The Elusive Quest for Questions

Einstein is reported to have said that if he only had one hour to solve a problem he would spend 55 minutes defining the problem and the remaining 5 minutes solving it

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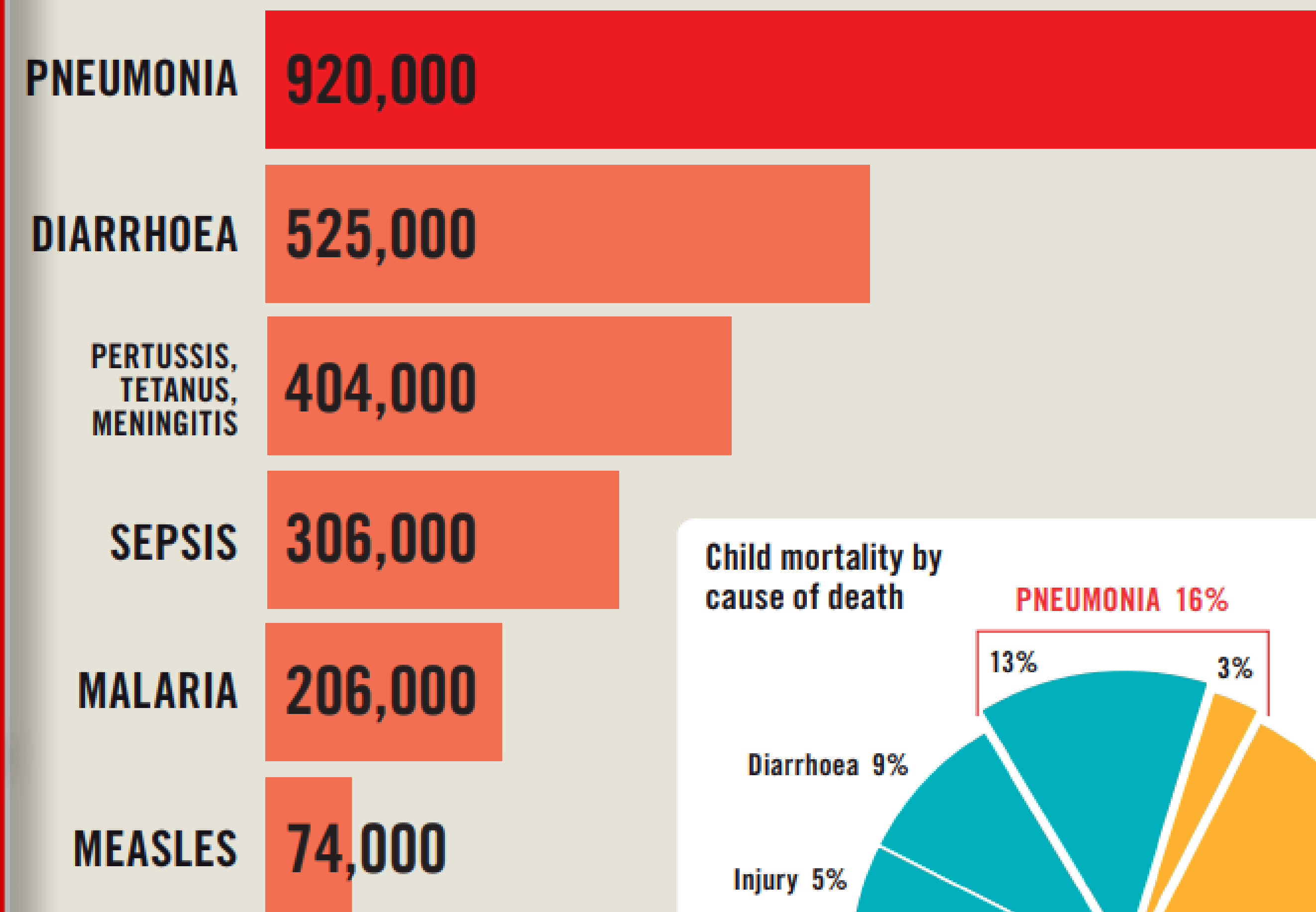
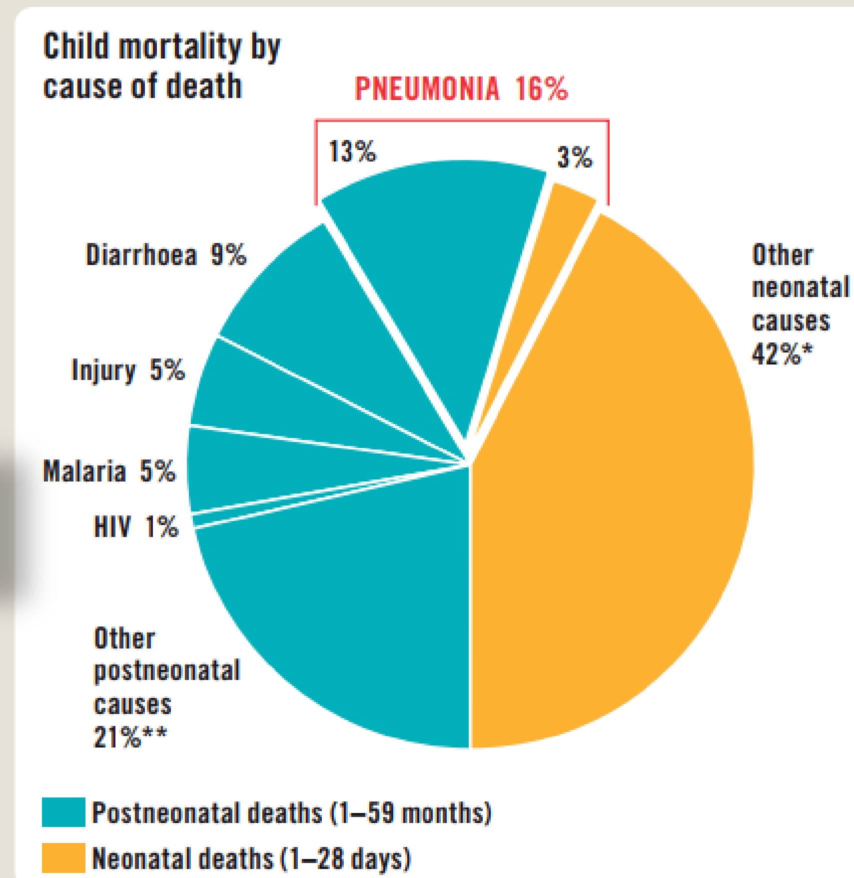
Apocryphal: https://quoteinvestigator.com/2014/05/22/solve/

Deaths due to infectious diseases: Children under 5 (2015)

CHILDREN under 5



2.5 million / year



* Neonatal causes include preterm, intrapartum related events, sepsis/meningitis, tetanus, congenital and diarrhoea

** Postneonatal causes include preterm, intrapartum related events, meningitis, tetanus, congenital and pertussis

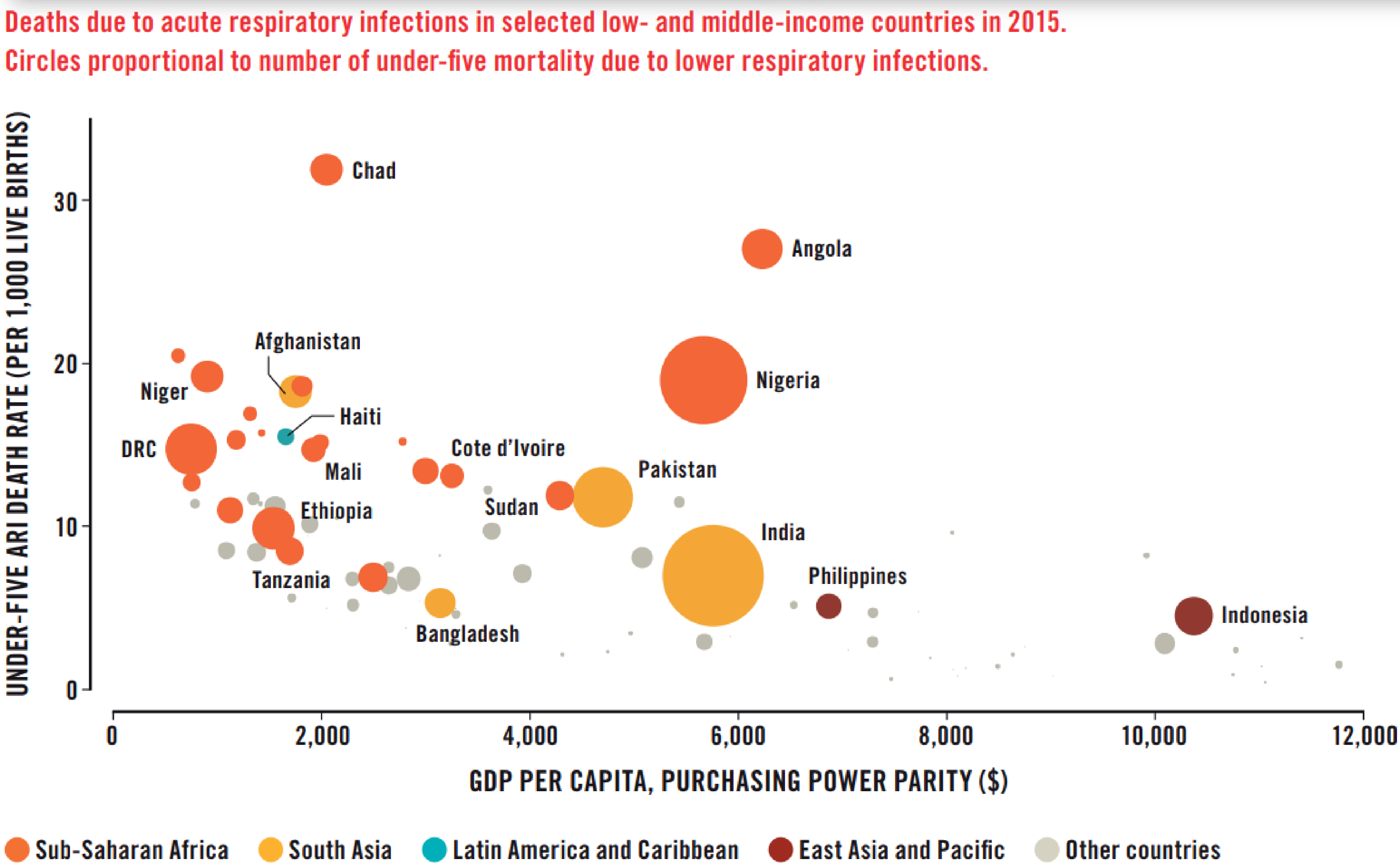
Data: World Health Organization, Global Health Observatory data repository, Liu L, Oza S, Hogan D, et al. (2016) *The Lancet*, **388**, 10063, p3029

www.savethechildren.org.uk/content/dam/global/reports/health-and-nutrition/fighting-for-breath-final-low-res.pdf

Question
Sense and Convergence

I don't know any answers but one clue is data fusion

Is ↑income linked to ↓pneumonia death?



www.savethechildren.org.uk/content/dam/global/reports/health-and-nutrition/fighting-for-breath-final-low-res.pdf

Imperative to frame, define and ask the correct questions

Answers depend on questions, what we sense, converge

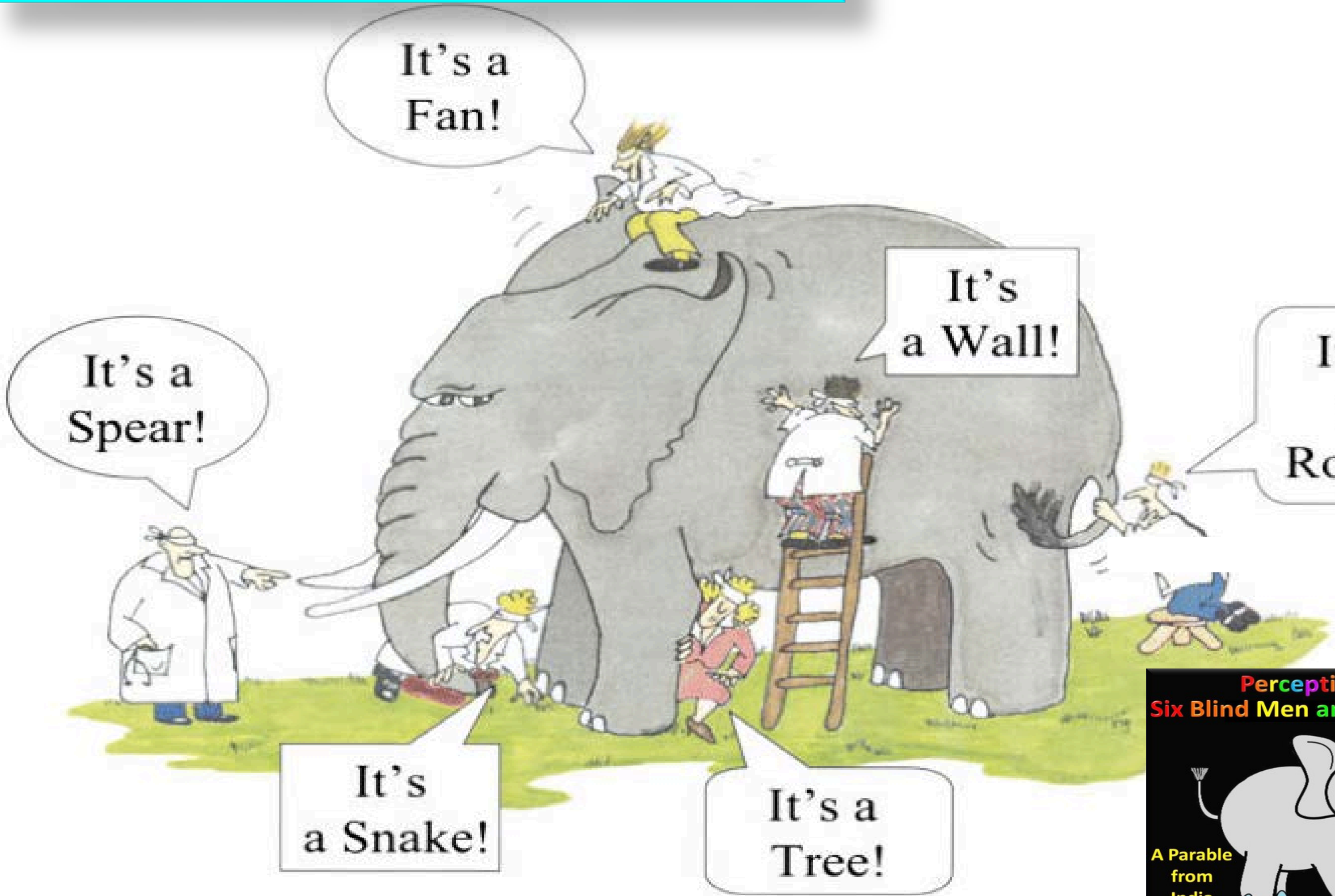
Pneumonia risks are skewed towards poor children, but health system provision is skewed towards wealthier children.

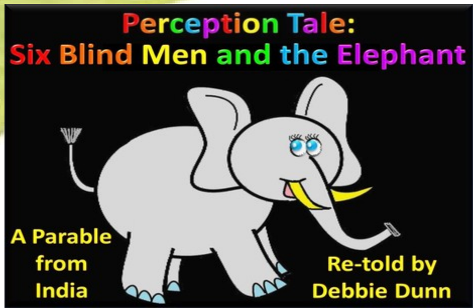
- Severe malnutrition multiplies the risk of pneumonia death by a factor of four compared with adequately nourished children. The 52 million children in the world who are wasted (below the appropriate weight for height) face grave risks.
- Pneumococcal vaccines (PCVs) could prevent the overwhelming majority of bacterial pneumonia cases, but 170 million children in developing countries are unimmunised.
- Weak health infrastructures and, especially in middle-income countries, the high costs of PCVs may limit coverage and cost lives.
- One-third of children with pneumonia-like symptoms do not seek appropriate care.
- Antibiotic treatment could prevent 70% of pneumonia deaths at an average cost of just 40 US cents – but antibiotic treatment is frequently either unavailable or not provided.
- Diagnostic and treatment failures are widespread, with late detection of hypoxaemia – the cause of 1.9 million hospital admissions for children annually – a major concern.

www.savethechildren.org.uk/content/dam/global/reports/health-and-nutrition/fighting-for-breath-final-low-res.pdf

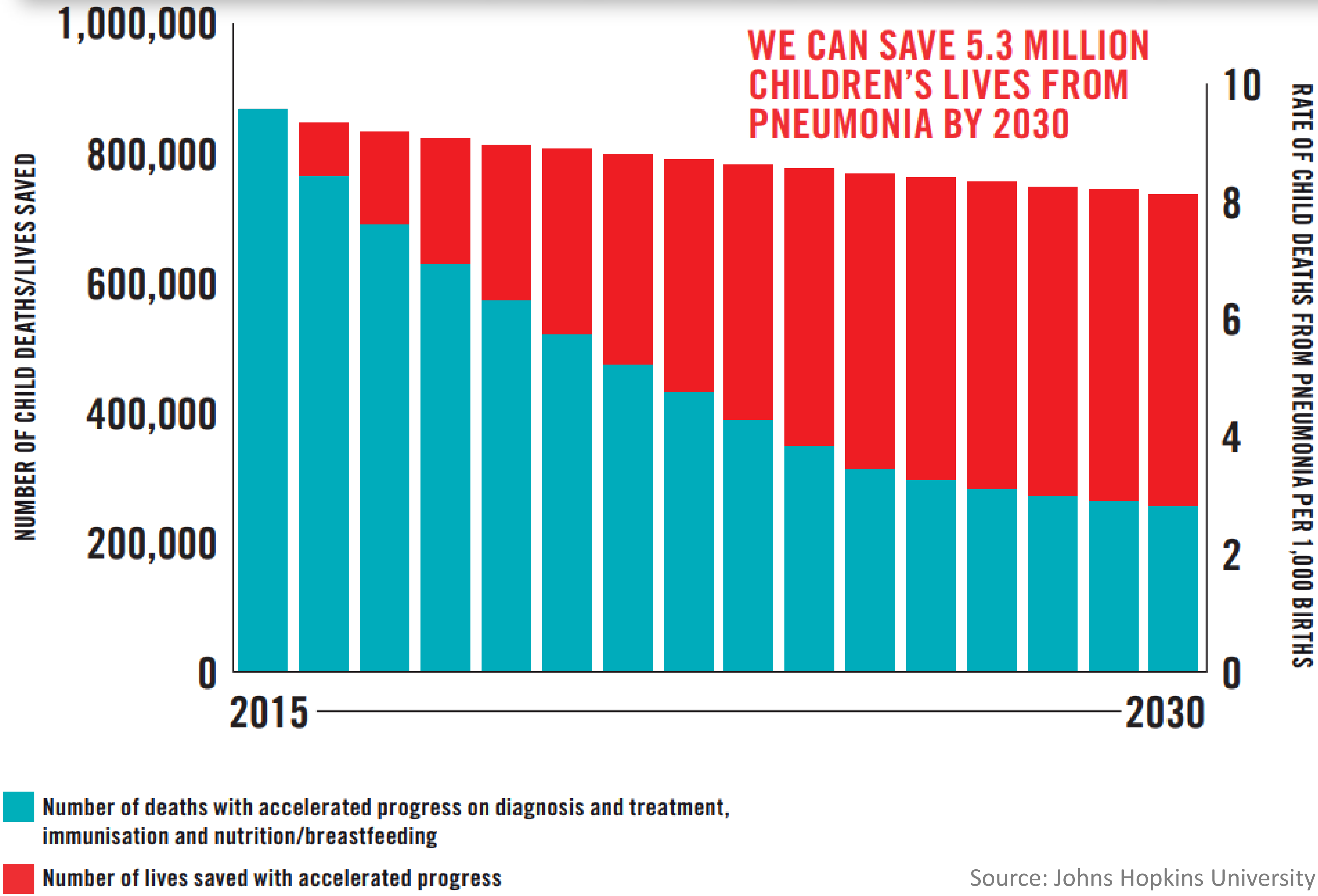
CONVERGENCE BY DESIGN
RISK POOLING COMPONENTS
MODULAR SYSTEMS ARCHITECTURE
INTEROPERABLE VARIANT CONFIGURATION

Children's story based on an Indian folk tale dating back at least 2000 years. Offers insight into what happens if the systems view of a problem is ignored. Six men who are very knowledgeable are blind. They encounter an elephant and each gives his analysis of the 'system' based on the particular part of the elephant (system) they happen to touch. Each is partly right since they have made contact with one major subsystem. However, they are wrong because in their blindness they failed to comprehend the system as a whole. Often in CPS the limited perspectives (embedded systems, communication, physical Plant) of individual domains may lead to failure for as a whole (integration).





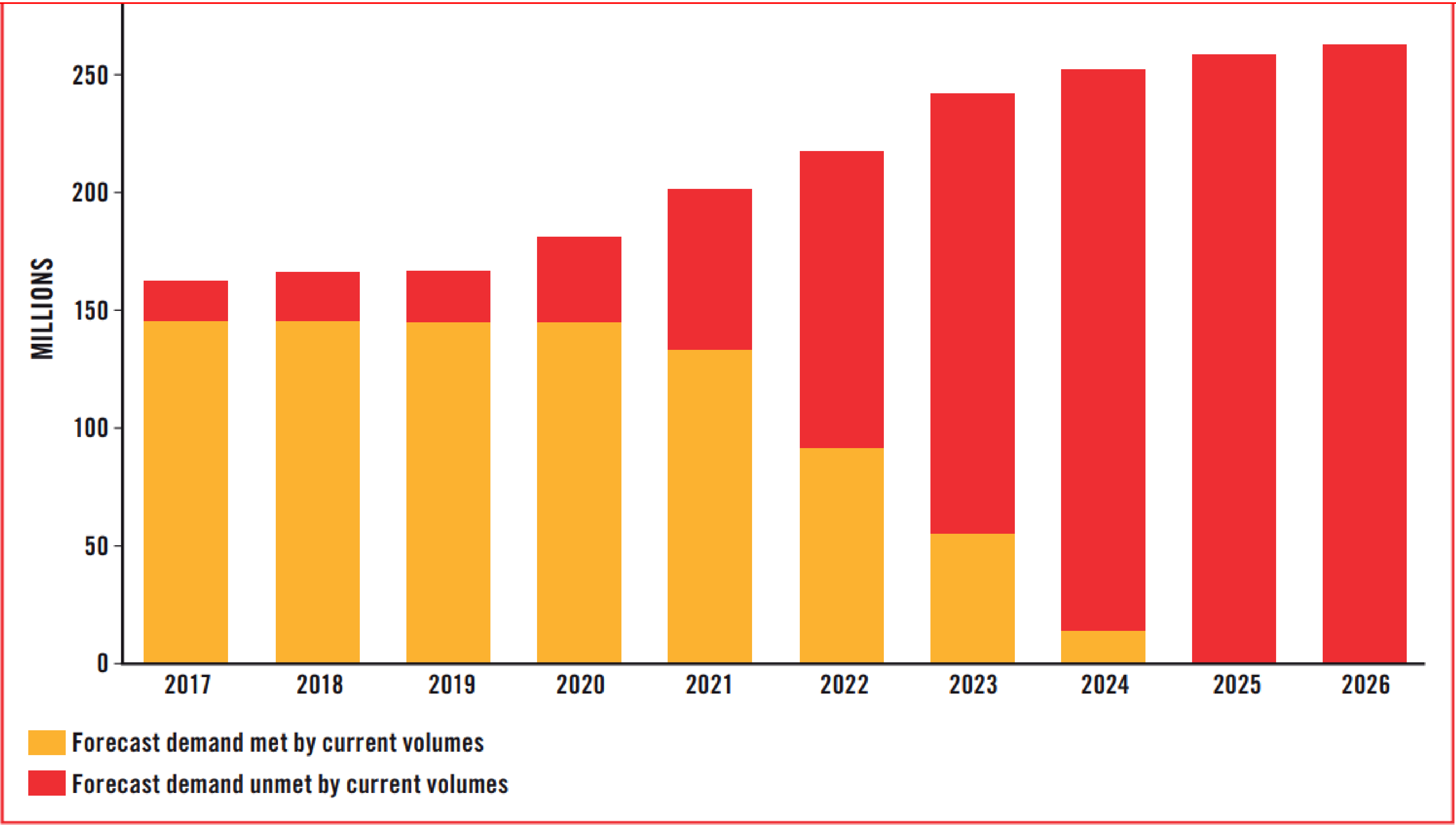
Is this prediction deliberately obsequious or desperately oblivious of the problems?



Source: Johns Hopkins University

Pneumococcal conjugate vaccine: supply vs demand

1 million children (under 5) dying each year due to Pneumonia



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Detecting or sensing or predicting the disease

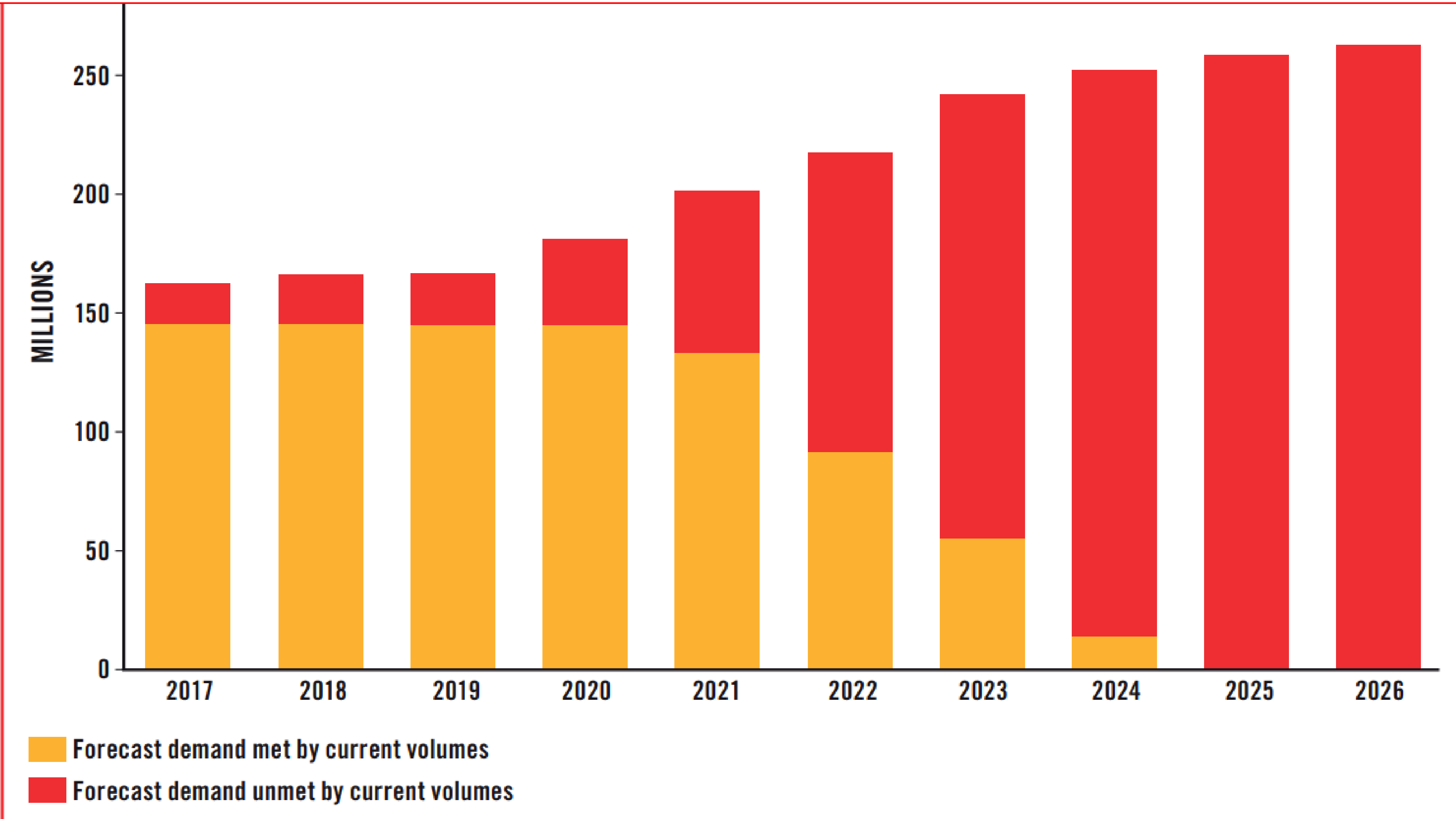
Data may not help the children – it is death due to the economy

Think Different

Apply Systems Thinking to Problems for Real-World Connected Solutions

Pneumococcal conjugate vaccine: social business op?

1 million children (under 5) dying each year due to Pneumonia



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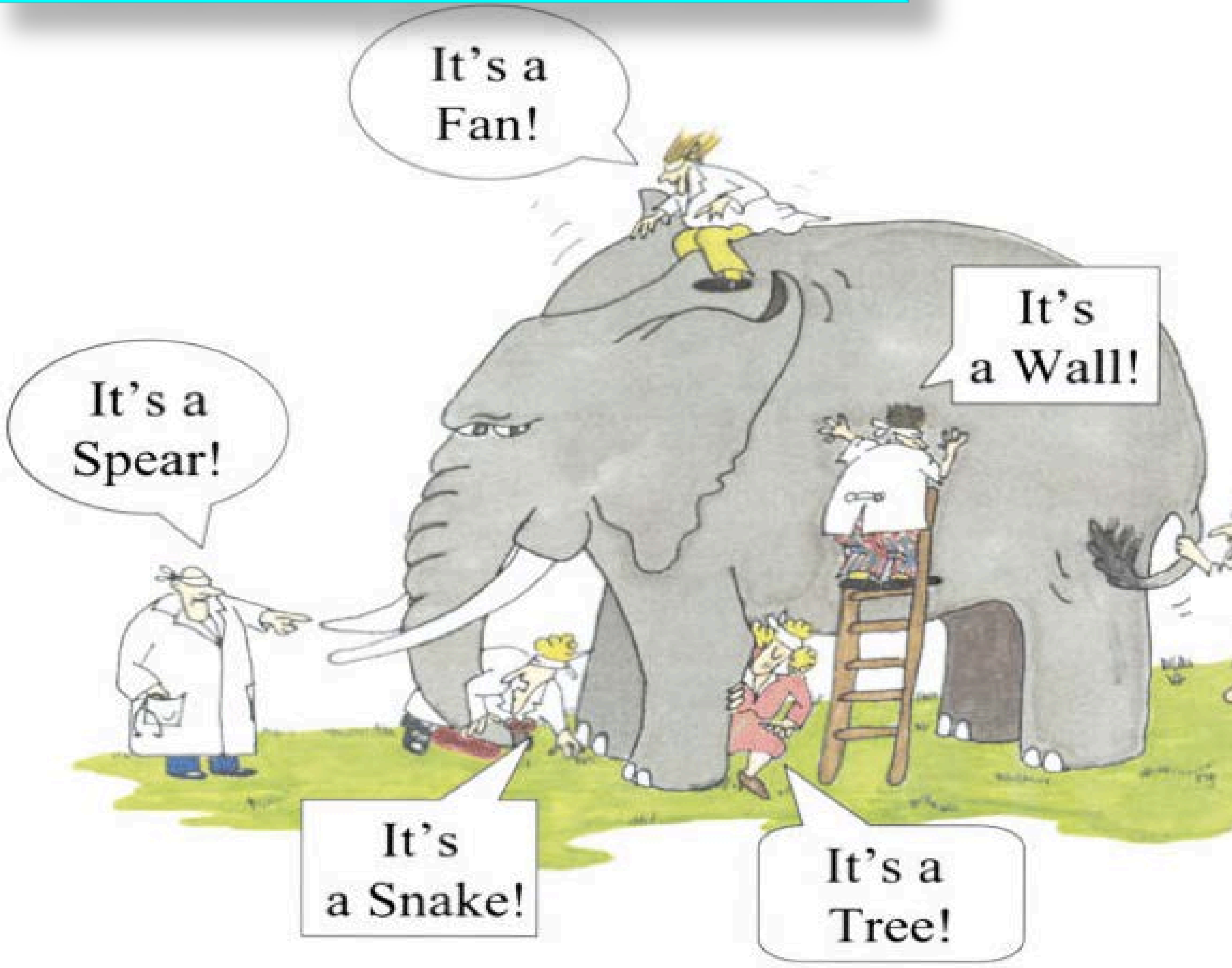
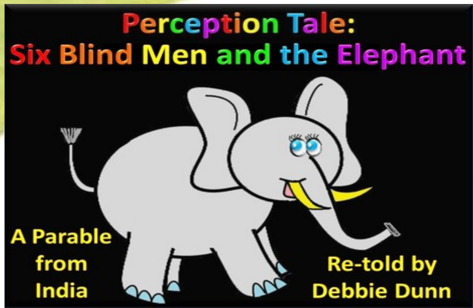
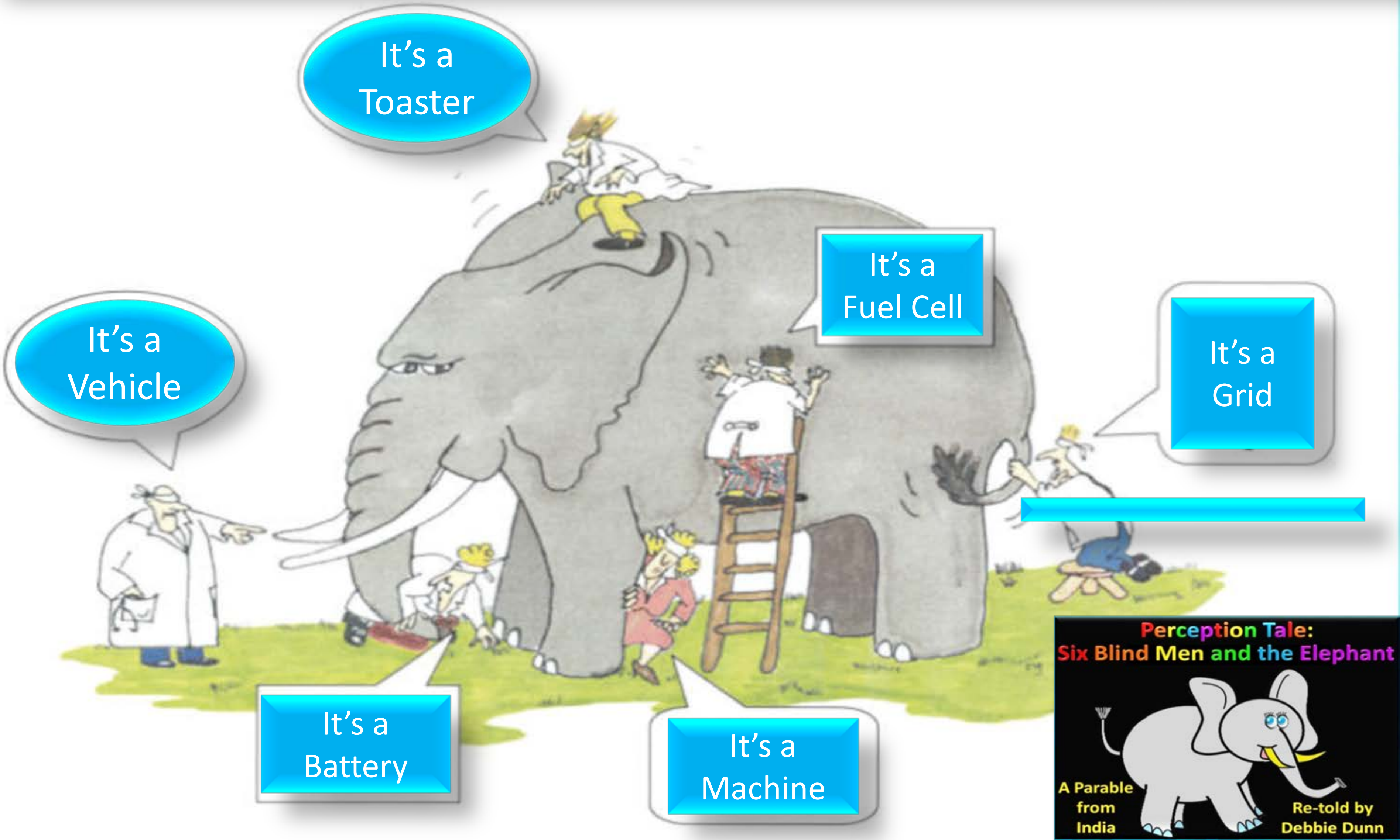




ENERGY in SYSTEMS DESIGN



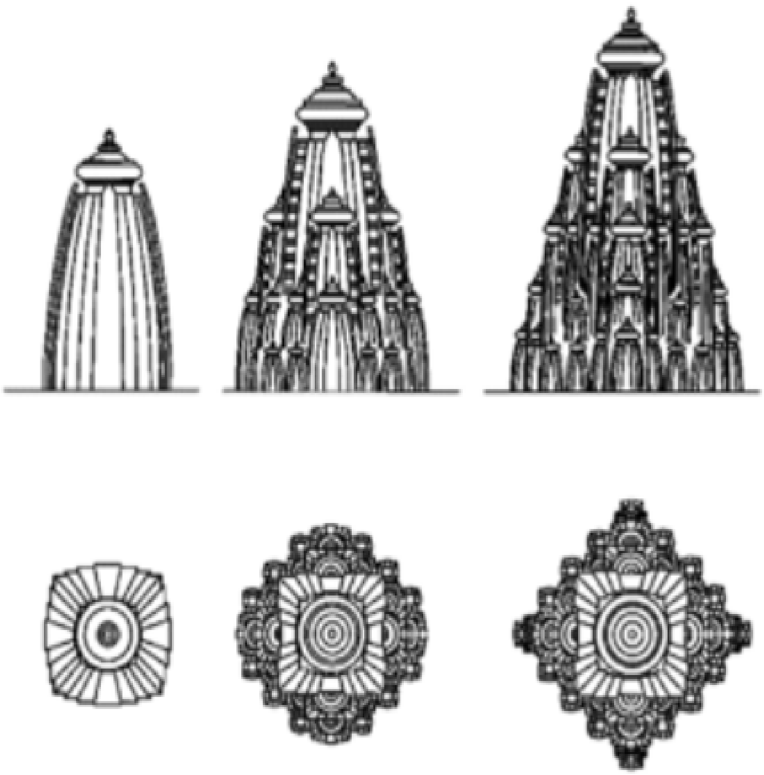
Data Analytics at the edge
Internet of Energy
Energy Efficiency
Form Factor
Mobility

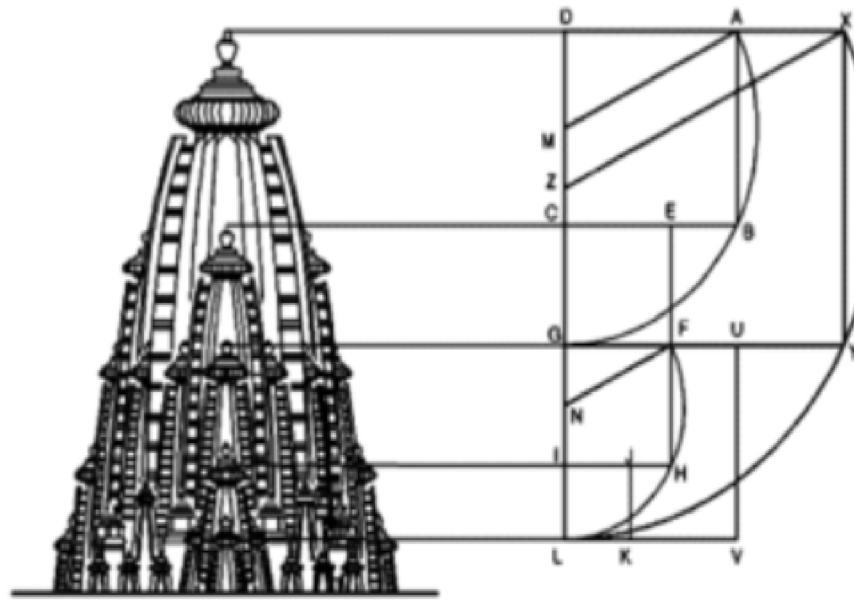
Intelligent Mitochondria

One tiny question?

3D printed sensors with fractal dimensions were more sensitive, compared to solid 2D areas

Natural occurring fractals can be found in the branching of a tree, the veins of a leaf, mountain ridges, rivers, vegetables and in the bronchial structure of lungs, to name a few.





https://spatialexperiments.wordpress.com/2016/09/18/fractal-geometry-in-nature-and-architecture/

The first mathematic tools for the description of fractal structures were developed by Gottfried Leibnitz in the 17. Century, when he wrote about recursive self-similarity. He and other mathematicians after him only touched the surface of fractal structures, because there were no mathematical tools for describing and analyzing them. Some of the mathematicians of this time gave fractals the name "‘mathematical monsters"’. It took two centuries for the first published fractal to emerge. Karl Weierstrass 1872 published a function (equation 1) which graph was a fractal (figure 1).

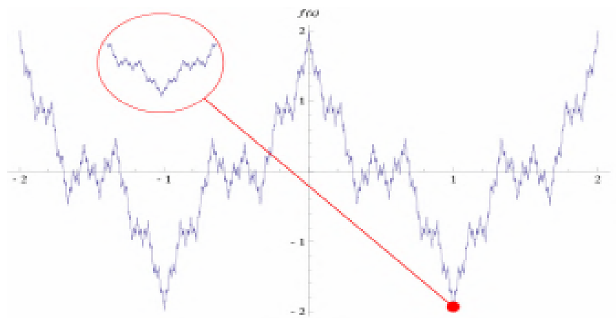


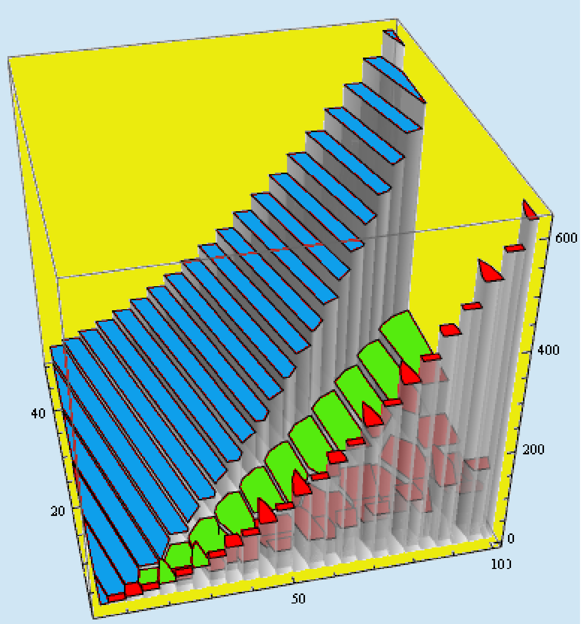
Figure 1: Weierstrass function [1].

$$f(x) = \sum_{n=0}^{\infty} a^n \cos(b^n \pi x) \tag{1}$$

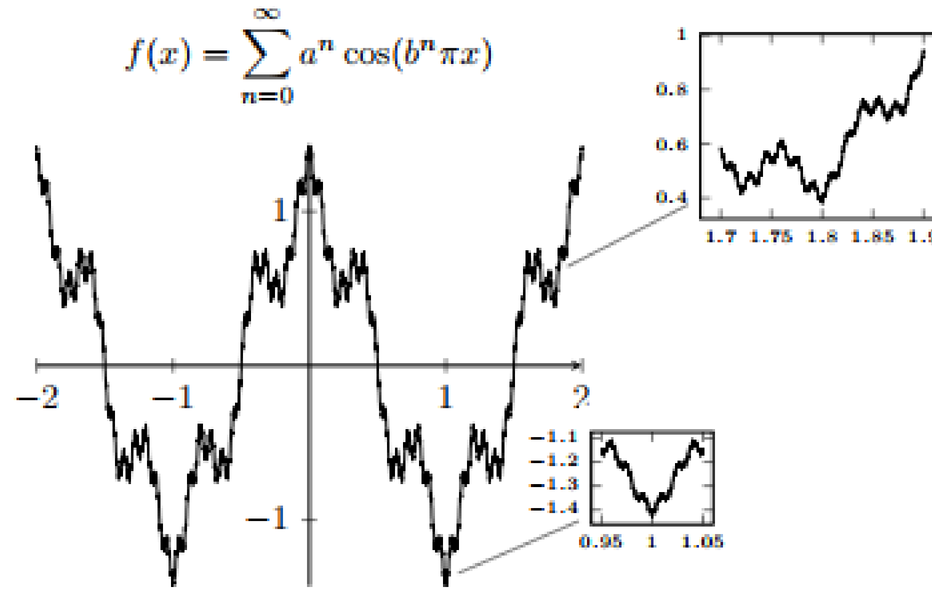
After him in 1883 Georg Cantor published a subset of the interval [0,1] which was a fractal and is today named the Cantor set. This type of fractal, which was described by an iteration of a set of rules, inspired a great breakthrough in 1904 by Helge von Koch. He described and constructed many new fractals with geometric recursive rules including his most known fractal the Koch snowflake. 10 years later Waclaw Sierpinski followed his example and constructed more fractals including the Sierpinski triangle. The next breakthrough was in 1918 when Pierre Fatou and Gaston Julia designed new fractals with a different approach. They used iterative functions on the complex plane to create the Julia set and others. At the same time Felix Hausdorff defined the fractal dimension which does not need to be an integer.

The main problem of these mathematicians was the representation of fractals. They had to be drawn by hand and many details were missed because of this. In 1960 Benoit B. Mandelbrot changed this with the use of computers. He collected the work of all mathematicians before him and joined it under the word he created: Fractal. The word was made from the Latin word fractus, which means broken or fractured.

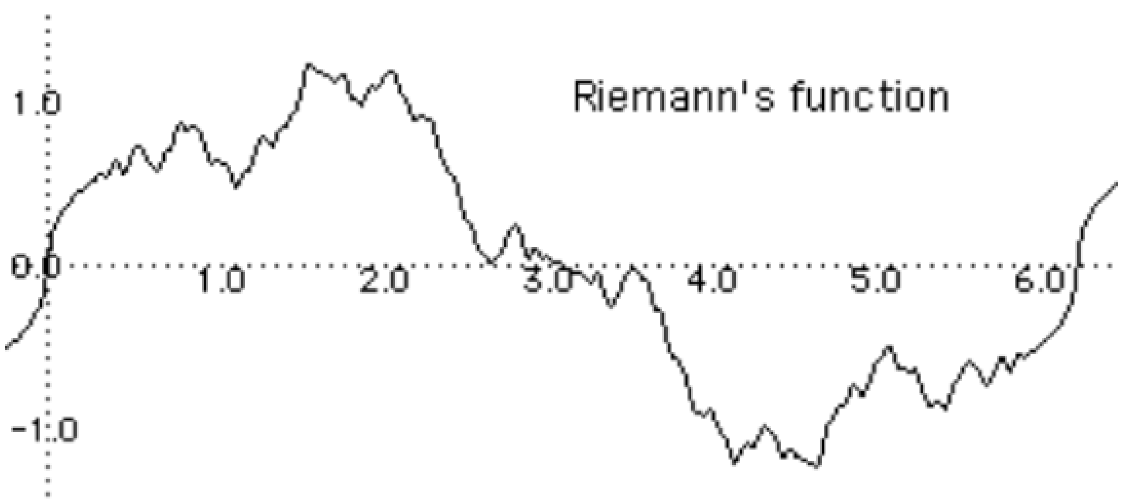
http://mafija.fmf.uni-lj.si/seminar/files/2012_2013/Fractal_Structures_Janez_Podhostnik.pdf

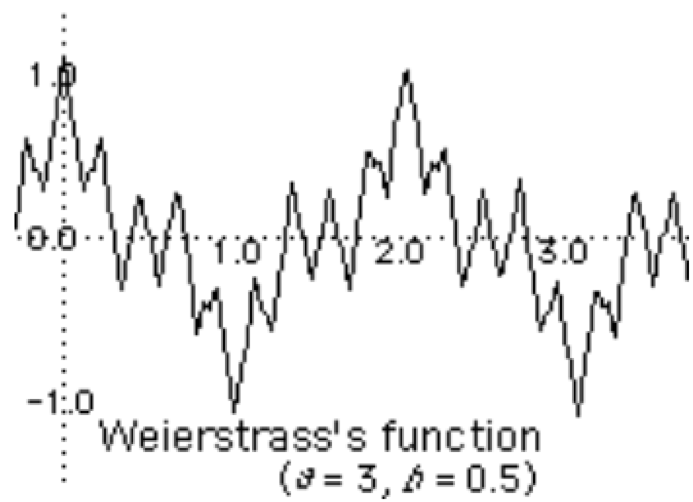


3D Riemann function - green → prime numbers



Weierstrass function – the graph is a fractal





1861●Bernhard Riemann (1826-1866)

1872●Karl Weierstrass (1815-1897)

Data analytics

Prime numbers in cryptography and cybersecurity

Plot of data reveals recursive self-similarity patterns

Can we use this tool in data analytics?

IDK

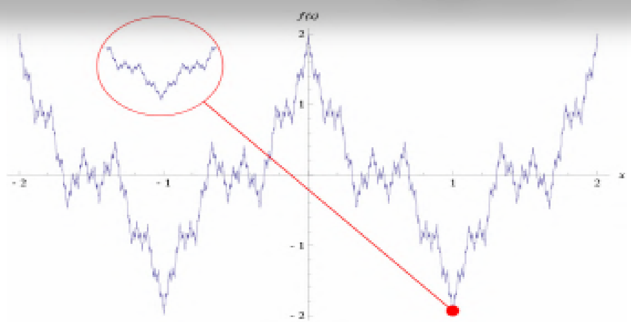


Figure 1: Weierstrass function [1].

$$f(x) = \sum_{n=0}^{\infty} a^n \cos(b^n \pi x) \quad (1)$$

Recursive self-similarity patterns are clues for recursive neural networks?

IDK

EVERYTHING

Including internet of things, is about making sense of data.

The President & Janitor may access the *same* data. Who can make sense of the data?

Cuneiform script, circa 3500 BC, in Sumeria (Mesopotamia) followed by wood block printing, circa 200 AD, to the printing press, by Johannes Gutenberg, circa 1440, spans about 5,000 years - the time it took to create tools for democratization of data, information and knowledge.

How many people may have read the Epic of Gilgamesh, which was written in cuneiform and carved on the Deluge tablet circa 2000 BC? You had to a Queen or the President. In the 21st Century, Rudyard Kipling's "If" may be downloaded by anybody, a teacher or a janitor, for free.

The transaction cost is approaching zero. Please thank the digital economy.

Transaction cost, pioneered as a business staple by Ronald Coase (1937), is critical, but not the only element for diffusion of digital transformation. Value, trust, security and interoperability between systems, are important.

The transformation to acquire data, transmit data or connect information, has profound implications for the adoption of the paradigm, atoms to bits.

The President and the janitor, can access the ***same*** data or information. Anyone, anywhere, may consume the same information. Democratization of data, due digitization and digital transformation, is the new normal.

The President & Janitor may access the *same* data. Who can make sense of the data?

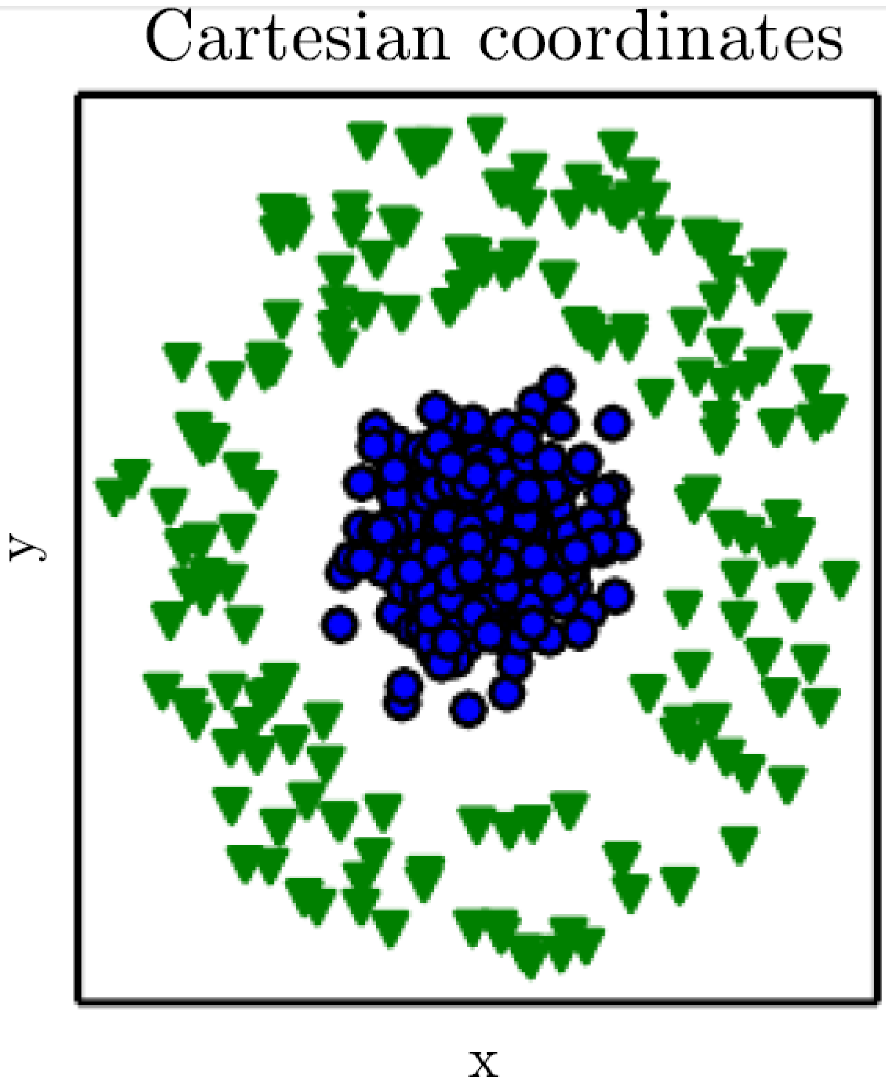


Figure 1.1: Example of different representations: suppose we want to separate two categories of data by drawing a line between them in a scatterplot. In the plot on the left, we represent some data using Cartesian coordinates, and the task is impossible.

From Ian Goodfellow in *Deep Learning*, MIT Press

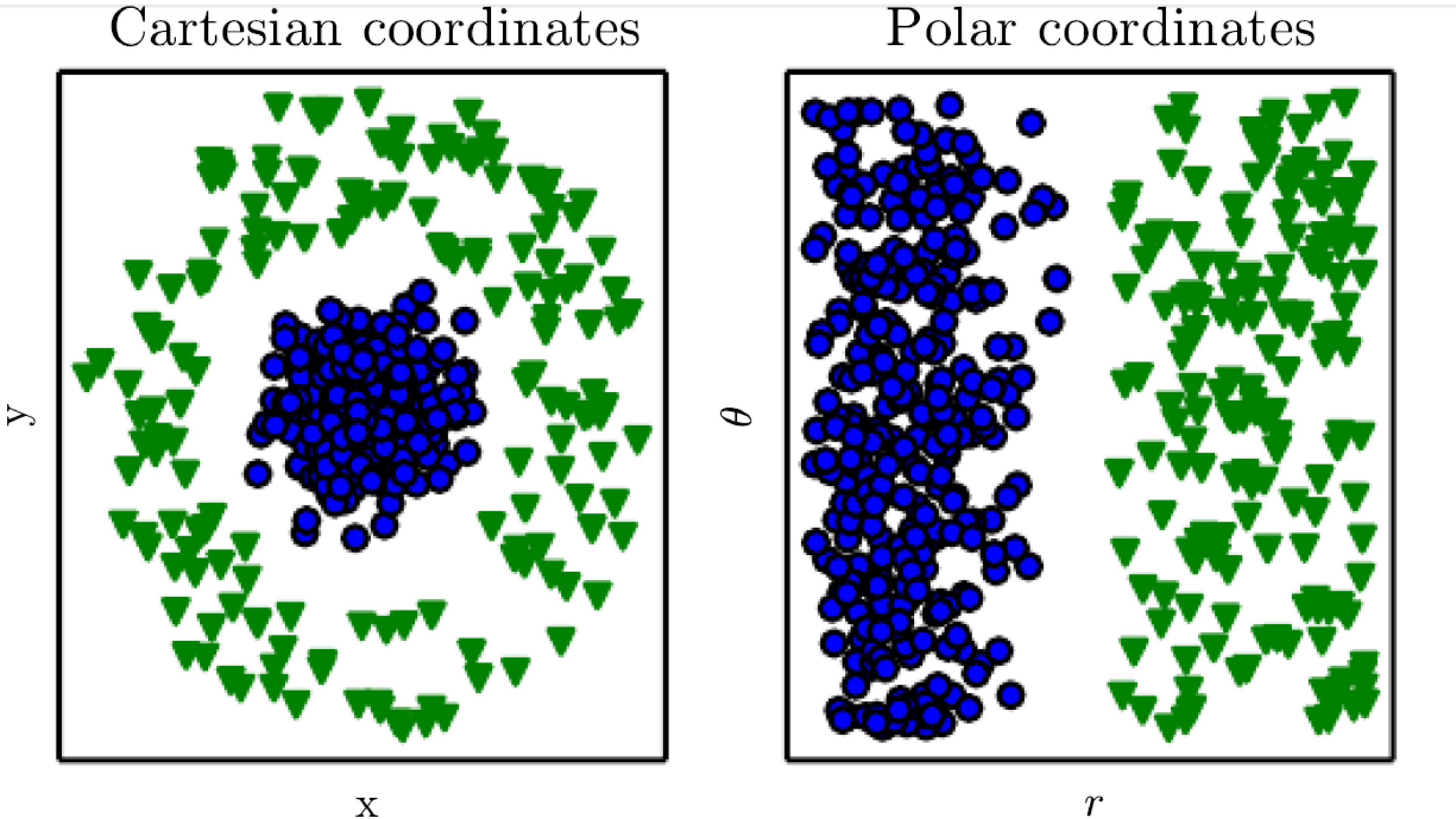


Figure 1.1: Example of different representations: suppose we want to separate two categories of data by drawing a line between them in a scatterplot. In the plot on the left, we represent some data using Cartesian coordinates, and the task is impossible. In the plot on the right, we represent the data with polar coordinates and the task becomes simple to solve with a vertical line. Figure from Ian Goodfellow in *Deep Learning*, MIT Press (2017)

Is data curation essential?

Can code adapt to available data?

http://tensor-compiler.org/kjolstad-oopsla17-tensor-compiler.pdf

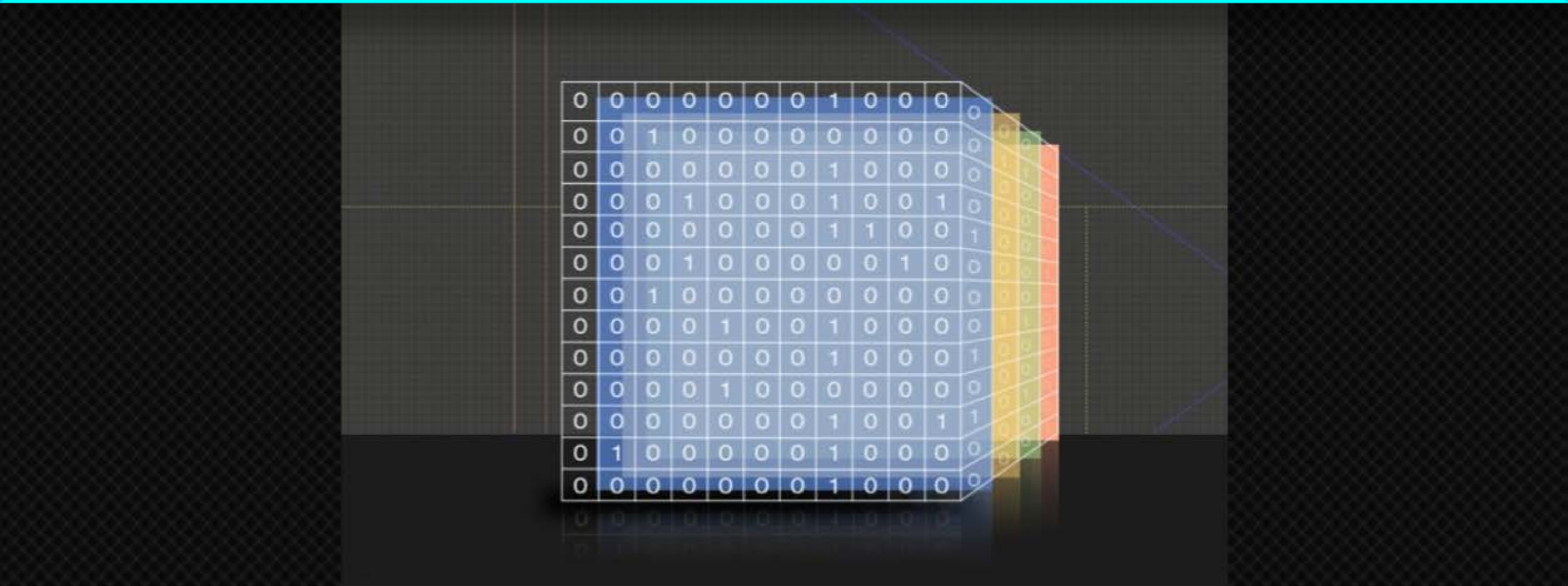
Tensor Algebra

Open Source TACO http://tensor-compiler.org

The Tensor Algebra Compiler

FREDRIK KJOLSTAD, Massachusetts Institute of Technology, USA
SHOAIB KAMIL, Adobe Research, USA
STEPHEN CHOU, Massachusetts Institute of Technology, USA
DAVID LUGATO, French Alternative Energies and Atomic Energy Commission, France
SAMAN AMARASINGHE, Massachusetts Institute of Technology, USA

Binary is 0's and 1's



A new MIT computer system speeds computations involving "sparse tensors," multidimensional data arrays that consist mostly of zeroes.

What if you could compute without zeroes and an automated code takes care of the missing zeroes in the kernel? Can such a tool vastly improve the speed of computation? Sparse matrix-vector multiplication (SpMV) is one of the most important operations in sparse linear algebra. Previous work since 1960's. WF Tinney and JW Walker. 1967. Direct solutions of sparse network equations by optimally ordered triangular factorization. Proceedings of IEEE **55** 11 1801–1809

http://tensor-compiler.org/kjolstad-oopsla17-tensor-compiler.pdf

President & Janitor may access *same* data. Who has the tools to make sense of data?


A
APPOINTMENT

SELF

L

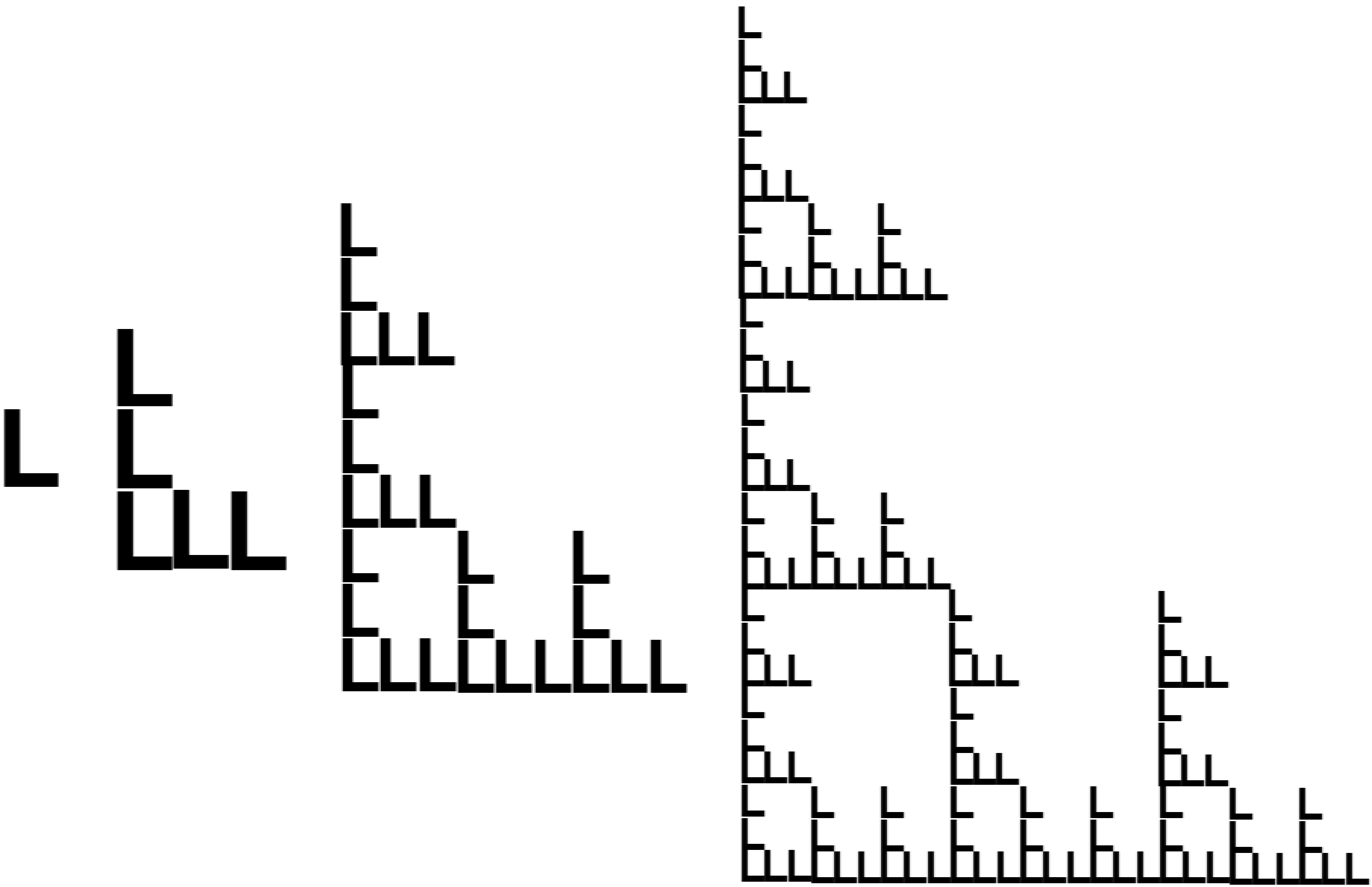
SELFIE

L

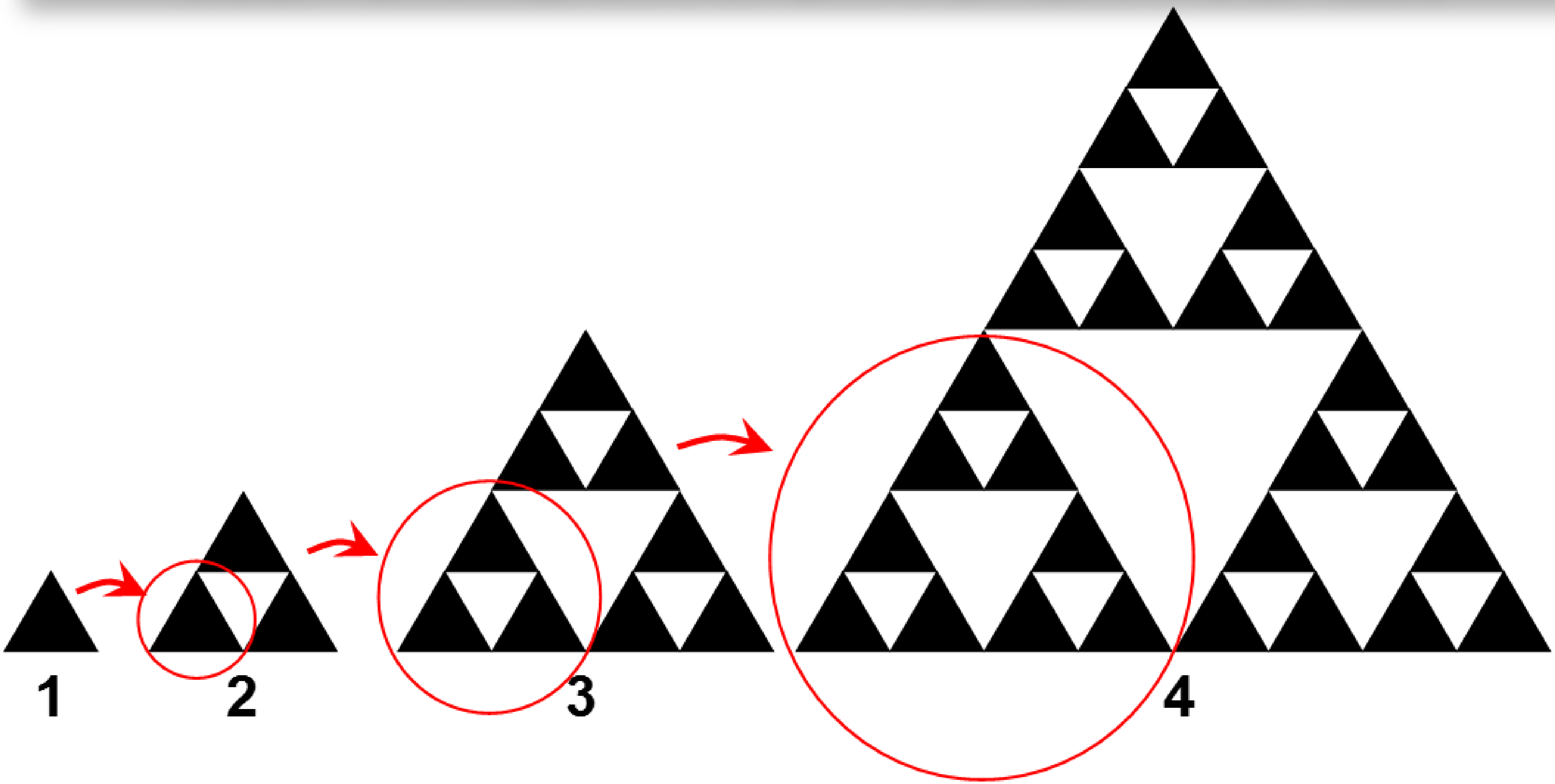
L L

LLL

SELF-SIMILAR



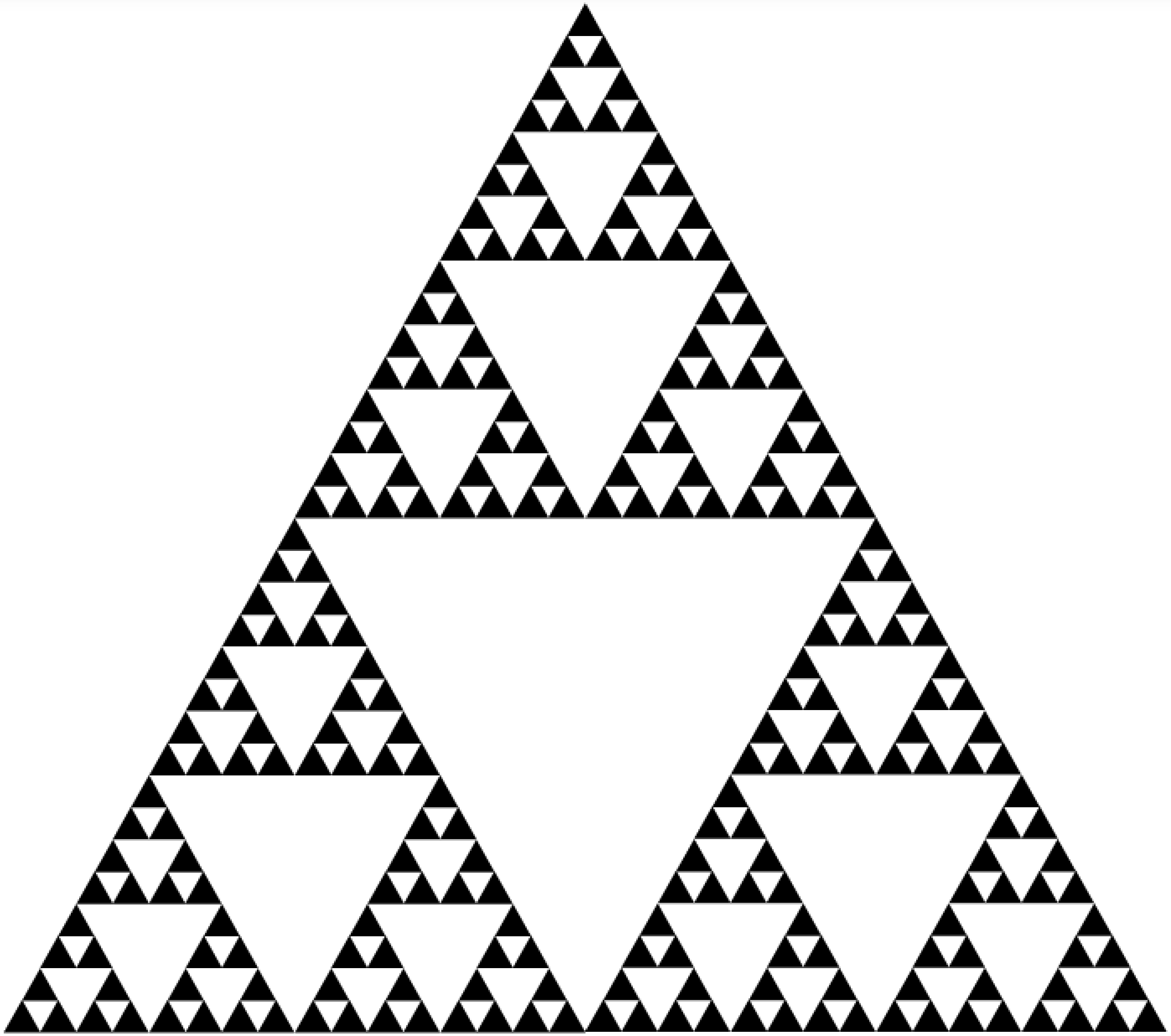
SELF-SIMILAR AT DIFFERENT SCALES



The Sierpinski Triangle. In each step, a new triangle is made from 3 copies of the previous structure.

Before "fractal" was in our vernacular – from Polish mathematician Waclaw Sierpinski (1882-1969)

SELF-SIMILARITY OF SIERPINSKI TRIANGLE



FRACTAL DIMENSION

$$N = m^D$$

The fractal dimension D is then

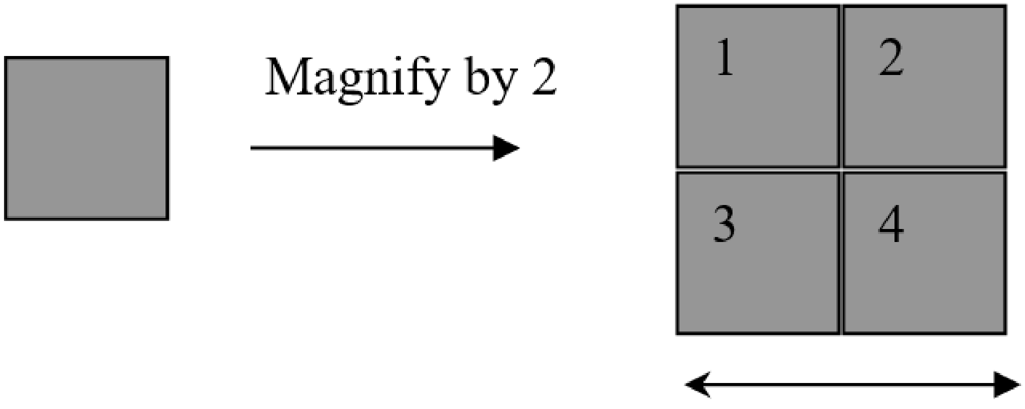
$$Log(N) = Log\ (m^D)$$
$$Log(N) = D\ Log\ (m)$$

$$D = log\ (N) / log\ (m)$$

D= Fractal dimension

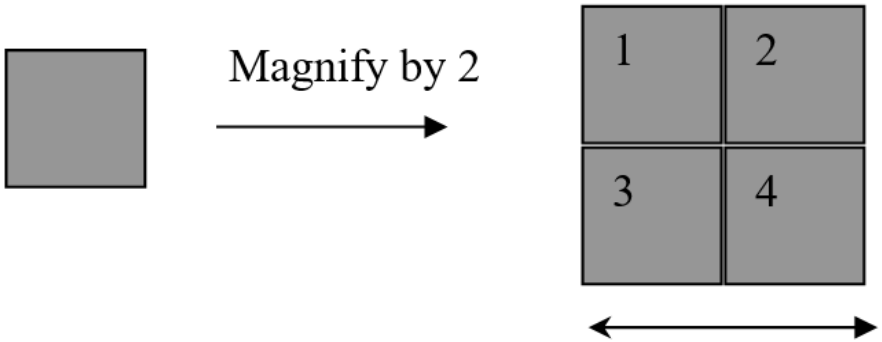
N= number of pieces

m= magnification



Magnifying by 2 means the width or height of the new object is twice as large

The new object must have the same shape, or must be "self-similar" to the original. It should still be square. So we need 4 copies of the original square to make the new larger square. We've magnified by 2 (m=2) and we need 4 square to do it (N=4)



Magnifying by 2 means the width or height of the new object is twice as large

The new object must have the same shape, or must be "self-similar" to the original. It should still be square. So we need 4 copies of the original square to make the new larger square. We've magnified by 2 ($m=2$) and we need 4 square to do it ($N=4$)

$N = m^D$ Where $m=2$ and $N=4$. We need to solve for D which is the dimension.
We take the log of both sides

$\log(N)=\log(m^D)$ The properties of logarithms allow us to pull the parameter D out in front.

$\log(N)=D\log(m)$

Solving for D

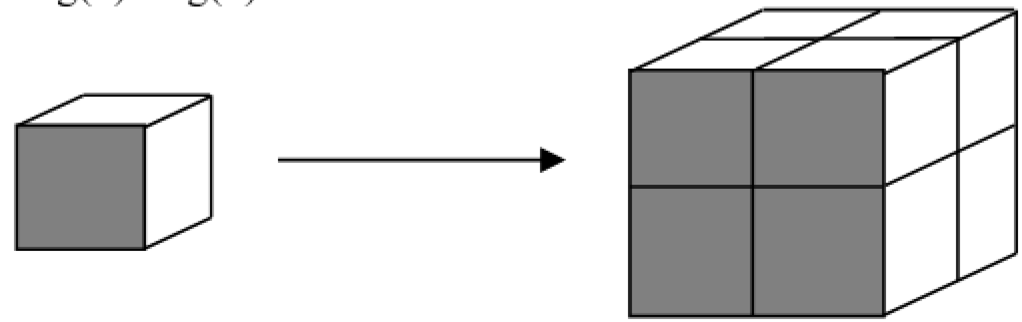
$$D = \log(N)/\log(m) = \log(4)/\log(2) = \log(2^2)/\log(2) = 2*\log(2)/\log(2) = 2$$

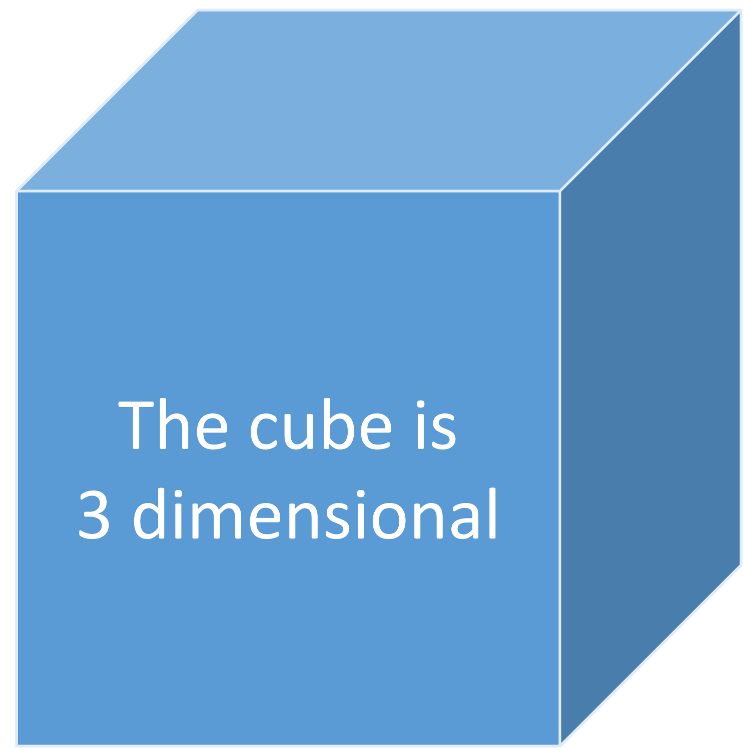
The square is
2 dimensional

Lets try a three dimensional object like a cube. Magnify by a factor of 2. Again this means the new bigger cube is twice as long along each side. To make a cube twice as long along each side, we need 8 cubes. So m = 2 and N = 8 (we need 8 cubes to make the bigger cube).

$$D = \mathrm{Log}\,(8)/\mathrm{Log}(2) = \mathrm{Log}(2^3)/\mathrm{Log}(2) = 3\ \mathrm{Log}(2)/\mathrm{Log}(2) = 3$$

It is 3 dimensional!!

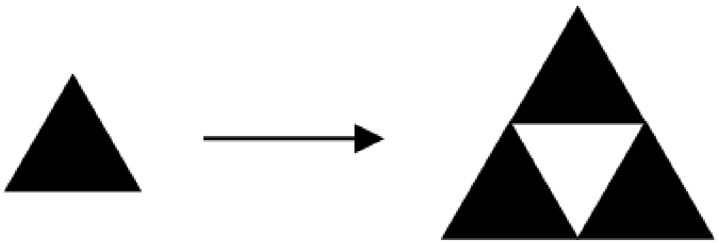




SELF-SIMILARITY vs FRACTAL DIMENSION

We are magnifying by 2. Magnifying by 2 means the width or height of the new object is twice as large

$m=2$



The new object must have the same overall shape, or must be "self-similar" to the original. So we need 3 copies of the original triangle to make the new larger triangle. We've magnified by 2 ($m=2$) and we need 3 triangles to do it ($N=3$)

Calculation:

$N = m^D$ $\quad$ $m=2$; $N=3$

$\log(N)=\log(m^D)$

$\log(N)=D\log(m)$

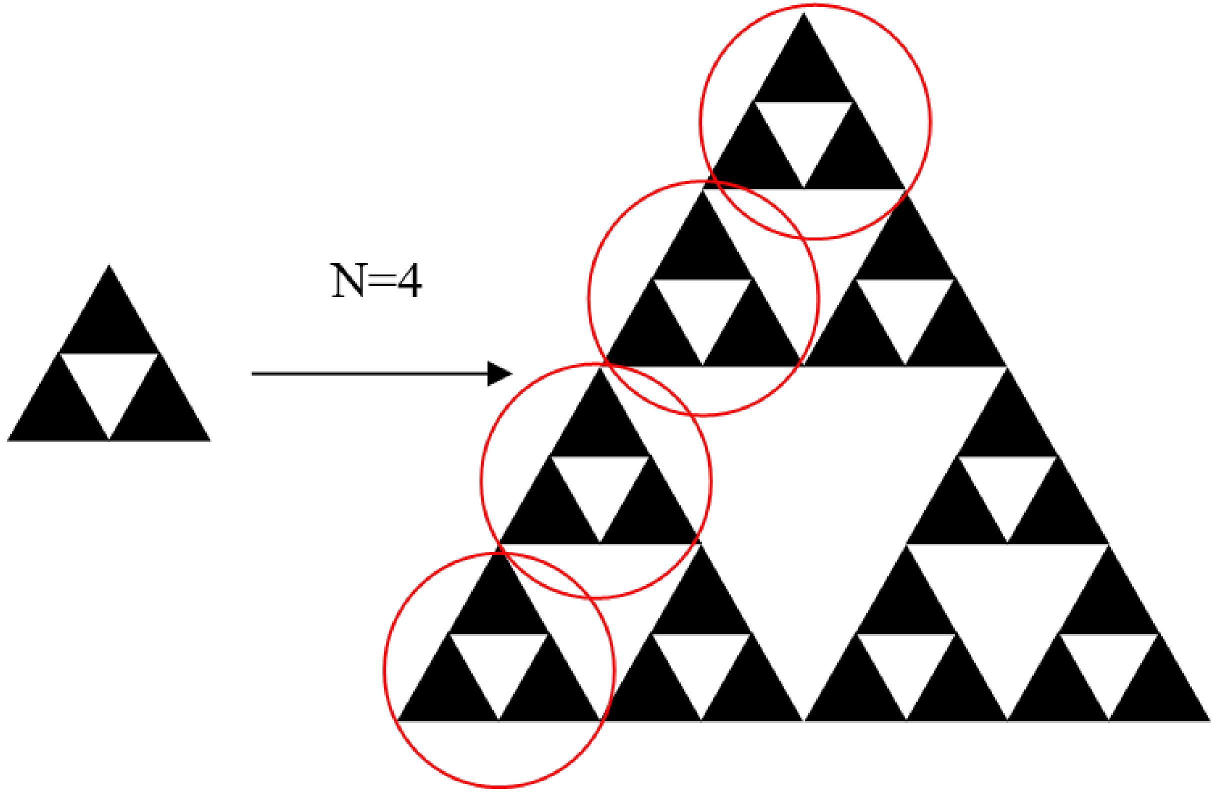
$D=\log(N)/\log(m)$

$D=\log(3)/\log(2)$

$D=1.585$

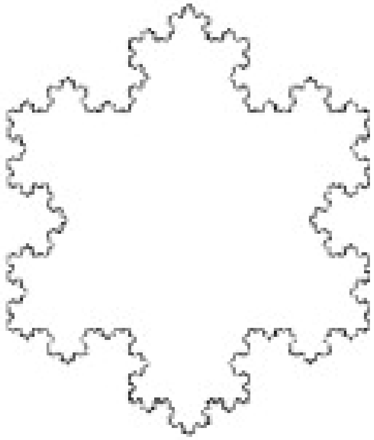
SELF-SIMILARITY vs FRACTAL DIMENSION

We are magnifying by 4. Magnifying by 4 means the width or height of the new object is 4 times as large

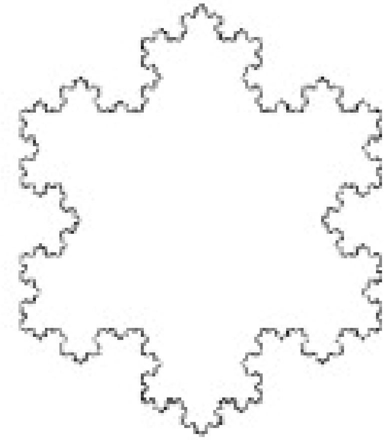


We need 9 copies of the smaller triangle to make the new larger triangle. We've magnified by 4 (m=4) and we need 9 copies to do it (N=9)

D= log(9)/log(4) = 1.585



http://www.math.umass.edu/~mconnors/fractal/fractal.html
http://math.rice.edu/~lanius/frac/
http://local.wasp.uwa.edu.au/~pbourke/fractals/
http://www.cevis.uni-bremen.de/fractals/nsfpe/Pythagorean_Trees/PT.html



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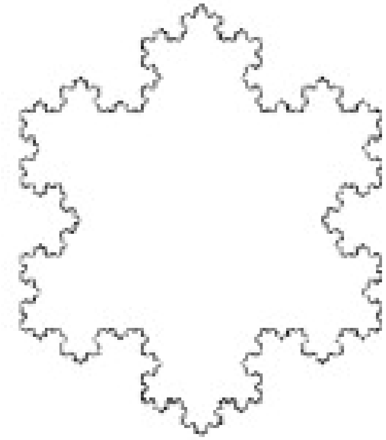
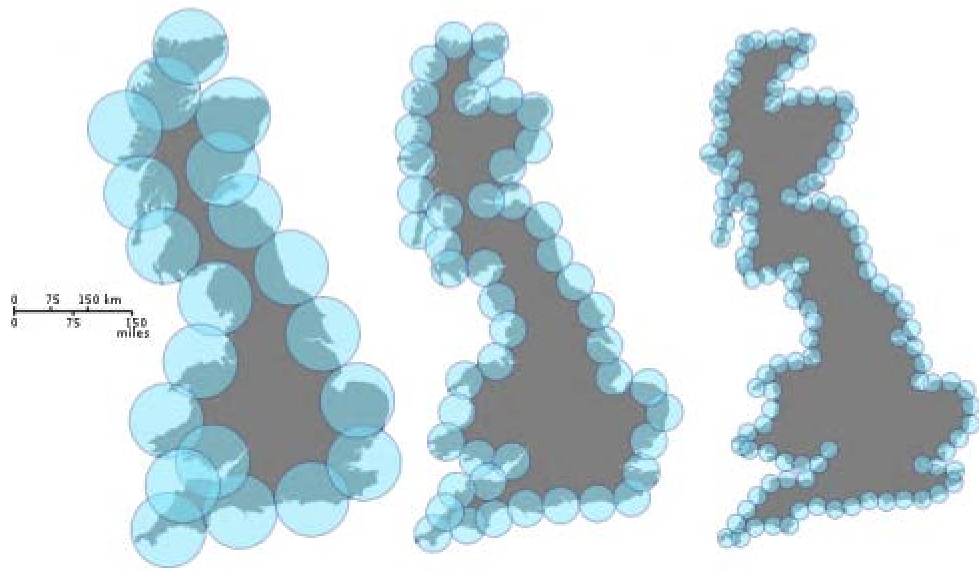

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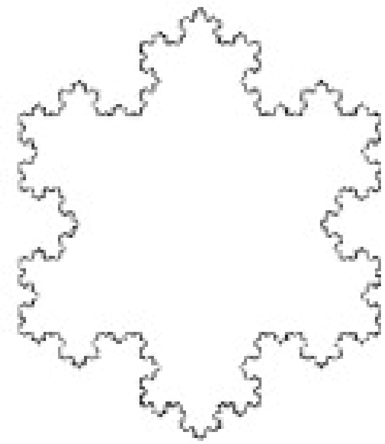
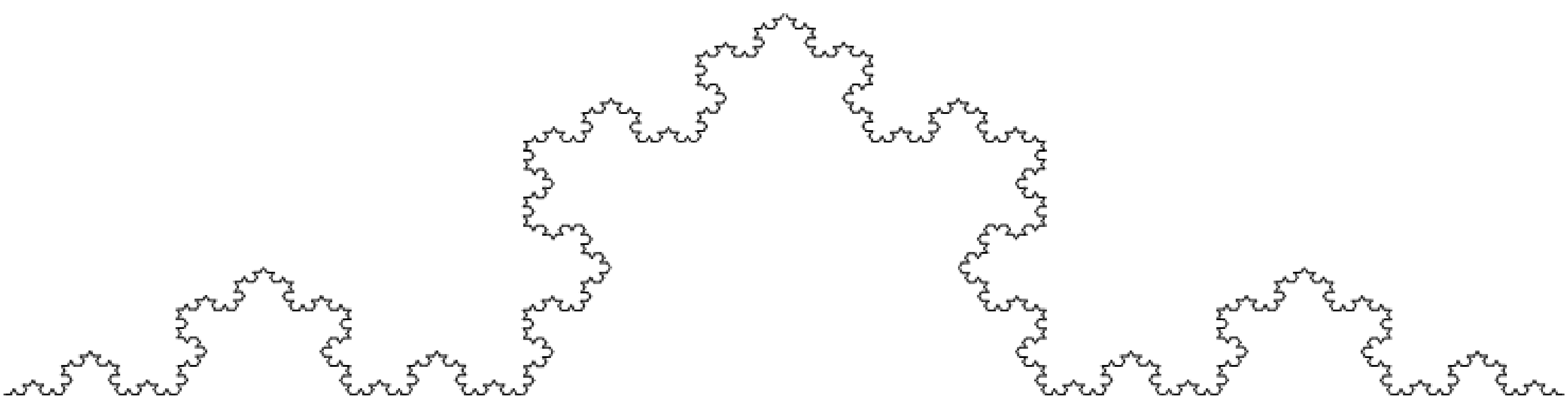
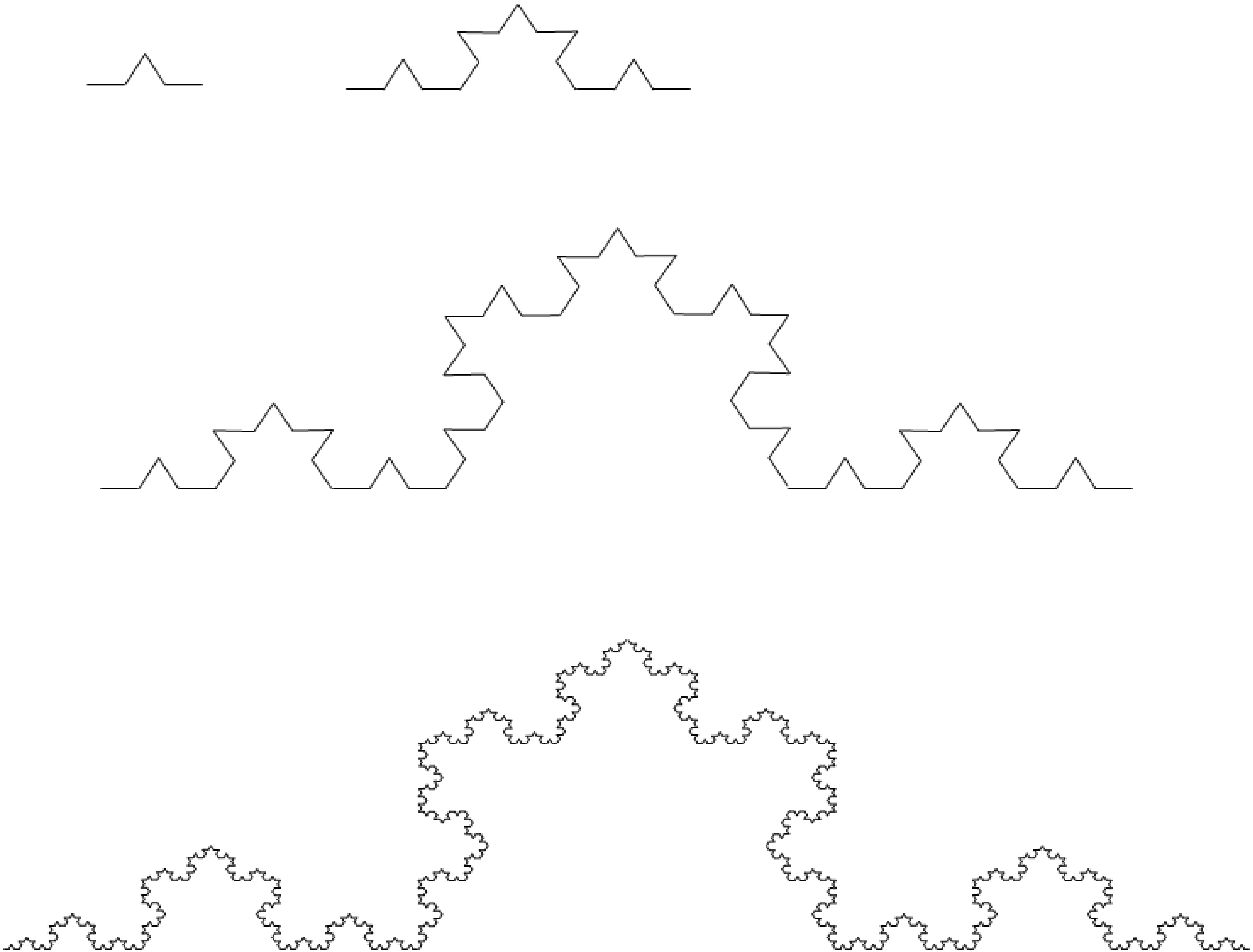
http://local.wasp.uwa.edu.au/~pbourke/fractals/
http://www.cevis.uni-bremen.de/fractals/nsfpe/Pythagorean_Trees/PT.html

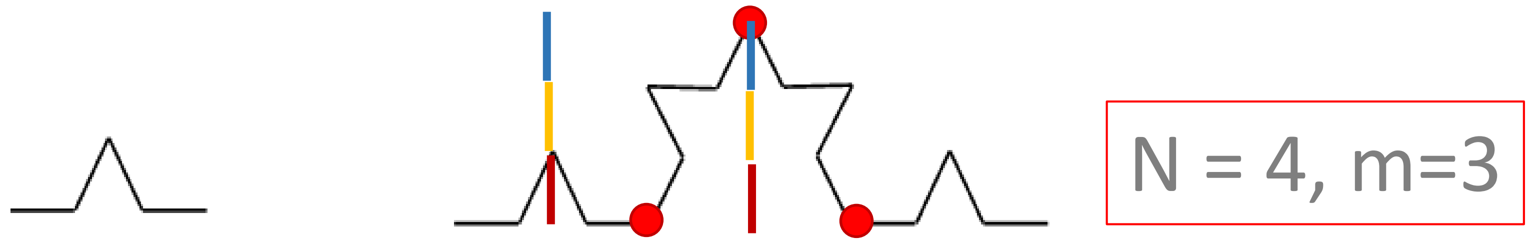
What is the fractal dimension of the following fractal?





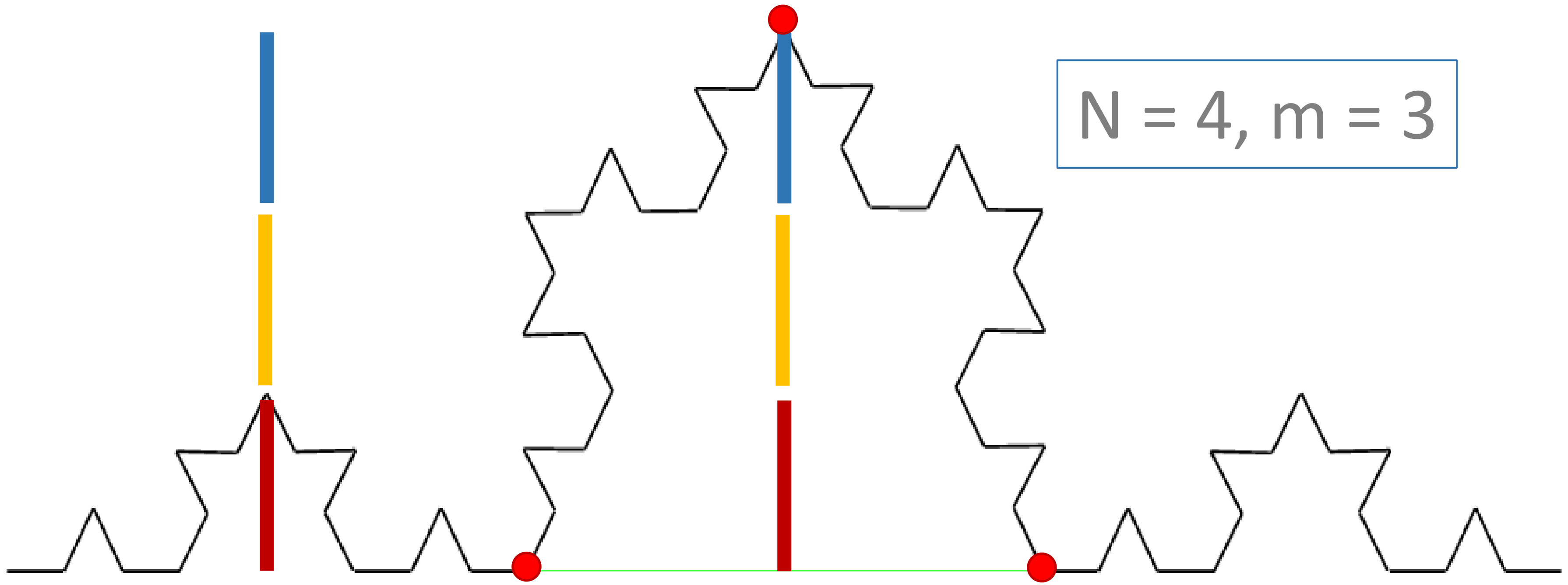


What is the fractal dimension of the following fractal?



As we go from iteration 1 to iteration 2, we need 4 pieces (N=4) and we've magnified by a factor of 3 (m =3). This is readily apparent by observing that the object is 3 times longer and taller in the next iteration.

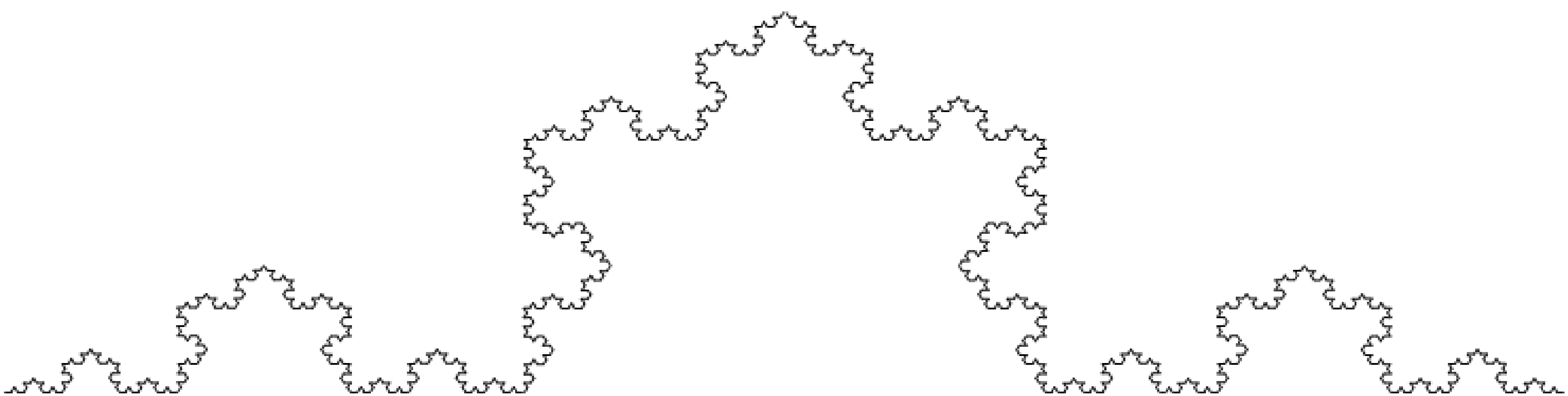
$$D = \log(4) / \log(3) = 1.262$$



What is the fractal dimension of the following fractal? **Answer: D = 1.262**

N = 4, m = 3

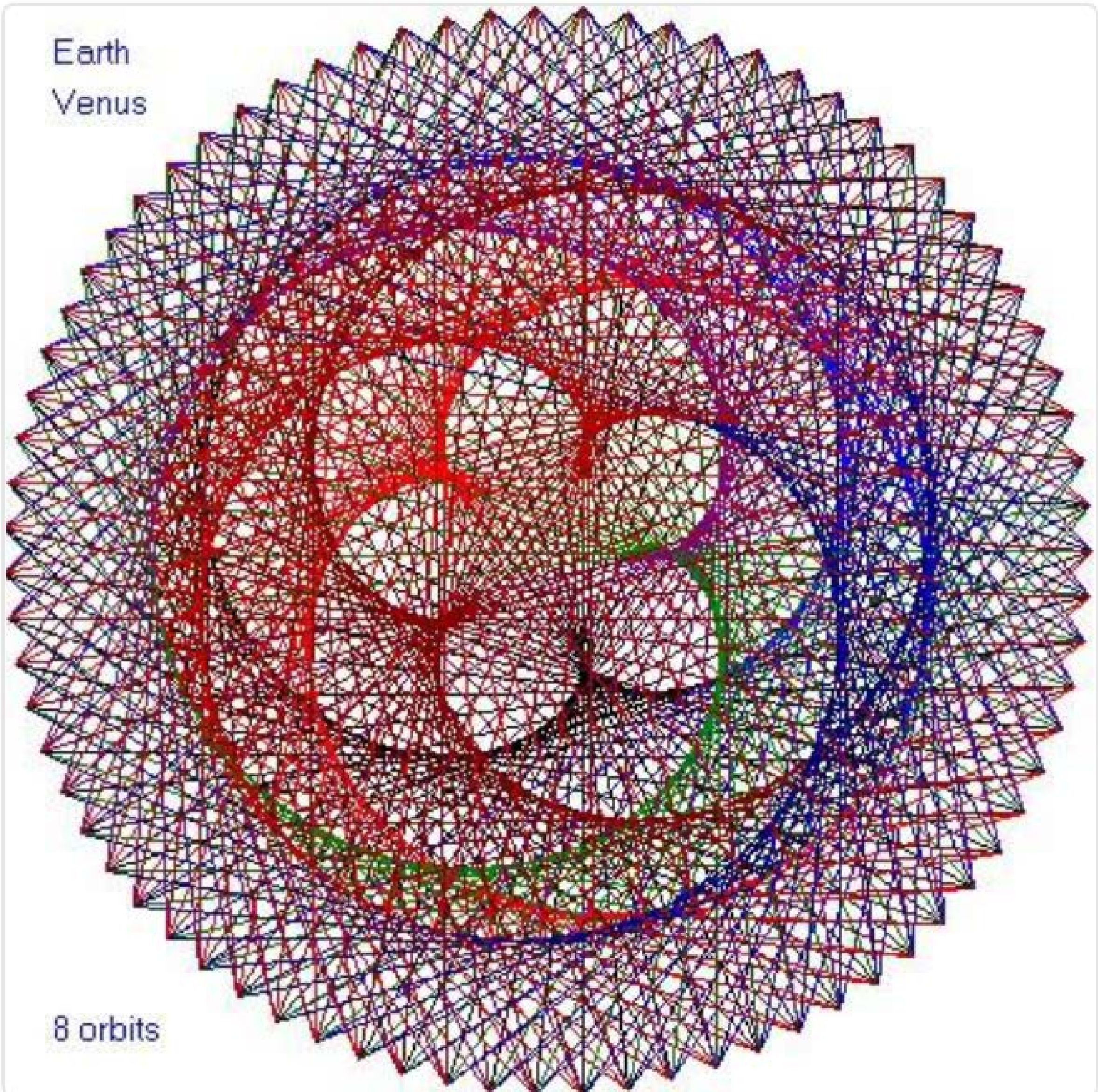
D = log (4) / log (3) = 1.262



Questions ➡ Convergence

I still don't know any answer

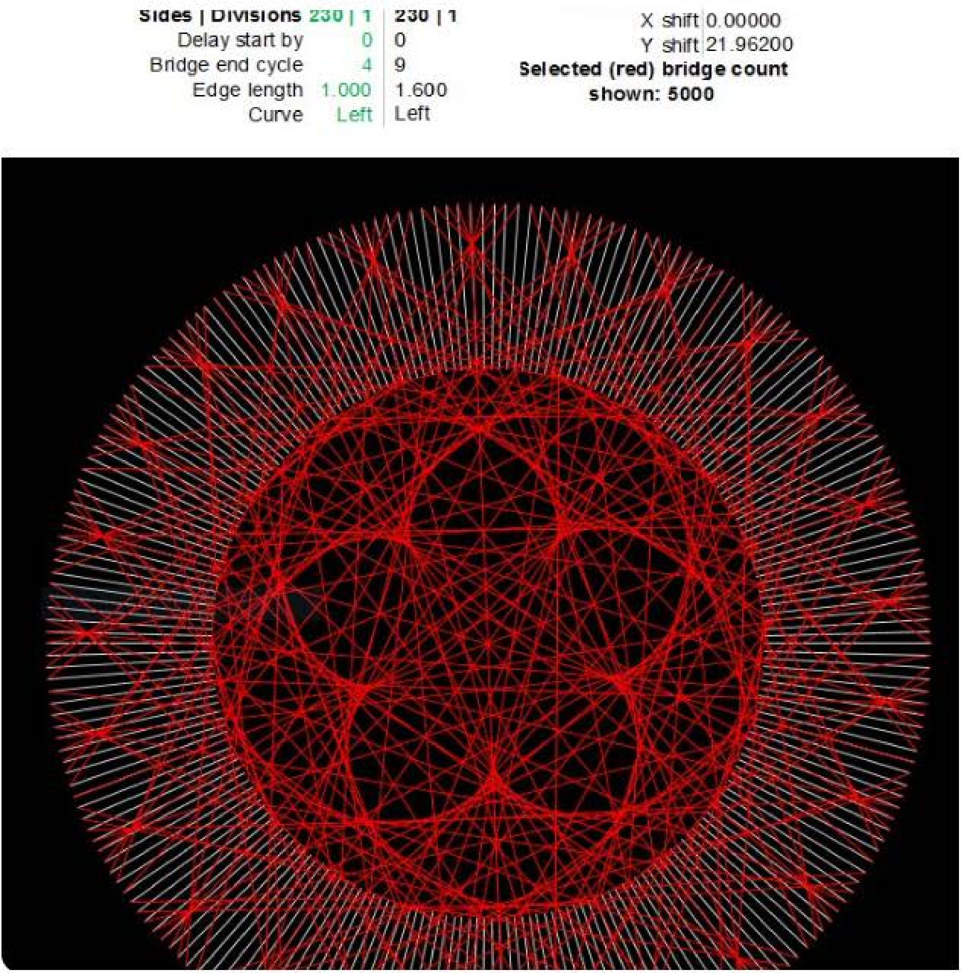
If you track the relative positions of Earth Venus over an 8 year period, this is the resulting pattern. Credits: Ensign

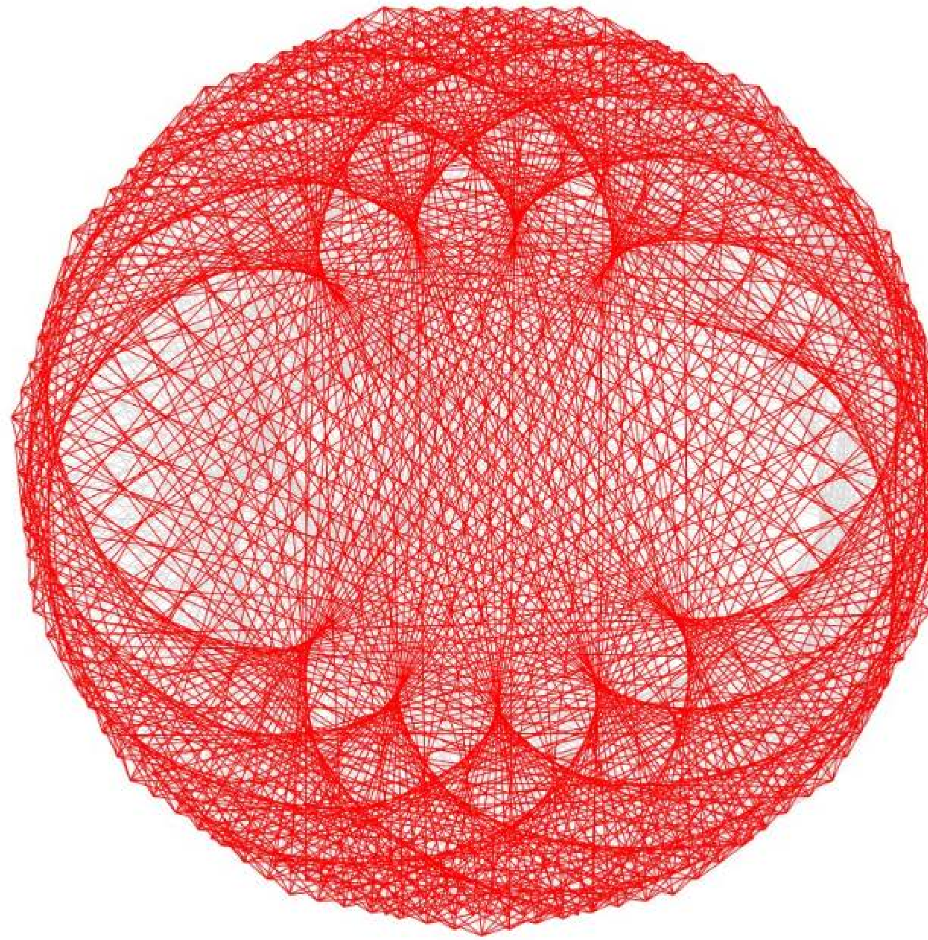


www.youtube.com/watch?time_continue=4&v=4cgQNUhtmHM

8 Earth Orbits equal 13 Venus Orbits with 5 Earth Venus 'Kisses'

You cannot see the future if your imagination is out of focus





Vision ● Trans-disciplinarity

Cross-pollination & confluence of ideas catalyzes critical global solutions

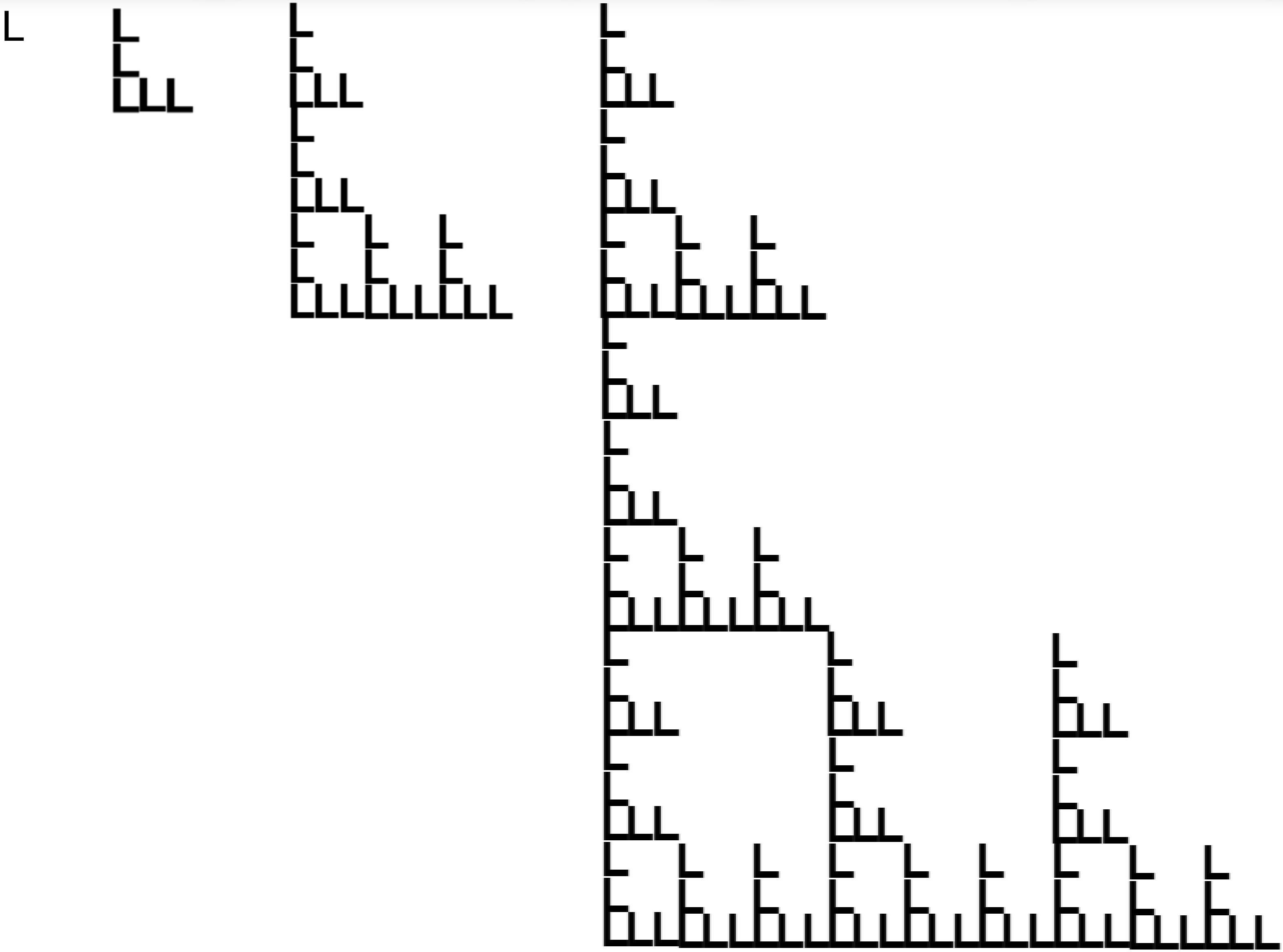
Biomimetic Entropic Patterning

BEP uses scale free network theory to engineer nanomaterial receptors on sensor surface using *in silico* 2D patterns based on network energy maximization, metallization, biofunctionalization. BEP increases transduction and signal-to-noise-ratio for electro-chemical and plasmonic sensors. These nano-bio-sensors can be used for field targets ranging from molecules to whole cells.

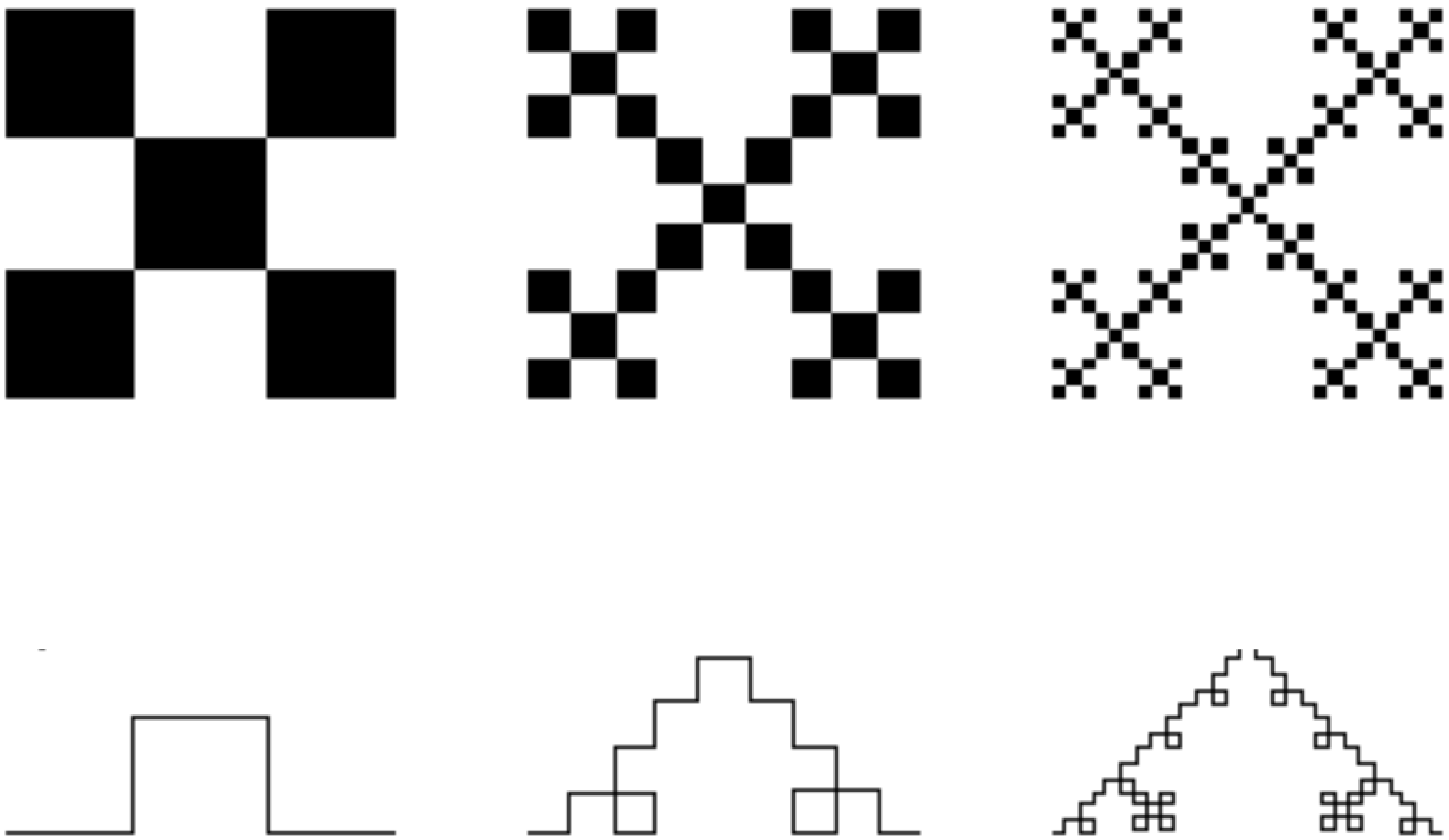
Entropy

disorder or randomness

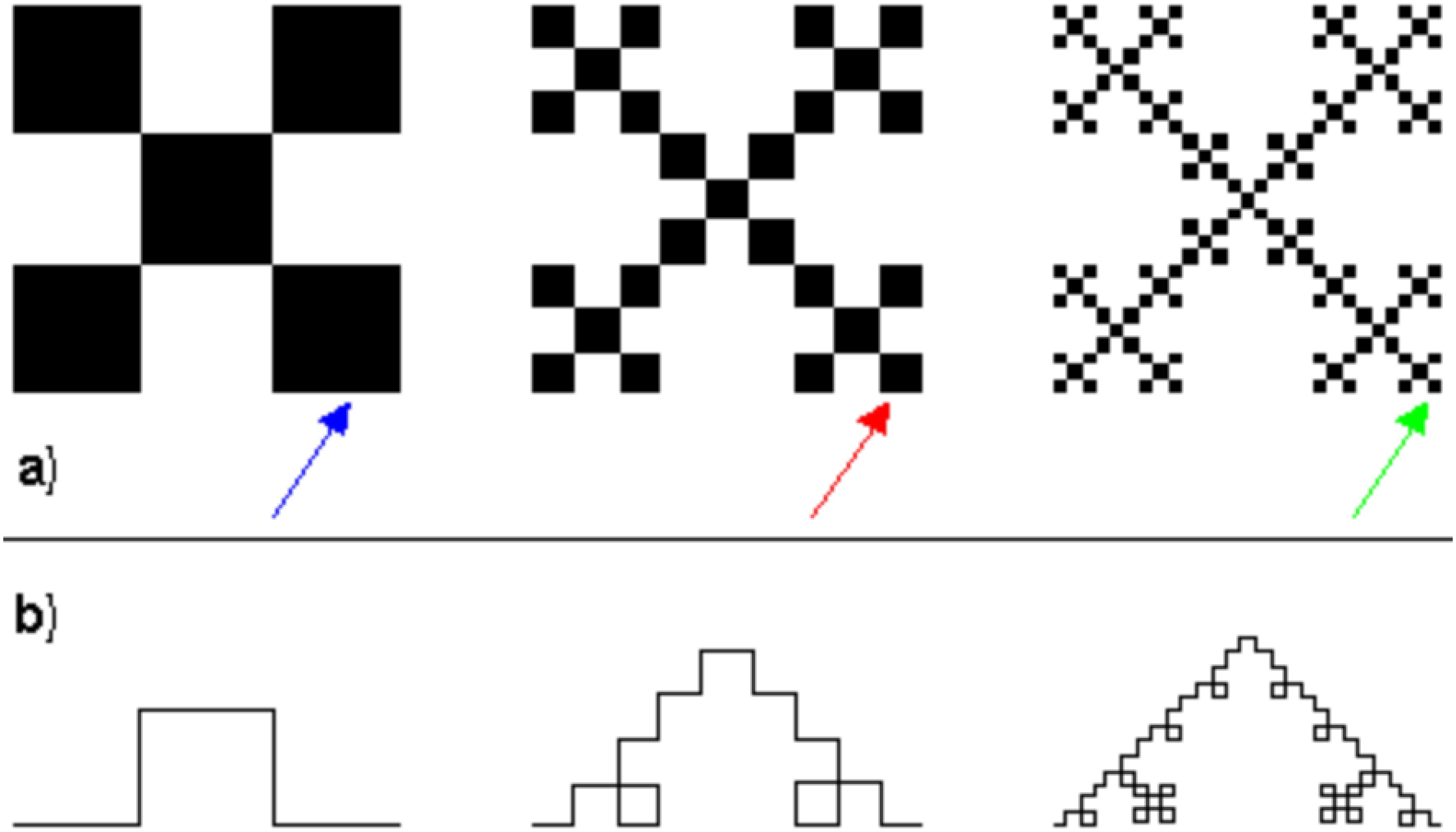
Is the disorder or randomness in a system (entropy) increasing from left (L) to right in this patterning?



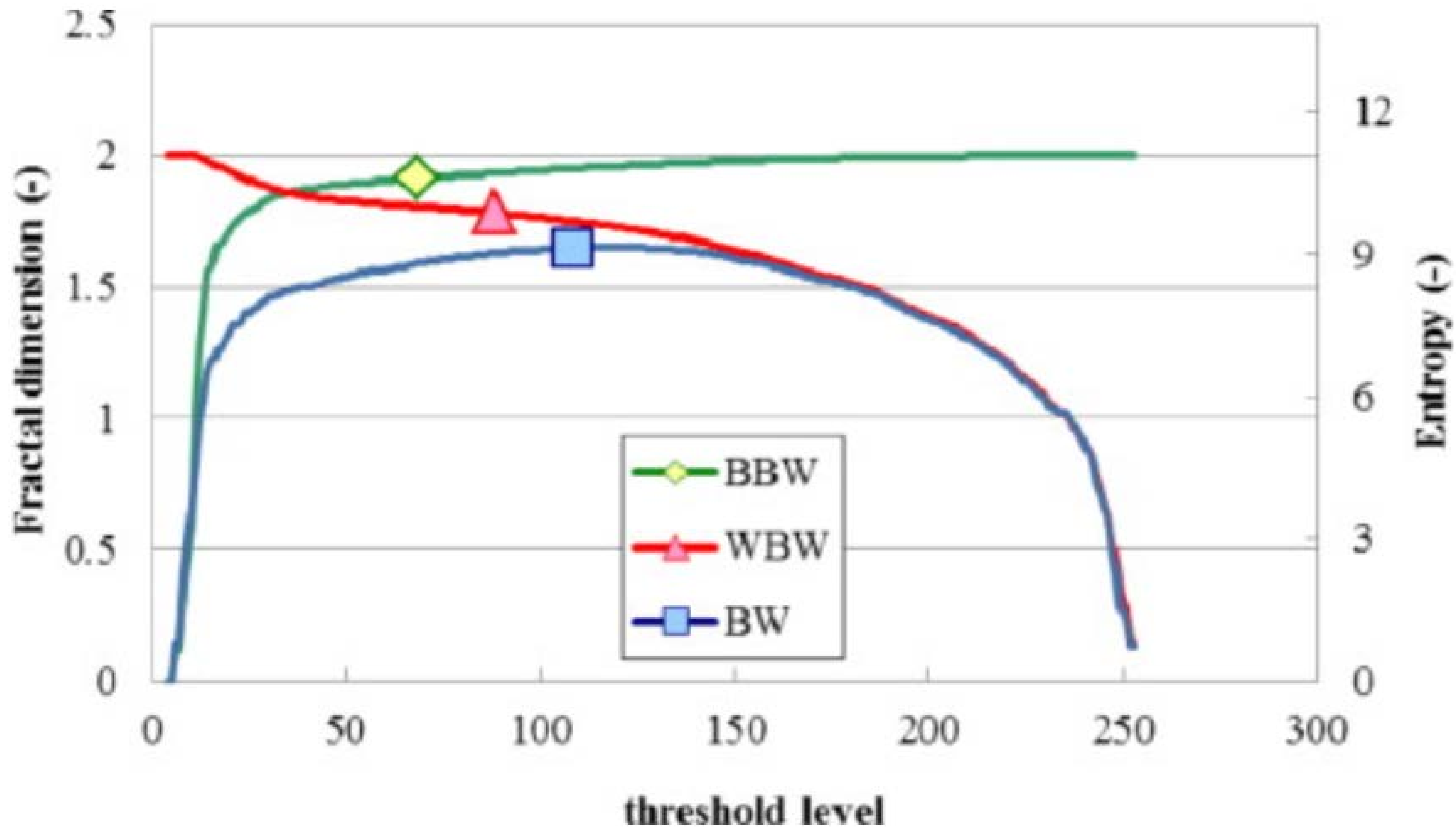
Is the disorder or randomness in a system (entropy) increasing from (L) to (R) in self-similar patterns?



Fractal Dimension vs Black (B) and White (W) Areas



Mandelbrot Fractal - Fragmented geometric shape can be subdivided in parts, each of which is (at least approximately), a reduced/size copy of the whole (self-similar).



Computers & Mathematics with Applications
Volume 66, Issue 2, August 2013, Pages 135-146

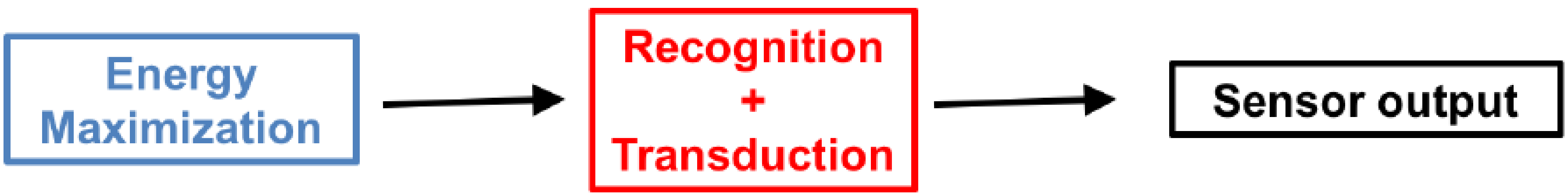
FRACTAL DIMENSION vs ENTROPY

Entropy of fractal systems

Oldrich Zmeskal, Petr Dzik, Michal Vesely

www.sciencedirect.com/science/article/pii/S0898122113000345

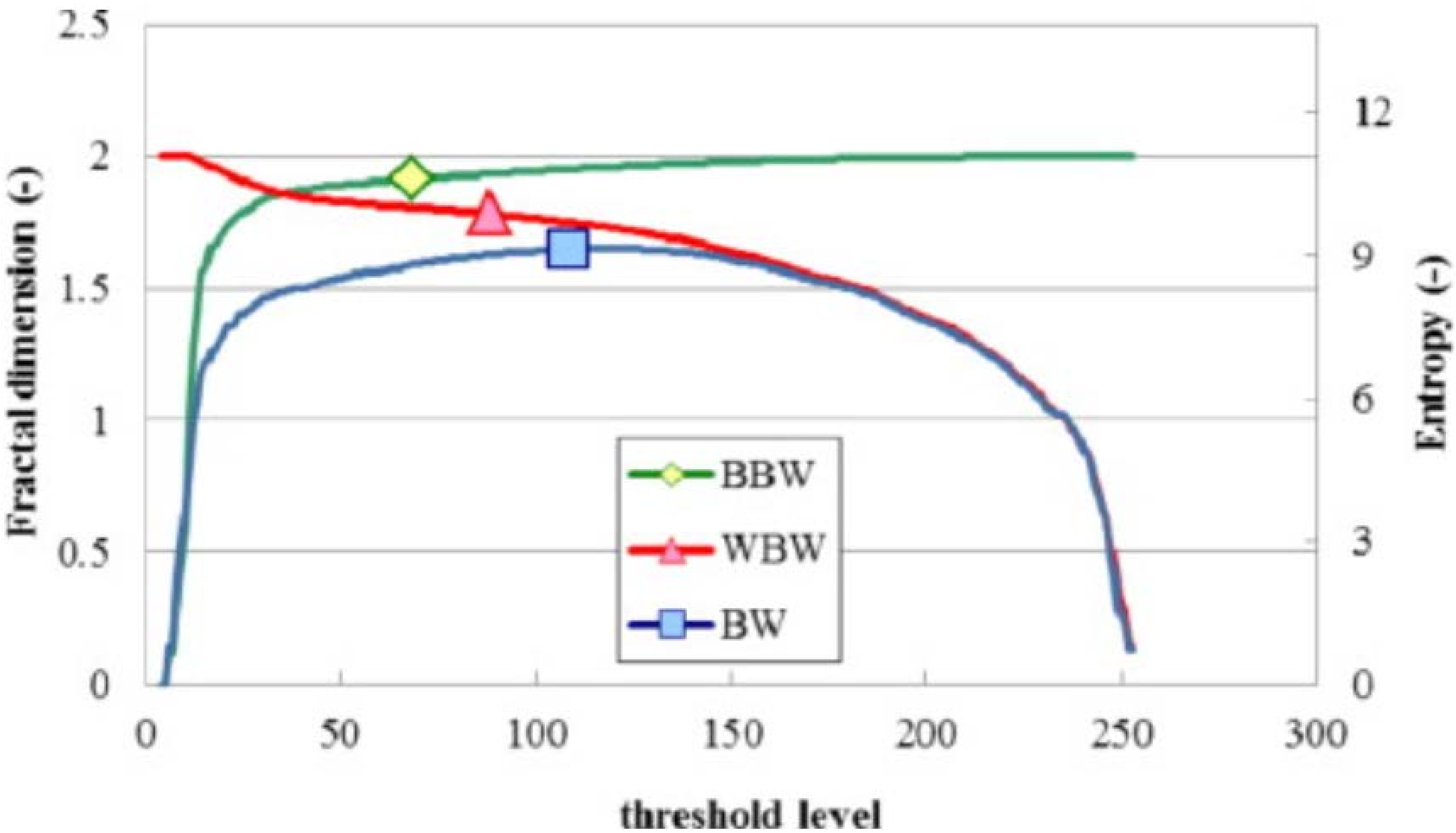
Increasing sensitivity in the context of sensor ?



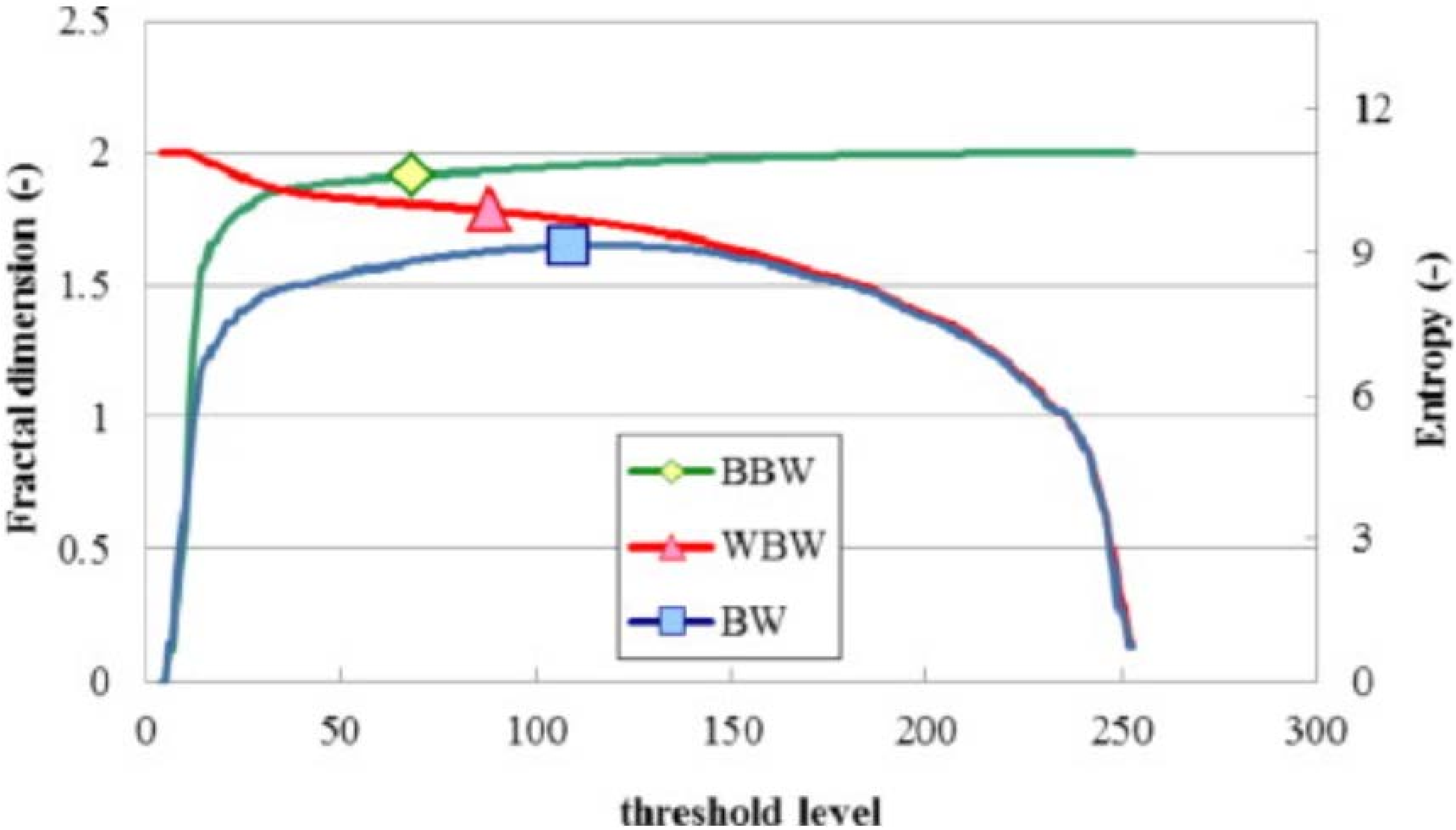
Sensor **data**

generates

information



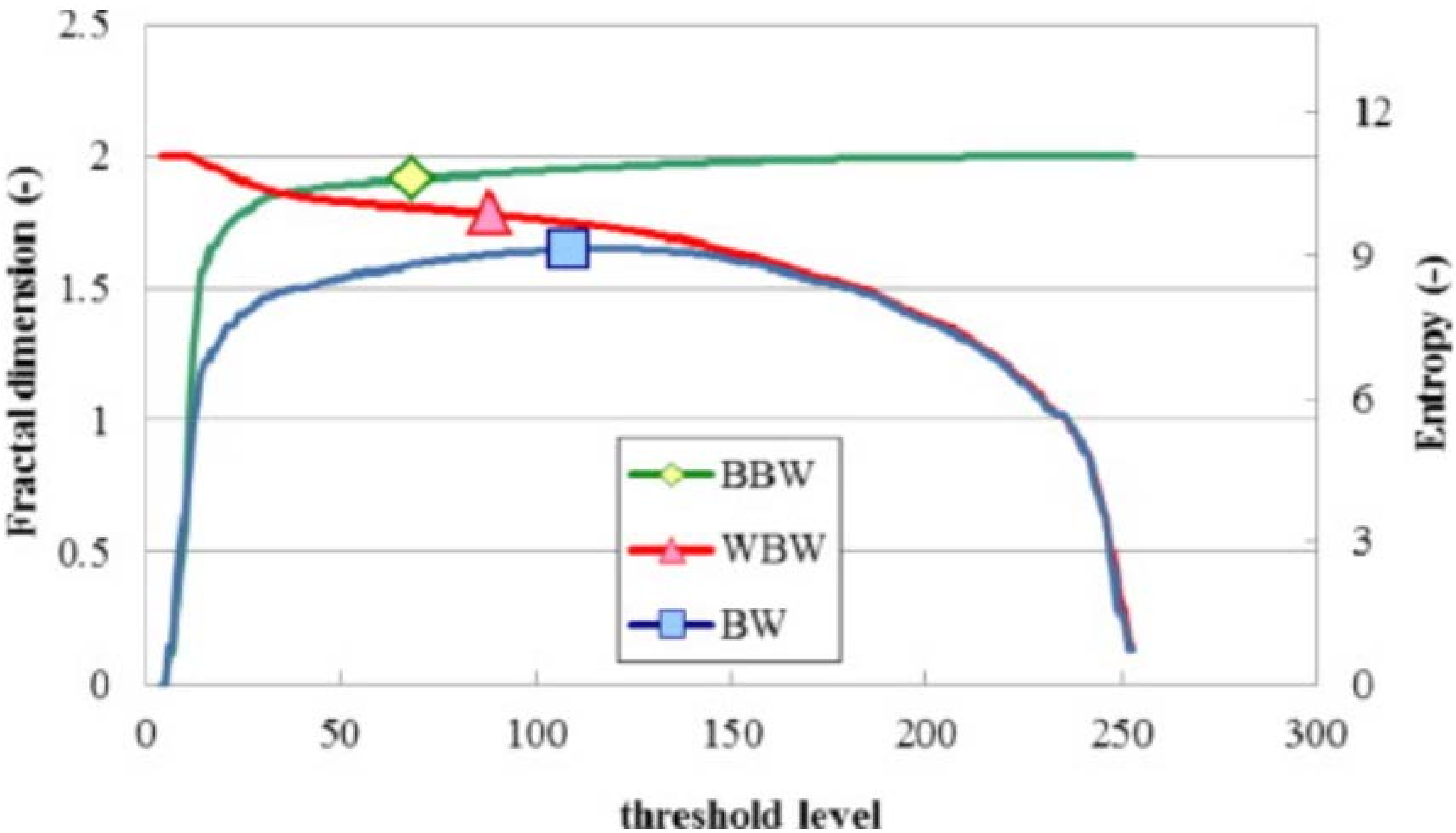
FRACTAL DIMENSION DATA FROM SENSOR INFORMATION



FRACTAL DIMENSION

ENTROPY

DATA



FRACTAL DIMENSION

ENTROPY

DATA → INFORMATION

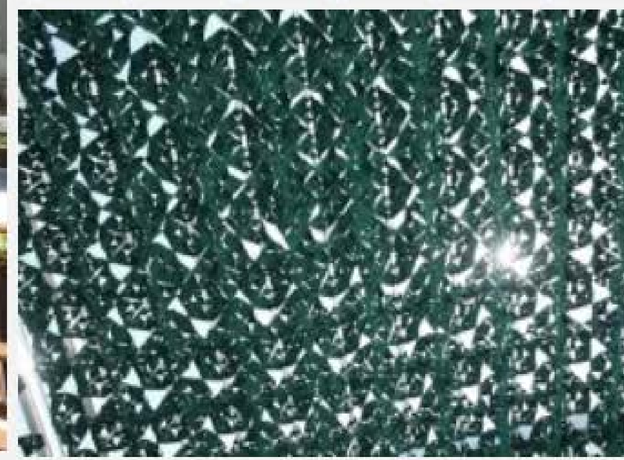
Usable Knowledge

It is good for? Application to improve lives?

FRACTAL DIMENSION

ENTROPY

DATA → INFORMATION



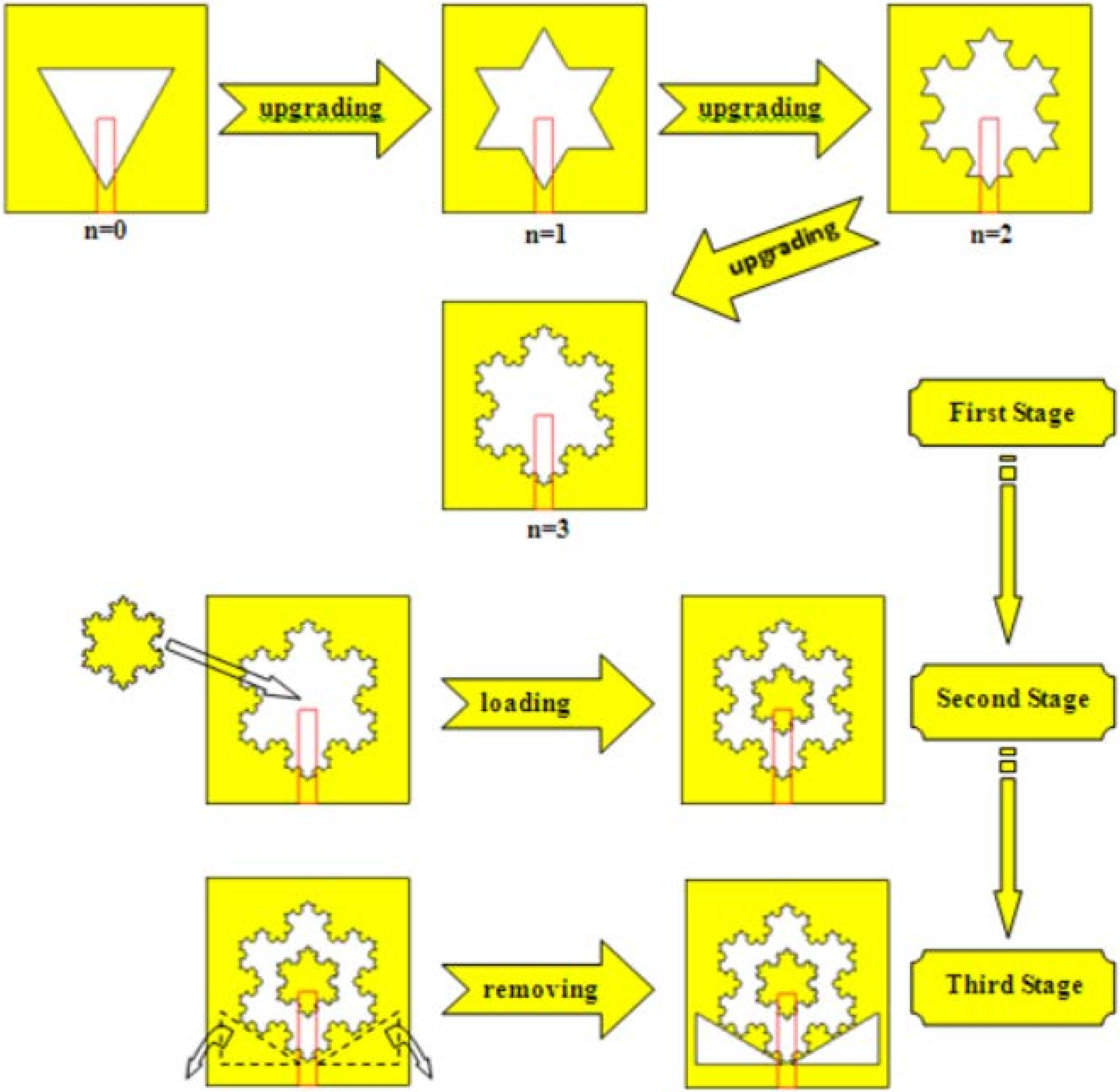
FRACTAL BIOMIMETICS

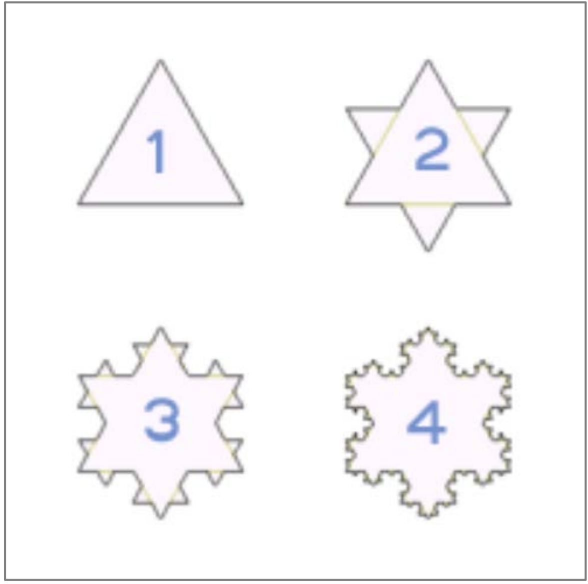
Lofsee Co., Ltd. sells a product called COMOLEVI "Forest Canopy." According to their website, COMOLEVI is a Japanese word meaning "sunlight filtering from leaves." It is modeled on natural tree branches and leaves, and allows the air to pass through while blocking sunlight, thereby providing the same cooling effect as natural shade. The shade, originally called the "Fractal Shade," was developed by a research team led by Dr. Satoshi Sakai, a professor of Graduate School of Human and Environmental Studies, Kyoto University. In their experiments, the artificial shade cooled the area it covered by up to 15 degrees Celsius, as compared to sun-exposed ground areas, and the temperature of the shade itself was up to 20 degrees Celsius lower than flat building roofs. The perceived temperature under the shade was two to three degrees Celsius cooler.

BIOMIMICRY STORY

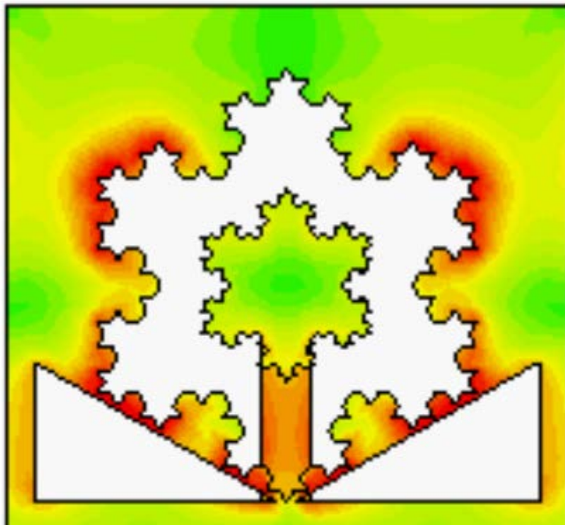
Inspired by the fact that the surfaces of leaves are cooler than the ambient air even under direct sunlight, the Kyoto University research team adopted Sierpinski Tetrahedrons, a geometric pattern similar to the structure, a fractal pattern, of natural tree branches and leaves. The result is dappled sunlight as occurs under a forest canopy, with air movement through the "canopy." Additional source: Kyoto University Develops Artificial Shade Structure Inspired by Natural Trees in Japan For Sustainability.

https://asknature.org/idea/comolevi-forest-canopy/#.WdesFGhSxdg

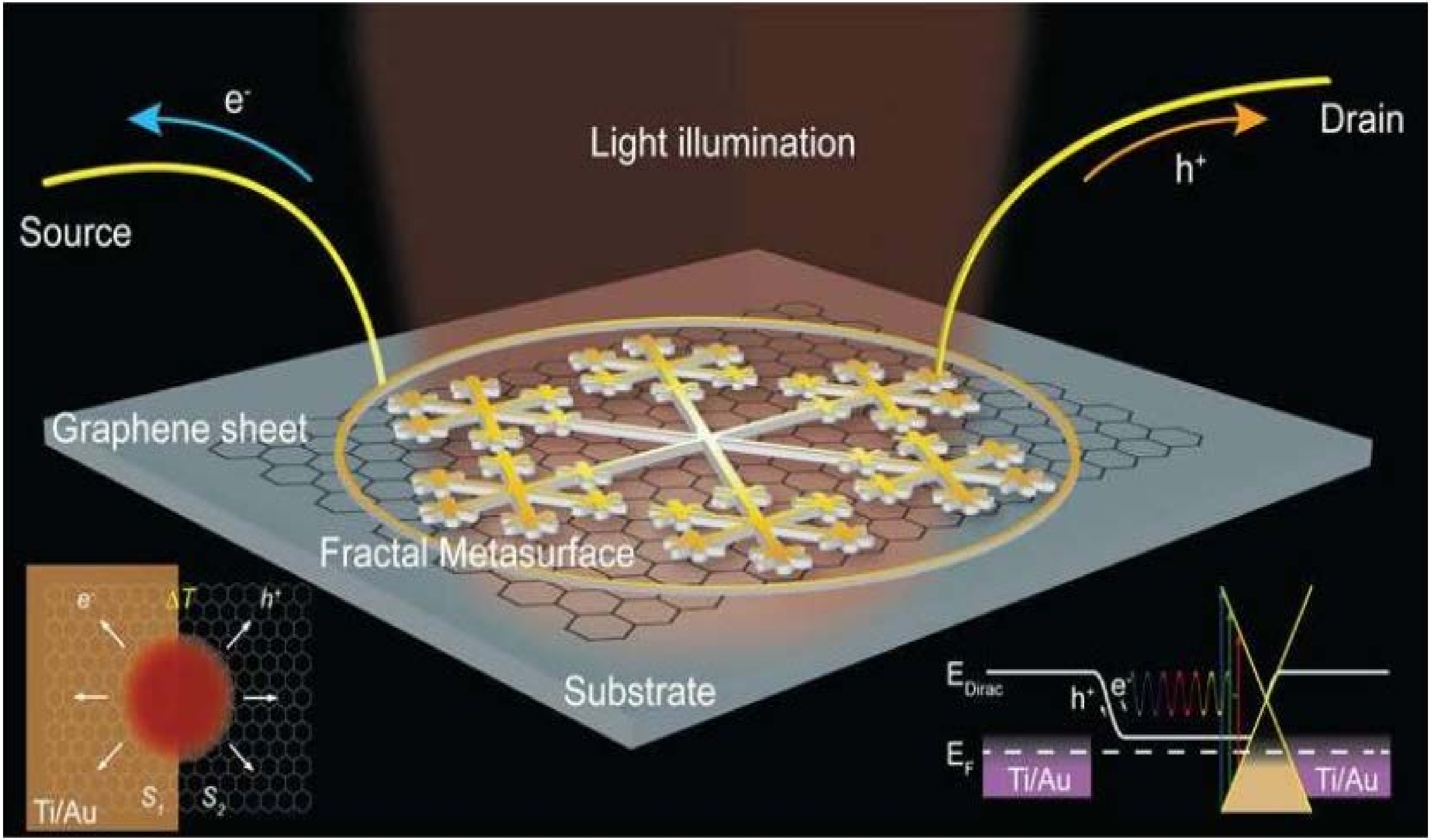




DOI: 10.13140/RG.2.1.4154.6485



Compact Dual-band Antenna with Fractal Slot Annular Ring and Defected Ground Structure



A graphene photodetector with gold contacts in the form of a snowflake-like fractal pattern has a higher optical absorption and an order-of-magnitude increase in photovoltage, as compared to graphene photodetectors that have contacts with plain edges. Credit: Fang et al. ©2016 American Chemical Society https://phys.org/news/2017-01-graphene-photodetector-fractal-golden-snowflake.html

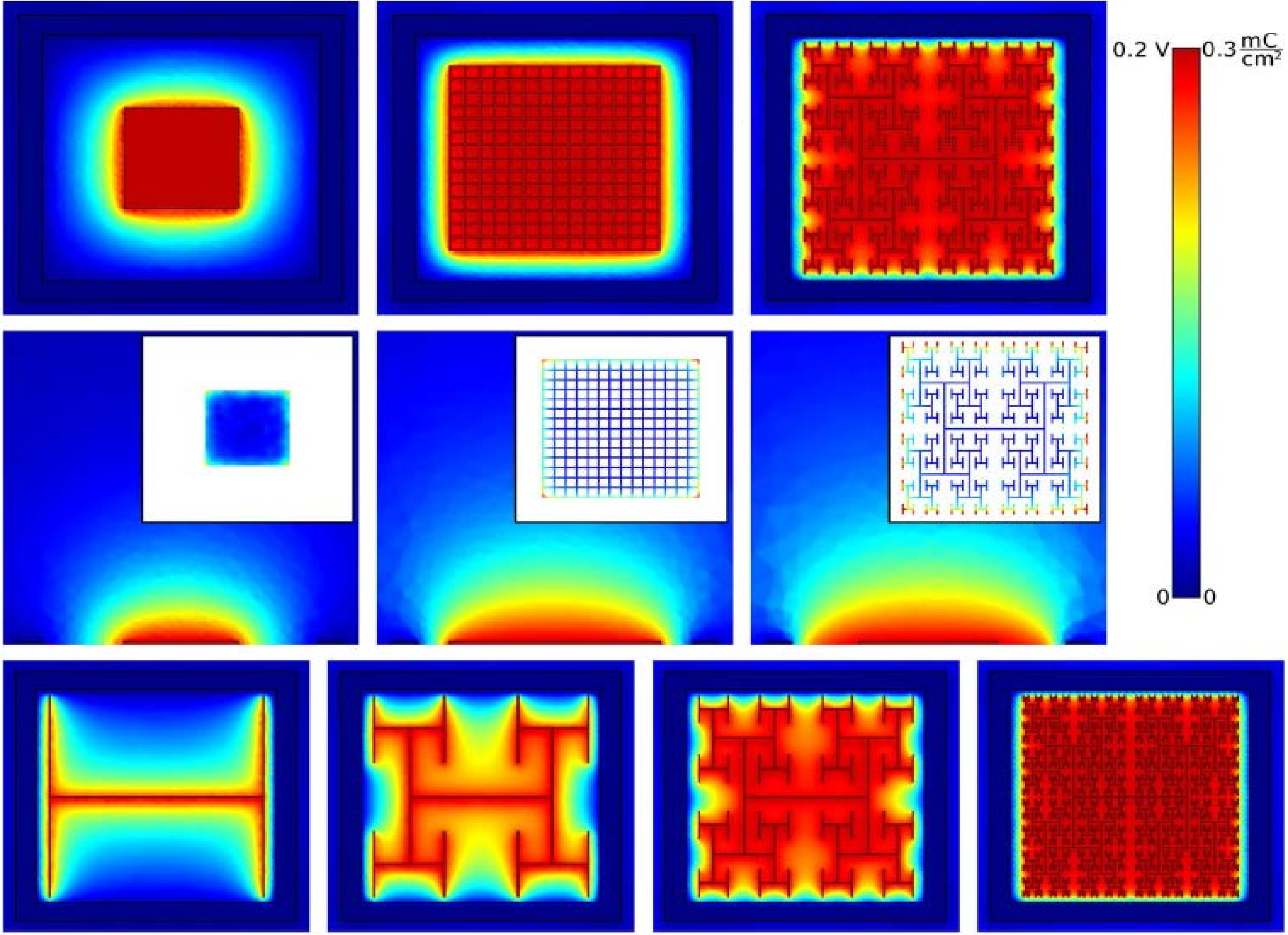
The Breakdown of Fractal Heart Rate Dynamics Predicts Prolonged Postoperative Myocardial Ischemia

Timo T. Laitio, MD[*], Heikki V. Huikuri, MD[||], Timo H. Mäkikallio, MD[||], Jouko Jalonen, MD[*], Erkki S. H. Kentala, MD[*], Hans Helenius, MSc[‡], Olar Pullisaar, MD[†], Jaakko Hartiala, MD[†],

Vision ● Trans-disciplinarity

Cross-pollination and confluence of ideas catalyzes global solutions

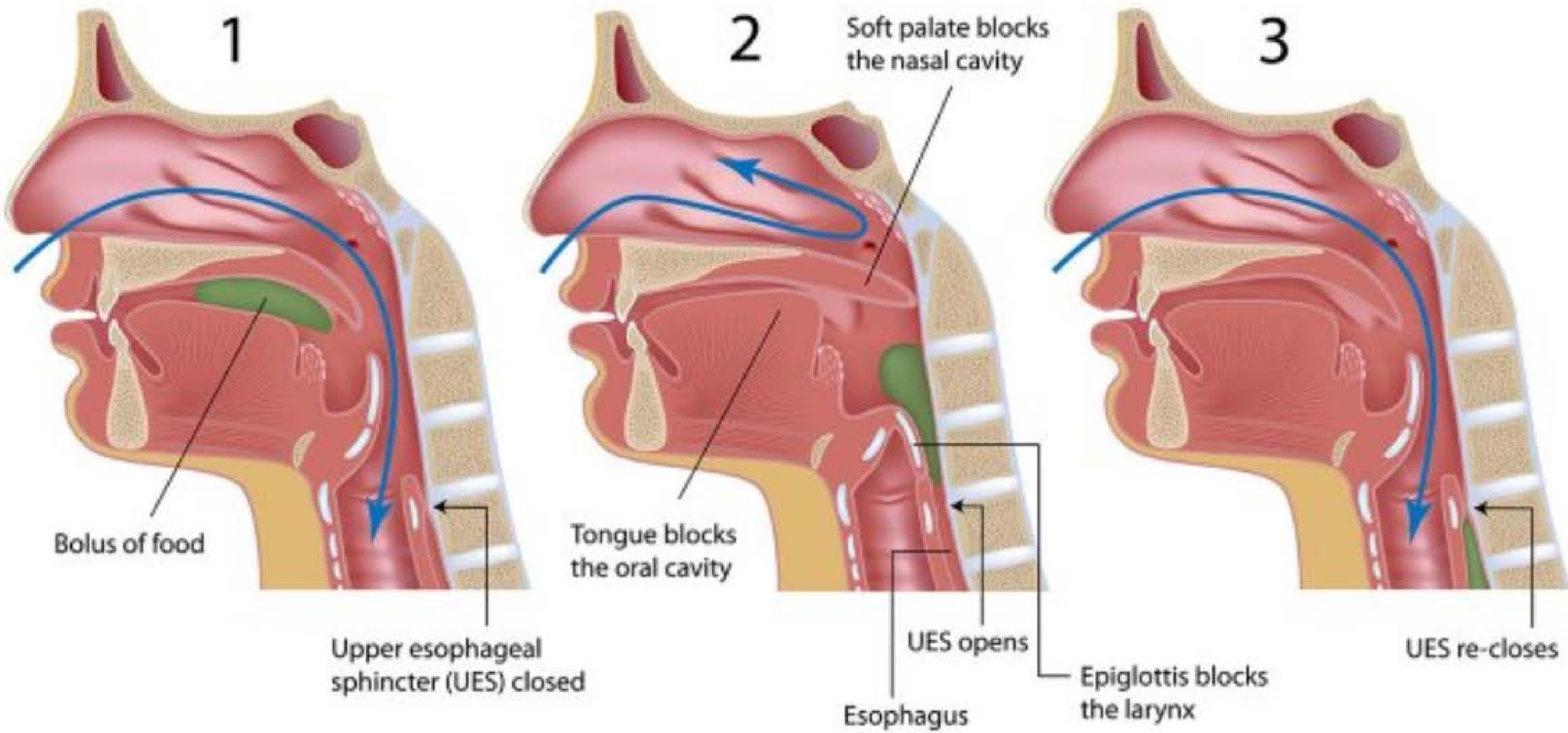
FRACTAL BASED RETINAL IMPLANT



Fractal Electrodes as a Generic Interface for Stimulating Neurons
W. J. Watterson, R. D. Montgomery & R. P. Taylor
DOI: 10.1038/s41598-017-06762-3

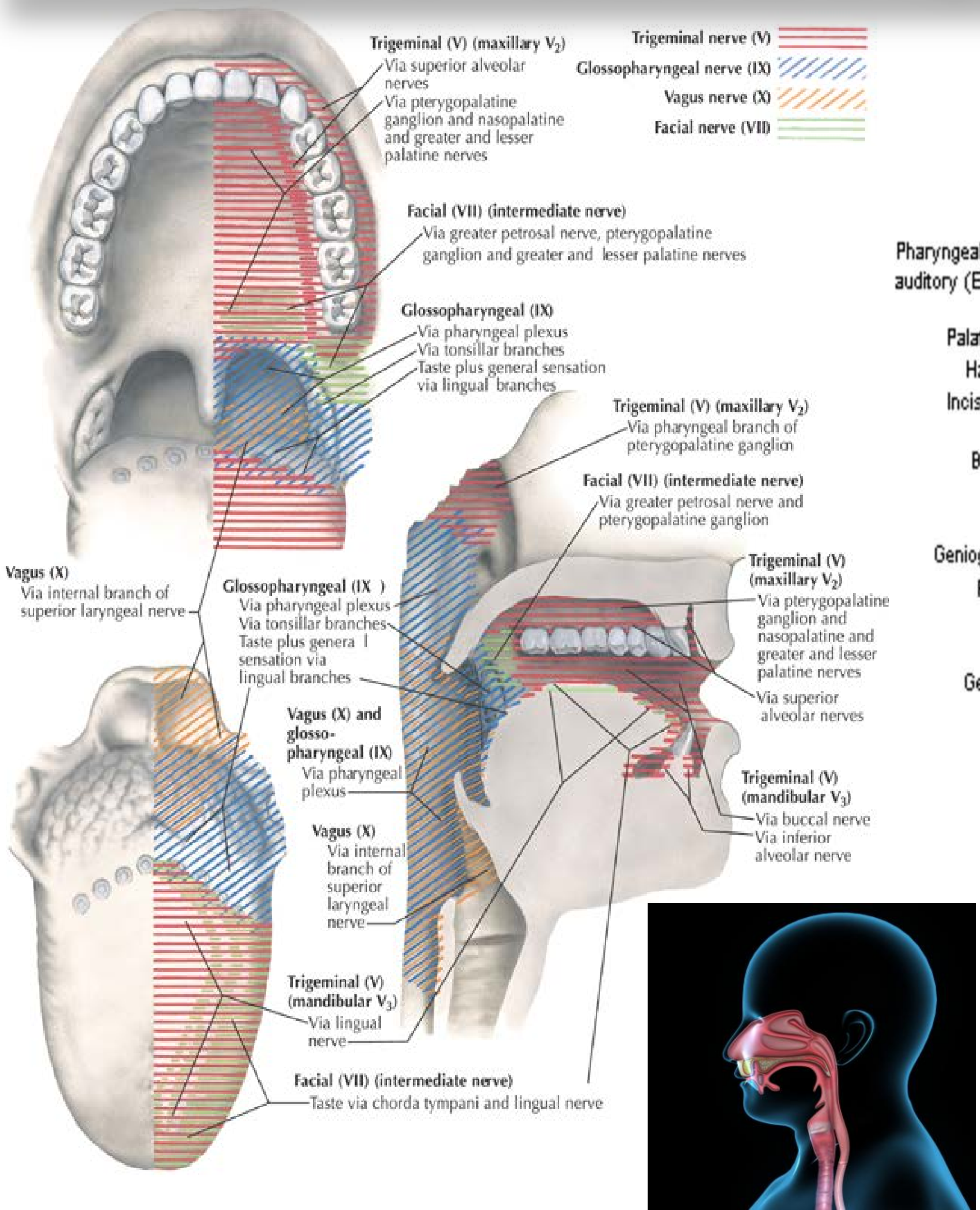
http://pubs.acs.org/doi/abs/10.1021/nl501738b

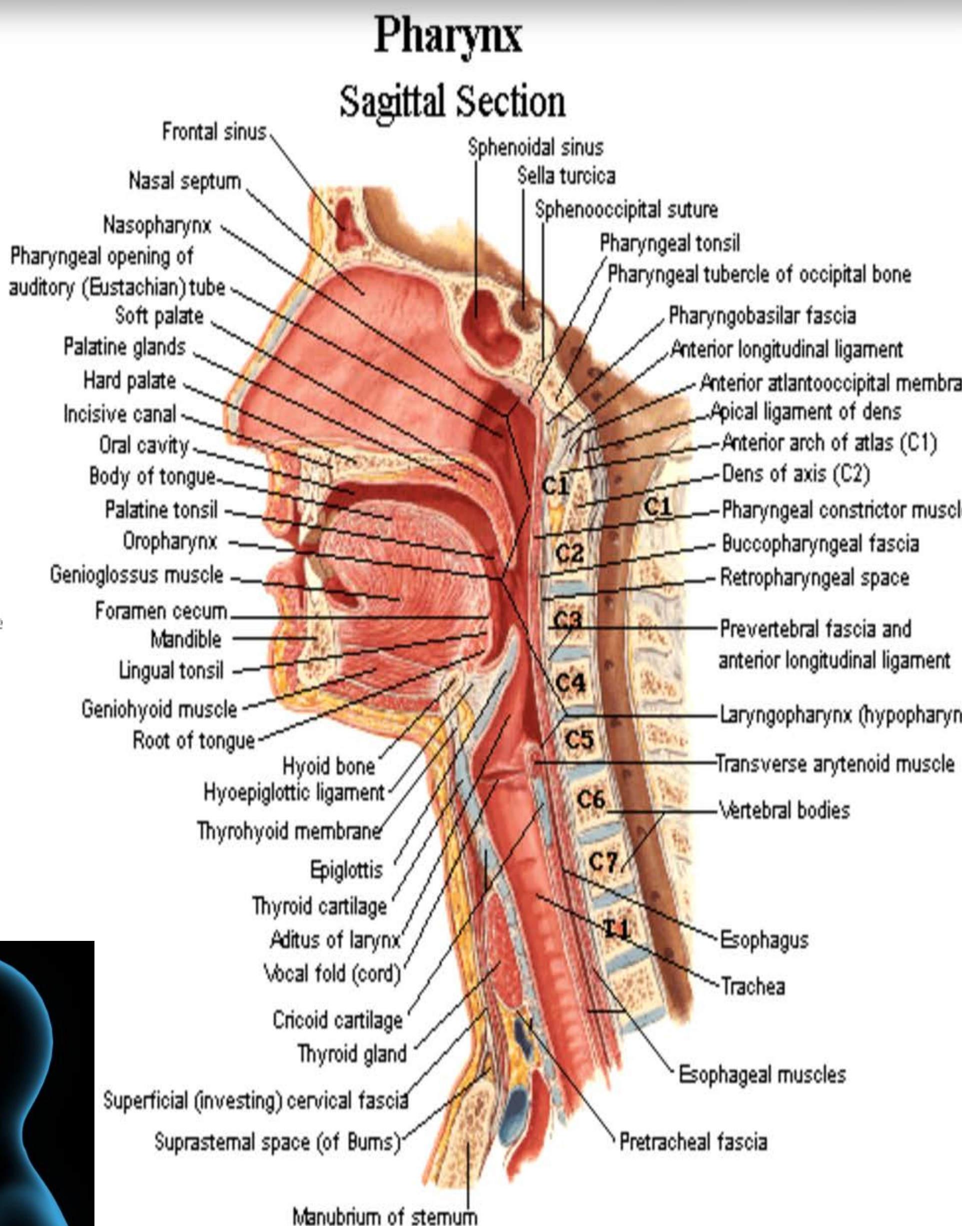
Figure 2. The maximum extracellular voltages reached during each oscillation for the square, grid, and the 3-iteration fractal electrodes (each with an electrode height of 250 nm). In each case, the applied voltage was $V_0 = 0.2$ V and $f = 1$ kHz. A horizontal slice (at the inner electrode's top surface) of the three-dimensional voltage distribution for each electrode geometry is shown in the top row. Vertical slices through the middle of the electrodes are shown in the middle row. The charge density on the top surface of each inner electrode is shown in the insets. The bottom row shows the field uniformity achieved by increasing from 0 to 4 iterations.

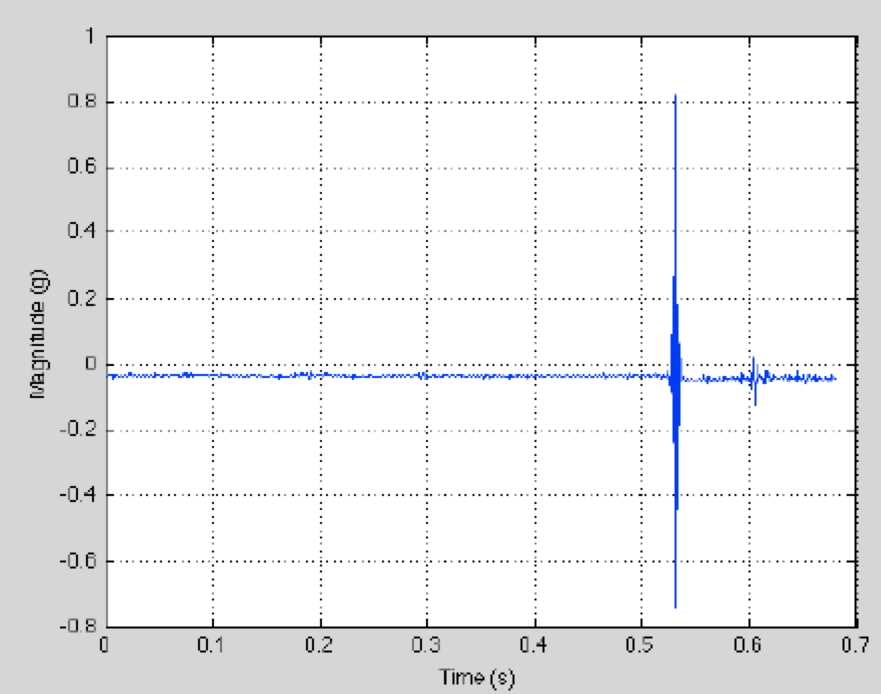


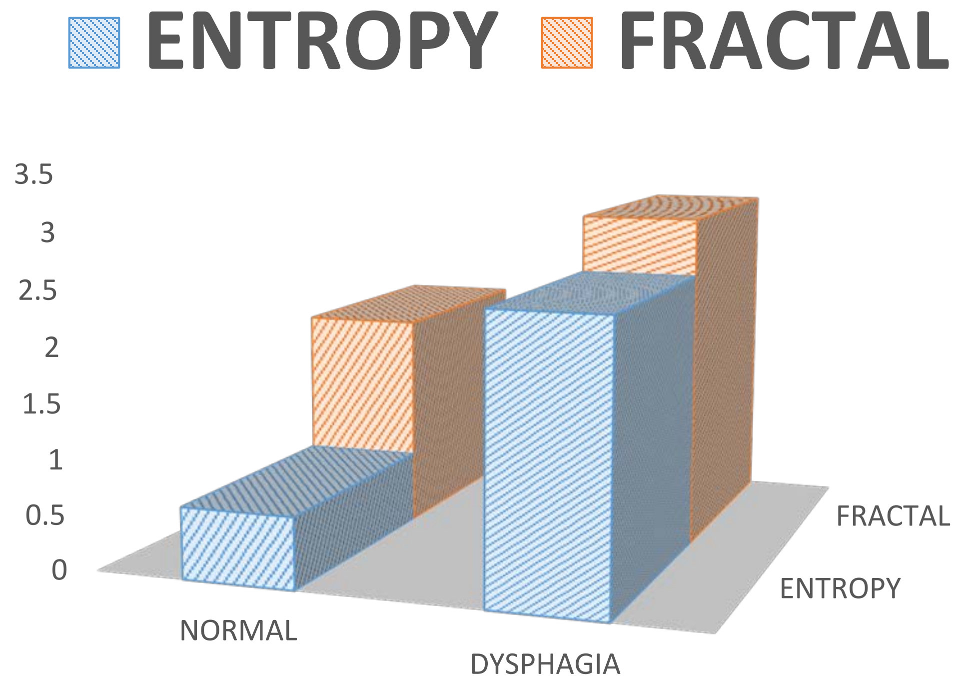
Deglutition / Swallowing

Entropy and Fractals as Diagnostic Tools in Dysphagia

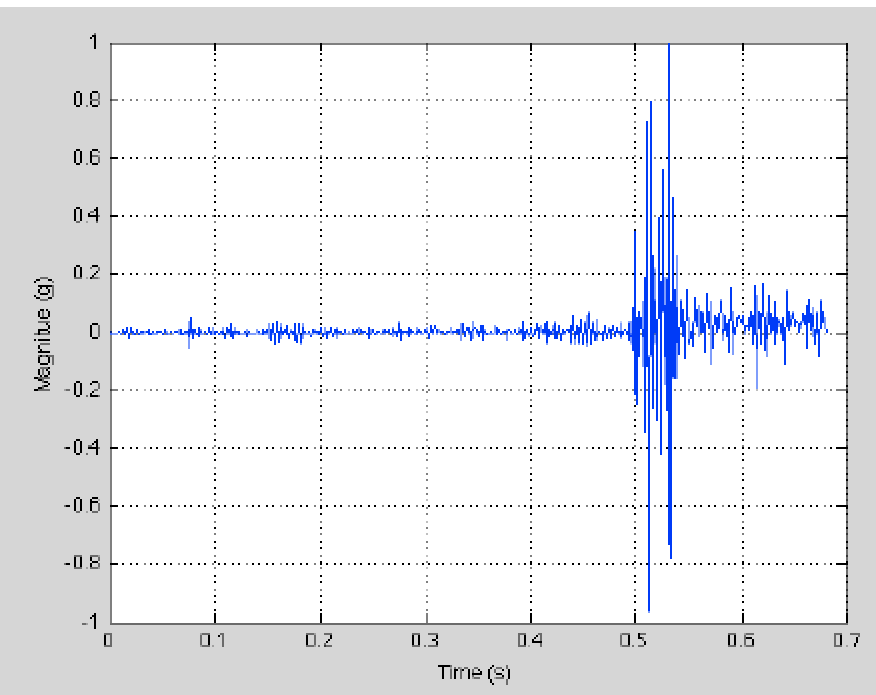


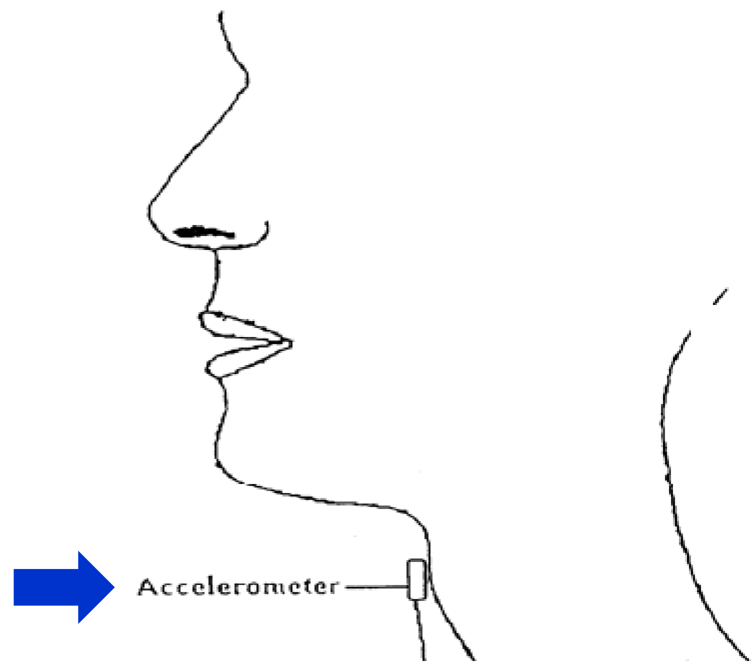






Entropy & Fractals as Diagnostic Tools in Dysphagia





http://rave.ohiolink.edu/etdc/view?acc_num=akron1313410479

Table 3: t-test results revealing significant differences between dysphagic and normal entropy values http://rave.ohiolink.edu/etdc/view?acc_num=akron1313410479

levels	5		10		15		20	
diagnosis	normal	dysphagic	normal	dysphagic	normal	dysphagic	normal	dysphagic
mean	0.11	0.55	0.53	1.35	0.43	1.36	0.65	1.82
Standard Dev	0.11	0.28	0.38	0.43	0.26	0.57	0.44	0.59
Variances	Unequal		Equal		Unequal		Equal	
Result	Reject Null		Reject Null		Reject Null		Reject Null	

Table 7: Fractal dimension calculated for normal subjects

levels	Normal		
trial	1	2	avg
Subject			
1	2.625	1.922	2.273
2	1.471	1.771	1.621
3	1.439	1.468	1.453
4	1.461	1.522	1.491
5	1.490	1.521	1.505
6	1.773	1.876	1.824
7	1.876	1.876	1.876
8	1.877	1.981	1.929
9	1.886	2.183	2.035
10	2.304	1.781	2.043
11	1.874	2.179	2.027
12	1.517	1.555	1.536
13	1.931	2.845	2.388
14	2.001	2.125	2.063
15	2.060	4.008	3.034
mean	1.839	2.041	1.940
Standard Dev	0.337	0.648	0.419

Table 8: Fractal dimension calculated for dysphagic subjects

levels	Dysphagic		
trial	1	2	avg
Patient			
1	2.710	1.865	2.288
2	2.569	2.252	2.411
3	2.432	2.805	2.619
4	2.196	2.196	2.196
5	2.401	2.895	2.648
6	4.590	4.281	4.435
7	2.077	2.077	2.077
8	3.273	3.812	3.543
9	2.560	3.616	3.088
10	3.506	5.923	4.714
11	3.402	4.295	3.848
12	2.125	2.593	2.359
13	3.085	3.927	3.506
14	3.229	2.898	3.063
15	2.329	2.543	2.436
mean	2.832	3.198	3.015
Standard Dev	0.682	1.100	0.829

How do we transform this data and information to diagnose patients with potential problems due to dysphagia or predict if a person may be experiencing some form of dysphagia (may be symptomatic of other problems - silent stroke).

Table 3: t-test results revealing significant differences between dysphagic and normal entropy values

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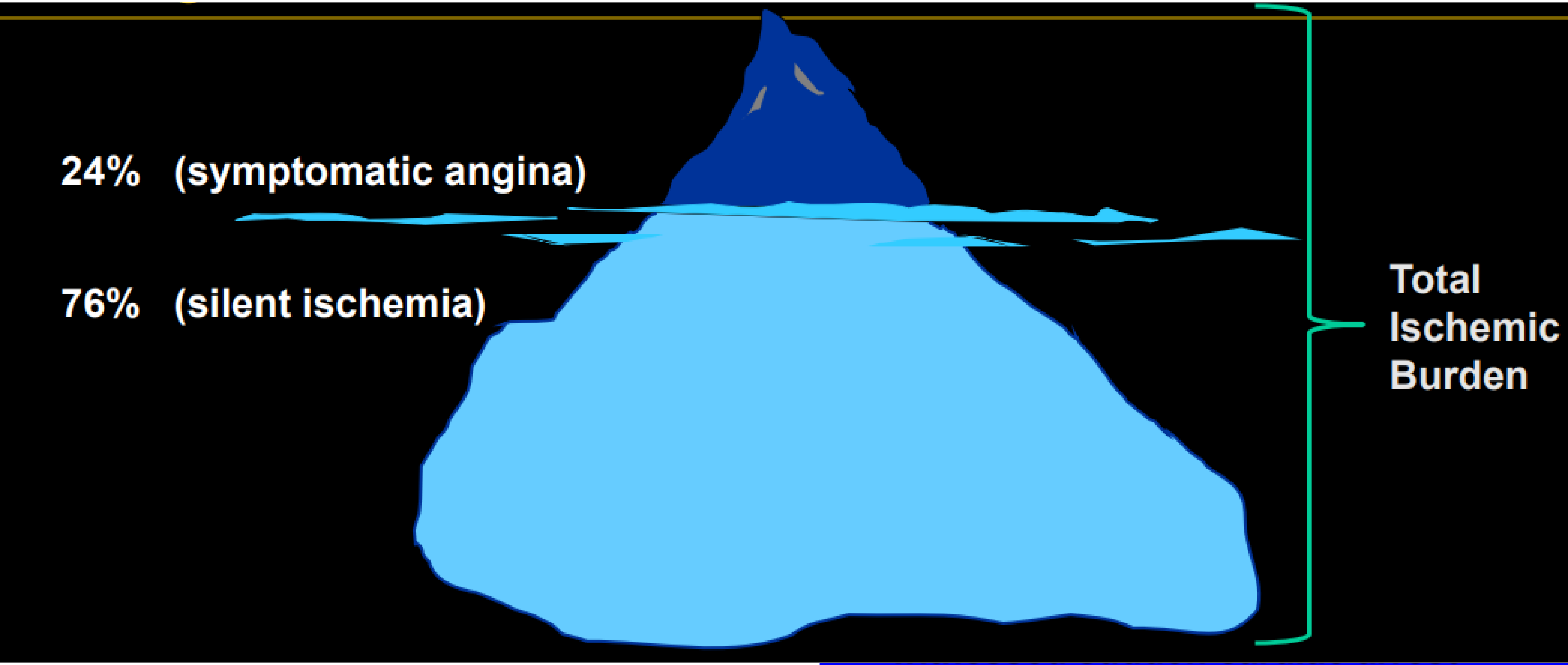
Symptomatic Angina: The Tip of the Ischemic Iceberg

www.escardio.org/static_file/Escardio/education/live-events/courses/education-resource/Fri-11-SMI-Gutterman.pdf

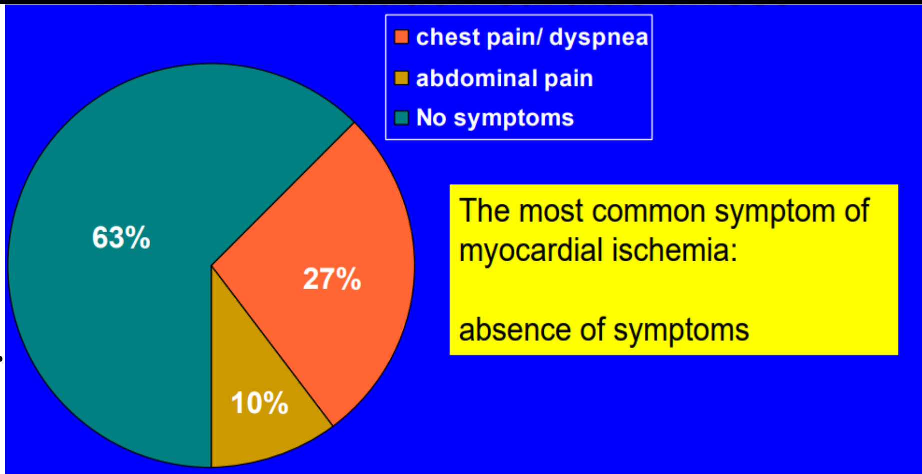


If you cannot sense, you cannot detect.

If you cannot predict, you cannot prevent.

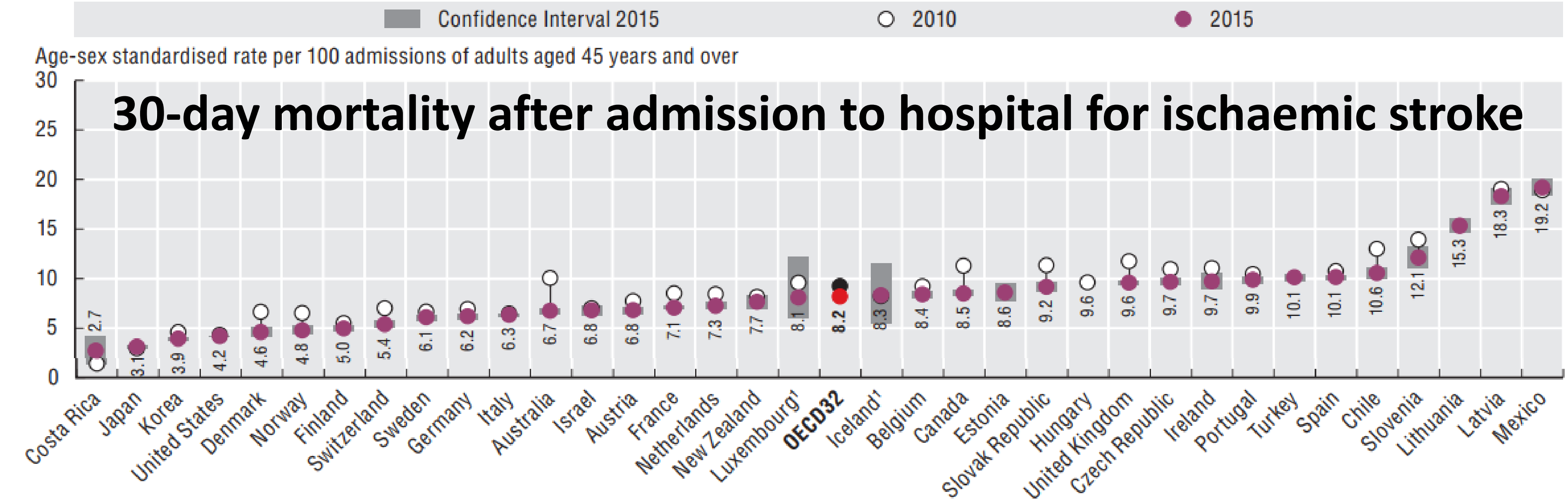
If you cannot measure, you do not have metrics.

If you do not have data, you cannot take a decision.



https://dspace.mit.edu/handle/1721.1/107893

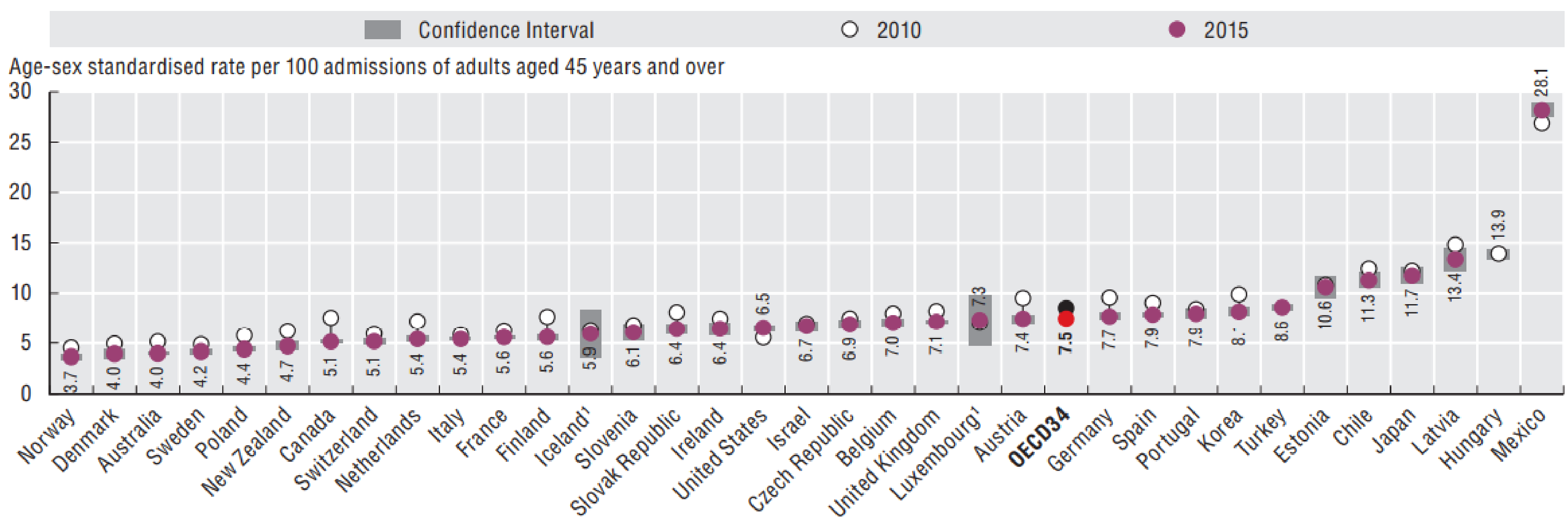
30-day mortality after admission to hospital for ischaemic stroke



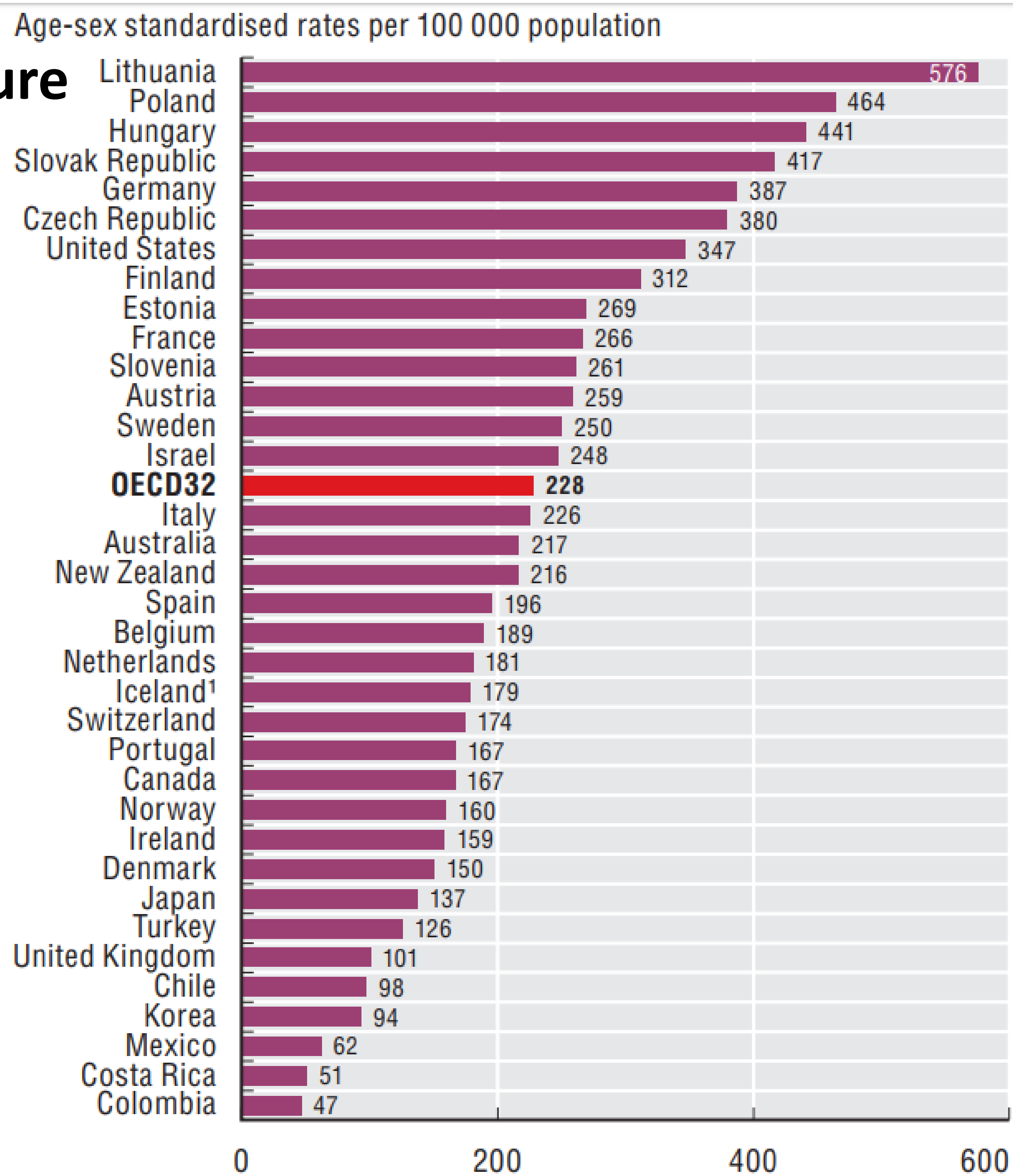
OECD Health Statistics 2017 http://dx.doi.org/10.1787/888933603602

Mortality following acute myocardial infarction (AMI)

Thirty-day mortality after admission to hospital for AMI based on unlinked data, 2010 and 2015 (or nearest years)



Congestive heart failure hospital admission (adults, 2015)

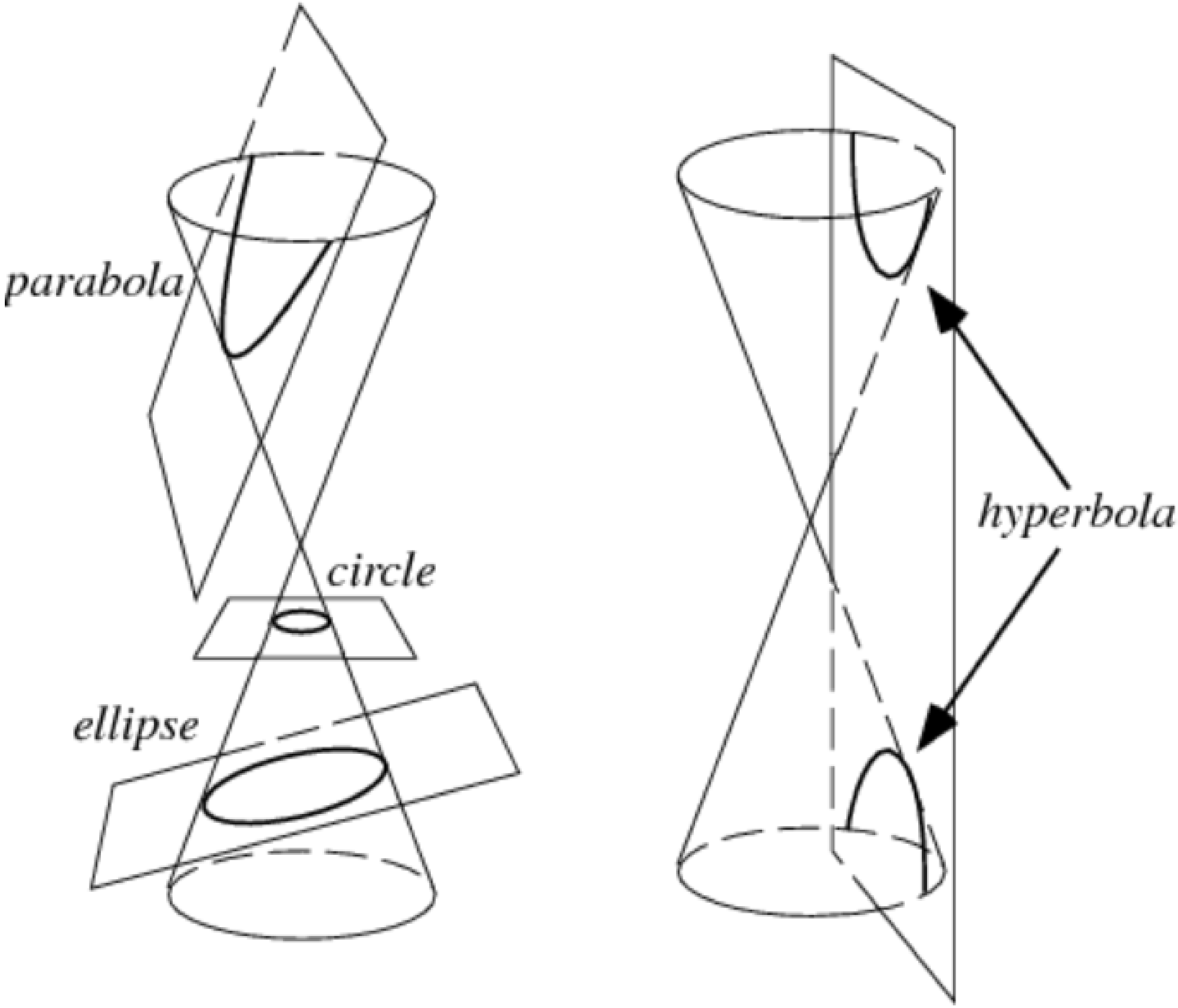


OECD Health Statistics 2017

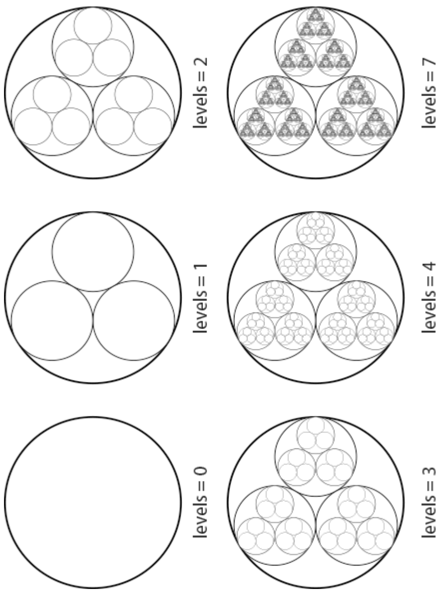
http://dx.doi.org/10.1787/888933603507

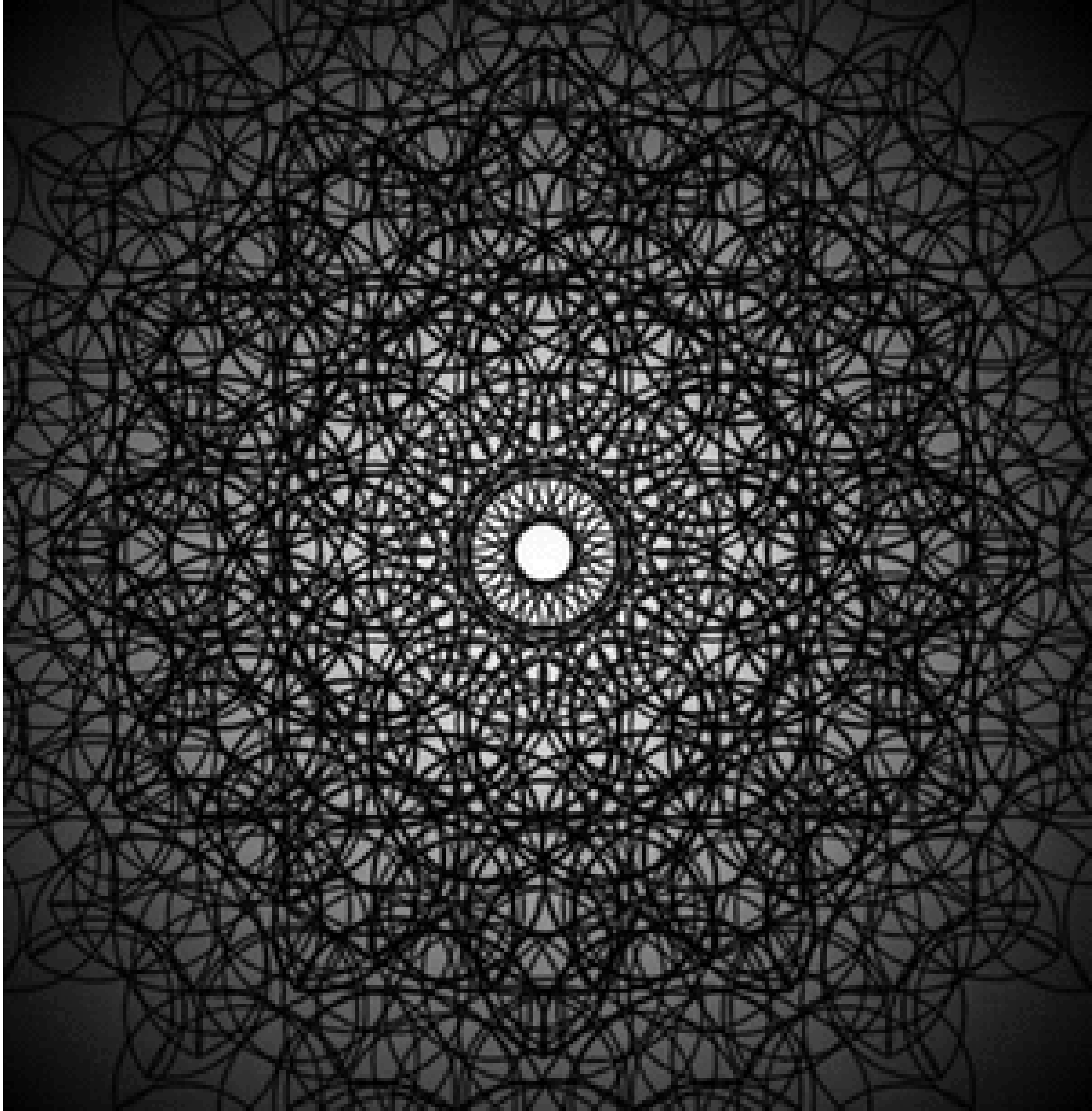
Entropy and Information

If information grows, does entropy increase?



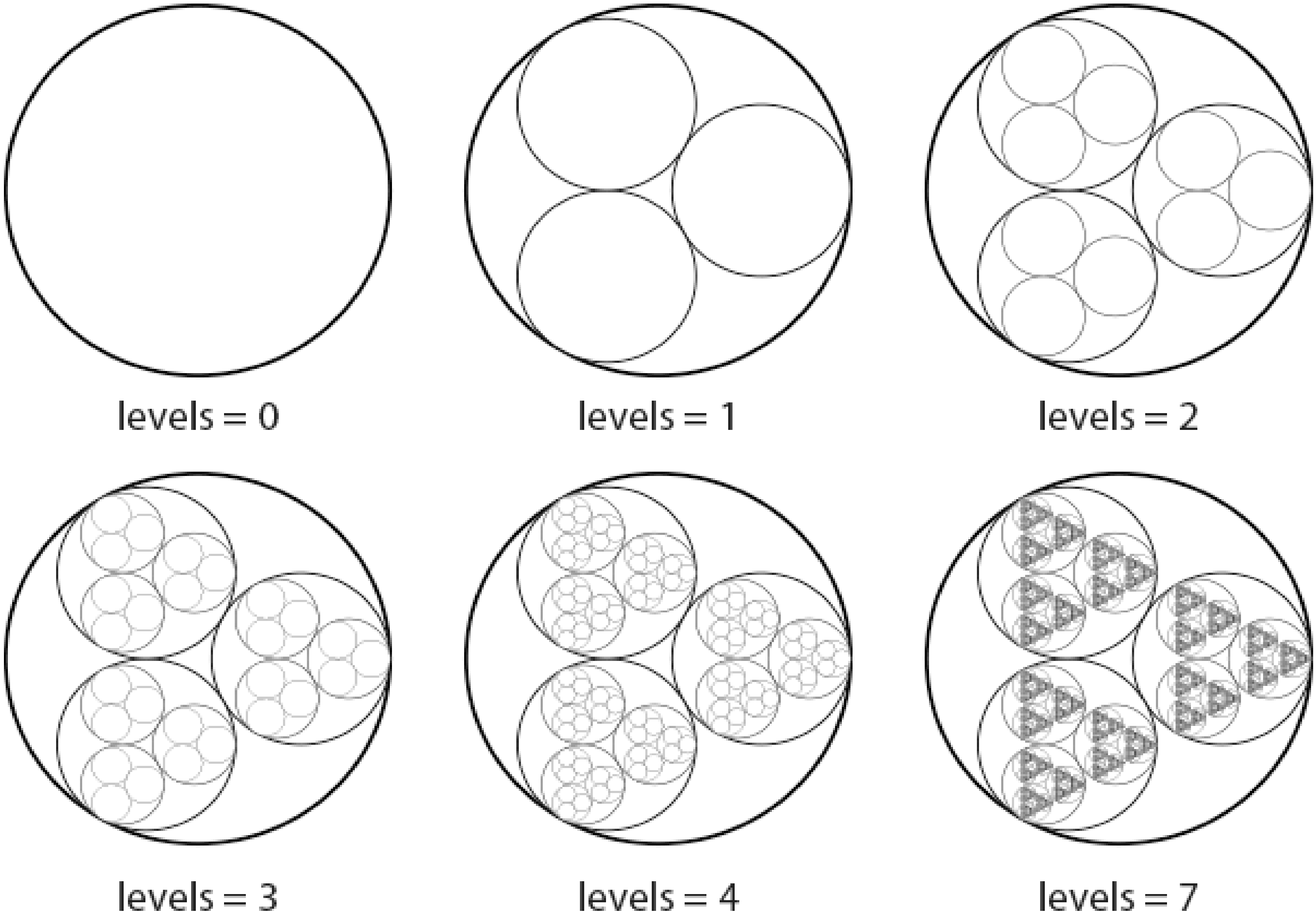
The conic sections are the nondegenerate curves generated by the intersections of a plane with one or two nappes of a cone. For a plane perpendicular to the axis of the cone, a circle is produced. For a plane that is not perpendicular to the axis and that intersects only a single nappe, the curve produced is either an ellipse or a parabola (Hilbert and Cohn-Vossen 1999, p. 8). The curve produced by a plane intersecting both nappes is a hyperbola (Hilbert and Cohn-





www.student.cs.uwaterloo.ca/~cs106/Winter2017/labs/l06/

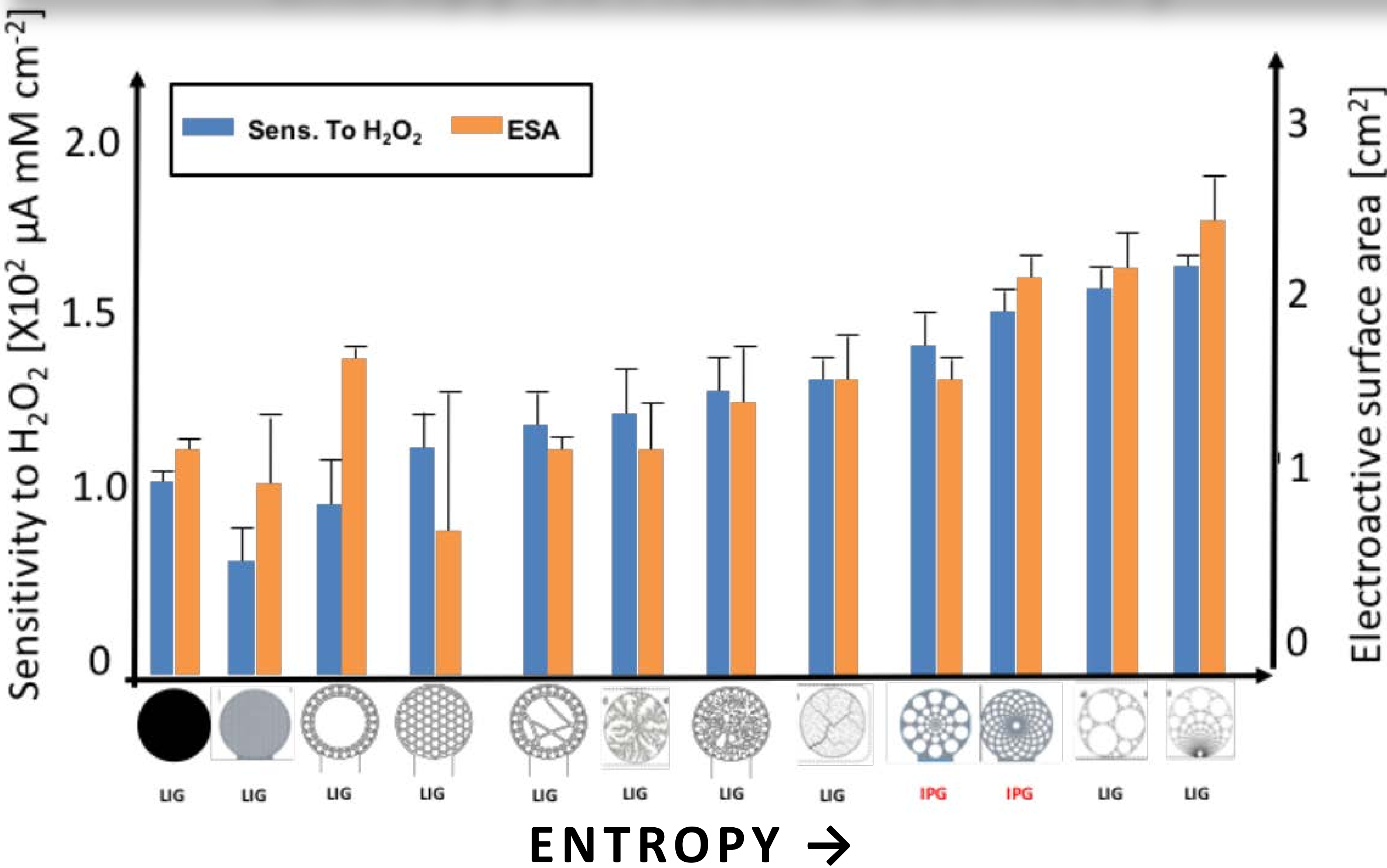
Mandelbrot Fractal - Fragmented geometric shape can be subdivided in parts, each of which is (at least approximately), a reduced/size copy of the whole (self-similar).



Example

Fractal vs Entropy

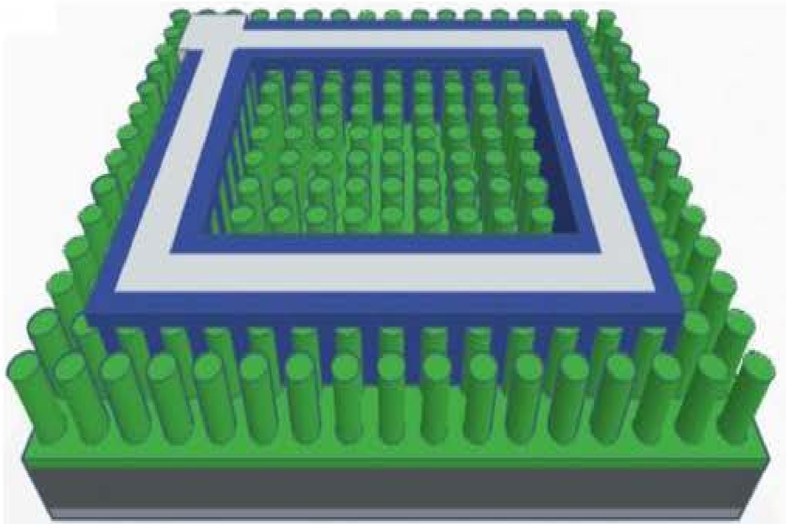
Entropy vs Fractal Geometry



Average sensitivity toward H_2O_2 (blue) and electroactive surface area (orange) for patterned laser inscribed graphene (LIG) and inkjet printed graphene (IPG) electrodes.

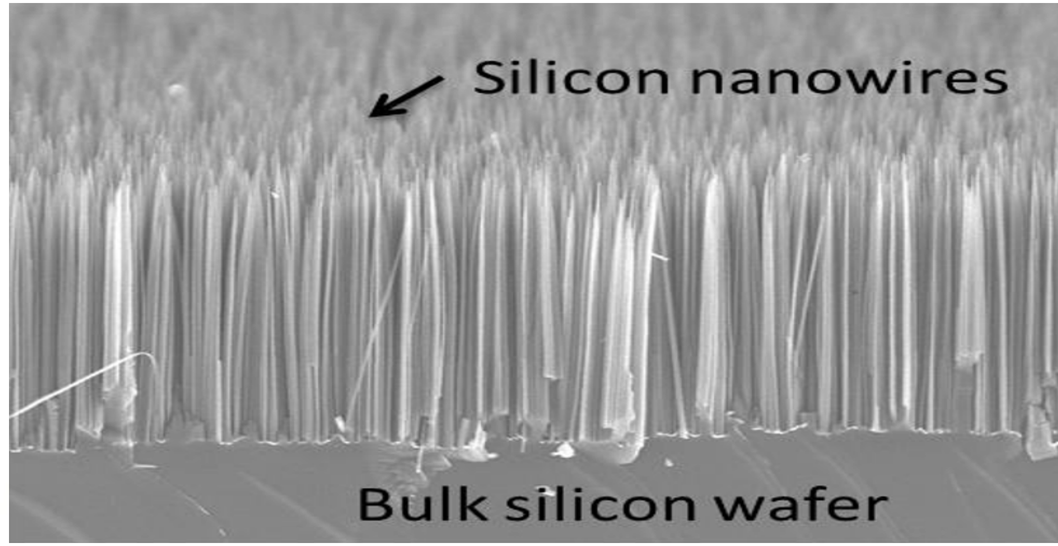
Nano-surfaces vs Sensitivity

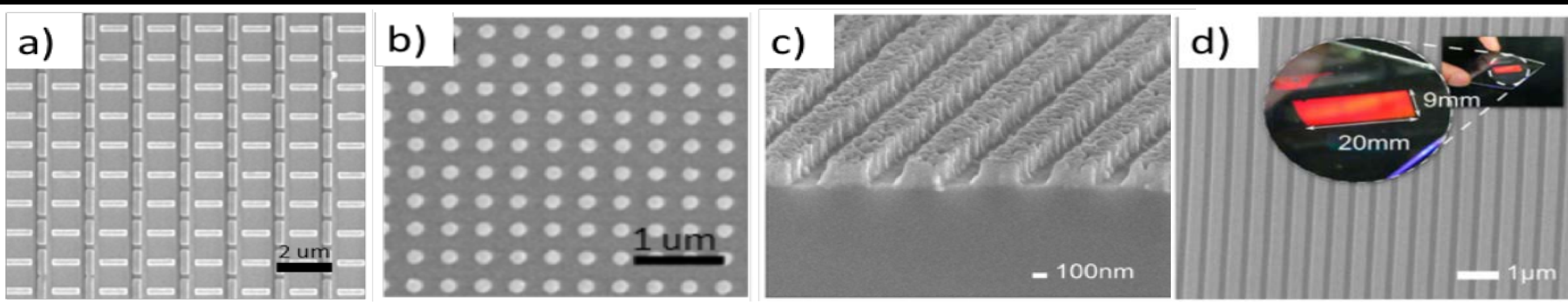
Silicon nano-wires, Surface enhanced Raman Spectroscopy (SERS) https://ftoor.lab.uiowa.edu/research



Marcie Black, ASG and Fatima Toor, Iowa

Silicon Nanowire based Optoelectronic Biosensors

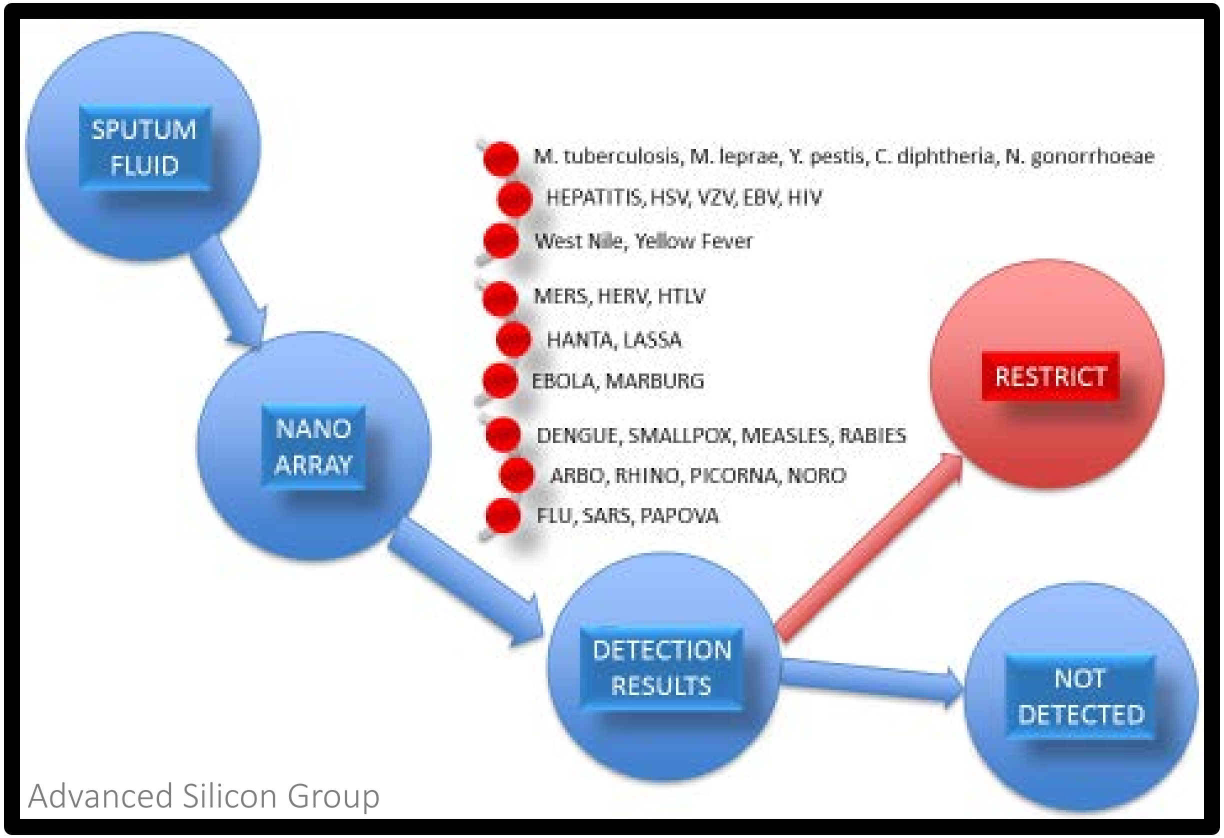




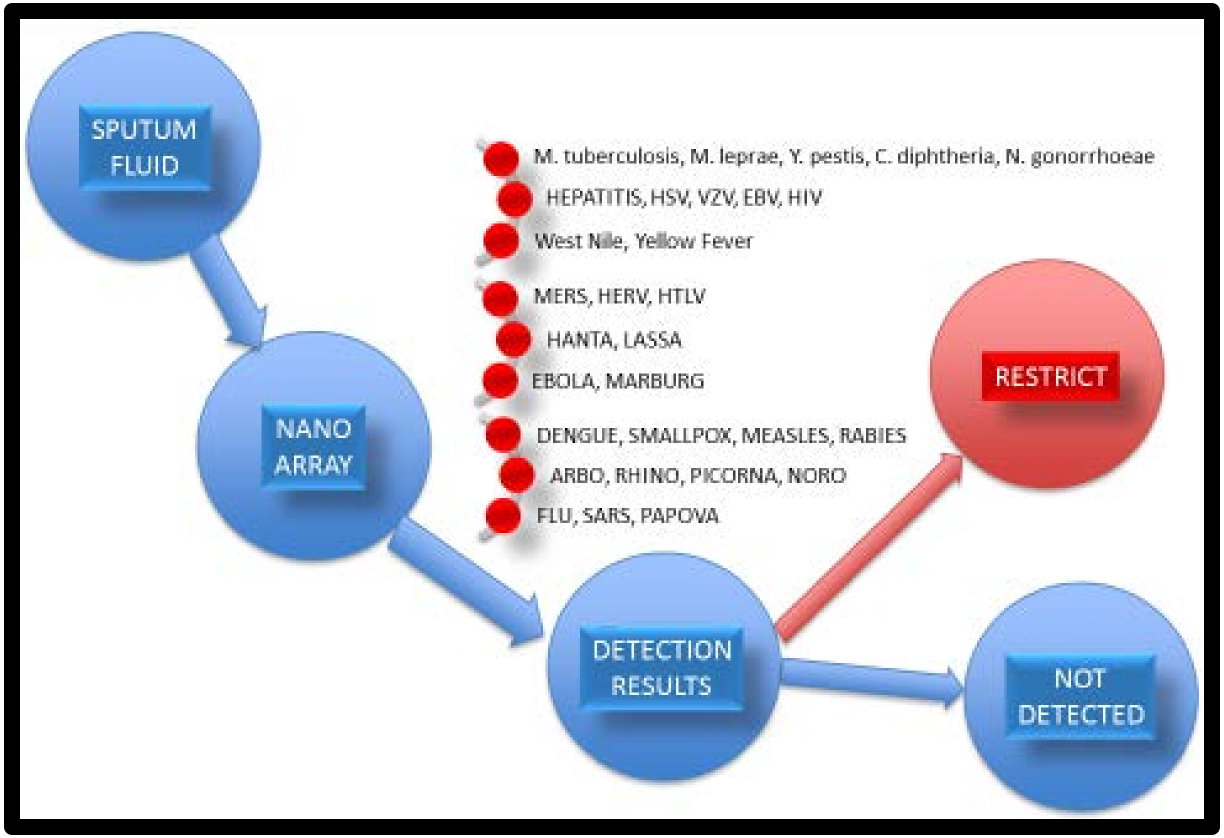
(a) Patterned gold nanocrystals by nanoimprint lithography (b) Gold (Au) evaporated thin films patterned on hydrogel (c) indium-tin-oxide (ITO) nanorods fabricated by combining nanoimprint lithography and etching.

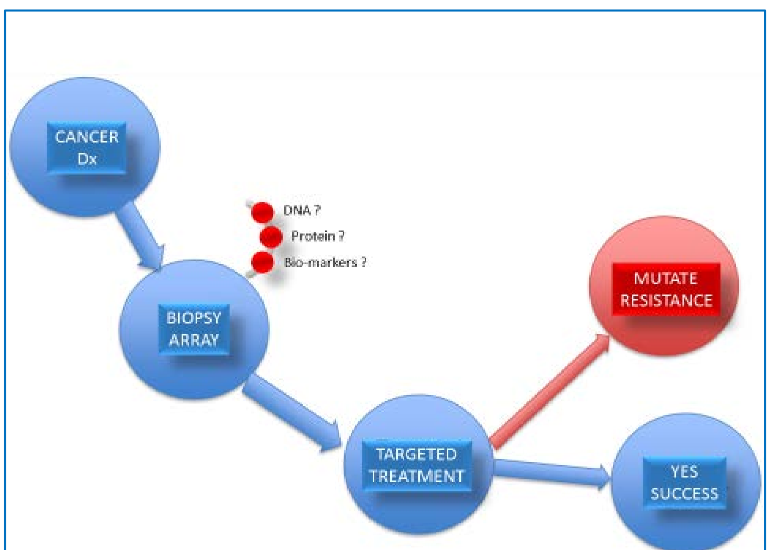
Application

Nanobiosensor, detection, data acquisition, transmission by smart phone

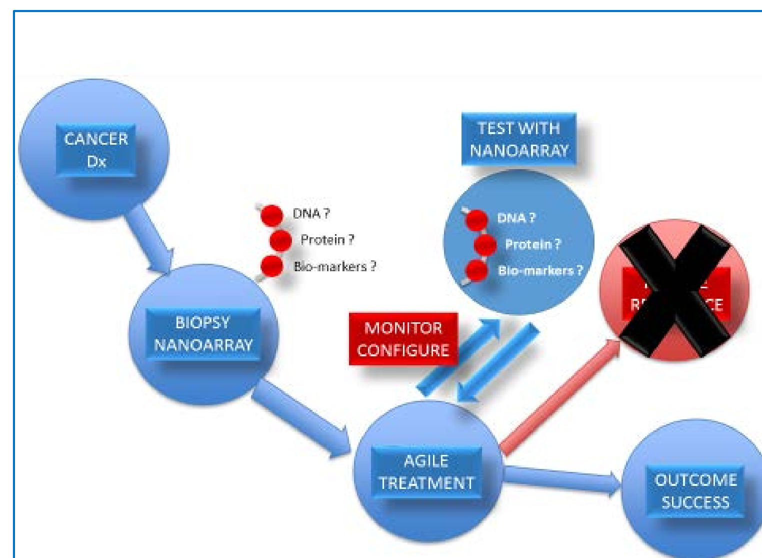


Digital in 4D (Healthcare and Medical IoT) https://dspace.mit.edu/handle/1721.1/107893

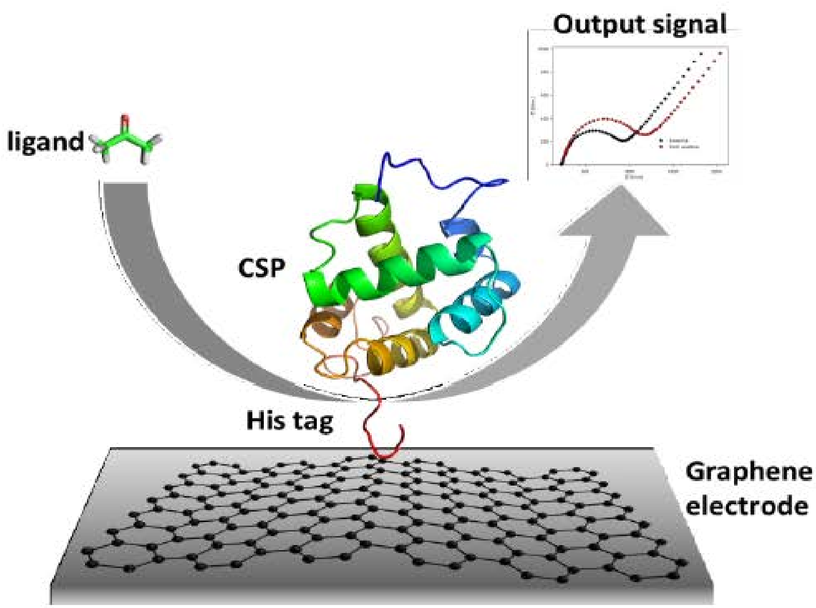


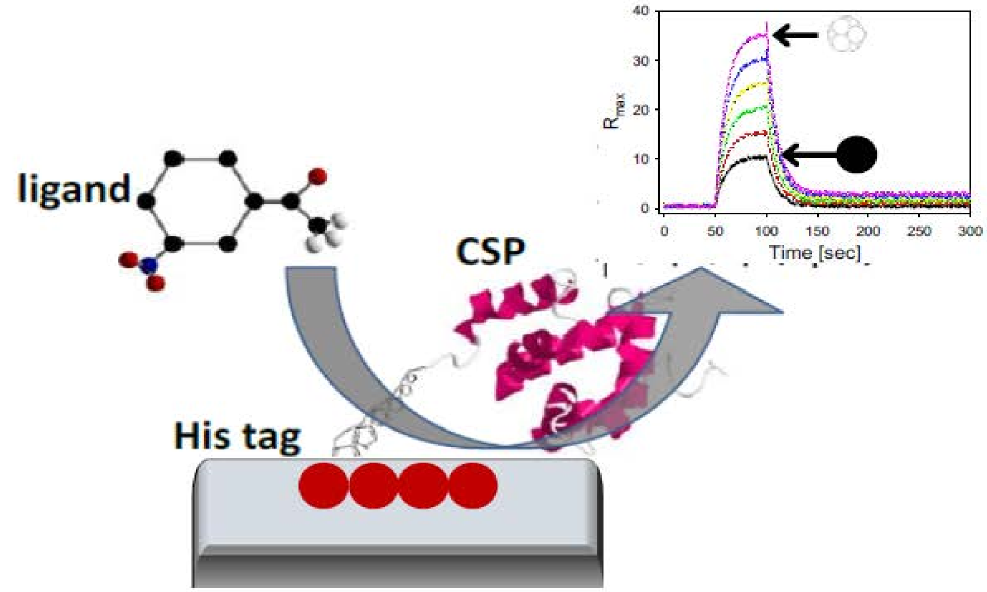


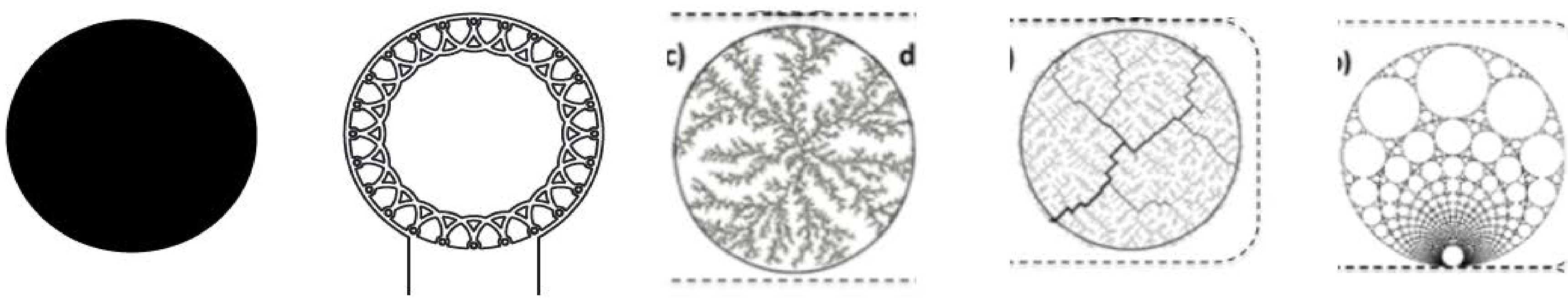
LUNG CANCER
Marcie Black
Fatima Toor



Nano-Bio-Sensor to detect water-soluble Imidacloprid (neonicotinoid insecticide inhibits nicotinic acetylcholine receptors (CNS). Causes honeybee colony collapse disorder (CCD).

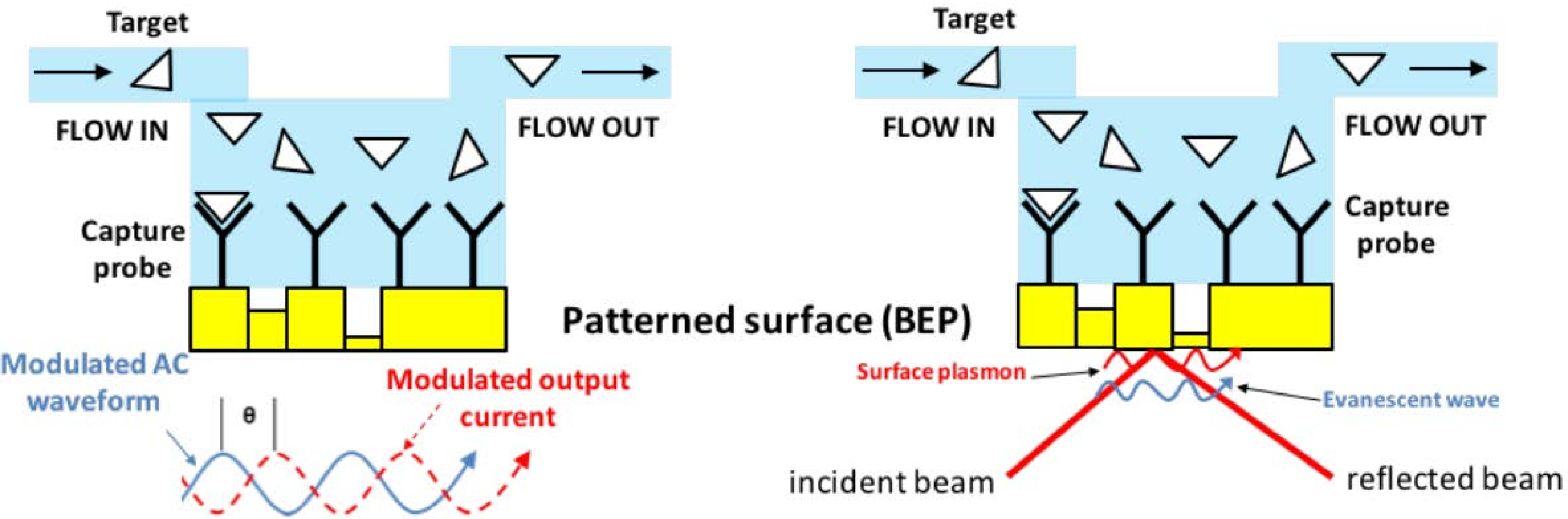






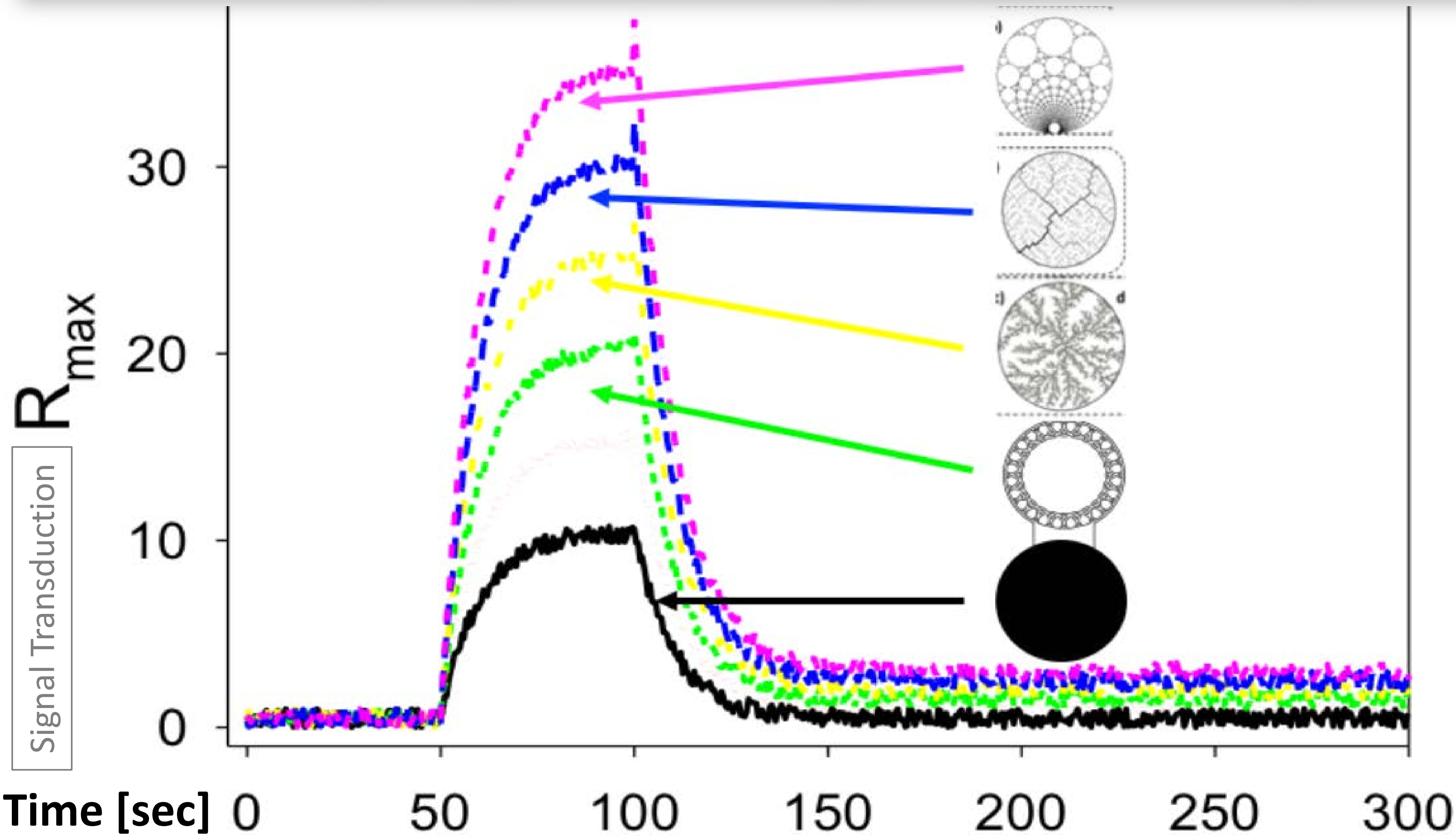
Histidine-tagged insect-derived chemosensory proteins (CSP) adsorbed to metallized nanosensor surface for small molecule sensing. 5 patterns at various levels of entropy were tested.

Nano-bio-sensors detect pathogens using smartphone



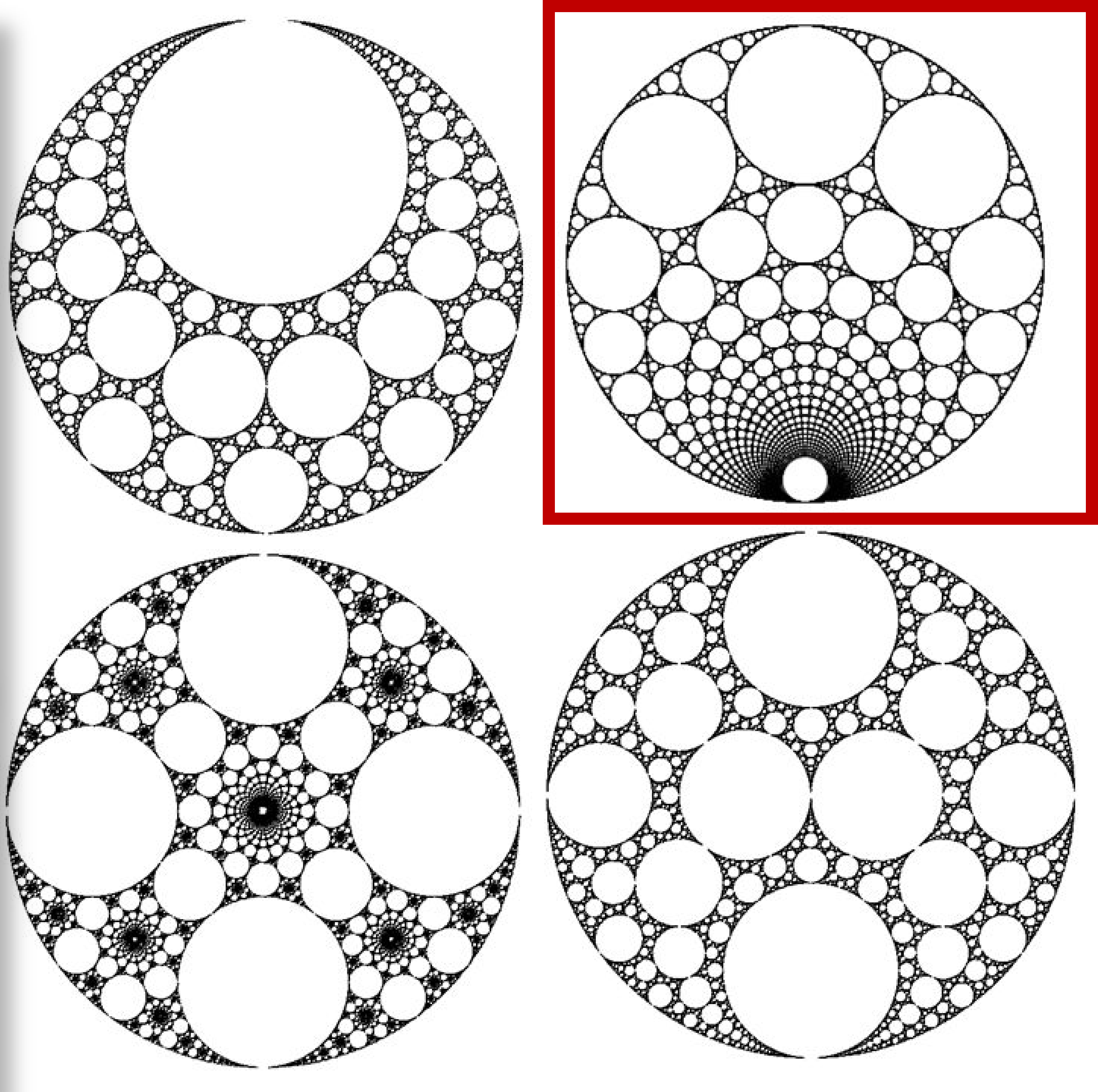
Biomimetic Entropic Patterning (BEP) nano-bio-sensors using (CSP) chemosensory proteins tested to detect Imidacloprid (for each fractal pattern) using electrochemical impedance spectroscopy (EIS, left) and localized surface plasmon resonance (LSPR, right).

LSPR (localized surface plasmon resonance) for avidin-biotin assay: increase in output signal for increasing entropy of nano-Au pattern.



Dr Eric Mclamore, Dept of Agriculture and Biological Engineering, University of Florida, Gainesville

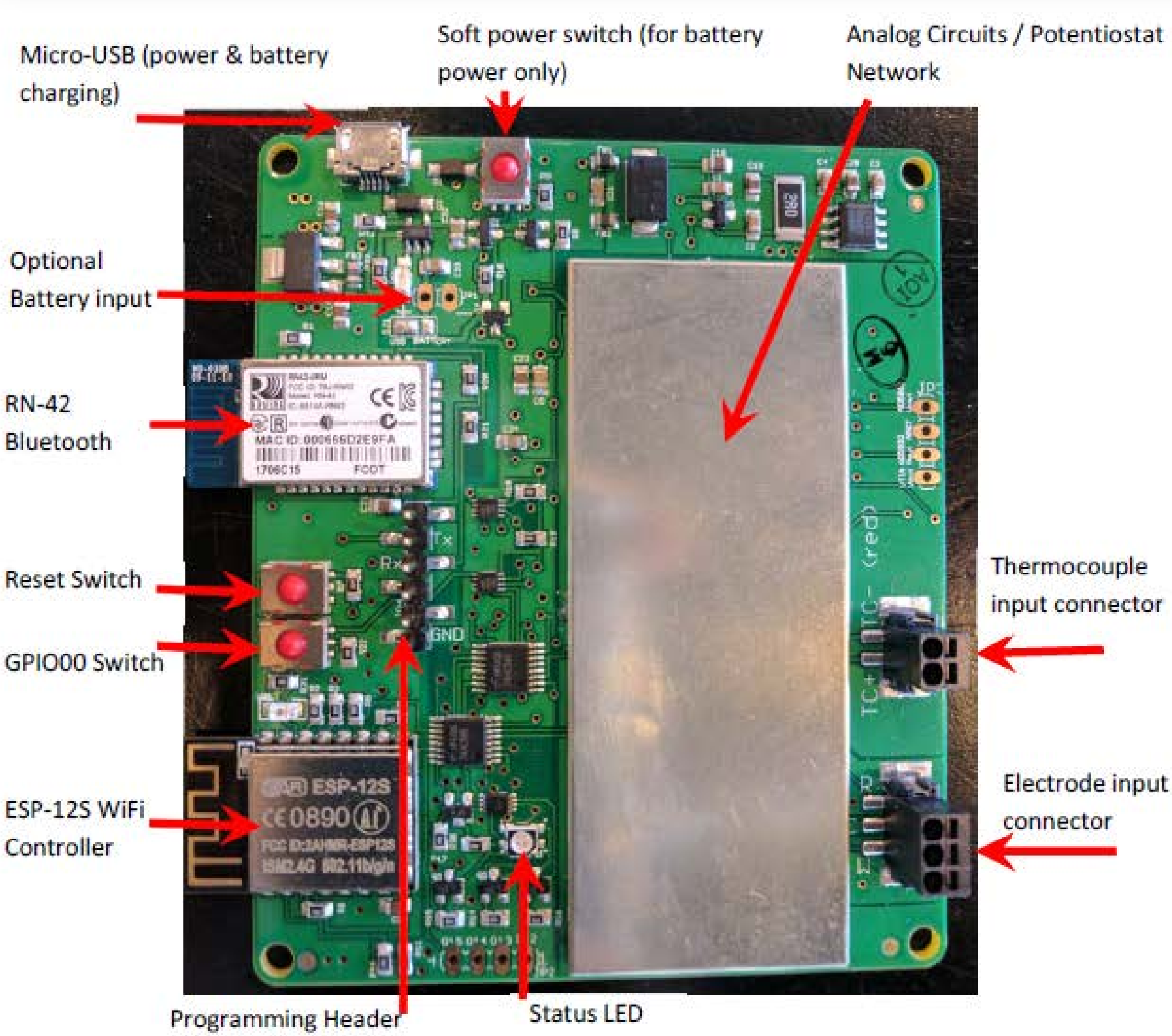
in silico Biomimetic Patterns: Tuning pattern entropy to maximize information exchange for nano-bio-sensors.

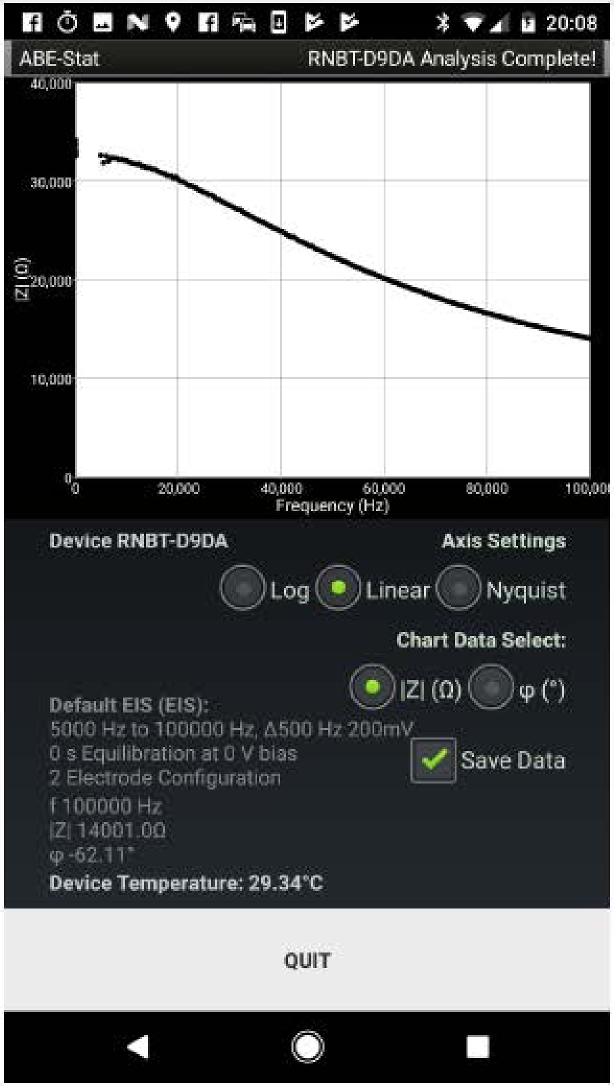


MAKING SENSE OF DATA

Nano-Bio-Sensor data acquisition and analytics using smartphone integrated app running ML algorithms

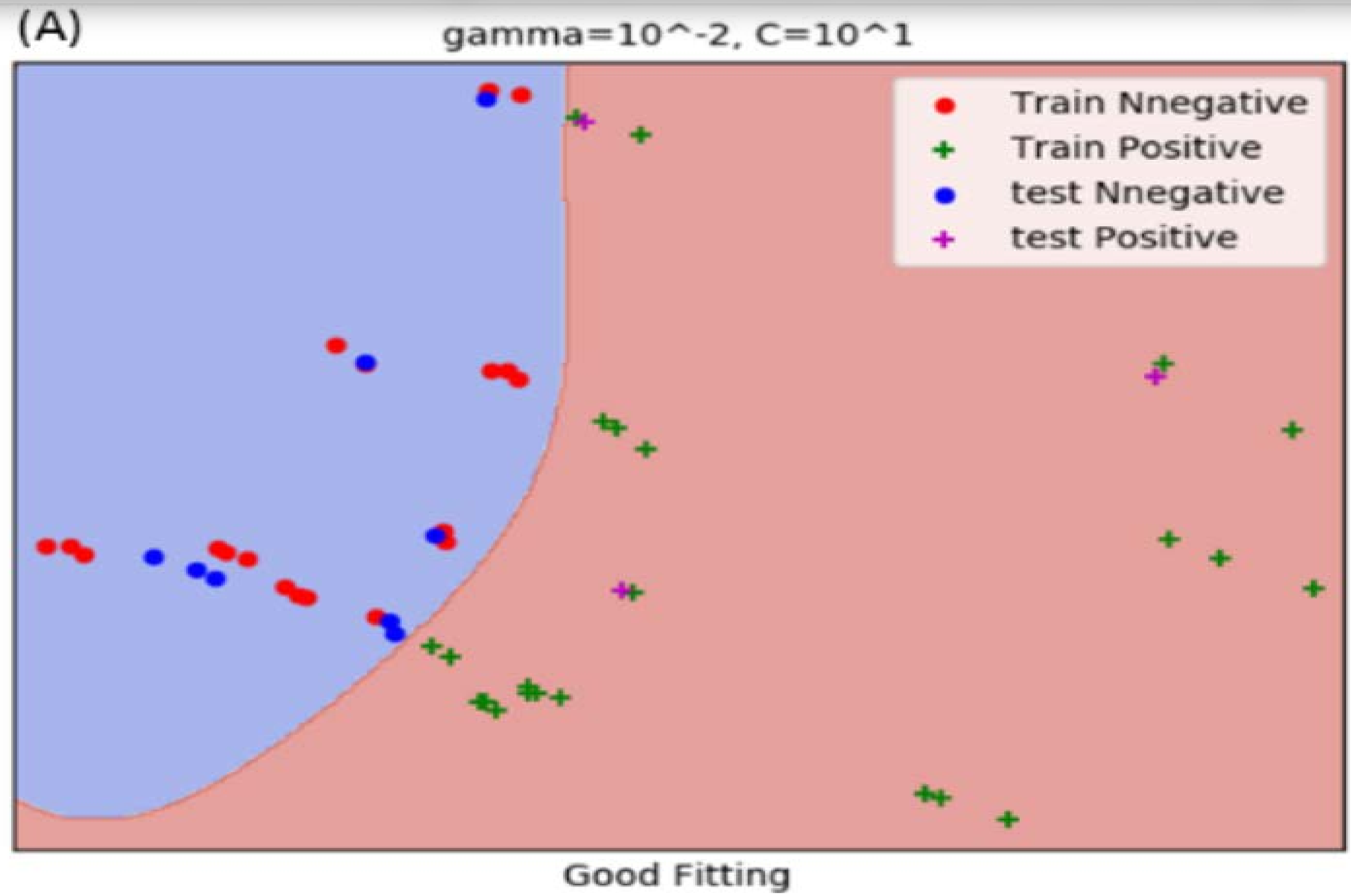
Android based mobile nano-bio-sensor acquisition devices for field analysis. Mobile app for pathogen sensing data display.





Dr Eric Mclamore, Dept of Agriculture and Biological Engineering, University of Florida, Gainesville

Mobile nano-bio-sensor data acquisition: data analytics and data visualization integrated in real-time on smartphone app



SVM classification of impedimetric (EIS) biosensor results for CSP-acetone binding

Mobile app integrated machine learning (ML) analytical tools for near real-time analysis of sensor data. For semi-quantitative sensor output (low sampling frequencies), data may be processed using a cloud-based app for SVM (support vector machine) classifier, to facilitate rapid on site detection. Early warning signals use time series data.

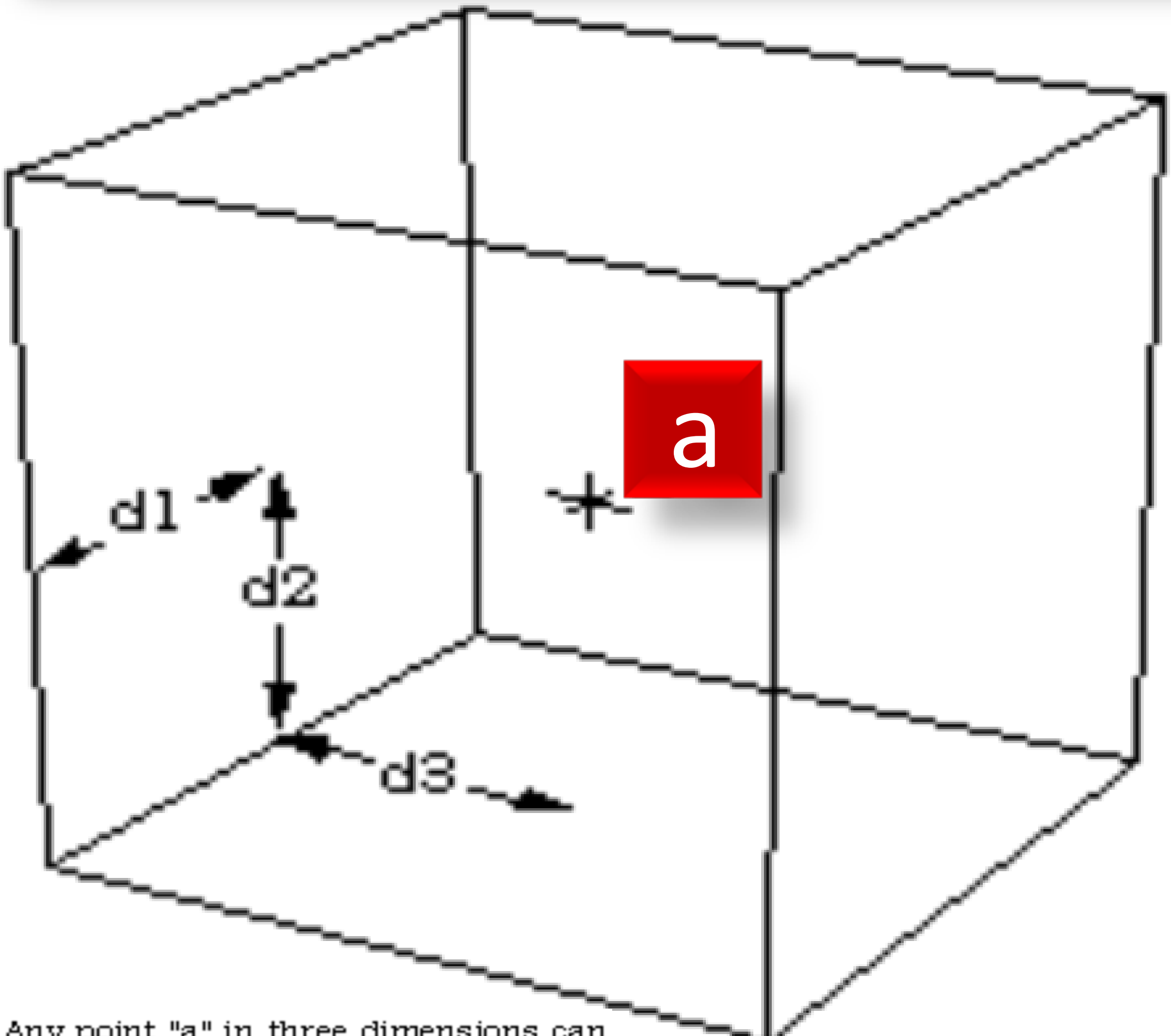
CONVERGENCE

Fractal pattern, entropy optimization, nano-bio-sensor sensitivity, signal transduction, mobile data acquisition, machine learning analytics real-time app, data generates near real-time actionable information and/or prediction

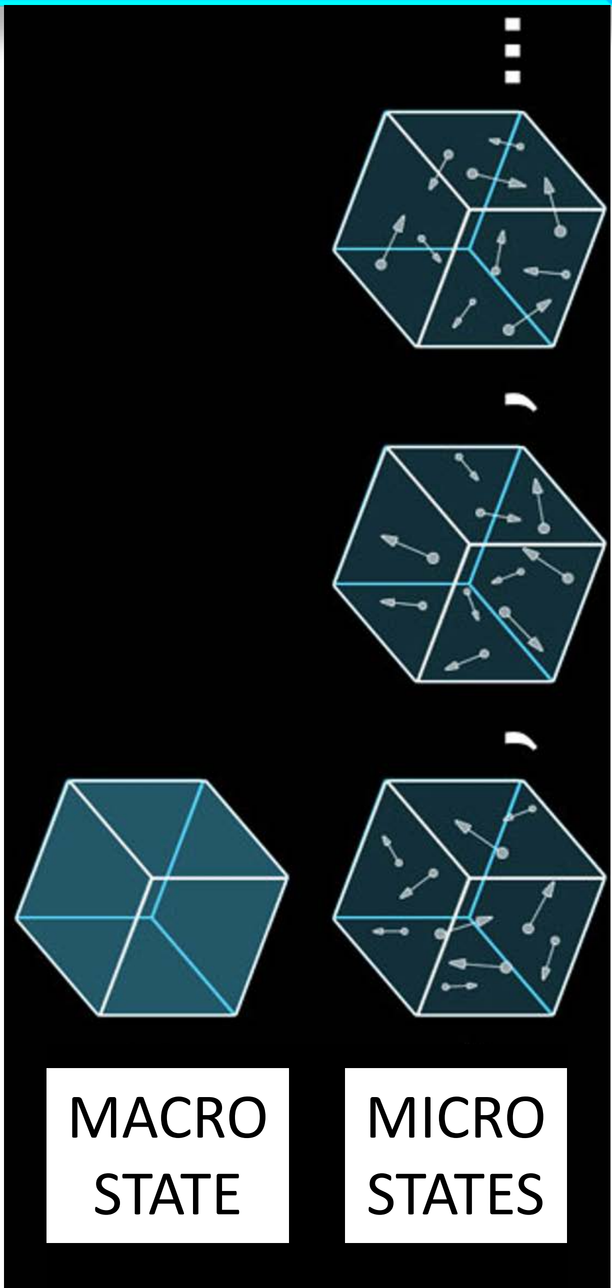
CONVERGENCE

Entropy → Information

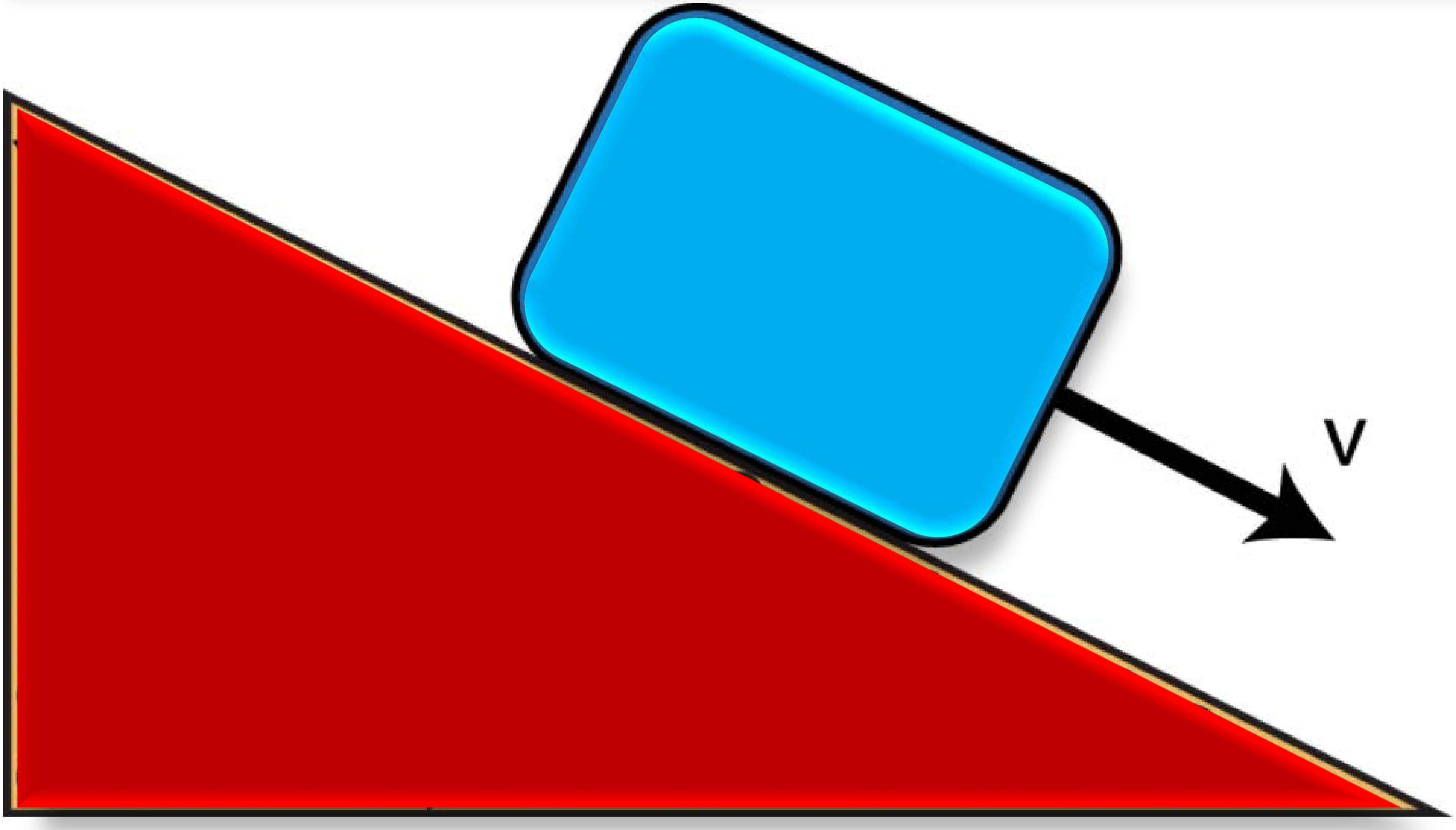
Entropy → Thermodynamics of Gas Molecules → Information



Any point "a" in three dimensions can be uniquely represented by three numbers. Typically these three numbers are the coordinates of the point using an orthogonal coordinate system.

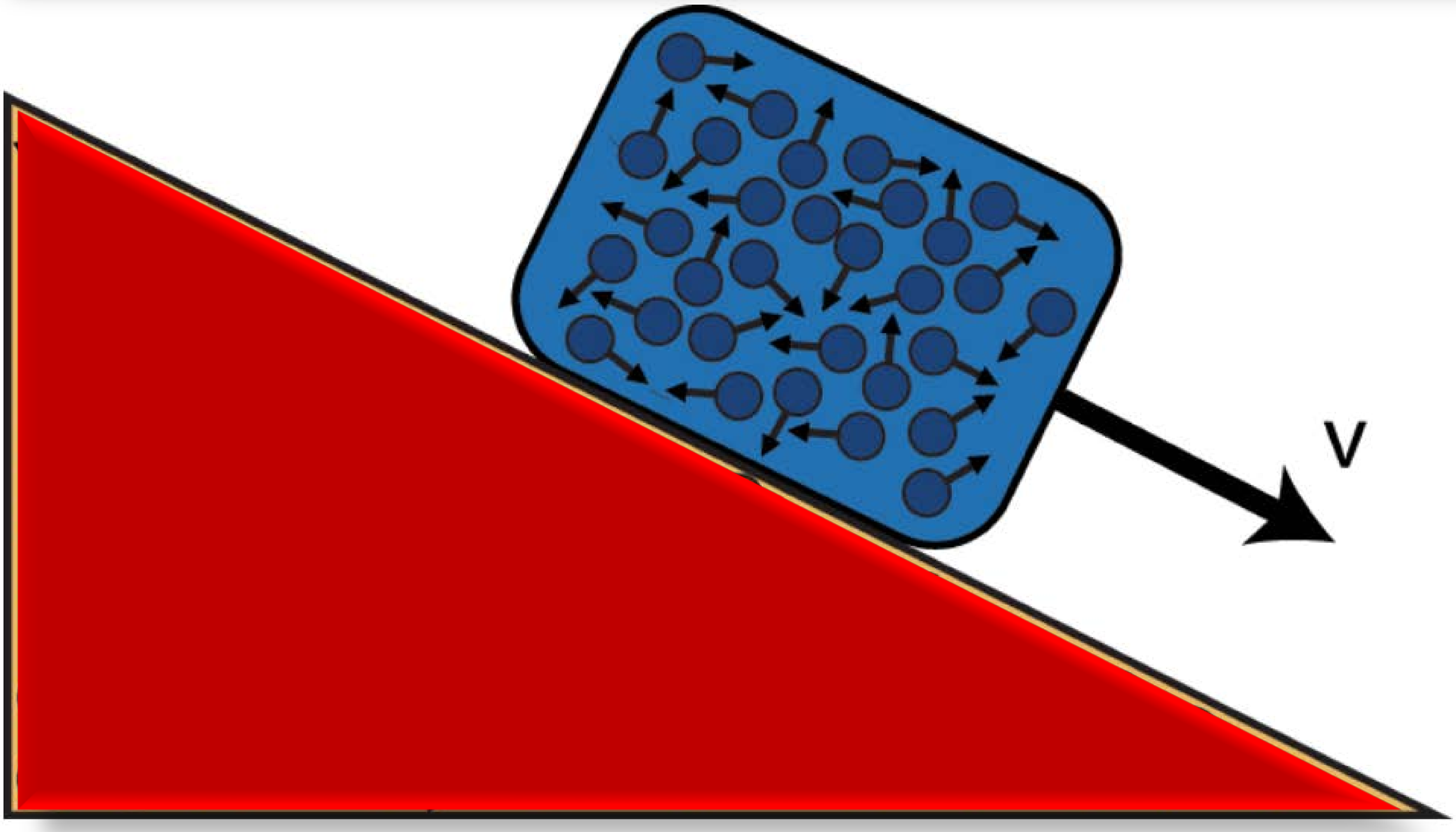


Block Sliding Down an Inclined Plane (velocity at a certain point = v)



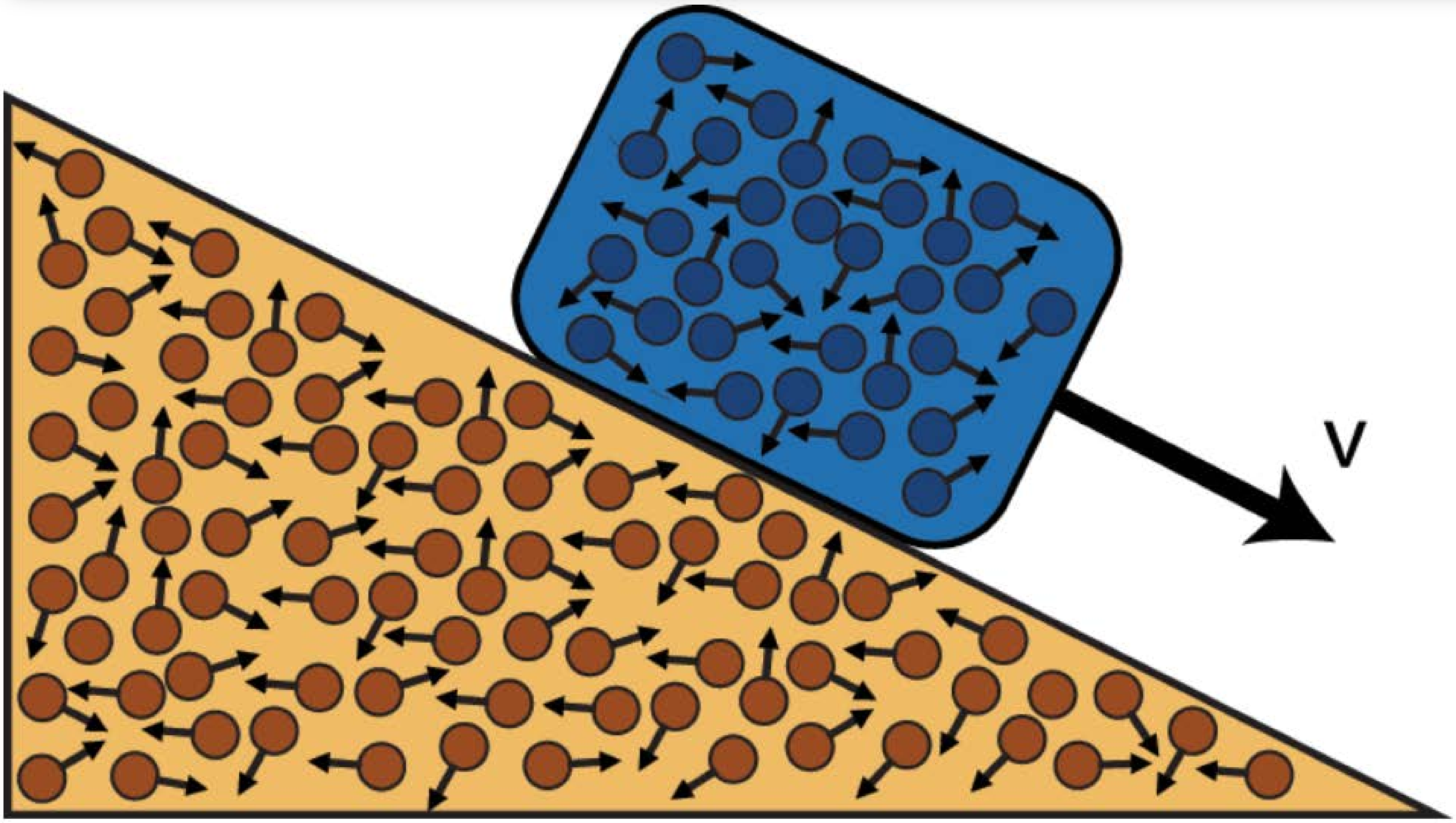
Macroscopic motion subject to gravity and friction (Newton's Laws of Motion)

Block Sliding Down an Inclined Plane (velocity at a certain point = v)



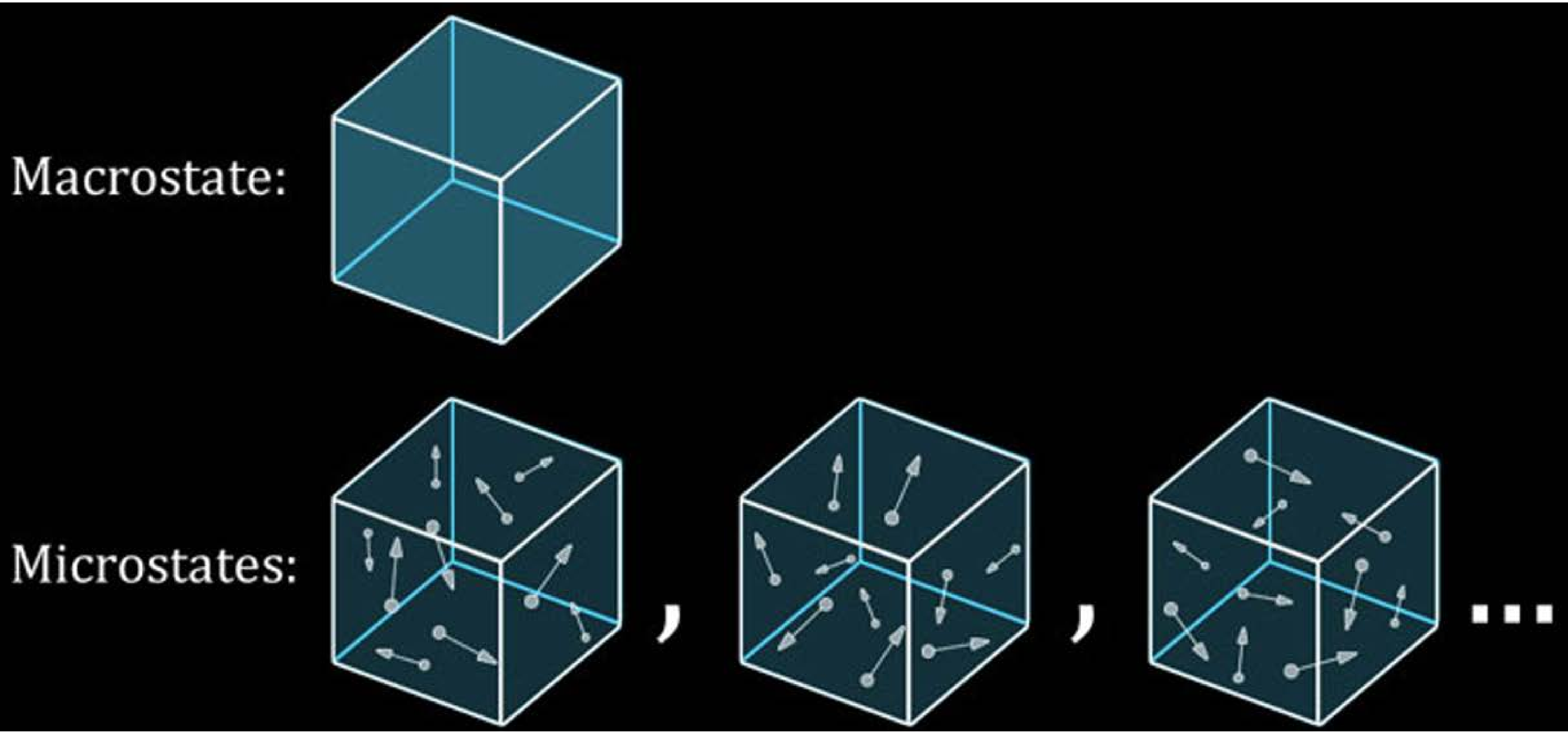
Microscopic behavior – local oscillations of groups of atoms – random and independent

Block Sliding Down an Inclined Plane (velocity at a certain point = v)



Microscopic behavior of atoms in accordance with laws of thermodynamics

Entropy → Thermodynamics → Information Theory



Entropy (2013) **15** 3396-3418; doi:10.3390/e15093396 & www.sciencedirect.com/science/article/pii/S0898122113000345

Fractal structures are characterized by fractal dimension (infinite family of fractal dimensions exists). A *generalized fractal dimension* can be defined in an E-dimensional space. The *Rényi entropy* and *generalized fractal dimension* are connected by a straight relation. Numerically, Kolmogorov entropy can be estimated as the *Rényi entropy*. A special case of Rényi entropy is the information theory of *Shannon entropy*. The product of Shannon entropy and Boltzmann constant is *thermodynamic entropy*.

Information entropy works with a set of events with arbitrary probabilities. In thermodynamics, it is assumed that gas particles occupy any region of a container with equal probability. Information entropy is a broader concept than thermodynamic entropy. Hence, thermodynamic entropy is a subset of information entropy.

The Kolmogorov entropy describes the degree of chaoticity of systems (average rate of information loss about a position of the phase point on the attractor).

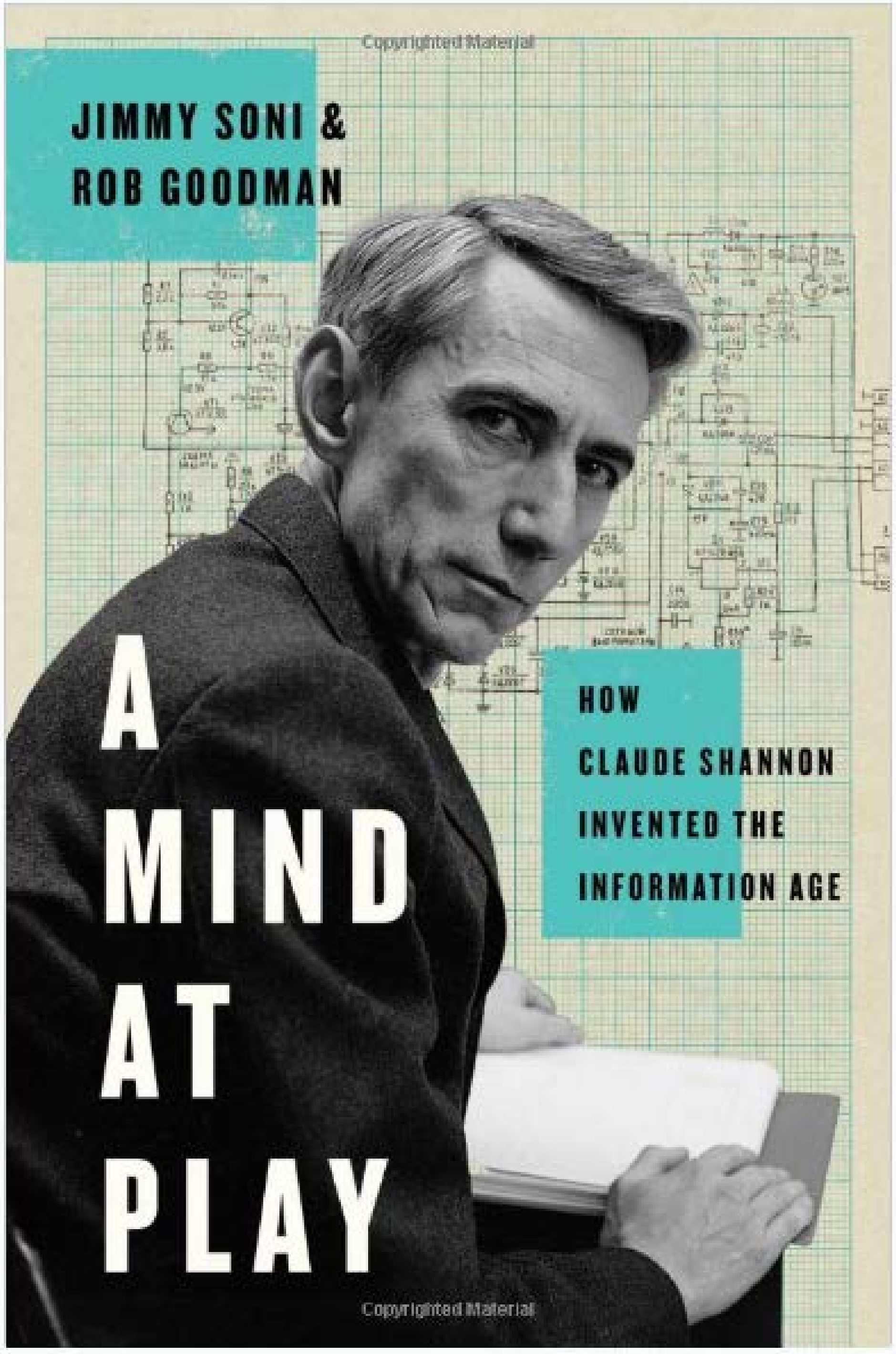
Claude Elwood Shannon

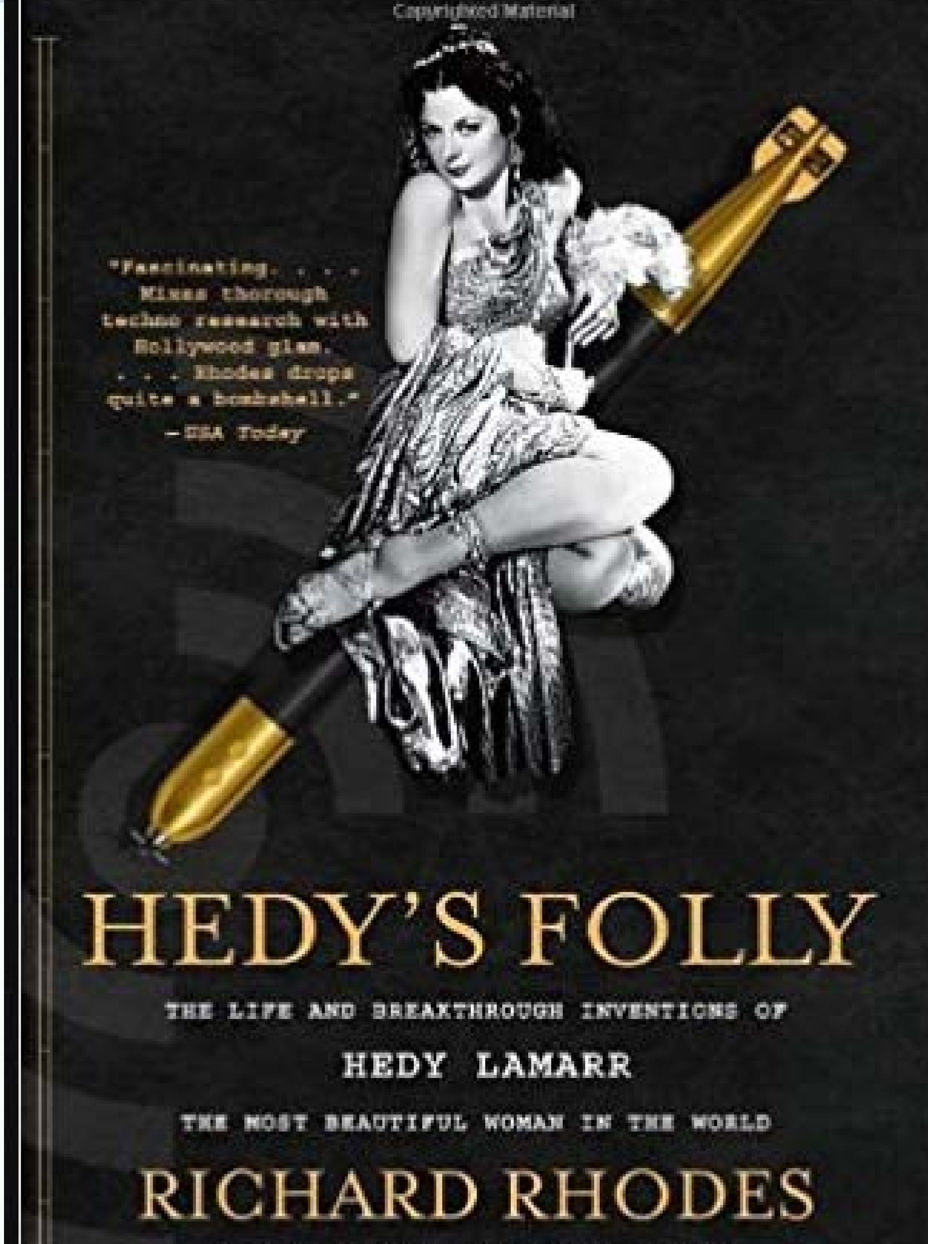
(April 30, 1916 – February 24, 2001)

Founded information theory, *A Mathematical Theory of Communication*, that he published in 1948. He founded digital circuit design theory in 1937 (21-yr-old MS student) at MIT. He wrote his thesis demonstrating that electrical applications of Boolean algebra could construct any logical, numerical relationship. Shannon received his Ph.D. from MIT in 1940. Vannevar Bush suggested that Shannon should work on his dissertation at the Cold Spring Harbor Laboratory, in order to develop a mathematical formulation for Mendelian genetics. This research was Shannon's Ph.D. thesis at MIT, *An Algebra for Theoretical Genetics.* He was a faculty at MIT until 1978.

http://math.harvard.edu/~ctm/home/text/others/shannon/entropy/entropy.pdf

Ivan Edward Sutherland (May 16, 1938) father of computer graphics (GUI). Sutherland earned his BS from CMU, MS from CalTech and PhD from MIT in 1963. He invented Sketchpad in 1962 at MIT. Claude Shannon was his PhD thesis advisor, in addition to Marvin Minsky and Steven Coons. Sutherland replaced J. C. R. Licklider as the head of US Defense Department Advanced Research Project Agency's (DARPA) Information Processing Techniques Office when JCR Licklider returned to MIT in 1964. http://ubiquity.acm.org/article.cfm?id=352537



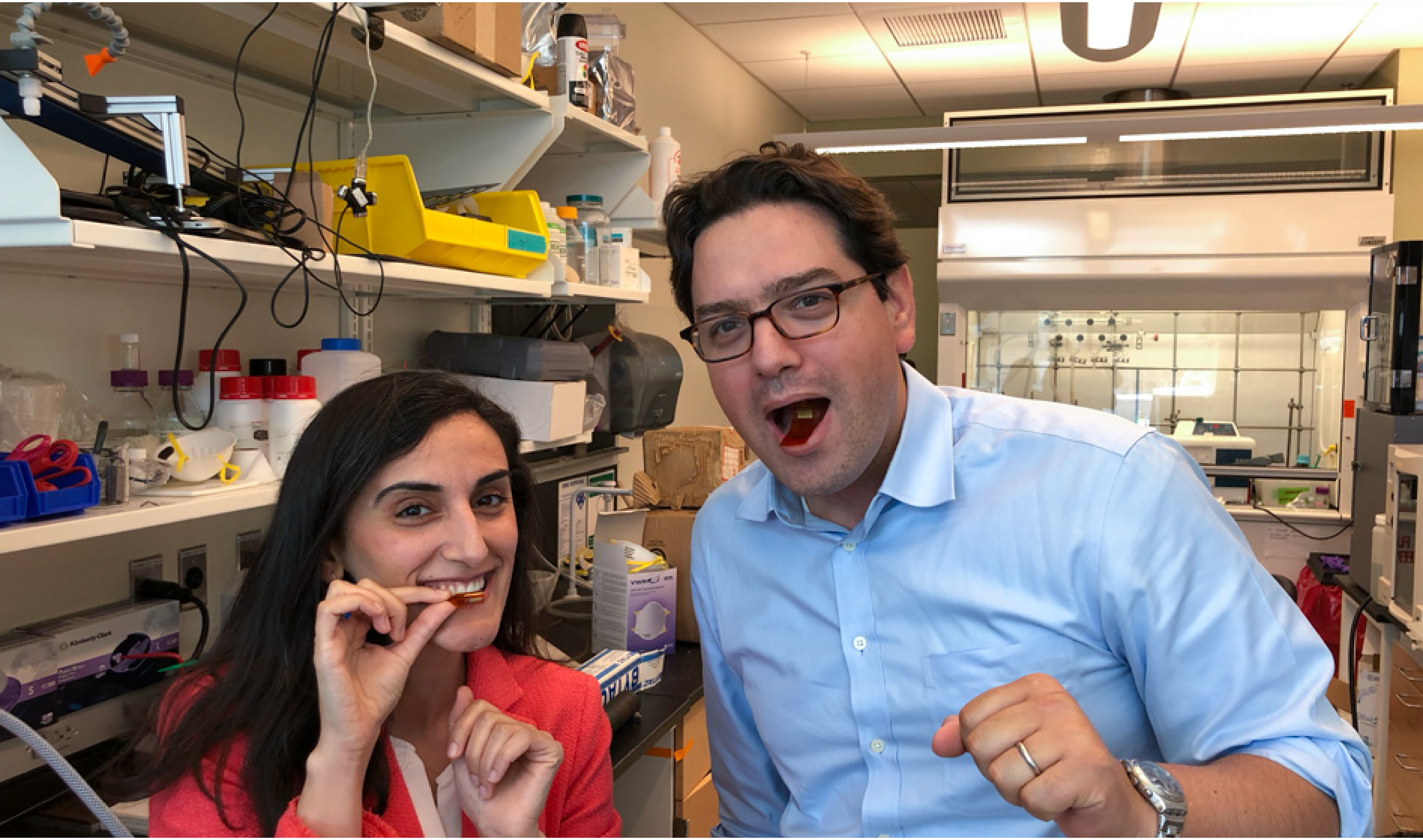


A ravishing film star and an avant-garde composer invented spread-spectrum radio, the technology that made wireless phones and GPS, possible.

Sense

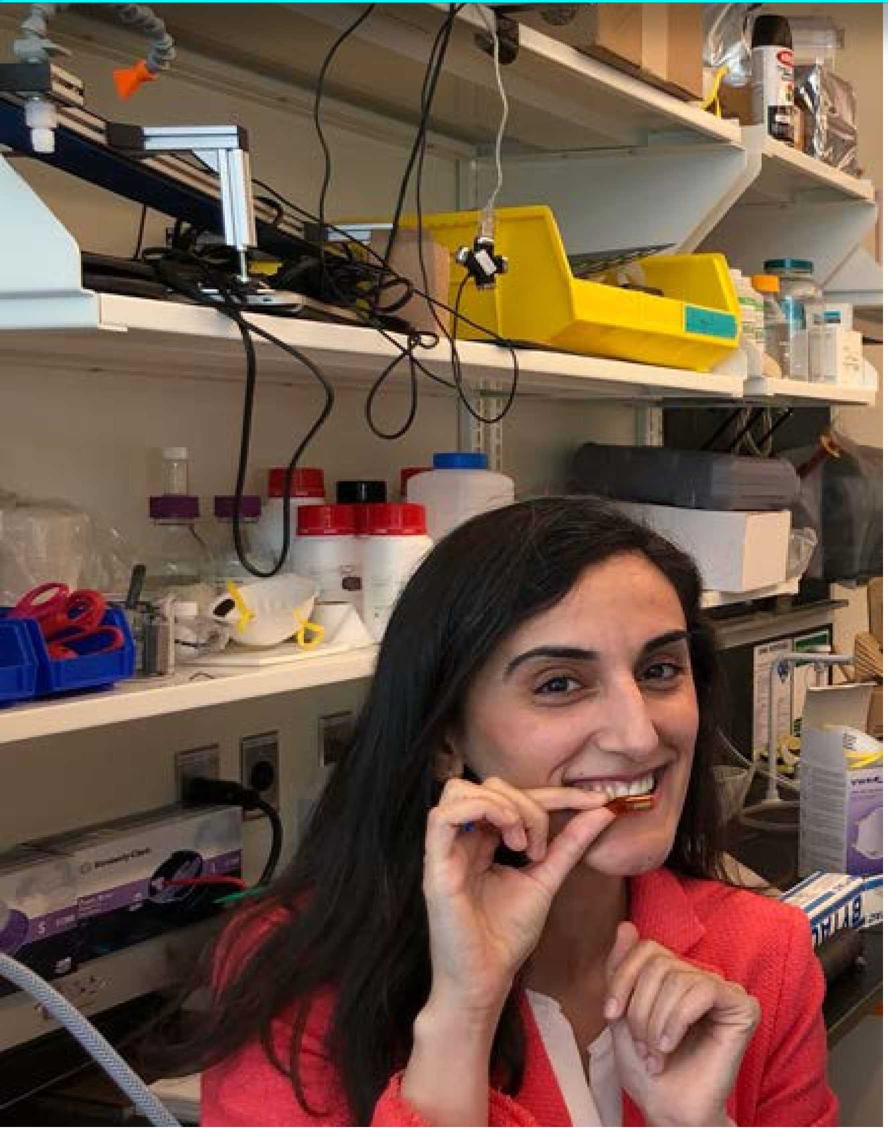
EVERYTHING

Flexible piezoelectric sensor is 2 by 2.5 cm, and can be rolled up and swallowed. It can stay in the stomach up to two days without any electrical or mechanical degradation. Professor Canan Dagdeviren (left) & researcher Giovanni Traverso, MIT (Oct 10, 2017).



http://news.mit.edu/2017/flexible-sensors-can-detect-movement-gi-tract-1010

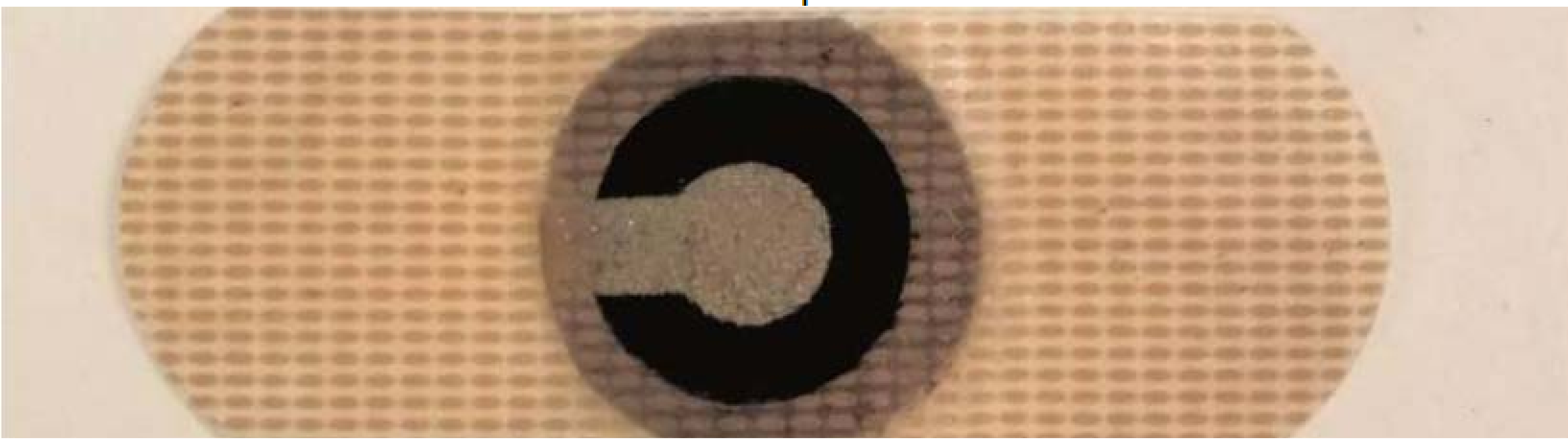
☑ Ingestible sensors transmitting metabolic data
☑ Chemical sensors detect landmines on iPhone



http://news.mit.edu/2017/cheaper-faster-food-testing-smartphone-0405

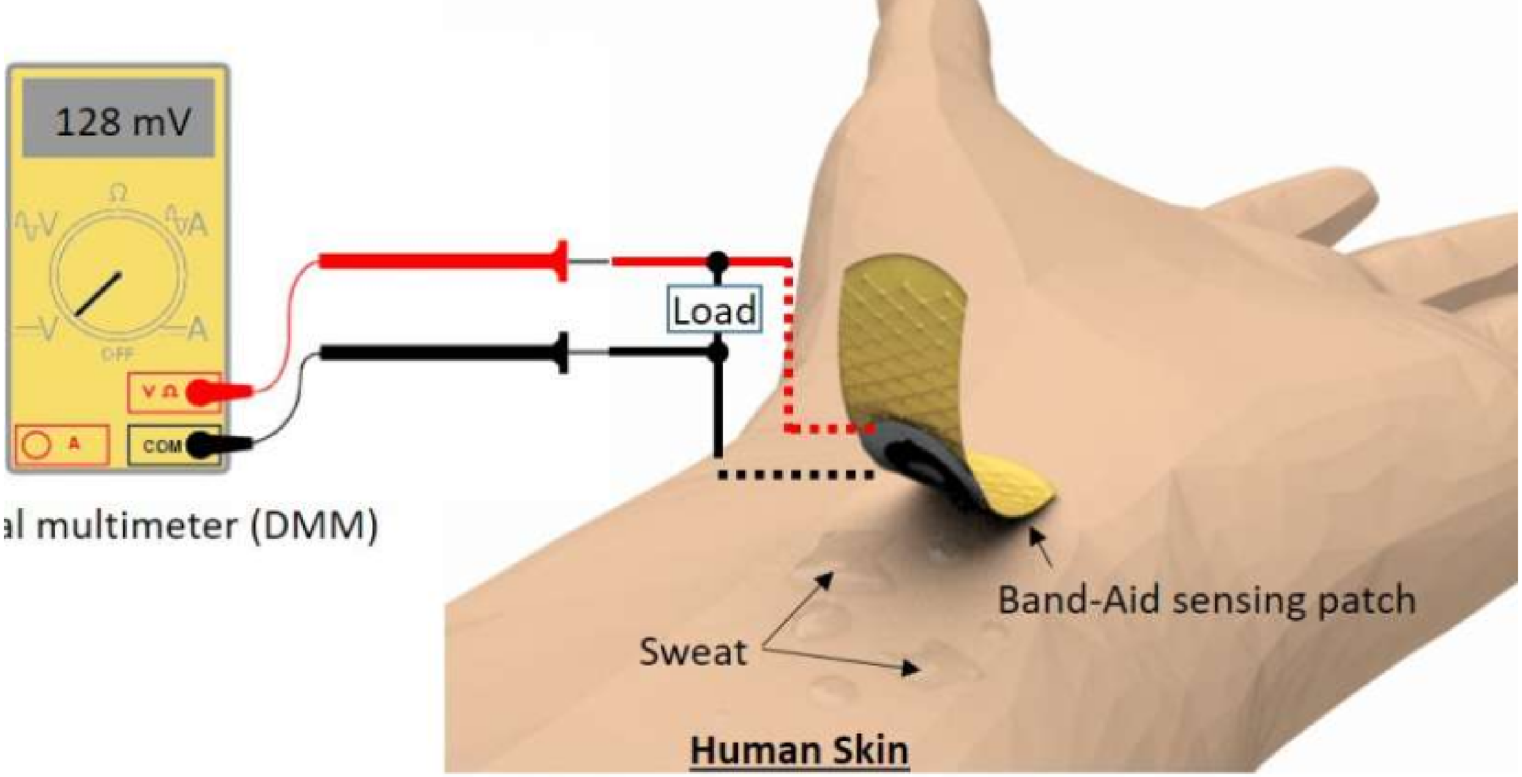
Secure | https://phys.org/news/2017-09-self-powered-paper-patch-diabetics-glucose.html

Choi and fellow researchers have developed and demonstrated a self-powered, wearable and disposable patch that allows for non-invasive monitoring of glucose in human sweat. This wearable, single-use biosensor integrates a vertically stacked, paper-based glucose/oxygen enzymatic fuel cell into a standard Band-Aid adhesive patch.



A new paper-based sensor patch developed by researchers at Binghamton University, State University of New York could allow diabetics to effectively measure glucose levels during exercise. Credit: Binghamton University Electrical and Computer Science Assistant Professor Seokheun Choi

"The paper-based device attaches directly to skin, wicks sweat to a reservoir where chemical energy is converted to electrical energy, and monitors glucose without external power and sophisticated readout instruments," said Choi.



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Explore further: **Skin-based biofuel cell developed for scavenging energy from human sweat**

More information: A Single-Use, Self-Powered, Paper-Based Sensor Patch for Detection of Exercise-Induced Hypoglycemia, *Micromachines* (2017).
DOI: 10.3390/mi8090265

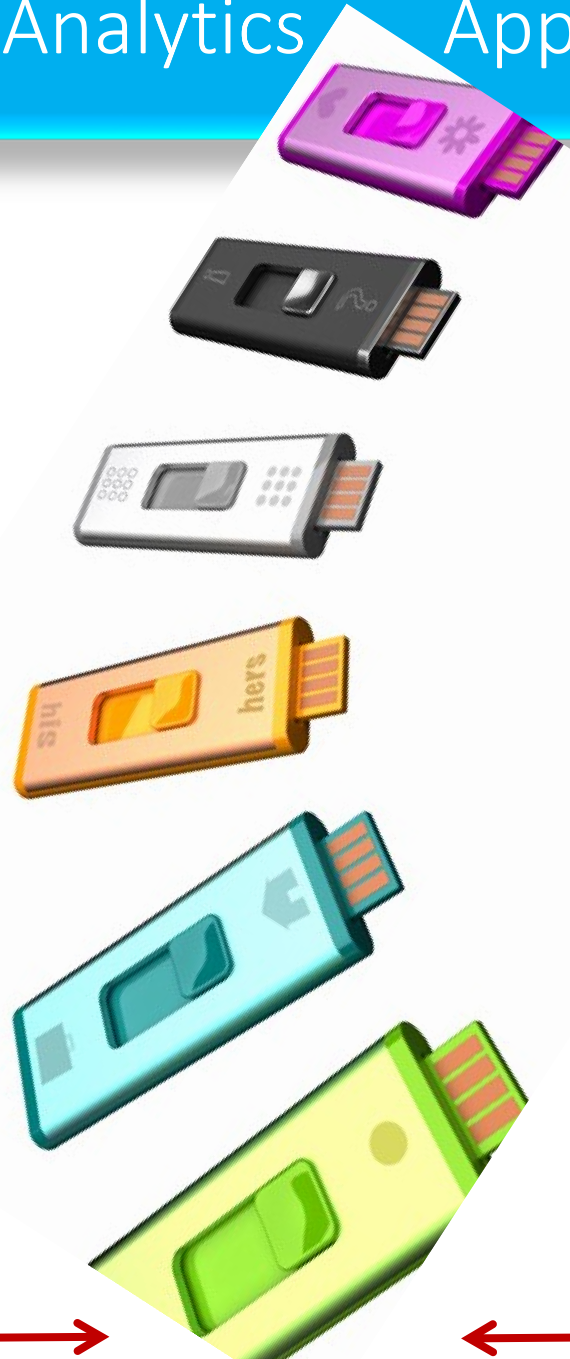
Pay 1c Per Analytics Apps, Data Distribution Service

Glucose Sensor

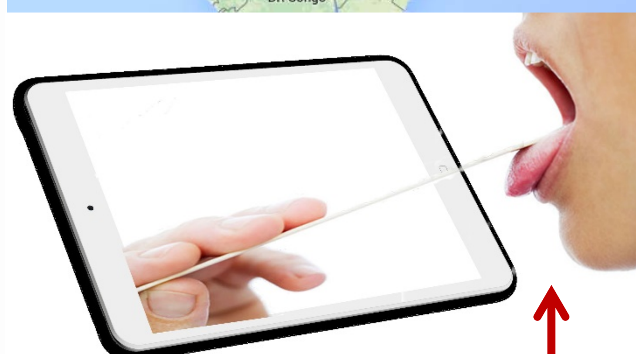
Cholesterol Sensor

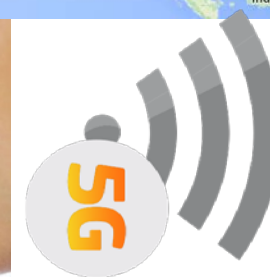
BNP Sensor

Stroke Sensor



What does the data suggest about my health?





Hot swappable, modular, smart

NK Labs
ARA Prototype

Luminescent sensing and imaging of oxygen: Fierce competition to the Clark electrode

*Otto S. Wolfbeis**

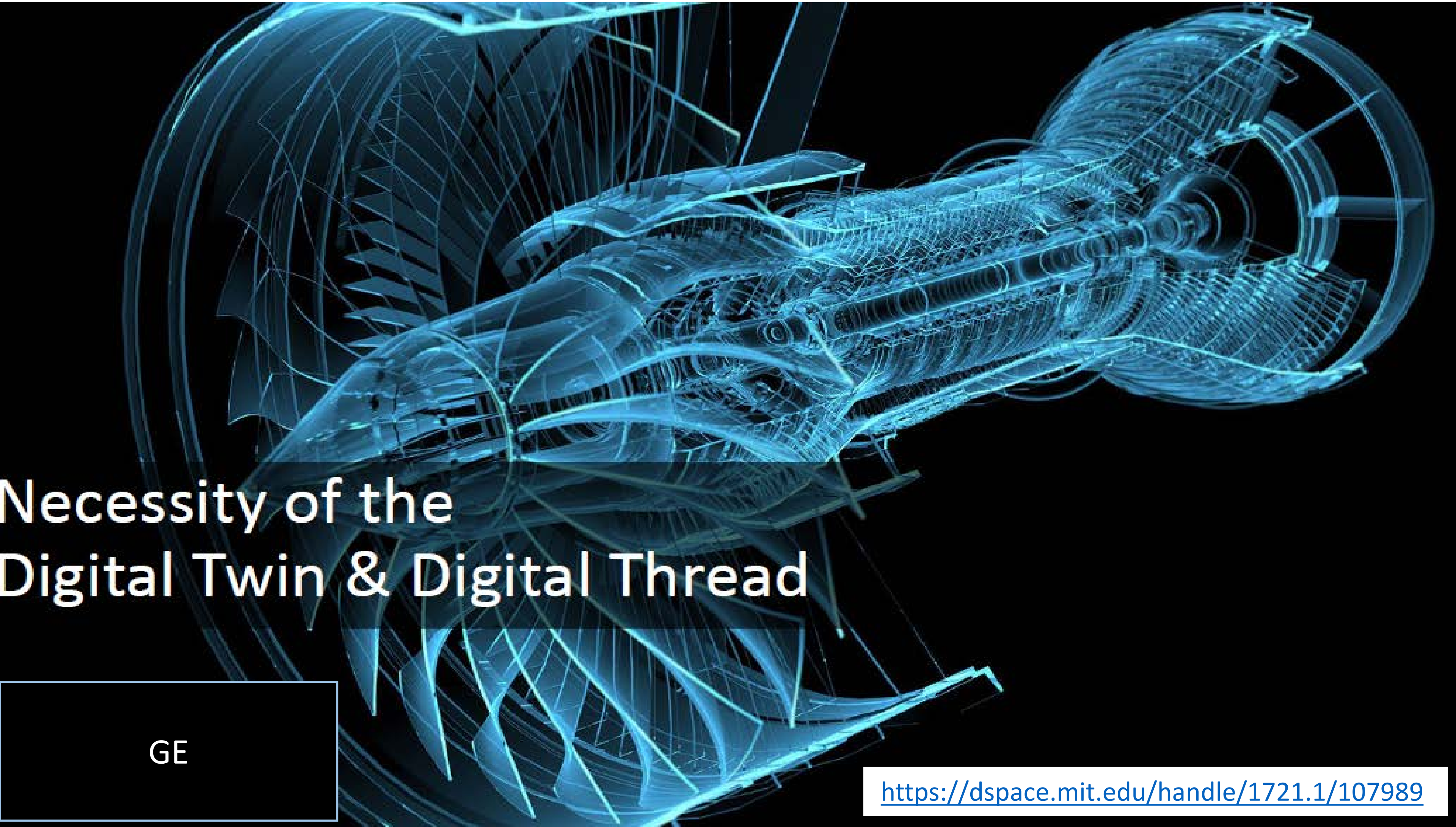
DOI 10.1002/bies.201500002

http://onlinelibrary.wiley.com/doi/10.1002/bies.201500002/epdf

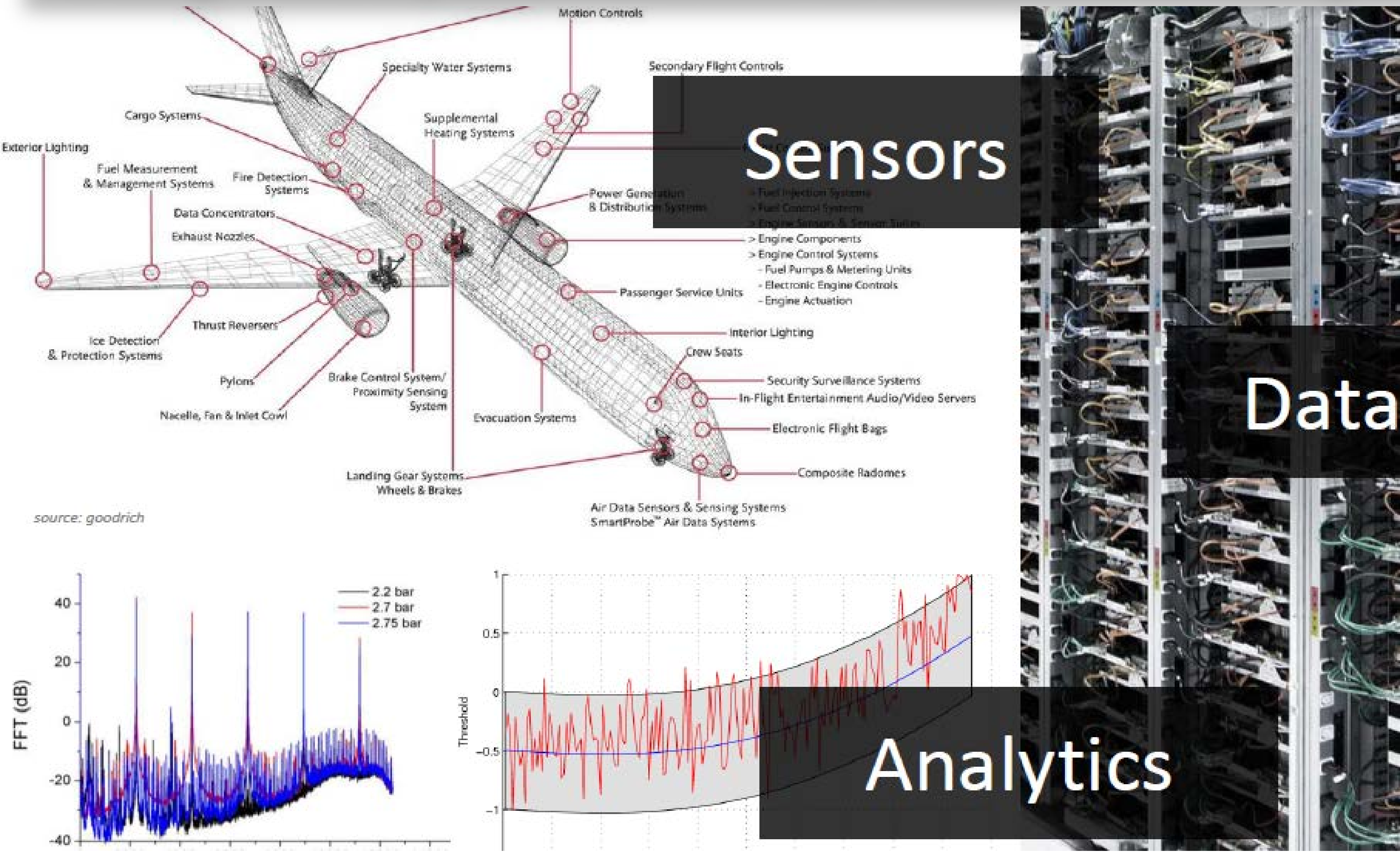
Sense

Not only for humans, healthcare and medicine, also for animals and the environment, as well as machines, tools and system of systems

The goal is to optimize efficiency of this turbine (which is inside a GE engine and the aircraft is flying at 37,000 feet, over Polynesia). Maximize the aircraft function (motion) while reducing NOx emissions (indirect GHG) without increasing carbon dioxide emissions. The “live” data in the Digital Twin concept is central to this solution. The flight control engineer wants data, in 2.5 second interval, of the *range* of temperatures inside the combustion chamber, while in flight.



Digital Twins - Concept from NASA - for IIoT ?
Design metaphor - industrial internet of things

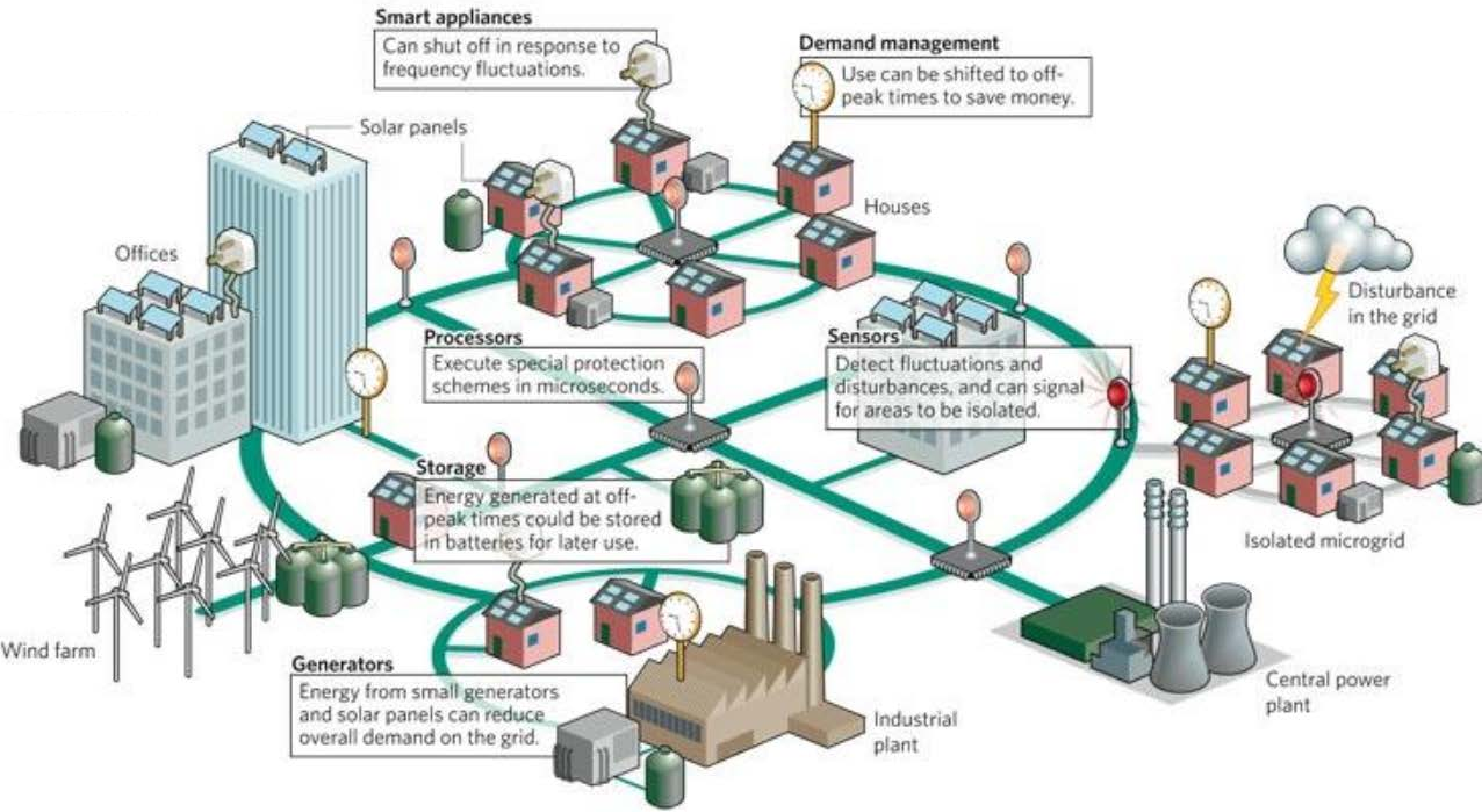


Morgan Stanley thinks cars of the future will be nothing but a 'data pipe'

Matthew DeBord

Jun. 7, 2017, 1:22 PM

Digital Twins
Machines, Cars, Cities, Energy Grid, Humans



Autonomous Control of Morphine Infusion Pump – Medical Device Integration Model

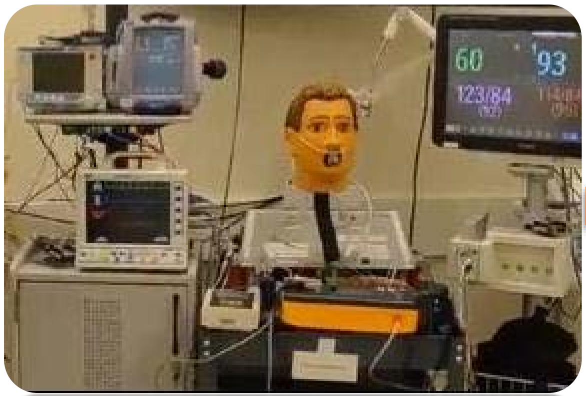
Infusion Pump

Capnometer

Patient Simulator
Ventilator

Intelligent Monitor

Digital Twin for Patient

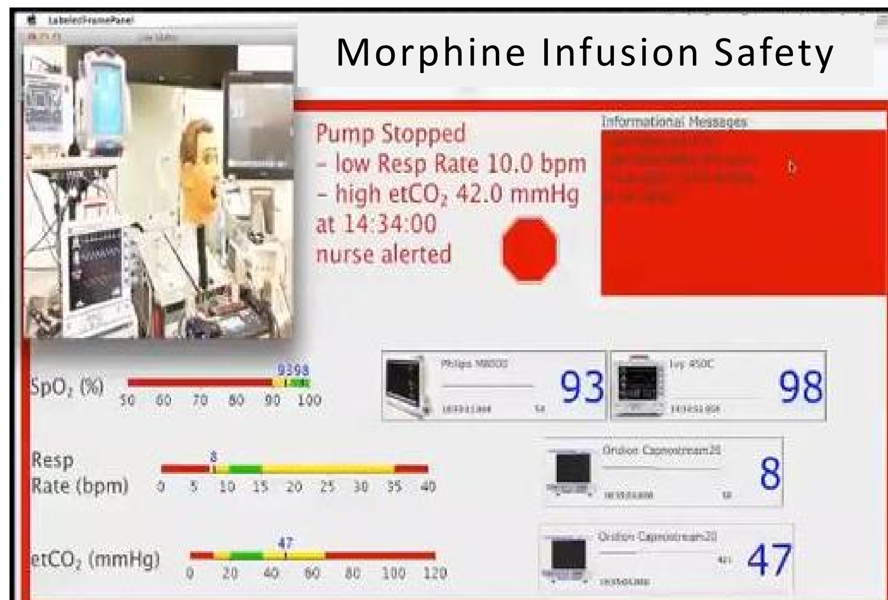


↓ O_2 Saturation

↓ Respiratory Rate

↑ end-tidal CO_2

Connected Data
Collective Analysis
Automated Response



Patient Controlled Analgesia Safety Application

Vital Signs Monitor

Simulator connected to vital signs monitor

Fluke ProSim 8 connected to intelligent monitor

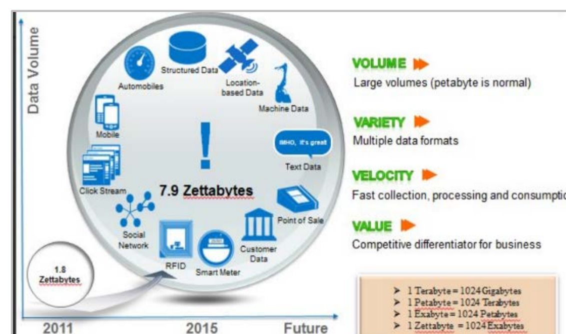
Julian Goldman MD (MDPnP.org and Partners.org)
Massachusetts General Hospital, Harvard Medical School
Harvard – MIT Center for Integrative Medicine and Information Technology

Sense

then, make sense of data

8 Billion Terabytes

2016 Data: 1,000TB on a DVD 0.5mm thick ~4km ~10 Empire State Building
800 billion full length movies ~100 Trillion hours ~10 billion years to watch



How do we transform this data and information to diagnose patients with potential problems due to dysphagia or predict if a person may be experiencing some form of dysphagia (may be symptomatic of other problems - silent stroke).

Table 3: t-test results revealing significant differences between dysphagic and normal entropy values

levels	5		10		15		20	
diagnosis	normal	dysphagic	normal	dysphagic	normal	dysphagic	normal	dysphagic
mean	0.11	0.55	0.53	1.35	0.43	1.36	0.65	1.82
Standard Dev	0.11	0.28	0.38	0.43	0.26	0.57	0.44	0.59
Variances	Unequal		Equal		Unequal		Equal	
Result	Reject Null		Reject Null		Reject Null		Reject Null	

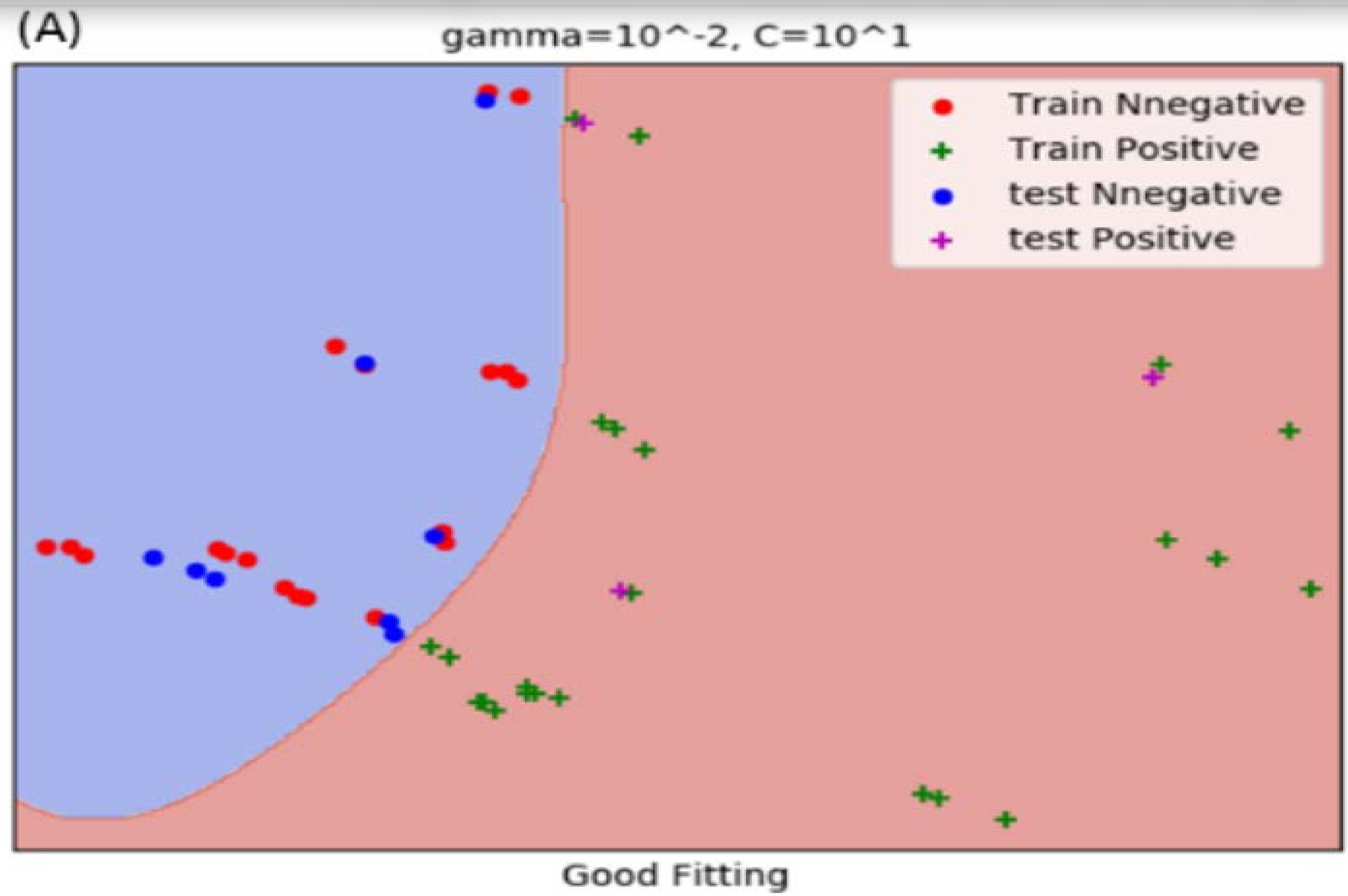
Table 7: Fractal dimension calculated for normal subjects

levels	Normal		
trial	1	2	avg
Subject			
1	2.625	1.922	2.273
2	1.471	1.771	1.621
3	1.439	1.468	1.453
4	1.461	1.522	1.491
5	1.490	1.521	1.505
6	1.773	1.876	1.824
7	1.876	1.876	1.876
8	1.877	1.981	1.929
9	1.886	2.183	2.035
10	2.304	1.781	2.043
11	1.874	2.179	2.027
12	1.517	1.555	1.536
13	1.931	2.845	2.388
14	2.001	2.125	2.063
15	2.060	4.008	3.034
mean	1.839	2.041	1.940
Standard Dev	0.337	0.648	0.419

Table 8: Fractal dimension calculated for dysphagic subjects

levels	Dysphagic		
trial	1	2	avg
Patient			
1	2.710	1.865	2.288
2	2.569	2.252	2.411
3	2.432	2.805	2.619
4	2.196	2.196	2.196
5	2.401	2.895	2.648
6	4.590	4.281	4.435
7	2.077	2.077	2.077
8	3.273	3.812	3.543
9	2.560	3.616	3.088
10	3.506	5.923	4.714
11	3.402	4.295	3.848
12	2.125	2.593	2.359
13	3.085	3.927	3.506
14	3.229	2.898	3.063
15	2.329	2.543	2.436
mean	2.832	3.198	3.015
Standard Dev	0.682	1.100	0.829

Mobile nano-bio-sensor data acquisition: data analytics and data visualization integrated in real-time on smartphone app



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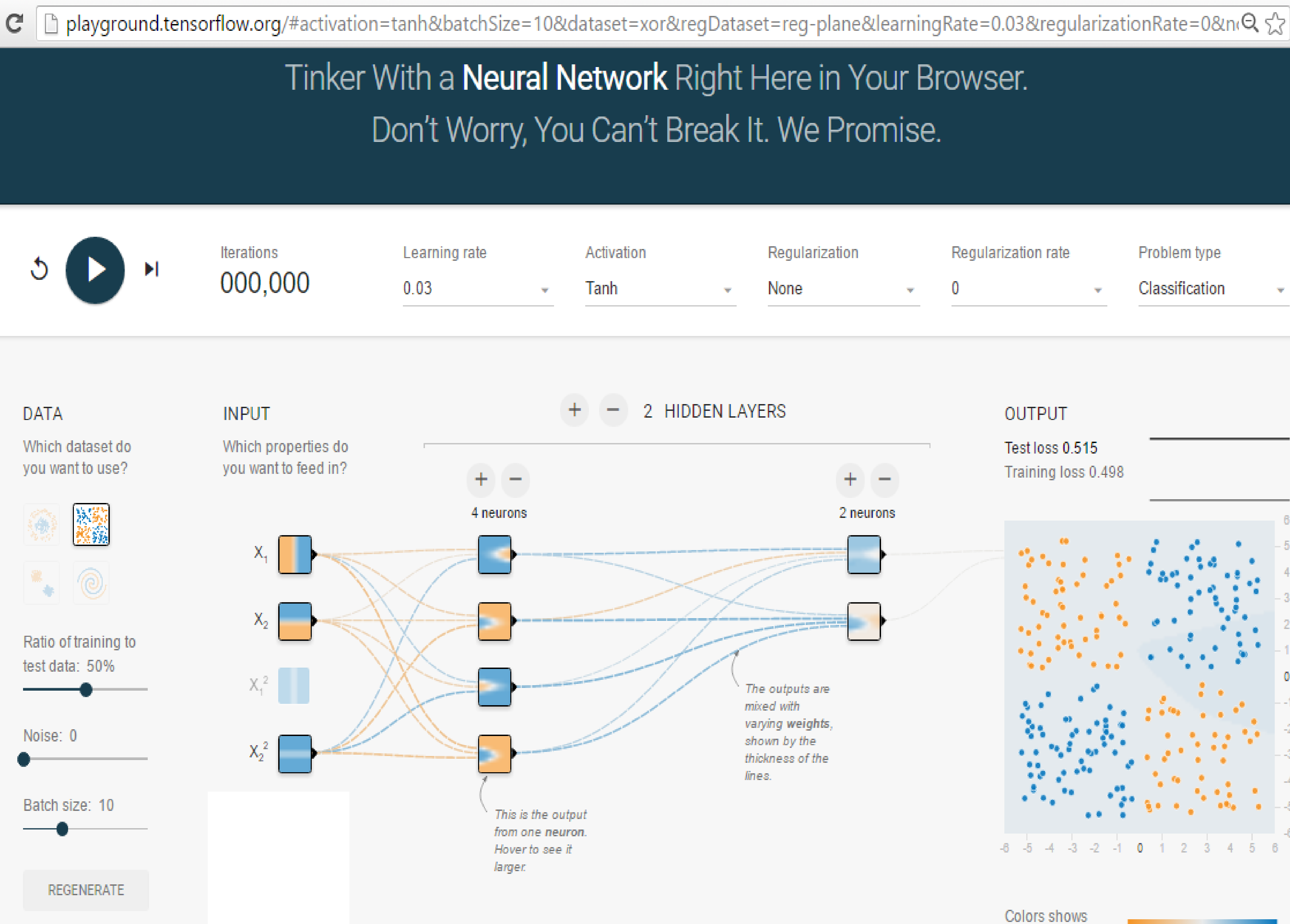
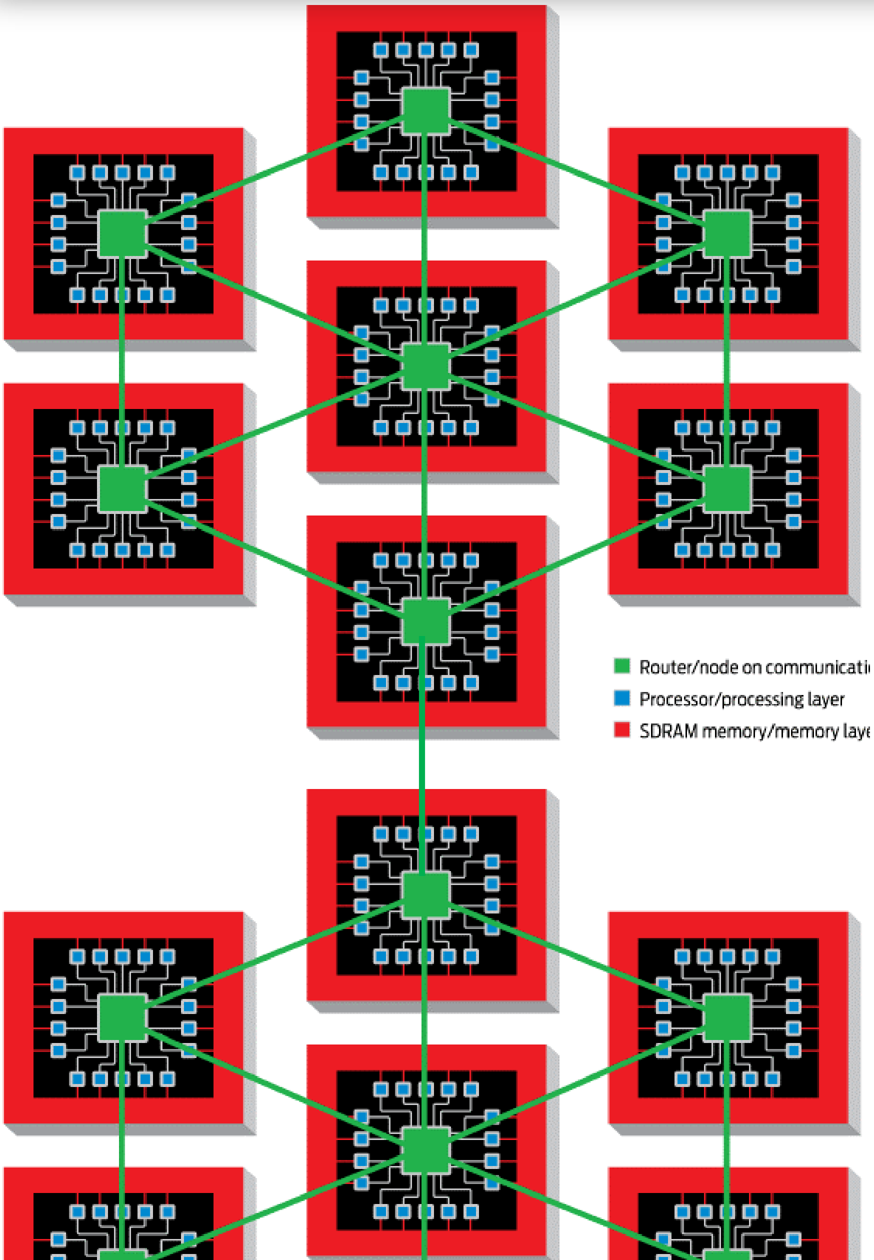
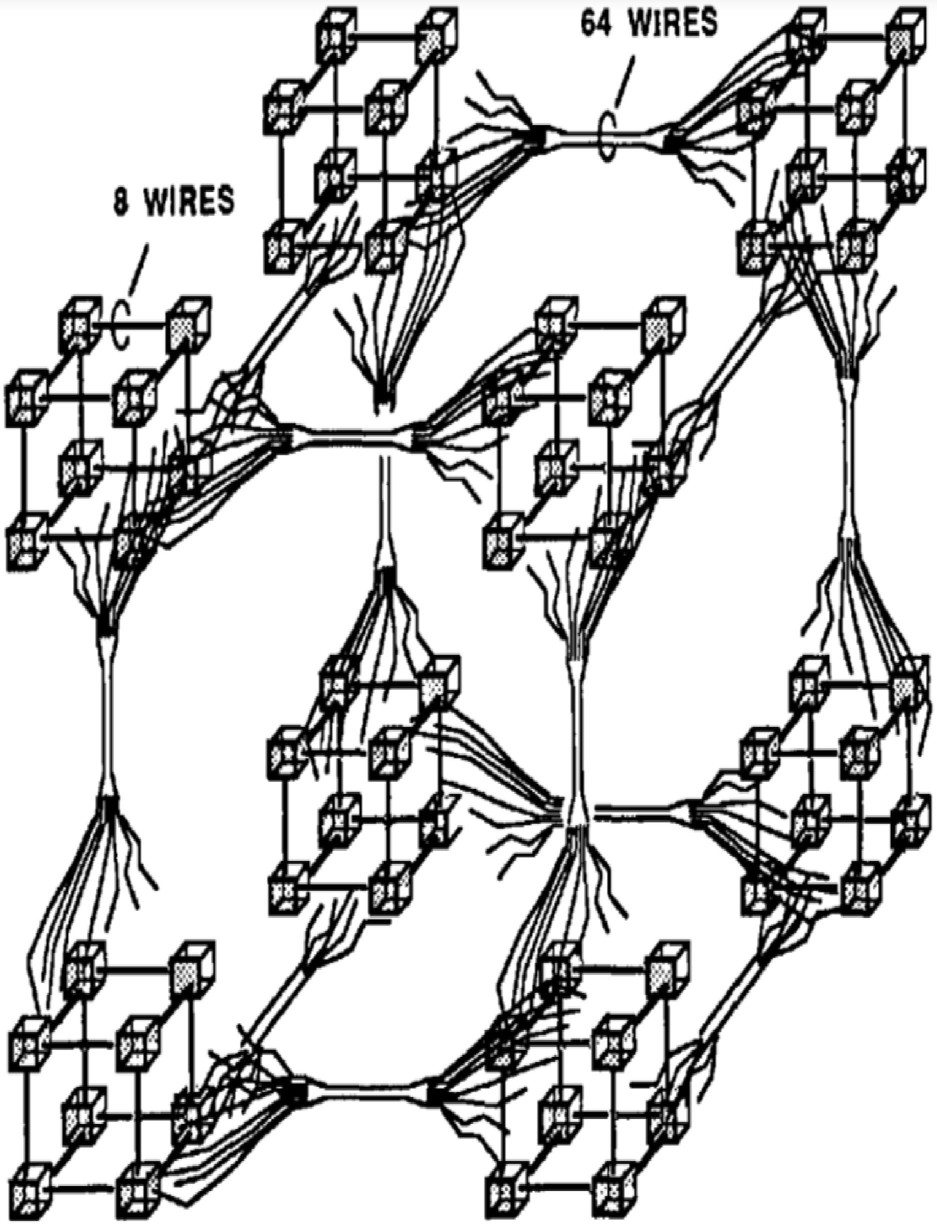


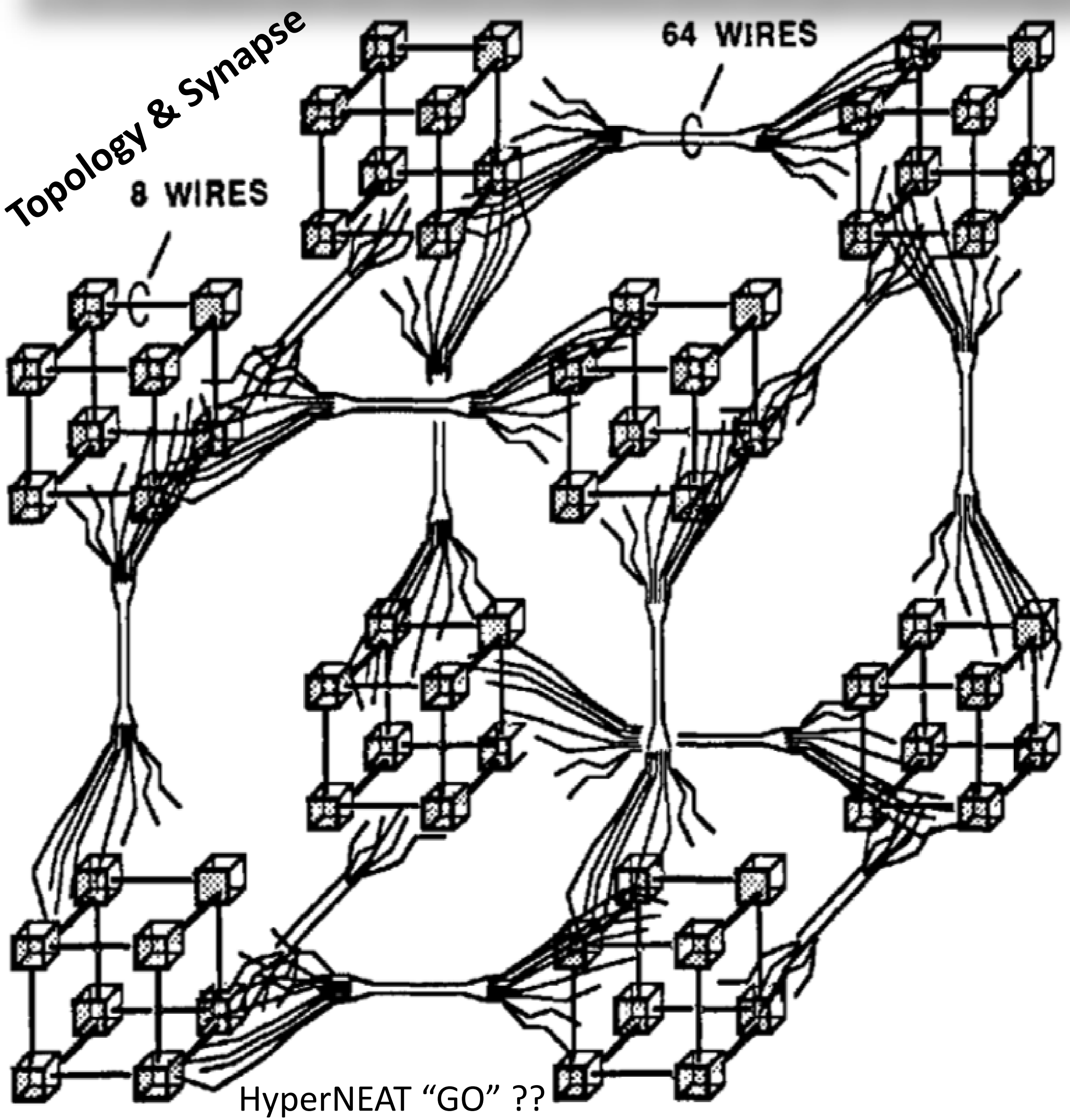
http://bit.do/NNDL-MN-BOOK

Neuro-Synaptic Chips by D. Modha (IBM) v Marvin Lee Minsky “Cube on Cube” (1959)





Intelligence is not a point, it is a tapestry of linked data, analysis & thinking punctuated by experience.
"Within a generation the problem of creating 'artificial intelligence' will substantially be solved." 1967
"In 3-8 years we will have a machine with the general intelligence of an average human being." 1970



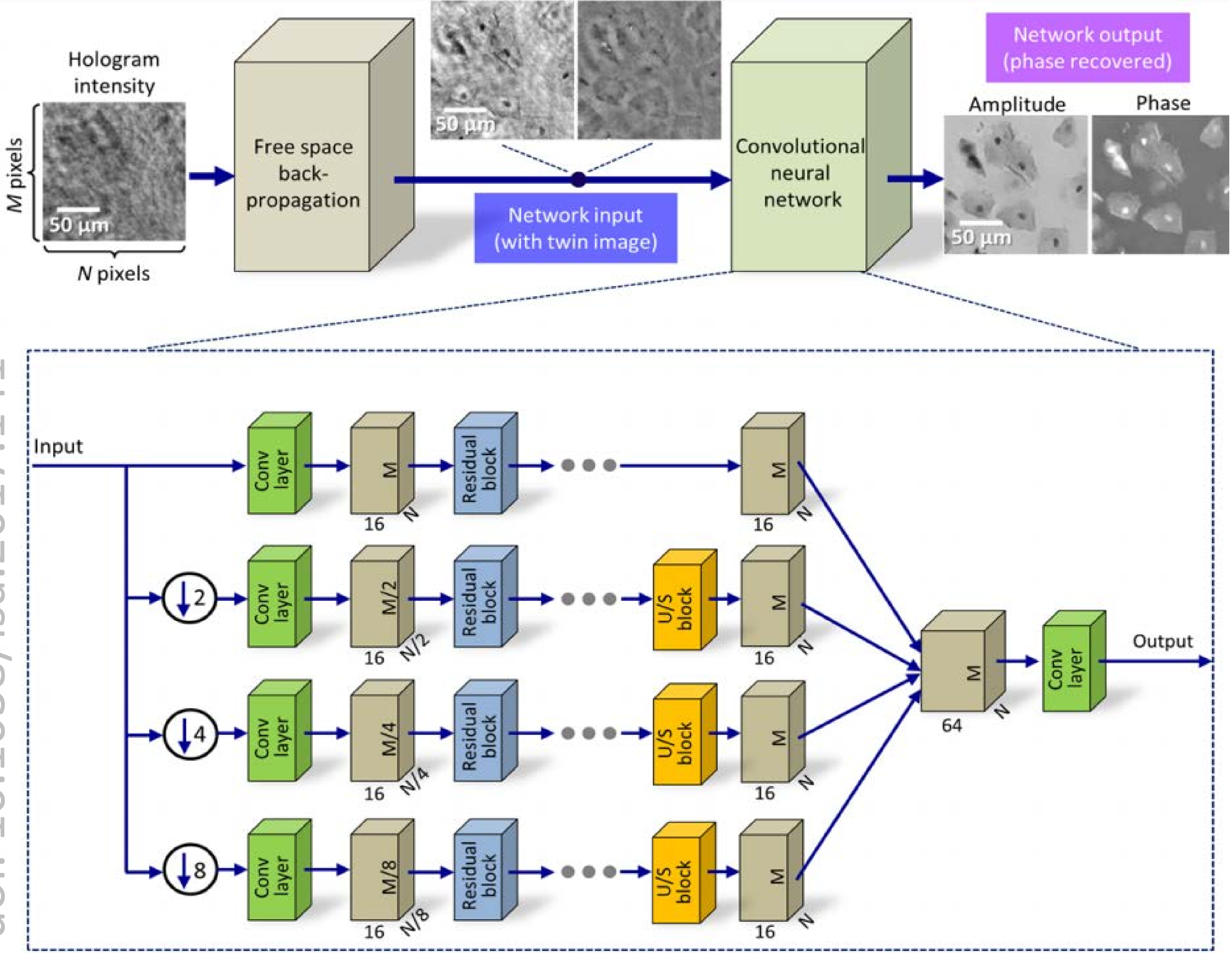
Here, 8 agents make a little cube, and 8 such cubes make a 64-agent supercube.

If we join 8 of these supercubes, we'll have 512 agents. And if we repeat this cube-on-cube pattern ten times, the resulting supercube will contain a billion agents!

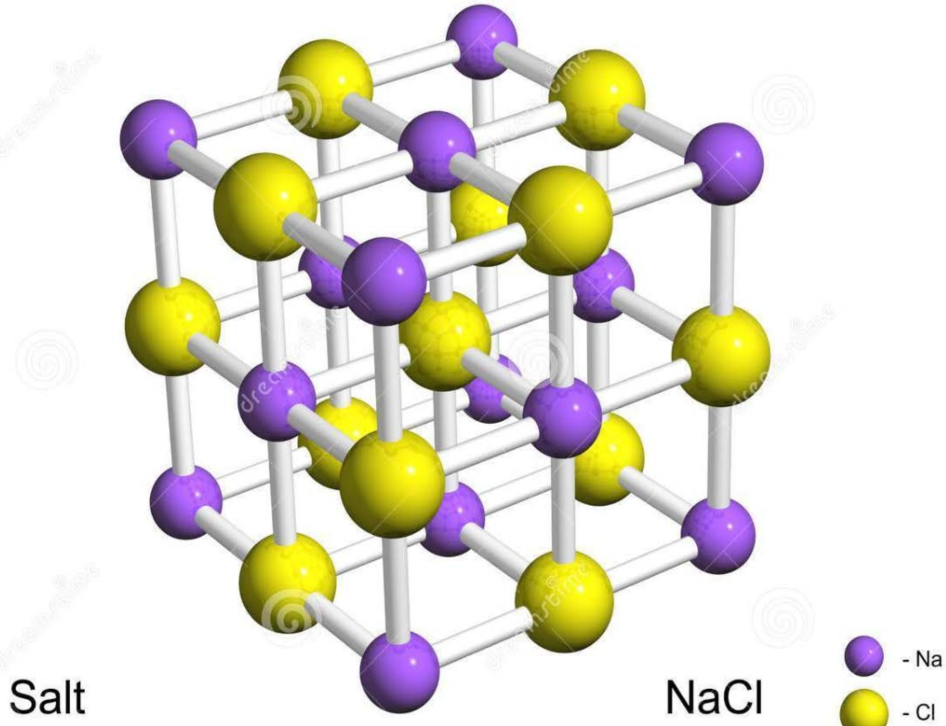
But if we link each agent to 30 others instead of only 6, then each agent could communicate with a billion others in only 6 steps.

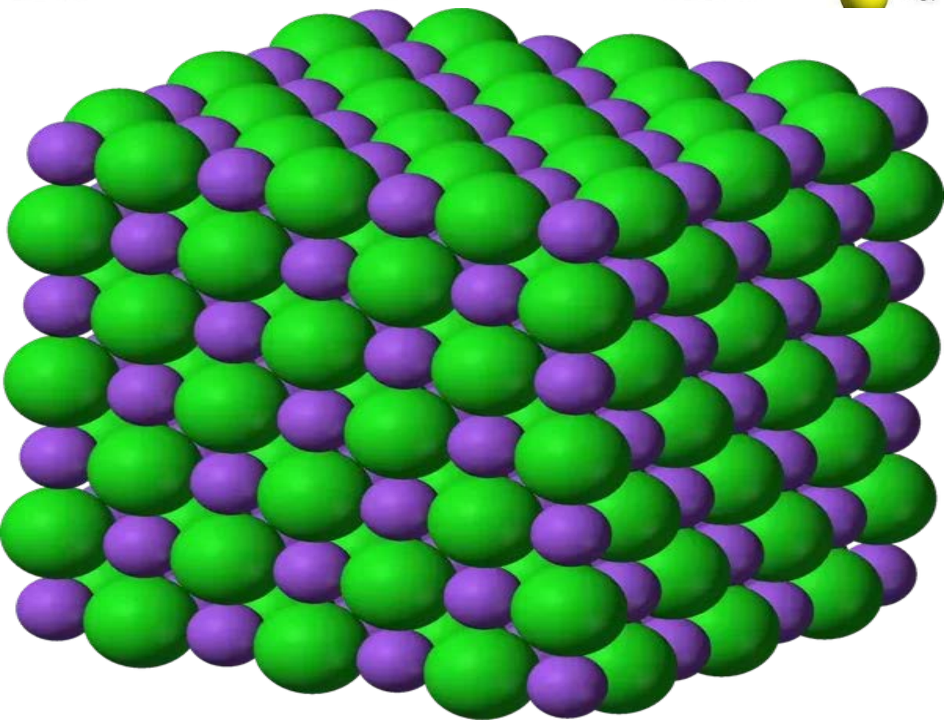
THE SOCIETY OF MIND
Marvin Lee Minsky (1959)

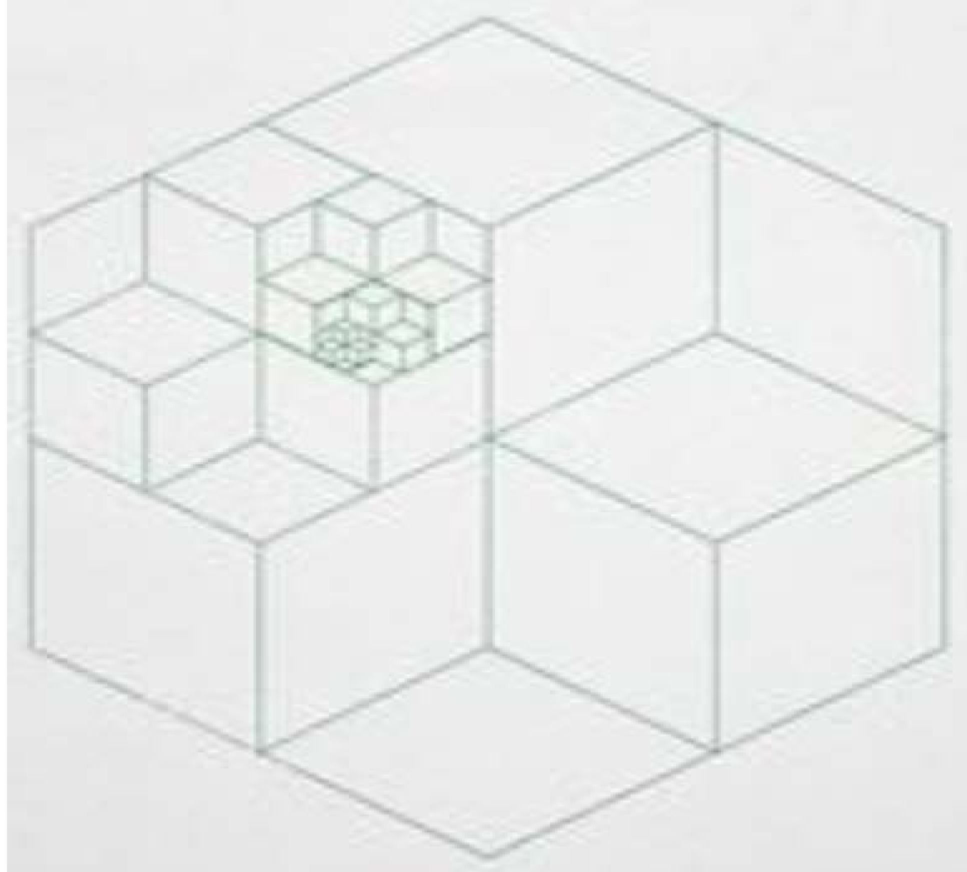
doi: 10.1038/lsa.2017.141

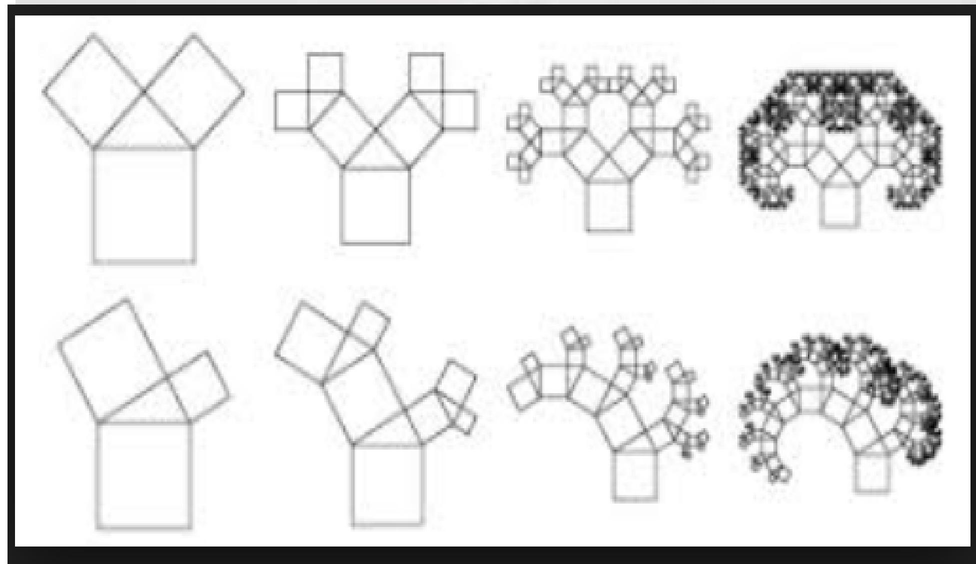


http://innovate.ee.ucla.edu/wp-content/uploads/2010/03/Ozcan-Group-CNN-LSA-2017-wSI.pdf


Salt
NaCl
- Na
- Cl





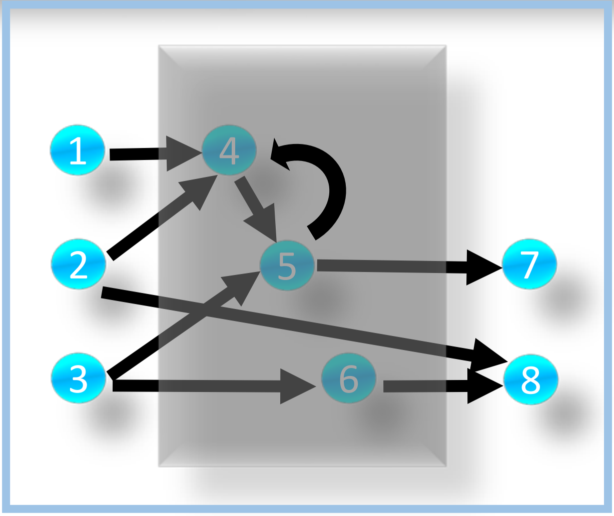


Data in Neural Paradigm

The design of classical weighted neural networks

Classical approach of ANN – predominantly inferential

Topological by design with generic weights generates inferential (obvious) output



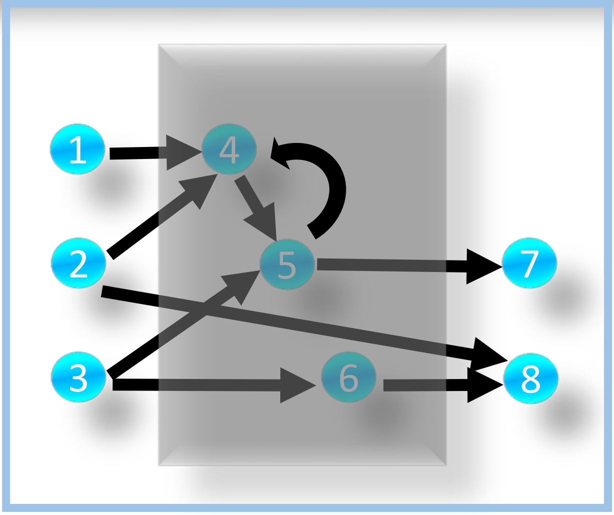
Recurrent Neural Network

$$
\begin{array}{cc}
 & \begin{array}{cccccccc} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \end{array} \\
\begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \end{array} &
\begin{bmatrix}
0 & 0 & 0 & w_{14} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & w_{24} & 0 & 0 & 0 & w_{28} \\
0 & 0 & 0 & 0 & w_{35} & w_{36} & 0 & 0 \\
0 & 0 & 0 & 0 & w_{45} & 0 & 0 & 0 \\
0 & 0 & 0 & w_{54} & 0 & 0 & w_{57} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & w_{68} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
\end{array}
$$

$(1,4, w_{14})$,
$(2,4, w_{24})$,
$(3,5, w_{35})$,
$(3,6, w_{36})$,
$(4,5, w_{45})$,
$(5,4, w_{54})$,
$(5,7, w_{57})$,
$(2,8, w_{28})$,
$(6,8, w_{68})$,

Non-obvious (inferential) relationship analysis?

The weighted brain "ecosystem"
- epigenetic (seconds to days)
- ontogenic (days to years)
- phylogenic (generations)

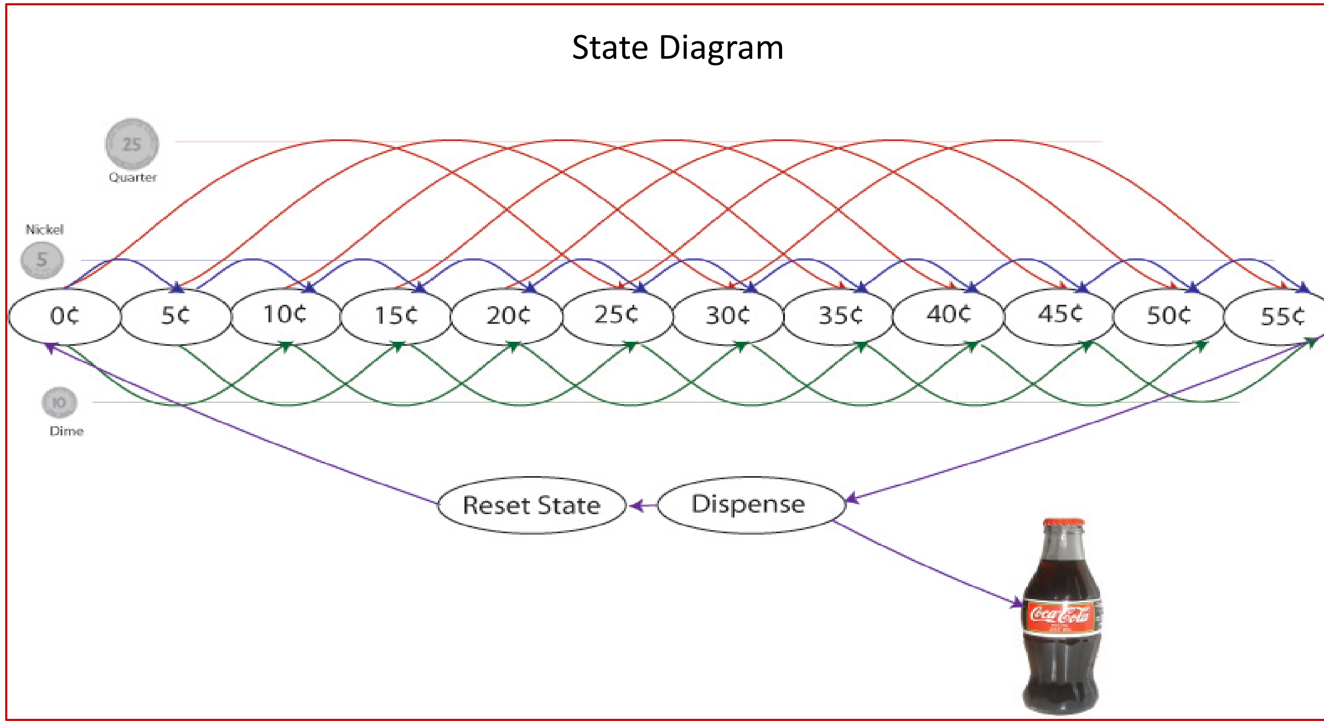


Recurrent Neural Network

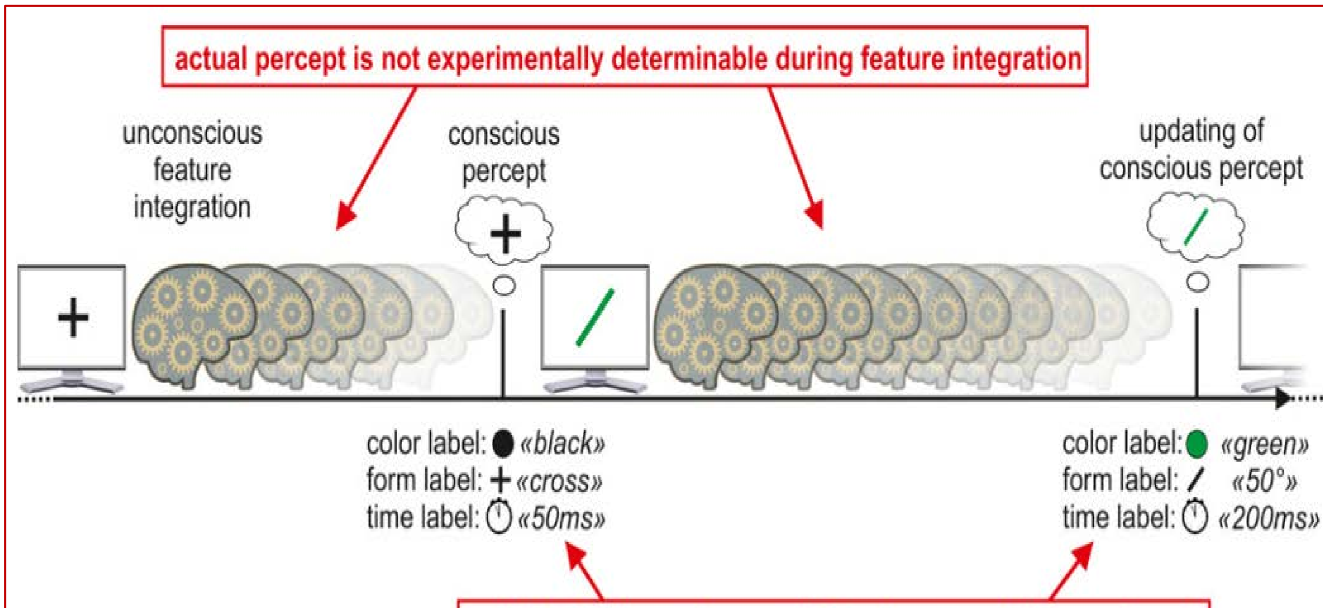
$$
\begin{array}{c|cccccccc}
 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\
\hline
1 & 0 & 0 & 0 & w_{14} & \boxed{0} & \boxed{0} & 0 & 0 \\
2 & 0 & 0 & 0 & w_{24} & 0 & 0 & \boxed{0} & w_{28} \\
3 & 0 & 0 & 0 & \boxed{0} & w_{35} & w_{36} & 0 & 0 \\
4 & \boxed{0} & 0 & 0 & 0 & w_{45} & 0 & 0 & 0 \\
5 & 0 & \boxed{0} & 0 & w_{54} & 0 & 0 & w_{57} & 0 \\
6 & 0 & 0 & \boxed{0} & 0 & 0 & 0 & 0 & w_{68} \\
7 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
8 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{array}
$$

Can we? Evolve from use of classical ANN which emulates NN topology to developmentally inspired engineering design based on neurogenesis and brain development modelling by creating programs which *generate* neural networks, hence adaptable, naturally.

The model of a function

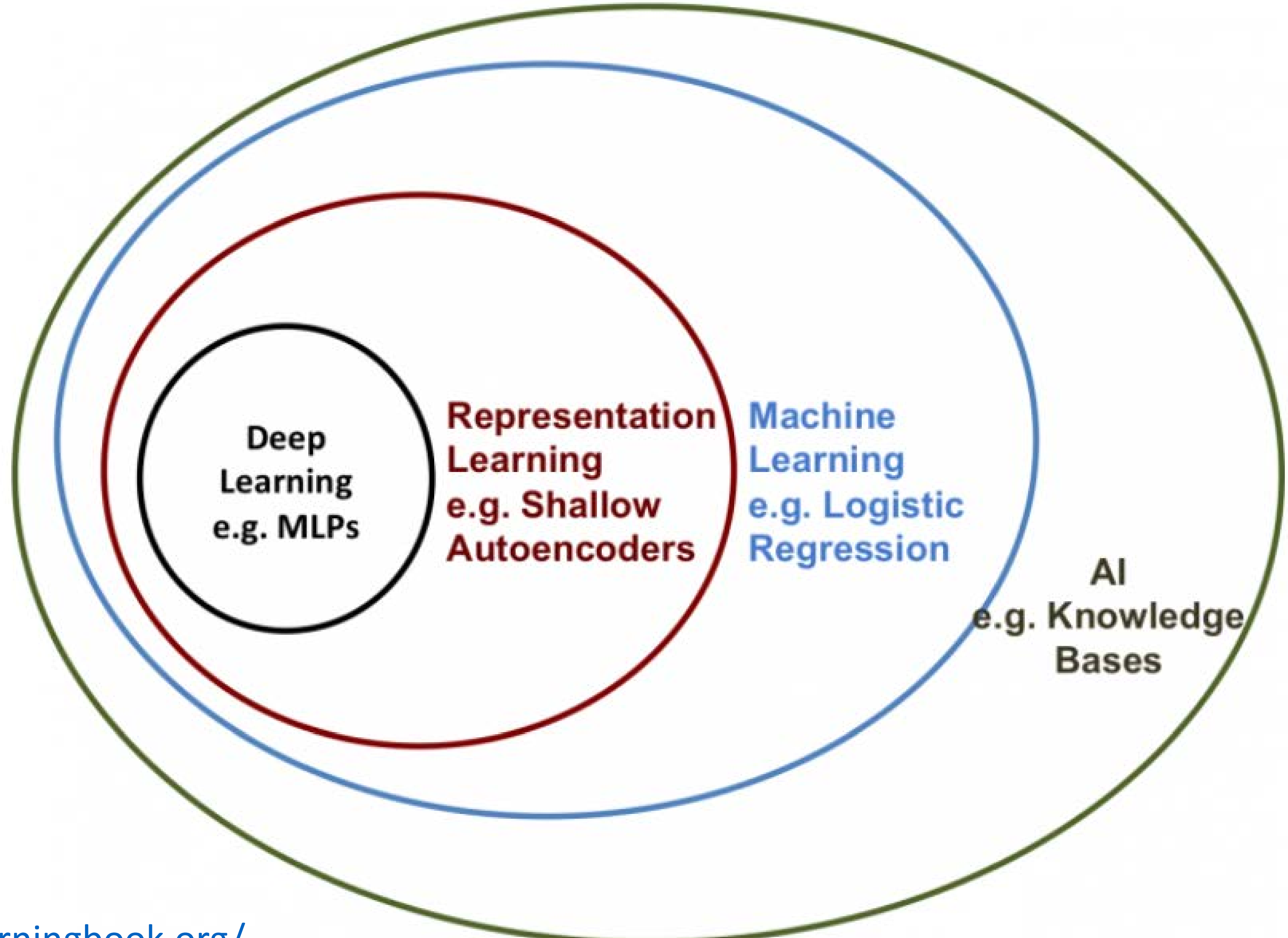


How the model functions

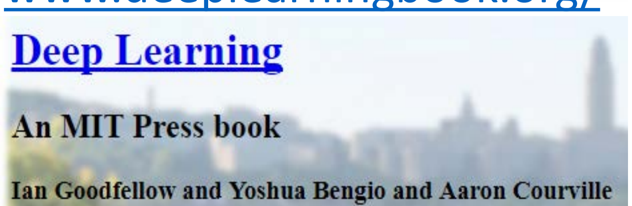


A two stage model of visual perception

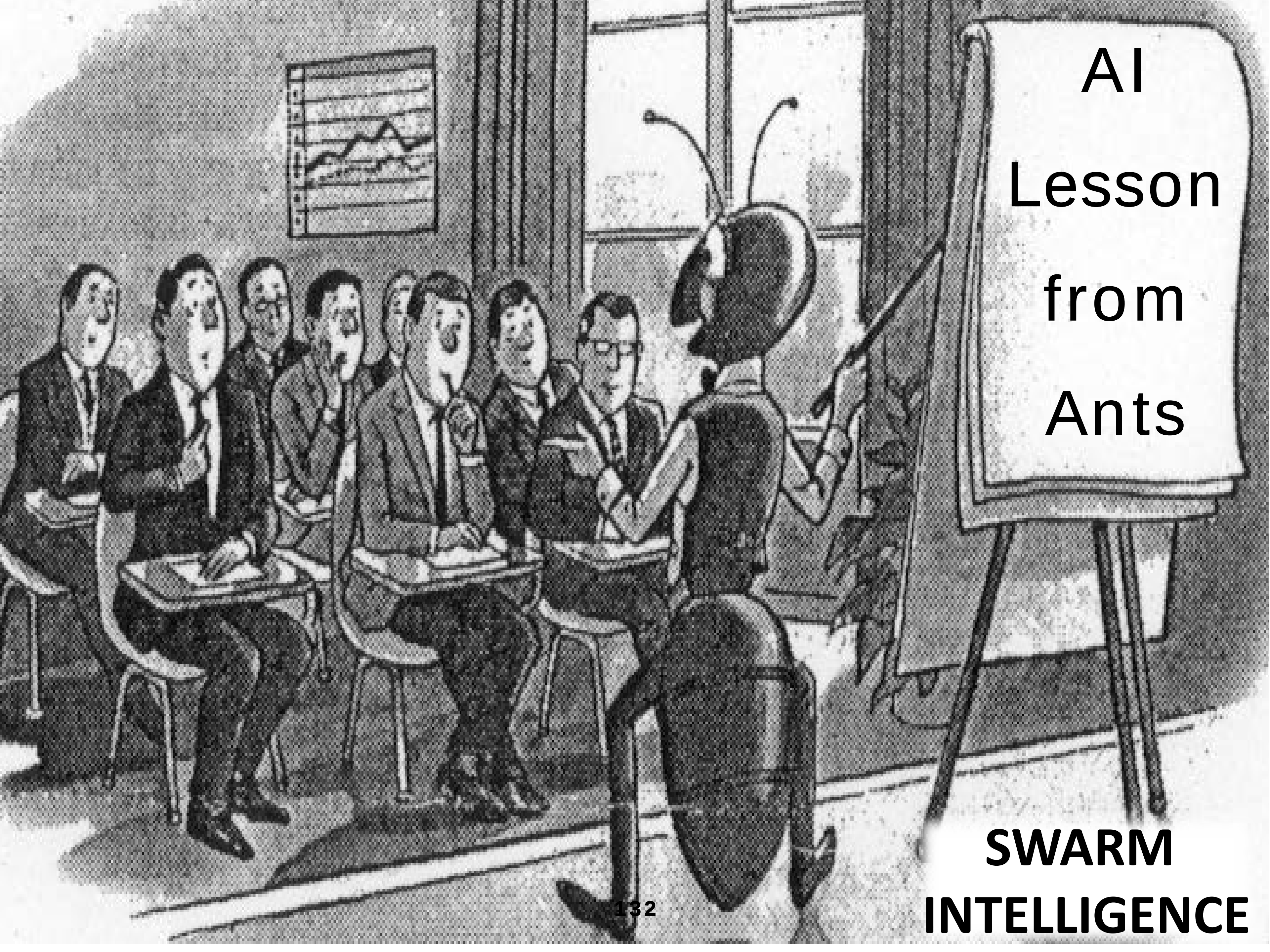
http://journals.plos.org/plosbiology/article/asset?id=10.1371%2Fjournal.pbio.1002433.PDF



www.deeplearningbook.org/



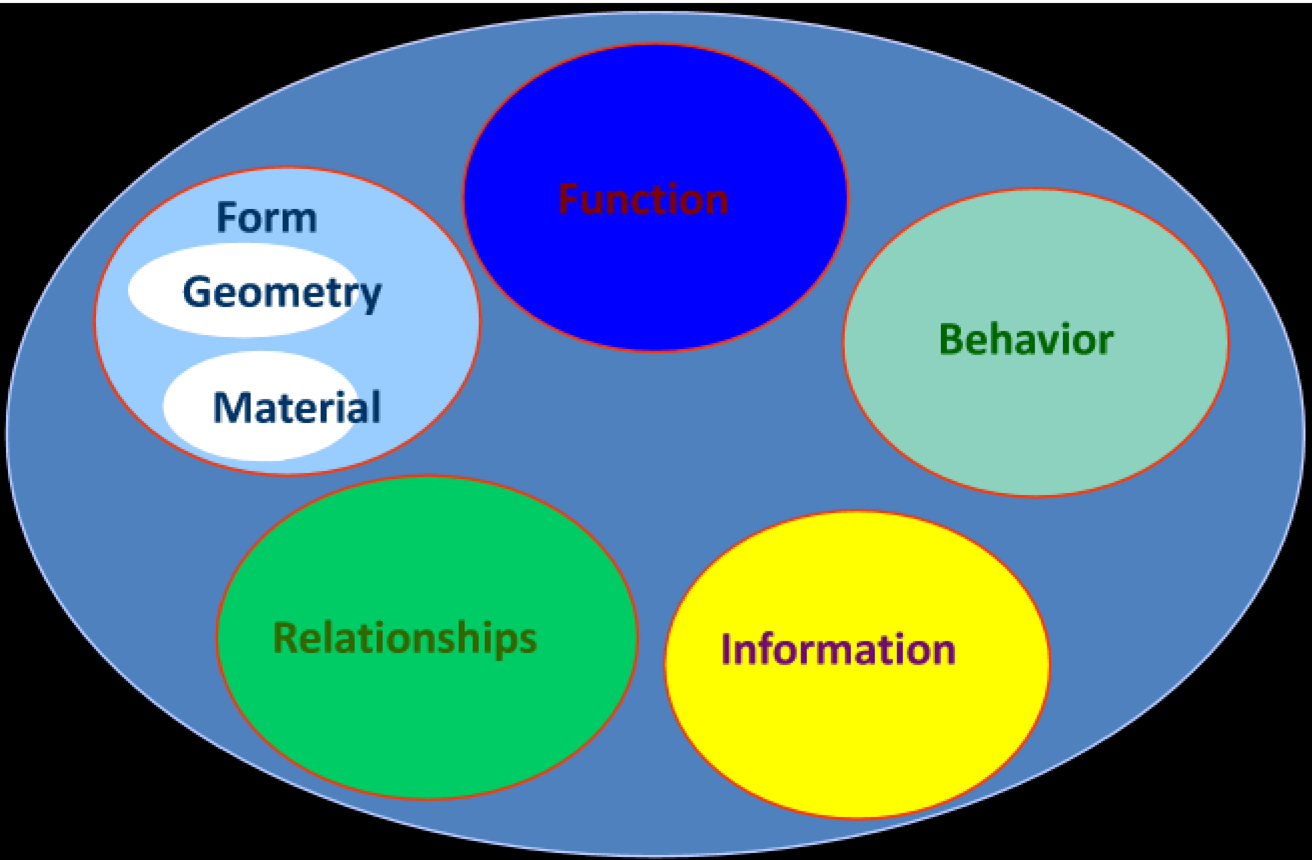
http://dai.fmph.uniba.sk/~sefranek/kri/handbook/handbook_of_kr.pdf


AI
Lesson
from
Ants
SWARM
INTELLIGENCE

Data in KR

The design of knowledge representation networks

KNOWLEDGE REPRESENTATION



A product is represented by a hierarchy of entities of the class Artifact, which is an aggregation of Function, Form and Behavior. Function represents what the artifact is supposed to do; Form represents the proposed design solution for the design problem specified by the Function; and Behavior represents the evaluation of how the artifact implements its function.

Ram Sriram, NIST

SYNTAX, SEMANTICS, CONTEXT

TOP

TOP LESS

OVER THE TOP

TOP OF WALL

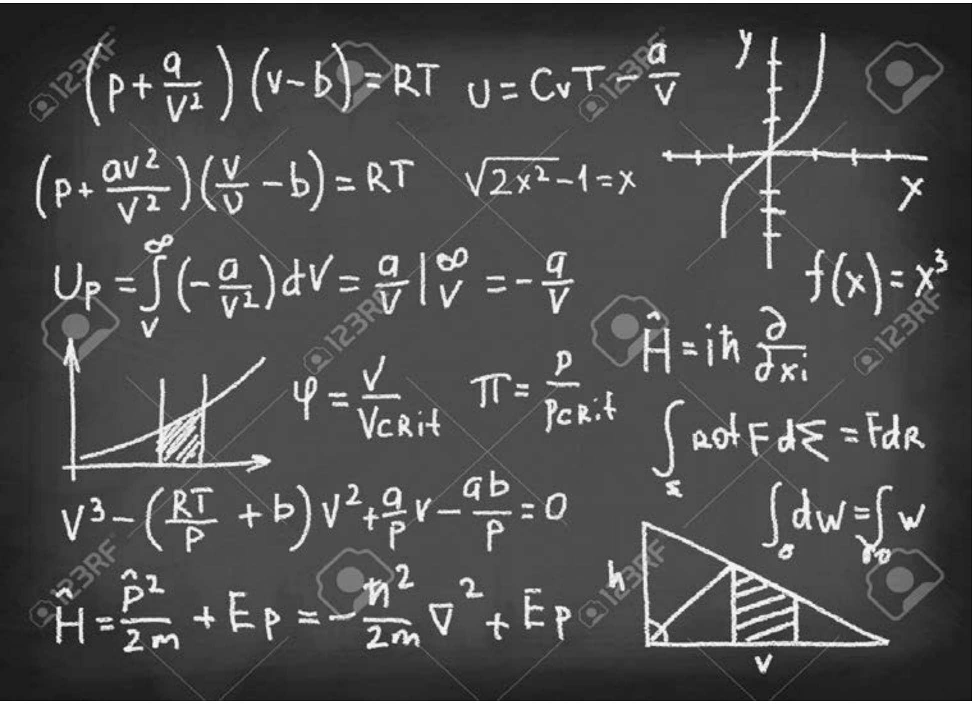
Which part of your brain "lights" up

TOP

TOPLESS

TOP LESS

TOP LESS



OVER THE TOP

TOP OF WALL

TOP Edit

最佳

Zuì jiā

TOPLESS

赤裸上身

Chìluǒ shàngshēn

TOP LESS

爐頂

Lú dǐng

OVER THE TOP

越過高峰

Yuèguò gāofēng

TOP OF WALL Edit

頂壁

Dǐng bì

Google Translate from English to Chinese (Traditional)

Semantic Ambiguity ?

2006
Chalmers
Sweden

Call 1
Loud cry, shout

喊叫 喊叫

Call 2
Animal's call

嚎叫 嚎叫

Call 3 →
Telephone call

电话 电话

Call 4 →
House visit

需求 需求

Semantics v Ontology

Semantic Differences

Call 1
Loud cry, shout

喊叫 喊叫

Call 2
Animal's call

嚎叫 嚎叫

Call 3
Telephone call

电话 电话

Call 4
House visit

需求 需求

Liping Wang Englund
2016 • Gothenberg
Email liping.wang@mets

Liping Wang Englund
Project Logistics Manager at Metso Power
Gothenburg, Sweden | Chemicals
Previous Metso Power, Volvo Penta, Maersk Line
Education CSCP(Certified Supply Chain Professional)

Immensely complicated
AI is not neuroscience

The deliberate commercial deception using AI hype

Intelligence in AI - https://dspace.mit.edu/handle/1721.1/108000

Why?

DATA IN CONTEXT

The chasm between semantic context and computation

http://oxygen.csail.mit.edu/Overview.html

Data curation may be rendered useless unless selected for context

The latest US influenza season is more severe and has caused more deaths than usual.

EPIDEMIOLOGY

When Google got flu wrong

US outbreak foxes a leading web-based method for tracking seasonal flu.

BY DECLAN BUTLER

When influenza hit early and hard in the United States this year, it quietly claimed an unacknowledged victim: one of the cutting-edge techniques being used to monitor the outbreak. A comparison with traditional surveillance data showed that Google Flu Trends, which estimates prevalence from flu-related Internet searches, had drastically overestimated peak flu levels. The glitch is no more than a temporary setback for a promising strategy, experts say, and Google is sure to refine its algorithms. But as flu-tracking techniques based on mining of web data and on social media proliferate, the episode is a reminder that they will complement, but not substitute for, traditional epidemiological surveillance networks.

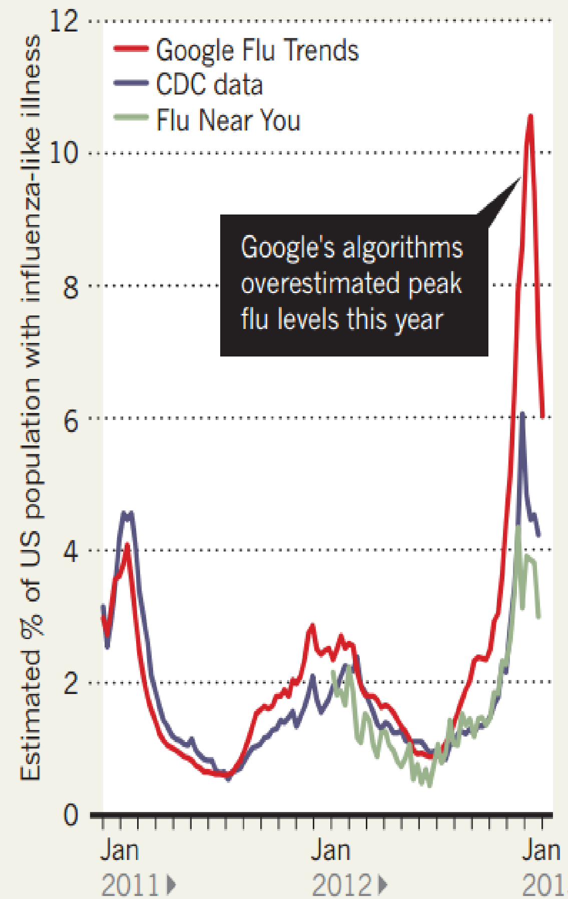
"It is hard to think today that one can provide disease surveillance without existing systems," says Alain-Jacques Valleron, an epidemiologist at the Pierre and Marie Curie University in Paris, and founder of France's Sentinelles monitoring network. "The new systems depend too much on old existing ones to be able to live without them," he adds.

This year's US flu season started around November and seems to have peaked just after Christmas, making it the earliest flu season since 2003. It is also causing more serious illness and deaths than usual, particularly among the elderly, because, just as in 2003, the predominant strain this year is H3N2 — the most

nologies could open the way to easier, faster estimates of ILI, spanning larger populations.

FEVER PEAKS

A comparison of three different methods of measuring the proportion of the US population with an influenza-like illness.



Machine Learning and Training ML Algorithms using Data

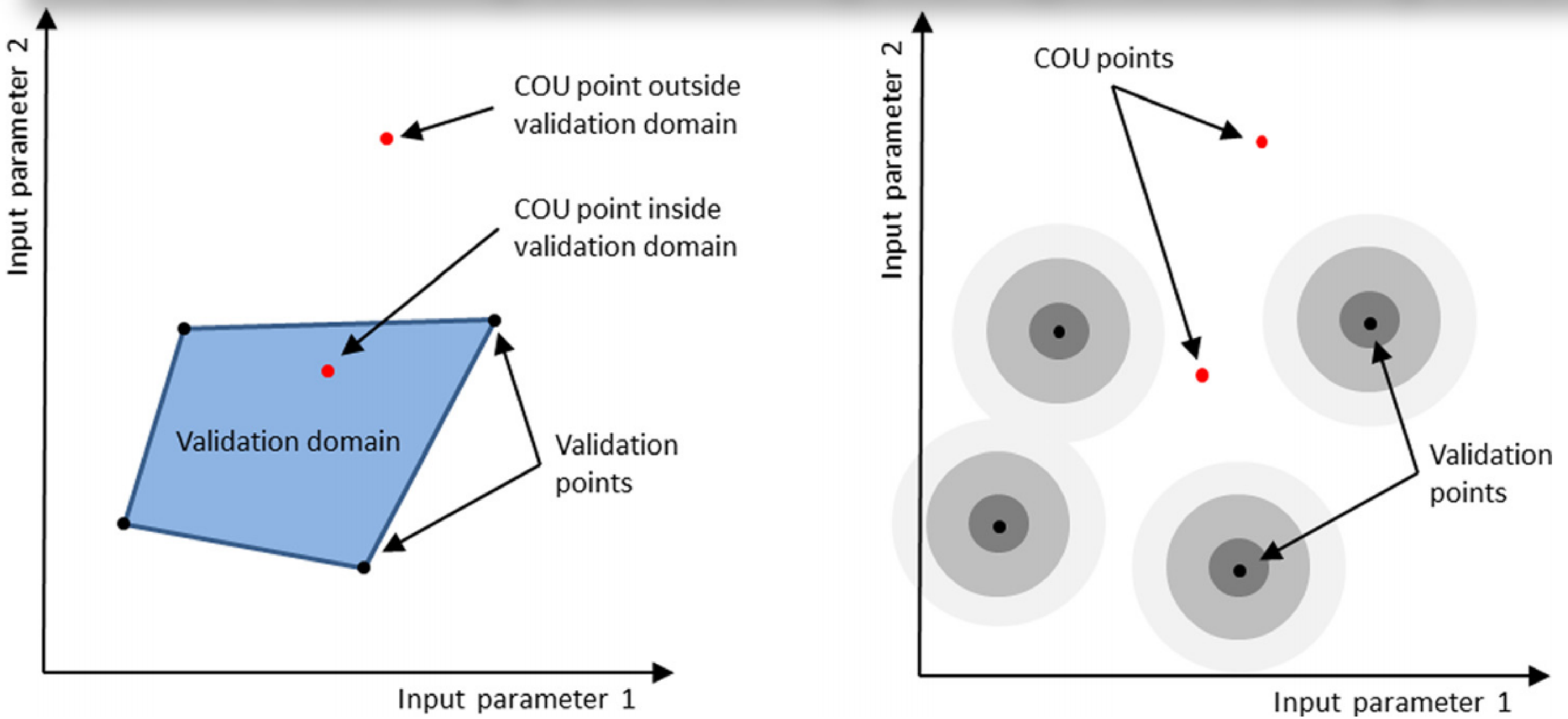


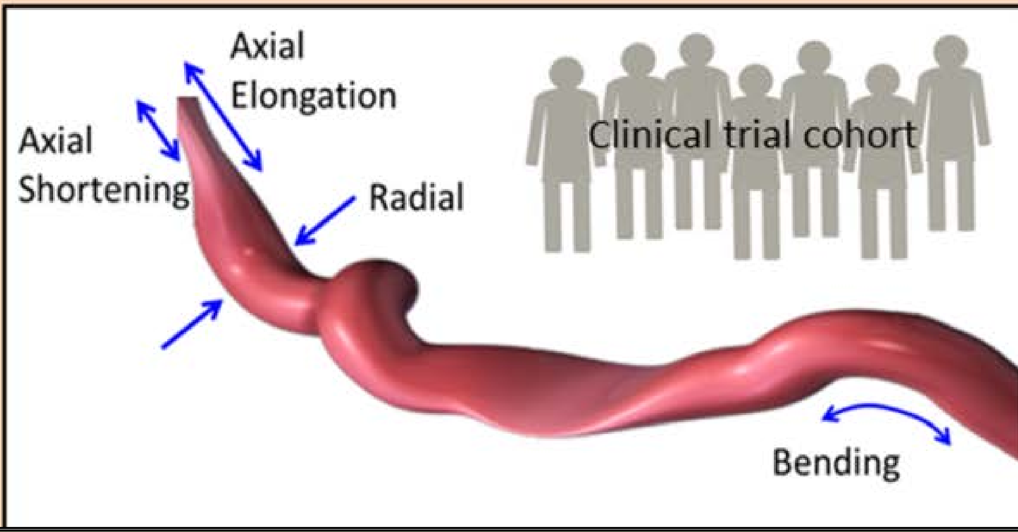
Fig. 1 Left: illustration of a "validation domain," defined through input parameters values at which validation was performed, and possible COU parameter values inside ("interpolation") or outside ("extrapolation") the validation domain. Right: alternative conceptual approach which relates confidence of predictions (denoted by the different shades of gray) to distance to validation points (see Ref. [18]).

J. Verif. Valid. Uncert 2(2), 021005 (Sep 07, 2017) doi: 10.1115/1.4037671

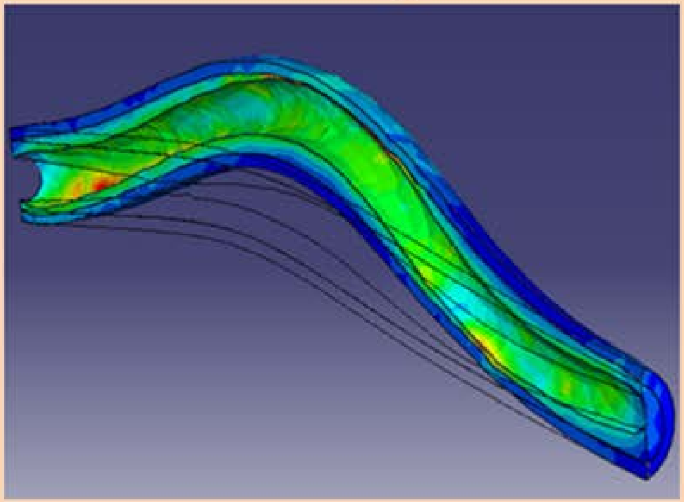
Context of Use Data vs Validation of Deterministic Models

CONTEXT OF USE

R-COU: Clinical setting

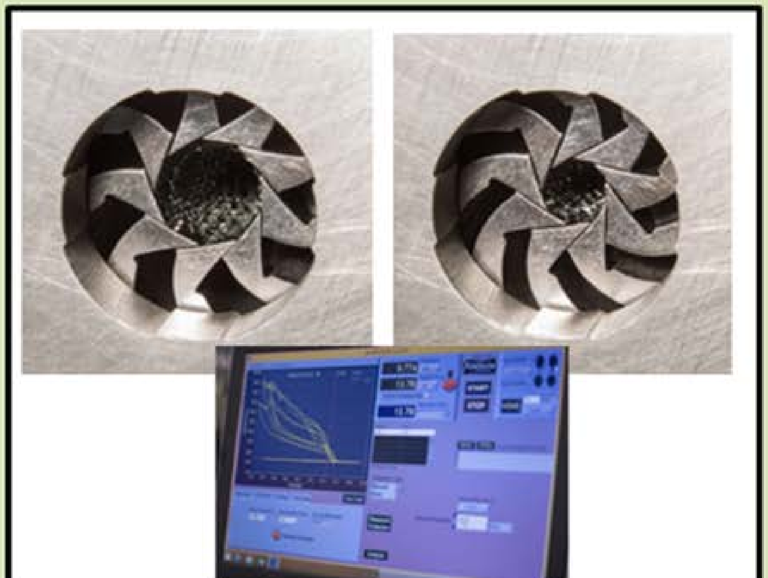


M-COU: computational model of stent and vessel under a range of conditions

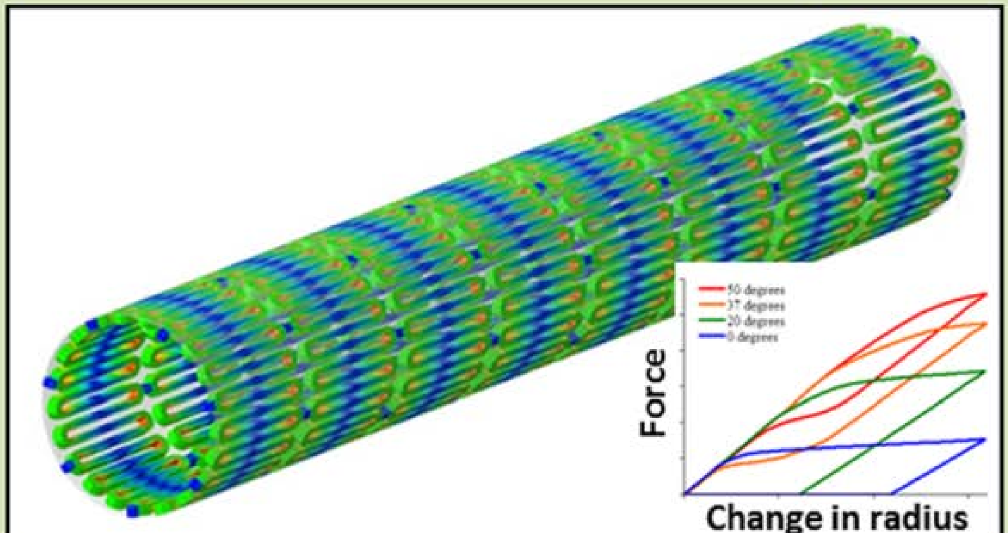


VALIDATION

R-VAL: Radial Loading apparatus



M-VAL: computational model of stent under radial loading



Concepts of Application and Context of Use (COU)

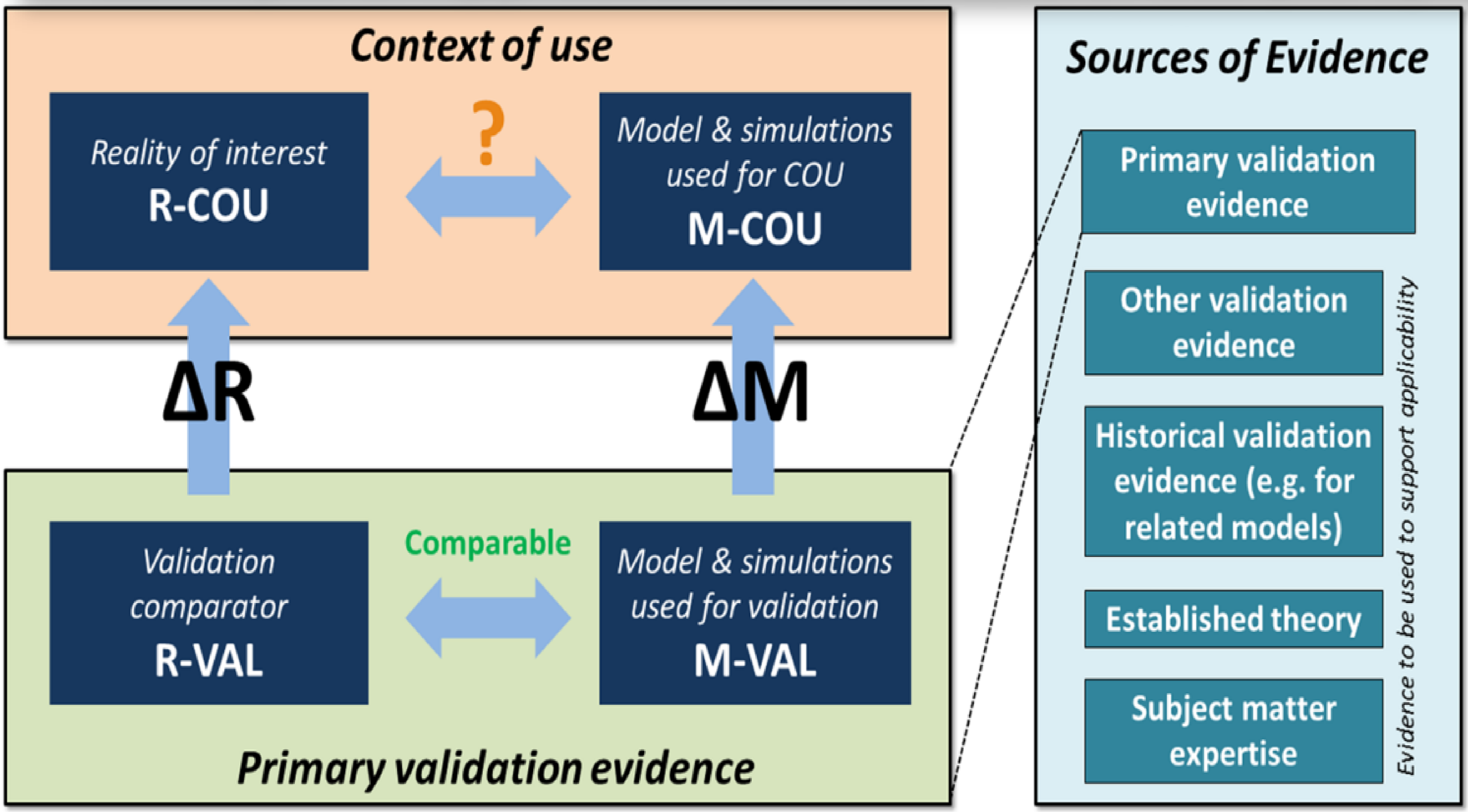
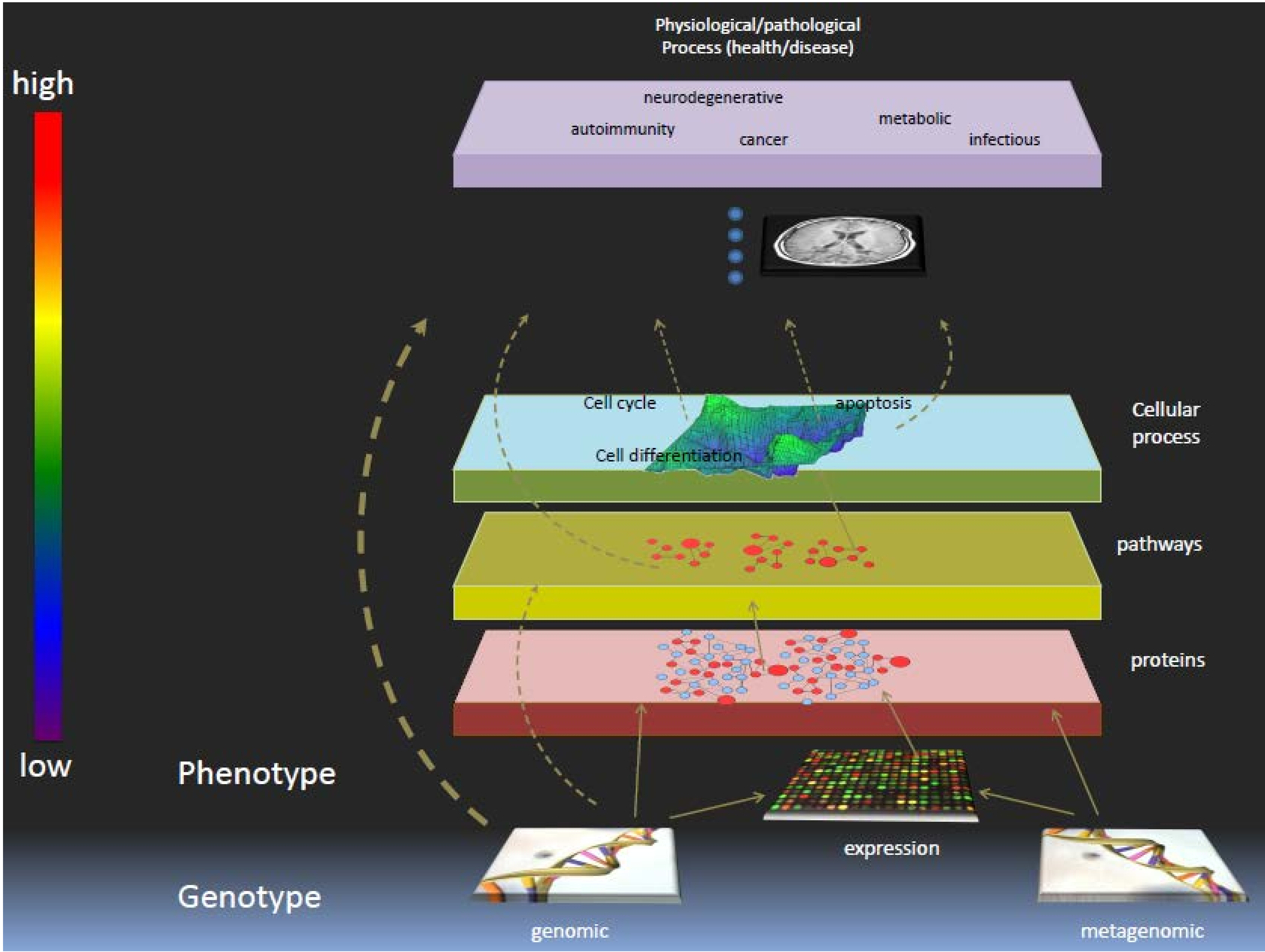


Fig. 2 The major concepts of the applicability framework. See text for discussion.

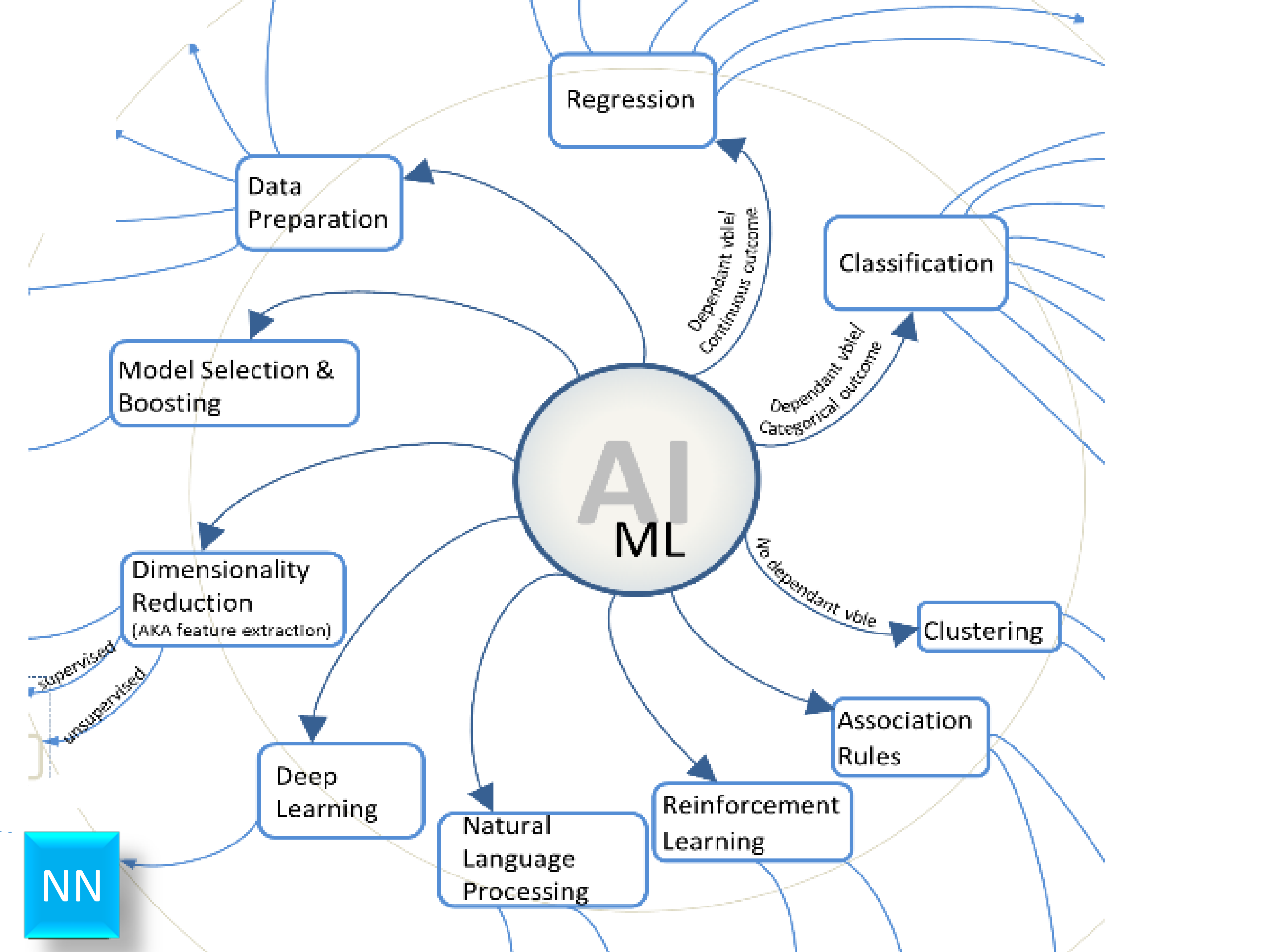
J. Verif. Valid. Uncert 2(2), 021005 (Sep 07, 2017) doi: 10.1115/1.4037671

Parameters, Variations, Attributes, Characteristics, Dependencies, Influencers, Nodes, Networks, Processes and Hierarchical Relationships that underlie Biological Complexity

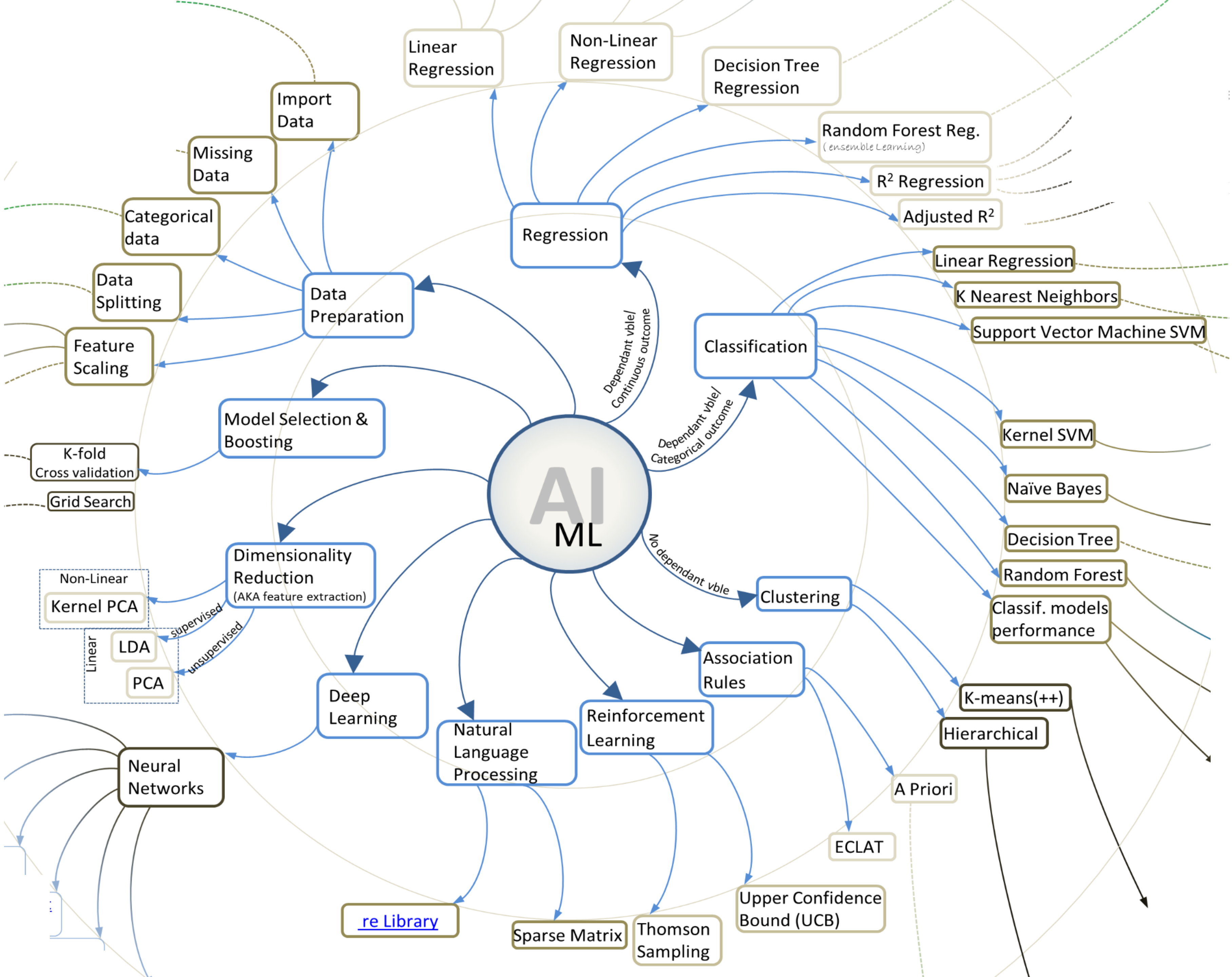


AI is an umbrella

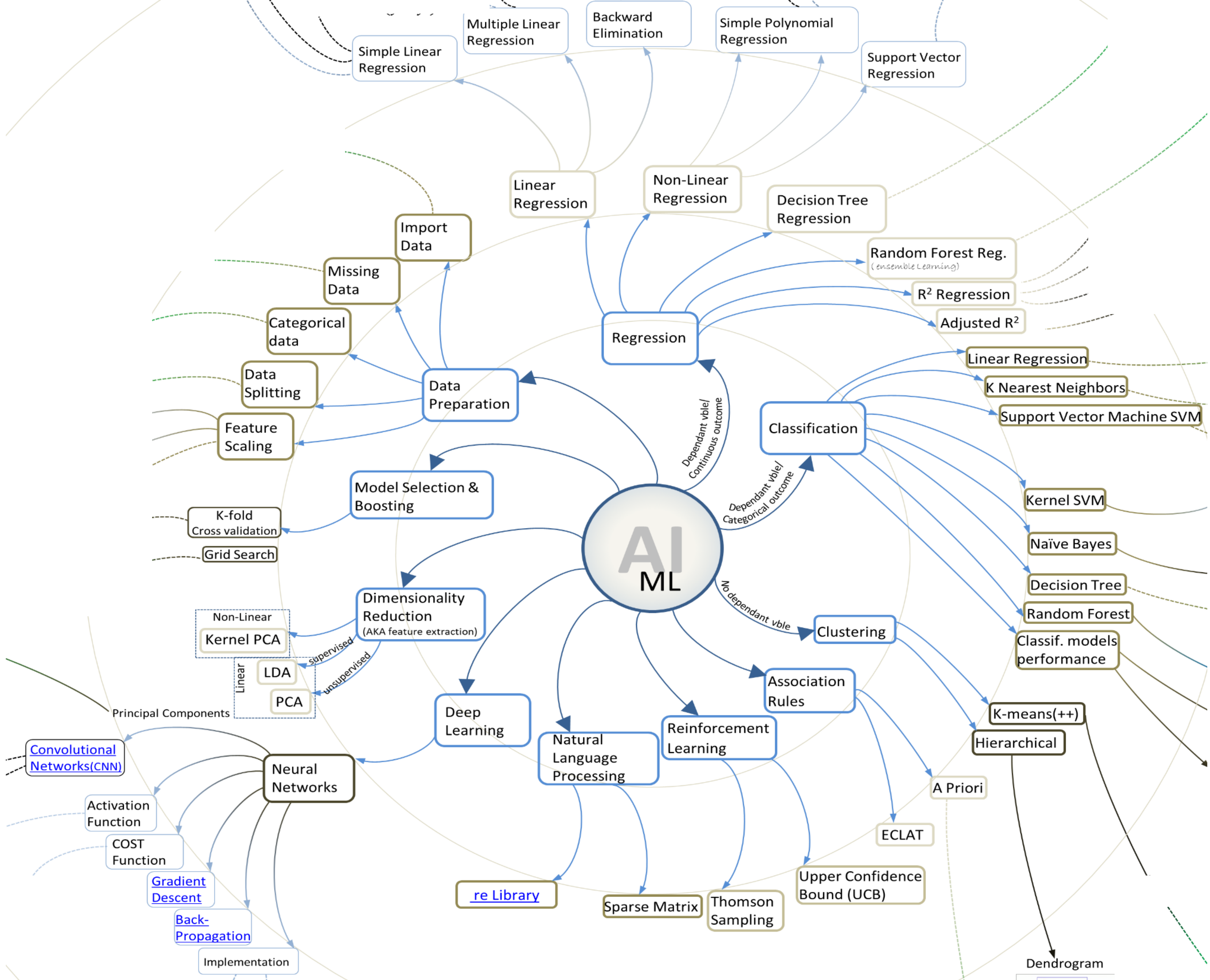
Vast complexity of tools and technologies



AI
ML
Regression
Data Preparation
Classification
Model Selection & Boosting
Dependant vble/ Continuous outcome
Dependant vble/ Categorical outcome
No dependant vble
Dimensionality Reduction
(AKA feature extraction)
supervised
unsupervised
Clustering
Association Rules
Deep Learning
Natural Language Processing
Reinforcement Learning
NN



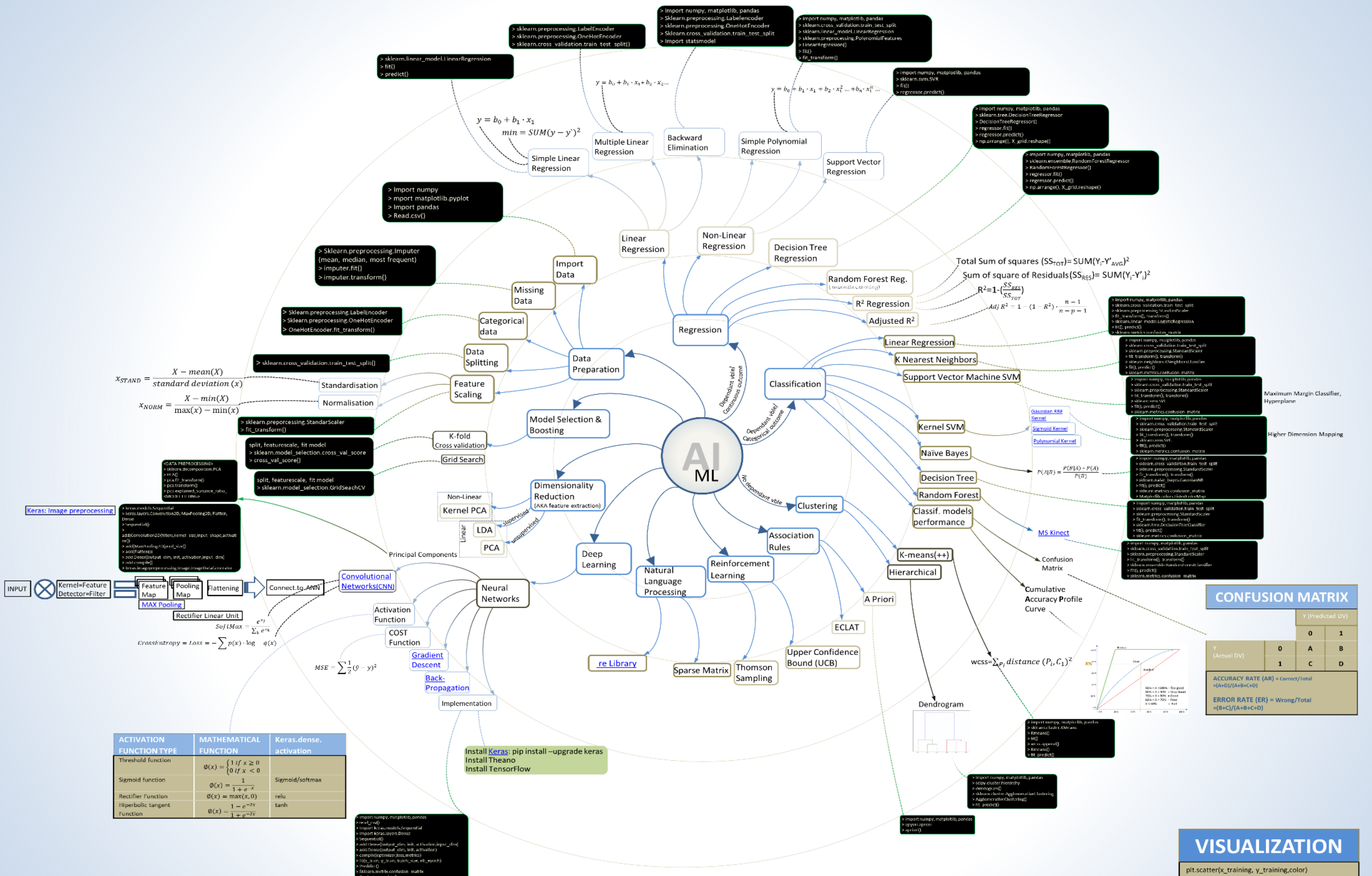
Linear Regression
Non-Linear Regression
Decision Tree Regression
Random Forest Reg.
(ensemble Learning)
R^2 Regression
Adjusted R^2
Import Data
Missing Data
Categorical data
Data Splitting
Feature Scaling
Data Preparation
Regression
Dependant vble/ Continuous outcome
Classification
Dependant vble/ Categorical outcome
Linear Regression
K Nearest Neighbors
Support Vector Machine SVM
Kernel SVM
Naïve Bayes
Decision Tree
Random Forest
Classif. models performance
Model Selection & Boosting
K-fold
Cross validation
Grid Search
AI
ML
No dependant vble
Clustering
K-means(++)
Hierarchical
Dimensionality Reduction
(AKA feature extraction)
Non-Linear
Kernel PCA
supervised
unsupervised
Linear
LDA
PCA
Association Rules
A Priori
ECLAT
Deep Learning
Neural Networks
Natural Language Processing
Reinforcement Learning
re Library
Sparse Matrix
Thomson Sampling
Upper Confidence Bound (UCB)



AI
ML
Regression
Linear Regression
Non-Linear Regression
Decision Tree Regression
Random Forest Reg.
(ensemble Learning)
R^2 Regression
Adjusted R^2
Simple Linear Regression
Multiple Linear Regression
Backward Elimination
Simple Polynomial Regression
Support Vector Regression
Dependant vble/ Continuous outcome
Classification
Dependant vble/ Categorical outcome
Linear Regression
K Nearest Neighbors
Support Vector Machine SVM
Kernel SVM
Naïve Bayes
Decision Tree
Random Forest
Classif. models performance
Clustering
No dependant vble
K-means(++)
Hierarchical
Dendrogram
Association Rules
A Priori
ECLAT
Reinforcement Learning
Upper Confidence Bound (UCB)
Thomson Sampling
Natural Language Processing
re Library
Sparse Matrix
Deep Learning
Neural Networks
Convolutional Networks(CNN)
Activation Function
COST Function
Gradient Descent
Back-Propagation
Implementation
Dimensionality Reduction
(AKA feature extraction)
Non-Linear
Kernel PCA
supervised
unsupervised
Linear
LDA
PCA
Principal Components
Model Selection & Boosting
K-fold
Cross validation
Grid Search
Data Preparation
Import Data
Missing Data
Categorical data
Data Splitting
Feature Scaling

Machine Learning A-Z Python Mind Map

Jose Gorchs, Sept 2017



ACTIVATION FUNCTION TYPE	MATHEMATICAL FUNCTION	Keras.dense. activation
Threshold function	$\phi(x) = \begin{cases} 1 & if\ x \geq 0 \\ 0 & if\ x < 0 \end{cases}$	
Sigmoid function	$\phi(x) = \frac{1}{1+e^{-x}}$	Sigmoid/softmax
Rectifier Function	$\phi(x) = \max(x, 0)$	relu
Hiperbolic tangent Function	$\phi(x) = \frac{1-e^{-2x}}{1+e^{-2x}}$	tanh

CONFUSION MATRIX

		Y (Predicted DV) 0	1
Y (Actual DV)	0	A	B
	1	C	D

ACCURACY RATE (AR) = Correct/Total =(A+D)/(A+B+C+D)

ERROR RATE (ER) = Wrong/Total =(B+C)/(A+B+C+D)

VISUALIZATION

```
plt.scatter(x_training, y_training,color)
plt.plot(x_training, regressor.predict(x_train), color)
plt.title()
plt.xlabel()
plt.ylabel()
plt.show()
```

Python Development Environment (SPYDER)

Download: https://github.com/spyder-ide/spyder

Documentation: https://pythonhosted.org/spyder/

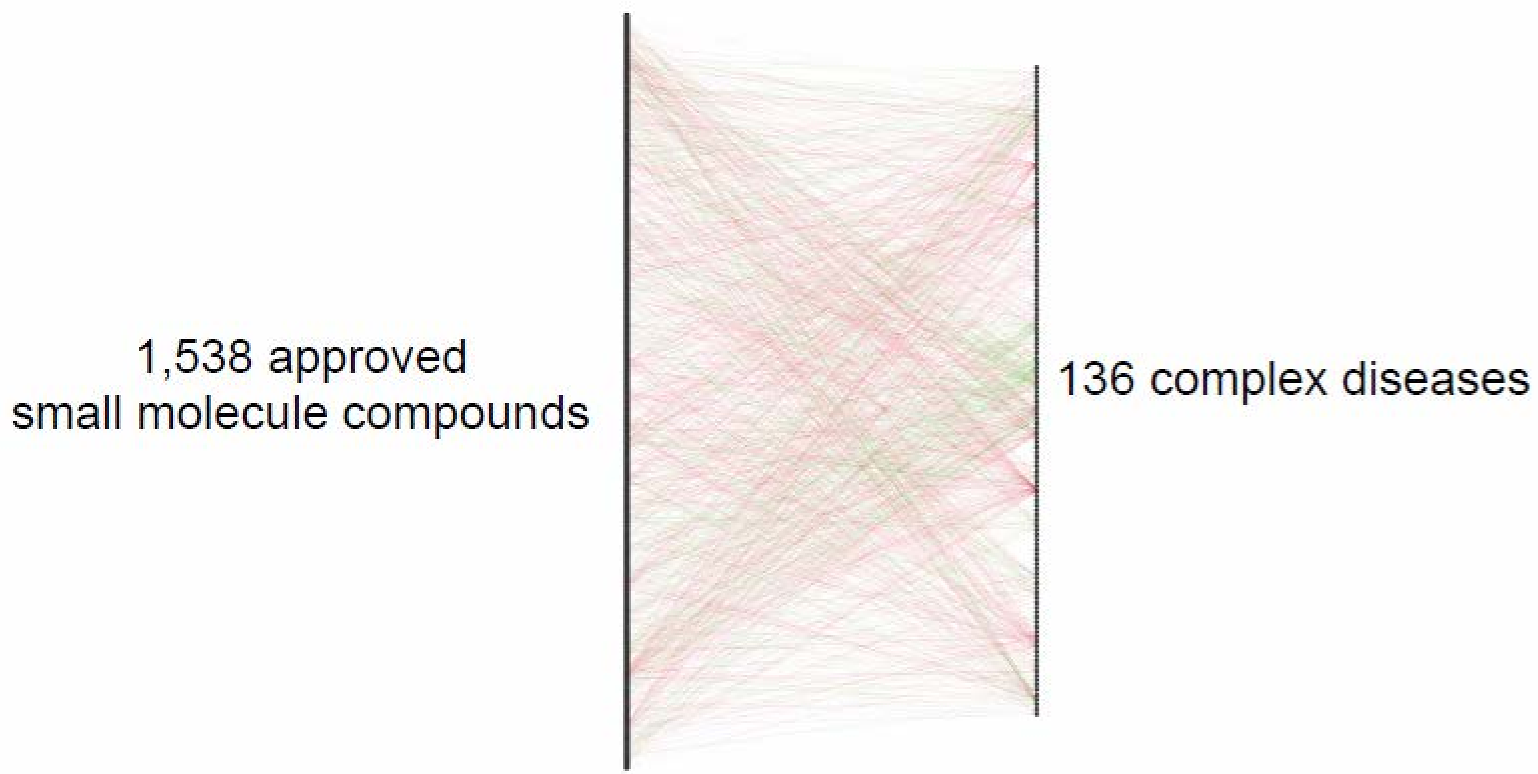
Can we train AI tools for diagnosis, treatment & drug repurposing

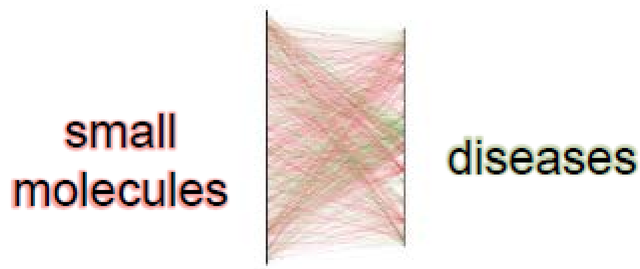
(Discovering new uses for approved drugs)

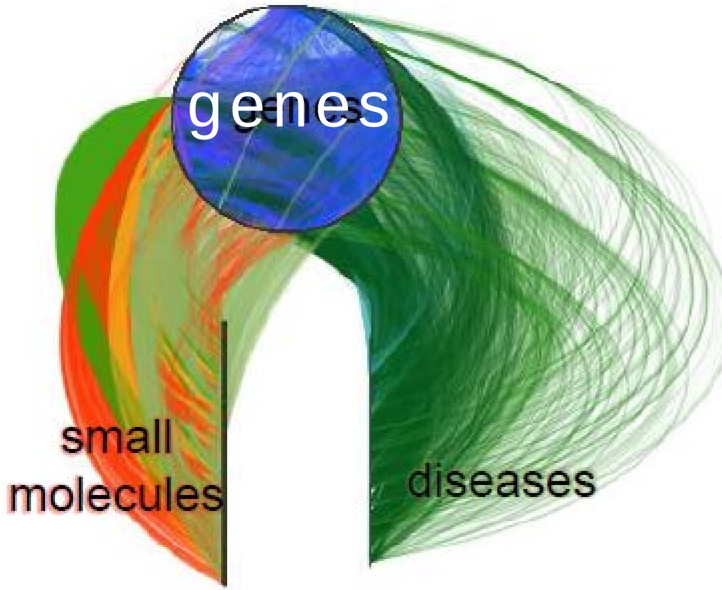
https://www.nature.com/polopoly_fs/1.20091!/menu/main/topColumns/topLeftColumn/pdf/534314a.pdf

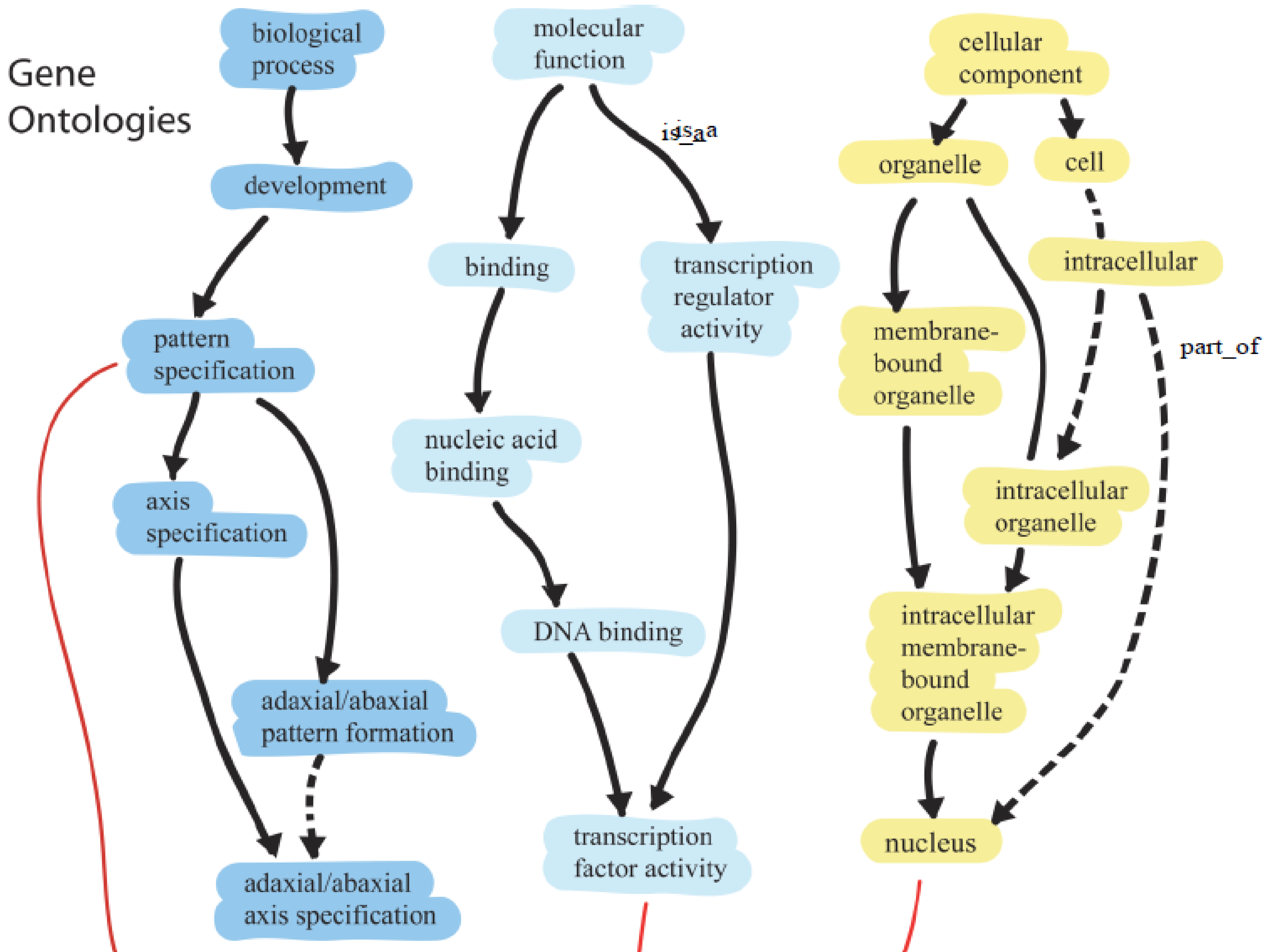
Imagine…

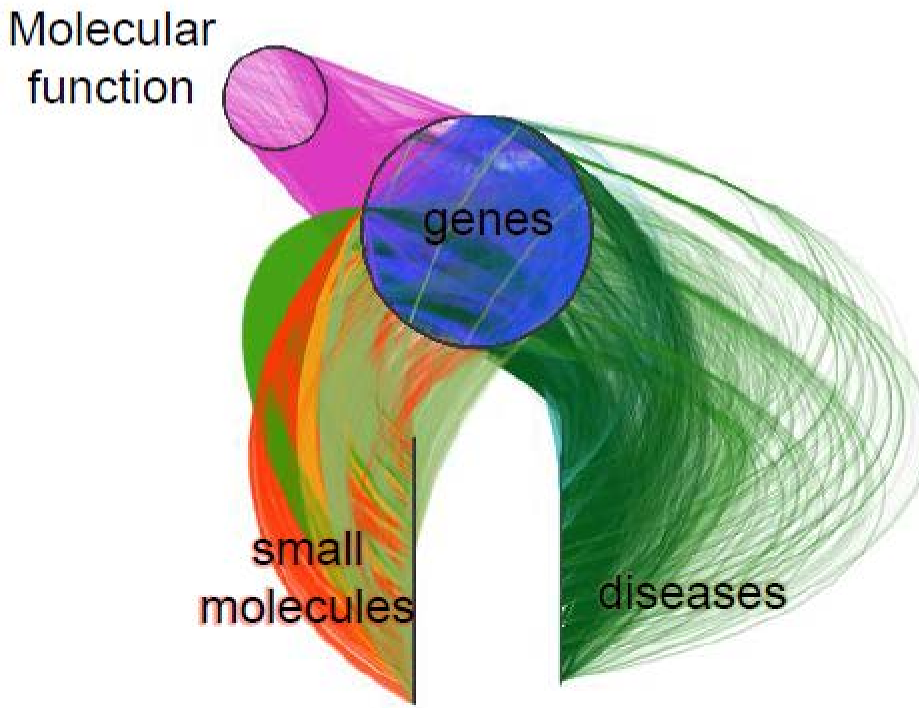
Sergio Baranzini, UCSF


1,538 approved
small molecule compounds
136 complex diseases

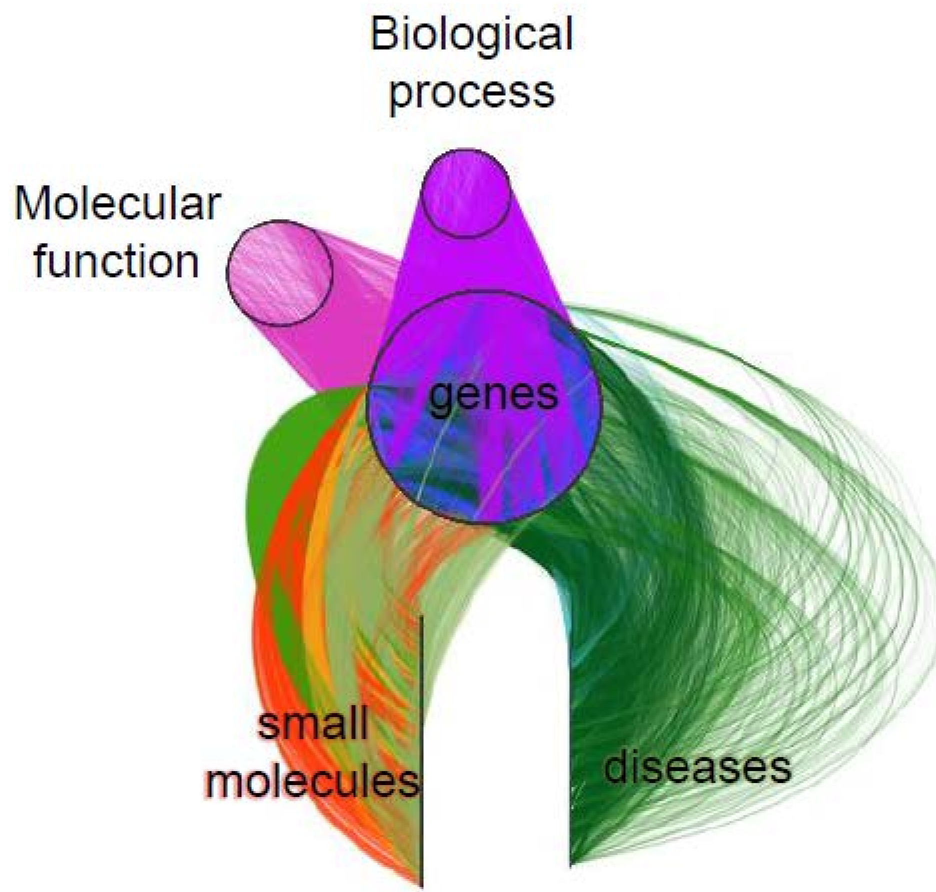

small
molecules
diseases

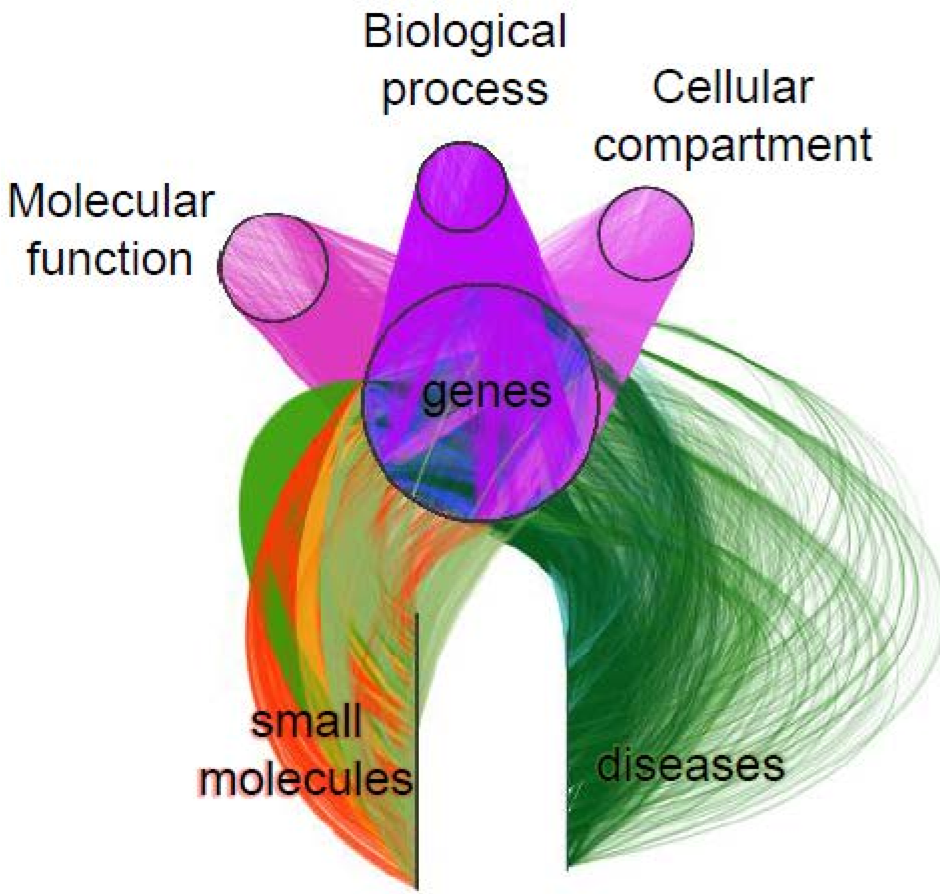

genes
small
molecules
diseases

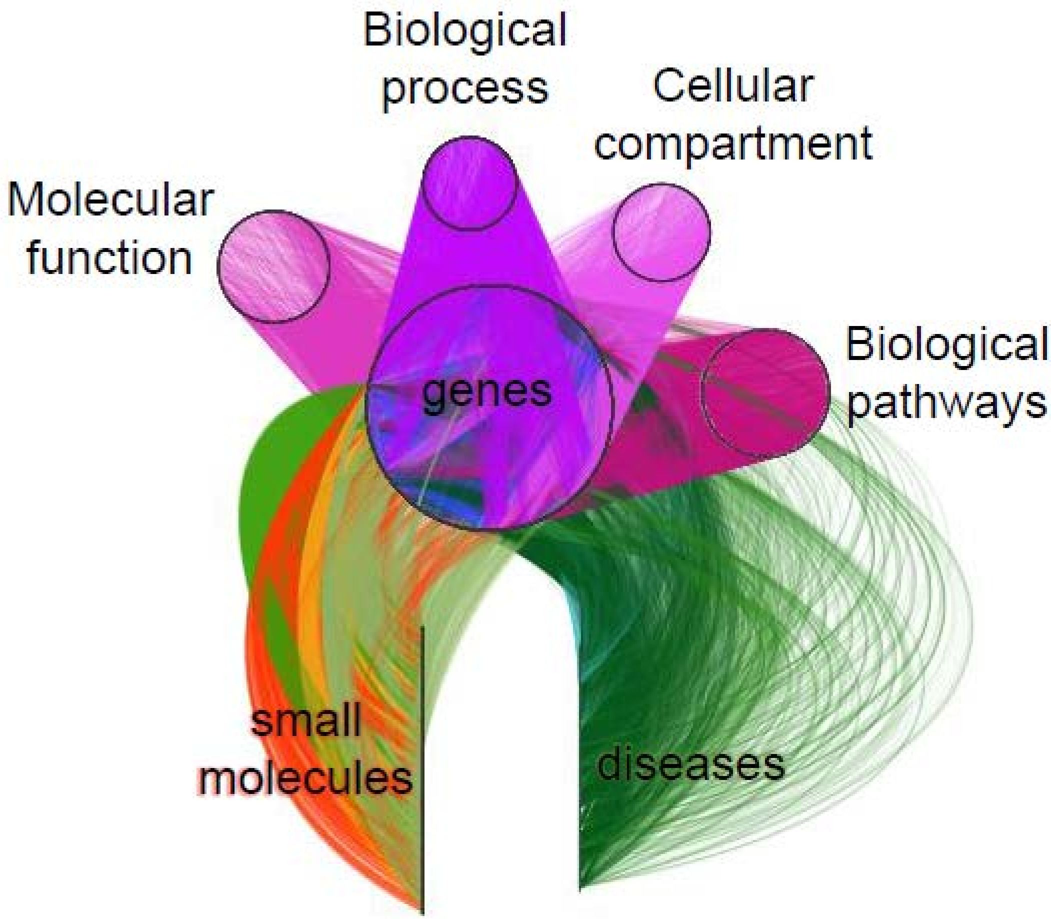

Gene Ontologies
biological process
development
pattern specification
axis specification
adaxial/abaxial pattern formation
adaxial/abaxial axis specification
molecular function
is_a
binding
nucleic acid binding
DNA binding
transcription regulator activity
transcription factor activity
cellular component
organelle
cell
intracellular
part_of
membrane-bound organelle
intracellular organelle
intracellular membrane-bound organelle
nucleus

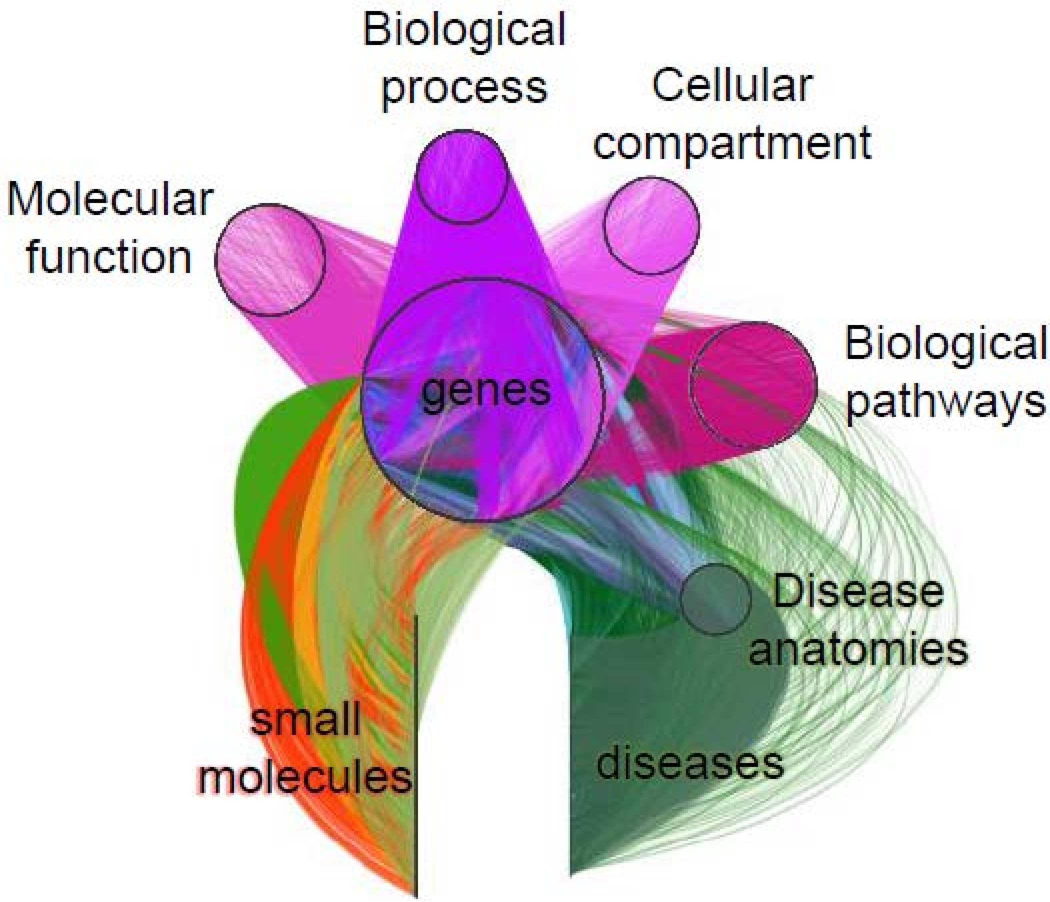


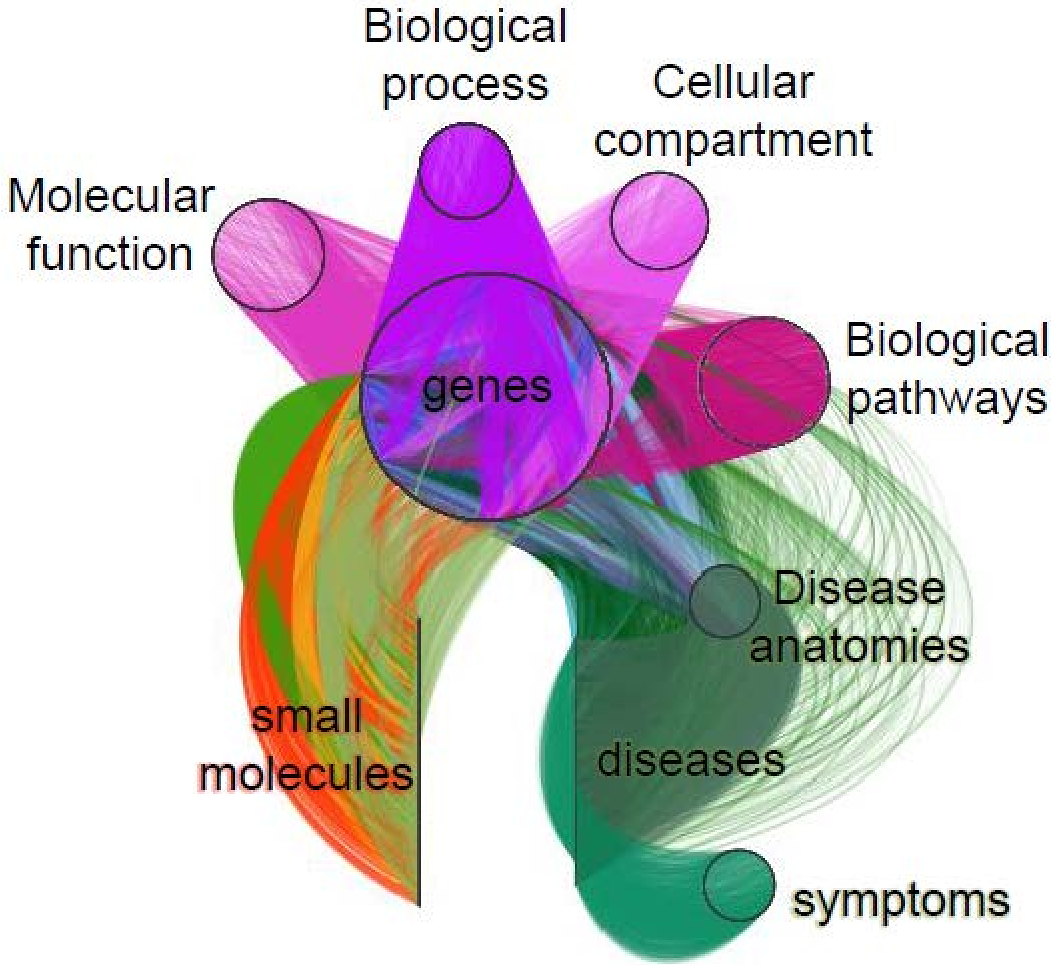
Molecular function
genes
small molecules
diseases

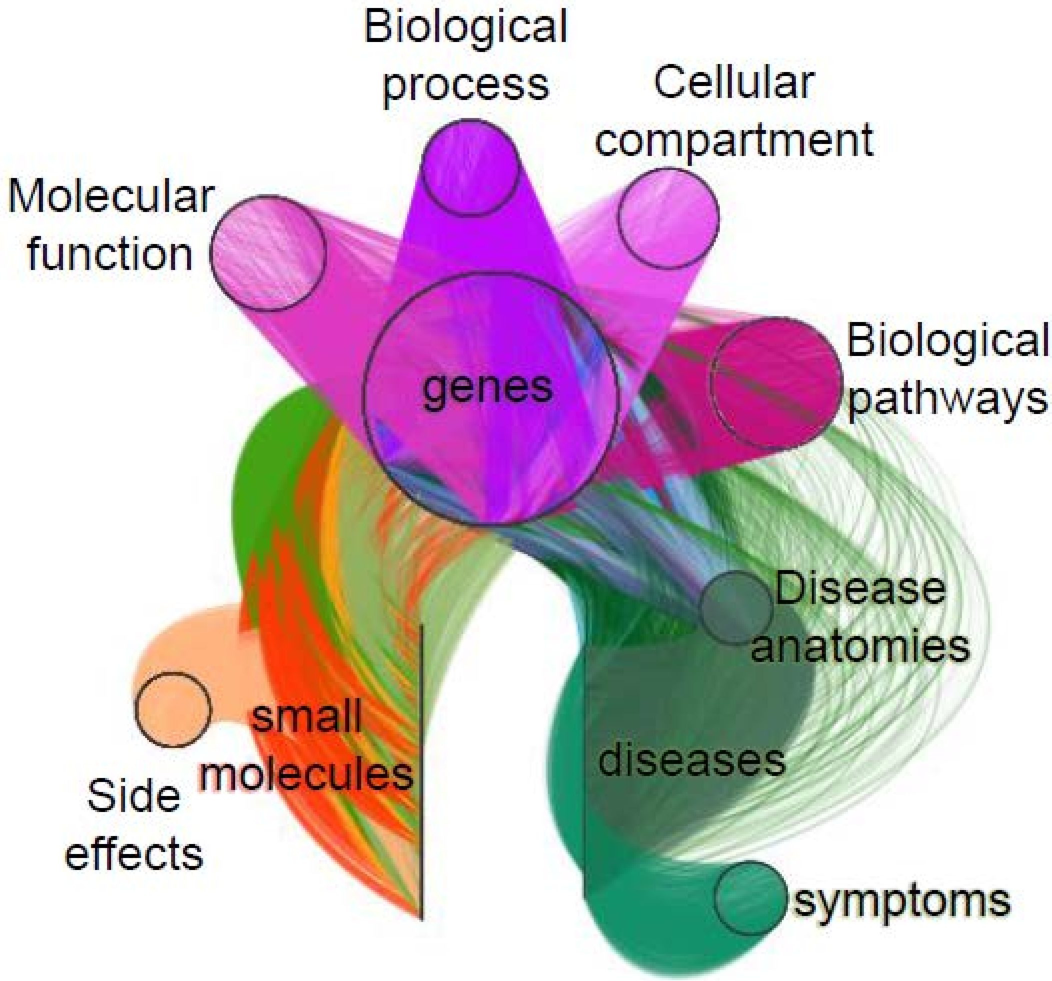

Biological process
Molecular function
genes
small molecules
diseases


Biological
process
Cellular
compartment
Molecular
function
genes
small
molecules
diseases

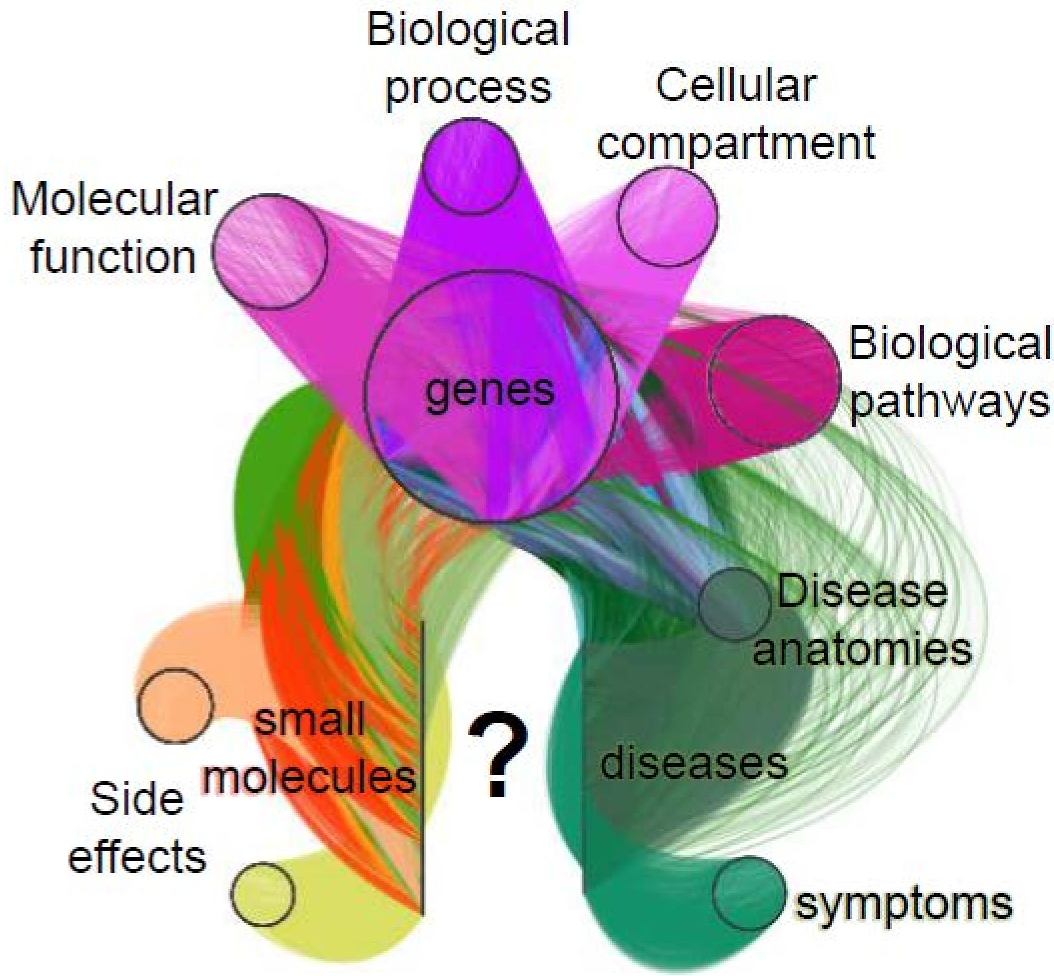

Biological
process
Cellular
compartment
Molecular
function
genes
Biological
pathways
small
molecules
diseases


Biological process
Cellular compartment
Molecular function
genes
Biological pathways
Disease anatomies
small molecules
diseases


Biological
process
Cellular
compartment
Molecular
function
genes
Biological
pathways
Disease
anatomies
small
molecules
diseases
symptoms



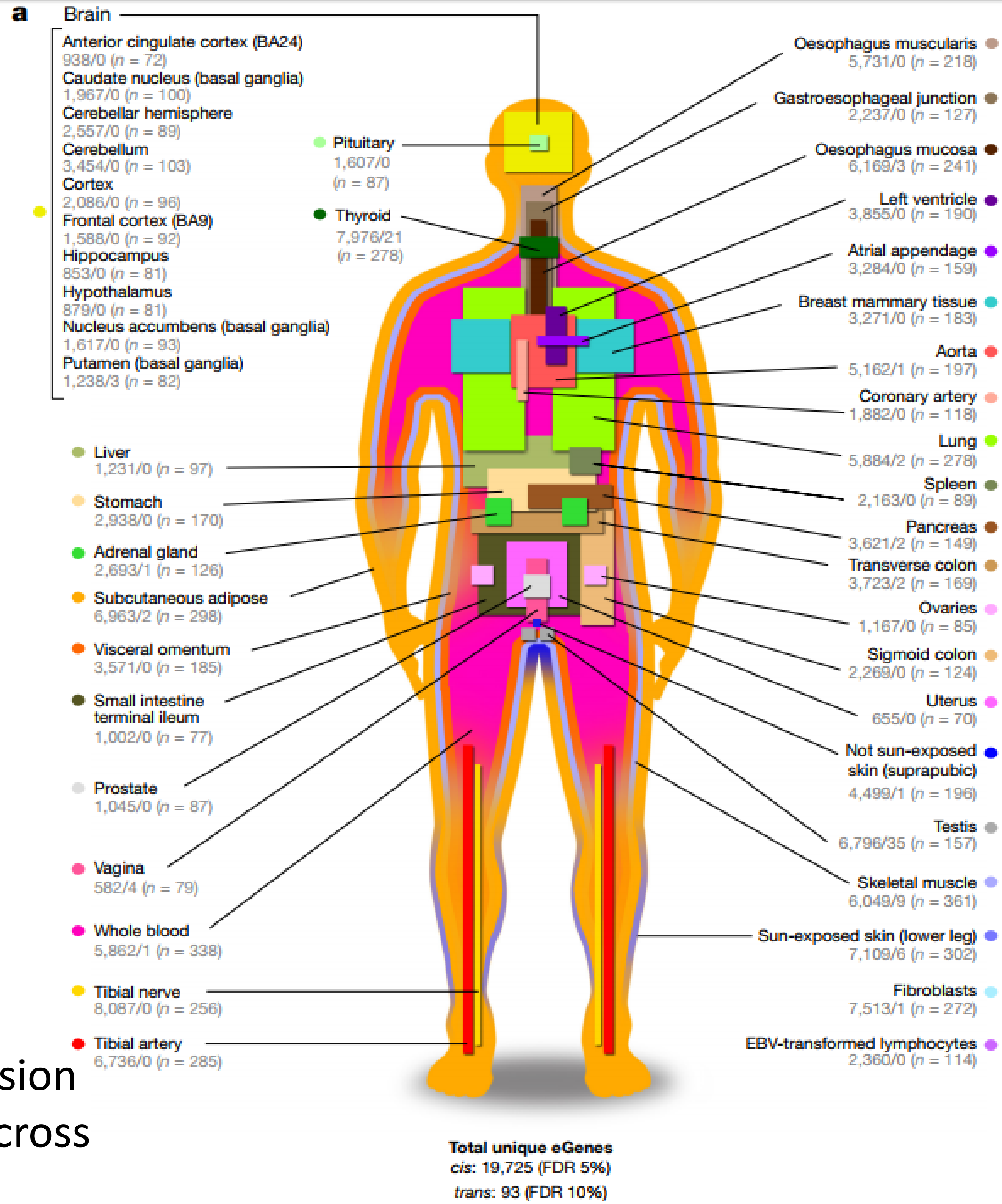
Biological process
Cellular compartment
Molecular function
genes
Biological pathways
Disease anatomies
small molecules
diseases
Side effects
symptoms



47,031 nodes (11 types)
2,250,197 relationships (24 types)

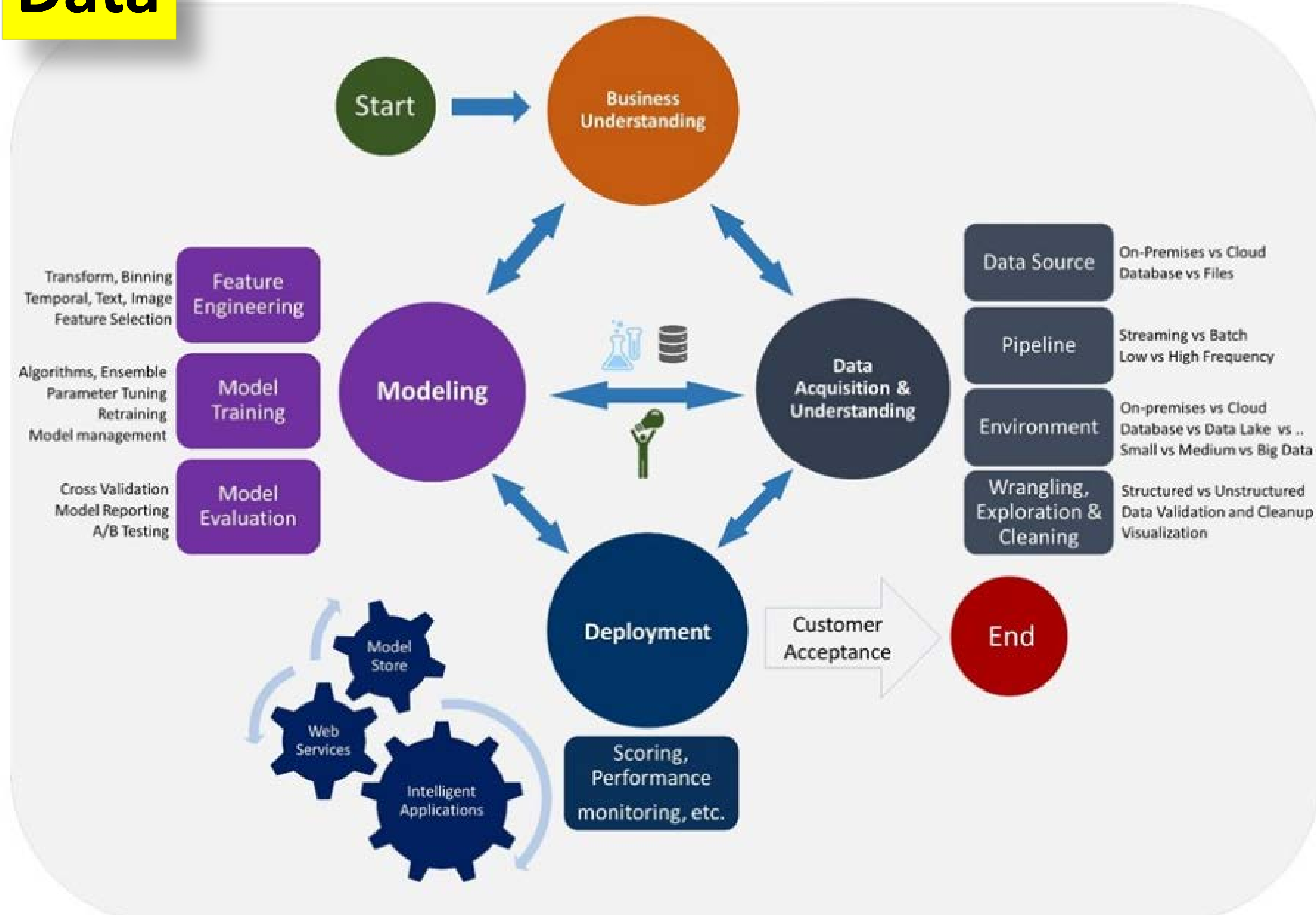
Sergio Baranzini, UCSF

Now, add this variability …



Genetic Effects on Gene Expression (http://rdcu.be/wFKx) levels across 44 human tissues.

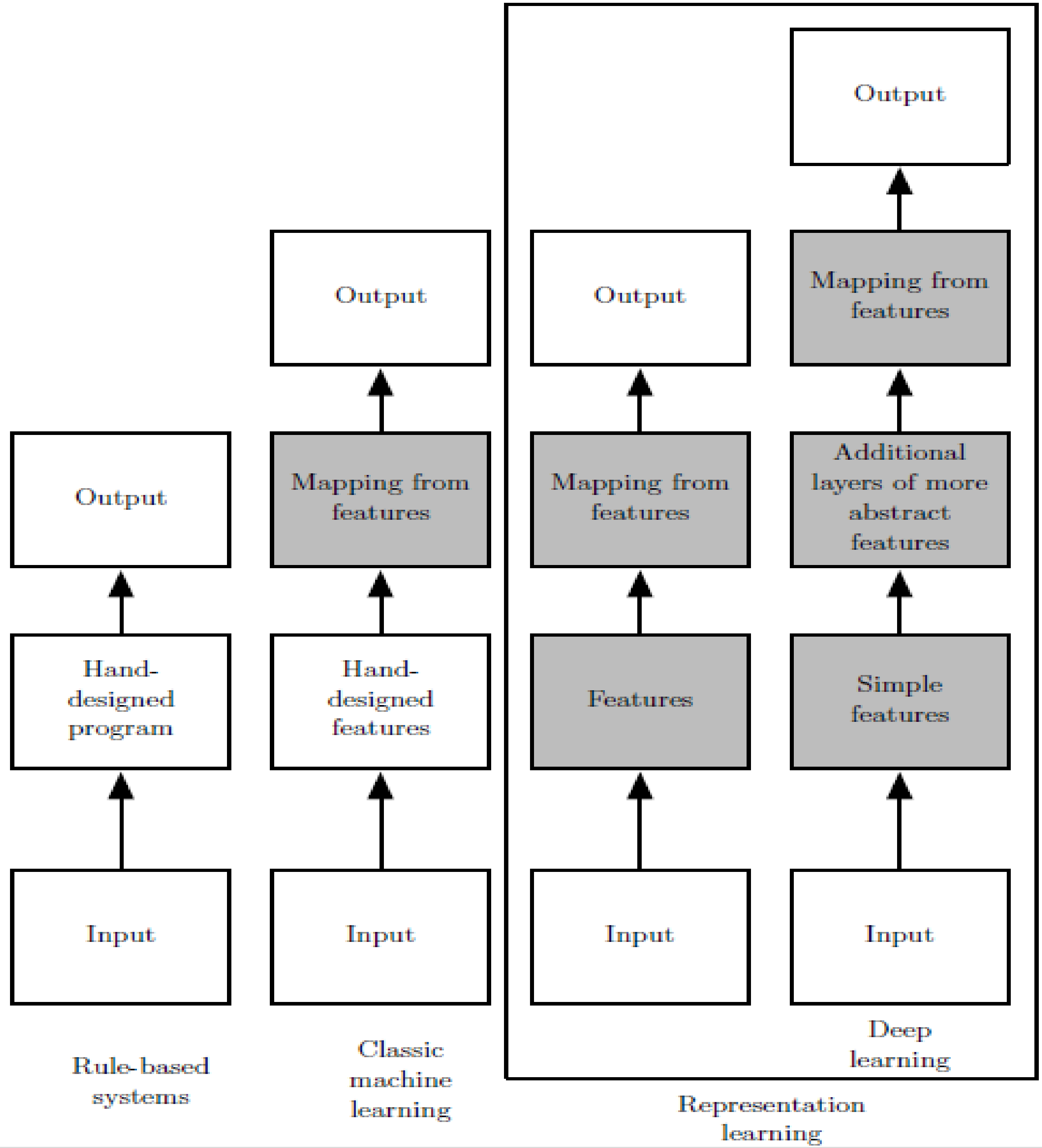
Data



Start
Business Understanding
Data Source
On-Premises vs Cloud
Database vs Files
Pipeline
Streaming vs Batch
Low vs High Frequency
Environment
On-premises vs Cloud
Database vs Data Lake vs ..
Small vs Medium vs Big Data
Wrangling, Exploration & Cleaning
Structured vs Unstructured
Data Validation and Cleanup
Visualization
Data Acquisition & Understanding
Modeling
Feature Engineering
Transform, Binning
Temporal, Text, Image
Feature Selection
Model Training
Algorithms, Ensemble
Parameter Tuning
Retraining
Model management
Model Evaluation
Cross Validation
Model Reporting
A/B Testing
Deployment
Scoring, Performance monitoring, etc.
Model Store
Web Services
Intelligent Applications
Customer Acceptance
End

Feature engineering is **key** to AI. Insufficient, noisy, unstructured data, with respect to features, renders these tools impotent. (Ian Goodfellow in *Deep Learning*. MIT Press. 2016

http://www.deeplearningbook.org

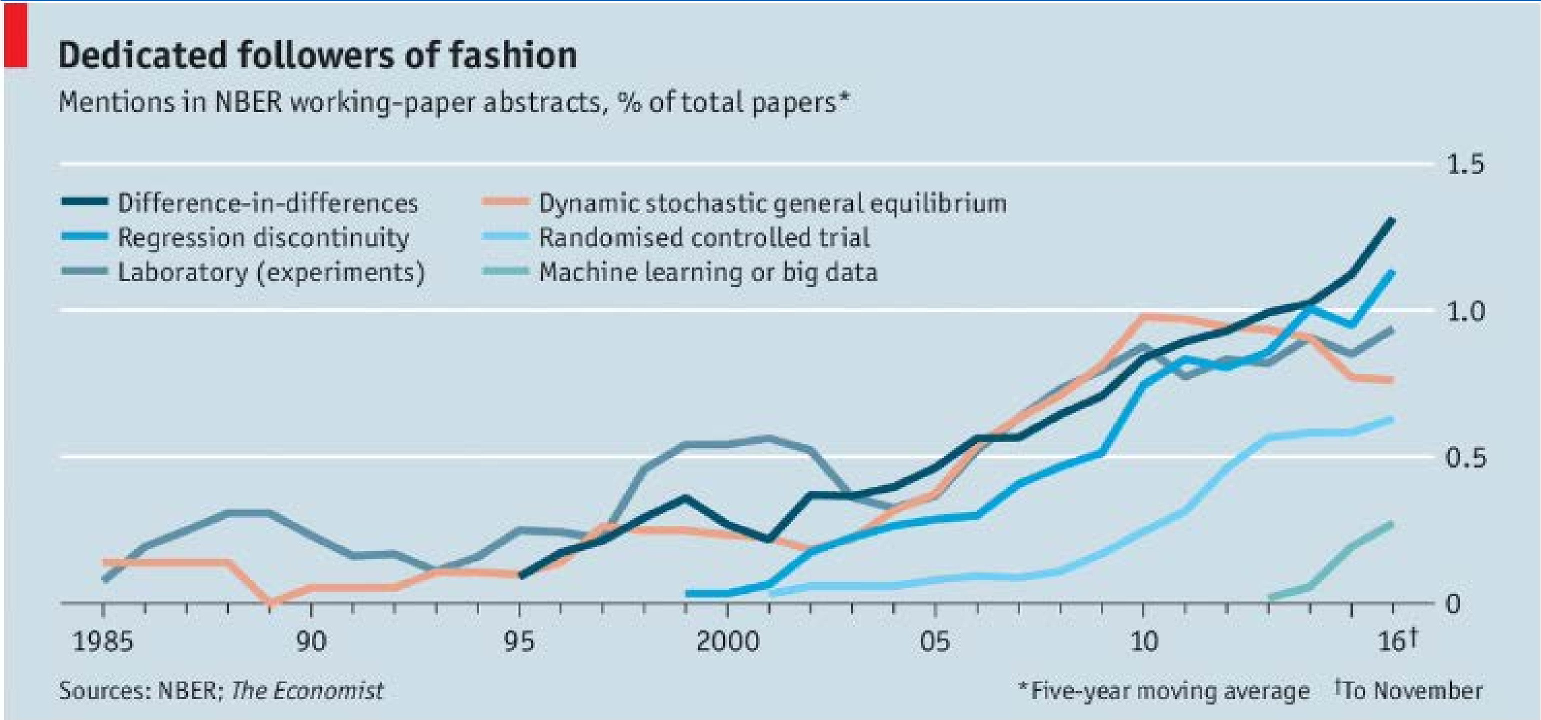


Economists are prone to fads – ML and Big Data are the latest

Big data have led to the latest craze in economic research

Nov 26th 2016

www.economist.com/news/finance-and-economics/21710800-big-data-have-led-latest-craze-economic-research-economists-are-prone



Economist.com

While most economics models assumed people were basically rational, Kahneman and Tversky demonstrated that human decision-making is biased in systematic, predictable ways. Many of the biases they described have now become famous — loss aversion, endowment effect, hindsight bias, the anchoring effect, and were described in Kahneman's brilliant book, "Thinking, Fast and Slow." www.nytimes.com/2016/11/25/opinion/does-decision-making-matter.html

It is the same company, which supported the claim by an employee, Dharmendra Modha, to have captured the “brain in a box” by 2020.

One company claims that their “Watson” AI tool can cure cancer

https://medium.com/mit-technology-review/the-seven-deadly-sins-of-ai-predictions-9d14e1f21fc5

A STAT INVESTIGATION

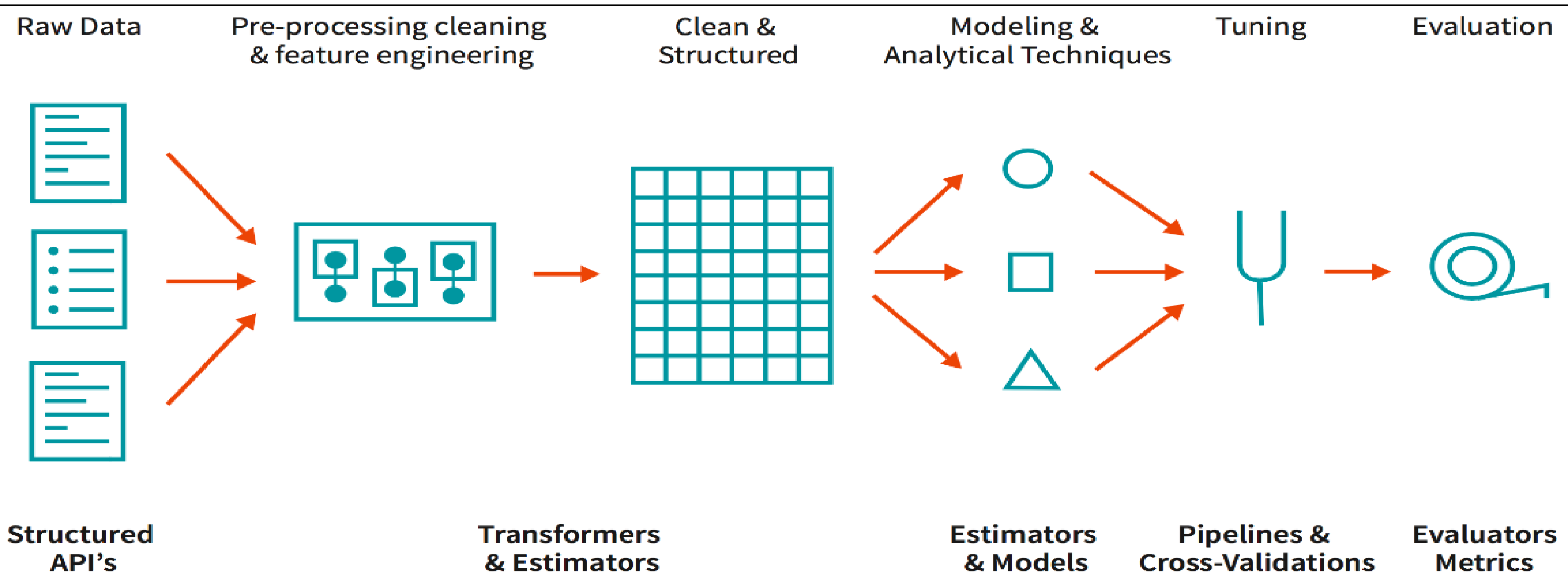
IBM pitched its Watson supercomputer as a revolution in cancer care. It’s nowhere close

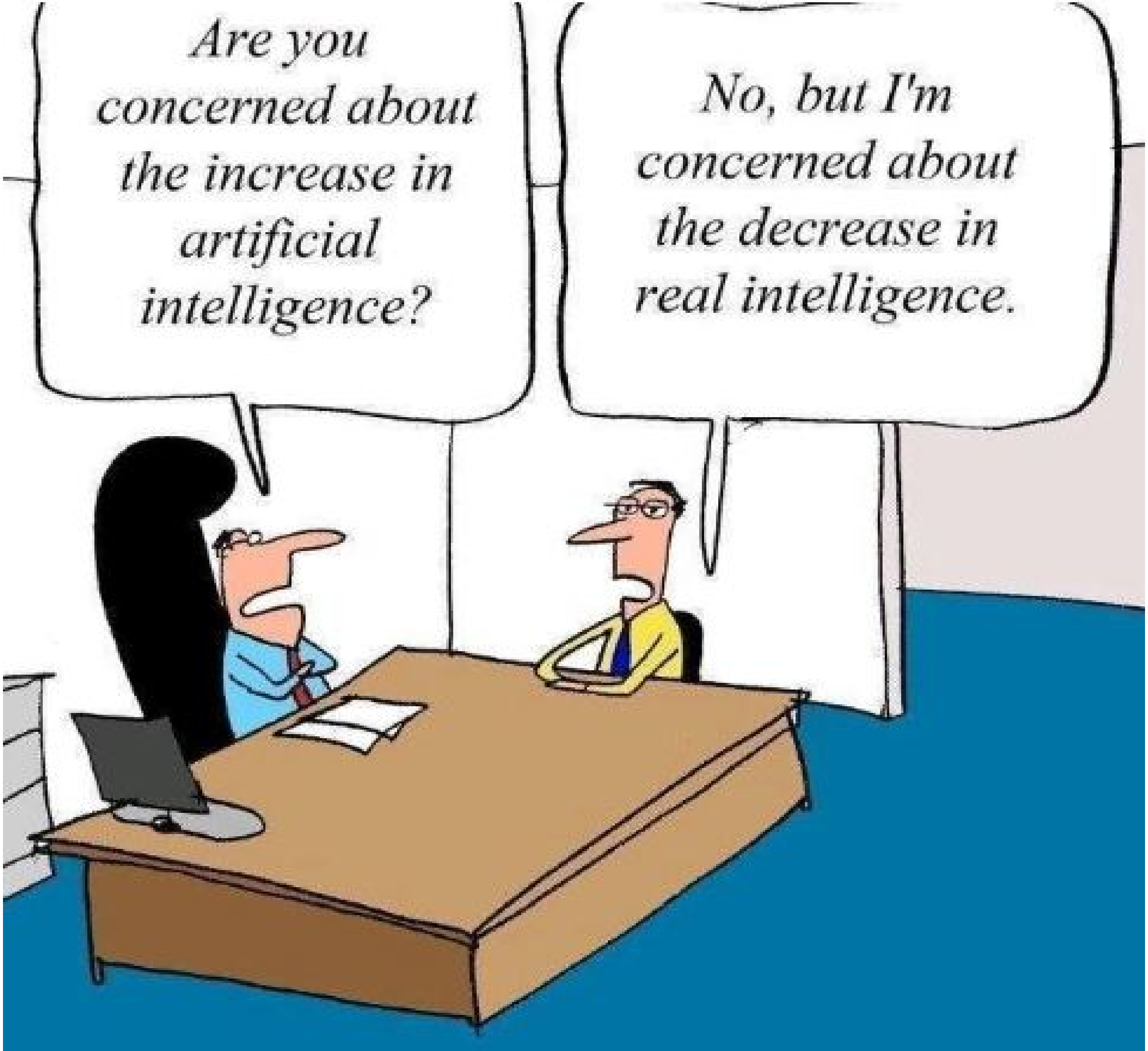
By CASEY ROSS @byCaseyRoss *and* IKE SWETLITZ @ikeswetlitz / SEPTEMBER 5, 2017

www.statnews.com/2017/09/05/watson-ibm-cancer/

But, AI tools, especially ML, can help in simple systems, eg, machine maintenance

AI can help in radiology (image detection) and systems where human decisions (uncertainty) are limited or absent. When humans enter the loop (driving, financial markets), "rules" get fuzzy and analytics may be less reliable.




Are you concerned about the increase in artificial intelligence?
No, but I'm concerned about the decrease in real intelligence.

Are our leaders global visionaries?

Science must serve society

Food, Energy, Water, Sanitation, Health, Education

You need to be a global visionary.

Causality

significant correlation?


bodybymilk.com
Smash hit by Hayden. Body by milk.
You don't have to be a hero to feel invincible. That's why i drink milk. The protein helps build muscle and some studies suggest teens who choose it tend to be leaner. Cheers to that.
got milk?

https://www.washingtonpost.com/news/wonk/wp/2014/06/20/the-mysterious-case-of-americas-plummeting-milk-consumption/

Sections

The Washington Post

20 June 2014

The mysterious case of America's plummeting milk consumption

Americans, on average, drink 37 percent less milk today than they did in 1970, according to data from the USDA. Forty years ago, per capita consumption was nearly one and a half cups per day; now it's nearer to 0.8. While the fallout spans every type of cow's milk—whole, low fat, and skim—it's been most unkind to the full fat variety. Whole milk per capita consumption has tumbled by 78 percent since 1970 (from more than 1.1 cups per day to fewer than .24).

http://bit.ly/GOT-MILK

Whole milk consumption plummets since 1970

Whole and skim milk consumption, cups per day

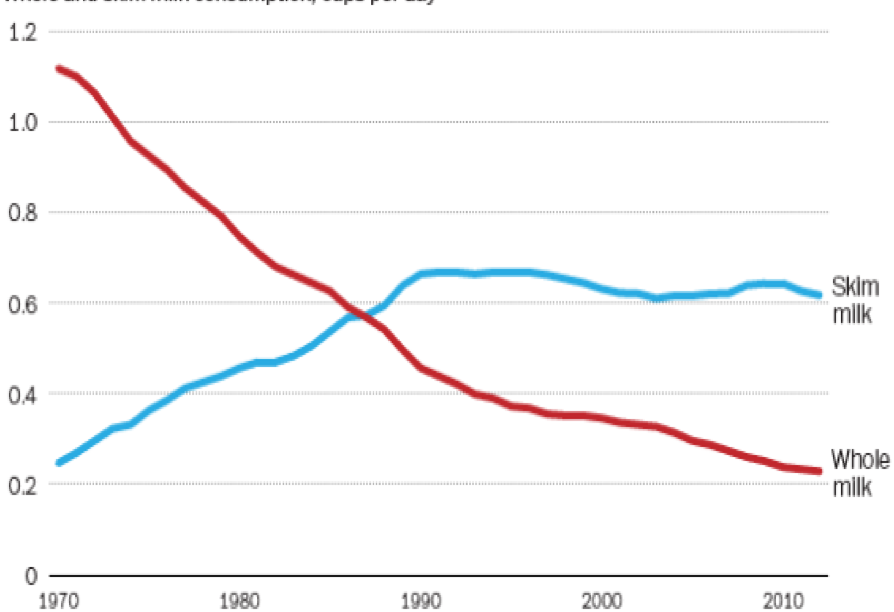
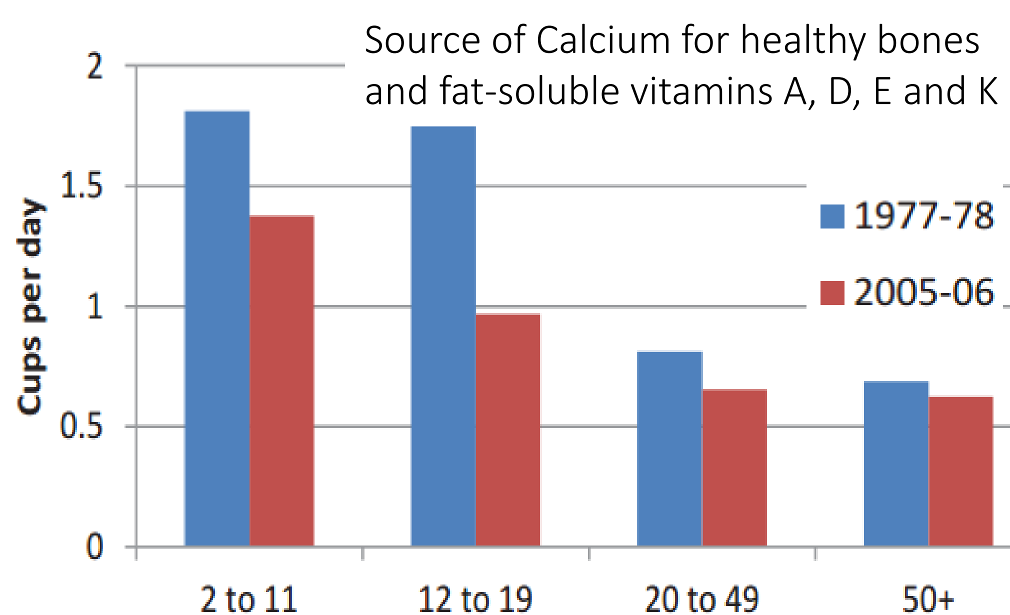
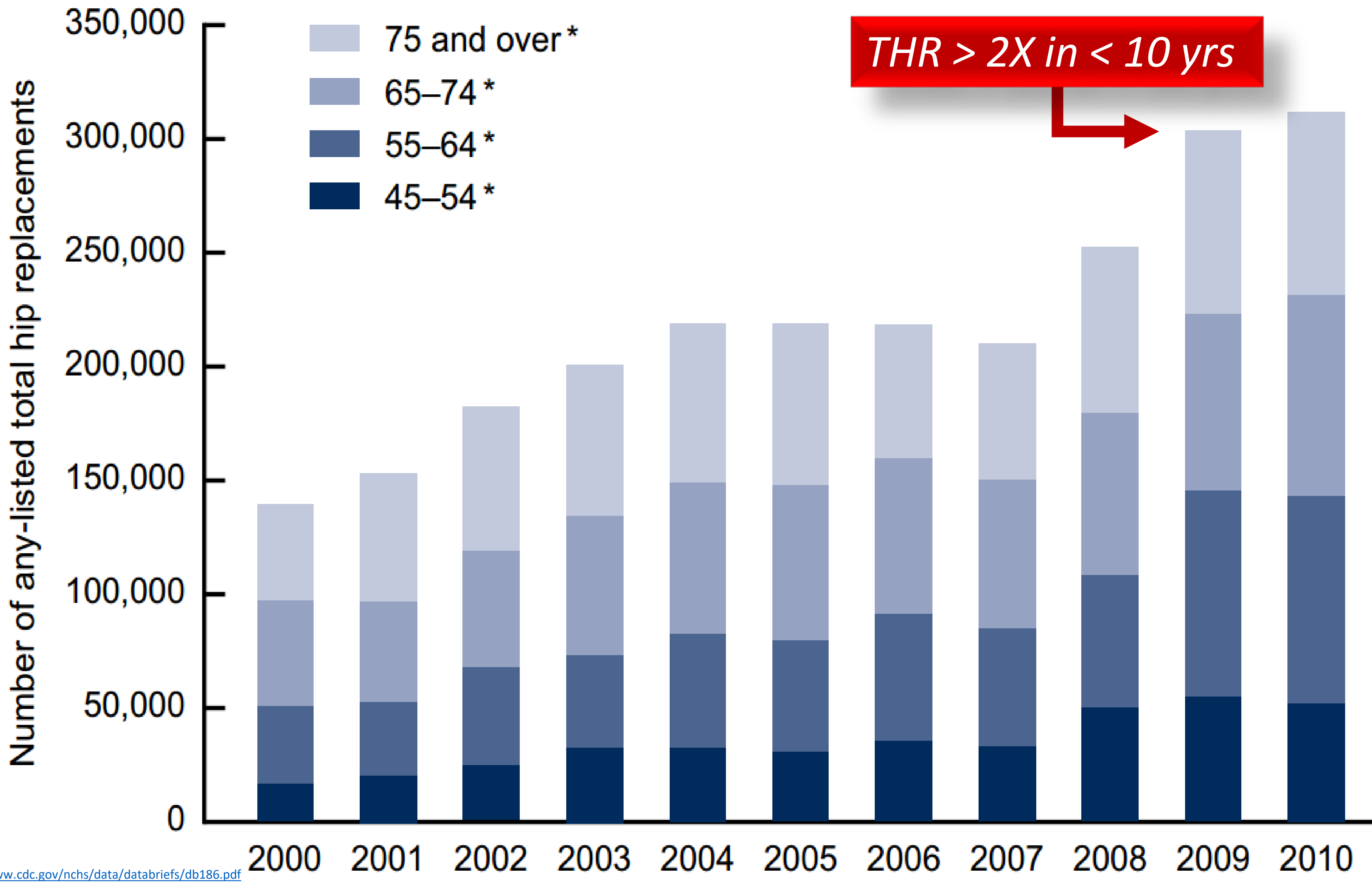


Figure 2: Mean Intake of Fluid Milk



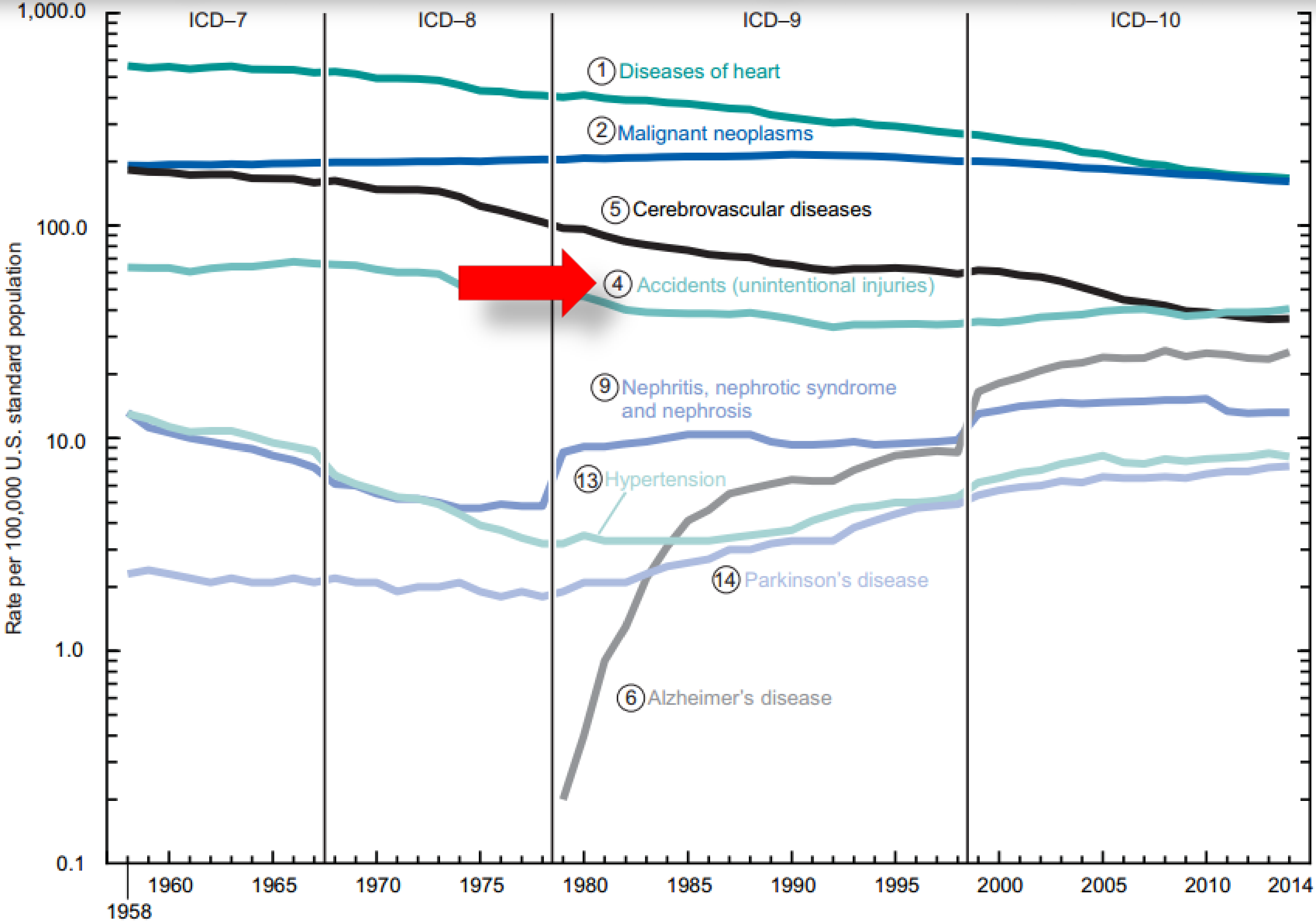
326,100 total hip replacements (US, 2010) 95% cases age 45+

www.cdc.gov/nchs/data/databriefs/db186.pdf



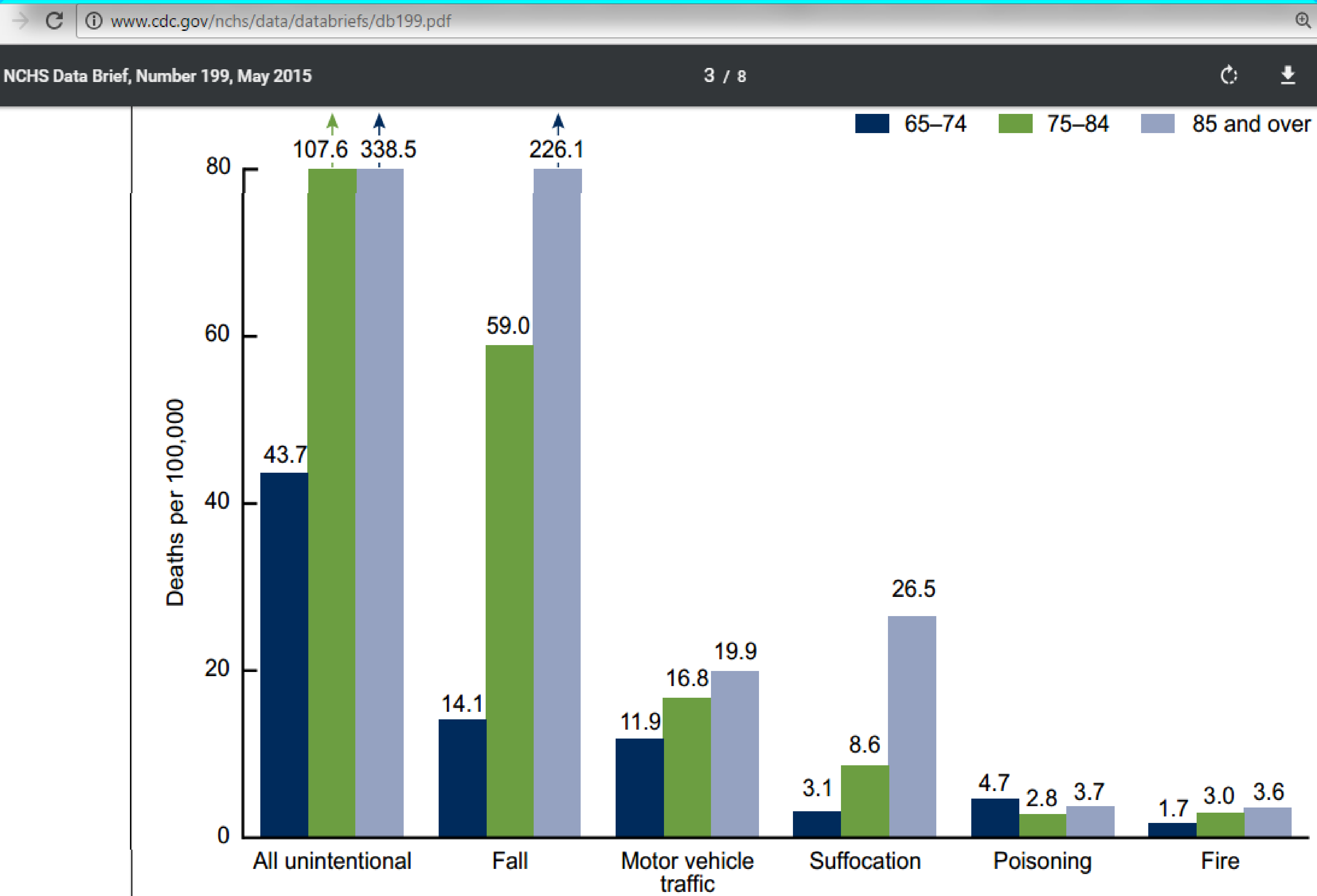
www.cdc.gov/nchs/data/databriefs/db186.pdf

Age-adjusted rates for leading causes of death in US



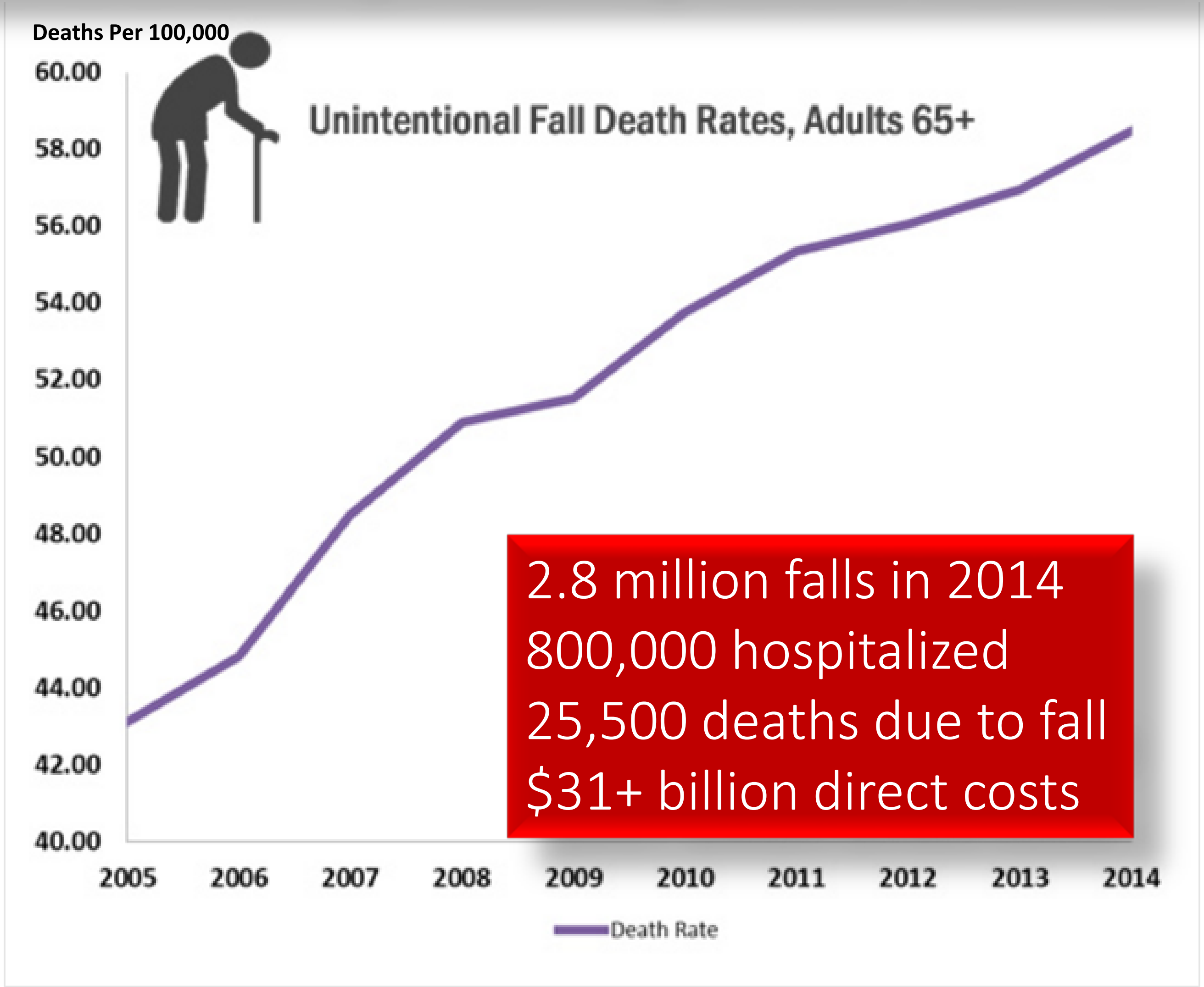
NOTES: ICD is the *International Classification of Diseases*. Circled numbers indicate ranking of conditions as leading causes of death in 2014.
SOURCE: NCHS, National Vital Statistics System, Mortality. http://www.cdc.gov/nchs/data/nvsr/nvsr65/nvsr65_04.pdf

Cause of death for US adults aged 65+ (2012–2013)



Hip fractures and brain injuries may follow from fall

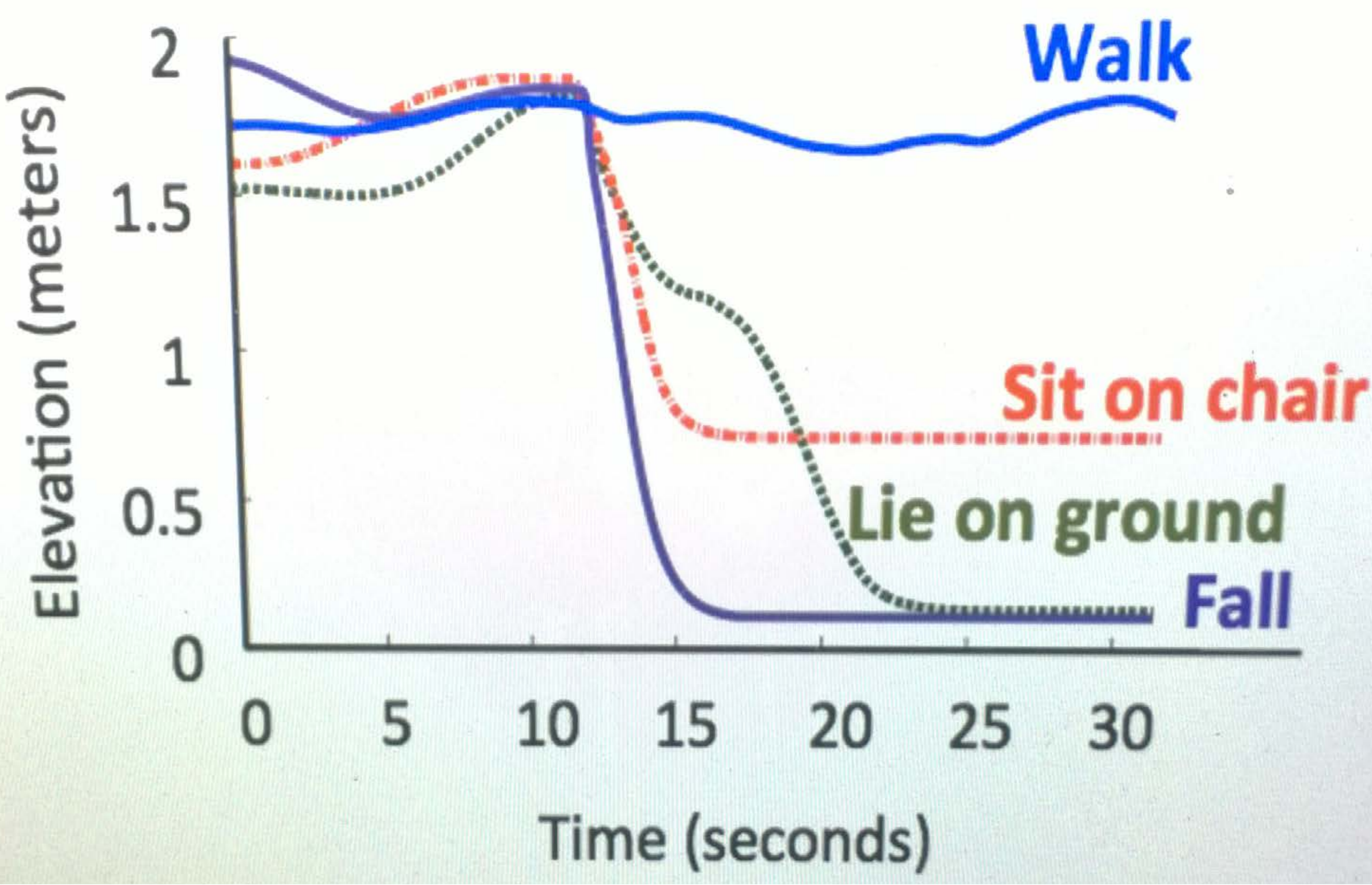
- One out of five falls causes a serious injury such as broken bones or a head injury.[3,4]
- Each year, 2.8 million older people are treated in emergency departments for fall injuries.[5]
- Over 800,000 patients a year are hospitalized because of a fall injury, most often because of a head injury or hip fracture.[5]
- Each year at least 300,000 older people are hospitalized for hip fractures.[6]
- More than 95% of hip fractures are caused by falling,[7] usually by falling sideways.[8]
- Falls are the most common cause of traumatic brain injuries (TBI).[9]



- Adjusted for inflation, the direct medical costs for fall injuries are $31 billion annually.[10] Hospital costs account for two-thirds of the total.

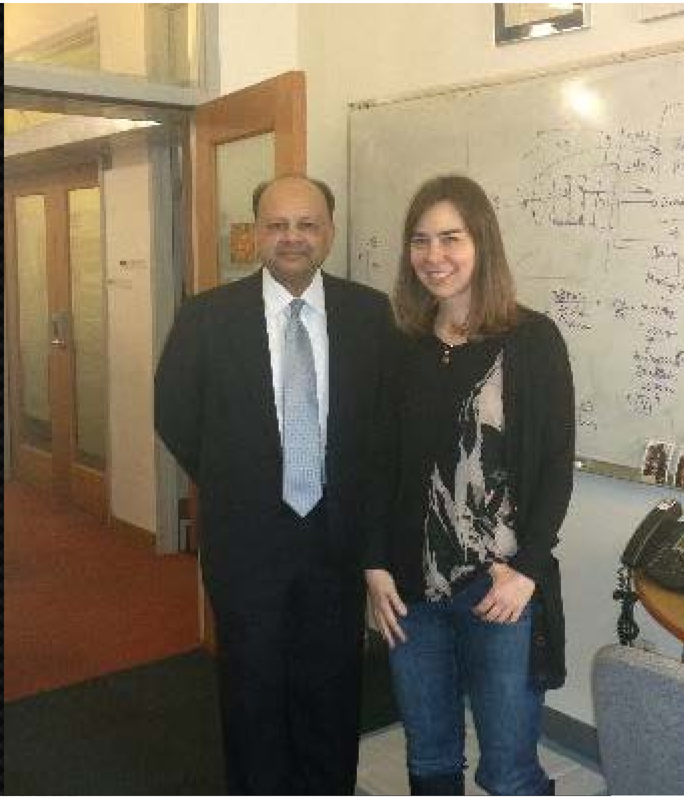
http://www.cdc.gov/homeandrecreationalsafety/falls/adultfalls.html

Fall Detection – Wire less, Sensor less, Without Wearables



Ambient RF Reflection Data – Professor Dina Katabi, Wireless Center, CSAIL, MIT

Professor Dina Katabi (MIT) presenting RF Reflection to President Obama (White House Demo, 4 August 2015)



President Obama invites MIT entrepreneurs to give demo at the White House http://bit.ly/President-Obama-with-Dina-Katabi

http://newsoffice.mit.edu/2015/president-obama-meets-mit-entrepreneurs-white-house-demo-day-0806

After the fall …

More than 30 million+ people may need implants

TKA and THA Replacement Potential	USA 325,000,000 population	EU-28 505,000,000 population	India 1.333 billion population	China 1.384 billion population
1% prevalence Knee and Hip combined	3,250,000	5,050,000	13,330,000	13,840,000
Total US folks TKA or THA	6.7 + 4.5 million 11,200,000			

- EU Ageing http://ec.europa.eu/eurostat
- Prevalence http://bit.ly/AAOS-2014

http://www.ors.org/Transactions/56/0214.pdf

Total Knee Replacement (TKR)

Age group	Female	Male
<50	0.1%	0.1%
50-59	1.8%	1.2%
60-69	5.5%	3.6%
70-79	10.1%	7.3%
80-89	11.0%	8.8%
90+	7.4%	7.4%

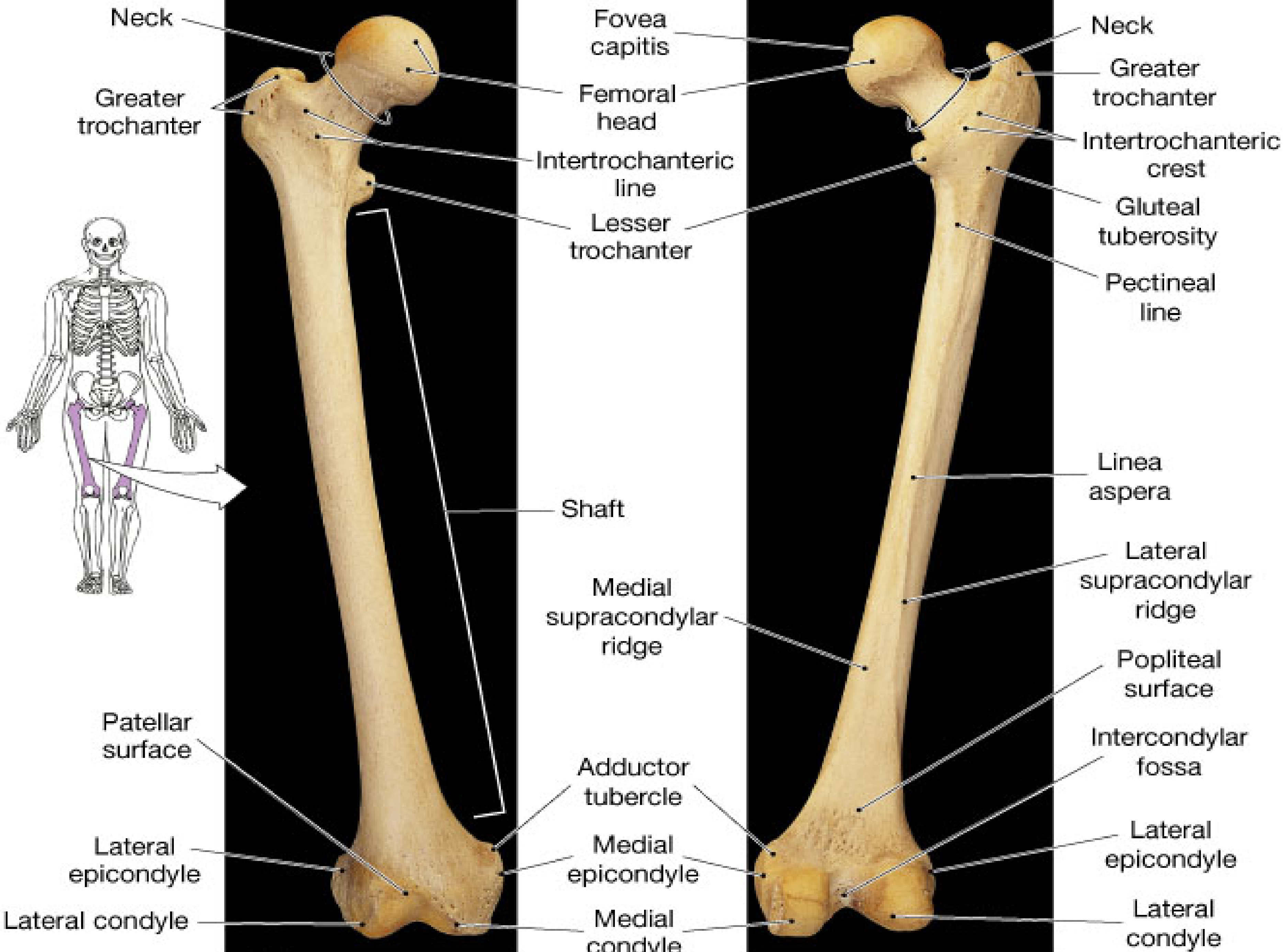
- 4.7 million (3.0 million women, 1.7 million men) individuals with total knee replacement in 2010

Total Hip Replacement (THR)

Age group	Female	Male
<50	0.1%	0.1%
50-59	0.8%	1.0%
60-69	2.1%	2.1%
70-79	4.4%	3.8%
80-89	6.3%	4.8%
90+	6.1%	4.8%

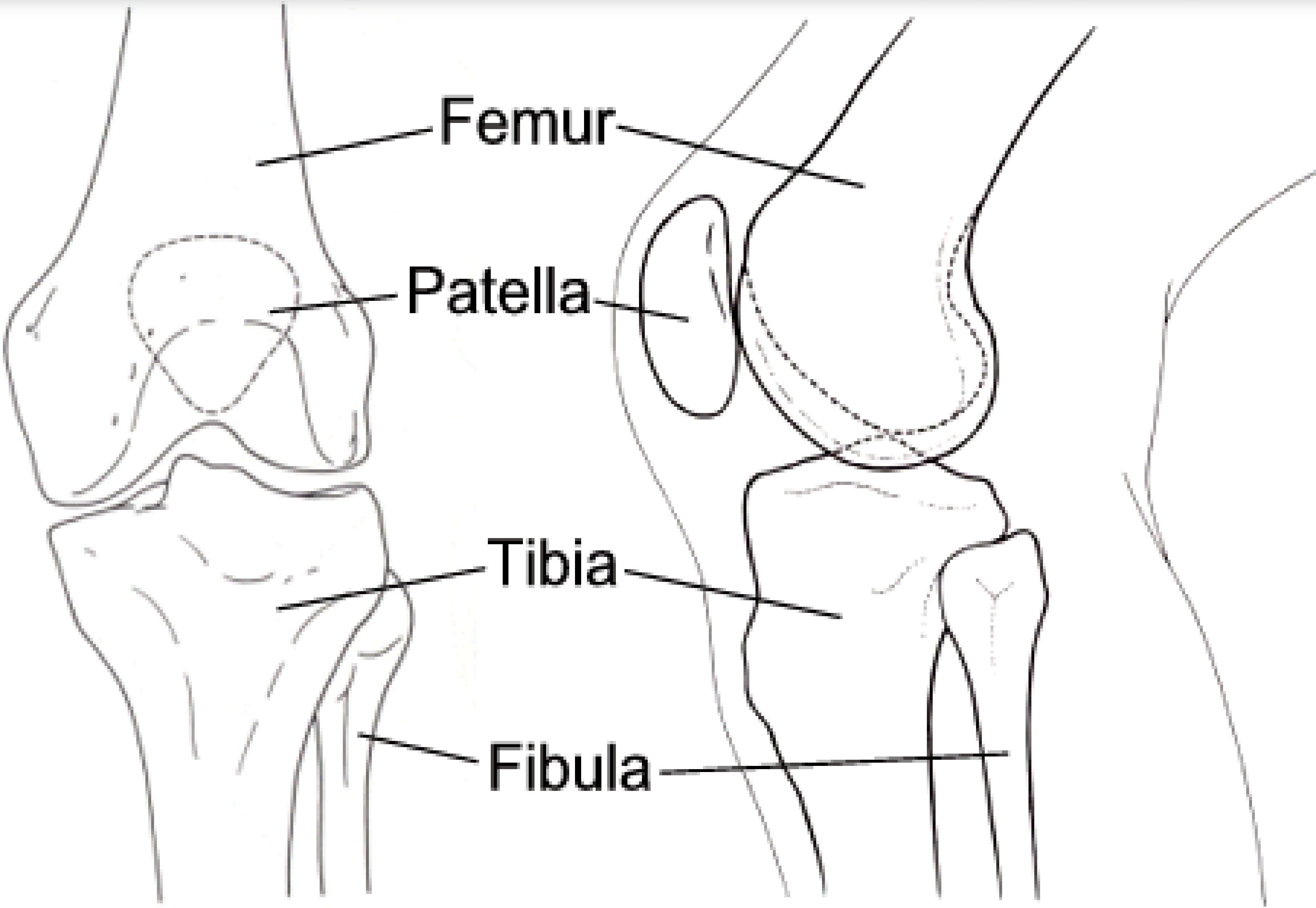
- 2.5 million (1.4 million women, 1.1 million men) individuals with total hip replacement in 2010

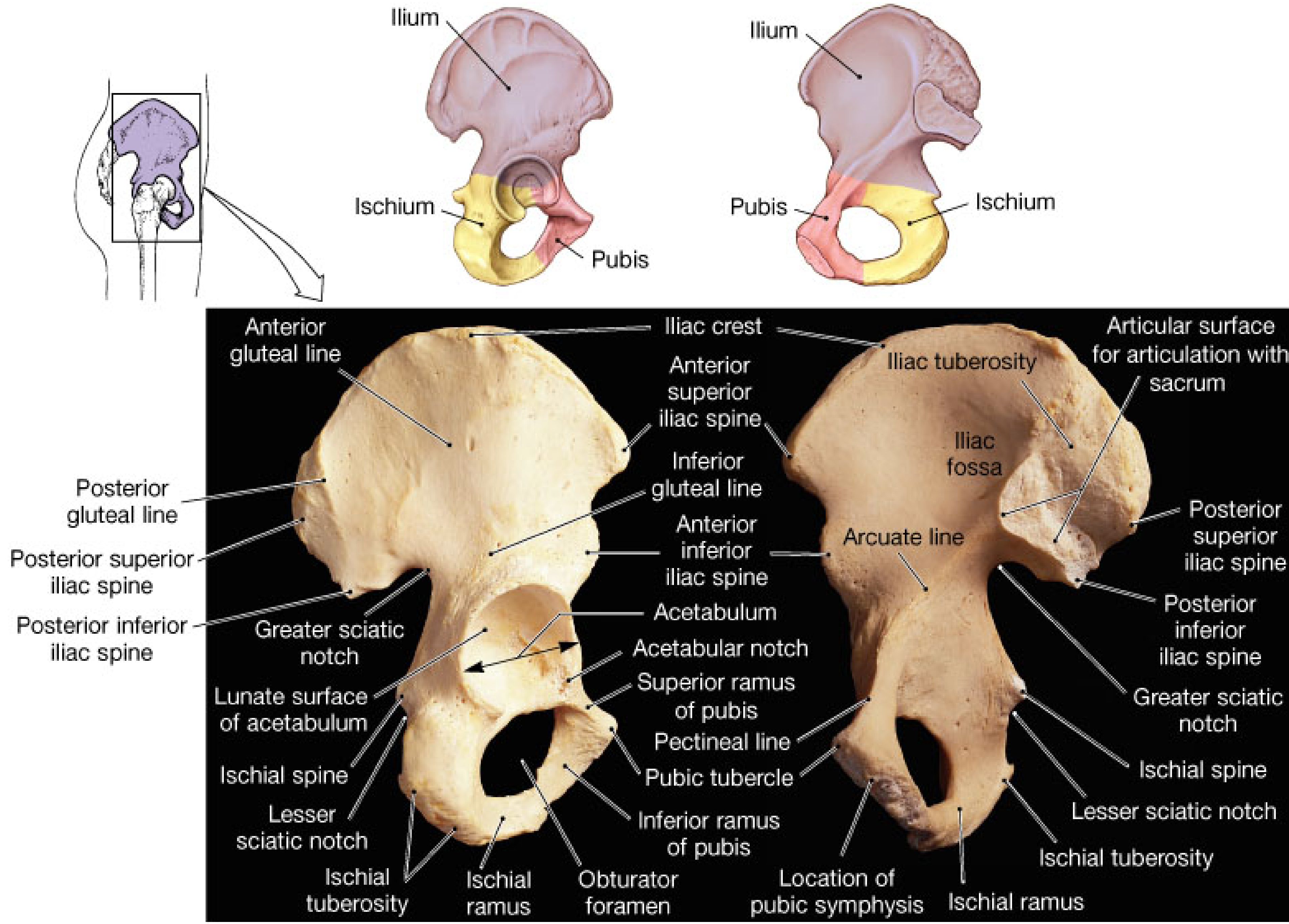
www.mayoclinic.org/medical-professionals/clinical-updates/orthopedic-surgery/study-hip-knee-arthroplasty-shows-7-2-million-americans-living-with-implants



(a) Anterior surface **(b) Posterior surface**

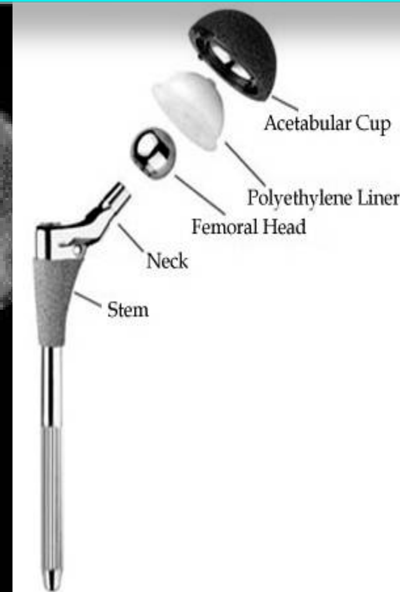
Anatomy of Knee Joint

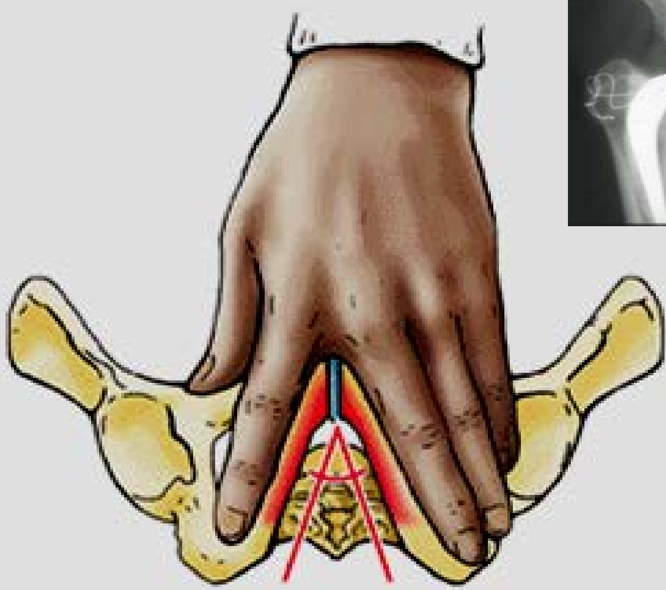


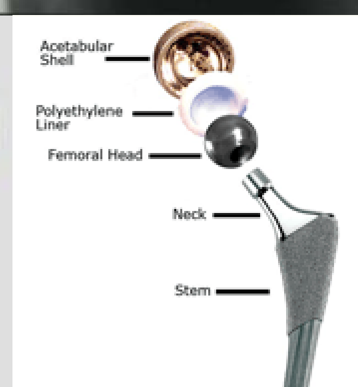


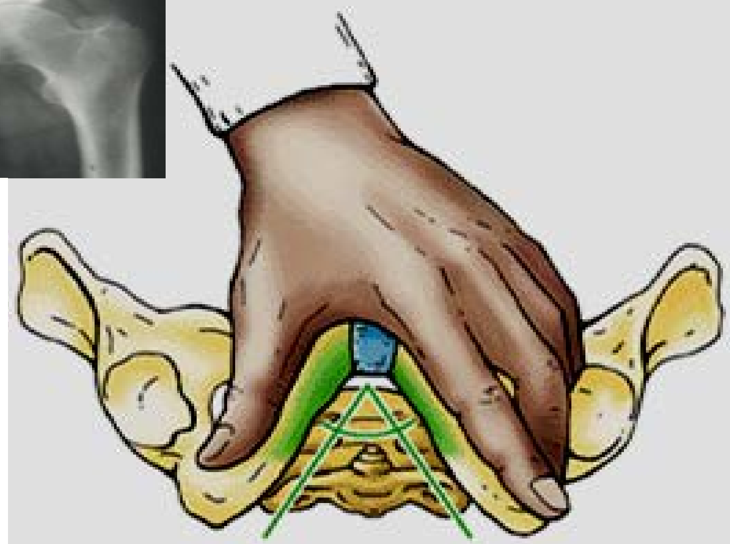
(a) Right os coxae, lateral **(b) Right os coxae, medial view**

Total Hip Arthoplastry - Are All Acetabular Caps Created Equal?

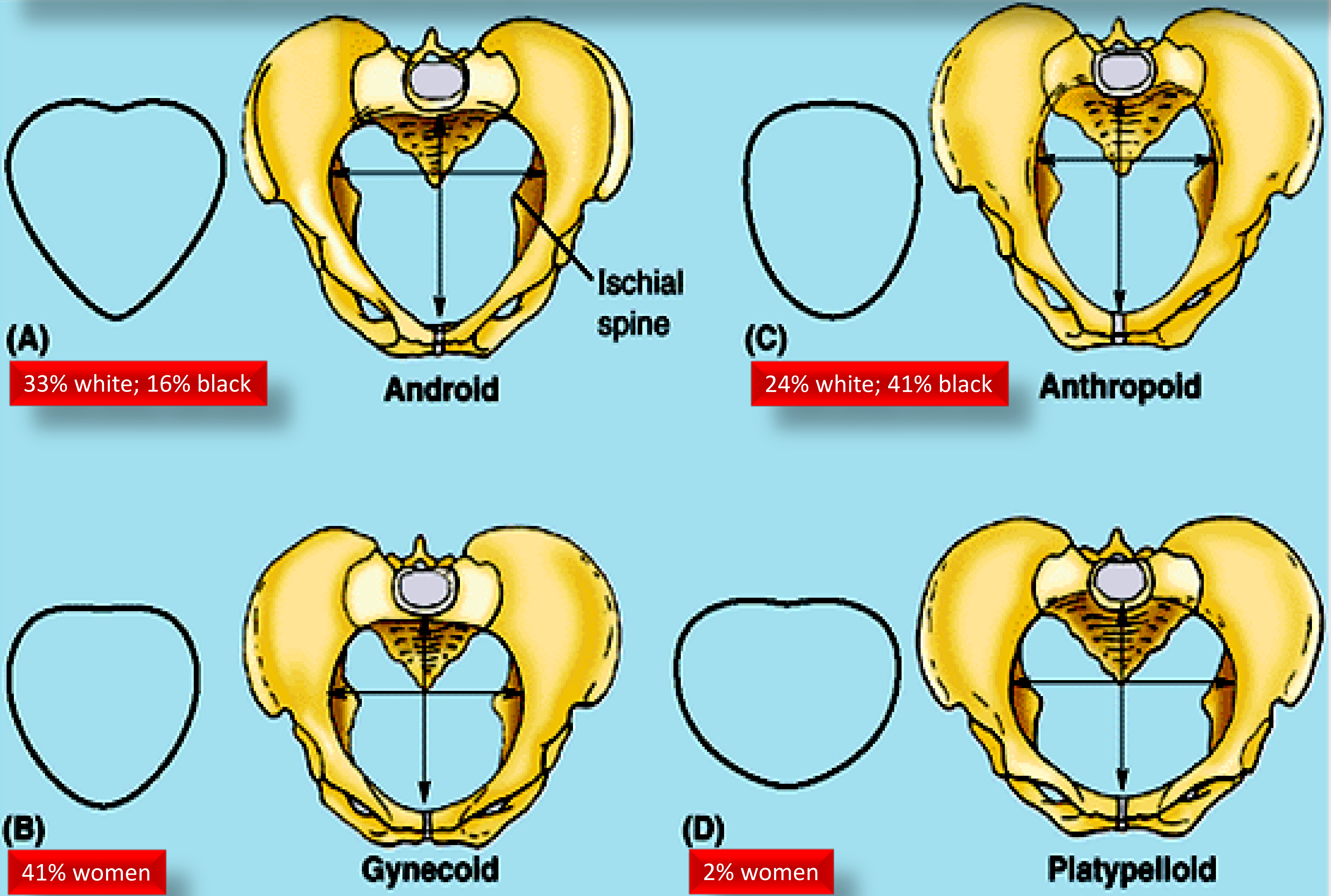








Total Hip Arthoplastry - Are All Female Hips Created Equal ?

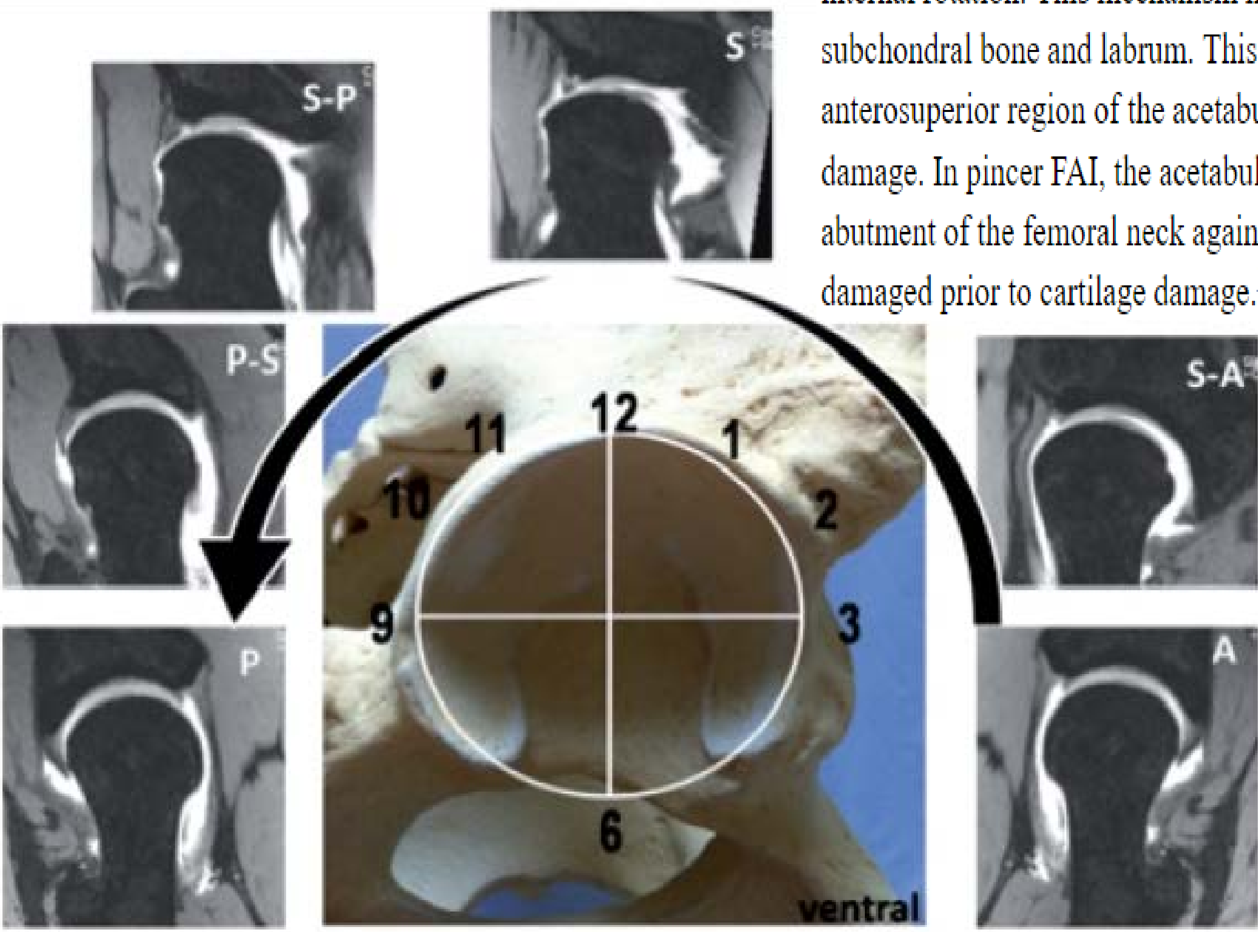


One shoe doesn't fit all

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3206516/

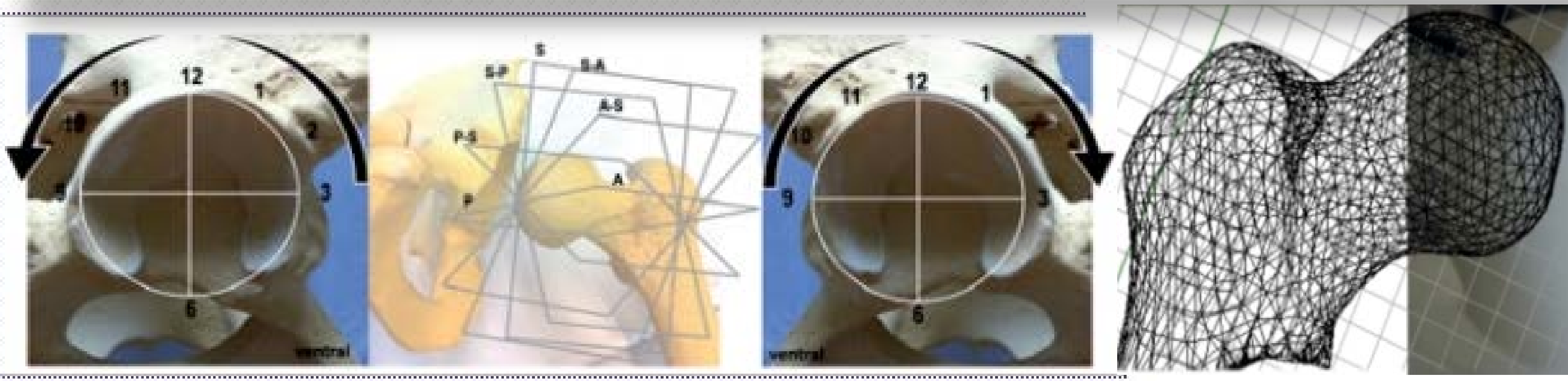
Femoroacetabular Impingement

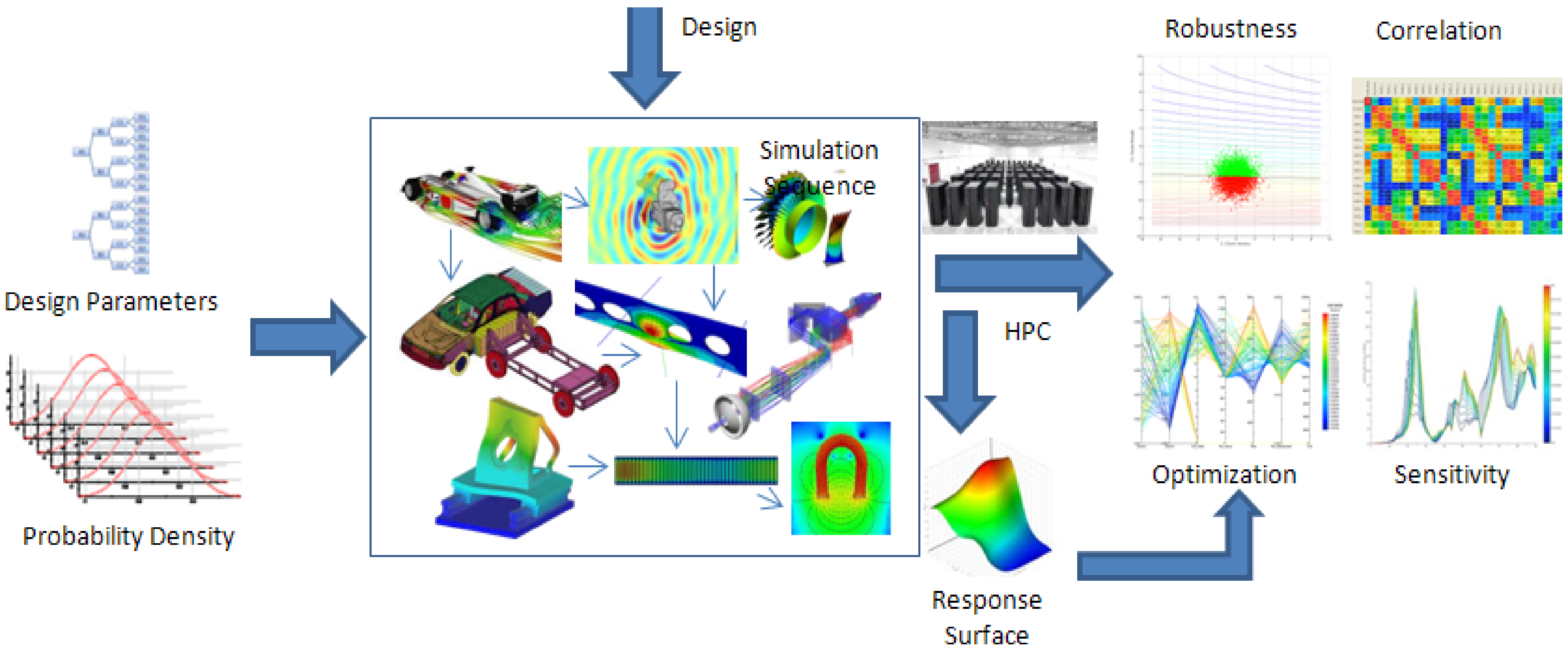
The concept of femoroacetabular impingement (FAI) as a major contributor to the development of premature hip OA has been recognized and accepted all over the world. Table 2 demonstrates the remarkable number of publications in PUBMED concerning *femoroacetabular impingement* within the past decade. The cam-lesion is the reduced head-neck offset and bashes against labrum and acetabular cartilage during flexion and internal rotation. This mechanism may cause cartilage delamination from the subchondral bone and labrum. This carpet phenomenon is located mostly in the anterosuperior region of the acetabulum.[68–70] as well as causing intraarticular cartilage damage. In pincer FAI, the acetabulum might be too deep globally or locally, causing an abutment of the femoral neck against the acetabulum so that the labrum might be damaged prior to cartilage damage.[71–75] Further causes for FAI are rotational anomalies



Connect ➲ Converge ➲ Compile

Hip arthroplasty (MRI/MRA) data integrated design & 3D Print



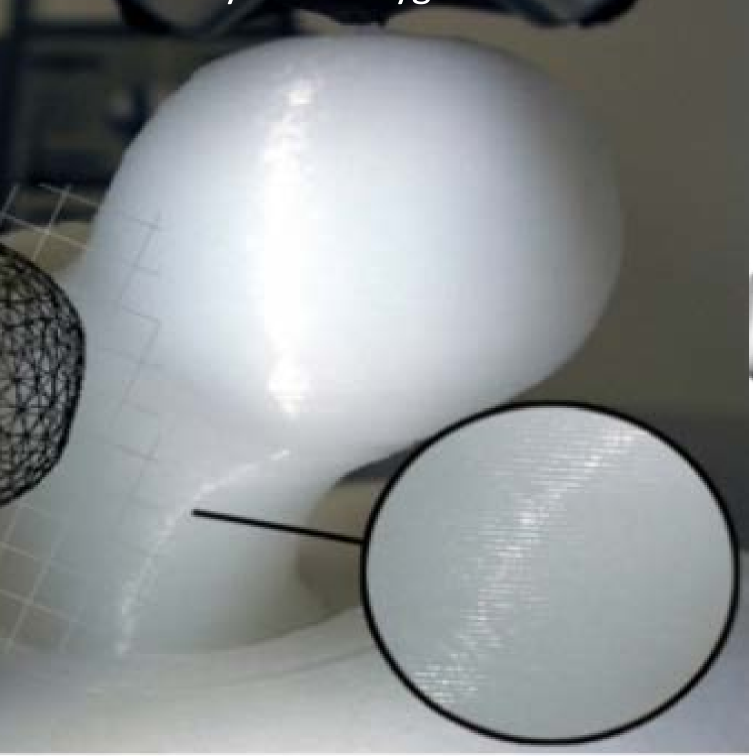


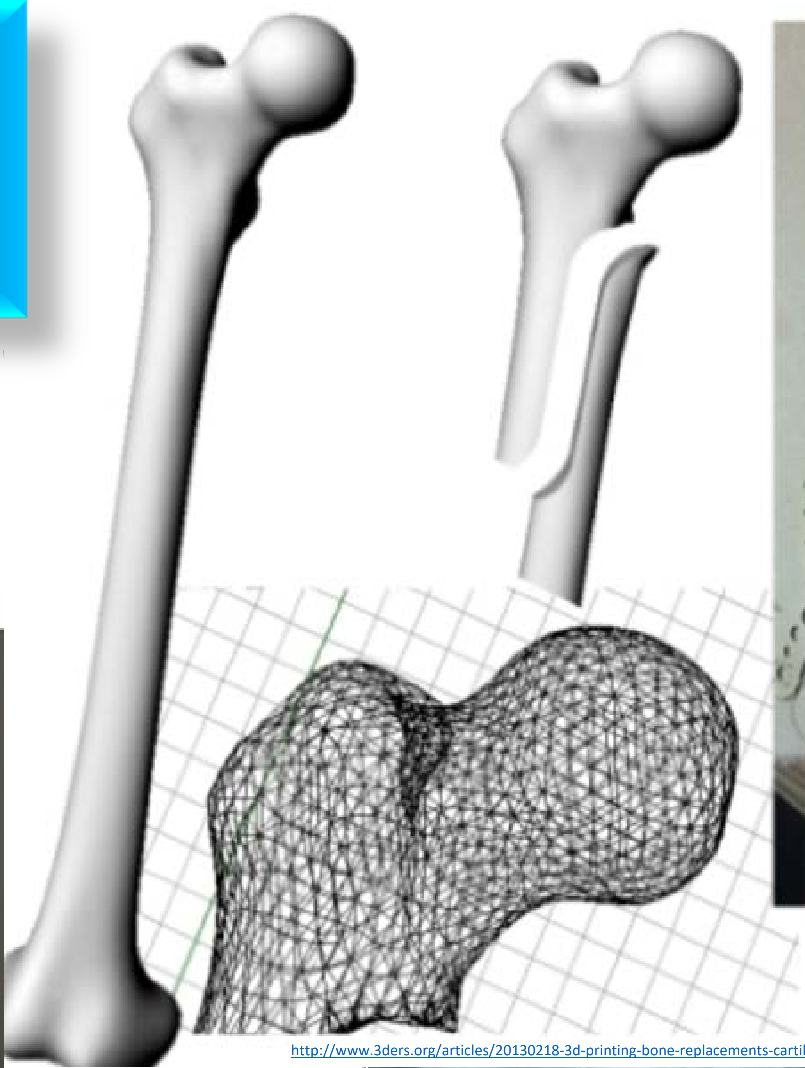
Connect ➲ Converge ➲ Communicate to 3D Printer

Upper Femur

3D Printed with 9572 psi tensile strength 618 nylon co-polymer

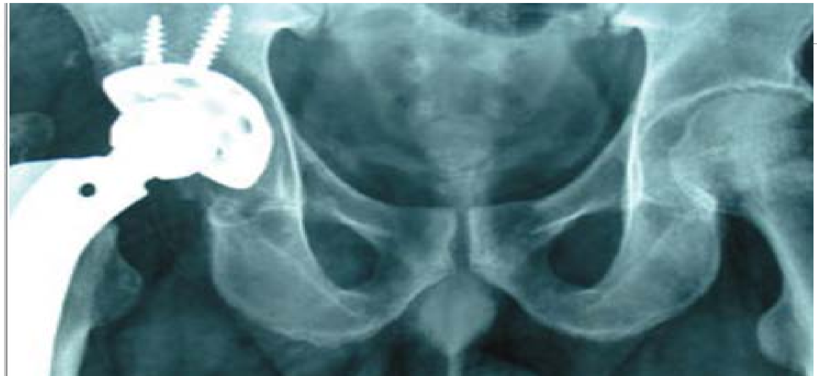
3D Printed by Steve Wygant of SeeMeCNC

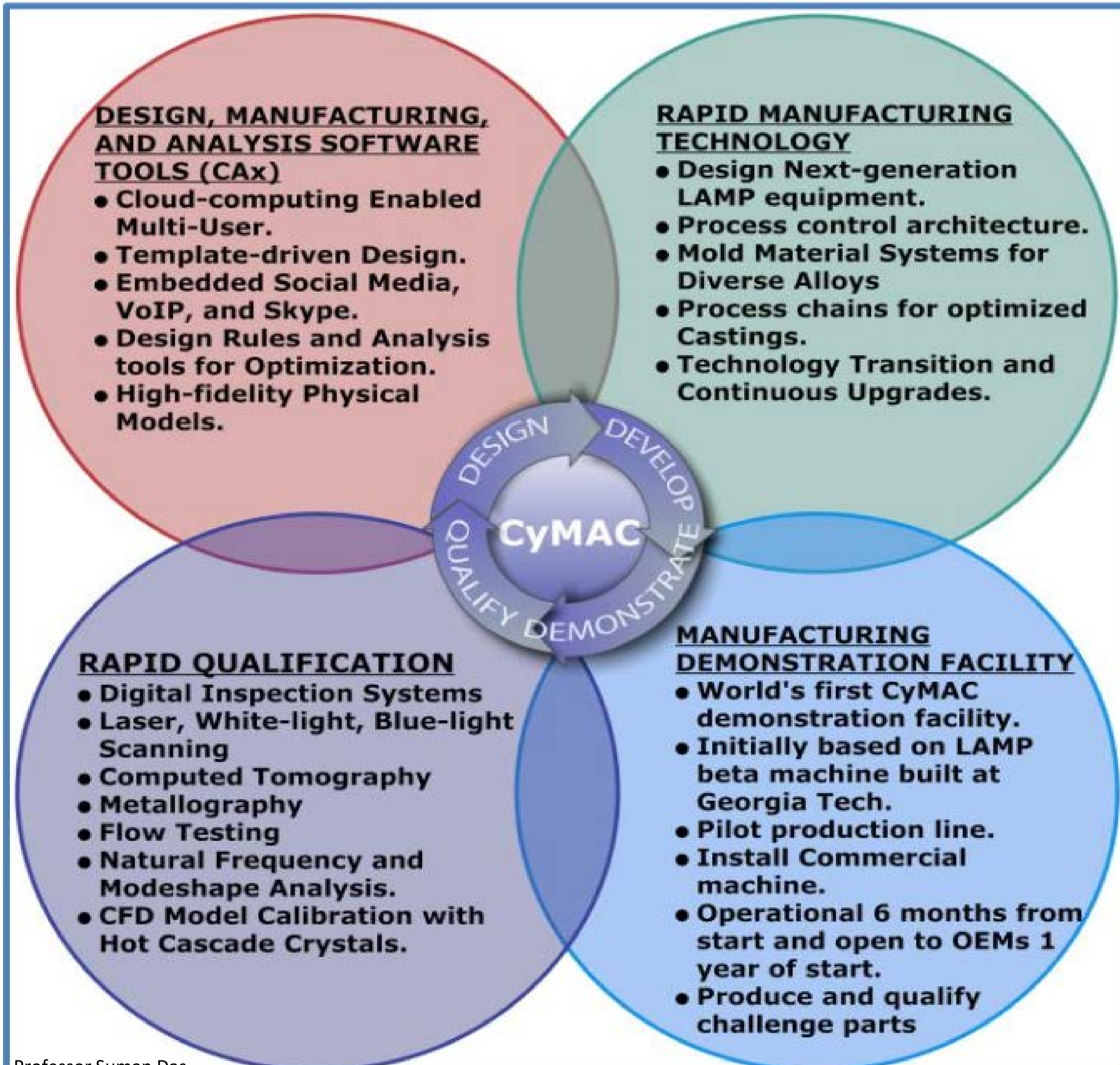




http://www.3ders.org/articles/20130218-3d-printing-bone-replacements-cartilage-replacements-medical-devices-with-618-nylon.html

http://bit.ly/AAOS-2014





Professor Suman Das

C
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C

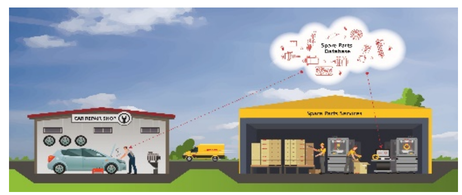
The Future Vision of a CeMS-DDM based Digital Foundry

Cloud-enabled Design, Manufacturing and Analysis Software Tools

- Multi-user collaborative design
- Embedded social media and live communication tools
- Design optimization and analysis tools
- High-fidelity physics-based models

Parts shipped as bitstreams, process parameters, support structure optimization,and design rules shipped back from process learning.

Industrial Internet



DDM Technologies

- Equipment and supporting software.
- Fleet of networked LAMP machines on site at Foundries and OEMs.
- Fleet of networked SLE machines on site at OEMs, MROs, DoD repair depots.
- Fleet of networked LAMP and SLE machines at DDM's production facility.

Industrial Internet

Part build history analysis, machine capability and feature manufacturability analysis, iterative design and process optimization, optimized inspection and testing protocols.

Production Control Systems

- Real-time process control.
- Machine and material health monitoring.
- Build history archiving.
- Digital inspection systems.
- Feedstock material development and optimization.
- Next-generation equipment designs.
- Component performance Testing and validation.

Industrial Internet

Machine performance history analysis, Feedstock material optimization, Process control optimization, Next-generation DDM machine design evolution.

Professor Suman Das, Director, Direct Digital Manufacturing Laboratory, GTMI at Georgia Tech and Morris M. Bryan, Jr. Chair in Mechanical Engineering for Advanced Manufacturing Systems

Margrit Harting, Maresa Harting-Hertz, Dietmar Harting, Chancellor, President, Philip Harting

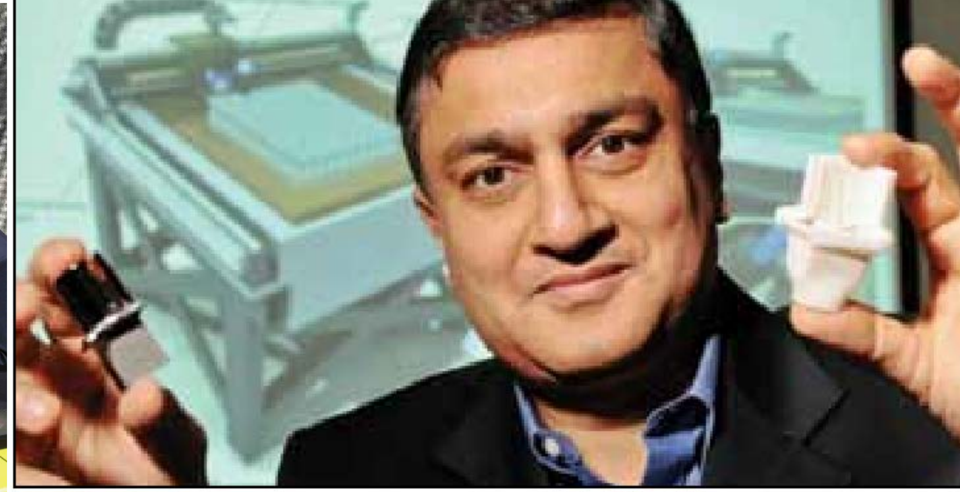
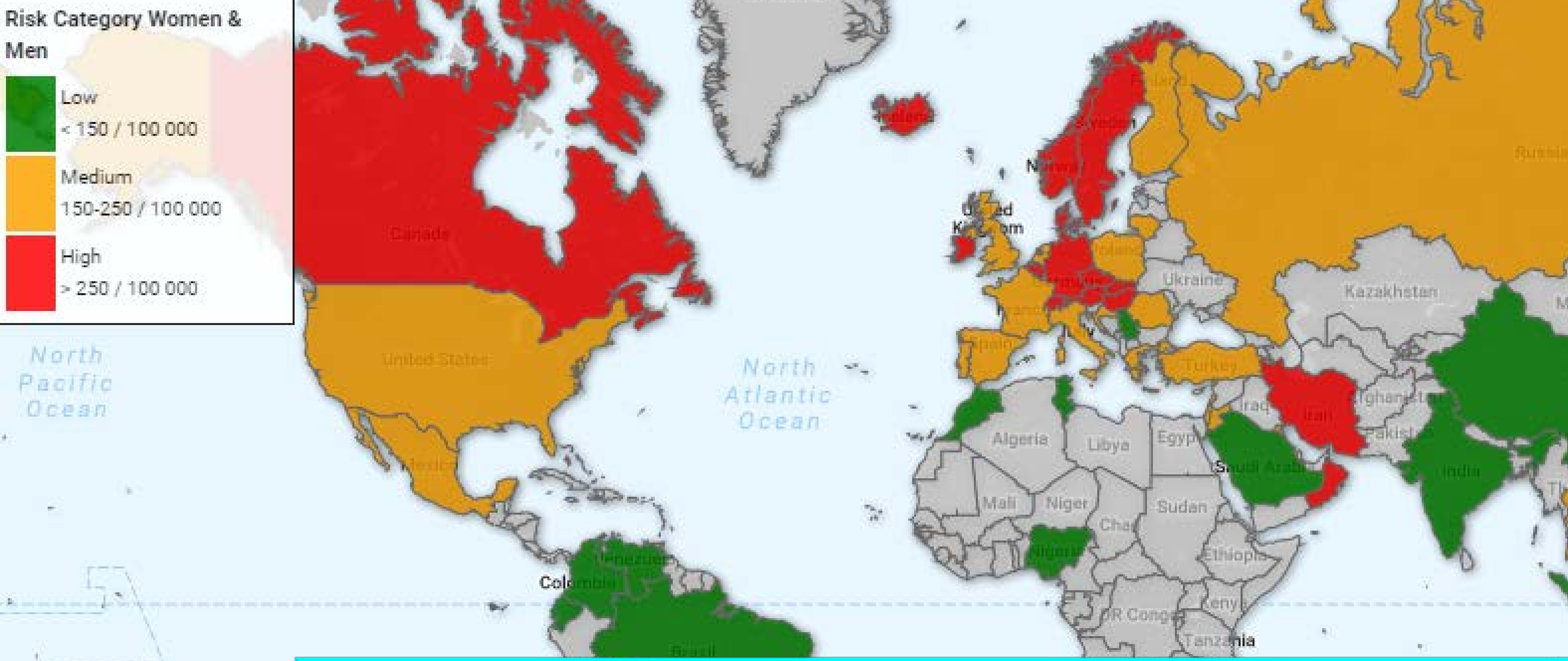


Figure 2. Suman Das shows an investment casting mold (right) fabricated by large-area maskless photopolymerization and a turbine blade casting (left).

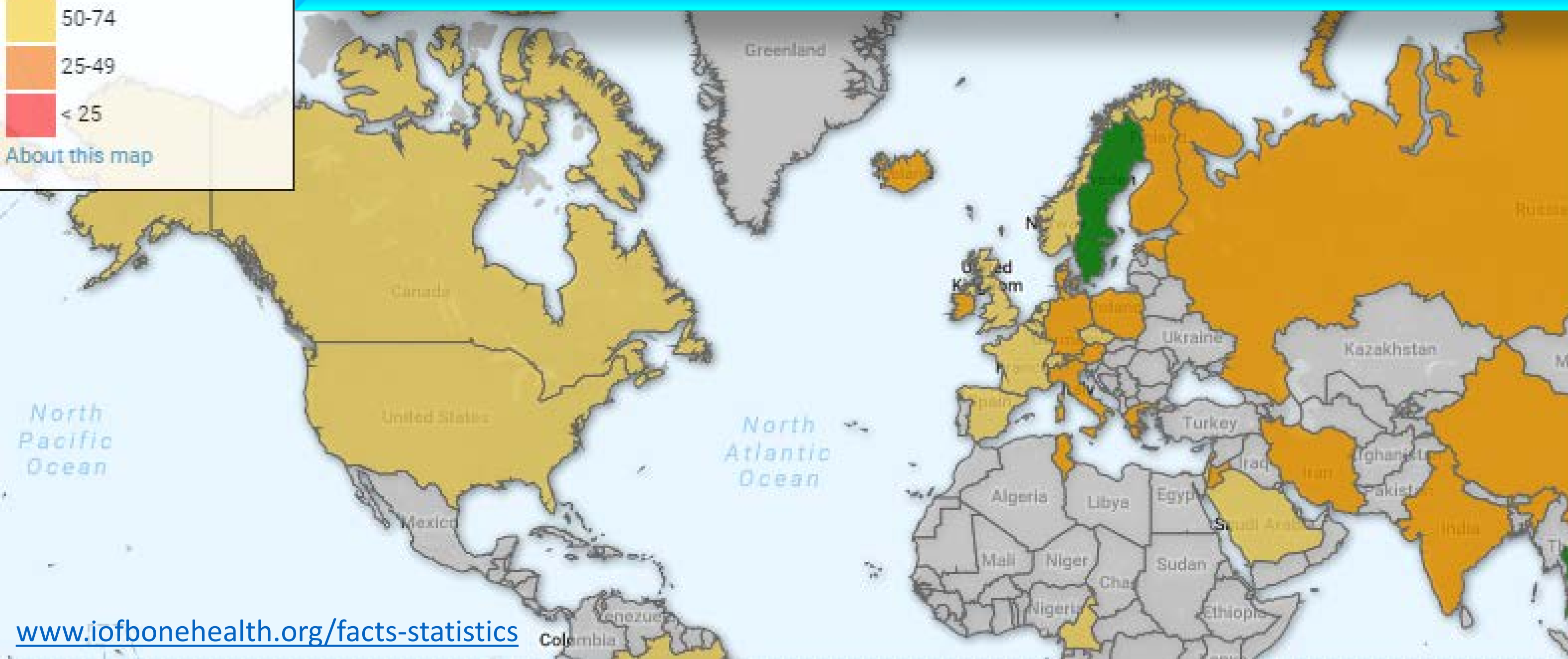
Convergence

Public Health Prevention and 3D Additive Manufacturing



HIP FRACTURE

Public health education may reduce healthcare cost due to osteoporosis



VITAMIN D LEVELS

www.iofbonehealth.org/facts-statistics

E-Business logistics, visions, innovations and research

ELO – E-Business Logistics Technology Programme 2002–2005

Editor Heikki Kekäläinen

Technology Review 196/2006

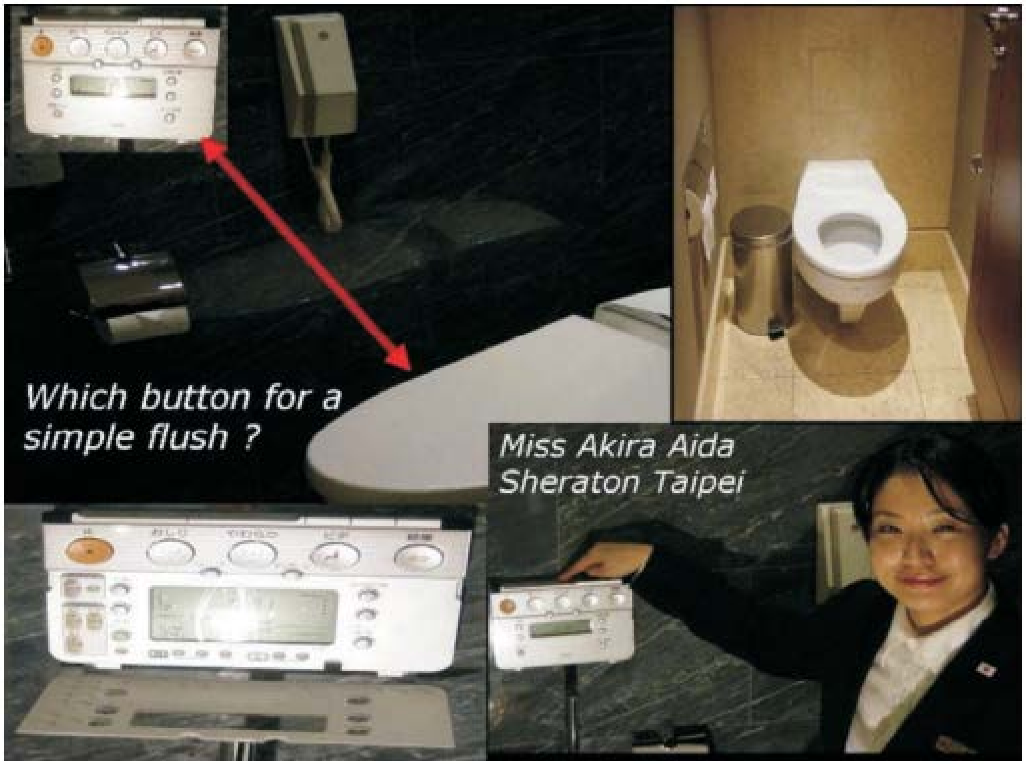


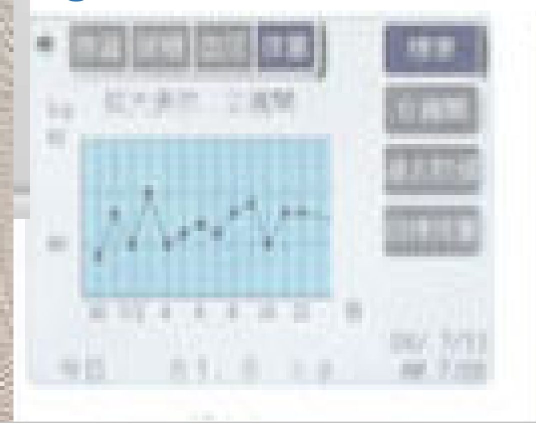
Figure 28. Innovation Down the Toilet?

Tekes

Technology Review 196/2006
Helsinki 2006

Pay-Per-Pee Home Health Monitor - Advancing Preventive Medical Primary Care Wireless Toilet Bowl Connected to Health IoT Systems or Hospital Systems

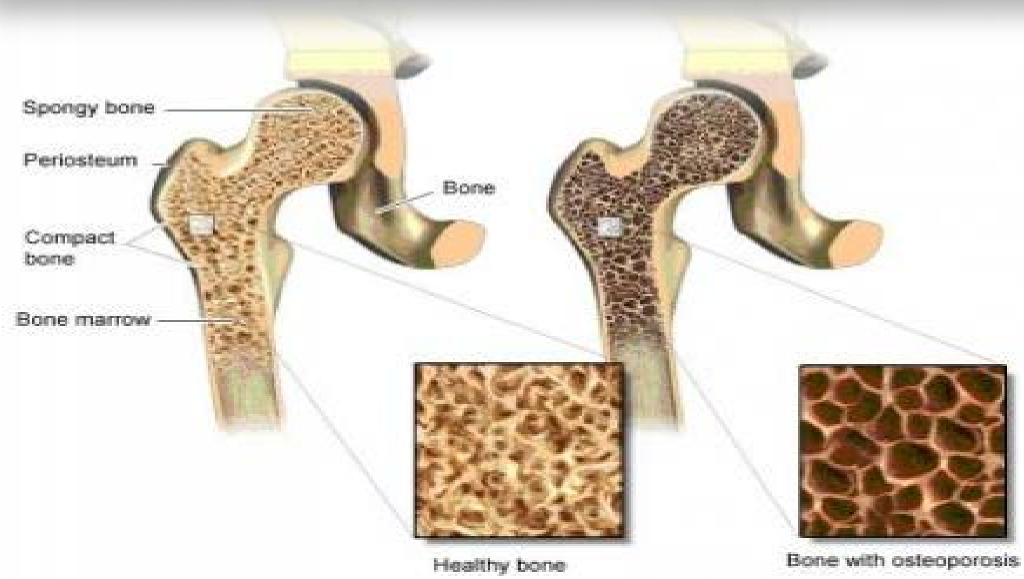
Digital Metabolomics in Precision Medicine



Weigh-scale, BMI, FOBT, urine analysis, sugar, ketone body analysis, blood pressure monitor, pulse oximeter, networked to phone via WiFi and/or Bluetooth with biometrics and face recognition for secure communication with physician and hospital or clinic, globally.

1st Point of Contact for Retail Medicine and Preventive Medical Primary Care ?

€1.99 for Bone Density • €1.99 Mammogram



PDEXA SCAN
BONE MINERAL
DENSITY PROFILE

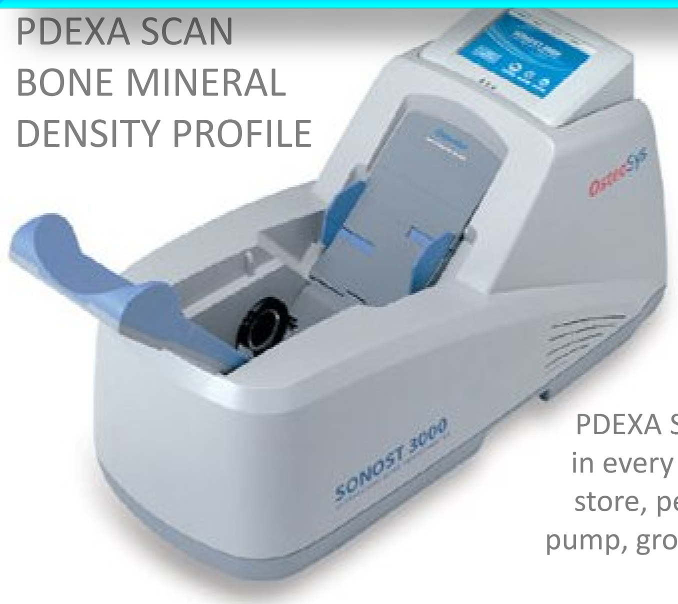
Monitor Nr. 662 vom 19.06.2014

Brustkrebs-Vorsorge: Mehr Schaden als Nutzen?

Bericht: Ursel Sieber, Frank Konopatzki, Jan Schmitt

Integrated system detects fall in bone density and correlates with reduced purchase of milk. Prevention for osteoporosis starts early. Avoids fall, trauma and morbidity from broken bones. Connected health IoT data.

PDEXA SCAN
BONE MINERAL
DENSITY PROFILE



PDEXA SCAN in every drug store, petrol pump, grocery

Osteoporosis

EU → 28 million in 2010 to 34 million in 2025 (increase of 23%)

US → 44 million (represents 55% of people aged 50+)

Brazil → 10 million (1 in every 17)

India → 36 million (2013)

China → 70 million (50+). Cost of treatment USD1.5 billion in 2006. Estimated US$12.5 billion in 2020 and US$265 billion in 2050.

CVS Special $0.99 for 1-quart Milk • $1.99 for Bone Density • $2.99 Mammogram

http://bit.ly/BONE-HEALTH

Health IoT

CONNECT

GROCERY STORE PURCHASE LOG

In 2008, Indonesia had 34 DXA machines, half of them in Jakarta (population 237 million) which translates to 0.001 machine per 10,000 population. The equivalent recommended number for Europe is 0.11 (per 10,000)

The new normal – SERVICES – not products

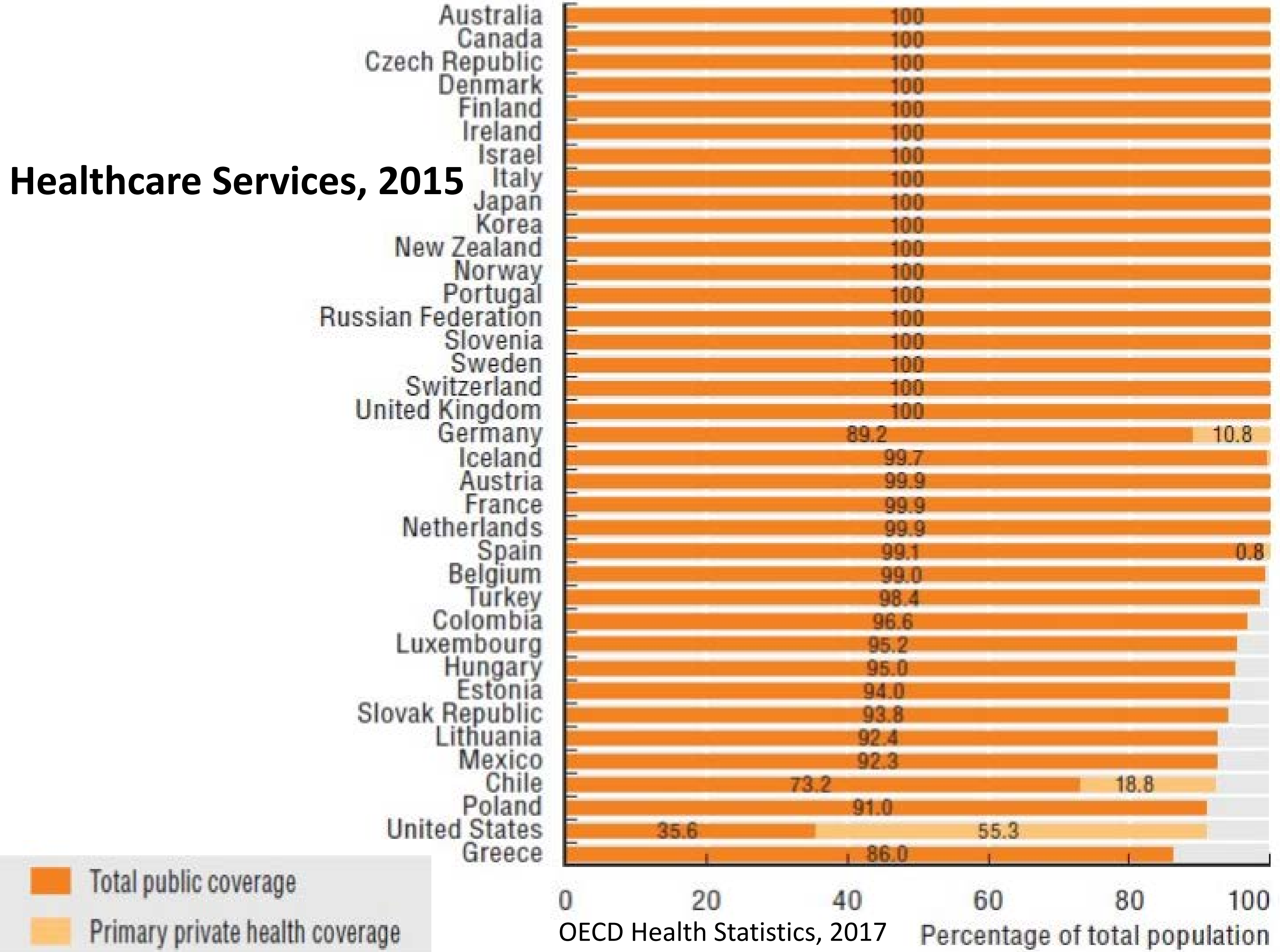
Internet of Things
isn't about things

IoT is a design metaphor applicable to any domain

Demand for healthcare

expected to grow in volume and acuity

Healthcare Services, 2015



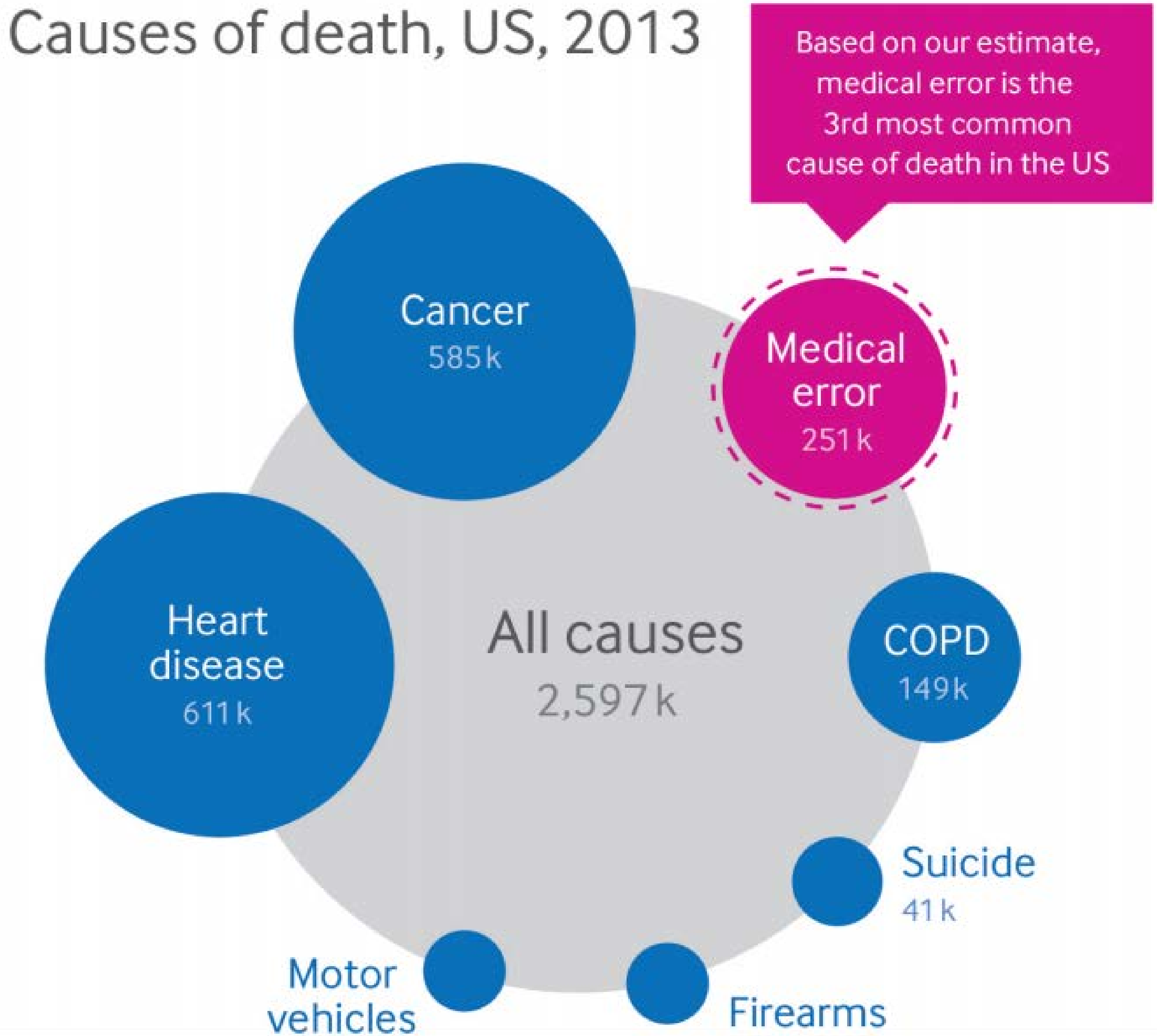
OECD Health Statistics, 2017

The variability in the healthcare industry

and the lack of device and systems interoperability is a significant problem and cause of death in the USA.

www.west-info.eu/files/Medical-error—the-third-leading-cause-of-death-in-the-US1.pdf

Medical errors cost $20 billion pa & $1 trillion pa in lost productivity.



E
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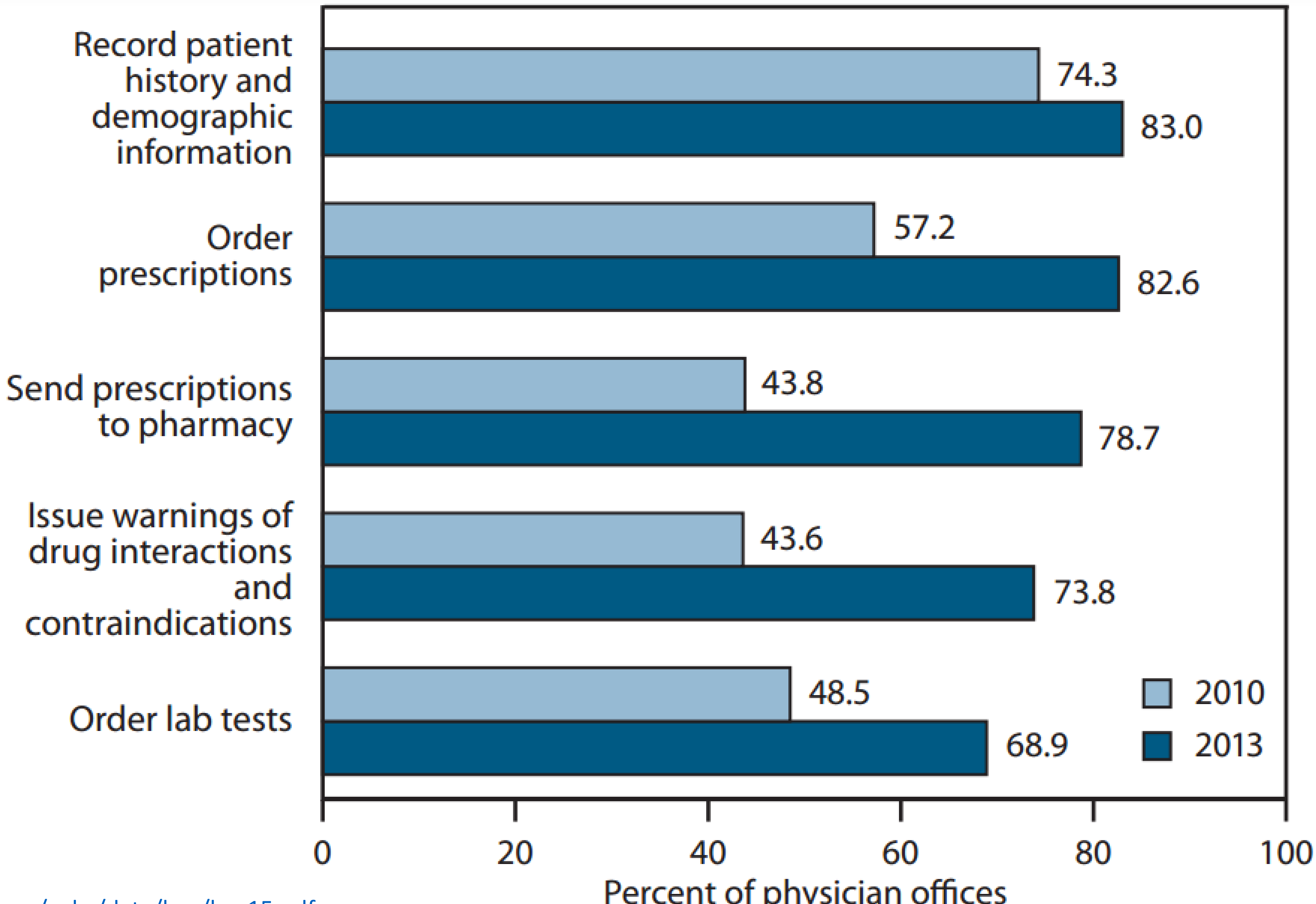
Error – Interoperability of electronic health records ?



www.cdc.gov/nchs/data/hus/hus15.pdf

1,100 EHR vendors: $37billion cost [Meaningful Use]

Rank	Vendor Name	Number of Physicians in Practice					
	www.practicefusion.com/blog/ehr-adoption-rates	1 to 3	4 to 10	11 to 25	26 to 40	41+	Overall
1	Epic	9.8%	21.4%	33.9%	40.1%	43.5%	12.4%
2	eClinicalWorks LLC	10.7%	8.9%	5.1%	2.8%	1.0%	10.3%
3	Allscripts	7.6%	10.8%	10.7%	9.9%	7.0%	8.2%
4	**Practice Fusion**	**7.9%**	**1.2%**	**0.2%**	**0.0%**	**0.0%**	**6.5%**
5	NextGen Healthcare	4.8%	7.7%	7.9%	3.9%	3.5%	5.4%
6	Cerner Corporation	3.5%	5.7%	8.7%	10.5%	9.0%	4.1%
7	athenahealth, Inc	4.0%	2.8%	1.2%	0.6%	0.5%	3.7%
8	GE Healthcare	2.9%	5.6%	6.4%	8.0%	4.5%	3.5%
9	Greenway Health	3.3%	4.6%	2.6%	0.6%	1.0%	3.5%
10	McKesson	3.3%	2.4%	2.0%	4.7%	1.5%	3.1%
11	AmazingCharts.com, Inc.	2.6%	0.4%	0.0%	0.0%	0.0%	2.1%
12	MEDITECH	1.7%	2.3%	3.8%	2.2%	1.0%	1.9%
13	13 e-MDs, Inc.	1.9%	1.1%	0.4%	0.3%	0.0%	1.7%
14	Care360, Quest Diagnostics	1.8%	0.3%	0.1%	0.0%	0.0%	1.5%
15	Office Ally	1.3%	0.2%	0.0%	0.0%	0.0%	1.1%
16	MEDENT-Community Computer Service Inc.	1.0%	1.4%	0.6%	0.0%	0.0%	1.1%
17	NexTech Systems Inc.	1.1%	0.5%	0.0%	0.0%	0.0%	0.9%
18	Aprima Medical Software, Inc	1.0%	0.6%	0.2%	0.3%	0.0%	0.9%
19	ADP	1.0%	0.3%	0.0%	0.0%	0.0%	0.9%
20	TRAKnet Solutions	1.0%	0.3%	0.0%	0.0%	0.0%	0.9%
21	All Other Vendors (466)	27.8%	21.5%	16.2%	16.3%	27.5%	26.5%
	TOTAL	100%	100%	100%	100%	100%	100%

Deliberate Deception of Epic Proportions ($37 billion+) EHR vendors do not want interoperability, by design EHR systems do not “talk” to each other, by design

1,1000 EHR systems including over 600 for providers accepting US Medicare.

With an EHR system, if you are a competing vendor and can’t access the clinical record on my system, you lose and I win. If I’m with a bigger system, the provider will be in a position to put pressure on the smaller collaborators to switch (if they bother). Often, one doctor’s office will print out the patient record, fax it to another doctor and their office will re-key the record (this happens this way since email is not HIPAA compliant).

The cost of this is ultimately born by insurance and taxpayers, since the doctor has to pay extra staff to do all this re-keying and therefore incentivized to bill as many procedures as possible just to cover office costs. It’s a downward spiral for the consumer by design. The greed of the EHR vendors is a reason for errors.

THE WALL STREET JOURNAL.

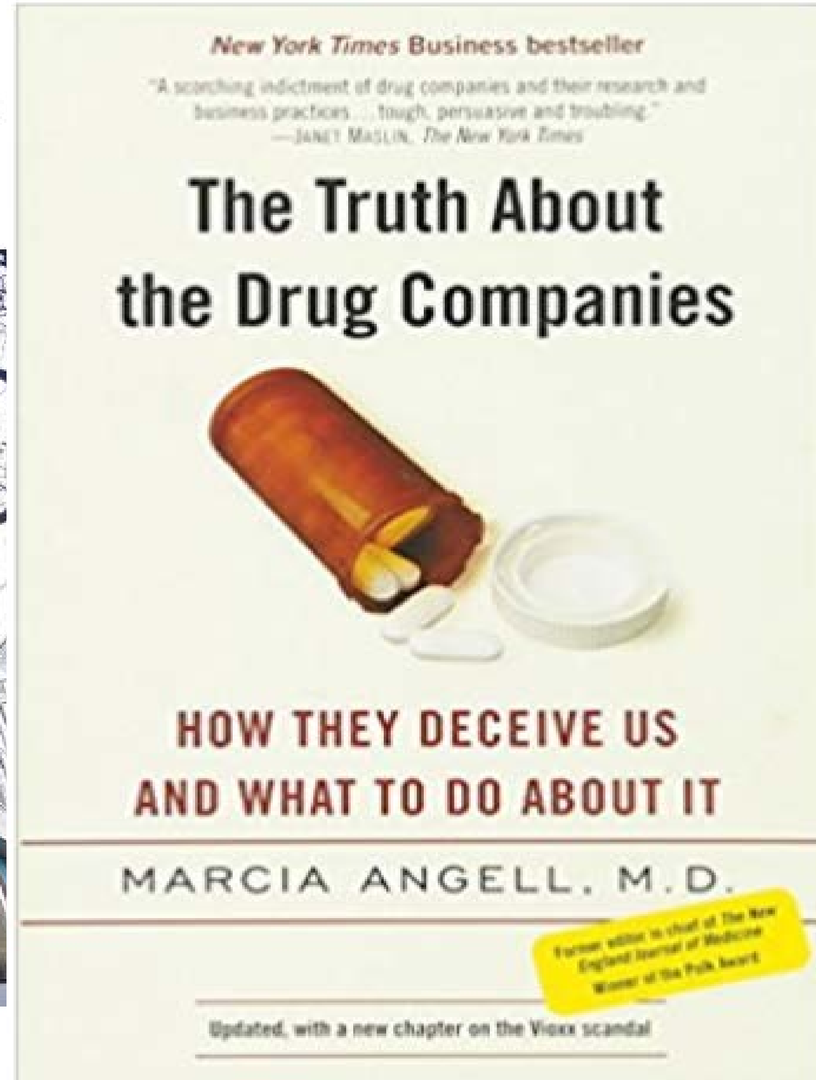
9th DECEMBER 2015

BUSINESS

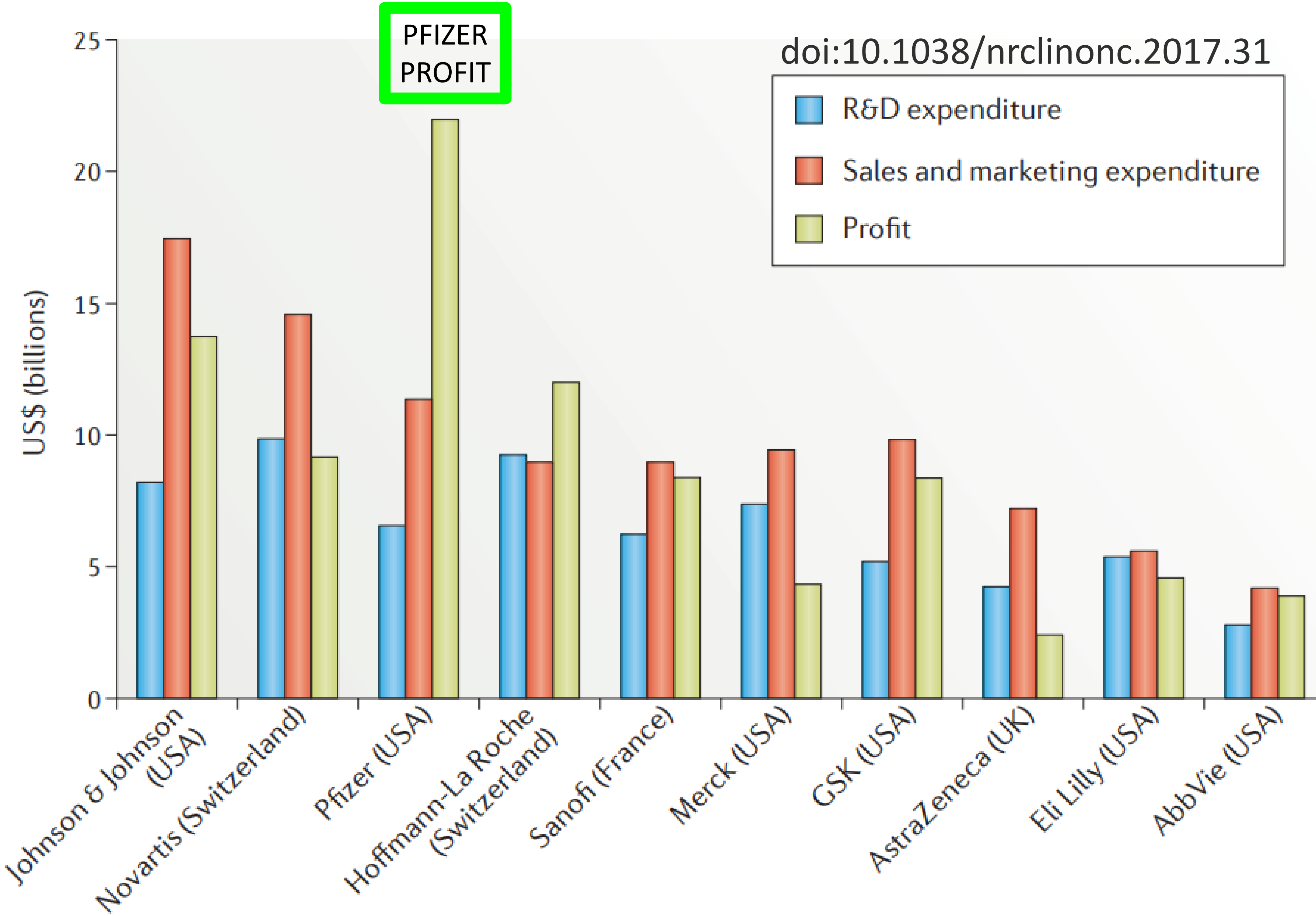
How Pfizer Set the Cost of Its New Drug at $9,850 a Month

Process of setting the price for breast-cancer treatment
U.S. drug prices

Pfizer set the price of a new breast-cancer drug in an elaborate process of market research that included testing the views of oncologists and health-plan officials.



doi:10.1038/nrclinonc.2017.31



Annual profits, and annual expenditure on research and development (R&D) and marketing for the 10 largest pharmaceutical companies in 2013 (REF 48).

Secure | https://dspace.mit.edu/handle/1721.1/107893

DSpace@MIT

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Home → Department of Civil and Environmental Engineering → MIT Forum for Supply Chain Innovation → Research Papers → View Item

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Healthcare and Medical IoT

Download

Author: Datta, Shoumen

Citable URI: http://hdl.handle.net/1721.1/107893

Date Issued: 2017-04-06

Abstract:

Detection of analytes in the context of nano-diagnostics for preventive medicine and global public health.

Description:

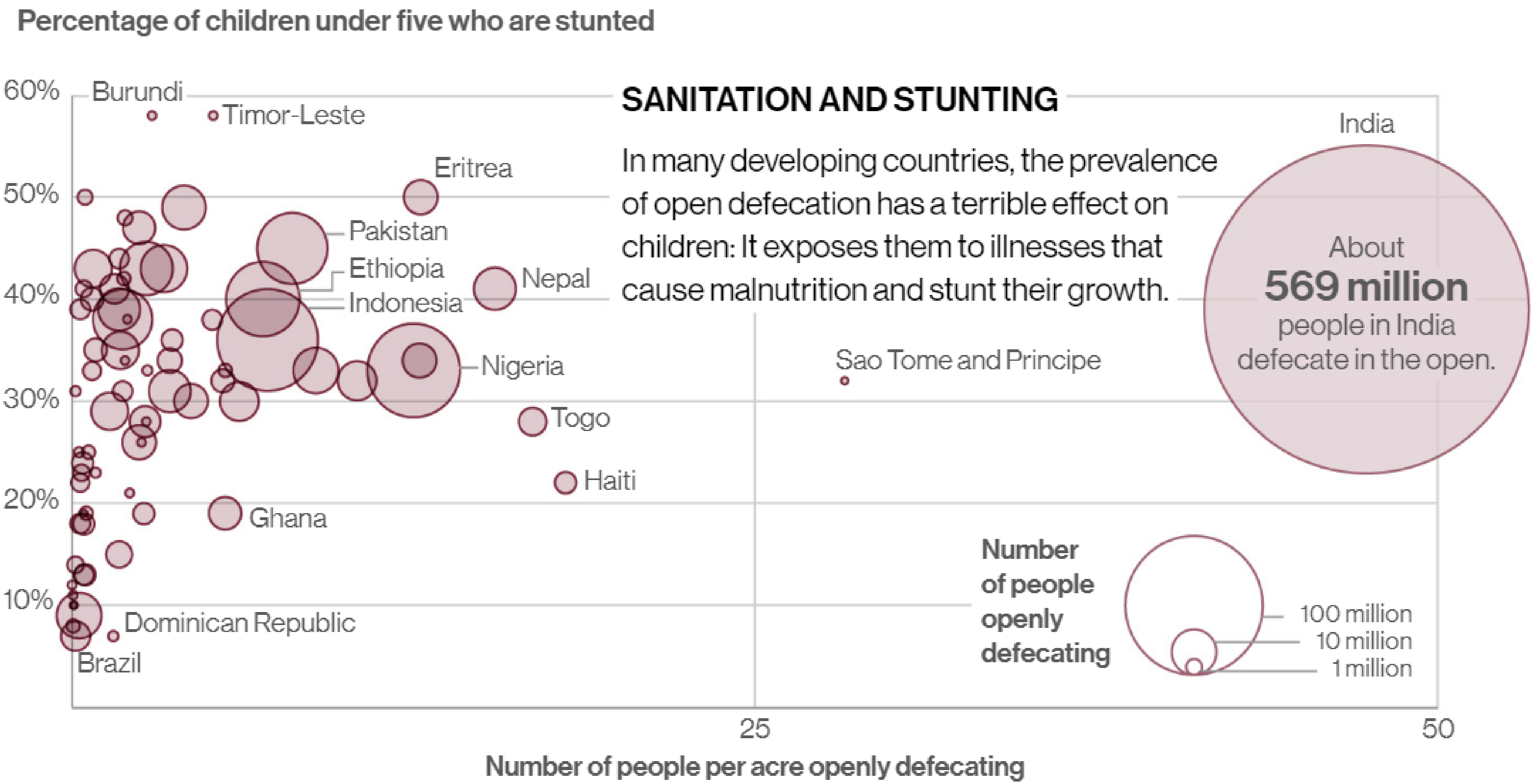
11 million children die each year from preventable causes. 70% of the deaths are due to 6 well documented diseases/causes. The mortality is concentrated in 10 countries. We have the tools and technologies to address this problem.

URI: http://hdl.handle.net/1721.1/107893

11 million children die each year from preventable causes. 70% of the deaths are due to 6 well documented diseases.

What is essential to health?

www.nationalgeographic.com/magazine/2017/08/toilet-defecate-outdoors-stunting-sanitation/



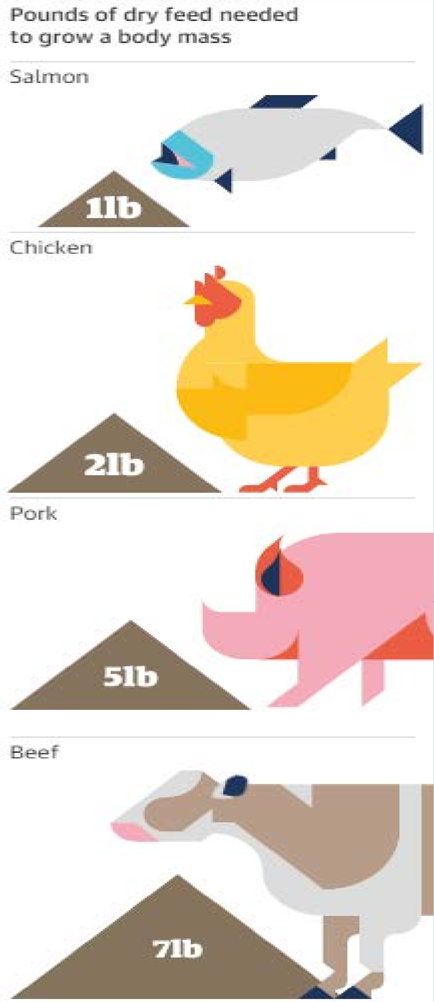
JASON TREAT AND MATTHEW W. CHWASTYK, NGM STAFF; KELSEY NOWAKOWSKI
SOURCES: WHO/UNICEF JOINT MONITORING PROGRAMME FOR WATER SUPPLY AND SANITATION; SANGITA VYAS, RESEARCH INSTITUTE FOR COMPASSIONATE ECONOMICS

What is essential to Health?

Internet of Food and 3D flexible electronic printing

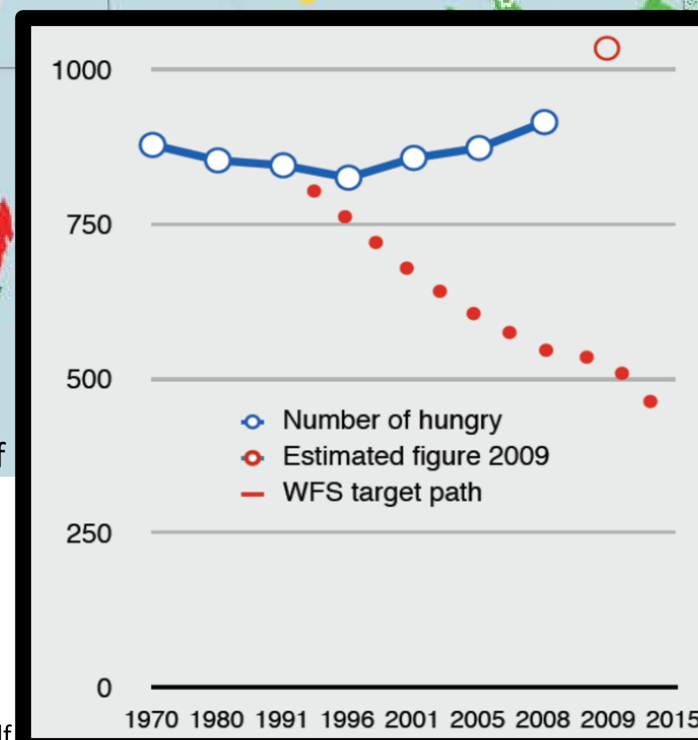
An estimated 9 billion people to feed in 2050

www.un.org/sustainabledevelopment/blog/2015/07/what-progress-has-been-made-in-ending-global-poverty/



The End of Plenty by Joel K Bourne

www.fao.org/3/a-i4674e.pdf



http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

People waste about 68% of the food in US

More than two-thirds of total food wasted – which is ~ 63 million tons

Value wasted ~ $150 Billion (total food wasted value US$218 Billion)

43

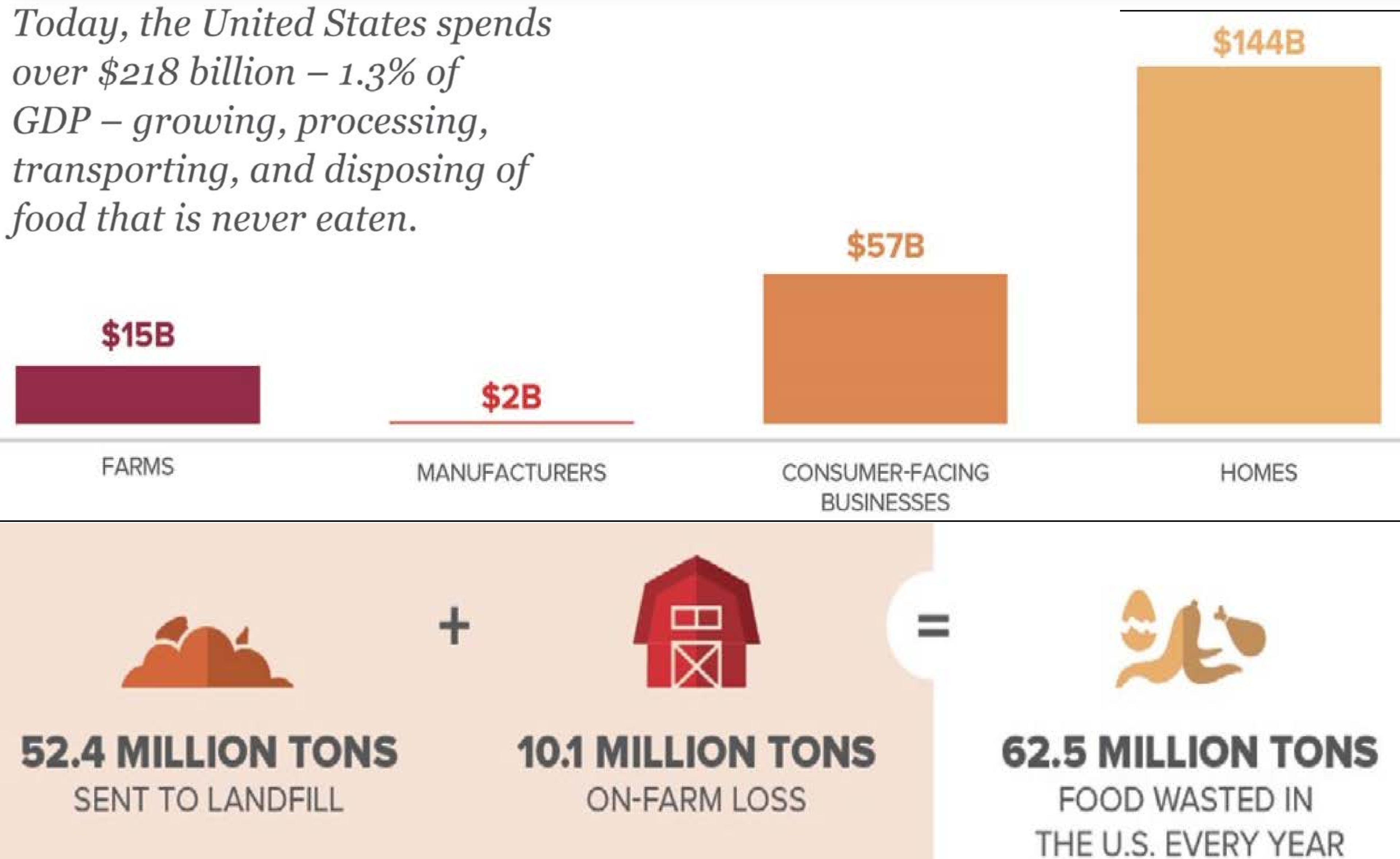
million tons

$150 Billion

US Report ● http://www.refed.com/downloads/ReFED_Report_2016.pdf
EU Report ● http://data.consilium.europa.eu/doc/document/ST-10730-2016-INIT/en/pdf from www.eu-fusions.org/

We, people in US, are the culprits - 68% FOOD WASTE

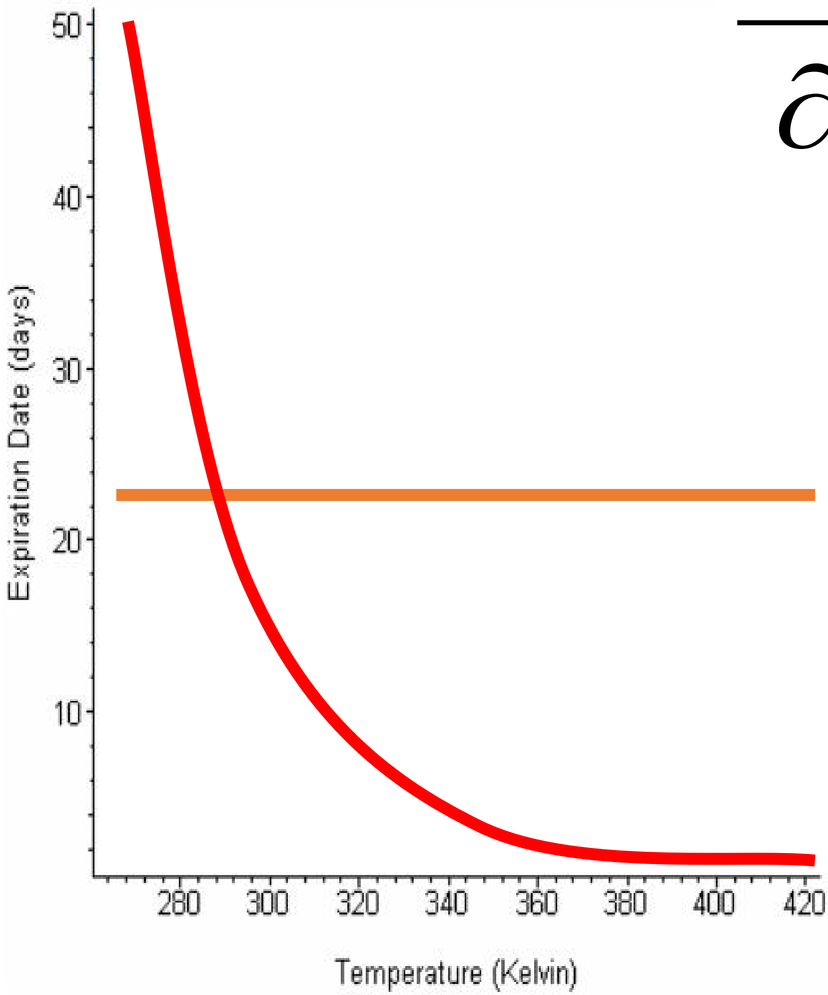
FOOD WASTE - 63 million tons, $218 billion, 1.3% GDP



http://www.refed.com/downloads/ReFED_Report_2016.pdf

Storage

$$\frac{\partial Q}{\partial t} = -k_1 e^{\left[-\frac{E_a}{R_g T(t)}\right]} Q^n$$



Variables

- E_a Activation energy
- k_1 Arrhenius constant
- n Order of the reaction
- T Temperature
- Q Quality
- t Time

2003

Shelf Life

Name: Activation Energy

Name: Arrhenius Constant

Name: Temperature

Name: Quality

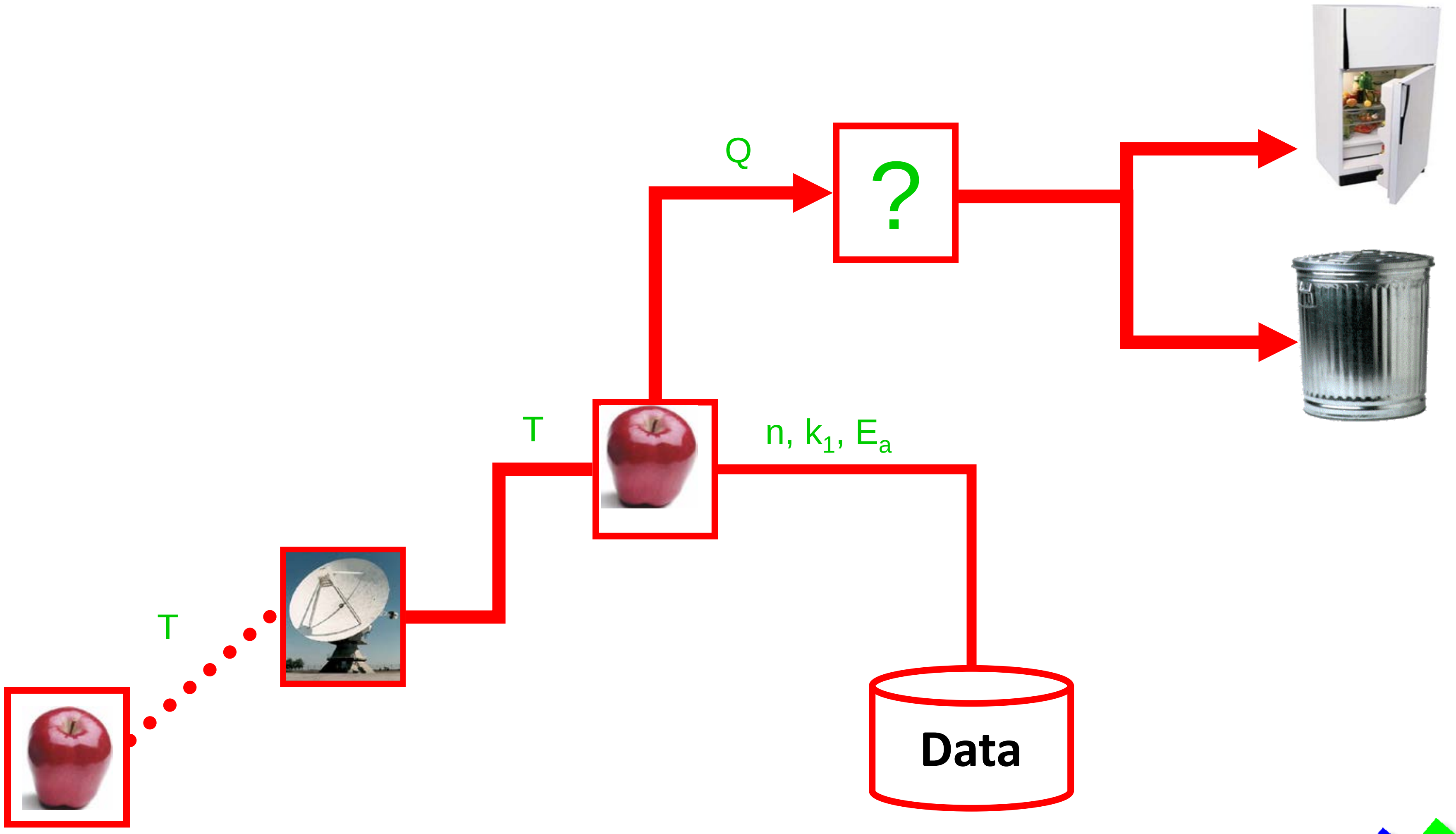
Name: Order of Reaction
Description: Order of Reaction
Symbol: n
Access: Read
ID: EPC: 01020084191000001289731
Class: Scalar
Type: Int
Unit:
Default: 1

Food Quality

Name: Food Quality
Description: Food Quality based Arrhenius
Developer: Natick Army Laboratories
ID: EPC: 010300908808BF60000000AA
Comp: $0.25 per month
Type: Analytic
Rate: 1 to 10,000 sec
Algorithm:

2003

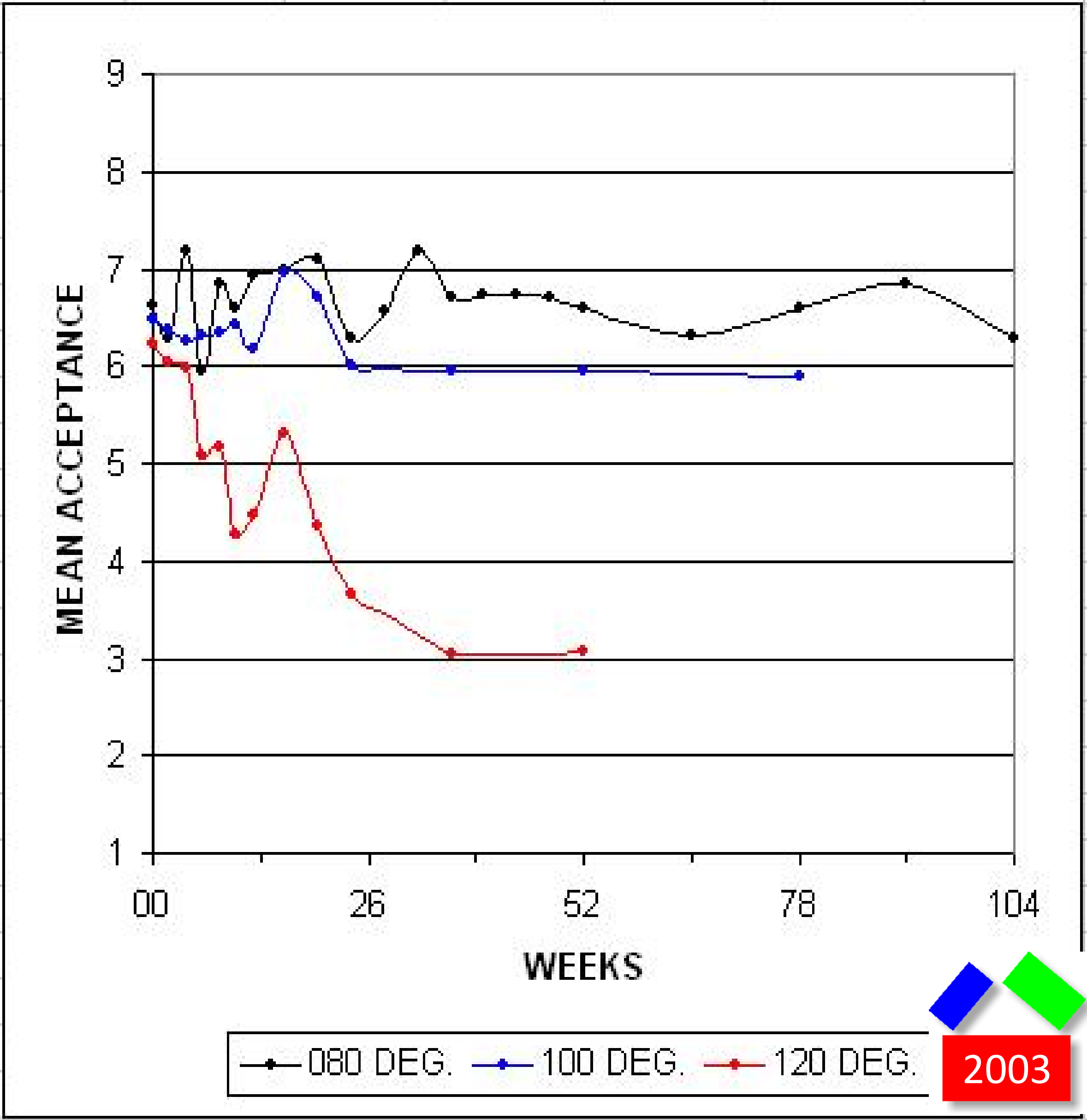
Shelf Life ➲ Answers (not numbers)



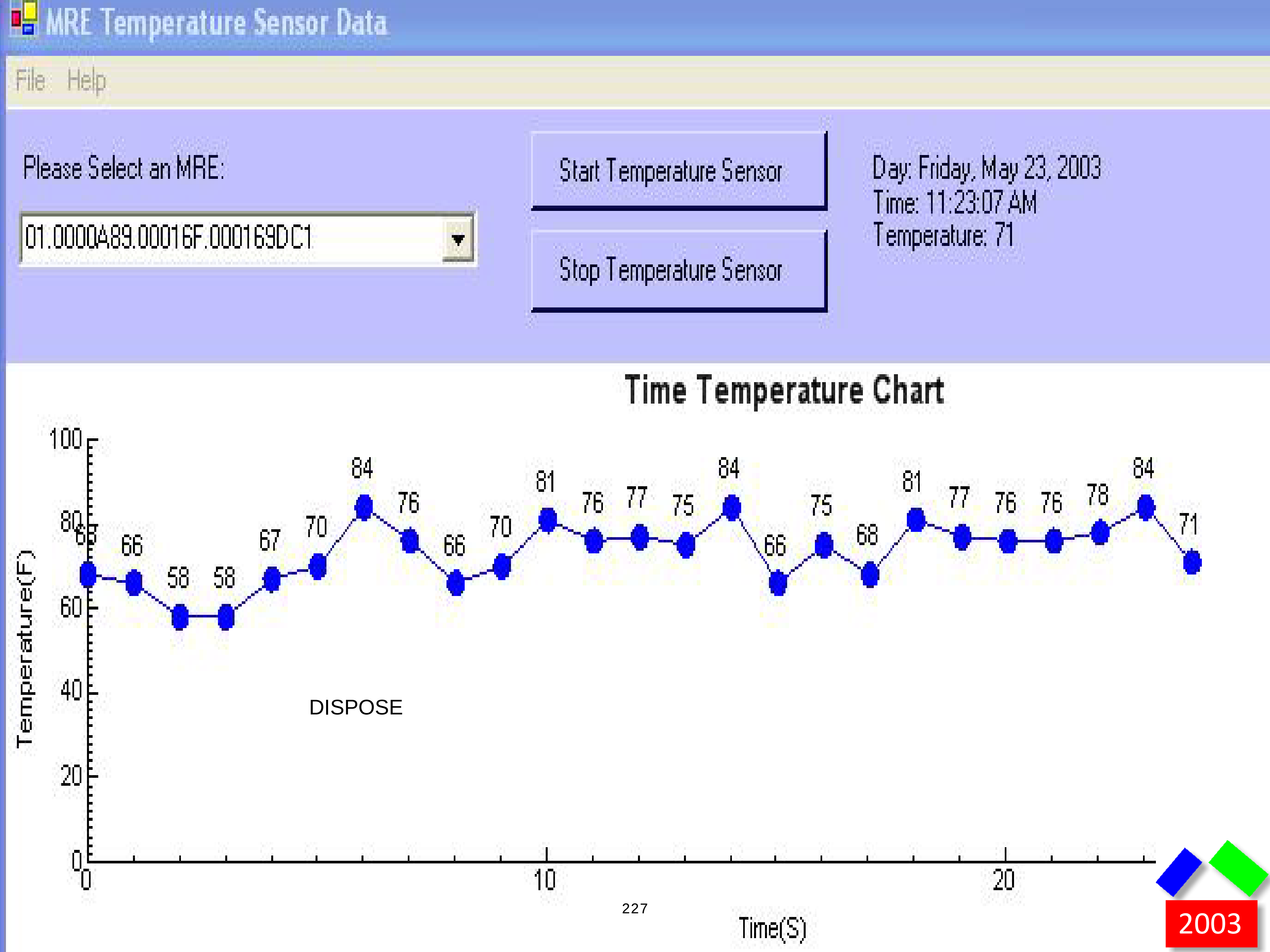
2003

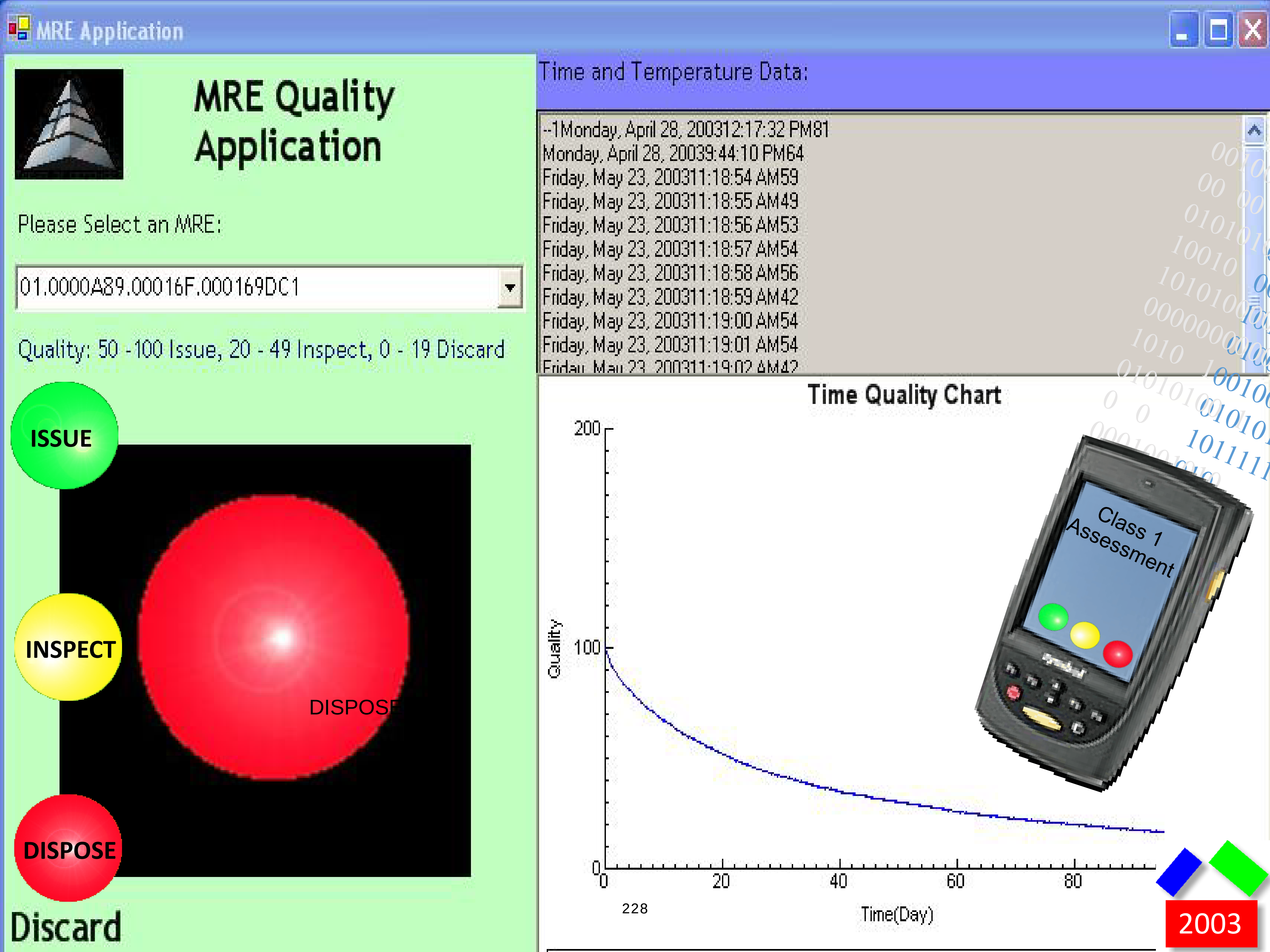
Monitoring Perishables (MRE Simulation)

WKS	080 DEG.	100 DEG.	120 DEG.
00	6.622	6.486	6.243
02	6.282	6.359	6.026
04	7.194	6.250	5.972
06	5.949	6.308	5.077
08	6.850	6.350	5.175
10	6.600	6.429	4.286
12	6.944	6.167	4.472
16	7.000	6.947	5.316
20	7.111	6.694	4.361
24	6.300	6.000	3.667
28	6.579		
32	7.189		
36	6.694	5.944	3.028
40	6.730		
44	6.730		
48	6.703		
52	6.583	5.944	3.056
65	6.316		
78	6.583	5.889	
91	6.842		
104	6.300		
130			
156			



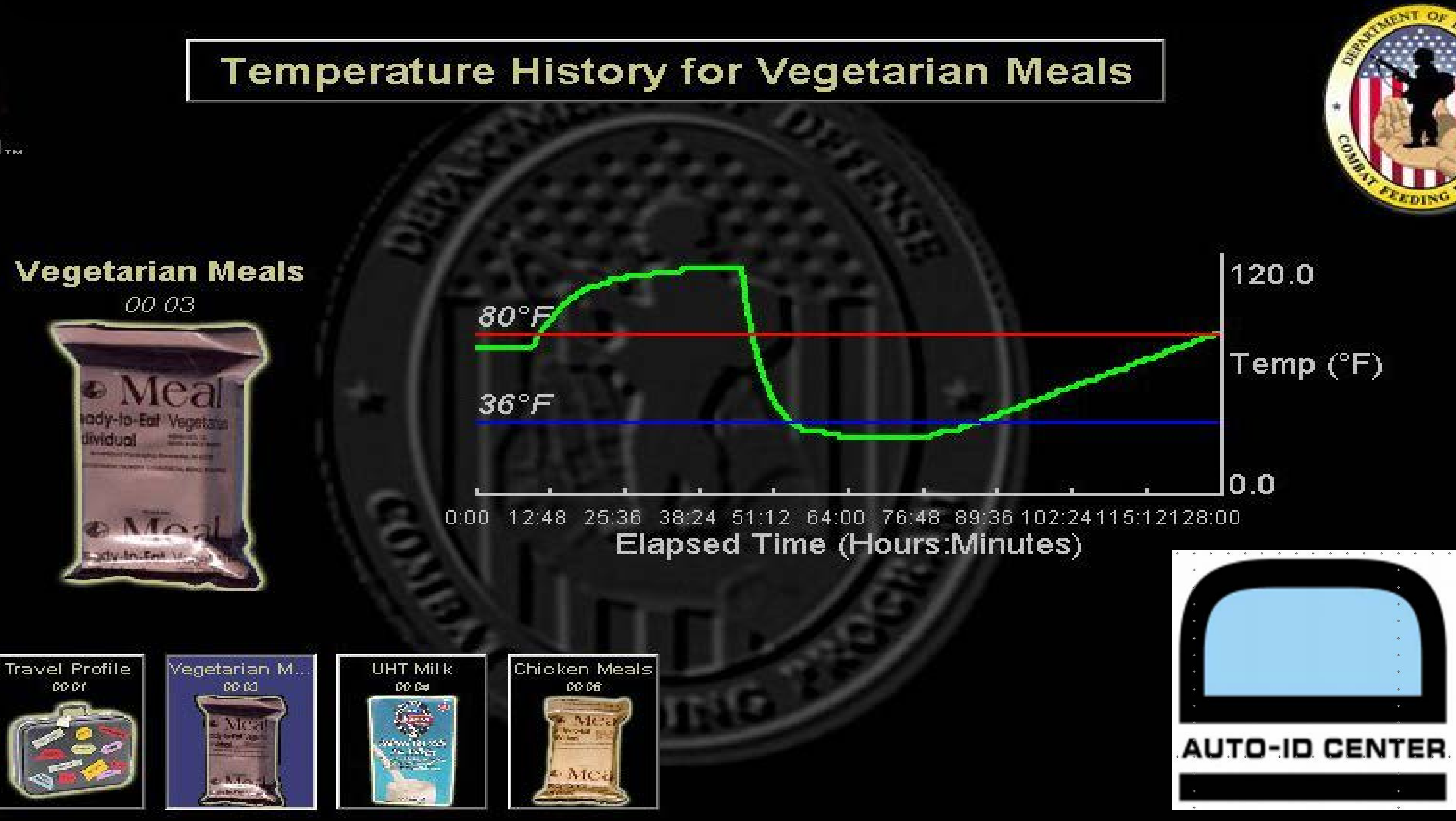
2003


MRE Temperature Sensor Data
File Help
Please Select an MRE:
01.0000A89.00016F.000169DC1
Start Temperature Sensor
Stop Temperature Sensor
Day: Friday, May 23, 2003
Time: 11:23:07 AM
Temperature: 71
Time Temperature Chart
Temperature(F)
Time(S)
DISPOSE
0
20
40
60
80
100
0
10
20
68 66 58 58 67 70 84 76 66 70 81 76 77 75 84 66 75 68 81 77 76 76 78 84 71
2003

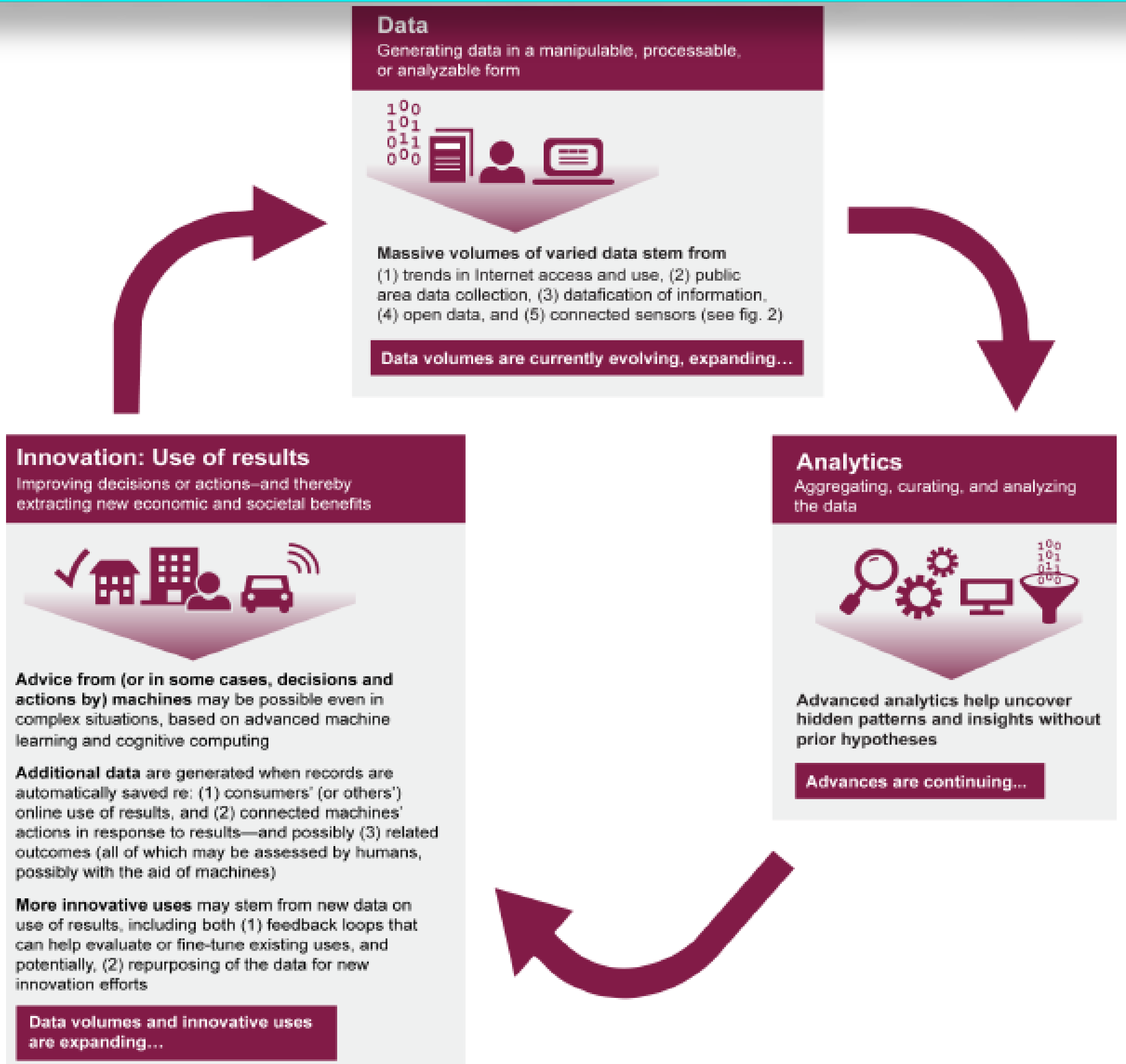

MRE Application
MRE Quality Application
Please Select an MRE:
01.0000A89.00016F.000169DC1
Quality: 50 - 100 Issue, 20 - 49 Inspect, 0 - 19 Discard
ISSUE
INSPECT
DISPOSE
DISPOSE
Discard
Time and Temperature Data:
--1Monday, April 28, 200312:17:32 PM81
Monday, April 28, 20039:44:10 PM64
Friday, May 23, 200311:18:54 AM59
Friday, May 23, 200311:18:55 AM49
Friday, May 23, 200311:18:56 AM53
Friday, May 23, 200311:18:57 AM54
Friday, May 23, 200311:18:58 AM56
Friday, May 23, 200311:18:59 AM42
Friday, May 23, 200311:19:00 AM54
Friday, May 23, 200311:19:01 AM54
Time Quality Chart
Quality
200
100
0
0
20
40
60
80
Time(Day)
Class 1 Assessment
2003

RFID + Temperature Sensor ● Convergence of Systems

MIT Auto-ID Center co-founders Sanjay Sarma and David Brock



Digital Transformation – Data, Analytics and Innovation



Data, Analytics, Innovation - Reduce Transaction Cost?

Published October 1, 2000. Distribution restricted to Sponsors until January 1, 2001.

AUTO-ID CENTER

WHITE PAPER

The Networked Physical World

Proposals for Engineering the Next Generation of Computing, Commerce & Automatic-Identification

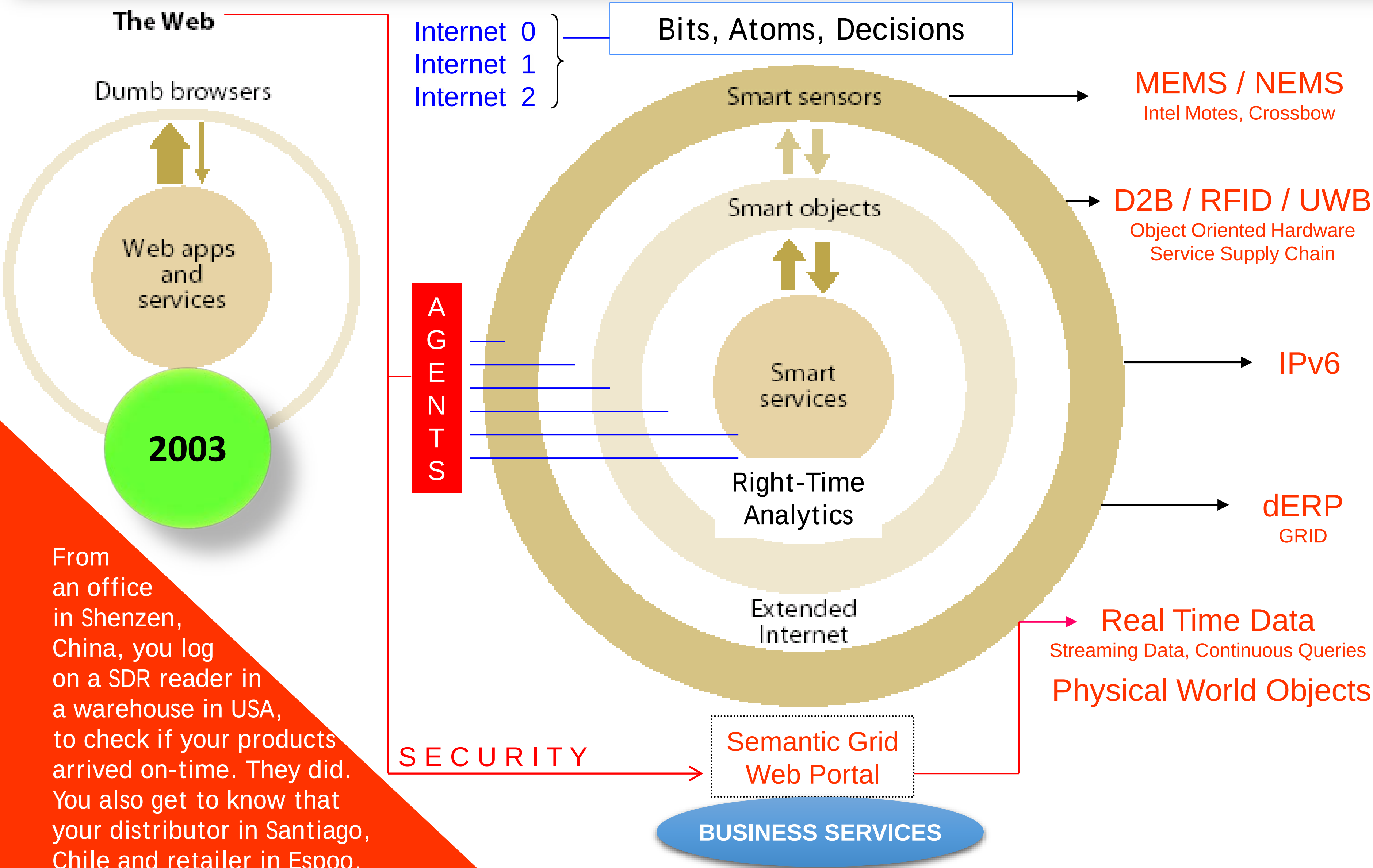
Sanjay Sarma, David L. Brock & Kevin Ashton

MIT AUTO-ID CENTER MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 77 MASSACHUSETTS AVENUE, BUILDING 3-449G, CAMBRIDGE, MA 02139-4307

ABSTRACT

The Auto-ID Center at the Massachusetts Institute of Technology is a new industry sponsored lab charged with researching and developing automated identification technologies and applications. The Center is creating the infrastructure, recommending the standards, and identifying the automated identification applications for a networked physical world. All technologies and intellectual property developed at the Auto-ID Center are freely distributed. This white paper outlines the Auto-ID Center's key conclusions and research progress after its first year of research.

Integrating Ubiquitous Analytics in Real-Time with Data, Information, Application



From an office in Shenzen, China, you log on a SDR reader in a warehouse in USA, to check if your products arrived on-time. They did. You also get to know that your distributor in Santiago, Chile and retailer in Espoo, Finland also checked the delivery status, moments before you logged on.

SDR Data Interrogators as Ubiquitous Internet Appliances in IoT (2003)

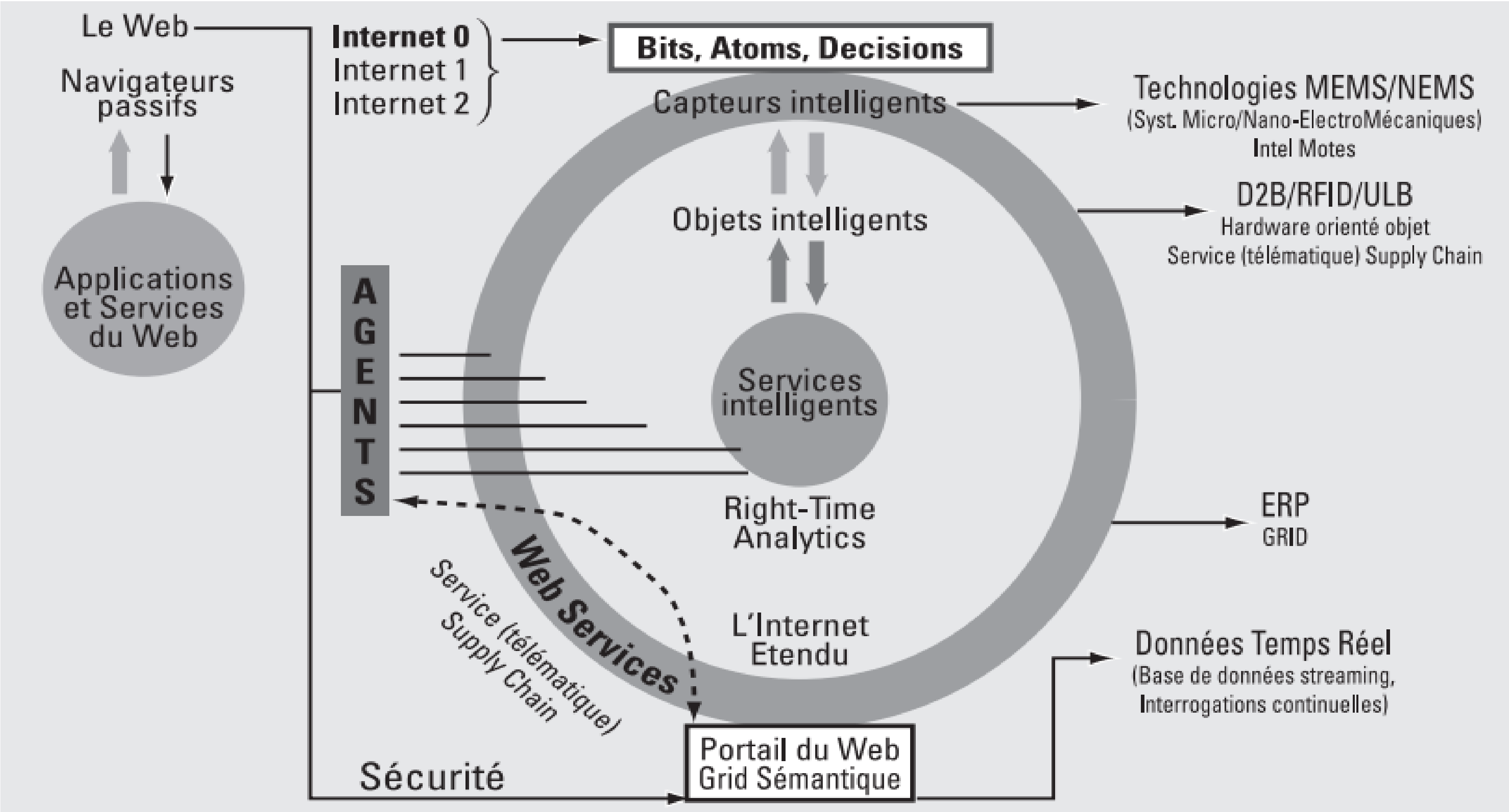
2004

ADAPTER, OPTIMISER, PRÉVOIR
La convergence des concepts, des outils, des technologies et des normes peut-elle accélérer l'innovation ?

Dr Shoumen DATTA
Chercheur, Département Ingénierie des Systèmes, Forum pour l'Innovation dans la chaîne logistique
Directeur général de l'Ecole d'Ingénierie, Massachusetts Institute of Technology

MIT DSpace http://hdl.handle.net/1721.1/41907

Figure 3 : Pour l'émergence de systèmes décisionnels adaptifs, il est nécessaire de mettre en communication bits, atomes et décisions.



Depuis un bureau à Shinzen en Chine, vous vous connectez à un lecteur SDR situé dans un entrepôt aux Etats-Unis de manière à vérifier si vos produits sont arrivés en temps voulu. Ce fut le cas. Vous allez aussi apprendre que votre distributeur à Santiago du Chili et votre détaillant à Espoo en Finlande ont eux aussi vérifié où en était la livraison quelques instants avant vous

MIT DSpace - http://hdl.handle.net/1721.1/41907

Think Transformation

Precision Farming – Converging IoS Ecosystems – Fertilizer, Salinity, Water

The potential convergence of Precision Farming ecosystem

- Seed to Mouth (S2M)
- Farm to Fork (F2F)

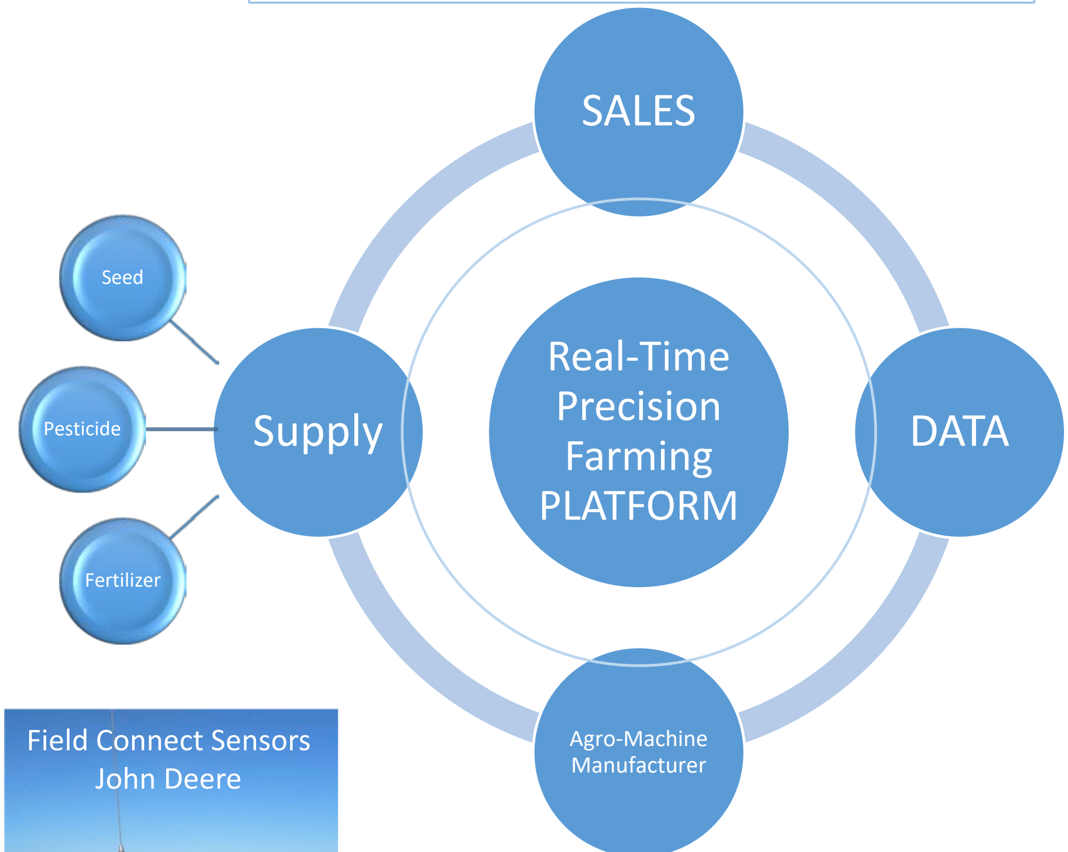
with other ecosystems, such as:

- Smart Cities
- Autonomous Transportation and operations management for trusted and secure supply chain network of partners.

Compliance with SOX-409 type regulations and DHS e-manifest are a part of this scenario. Additional links to energy and environmental systems are also obvious. Food safety, security, nutrition, availability and consumption are inextricably linked with global health, malnutrition, infant mortality and healthcare, in general.

Farming in California alone is a $50 billion industry

Retail Supply Chain – Sourcing / Distribution / Warehouse / Transportation
Track & Trace – Commodity Traders – Risk Management – Regulators (FDA)



-Measure, understand and apply
-Impact of data on quality & yield

-Weather data
-GPS micro-localization data
-Soil chemistry (GCMS) specifics
-Seed (sterile unless cultivated)
-Fertilizers (catalytic vs toxicity)
-Protection (pesticide, herbicide)
-Storage, shelf-life and waste
-Country of origin - goods supply

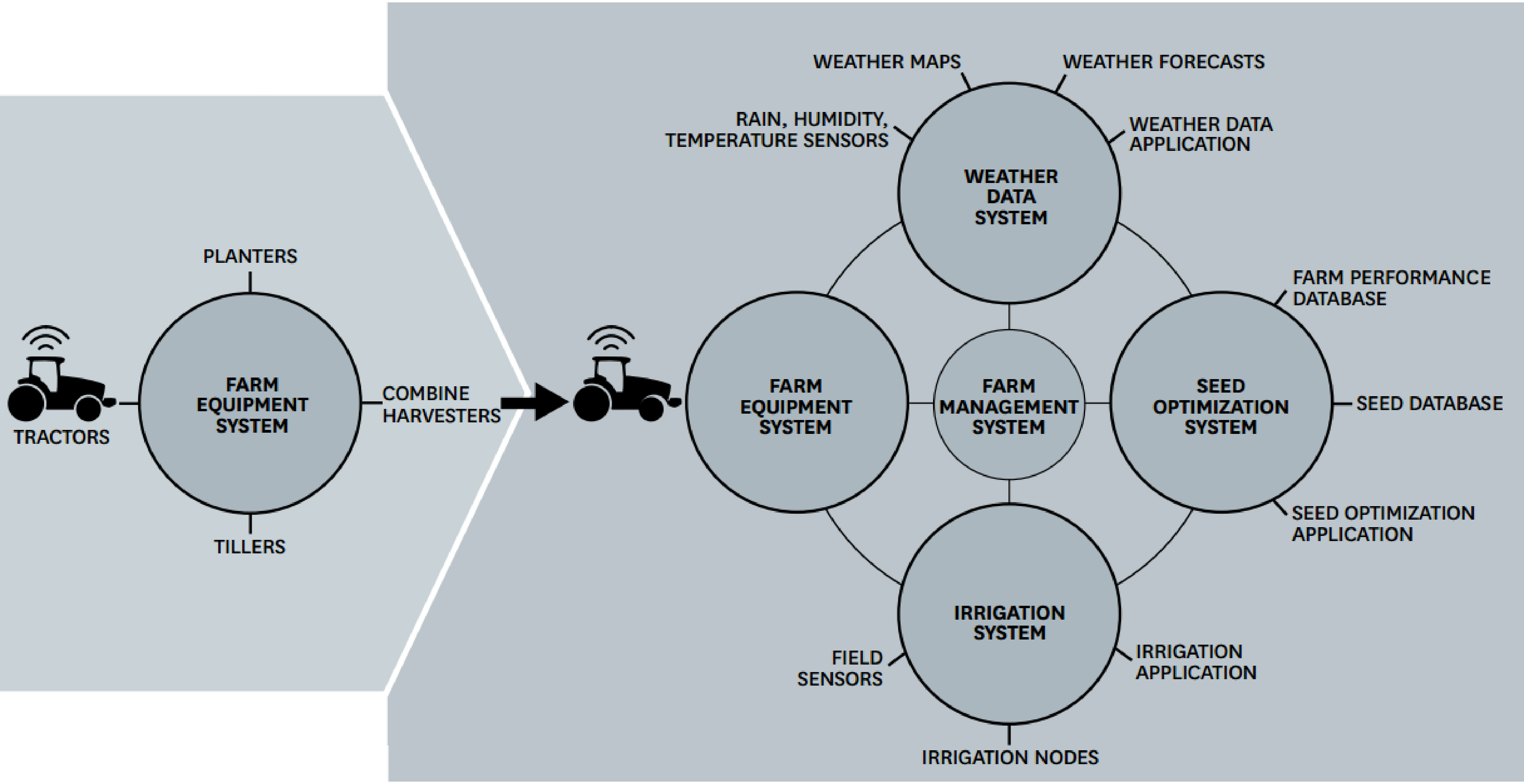
Leverage data to run long and short term simulations to plan for "what if" to optimize profit
- Weather patterns
- Demand uncertainty
- Export and import
- Tariff, cost, excise
- Regulatory policy

Field Connect Sensors
John Deere

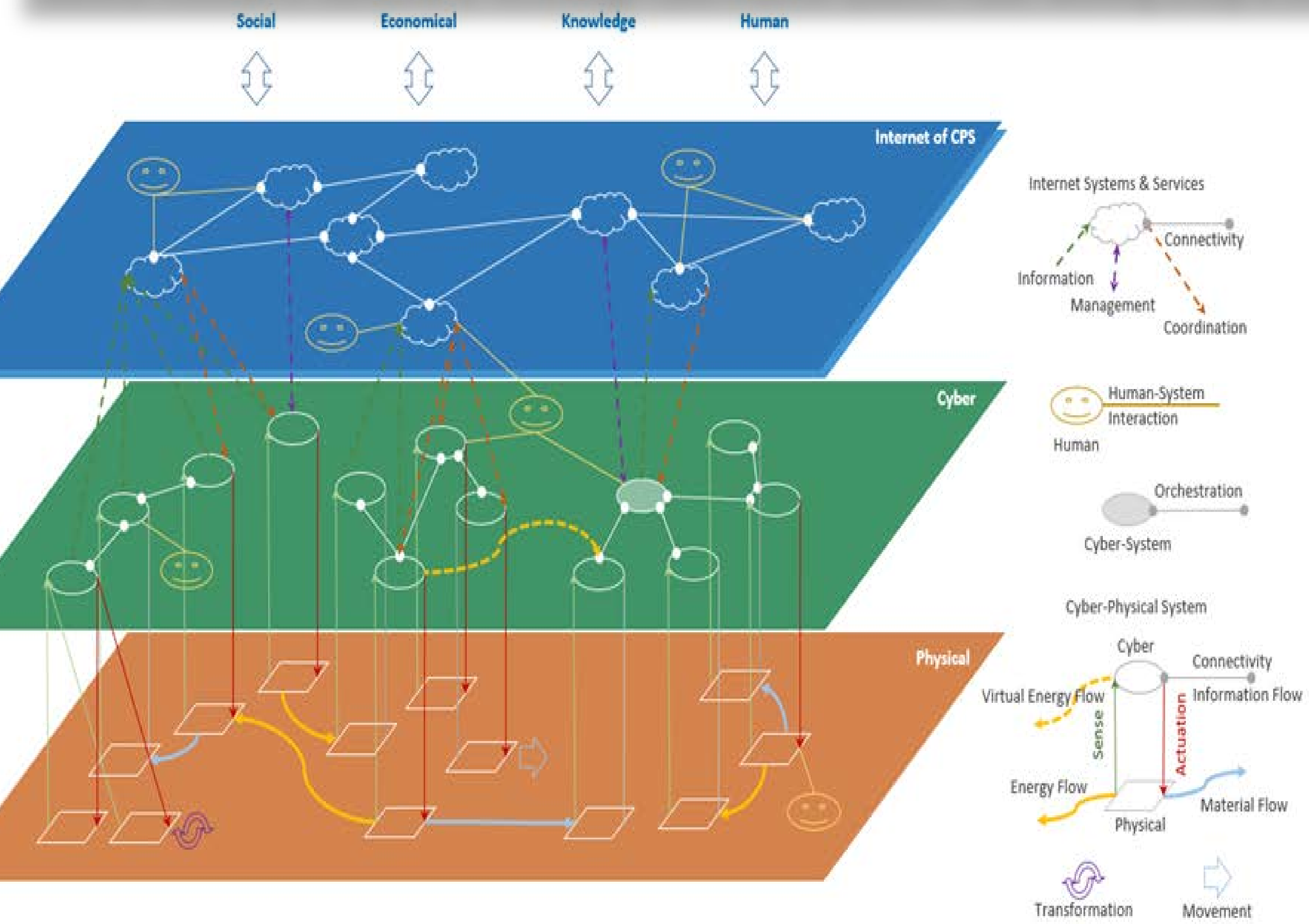
- Optimize MRO to improve asset uptime
- Mobile data collection and dissemination
  - soil sample / nutrient analysis (GCMS)
  - moisture monitors / field connect data
  - temperature / dielectric constant
  - color and chemistry of crops
  - growth rate / fertilizer distribution
  - weather micro-impact / acidity-alkalinity

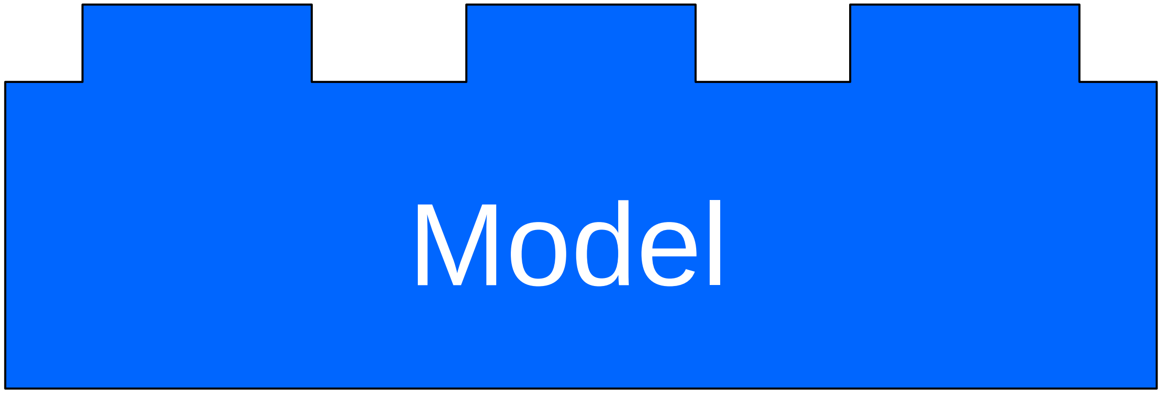
NASA Soil Moisture Active Passive (SMAP)

Classical Agricultural System of Systems

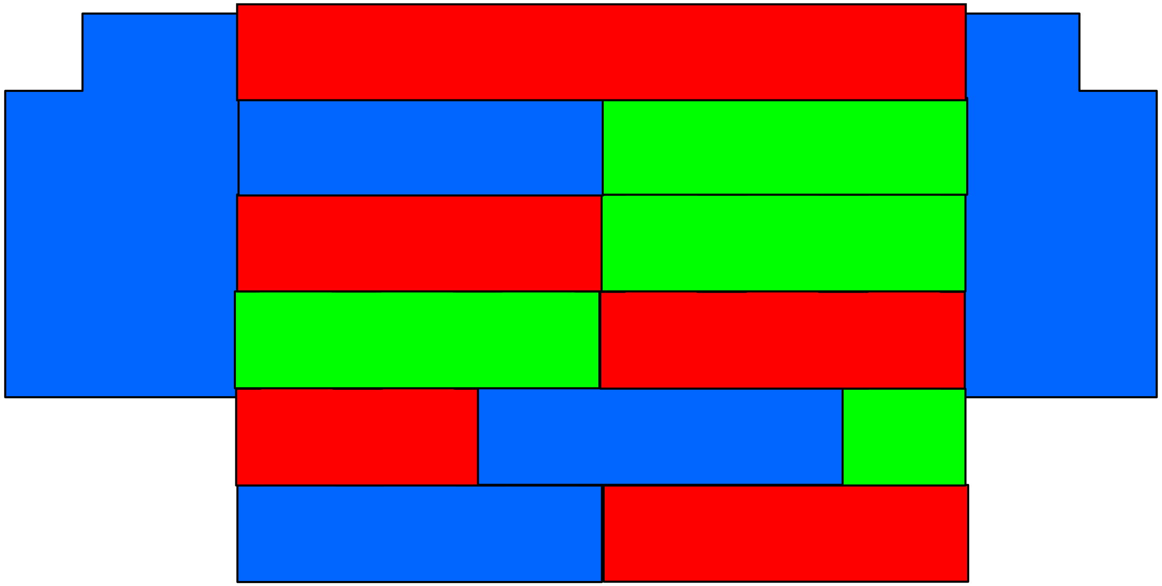


http://bit.ly/HBR-IoT-PDF

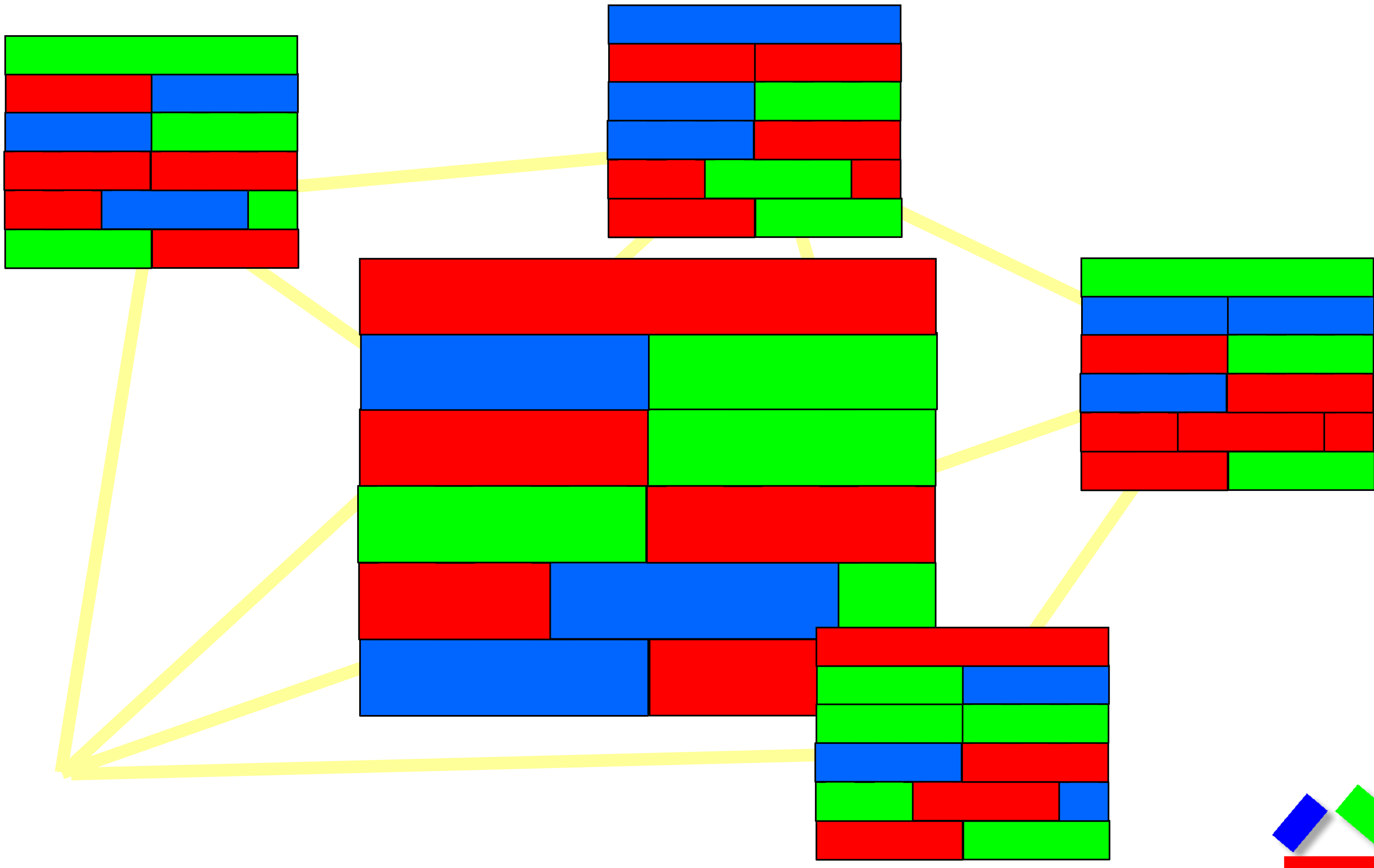

Social
Economical
Knowledge
Human
Internet of CPS
Cyber
Physical
Internet Systems & Services
Connectivity
Information
Management
Coordination
Human-System
Interaction
Human
Orchestration
Cyber-System
Cyber-Physical System
Cyber
Connectivity
Virtual Energy Flow
Information Flow
Sense
Actuation
Energy Flow
Material Flow
Physical
Transformation
Movement


Model

Software Defined Architecture - Modularity, Integration, Interoperability



Modular Architecture – Networks, System of Systems, Global Integration



POTENTIAL FOUNDATIONAL STEPS for ENTERPRISE EVOLUTION

OUTCOME

Translational Engineering

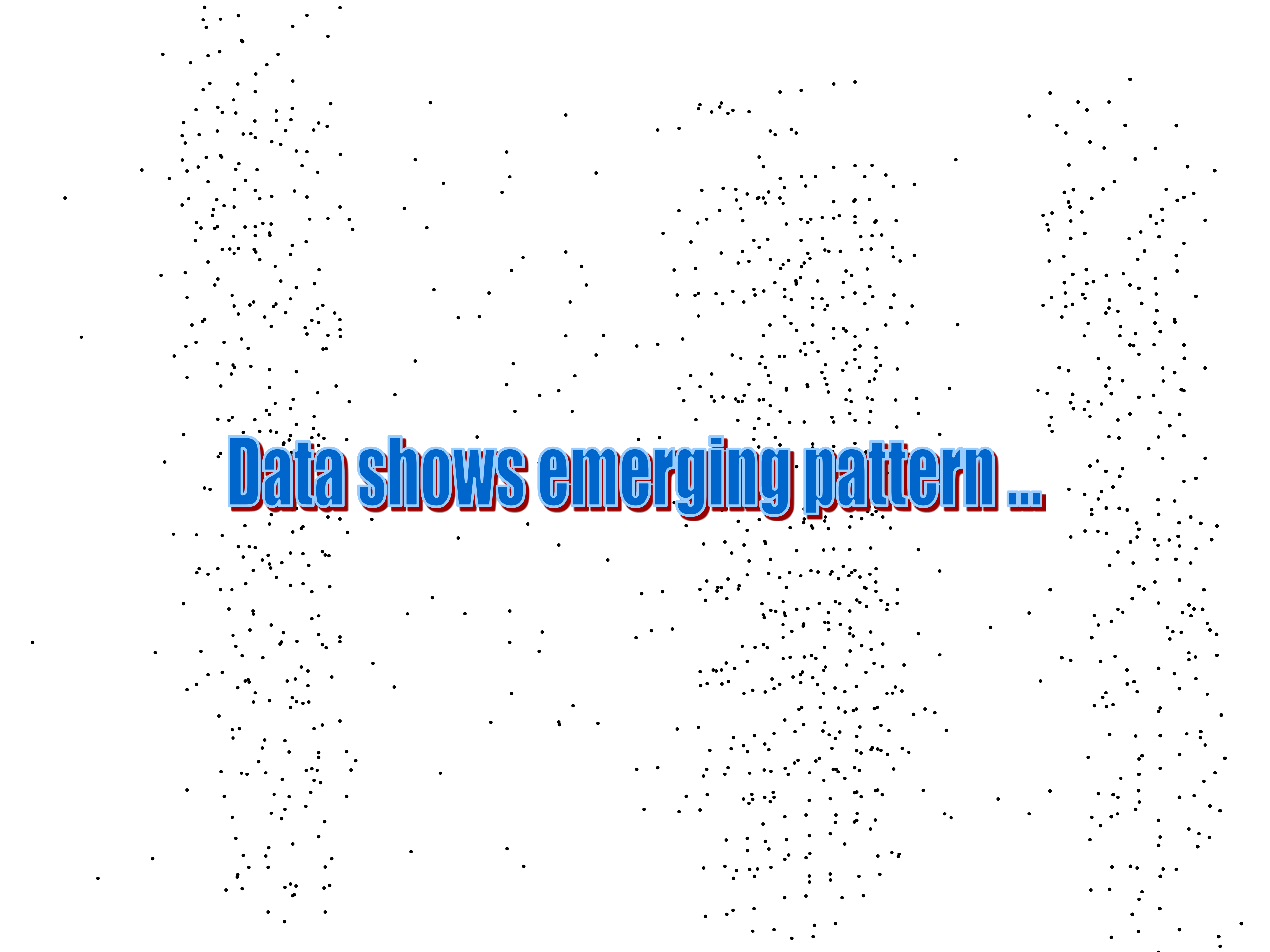
IT IS NOT A ROADMAP. IT IS A COMPASS. IT IS A CONTINUUM.

You can't build an elephant using the mouse as a model

Necessitates industry partnerships and innovation to create products and services which can harvest R&D efforts and lead to economic growth ie profitability.

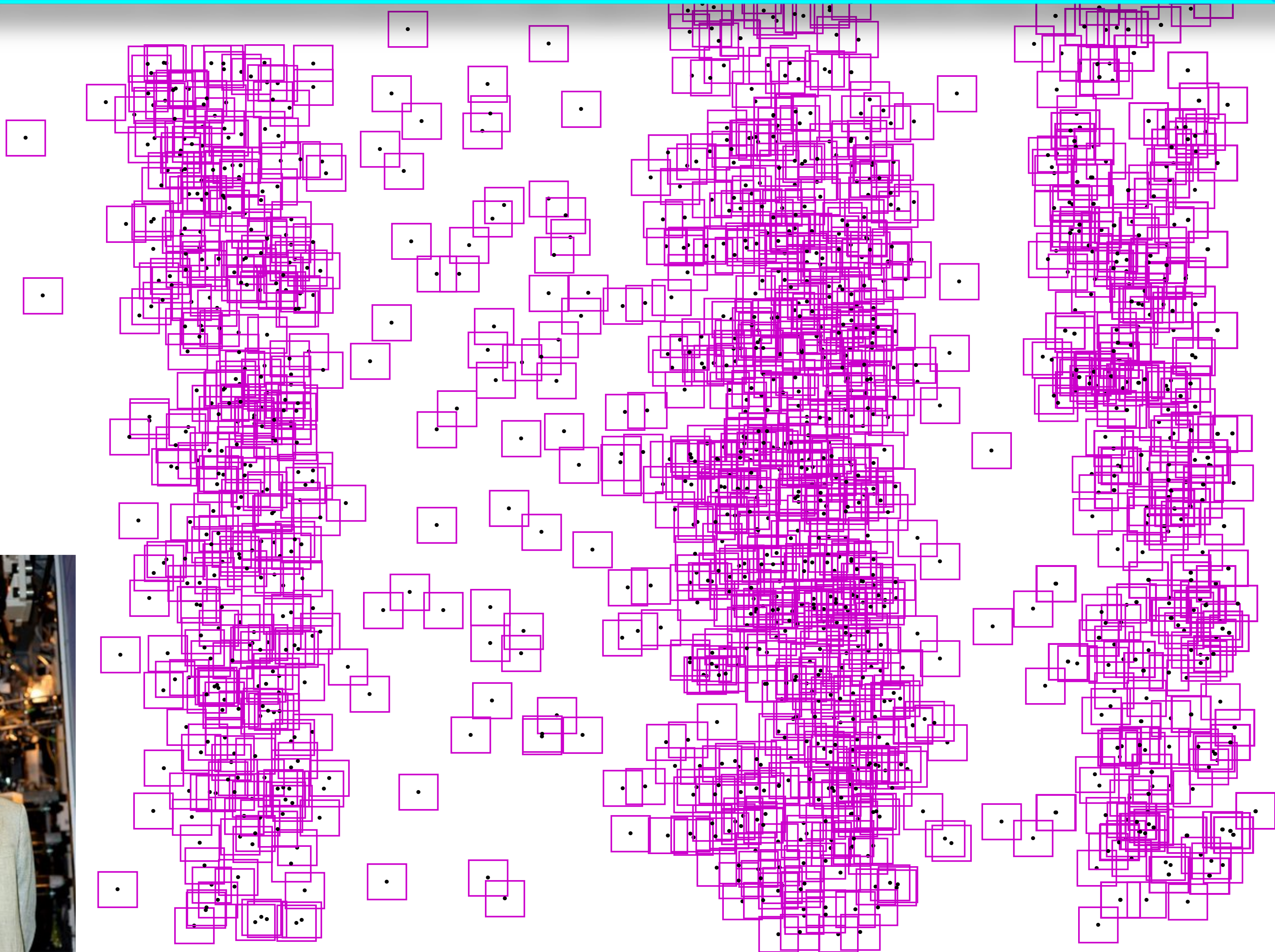
Data …

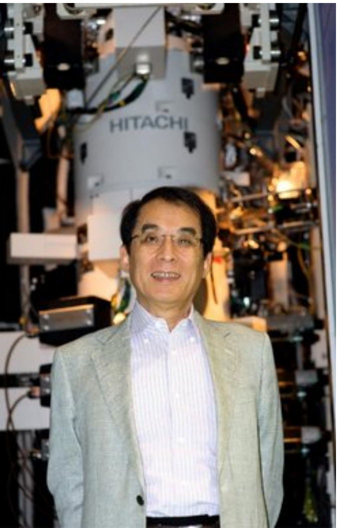

More data points ...


Data shows emerging pattern ...

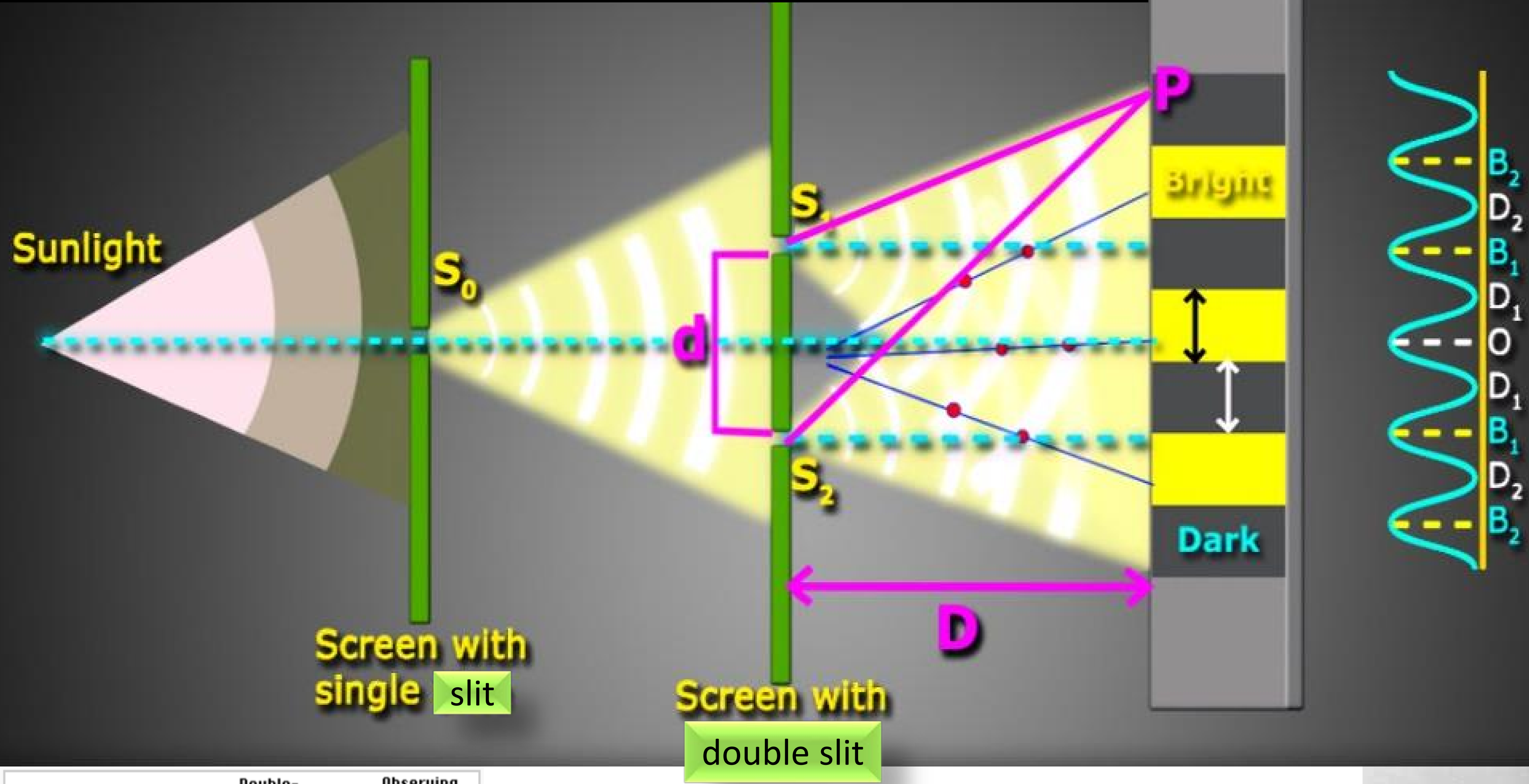
Young’s Double Slit Experiment with Electrons

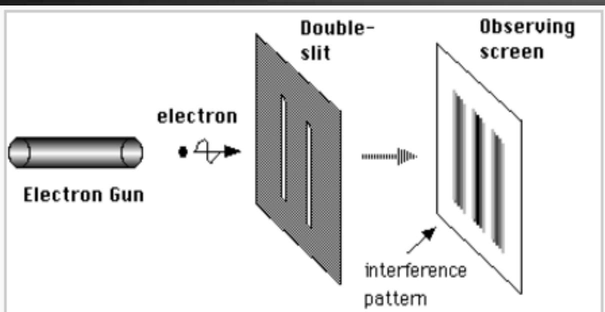
Dr. Akira Tonomura, Hitachi Research Laboratories, 1-280, Higashi-Koigakubo, Kokubunji-shi, Tokyo 185-8601, Japan



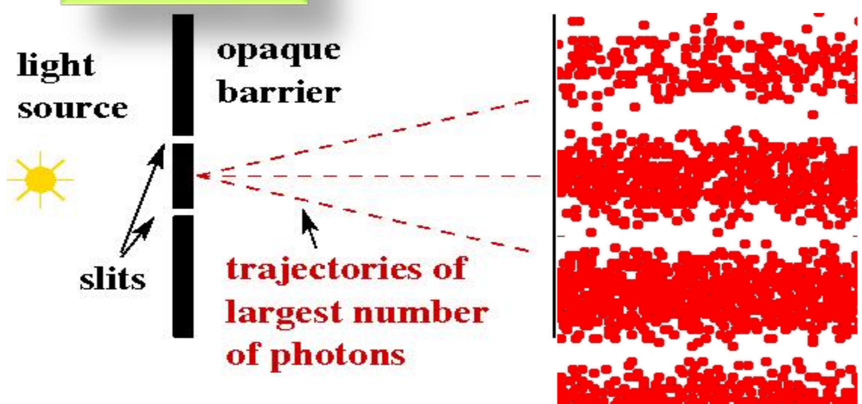


http://blogs.scientificamerican.com/guest-blog/what-does-the-new-double-slit-experiment-actually-show/





Photons or particles of matter (like an electron) produce a wave pattern

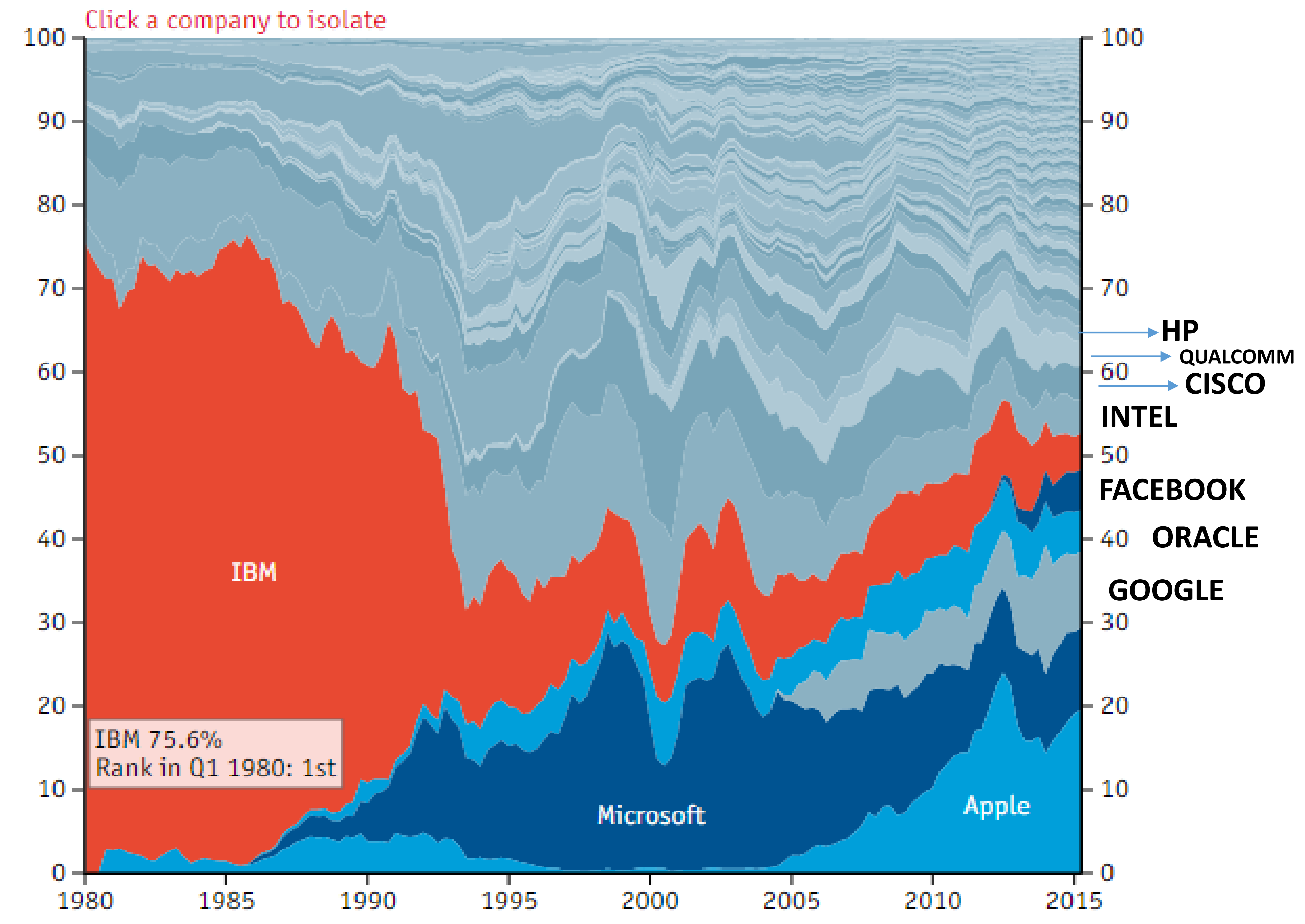


Transform ideas into reality

OUTCOME

5 MB hard drive being shipped out of IBM (1956)

2 TB hard drive slightly larger than a credit card (2015)



Sources: Thomson Reuters; *The Economist*

*As of Q2 2015

> $ 2.1 Trillion

< $0.4 Trillion

Digital Transformation

Autonomy and Algorithms are inextricably linked with

Data Economy

Transportation - Automobiles and Aviation

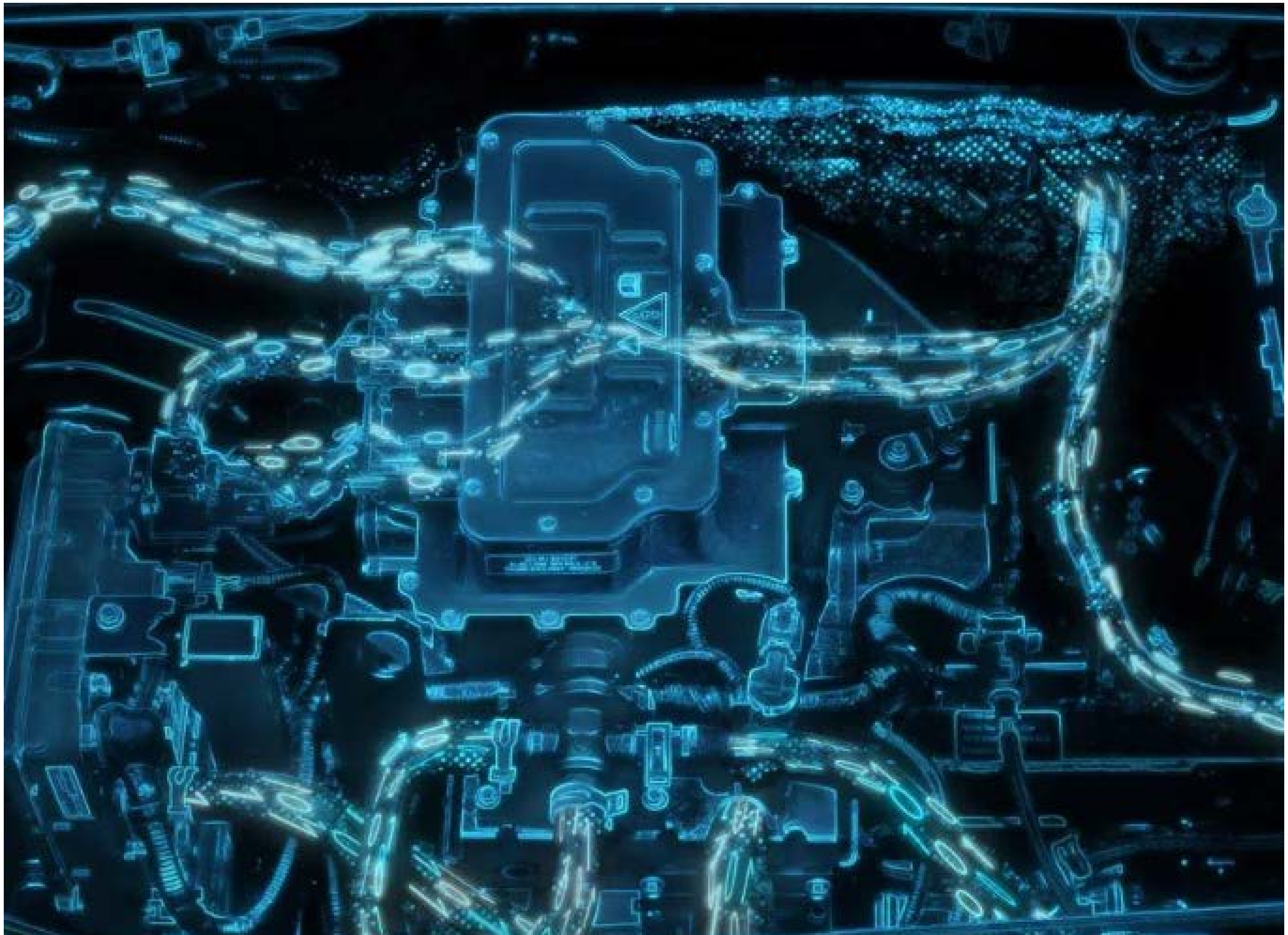
Smart Cities (Sensor Networks)

Automobile Manufacturers in Quest of Silicon Valley

Equal to about a dozen HD movies and exceeds storage capacity of most smartphones

https://qz.com/344466/connected-cars-will-send-25-gigabytes-of-data-to-the-cloud-every-hour/

Connected cars will send 25 gigabytes of data to the cloud every hour



Cost of 3G (2013) vs 3G/4G (2016) US Data Plans

Bandwidth (Gb)	AT&T	Verizon	Sprint	T-mobile
.5				$20
1				
2				
2.5				$30
3			$34.99	
4	$30	$30		
4.5				$40
6	$40	$40	$49.99	
6.5				$50
8		$50		
8.5				$60
$\boxed{10}$	$\boxed{\$60}$	$\boxed{\$60}$		
10.5				$70
12		$70	$79.99	
14		$80		
15	$90			
16		$90		
18		$100		Not Available
20	$110	$110		
30	$185	$185		
40	$260	$260		
50	$335	$335		

Affordability	B+	C	A+
1GB - 1.5GB			
2GB - 3GB	$40		$20
4GB - 5GB	$50	$50	
6GB - 7GB	$60	$70	$35
8GB	$70		
$\boxed{10GB}$	$\boxed{\$80}$	$\boxed{\$90}$	$50
12GB	$90		

http://www.toptenreviews.com/services/internet/best-mobile-broadband-providers/

Autonomous car data

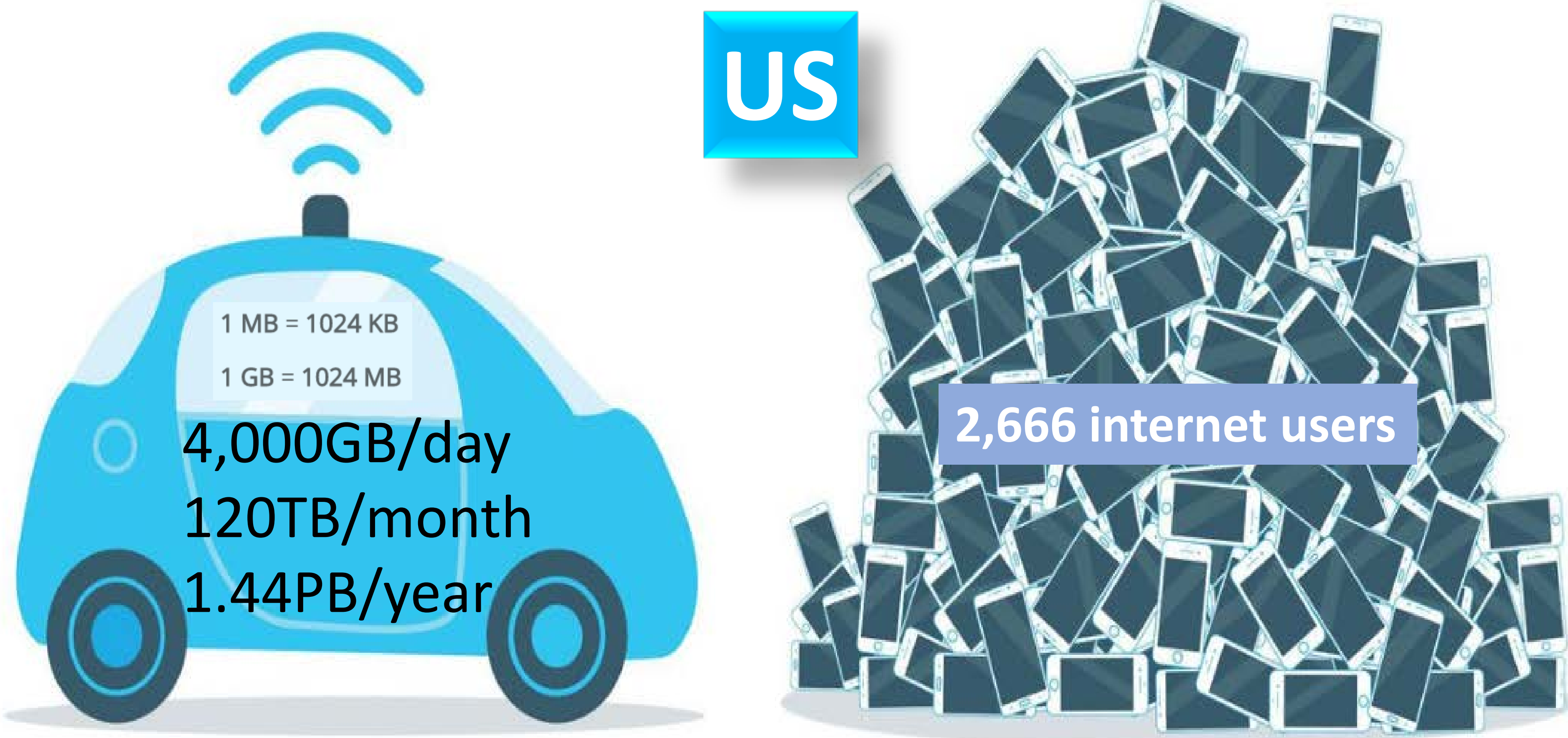
In 2020, the average autonomous car may process 4,000 gigabytes of data per day, while the average internet user will process 1.5 gigabytes.

1 autonomous car = 2,666 internet users

Autonomous car data $12.41 million per car per year

In 2020, the average autonomous car may process 4,000 gigabytes of data per day, while the average internet user will process 1.5 gigabytes.

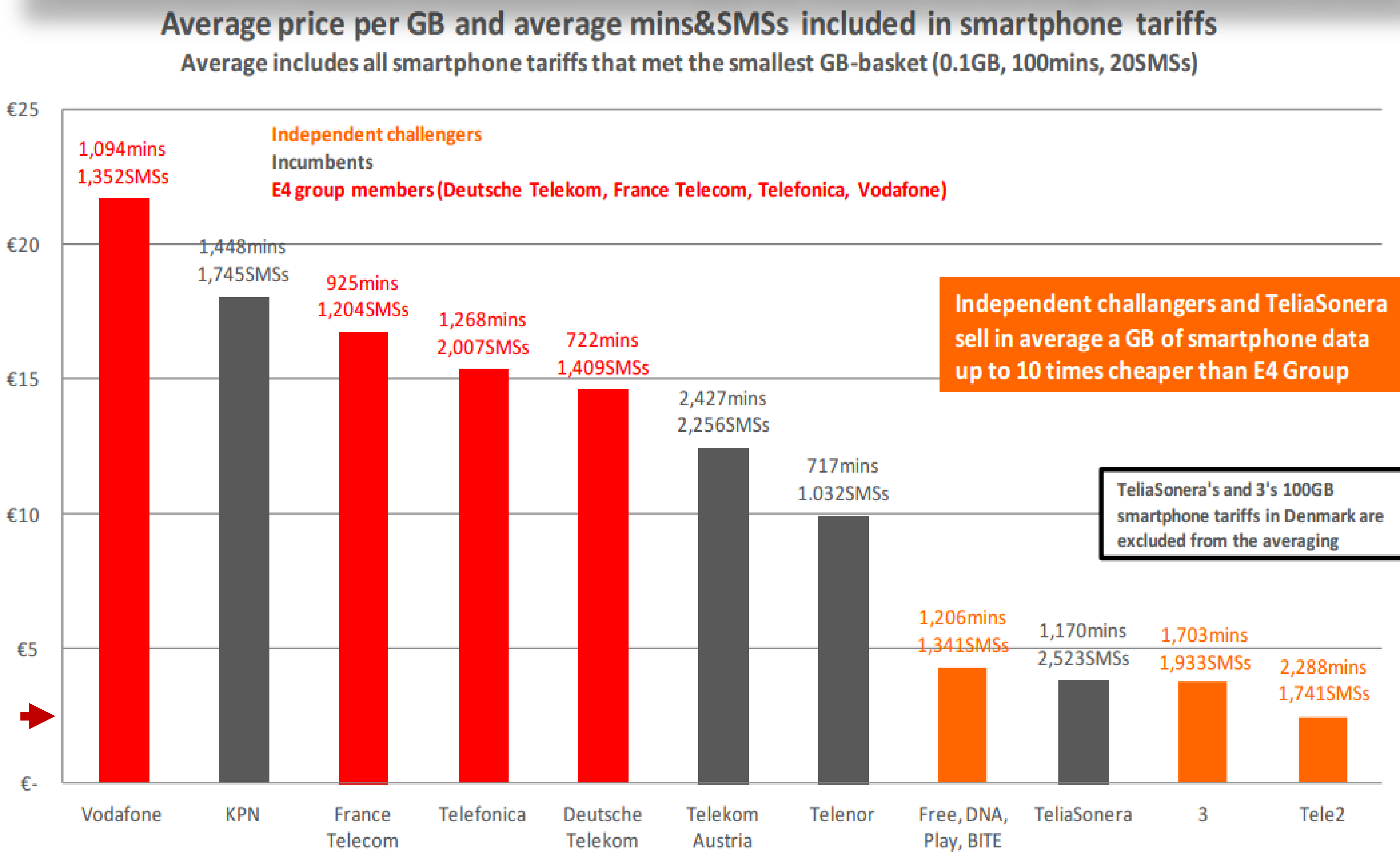
2016 US Data Plans 10 GB data (per month) = $85 or 2% of GNI per person



African fixed broadband prices are, on average, 64% of GNI per capita

www.oafrica.com/broadband/african-internet-and-broadband-facts-from-measuring-the-information-society-2013-report/

Lowest cost of Mobile Broadband in EU approx. US$26.30/GB (highest US$231.4/GB)



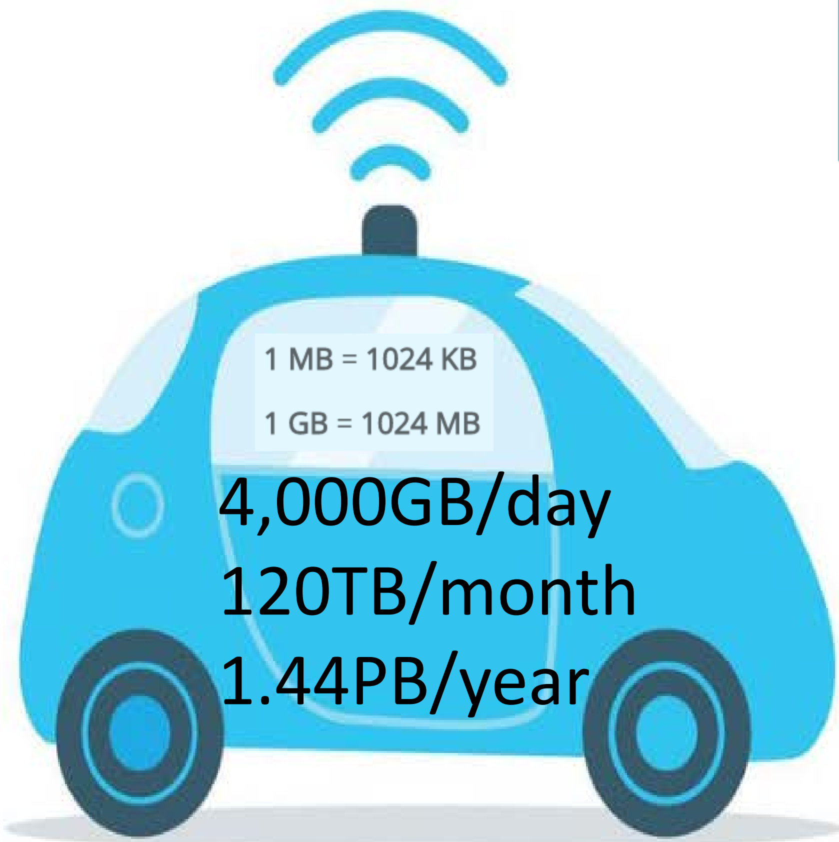
https://ec.europa.eu/digital-single-market/en/news/mobile-broadband-prices-europe-2016
http://www.rewheel.fi/downloads/Rewheel_EU27_mobile_data_cost_competitiveness_report_May_2013_FINAL.pdf

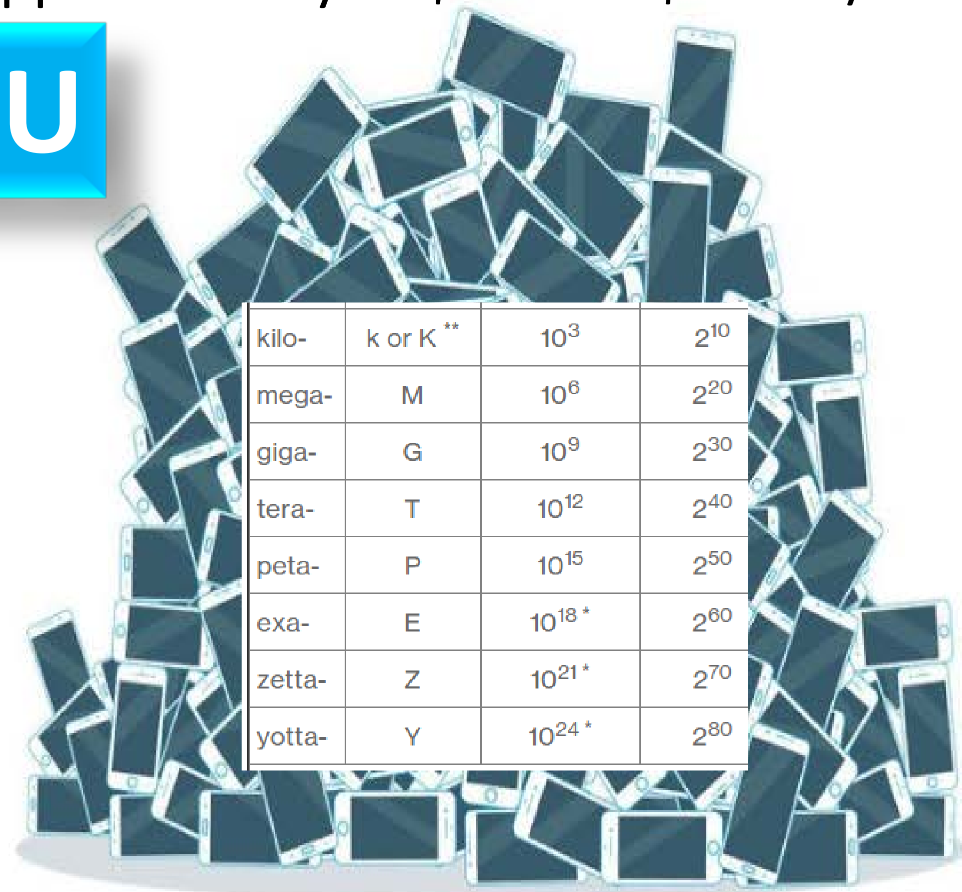
Autonomous car data $38.40 million per car per year

In 2020, the average autonomous car may process 4,000 gigabytes of data per day, while the average internet user will process 1.5 gigabytes.

Lowest cost of 0.1GB data in EU27 approximately US$2.63 or $26.30 / GB

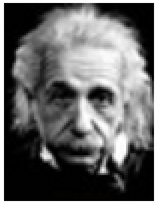
EU





kilo-	k or K **	10^{3}	2^{10}
mega-	M	10^{6}	2^{20}
giga-	G	10^{9}	2^{30}
tera-	T	10^{12}	2^{40}
peta-	P	10^{15}	2^{50}
exa-	E	10^{18} *	2^{60}
zetta-	Z	10^{21} *	2^{70}
yotta-	Y	10^{24} *	2^{80}

1 autonomous car = 2,666 internet users



"We can not solve our problems with the same level of thinking that created them"

Autonomous Vehicles

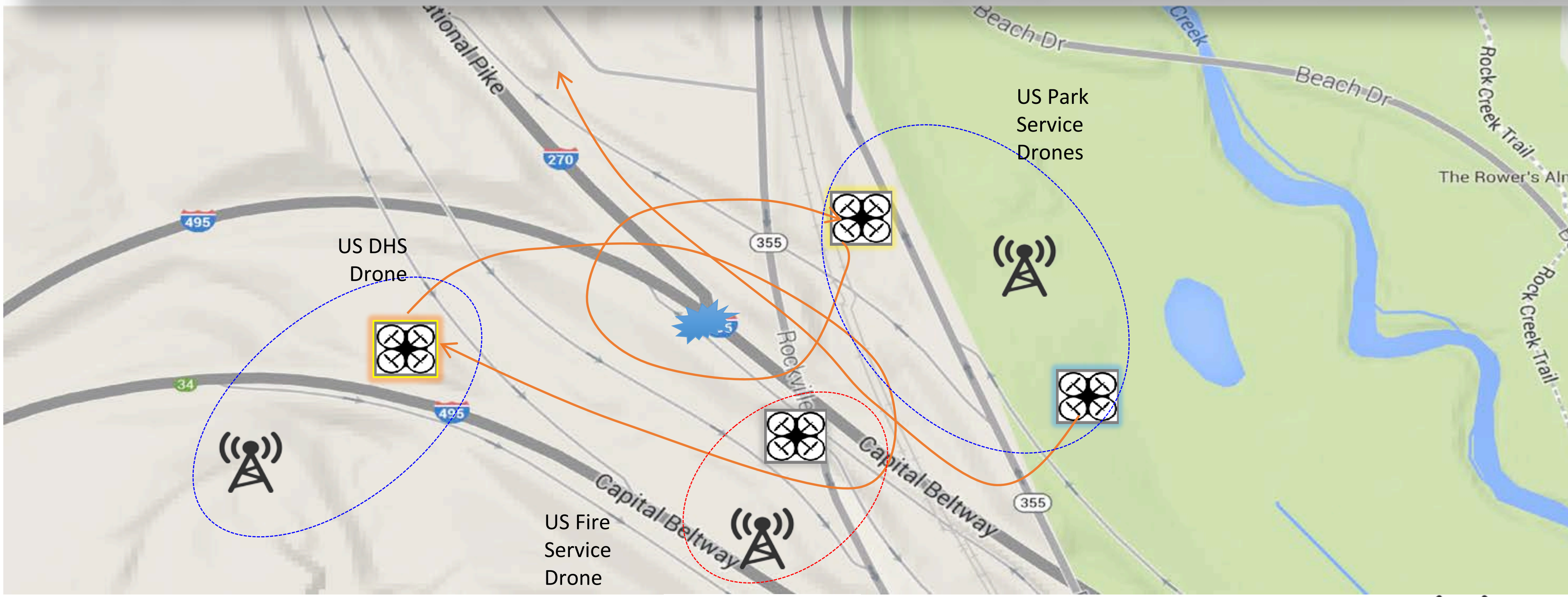
NEW tools, NEW technologies, NEW economic models, NEW transaction cost structures, NEW digital businesses, NEW engineering design, NEW computational paradigms

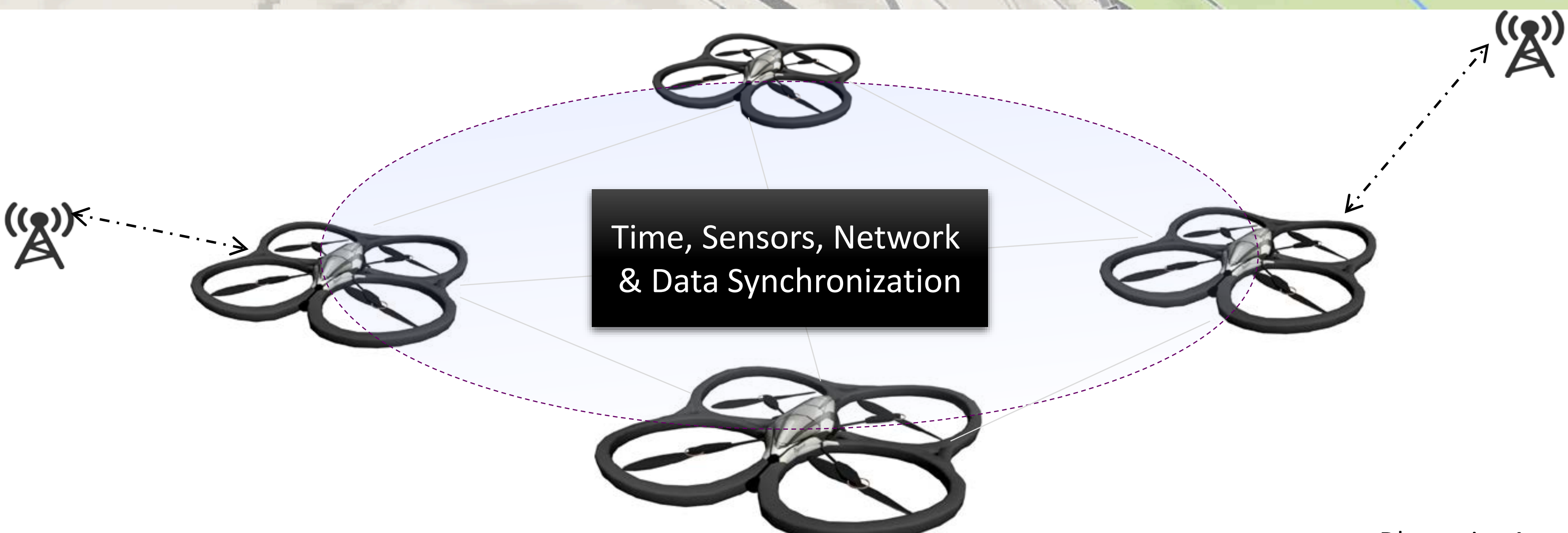
The NEW normal – SERVICES – not products

Adoption (of autonomous cars) is unrelated to cost of product (car) but determined by the cost of essential services (zero latency, mobile computation, connectivity, cybersecurity, energy recharge)

Transportation Coordination - Emergency “Crash to Care” Response

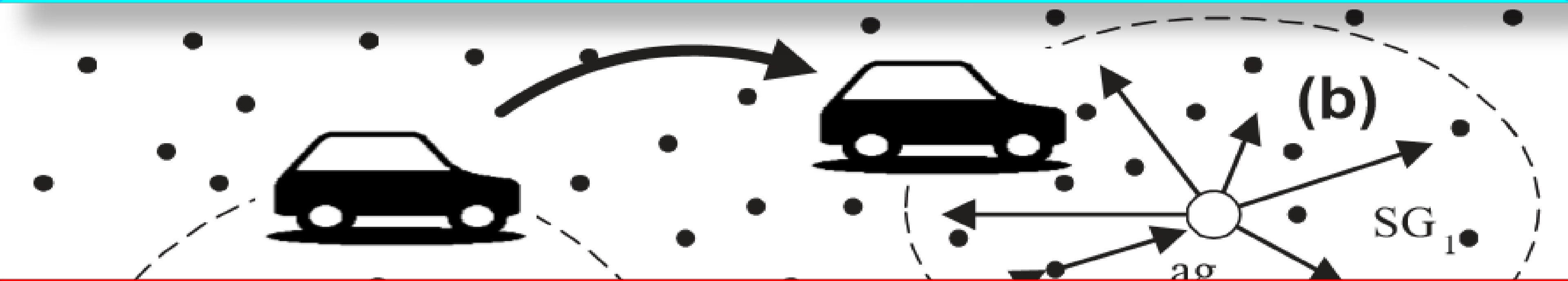
Transportation of real-time data key to emergency search and rescue drones





Dhananjay Anand, NIST

WSN In-Network Processing



EDGE INTELLIGENCE

Eyeriss: An Energy-Efficient Reconfigurable Accelerator for Deep Convolutional Neural Networks

EYERISS

THE MOBILE RULE

EDGE DEVICE

PRESS RELEASE

JANUARY 9, 2007

Apple Reinvents the Phone with iPhone

MACWORLD SAN FRANCISCO—January 9, 2007—Apple® today introduced iPhone, combining three products—a revolutionary mobile phone, a widescreen iPod® with touch controls, and a breakthrough Internet communications device with desktop-class email, web browsing, searching and maps—into one small and lightweight handheld device. iPhone introduces an entirely new user interface based on a large multi-touch display and pioneering new software, letting users control iPhone with just their fingers. iPhone also ushers in an era of software power and sophistication never before seen in a mobile device, which completely redefines what users can do on their mobile phones.

"iPhone is a revolutionary and magical product that is literally five years ahead of any other mobile phone," said Steve Jobs, Apple's CEO. "We are all born with the ultimate pointing device—our fingers—and iPhone uses them to create the most revolutionary user interface since the mouse."

c. Apple and the inevitable communication convergence

Atoms to Bits

Published by TEKES 2005
Government of Finland
Pages 44-45

20 million visitors to Apple's website in October 2005 do not signal a revival of the PC buying craze, if ever there was one. Doubling of unique visitors since October 2004 suggest that the lure of the Apple may be in the flavour of the iPod du jour. Hence, the PC assembler and interface innovator (Apple Inc) is blurring the compartmentalization along industry lines in ways that earlier device manufacturers (Sony, Phillips) failed to penetrate. Apple did not stop at providing the receptacles for music, video and movies (iPod) but has organized services (iTunes, iMovies) that shall continue to prod Mr Steve Jobs to make frequent visits to the bank, online, of course. In other words, it is a rehash of the old system where you get the telephone for free but pay for services or the reason why Xerox is eager to offer you a discount on the purchase of a photocopier only to sell you products with high profit margins (ink cartridges, paper). The uncanny innovator in Mr Jobs has extracted the service model through iTunes and may be poised to compete with the likes of Nokia or NTT DoCoMo. Skype-like features in an IPv6 enabled iPod will come with built-in 802.11g, 802.15.4 and 802.16 features (WiFi, Zigbee, WiMax) but aesthetically engineered to expose the crème

Prediction
iPhone

https://www.tekes.fi/globalassets/julkaisut/e_business.pdf

Mobile Pay
Apple Pay

de la crème of human-machine interface that is central to Apple's innovation. Wave your iPod.femto at a Marks & Spencer store to compare the price of the "collezione" charcoal grey pure cashmere scarf that you saw at Tie Rack, buy petrol and pay for groceries at Tesco or pause "Sleepless in Seattle" if Mum is Skype-in mode to you.

The iPod of the very near future can hold more than 40 petabytes (40,000,000 gigabytes) of data. But, only 10,000 gigabytes will be needed for the 20 million books in the US Library of Congress. With all that remaining storage capacity why not download all of the nearly 500,000 movies currently available in the world? The irony is that it is not inconceivable that all this is possible but it is truly incredible that these scenarios represent a march of reasonable convergence of innovation at hand and in progress. To see a world in a grain of sand and hold infinity in the palm of your hand is not only the innovation of iPod in action but poetry (of William Blake) in motion as well as locomotion (see figure 26) when the iPod evolves as your secure-car operation platform.

iDrive

https://dspace.mit.edu/bitstream/handle/1721.1/56251

Secure | https://www.youtube.com/watch?v=oHDwKT564Kk

YouTube https://www.youtube.com/watch?v=oHDwKT564Kk

iDriver - iPhone remote controlled car http://autonomos-labs.com/

1,085,536 views 1K 107 SHARE

Appirion
Published on Oct 9, 2009

SUBSCRIBE 476

iDriver is an iPhone application to remote control a car. Go to http://autonomos-labs.com for

2005

Tekes

Technology Review 196/2006
Helsinki 2006

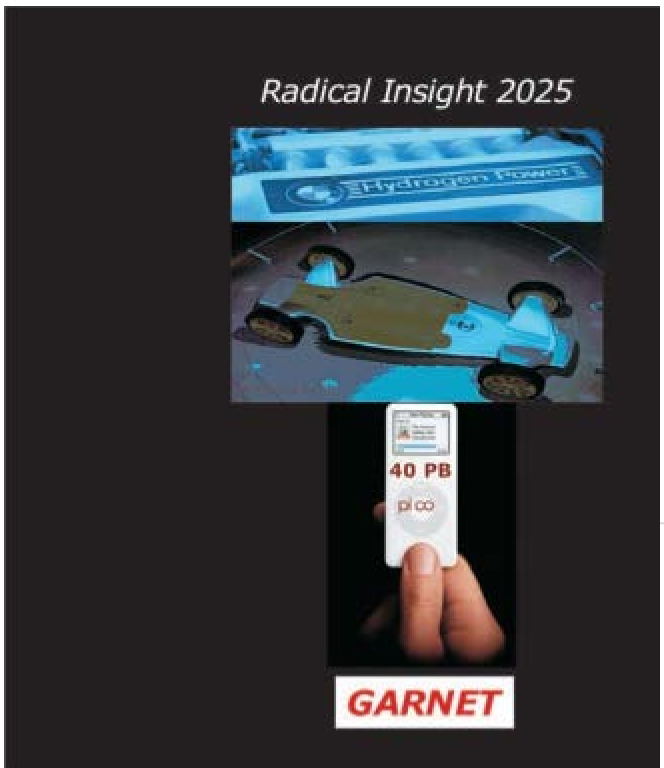
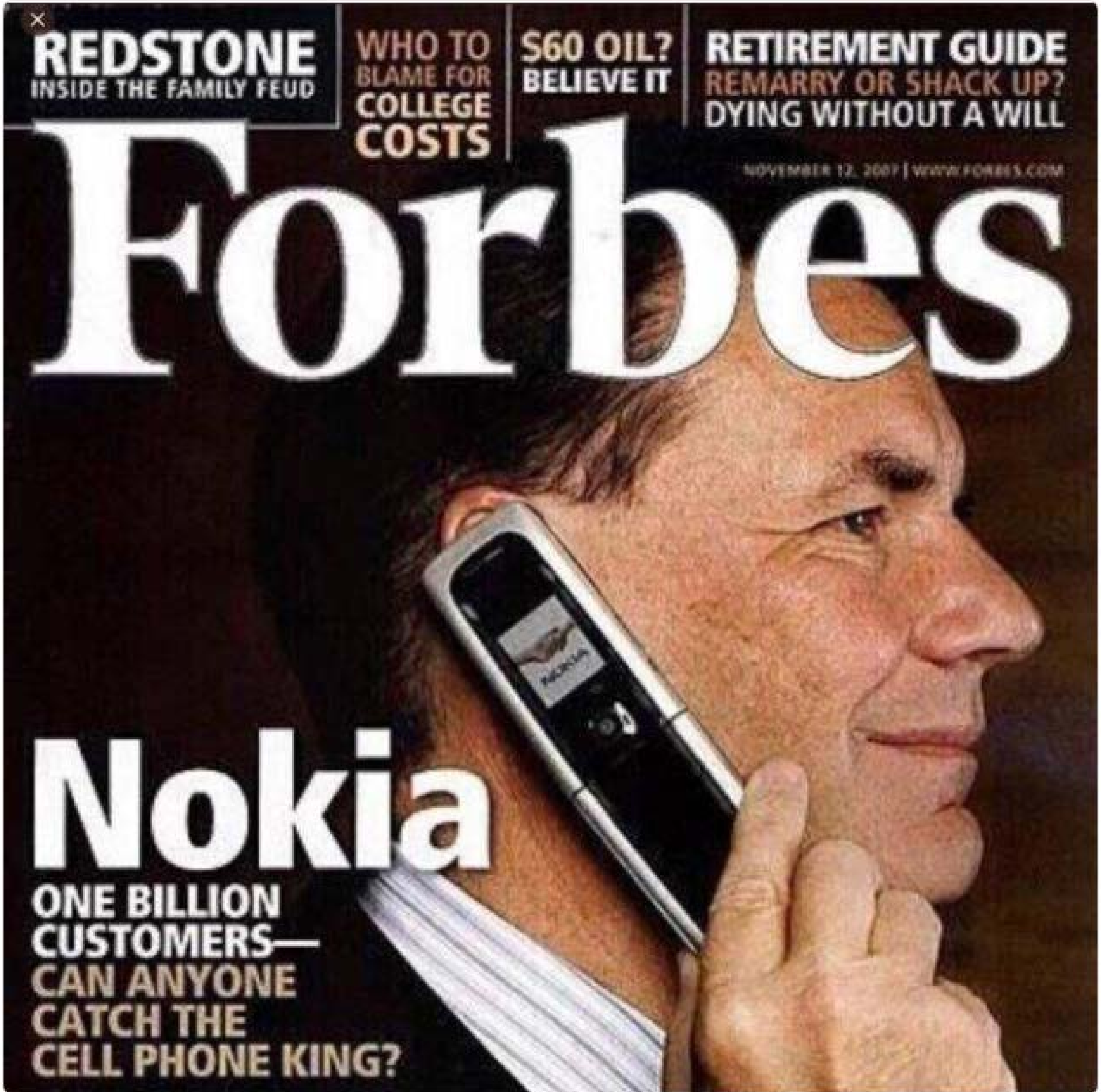


Figure 26. Radical Insight?

POC ● 2009 ● http://bit.do/Smooth-Operator

NOVEMBER 12, 2007



26 OCT 2007

https://www.forbes.com/forbes/2007/1112/048.html

TECH | 10/26/2007 @ 2:00PM

The Next Billion

Nokia covers the globe, but its phones are missing in the U.S., and it's a weakling on the Web. The plan to change all that is afoot.

Every day 900 million people haggle, gossip, flirt, laugh, scream and cry on a Nokia . One day in the next few months Nokia will put a phone into the hands of its billionth customer. McDonald's and Coca-Cola can claim more customers, but the experience they offer is a bit more transient. You don't leave home without your phone. If you judge a brand on influence or reach, Nokia may be the most successful brand in history.

Dominance has been good lately to Nokia. The Helsinki, Finland firm will sell 430 million handsets this year, equal to the combined volume of Motorola , Samsung and Sony Ericsson . Its revenue will grow 30% to $76 billion, with profits (before some one-time items) probably up one-quarter to $7.8 billion. It is number one in each of the fastest-growing markets–China, Southeast Asia and India–and its global sales and manufacturing are so well honed that Nokia takes 80% of the industry's profit on 38% of the volume.

From his sunny conference room five floors above a blue inlet of the Gulf of Finland, Nokia's chief executive, Olli-Pekka Kallasvuo, can't help crowing. "We have the widest portfolio in the industry and the deepest understanding of it, as opposed to having one or two hit products at a time."

Worldwide Mobile Terminal Sales to End Users in 2009 (Thousai

Company	2009 Sales	2009 Market Share (%)	2008 Sales	2008 Market Share (%)
Nokia	440,881.60	36.4	472,314.90	38.6
Samsung	235,772.00	19.5	199,324.30	16.3
LG	122,055.30	10.1	102,789.10	8.4
Motorola	58,475.20	4.8	106,522.40	8.7
Sony Ericsson	54,873.40	4.5	93,106.10	7.6
Others	299,179.20	24.7	248,196.10	20.3
Total	**1,211,236.60**	**100**	**1,222,252.90**	**100**

Table 1 Global LTE Multimode Smartphone Shipments

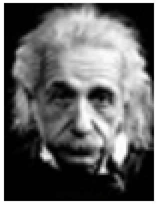
LTE Smartphone Vendor	2011 Shipments	2011 Market Share	1Q12 Shipments	1Q12 Market Share
Samsung	3.33	48.1%	3.28	58.9%
Motorola	0.95	13.7%	0.71	12.8%
LG	0.59	8.5%	0.60	10.8%
HTC	1.92	27.8%	0.53	9.5%
Pantech	0.11	1.6%	0.15	2.7%
Fujitsu/Toshiba	0.02	0.3%	0.1	2.4%
NEC	0.00	0.0%	0.1	1.8%
Nokia	0.00	0.0%	0.1	1.1%
Total (M units)	**6.92**	**100%**	**5.6**	**100%**

2009 Nokia 36.4% market share
2011 Nokia 00.0% market share

Worldwide Smartphone Sales to End Users by Vendor in 1Q17 (Thousands of Units)

Vendor	1Q17 Units	1Q17 Market Share (%)	1Q16 Units	1Q16 Market Share (%)
Samsung	78,671.4	20.7	81,186.9	23.3
Apple	51,992.5	13.7	51,629.5	14.8
Huawei	34,181.2	9.0	28,861.0	8.3
Oppo	30,922.3	8.1	15,891.5	4.6
Vivo	25,842.2	6.8	14,001.0	4.0
Others	158,367.7	41.7	156,654.2	45.0
Total	**379,977.3**	**100.0**	**348,224.2**	**100.0**

Source: Gartner (May 2017)

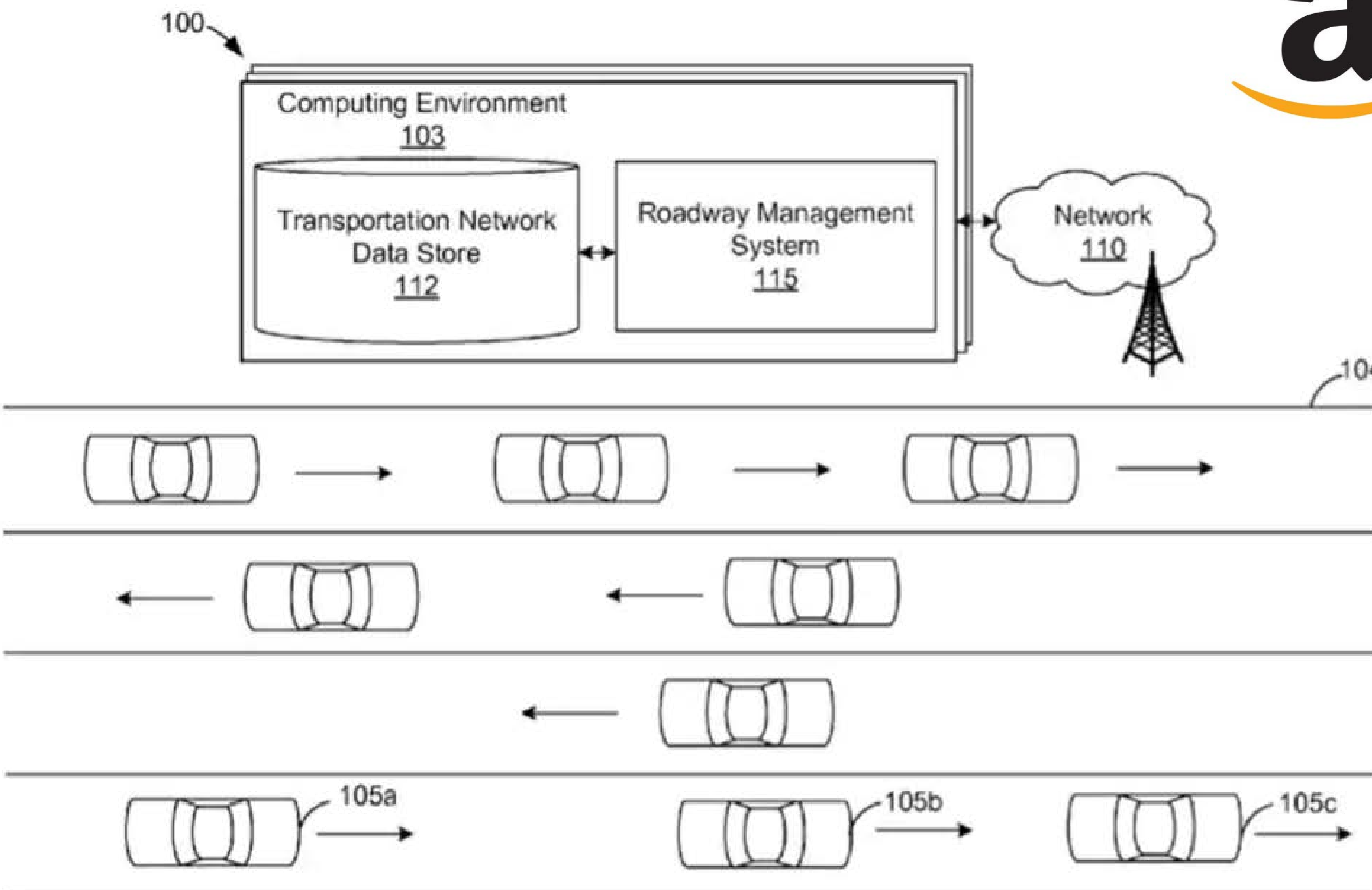


"We can not solve our problems with the same level of thinking that created them"

No large innovation has come from within a system. Tesla didn't come out of the automotive industry. SpaceX didn't come out of Boeing or Lockheed and by the way GM spent millions of dollars trying to do an electric car before Tesla. More money, more resources, more knowledge, too much knowledge. Wal-Mart didn't innovate retail. Amazon did. NBC and CBS didn't innovate media. Facebook, Twitter and YouTube did. Genentech didn't come out of Pharma. It came from a guy who was an associate at Kleiner – Bob Swanson *(in partnership with Herbert Boyer of UCSF).*

http://medcitynews.com/2017/01/vinod-khosla-healthcare-startups-hate/

Reversible lanes pose problem for autonomous cars and trucks, but Amazon has worked out a possible solution

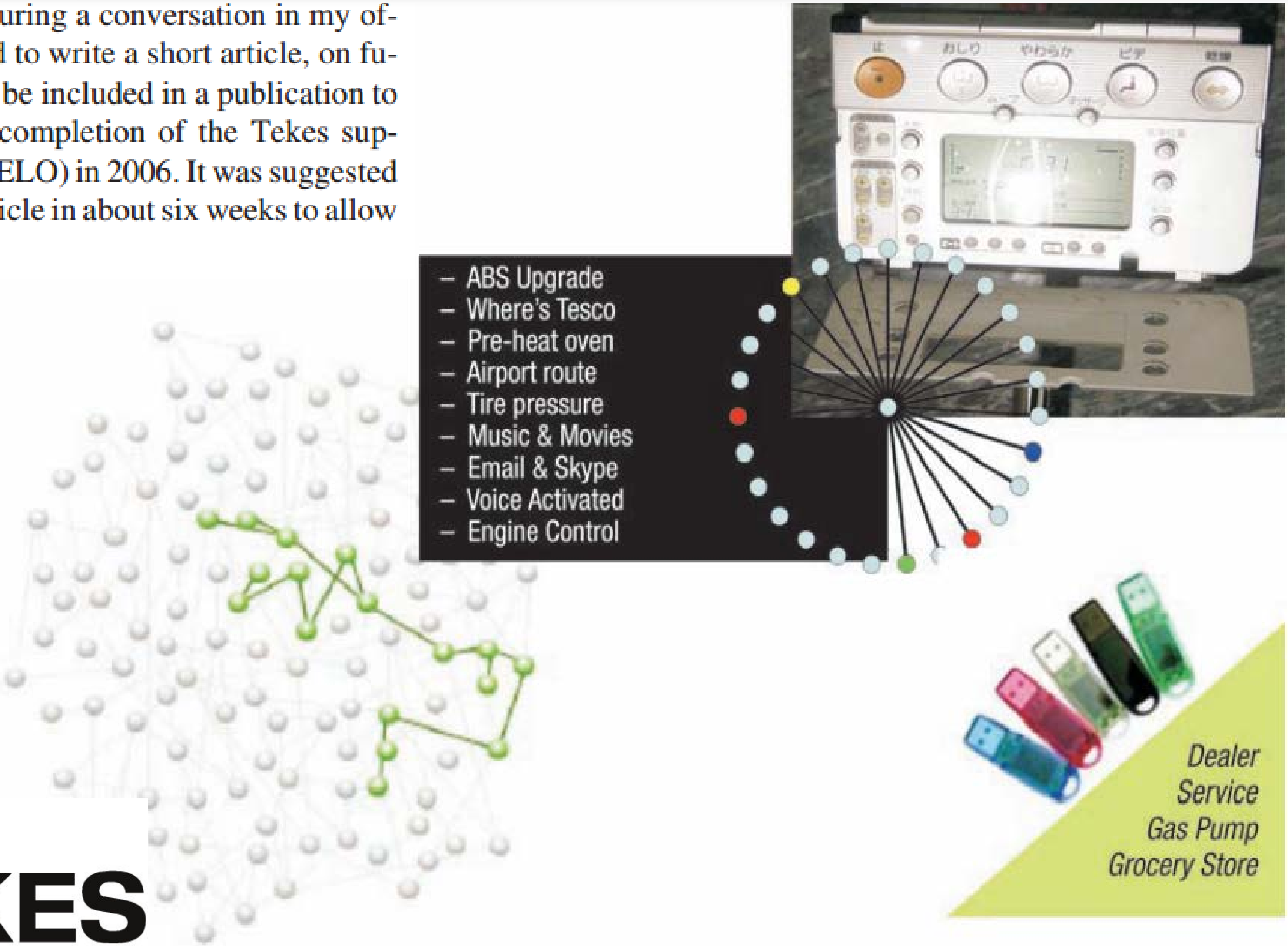


Amazon's self-driving patent proposes a centralised roadway management system that communicates with self-driving cars to help coordinate vehicle movement at a large scale. Photograph: USPTO

2005 – Swap form factor for "atoms" (connect bits, cars, engines, toilets)

12 years later, swappable car batteries are in discussion, but form factor for energy is still large.

On 17th November 2005, during a conversation in my office at MIT, I was requested to write a short article, on future trends in e-business, to be included in a publication to accompany the successful completion of the Tekes supported e-logistics program (ELO) in 2006. It was suggested that I send the completed article in about six weeks to allow for translation in Finnish.



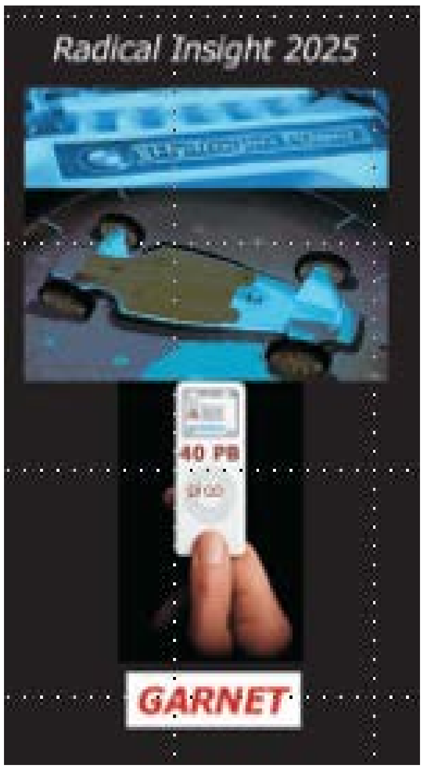
TEKES

2006 Paradigm Shift in Interoperability? https://dspace.mit.edu/handle/1721.1/56251

Swap "atoms" form factor

19. Wigner E. and Huntington H.B. On the possibility of a metallic modification of hydrogen. *J. Chem. Phys.*, 1935, v.3, 764–770.

12 years ago, the idea was of "portability" of atoms [eg: running your car on (metallic) hydrogen]



S. Datta, published (by TEKES in 2006)
https://dspace.mit.edu/handle/1721.1/56251

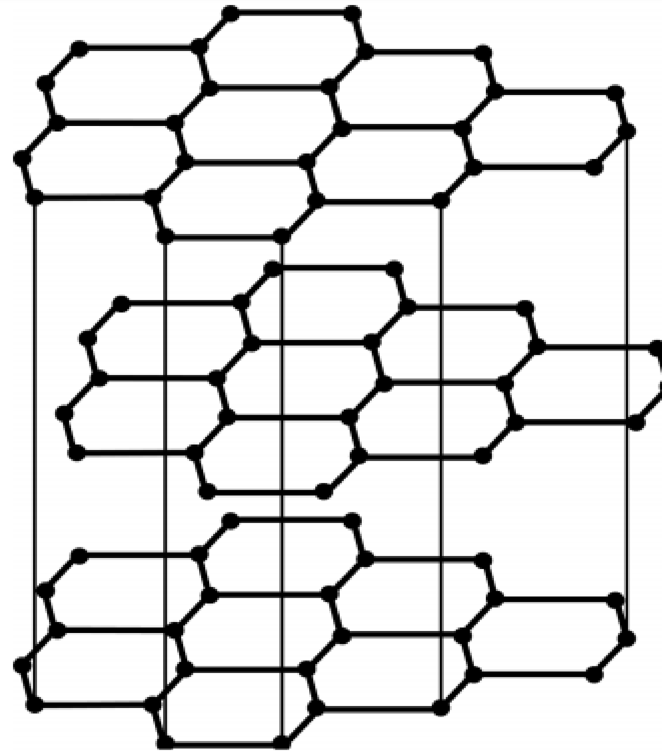


Fig. 1: Schematic representation of the layered lattice of graphite. Wigner and Huntington [19] would propose that most energetically favorable form of metallic hydrogen would assume this crystal structure. http://www.ptep-online.com/index_files/2011/PP-26-07.PDF

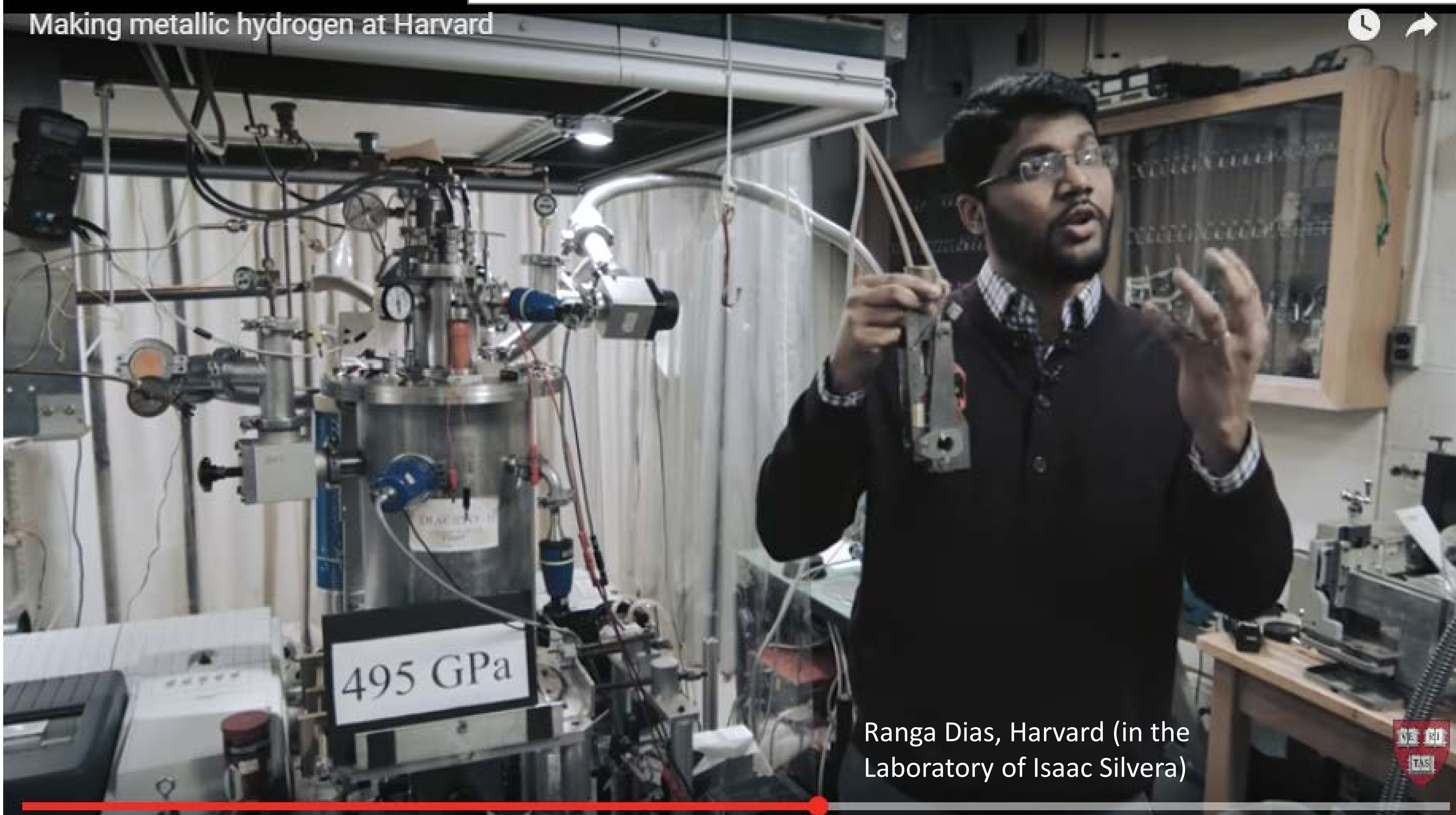
J. D. Bernal who first put forward the view that all substances go over under very high pressure into metallic or valence lattices" [19].

The rationale of "portability" of atoms was based on the theory of metastable metallic hydrogen

Harvard scientists announce they've created metallic hydrogen, which has been just a theory

January 26, 2017 |

19. Wigner E. and Huntington H.B. On the possibility of a metallic modification of hydrogen. *J. Chem. Phys.*, 1935, v.3, 764–770.



http://news.harvard.edu/gazette/story/2017/01/a-breakthrough-in-high-pressure-physics/

Swap "atoms" form factor – a different way of thinking about inventory at hand

12 years ago, the idea was of "portability" of atoms [eg: running your car on (metallic) hydrogen]

Drive any vehicle – car, ship, plane, rocket
Use metallic hydrogen in a USB drive form

Swap it anywhere to replenish

Think SCM - near-zero inventory of fuel, the weight of fuel, inventory carrying cost and energy used to carry inventory

https://dspace.mit.edu/handle/1721.1/56251

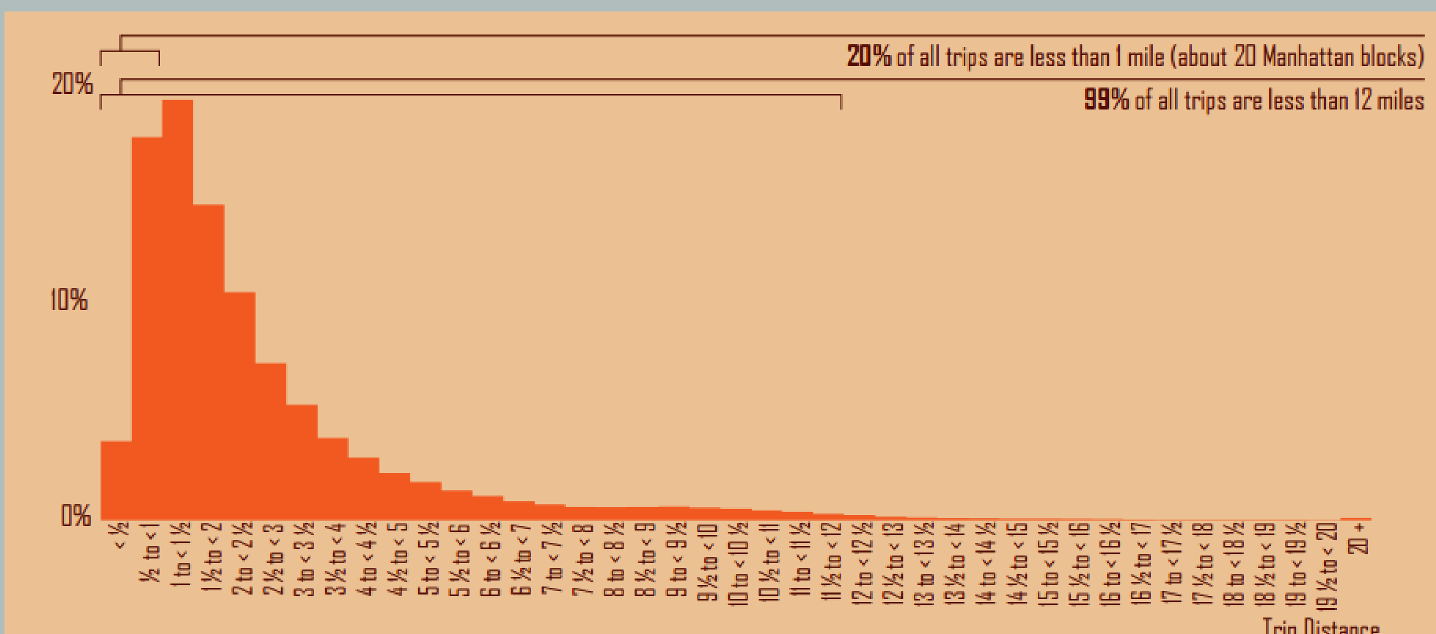
Swap “atoms” form factor – a different way of thinking about a typical taxi ride

http://www.nyc.gov/html/tlc/downloads/pdf/2014_taxicab_fact_book.pdf

Yellow taxis provide an average of

485,000
trips/day

The average trip distance is **2.6** miles



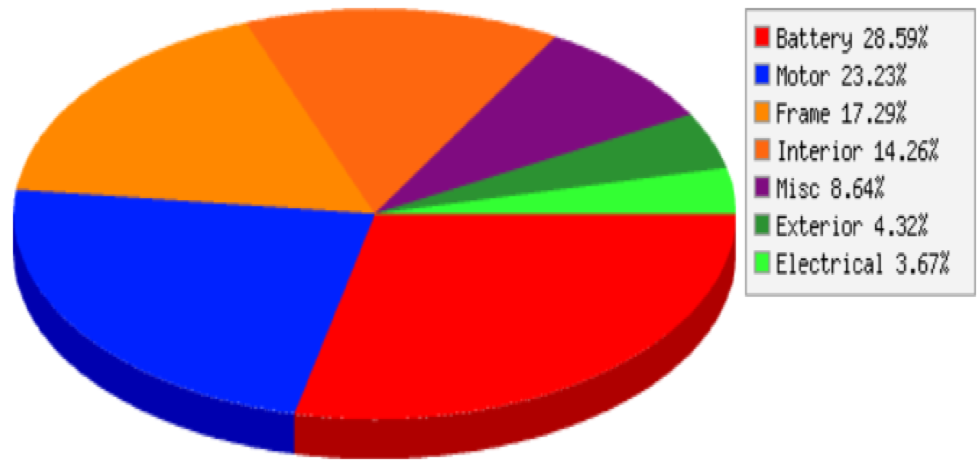
http://map.mathshell.org/download.php?fileid=1706

12 gallons

72 lb @ 6 lb/gal

Smaller cars generally have gas tanks that hold **12 gallons** worth of gas, while larger cars can hold 15 or **16 gallons**. For the purpose of this story, let's say gas costs $3.85 a gallon. A car with a **12**-gallon tank costs $46.20 to fill up while a larger car with a 15-gallon tank costs $57.75. Jul 5, 2013

TESLA MODEL S WEIGHT – 4,600+ LB



How much energy (inventory) and weight of energy (gas or battery) is a vehicle carrying for an average 2.6 mile trip?

Battery Pack **1323 lb**

- 1323 lb (1)

Aluminum Space Frame

- ~ 800 lb

Motor / Drivetrain

- ~ 350 lb – electric motor + inverter
- ~ 175 lb – differential
- ~ 250 lb – wheels + tires
- ~ 120 lb – brakes calipers, discs, lines
- ~ 80 lb – air suspension

Interior

- ~ 200 lb – front powered seats + rears
- ~ 190 lb – windshield, windows, hatch
- ~ 150 lb – pano glass and assembly
- ~ 80 lb – carpet, padding, mats
- ~ 40 lb – dash, trim, panels

Exterior

- ~200 lb – doors, frunk, hatch, body

Misc

www.teslarati.com/tesla-model-s-weight/

Swap "atoms" form factor – a different way of thinking about a typical taxi ride

http://www.nyc.gov/html/tlc/downloads/pdf/2014_taxicab_fact_book.pdf

Yellow taxis provide an average of

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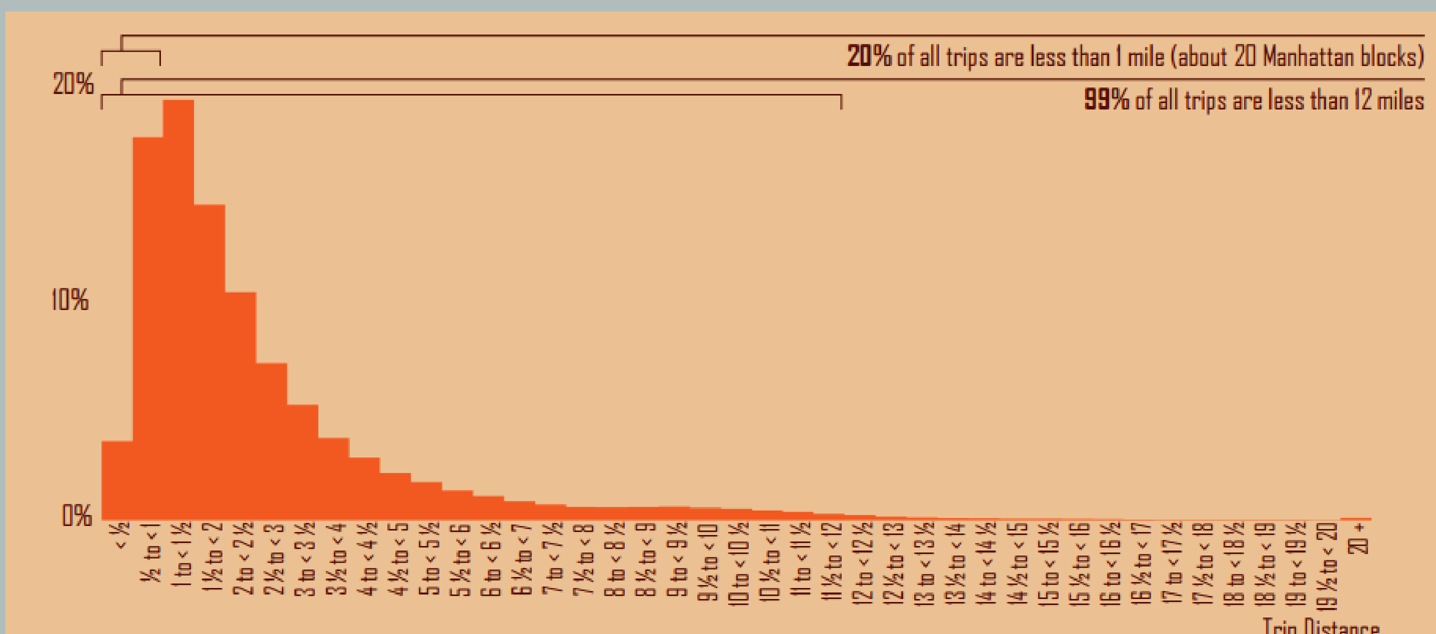
trips/day

1300 lb battery for a 2.6 mile trip?

The average trip distance is **2.6** miles



http://map.mathshell.org/download.php?fileid=1706

12 gallons **72 lb @ 6 lb/gal**

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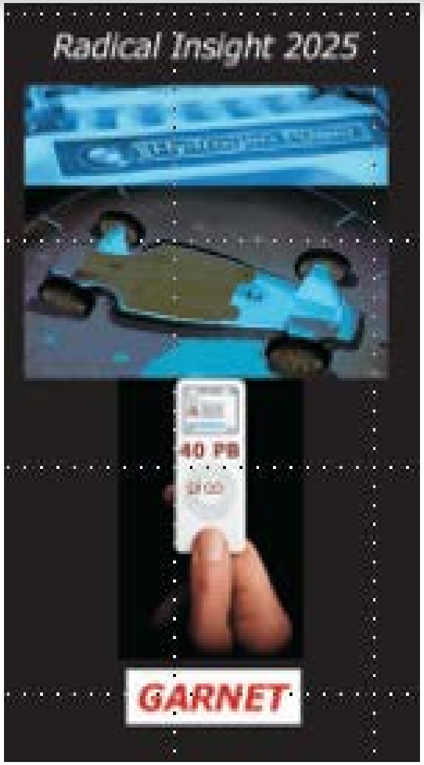
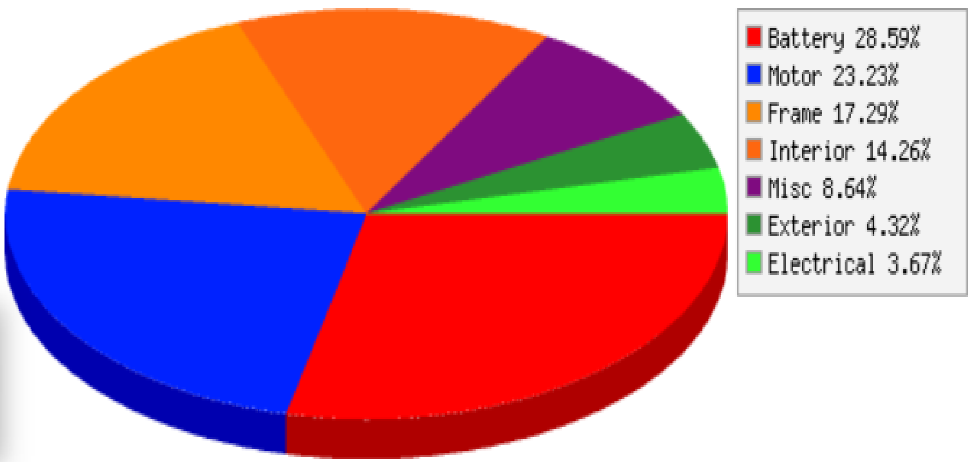
Change the equation!



10 gram Hydro-Stick
(Shoumen Datta, 2017)

TESLA MODEL S WEIGHT – 4,600+ LB



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- ~ 40 lb – dash, trim, panels

Exterior

- ~200 lb – doors, frunk, hatch, body

Misc

www.teslarati.com/tesla-model-s-weight/

Changed the equation!

https://qz.com/1001518/indias-electric-vehicle-revolution-will-begin-with-auto-rickshaws-running-on-swappable-batteries/

QUARTZ
India

EV, OR NOT TO BE?

India's electric vehicle revolution will begin with auto-rickshaws running on swappable batteries

https://qz.com/1001518

SWAPPABLE ATOMS

Changed the equation!

swappable batteries

https://qz.com/1001518

Energy
Design Metaphor

“Swappable Atoms”

Atoms to Bits

1942 ABC

Swap “atoms” form factor – Hydro-Stick of metallic Hydrogen is not a panacea

The form factor of energy and its source for transportation may undergo many radical metamorphoses because one solution may not suit all the different type of needs. Tesla’s approach may be overdue for an overhaul.

New ideas. New solutions. New engineering.

TRANSLATIONAL ENGINEERING

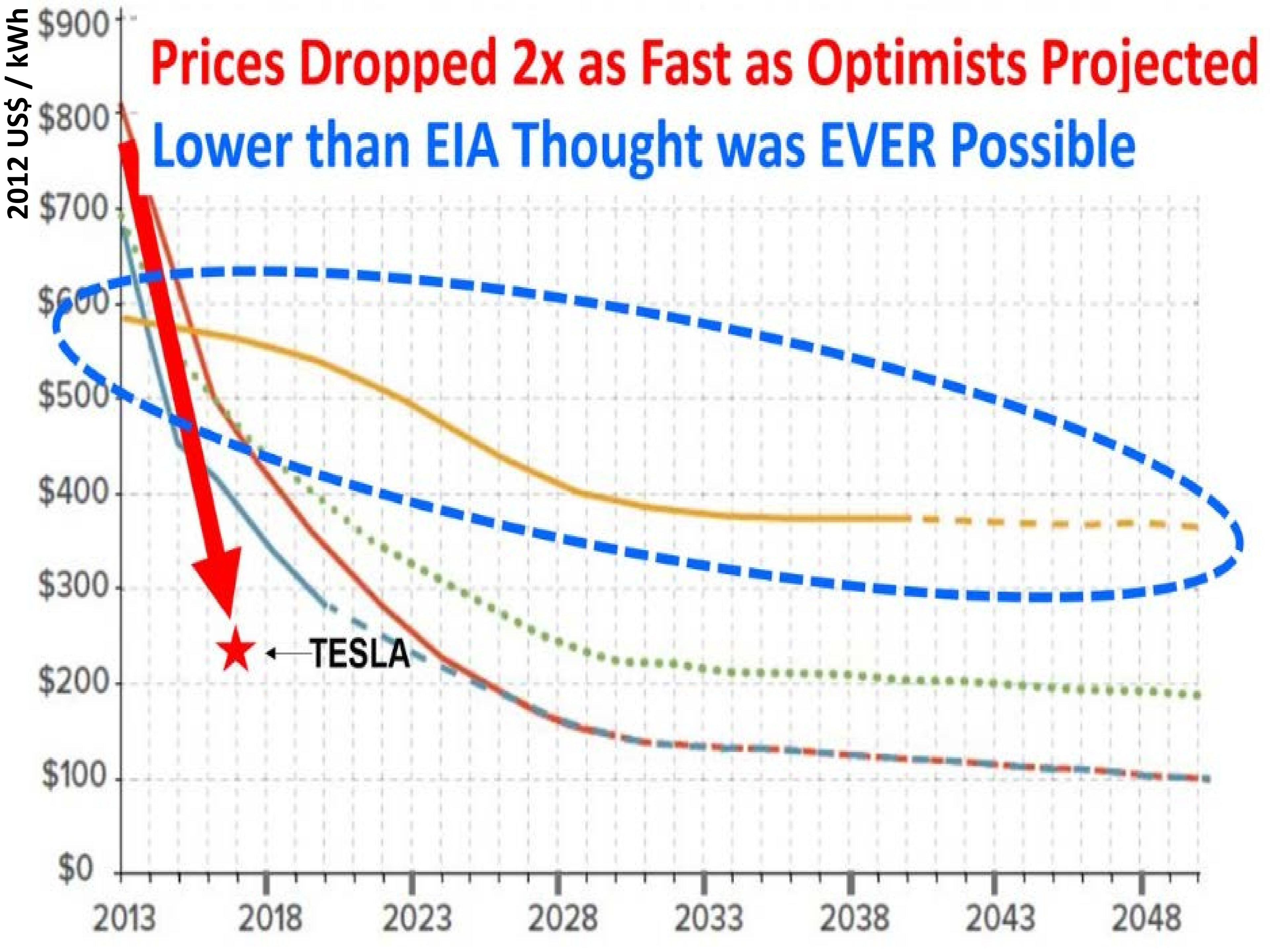
5 MB hard drive being shipped out of IBM (1956)

IBM 5 MB hard drive transported by PanAm (1956)

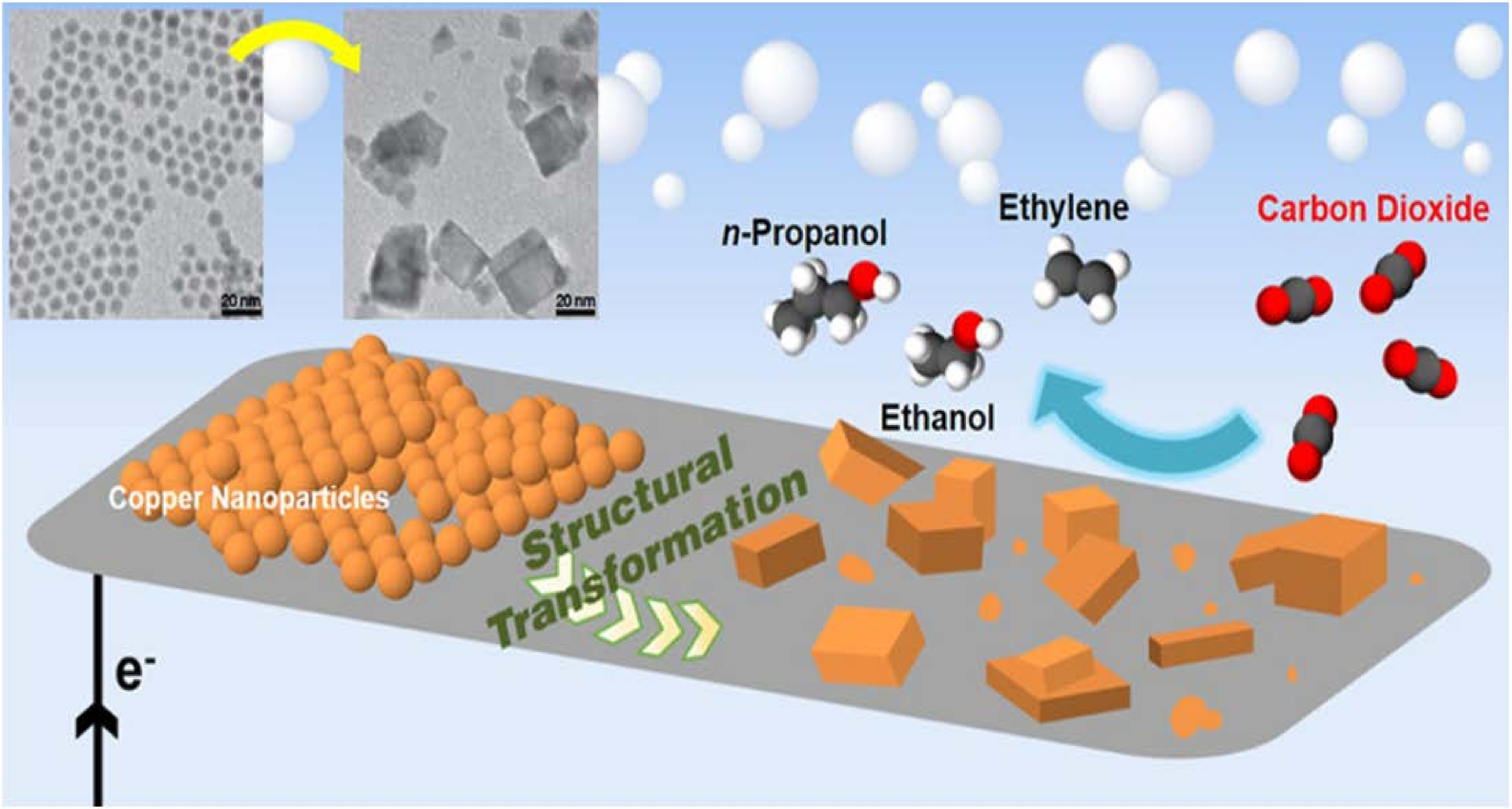
2TB credit card size HD is not made by IBM (2015)

From EV to FCV ??

Hydrogen Fuel Cell Vehicle in 2020’s

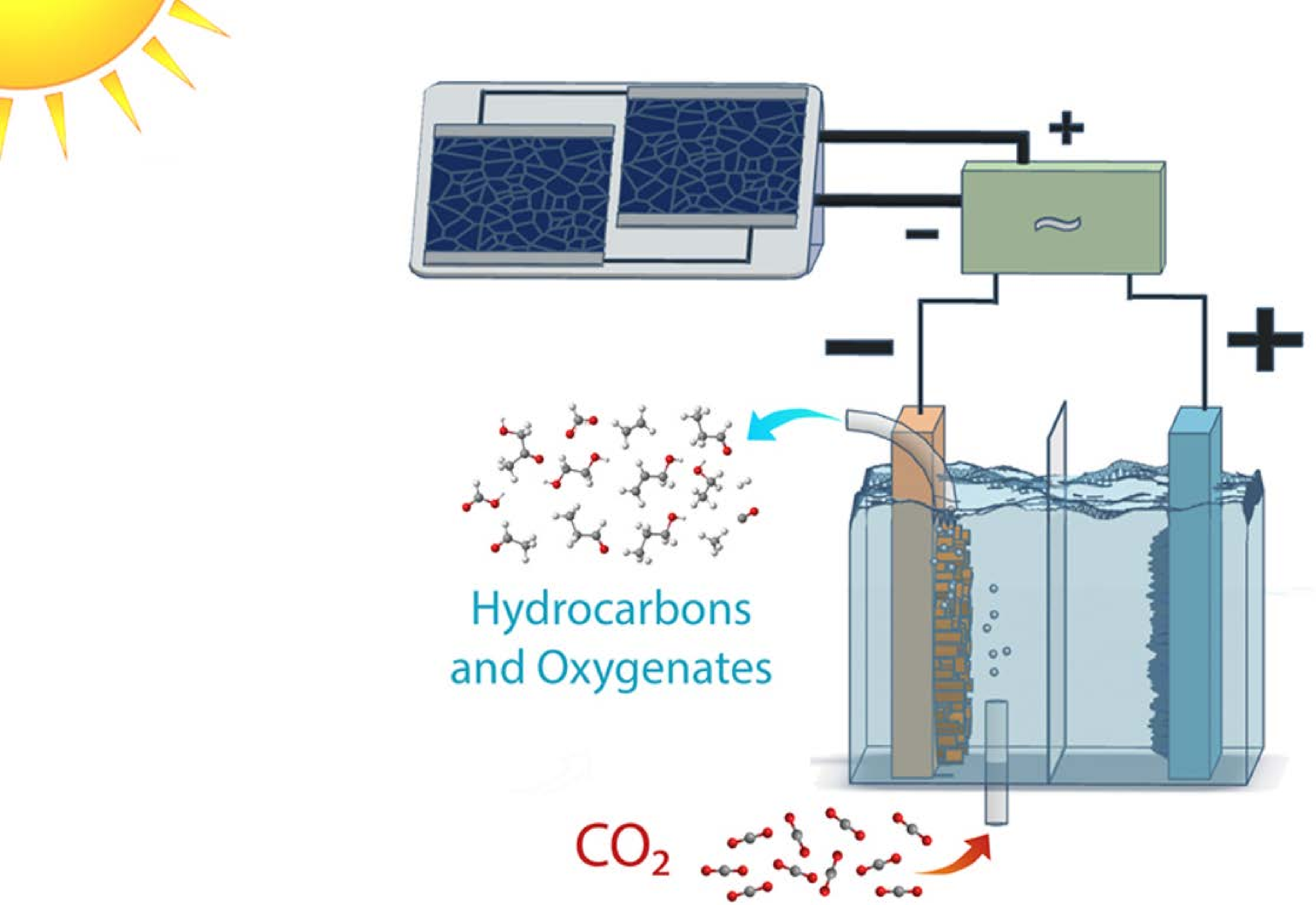

2012 US$ / kWh
Prices Dropped 2x as Fast as Optimists Projected
Lower than EIA Thought was EVER Possible
$900
$800
$700
$600
$500
$400
$300
$200
$100
$0
TESLA
2013
2018
2023
2028
2033
2038
2043
2048

Copper Nanoparticles Catalyze Conversion of Carbon Dioxide to Multi-Carbon Alcohols



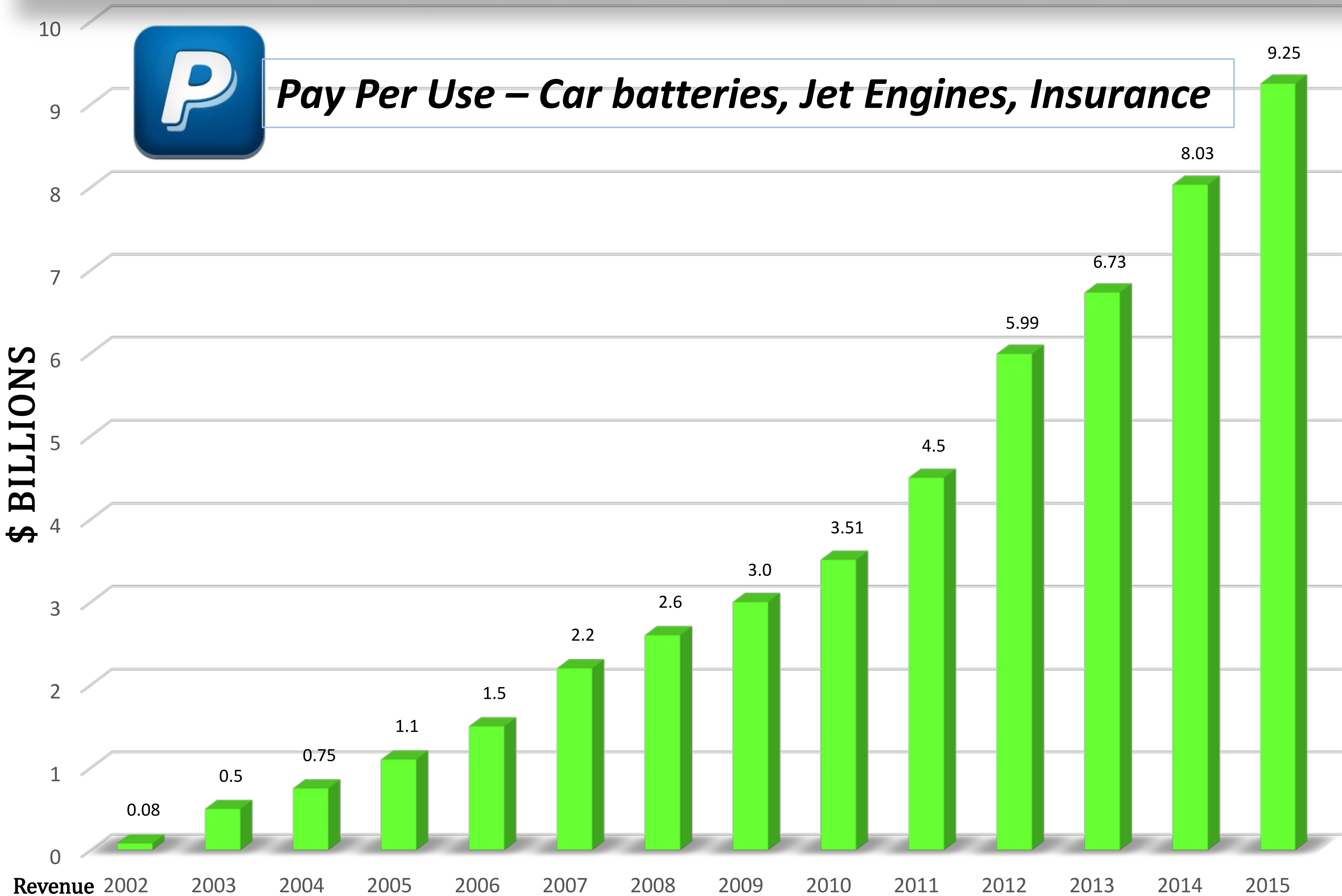
Schematic of a new catalyst made of copper nanoparticles that converts carbon dioxide to multicarbon products (ethylene, ethanol, and propanol). At top left are transmission electron microscope images of the copper nanoparticles. The transformation of the nanoparticles from spheres to cube-like structures is key to keeping the energy input low for the reactions. (Credit: Dohyung Kim/Berkeley Lab)

10.1073/pnas.1711493114 and http://newscenter.lbl.gov/2017/09/18/copper-catalyst-yields-high-efficiency-co2-fuels-conversion/



www.rsc.org/suppdata/c7/ee/c7ee01764b/c7ee01764b1.pdf - DOI 10.1039/C7EE01764B

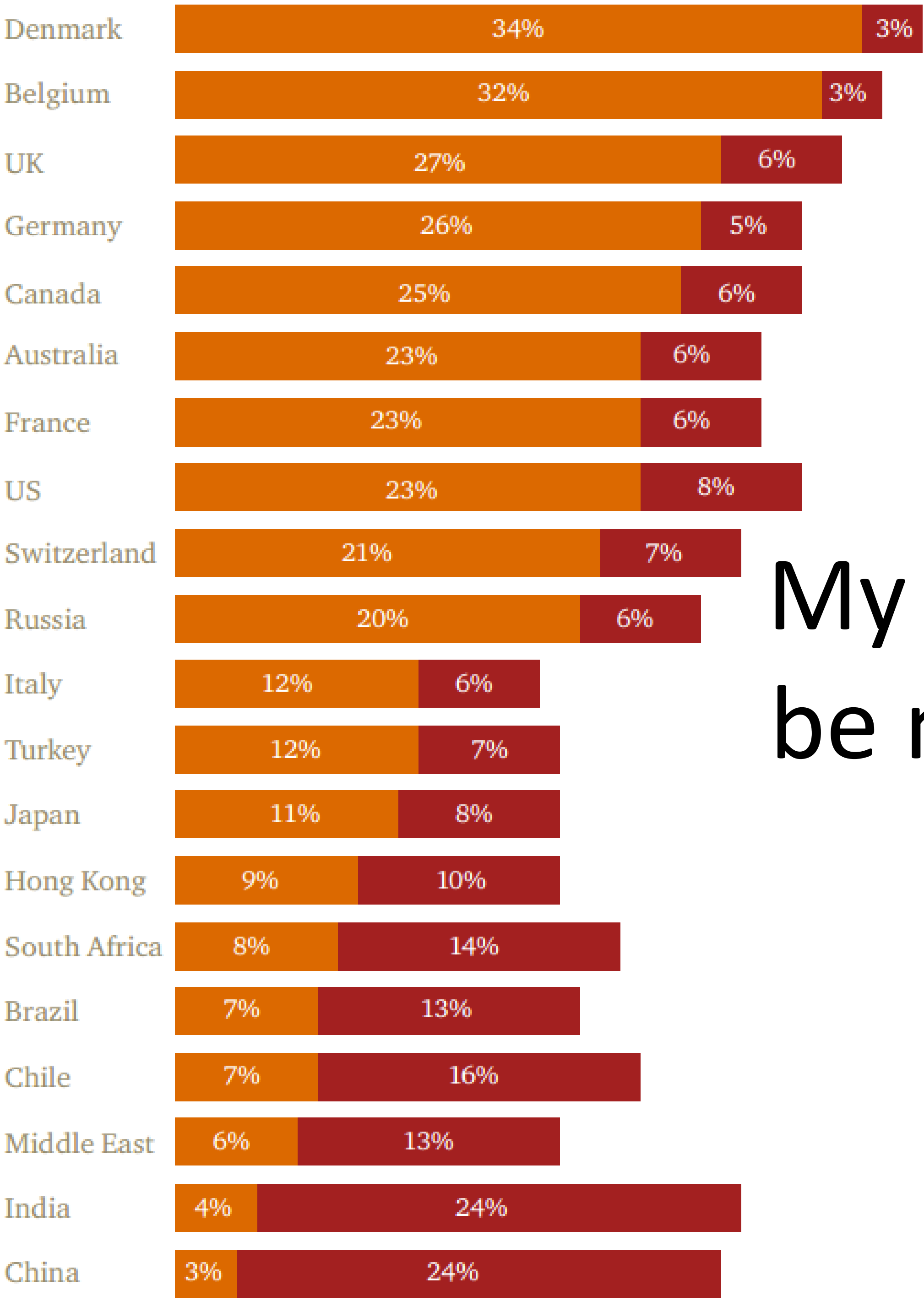
Transaction Cost Economics – The Micro-Revenue Revolution



Farmer pays 1 penny each time she checks for salinity in her rice field zone AB

Vast number of low cost sensors as a pervasive part of our existential fabric, offered a very lost cost to penetrate, globally, and improve quality of life

Digitalization Morphs Behavior?



My mobile phone will be my purchasing tool

Strongly disagree Strongly agree

http://bit.do/PURCHASING-TOOL

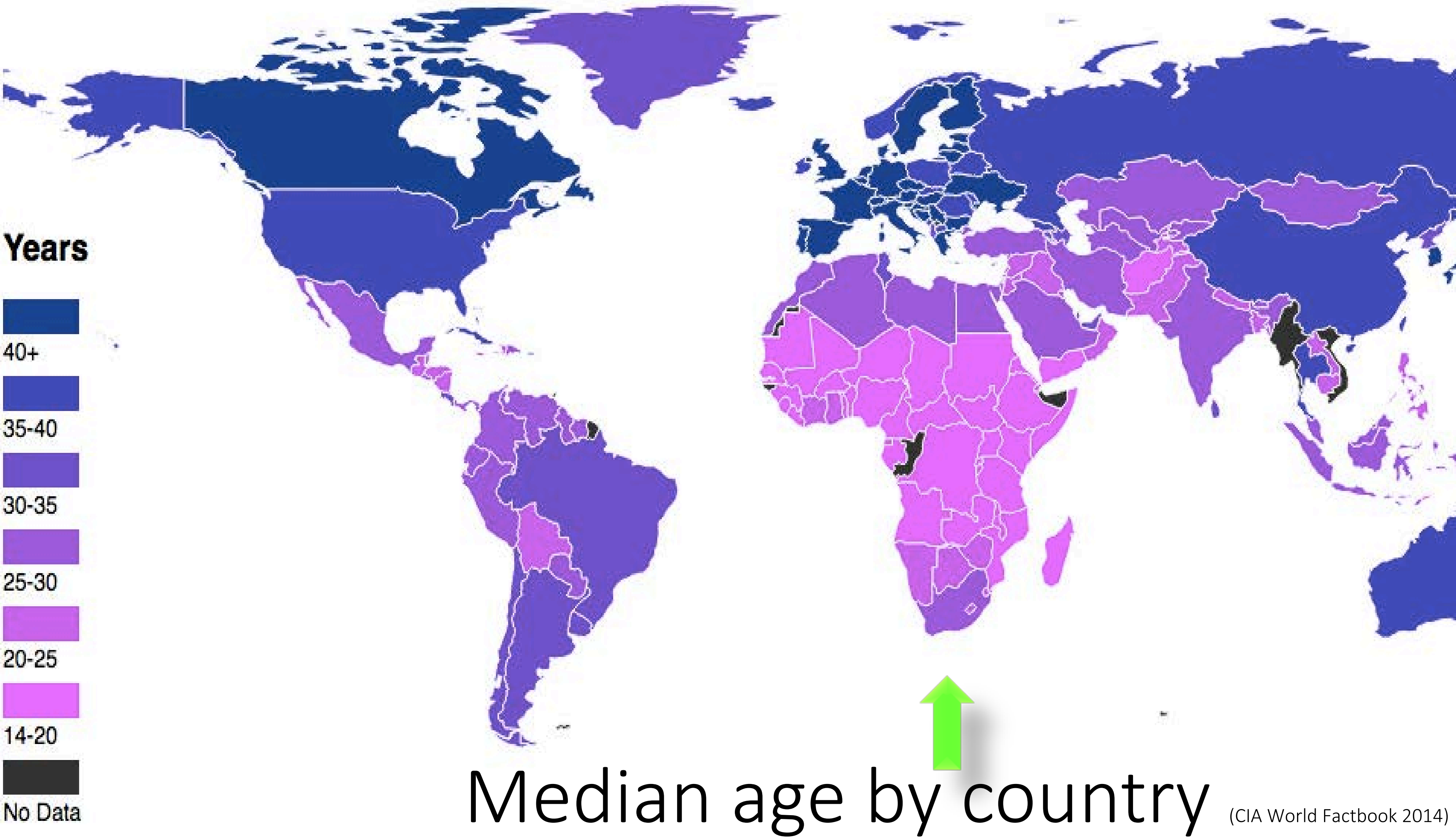
Median Age
DE / JP – 46
Belgium – 43
DK / FR – 42
CAN / UK – 41
US / CN – 37
India – 27
Niger – 15

The Final Frontier ?

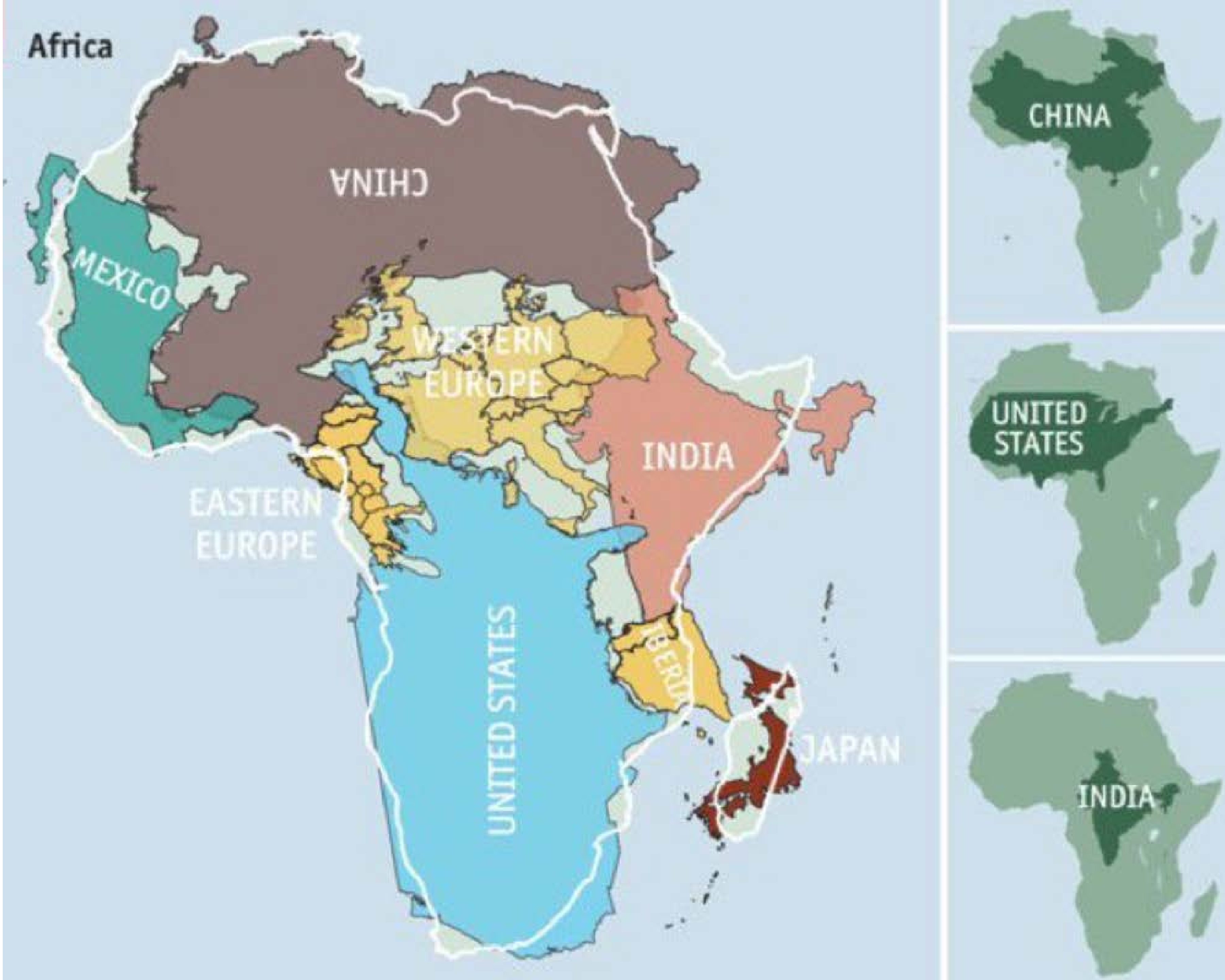
Mobile Africa ?

Where are the future markets?

11 million children die each year from preventable causes. 70% of deaths are due to 6 diseases. The mortality is concentrated in ten countries, mostly in the Sub-Saharan region of Africa.



Median age by country (CIA World Factbook 2014)


Africa
CHINA
MEXICO
WESTERN
EUROPE
INDIA
EASTERN
EUROPE
UNITED STATES
IBERI
JAPAN
CHINA
UNITED
STATES
INDIA

FLOOD THE SAHARA ??

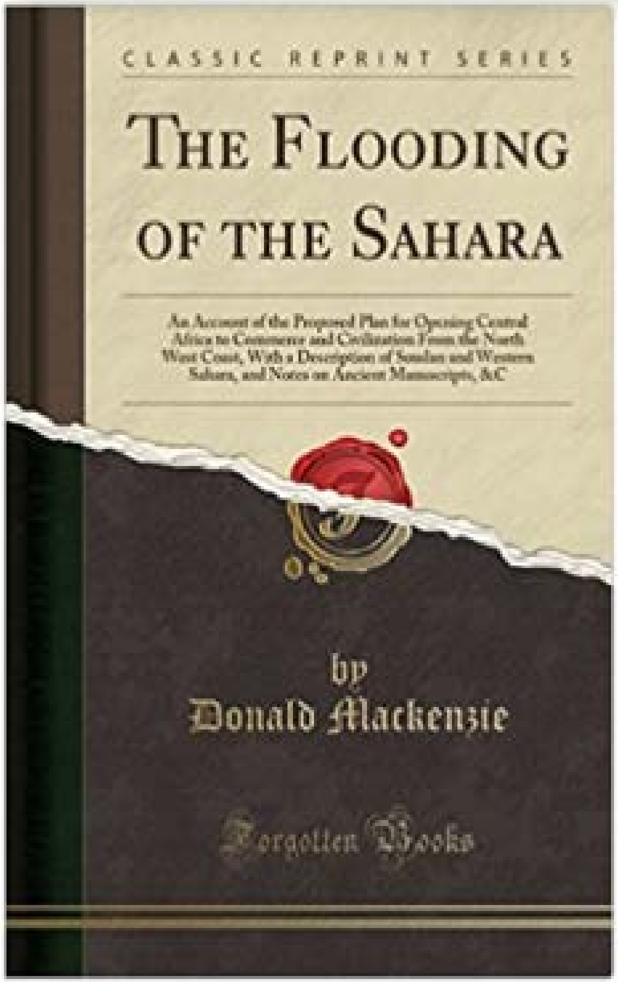
If you flood the Sahara – think Suez Canal, Panama Canal, Euro Tunnel – the food supply for Africa will increase and the temperature of the Sahara Desert may decrease by a few degrees. Perhaps, the latter may reduce the number of hurricanes brewing from Atlantic?

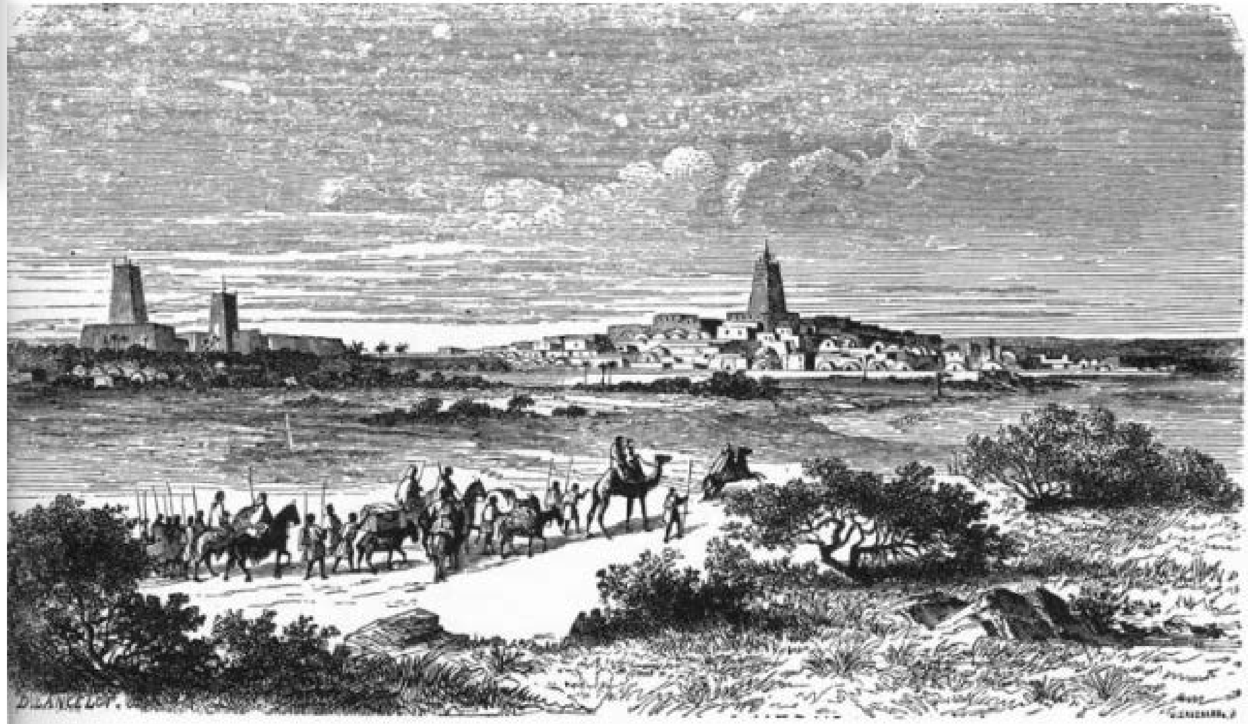
What is your role?

Change the World

The Great Sahara Sea That Almost Was

Ron Miller
7/20/13 5:00pm





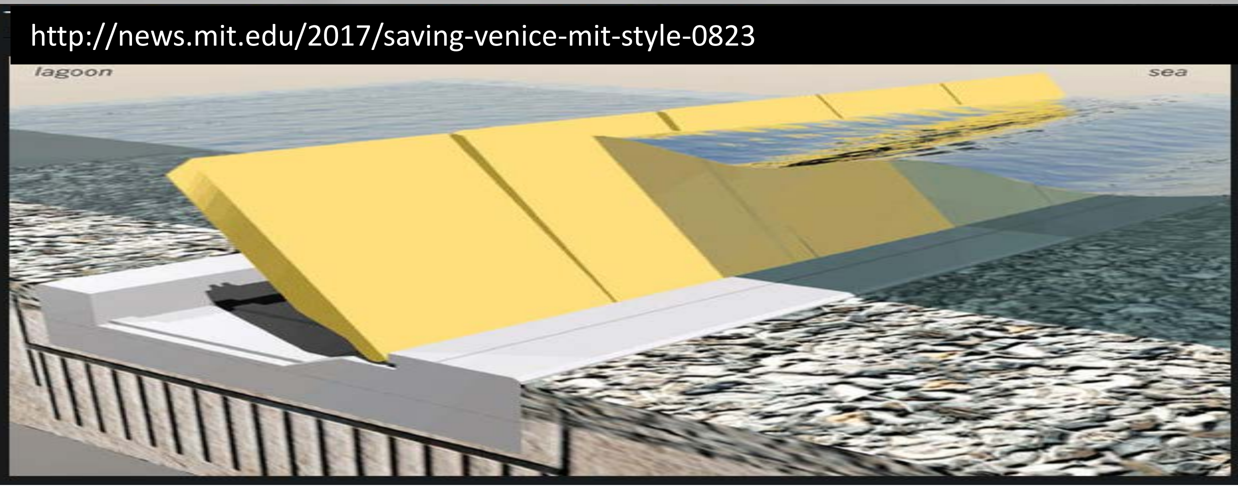
TIMBUCTOO.

1874

In 1874, Captain Francois-Elie Roudaire, a geographer in the French army proposed a daring idea. No doubt inspired by the successful completion of the Suez canal a few years earlier, he suggested the creation of a 120-mile-long canal that would connect the Mediterranean Sea to a part of the Sahara Desert in Algeria that lies below sea level. The result would be the flooding of more than 3000 square miles of territory. Roudaire hoped that such a huge body of water would not only allow ships to navigate into the interior of North Africa, it would also significantly change the local climate. All at a cost of a mere 25 million francs.

https://io9.gizmodo.com/the-great-sahara-sea-that-almost-was-837206551

What if we want to stop the flooding? Close the water gates to the canal



Desalination

Cascade of porous barriers with layers of nano-structured membranes

Single-Layer Graphene Membranes Withstand Ultrahigh Applied Pressure

Luda Wang*, Christopher M. Williams, Michael S. H. Boutilier, Piran R. Kidambi, and Rohit Karnik*
Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, United States

Nano Lett., **2017**, *17* (5), pp 3081–3088
DOI: 10.1021/acs.nanolett.7b00442
Publication Date (Web): April 24, 2017

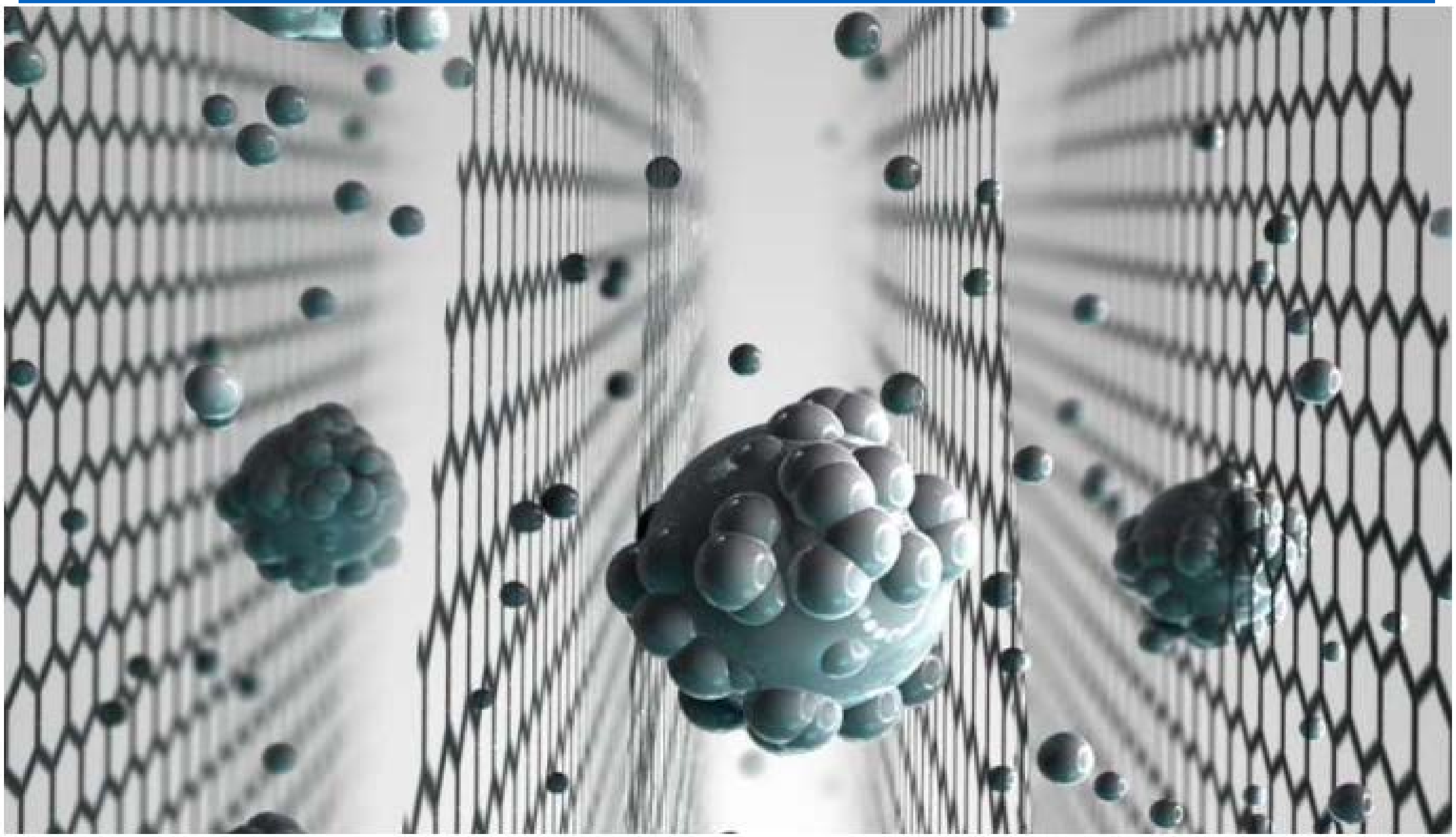
http://news.mit.edu/2017/graphene-high-pressure-desalination-more-productive-0424

Secure | https://phys.org/news/2017-04-graphene-sieve-seawater.html

Graphene sieve turns seawater into drinking water

April 3, 2017

https://www.nature.com/nnano/journal/v12/n6/pdf/nnano.2017.21.pdf



A graphene membrane. Credit: The University of Manchester

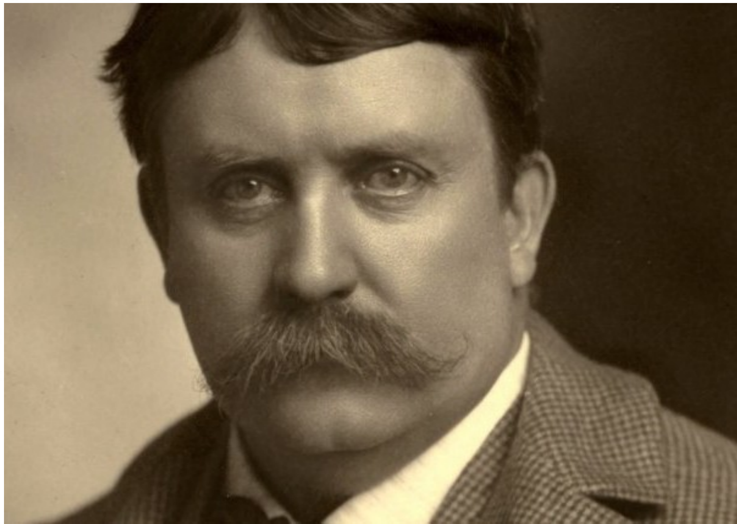
Graphene-oxide membranes have attracted considerable attention as promising candidates for new filtration technologies. Now the much sought-after development of making membranes capable of sieving common salts has been achieved.

Tunable sieving of ions using graphene oxide membranes

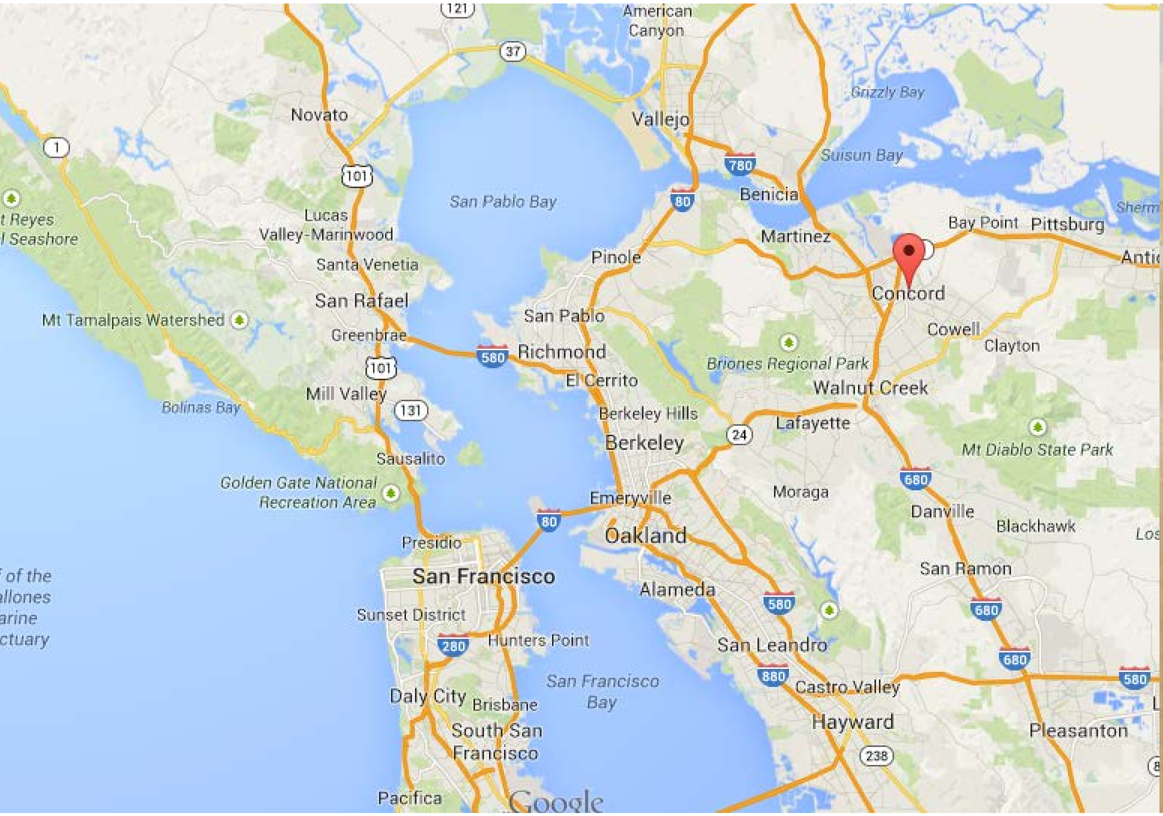
Jijo Abraham[1,2,3†], Kalangi S. Vasu[1,2†], Christopher D. Williams[2], Kalon Gopinadhan[3], Yang Su[1,2], Christie T. Cherian[1,2], James Dix[2], Eric Prestat[4], Sarah J. Haigh[4], Irina V. Grigorieva[1], Paola Carbone[2], Andre K. Geim[3] and Rahul R. Nair[1,2*]

Make no little plans; they have no magic to stir men's blood and probably themselves will not be realized. Make big plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with ever-growing insistency.

—DANIEL BURNHAM



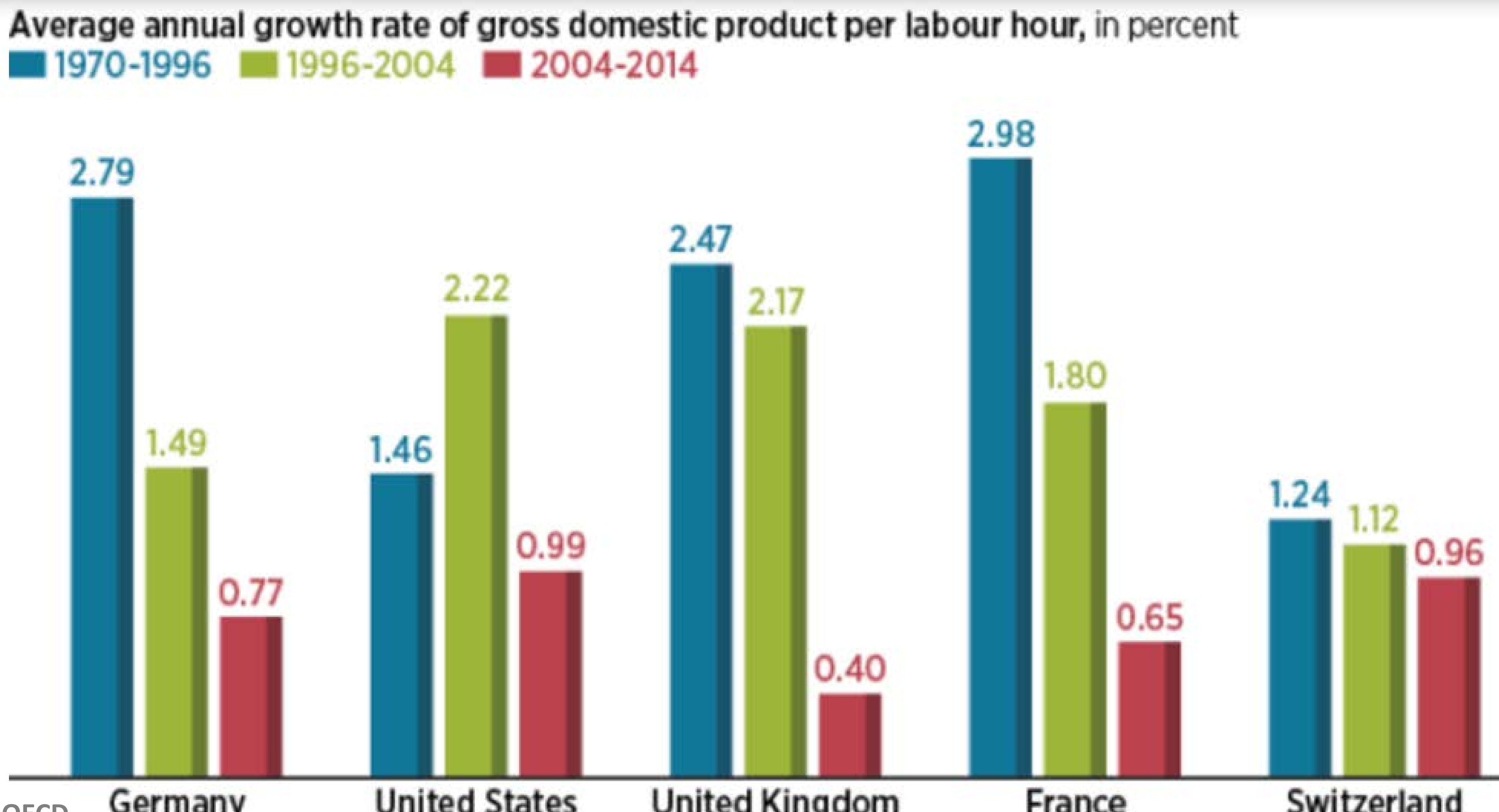
Diffusion of the Internet - NetDay 1996



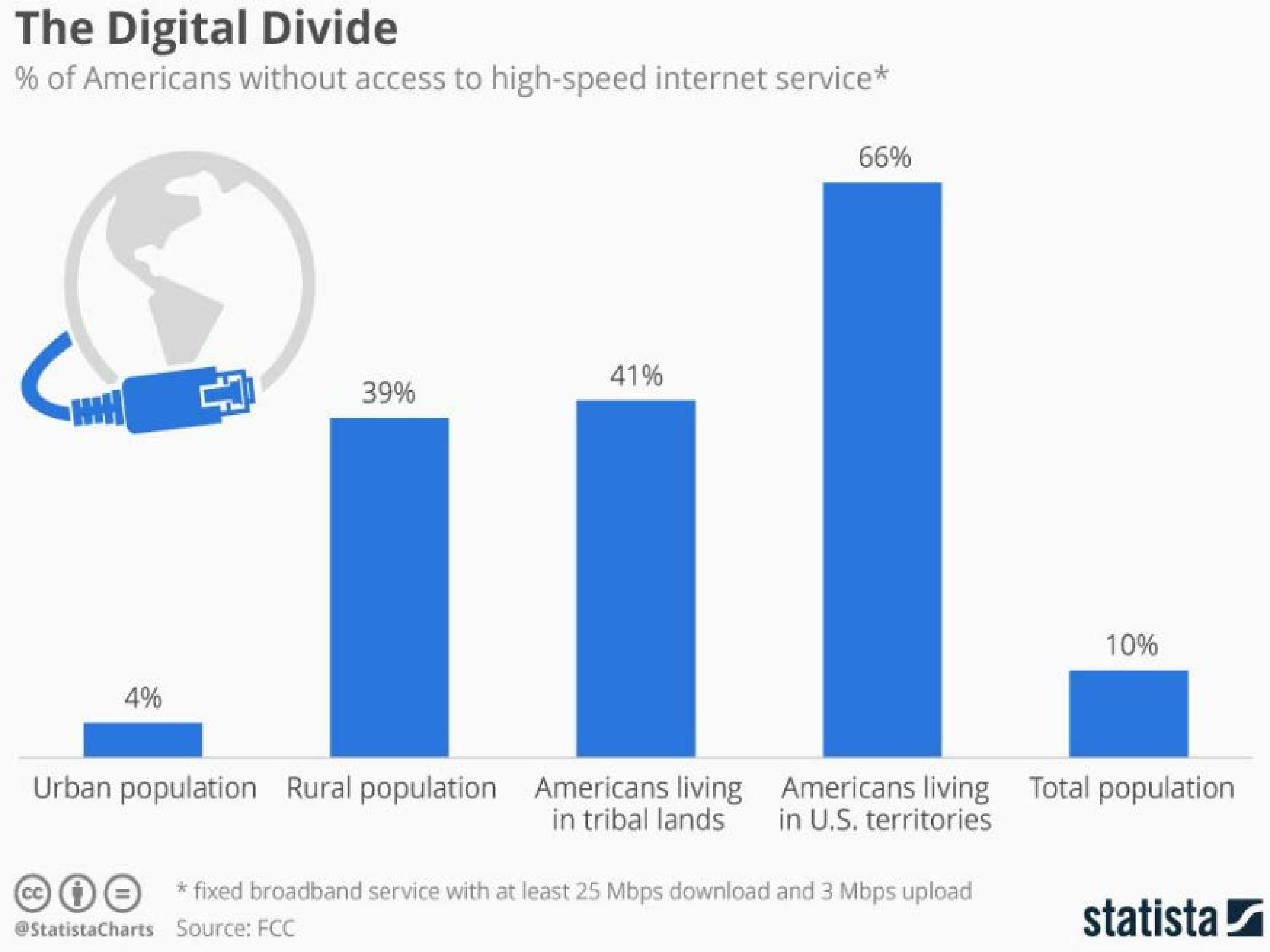
President Bill Clinton installing computer cables with Vice President Al Gore on NetDay at Ygnacio Valley High School (Concord, CA - March 9, 1996)

Sign posts on the road ahead?

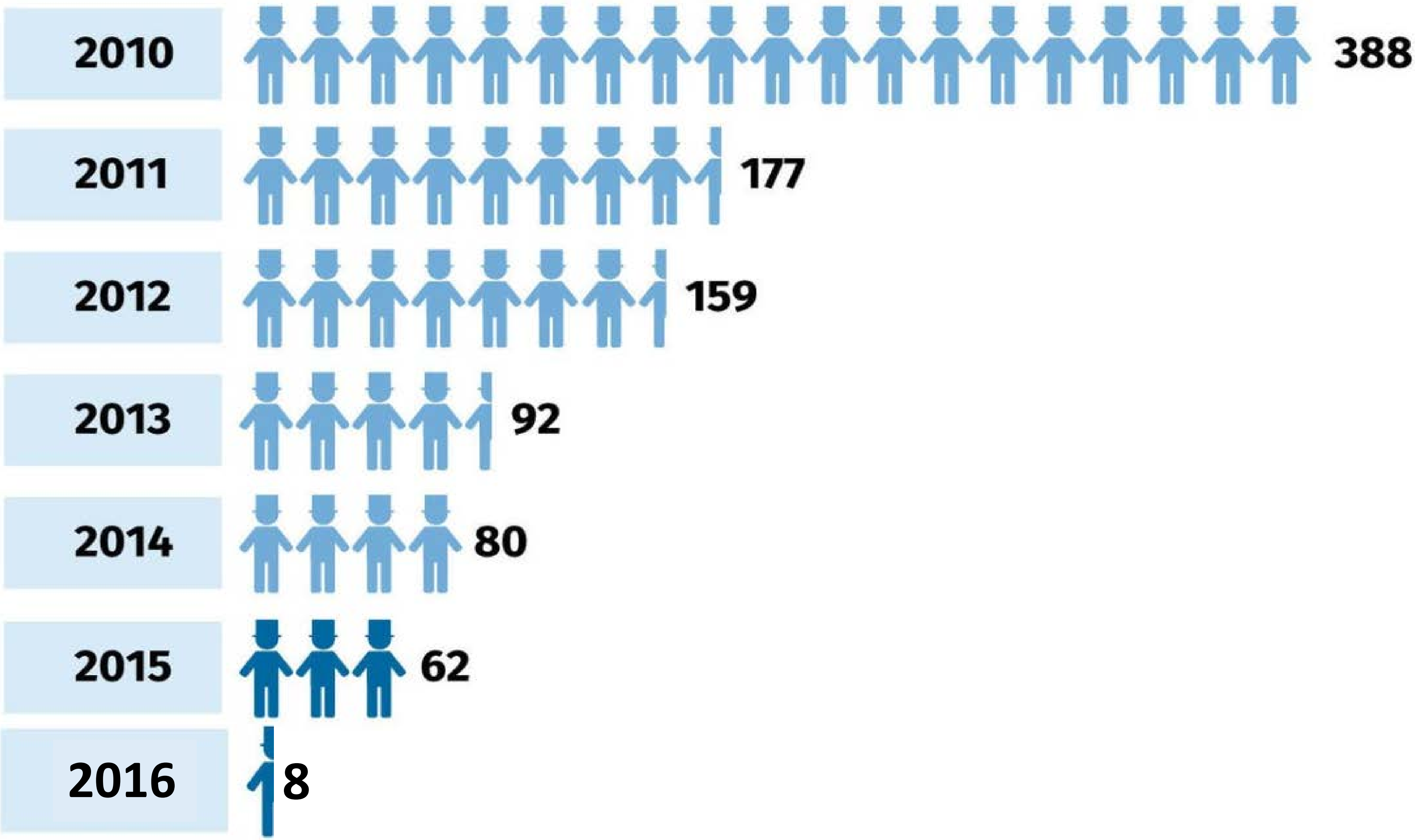
Productivity Growth Has Slowed Down? It takes about 30 years



OECD

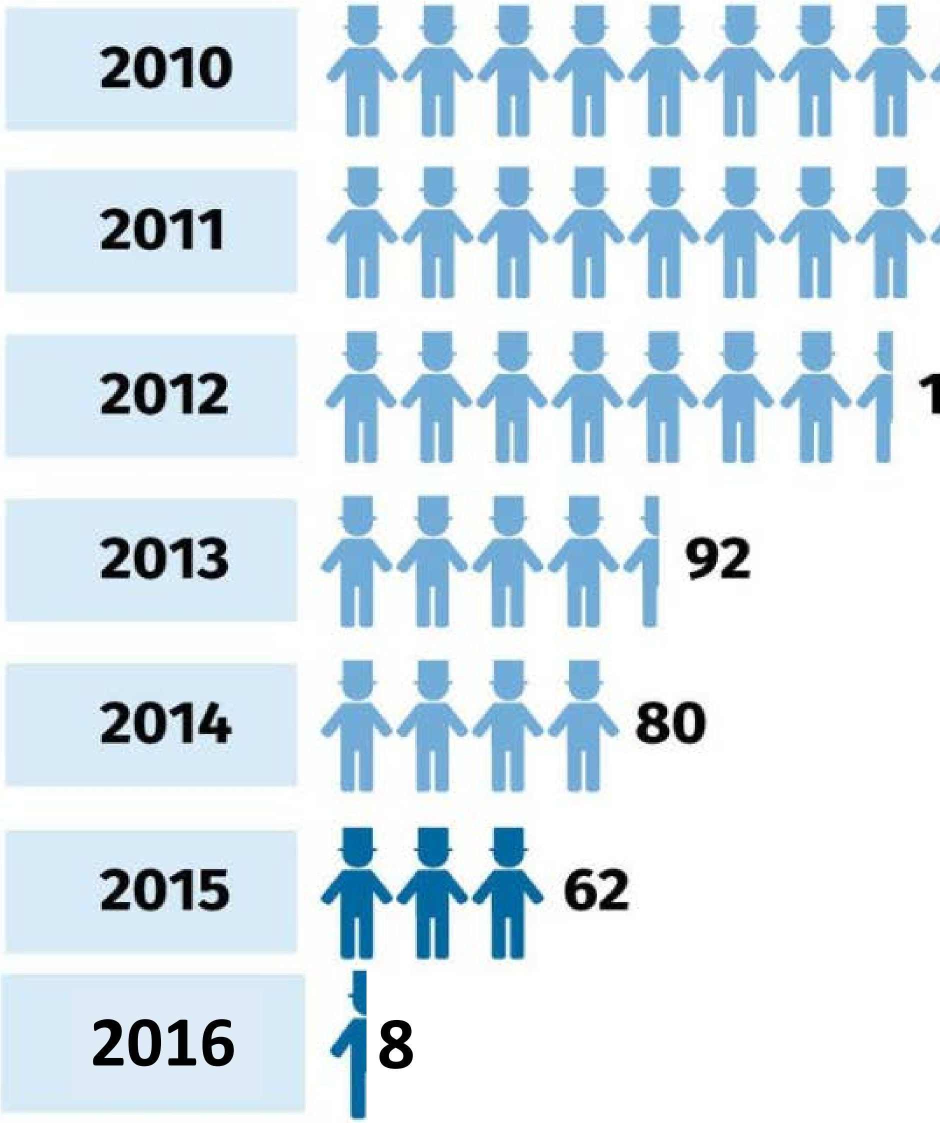

The Digital Divide
% of Americans without access to high-speed internet service*
4%
39%
41%
66%
10%
Urban population
Rural population
Americans living in tribal lands
Americans living in U.S. territories
Total population
* fixed broadband service with at least 25 Mbps download and 3 Mbps upload
@StatistaCharts
Source: FCC
statista

Number of billionaires owning as much as the poorest half of the world's population



OXFAM 10.21201/2016.592643

Number of billionaires owning as much as the poorest half of the world's population



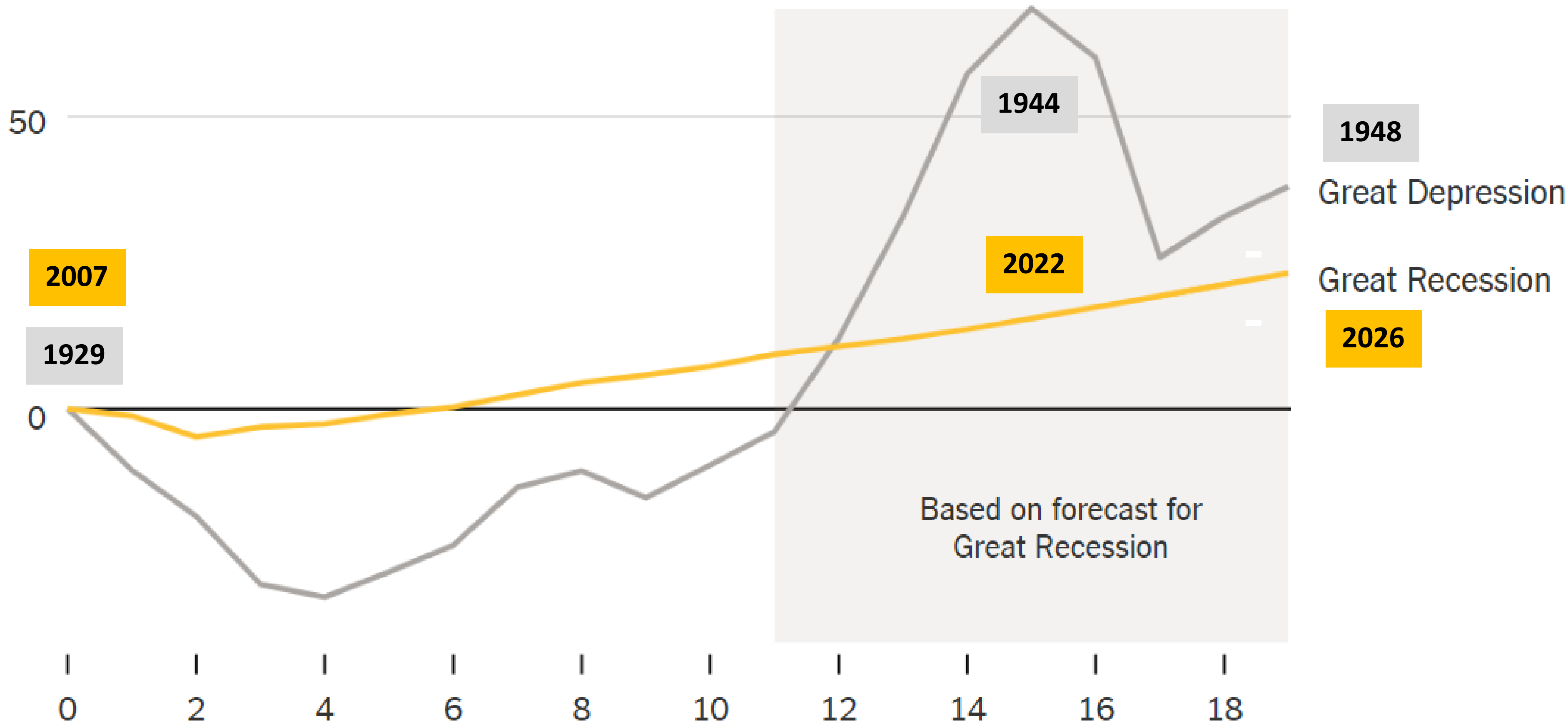
EUROPEAN PRESSPHOTO AGENCY

The eight richest people in the world — all men — together own about $426 billion, according to an Oxfam report. Top, from left: Bill Gates, Amancio Ortega, Warren Buffett, and Carlos Slim. Bottom, from left: Jeff Bezos, Mark Zuckerberg, Larry Ellison, and Michael Bloomberg.

By Matt Rocheleau | GLOBE STAFF JANUARY 18, 2017

OXFAM 10.21201/2016.592643

Cumulative percent change in G.D.P. per working-age adult, each year since start of crisis



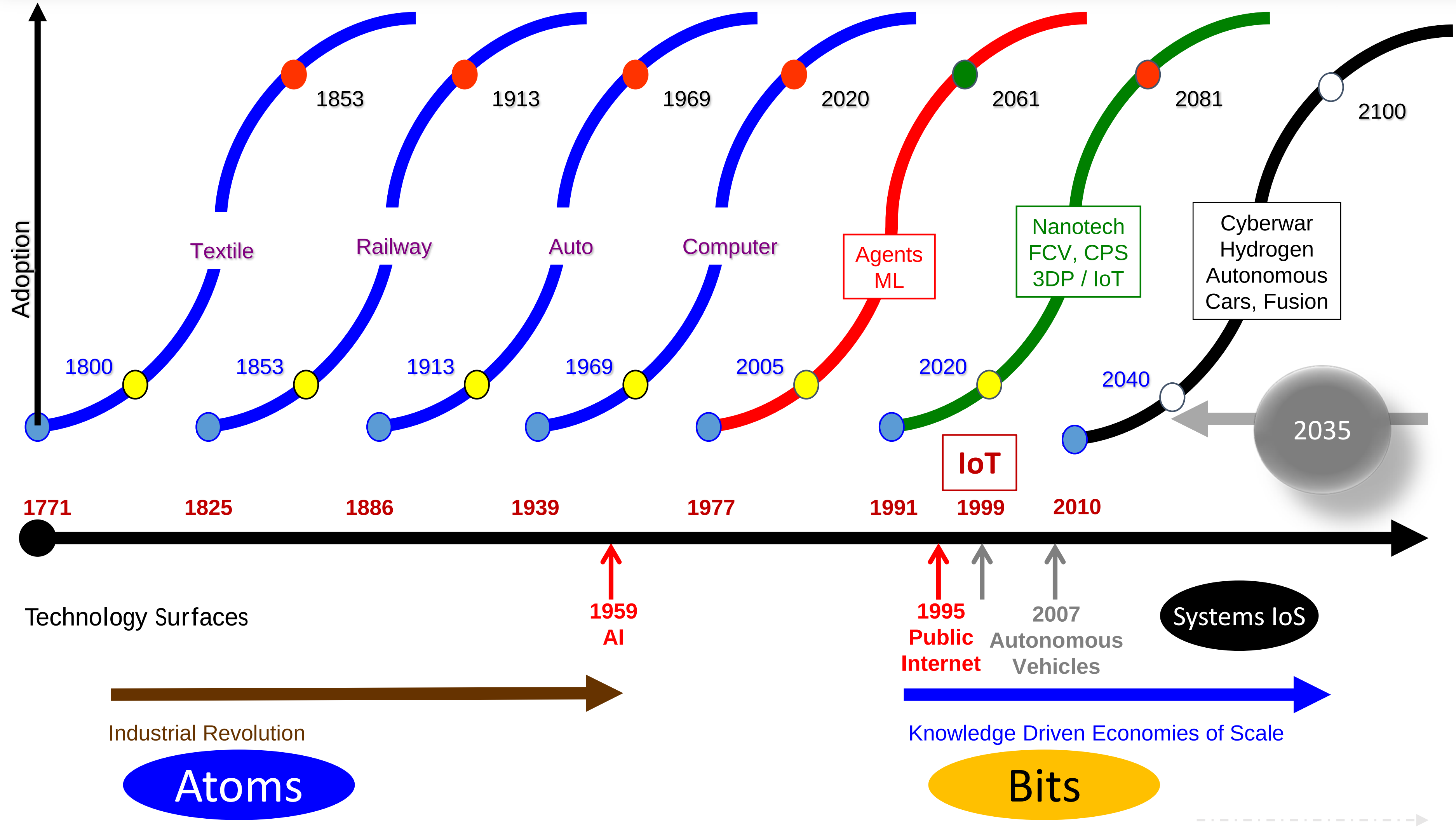
Notes: Great Depression starts in 1929, Great Recession in 2007. Working-age adults are ages 18 to 64. Forecasts for future years come from Congressional Budget Office and Census Bureau.

By The New York Times | Source: Olivier Blanchard and Larry Summers

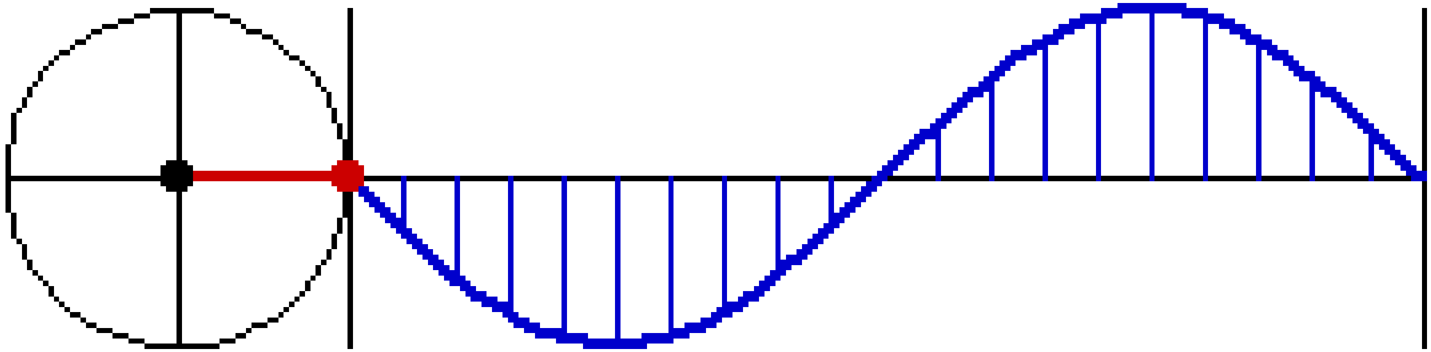
Conference on "Rethinking Macroeconomic Policy," coordinated by Olivier Blanchard, PIIE C. Fred Bergsten Senior Fellow and Lawrence Summers, Harvard University, member of the Institute's Executive Committee, on October 12–13, 2017, WDC.

Transmutation of the Uncommon - Transaction Cost Economics

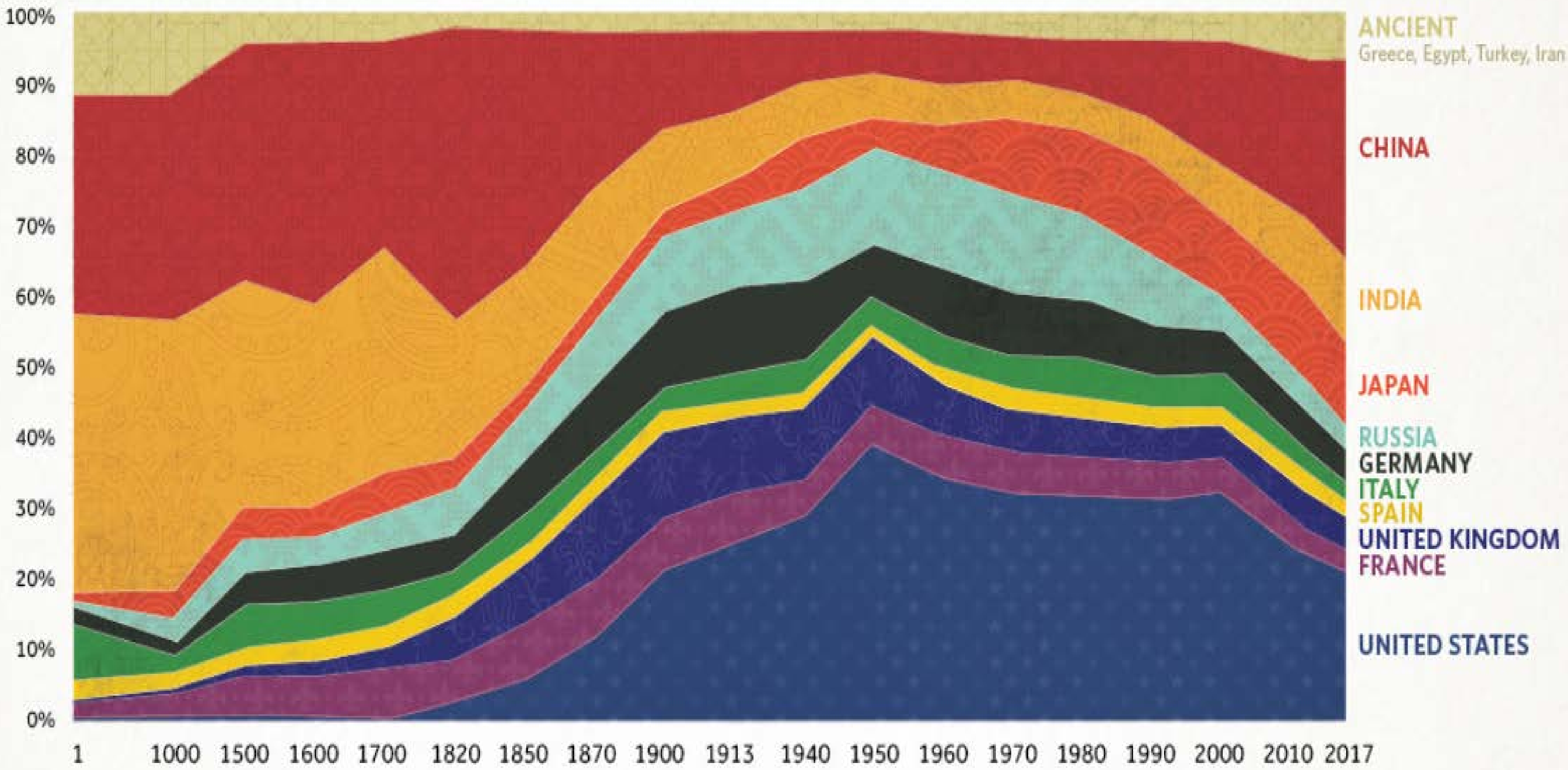
Economic history and data related to Textile, Railway, Automobiles and Computers taken from work by Norman Poire



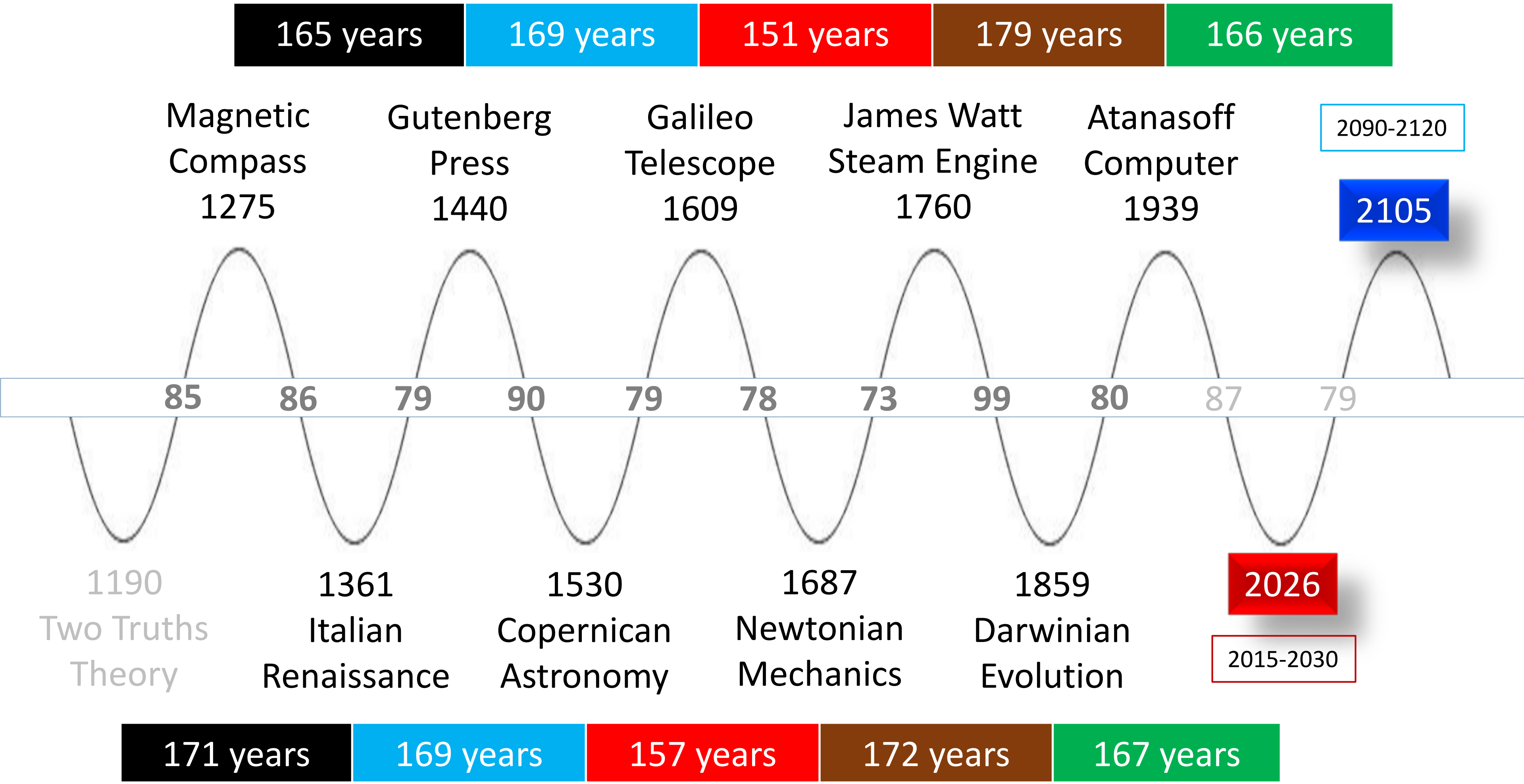
It takes about 28-30 years for an idea to be socialized before it is accepted and adopted. 1999 was the birth year for IoT concept. Expect exponential growth of IoS ~ 2025-2026.



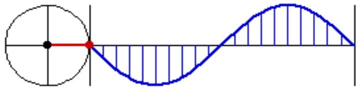
SHARE OF GDP (WORLD POWERS)

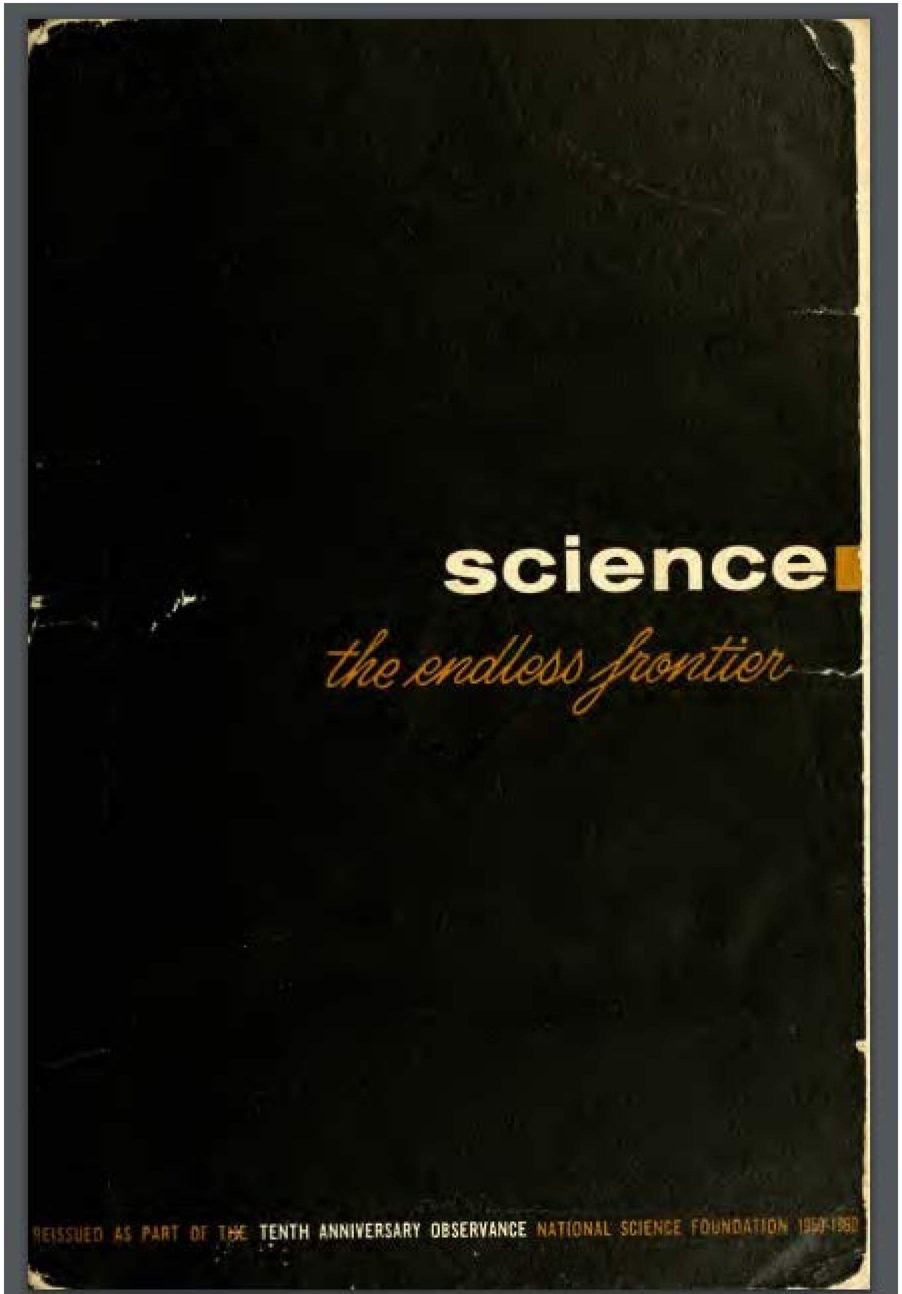


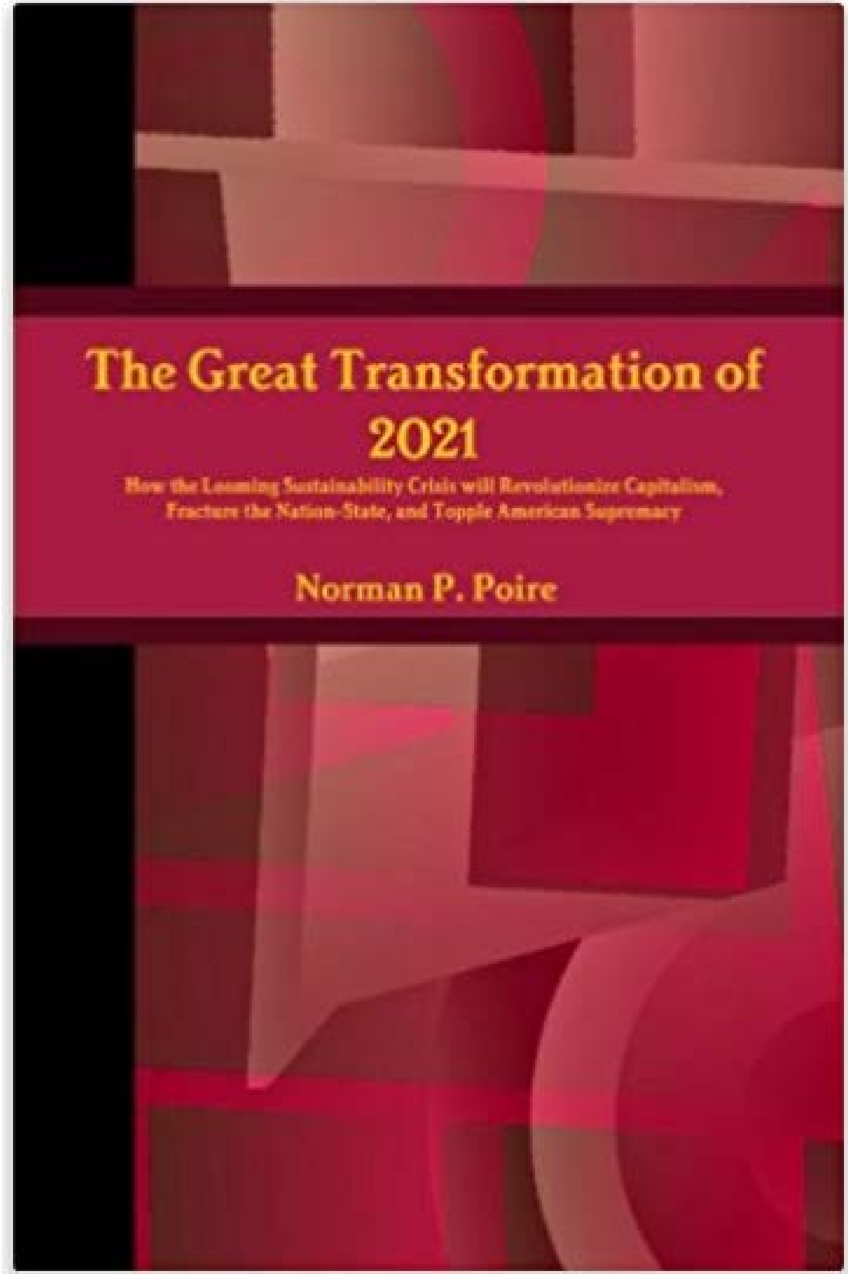
Technology – Imagination, Invention, Innovation



Social, Cultural and Economic, Paradigm Shift







https://ia800207.us.archive.org/12/items/scienceendlessfr00unit/scienceendlessfr00unit.pdf

Fundamentals

GLOBAL DISSEMINATION OF EDUCATION AND DIGITAL LEARNING

Moonshot ● https://github.com/chrislgarry/Apollo-11

```
P40AUTO         TC      MAKECADR        # HELLO THERE.
                TS      TEMPR60         # FOR GENERALIZED RETURN TO OTHER BANKS.
P40A/P          TC      BANKCALL        # SUBROUTINE TO CHECK PGNCS CONTROL
                CADR    G+N,AUTO# AND AUTO STABILIZATION MODES
                CCS     A               # +0 INDICATES IN PGNCS, IN AUTO
                TCF     TURNITON        # + INDICATES NOT IN PGNCS AND/OR AUTO
                CAF     APSFLBIT        # ARE WE ON THE DESCENT STAGE?
                MASK    FLGWRD10
                CCS     A
                TCF     GOBACK          # RETURN
                CAF     BIT5            # YES, CHECK FOR AUTO-THROTTLE MODE
                EXTEND
                RAND    CHAN30
                EXTEND
                BZF     GOBACK          # IN AUTO-THROTTLE MODE -- RETURN
TURNITON        CAF     P40A/PMD        # DISPLAYS V50N25 R1=203 PLEASE PERFORM
                TC      BANKCALL        # CHECKLIST 203 TURN ON PGNCS ETC.
                CADR    GOPERF1
                TCF     GOTOP00H        # V34E TERMINATE
                TCF     P40A/P          # RECYCLE
GOBACK          CA      TEMPR60
                TC      BANKJUMP        # GOODBYE.  COME AGAIN SOON.
```

A moonshot, in a technology context, is an ambitious, exploratory and ground-breaking project undertaken without any expectation of near-term profitability or benefit and also, perhaps, without a full investigation of potential risks and benefits.

MIT News

ON CAMPUS AND AROUND THE WORLD

FULL SCREEN

Computer scientist Margaret Hamilton poses with the Apollo guidance software she and her team developed at MIT.

Photos: MIT Museum

Scene at MIT: Margaret Hamilton's Apollo code

A brief history of the famous 1969 photo of the software that sent humans to the moon.

The Woman Who Helped Put The First Man On The Moon

MARGARET HAMILTON

Margaret Hamilton

- 35.2% of chemists are women;
- 11.1% of physicists and astronomers are women;
- 33.8% of environmental engineers are women;
- 22.7% of chemical engineers are women;
- 17.5% of civil, architectural, and sanitary engineers are women;
- 17.1% of industrial engineers are women;
- 10.7% of electrical or computer hardware engineers are women; and
- 7.9% of mechanical engineers are women

https://ngcproject.org/statistics

Margaret Hamilton came onto the scene a bit later, when programming computers was less a confidential government initiative and more a niche scientific pursuit. She had studied math, and got a job as a programmer at MIT to support her husband (who was attending Harvard) and daughter. Her capacity was quickly recognized and she was tapped to work with the Apollo program, creating the mission's onboard flight systems.


November 22, 2016 ● The White House

On July 20, 1969, minutes before the astronauts aboard the Apollo 11 lunar module were about to make their historic landing on the moon, alarms sounded.

The computer running the lunar module was trying to shift to a radar system. If the system were allowed to make the shift, the mission would have to be aborted, and the astronauts would have to turn their spacecraft around and return to earth.

Fortunately, a different set of instructions took control of the computer, and the mission continued. The Apollo 11 lunar module landed, and astronaut Neil Armstrong became the first man to step onto the surface of the moon.

Margaret Hamilton, MIT

This past summer, the computer code that ran the systems responsible for putting Armstrong and his colleague Buzz Aldrin on the moon was published in its entirety on Github, a popular open source platform that software developers use to publish and edit each other's code.

The code was developed by a team of software engineers at MIT's Software Engineering Lab led by Margaret Hamilton. Hamilton was honored by NASA in 2003,

At the award ceremony in the White House, President Obama said Hamilton represents "that generation of unsung women who helped send humankind into space."

http://nces.ed.gov/programs/digest/d12/tables/dt12_349.asp
https://nsf.gov/statistics/2016/nsb20161/uploads/1/nsb20161.pdf

COMPUTER SCIENCE

WOMEN

BS in CS

1983-84 37.1%

2010-11 17.6%

	Bachelor's degrees					Master's degrees			Doctor's degrees		
	Total										
	Number	Annual percent change	Males	Females	Females as a percent of total	Total	Males	Females	Total	Males	Females
	2	3	4	5	6	7	8	9	10	11	12
1970-71	2,388	†	2,064	324	13.6	1,588	1,424	164	128	125	3
1971-72	3,402	42.5	2,941	461	13.6	1,977	1,752	225	167	155	12
1972-73	4,304	26.5	3,664	640	14.9	2,113	1,888	225	196	181	15
1973-74	4,756	10.5	3,976	780	16.4	2,276	1,983	293	198	189	9
1974-75	5,033	5.8	4,080	953	18.9	2,299	1,961	338	213	199	14
1975-76	5,652	12.3	4,534	1,118	19.8	2,603	2,226	377	244	221	23
1976-77	6,407	13.4	4,876	1,531	23.9	2,798	2,332	466	216	197	19
1977-78	7,201	12.4	5,349	1,852	25.7	3,038	2,471	567	196	181	15
1978-79	8,719	21.1	6,272	2,447	28.1	3,055	2,480	575	236	206	30
1979-80	11,154	27.9	7,782	3,372	30.2	3,647	2,883	764	240	213	27
1980-81	15,121	35.6	10,202	4,919	32.5	4,218	3,247	971	252	227	25
1981-82	20,267	34.0	13,218	7,049	34.8	4,935	3,625	1,310	251	230	21
1982-83	24,565	21.2	15,641	8,924	36.3	5,321	3,813	1,508	262	228	34
1983-84	32,439	32.1	20,416	12,023	37.1	6,190	4,379	1,811	251	225	26
1984-85	39,121	20.6	24,737	14,384	36.8	7,101	5,064	2,037	248	223	25
1985-86	42,337	8.2	27,208	15,129	35.7	8,070	5,658	2,412	344	299	45
1986-87	39,767	-6.1	25,962	13,805	34.7	8,481	5,985	2,496	374	322	52
1987-88	34,651	-12.9	23,414	11,237	32.4	9,197	6,726	2,471	428	380	48
1988-89	30,560	-11.8	21,143	9,417	30.8	9,414	6,775	2,639	551	466	85
1989-90	27,347	-10.5	19,159	8,188	29.9	9,677	6,960	2,717	627	534	93
1990-91	25,159	-8.0	17,771	7,388	29.4	9,324	6,563	2,761	676	584	92
1991-92	24,821	-1.3	17,685	7,136	28.7	9,655	6,980	2,675	772	669	103
1992-93	24,519	-1.2	17,606	6,913	28.2	10,353	7,557	2,796	805	689	116
1993-94	24,527	#	17,528	6,999	28.5	10,568	7,836	2,732	810	685	125
1994-95	24,737	0.9	17,684	7,053	28.5	10,595	7,805	2,790	887	726	161
1995-96	24,506	-0.9	17,757	6,749	27.5	10,579	7,729	2,850	869	743	126
1996-97	25,422	3.7	18,527	6,895	27.1	10,513	7,526	2,987	857	721	136
1997-98	27,829	9.5	20,372	7,457	26.8	11,765	8,343	3,422	858	718	140
1998-99	30,552	9.8	22,289	8,263	27.0	12,843	8,866	3,977	806	656	150
1999-2000	37,788	23.7	27,185	10,603	28.1	14,990	9,978	5,012	779	648	131
2000-01	44,142	16.8	31,923	12,219	27.7	16,911	11,195	5,716	768	632	136
2001-02	50,365	14.1	36,462	13,903	27.6	17,173	11,447	5,726	752	581	171
2002-03	57,433	14.0	41,950	15,483	27.0	19,509	13,267	6,242	816	648	168
2003-04	59,488	3.6	44,585	14,903	25.1	20,143	13,868	6,275	909	709	200
2004-05	54,111	-9.0	42,125	11,986	22.2	18,416	13,136	5,280	1,119	905	214
2005-06	47,480	-12.3	37,705	9,775	20.6	17,055	12,470	4,585	1,416	1,109	307
2006-07	42,170	-11.2	34,342	7,828	18.6	16,232	11,985	4,247	1,595	1,267	328
2007-08	38,476	-8.8	31,694	6,782	17.6	17,087	12,513	4,574	1,698	1,323	375
2008-09	37,994	-1.3	31,215	6,779	17.8	17,907	13,063	4,844	1,580	1,226	354
2009-10	39,589	4.2	32,410	7,179	18.1	17,953	13,017	4,936	1,599	1,250	349
2010-11	43,072	8.8	35,478	7,594	17.6	19,446	13,956	5,490	1,588	1,267	321
Percent change											
2000-01 to 2005-06	7.6	†	18.1	-20.0	†	0.9	11.4	-19.8	84.4	75.5	125.7
2005-06 to 2010-11	-9.3	†	-5.9	-22.3	†	14.0	11.9	19.7	12.1	14.2	4.6

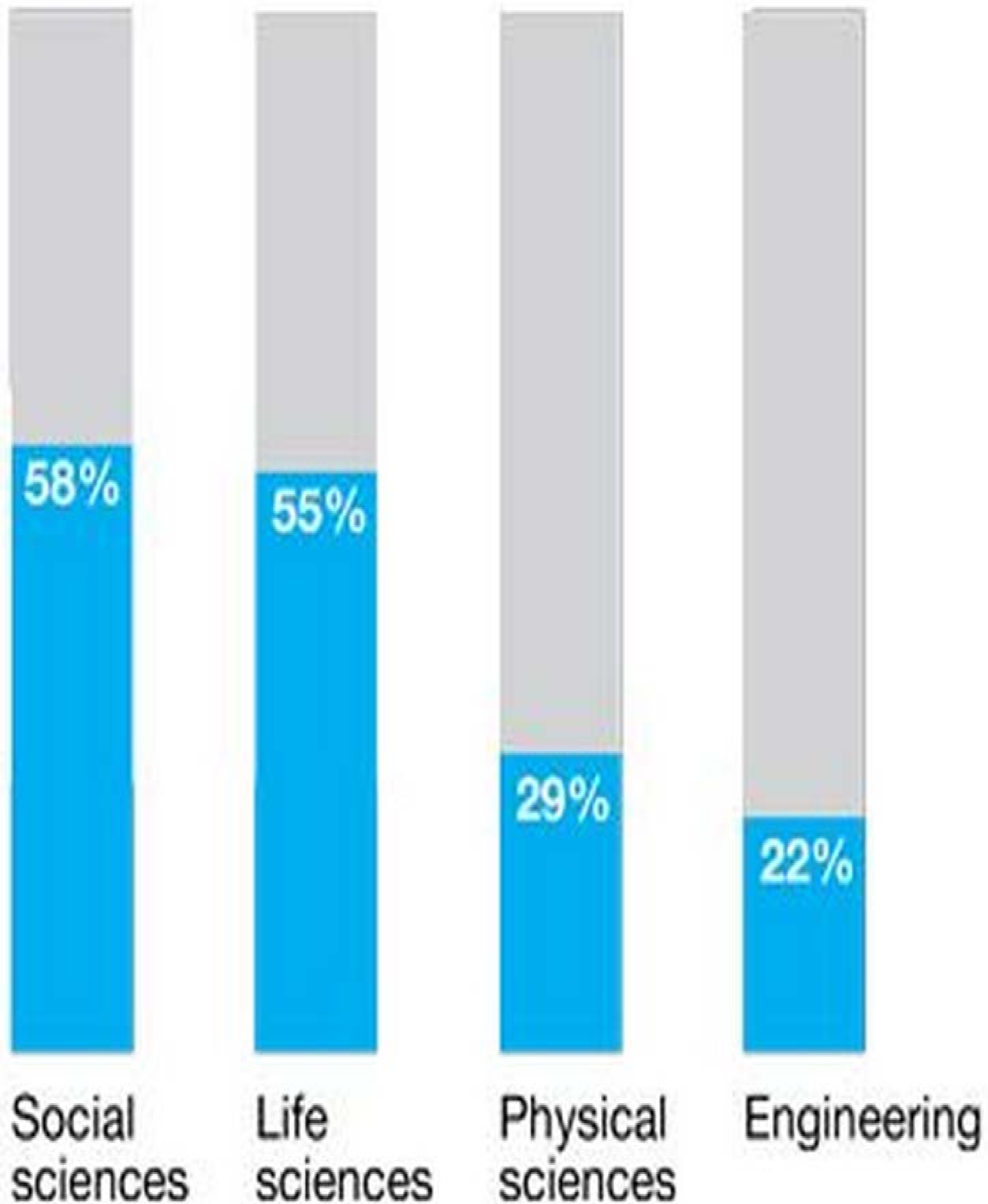
https://www.census.gov/hhes/school/files/ACS-CPS-CCD_02-18-14.pdf

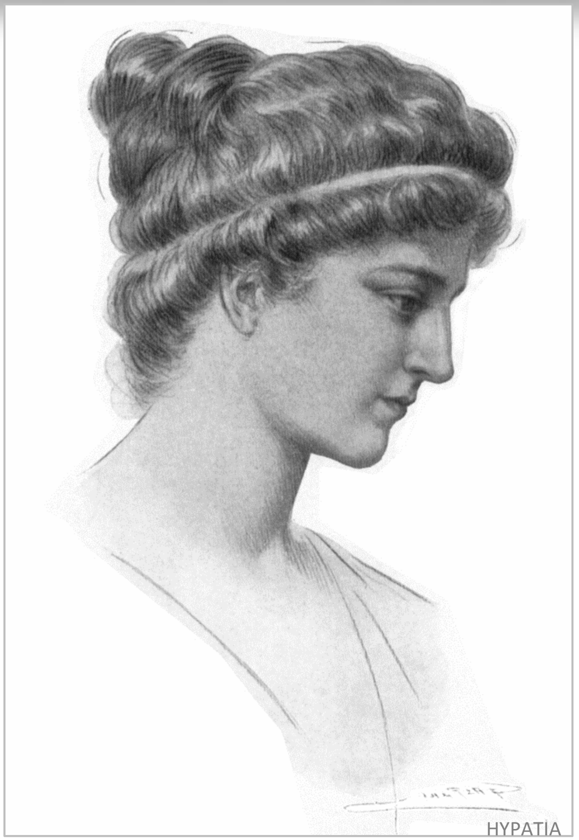
5,807 female US high school students took AP Computer Science (15 million students in US HS)

media.collegeboard.com/digitalServices/pdf/research/2013/Program-Summary-Report-2013.pdf

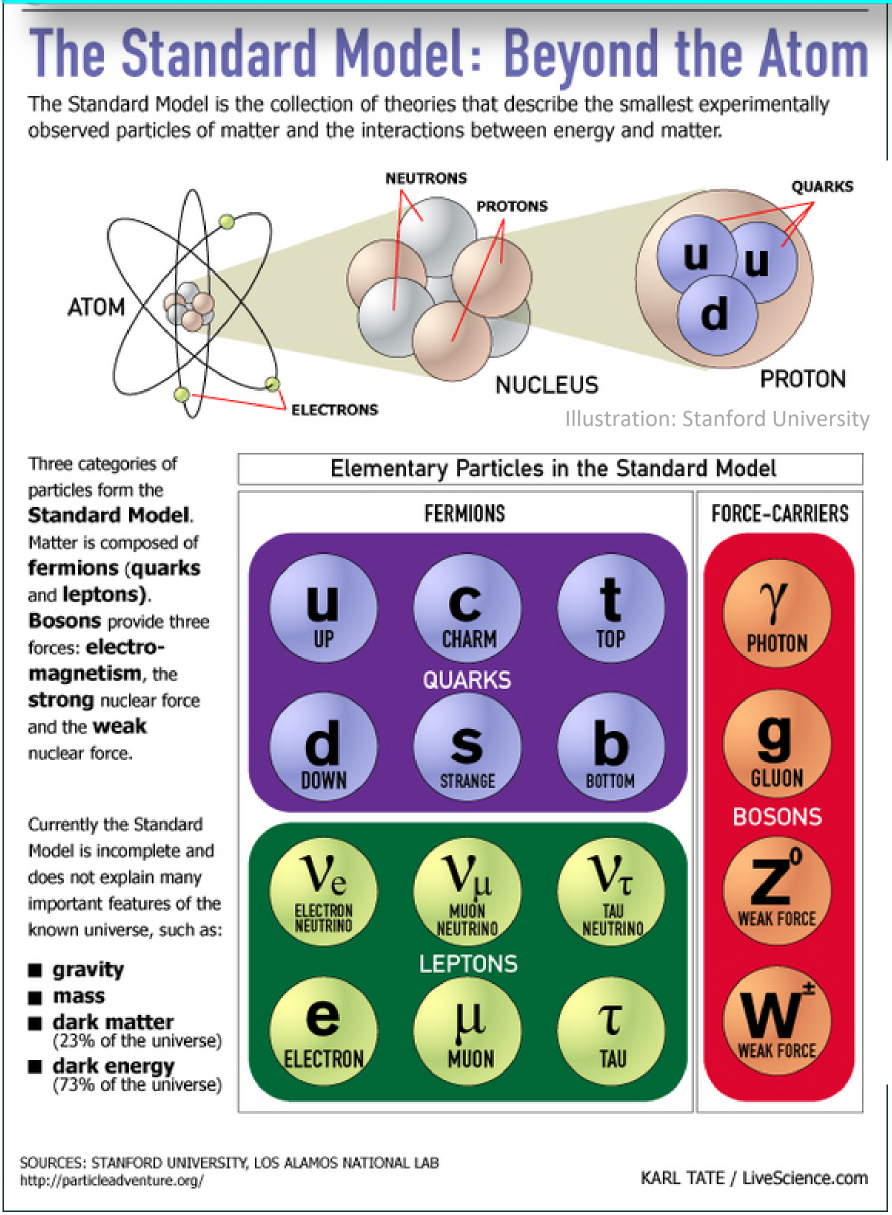
	SCHOOLS	9TH GRADE	10TH GRADE	11TH GRADE	STUDENTS IN 12TH GRADE	Not HS	<9TH GRADE	NOT STATED	MALE	FEMALE	2012 PROGRAM TOTAL	2013 PROGRAM TOTAL	% CHANGE 2012-2013	NO. OF COLLEGES
ART HISTORY	1,912	230	3,326	7,369	11,370	11	5	412	7,960	14,763	22,650	22,723	0	1,219
BIOLOGY	10,161	2,373	23,016	77,642	97,228	161	34	2,735	84,656	118,533	191,773	203,189	6	2,696
CALCULUS AB	13,559	423	5,051	66,896	206,312	783	79	3,270	147,404	135,410	266,994	282,814	6	2,945
CALCULUS BC	6,386	365	2,872	27,136	72,372	671	59	1,008	62,164	42,319	94,403	104,483	11	1,800
CHEMISTRY	8,444	219	10,089	76,909	50,998	392	20	1,379	75,066	64,940	132,425	140,006	6	2,200
CHINESE LANGUAGE & CULTURE	1,460	907	2,265	3,573	3,195	15	34	132	4,603	5,518	9,357	10,121	8	400
COMPUTER SCIENCE A	3,249	738	5,607	10,657	13,583	65	39	428	25,310	5,807	26,103	31,117	19	1,200
MACROECONOMICS	4,359	531	3,113	15,444	86,757	721	7	1,646	60,885	47,334	99,903	108,219	8	2,100
MICROECONOMICS	3,569	193	2,846	13,388	49,283	745	12	1,038	39,491	28,014	62,351	67,505	8	1,800
ENGLISH LANGUAGE & COMP.	11,407	258	11,117	403,936	53,316	122	14	7,514	182,283	293,994	443,835	476,277	7	3,000
ENGLISH LITERATURE & COMP.	13,497	54	1,900	43,611	334,592	261	11	5,147	144,911	240,665	380,608	385,576	1	3,200
ENVIRONMENTAL SCIENCE	4,896	3,525	7,432	40,266	65,046	48	10	1,961	53,683	64,605	108,839	118,288	9	2,200
EUROPEAN HISTORY	4,700	1,040	65,783	15,707	25,551	47	0	1,750	51,810	58,068	108,854	109,878	1	2,000
FRENCH LANGUAGE & CULTURE	3,280	240	1,249	5,614	13,232	21	70	299	6,660	14,065	19,769	20,725	5	1,200
GERMAN LANGUAGE & CULTUR	1,200	81	361	919	3,474	9	34	88	2,564	2,402	4,754	4,966	4	700
GOVT. & POL. - COMP.	1,229	110	1,958	3,935	14,001	13	1	299	10,540	9,777	18,402	20,317	10	1,100
GOVT. & POL. - U.S.	8,193	4,806	19,803	31,991	195,151	159	16	3,832	123,033	132,725	239,513	255,758	7	2,800
HUMAN GEOGRAPHY	3,049	67,070	18,935	11,142	14,692	33	32	2,457	51,706	62,655	98,679	114,361	16	1,700
ITALIAN LANGUAGE & CULTURE	339	8	67	330	1,528	2	7	38	741	1,239	1,806	1,980	10	300
JAPANESE LANGUAGE & CULTU	610	93	272	684	1,148	2	2	33	954	1,280	2,177	2,234	3	300
LATIN - VERGIL	1,104	14	353	2,150	4,076	4	1	69	3,356	3,311	6,424	6,667	4	600
MUSIC THEORY	2,945	215	2,266	6,331	9,033	6	27	314	10,274	7,918	18,161	18,192	0	1,251
PHYSICS B	5,654	317	3,253	34,038	50,410	118	48	1,079	58,436	30,827	80,584	89,263	11	2,033
PHYSICS C - E&M	2,190	27	271	2,698	15,945	214	7	218	14,880	4,500	17,380	19,380	12	796
PHYSICS C - MECH	3,714	48	530	6,973	34,509	298	20	480	31,689	11,169	38,630	42,858	11	1,300
PSYCHOLOGY	6,924	538	16,175	89,610	128,670	185	33	3,751	88,603	150,359	220,361	238,962	8	2,818
SPANISH LANGUAGE	7,310	5,072	19,175	48,926	54,668	45	4,802	2,571	51,345	83,914	129,674	135,259	4	2,276
SPANISH LITERATURE	1,602	322	1,428	6,174	10,469	5	1	386	6,571	12,214	17,919	18,785	5	1,026
STATISTICS	7,357	428	8,032	32,553	125,329	644	164	2,358	83,380	86,128	153,859	169,508	10	2,637
STUDIO ART - DRAWING	3,446	23	420	3,150	11,537	5	0	1,462	3,974	12,623	16,188	16,597	3	1,400
STUDIO ART - 2-D DESIGN	3,923	46	769	4,786	17,187	10	1	2,129	6,599	18,329	23,591	24,928	6	1,700
STUDIO ART - 3-D DESIGN	1,344	2	91	647	3,059	1	0	367	1,244	2,923	3,840	4,167	9	700
U.S. HISTORY	12,176	1,899	46,883	370,643	16,523	89	16	6,837	207,441	235,449	427,796	442,890	4	2,800
WORLD HISTORY	5,783	15,397	181,457	20,222	7,964	42	670	4,355	105,279	124,828	210,805	230,107	9	2,188
TOTAL NO. OF EXAMS TAKEN		107,612	468,165	1,486,050	1,802,208	5,947	6,276	61,842	1,809,495	2,128,605	3,698,407	3,938,100	6	
TOTAL NO. OF STUDENTS		102,356	395,045	818,812	852,782	2,572	6,124	40,887	986,137	1,232,441	2,099,948	2,218,578	6	

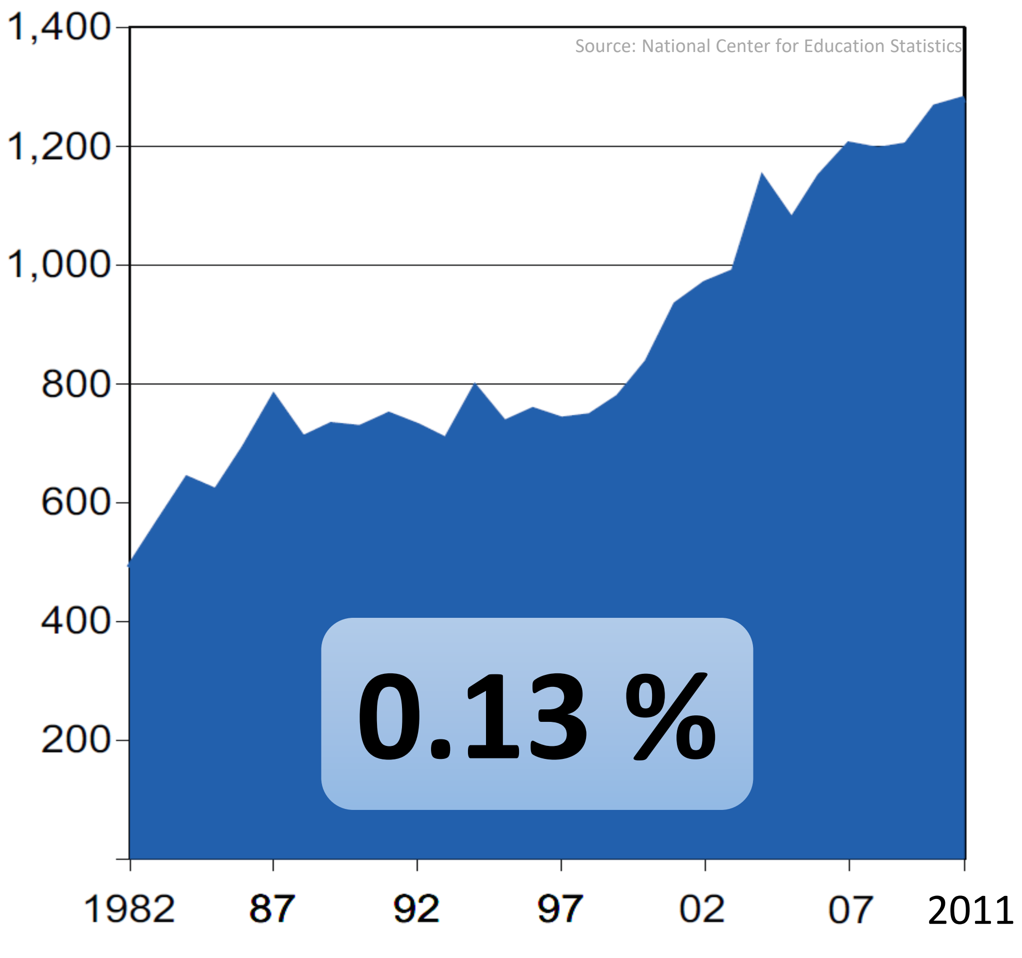
Doctorates awarded to female candidates (NSF, 2012)





US Math-Science → Women BS Physics → 1,300 out of 1,000,000 (2011)





Fifth Solvay International Conference on Electrons and Photons (Brussels, 1927)

Back: Auguste Piccard, Émile Henriot, Paul Ehrenfest, Édouard Herzen, Théophile de Donder, Erwin Schrödinger, JE Verschaffelt, Wolfgang Pauli, Werner Heisenberg, Ralph Fowler, Léon Brillouin.

Middle: Peter Debye, Martin Knudsen, William Lawrence Bragg, Hendrik Anthony Kramers, Paul Dirac, Arthur Compton, Louis de Broglie, Max Born, Niels Bohr.

Front: Irving Langmuir, Max Planck, Marie Curie, Hendrik Lorentz, Albert Einstein, Paul Langevin, Charles-Eugène Guye, CTR Wilson, Owen Richardson.

http://bit.ly/1927-SOLVAY-BRUSSELS

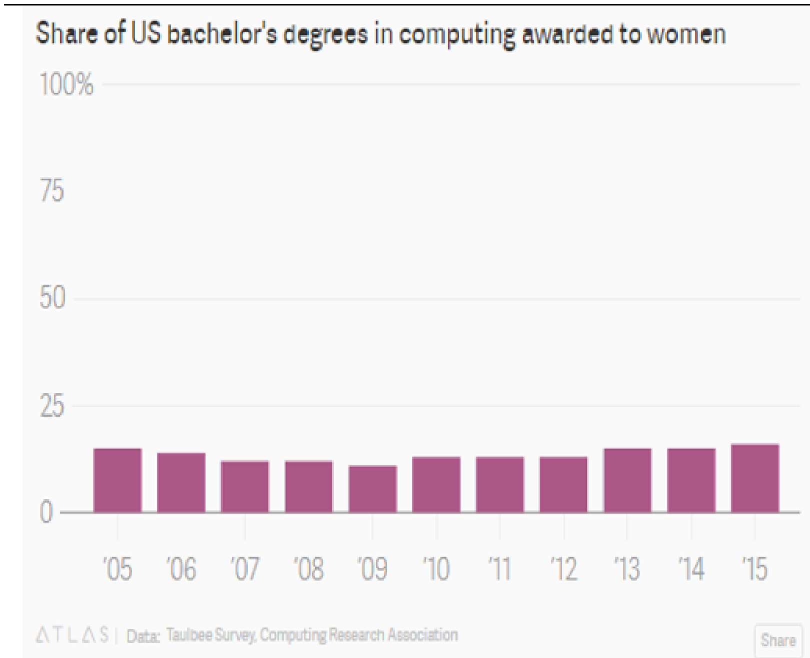
Fifth Solvay International Conference on Electrons and Photons (Brussels, 1927)

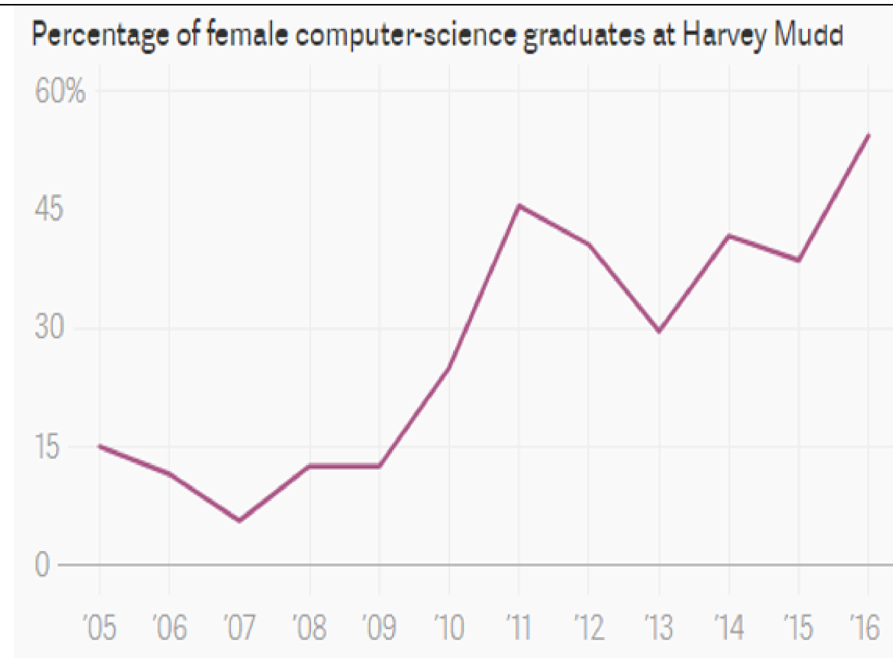
$$\frac{1}{29}$$

Raison d'être

Women In Science and Engineering

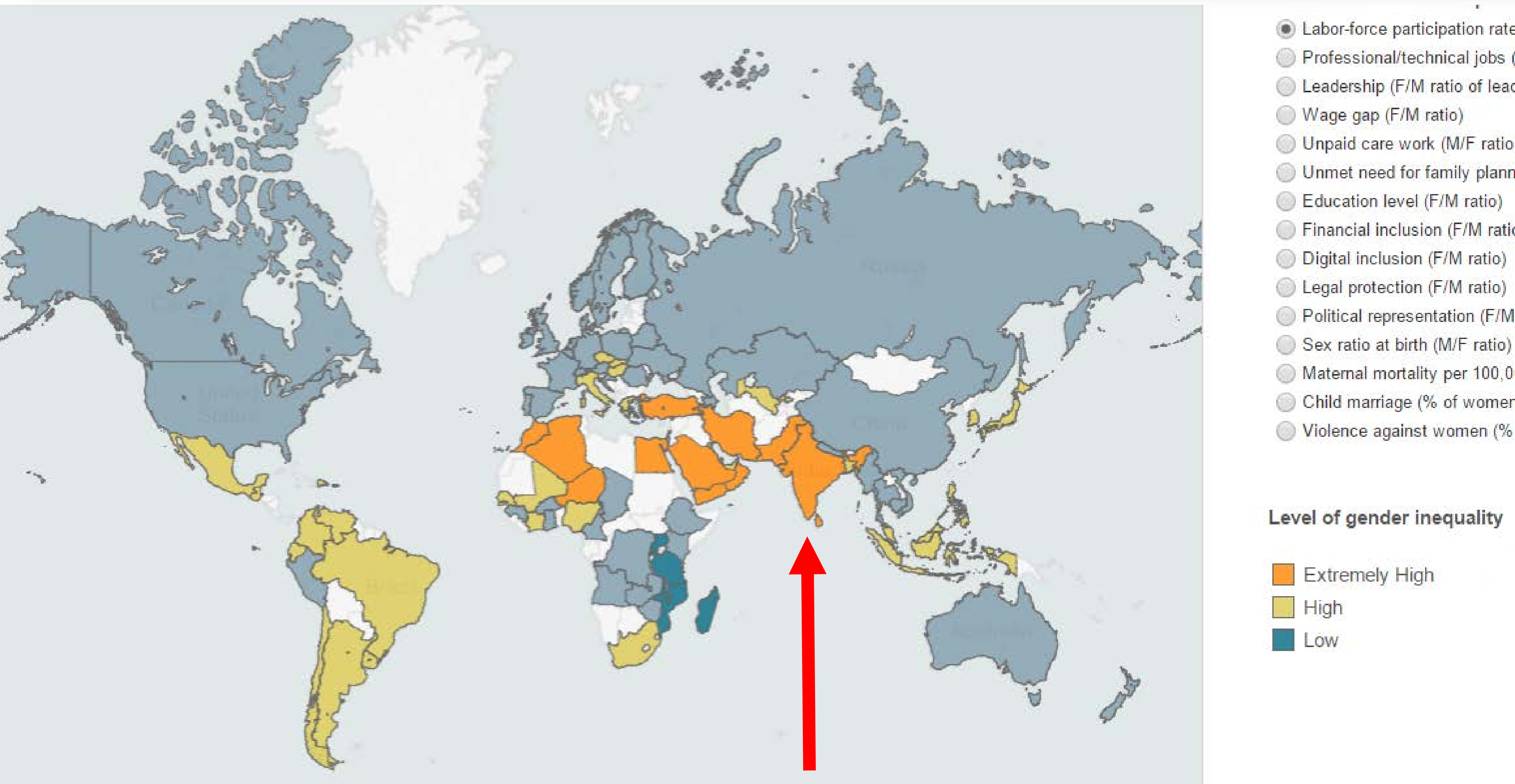
WISE





Maria Klawe at Harvey Mudd sets a high bar for STEM reform.

Inequality

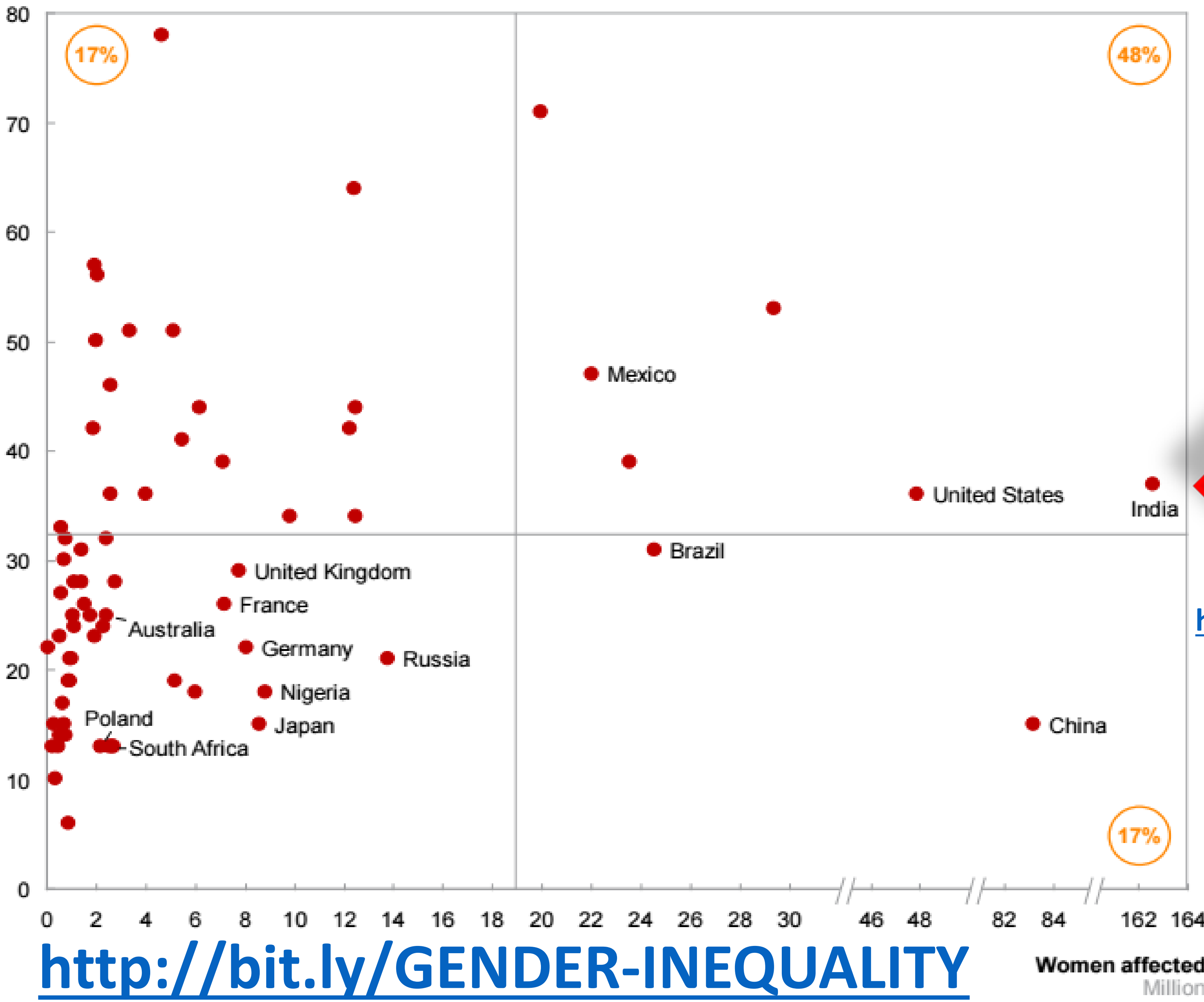


Labor-force participation rate
Professional/technical jobs (
Leadership (F/M ratio of lead
Wage gap (F/M ratio)
Unpaid care work (M/F ratio
Unmet need for family plann
Education level (F/M ratio)
Financial inclusion (F/M ratio
Digital inclusion (F/M ratio)
Legal protection (F/M ratio)
Political representation (F/M
Sex ratio at birth (M/F ratio)
Maternal mortality per 100,0
Child marriage (% of women
Violence against women (%
Level of gender inequality
Extremely High
High
Low

Violence against women

Percent of women who have experienced physical and/or sexual violence from an intimate partner at some time in their lifetime

www.worldbank.org/en/topic/socialdevelopment/brief/violence-against-women-and-girls



http://bit.do/VAW

http://bit.ly/GENDER-INEQUALITY

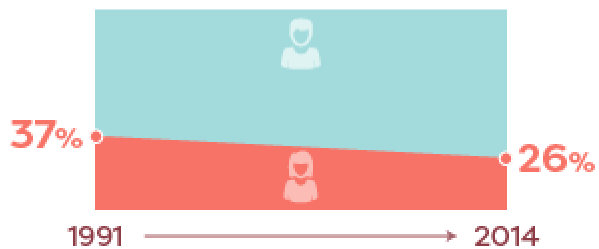
Less than

7%

of tech positions in Europe are filled by women.

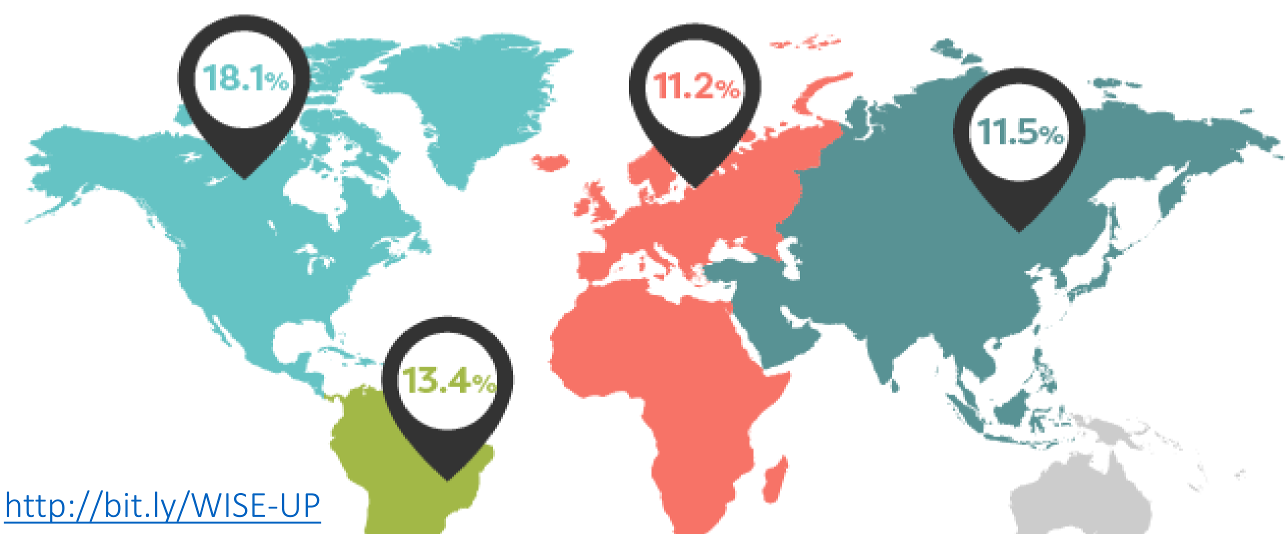
While more women are in the workforce today, less are working in technology.

In the US, only a small number of computing jobs are held by women.



Worldwide, women are a minority within tech leadership – accounting for less than 20% in their respective countries.

Tech leadership roles held by women



http://bit.ly/WISE-UP

Tackling gender inequality could add $12tn to world economy, study finds

Researchers say extra GDP output could come from reforms, such as allowing more women in workforce in countries where they currently face restrictions

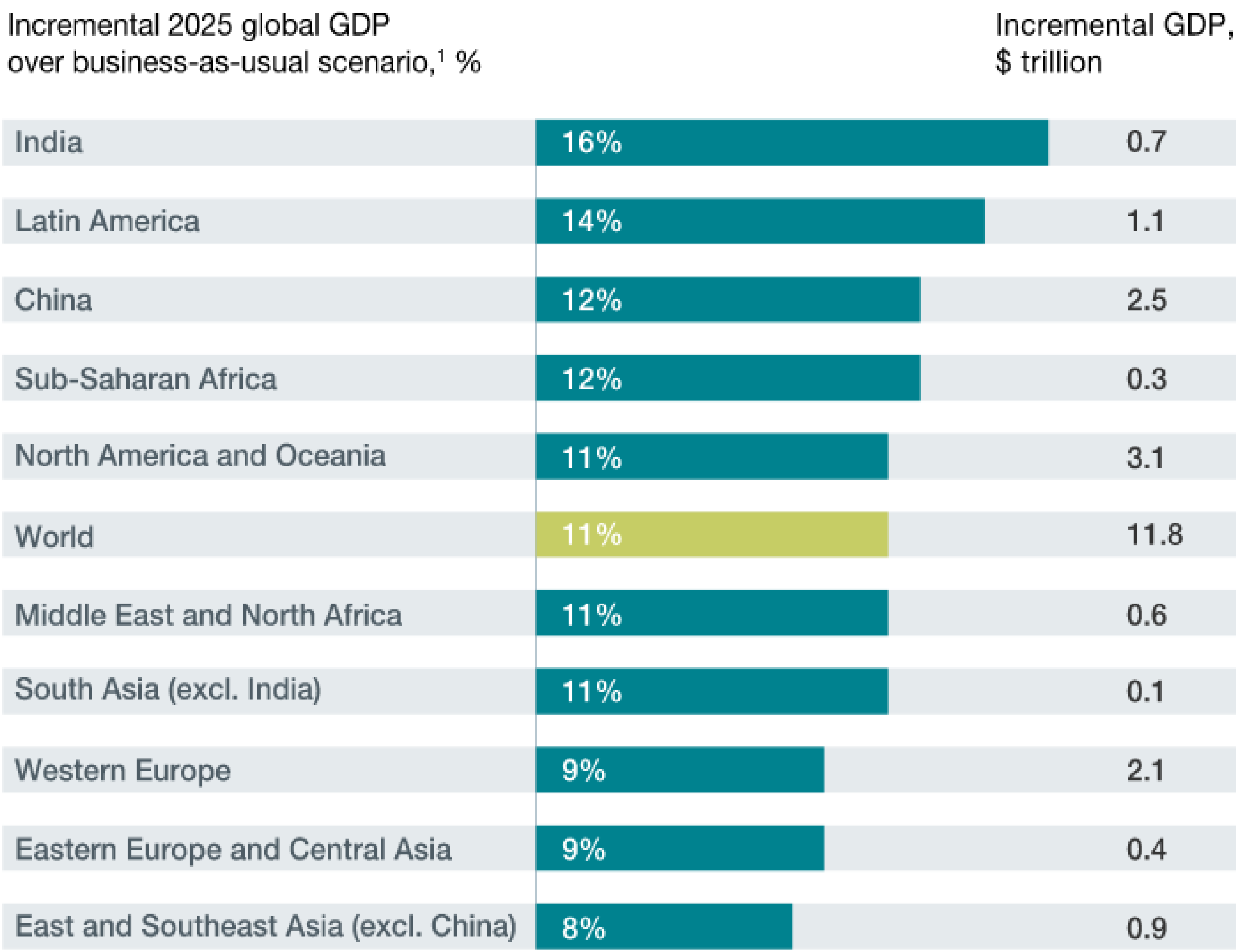
A woman working at a salt pan in Mumbai. Due to gender inequality, only 17% of India's GDP comes from women. The figure is 40% in the US and western Europe. Photograph: Divyakant Solanki/EPA

Tackling gender inequality and boosting women's opportunities in the labour market could add $12tn (£7.8tn) to annual global GDP over the next decade, according to new research.

Der wichtigste Grund

http://bit.ly/GENDER-INEQUALITY

If every country matched the progress toward gender parity of its fastest-improving neighbor, global GDP could increase by up to $12 trillion in 2025.



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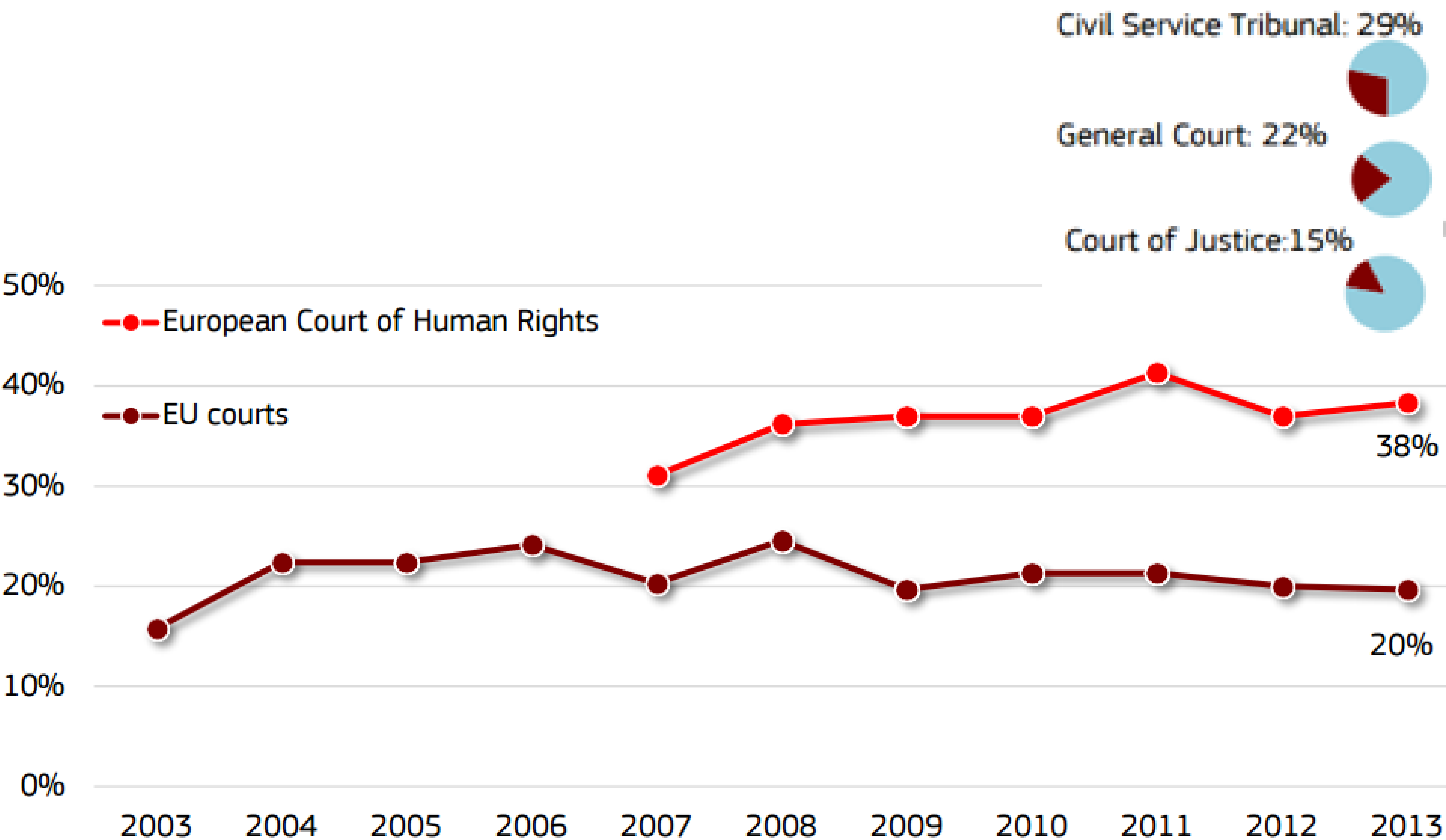
Remediable Injustice ?

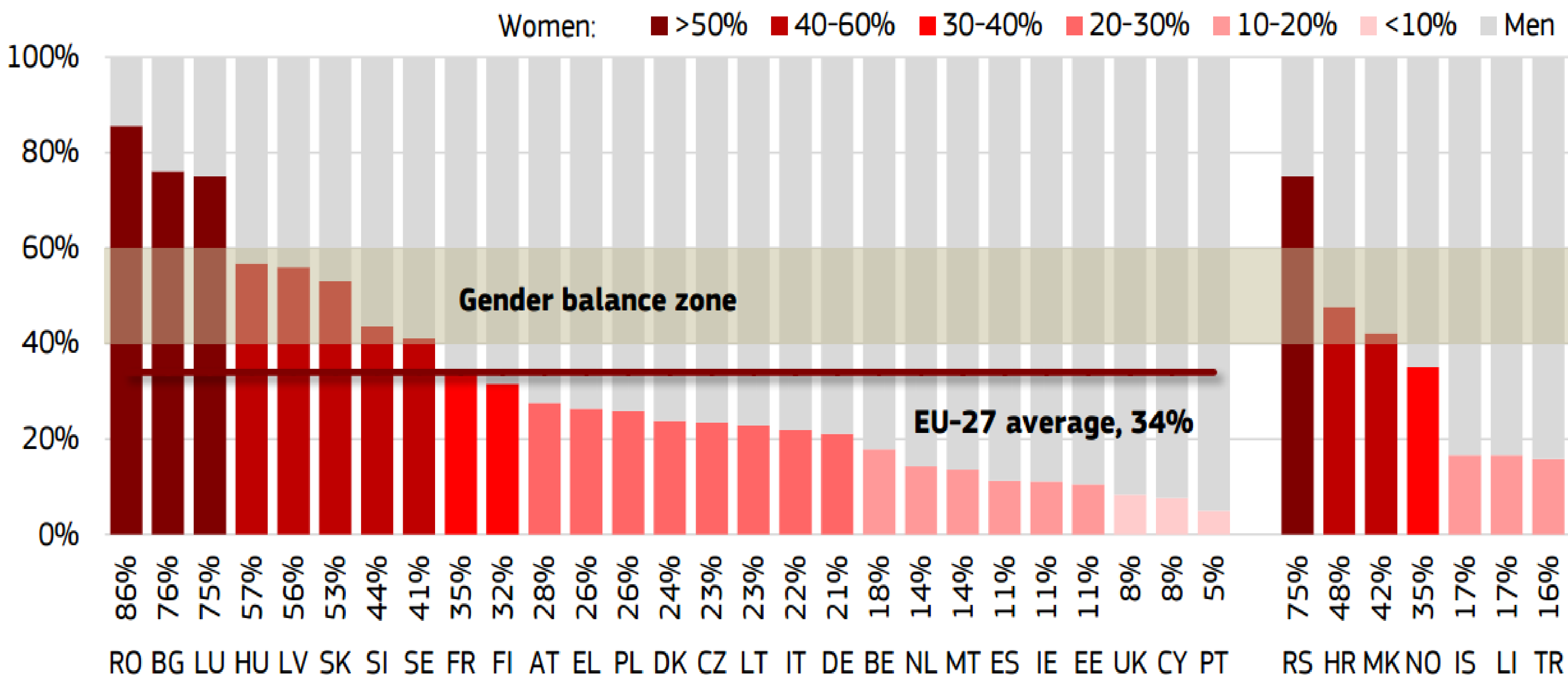
Women Judges

Breakdown of % women in EU courts, 2013:



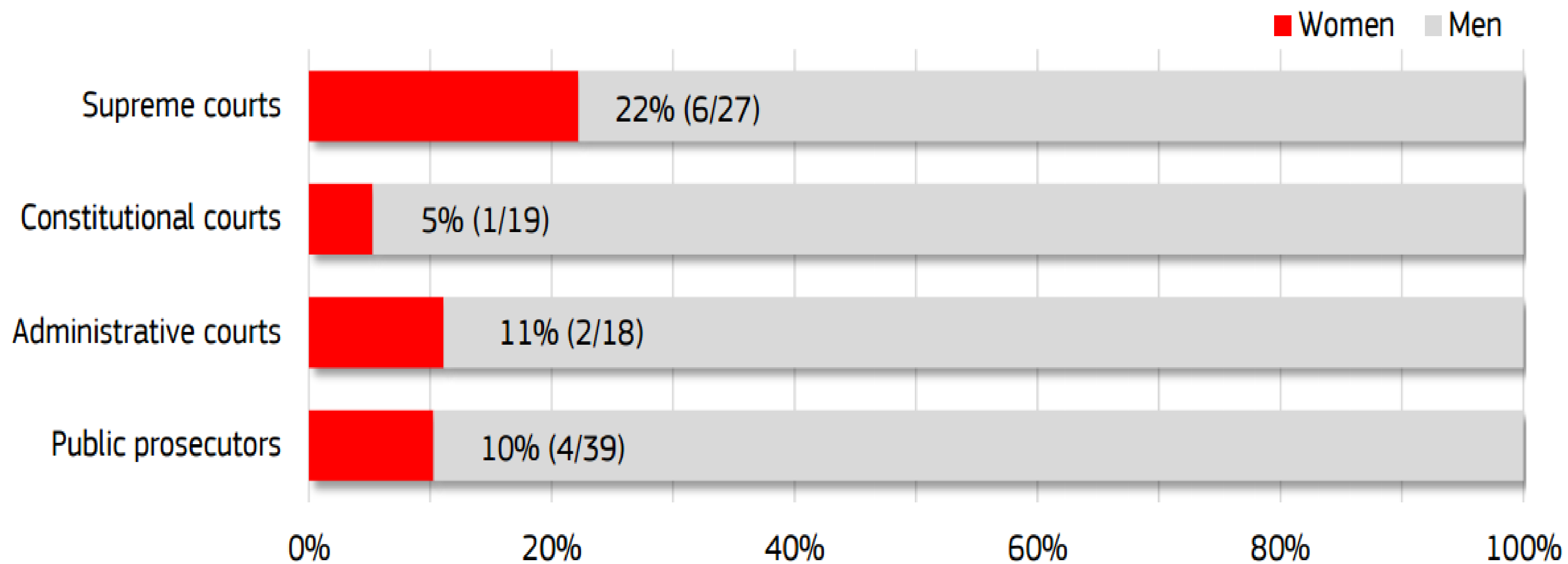
Source: European Commission, Database on women and men in decision-making.
Note: The Civil Service Tribunal came into existence in 2005 and is therefore not included in data before this point.

Judges of European National Courts (2012)



Source: European Commission, Database on women and men in decision-making.

Presidents of Courts & Public Prosecutors (EU-27)



Source: European Commission, Database on women and men in decision-making.

The New York Times

WORLD

Most Nations Miss a Goal for Women in Leadership

By SOMINI SENGUPTA AUG. 31, 2015

UNITED NATIONS — The corridors of the United Nations hummed on Monday as hundreds of men, in polished wingtips and natty ties, arrived here for the annual conclave of lawmakers from around the world.

By now, the other half of humanity was to be better represented in their ranks. Yet despite a promise made by world leaders two decades ago to have women make up at least 30 percent of their national legislatures, most of the world's parliaments remain largely the province of men. The conference at the United Nations reflected just that.

Among 190 countries, only 44 legislatures have met the 30 percent goal, according to an analysis by the Inter-Parliamentary Union. They include Rwanda (nearly 64 percent of members of its lower house of Parliament are women) and Bolivia (53 percent).

Think different

Apple Developers Conference ● Santa Clara Convention Ctr ● March 2014

A Reason To Believe ?

Irrational Exuberance ?

How the cookie crumbles – Women on Street

Wenn Sie Autos verkaufen wollen, helfen, die Straßen zu bauen

If you want to sell cars help build the road

The education of a boy changes the fate of a man.

The education of a girl changes the destiny of a nation.

 Please write to shoumen@mit.edu or sdatta8@mgh.harvard.edu

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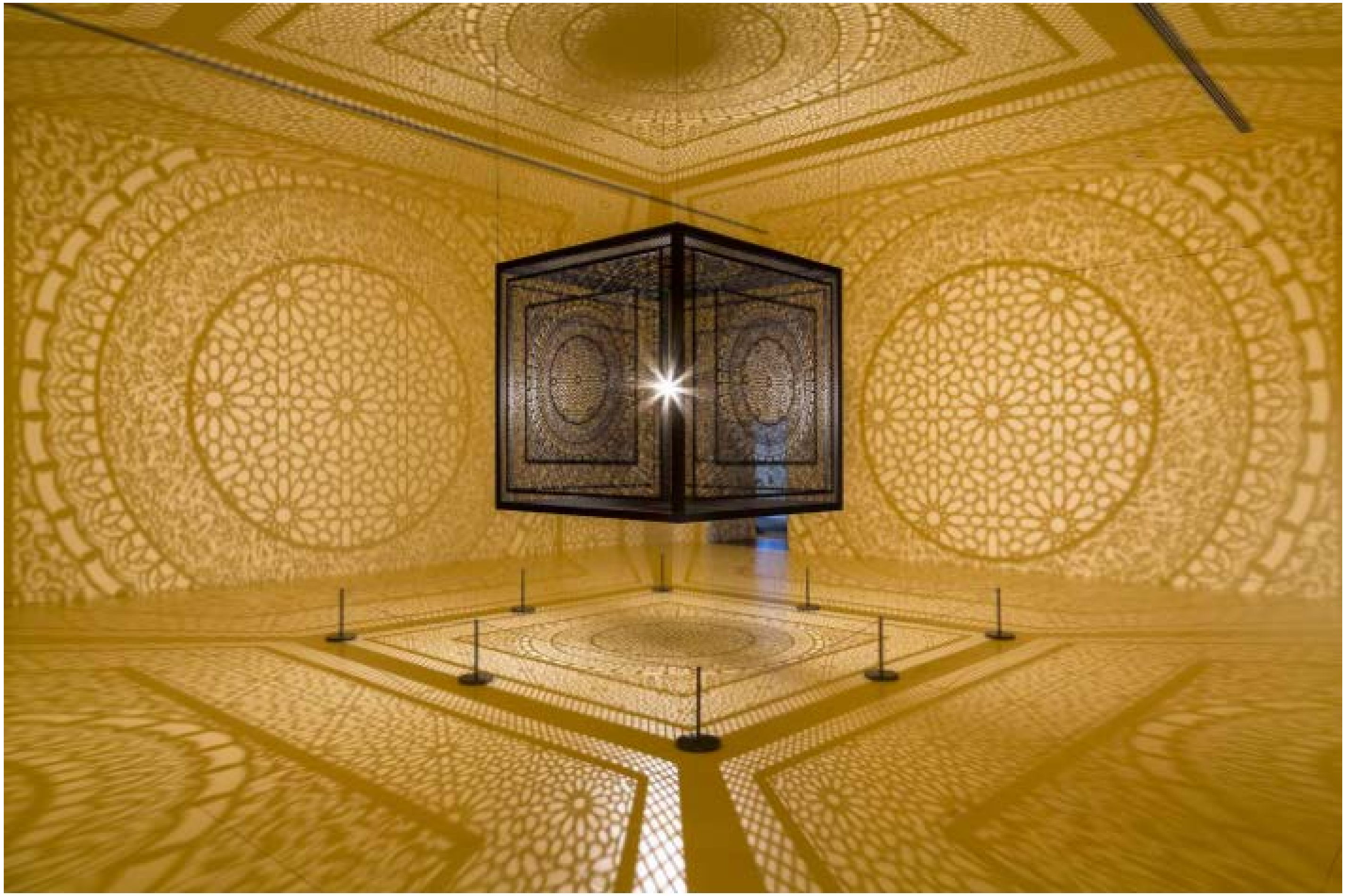

Dr Shoumen Palit Austin Datta

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