

Frontiers of Network Science Fall 2021

Class 2: Introduction Part II (Chapter 1 in Textbook)

Boleslaw Szymanski

based on slides by
Albert-László Barabási
and Roberta Sinatra

Complex

[adj., v. kuh m-pleks, kom-pleks; n. kom-pleks]
–adjective

1.
composed of many interconnected parts;
compound; composite: a complex highway
system.

2.
characterized by a very complicated or
involved arrangement of parts, units, etc.:
complex machinery.

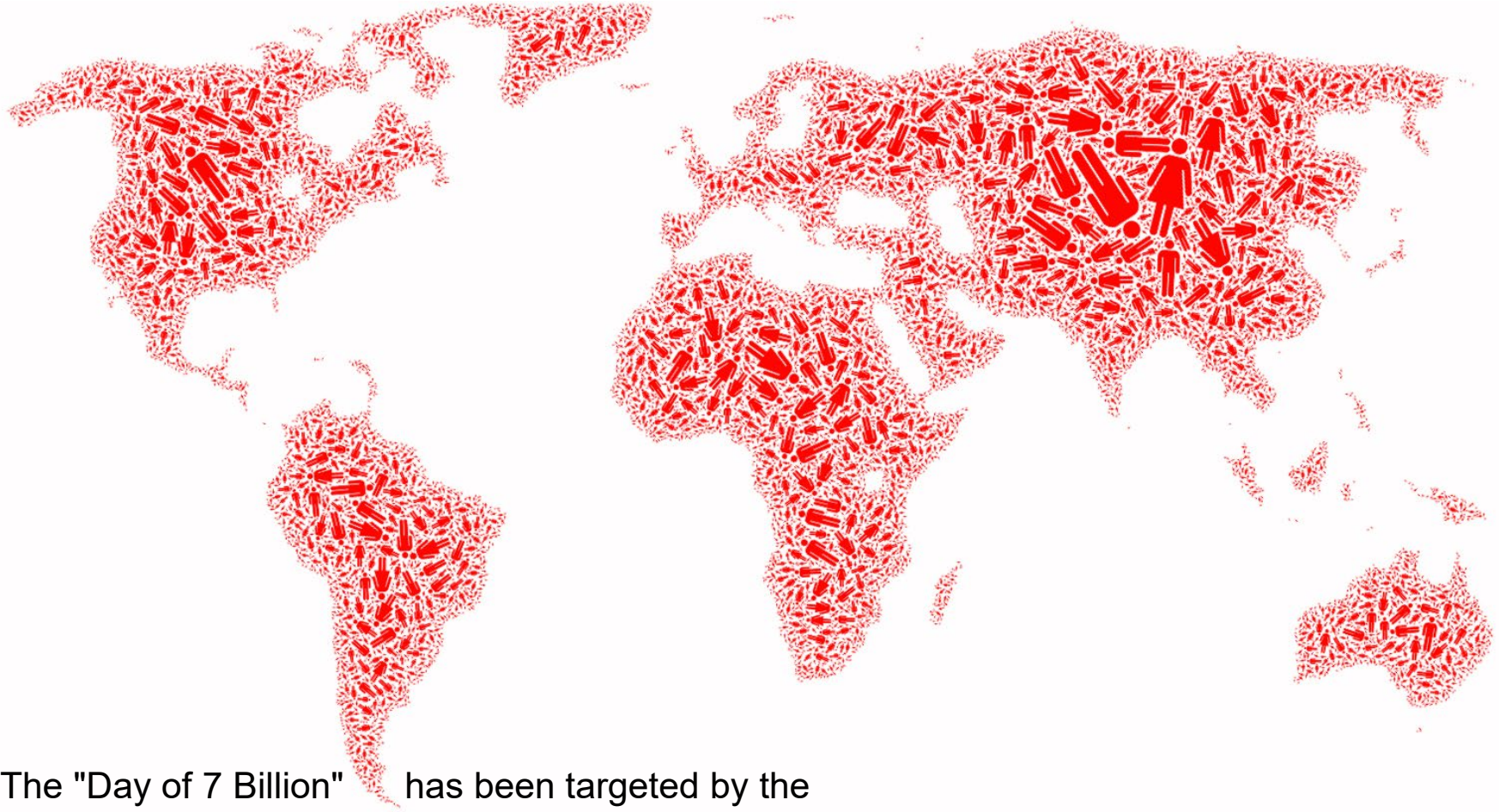
3.
so complicated or intricate as to be hard to
understand or deal with: a complex problem.

Source: Dictionary.com

Complexity, a **scientific theory** which asserts that some systems display behavioral phenomena that are completely inexplicable by any conventional analysis of the systems' constituent parts. These phenomena, commonly referred to as emergent behaviour, seem to occur in many complex systems involving living organisms, such as a stock market or the human brain.

Source: John L. Casti, Encyclopædia Britannica

Complexity



The "Day of 7 Billion" has been targeted by the United States Census Bureau to be in July 2012.

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



**Human Brain has
between
10-100 billion
neurons.**

The world economy produced goods and services worth almost \$55 trillion in 2005.
(<http://siteresources.worldbank.org/ICPINT/Resources/CPreportprelim.pdf>)



How Many Genes are in
the Human Genome?

23,299

http://www.ornl.gov/sci/techresources/Human_Genome/faq/genenumber.shtml



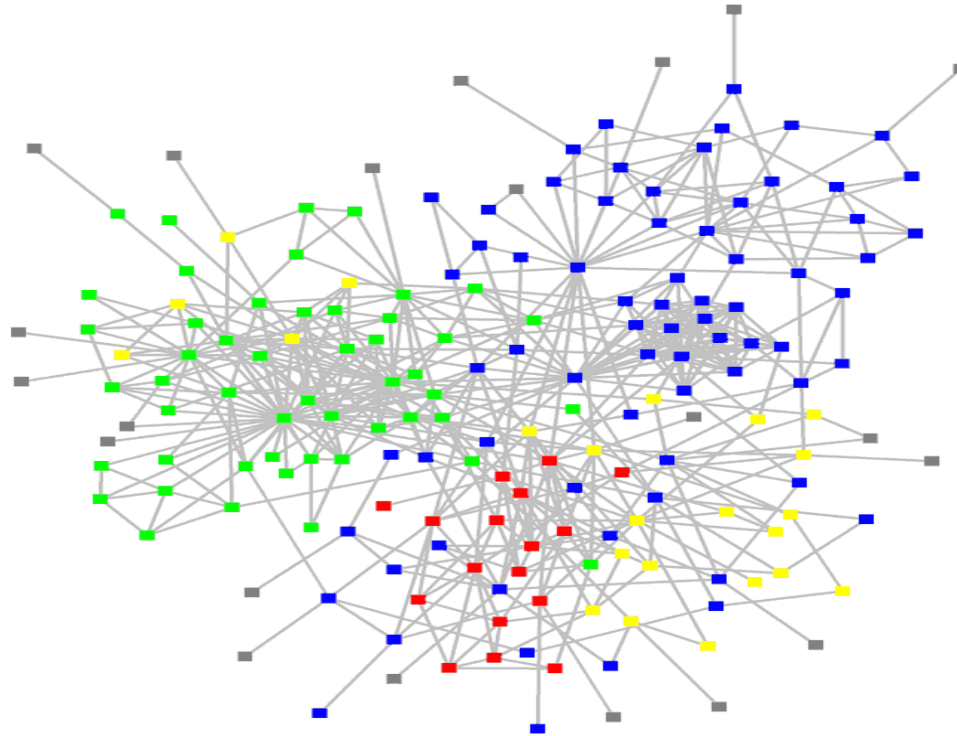
Behind each complex system there is a **network**, that defines the interactions between the components.



The “Social Graph” behind Facebook

Keith Shepherd's "Sunday Best". <http://baseballart.com/2010/07/shades-of-greatness-a-story-that-needed-to-be-told/>

STRUCTURE OF AN ORGANIZATION



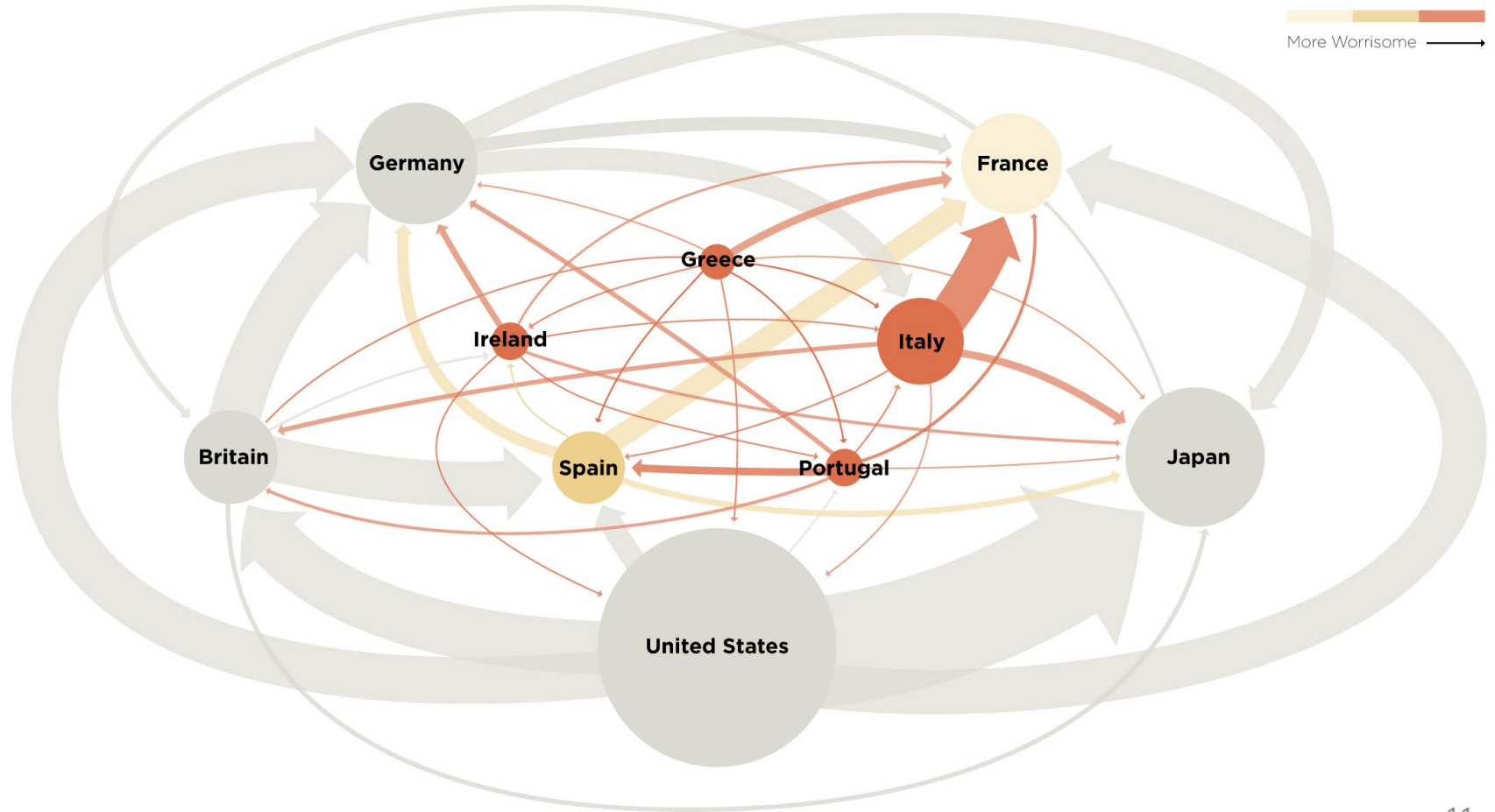
www.orgnet.com

- : departments
- : consultants
- : external experts

The subtle financial networks



The not so subtle financial networks: 2011



BUSINESS TIES IN US BIOTECH-INDUSTRY

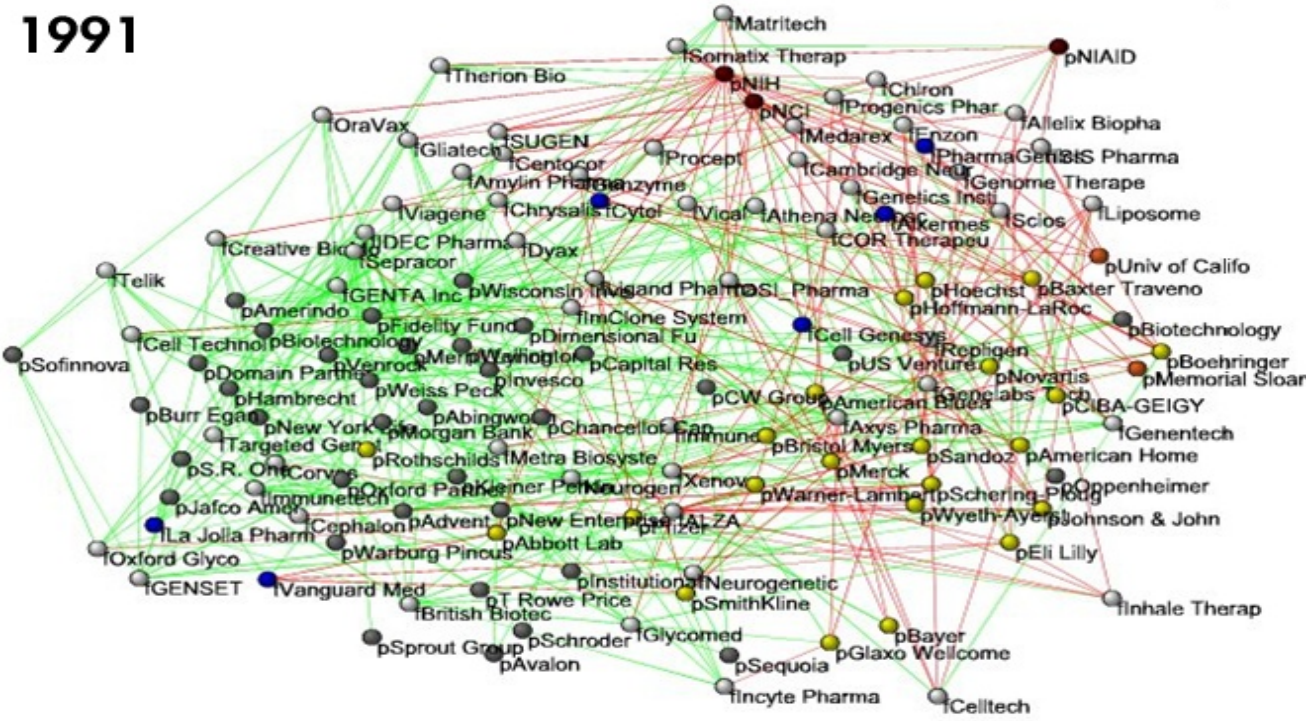
1991

Nodes:

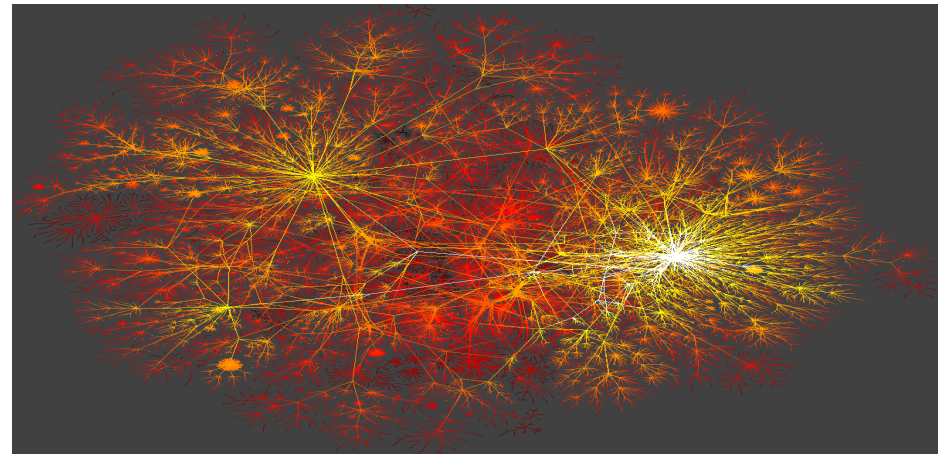
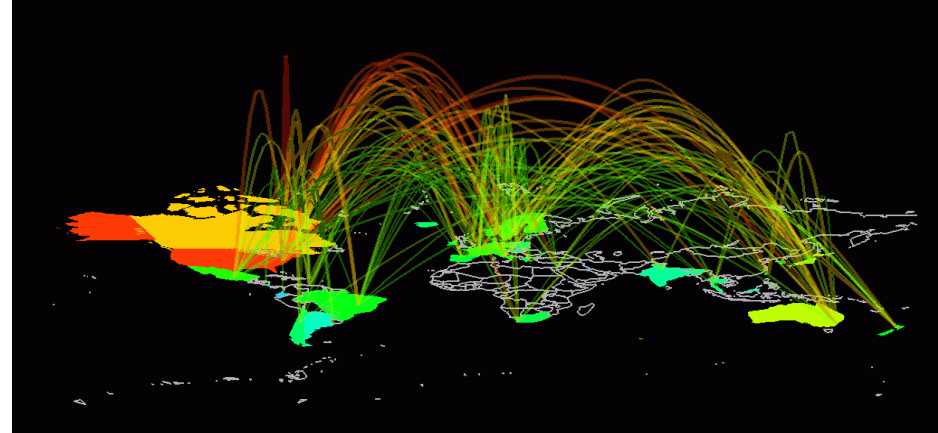
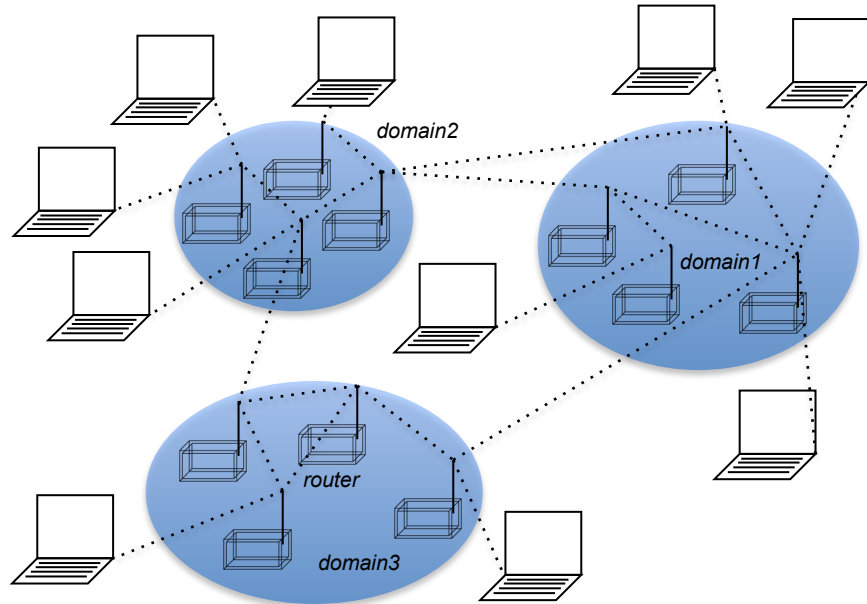
- Companies 
- Investment 
- Pharma 
- Research Labs 
- Public 
- Biotechnology 

Links:

- Collaborations 
- Financial 
- R&D 

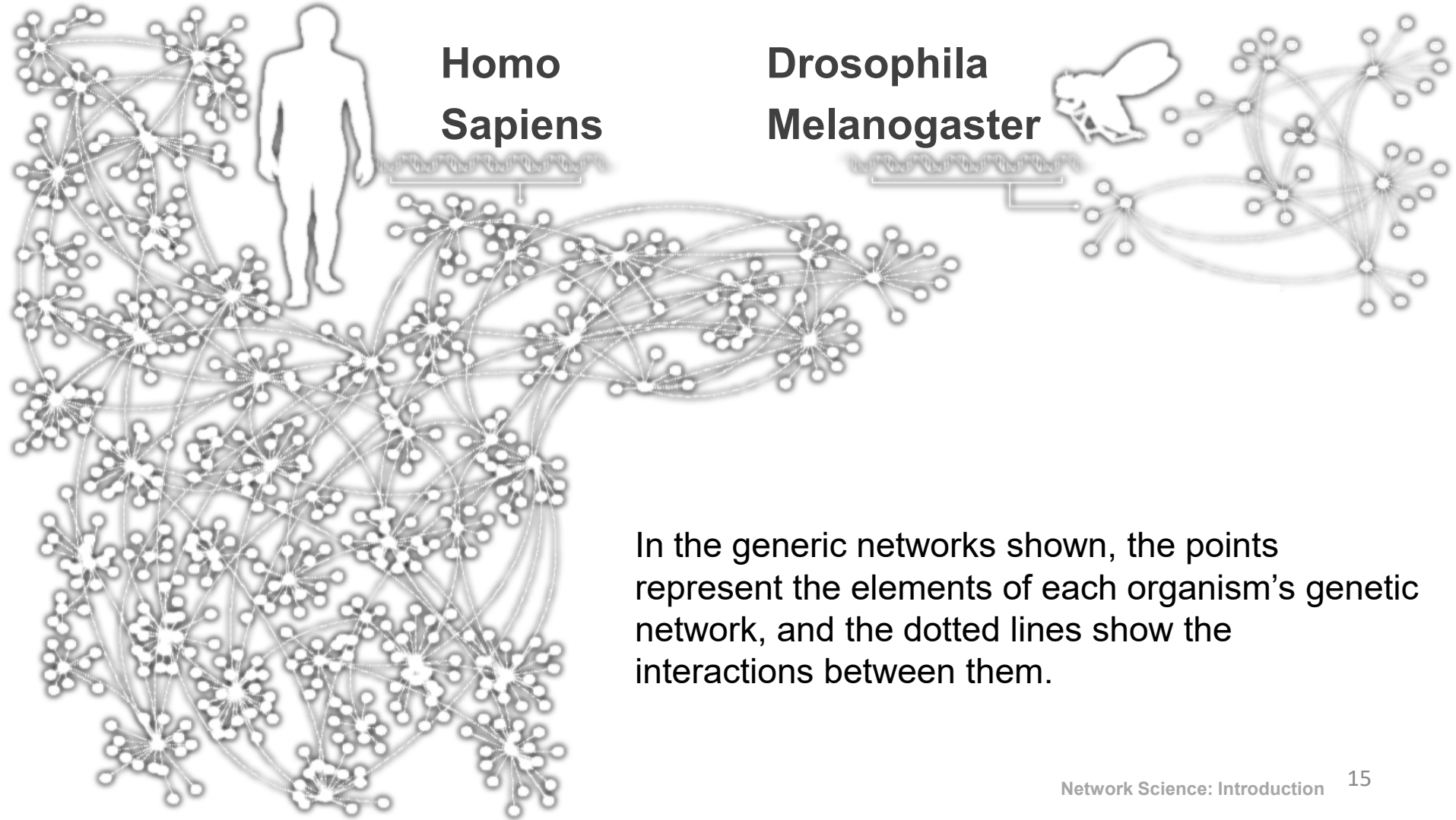


<http://ecclectic.ss.uci.edu/~drwhite/Movie>

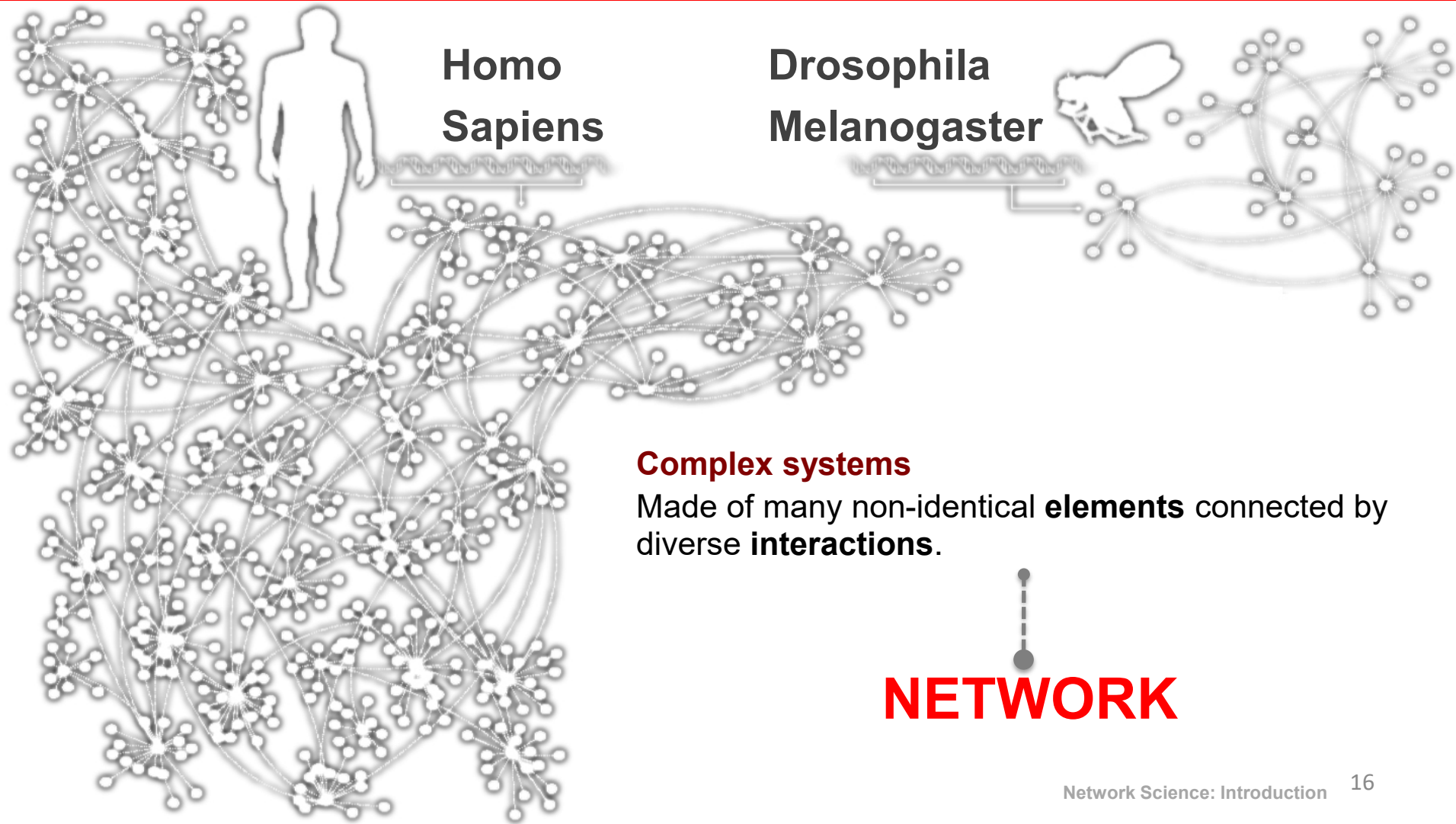


**Human Brain
has between
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HUMANS GENES



HUMANS GENES



Behind each system studied in complexity there is an intricate wiring diagram, or a **network**, that defines the interactions between the component.

We will never understand complex system unless we map out and understand the networks behind them.

TWO FORCES HELPED THE EMERGENCE OF NETWORK SCIENCE

The emergence of network maps:

Movie Actor Network, 1998;
World Wide Web, 1999.
C elegans neural wiring diagram 1990
Citation Network, 1998
Metabolic Network, 2000;
PPI network, 2001

The universality of network characteristics:

The architecture of networks emerging in various domains of science, nature, and technology are more similar to each other than one would have expected.

Data Availability: C elegans neural wiring diagram 1990
Movie Actor Network, 1998
Citation Network, 1998
World Wide Web, 1999
Metabolic Network, 2000
PPI network, 2001

Universality: The architecture of networks emerging in various domains of science, nature, and technology are more similar to each other than one would have expected.

The (urgent) need to understand complexity: Despite the challenges complex systems offer us, we cannot afford to not address their behavior, a view increasingly shared both by scientists and policy makers. Networks are not only essential for this journey, but during the past decade some of the most important advances towards understanding complexity were provided in context of network theory.

Graph theory: 1735, Euler

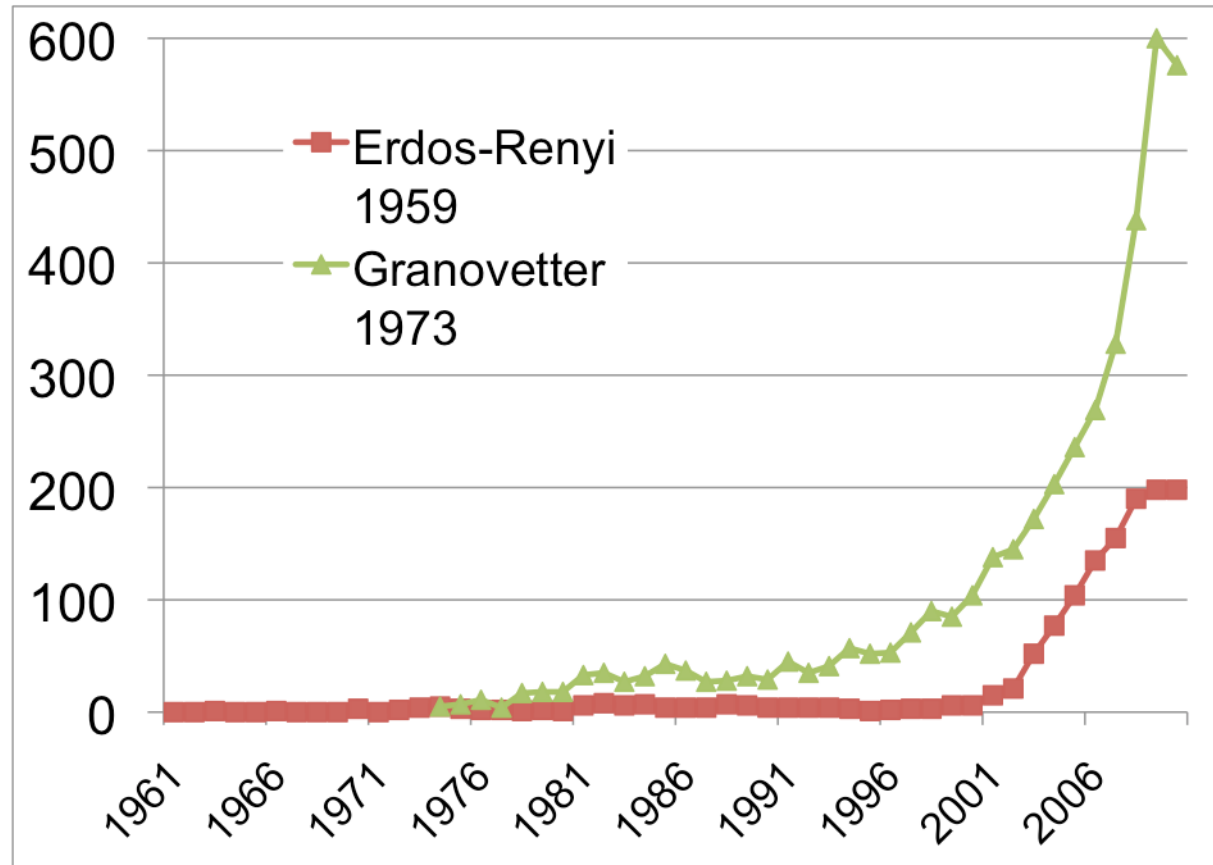
Social Network Research: 1930s, Moreno

Communication networks/internet: 1960s

Ecological Networks: May, 1979.

- > Graph theory**
- > Social network theory**
- > Statistical physics**
- > Computer science**
- > Biology**
- > Statistics**

THE HISTORY OF NETWORK ANALYSIS



THE CHARACTERISTICS OF NETWORK SCIENCE

Interdisciplinary

Empirical

Quantitative and Mathematical

Computational

Interdisciplinary

Empirical, data driven

Quantitative and Mathematical

Computational

Interdisciplinary

Empirical

Quantitative and Mathematical

Computational

Interdisciplinary

Empirical

Quantitative and Mathematical

Computational

THE IMPACT OF NETWORK SCIENCE

Quantum Mechanics: 1900

- electron microscope 1931
- transistor 1947
- laser 1957
- magnetic resonance imaging 1973
- quantum computing 2015

Much of modern **technology** operates at a scale where quantum effects are significant.

At least a 30 year gap between the science and technology.

ECONOMIC IMPACT



Google
Market Cap(Jan 1, 2010):
\$189 billion

Cisco Systems
networking gear Market
cap (Jan 1, 2010):
\$112 billion

Facebook
market cap:
\$50 billion

www.bizjournals.com/austin/news/2010/11/15/facebooks... - Cached

DRUG DESIGN, METABOLIC ENGINEERING:

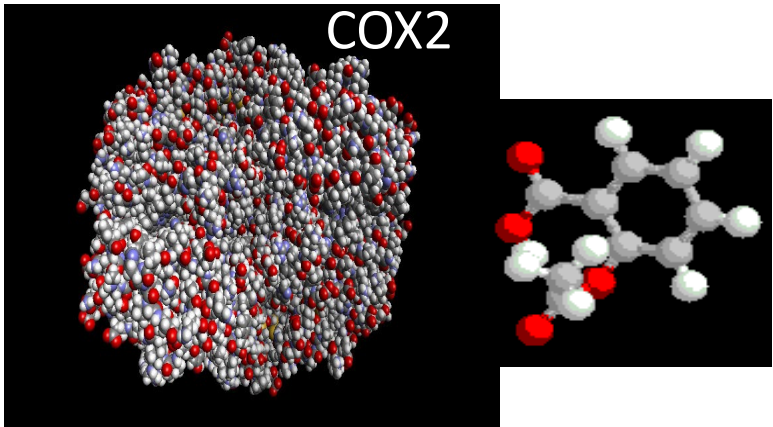
Reduces
Inflammation
Fever
Pain



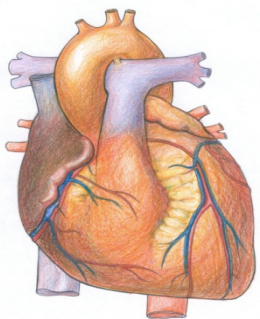
Prevents
Heart attack
Stroke



Reduces the risk of
Alzheimer's Disease



Reduces the risk of
breast cancer
ovarian cancers
colorectal cancer



Causes
Bleeding
Ulcer

DRUG DESIGN, METABOLIC ENGINEERING:

