# Examples of Complex Networks

Introduction to Network Science

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Topic 02

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# Sources

- Albert László Barabási: Network Science. Cambridge University Press, 2016.
  - Chapter 01, Chapter 02
- Filippo Menczer, Santo Fortunato, and Clayton A. Davis. A First Course in Network Science. Cambridge University Press, 2020.
  - Chapter 00
- URLs cited in the footer of specific slides

# Wikipedia definition

- **Network science** is an academic field which studies **complex networks** such as
  - telecommunication networks, computer networks, biological networks, cognitive and semantic networks, and social networks,
- considering
  - distinct elements or actors represented by **nodes** and
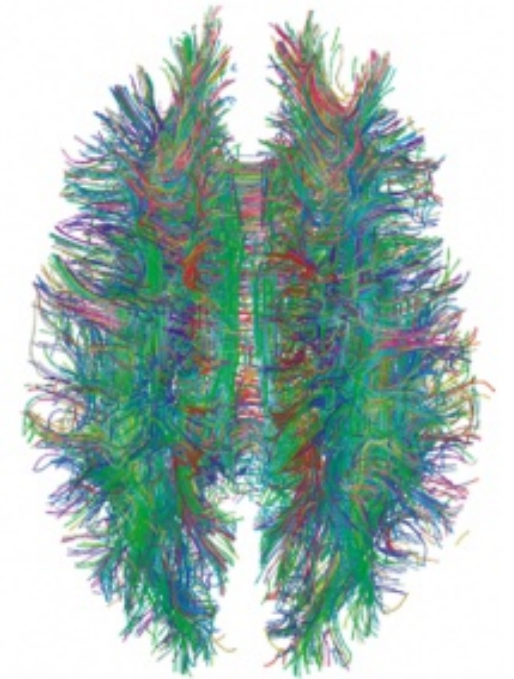  - the connections between the elements or actors as **links**.
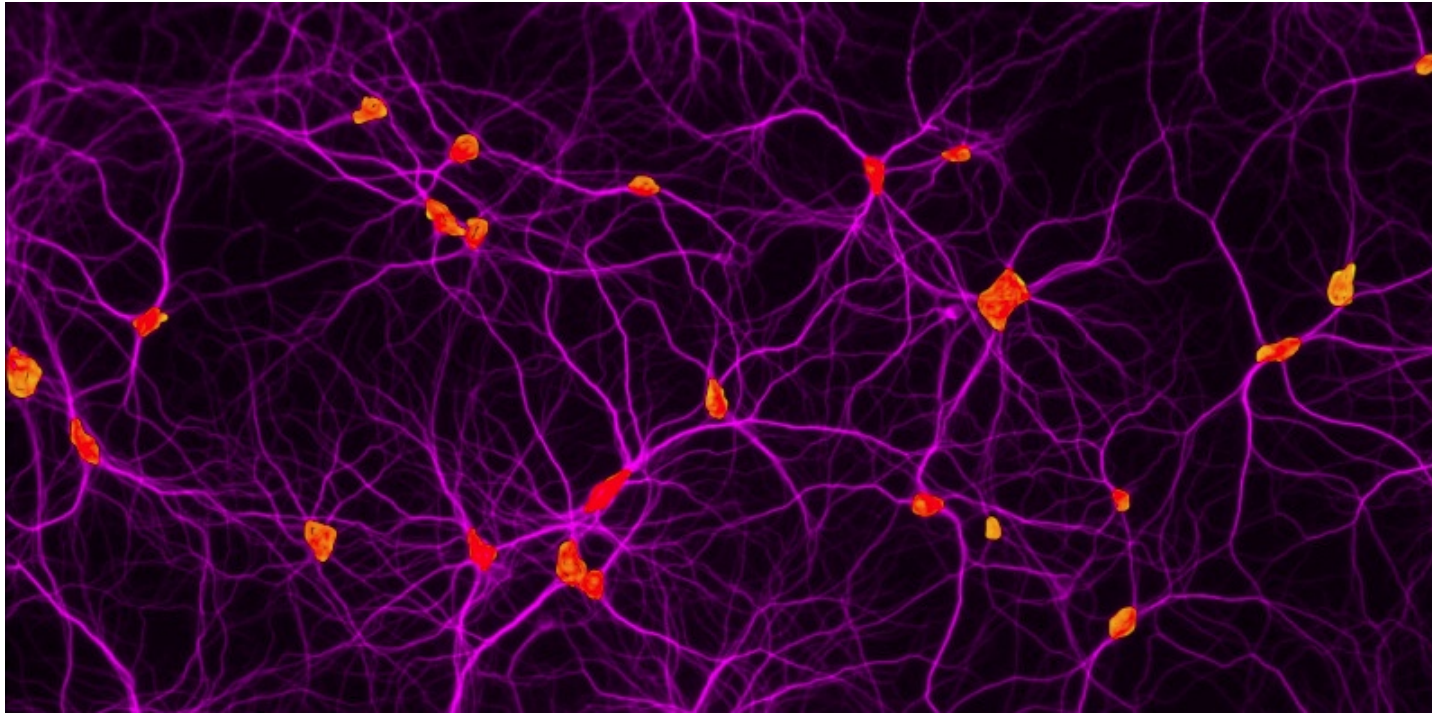
# Complex systems

- Many interconnected parts
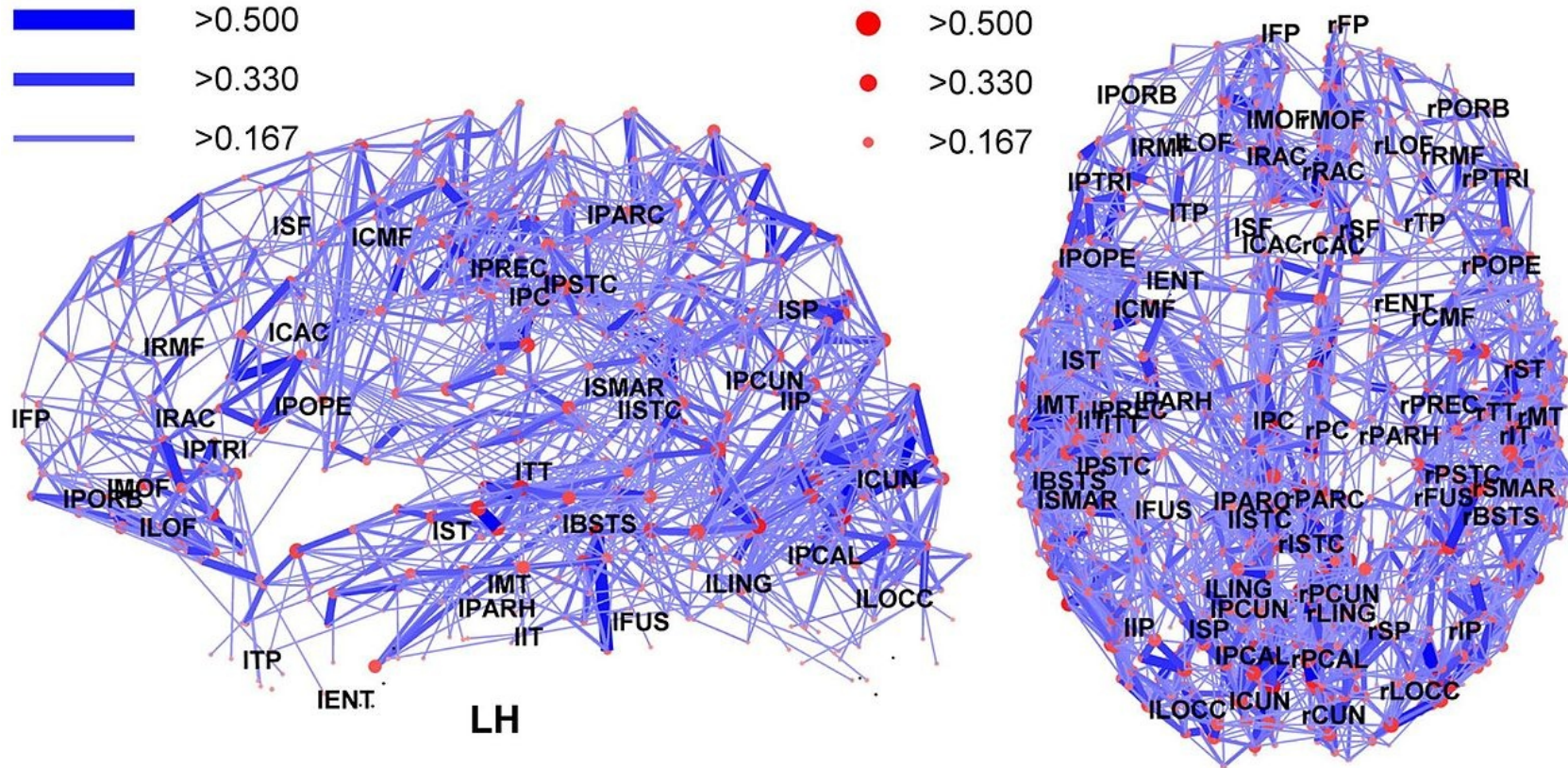- Complicated arrangement of connections
- Emerging properties

# Behind every complex system there is a complex network

- Connections between neurons in the brain

- Interactions between genes and proteins

- Family/friendship links in human and non-human animals

- Infrastructure of telecommunications, electricity

- Commerce/trade networks
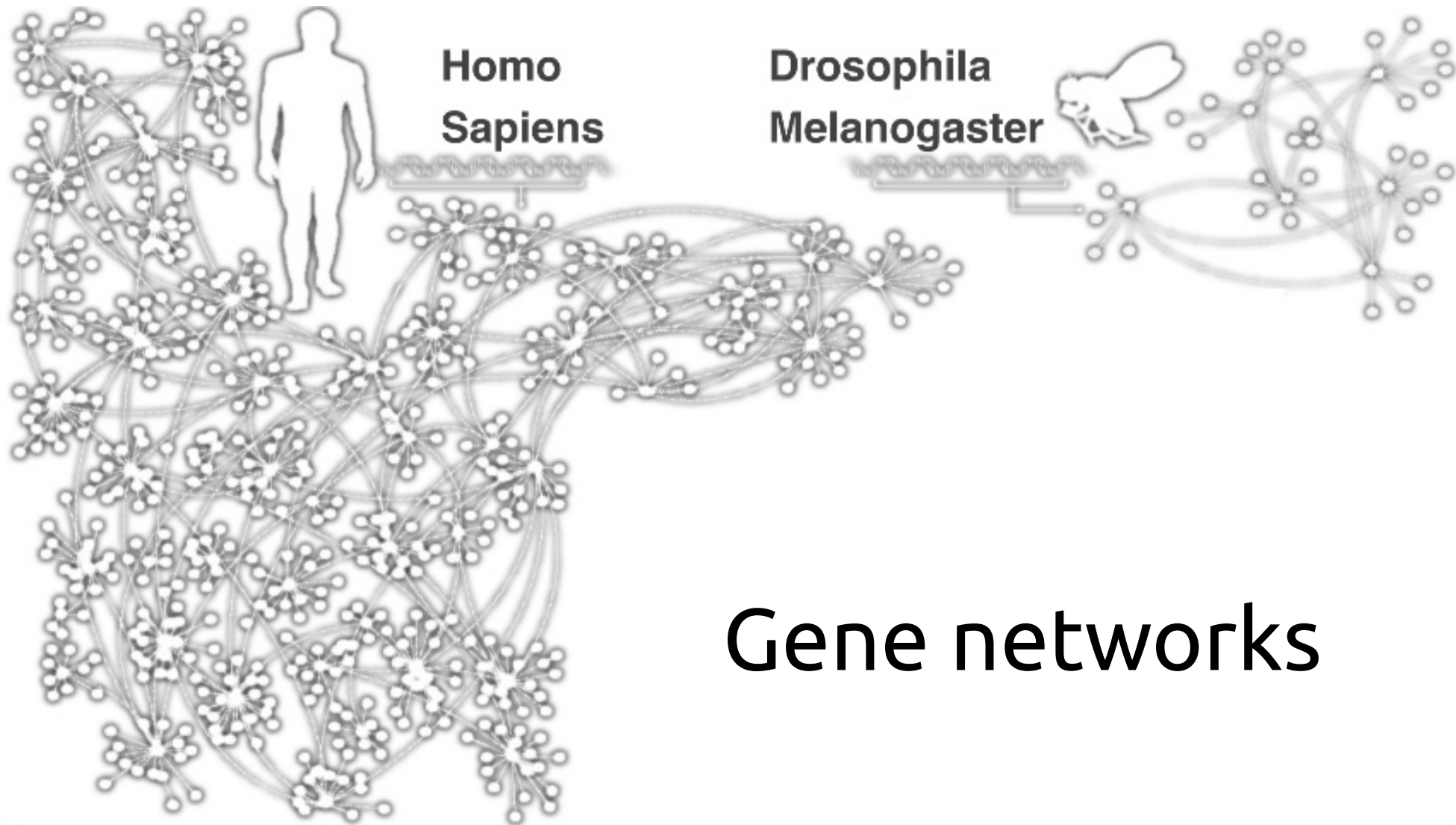
# Human brain: $|V| \simeq 90 \times 10^9$
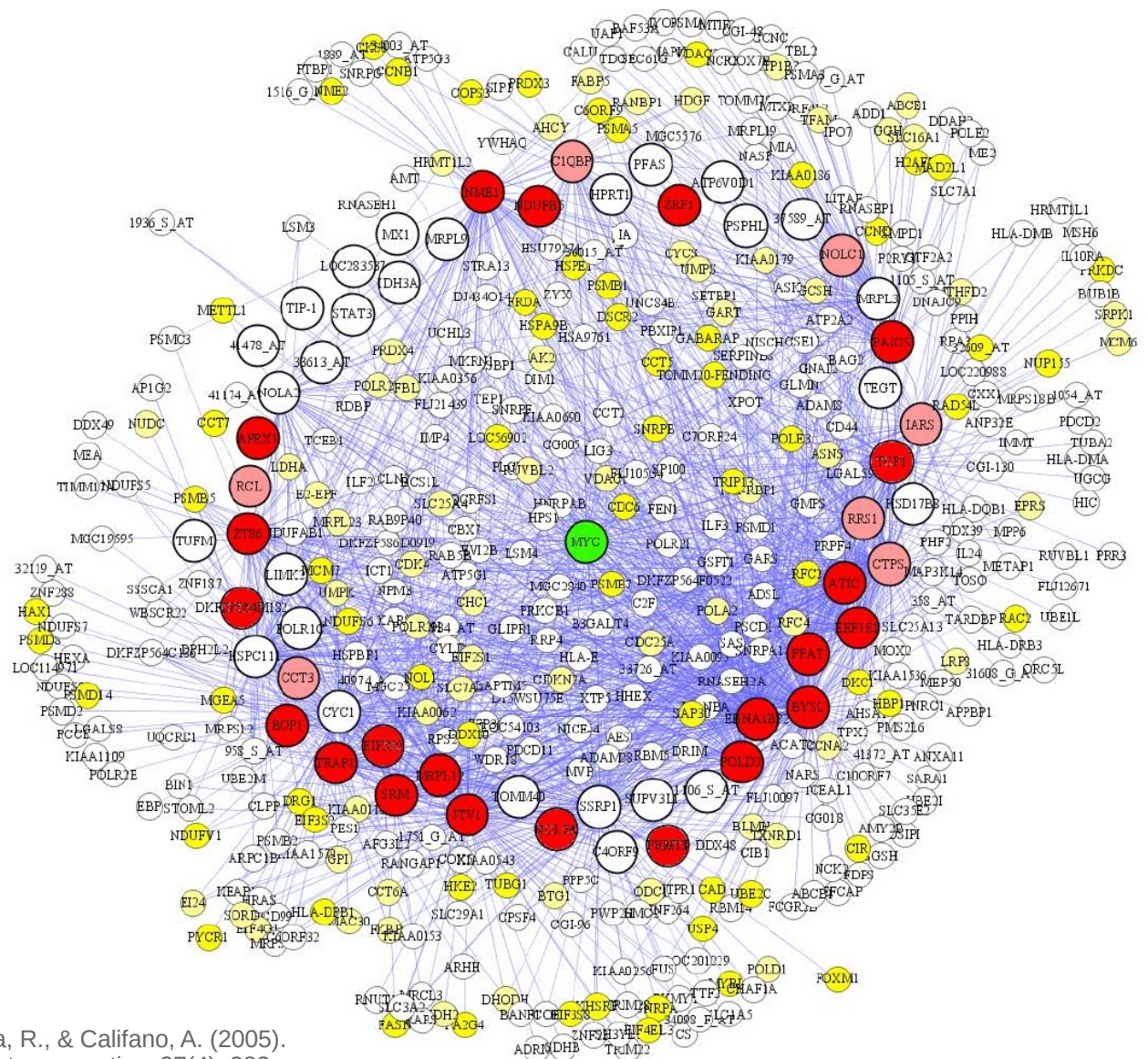
# Regions in the human brain

Homo Sapiens

Drosophila Melanogaster

Gene networks

# Co-expression of Genes

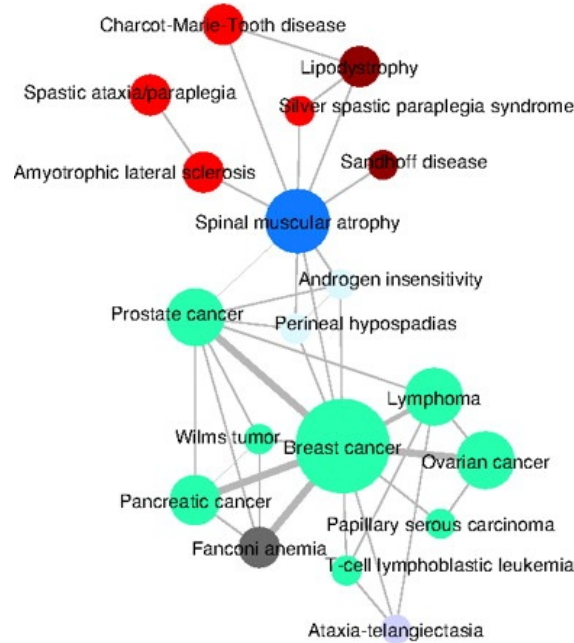## |V|=500 in this plot

Basso, K., Margolin, A. A., Stolovitzky, G., Klein, U., Dalla-Favera, R., & Califano, A. (2005).
Reverse engineering of regulatory networks in human B cells. Nature genetics, 37(4), 382.
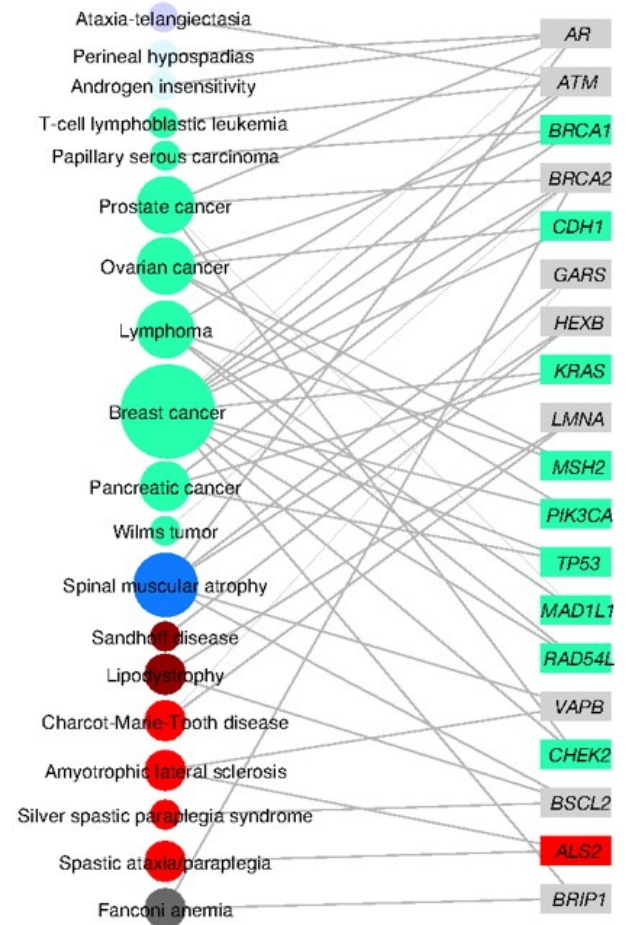
# Human disease network
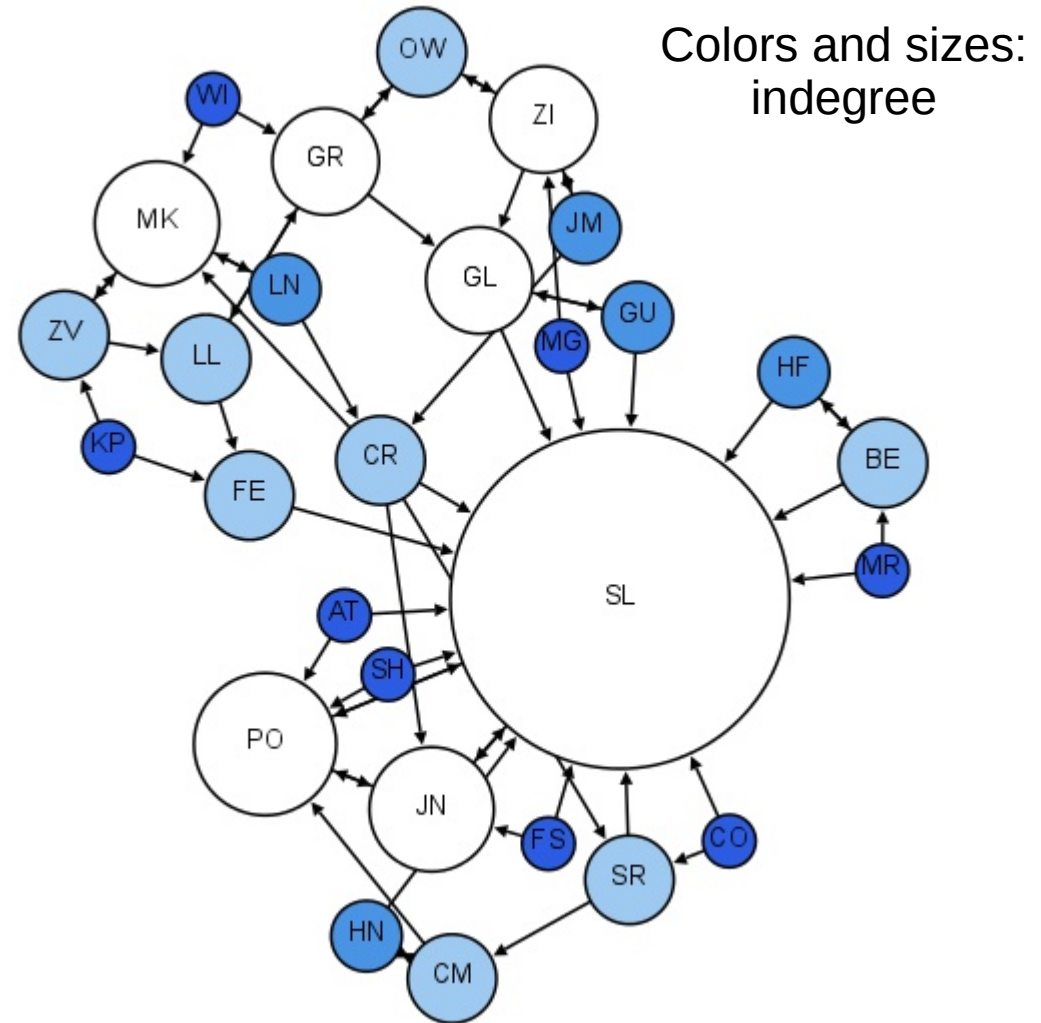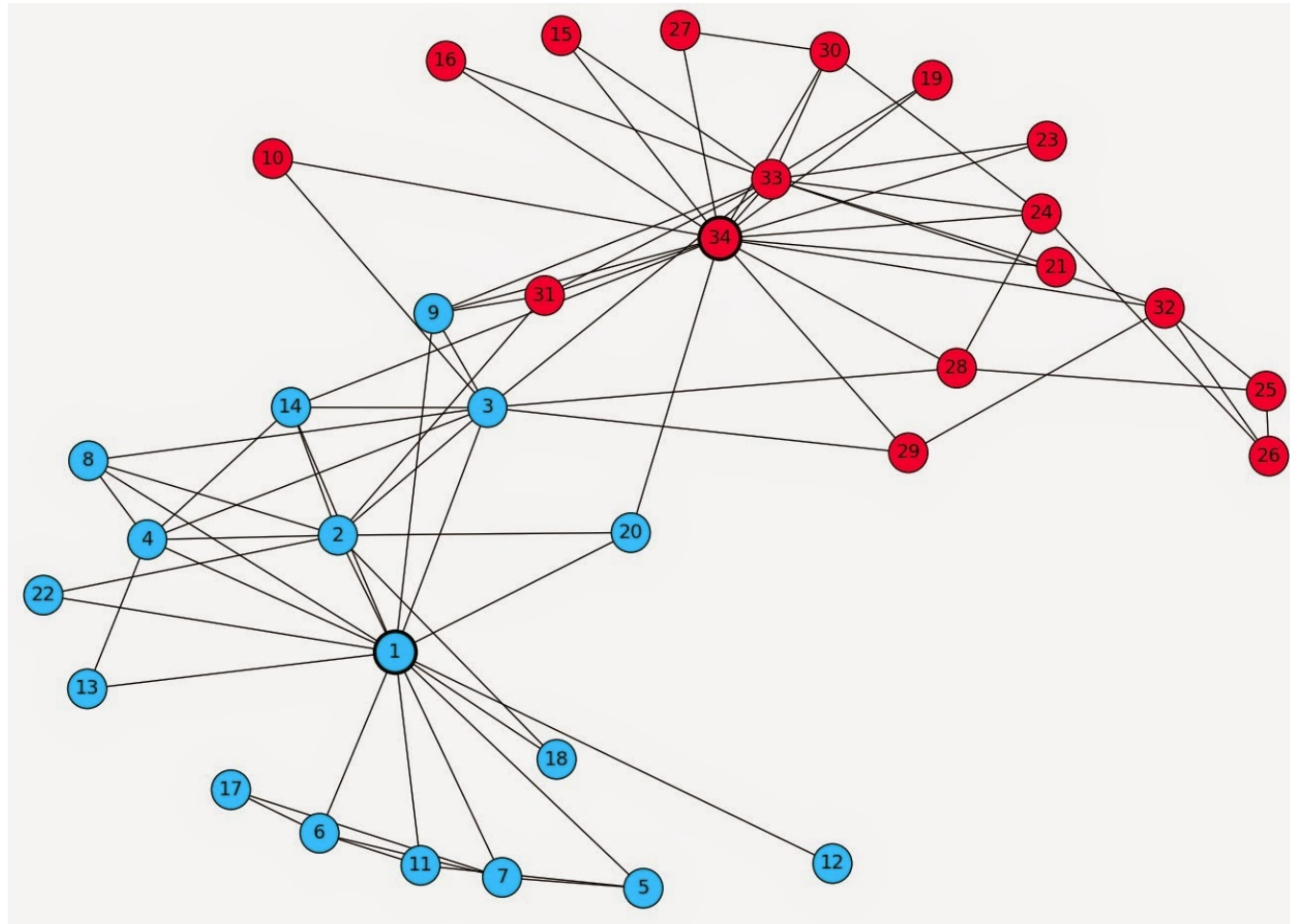


Human Disease Network (HDN)

DISEASOME

# Moreno's sociograms

- Early 1930s
- Children in 2nd grade
- Who would you like to sit with?
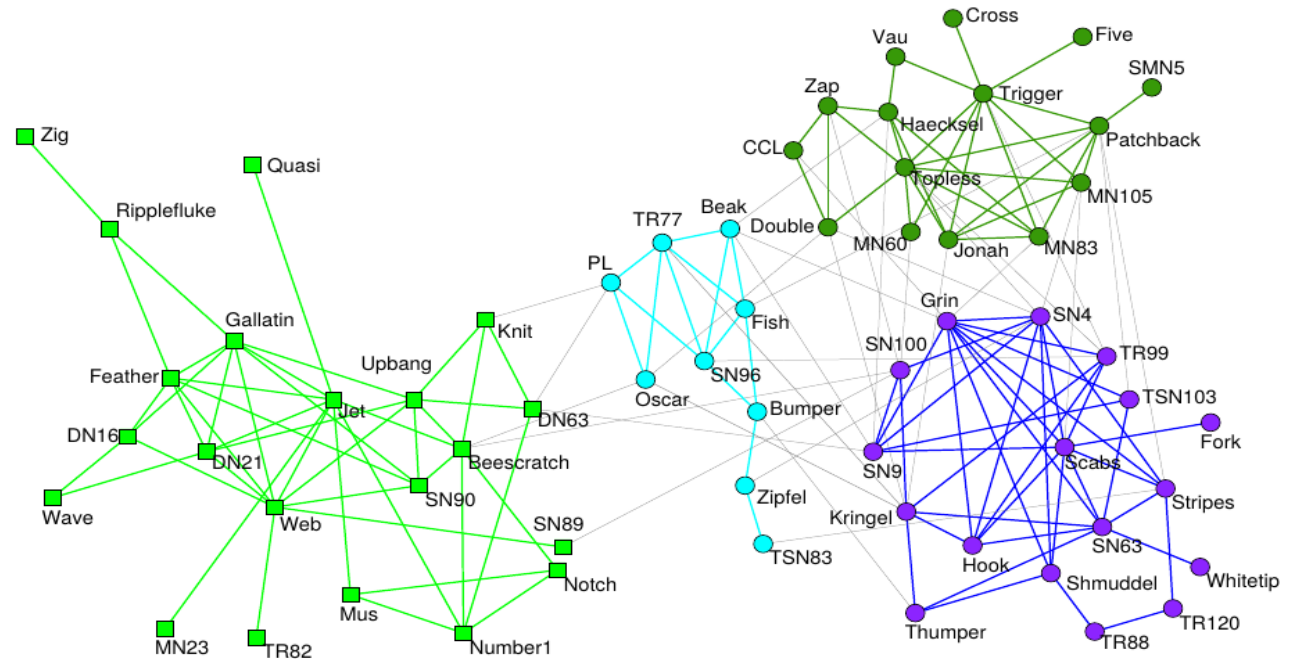


Colors and sizes: indegree

# Zachary's Karate Club

Karate club that split into two clubs
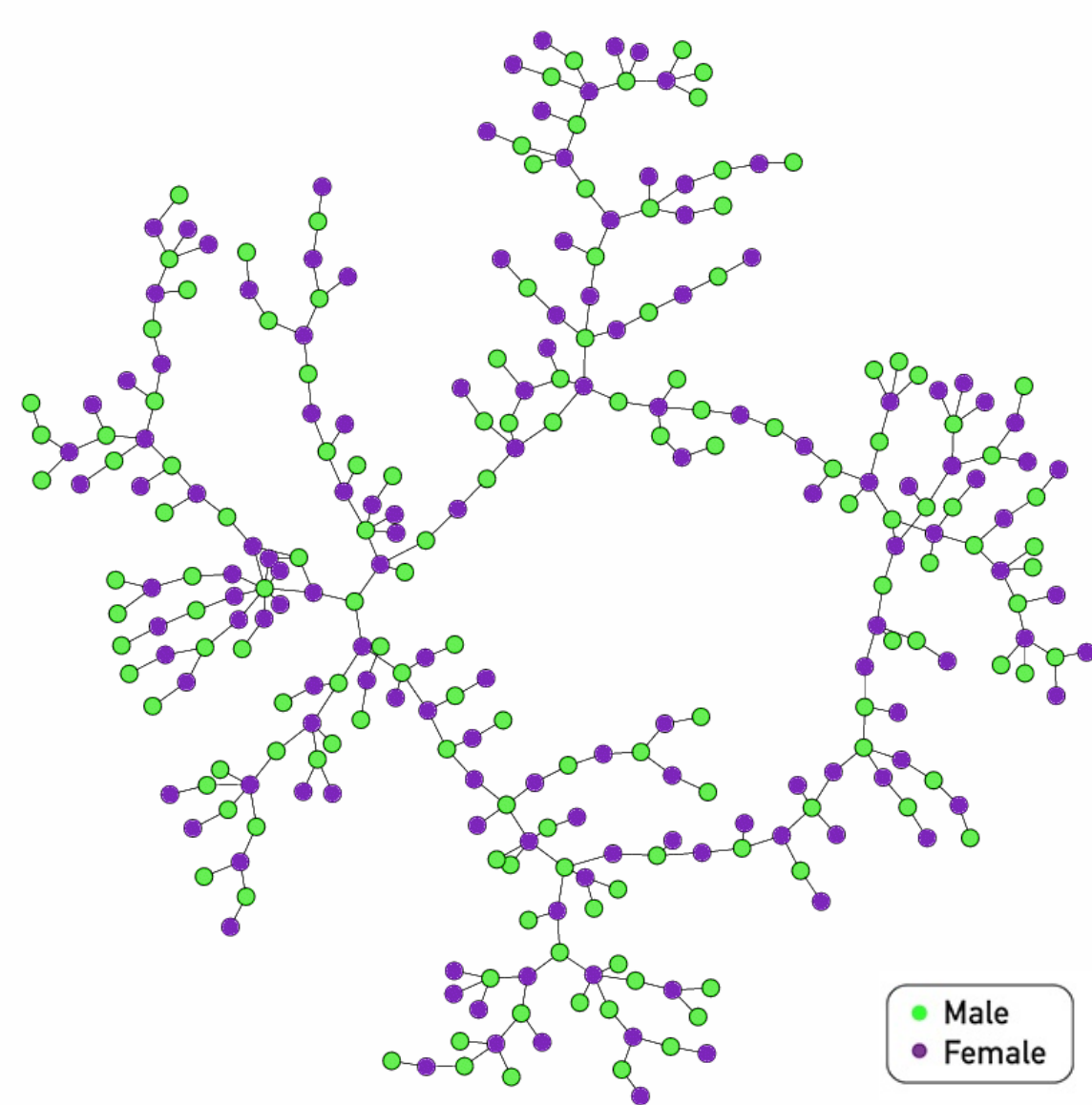
(led by 1 and 34)

# Dolphins in a fjord in New Zealand

- Research following a school of dolphins in the wild (2003)

- Look for dolphins swimming together

- Found **long-lasting associations;** research has been repeated with other non-human animals (e.g., sheep)
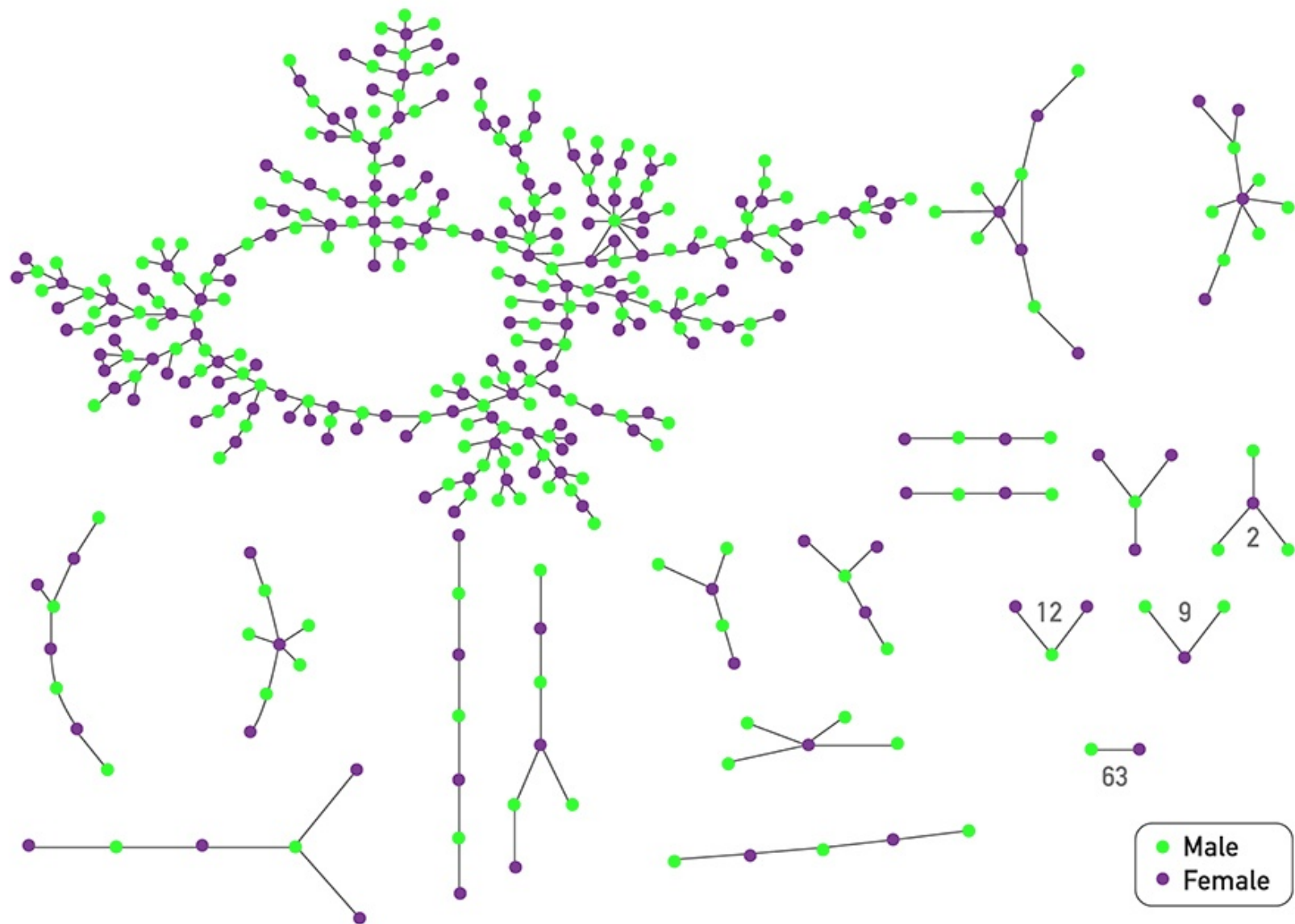


https://doi.org/10.1007/s00265-003-0651-y
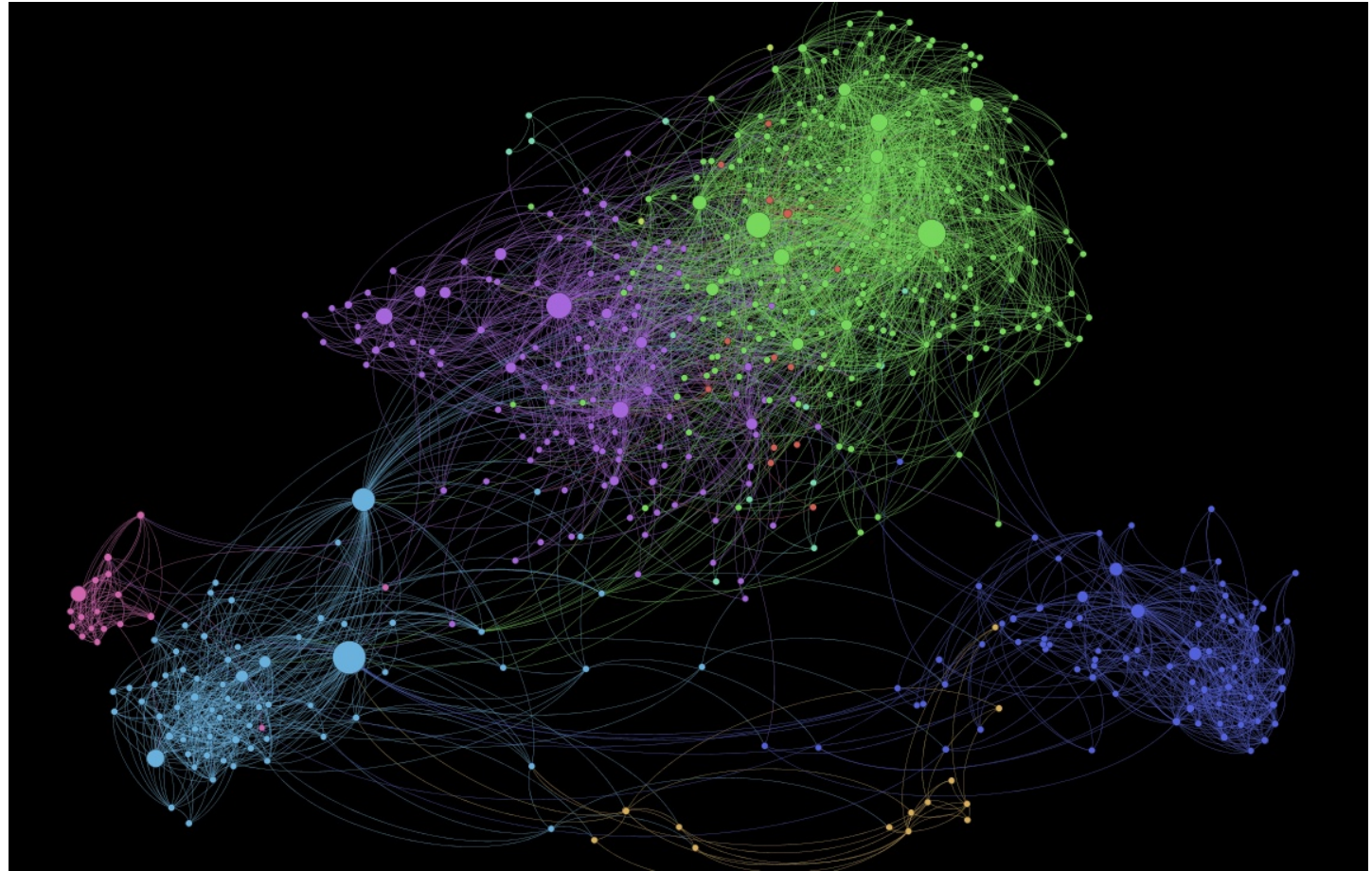
13

Male
Female

# Chains of affection

- Early 2000s

- Adolescents in high school

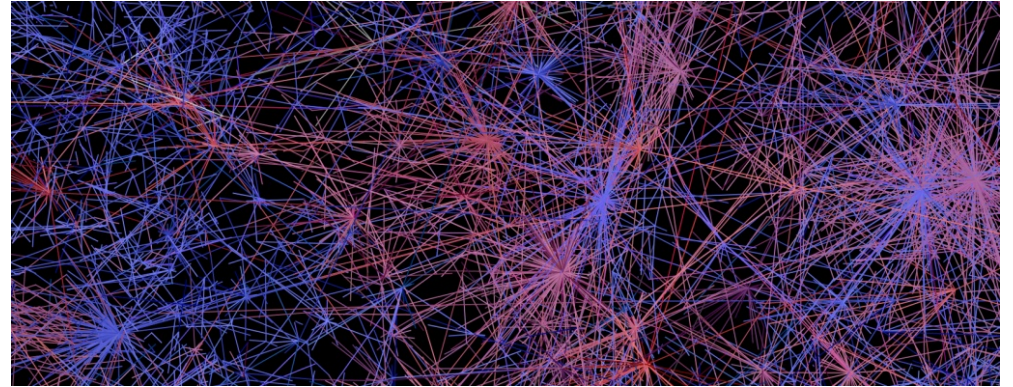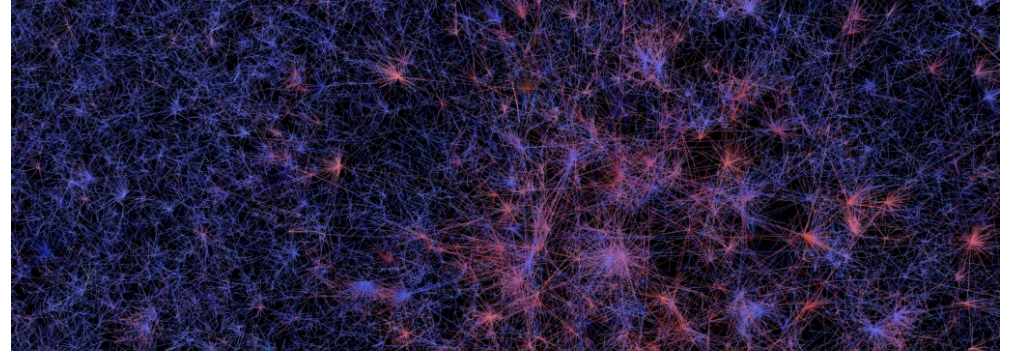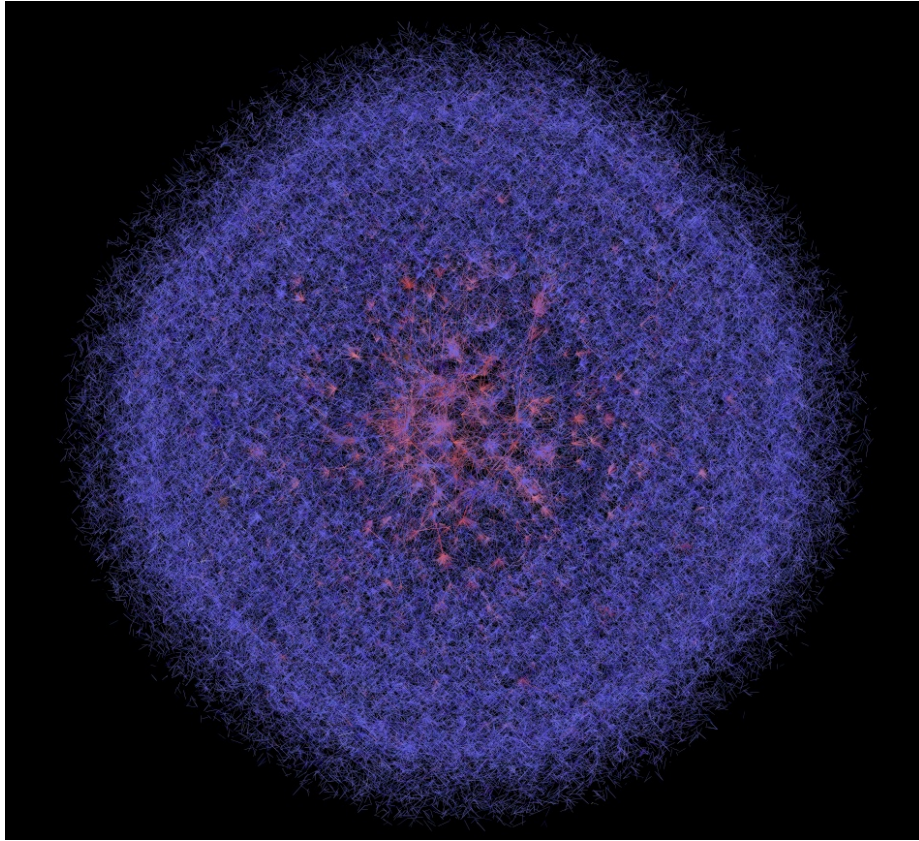- A "*special romantic relationship*" or a "*nonromantic sexual relationship*" in the past 18 months

Bearman, P. S., Moody, J., & Stovel, K. (2004). Chains of affection: The structure of adolescent romantic and sexual networks. American journal of sociology, 110(1), 44-91.

14

2

12

9

63

Male
Female

15

# 1,000 Somali Users of Facebook

# 400,000 Twitter Users

# Exercise

- Find examples of networks, just indicating:
  - Name
  - Number of nodes (approximately)
  - Number of edges (approximately)

Answer in Nearpod Collaborate
https://nearpod.com/student/
Code to be given during class

# Things to remember

- Definitions: complex system, complex network
- Examples of complex networks