Emergence of complexity, from observations to predictions

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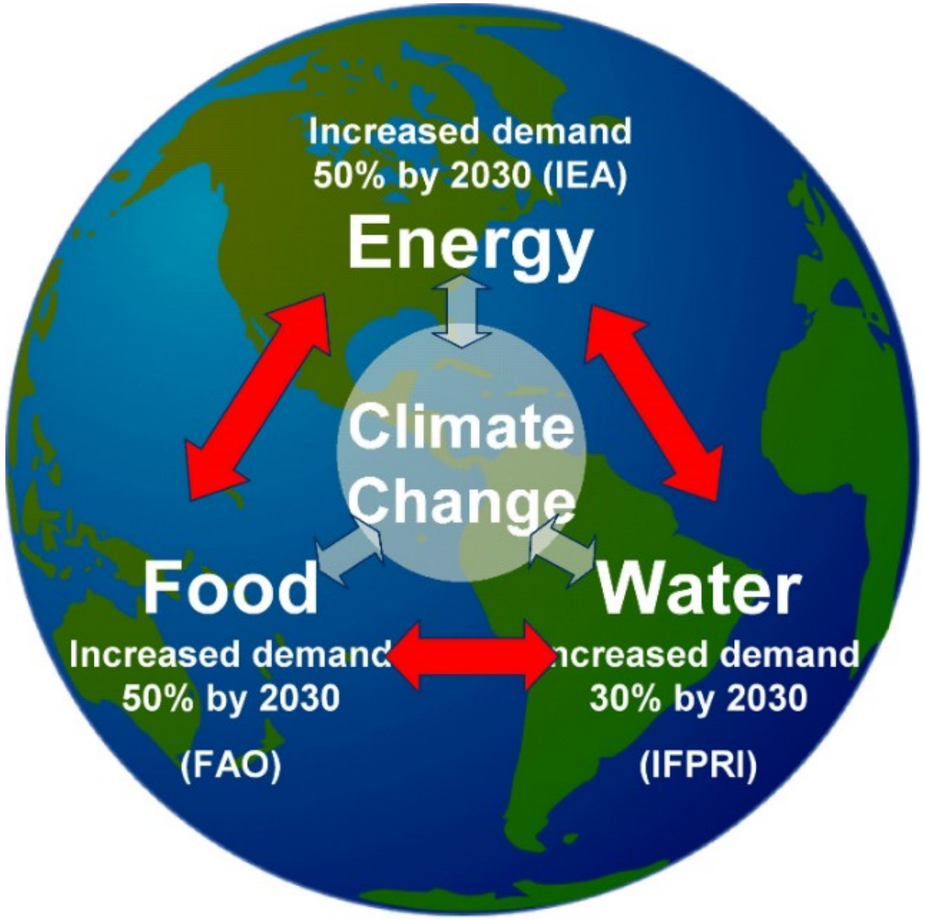
https://publons.com/researcher/2892753/jozsef-baranyi/

Interconnected world

Global issues - 2030

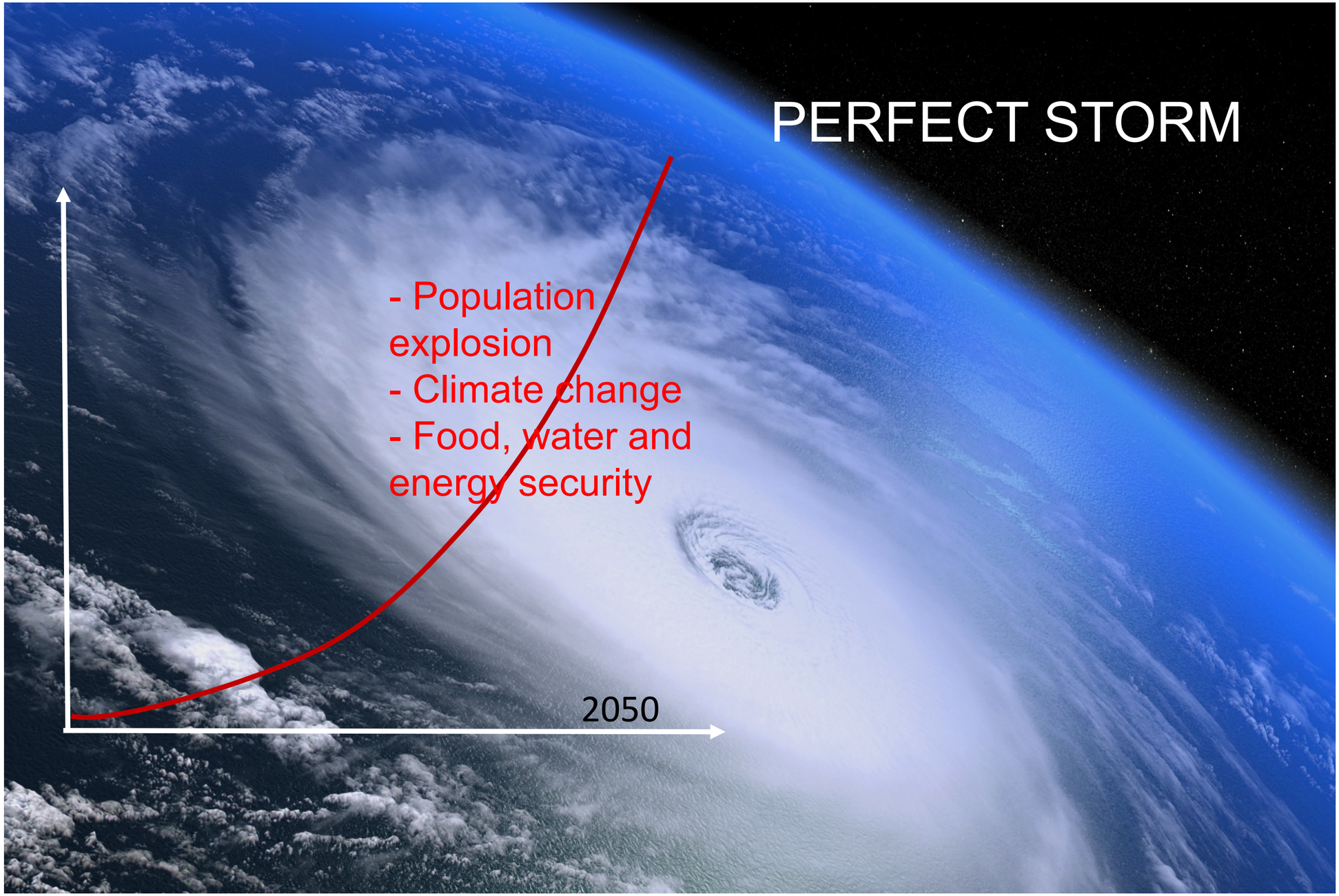


To tackle, make use of

- IT tools explosion
- Network science
- Complexity science
- Multi-disciplinary collaborations

FOOD is especially suitable to utilize progress in the above

John Beddington
UK Government Chief Scientist, 2012


PERFECT STORM
- Population explosion
- Climate change
- Food, water and energy security
2050

Mathematical developments have always been induced by demands in science, industry and business

(László Lovász, President of Hung.Ac.Sci; NetSci 2011)

Land-issues	➔	**Euclidian geometry**
Newton's physics	➔	**Calculus**
Quantum mechanics	➔	**Probability**
Weather forecast	➔	**Chaos**
Economy, Ecology	➔	**Game theory**

Now: Century of Complexity

Climate change, Food, Water and Energy security

Globalisation ➔ **Science of Complexity** (System theory, Network analysis, Chaos, Sensitivity Analysis, Game theory, Risk and Uncertainty)

Globalisation

"Today the world faces major problems. Some uppermost in my mind are

- climate change,
- food security,
- global health and making economies sustainable…."

However, … "debates are sometimes threatened by … inappropriate headlines in the media, and by those who distort the science with ideology, politics, and religion."

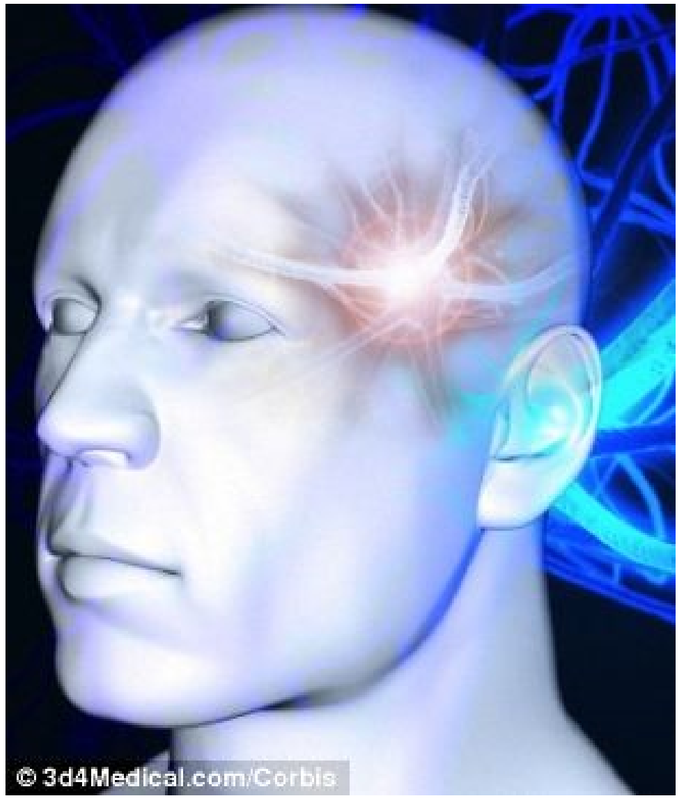
Dimbleby lecture of Nobel Laurate Paul Nurse, 28. Febr, 2012

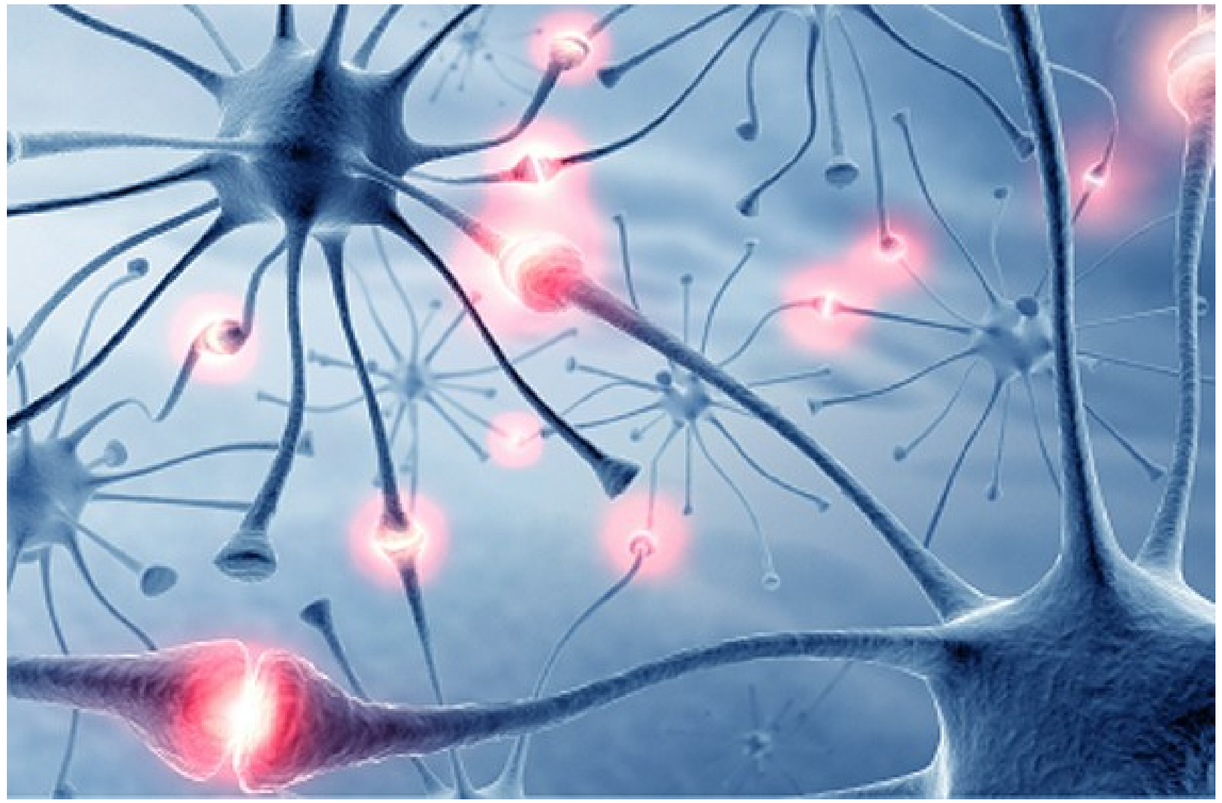
Part 1.

Links and Interactions.

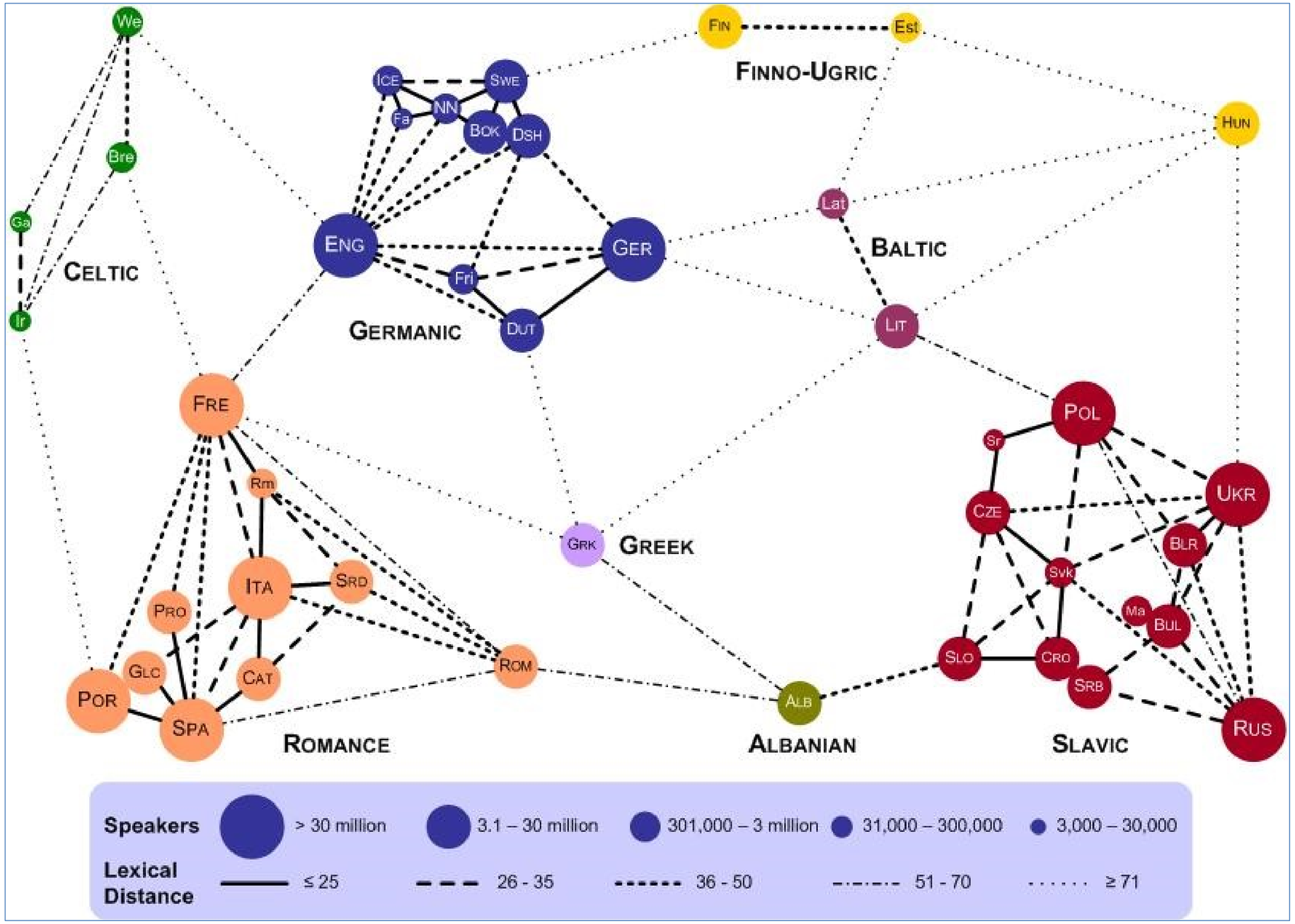
Think networks

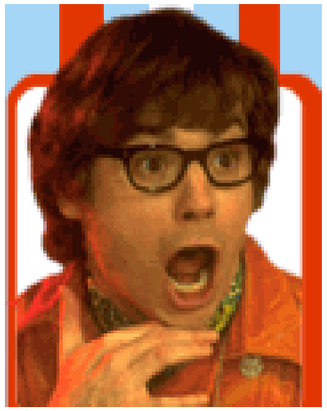
Structural and functional connections in the brain explored by network theory





Family ties between languages





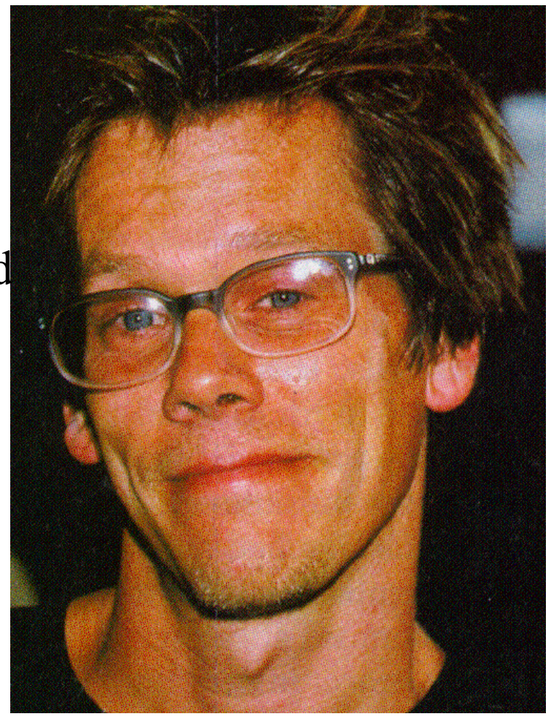
Austin Powers:
The spy who
shagged me

Let's make
it legal

Robert Wagner

Wild Things

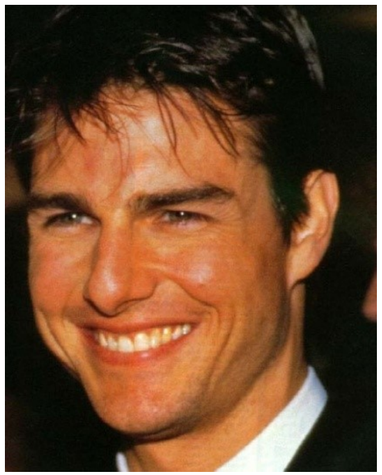
What Price Glory



Barry Norton

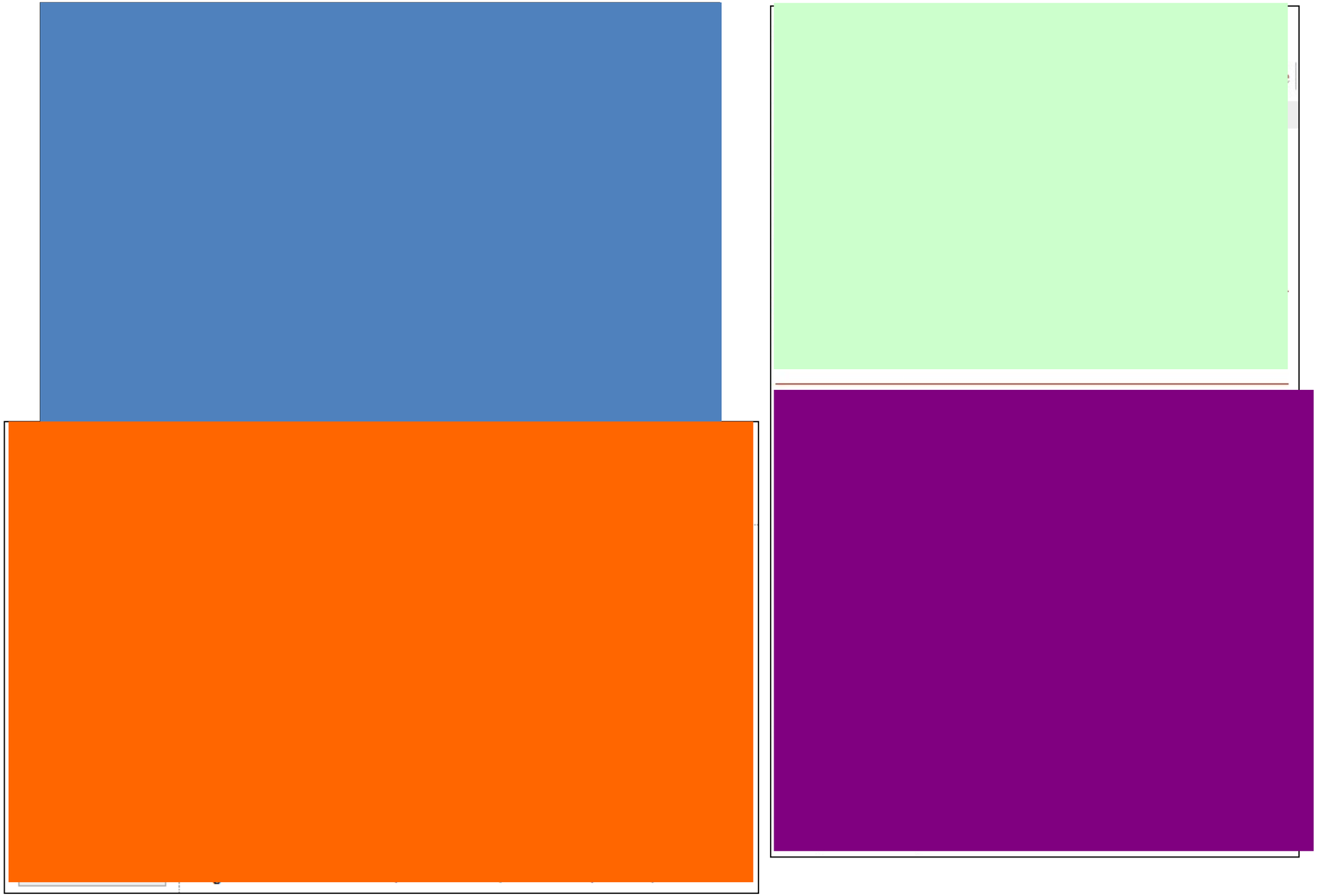
A Few Good
Man

Monsieur
Verdoux



Ackn: Barabási
Albert-László

What is “Six Degrees of separation”?

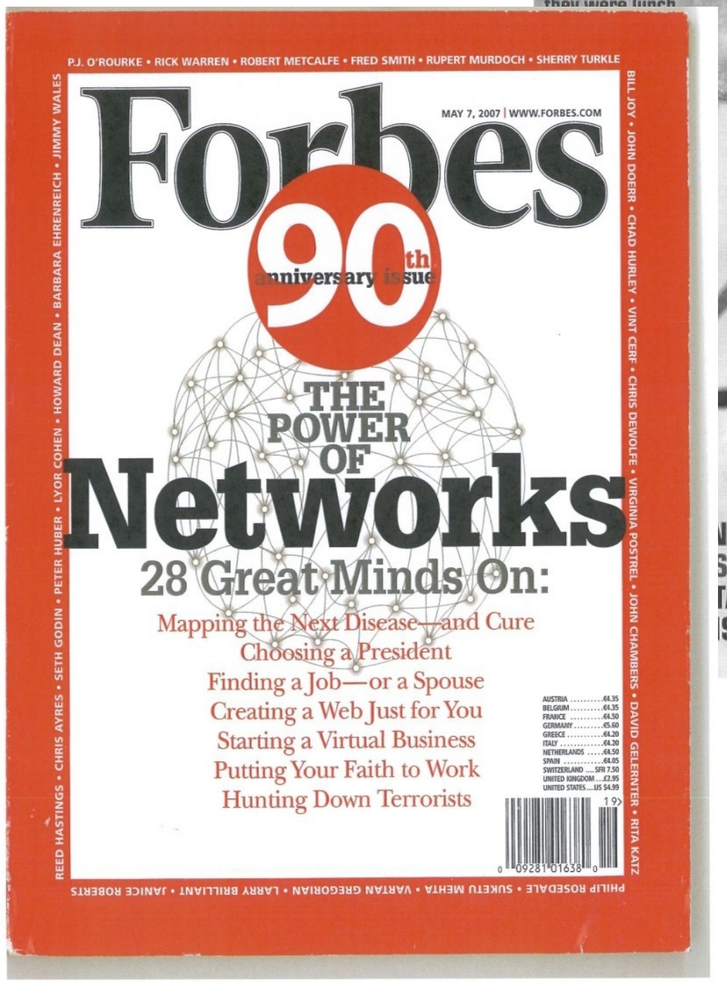


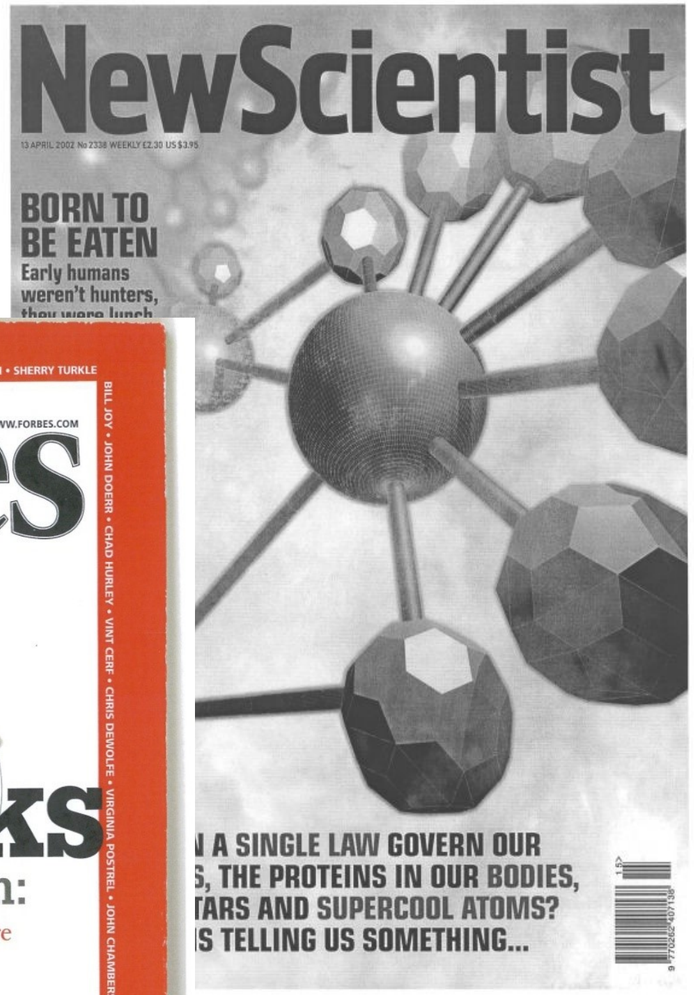
Six Degrees of Separation on BBC2

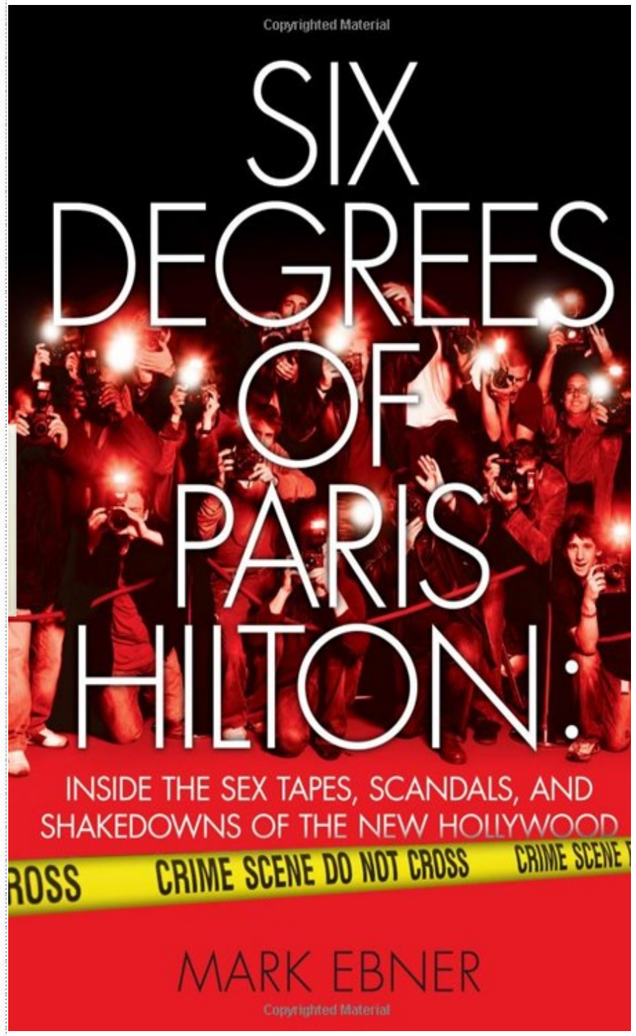
Documentary unfolding the science behind the idea of six degrees of separation. Originally thought to be an urban myth, it now appears that anyone on the planet can be connected in just a few steps of association.

Six degrees of separation is also at the heart of a major scientific breakthrough; that there might be a law which nature uses to organize itself and that now promises to solve some of its deepest mysteries.

Fascination with "Six Degrees of separation"

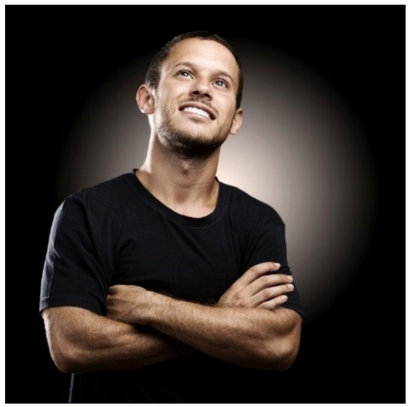


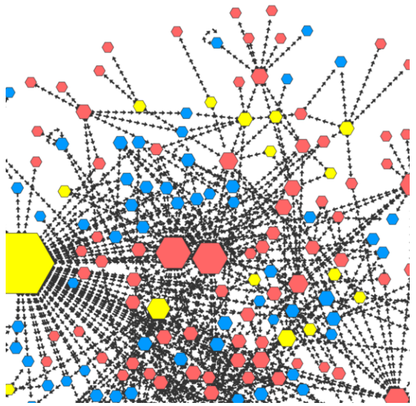
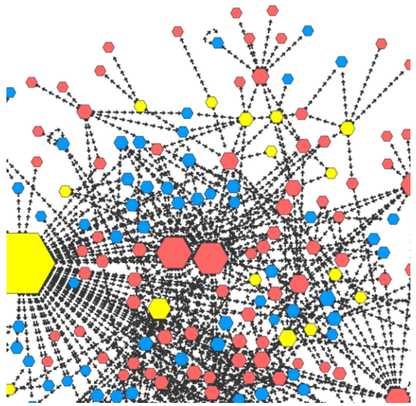
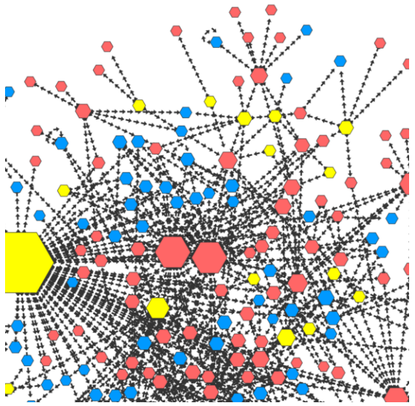
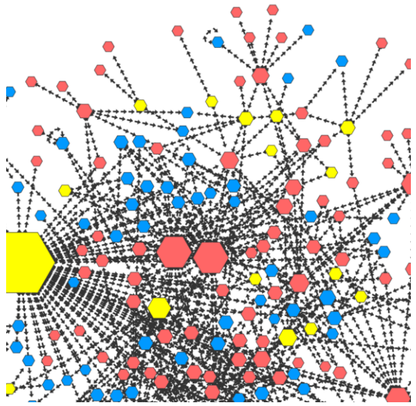




Interwoven networks, frequently of similar structure, at every level of life





https://www.youtube.com/watch?v=3n40IdtCfbA

Globalization – living in increasingly *Small-world-networks*

Friendship-network on Facebook, December 2011

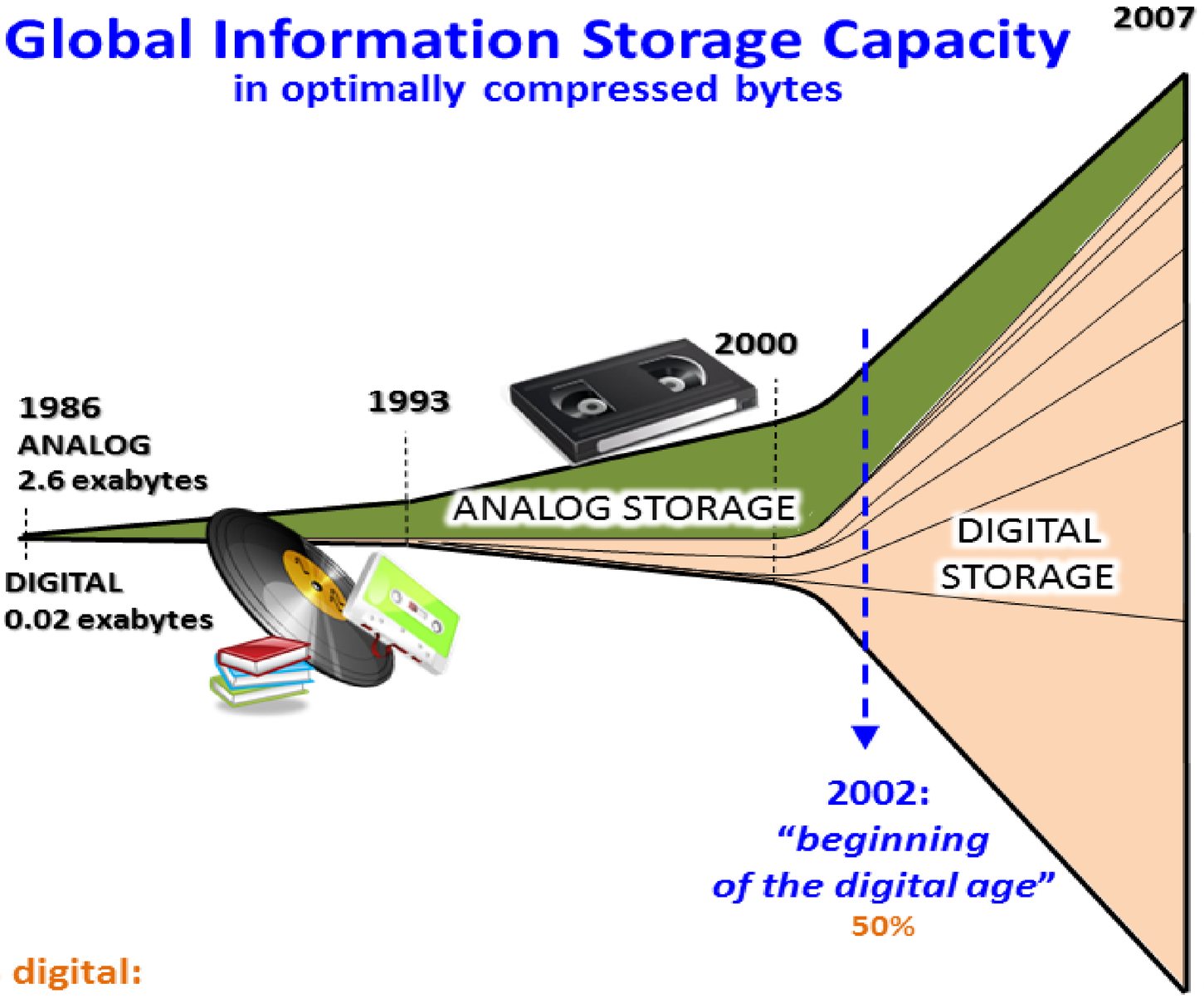
Part 2.

Many interacting constituents

DATA SCIENCE

Global Information Storage Capacity

in optimally compressed bytes



2007 **ANALOG**
19 exabytes

- Paper, film, audiotape and vinyl: 6 %
- Analog videotapes (VHS, etc): 94 % **ANALOG**

DIGITAL

- Portable media, flash drives: 2 %
- Portable hard disks: 2.4 %
- CDs and minidisks: 6.8 %
- Computer servers and mainframes: 8.9 %
- Digital tape: 11.8 %
- DVD/Blu-ray: 22.8 %

- PC hard disks: 44.5 %
  123 billion gigabytes

- Others: < 1 % (incl. chip cards, memory cards, floppy disks, mobile phones, PDAs, cameras/camcorders, video games)

DIGITAL
280 exabytes

Source: Hilbert, M., & López, P. (2011). The World's Technological Capacity to Store, Communicate, and Compute Information. *Science*, 332(6025), 60 –65. http://www.martinhilbert.net/WorldInfoCapacity.html

What is "Big Data"?

Volume
SCALE OF DATA

40 ZETTABYTES
[43 TRILLION GIGABYTES]
of data will be created by 2020, an increase of 300 times from 2005

It's estimated that
2.5 QUINTILLION BYTES
[2.3 TRILLION GIGABYTES]
of data are created each day

6 BILLION PEOPLE
have cell phones

WORLD POPULATION: 7 BILLION

Most companies in the U.S. have at least
100 TERABYTES
[100,000 GIGABYTES]
of data stored

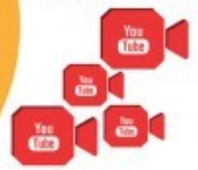
Variety
DIFFERENT FORMS OF DATA

As of 2011, the global size of data in healthcare was estimated to be
150 EXABYTES
[161 BILLION GIGABYTES]

30 BILLION PIECES OF CONTENT
are shared on Facebook every month

By 2014, it's anticipated there will be
420 MILLION WEARABLE, WIRELESS HEALTH MONITORS

4 BILLION+ HOURS OF VIDEO
are watched on YouTube each month



400 MILLION TWEETS
are sent per day by about 200 million monthly active users

Velocity
ANALYSIS OF STREAMING DATA

The New York Stock Exchange captures
1 TB OF TRADE INFORMATION
during each trading session

Modern cars have close to
100 SENSORS
that monitor items such as fuel level and tire pressure

By 2016, it is projected there will be
18.9 BILLION NETWORK CONNECTIONS
– almost 2.5 connections per person on earth

Veracity
UNCERTAINTY OF DATA

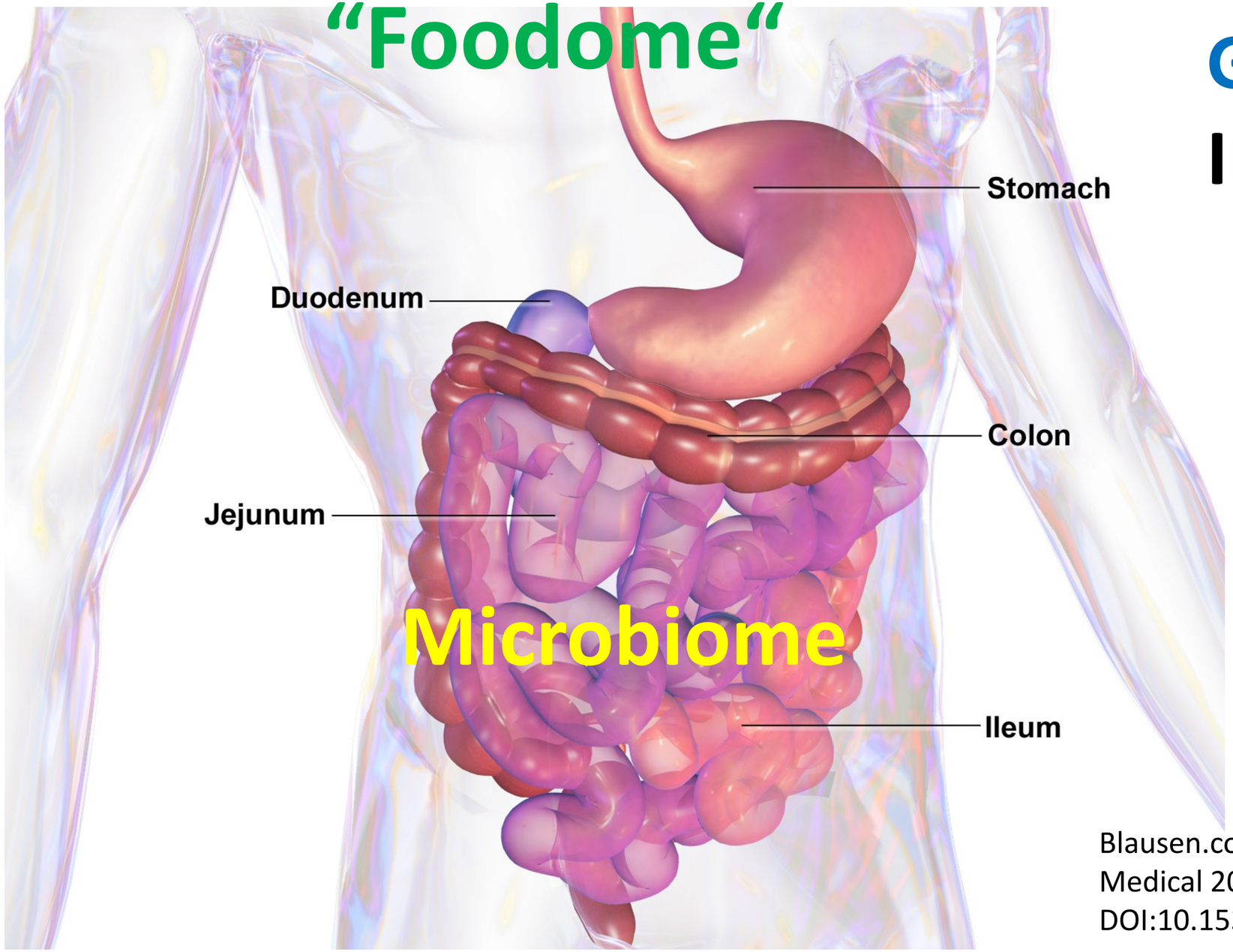
1 IN 3 BUSINESS LEADERS
don't trust the information they use to make decisions

in one survey were unsure of how much of their data was inaccurate

Poor data quality costs the US economy around
$3.1 TRILLION A YEAR

Sources: McKinsey Global Institute, Twitter, Cisco, Gartner, EMC, SAS, IBM, MEPTEC, QAS

IBM



GENOME ➔ IMMUNE SYSTEM

To keep the GIT microbial ecology healthy and stable

For a repository on kinetic behaviour of bacteria, see for example www.combase.cc

Blausen.com staff (2014). "Medical gallery of Blausen Medical 2014". WikiJournal of Medicine 1 (2). DOI:10.15347/wjm/2014.010.

Don’t be fooled by the concept of “average”

An average human has one breast and one testicle…

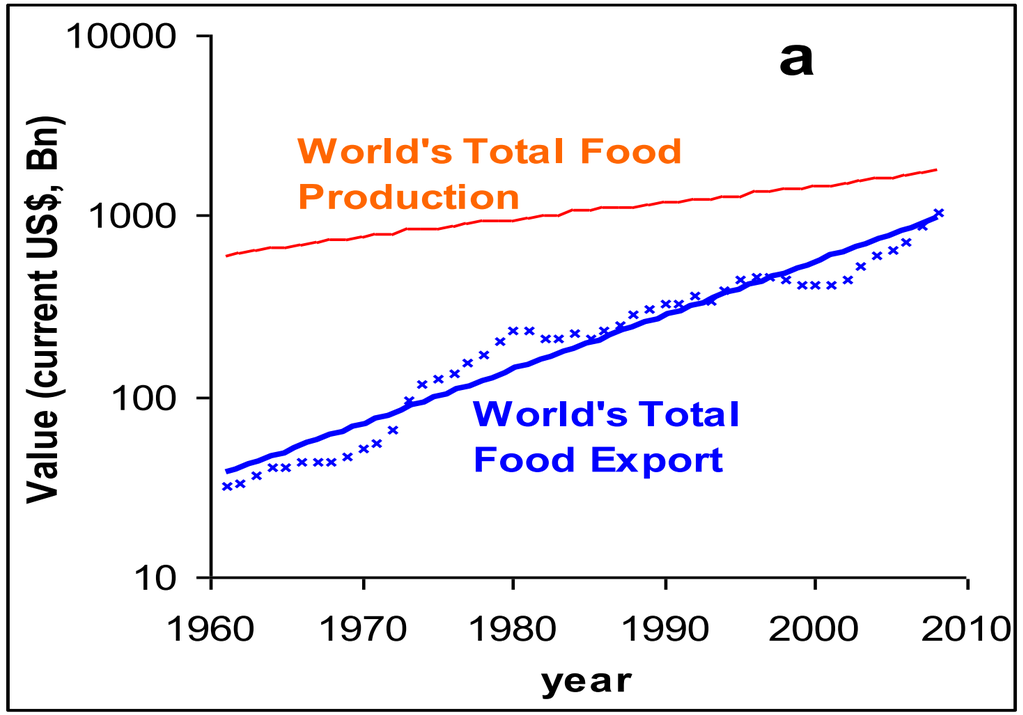
Des MacHale

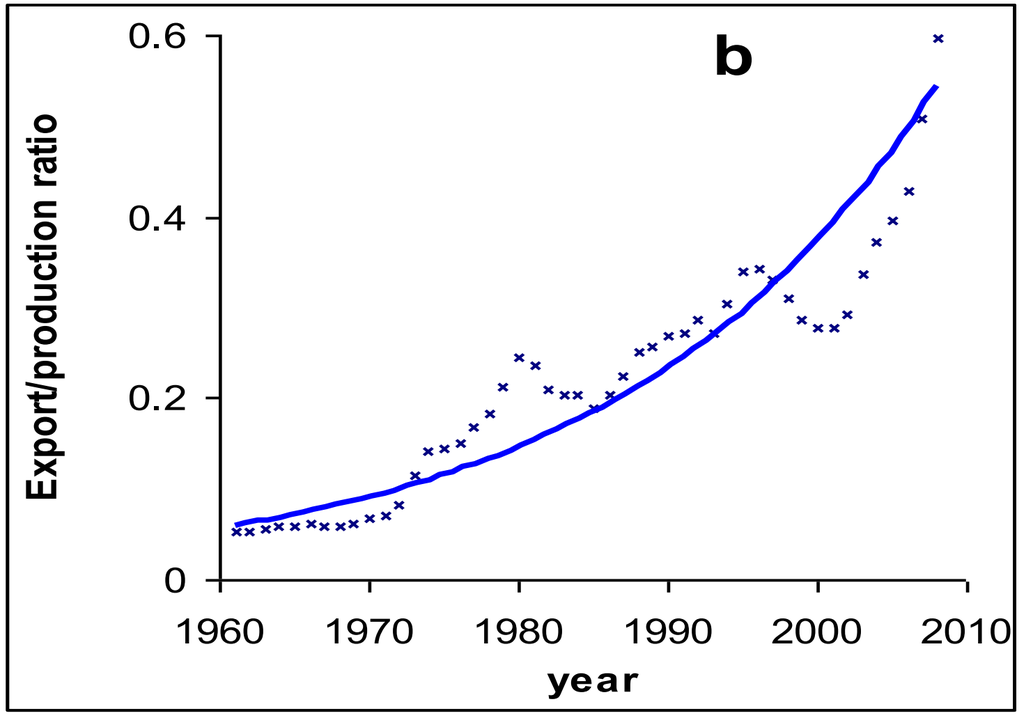
If you put your head in the oven and your bottom in the fridge then your average body temperature should be OK

Unknown

3. Case studies for global complex networks

Exponential growth of the International Food Trade Network (IFTN)

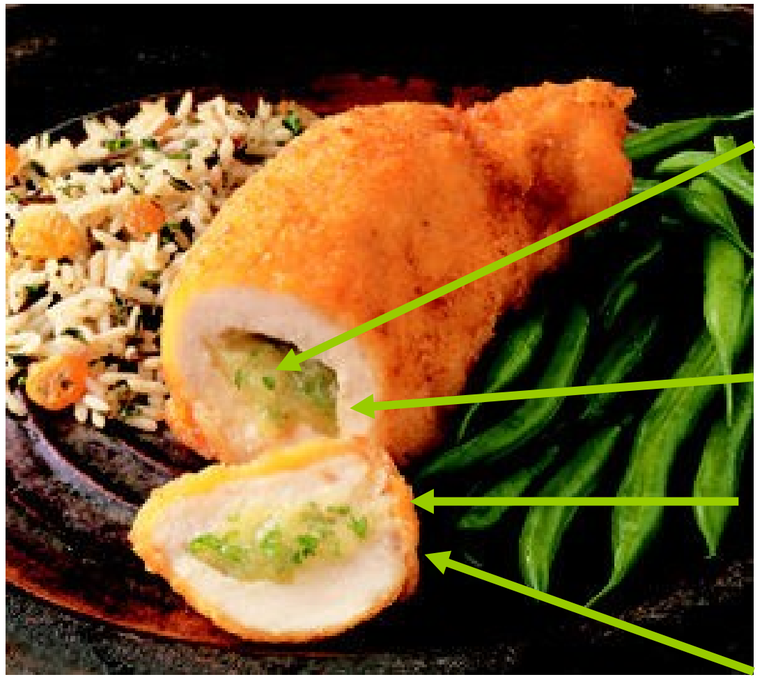




M Ercsey-Ravasz, Z Toroczkai, Z Lakner, J Baranyi (2012); PloS One 7(5) e37810

Globalisation of Food Trade

"The World on your Plate"



Chicken Kiev

Herb Butter:

Salted butter	- Ireland
garlic puree	- China, USA, Spain
garlic salt	- China, USA, Spain
lemon	- USA
parsley	- France, UK
pepper	- India
water	- Ireland

Chicken Breast: Chicken - Ireland, Belgium UK, Thailand etc.

Batter:

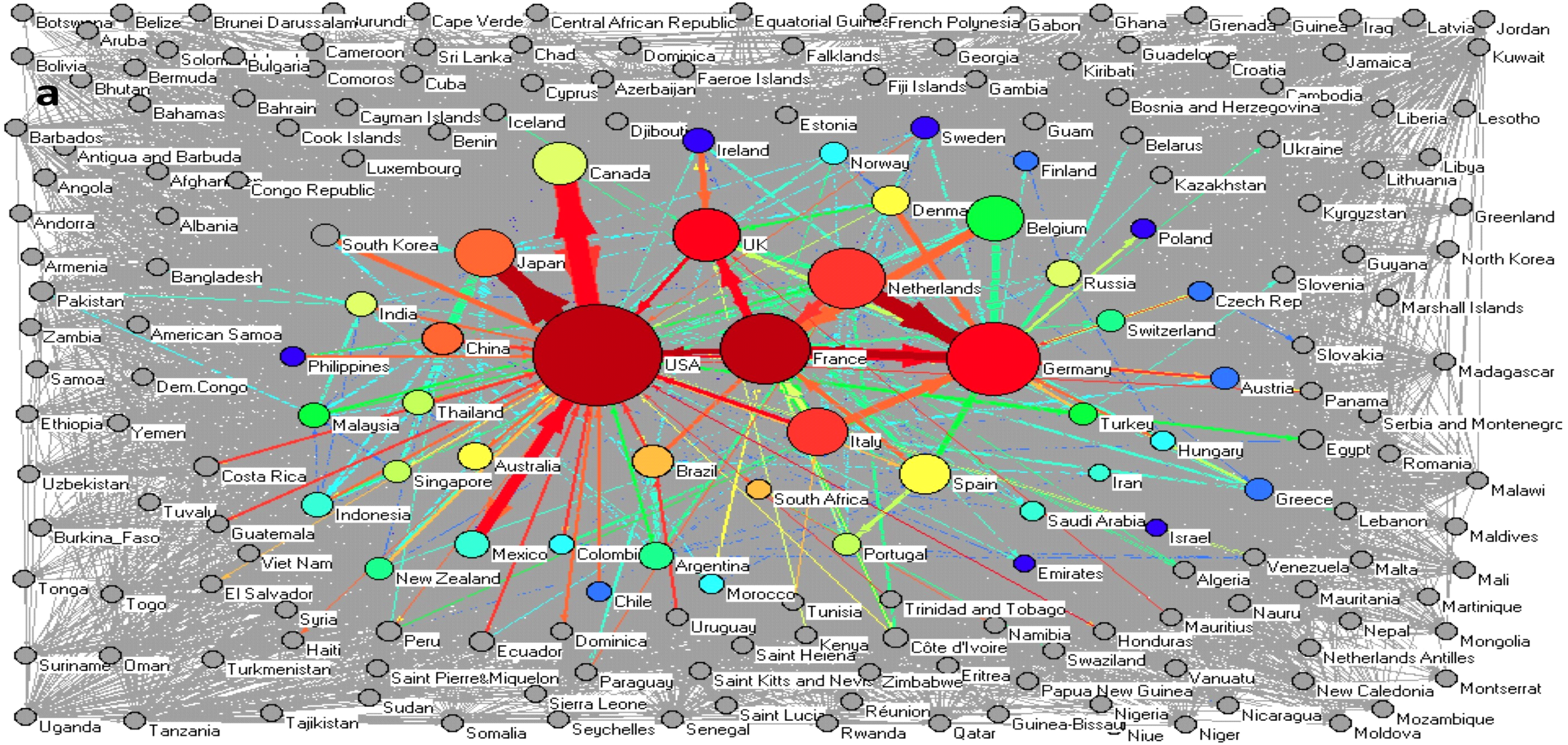
Flour	- Belgium, France
Water	- Ireland

Bread Crumb:

Bread crumb	- Ireland, UK
Rape-seed oil	- EU, Australia Eastern Europe

Alan Reilly, CEO, Food Safety Authority of Ireland

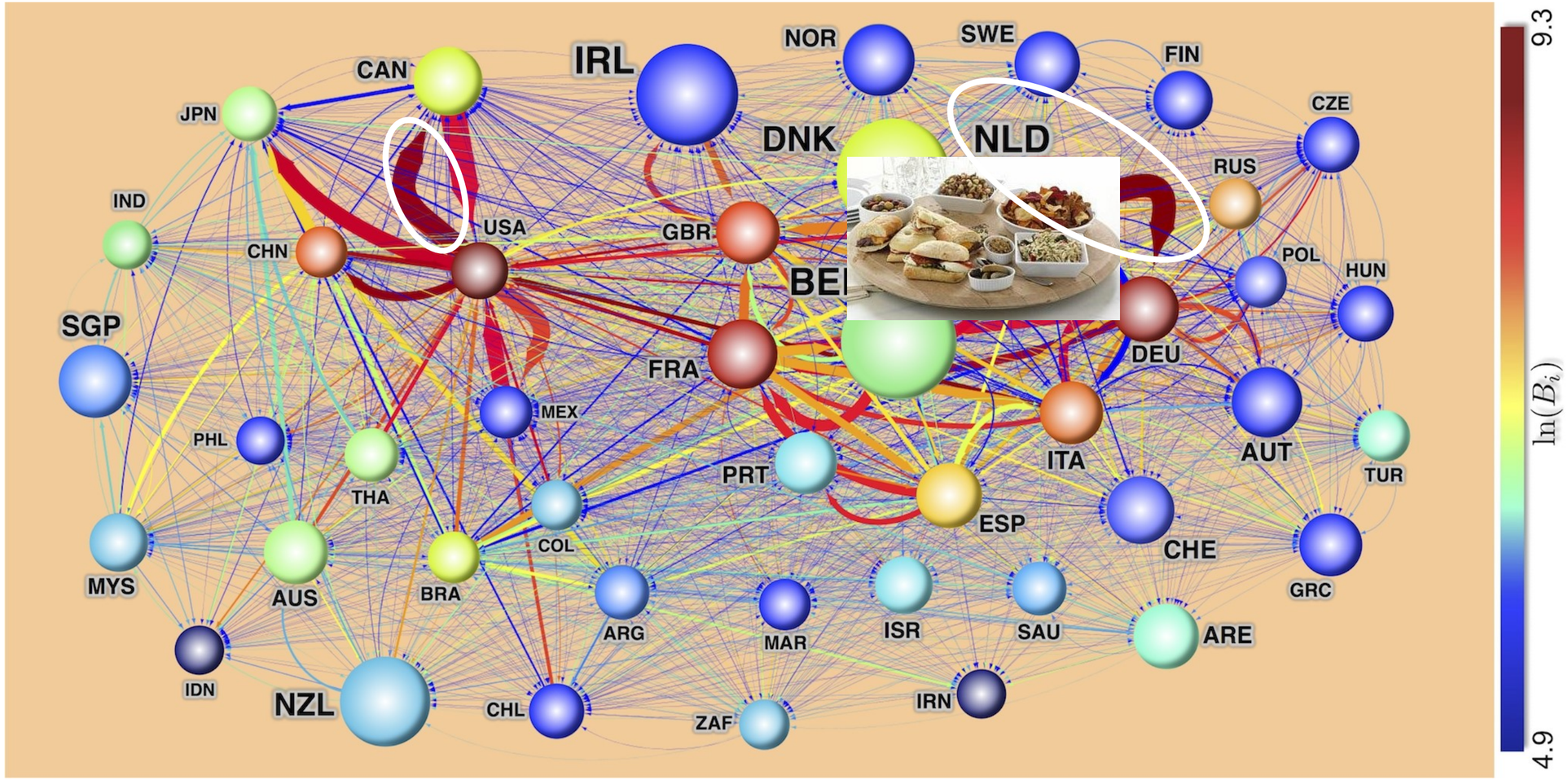
The International Food Trade Network (IFTN)



Size of nodes and thickness of links are proportional to the trade volume.

The hotter the colour the higher the betweennes centrality of the node / link (i.e. the more probable that a trade route between two randomly chosen countries go through it.

Backbone of the IFTN



Size of nodes and are proportional to the trade volume *per agro-food population*.
The warmer the colour the higher the "betweenness-centrality".
The Dutch food business is the "*Lazy Suzanne*" of the world ➔ High responsibility in biotracing.

M Ercsey-Ravasz, Z Toroczkai, Z Lakner, J Baranyi (2012); PloS One 7(5) e37810

A probabilistic framework

Past

Information **(x)** with its probability distribution and mathematical models provide a decision support tool on future events scored by **y**. Predicton on **y** is **g(x)**:

E(g(x)) = E(y)

Present

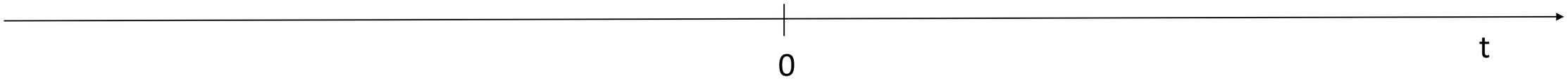
Make a decision to mitigate the effect of a possibly hazardous future event.

Go for which "bet" **b** ?

Future

Uncertainty of the y_i outcomes of a future event quantified the p_i probabilities

$y_1 \ldots y_n$
$p_1 \ldots p_n$



Data, Statistical Analysis

Decision now

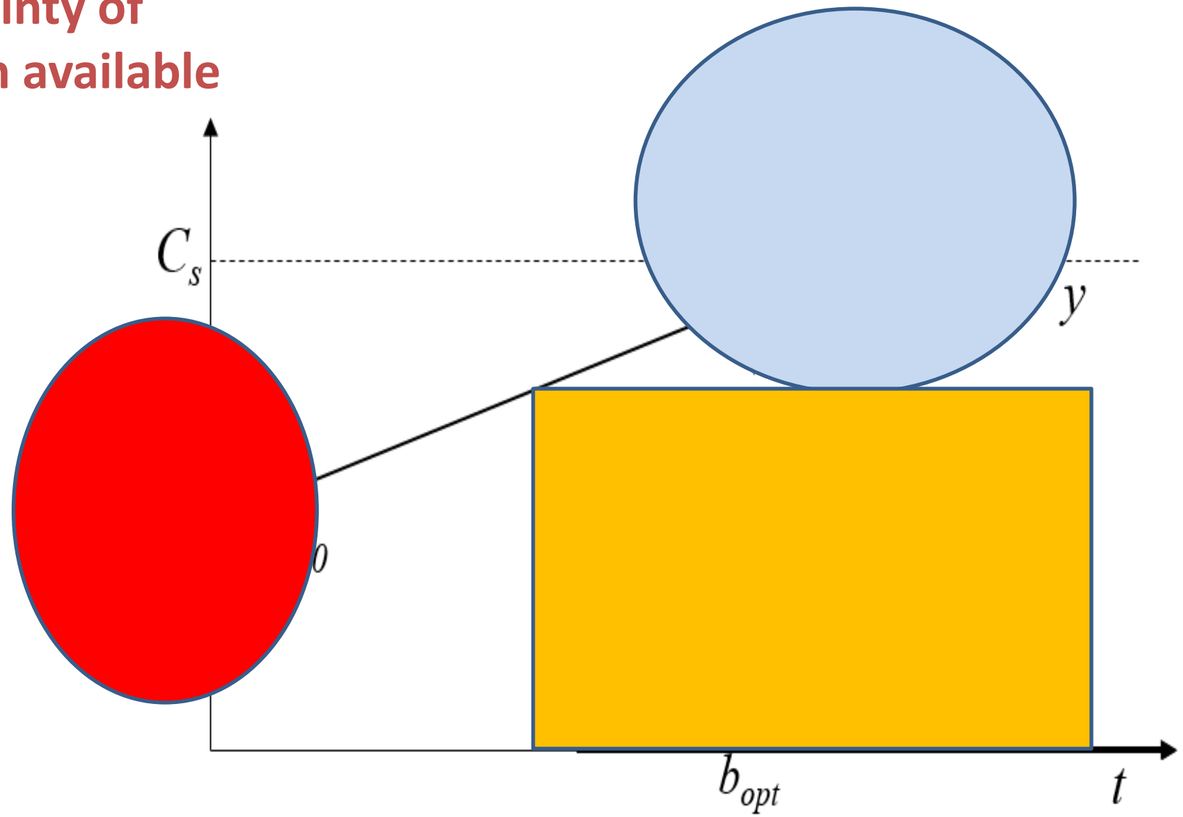
Uncertain event

Go for the **b** bet for which the expected cost of the (**b-y**) discrepancy is minimum

An example: when to take a product off the shelf?

Inaccuracy of the predictor

Uncertainty of information available



Asymmetric cost for prediction error

The nature of cost is different for under- and over-estimations.
Due the structure of cost function the optima are highly sensitive.
➔ Random factors, hitherto unaccounted for, may have more significant effects than the modelled ones do.

Pattern ➔ Law ???

Én fölnéztem az est alól
az egek fogaskerekére –
csilló véletlen szálaiból
törvényt szőtt a mult szövőszéke
és megint fölnéztem az égre
álmaim gőzei alól
s láttam, **a törvény szövedéke**
mindíg fölfeslik valahol.

József Attila: Eszmélet

….
….
from glistening threads of chance
the loom of the past was weaving law…
….
….
Than I saw that the fabric of the law
was always broken by a hole.

Translation: Michael Beevor