Emergence of complexity, from observations to predictions

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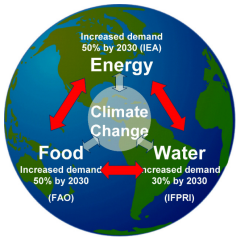
https://publons.com/researcher/2892753/jozsef-baranyi/

Introduction: see the web page

Interconnected world

Global issues - 2030

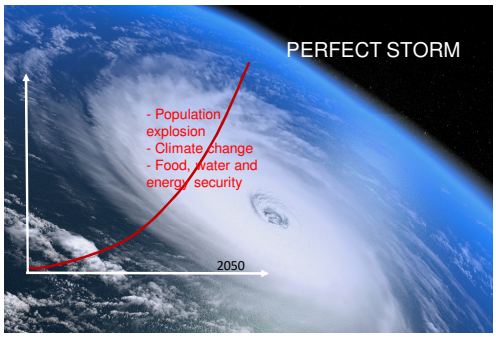


To tackle, make use of
- IT tools explosion
- Network science
- Complexity science
- Multi-disciplinary collaborations

FOOD is especially suitable to utilize progress in the above

John Beddington
UK Government Chief Scientist, 2012

Globalisation: no one is exempt from the effect of others ➔ interwoven, increasingly complex world



If all the main areas are in crises ➔ "perfect storm" as introduced by John Beddington, Imperial College

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)

The presenter being a mathematician shows how mathematical models reflected the most important scientific and social questions during history.
Present: how to describe globalisation, i.e. complex, dense interdependency within a system

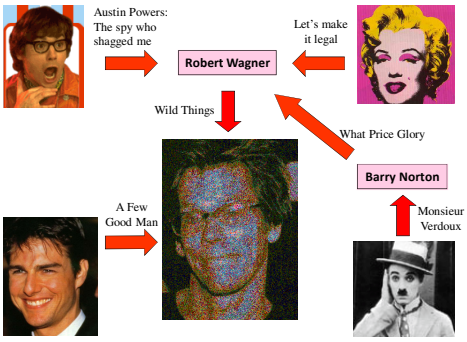
Part 1.

Links and Interactions.

Think networks

Structural and functional connections in the brain explored by network theory

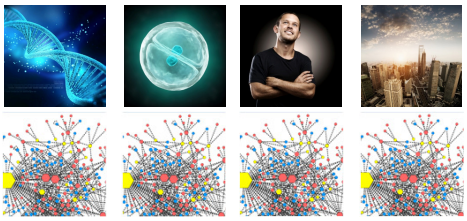
Networks of neurons via axons. Learning: Associations between observations and knowledge. Intellect: ability for non-trivial "far" associations. This appears physically, via long axons to other brain areas



Ackn: Barabási Albert-László

Origin of IMDB movie database: link between actors via movies they played together in.

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

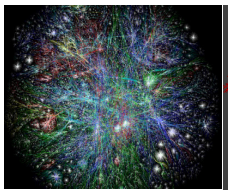


https://www.youtube.com/watch?v=3n40ldtCIbA

Structure (or topology) greatly affects the way how fluxes (signals, materials, information, etc) travel on the network

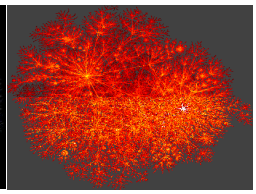
Living in a connected world

Internet connected by routers physically)



Physical links

Web-pages connected by links (URL addresses)



Clicks on web pages

Ackn: Barabási Albert-László

Today more web pages are available than how many persons live on the planet. Big hubs (like Google, Facebook) have decisive role and responsibility.

Globalization – living in more and more "*small-world" networks*

Friendship-network on Facebook, December 2011

Ackn: Barabási Albert-László

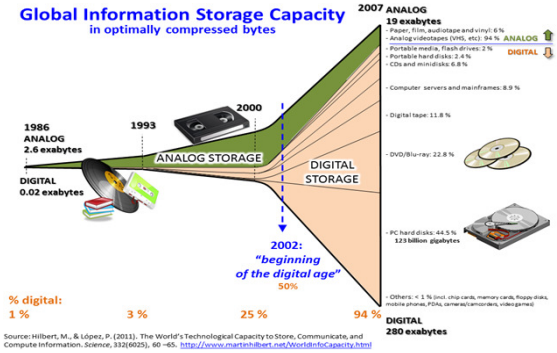
Every user provides ca 5000 data-points to Facebook (e.g. one "like" is one point)

Part 2.

Many interacting constituents

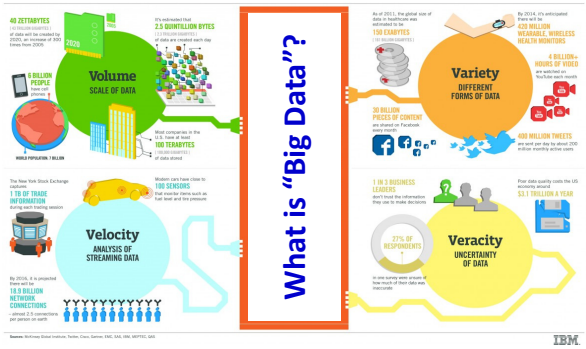
DATA SCIENCE

Global Information Storage Capacity in optimally compressed bytes

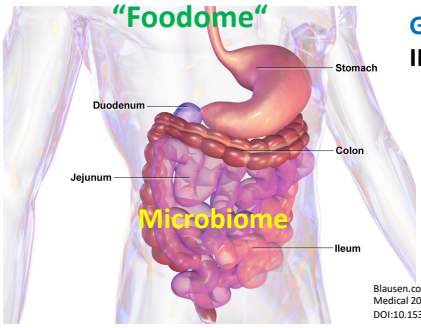


Source: Hilbert, M., & López, P. (2011). The World's Technological Capacity to Store, Communicate, and Compute Information. *Science*, 332(6025), 60 –65. http://www.martinhilbert.net/WorldInfoCapacity.html

Exponential growth on the log scale! More data in 2 days than the total produced until 2000



Big Data defined by four V-s.

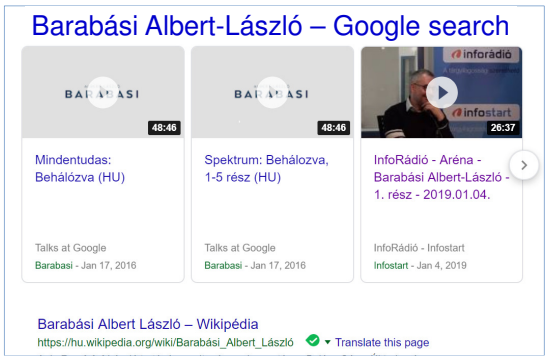


GENOME ➔
IMMUNE SYSTEM
To keep the GIT microbial ecology healthy and stable

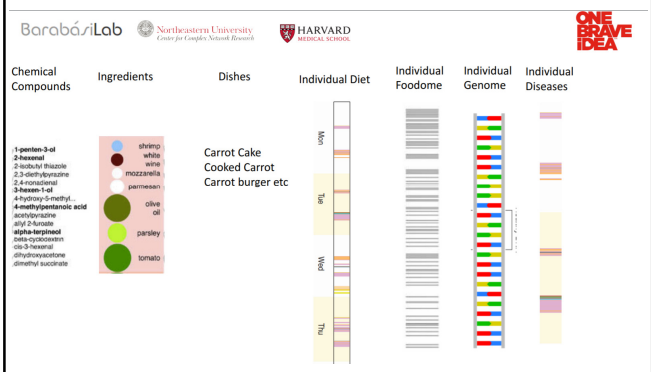
For a repository on kinetic behaviour of bacteria, see for example www.combase.cc

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

Health defined by Genome – Microbiome – External exposure, especially Food. The "Foodome" big data project needs a PhD student!



The Foodome PhD project gives an opportunity to collaborate world-class scientists



One Brave Idea: collaboration between prestigious institutions.

THESIS TOPIC PROPOSAL

"Big Data" and computational nutrition for healthy diet

Institute: **University of Debrecen**
Doctoral School of Nutrition and Food Sciences

Thesis supervisor: **József Baranyi**

Apply on https://doktori.hu/index.php?menuid=195&lang=HU&tk_ID=165404

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

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

Randomness can produce pattern and law – but the law sooner or later (randomly!) breaks down

3. A case study for global complex networks

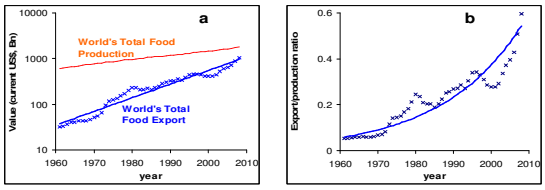
What is a complex network?

A pizza is not "***complex***", just ***heterogeneous***.
(Complex) network may arise when **LINKS** are defined between its ingredients.

LINKS can be:
- **Physical** interactions (texture);
- **Biochemical** relations (flavour / health)
- **Economic** relations (transport / price / etc)

Complexity emerges when the links between the constituents of a system is more numerous and in some way more important than the constituents themselves.

Exponential growth of the International Food Trade Network (IFTN)



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

The world's food production doubles in ca. 30 years, while the amount of food transported on the IFTN increases by ca. 10-fold in the same time. Food ingredients arrive from a fast increasing number of countries at the consumers, shown by the exponentially increasing [world export] / [world production] ratio.
Note that the US$ inflation rate has no effect on the ratio. Data downloaded from UN databases (ComTrade).

Globalisation of Food Trade

"The World on your Plate"

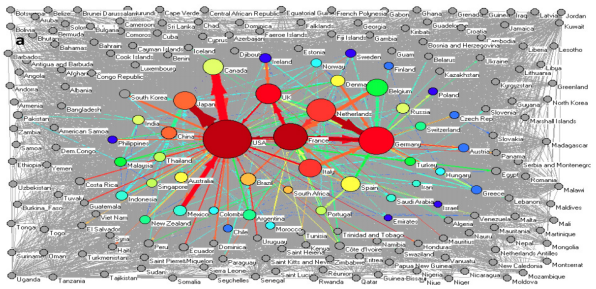
Chicken Kiev

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

Inspiration: an article in HVG, a Hungarian economic weekly.
On average: 1. ca every 2nd molecule we eat comes from abroad. 2. It takes ca 2000 km to arrive from farm to table

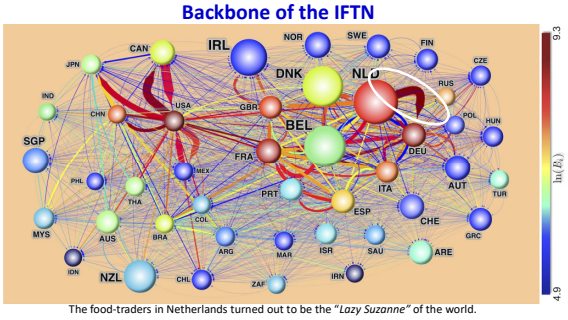
The International Food Trade Network (IFTN)



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.

Betweennes centrality of a country: the chance that it is a (possibly inadvertent) "middle-man" between two other countries, The higher this index (the more towards the red on this heat-map) the bigger is the responsibility of the country in the global food network.

Backbone of the IFTN



The food-traders in Netherlands turned out to be the "*Lazy Suzanne*" of the world.

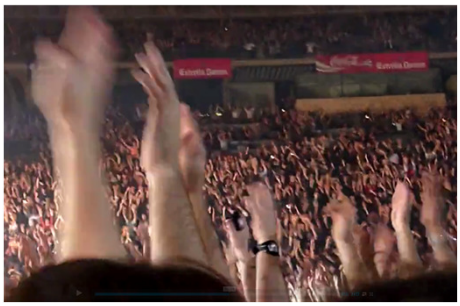
M Ercsey-Ravasz, Z Toroczkai, Z Lakner, J Baranyi (2012); PloS One 7(5) e37810

To eliminate the effect of the sizes of the countries, divide the food amounts by the size of the respective agri-food population. Result: In Europe, the Dutch and German agri-food population has the biggest responsibility in the food network, and the traceability is the most difficult there. Compare this result with the fact that the source of the 2011 E-coli outbreak in Germany, causing the death and serious illness of 50 and 3000 people, was caused by sprout that was impossible to trace for three weeks. Today we know that the deadly bug was in the sprout seeds imported from Egypt by the Netherlands.

Part 4.

Emergence and decisions

Iron-clap: a synchronisation within the network.



Waving on the music: another synchronisation. To make sure that the whole crowd is left-right (and nobody is right-left) waving is not easy. Explanation: with the clap we adjust to only a few other neighbours but with waving we try to adjust to much more.
Also in society: it's easier to control people who do not look too far → populism is relying on less educated people

A framework for decision making

Observation → Prediction

Past	Present	Future
OBSERVATIONS, EXPERIMENTS SYSTEMATIC DATA COLLECTION	PATTERN RECOGNITION, STAT / MATH MODEL DEVELOPMENT	LEARNING FROM DISAGREEMENT BETWEEN PREDICTION AND REAL OUTCOME
Statistical Analysis	Modelling, Risk analysis	Decision making

0 — time

Predictions are based on our current knowledge and on (mathematical) models. A model is not only a set of formulae, but rather of certain logical rules. We do not necessarily make decisions according to the expected outcome, but try to minimize the cost that the outcome more or less but inevitably differ from the prediction.

Cognitive influence:

Bigger choice delays decisions

Shop 1:
6 options

Shop 2:
24 options, refinements of the other 6 items

Customers spent more time here but spent less

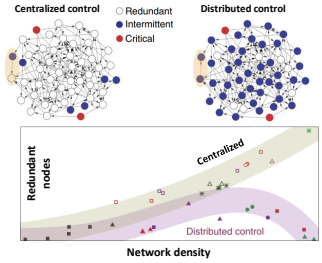
Decision is faster and more robust on smaller number of choices.

Fear of not having made the “best” decision increases the perception of cost

Barry Schwartz: Paradox of choice

We are not happy with “good enough” outcomes, we want the “best”.

From centralized (stress management) to distributed (growth-centred) control



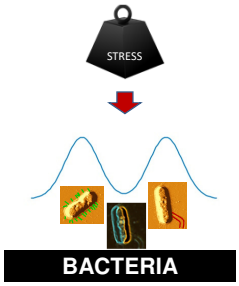
All studied directed complex networks with sufficiently high density show *BISTABILITY*.

The centralized and distributed control states can flip into each other by changing just a few edges.

Jia et al (2013). Nature communications

Bi-stability: two distinct strategies to cope stress: Centralized control (like military dictatorship to solve a crisis) and distributed control (typical of growth-centred environment) with many non-vital nodes (e.g. infrastructure).

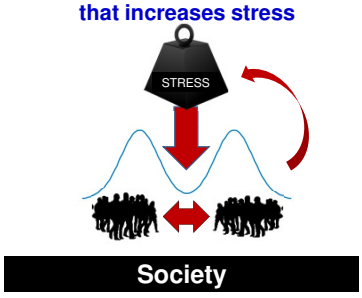
Stress and segregation



http://www.tedxdanubia.com/tedx-videok/a-bakteriumok-kozgazdasagtana:-baranyi-jozsef-at-tedxdanubia-2014

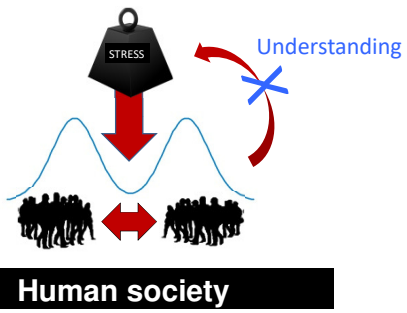
Analogy: Bi-stabilty emerges for bacteria under stress; in this case salmonella divides into two subpopulations, one with the other without flagella. THERE IS NO MUTATION, the bifurcation happens at gene-expression level!

Ignorance generates an autocatalytic process that increases stress



Bridges are needed

Society does the same: stress triggers segregation. However, opposing to bacteria, here the separated subpopulations turn against each other, increasing the stress. Which, in turn, further deepens segregation, etc. The feed-back generates an autocatalytic process, leading to wars and misery.



At least to prevent the escalation, we need to understand the process. So we do not increase the stress. Understanding is a pleasure (see the Richard Feynman on the “Pleasure Of Finding Things Out” - https://www.dailymotion.com/video/x6ptg1x).

…
If you can trust yourself when all men doubt you,
But make allowance for their doubting too…
(Rudyard Kipling: If …)

“… ha kétkednek benned, s bízol magadban, de érted az ő kétkedésüket…”

(Translation: Dezső Kosztolányi)