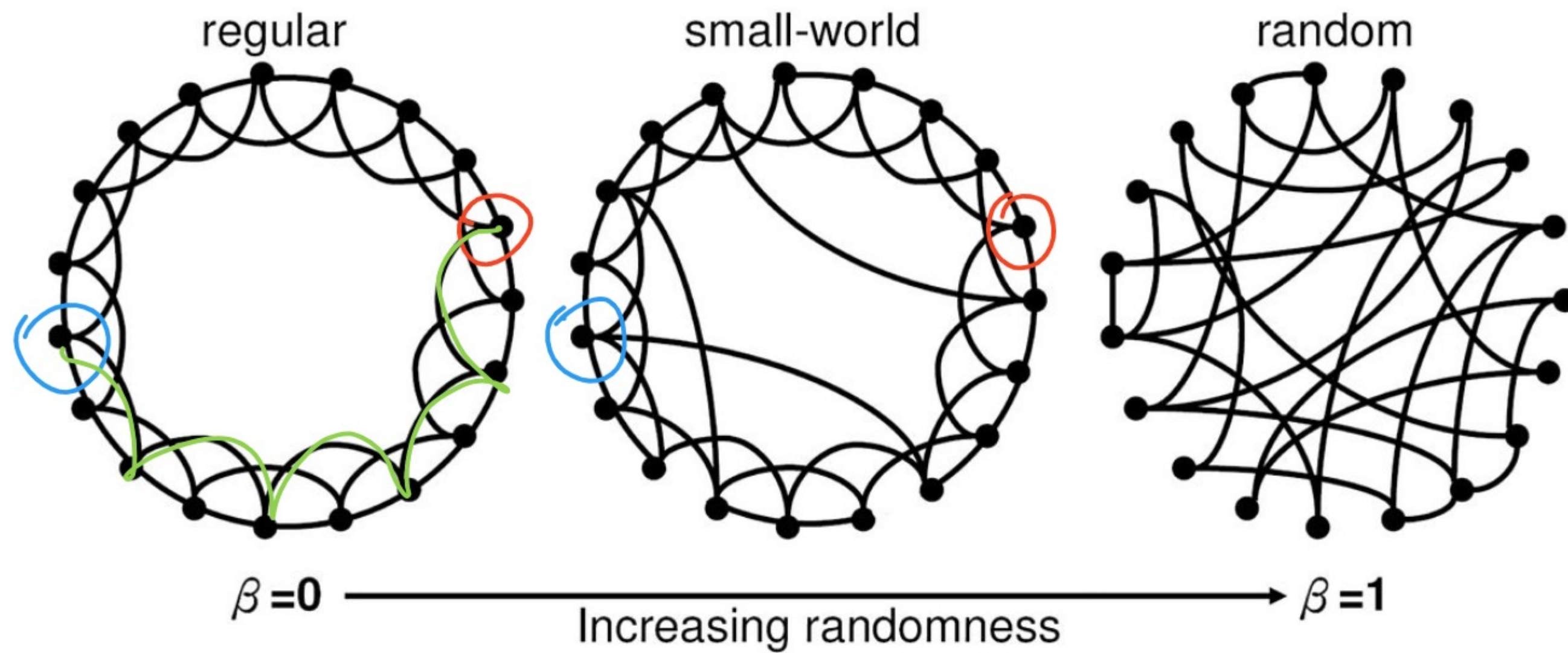
From regular to random networks



From regular to random networks

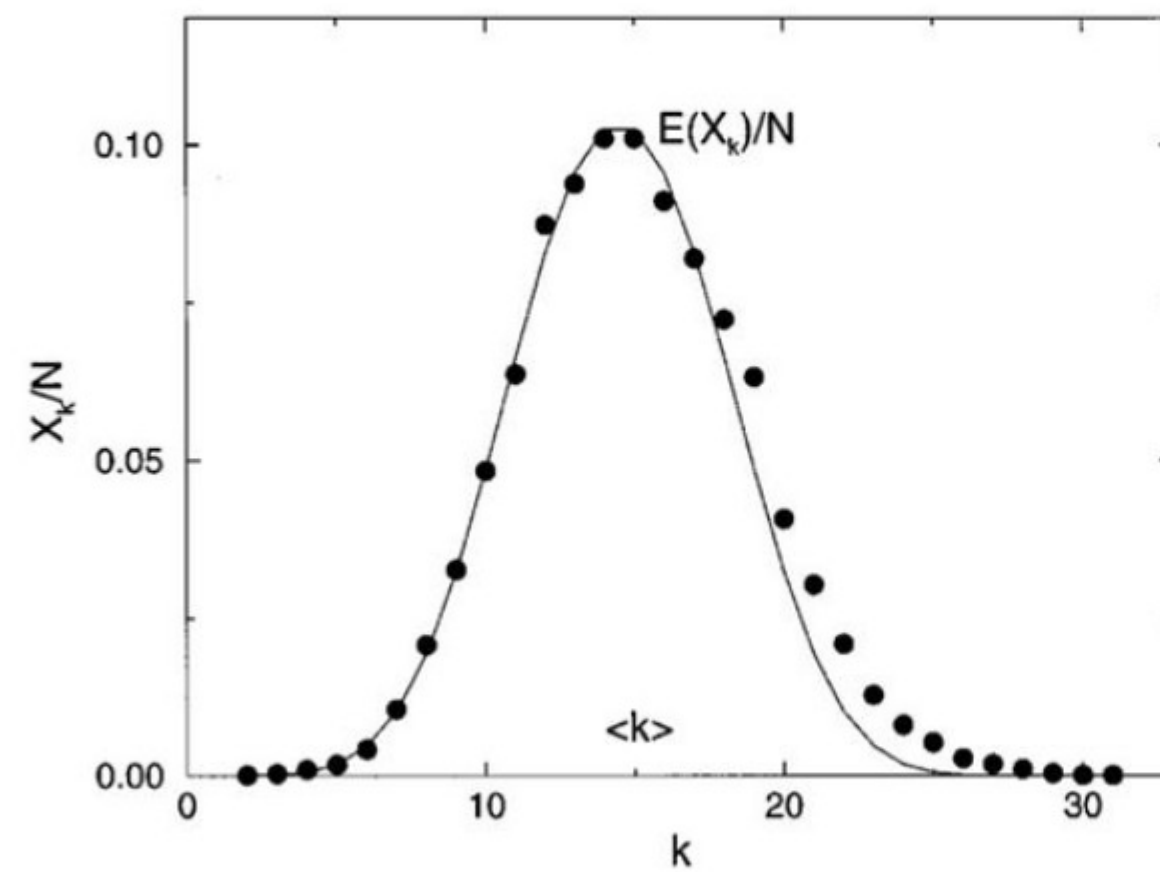
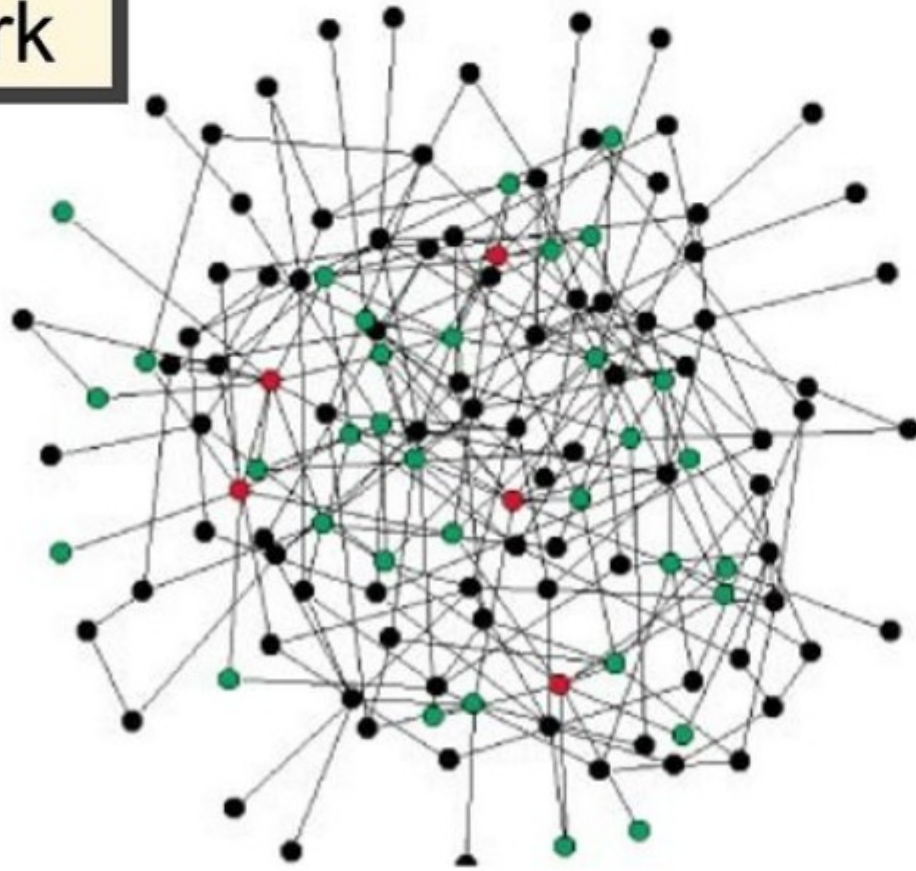


Small-world networks



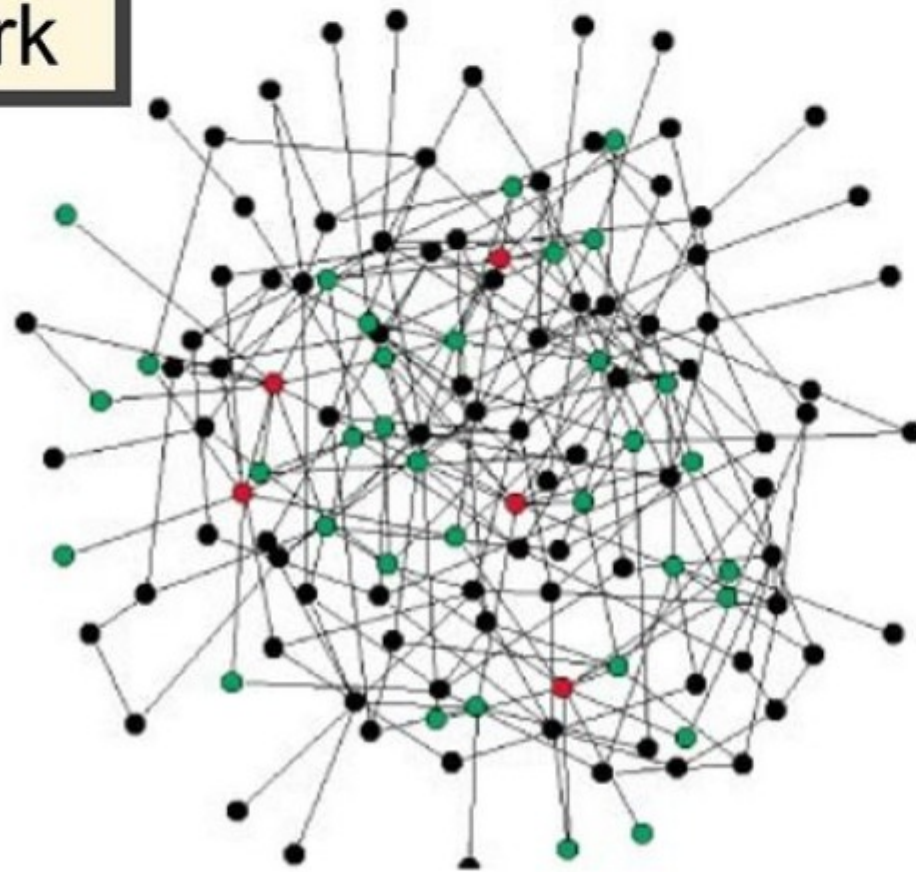
Degree distribution

random
network

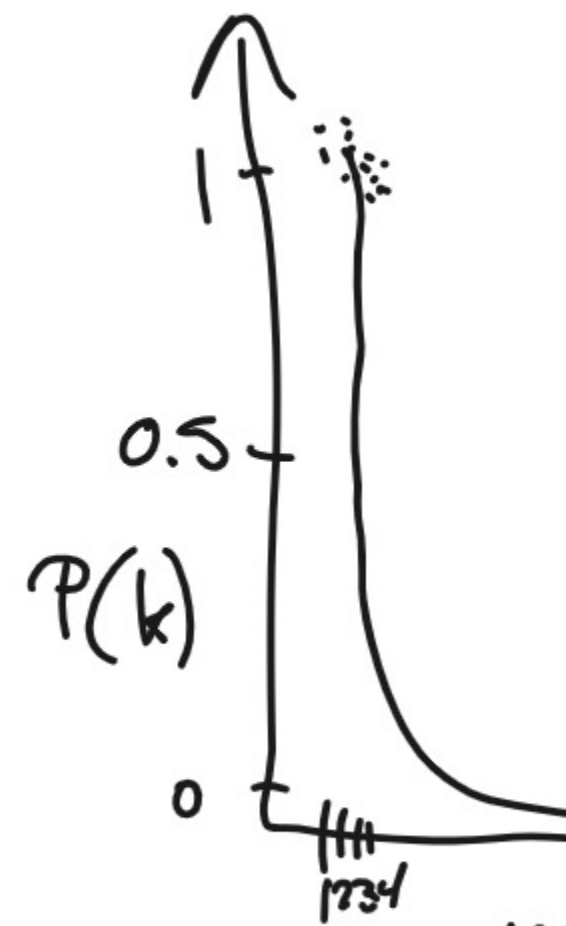
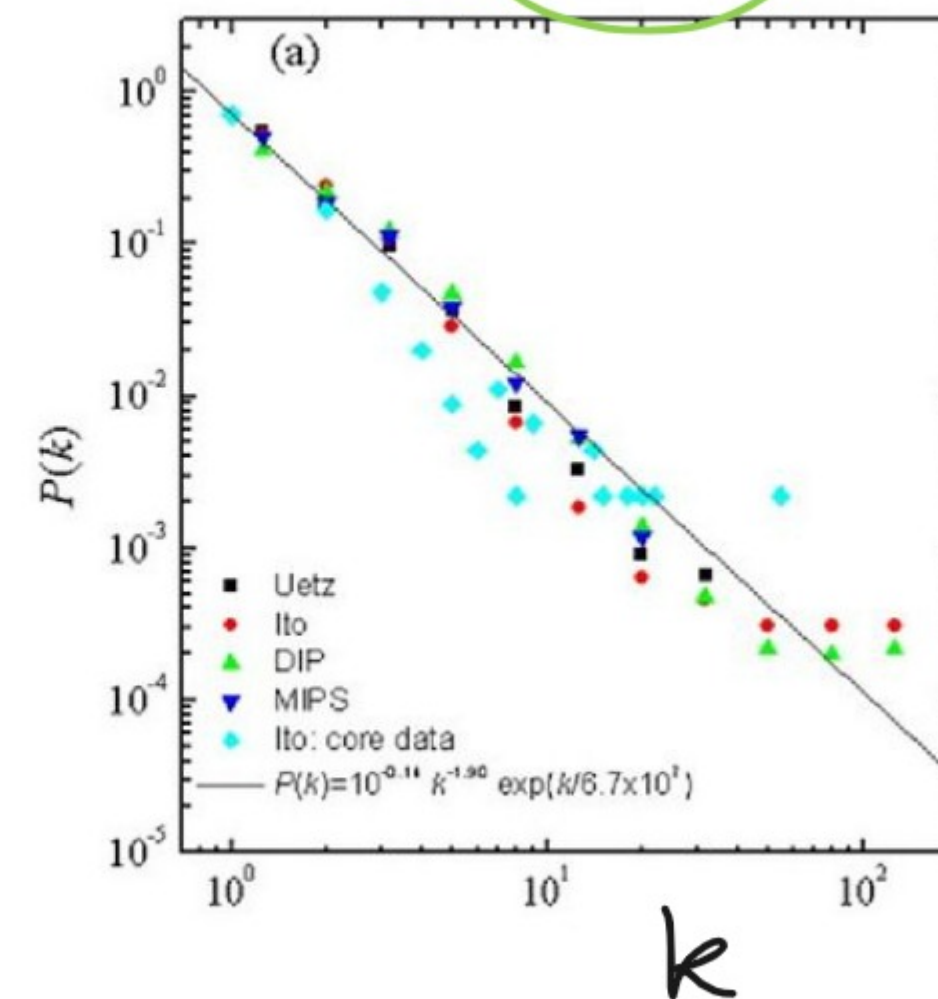
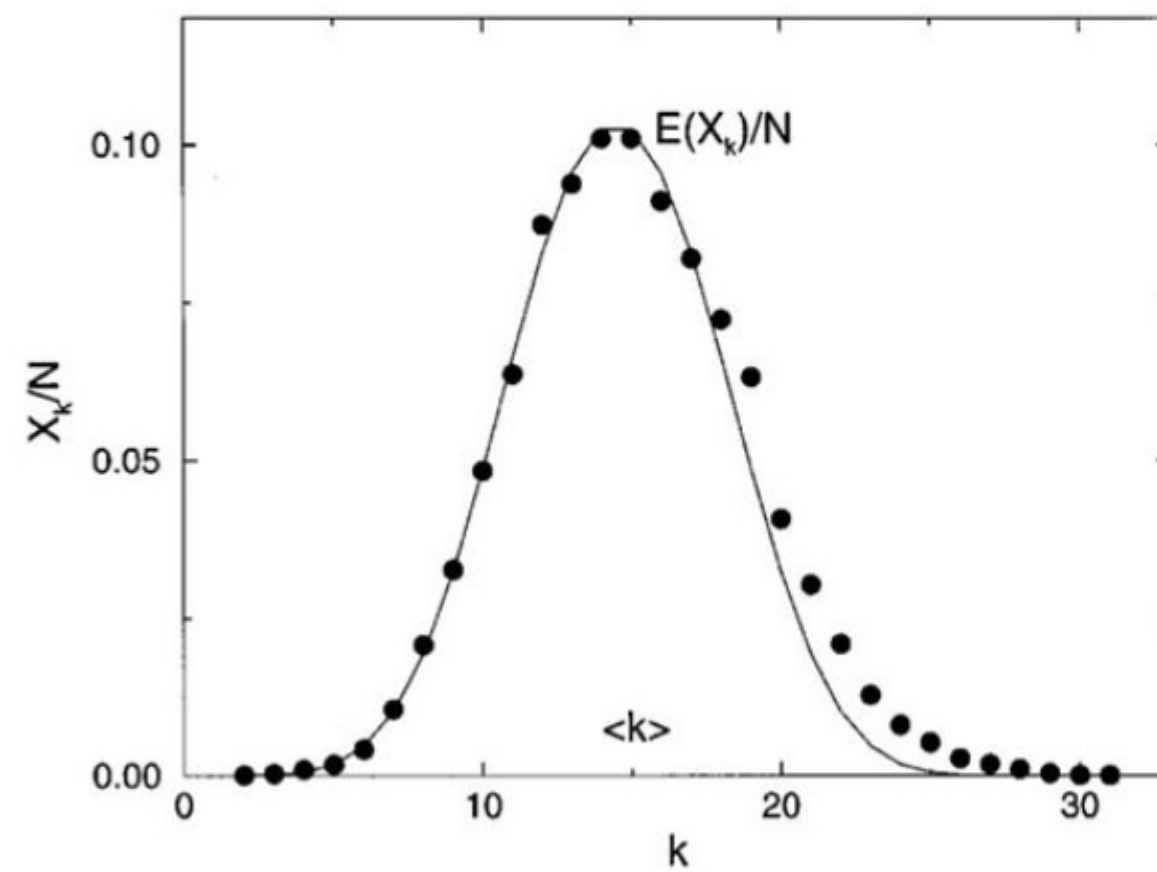
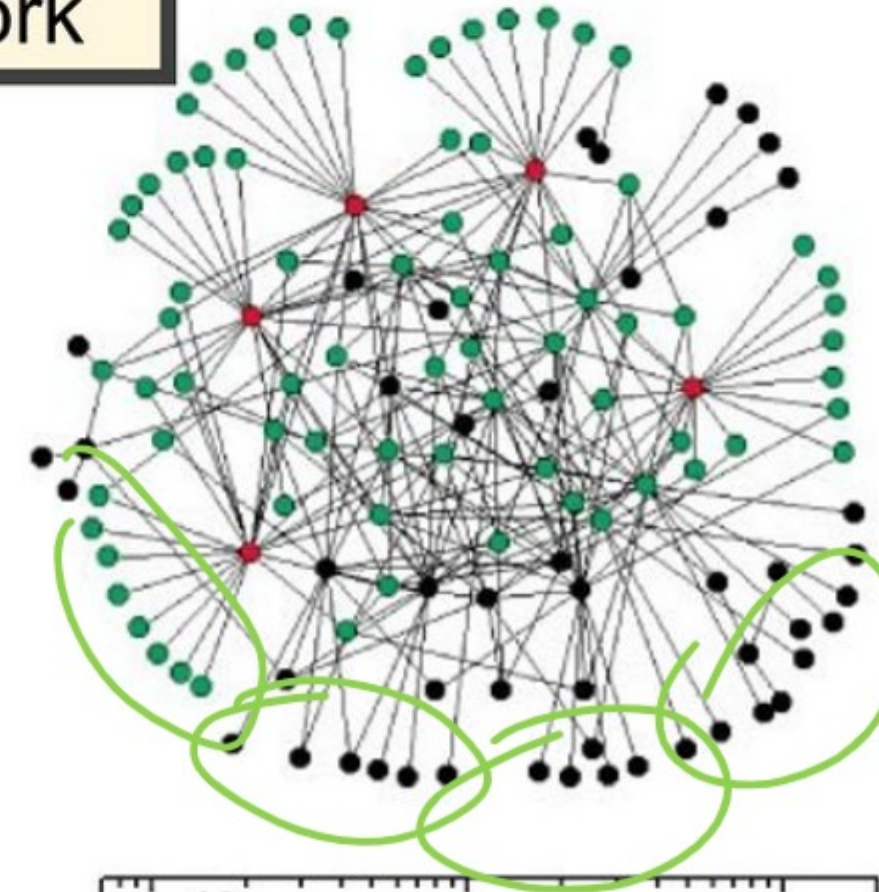


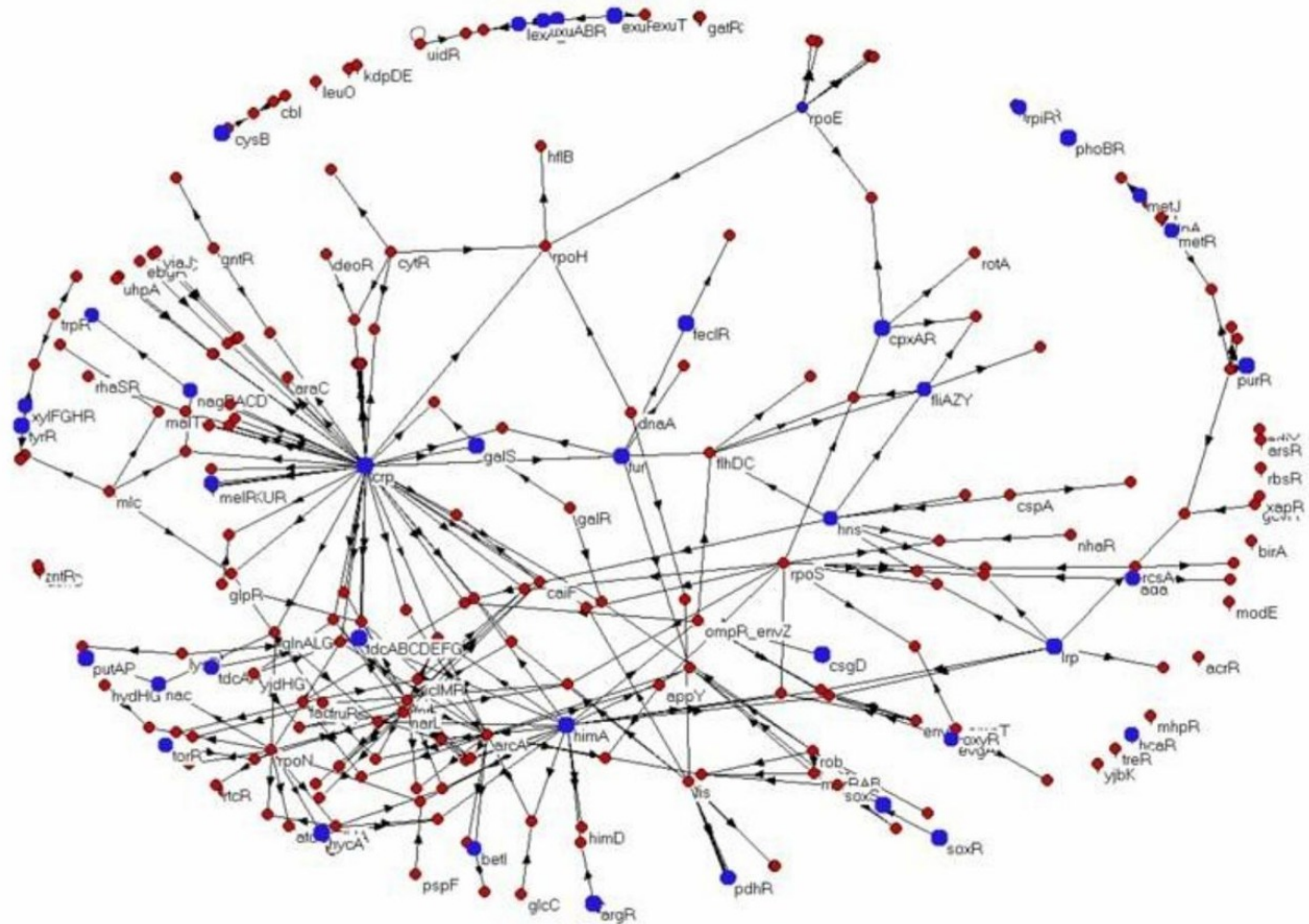
Scale-free networks

random network

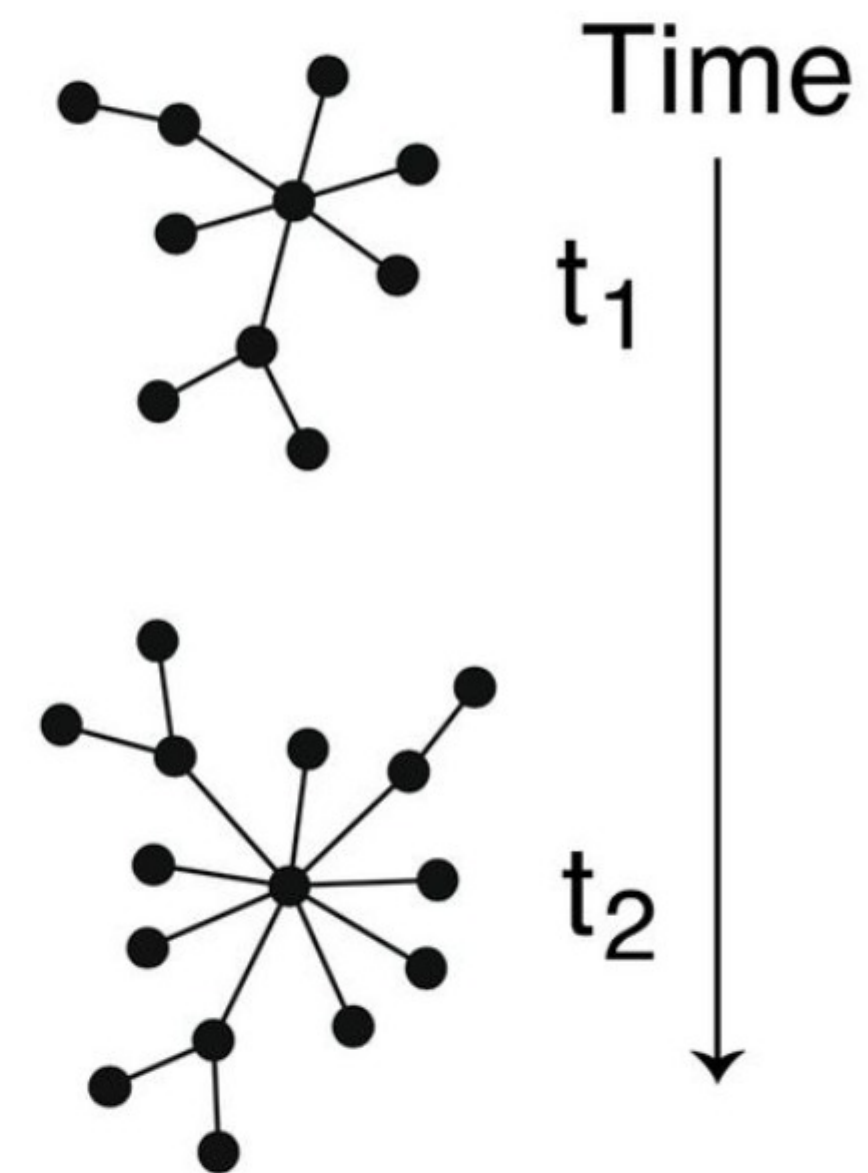
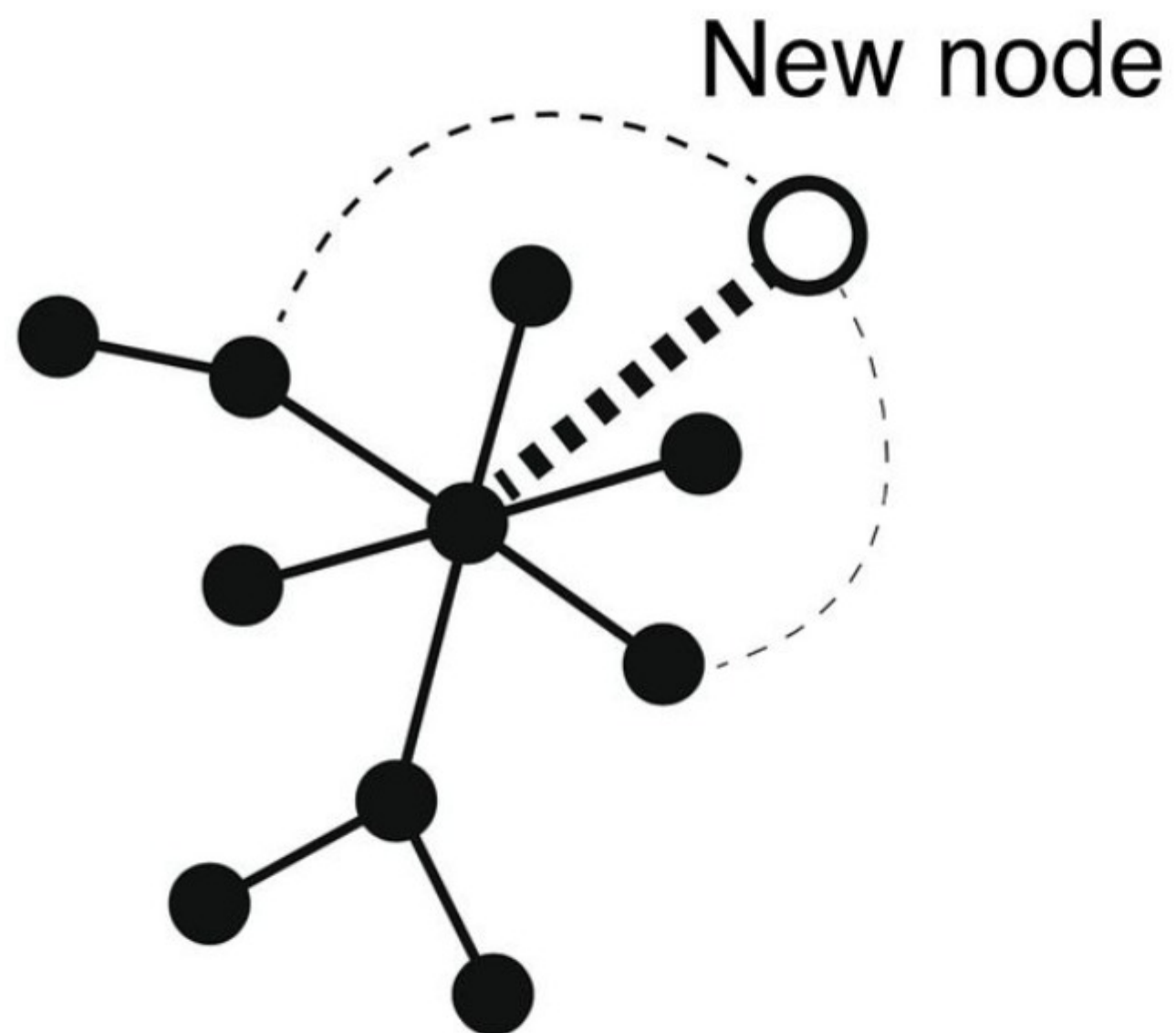


scale-free network

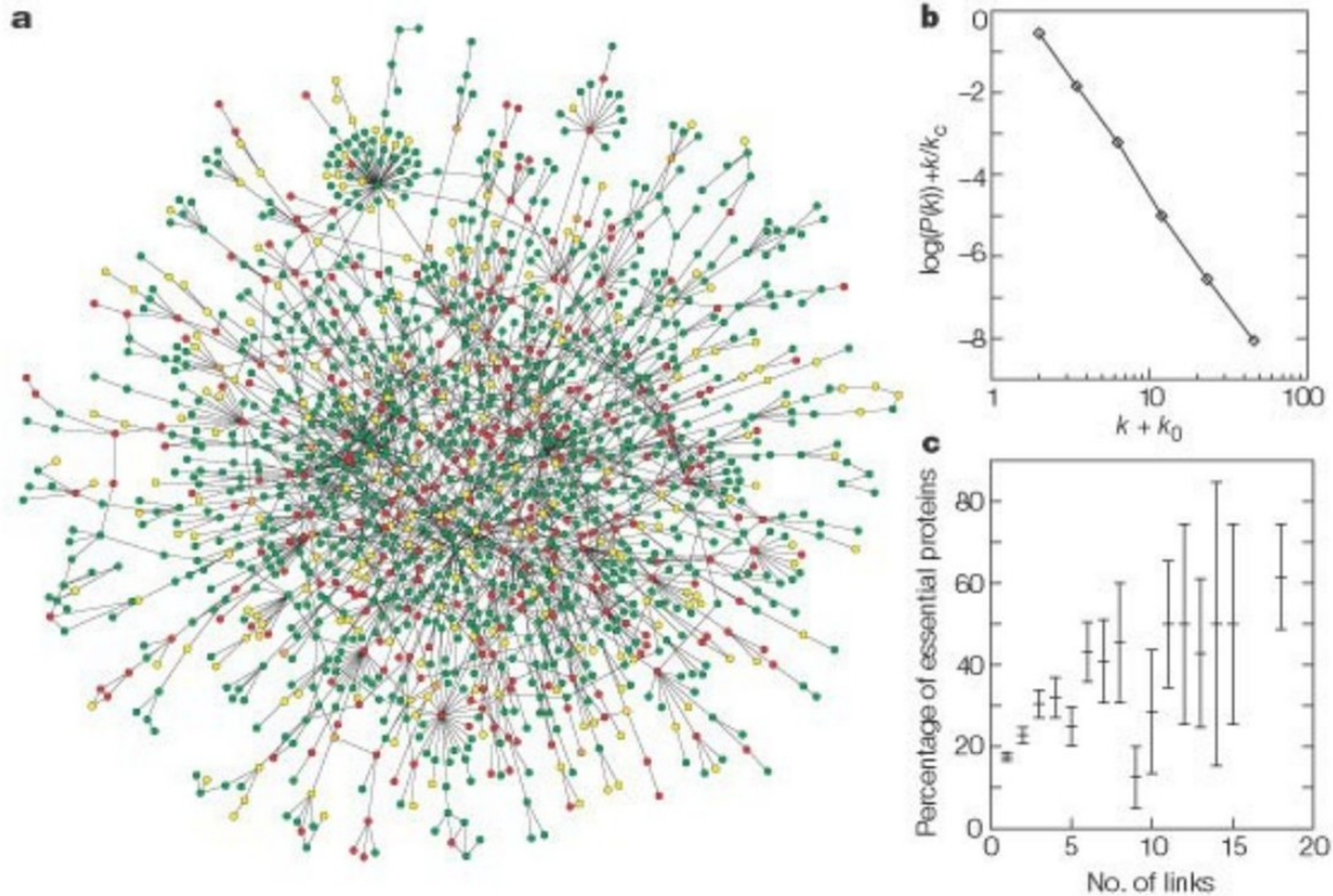




Preferential attachment



Lethality and network architecture

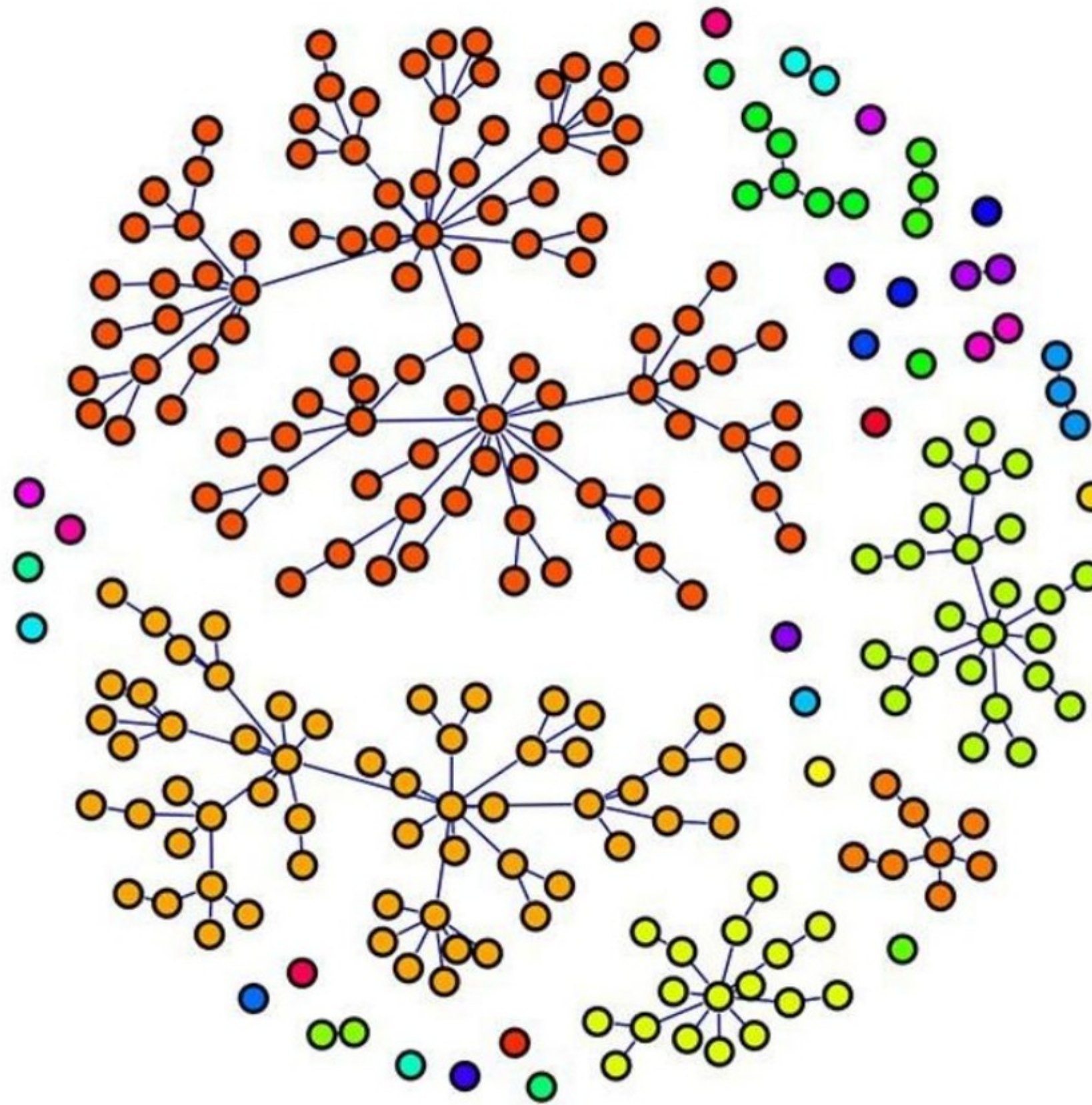


Lethality and centrality in protein networks

H. Jeong, S. P. Mason, A.-L. Barabási and Z. N. Oltvai
Nature **411**, 41-42(3 May 2001)

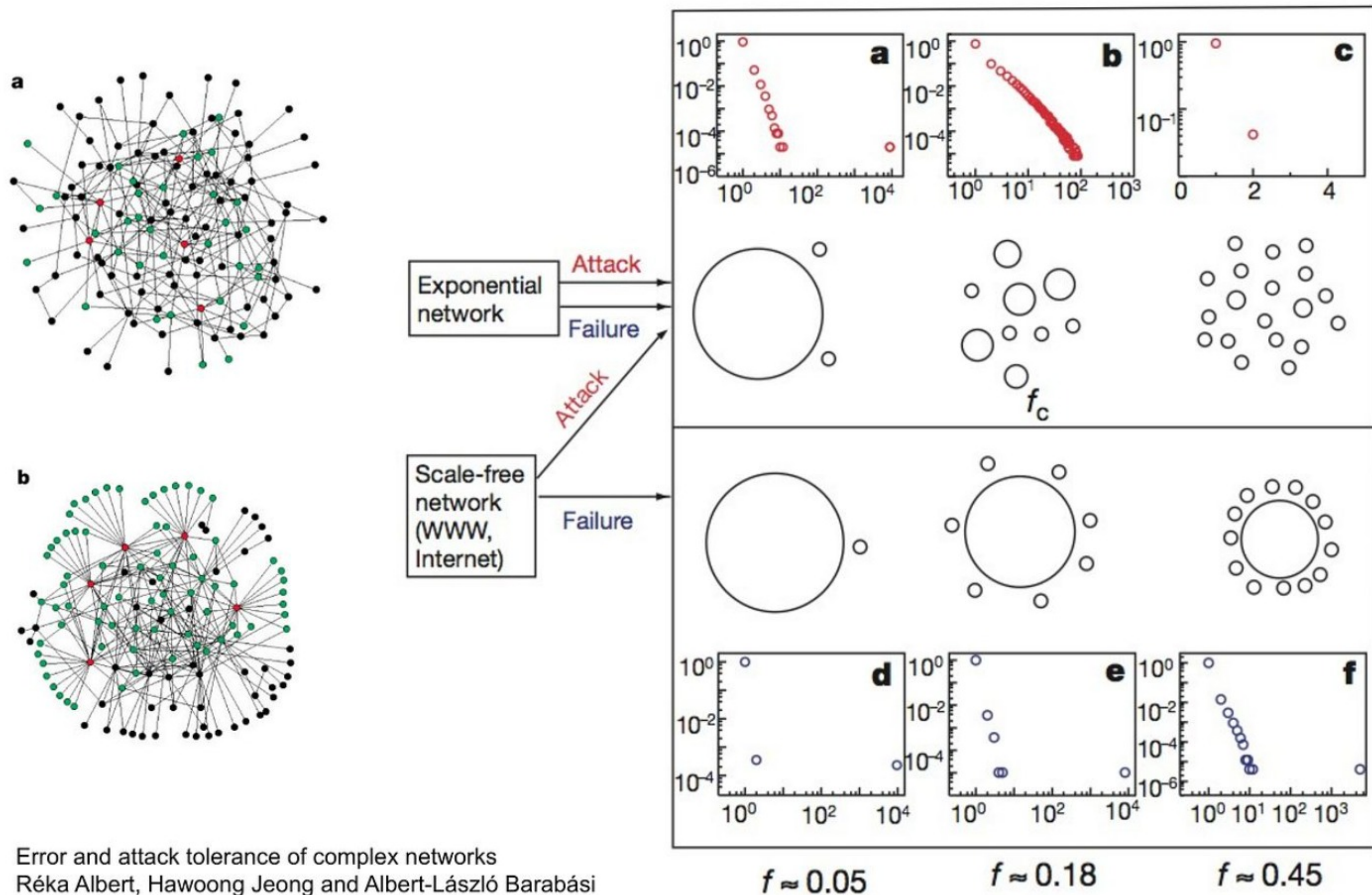
Connected components

Attack
Failure



Biological
Network

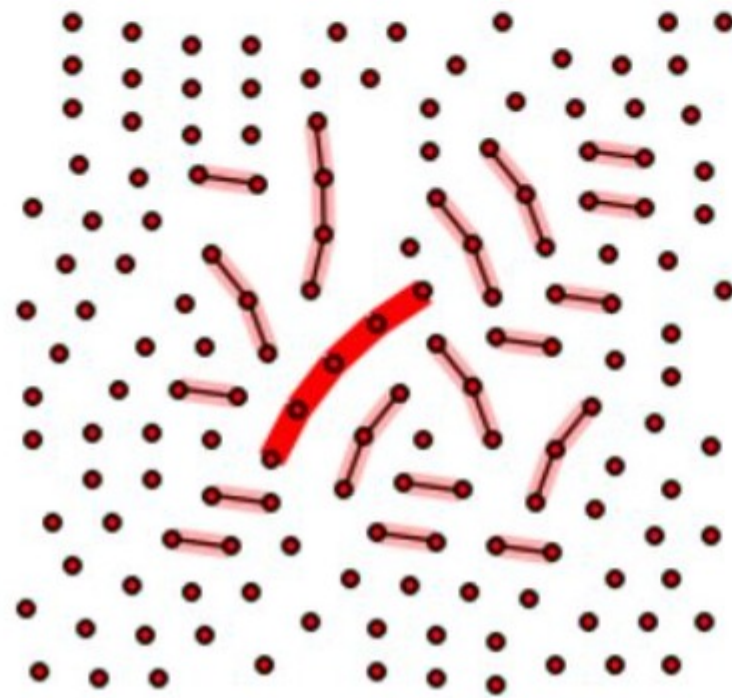
Tolerance of complex networks to errors and attacks



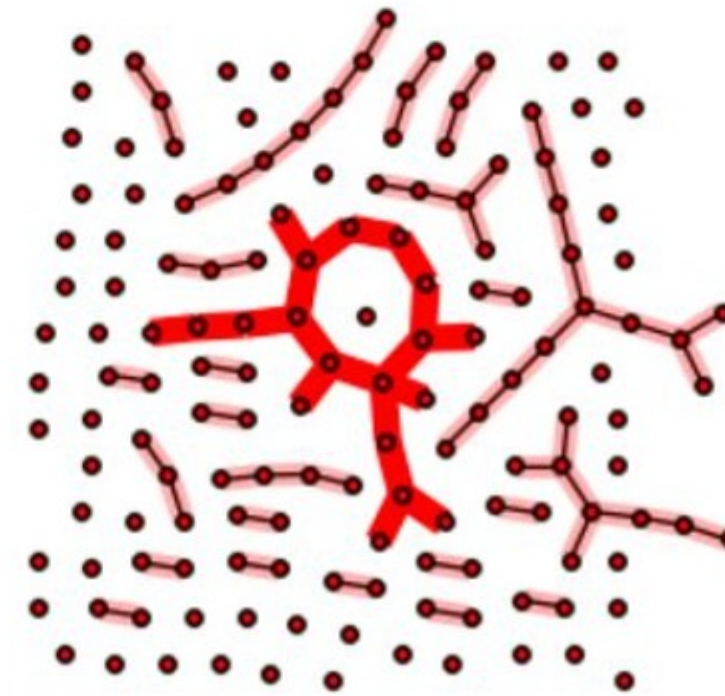
Error and attack tolerance of complex networks
 Réka Albert, Hawoong Jeong and Albert-László Barabási
Nature **406**, 378-382 (27 July 2000)

Giant component

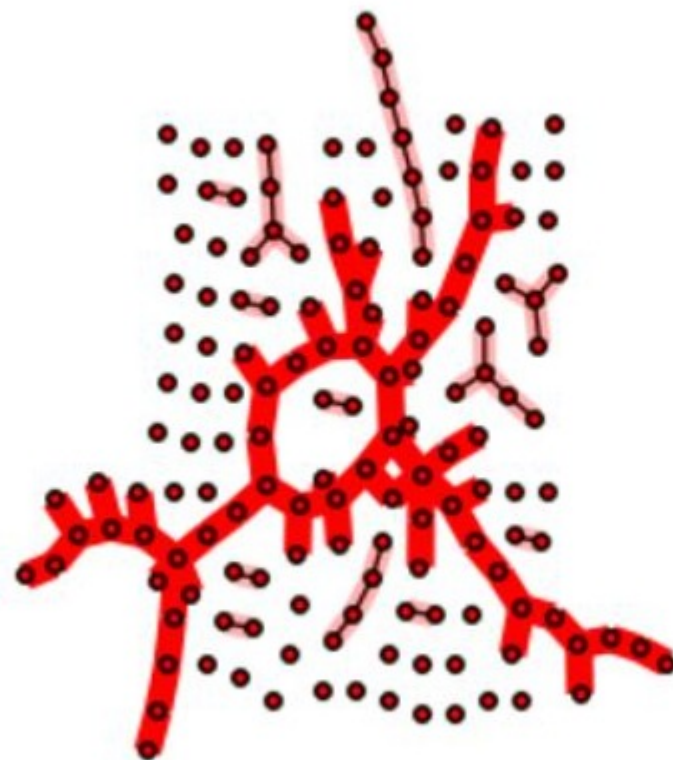
$p = 0.003$



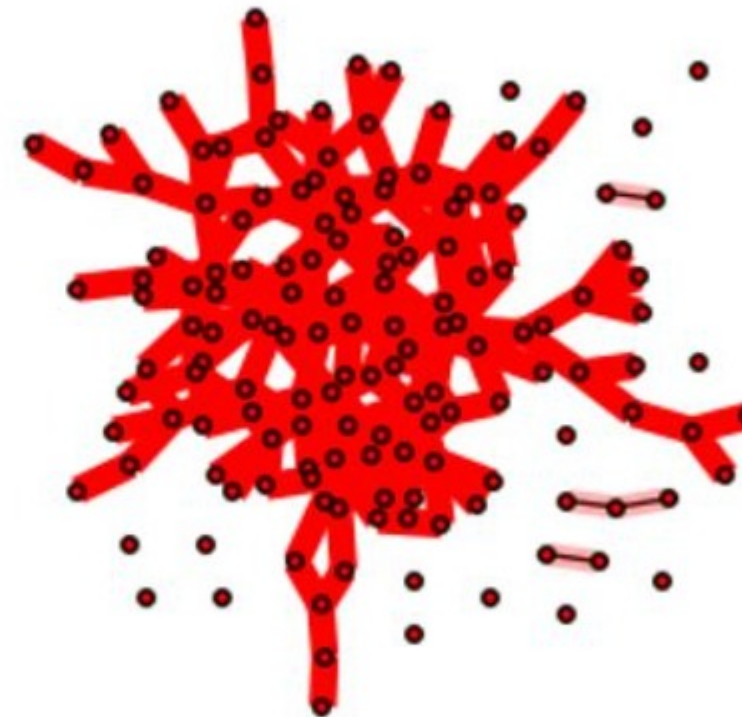
$p = 0.006$



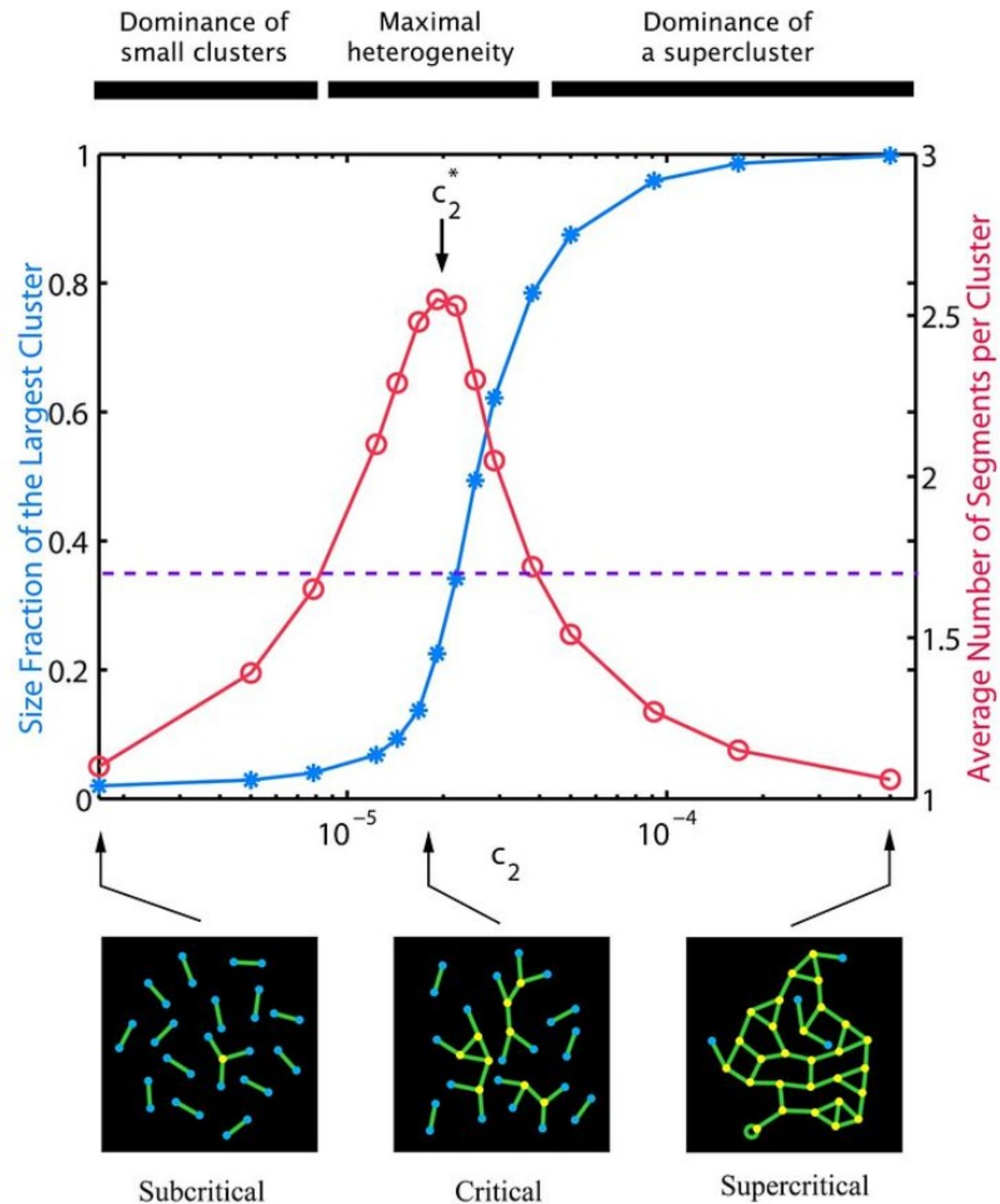
$p = 0.008$



$p = 0.015$



Percolation transition



Sukhorukov et al (2012)
PLoS Comput Biol 8(10):
e1002745

μ = prob NOT connected to giant component

$$\mu = (1 - p + p\mu)^{n-1}$$

$$\ln \mu = (n-1) \ln \left(1 - \frac{c}{n-1} (1-\mu) \right)$$

$$\approx -(n-1) \frac{c}{n-1} (1-\mu)$$

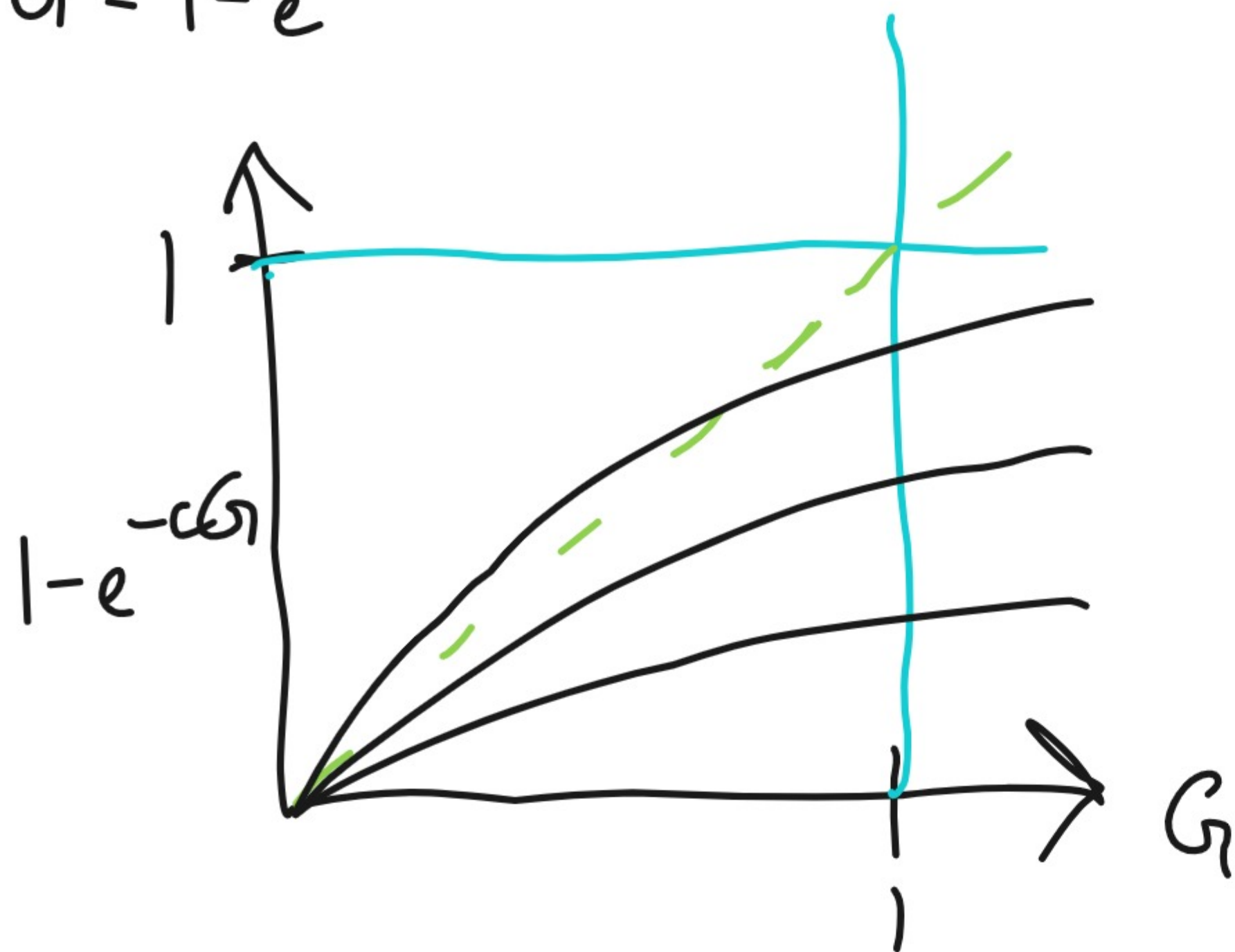
$$= -C(1-\mu)$$

$$\mu = e^{-C(1-\mu)}$$

G = prob YES connected to giant component

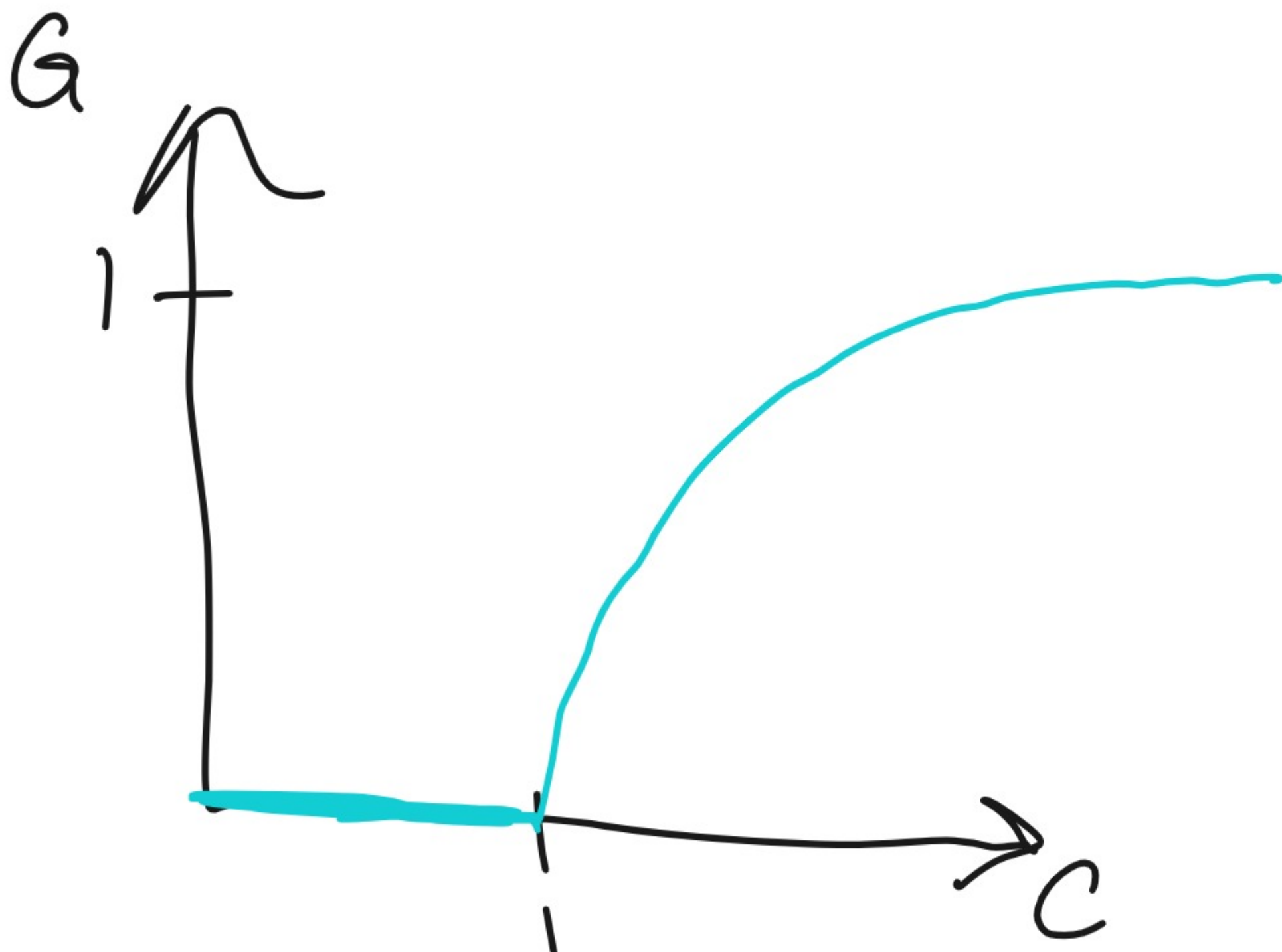
$$G = 1 - \mu$$

$$G = 1 - e^{-cG}$$

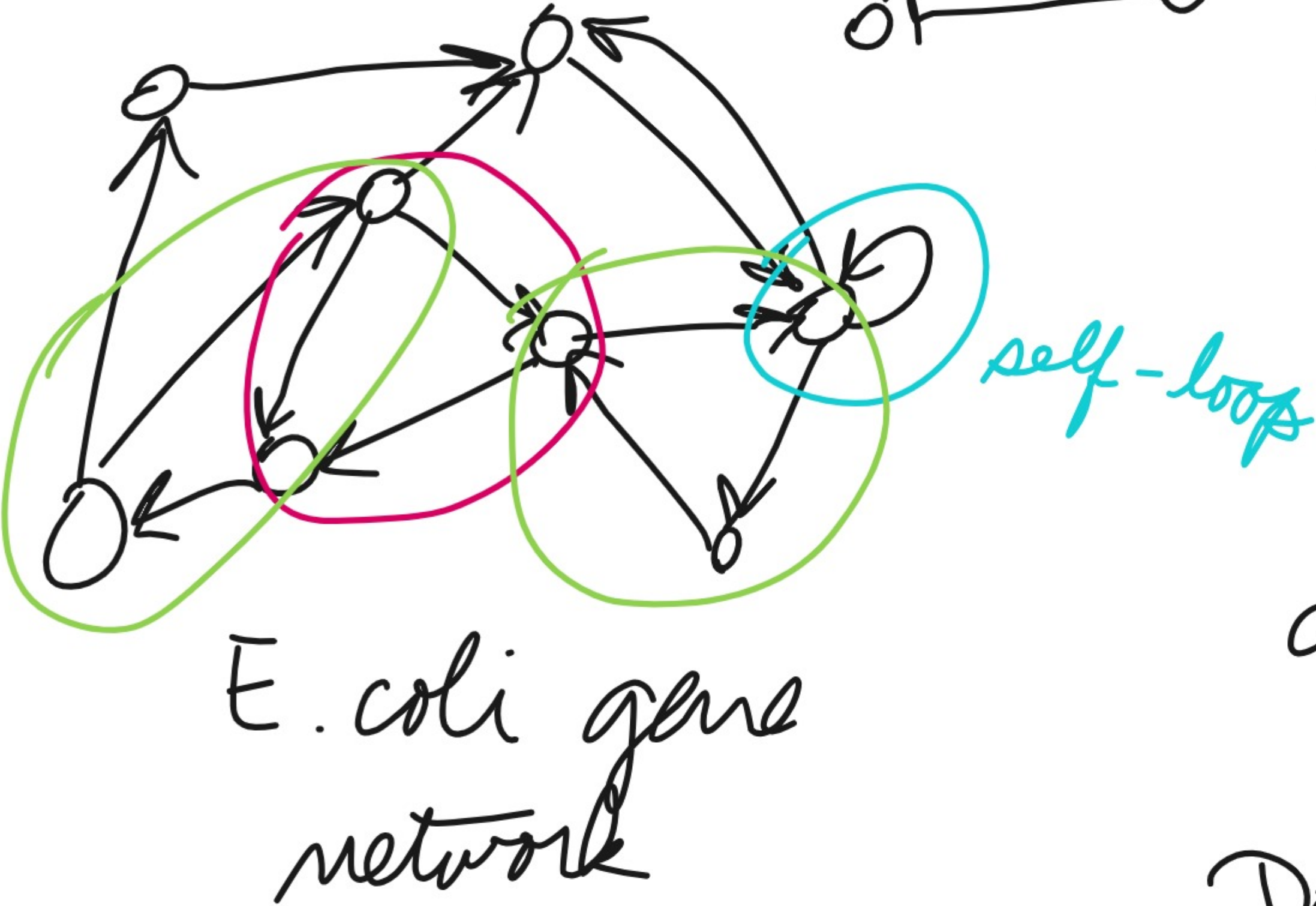
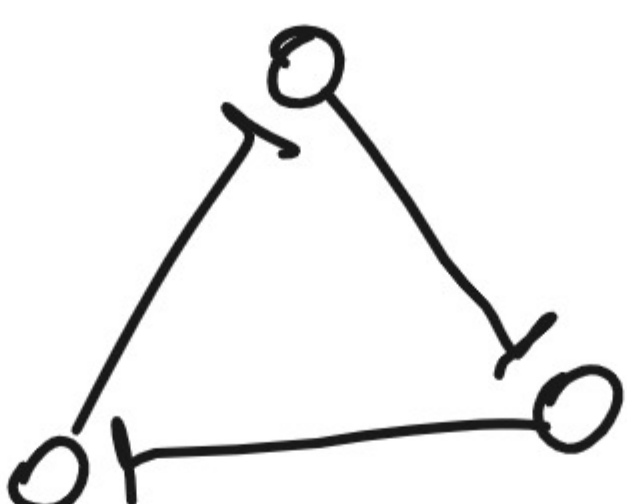
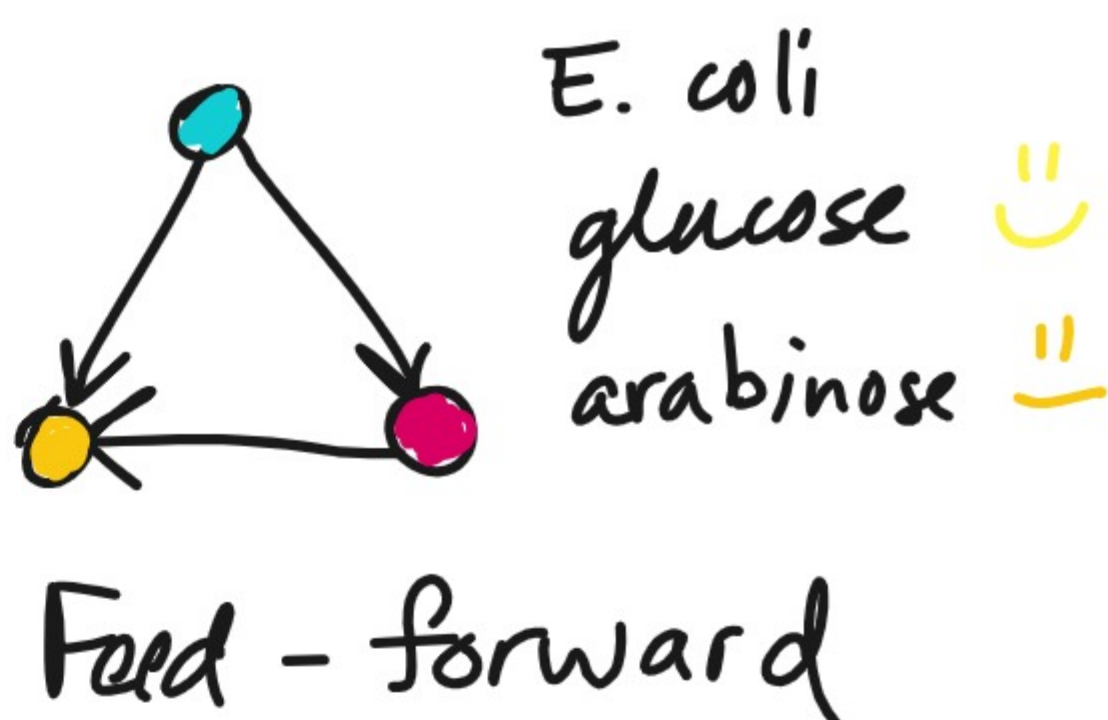
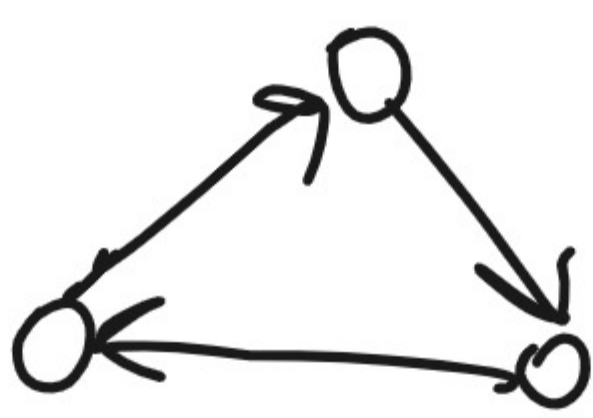
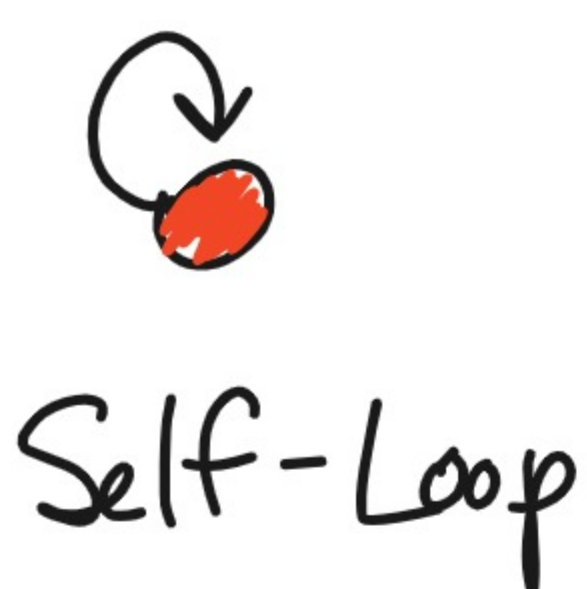


critical value

$$C = 1$$



Network Motif



Is the # of motifs significant?

compare to random network

1 self-loop

Random Network (100 x)

10 self-loops

12
6
17
20

