SOFT

Sense of Future Trends

Progress is not a point but an asynchronous continuum of punctuated equilibria, perhaps an unevenly braided canvas of communities embracing change, chance, choice, and character.

A Sense of the Future: Essays in Natural Philosophy by Jacob Bronowski (MIT Press, 1977) ◆ https://mitpress.mit.edu/books/sense-future

Table of contents

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https://dspace.mit.edu/handle/1721.1/131129

SOFT may be downloaded from AWS (Amazon Web Services) using this short, secure URL

https://bit.ly/2021-SOFT

To Whom It May Concern: **SOFT** was created for students aspiring to become professional catalysts to improve, globally, the quality of life and living. The content is biased in its focus on science and the issues related to lives of 80% of the world's population with actual problems (not the fictitious idiosyncrasies of the 20% affluent world). Examples are limited by the knowledge on the part of the author. Most ideas are borrowed and presented here only as suggestions. The author neither created these examples nor has made any scientific contribution. Exercise caution in reviewing the author's proposals and predictions because the author may be best described as a successful failure in almost all professional efforts as well as in research and in his career in science. Opinions are due to the author alone and doesn't represent the views of the institutions with which the author may be affiliated.

Shoumen Palit Austin Datta, Massachusetts Institute of Technology and Massachusetts General Hospital, Harvard Medical School, Harvard University ◆ http://bit.ly/BIO-SD

After reading through this document will you learn anything you didn't know?

There is nothing “new” here.
It is a re-telling of facts already known to many, in some form.

Mathematics, science and engineering is catalytic to the progress of human civilization.

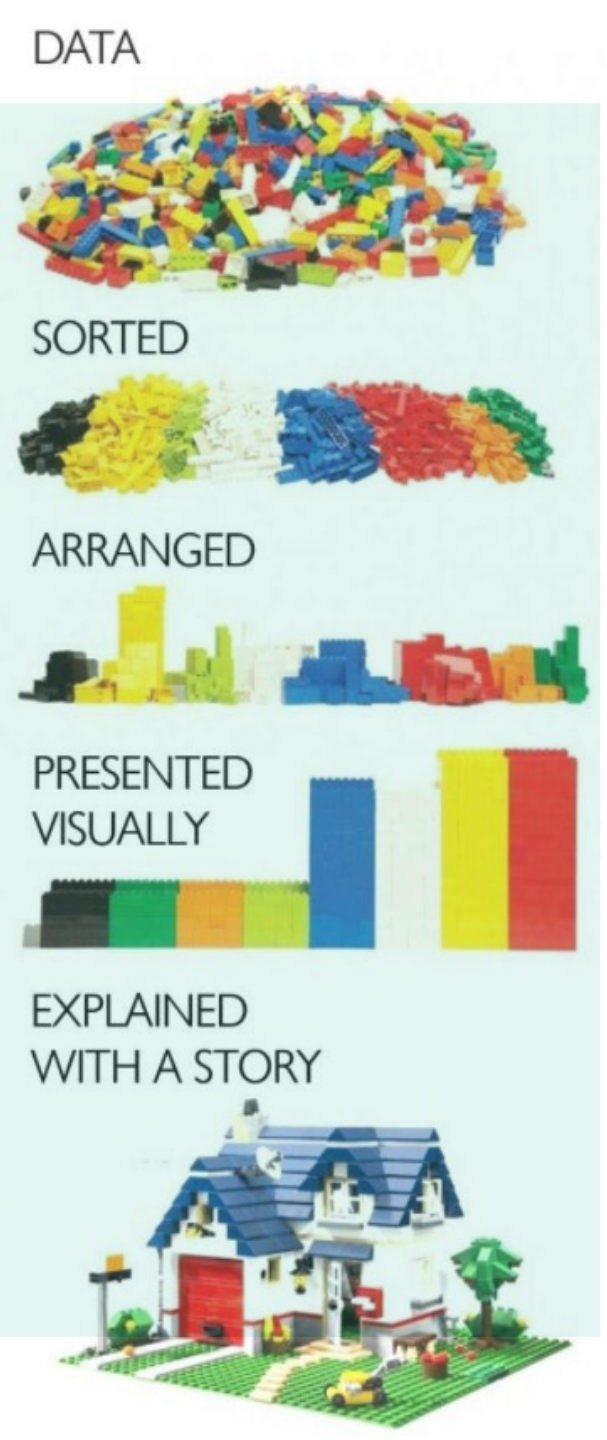
You knew that, already. Didn't you?

This is my version of the same old story.

If I have wasted your time, I'm sorry. I apologize.

Think “SOFT” as a heap of data …

CREATE YOUR OWN STORY …



Future → Forward

FEWSH

Food Energy Water Sanitation Healthcare

Shoumen Palit Austin Datta

F	Food
E	Energy
W	Water
S	Sanitation
H	Healthcare

Your contribution to society matters.

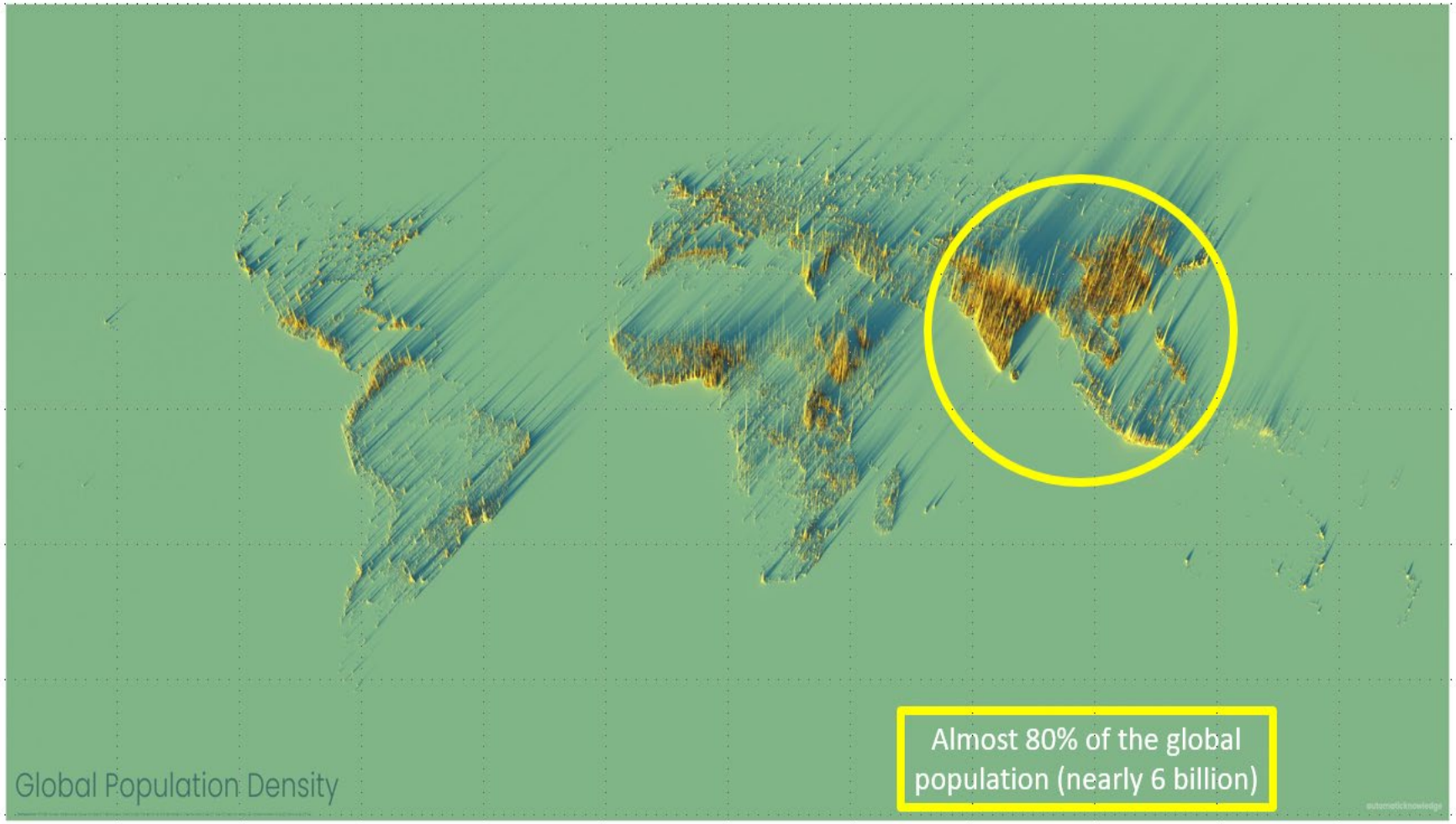
Science and Scientists for Society

Why the emphasis on FEWSH

We are neither discounting nor discarding space stations, deep sea explorations, asteroid mining, autonomous transportation or other engineering marvels from the affluent world.

Focus on FEWSH offers a life-line to 80% of the less-affluent global population. Asia and Africa will continue to contribute to the global population (may exceed 10 billion by 2100).

I am, however, advocating that we discard and disregard fake artificial intelligence (AI) which has viciously infected almost everything, the stupid hype associated with “smart cities” and technical tools that increase the carbon footprint (egg-minders sending SMS to mobile apps).


Global Population Density
Almost 80% of the global population (nearly 6 billion)

Key threads this discussion includes

INFORMATION and CONNECTIVITY

Attempt to review, learn, compare, criticize and evaluate science through the lens of

Information

The Information Age is all around us. It started with the Big Bang, created the Solar System and it may persist *ad infinitum* as long as the Solar System continues its physical existence. Information is the fundamental fabric of intellectual connectivity. Our understanding of the difference between hydrogen and oxygen is based on information. The difference between bauxite and the material of the Coke can is information. Information is the differentiator between Apple Newton PDA which died prematurely vs the almost identical Palm Pilot that climbed the summit of popularity. Information changes when the car you are driving is suddenly crushed in a collision. Think about the approximately 500 inhabitants of Mureybet, Syria in 8000BC and compare their information content to the approximately 1500 modern day inhabitants of Dingle village in County Kerry (Ireland) which boasts of at least 50 pubs in this miniscule hamlet near the Atlantic. Described by Claude Shannon in 1948 as informational entropy, it has been shown that the interpretation of entropy (formula) provided by Ludwig Boltzmann (the Boltzmann equation) becomes the Shannon equation, thus mathematically linking entropy and information.

Attempt to review, learn, compare, criticize and evaluate science/engineering in terms of

Connectivity

Connectivity is fundamentally pervasive between almost every entity – physical, metaphysical and cyberphysical. Connectivity transcends the sub-nano realm and the super-macro domain. Doesn't it define the astronomical universe, all biological systems and everything conceptual in between? The mobility of ancient civilizations to explore new worlds were physical connections between atoms. The bargain hunter's app to compare prices between various retailers is the new sense of value which connects bits with atoms. All things and processes are about connectivity. Invention and innovation was, is and will be about connecting the dots, real and/or virtual, perceived and/or imagined. Human thought, technological progress and the future of synaptic relationships are likely to be manifestations of connectivity, convergence and confluence of concepts. The sense of connectivity is germane to life. Its ubiquity makes us oblivious to its quintessential nature. To evoke the central theme of connectivity, therefore, is not an insight but rather recognizing the fabric of the future (SOFT) hiding in plain sight. Connect the dots!

What this discussion excludes

THE BS AND NONSENSE ABOUT FAKE AI (ARTIFICIAL INTELLIGENCE) CLAIMS

https://bit.ly/BS-about-AI

https://bit.ly/BS-about-AI

Articles in support of the fact that the propaganda about artificial intelligence (fake AI) may be a scientific absurdity.

Datta, Shoumen Palit Austin (2016) Intelligence in Artificial Intelligence • https://arxiv.org/ftp/arxiv/papers/1610/1610.07862.pdf

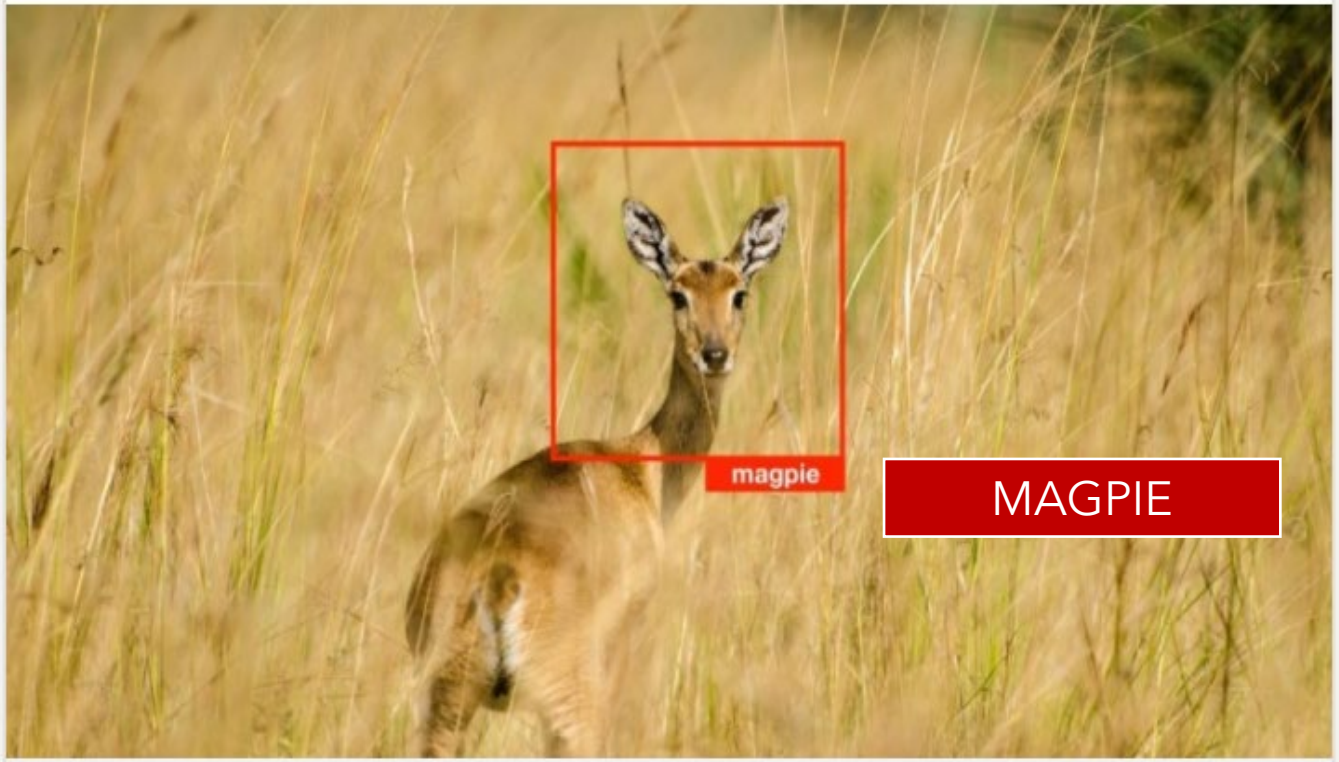
Datta, Shoumen Palit Austin, Tausifa Jan Saleem, Molood Barati, María Victoria López López, Marie-Laure Furgala, Diana C. Vanegas, Gérald Santucci, Pramod P. Khargonekar and Eric S. McLamore (2021) *Data, Analytics and Interoperability between Systems (IoT) is Incongruous with the Economics of Technology: Evolution of Porous Pareto Partition (P3).* Chapter 2 in "*Big Data Analytics for Internet of Things*" 1st ed. Editors Tausifa Jan Saleem and Mohammad Ahsan Chishti. Publisher: Wiley Inc., 2021.
Book - Wiley Online Library https://onlinelibrary.wiley.com/doi/book/10.1002/9781119740780
Book Chapter 2 – Wiley Online Library https://onlinelibrary.wiley.com/doi/abs/10.1002/9781119740780.ch2
Book Chapter 2 – free from MIT Library – PDF copy of "P3" in the MIT Library https://dspace.mit.edu/handle/1721.1/123984
Published: 2 April 2021 ▪ Print ISBN: 9781119740759 ▪ Online ISBN: 9781119740780 ▪ DOI: 10.1002/9781119740780

MIT Technology Review

933,582 followers

1w •

The 10 most cited AI data sets are riddled with errors.



MAGPIE

AI datasets are filled with errors. It's warping what we know about AI

https://bit.ly/BS-about-AI

nytimes.com/2021/07/16/technology/what-happened-ibm-watson.html

The New York Times

What Ever Happened to IBM's Watson?

IBM's artificial intelligence was supposed to transform industries and generate riches for the company. Neither has panned out. Now, IBM has settled on a humbler vision for Watson.

https://bit.ly/BS-about-AI

SNAKE OIL SALES

technologyreview.com/2021/07/30/1030329/machine-learning-ai-failed-covid-hospital-diagnosis-pandemic/

MIT Technology Review

Artificial intelligence / Machine learning

Hundreds of AI tools have been built to catch covid. None of them helped.

MIT Technology Review

Related Story

Google's medical AI was super accurate in a lab. Real life was a different story.

If AI is really going to make a difference to patients we need to know how it works when real humans get their hands on it, in real situations.

It never happened—but not for lack of effort. Research teams around the world stepped up to help. The AI community, in particular, rushed to develop software that many believed would allow hospitals to diagnose or triage patients faster, bringing much-needed support to the front lines—in theory.

In the end, many hundreds of predictive tools were developed. None of them made a real difference, and some were potentially harmful.

That's the damning conclusion of multiple studies published in the last few months. In June, the Turing Institute, the UK's national center for data science and AI, put out a report summing up discussions at a series of workshops it held in late 2020. The clear consensus was that AI tools had made little, if any, impact in the fight against covid.

Not fit for clinical use

https://bit.ly/BS-about-AI

A systematic review shows no performance benefit of machine learning over logistic regression for clinical prediction models

Evangelia Christodoulou [a], Jie Ma [b], Gary S. Collins [b, c], Ewout W. Steyerberg [d], Jan Y. Verbakel [a, e, f], Ben Van Calster [a, d]

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[b] Centre for Statistics in Medicine, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, Botnar Research Centre, University of Oxford, Windmill Road, Oxford, OX3 7LD UK
[c] Oxford University Hospitals NHS Foundation Trust, Oxford, UK
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[e] Department of Public Health & Primary Care, KU Leuven, Kapucijnenvoer 33J box 7001, Leuven, 3000 Belgium
[f] Nuffield Department of Primary Care Health Sciences, University of Oxford, Woodstock Road, Oxford, OX2 6GG UK

https://www.jclinepi.com/article/S0895-4356(18)31081-3/fulltext

Accepted 5 February 2019, Available online 11 February 2019.

Real emphasis is on

MATH

SCIENCE

ENGINEERING

FEWSH

is the outcome from

MATH

SCIENCE

ENGINEERING

www.pnas.org/content/pnas/107/5/1860.full.pdf

PNAS PNAS PNAS

Female teachers' math anxiety affects girls' math achievement

Sian L. Beilock[1], Elizabeth A. Gunderson, Gerardo Ramirez, and Susan C. Levine

Department of Psychology and Committee on Education, University of Chicago, IL 60607

Edited* by Edward E. Smith, Columbia University, New York, NY, and approved December 17, 2009 (received for review September 23, 2009)

People's fear and anxiety about doing math—over and above actual math ability—can be an impediment to their math achievement. We show that when the math-anxious individuals are female elementary school teachers, their math anxiety carries negative consequences for the math achievement of their female students. Early elementary school teachers in the United States are almost exclusively female (>90%), and we provide evidence that these female teachers' anxieties relate to girls' math achievement via girls' beliefs about who is good at math. First- and second-grade female teachers completed measures of math anxiety. The math achievement of the students in these teachers' classrooms was also assessed. There was no relation between a teacher's math anxiety and her students' math achievement at the beginning of the school year. By the school year's end, however, the more anxious teachers were about math, the more likely girls (but not boys) were to endorse the commonly held stereotype that "boys are good at math, and girls are good at reading" and the lower these girls' math achievement. Indeed, by the end of the school year, girls who endorsed this stereotype had significantly worse math achievement than girls who did not and than boys overall. In early elementary school, where the teachers are almost all female, teachers' math anxiety carries consequences for girls' math achievement by influencing girls' beliefs about who is good at math.

education | mathematics | gender | stereotype | modeling

This US-centric view may be applicable to the "Western" world. Is it applicable to female math teachers in Asia and Africa?

If you wish to choose only one . . .

Future of FEWSH

Science begins with

MATHEMATICS

Shoumen Palit Austin Datta

If you excel in mathematics

you can do almost anything

However, no matter how good or promising something may seem, nothing by itself is a panacea. Solutions for life are not points but fabrics of convergence which may change or evolve.

Shoumen Palit Austin Datta

But, . . .

Mathematics improves your analytical thinking which is central to almost everything in the professional arena where skills are essential.

Mathematics is the salt of science and engineering.

But, knowledge without compassion is inhuman.

Compassion without knowledge is ineffective.

Taken together …

Mathematics improves analytical thinking which is central to almost everything in the professional arena. Mathematics ***is*** the salt of the earth. But, knowledge without compassion is inhuman. Compassion without knowledge is ineffective. Intellectual balance for social good is a convergence of the analytical mind with magnanimity. Arts, humanities, and philosophy enriches our humanity. Languages, linguistics and music are the heart and soul of communication. Understanding economics helps.

It is a widely held belief that science and the fruits from science (engineering, technology) may catalyze new developments to lift the lives of billions of people and provide solutions for remediable injustices in an ethical, egalitarian, civil society.

Hence, one purpose of this talk/presentation is to discuss science.

I will present a few examples of potential scientific strides in each of these FIVE categories (FEWSH), which are not in silos but inextricably linked in our daily lives, agnostic of where we live.

These examples are selected from millions of potential clues from ongoing research and development, globally. What I/we know is insignificant. The unknown unknowns are so immense that I do not even know how to begin to describe the things which may be possible in the future. The latter excludes ideas that may appear impossible, at this time. If we know about an idea then it is no longer in the realm of unknown unknowns.

It is your mission to take your imagination to a plane where you can begin to think about development in terms of thoughts none has thought before, inventions that we have not imagined, yet.

F	Food
E	Energy
W	Water
S	Sanitation
H	Healthcare

Science and Scientists for Society

Before suggesting how to build your foundation to deal with the challenges of FEWSH

Let me remind you that women are the foundation of any civil society.

You ought to know about the foundation of global society.

https://leftinparis.org/people/louis-aragon-2/

Underpinning for global economic growth and development:

La femme est l'avenir de l'homme

woman is the future of man

www.youtube.com/watch?v=V7eTE4hmhg4
www.youtube.com/watch?v=8YFYt3vZ0xE

Discussion

Number 0

Mathematics begins with zero

https://www.youtube.com/watch?v=V1bFr2SWP1I

The education of a boy may change the fate of a man. The education of a girl may change the destiny of a nation.

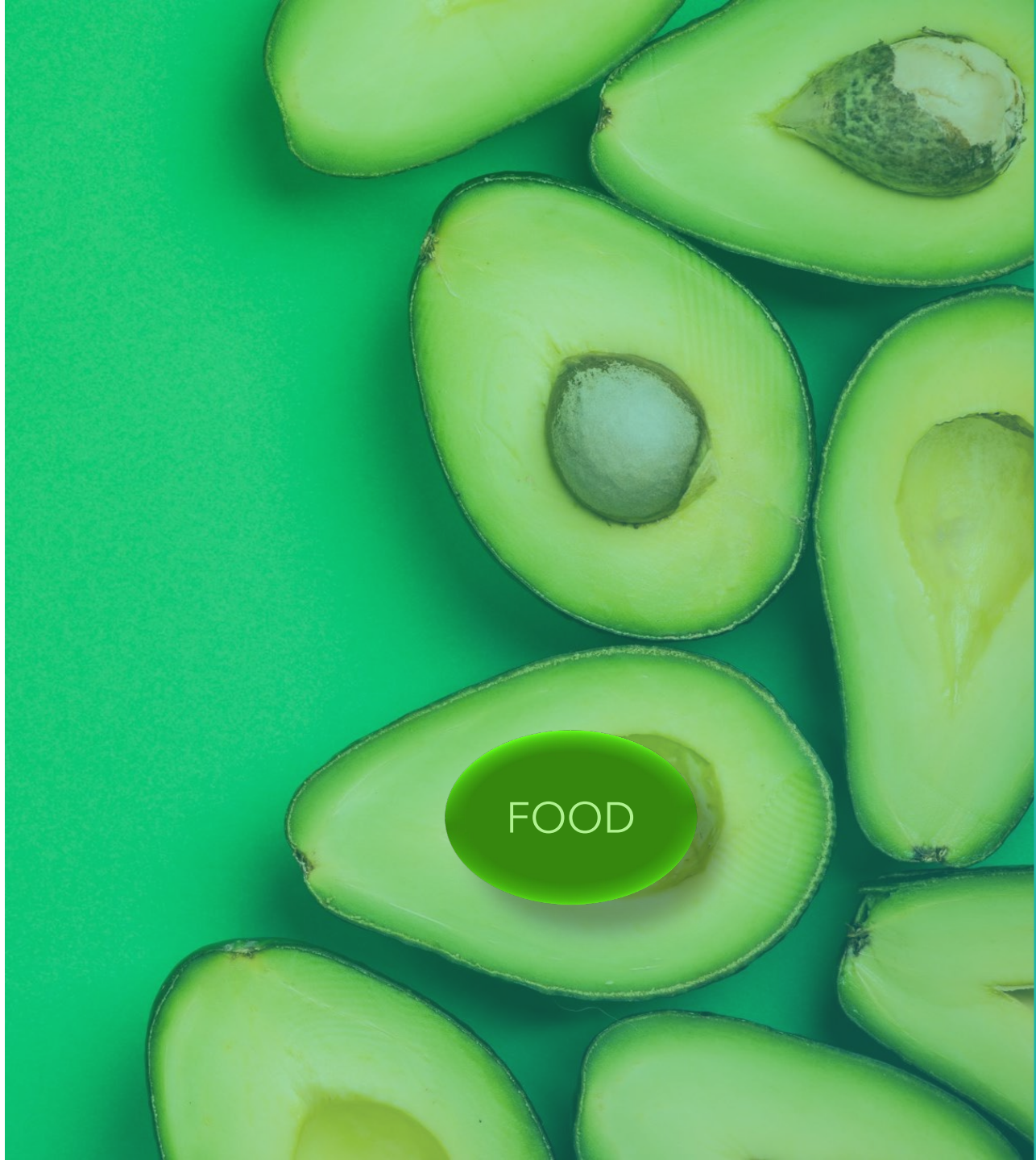
It matters.

https://www.youtube.com/watch?v=GK96bciRXiY

WIDE

Women In Decision Economy

In the 1960's the Rockefeller Foundation funded a meal program for school children in southern India. Poor families began sending not only "boys" but also the girls to school. The girls became educated women and created educated families, educated boys and an educated society. But, poverty was not discouraged by this march of reason and educational resources still consisted of paper and pencil. Mathematics had no problem with just paper and pencil. The children were fed on a diet of mathematics. Half a century later the trinity of food, poverty and mathematics evolved as a force of consilience. Their synergistic convergence resulted in making parts of southern India (Tamilnadu, Kerala) the software capital of the 21st century world. The literacy rate in the state of Kerala (92%) is higher than in Massachusetts (90%).



MATHEMATICS for MOTHERS

MATH-HERS

Pronounced “MATTERS”

Why it matters? https://bit.ly/MATH-HERS

https://www.youtube.com/watch?v=sxj5bE-wbZw

Discussion: Snippets of Examples

Number 1

https://www.youtube.com/watch?v=ZbZSe6N_BXs

F Food

Your contribution to society matters.

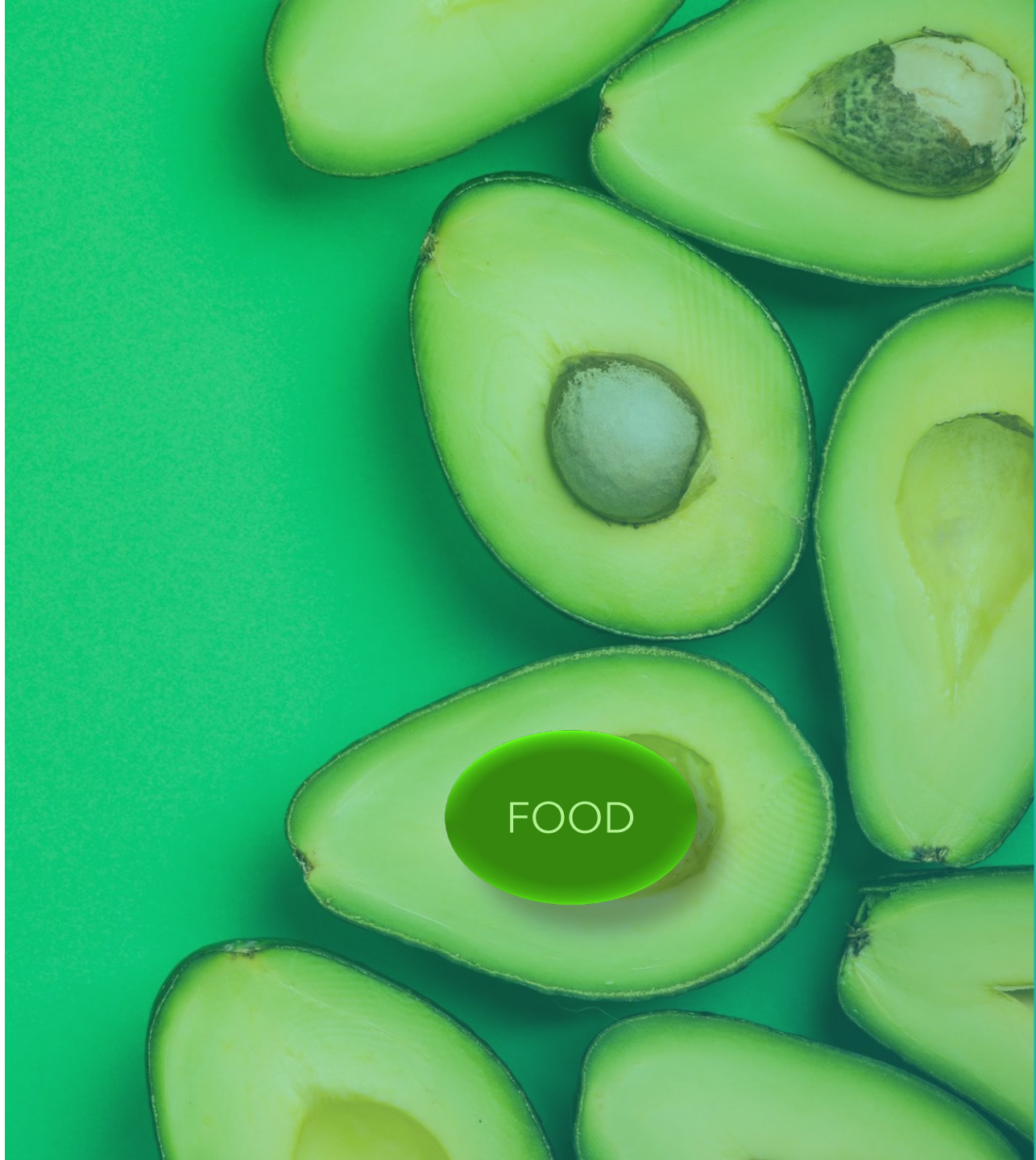
Science and Scientists for Society

WISE

Women in Science & Engineering

Each year $285 billion worth of food is thrown away in the US. Food produced with scarce resources (water, slaughtered animals, soil). 54 million tons of food won't be on the plates of people who go hungry every day. 54 million tons of food trashed in the US, each year.

http://eosfoundation.org/combatting-hunger



a vulture waiting for a starving boy to die to eat him. Taken by Kevin Carter who later committed suicide. Sudan, 1993.

http://100photos.time.com/photos/kevin-carter-starving-child-vulture

http://content.time.com/time/magazine/article/0,9171,165071,00.html

https://www.nytimes.com/1994/07/29/world/kevin-carter-a-pulitzer-winner-for-sudan-photo-is-dead-at-33.html

US centric discussion: cost of food …

Report

https://www.rockefellerfoundation.org/wp-content/uploads/2021/07/True-Cost-of-Food-Full-Report-Final.pdf

Explore

www.rockefellerfoundation.org/report/true-cost-of-food-measuring-what-matters-to-transform-the-u-s-food-system/

A $1 dollar plate of bean stew costs the equivalent of $320 in South Sudan

The real price of a plate of bean stew is $321.7 in South Sudan. The result is hunger. Image: REUTERS/Andreea Campeanu

https://www.weforum.org/agenda/2017/10/a-plate-of-bean-stew-costs-320-in-this-country/

2017

Food

- Reduce Waste
- Increase Production?

Food ▪ Depends on Population

- Reduce Waste
- Increase Production?

THE LANCET

https://www.thelancet.com/action/showPdf?pii=S0140-6736%2820%2930677-2

The Lancet, British medical journal established in 1823.

ARTICLES | VOLUME 396, ISSUE 10258, P1285-1306, OCTOBER 17, 2020

Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the Global Burden of Disease Study

Prof Stein Emil Vollset, DrPH • Emily Goren, PhD • Chun-Wei Yuan, PhD • Jackie Cao, MS • Amanda E Smith, MPA • Thomas Hsiao, BS • Catherine Bisignano, MPH • Gulrez S Azhar, PhD • Emma Castro, MS • Julian Chalek, BS • Andrew J Dolgert, PhD • Tahvi Frank, MPH • Kai Fukutaki, BA • Prof Simon I Hay, FMedSci • Prof Rafael Lozano, MD • Prof Ali H Mokdad, PhD • Vishnu Nandakumar, MS • Maxwell Pierce, BS • Martin Pletcher, BS • Toshana Robalik, BSc • Krista M Steuben, MS • Han Yong Wunrow, BSc • Bianca S Zlavog, BS • Prof Christopher J L Murray, DPhil

Show less

Open Access • Published: July 14, 2020 • DOI: https://doi.org/10.1016/S0140-6736(20)30677-2

JUNE 17, 2019

World's population is projected to nearly stop growing by the end of the century

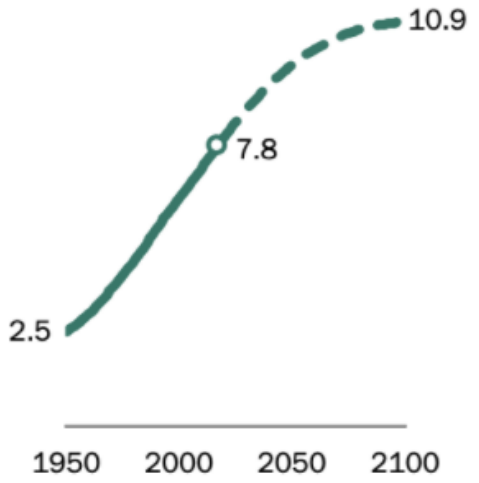
BY ANTHONY CILLUFFO AND NEIL G. RUIZ

For the first time in modern history, the world's population is expected to virtually stop growing by the end of this century, due in large part to falling global fertility rates, according to a Pew Research Center analysis of new data from the United Nations.

By 2100, the world's population is projected to reach approximately 10.9 billion, with annual growth of less than 0.1% – a steep decline from the current rate. Between 1950 and today, the world's population grew between 1% and 2% each year, with the number of people rising from 2.5 billion to more than 7.7 billion.

World population growth is projected to flatten in coming decades

World population, in billions



theguardian.com/world/2020/jul/15/world-population-in-2100-could-be-2-billion-below-un-forecasts-study-suggests

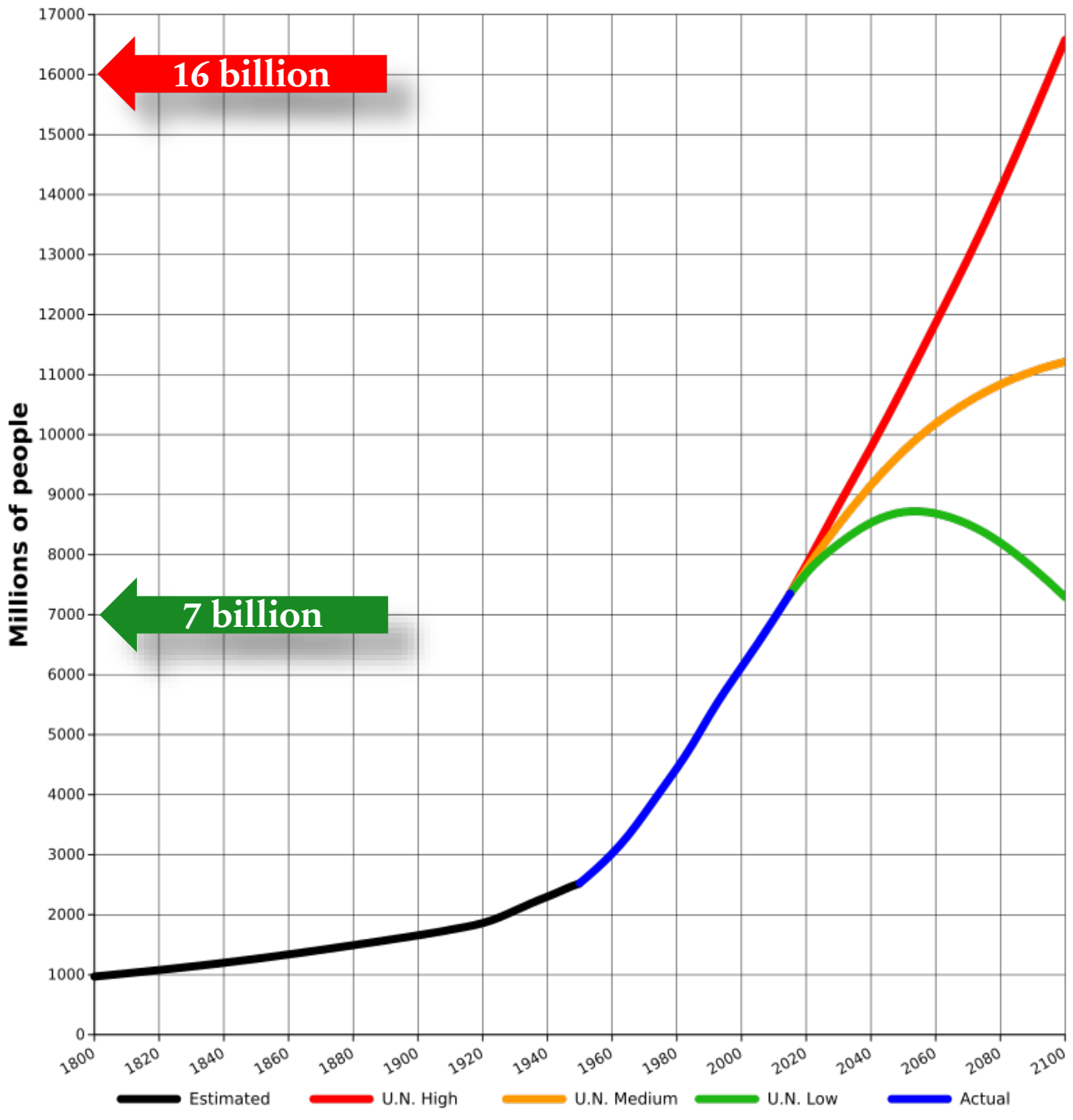
Population

This article is more than **11 months old**

World population in 2100 could be 2 billion below UN forecasts, study suggests

Changes in population structure due to improving equality and ageing societies will pose policy dilemmas

UN 2010 projections & US Census Bureau historical estimates.
https://commons.wikimedia.org/w/index.php?curid=19813379

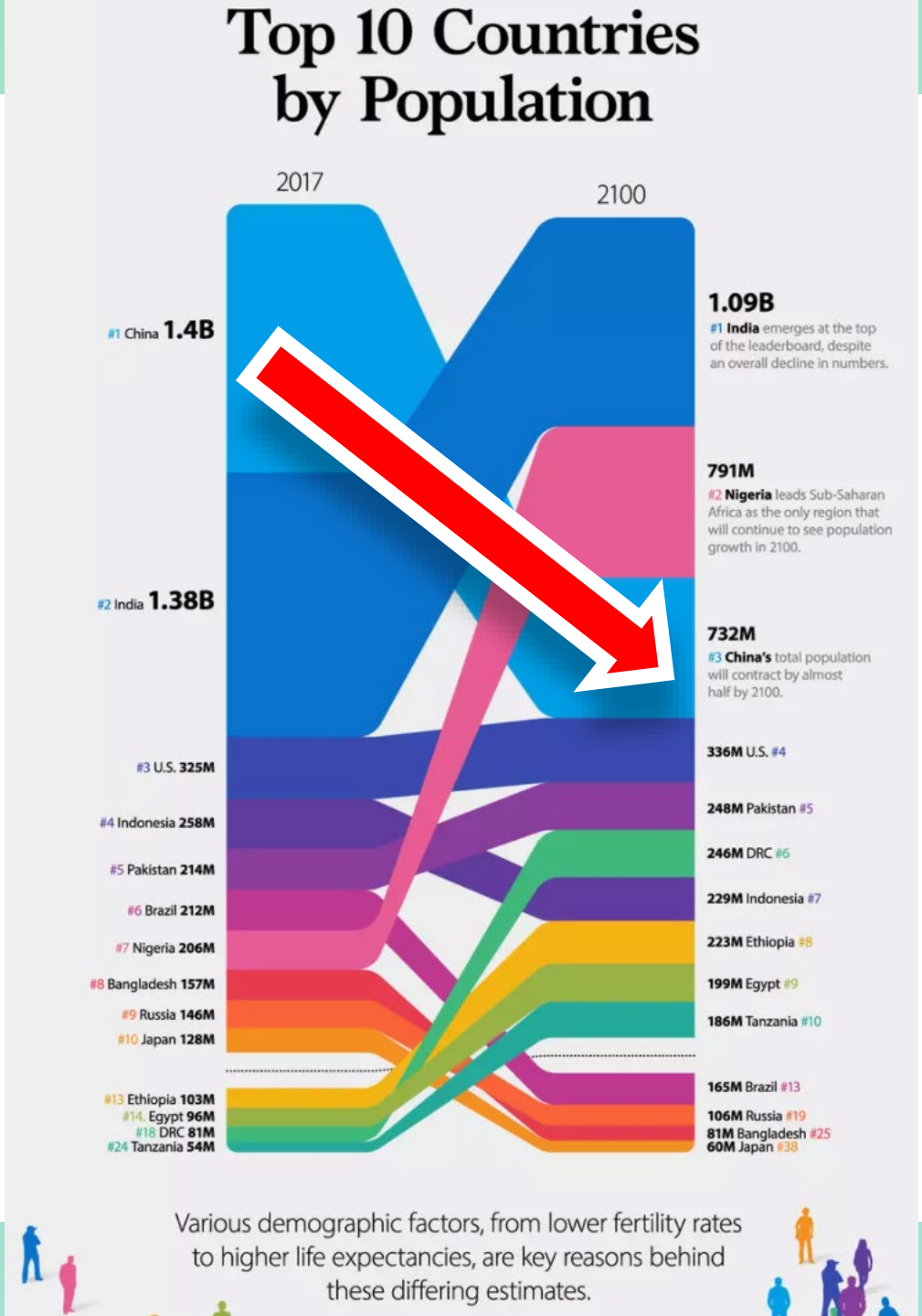


By 2100, the world population may rise to 16 billion or decline to 7 billion or as low as 6 billion.

Food ▪ feed 16 billion or 6 billion people ?

- Reduce Waste
- Increase Production?


FOOD



Number 1 in 2100
India ~1 billion

www.weforum.org/agenda/2020/09/the-world-population-in-2100-by-country/

https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/food-packaging

Food ▪ SCIENCE

- Reduce Waste
- Packaging?

Lot of talk and hot air from the US National Academies of Sciences ▪ https://www.nap.edu/cart/download.cgi?record_id=25876

Toxicol Res (Camb). 2020 Dec 3;9(6):808-822. doi: 10.1093/toxres/tfaa082. eCollection 2020 Dec.

Physical, chemical, and toxicological characterization of sulfated cellulose nanocrystals for food-related applications using *in vivo* and *in vitro* strategies

James D Ede [1], Kimberly J Ong [1], Marina R Mulenos [2], Sahar Pradhan [2], Matthew Gibb [3], Christie M Sayes [2], Jo Anne Shatkin [1]

Affiliations

1 Vireo Advisors LLC, Boston, MA 02130-4323, USA.
2 Institute of Biomedical Studies, Baylor University, One Bear Place #97266, Waco, TX 76798-7266, USA.
3 Department of Environmental Science, Baylor University, One Bear Place #97266, Waco, TX 76798-7266, USA.

PMID: 33447365 PMCID: PMC7786165 (available on 2021-12-03) DOI: 10.1093/toxres/tfaa082

Reduce food waste: nano-material science may improve food quality and packaging

Abstract

Cellulose nanocrystals (CNCs) are a next-generation cellulose product with many unique properties

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Cellulose nanocrystals (CNCs) are a next-generation cellulose product with many unique properties

What do you need to know if you want to understand and evaluate this research paper?

What is cellulose?
What is a nano-crystal?
What is an in vivo assay?
What is an in vitro assay?
What is toxicology?

pubmed.ncbi.nlm.nih.gov/33447365/

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MATHEMATICS
SCIENCE
and
ENGINEERING

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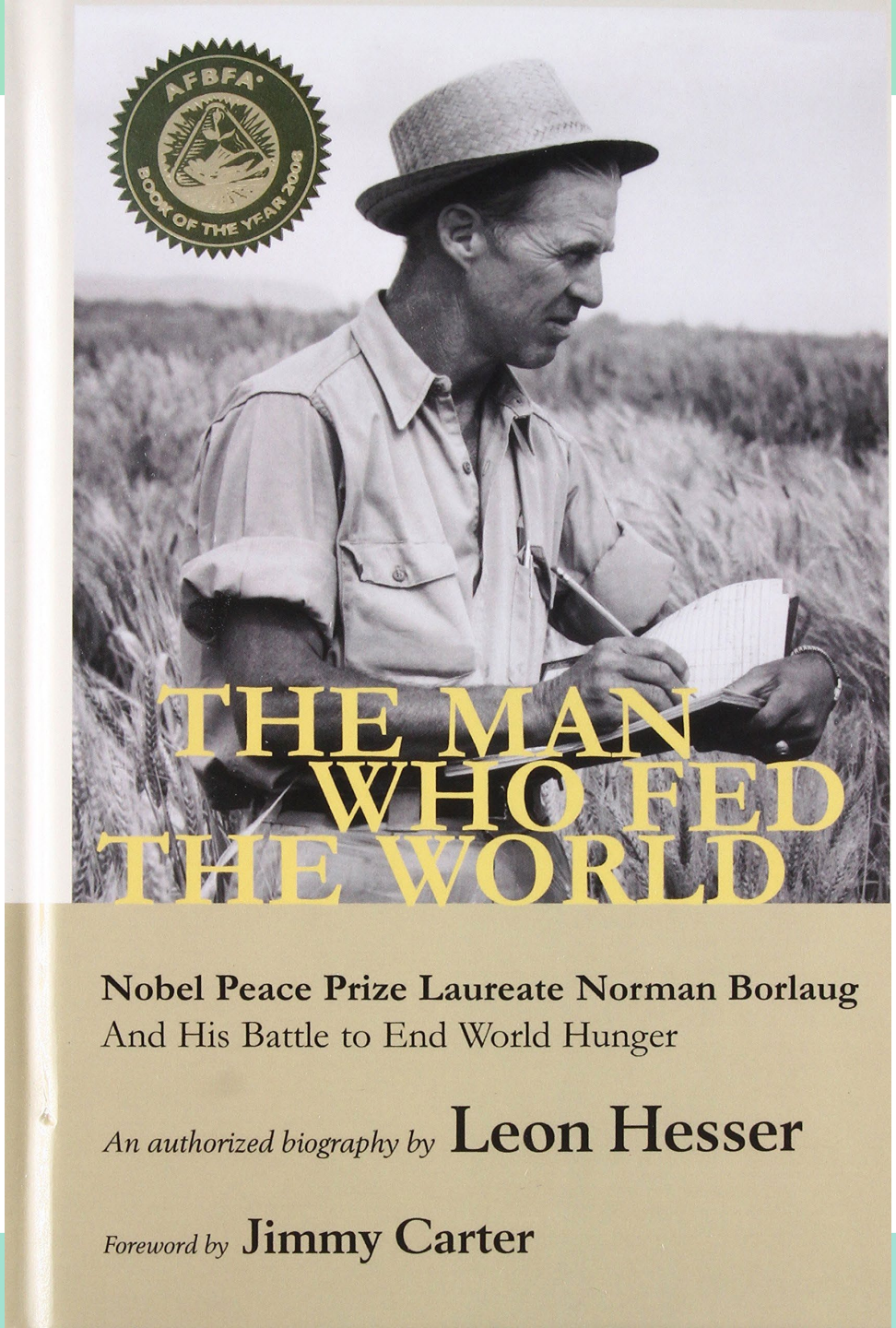
MATHEMATICS
SCIENCE
and
ENGINEERING

Food ▪ feed 16 billion or 6 billion people ?

- Increase Production?
  - Process
  - Soil, fertilizer, water, energy
  - Herbicides, pesticides
  - Seeds
  - Yield
    - Genetics



Dr. Norman Borlaug is credited with saving over a billion people from starvation. He was awarded the Nobel Peace Prize, the Presidential Medal of Freedom and the US Congressional Gold Medal.

Dr. Borlaug received the **Padma Vibhushan**, the highest civilian award the government of India can present to a non-citizen.

The immense complexity

Tomato

Theoretical and Applied Genetics (2020) 133:1753–1762
https://doi.org/10.1007/s00122-020-03582-4

REVIEW

Just 1 paper

Noncoding RNAs: functional regulatory factors in tomato fruit ripening

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Abstract

Tomato has emerged as the model system for investigations into the regulation of fleshy-fruit ripening and senescence, and the ripening process involving the coordinated regulation at the gene/chromatin/epigenetic, transcriptional, post-transcriptional and protein levels. Noncoding RNAs play important roles in fruit ripening as important transcriptional and post-transcriptional regulatory factors. In this review, we systematically summarize the recent advances in the regulation of tomato fruit ripening involved in ethylene biosynthesis and signal transduction, fruit pigment accumulation, fruit flavor and aroma, fruit texture by noncoding RNAs and their coordinate regulatory network model were set up and also suggest future directions for the functional regulations of noncoding RNAs on tomato fruit ripening.

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Table 1 The ncRNAs related to ethylene pathway in tomato fruit

ncRNA	Target gene	Target description	Related pathway	References
miR159	Solyc08g081550.2.1	*1-Aminocyclopropane-1-carboxylate synthase (ACS)*	Ethylene pathway	Karlova et al. (2013)
miR171	Solyc12g011330.2.1	*Ethylene receptor (ETR)*	Ethylene pathway	Karlova et al. (2013)
miR172a	Solyc05g009450.1	*Ethylene-responsive transcription factor 118 (ERF118)*	Ethylene pathway	Wang et al. (2017a, b)
miR1916	Solyc12g056430.1.1	*Ethylene-responsive transcription factor 10 (ERF10)*	Ethylene pathway	Karlova et al. (2013)
miR1917	Solyc03g096050.2.1	*1-Aminocyclopropane-1-carboxylate oxidase 1(ACO1)*	Ethylene pathway	Wang et al. (2017a, b)
miR1918	Solyc05g051180.1.1	*Ethylene-responsive transcription factor 2 (ERF2)*	Ethylene pathway	Karlova et al. (2013)
miR1919	Solyc05g052410.1.1	*Ethylene-responsive transcription factor 1 (ERF1)*	Ethylene pathway	Wang et al. (2017a, b)
miR390	Solyc04g082510.2.1	*Serine/threonine protein kinase CONSTITUTIVE TRIPLE RESPONSE (CTR1)*	Ethylene pathway	Karlova et al. (2013)
miR394	Solyc08g081540.2.1	*1-Aminocyclopropane-1-carboxylate synthase (ACS)*	Ethylene pathway	Karlova et al. (2013)
miR395	Solyc12g038920.1.1	*Serine/threonine protein kinase (CTR1)*	Ethylene pathway	Wang et al. (2017a, b)
miR396b	Solyc12g005940.1	*1-Aminocyclopropane-1-carboxylate oxidase 2 (ACO2)*	Ethylene pathway	Karlova et al. (2013)
miR397	Solyc06g073580.2.1	*1-Aminocyclopropane-1-carboxylate oxidase 1(ACO1)*	Ethylene pathway	Karlova et al. (2013)
mir398	Solyc04g050750.1.1	*Ethylene-responsive transcription factor 1 (ERF1)*	Ethylene pathway	Karlova et al. (2013)
miR403	Solyc02g031860.2.1	*Serine/threonine protein kinase (CTR1)*	Ethylene pathway	Karlova et al. (2013)
miR4376	Solyc03g117790.1.1	*Serine/threonine protein kinase (CTR1)*	Ethylene pathway	Wang et al. (2017a, b)
miR472	Solyc12g009240.1.1	*Ethylene-responsive transcription factor 4 (ERF 4)*	Ethylene pathway	Karlova et al. (2013)
miR482e-3p	Solyc03g043890.2	*1-Aminocyclopropane-1-carboxylate synthase (ACS)*	Ethylene pathway	Karlova et al. (2013)

miR5301	Solyc08g066410.1.1	*Serine/threonine protein kinase (CTR1)*	Ethylene pathway	Wang et al. (2017a, b)
miR5302	Solyc04g080910.1.1	*Ethylene-responsive transcription factor 13 (ERF13)*	Ethylene pathway	Karlova et al. (2013)
miR5303	Solyc09g066360.1.1	*Ethylene-responsive transcription factor 2 (ERF2)*	Ethylene pathway	Wang et al. (2017a, b)
miR6022	Solyc06g068590.2.1	*Serine/threonine protein kinase (CTR1)*	Ethylene pathway	Karlova et al. (2013)
miR6023	Solyc03g118190.2	*Ethylene-responsive transcription factor 114 (ERF114)*	Ethylene pathway	Wang et al. (2017a, b)
miR858	Solyc11g065590.1.1	*Ethylene receptor (ETR)*	Ethylene pathway	Wang et al. (2017a, b)
miR894	Solyc02g071470.2.1	*1-Aminocyclopropane-1-carboxylate oxidase 1 (ACO1)*	Ethylene pathway	Karlova et al. (2013)
miR9470-3p	Solyc11g042580.1	*Ethylene-responsive transcription factor 021 (ERF021)*	Ethylene pathway	Karlova et al. (2013)
lncRNAZ018	Solyc01g095080.2	*1-Aminocyclopropane-1-carboxylate synthase 2 (ACS2)*	Ethylene pathway	Wang et al. (2017a, b)
lncRNAZ037	Solyc01g067540.1	*Ethylene-responsive transcription factor 086 (ERF086)*	Ethylene pathway	Wang et al. (2017a, b)
lncRNAZ113	Solyc12g005940.1	*1-Aminocyclopropane-1-carboxylate oxidase 2 (ACO2)*	Ethylene pathway	Wang et al. (2017a, b)
lncRNAZ118	Solyc12g005940.1	*1-Aminocyclopropane-1-carboxylate oxidase 2 (ACO2)*	Ethylene pathway	Wang et al. (2017a, b)
lncRNAZ306	Solyc06g065820.2	*Ethylene response factor 1 (ERF1)*	Ethylene pathway	Wang et al. (2017a, b)
lncRNAZ307	Solyc06g065820.2	*Ethylene response factor 1 (ERF1)*	Ethylene pathway	Wang et al. (2017a, b)
lncRNAZ317	Solyc07g056580.2	*Ethylene receptor (ETR)*	Ethylene pathway	Wang et al. (2017a, b)
lncRNAZ327	Solyc07g056580.2	*Ethylene receptor (ETR)*	Ethylene pathway	Wang et al. (2017a, b)
lncRNAZ363	Solyc08g008100.2	*1-Aminocyclopropane-1-carboxylate synthase (ACS)*	Ethylene pathway	Wang et al. (2017a, b)
3:12165611|12167830	Solyc05g009450.1	*Ethylene-responsive transcription factor 118 (ERF118)*	Ethylene pathway	Wang et al. (2017a, b)
3:64444135|64445667	Solyc05g009450.1	*Ethylene-responsive transcription factor 118 (ERF118)*	Ethylene pathway	Wang et al. (2017a, b)
5:22621180|22630239	Solyc07g064890.1	*Ethylene-responsive factor (ERF)*	Ethylene pathway	Wang et al. (2017a, b)
6:39644680|39646142	Solyc05g009450.1	*Ethylene-responsive transcription factor 118 (ERF118)*	Ethylene pathway	Wang et al. (2017a, b)

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Table 2 The miRNAs related to fruit color in tomato

ncRNA	Target gene	Target description	Related pathway	References
miR399	Solyc12g098710.1.1	*15-Cis-zeta-carotene isomerase (ZISO)*	Color pathway	Wang et al. (2017a, b)
miR414	Solyc12g098710.1.1	*15-Cis-zeta-carotene isomerase (ZISO)*	Color pathway	Wang et al. (2017a, b)
miR5300	Solyc12g098710.1.1	*15-Cis-zeta-carotene isomerase (ZISO)*	Color pathway	Karlova et al. (2013)
miR482	Solyc03g007960.2.1	*Beta-carotene hydroxylase 2 (CrtZ-2)*	Color pathway	Karlova et al. (2013)
miR1916	Solyc06g074240.1.1	*Chromoplast-specific lycopene beta-cyclase (CYC-B)*	Color pathway	Wang et al. (2017a, b)
miR390	Solyc06g074240.1.1	*Chromoplast-specific lycopene beta-cyclase (CYC-B)*	Color pathway	Karlova et al. (2013)
miR159	Solyc10g079480.1.1	*Lycopene beta-cyclase 2 (LCYB)*	Color pathway	Wang et al. (2017a, b)
miR156/157	Solyc02g077920.2.1	*Colorless non-ripening (CNR)*	Color pathway	Moxon et al. (2008)

Table 3 The ncRNAs related to fruit flavor in tomato

ncRNA	Target gene	Target description	Related pathway	References
miR396	Solyc01g068210.2.1	*Glutamate dehydrogenase (GLDH)*	Flavor pathway	Li et al. (2012)
miR397	Solyc01g068210.2.1	*Glutamate dehydrogenase (GLDH)*	Flavor pathway	Karlova et al. (2013)
miR158	Solyc03g094010.2.1	*Glutamate dehydrogenase (GLDH)*	Flavor pathway	Li et al. (2012)
miR6022	Solyc03g094010.2.1	*Glutamate dehydrogenase (GLDH)*	Flavor pathway	Li et al. (2012)
miR1917	Solyc06g059920.1.1	*Sesquiterpene synthase 2 SSTLE2*	Flavor pathway	Karlova et al. (2013)
miR5303	Solyc05g008910.2.1	*Glutamine amidotransferase (GATD)*	Flavor pathway	Karlova et al. (2013)
miR6024	Solyc05g008910.2.1	*Glutamine amidotransferase (GATD)*	Flavor pathway	Li et al. (2012)
miR414	Solyc07g042630.2.1	*Beta-Amyrin Synthase (β-AS)*	Flavor pathway	Karlova et al. (2013)
LncRNAZ063	Solyc10g078550.1	*Glutamate dehydrogenase (GATD)*	Flavor pathway	Wang et al. (2017a, b)
LncRNA192	Solyc03g096050.2	*Flavonol synthase (FLS)*	Flavor pathway	Wang et al. (2017a, b)
LncRNA291	Solyc06g069900.2	*Flavonol synthase (FLS)*	Flavor pathway	Wang et al. (2017a, b)
LncRNA135	Solyc02g083620.2	*L-ascorbate peroxidase 3 (APX3)*	Flavor pathway	Wang et al. (2017a, b)
LncRNA027	Solyc01g099150.2	*Lipoxygenase (LOX)*	Flavor pathway	Wang et al. (2017a, b)
LncRNA143	Solyc02g083270.2	*Vitamin K epoxide reductase (VKOR)*	Flavor pathway	Wang et al. (2017a, b)

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ncRNA	Target gene	Target description	Related pathway	References
miR158	Solyc05g014000.2.1	*Pectate lyase (PL)*	Fruit texture	Wang et al. (2017a, b)
miR167	Solyc09g072820.2.1	*Cellulose synthase (CeSA)*	Fruit texture	Zuo et al. (2012)
miR1916	Solyc02g014300.1.1	*Pectinesterase (PE)*	Fruit texture	Karlova et al. (2013)
miR1917	Solyc02g061770.2.1	*Chitinase (CHI)*	Fruit texture	Karlova et al. (2013)
miR1918	Solyc10g049370.1.1	*Pectinesterase (PE)*	Fruit texture	Zuo et al. (2012)
miR394	Solyc12g015770.1.1	*Cellulose synthase (CeSA)*	Fruit texture	Zuo et al. (2012)
miR395	Solyc00g030000.1.1	*Cellulose synthase4 (CeSA4)*	Fruit texture	Wang et al. (2017a, b)
miR396	Solyc03g058910.2.1	*Pectate lyase (PL)*	Fruit texture	Wang et al. (2017a, b)
miR408	Solyc01g057220.2.1	*Pectinesterase (PE)*	Fruit texture	Wang et al. (2017a, b)
miR472	Solyc00g030000.1.1	*Cellulose synthase4 (CeSA4)*	Fruit texture	Wang et al. (2017a, b)
miR482	Solyc12g019220.1.1	*Polygalacturonase 7 PG7*	Fruit texture	Karlova et al. (2013)
miR5301	Solyc01g079180.2.1	*Pectinesterase (PE)*	Fruit texture	Karlova et al. (2013)
miR5303	Solyc02g080290.2.1	*Beta-glucosidase 47 β-Glu47*	Fruit texture	Wang et al. (2017a, b)
miR6022	Solyc01g091050.2.1	*Pectinesterase (PE)*	Fruit texture	Zuo et al. (2012)
miR6023	Solyc01g097270.2.1	*Chitinase (CHI)*	Fruit texture	Karlova et al. (2013)
miR6024	Solyc01g087280.1.1	*Polygalacturonase (PG)*	Fruit texture	Wang et al. (2017a, b)
miR6026	Solyc12g009420.1.1	*Polygalacturonase (PG)*	Fruit texture	Karlova et al. (2013)
miR858	Solyc09g098270.2.1	*Polygalacturonase (PG)*	Fruit texture	Zuo et al. (2012)
lncRNAZ033	Solyc01g087280.1	*Polygalacturonase-like (PG-like)*	Fruit texture	Wang et al. (2018a, b, c)
lncRNAZ069	Solyc10g049450.1	*Pectinesterase-like (PE-like)*	Fruit texture	Wang et al. (2018a, b, c)
lncRNAZ138	Solyc02g080210.2	*Pectinesterase-like (PE-like)*	Fruit texture	Wang et al. (2018a, b, c)
lncRNAZ180	Solyc03g123620.2	*Pectinesterase 3 (PE3)*	Fruit texture	Wang et al. (2018a, b, c)
lncRNAZ316	Solyc07g044870.2	*Polygalacturonase-like (PG-like)*	Fruit texture	Wang et al. (2018a, b, c)
lncRNAZ346	Solyc08g042020.1	*Beta-glucosidase 31-like β-Glu31*	Fruit texture	Wang et al. (2018a, b, c)
lncRNAZ386	Solyc09g075060.2	*Beta-glucosidase 11-like β-Glu11*	Fruit texture	Wang et al. (2018a, b, c)
1:36612324|36616003	Solyc12g096730.1	*Polygalacturonase-like (PG-like)*	Fruit texture	Wang et al. (2017a, b)
10:60887167|60889411	Solyc12g096730.1	*Polygalacturonase-like (PG-like)*	Fruit texture	Wang et al. (2017a, b)
10:61293869|61299867	Solyc12g096730.1	*Polygalacturonase-like (PG-like)*	Fruit texture	Wang et al. (2017a, b)
2:32910844|32913066	Solyc12g096730.1	*Polygalacturonase-like (PG-like)*	Fruit texture	Wang et al. (2017a, b)
5:22621180|22630239	Solyc12g096730.1	*Polygalacturonase-like (PG-like)*	Fruit texture	Wang et al. (2017a, b)
6:3511784|3512526	Solyc02g068410.1	*Polygalacturonase QRT3 (PG)*	Fruit texture	Wang et al. (2017a, b)
8:144804|149694	Solyc12g096730.1	*Polygalacturonase-like (PG-like)*	Fruit texture	Wang et al. (2017a, b)

So many genes, *so little is known*

Tomato Fruit Ripening

Understanding just one process (ripening) in one fruit (tomato) requires knowledge of molecular biology, genetics, biochemistry, biophysics, plant physiology, soil chemistry and mathematics (always).

So many genes, ***let us do something***

news.uchicago.edu/story/rna-breakthrough-crops-grow-50-percent-more-potatoes-rice-climate-change

uchicago news

RNA breakthrough creates crops that can grow 50% more potatoes, rice

https://news.uchicago.edu/story/rna-breakthrough-crops-grow-50-percent-more-potatoes-rice-climate-change

A genetic tweak that targets RNA can grow crops that yield significantly more food and show increased drought tolerance, announced scientists from the University of Chicago, Peking University and Guizhou University.

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By Louise Lerner
Jul 22, 2021

RNA demethylation increases the yield and biomass of rice and potato plants in field trials

Qiong Yu[1,10], Shun Liu[2,3,10], Lu Yu[4], Yu Xiao[1], Shasha Zhang[1], Xueping Wang[1], Yingying Xu[1], Hong Yu[5], Yulong Li[6], Junbo Yang[1], Jun Tang[1], Hong-Chao Duan[1], Lian-Huan Wei[1], Haiyan Zhang[7], Jiangbo Wei[2,3], Qian Tang[1], Chunling Wang[1], Wutong Zhang[1], Ye Wang[1], Peizhe Song[1], Qiang Lu[1], Wei Zhang[1], Shunqing Dong[1], Baoan Song[4] ✉, Chuan He[2,3,8] ✉ and Guifang Jia[1,9] ✉

RNA N^6-methyladenosine (m^6A) modifications are essential in plants. Here, we show that transgenic expression of the human RNA demethylase FTO in rice caused a more than threefold increase in grain yield under greenhouse conditions. In field trials, transgenic expression of FTO in rice and potato caused ~50% increases in yield and biomass. We demonstrate that the presence of FTO stimulates root meristem cell proliferation and tiller bud formation and promotes photosynthetic efficiency and drought tolerance but has no effect on mature cell size, shoot meristem cell proliferation, root diameter, plant height or ploidy. FTO mediates substantial m^6A demethylation (around 7% of demethylation in poly(A) RNA and around 35% decrease of m^6A in non-ribosomal nuclear RNA) in plant RNA, inducing chromatin openness and transcriptional activation. Therefore, modulation of plant RNA m^6A methylation is a promising strategy to dramatically improve plant growth and crop yield.

Yu, Q., Liu, S., Yu, L. *et al.* RNA demethylation increases the yield and biomass of rice and potato plants in field trials. *Nature Biotech* (July 22, 2021) ♦ https://doi.org/10.1038/s41587-021-00982-9

Soil Chemistry ??

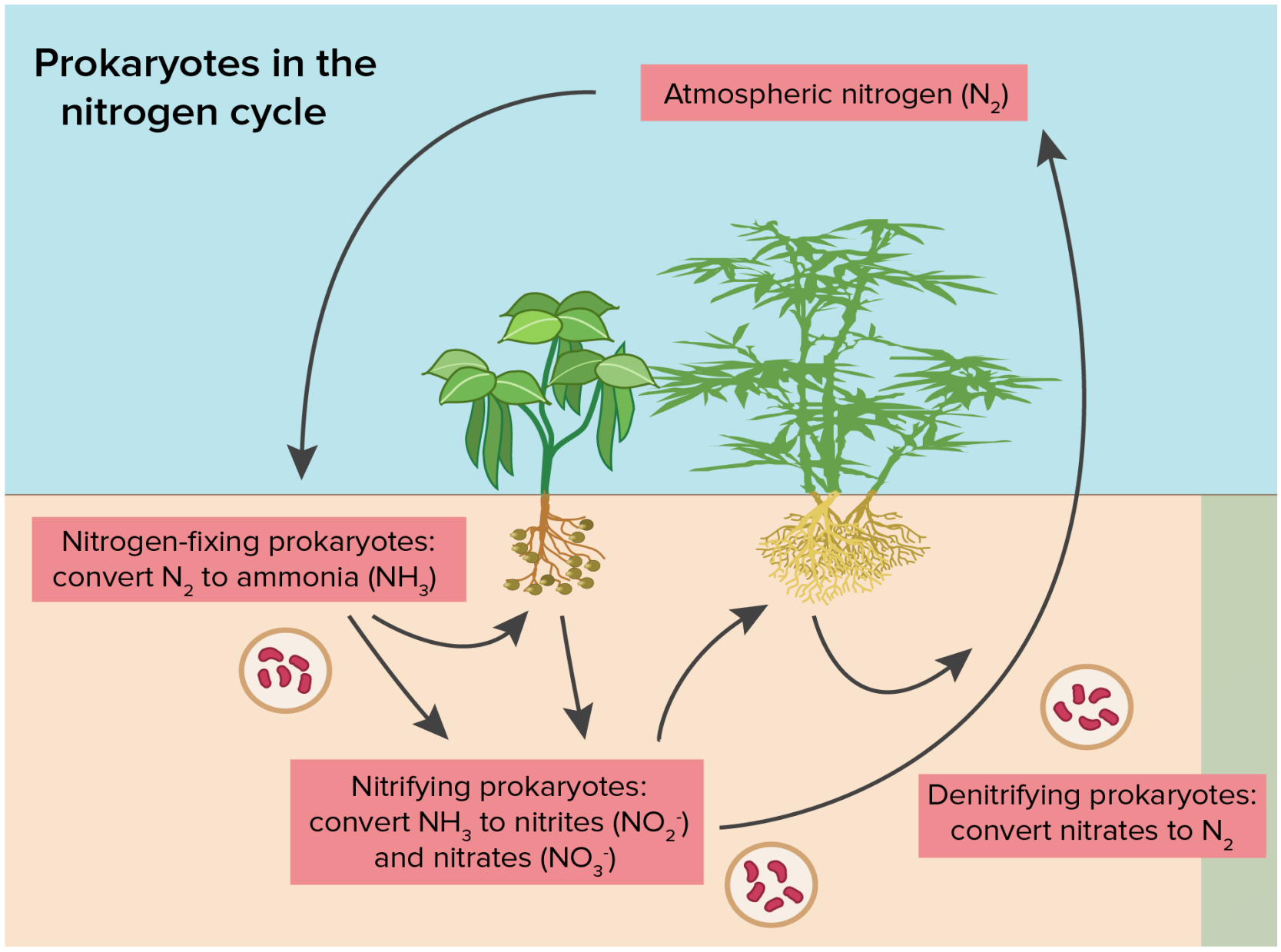
Understanding the multifactorial dynamics of geo-bio-chemistry

SOIL

GEOBIOCHEMICAL CYCLES

BIOTIC / ABIOTIC

WATER
CARBON
SULPHUR
NITROGEN
PHOSPHOROUS

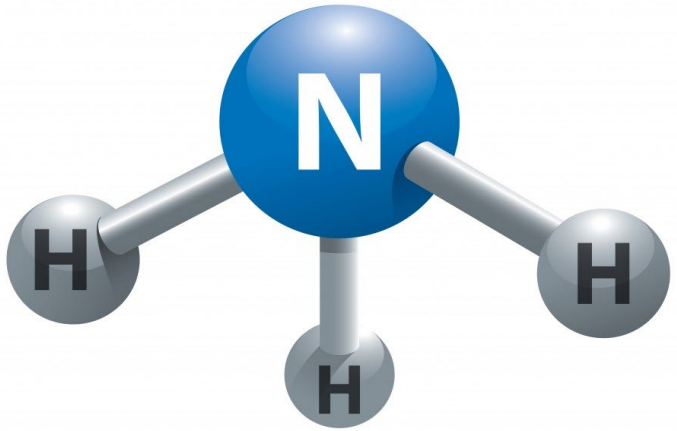


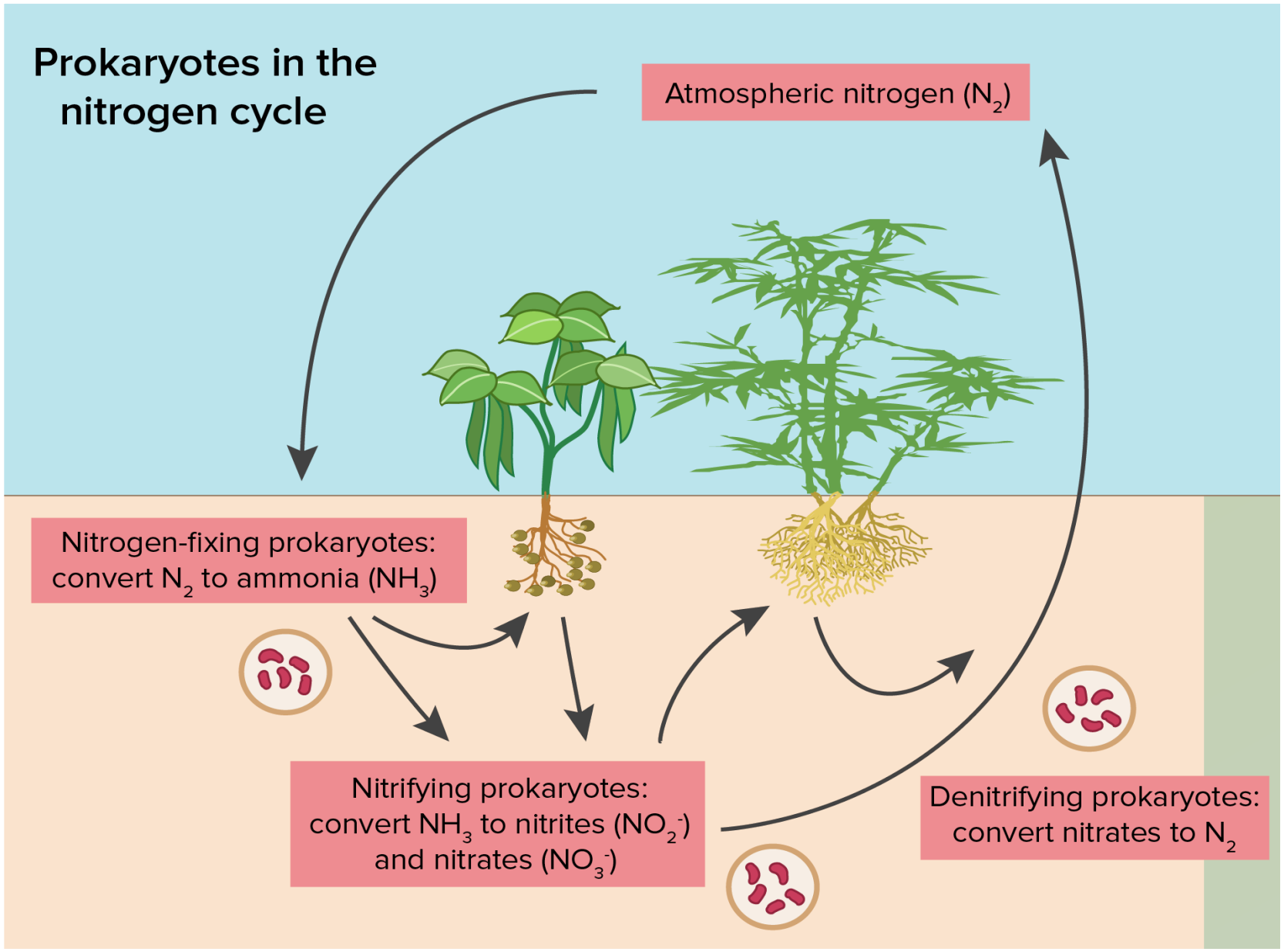
www.khanacademy.org/science/biology/ecology/biogeochemical-cycles/a/introduction-to-biogeochemical-cycles

Second critical contribution of chemistry to humanity ?

What is the first?

www.nobelprize.org/prizes/chemistry/1918/summary/ ▪ https://phys.org/news/2015-10-dark-side-nobel-prizewinning.html





www.khanacademy.org/science/biology/ecology/biogeochemical-cycles/a/introduction-to-biogeochemical-cycles

www.nobelprize.org/prizes/chemistry/1918/summary/
https://phys.org/news/2015-10-dark-side-nobel-prizewinning.html

Nitrogen
From the air

Hydrogen
From natural gas

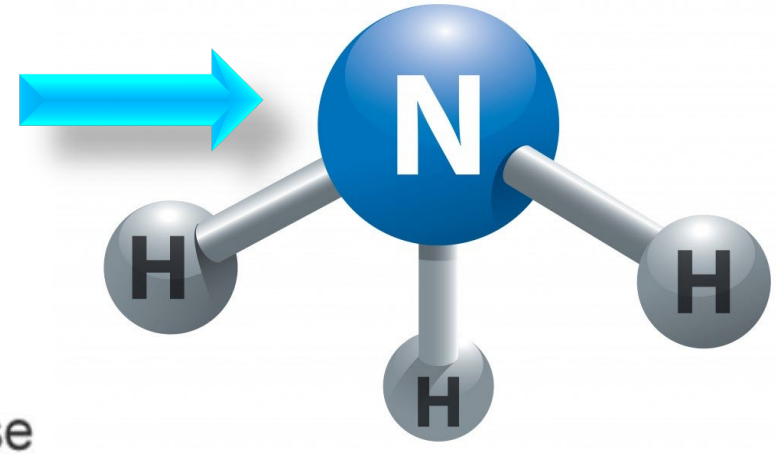
Nitrogen And Hydrogen
1:3 by volume

400 - 450°c
200 atm
iron catalyst

Unreacted gases Recycled

gases are cooled and ammonia turns to liquid

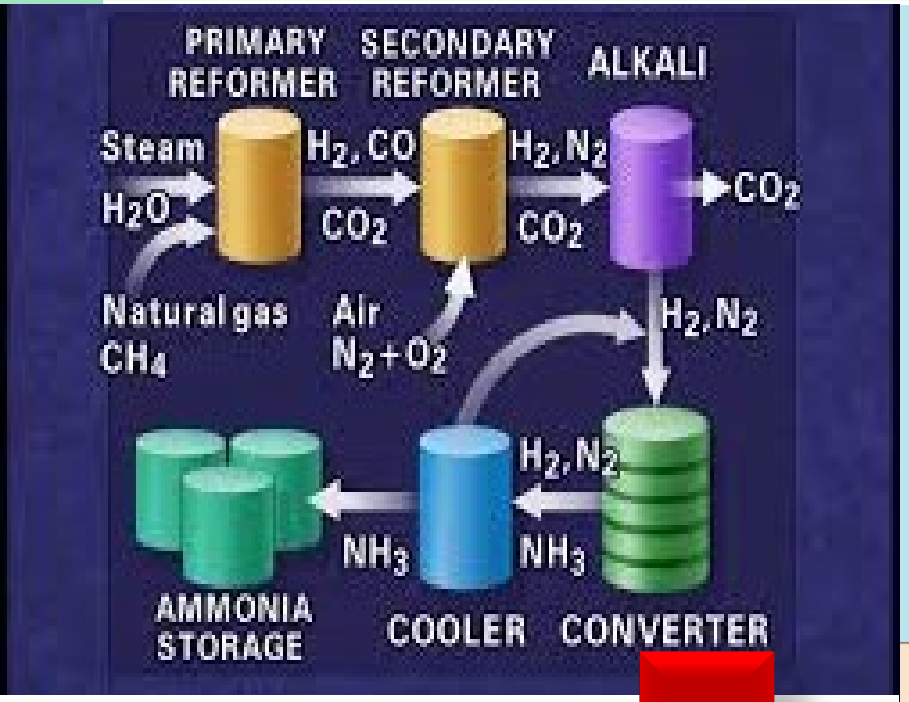
To storage/ industrial use

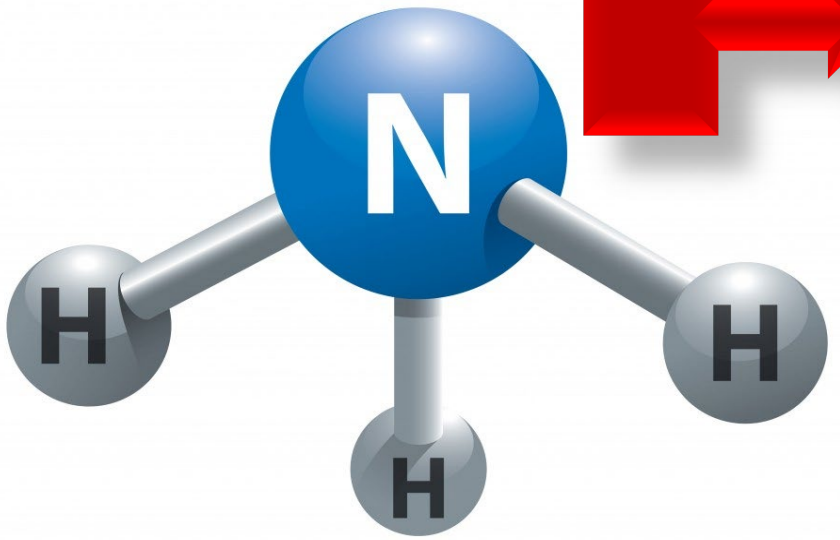


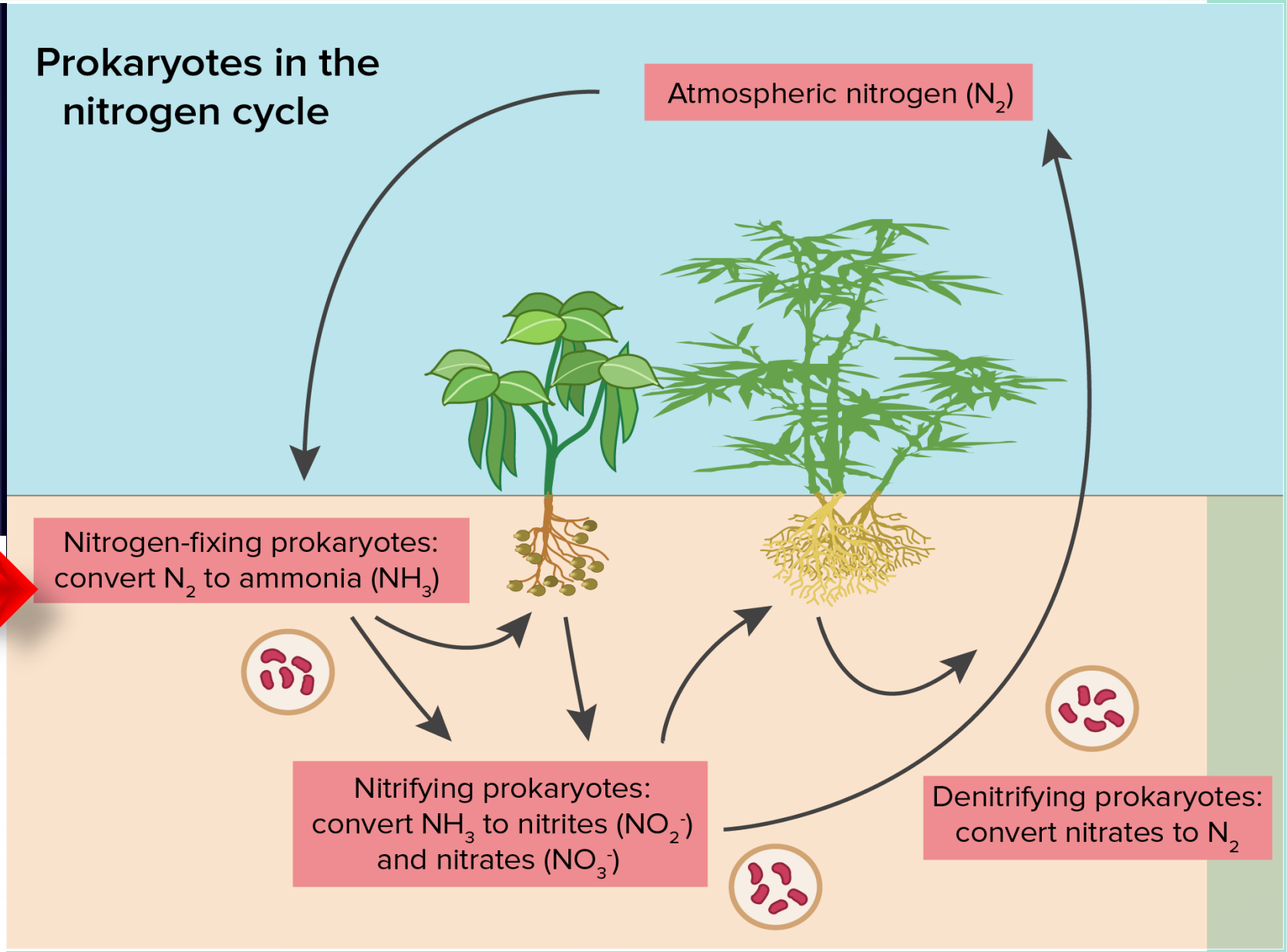
HABER-BOSCH PROCESS

AMMONIA

www.nobelprize.org/prizes/chemistry/1918/summary/ ▪ https://phys.org/news/2015-10-dark-side-nobel-prizewinning.html

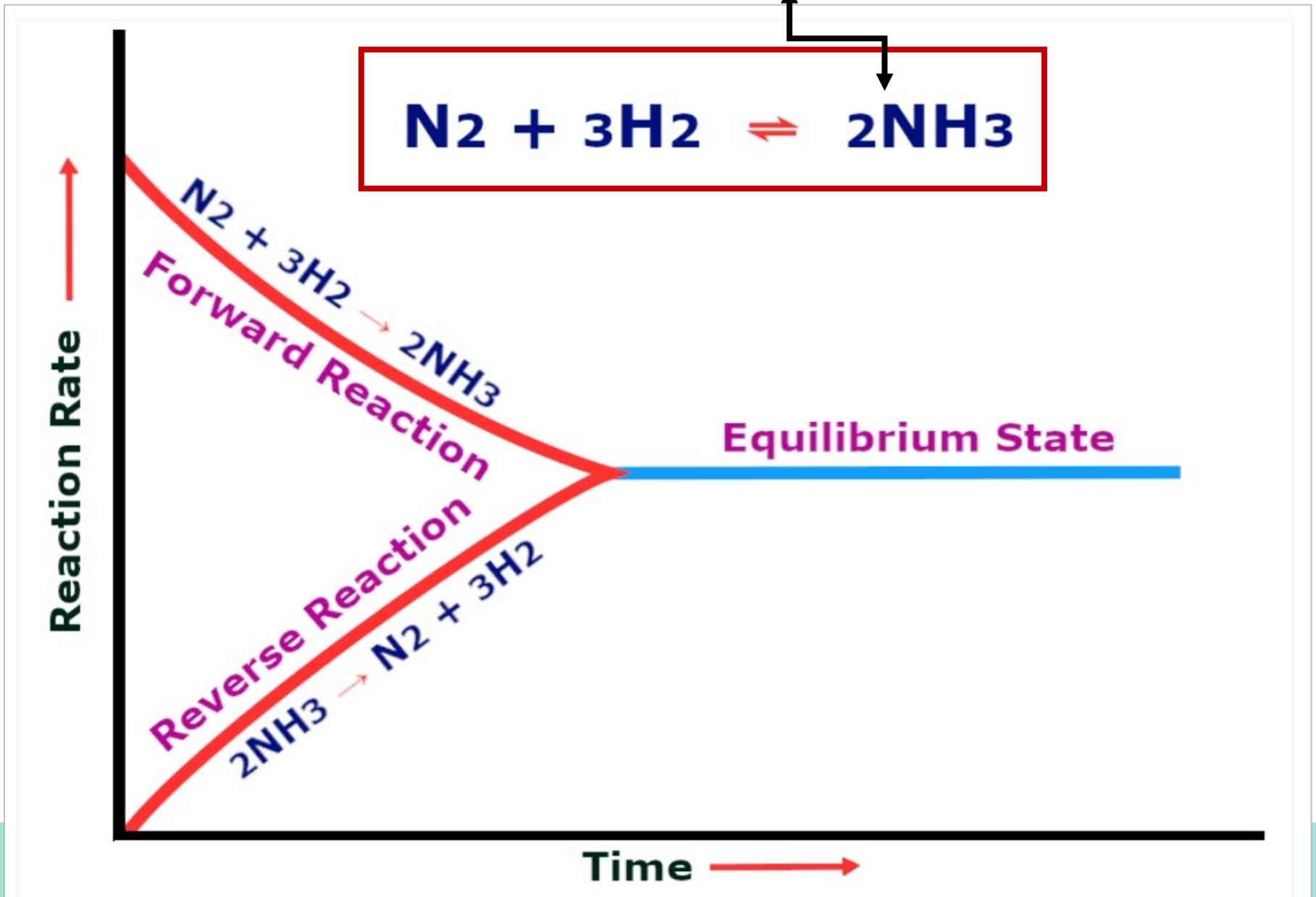




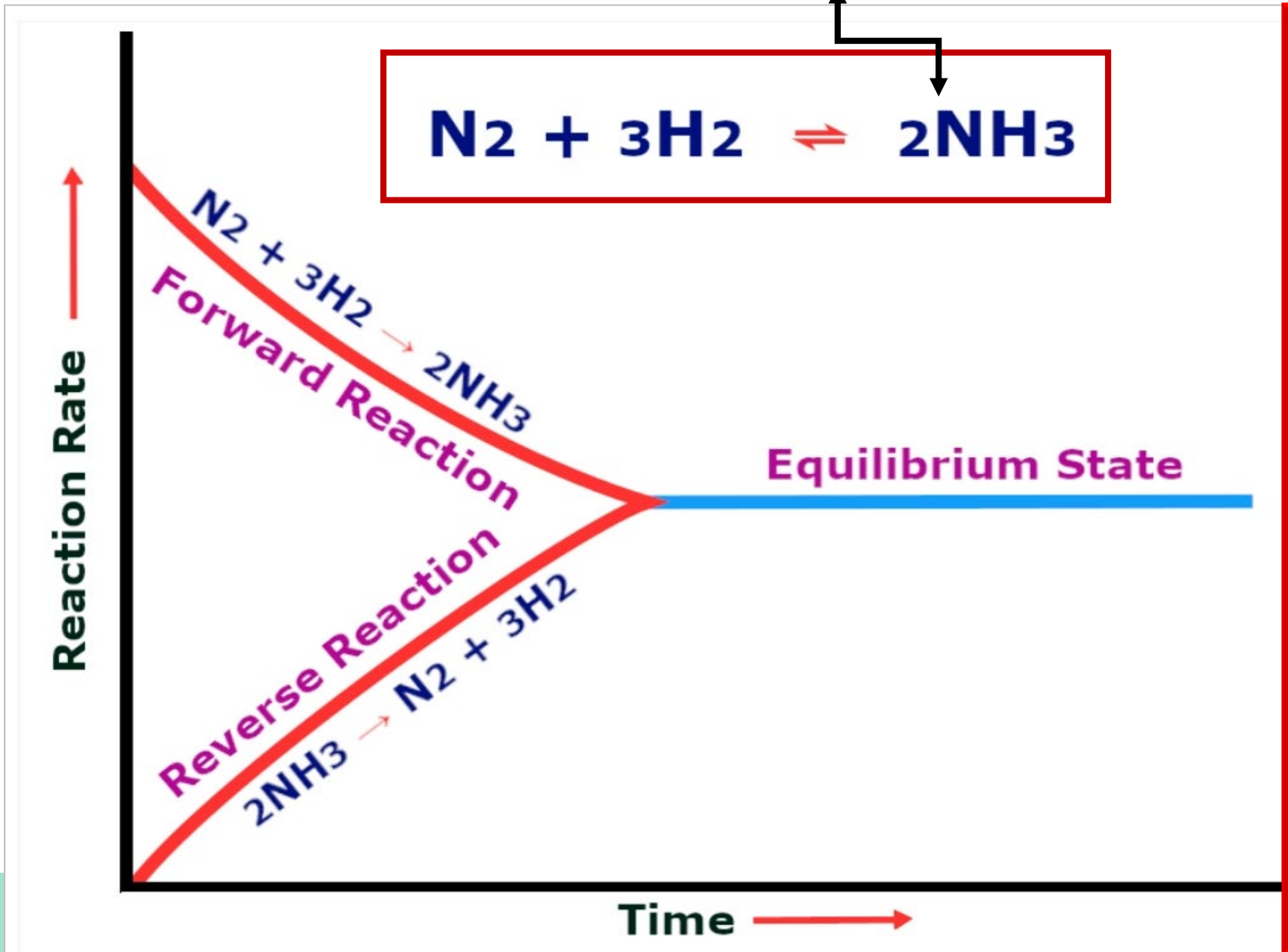


www.scienceabc.com/pure-sciences/the-haber-bosch-process-what-is-it-why-is-the-process-so-important.html

$$N_2 + 8\,H^+ + 8\,e^- + 16\,ATP \rightarrow 2\,NH_3 + H_2 + 16\,ADP + 16\,Pi$$



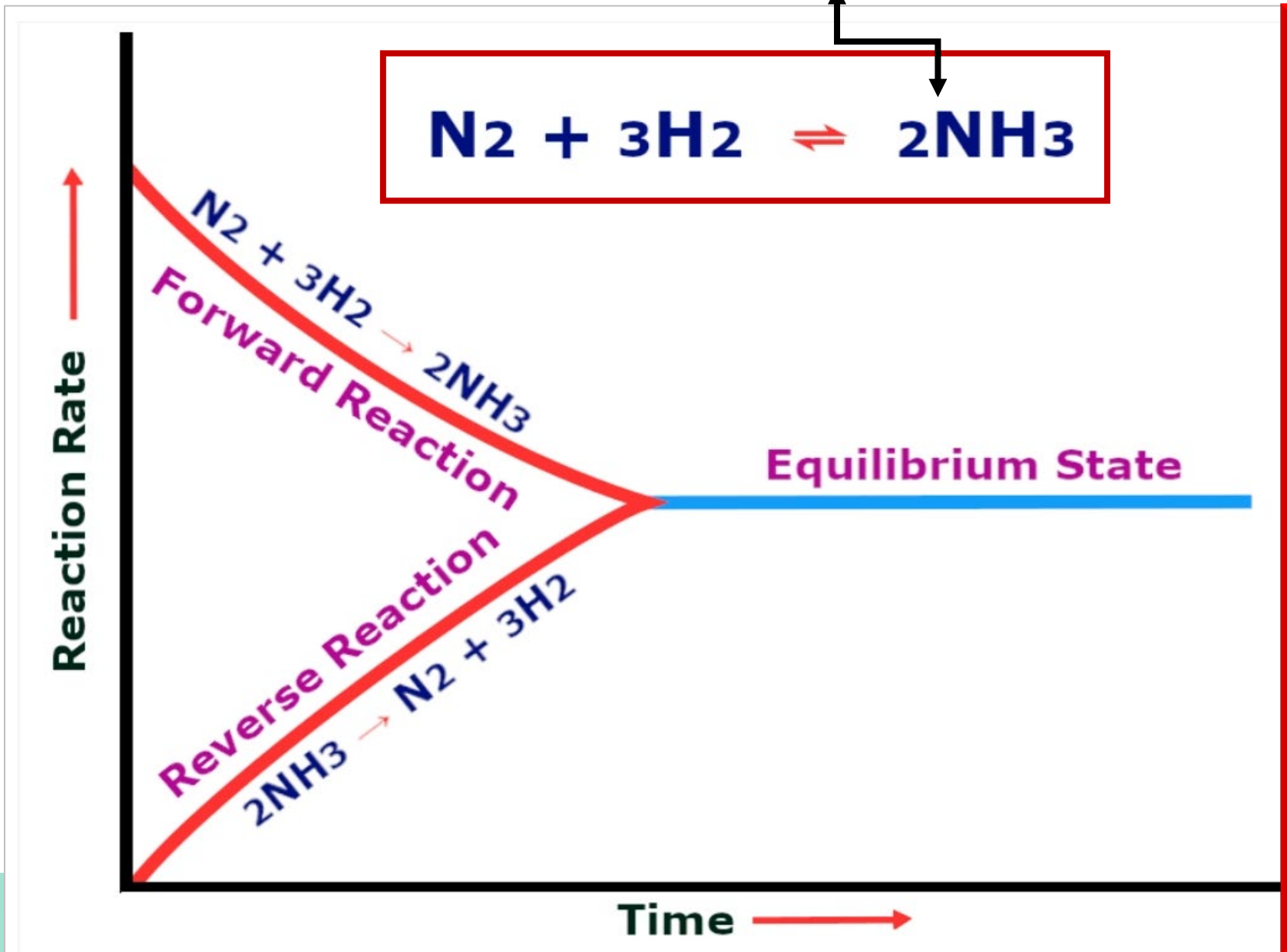
$$N_2 + 8\,H^+ + 8\,e^- + 16\,ATP \rightarrow 2\,NH_3 + H_2 + 16\,ADP + 16\,Pi$$



Are the two equations representing the same process of ammonia synthesis?

https://bmcbiol.biomedcentral.com/articles/10.1186/s12915-019-0710-0

$$N_2 + 8\,H^+ + 8\,e^- + 16\,ATP \rightarrow 2\,NH_3 + H_2 + 16\,ADP + 16\,Pi$$



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https://bmcbiol.biomedcentral.com/articles/10.1186/s12915-019-0710-0

www.nobelprize.org/prizes/chemistry/1918/summary/
https://phys.org/news/2015-10-dark-side-nobel-prizewinning.html

Nitrogen
From the air

Hydrogen
From natural gas

Nitrogen And Hydrogen
1:3 by volume

400 - 450°c
200 atm
iron catalyst

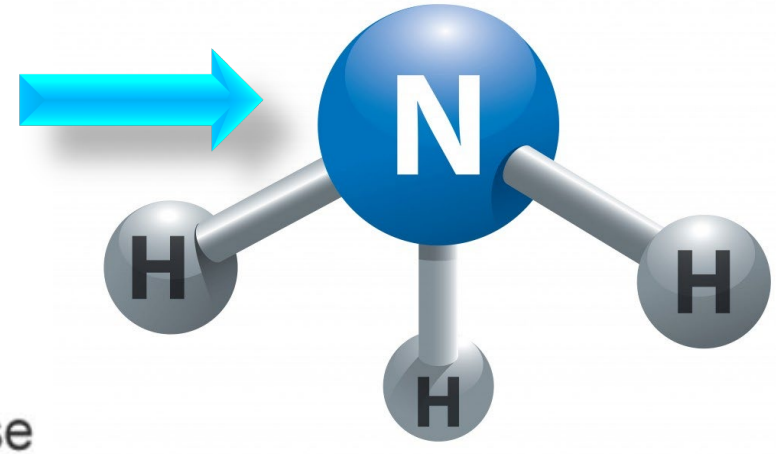
Unreacted gases Recycled

gases are cooled and ammonia turns to liquid

To storage/ industrial use

The Haber process

$N_2 + 3H_2 \rightleftharpoons 2NH_3$



HABER-BOSCH PROCESS

AMMONIA

$$N_2 + 8\,H^+ + 8\,e^- + 16\,ATP \rightarrow 2\,NH_3 + H_2 + 16\,ADP + 16\,Pi$$

BIOLOGICAL PROCESS
ENZYME CATALYZED

Crop	Nodulating Bacteria
Alfalfa	*Sinorhizobium melilotii*
Beans	*Rhizobium legumninosarum biovar phaseoli* and *Rhizobium tropici*
Clover	*Rhizobium leguminosarum biovar trifolii*
Lotus	*Mesorhizobium loti*
Peas	*Rhizobium leguminosarum biovar viceae*
Soybean	*Bradyrhizobium japonicum*, *Bradyrhizobium elkanii*, *Rhizobium fredii*
Sesbania	*Azorhizobium caulinodans*

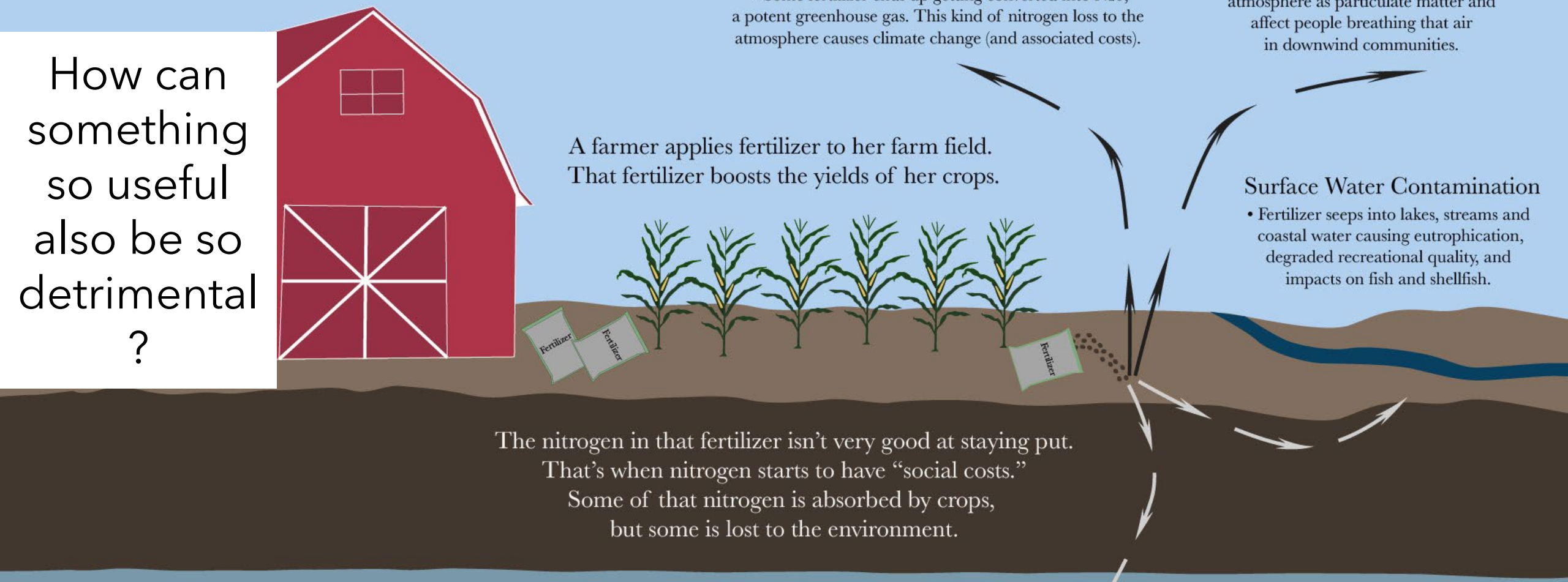
Beijerinck, M. W. (1901) Über oligonitrophile Mikroben. *Zbl. Backt.* 7, 561-582

http://environment.umn.edu/discovery/natural-capital-project/much-fertilizer-really-cost/

Social Costs of Nitrogen Pollution

How does nitrogen cause problems for people?

How can something so useful also be so detrimental ?



WATER POLLUTION

Too much nitrogen and phosphorus in the water causes algae to grow faster than ecosystems can handle. Significant increases in algae harm water quality, food resources and habitats, and decrease the oxygen that fish and other aquatic life need to survive. Large growths of algae are called algal blooms and they can severely reduce or eliminate oxygen in the water, leading to illnesses in fish and the death of large numbers of fish. Some algal blooms are harmful to humans because they produce elevated toxins and bacterial growth that can make people sick if they come into contact with polluted water, consume tainted fish or shellfish, or drink contaminated water. www.epa.gov/nutrientpollution/issue

INEXTRICABLY LINKED

BALANCING THE CYCLE ?

Science R&D may provide solutions.

Who will imagine, invent, innovate and implement?

YOU ?

Discussion: Snippets of Examples

Number 2

https://www.youtube.com/watch?v=ZbZSe6N_BXs

E	Energy

Your contribution to society matters.

Science and Scientists for Society

Even more shocking, almost 3 billion people – over a third of the world's population – don't have access to clean cooking facilities.

The UN estimate that almost 4 million people will die prematurely this year due to the use of unclean cooking fuels.

80% of the world's population today live in countries where energy consumption is so low, that increases in energy tend to go hand-in-hand with significant improvements in human development.

The world needs more energy to grow and prosper.

Access to safe, secure, affordable energy enriches lives.

ENERGY

In need of herculean transformation

This is just lame, incremental and inconsequential. It's NOT radical.

technologyreview.com/2021/02/24/1018102/lithium-metal-batteries-electric-vehicle-car

MIT Technology Review www.technologyreview.com/2020/12/08/1013357/quantumscape-vw-litihium-metal-battery/

Making electric cars more competitive with gas-powered ones will require a breakthrough battery that remedies those shortcomings. That, at least, is the argument of Jagdeep Singh, chief executive of QuantumScape, a Silicon Valley startup that claims to have developed just such a technology.

The company asserts it did so by solving a chemistry puzzle that has stumped researchers for nearly half a century: how to use lithium, the lightest metal on the periodic table, to boost the amount of energy that can be packed into a battery without posing a routine risk of fire or otherwise sacrificing performance. The company says it achieved this, in large part, by developing a solid version of the flammable liquid electrolyte.

VW was impressed enough to invest hundreds of millions of dollars in QuantumScape. The German auto giant also agreed to set up a joint venture with the company to mass-produce the batteries and says they'll be in its electric cars and trucks on the road by 2025.

A Radical Design Metaphor ?

“Swappable Atoms”

The Paradigm of Atoms to Bits

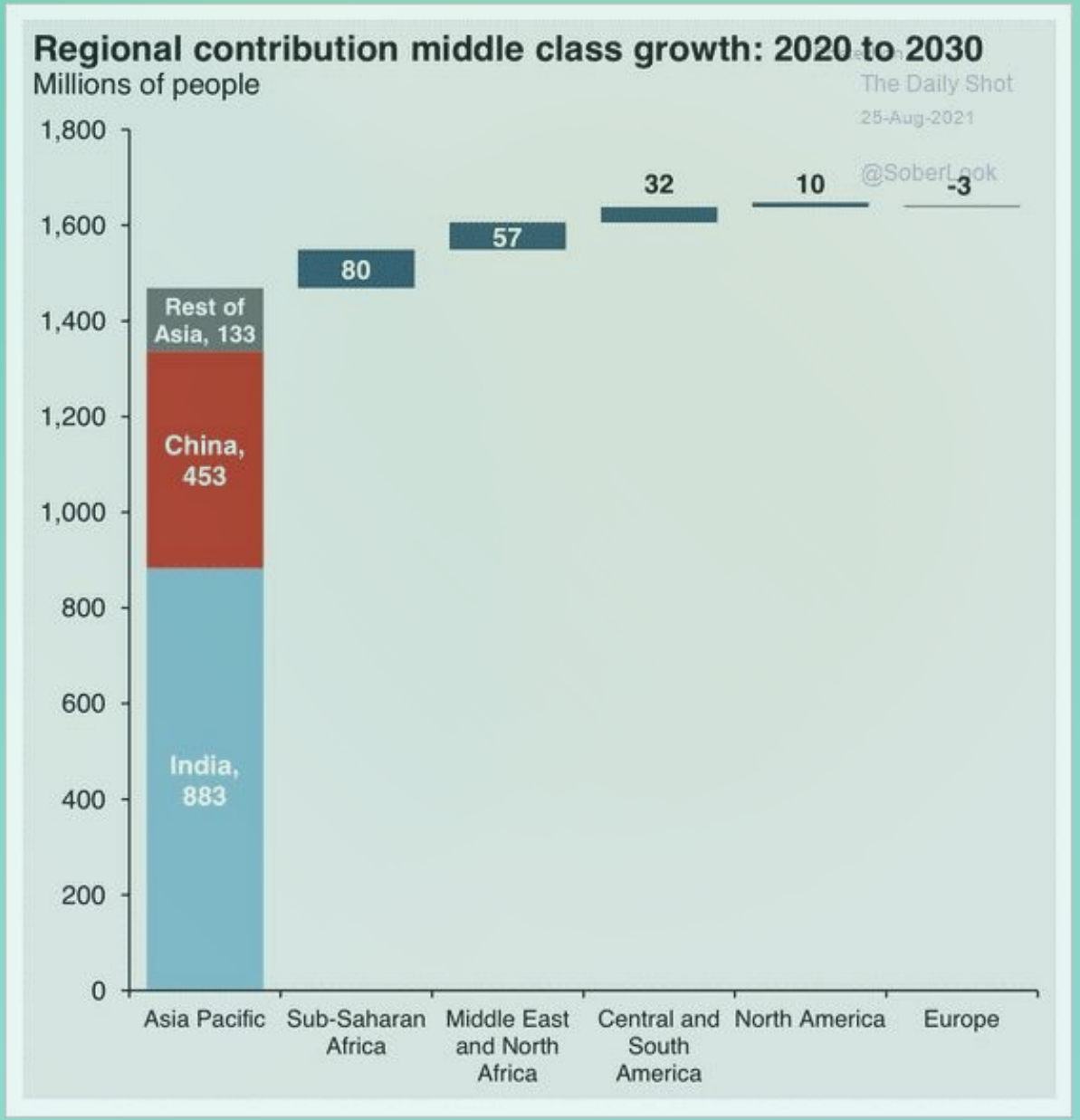
The form factor of energy, and its **source**, must/will undergo radical metamorphoses. One solution will not suit all.

New imagination. New ideas. New inventions. New innovations. New implementations.

New science? New engineering? New technologies?

Think radically different

Growth in India over the next decade will create new demand



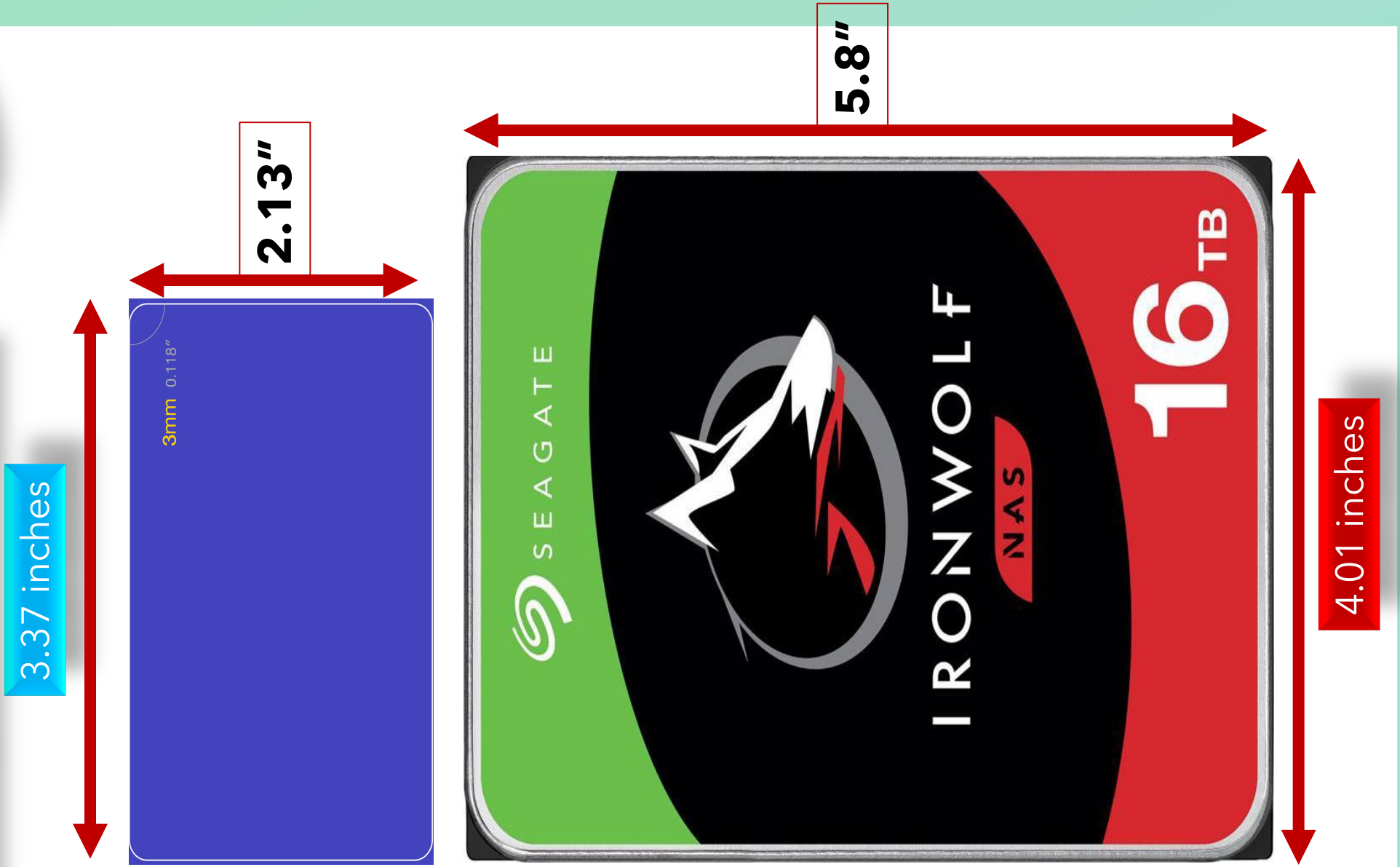
1956

5 MB hard drive being shipped out of IBM

2020

16 million MB

16 TB hard drive slightly bigger than a credit card



Credit Card

1956

5 MB hard drive air lifted on to PAN AM

2020

16 million MB

16 TB hard drive fits in your palm & pocket

Size of credit card

18TB HD 2X SIZE of CREDIT CARD

TRANSFORMATION IN ENERGY MUST HAPPEN ON A MASSIVE SCALE

18TB HD 2X SIZE
of CREDIT CARD

HYDROGEN GAS? SOLID?

ENERGY FROM HYDROGEN

HYDROGEN HYDROXIDE

Abundant. But, we don’t know how to break down water (for energy-positive extraction of hydrogen).

Simplest things we don’t know

We still do not know how to break down water to generate hydrogen and oxygen (in a manner which is energy positive and generates energy). Electrolysis of water consumes energy. It was first demonstrated in 1789 by Jan Rudolph Deiman and Adriaan Paets van Troostwijk (Dutch) using an electrostatic generator to produce a discharge between two gold electrodes immersed in water. Michael Faraday's laws of electrolysis are quantitative relationships which were published in 1833 (in UK).

https://www.sciencedirect.com/topics/engineering/water-electrolysis

Energy is an economic differentiator

Leapfrogging the barriers of conventional wisdom and the dead weight of old technology.

Radical Energy Design Metaphor

“Swappable Atoms”

The Paradigm of Atoms to Bits? Not easy!

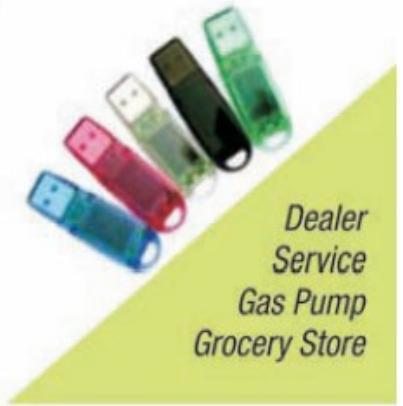
Replaces the “atoms” with low energy with high energy atoms.

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

16 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.

- ABS Upgrade
- Where's Tesco
- Pre-heat oven
- Airport route
- Tire pressure
- Music & Movies
- Email & Skype
- Voice Activated
- Engine Control



Dealer
Service
Gas Pump
Grocery Store

TEKES

https://tem.fi/etusivu . Paradigm Shift in Interoperability?

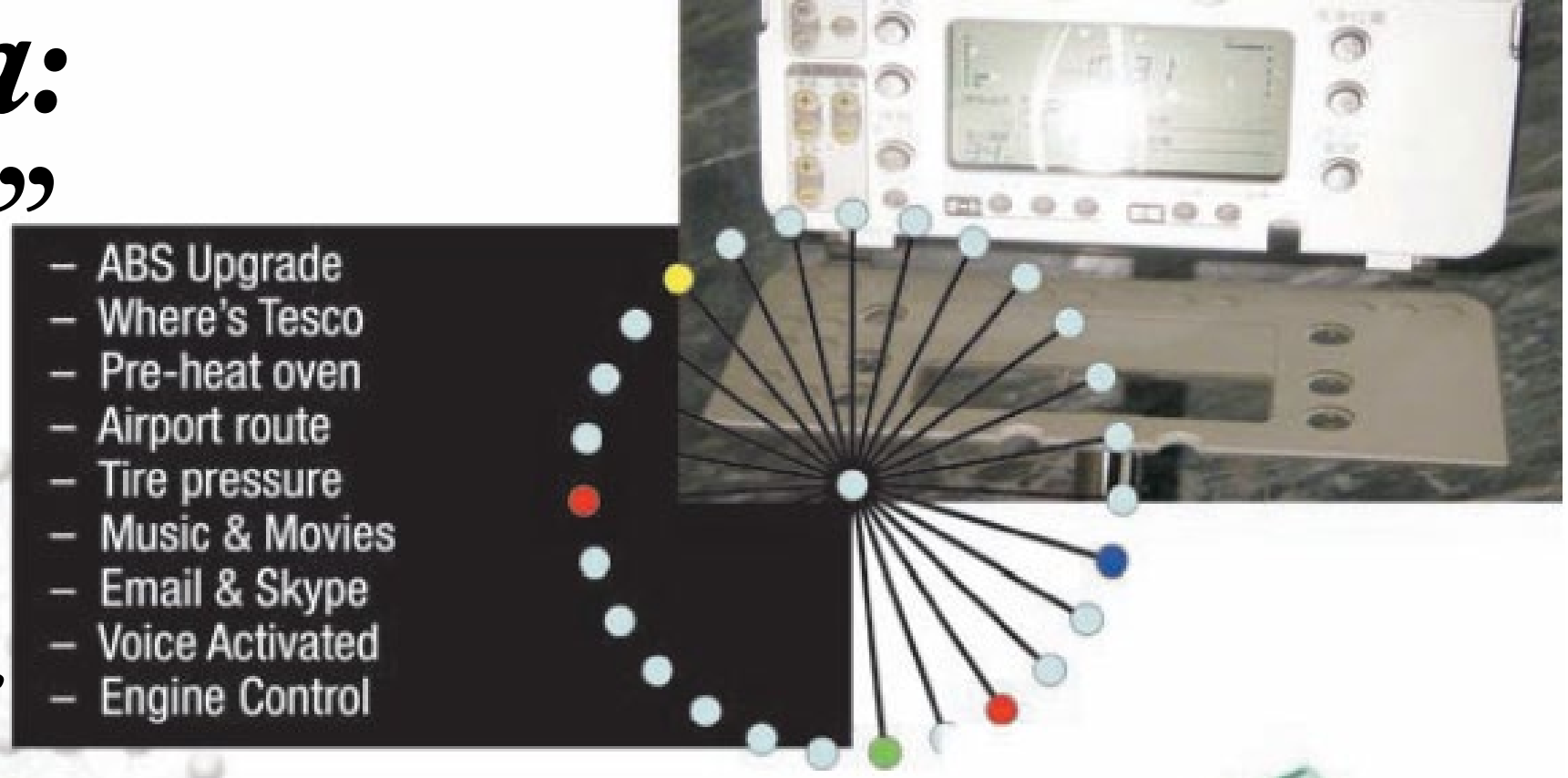
https://dspace.mit.edu/handle/1721.1/56251

Radical idea: "portability" of atoms, eg. running automobiles on metallic hydrogen as fuel source.

- ABS Upgrade
- Where's Tesco
- Pre-heat oven
- Airport route
- Tire pressure
- Music & Movies
- Email & Skype
- Voice Activated
- Engine Control

Dealer
Service
Gas Pump
Grocery Store

Radical idea: "portability" of atoms, eg. running automobiles on metallic hydrogen as fuel source.



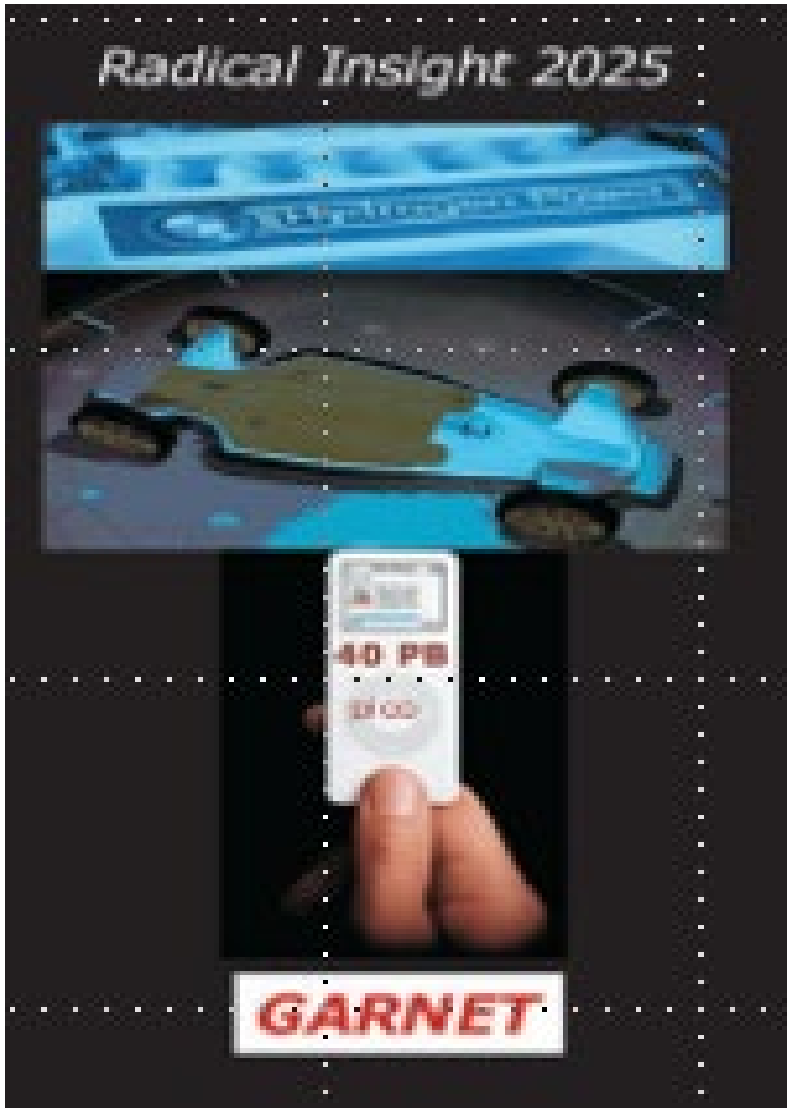
FUEL STICKS ??

Dealer
Service
Gas Pump
Grocery Store

Radical idea – "portability" of atoms e.g. metallic hydrogen as fuel source.

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

Born	Wigner Jenő Pál November 17, 1902 Budapest, Austria-Hungary
Died	January 1, 1995 (aged 92) Princeton, New Jersey, US



S. Datta, published
by TEKES in 2006

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

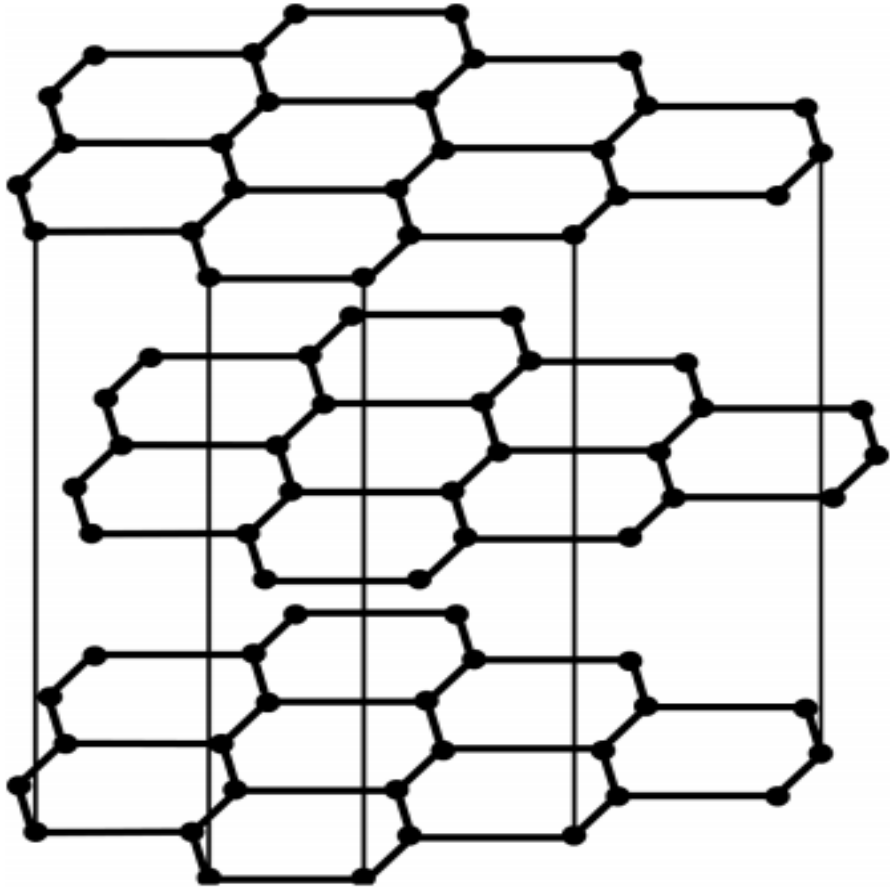


Fig. 1: Schematic representation of the layered lattice of graphite. Wigner and Huntington [19] would propose that most energetically favorable form of metallic hydrogen would assume this crystal structure.

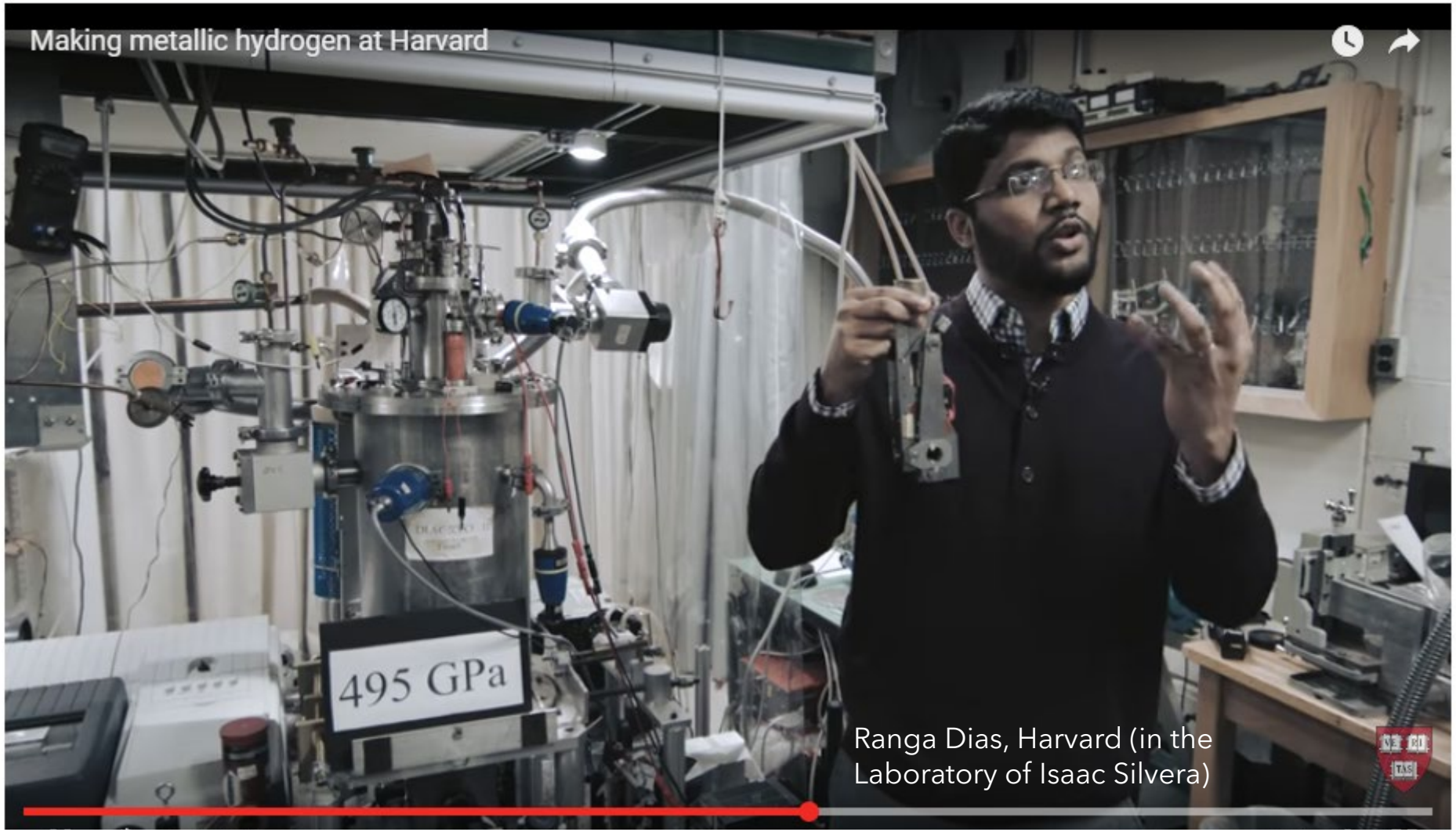
J. D. Bernal who first put forward the view that all substances go over under very high pressure into metallic or valence lattices" [19].www.ptep-online.com/index_files/2011/PP-26-07.PDF

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

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

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

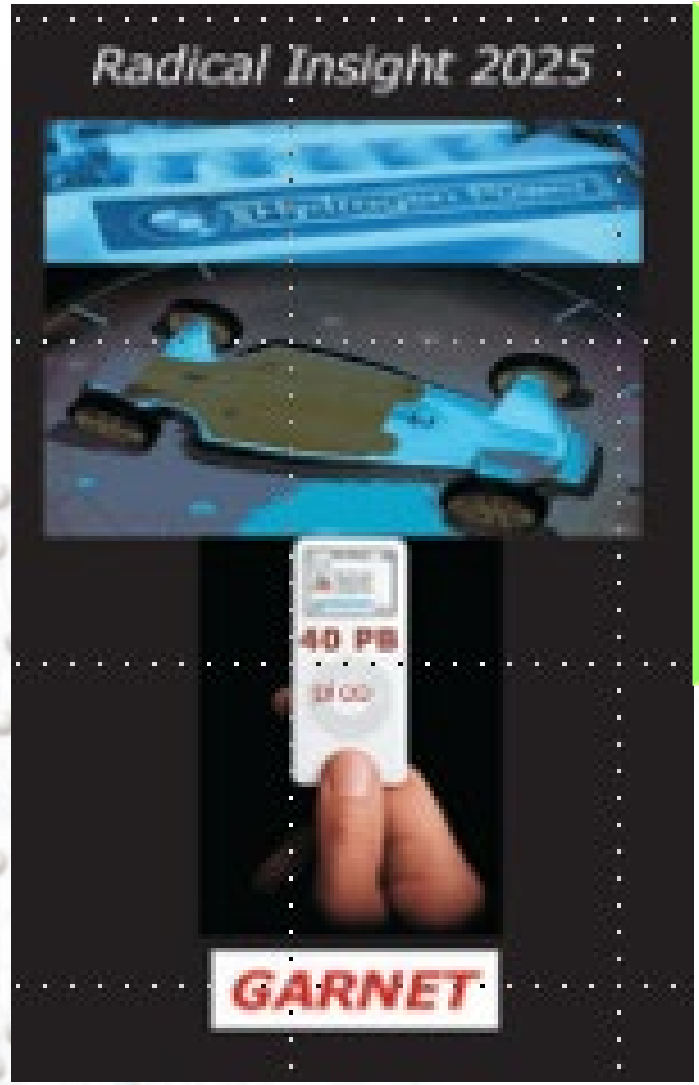
January 26, 2017 |



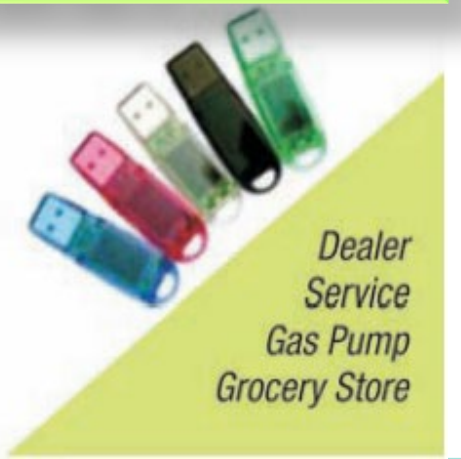
http://news.harvard.edu/gazette/story/2017/01/a-breakthrough-in-high-pressure-physics/

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

Drive cars, ship, plane, rocket, with metallic hydrogen in a fuel stick (USB flash drive format).



Swap anywhere to replenish fuel



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

What is the energy form factor now ?

The case for taxicabs in cities.

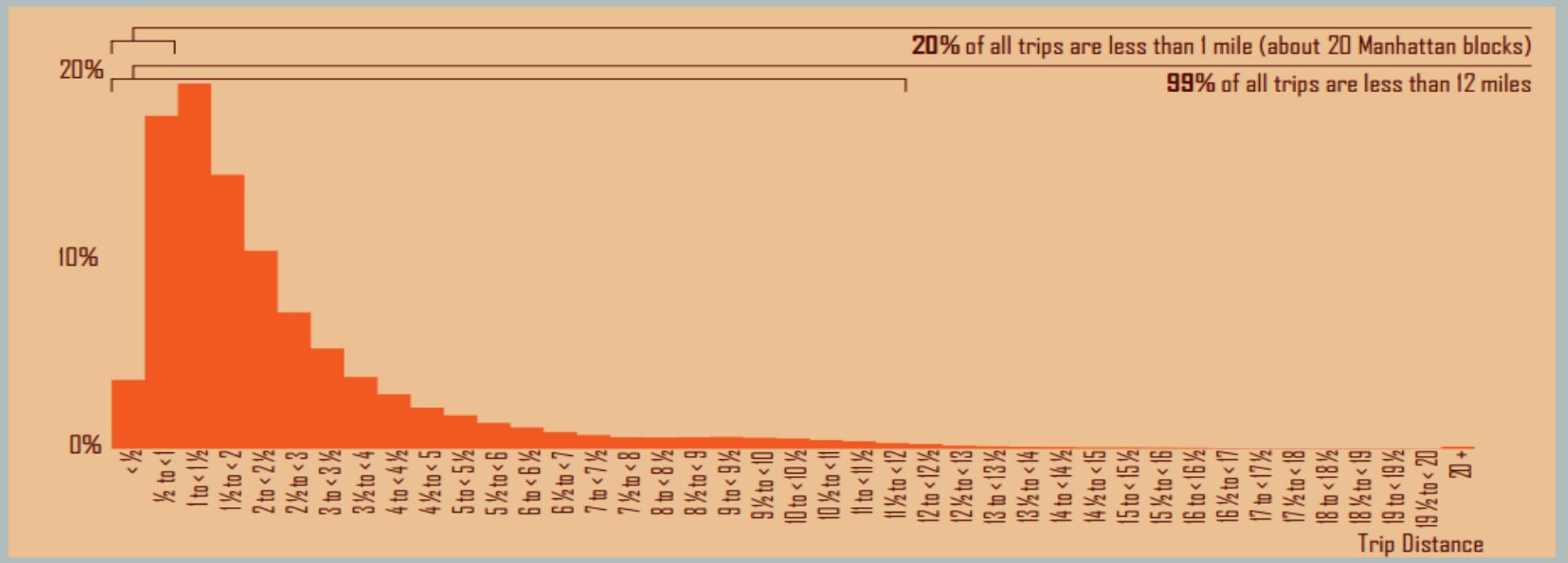
http://www.nyc.gov/html/tlc/downloads/pdf/2014_taxicab_fact_book.pdf

Yellow taxis provide an average of

485,000
trips/day

The average trip distance is **2.6** miles

Average taxi ride approx. 2.6 miles



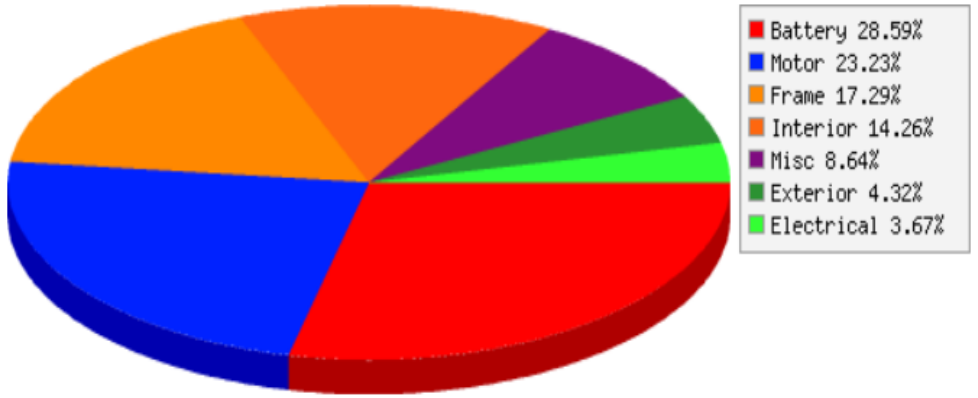
http://map.mathshell.org/download.php?fileid=1706

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

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

TESLA MODEL S WEIGHT – 4,600+ LB



Battery Pack

1323 lb

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/

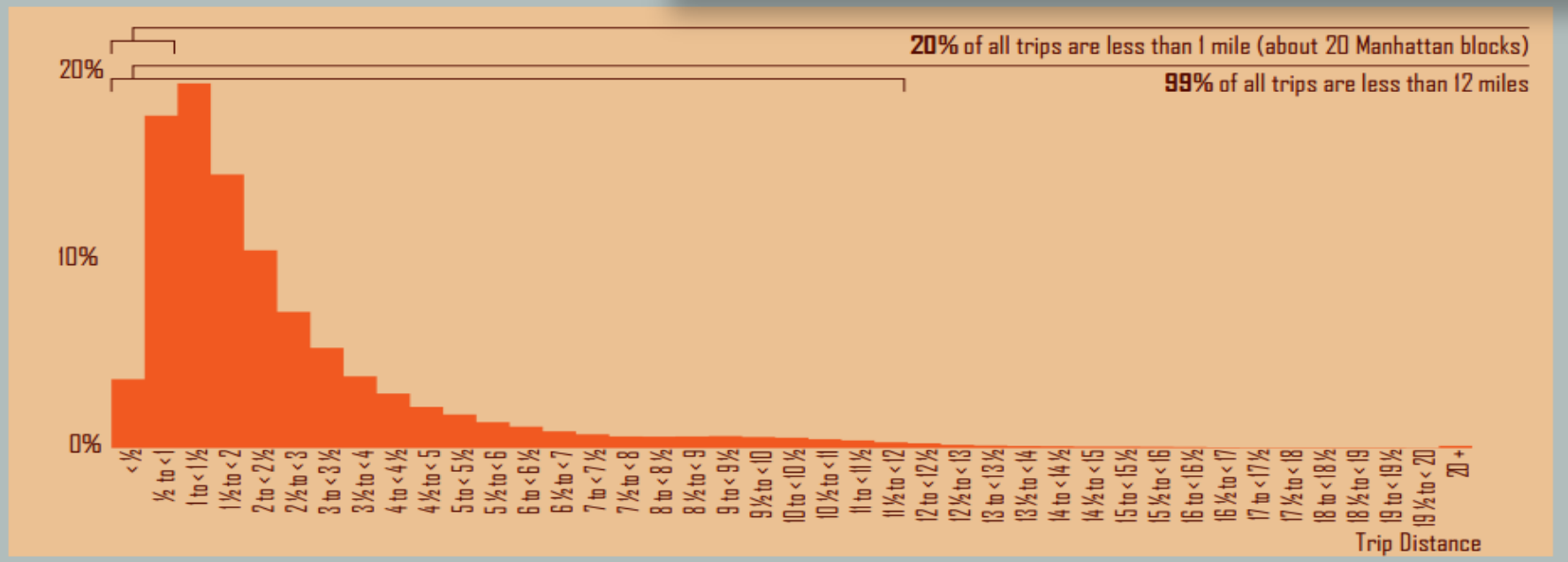
http://www.nyc.gov/html/tlc/downloads/pdf/2014_taxicab_fact_book.pdf

Yellow taxis provide an average of

485,000
trips/day

The average trip distance is **2.6** miles

1300lb battery (weight) even for 2.6 mile trip?



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

Change is slow. But change the equation. Can we take baby steps?

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

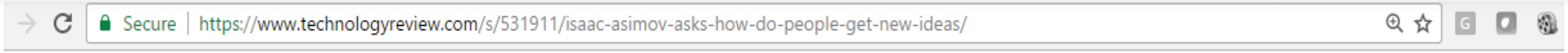
swappable

batteries

Not quite metallic hydrogen but we are changing the equation in India. Aren't we?

https://qz.com/1001518

SWAPPABLE ATOMS – A DESIGN METAPHOR



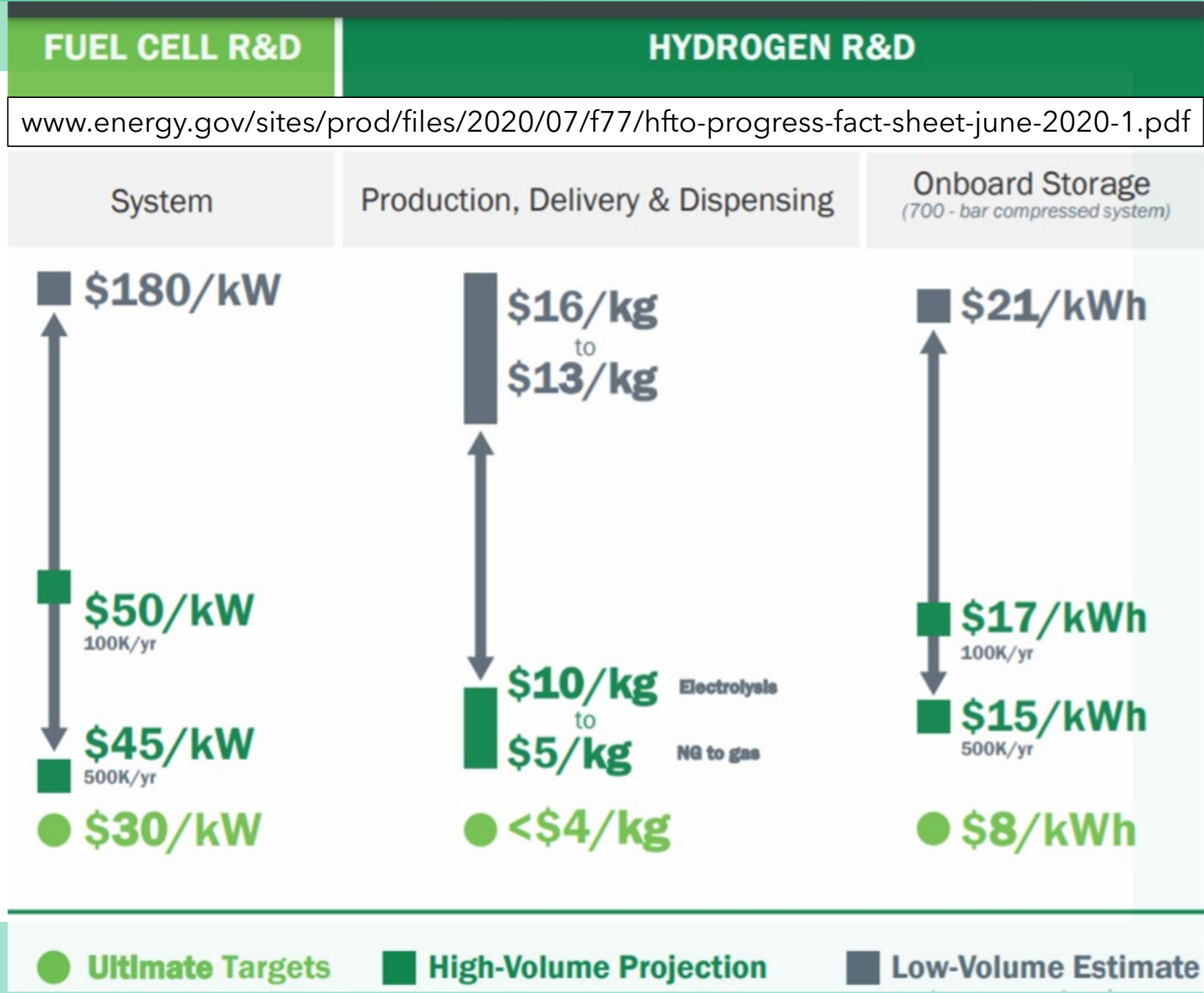
A person willing to fly in the face of reason, authority, and common sense must be a person of considerable self-assurance. Since he occurs only rarely, he must seem eccentric (in at least that respect) to the rest of us. A person eccentric in one respect is often eccentric in others.

Consequently, the person who is most likely to get new ideas is a person of good background in the field of interest and one who is unconventional in his habits. (To be a crackpot is not, however, enough

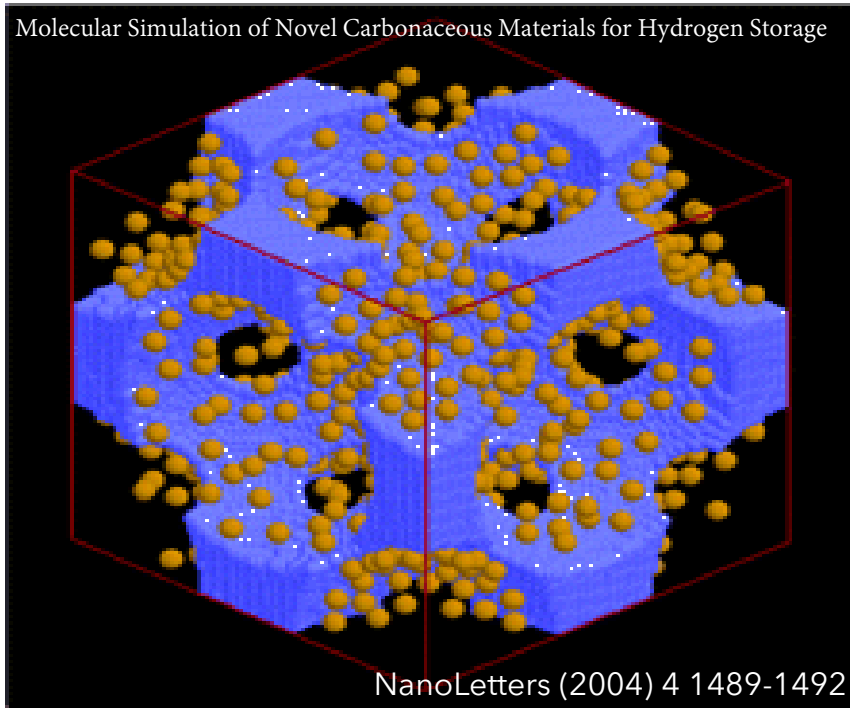
ISAAC ASIMOV

What about conventional hydrogen fuel cells and hydrogen storage ?

>8,600 hydrogen fuel cell cars on US roads (6/2020).



Adsorbed Hydrogen in the frame of the vehicle may even eliminate the need for fuel cell or tank



Hydrogen molecules (yellow) adsorbed in graphitic carbon inverse opal (GCIO, blue).

https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.973.1042&rep=rep1&type=pdf

Liquid Fuel

Think Different

Glucose

Glucose was first isolated in 1747 from raisins by Andreas Marggraf. The name *glucose* was coined in 1838 by Jean Dumas, from the greek *glycos*. Structure was first discovered by Emil Fischer in1891.

https://www.chemie.tu-darmstadt.de/media/lth/papers/183_neu_eng.pdf

432. Emil Fischer: Ueber die Configuration des Traubenzuckers und seiner Isomeren. II.

[Mittheilung aus dem chemischen Laboratorium der Universität Würzburg.]

(Eingangen am 8. August.)

In der ersten Abhandlung [1]) habe ich für den Traubenzucker die Formel

$$CH_2(OH).CH(OH).CH(OH).CH(OH).CH(OH).COH$$
$$\quad\quad +\quad\quad +\quad\quad +\quad\quad -$$

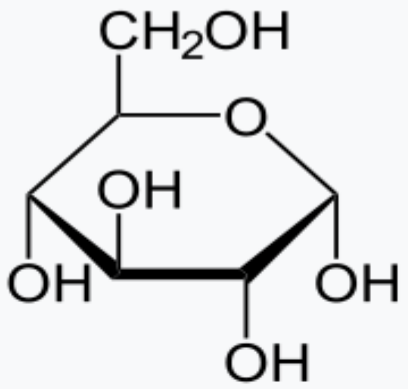
entwickelt. Die Bezeichnung der räumlichen Anordnung durch + und —, welche von van't Hoff eingeführt und von mir in unveränderter Form beibehalten wurde, kann aber bei solchen complicirten Molekülen leicht eine irrthümliche Auffassung zur Folge haben. Um dies zu verhüten, halte ich eine ausführlichere Interpretation der Formeln für nöthig und bezeichne für den Zweck die vier asymmetrischen Kohlenstoffatome mit den Zahlen 1 bis 4

$$CH_2(OH).\overset{1}{C}H(OH).\overset{2}{C}H(OH).\overset{3}{C}H(OH).\overset{4}{C}H(OH).COH.$$

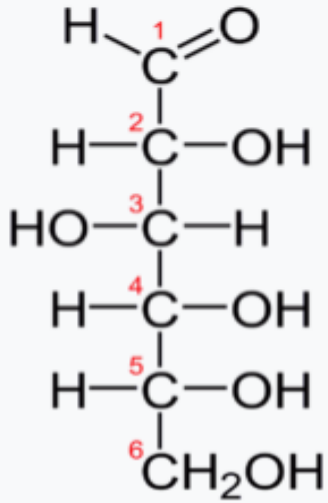
[1]) Diese Berichte XXIV, 1836.

Glucose Structure

D-Glucose



Haworth projection of α-D-glucopyranose



Fischer projection of D-glucose

Published: 03 November 1887

Synthesis of Glucose

A. E. TUTTON

Nature **37**, 7–8 (1887) | Cite this article

Abstract

ANOTHER important acquisition to our store of knowledge has recently been made. Glucose, commonly called grape-sugar, has been artificially prepared by Drs. Emil Fischer and Julius Tafel in the chemical laboratory of the University of Würzburg. This happy achievement, which is announced in the number of the *Berichte* just received, is one which has long been looked forward to, and which cannot fail to give deep satisfaction in chemical circles all over the world. As is generally the case in syntheses of this description, not only has the sugar itself been actually prepared, but, what is at least quite as important, considerable light has been thrown upon that much-discussed question—the constitution of sugars. A most remarkable, and yet only to be expected, attribute of this artificial sugar is that it is found to be entirely incapable of rotating a beam of polarized light. As is well

SYNTHESIS OF GLUCOSE.

ANOTHER important acquisition to our store of knowledge has recently been made. Glucose, commonly called grape-sugar, has been artificially prepared by Drs. Emil Fischer and Julius Tafel in the chemical laboratory of the University of Würzburg.

We have known GLUCOSE since 1747, it was synthesized in 1887 and structure confirmed in 1891.

Yet we are still incapable of efficient *de novo* synthesis of glucose.

FUTURE
Post-2100

Chloroplast nano-chips

Non-sugar synthesis

DE NOVO

CORN

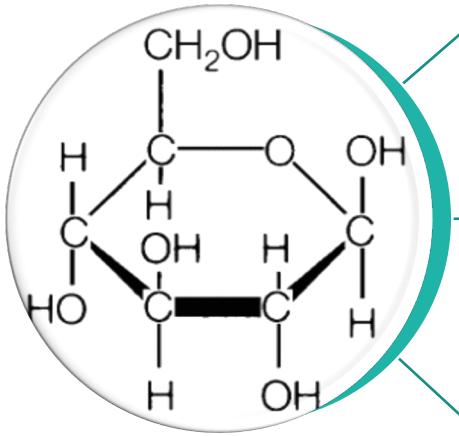
PLANT GROWTH

COSKATA

WASTE CARBON

Bacteria, Algae

PHOTO



Butanol

- Prather 2009
- Atsumi 2008

Pentanol

Ethanol

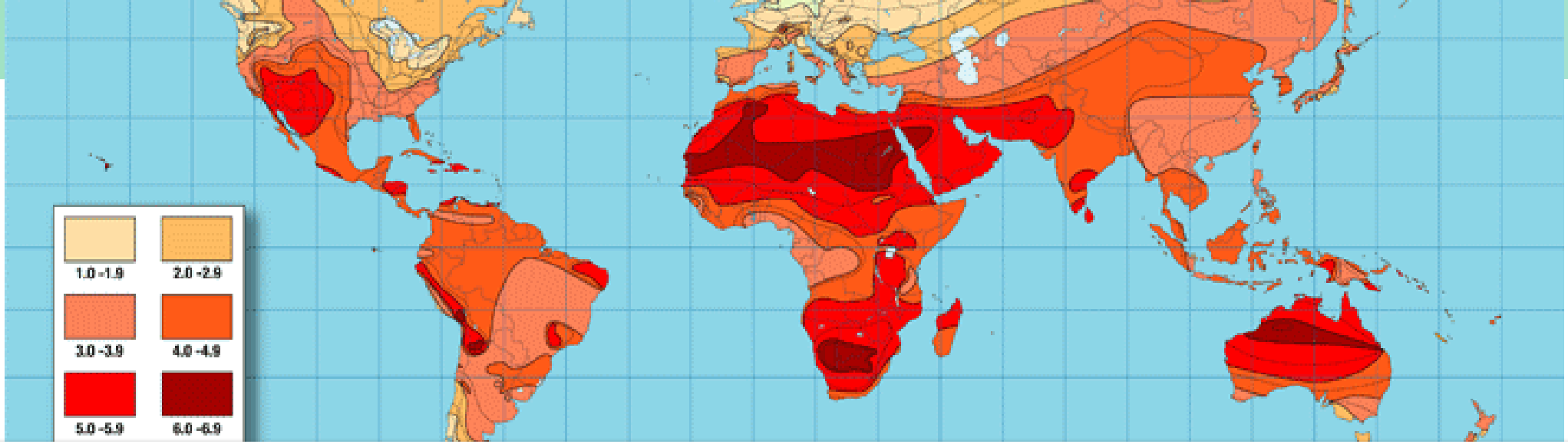
- Stephanopoulos 2006

Glucose

Immobile Enzymes

Butanol Generator

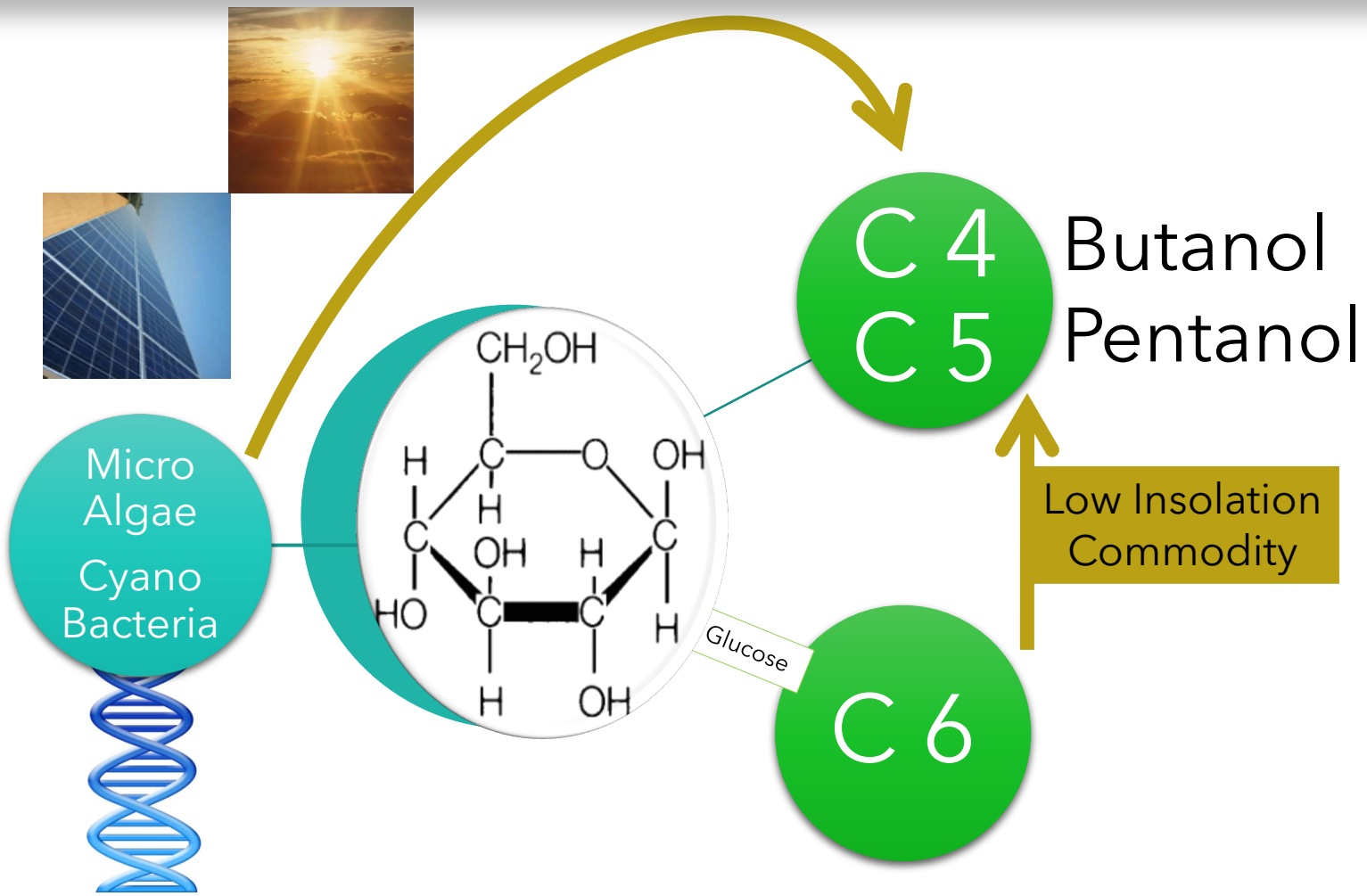
In the post-2100 era, nuclear fusion may dominate Grid power in affluent nations. Liquid fuel demand will exist in 80% of the world. Will it catapult glucose?



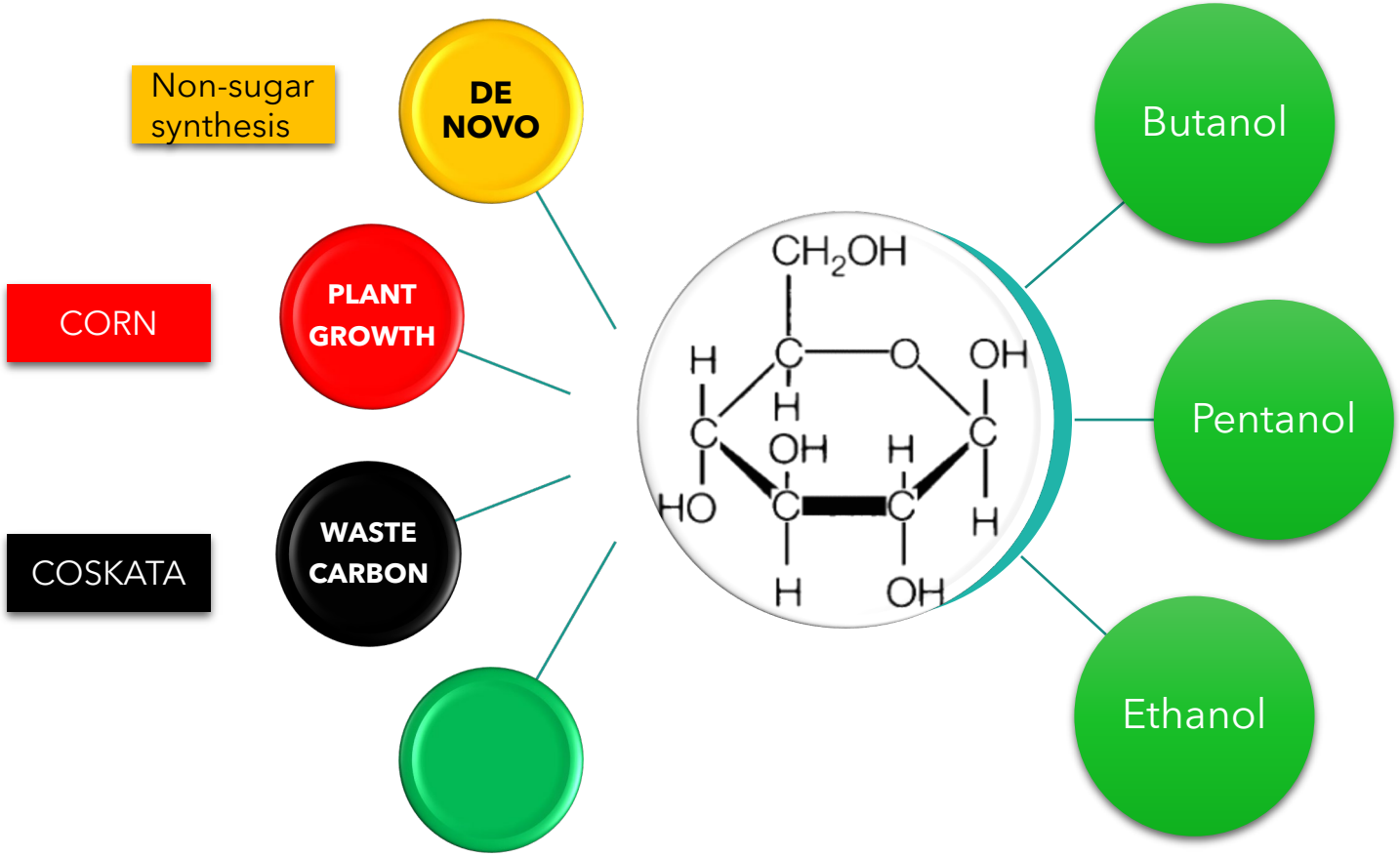
High Insolation Zones

SAHARA SOLAR CORPORATION

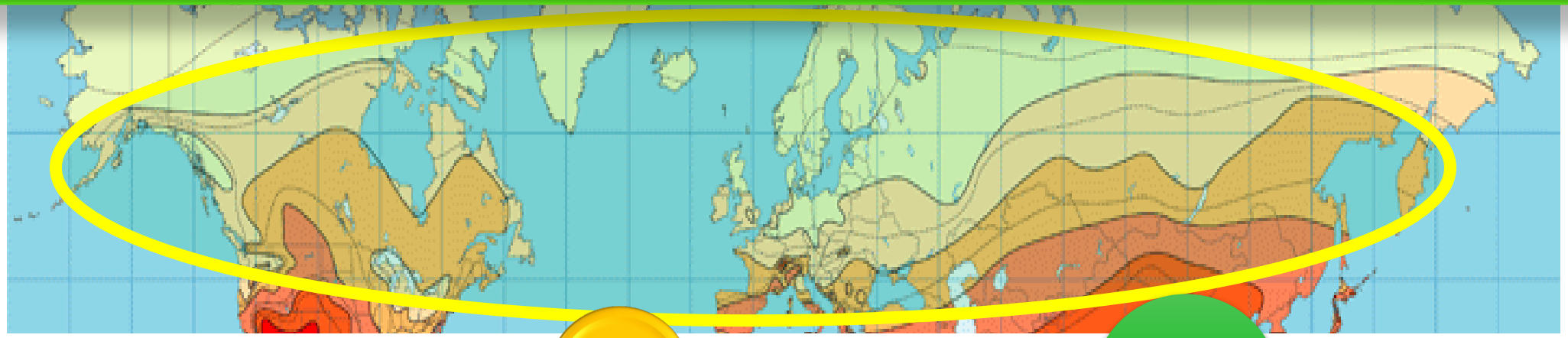
Photosynthetic Butanol Production in High Insolation Zones



Glucose as a Commodity for Liquid Fuel Supply Chain? Can Glucose serve as an intermediary in low insolation?



Glucose as an intermediary in Low Insolation Zones ?

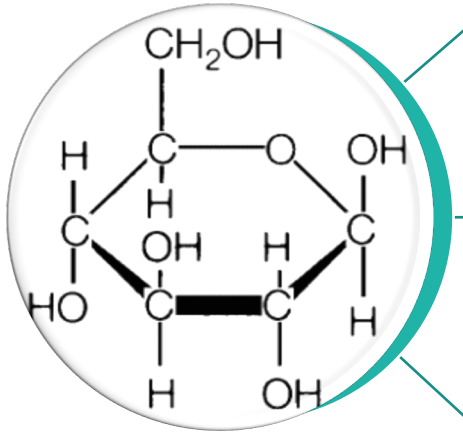


Non-sugar synthesis

DE NOVO

PLANT GROWTH

WASTE CARBON

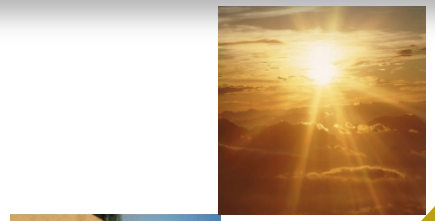


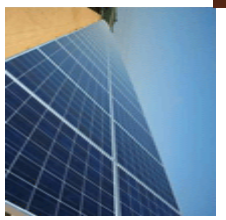
Butanol

Pentanol

Ethanol

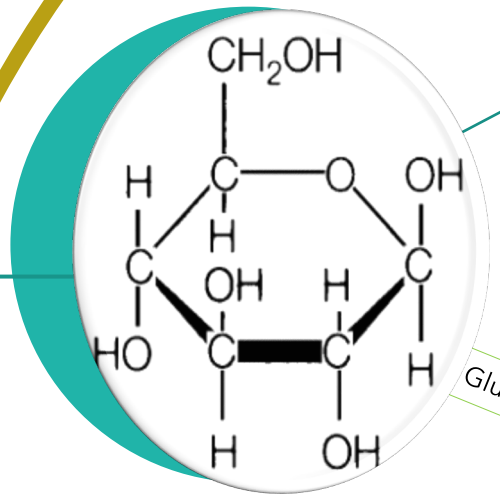
Glucose from low insolation zones can be used to produce Butanol & Pentanol which can be used directly as liquid fuel





Micro Algae

Cyano Bacteria



Glucose

C 6

C 4
C 5

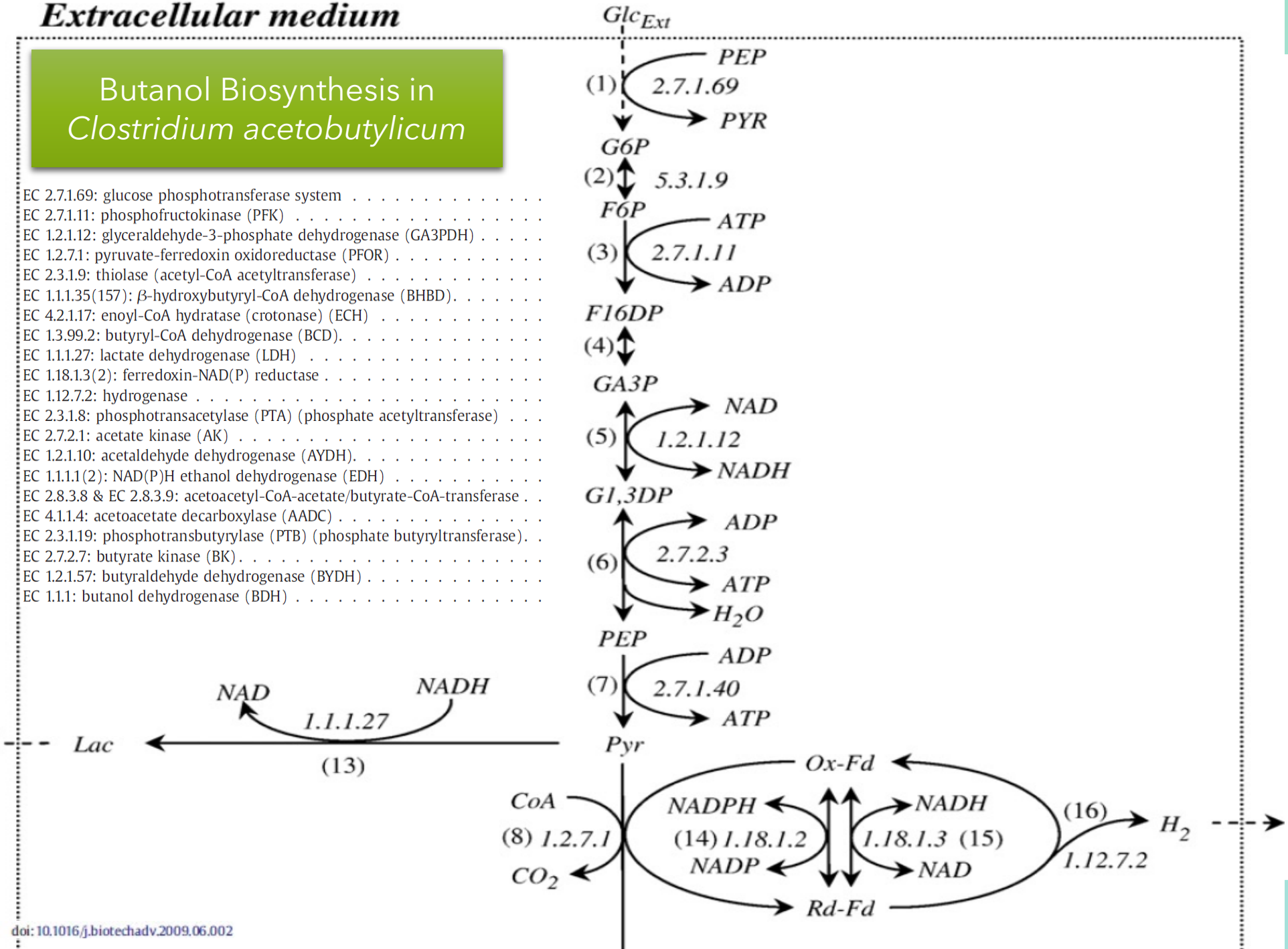
Butanol
Pentanol

Low Insolation Commodity

Glucose

How difficult is it to produce butanol and pentanol ?

Butanol Biosynthesis in *Clostridium acetobutylicum*



EC 2.7.1.69: glucose phosphotransferase system
EC 2.7.1.11: phosphofructokinase (PFK)
EC 1.2.1.12: glyceraldehyde-3-phosphate dehydrogenase (GA3PDH)
EC 1.2.7.1: pyruvate-ferredoxin oxidoreductase (PFOR)
EC 2.3.1.9: thiolase (acetyl-CoA acetyltransferase)
EC 1.1.1.35(157): β-hydroxybutyryl-CoA dehydrogenase (BHBD)
EC 4.2.1.17: enoyl-CoA hydratase (crotonase) (ECH)
EC 1.3.99.2: butyryl-CoA dehydrogenase (BCD)
EC 1.1.1.27: lactate dehydrogenase (LDH)
EC 1.18.1.3(2): ferredoxin-NAD(P) reductase
EC 1.12.7.2: hydrogenase
EC 2.3.1.8: phosphotransacetylase (PTA) (phosphate acetyltransferase)
EC 2.7.2.1: acetate kinase (AK)
EC 1.2.1.10: acetaldehyde dehydrogenase (AYDH)
EC 1.1.1.1(2): NAD(P)H ethanol dehydrogenase (EDH)
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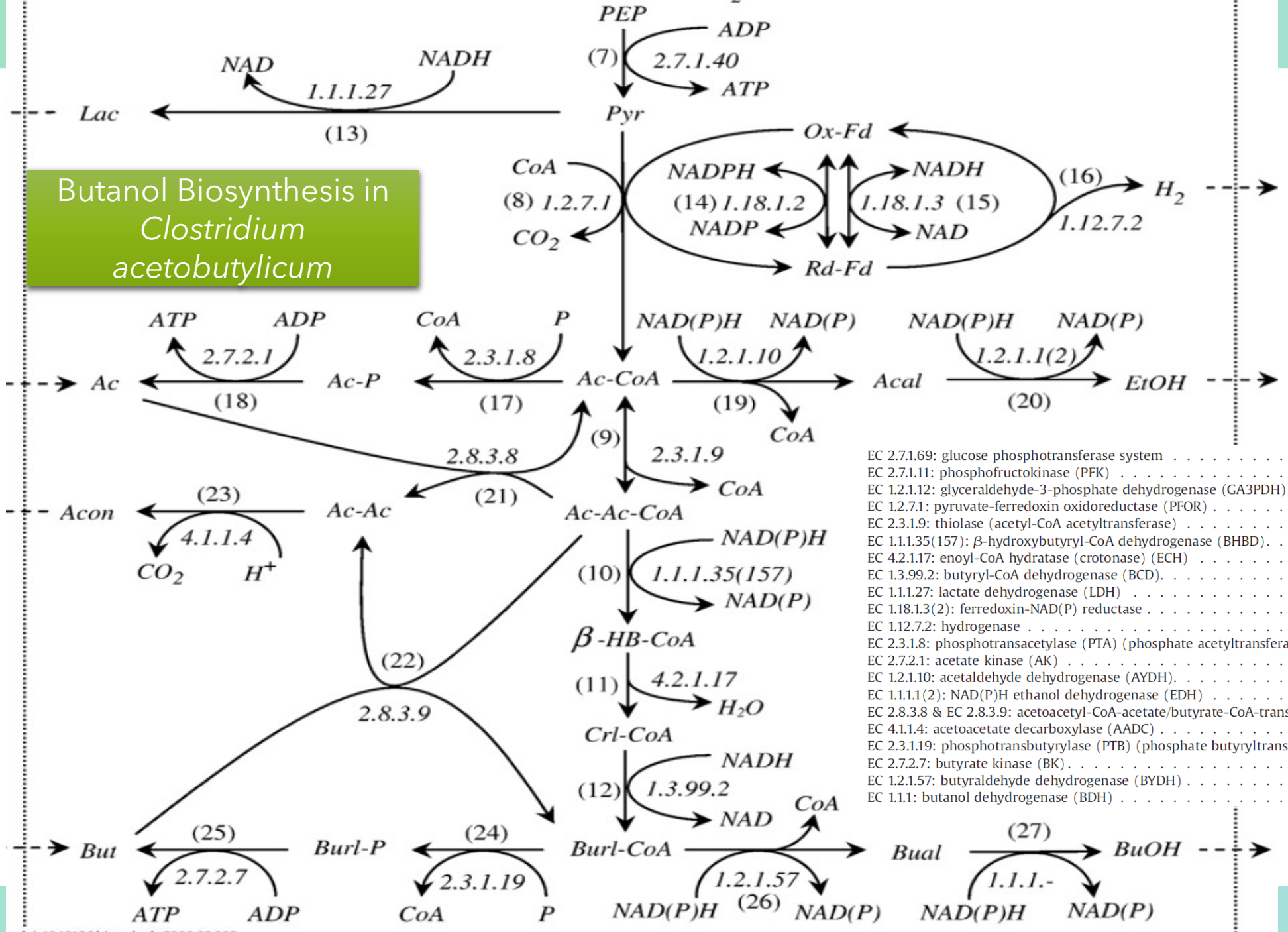
EC 1.2.1.57: butyraldehyde dehydrogenase (BYDH)
EC 1.1.1: butanol dehydrogenase (BDH)

doi: 10.1016/j.biotechadv.2009.06.002

Butanol Biosynthesis in *Clostridium acetobutylicum*



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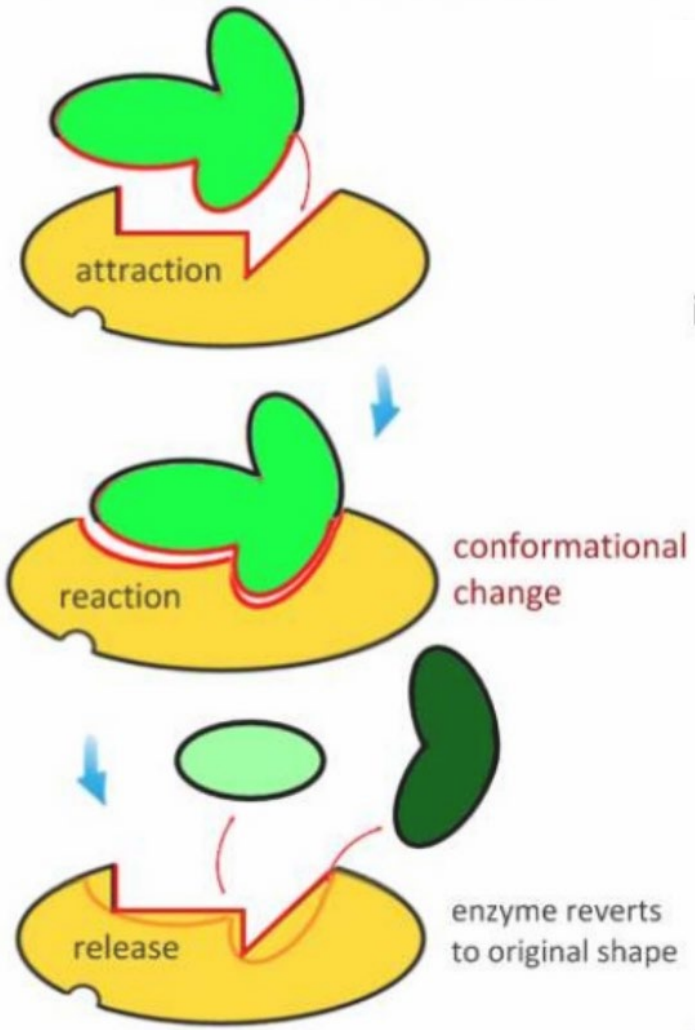
doi: 10.1016/j.biotechadv.2009.06.002

Bio-mimicry?

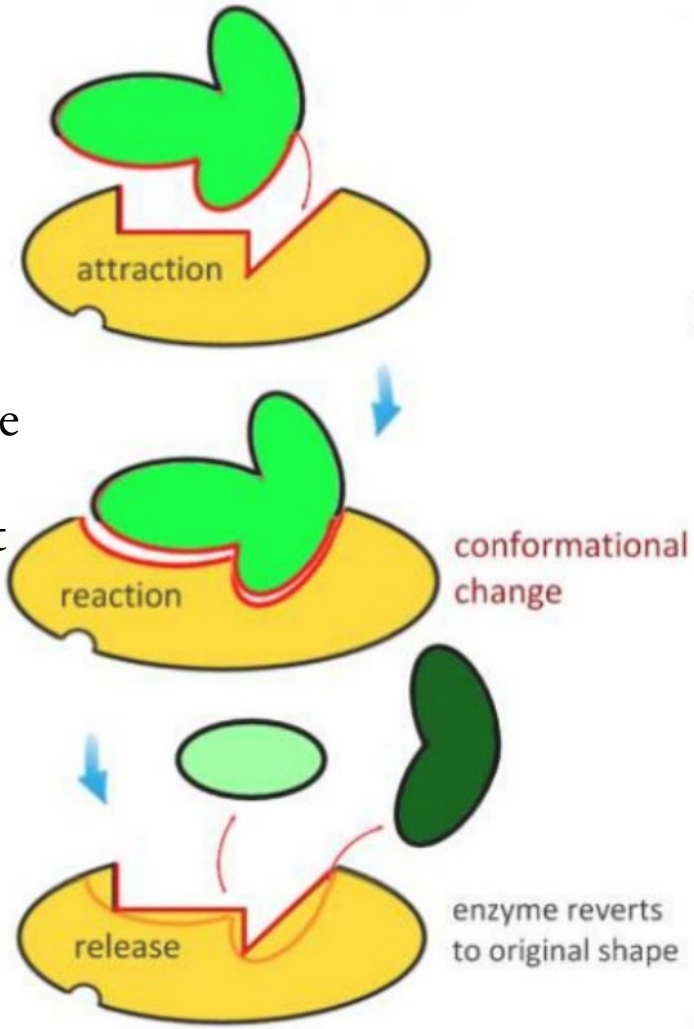
Can we mimic these sequential enzyme-catalyzed steps in a cascade of immobilized enzymes (on material surfaces)?

ENZYMES


attraction
reaction
conformational change
release
enzyme reverts to original shape

ENZYMES

Biological Catalysts



French chemist Anselme Payen was the 1st to discover an enzyme, diastase, in 1833. In 1877, German physiologist Wilhelm Kühne (1837–1900) first used the term *enzyme*, which comes from Greek ἔνζυμον, "leavened" or "in yeast" to describe this process. To explain the specificity of enzymes, in 1894 Emil Fischer proposed that enzymes and substrates possess specific complementary geometric shapes that fit exactly into one another. But the "lock and key" model was modified in 1958 by Daniel Koshland who proposed the induced-fit mechanism of enzyme action.

Payen A, Persoz JF (1833). "Mémoire sur la diastase, les principaux produits de ses réactions et leurs applications aux arts industriels" [Memoir on diastase, the principal products of its reactions, and their applications to the industrial arts]. *Annales de chimie et de physique*. 2nd (in French). **53**: 73–92.

Fischer E (1894). "Einfluss der Configuration auf die Wirkung der Enzyme"[Influence of configuration on the action of enzymes]. *Berichte der Deutschen Chemischen Gesellschaft zu Berlin* (in German). **27** (3): 2985–2993. doi:10.1002/cber.18940270364

https://www.jstor.org/stable/229596

ncbi.nlm.nih.gov/pmc/articles/PMC335371/

In **1958**, Daniel Koshland suggested a modification to Emil Fischer's (1894) ***lock and key*** mechanism of enzyme action. Enzymes are flexible structures. In the **induced-fit model** active sites are continuously reshaped by interactions with the substrate as the substrate interacts with the enzyme.

Proc Natl Acad Sci U S A. 1958 Feb; 44(2): 98–104. PMCID: PMC335371
doi: 10.1073/pnas.44.2.98 PMID: 16590179

Application of a Theory of Enzyme Specificity to Protein Synthesis*

D. E. Koshland, Jr.†

Author information ▸ Copyright and License information Disclaimer

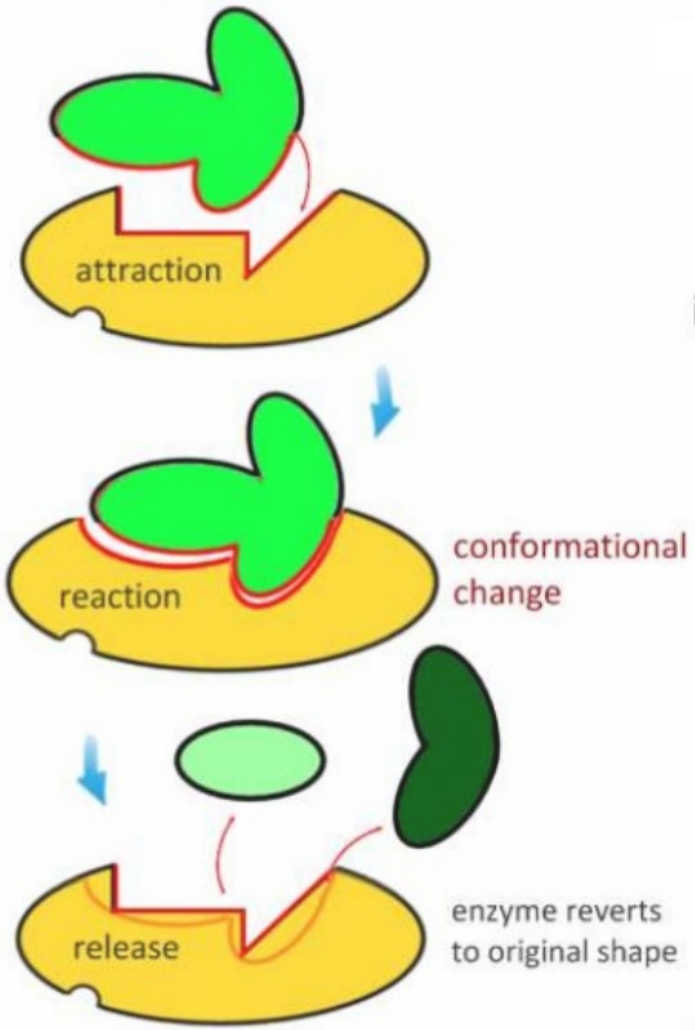
BIOLOGY DEPARTMENT, BROOKHAVEN NATIONAL LABORATORY, UPTON, NEW YORK

† Visiting professor of chemistry, Cornell University, 1957-58.

* Research carried out at Brookhaven National Laboratory under the auspices of the U.S. Atomic Energy Commission.

Proc Natl Acad Sci U S A

The Induced-Fit Model



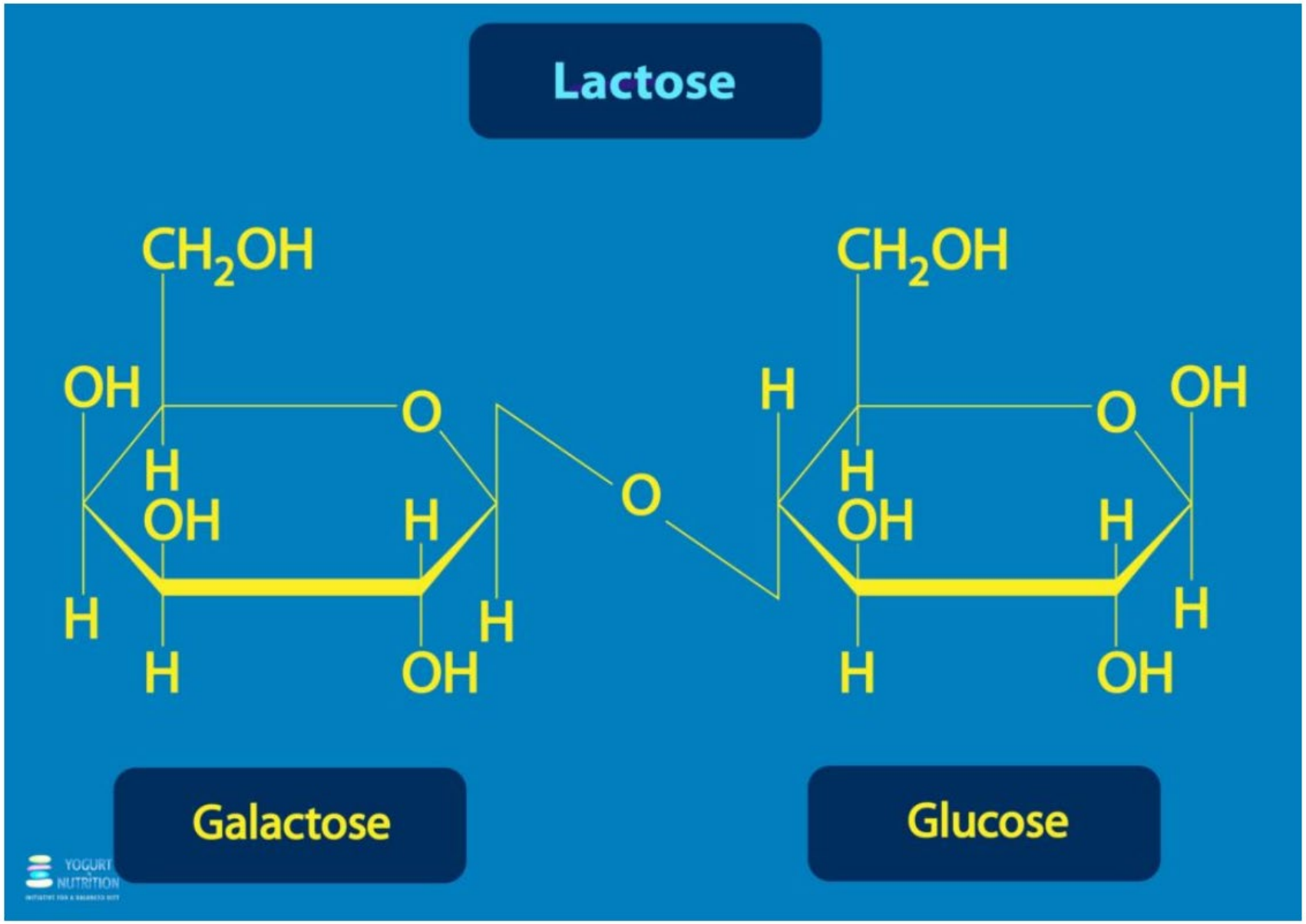
www.ncbi.nlm.nih.gov/pmc/articles/PMC335371/pdf/pnas00681-0050.pdf

Immobilized enzymes

Application of enzymes tethered to surfaces.

Science for society.

The lactose is a carbohydrate (“sugar”) exclusively found in milk and dairy products. It is a disaccharide, composed of galactose and glucose. www.yogurtinnutrition.com/tag/lactose



Lactose malabsorption exists in **two-thirds of the world's population.** Data reveals regional pattern of **lactose intolerance.**

mayoclinic.org/diseases-conditions/lactose-intolerance/symptoms-causes/syc-20374232

Patient Care & Health Information › Diseases & Conditions

Lactose intolerance

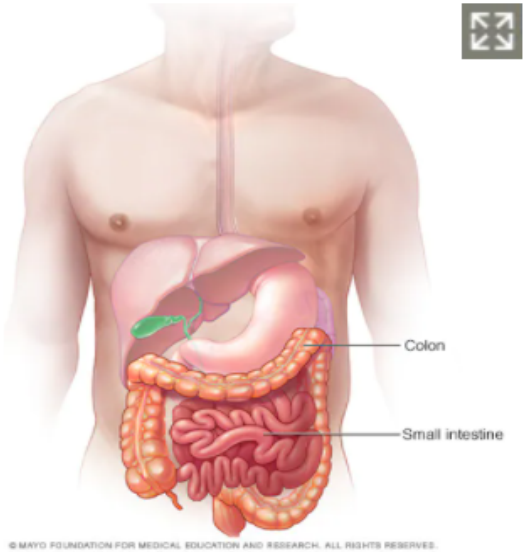
Symptoms & causes | Diagnosis & treatment | Doctors & departments

Overview

Print

People with lactose intolerance are unable to fully digest the sugar (lactose) in milk. As a result, they have diarrhea, gas and bloating after eating or drinking dairy products. The condition, which is also called lactose malabsorption, is usually harmless, but its symptoms can be uncomfortable.

Too little of an enzyme produced in your small intestine (lactase) is usually responsible for lactose intolerance. You can have low levels of lactase and still be able to digest milk products. But if your levels are too low you become lactose intolerant, leading to symptoms after you eat or drink dairy.



Small intestine

https://www.niddk.nih.gov/health-information/digestive-diseases/lactose-intolerance

Lactose malabsorption exists in **two-thirds of the world's population.** Data reveals regional pattern of **lactose intolerance.**

THE LANCET
Gastroenterology & Hepatology

ARTICLES | VOLUME 2, ISSUE 10, P738-746, OCTOBER 01, 2017

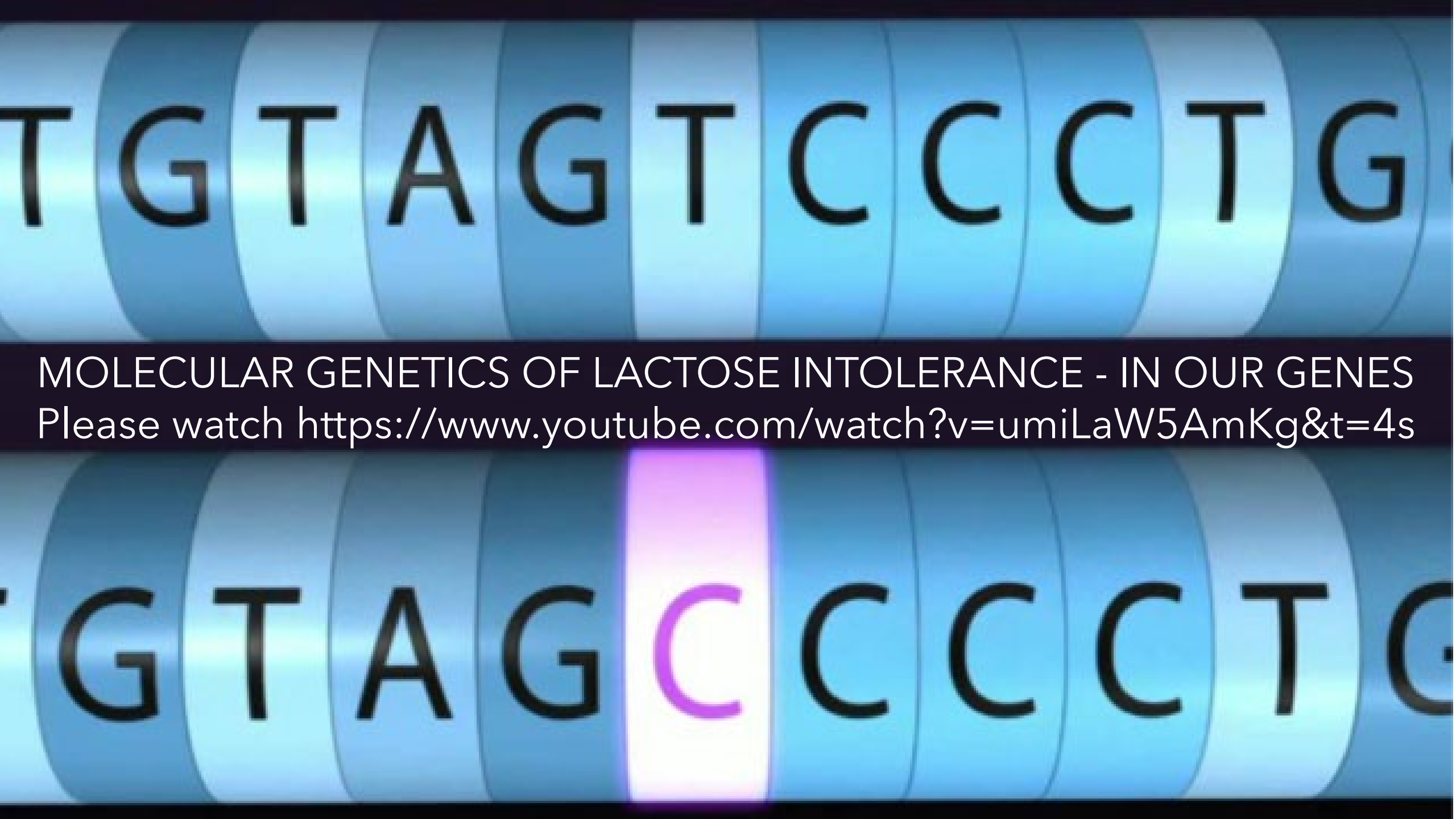
Country, regional, and global estimates for lactose malabsorption in adults: a systematic review and meta-analysis

Christian Løvold Storhaug, MS † • Svein Kjetil Fosse, MS † • Dr Lars T Fadnes, PhD • Show footnotes

Published: July 06, 2017 • DOI: https://doi.org/10.1016/S2468-1253(17)30154-1 • Check for updates

www.thelancet.com/action/showPdf?pii=S2468-1253%2817%2930154-1

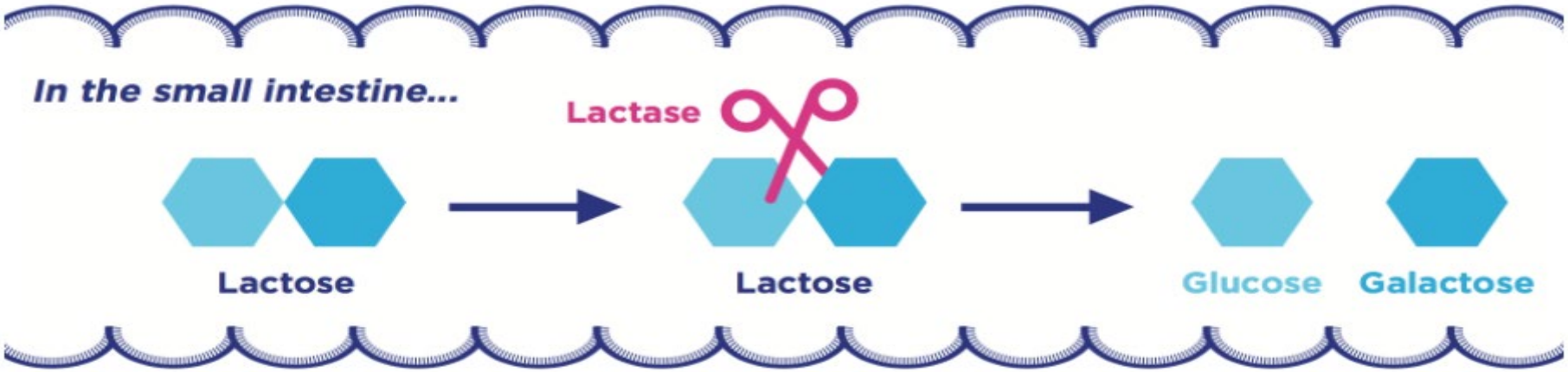
Widespread Lactose malabsorption exists in **two-thirds of the world's population.** Data reveals regional patterns of **lactose intolerance.**


TGTAGTCCCTG
MOLECULAR GENETICS OF LACTOSE INTOLERANCE - IN OUR GENES
Please watch https://www.youtube.com/watch?v=umiLaW5AmKg&t=4s
GTAGCCCCTG

Science for society offers a solution

Lactase, an enzyme present in the small intestine, is necessary to split lactose into **glucose** and **galactose**, two simple sugars. https://www.yogurtinnutrition.com/lactose-as-a-nutrient

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC322277/pdf/jcinvest00210-0168.pdf



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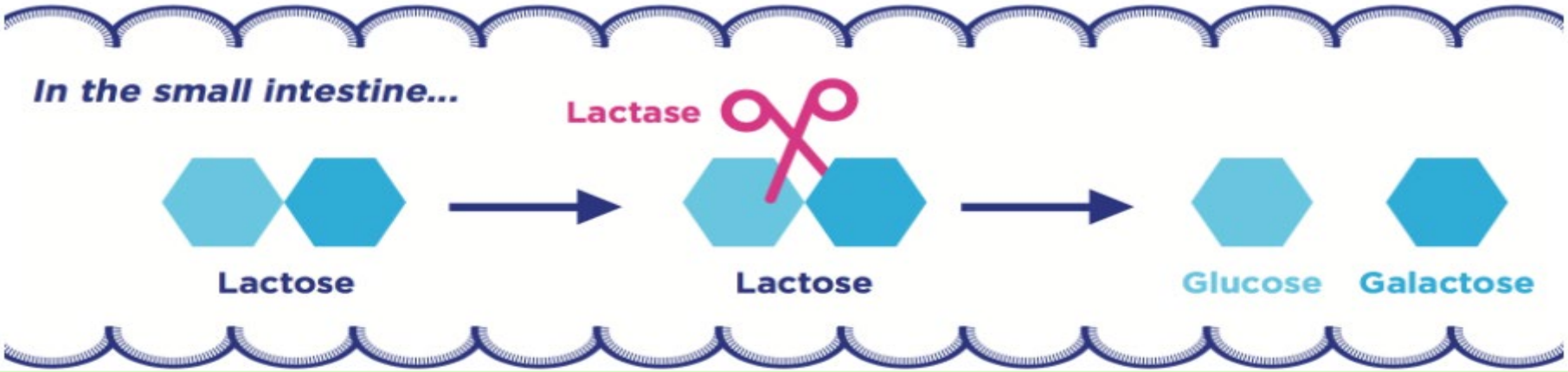
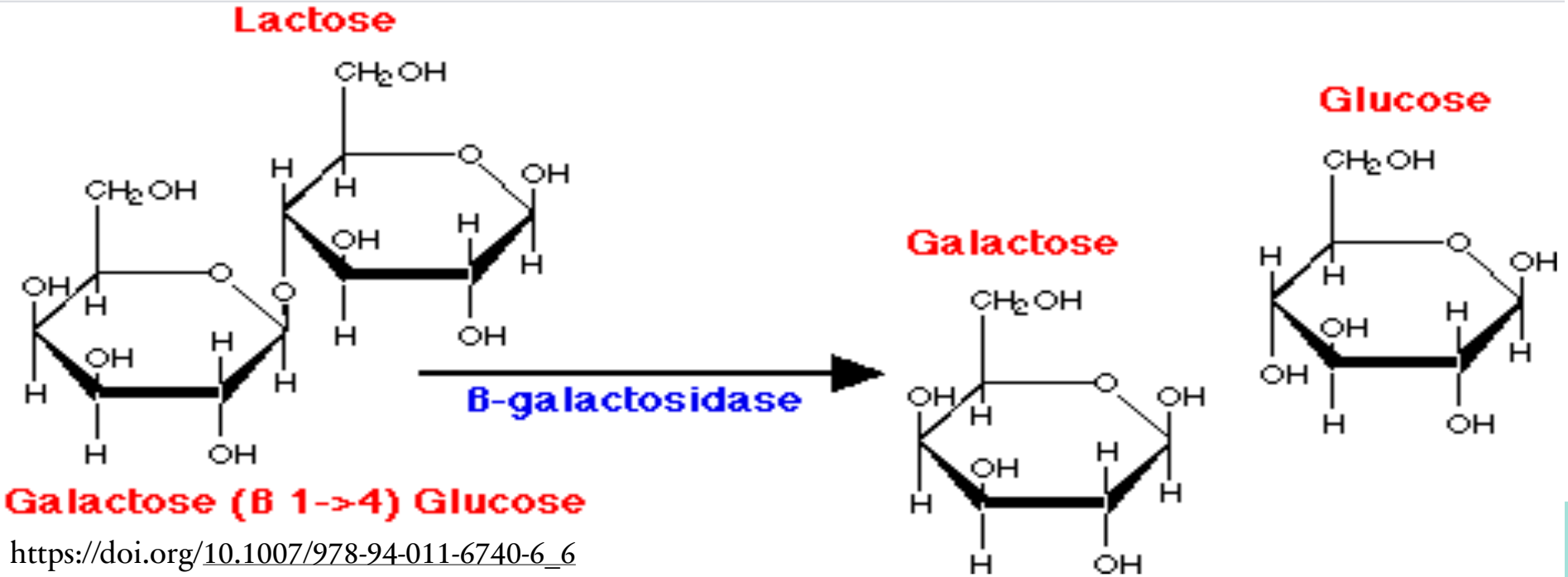
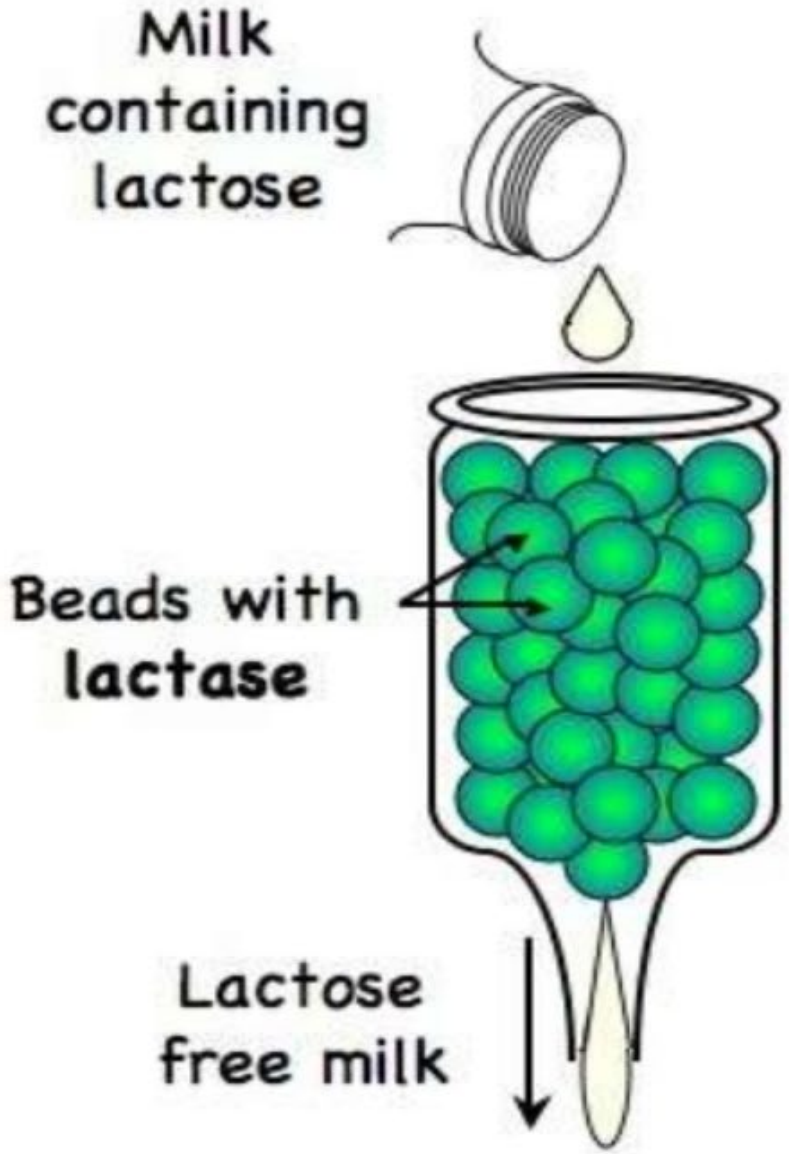


Nijpels H.H. (1981) Lactases and their Applications. In: Birch G.G., Blakebrough N., Parker K.J. (eds) Enzymes and Food Processing. Springer, Dordrecht.



https://doi.org/10.1007/978-94-011-6740-6_6

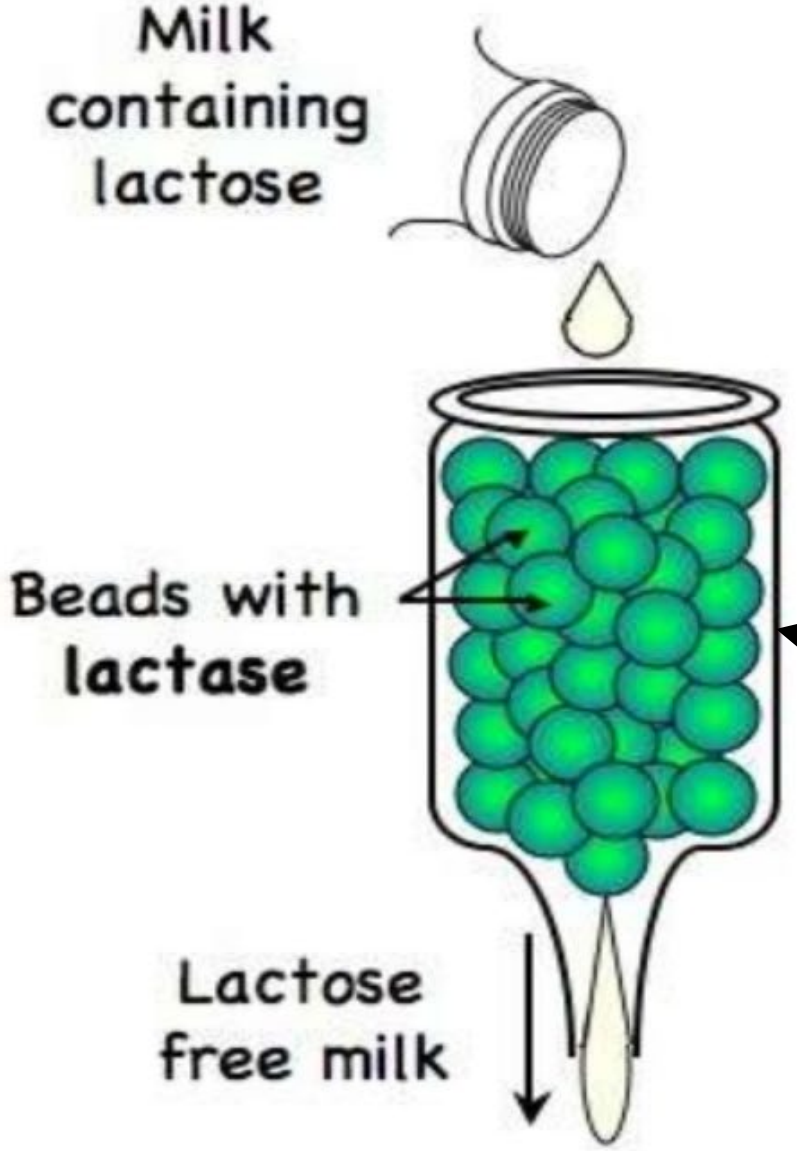
https://www.chemedx.org/article/immobilization-lactase-enzyme-alginate-beads-quick-test



Production of Lactose-free milk

- Lactase obtained from commonly from yeast (bacteria is an alternative)
- Lactase is bound to the surface of alginate beads
- Milk is passed (repeatedly) over the beads
- The lactose is broken down into glucose and galactose
- The immobilized enzyme remains to be used again and does not affect the quality of the lactose free milk

https://www.springer.com/gp/book/9780751401752



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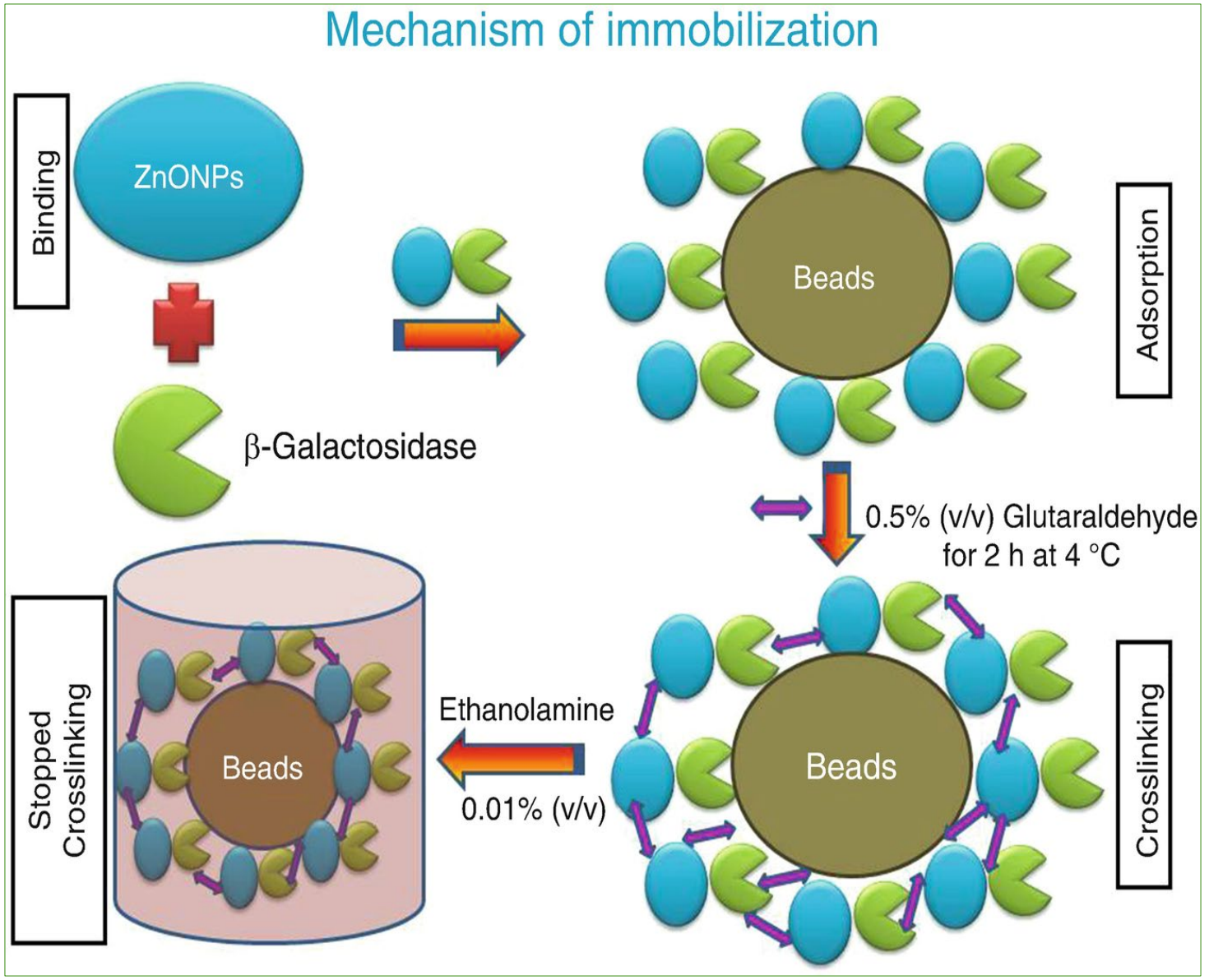
https://pubs.acs.org/doi/pdf/10.1021/acs.jafc.9b04385

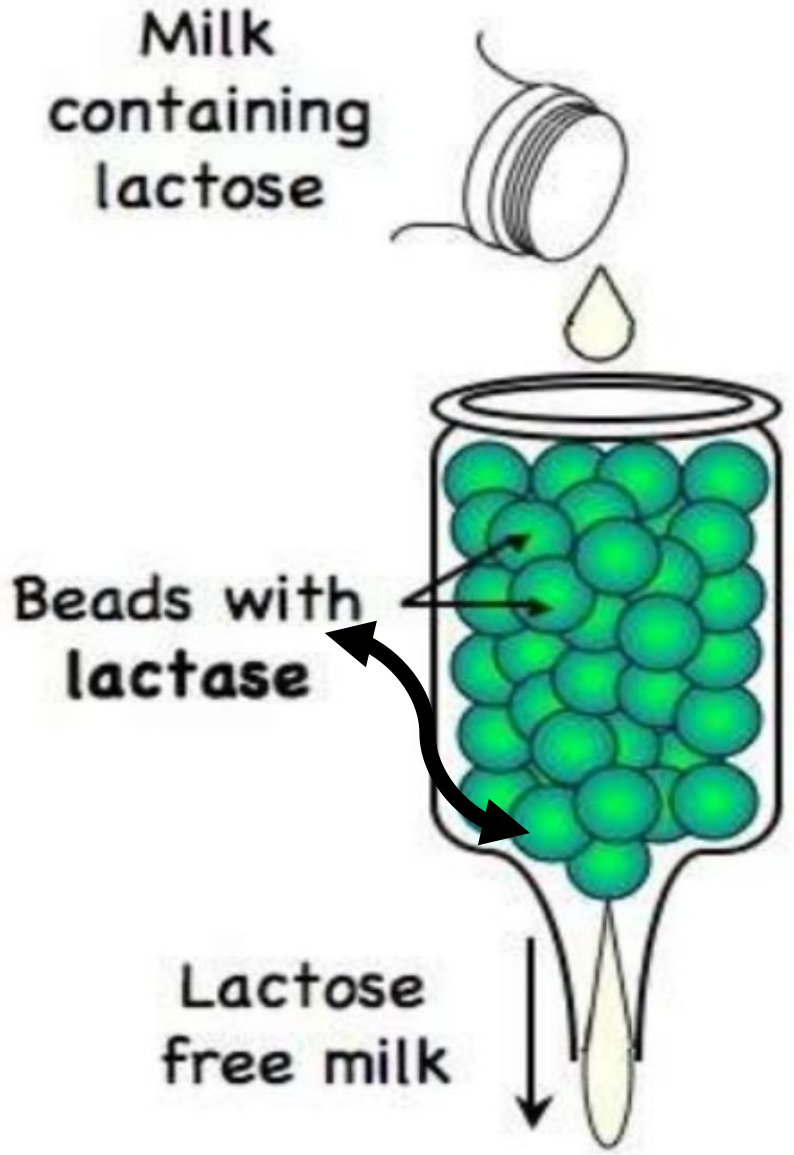
Immobilized Enzymes Science for Society

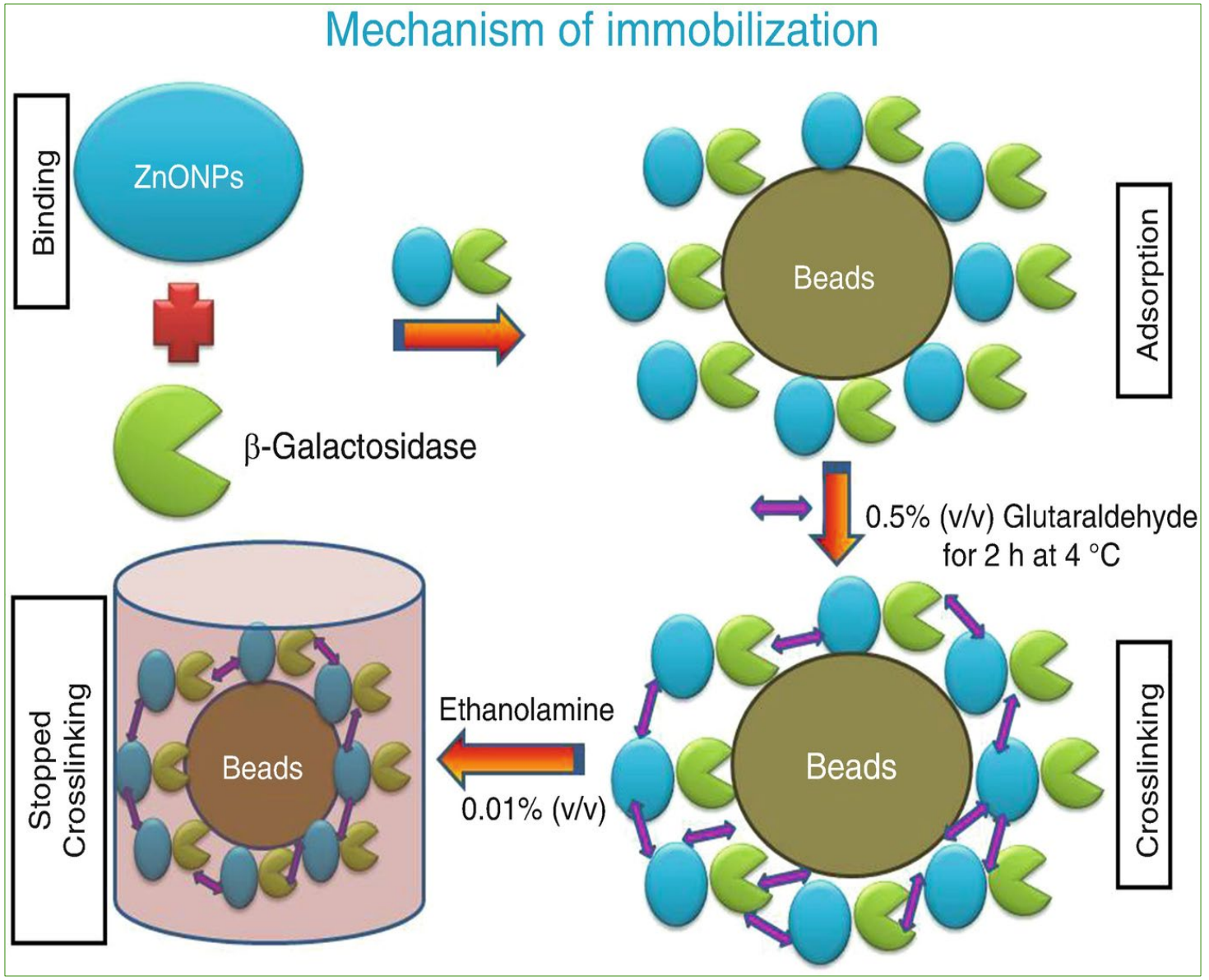
www.researchgate.net/publication/318760978_Immobilized_enzymes_in_food_processing_Methods_and_applications



https://link.springer.com/chapter/10.1007/978-3-319-97922-9_7

YOU CAN EXPERIMENT IN YOUR CLASSROOM ■ https://pubs.acs.org/doi/10.1021/ed075p1430





www.researchgate.net/publication/318760978_Immobilized_enzymes_in_food_processing_Methods_and_applications

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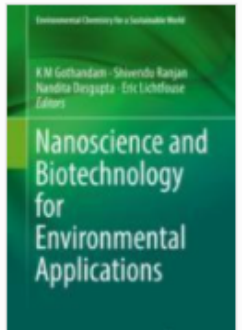
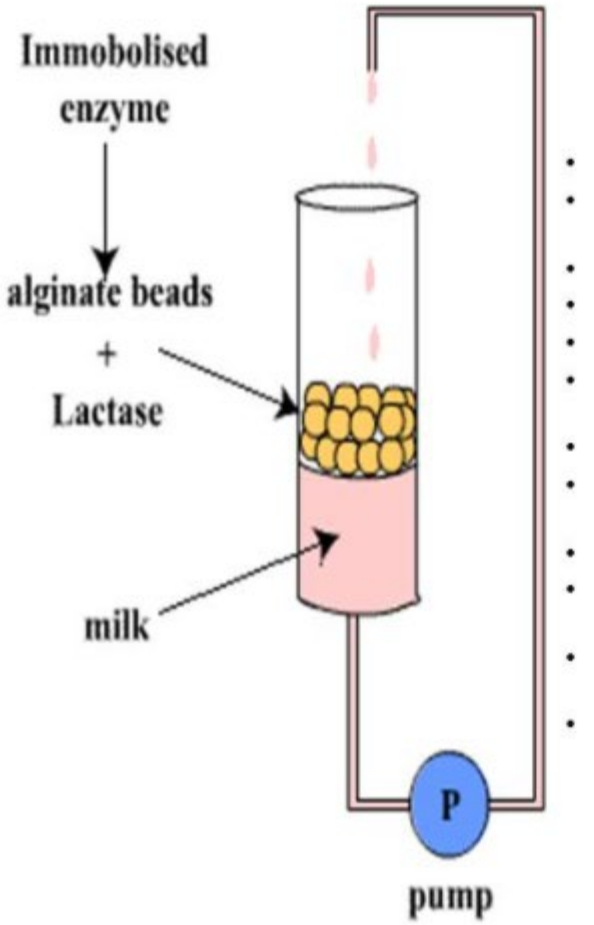


Nanoscience and Biotechnology for Environmental Applications pp 199-223 | Cite as

Nanoimmobilization of β-Galactosidase for Lactose-Free Product Development



Lactose —(Lactase)→ **Glucose + Galactose**

- **Enzyme Immobolisation:**
- It is possible to make the process more efficient by immobilising the lactose on recoverable surface such as alginate.
- First the Lactase is immobilised in alginate beads.
- Next the beads are placed in a container over which milk can be passed.
- The milk is collected and re-circulated (pump) to convert any remaining lactose to glucose and galactose.
- The circulation is maintained until all lactose has been converted.
- This model of an industrial process allow the lactase to be recovered and re-used (cheaper).
- Efficient conversion of lactose to glucose and galactose.
- reduced purification of milk since enzyme is retained and a high % lactose conversion is achieved.
- All these factors reduce cost particularly on the downstream processing and purification.

Vaithilingam Mohanasrinivasan

Request for the Book Chapter

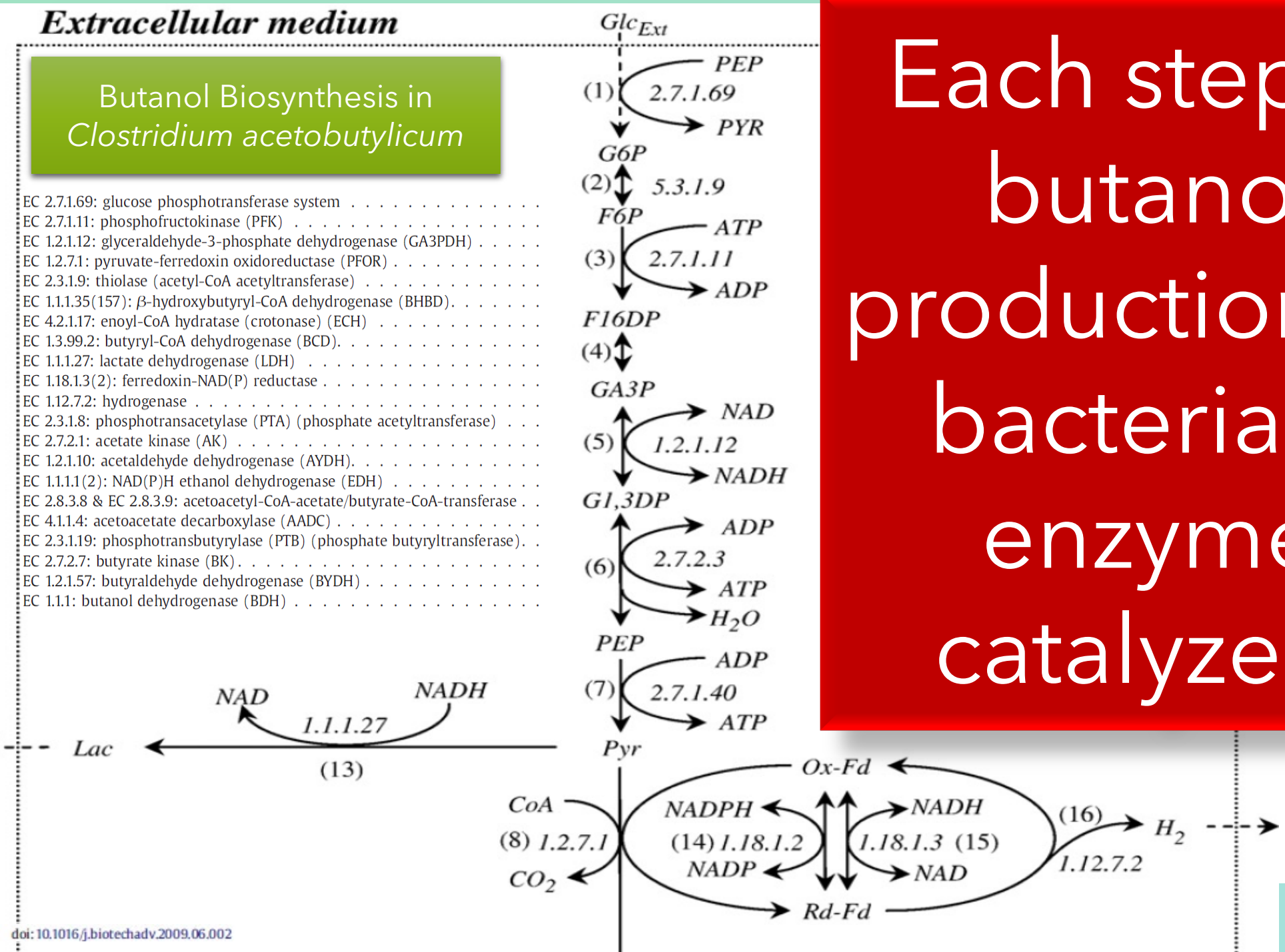
v.mohan@vit.ac.in

Science for Society

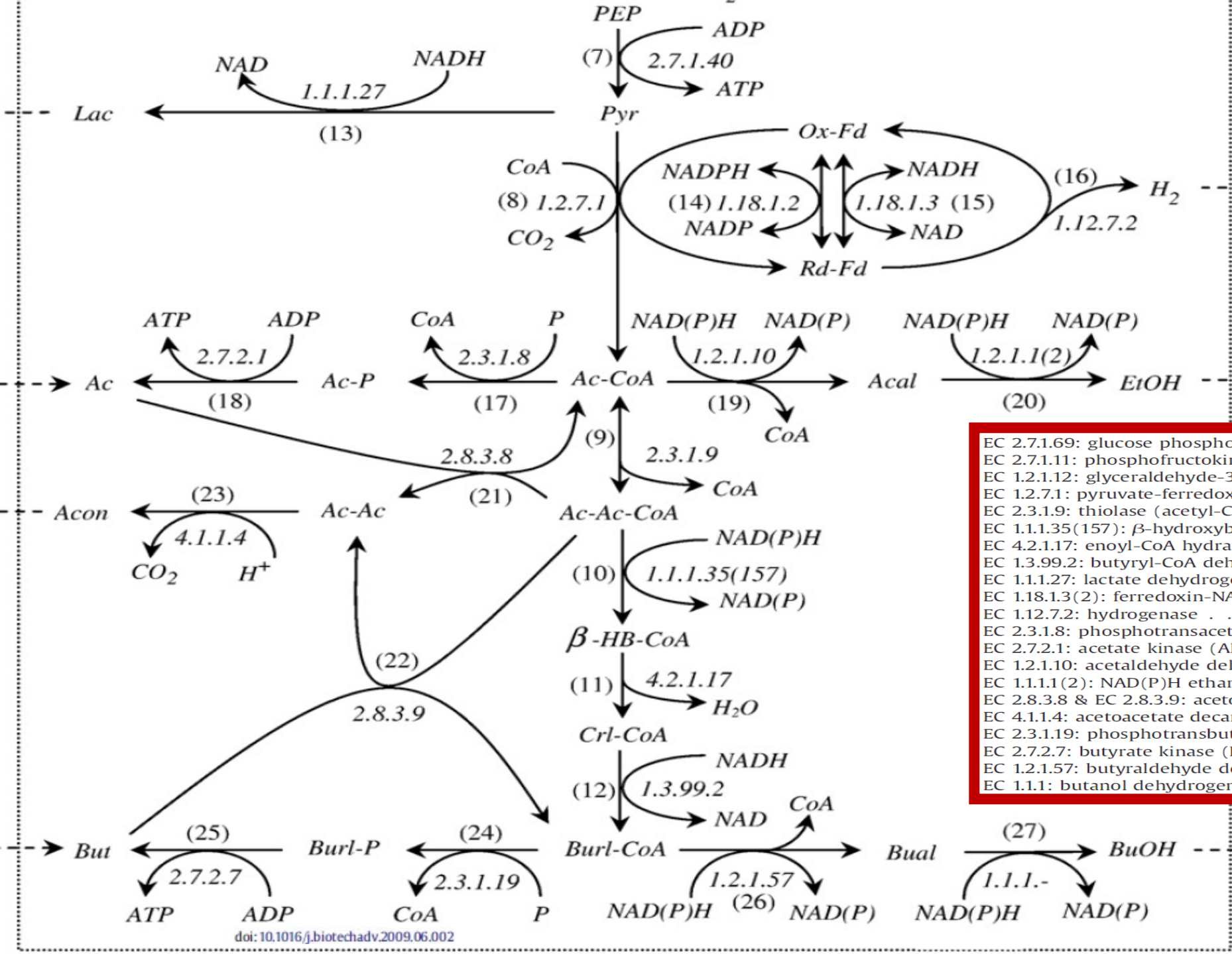
Think big.

Immobilized Enzymes Science for Society

Butanol Biosynthesis in *Clostridium acetobutylicum*



Each step in butanol production by bacteria is enzyme catalyzed.



doi: 10.1016/j.biotechadv.2009.06.002

Each "EC" is an enzyme. *Immobilize ?*

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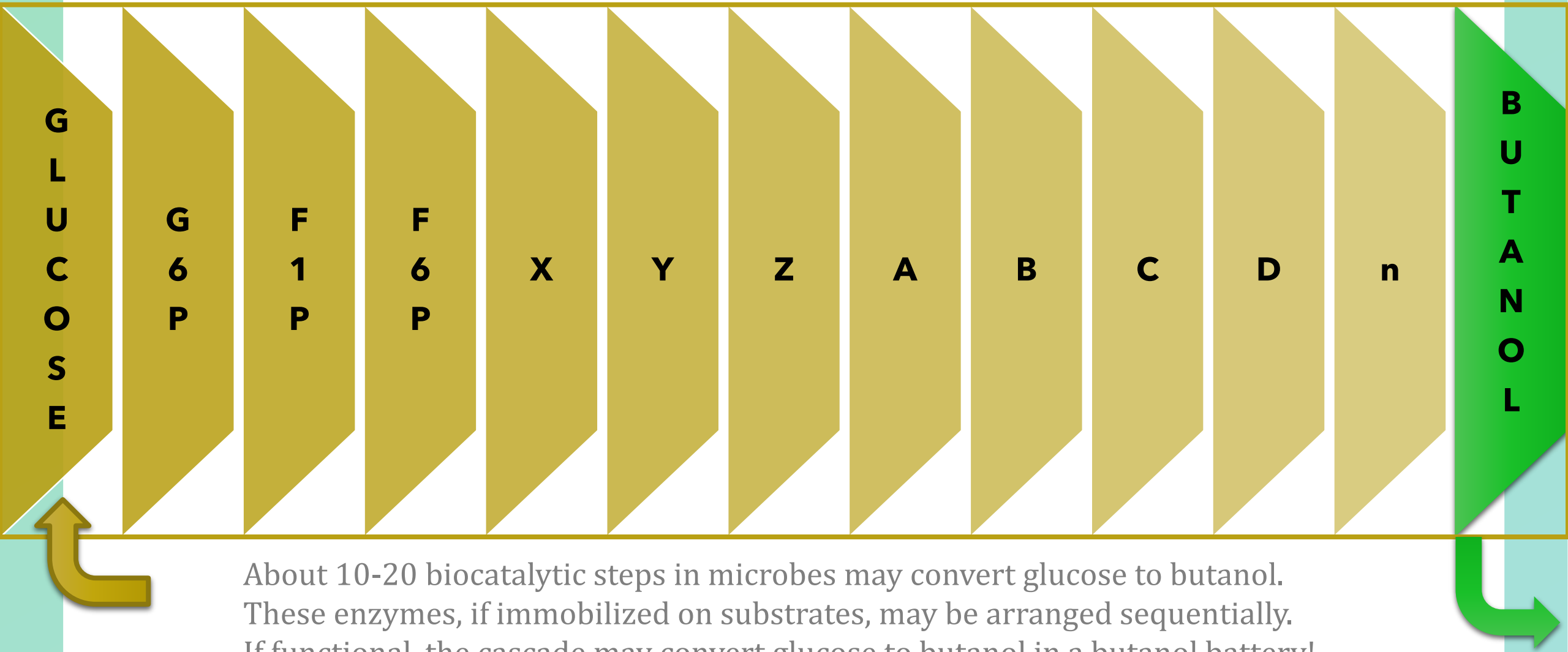
Butanol Biosynthesis in *Clostridium acetobutylicum*

Think big. Dream bigger.

Immobilized Enzymes
Science for Society

Hypothetical Immobilized Enzymatic Catalysis of Glucose to Butanol

Butanol Battery *(I thought ca. 2000 it was going to be real by 2020)*



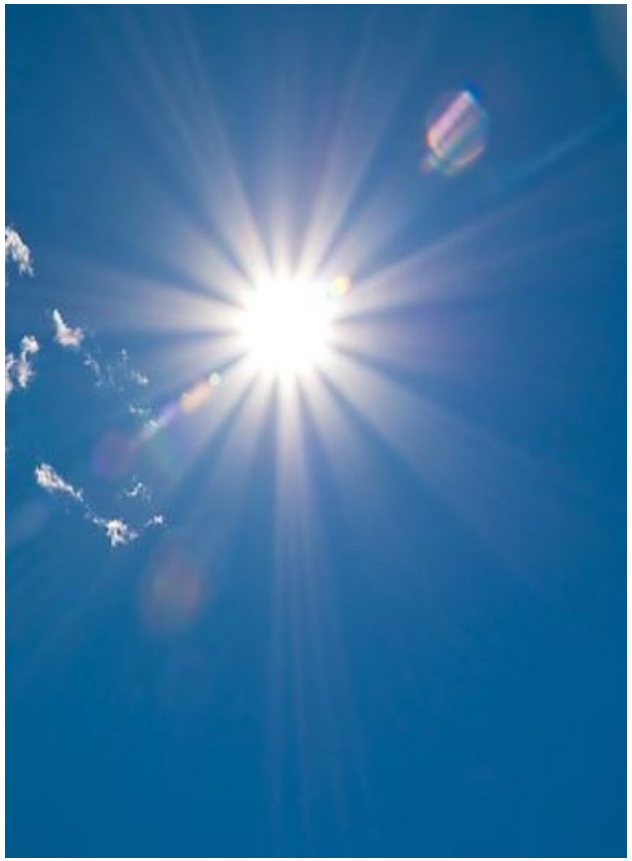
About 10-20 biocatalytic steps in microbes may convert glucose to butanol.
These enzymes, if immobilized on substrates, may be arranged sequentially.
If functional, the cascade may convert glucose to butanol in a butanol battery!

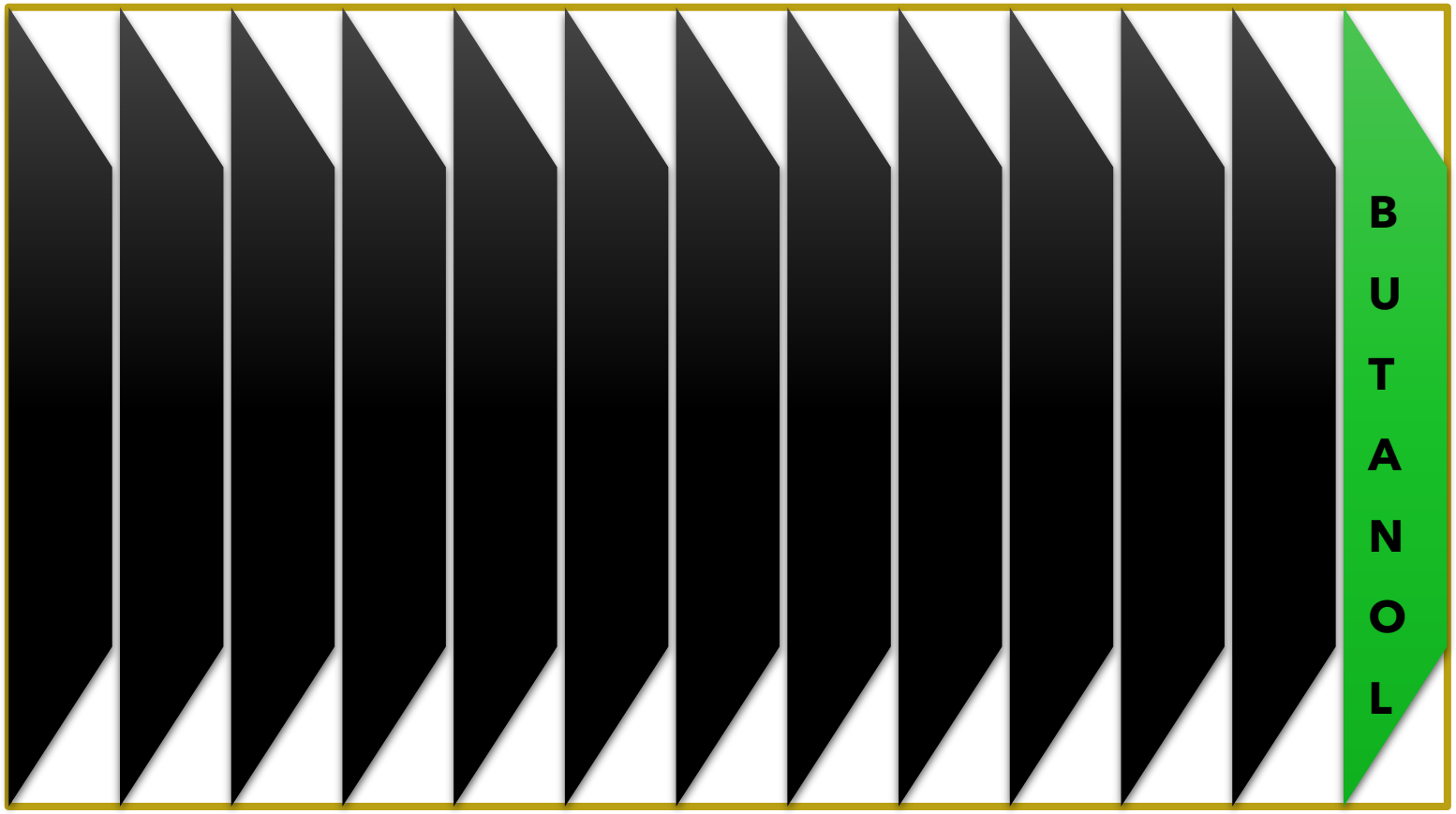
Even bigger ??

Capture NATURE

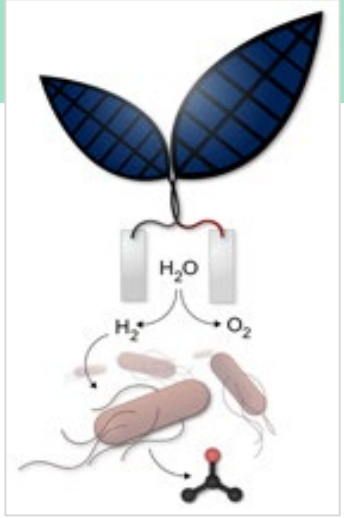
Hypothetical Immobilized Enzymatic Catalysis in Nano-Chloroplasts

2100 AD ??





Light-dependent (photosystem I and II) and light-independent reactions of photosynthesis may be difficult (not impossible) to immobilize *(cartoon).*
Many integral proteins in thylakoids in chloroplasts makes it immensely complex.



Bohr,

to Pauli and Heisenberg

"We are all agreed that your theory is crazy. The question that divides us is whether it is crazy enough to have a chance of being correct."

Wright Flyer in 1903

Heavier-than-air flying machines are impossible.

Lord Kelvin

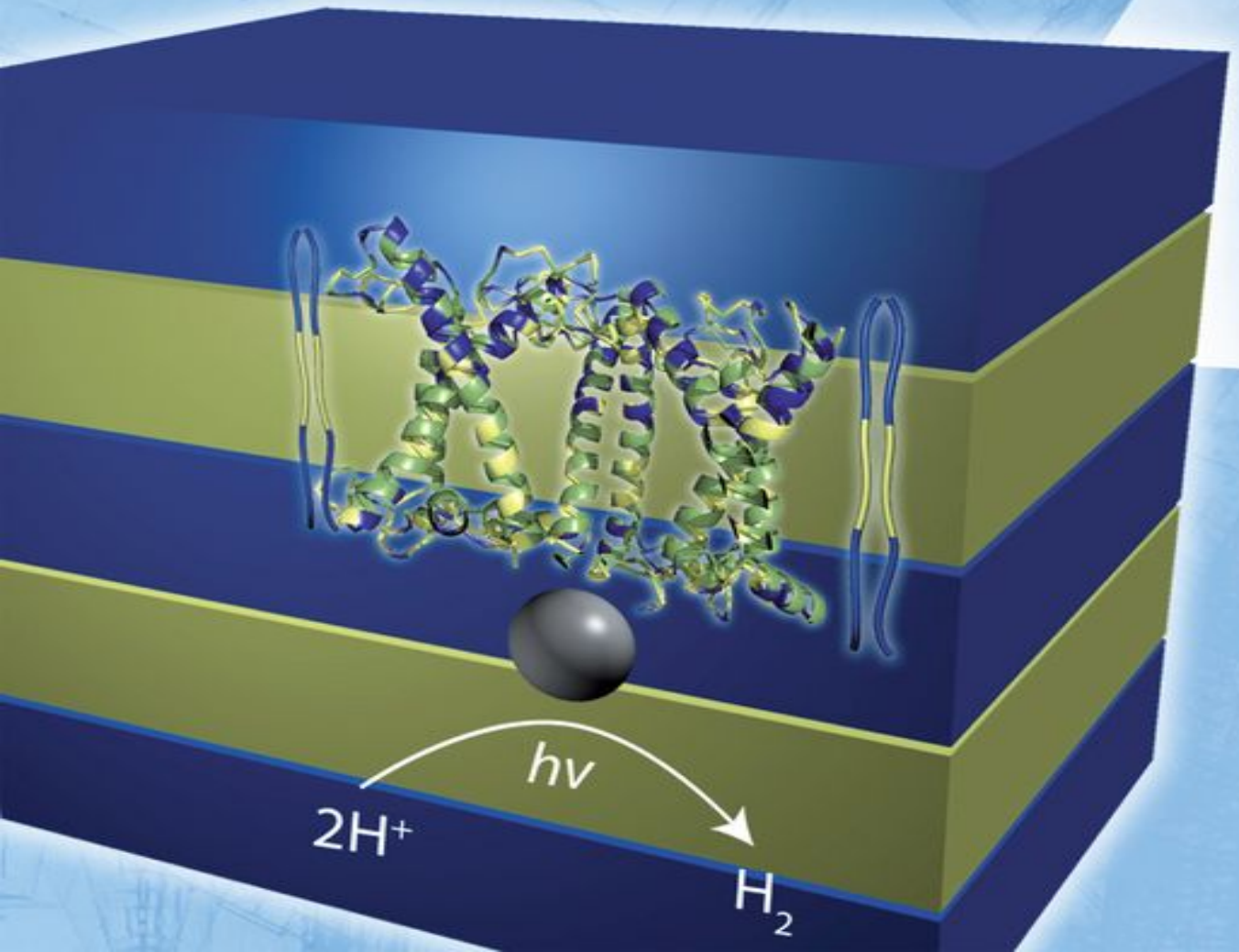
Wright Flyer in 1903

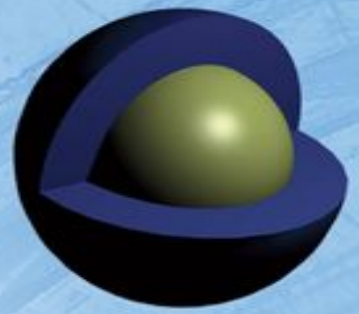
Heavier-than-air flying machines are impossible.

Lord Kelvin

THE PERSON WHO SAY IT CANNOT BE DONE SHOULD NOT INTERRUPT THE PERSON WHO IS DOING IT

Supramolecular Assembly of Biohybrid Photo-conversion Systems (2011) Mateus B. Cardoso, Dmitriy Smolensky, William T. Heller, Kunlun Hong & Hugh O'Neill. Energy & Environmental Science (2011) 4 181-188. DOI: 10.1039/C0EE00369G





Synthetic photo-bio Hydrogen ??

Dr Hugh O'Neill *et al* at the ORNL Center for Structural Molecular Biology and Center for Nanophase Materials Sciences (Oak Ridge National Lab) have developed a bio-hybrid photo-conversion system based on the interaction of photo-synthetic plant proteins with synthetic polymers which can convert visible light into hydrogen fuel. What's next?

In the future, pH may also signify …

Powered by pH (portable Hydrogen)

You can help to transform these ideas into reality.

Can't you?

portable Hydrogen (pH)

Glucose

A grand challenge that can lift many boats but first we must unlock the science. Society in need of scientists.

FUTURE
Post-2100

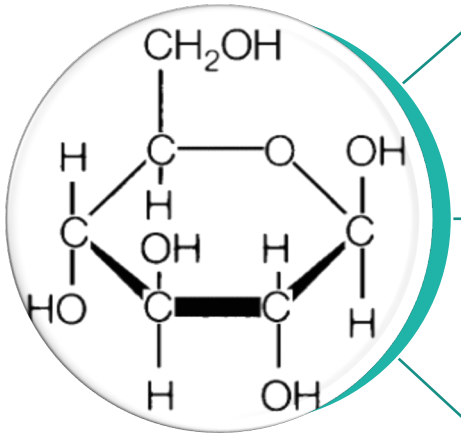
Chloroplast nano-chip

DE NOVO

PLANT GROWTH

WASTE CARBON

PHOTO



Butanol

Pentanol

Ethanol

Personal Electricity Generator

Immobile Enzymes

Butanol Generator

Simplest things we don't know

DE NOVO (Latin for "new") synthesis of Glucose is still beyond current knowledge of science and scientists. We do not know how to create glucose molecules from elements (C, carbon; H, Hydrogen; O, oxygen) or common compounds such as water (H_2O) and carbon dioxide (CO_2). What the world needs urgently is a "glucose" version of the chemical synthesis of Penicillin (which saved billions of lives) created in 1957 at MIT by John C. Sheehan and Kenneth R. Henery-Logan. An alternative approach may be a version of the Haber-Bosch process for glucose. Haber-Bosch process uses nitrogen (N) from air and hydrogen (H) from natural gas to synthesize ammonia (NH_3), a fertilizer, which has made it possible to feed billions of people.

1957, MIT ◆ Total Synthesis of Penicillin by John C. Sheehan and Kenneth R. Henery-Logan
https://pharmacy.rutgers.edu/wp-content/uploads/Med-Chem-Examples-of-Total-Synthesis.pdf

But plants do  Photosynthesis

Carbon dioxide + Water $\xrightarrow[\text{Chlorophyll}]{\text{Light}}$ Glucose + Oxygen

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6O_2$$

Grand Challenge – Can immobilized enzymatic catalysis (nano-chloroplasts) capture photosynthesis *in silico* ??

At least, can we synthesize glucose from carbon dioxide and water if we cannot capture photosynthesis *in silico* ??

Scientists – we need synthetic glucose

Glucose (sugar) is easily transported in bags and packs. It is energy. We use sugar (glucose) to obtain our energy inside our bodies. What if we can use glucose for energy for cars (power for batteries) and homes (power for batteries). Just like ammonia, "glucose" plants can produce massive amounts of glucose. We can use the glucose (anywhere in the world) to feed the bacteria (in small domestic use equipment or large commercial fermenters) to produce fuel in the form of butanol and/or pentanol which can replace petroleum fossil fuel (petrol). Every household in the world can buy glucose from the grocery store and can produce their own liquid fuel (butanol, pentanol) in their home. The liquid fuel can be used in a generator (replaces petrol, kerosene, gasoline) to power homes and batteries. The batteries can powe cars, scooters, vans and when they run out of charge (power) they can be swapped (swappable atoms). We will have power without the shining sun, if it is raining (Cherrapunji, India) or if it is Arctic Cold (Karasjok, Norway). Glucose is a low-cost solution for world's energy. We need chemists, biologists, and other scientists/enginners to invent/discover how to make synthetic glucose.

What will happen if all of us produces **C4 and C6** *liquid fuels?*

Anastomosis of sunlight-dependent C4 production with sunlight-agnostic production of C5

Renewable liquid butanol (C4) can be produced by micro-organisms using energy from sunlight and carbon dioxide from air. Because sunlight is not sufficiently available in parts of the world, butanol can be made in the ABSENCE OF SUNLIGHT if microorganisms are supplied with another source of primary energy, for example, glucose. At present many good sources of glucose are from food items (sugar cane, corn). It has ignited the food v fuel debate due to increasing cost of food items. We can avoid depleting food sources for glucose. Instead of food we can use cyano-bacteria which can directly (auto-trophic) produce glucose from sunlight & atmospheric carbon dioxide. Thus, glucose may be viewed as a cash crop and commodity which can create new lines of global business and serve as a novel ingredient in the emerging supply chain of micro-scale renewable energy manufacturing futures. Any country with sufficient sunlight can manufacture glucose. Glucose can be used in the ABSENCE OF SUNLIGHT by other micro-organisms which can use glucose as the primary energy source (and carbon dioxide from air) to produce butanol in an appliance which may function indoors. Hence, butanol can be produced WITHOUT DEPLETING FOOD sources and is agnostic of sunlight (insolation independent). The anastomosis of sunlight-dependent glucose production (as a new commodity in the energy supply chain) with sunlight-agnostic production of butanol may usher microscale energy manufacturing platform as a tool for global economic development and job growth. http://dspace.mit.edu/handle/1721.1/59804

This is a hypothetical proposal by the author (Shoumen Palit Austin Datta). It draws on published research from multiple sources including MIT and UC Berkeley.

Temporary Questions ?

Is it feasible to partially reduce green house gas (GHG) emissions by manufacturing vegetation-independent non-fossil carbon-neutral C4-C5 renewable liquid fuel from cyano-bacteria (micro-algae) using sunlight and carbon dioxide?

The risk in this manufacturing process is scalability of production volume to make a sufficient contribution as fuel source for global use. The risk may also be a reward. If cost or technology for scalability is unsuitable then production volume may remain low. The low volume product may be suitable and affordable for domestic use or small businesses. If each home or small business owned its independent energy manufacturing appliance (liquid fuel generator), it may reduce demand for grid distributed power. 80% of the global population benefits from low volume even if the affluent nations find it limiting.

Fuel (four-Carbon C4, five-Carbon C5) produced in high insolation (plenty of sun shine) zones will be useful locally but transportation is costly. Hence, the emergence of glucose (six-Carbon C6) as a driver of the future liquid energy supply chain. High insolation zones in developing nations can produce C6 and sell the product to industrialized nations in low insolation zones (less sun shine). Glucose may be converted by a variety of microbial or other methods to C4,C5 fuels without sunlight or the need to source vegetation or waste. Inventory of glucose may provide nations with energy security and partially reduce the uncertainty from energy prices which triggers volatility in economic development and socio-economic stability.

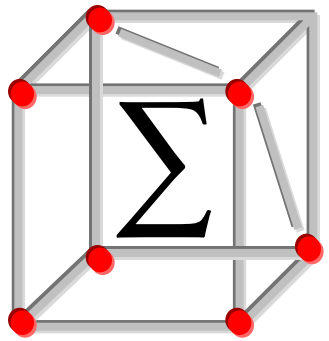
Production of C6 from embedded photosynthetic enzymatic components immobilized on chips is a possible extension of the convergence of bio and nano-technology for renewable energy. In a manner similar to present-day solar panels, 22nd Century may expect “nano-chloroplast” panels for manufacturing glucose-on-a-chip or C4/C5 chips. The latter may harness solar energy in chemical bonds. It may be used on-demand rather than directly generating electricity from photo-voltaic cells where energy may rapidly perish, if unused (unless storage technology significantly improves the life of energy in batteries). In the interim, glucose from microbes may become an important energy commodity and lift many nations out of poverty.

Distributed Energy Production

Energy Manufacturing as a Cottage Industry ??

Hypothetical Proposal by Shoumen Palit Austin Datta, 2009-2010 ◆ http://dspace.mit.edu/handle/1721.1/59804

Nobel Prize winner (chemistry) Robert F. Curl vehemently **disagreed** with this hypothetical proposal by the author (Shoumen Palit Austin Datta).



MICRO-SCALE

ENERGY MANUFACTURING

Photo Bio C4(C5) Reactor

Nobel Prize winner (chemistry) Robert F. Curl vehemently disagreed with this hypothetical proposal by the author (Shoumen Palit Austin Datta).

C4 PRODUCT DEVELOPMENT

SOLAR DEPENDENT PHOTO BIO C4 REACTOR

INSIDE BIO-REACTOR

ROTARY SHAKER

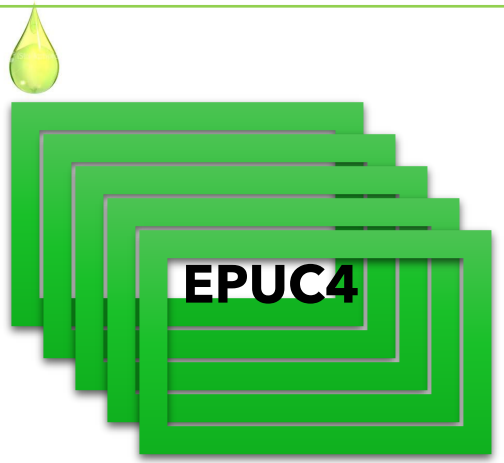
AERATION FOR GROWTH

INPUT
MICRO-ORGANISMS
+ MINIMAL MEDIA

EXPOSE TO
SUNLIGHT

**OUTDOOR
APPLIANCE**

Microbes use sunlight for photo-catalytic conversion of nutrients to glucose (or other saccharides) and then convert the glucose (C6) to butanol (C4) liquid fuel. If we add glucose as the primary nutrient then the process is agnostic of sunlight.

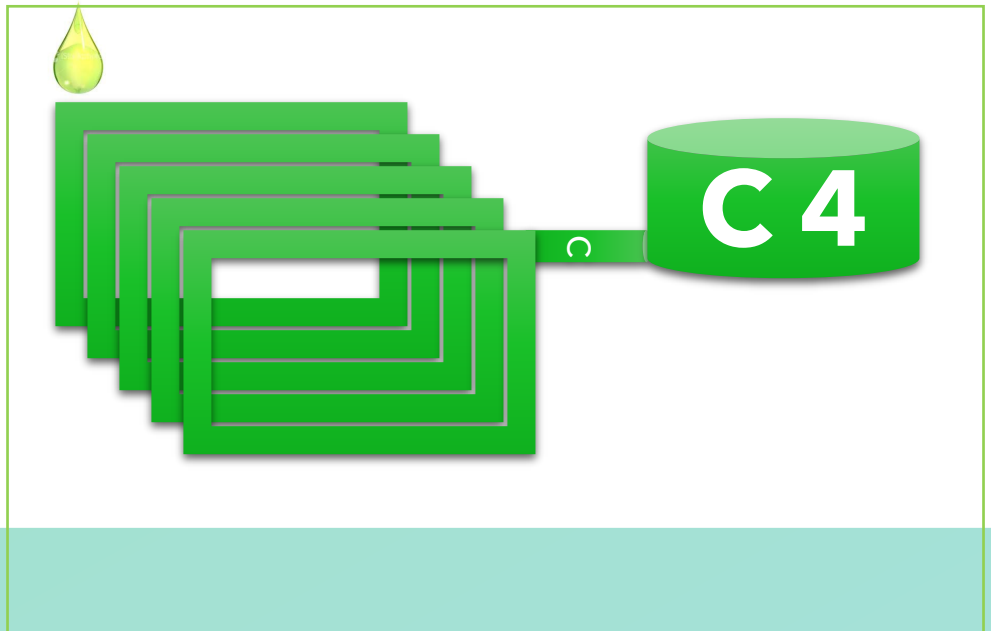


OUTPUT

DILUTE BUTANOL ?
PURIFIED BUTANOL ?
BUTANOL MIXTURE ?

EPUC4 - C4
EXTRACTION
PURIFICATION UNIT

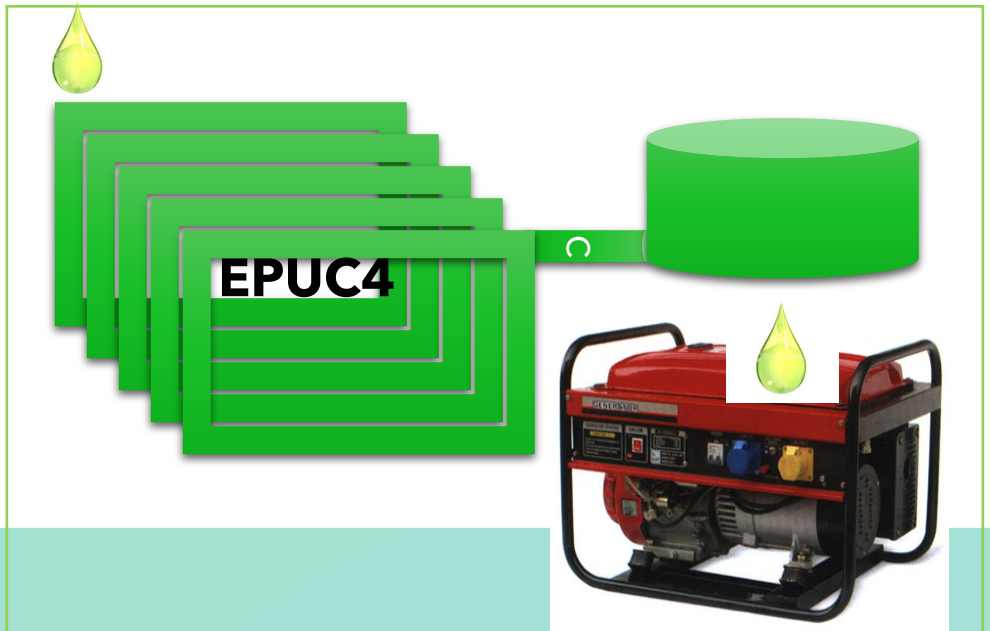
This is a stumbling block. Purifying C4 Butanol from this mix needs innovation.



FUEL ? GRADE C4

BUTANOL

How "fuel grade" is required?
Think kerosene: not quite pure!
Can we still use low grade C4?



C4 - BUTANOL

low efficiency conversion

➔ ELECTRICITY

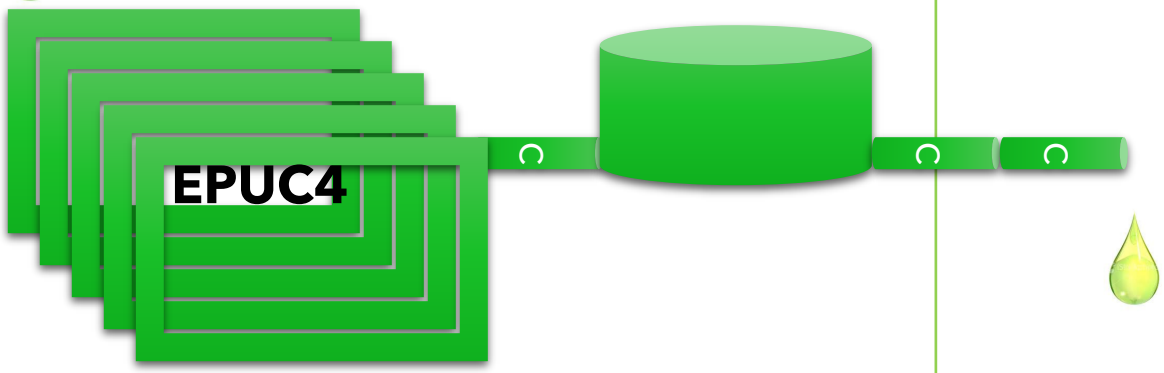
using commercial

GENERATOR

BUTANOL

DIRECT USE AS COMBUSTION FUEL

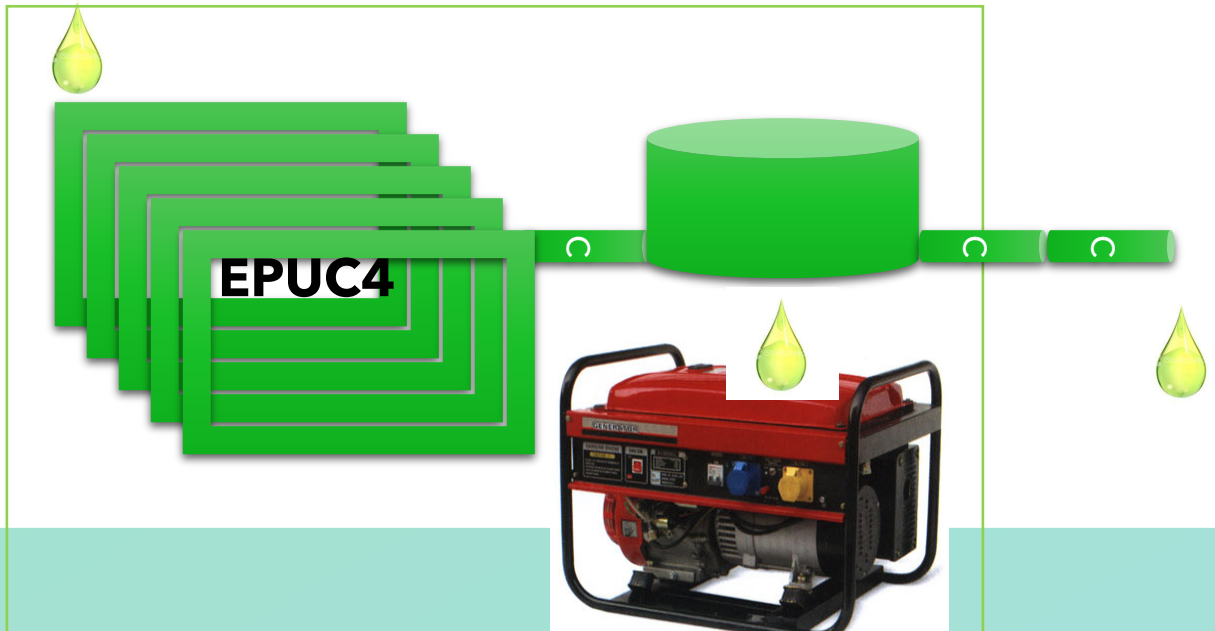
TRANSPORTATION



BUTANOL
ELECTRICITY

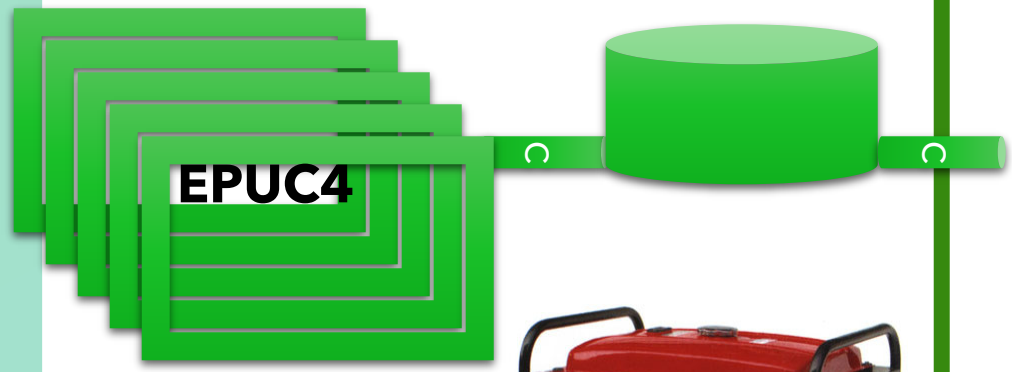
for

DOMESTIC USE
ELECTRIC VEHICLES
SELL BACK TO GRID



SOLAR DEPENDENT
PHOTO BIO C4
BUTANOL REACTOR

OUTDOOR APPLIANCE



INDOOR GARAGE UNIT

FOR
ELECTRICITY
GENERATION

SOLAR DEPENDENT

PHOTO BIO C4

BUTANOL REACTOR

TWO-COMPONENT ELECTRICITY GENERATION

BUTANOL
PENTANOL
for ELECTRICITY

DOMESTIC USE
ELECTRIC VEHICLES
SELL BACK TO GRID

EPUC4

While we wait for scientists to chemically synthesize glucose from carbon dioxide and water …

Very important fork in the road …

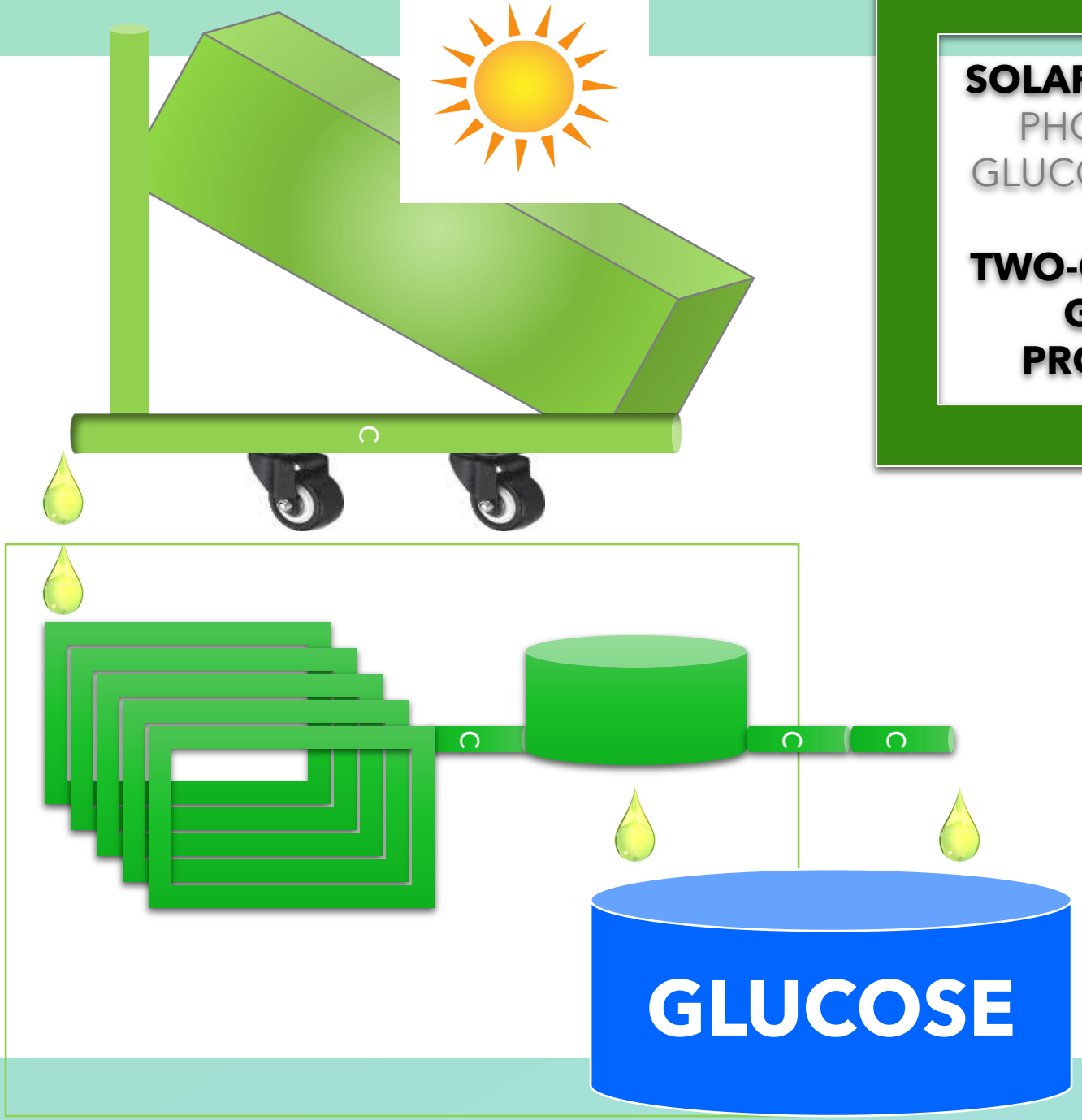
Instead of photo-bio C4/C5, can we use this two-component system to create microbial **GLUCOSE?**
What if the microbial growth solution was partially dehydrated to form glucose paste (think molasses)?

SOLAR DEPENDENT

PHOTO BIO C6

GLUCOSE REACTOR

TWO-COMPONENT GLUCOSE PRODUCTION



Why create glucose paste ?

Glucose paste can be transported easily as a “feed” or nutrient. Microbes can use glucose directly to synthesize butanol (C4) or pentanol (C5) **WITHOUT SUNLIGHT** for insolation-independent (**indoor**) bio-C4/C5 production (anywhere). The Sahara Desert, The Thar Desert, The Gobi Desert, The Atacama Desert and other high insolation arid regions can be the **GLUCOSE FACTORIES** of the world to spur energy manufacturing in any garage, in any **cottage**.

Photo-Bio Glucose [C6] Production

New Line of Global Manufacturing Business.

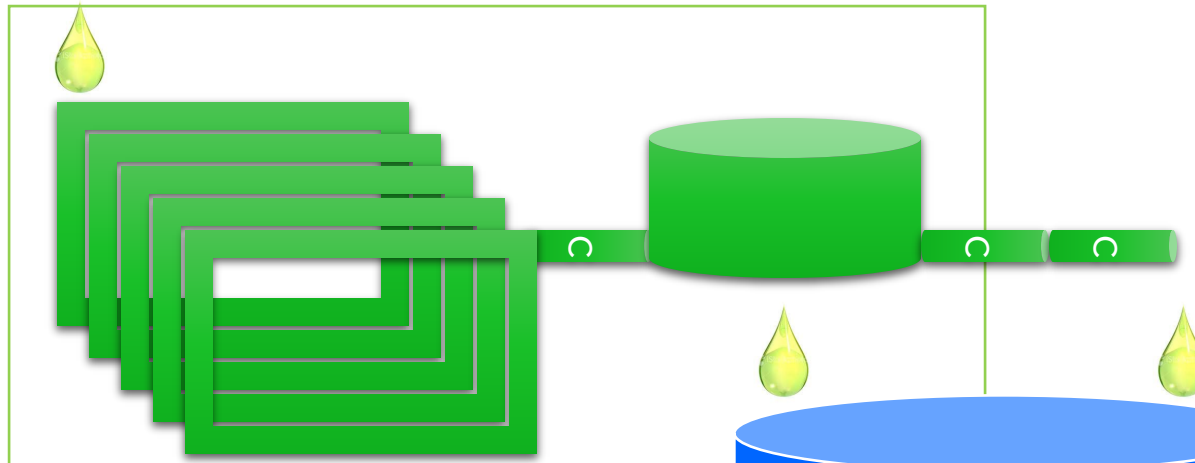
New Business. New Jobs. New Economic Growth.

New Commodity in the Renewable Energy Supply Chain.

Photo-Bio Glucose [C6] Production

SOLAR DEPENDENT
PHOTO BIO C6
GLUCOSE REACTOR

TWO-COMPONENT GLUCOSE PRODUCTION



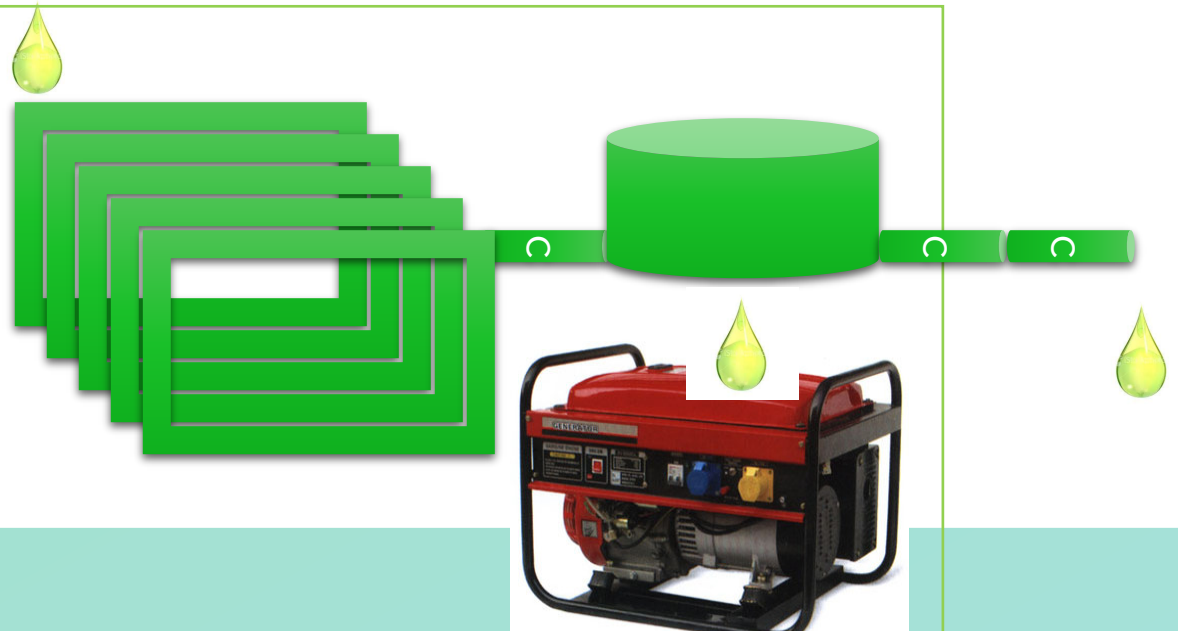
Glucose containing slurry dehydrated to glucose paste

Transport anywhere in the world

GLUCOSE
and microbes

INPUT

C6



SUNLIGHT AGNOSTIC

BUTANOL
PENTANOL
ELECTRICITY for
DOMESTIC USE
ELECTRIC VEHICLES
SELL BACK TO GRID

Insolation Independent (Sunlight-Free) Butanol Pentanol Production Anywhere!

Insolation-Independent (Sunlight Agnostic) Photo-Bio C6-Dependent C4/C5 Bio-Reactor Electricity

Easy to propose, in principle, in a cartoon.

Very difficult to accomplish as a global practice.

Will change the global economy, if accomplished.

Insolation-Independent (Sunlight Agnostic) Photo-Bio C6-Dependent C4/C5 Bio-Reactor Electricity

"With willing hearts and skillful hands, the difficult we do at once; the impossible takes a bit longer."

"The impossible we do at once; the miraculous takes a little longer."

Attribution of quotes - https://www.bartleby.com/73/1183.html

Distributed Energy Production

Energy Manufacturing as a Cottage Industry ??

Hypothetical Proposal by Shoumen Palit Austin Datta, 2009-2010 ◆ http://dspace.mit.edu/handle/1721.1/59804

Nobel Prize winner (chemistry) Robert F. Curl vehemently **disagreed** with this hypothetical proposal by the author (Shoumen Palit Austin Datta).

Comment by Nobel Prize winner Robert F Curl with respect to the hypothetical proposal by Shoumen Datta (distributed energy production involving potential manufacturing of liquid fuel as energy cottage industry).

"I cannot believe that it may ever make economic sense for an individual/home to make the capital expenditure for their own electric generation unless they can't connect to the grid. I do not believe in the assumptions about the future that your (energy) paper is based upon."

– *Robert F Curl (10th November 2010)*

Robert F Curl co-discovered the field of nanotechnology & was awarded the Nobel Prize in Chemistry,1996

https://www.nobelprize.org/prizes/chemistry/1996/curl/facts/

"I have traveled the length and breadth of this country and talked with the best people, and I can assure you that data processing is a fad that won't last out the year." -- *The editor in charge of business books for Prentice Hall, 1957.*

"There is no reason anyone would want a computer in their home." -- *Ken Olson, president, chairman and founder of Digital Equipment Corp., 1977.*

"This 'telephone' has too many shortcomings to be considered as a means of communication. Device is inherently of no value." - *Western Union 1876*
.
"The Americans have need of the telephone, but we do not. We have plenty of messenger boys." -- *Sir William Preece, chief engineer, British Post, 1876.*

"Radio has no future." -- *William Thomson, Lord Kelvin, British scientist, 1899.*

"The wireless music box has no imaginable commercial value. Who would pay for a message sent to nobody in particular?" –
David Sarnoff's associates in response to his urgings for investment in the radio in the 1920s.

"The concept is interesting and well-formed, but in order to earn better than a 'C', the idea must be feasible." -- *A Yale University management professor in response to Fred Smith's paper proposing reliable overnight delivery service. (Smith went on to found Federal Express Corp, aka FedEx)*

"Who the hell wants to hear actors talk?" -- *H. M. Warner, Warner Brothers, 1927.*

"We don't like their sound, and guitar music is on the way out." -- *Decca Recording Co. rejecting the Beatles, 1962.*

"Stocks have reached what looks like a permanently high plateau." -- *Irving Fisher, Professor of Economics, Yale University, 1929.*

"There is not a slightest indication that nuclear energy will be obtainable. It would mean the atom would have to be shattered at will." - *Einstein, 1932.*

KEEP CALM
AND
CARRY ON

Bob (Robert F Curl) is correct per ***conventional wisdom*** as relates to economics of technology.

Bob is drawing on the rationale of economics of technology ◆ The foundation of this thinking is here - http://bit.ly/Economics-of-Technology

Can science, engineering and technology change economics?

YES

https://www.technologyreview.com/2019/12/27/131259/the-productive-career-of-robert-solow/

Robert Merton Solow
MIT

Nobel Prize in Economics, 1987

demonstrated that technology could alter the rate of economic growth.

https://www.nobelprize.org/prizes/economic-sciences/1987/solow/facts/

Left - Bob Solow
Right – SD
MIT, 2009

Left - Bob (Robert F Curl) with Rebecca Jane Austin, my wife. In our home, 2013.

Bob Curl vs Bob Solow

Who is correct?

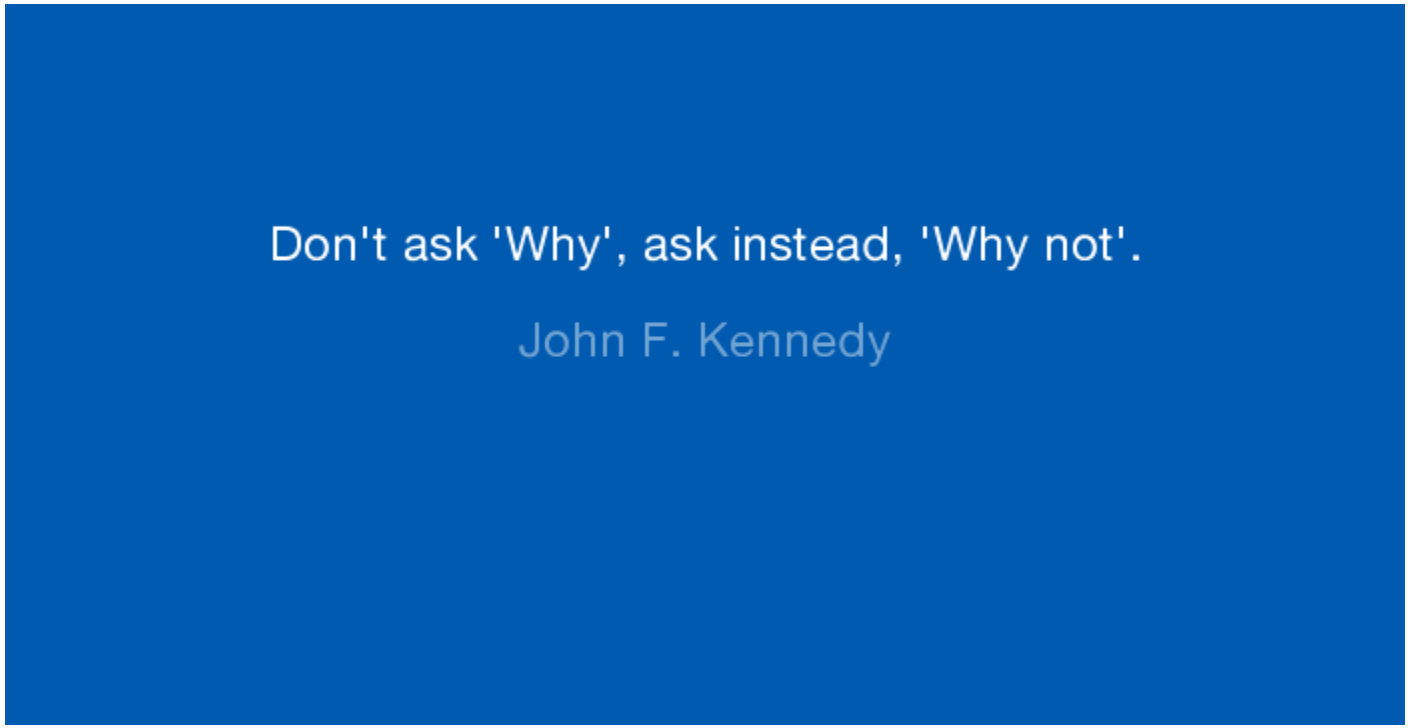
Bob Curl vs Bob Solow

Who is correct?

I think both. It doesn't matter. What matters most is that in science it is imperative that we respect disagreements, especially if the person is a giant intellectual or is eminently qualified to comment on the matter. Debate and disagreement must be invited to maintain scientific clarity of thought and actions. Even though Bob Curl is a friend (and Bob Solow), he had no problem in providing his unvarnished remark in 2010. Even though we disagreed, Bob Curl visited us at our home in 2013 because he wanted me to cook him dinner. In 1995, while making a strenuous professional decision, I called Bob (Solow) and asked him for guidance. What he (Bob Solow) said to me and his wisdom, changed the trajectory of my life's path.

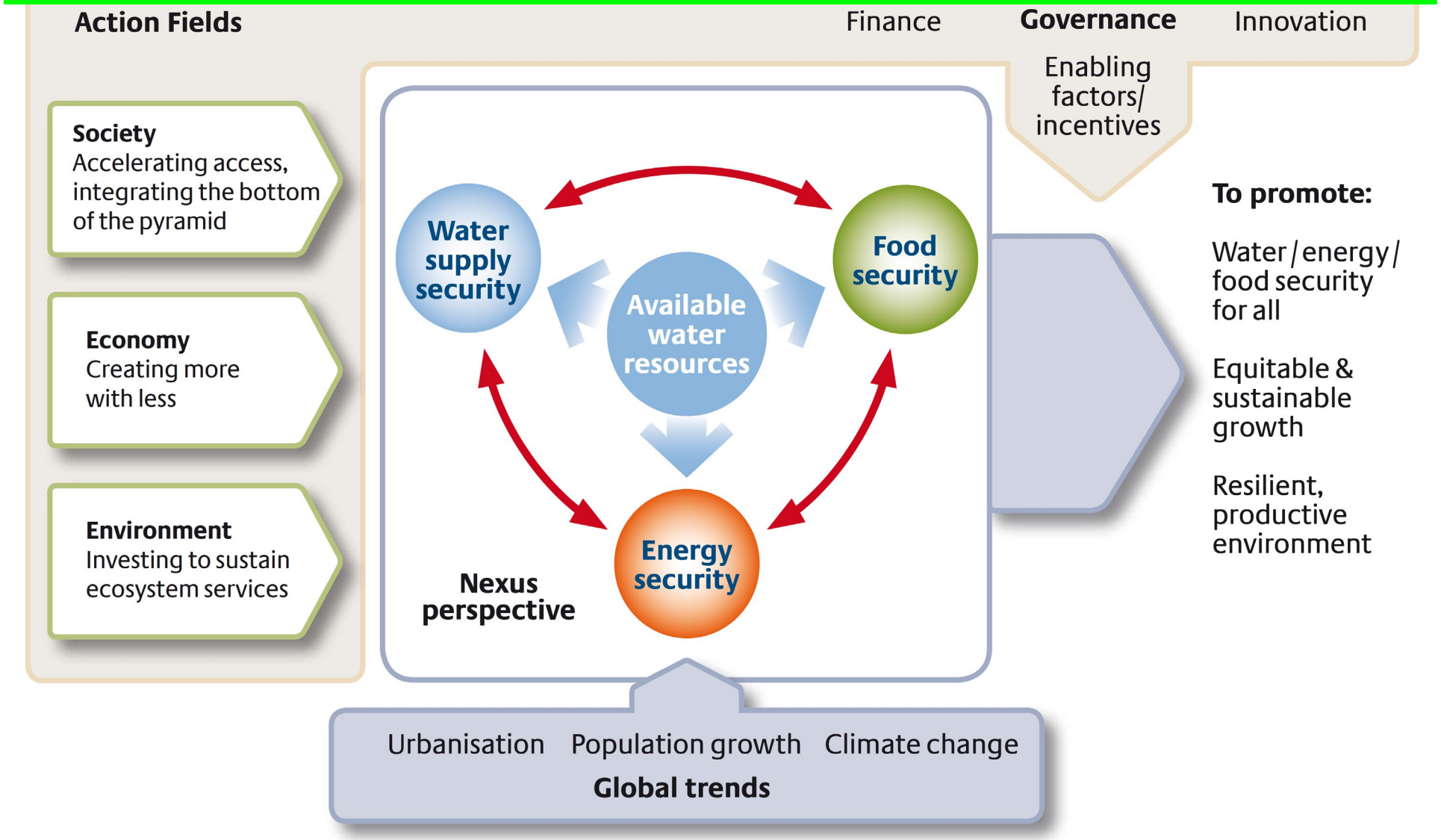
Distributed Energy Production

Energy Manufacturing as a Cottage Industry ??



Why energy is the “glue” in any economy

Food-Energy-Water Nexus



Hoff, H.(2011) Understanding the Nexus. Bonn 2011 Conference: Water, Energy and Food Security Nexus. Stockholm Environment Institute, Sweden.
holger.hoff@sei-international.org ◆ http://wef-conference.gwsp.org/fileadmin/documents_news/understanding_the_nexus.pdf

Lot more for energy innovation …

Distributed Energy Production

Distributed Energy Production

We may be on the brink of a new paradigm for nuclear power, a group of nuclear specialists suggested in The Bridge (June, 2021) the journal of the US National Academy of Engineering. Much as large, expensive, and centralized computers gave way to distributed PCs of today, a new generation of relatively tiny and inexpensive factory-built reactors, designed for autonomous plug-and-play operation, similar to plugging in an oversized battery, is on the horizon.

www.nae.edu/255810/A-Strategy-to-Unlock-the-Potential-of-Nuclear-Energy-for-a-New-and-Resilient-Global-EnergyIndustrial-Paradigm

My op-ed prediction on this topic in 2007-2008 https://dspace.mit.edu/handle/1721.1/41897
"WiFi Meet FuFi: Disruptive Innovation in Logistics Catalysed by Energy" by S. Datta, MIT

3Q: Why "nuclear batteries" offer a new approach to carbon-free energy

Jacopo Buongiorno and others say factory-built microreactors trucked to usage sites could be a safe, efficient option for decarbonizing electricity systems.

David L. Chandler | MIT News Office
June 25, 2021

This cut-away rendering of the MIT nuclear battery concept shows important components such as the instrumentation and control module, the reactor, and the power module.

Courtesy of the researchers

news.mit.edu/2021/course-create-fusion-power-plant-0429

Massachusetts Institute of Technology

Education Research Innovation

MIT News

ON CAMPUS AND AROUND THE WORLD

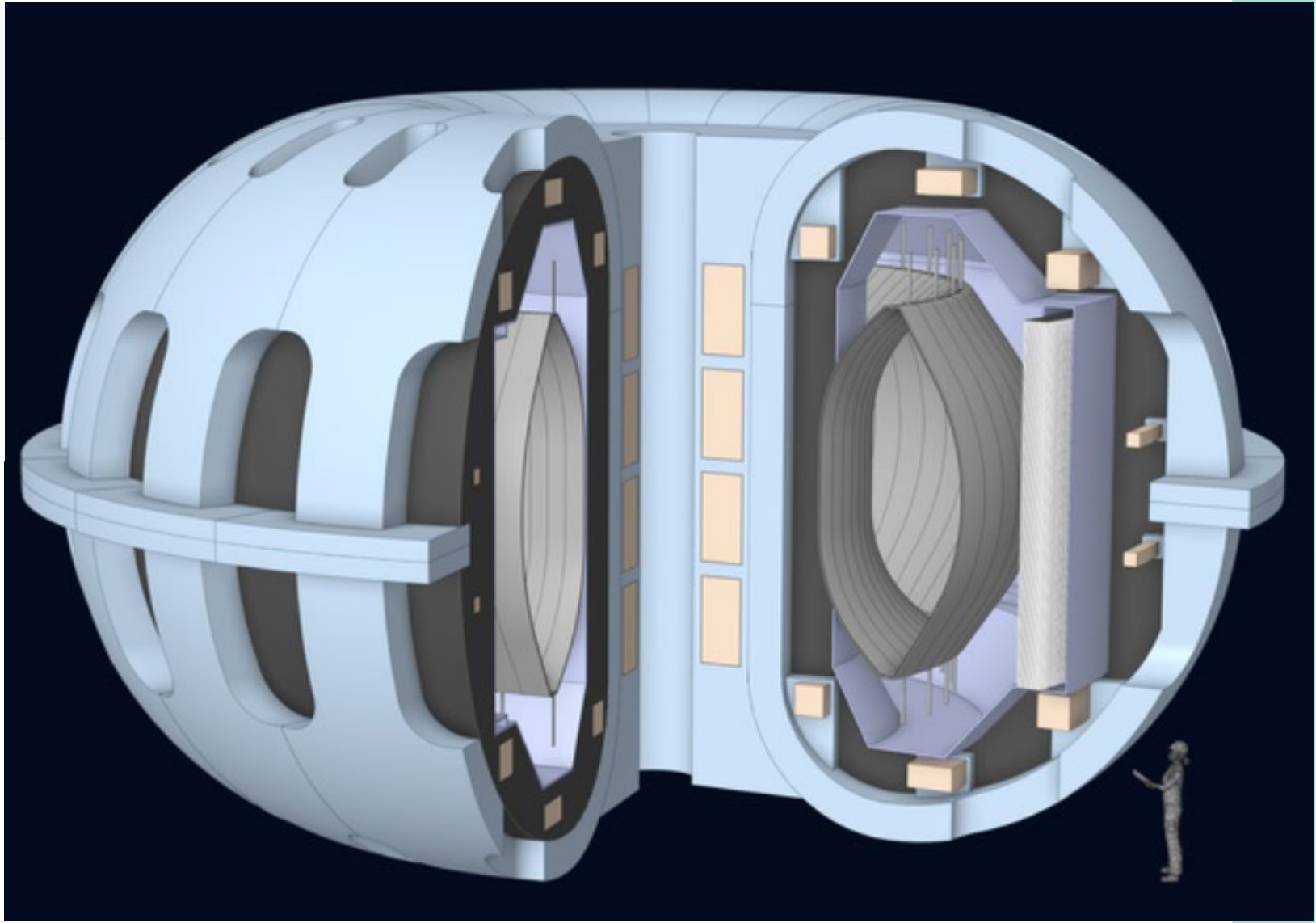
On course to create a fusion power plant

How an MIT engineering course became an incubator for fusion design innovations.

Paul Rivenberg | Plasma Science and Fusion Center

April 29, 2021

ARCH is a design for an onboard fusion device capable of generating ammonia fuel for ship engines.



Distributed Energy Production appears easy in a cartoon

Commercial scale fusion reactor for power grids

Ambient temperature superconductor to reduce waste

High density material films for batteries to store remote energy

On course to create a fusion power plant

How an MIT engineering course became an incubator for fusion design innovations.

Paul Rivenberg | Plasma Science and Fusion Center

April 29, 2021

FUSION POWER –

THE HOLY GRAIL

Large-bore, full-scale high-temperature superconducting magnet designed and built by CFS (Commonwealth Fusion Systems) and MIT's Plasma Science and Fusion Center (PSFC) demonstrated a record-breaking 20 tesla magnetic field.

https://news.mit.edu/2021/MIT-CFS-major-advance-toward-fusion-energy-0908

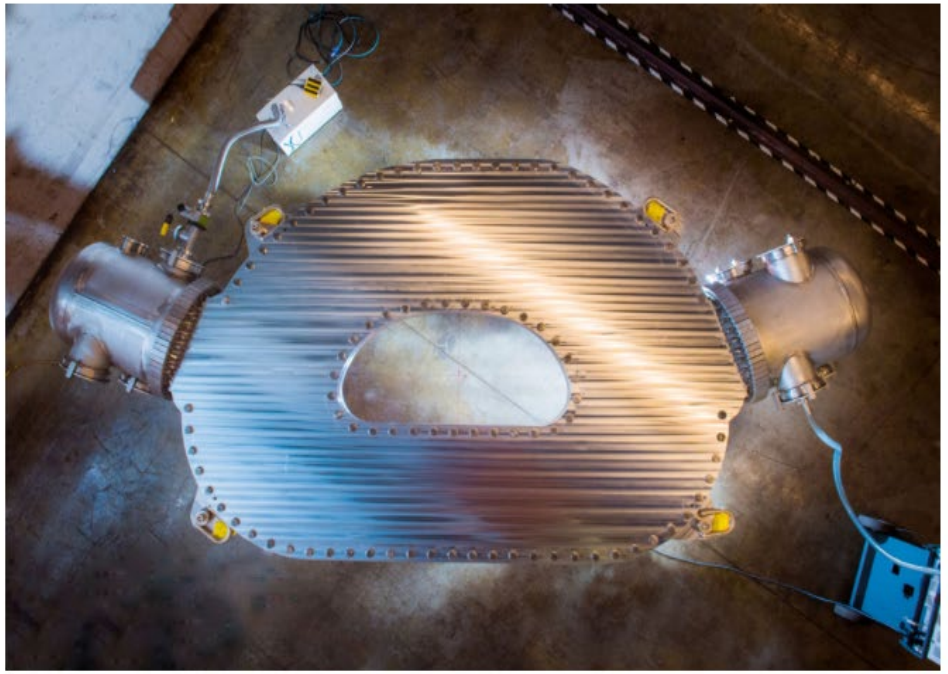
news.mit.edu/2021/MIT-CFS-major-advance-toward-fusion-energy-0908

MIT-designed project achieves major advance toward fusion energy

New superconducting magnet breaks magnetic field strength records, paving the way for practical, commercial, carbon-free power.

Watch Video

David Chandler | MIT News Office
September 8, 2021



It was a moment three years in the making, based on intensive research and design work: On Sept. 5, for the first time, a large high-temperature superconducting electromagnet was ramped up to a field strength of 20 tesla, the most powerful magnetic field of its kind ever created on Earth. That successful demonstration helps resolve the greatest uncertainty in the quest to build the world's first fusion power plant that can produce more power than it consumes, according to the project's leaders at MIT and startup company Commonwealth Fusion Systems (CFS).

Discussion: Snippets of Examples

Number 3

https://www.youtube.com/watch?v=ZbZSe6N_BXs

W	Water

Your contribution to society matters.

Science and Scientists for Society

About 0.5% of the earth's water is available fresh water

usbr.gov/mp/arwec/water-facts-ww-water-sup.html

Oceans	97.2%
Ice Caps/Glaciers	2.0%
Groundwater*	0.62%
Freshwater Lakes	0.009%
Inland seas/salt lakes	0.008%
Atmosphere	0.001%
Rivers	0.0001%
TOTAL	99.8381%

https://www.usbr.gov/mp/arwec/water-facts-ww-water-sup.html

Simplest things we don't know

DE NOVO (Latin for "new") synthesis of water (dihydrogen monoxide) in amounts feasible for mass consumption is beyond the current capabilities of science and scientists. However, we can create a few water molecules but only on a laboratory bench.

Homogeneous Catalytic Reduction of Dioxygen Using Transfer Hydrogenation Catalysts
Zachariah M. Heiden and Thomas B. Rauchfuss *J. Am. Chem. Soc.* 2007, 129, 46, 14303–14310
https://doi.org/10.1021/ja073774p and https://phys.org/news/2007-10-scientists.html

About 0.5% of the earth's water is available fresh water

usbr.gov/mp/arwec/water-facts-ww-water-sup.html

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Groundwater*	0.62%
Freshwater Lakes	0.009%
Inland seas/salt lakes	0.008%
Atmosphere	0.001%
Rivers	0.0001%
TOTAL	99.8381%

We have 326 million cubic miles of water on the planet but 320 million cubic miles of water is **unusable** salt water in oceans (usable for cooling).

Solution: Remove Salt

Commercial Desalination

https://www.usbr.gov/mp/arwec/water-facts-ww-water-sup.html

Tests on an MIT building rooftop showed that a simple proof-of-concept desalination device could produce clean, drinkable water at a rate of about 1.5 gallons (5.6 liters) per hour for each square meter of solar collecting area.

http://meche.mit.edu/people/faculty/enwang@mit.edu

news.mit.edu/2020/passive-solar-powered-water-desalination-0207

Massachusetts Institute of Technology

Education Research Innovation Admissions + Aid

MIT News
ON CAMPUS AND AROUND THE WORLD

Simple, solar-powered water desalination

System achieves new level of efficiency in harnessing sunlight to make fresh potable water from seawater.

David L. Chandler | MIT News Office
February 6, 2020

A completely passive solar-powered desalination system developed by researchers at MIT and in China could provide more than 1.5 gallons of fresh drinking water per hour for every square meter of solar collecting area. Such systems could potentially serve off-grid arid coastal areas

news.mit.edu/2020/passive-solar-powered-water-desalination-0207

Massachusetts Institute of Technology

Education Research Innovation Admissions + Aid

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Energy & Environmental Science

ROYAL SOCIETY OF CHEMISTRY

COMMUNICATION

View Article Online
View Journal | View Issue

Check for updates

Cite this: *Energy Environ. Sci.*, 2020, **13**, 830

Received 21st December 2019,
Accepted 15th January 2020

DOI: 10.1039/c9ee04122b

Ultrahigh-efficiency desalination *via* a thermally-localized multistage solar still†

Zhenyuan Xu, ‡[ab] Lenan Zhang, ‡[b] Lin Zhao, ‡[b] Bangjun Li,‡[a] Bikram Bhatia,[b] Chenxi Wang,[a] Kyle L. Wilke,[b] Youngsup Song,[b] Omar Labban,[b] John H. Lienhard,[b] Ruzhu Wang *[a] and Evelyn N. Wang *[b]

https://pubs.rsc.org/en/content/articlepdf/2020/ee/c9ee04122b

The critical and most expensive barrier for commercial desalination is

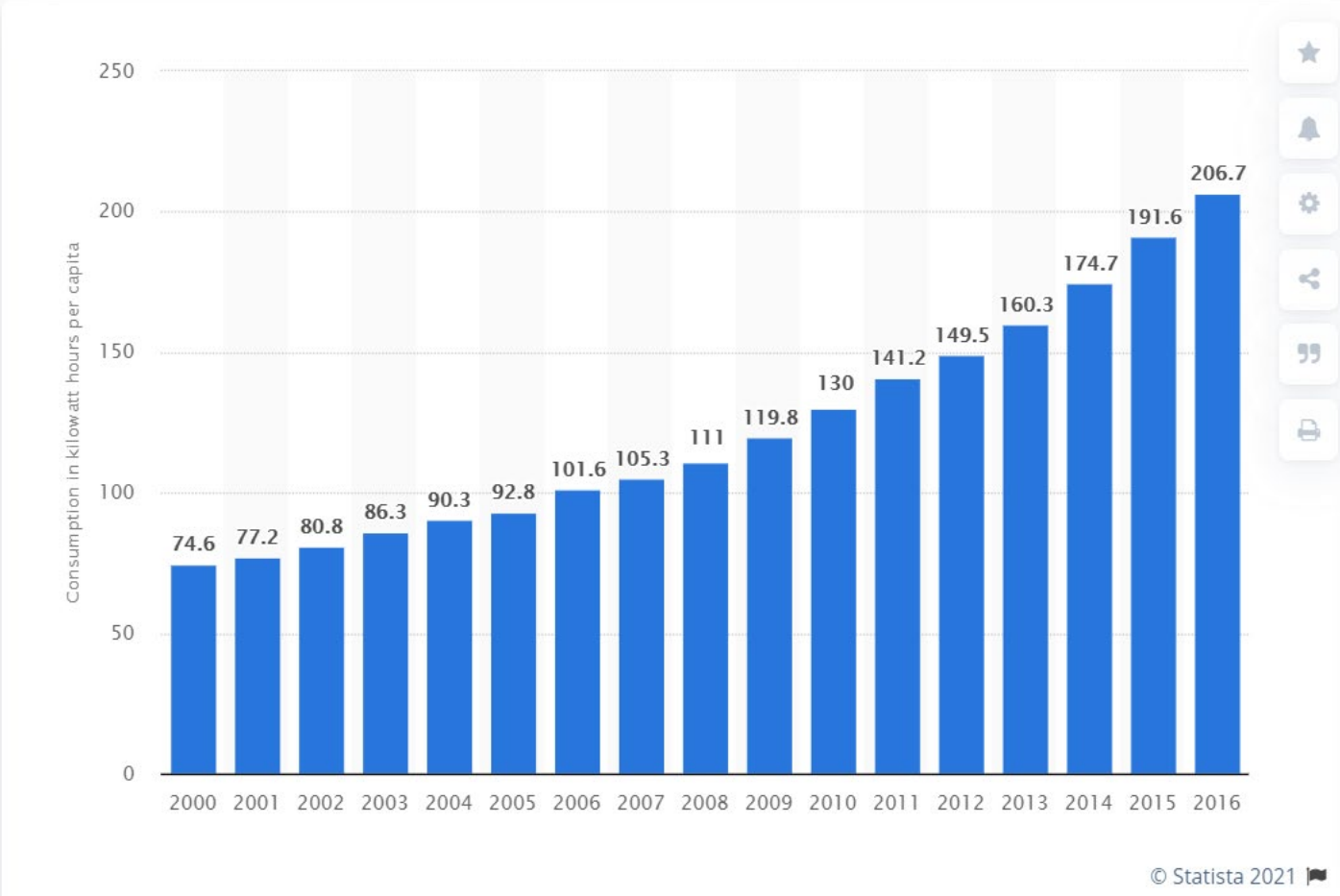
ENERGY

statista.com/statistics/597796/household-consumption-of-electricity-per-capita-in-india/

Energy & Environment › Energy

Household electricity consumption per capita in India

(in kilowatt hours)



https://timesofindia.indiatimes.com/city/bengaluru/10-of-bengalureans-use-twice-the-water-they-need/articleshow/62142987.cms

Processes **2021**, *9*(2), 262; https://doi.org/10.3390/pr9020262 ◆ https://www.mdpi.com/2227-9717/9/2/262/pdf

206.7 kWh

Average per capita electricity used in India

Table 1. Energy requirements for different water sources.

Water Source	Energy (kWh/m^3)
Seawater	2.58–8.5
Wastewater reuse	1.0–2.5
Wastewater treatment	0.62–0.87
Groundwater	0.48

Table 2. Typical total electrical energy consumptions in different desalination technologies.

Desalination Technology	Specific Energy Requirements
Multi-Effect Distillation	14–21 kWh/m^3
Multi-Stage Flash	20–27 kWh/m^3
Mechanical Vapor Compression	7–12 kWh/m^3
Thermal Vapor Compression	16.26 kWh/m^3
Seawater Reverse Osmosis	4–6 kWh/m^3

Commercial Thermal Technologies for Desalination of Water from Renewable Energies: State of the Art Review

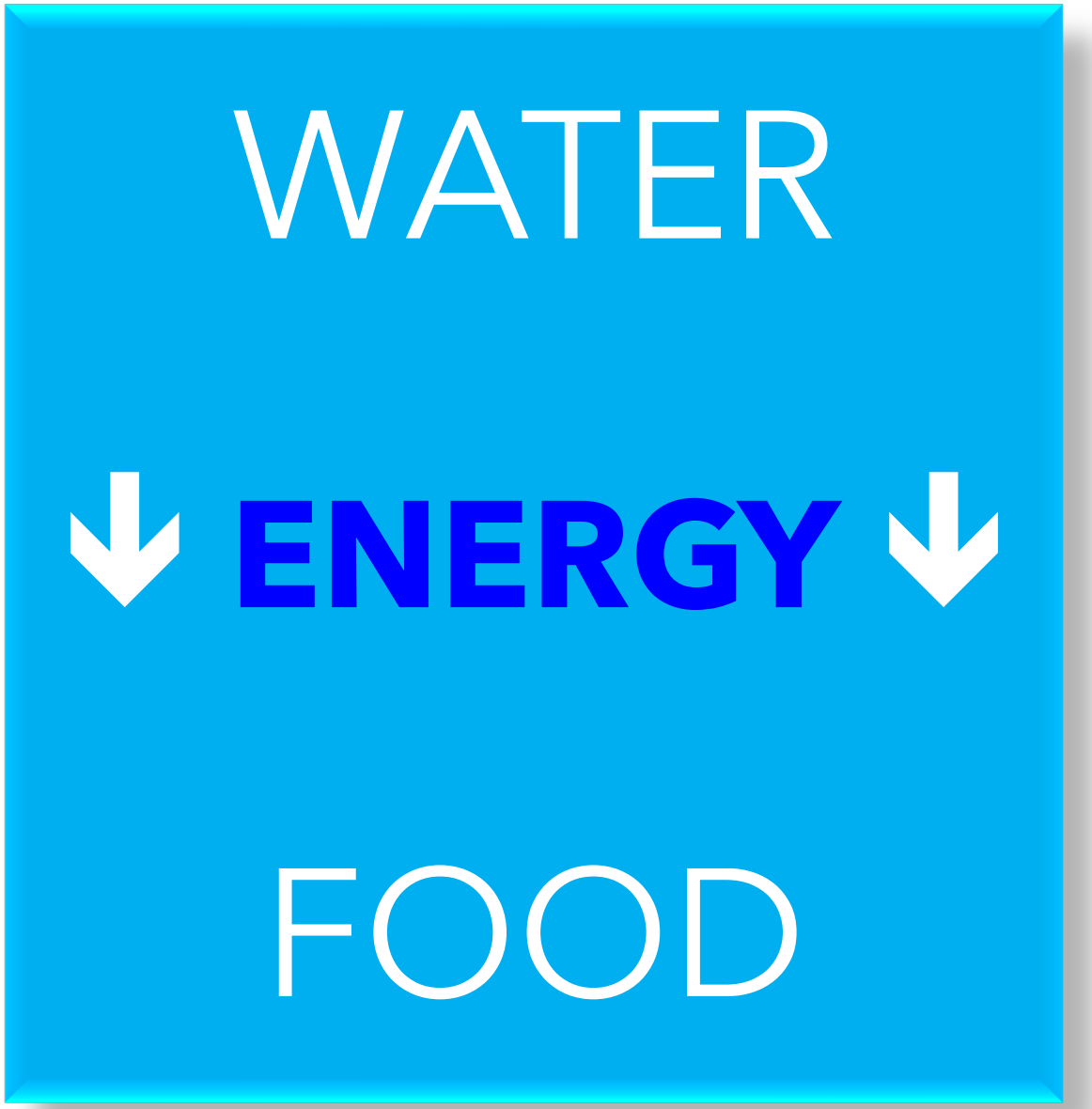
by Jhon Jairo Feria-Díaz [1,2,*], María Cristina López-Méndez [1], Juan Pablo Rodríguez-Miranda [3], Luis Carlos Sandoval-Herazo [1] and Felipe Correa-Mahecha [4]

0.135 m^3

Average household water used in India

https://www.usbr.gov/mp/arwec/water-facts-ww-water-sup.html

About 0.5% of the earth's water is available fresh water



How Much Water Does it Take to Produce Your Food?

Food	Portion	Gallons of Water
Orange Juice	1 cup	49
Orange	1 medium	14
Cantaloupe	1 melon	160
Broccoli	2 cups	11
Catsup	1 ounce	3
Corn	1 ear	80
Lettuce	1 cup	3
Tomato	1 small	8
Tomato Sauce	4 ounces	13
Butter	1 pat	46
Cheese	1 ounce	56
Milk	1 cup	48
Yogurt	1 cup	88
Beef Steak	8 ounces	1,232
Chicken	8 ounces	330
Egg	1 each	50
Hamburger	4 ounces	616
Tofu	2 cups	61
Almonds	1 ounce	80
Sugar	1 Tablespoon	7
White Rice	2 cups	25
Brown Rice	2 cups	16
Wheat Bread	1 slice	7
White Bread	1 slice	11
Pasta	2 ounces	36

Will the world run dry without the science/engineering of desalination?

Can bio-mimicry help desalination?

Water channel proteins used by cells/organisms to regulate salt.

The best way to do almost anything is to look for something similar in our natural environment

Desalination naturally?

Yes! Water channel proteins: Aquaporin.

Molecular Cloning, Overexpression and Characterization of a Novel Water Channel Protein from *Rhodobacter sphaeroides*

Mustafa Erbakan[1], Yue-xiao Shen[2], Mariusz Grzelakowski[3], Peter J. Butler[1], Manish Kumar[2]*, Wayne R. Curtis[1,2]*

1 Department of Biomedical Engineering, Pennsylvania State University, University Park, Pennsylvania, United States of America, **2** Department of Chemical Engineering, Pennsylvania State University, University Park, Pennsylvania, United States of America, **3** AquaZ Inc, Cincinnati, Ohio, United States of America

Abstract

Aquaporins are highly selective water channel proteins integrated into plasma membranes of single cell organisms; plant roots and stromae; eye lenses, renal and red blood cells in vertebrates. To date, only a few microbial aquaporins have been characterized and their physiological importance is not well understood. Here we report on the cloning, expression and characterization of a novel aquaporin, RsAqpZ, from a purple photosynthetic bacterium, *Rhodobacter sphaeroides ATCC 17023*. The protein was expressed homologously at a high yield (~20 mg/L culture) under anaerobic photoheterotrophic growth conditions. Stopped-flow light scattering experiments demonstrated its high water permeability (0.17±0.05 cm/s) and low energy of activation for water transport (2.93±0.60 kcal/mol) in reconstituted proteoliposomes at a protein to lipid ratio (w/w) of 0.04. We developed a fluorescence correlation spectroscopy based technique and utilized a fluorescent protein fusion of RsAqpZ, to estimate the single channel water permeability of RsAqpZ as 1.24 (±0.41) x 10^{-12} cm^3/s or 4.17 (±1.38)×10^{10} H_2O molecules/s, which is among the highest single channel permeability reported for aquaporins. Towards application to water purification technologies, we also demonstrated functional incorporation of RsAqpZ in amphiphilic block copolymer membranes.

https://pubmed.ncbi.nlm.nih.gov/24497982/

Citation: Erbakan M, Shen Y-x, Grzelakowski M, Butler PJ, Kumar M, et al. (2014) Molecular Cloning, Overexpression and Characterization of a Novel Water Channel Protein from *Rhodobacter sphaeroides*. PLoS ONE 9(1): e86830. doi:10.1371/journal.pone.0086830

nature nanotechnology

ARTICLES

https://doi.org/10.1038/s41565-019-0586-8

Corrected: Author Correction

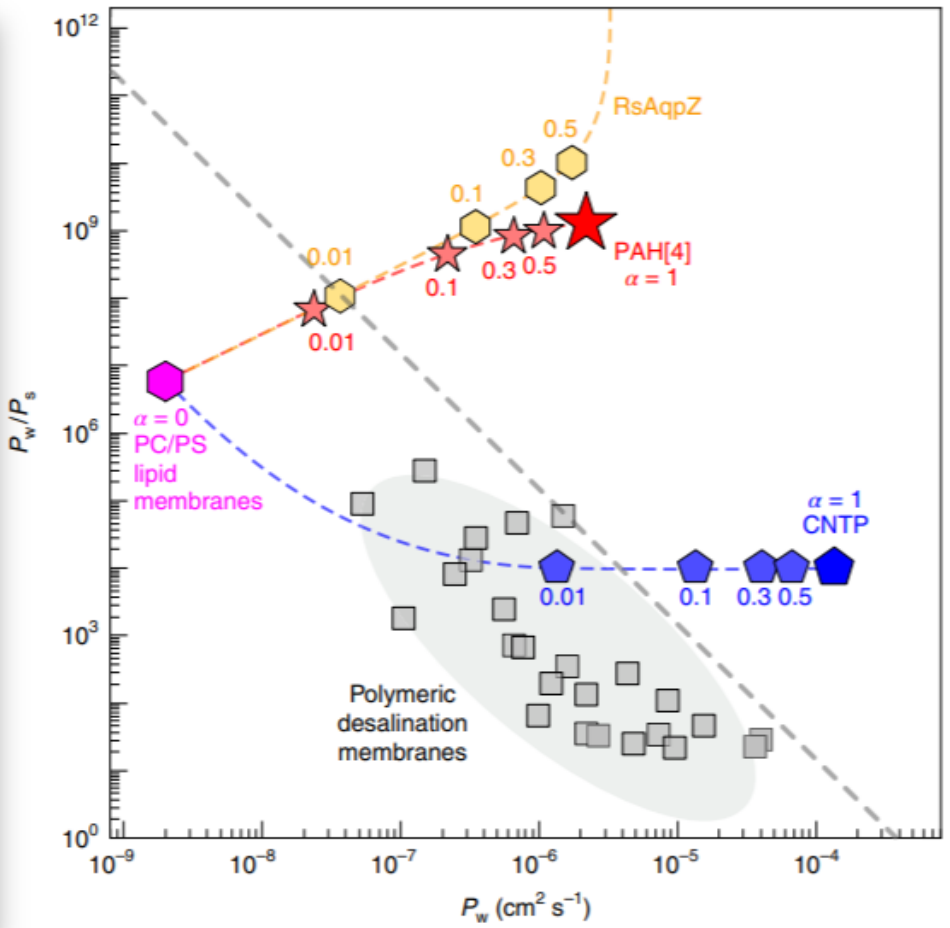
Artificial water channels enable fast and selective water permeation through water-wire networks

Woochul Song[1,10], Himanshu Joshi[2], Ratul Chowdhury[1], Joseph S. Najem[3,11], Yue-xiao Shen[4], Chao Lang[1], Codey B. Henderson[5], Yu-Ming Tu[1,10], Megan Farell[1], Megan E. Pitz[3], Costas D. Maranas[1], Paul S. Cremer[5], Robert J. Hickey[6], Stephen A. Sarles[3], Jun-li Hou[7], Aleksei Aksimentiev[2] and Manish Kumar[1,8,9,12*]

Artificial water channels are synthetic molecules that aim to mimic the structural and functional features of biological water channels (aquaporins). Here we report on a cluster-forming organic nanoarchitecture, peptide-appended hybrid[4]arene (PAH[4]), as a new class of artificial water channels. Fluorescence experiments and simulations demonstrated that PAH[4]s can form, through lateral diffusion, clusters in lipid membranes that provide synergistic membrane-spanning paths for a rapid and selective water permeation through water-wire networks. Quantitative transport studies revealed that PAH[4]s can transport >10^9 water molecules per second per molecule, which is comparable to aquaporin water channels. The performance of these channels exceeds the upper bound limit of current desalination membranes by a factor of ~10^4, as illustrated by the water/NaCl permeability–selectivity trade-off curve. PAH[4]'s unique properties of a high water/solute permselectivity via cooperative water-wire formation could usher in an alternative design paradigm for permeable membrane materials in separations, energy production and barrier applications.

Engineering, The University of Texas at Austin, Austin, TX, USA. *e-mail: manish.kumar@utexas.edu

WATER CHANNEL PROTEINS used for Water Desalination



Water-channel protein, Aquaporin Z, RsAqpZ, from the purple photosynthetic bacterium, *Rhodobacter sphaeroides* ATCC 17023.

Fig. 3 | Intrinsic water/NaCl selectivity (P_w/P_s) versus P_w of PAH[4]-, CNTP- and RsAqpZ-based biomimetic membranes.

Kumar *et al* (2020) reports that cluster-forming organic nanoarchitecture, peptide-appended hybrid[4]arene (PAH[4]) is a new class of artificial water channel (**RED STAR**) which is orders of magnitude superior for water desalination compared to carbon nanotube porins (CNTP, **blue**). For PAH[4] the ratio of water vs salt (y-axis) is one part of salt in a billion (10^9) part of desalinated water (CNTP ratio 1:10^4). That is an improvement of 5 orders of magnitude. While promising, it is still a very long way from commercial implementation.

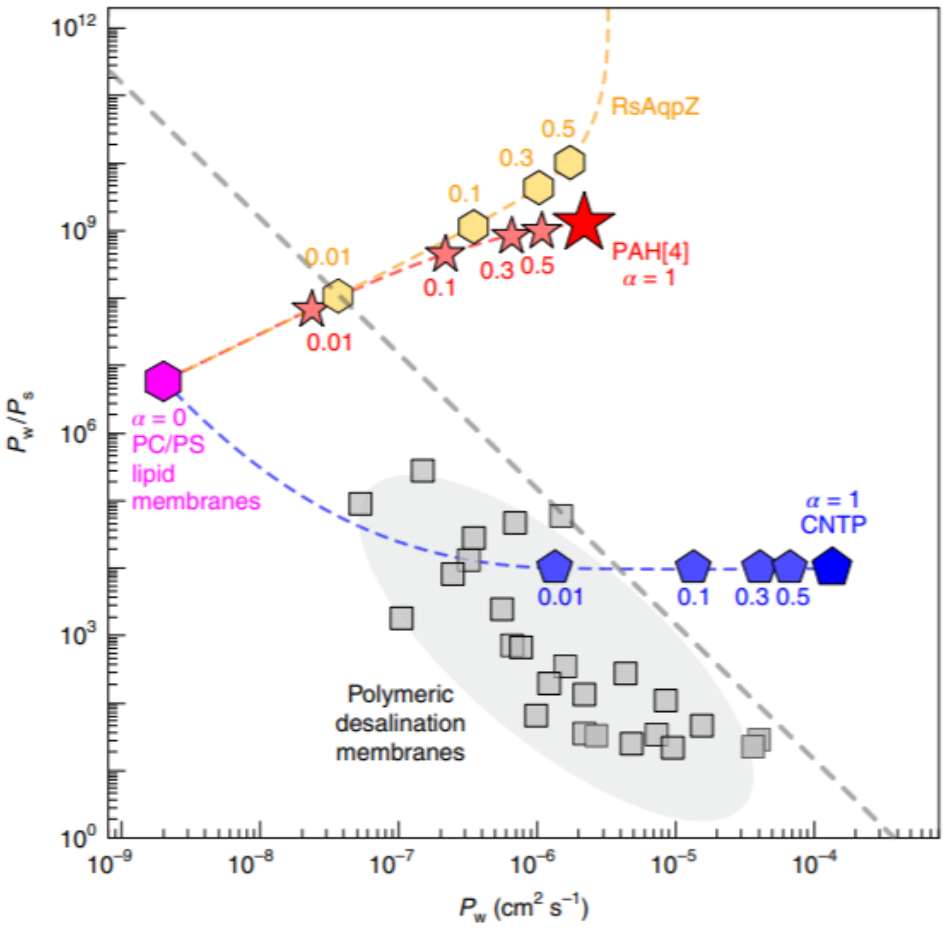
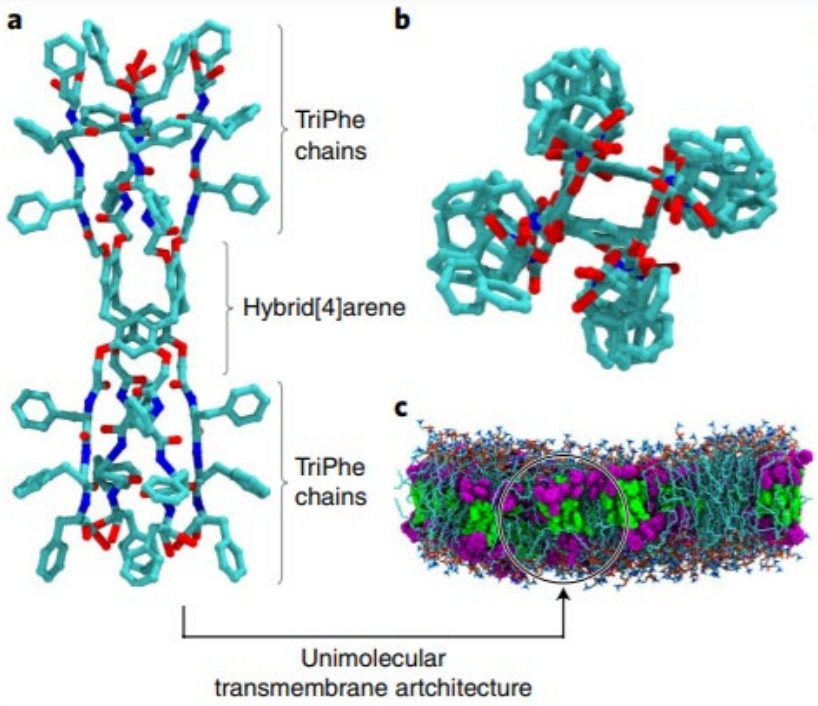
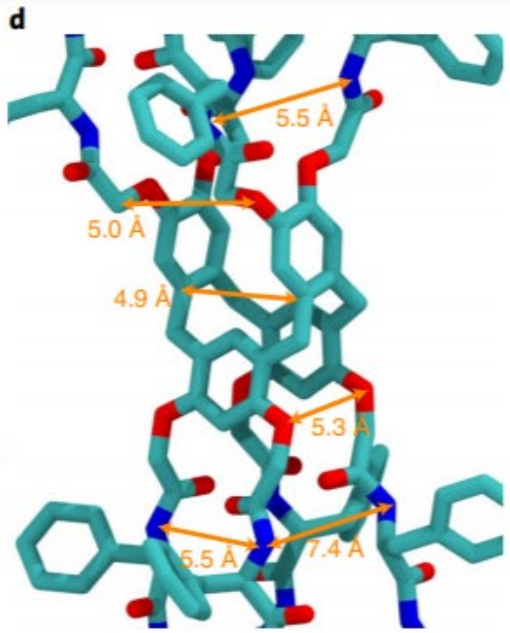


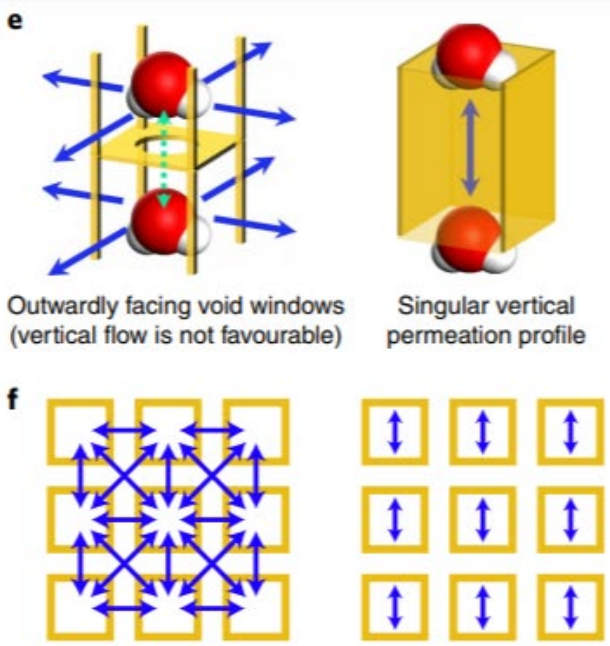
Fig. 3 | Intrinsic water/NaCl selectivity (P_w/P_s) versus P_w of PAH[4]-, CNTP- and RsAqpZ-based biomimetic membranes.

Water-channel protein, Aquaporin Z, RsAqpZ, from the purple photosynthetic bacterium, *Rhodobacter sphaeroides* ATCC 17023.

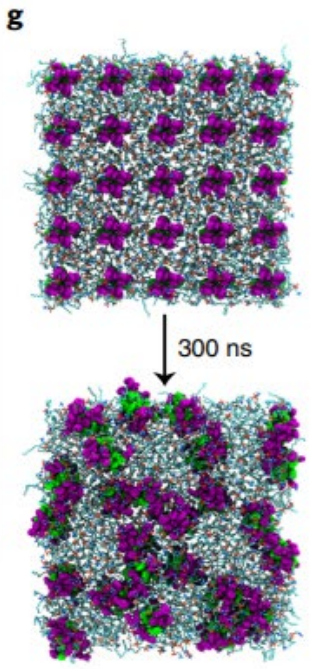
The road to desalination runs through nano-chemistry

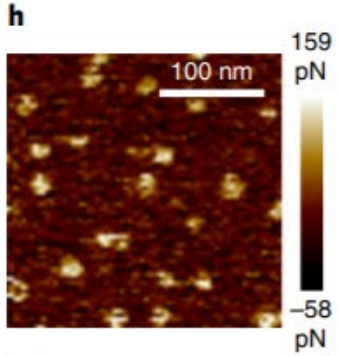


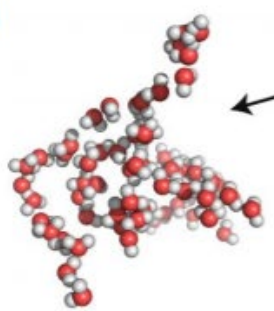


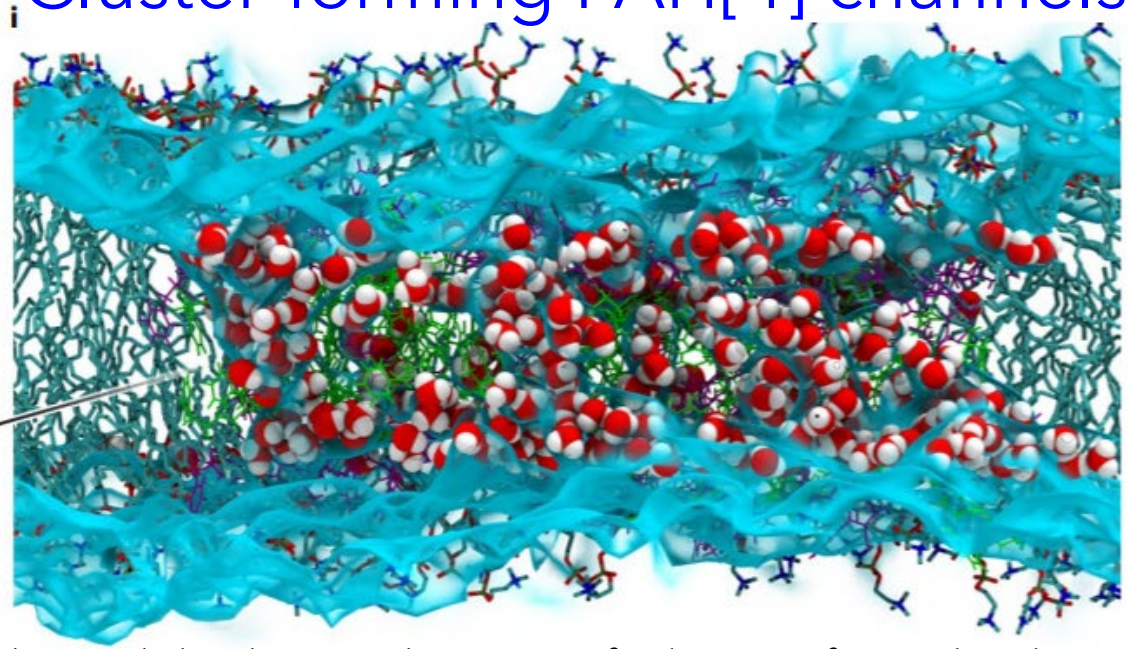


Cluster-forming PAH[4] channels









https://scholarsphere.psu.edu/resources/5f431be6-8672-4f12-83ce-b6a0d8c0823f

Domestic Water Purification

Low cost, small scale, purifiers may reduce risk of diseases

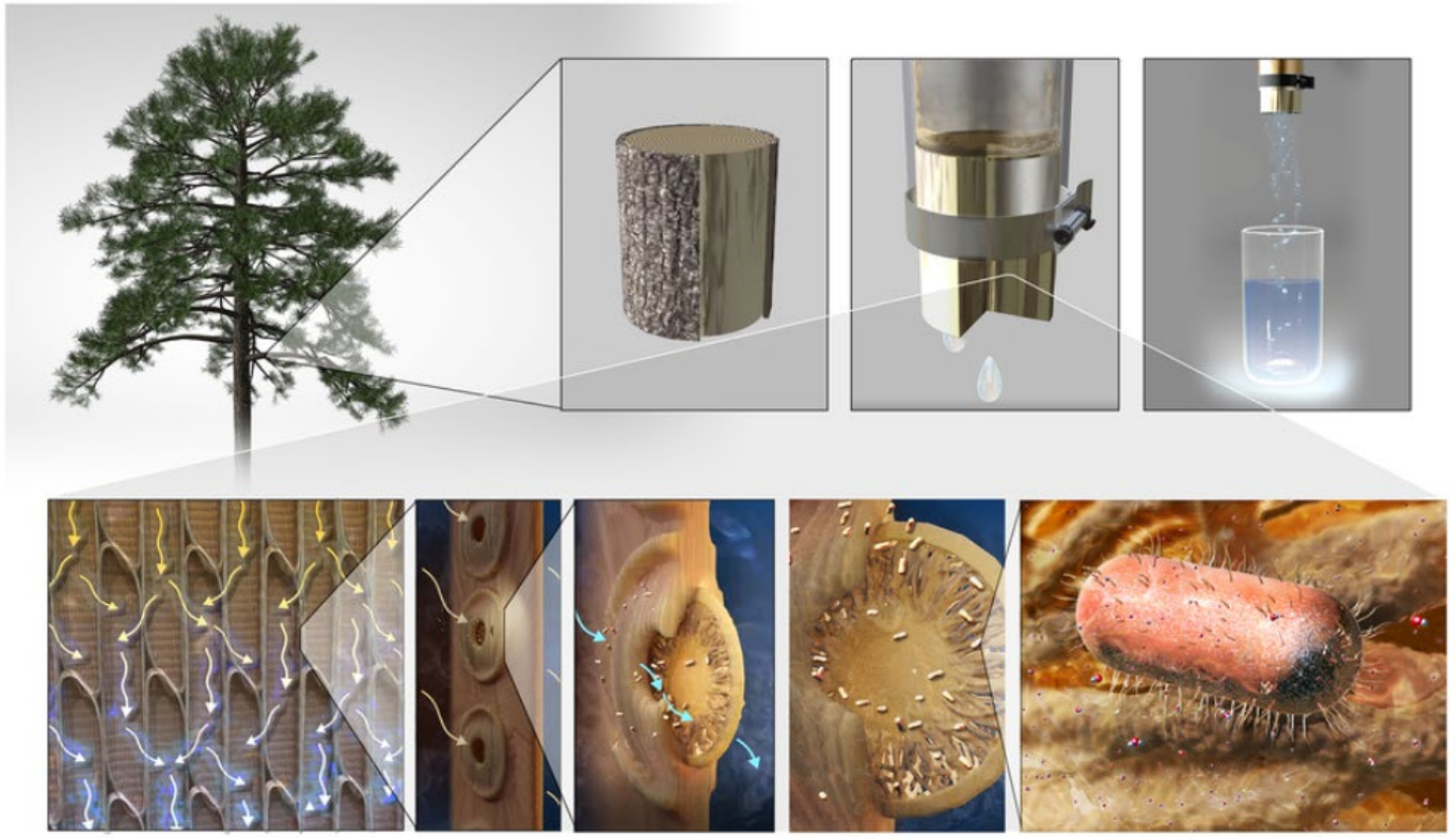
news.mit.edu/2021/filters-sapwood-purify-water-0325

MIT engineers make filters from tree branches to purify drinking water

Prototypes tested in India show promise as a low-cost, natural filtration option.

Watch Video

Jennifer Chu | MIT News Office
March 25, 2021



Professor
Rohit Karnik

Professor of Mechanical Engineering; Associate Department Head Education

INTERESTS

1. Microfluidic and nanofluidic transport
2. Graphene and nanostructured membranes
3. BioMEMS and lab-on-a-chip devices

http://meche.mit.edu/people/faculty/karnik@mit.edu

Xylem in gymnosperm sapwood can be used for water filtration. Xylem is comprised of conduits that are interconnected by membranes that filter out contaminants present in water, e.g., microbes.

Xylem Water Filter

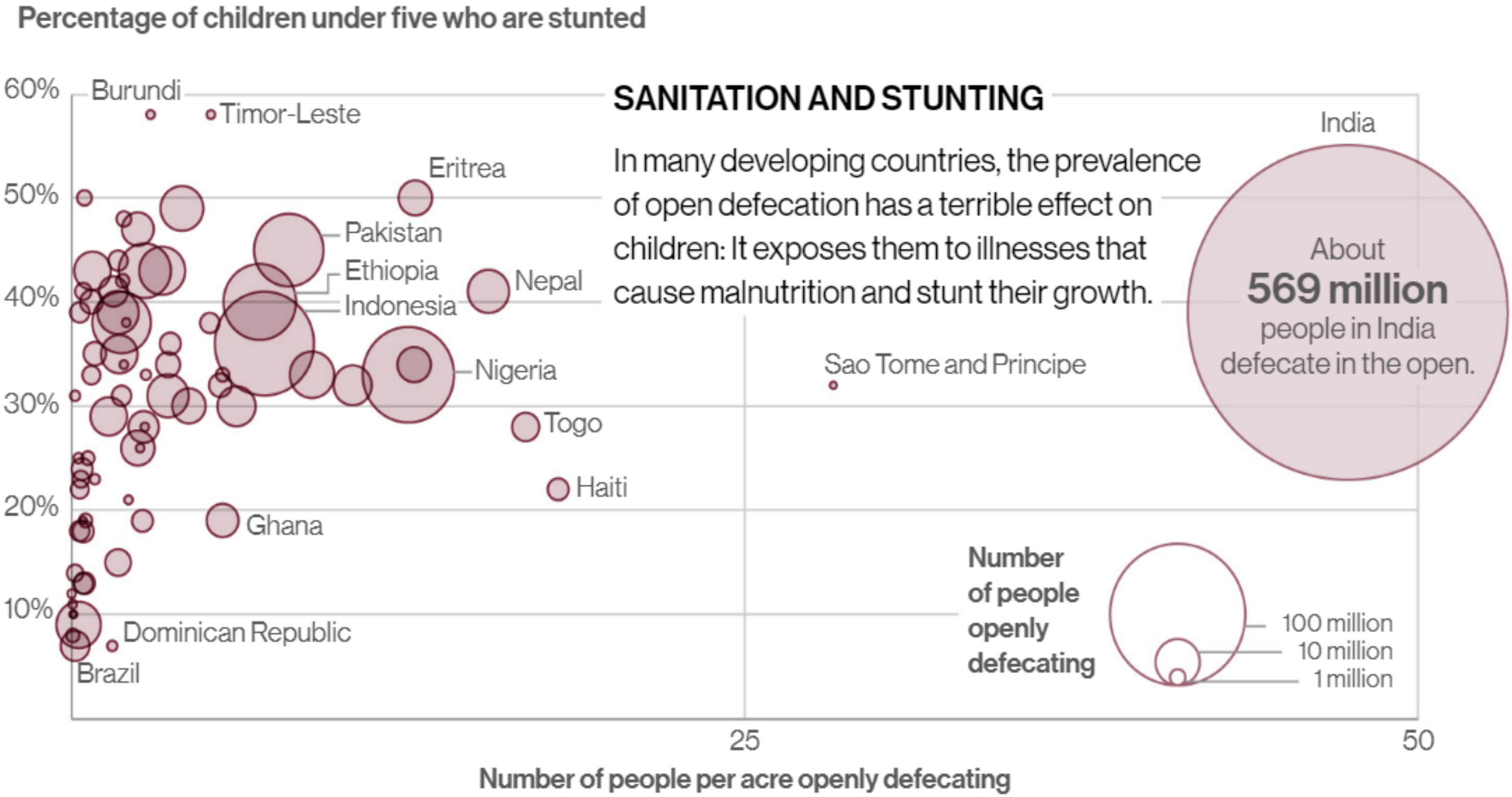
Women holding prototype of xylem water filter, India, 2018.

Developing low-cost water filters that exploit the natural filtration capabilities of xylem tissue in wood.

theguardian.com/science/blog/2016/nov/22/crappy-water-and-the-science-of-sanitation

Stunting, death and malnutrition: why contaminated water has far more serious effects than the odd bout of diarrhoea

▲ Eight year olds in Monze District, Zambia beneath a chalk line indicating the global average height 40% of children in Zambia suffer from stunted growth, the 10th highest rate in Africa. Photograph: WaterAid/Chileshe Chanda



https://www.who.int/news-room/detail/18-06-2019-1-in-3-people-globally-do-not-have-access-to-safe-drinking-water---unicef-who

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1 in 3 people globally do not have access to safe drinking water – UNICEF, WHO

New report on inequalities in access to water, sanitation and hygiene also reveals more than half of the world does not have access to safe sanitation services.

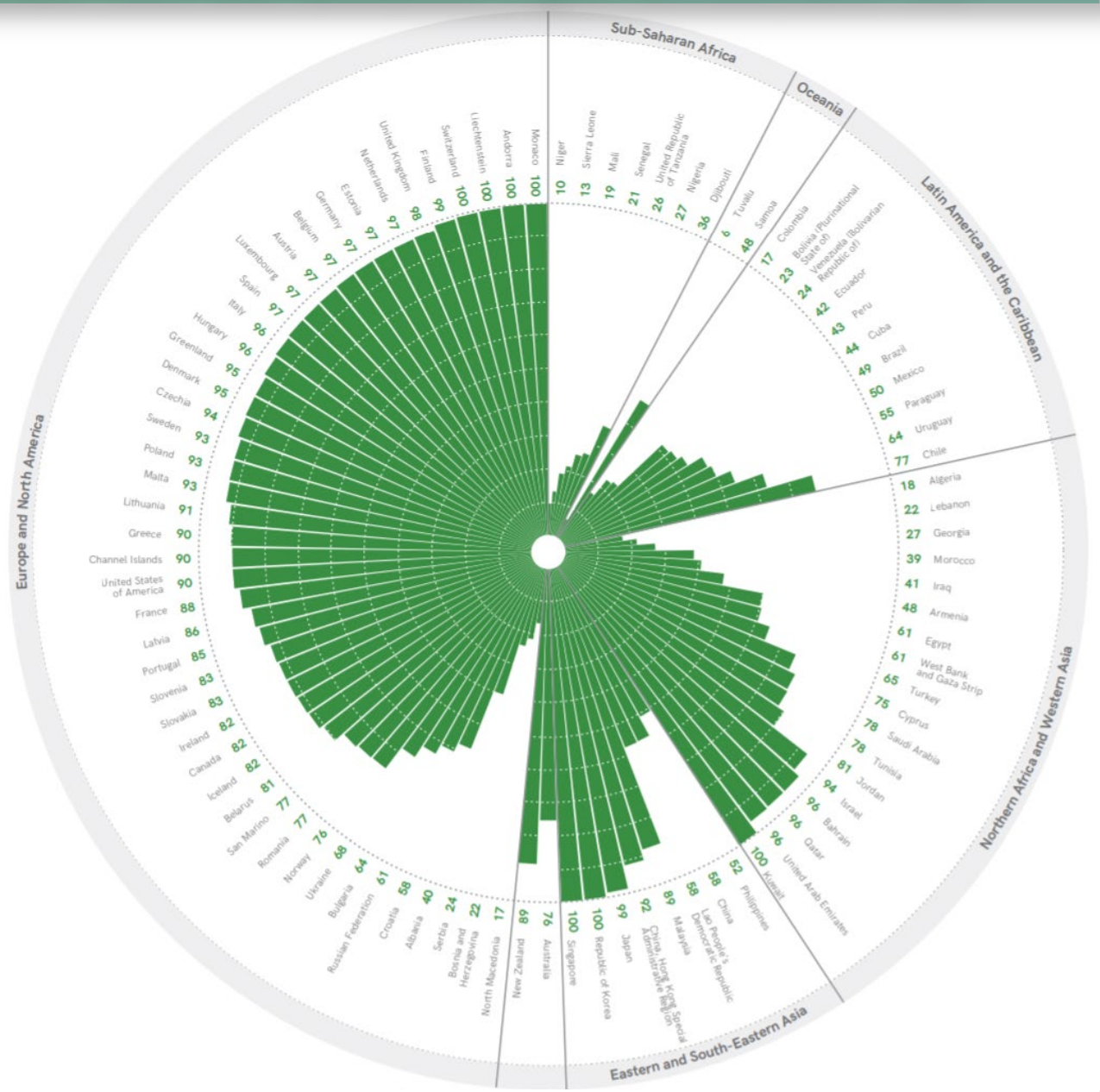
18 June 2019 | News release | New York, Geneva

Billions of people around the world are continuing to suffer from poor access to water, sanitation and hygiene, according to a new report by UNICEF and the World Health Organization. Some 2.2 billion people around the world do not have safely managed* drinking water services, 4.2 billion people do not have safely managed sanitation services, and 3 billion lack basic** handwashing facilities.

Nada Osseiran
Communications Officer
WHO
Mobile: +41 79 445 1624

www.who.int/water_sanitation_health/publications/jmp-2019-full-report.pdf?ua=1

Proportion of population with safely managed water (left) and sanitation (right) services, 2017 (%)



(L) Fig 51 (water) and (R) Fig 69 (sanitation) from www.who.int/water_sanitation_health/publications/jmp-2019-full-report.pdf?ua=1

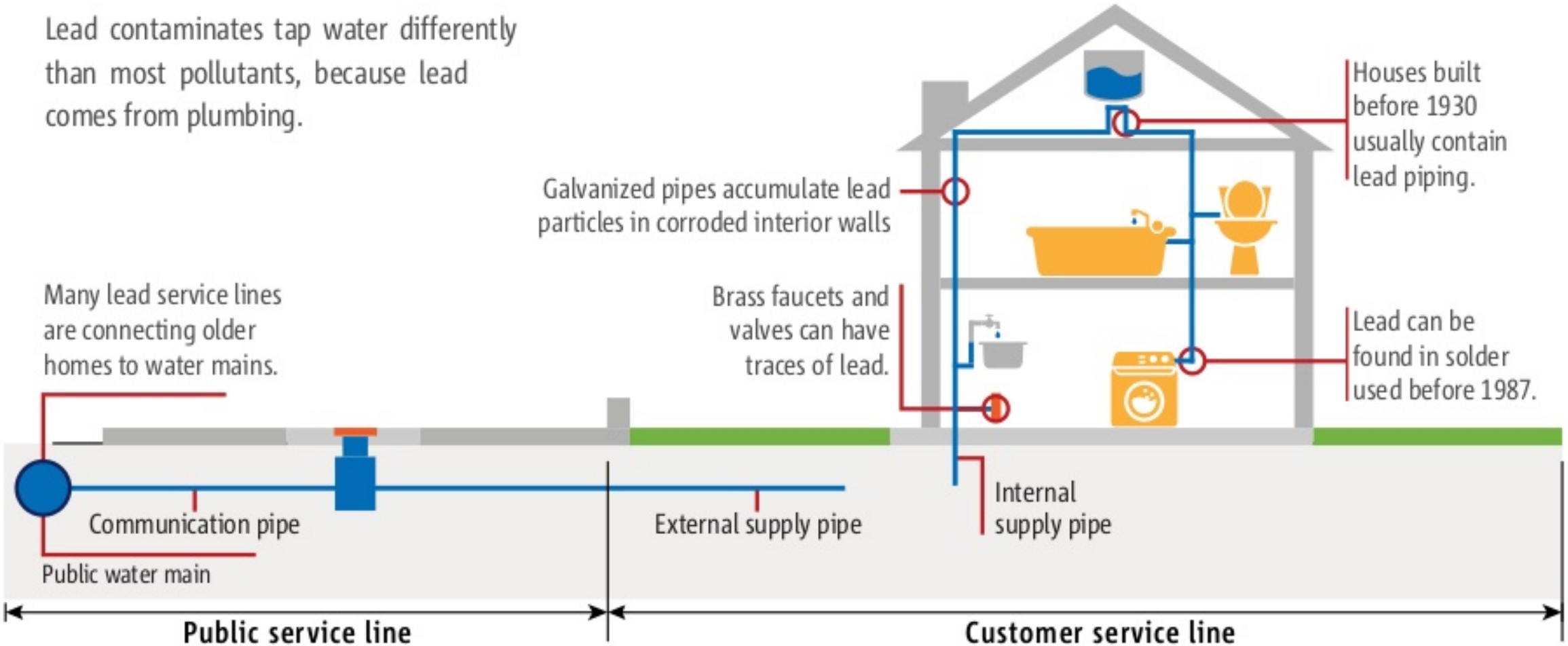
Plumbum (Latin for Lead) – Lead Pipes are used for plumbing water

Published in final edited form as:
J Public Health Manag Pract. 2019 ; 25(Suppl 1 LEAD POISONING PREVENTION): S84–S90. doi: 10.1097/PHH.0000000000000871.

The Flint Water Crisis: A Coordinated Public Health Emergency Response and Recovery Initiative

THE PIPES

Lead contaminates tap water differently than most pollutants, because lead comes from plumbing.



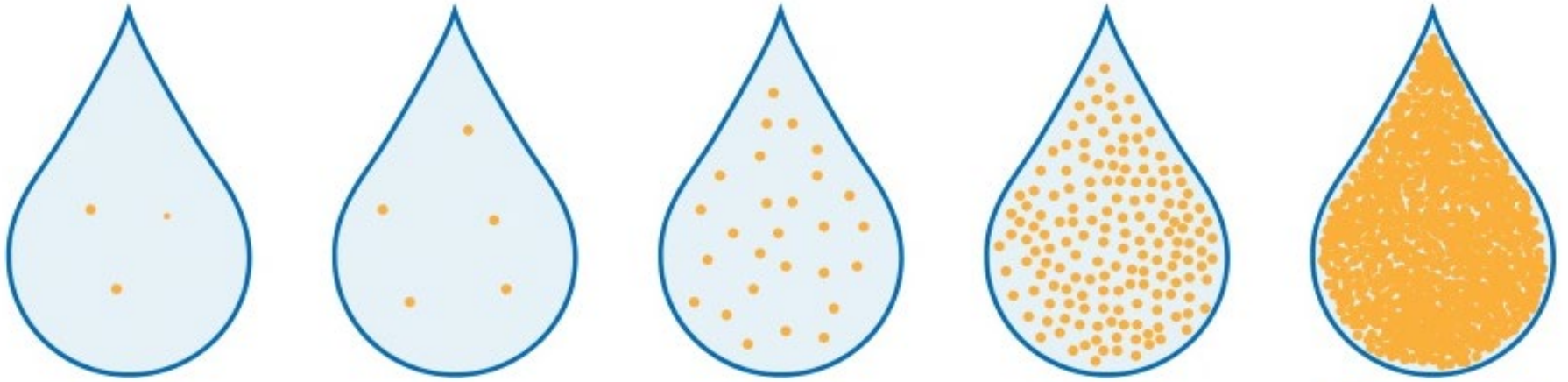
Summing up: water from Flint River moved through lead pipes, picking up the toxin as it went, and spread it throughout the population.

https://www.slideshare.net/lbuckfire/the-flint-michigan-water-crisis-causes-effects

FLINT, MICHIGAN WATER CRISIS - **LEAD POISONING FACTS AND FIGURES**

THE KEY PROBLEM

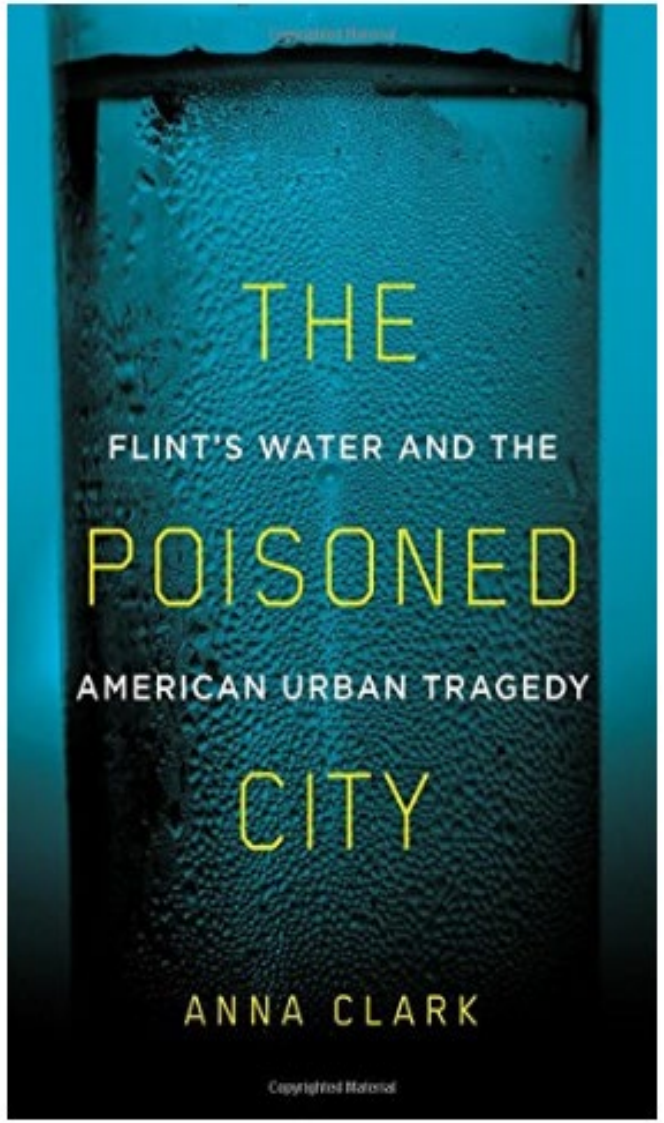
Water from the Flint River is highly corrosive (its water has about 8 times more chloride (Cl^-) in it than Detroit water) to iron and lead. Unfortunately, these pipe materials are widely used throughout Flint.



2.3	5	27	158	13,000
parts per billion	parts per billion	parts per billion	parts per billion	parts per billion
Detroit water	Cause for concern	Flint water	Highest level found in Virginia Tech's Flint sample	Highest level found in Flint

And, if these pipes are exposed to corrosive water, or if water sits too long inside them, the lead could be released and may end up coming out of the tap.

https://www.slideshare.net/lbuckfire/the-flint-michigan-water-crisis-causes-effects



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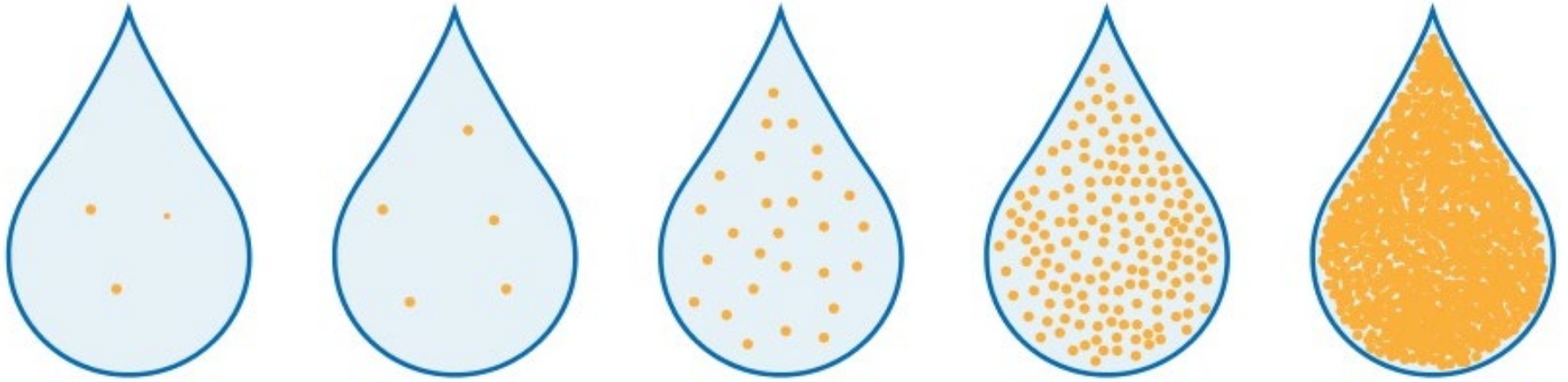

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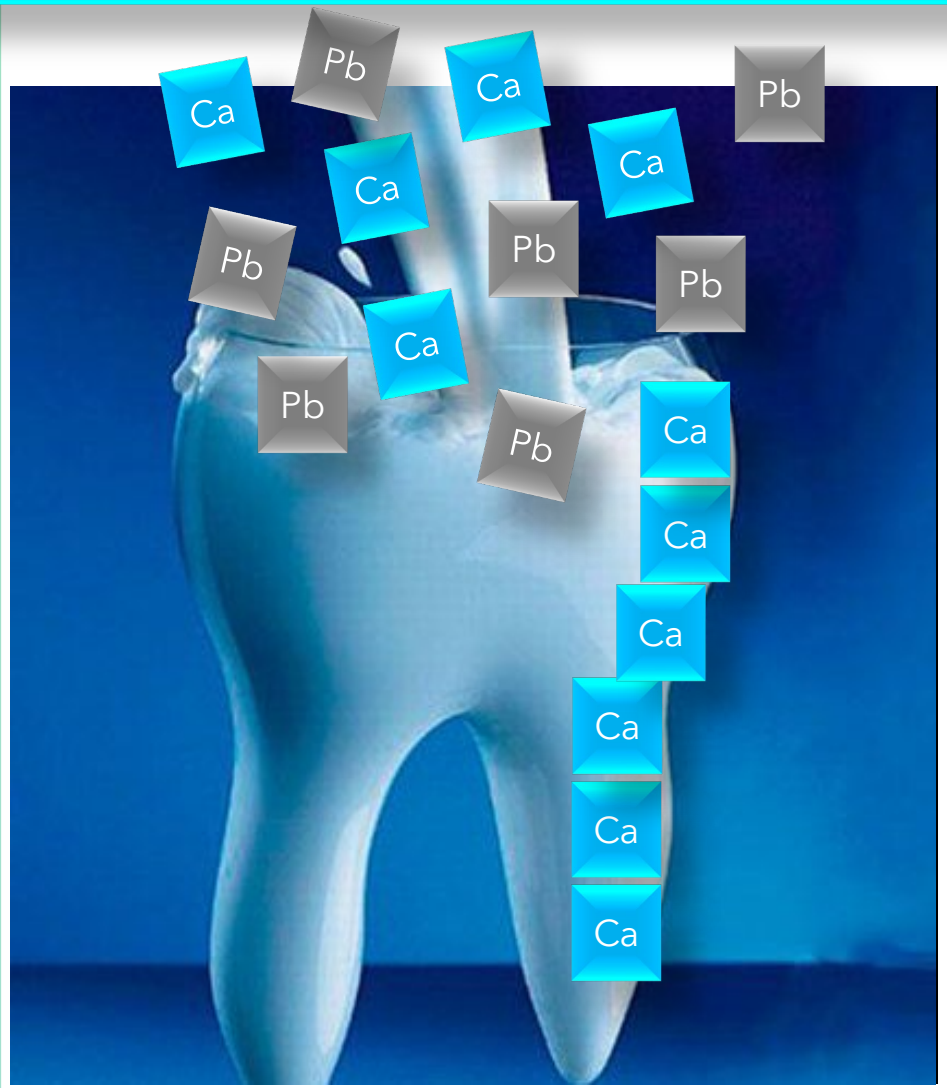
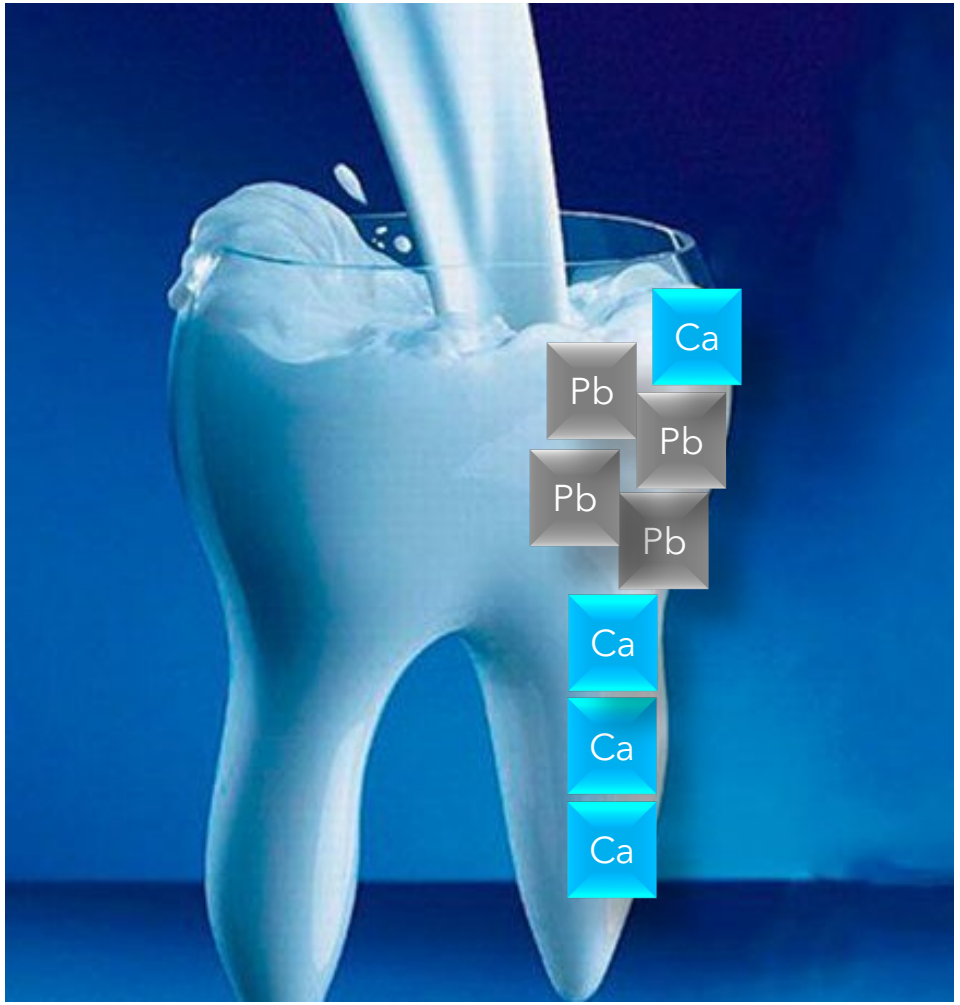
https://www.slideshare.net/lbuckfire/the-flint-michigan-water-crisis-causes-effects

Lead (Pb) accumulates in teeth and bones



More lead exposure

More lead is stored



https://edu.glogster.com/glog/calcium/2ar2hn030do?=glogpedia-source

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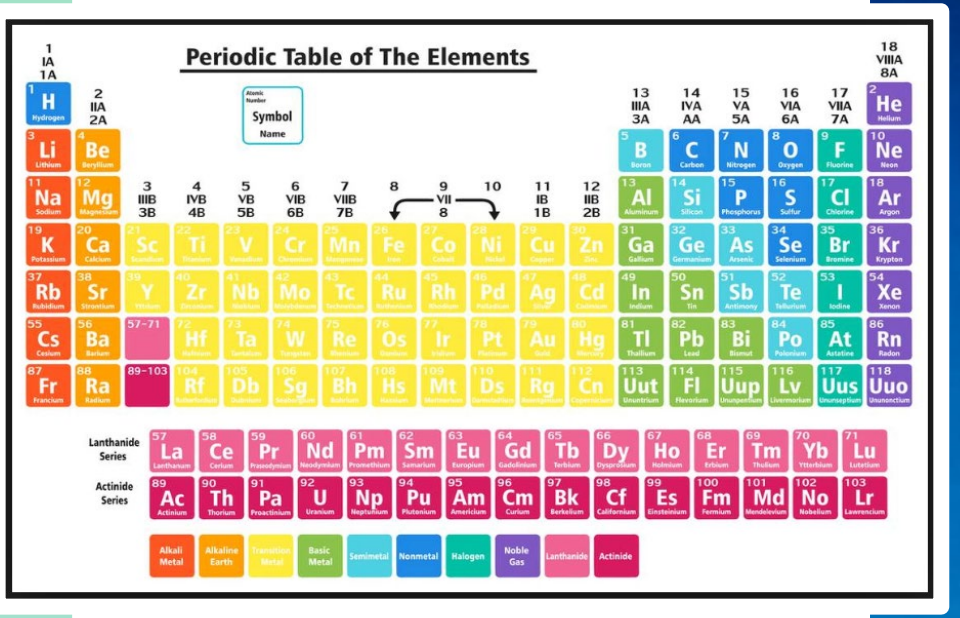

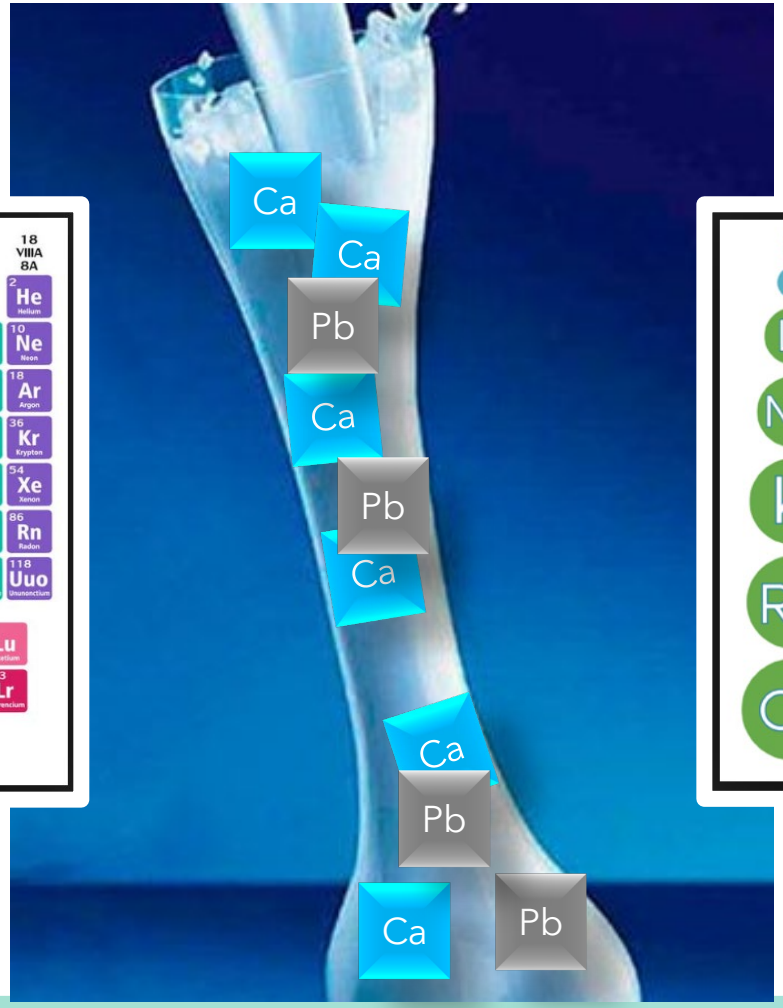

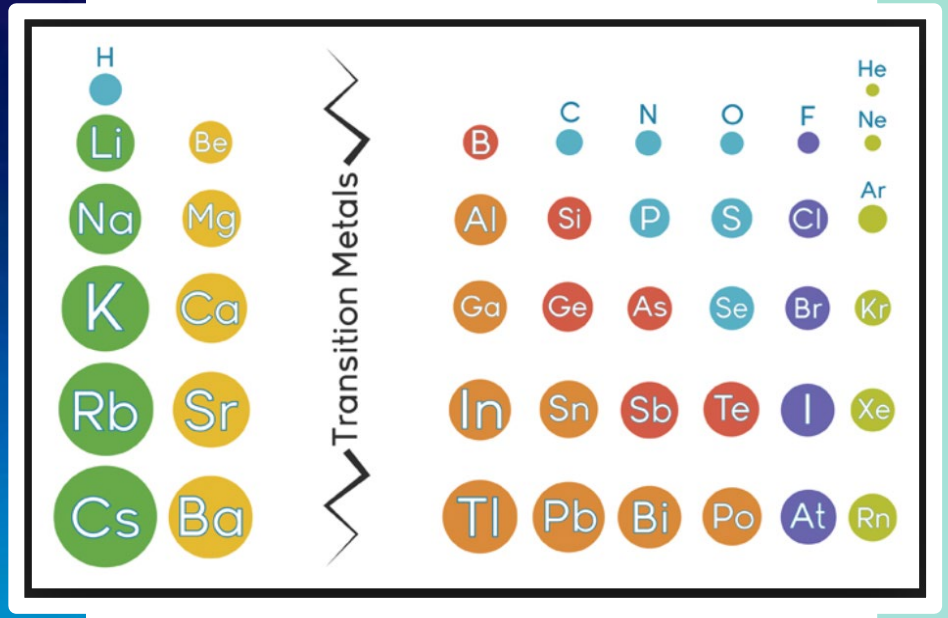

https://chemistryonline.guru/ionic-radius/

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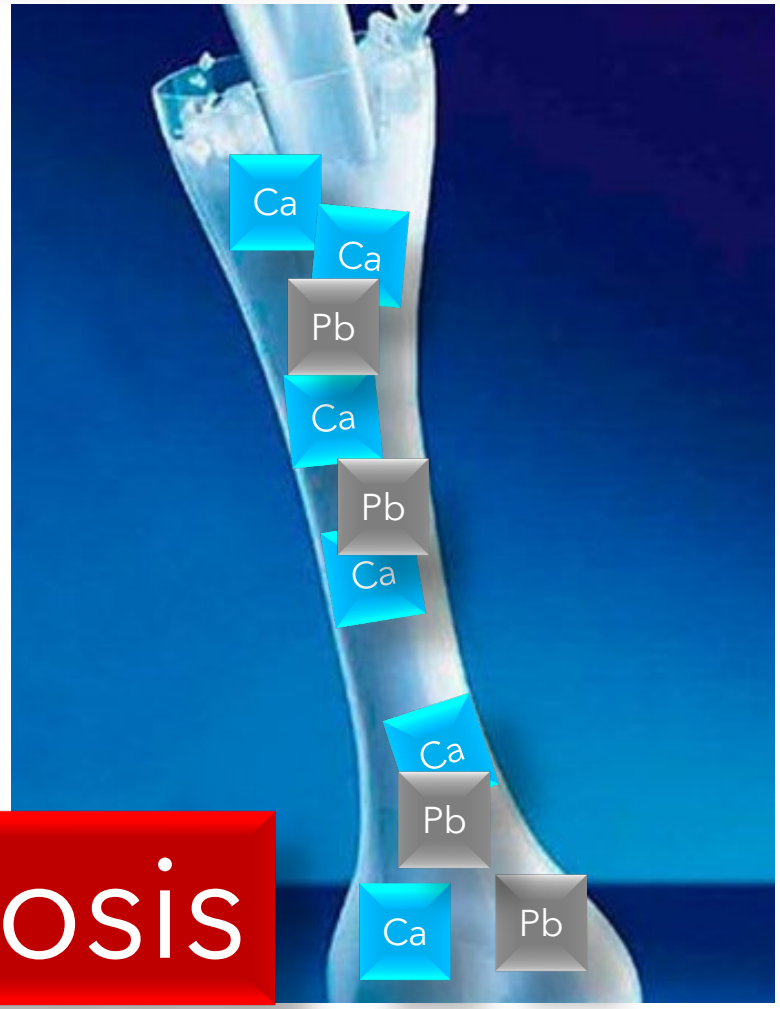


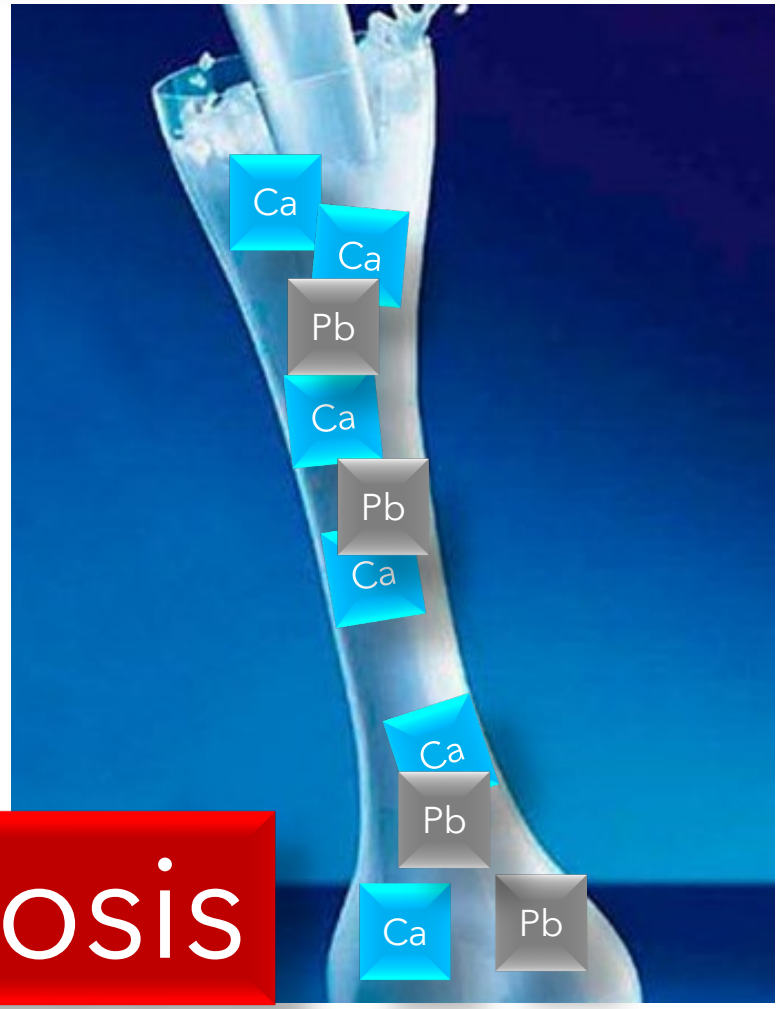
Pb Pb ? Pb Pb

What happens to the **Pb** in the bones?

Osteoporosis

Courtesy of Rebecca Jane Austin Datta https://www.linkedin.com/in/rebecca-jane-austin-datta-5b257129/

Lead (Pb) concentration increases in the blood



Pb Pb ? Pb Pb

What happens to the **Pb** in the bones?

Osteoporosis

Childhood Lead Poisoning causes dementia in adults

ehp Environmental Health Perspectives
https://ehp.niehs.nih.gov/doi/10.1289/ehp.9716

The Association between Blood Lead Levels and Osteoporosis Adults—Results from the Third National Health and Nutrition Examination Survey (NHANES III)

James R. Campbell and Peggy Auinger

Published: 1 July 2007 | https://doi.org/10.1289/ehp.9716 | Cited by: 35

78% of the U.S. population (1970s) had blood lead levels ≥ 10 μg/dL. Bone is a repository for 90–95% of the total body burden of lead and harbors it for years after initial exposure. Thus, a high proportion of adult Americans may currently have elevated bone lead levels. With this many who were exposed to lead when younger, and the morbidity associated with osteoporosis, it is important to investigate whether an association exists between lead exposure and osteoporosis in humans. Our objective was to conduct a secondary analysis to explore an association between lead exposure and osteoporosis in U.S. adults.

Pb from water accumulates in teeth and bones. When Pb leaches out of bones, it may contribute to osteoporosis in adult life. Increased amount of Pb in blood may also contribute to dementia, Alzheimer's and neurotoxicity.

Published in final edited form as:
Curr Alzheimer Res. 2012 June ; 9(5): 563–573.

Alzheimer's Disease and Environmental Exposure to Lead: The Epidemiologic Evidence and Potential Role of Epigenetics

Kelly M. Bakulski[1], **Laura S. Rozek**[1,2], **Dana C. Dolinoy**[1], **Henry L. Paulson**[3], and **Howard Hu**[1,4,5,*]

[1]University of Michigan, School of Public Health, Department of Environmental Health Sciences

[2]University of Michigan, Medical School, Department of Otolaryngology

[3]University of Michigan, Department of Neurology

[4]University of Michigan, Department of Epidemiology

[5]University of Michigan, Medical School, Department of Internal Medicine

Abstract

Several lines of evidence indicate that the etiology of late-onset Alzheimer's disease (LOAD) is complex, with significant contributions from both genes and environmental factors. Recent research suggests the importance of epigenetic mechanisms in defining the relationship between environmental exposures and LOAD. In epidemiologic studies of adults, cumulative lifetime lead (Pb) exposure has been associated with accelerated declines in cognition. In addition, research in animal models suggests a causal association between Pb exposure during early life, epigenetics, and LOAD. There are multiple challenges to human epidemiologic research evaluating the relationship between epigenetics, LOAD, and Pb exposure. Epidemiologic studies are not well-suited to accommodate the long latency period between exposures during early life and onset of Alzheimer's disease. There is also a lack of validated circulating epigenetics biomarkers and retrospective biomarkers of Pb exposure. Members of our research group have shown bone Pb is an accurate measurement of historical Pb exposure in adults, offering an avenue for future epidemiologic studies. However, this would not address the risk of LOAD attributable to early-life Pb exposures. Future studies that use a cohort design to measure both Pb exposure and validated epigenetic biomarkers of LOAD will be useful to clarify this important relationship.

Do you know what is in your drinking water?

https://www.cdc.gov/nceh/lead/publications/nceh_prevent_childhood_lead_poisoning_508.pdf

WATER: science, engineering, technology, data

Source: Eric McLamore, Shoumen Datta

VALUE

VALUE

Flint, Michigan

Fes, Morocco

Fatehpur, India

Fuzhou, China

What can the user do with this data ??

World needs advanced tools and technologies to use the mobile data platform of smartphones for safety of people.

More than 1 billion people worldwide lack access to water, and almost 3 billion find water scarce for at least one month of the year. Inadequate sanitation is also a problem for more than 2 billion people, which exposes them to diseases, such as cholera and typhoid fever, and other water-borne illnesses. 2 million children die each year from diarrheal diseases alone, which is eminently preventable.

~ ~ ~ WATER ~ ~ ~

Immensely important global topic deserves intensely focused science and engineering research to alleviate human suffering.

https://www.worldwildlife.org/threats/water-scarcity

Discussion: Snippets of Examples

Number 4

https://www.youtube.com/watch?v=ZbZSe6N_BXs

S	Sanitation

Your contribution to society matters.

Science and Scientists for Society

Mary-Ann Ochota

@MaryAnnOchota

Tue 22 Nov 2016 07.48 EST

3

At the start of this year, the UN recognised sanitation as a universal human right. The Sustainable Development Goals aim to achieve global sanitation by 2030. But despite these grand ambitions, and a hard-working WASH (Water, Sanitation and Hygiene) development sector, 2.4 billion people around the world still don't have access to a proper toilet.

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Lippenbekenntnis GERMAN

English translation of 'Lippenbekenntnis'

Lippenbekenntnis

NEUTER NOUN

lip service

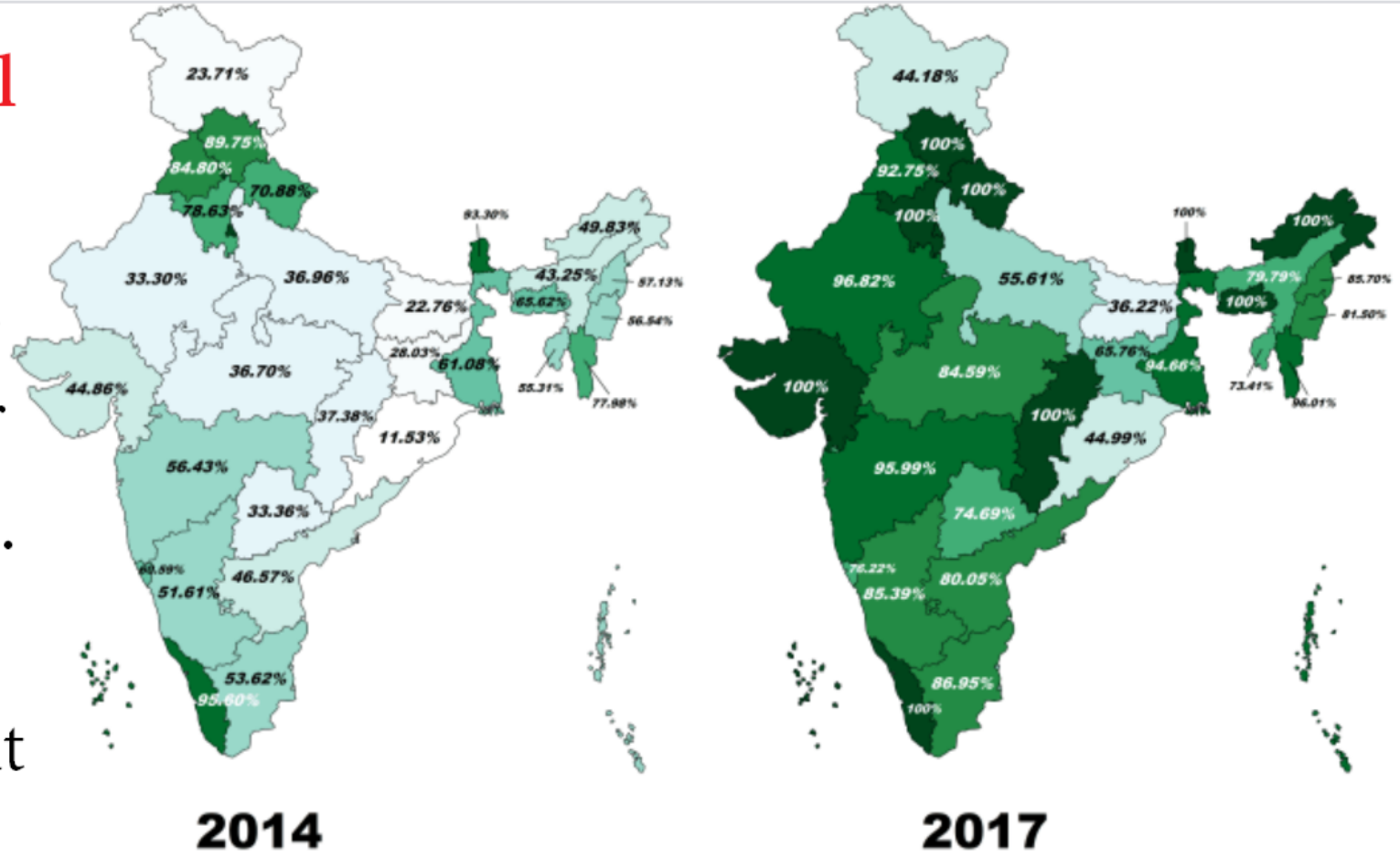
ein Lippenbekenntnis ablegen to pay lip service (to one's ideals *etc*)

brilliantmaps.com/indian-toilets/

Theoretical Change:

Household with their own toilets.

What about those that do not have a house?



Map created by Reddit user brahminthrowaway9460

The map above shows the theoretical change in the percentage of Indian Households with their own toilets between 2014 and 2017.

35.5 Crore Women Don't Have Access To Toilet In India: Report

The Logical Indian

20 Nov 2017

Editor : The Logical Indian

Image Credit: The Hindu www.ncbi.nlm.nih.gov/pmc/articles/PMC2981586/pdf/pmed.1000363.pdf

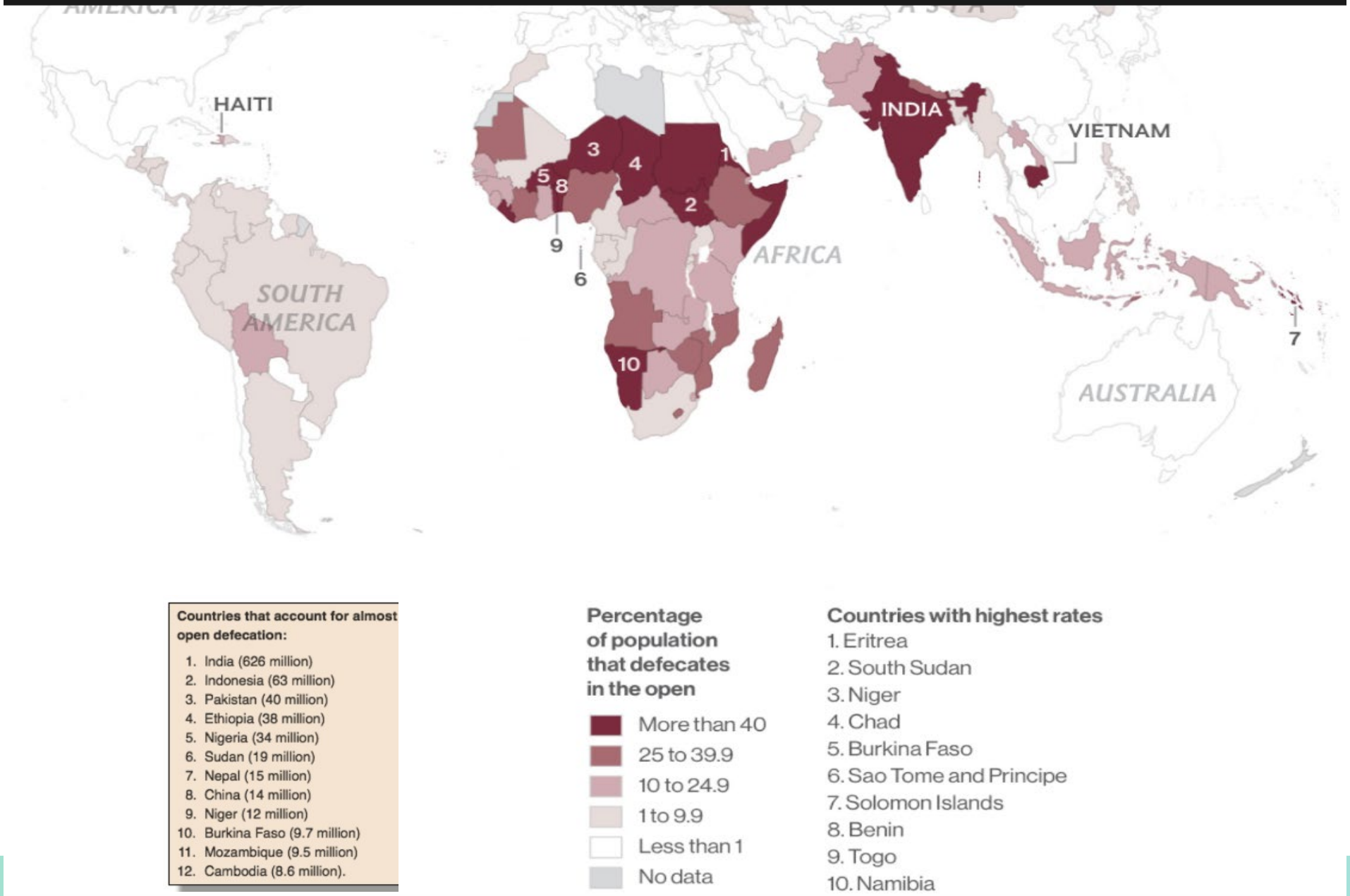
Wastewater-based Epidemiology

In India?

It is akin to telling a hair-raising story to a bald-headed man!

Courtesy of Rebecca Jane Austin Datta https://www.linkedin.com/in/rebecca-jane-austin-datta-5b257129/

blogs.nvcc.edu/damiller/tag/national-geographic/



Countries that account for almost open defecation:

1. India (626 million)
2. Indonesia (63 million)
3. Pakistan (40 million)
4. Ethiopia (38 million)
5. Nigeria (34 million)
6. Sudan (19 million)
7. Nepal (15 million)
8. China (14 million)
9. Niger (12 million)
10. Burkina Faso (9.7 million)
11. Mozambique (9.5 million)
12. Cambodia (8.6 million).

Percentage of population that defecates in the open

- More than 40
- 25 to 39.9
- 10 to 24.9
- 1 to 9.9
- Less than 1
- No data

Countries with highest rates

1. Eritrea
2. South Sudan
3. Niger
4. Chad
5. Burkina Faso
6. Sao Tome and Principe
7. Solomon Islands
8. Benin
9. Togo
10. Namibia

https://science.sciencemag.org/content/346/6216/1477.8/tab-pdf

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3774764/pdf/pone.0073784.pdf

A gargantuan infrastructure problem compounded by lack of adequate energy and water

Is it mostly an infrastructure engineering problem?

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6843932/pdf/ijerph-16-04049.pdf

Chemistry as a central SCIENCE in Sanitation Systems Engineering

Water-free nano-membrane toilet is indeed a good idea but is this high-maintenance system feasible?

cranfield.ac.uk/people/dr-alison-parker-734615

Cranfield University

Watch on YouTube
https://www.youtube.com/watch?v=jGPpXF7y9Rg
https://www.youtube.com/watch?v=x2gjipWubs0

Home /

Dr Alison Parker

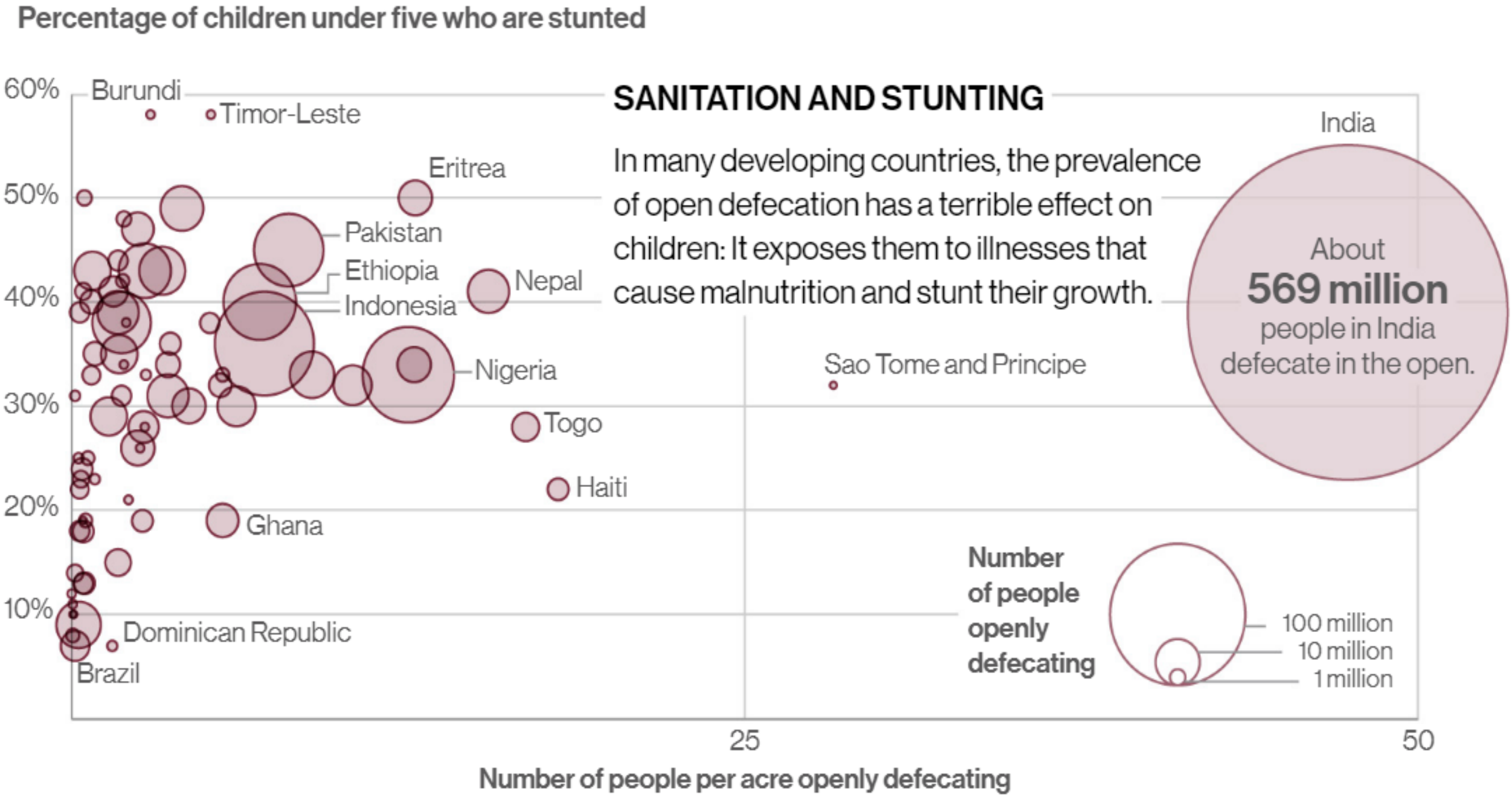
FGS, FHEA

Senior Lecturer in International Water and Sanitation

Cranfield Water Science Institute

Sanitation

May provide clues for health and healthcare



AMERICAN SOCIETY FOR MICROBIOLOGY | mSystems®

RESEARCH ARTICLE
Applied and Environmental Science

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7566278/pdf/mSystems.00614-20.pdf

SARS-CoV-2 Titers in Wastewater Are Higher than Expected from Clinically Confirmed Cases

Fuqing Wu,[a,n,o] Jianbo Zhang,[a,n] Amy Xiao,[a,n,o] Xiaoqiong Gu,[b,m] Wei Lin Lee,[b,m] Federica Armas,[b,m] Kathryn Kauffman,[c] William Hanage,[d] Mariana Matus,[e] Newsha Ghaeli,[e] Noriko Endo,[e] Claire Duvallet,[e] Mathilde Poyet,[a,n,o] Katya Moniz,[a,n,o] Alex D. Washburne,[p] Timothy B. Erickson,[f,g] Peter R. Chai,[f,h,i] Janelle Thompson,[j,k,m] Eric J. Alm[a,b,e,l,m,n,o]

[a]Center for Microbiome Informatics and Therapeutics, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA
[b]Singapore-MIT Alliance for Research and Technology, National University of Singapore, Singapore
[c]University at Buffalo, The State University of New York, Buffalo, New York, USA
[d]Center for Communicable Disease Dynamics, Department of Epidemiology, Harvard T. H. Chan School of Public Health, Boston, Massachusetts, USA
[e]Biobot Analytics, Inc., Cambridge, Massachusetts, USA
[f]Division of Medical Toxicology, Department of Emergency Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts, USA
[g]Harvard Humanitarian Institute, Cambridge, Massachusetts, USA
[h]The Fenway Institute, Boston, Massachusetts, USA
[i]The Koch Institute for Integrated Cancer Research, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA
[j]Singapore Center for Environmental Life Sciences Engineering, Nanyang Technological University, Singapore
[k]Asian School of the Environment, Nanyang Technological University, Singapore
[l]Broad Institute of MIT and Harvard, Cambridge, Massachusetts, USA
[m]Campus for Research Excellence and Technological Enterprise, Singapore
[n]Department of Biological Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA
[o]Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA
[p]Selva Analytics, LLC, Bozeman, Montana, USA

Jianbo Zhang and Amy Xiao contributed equally.

ABSTRACT Wastewater surveillance represents a complementary approach to clinical surveillance to measure the presence and prevalence of emerging infectious diseases like the novel coronavirus SARS-CoV-2. This innovative data source can improve the precision of epidemiological modeling to understand the penetrance of SARS-CoV-2 in specific vulnerable communities.

INFECTIOUS DISEASE

Novel coronavirus found in surprisingly high levels in sewage

Viral levels higher than expected based on confirmed COVID-19 cases

by ***Celia Henry Arnaud***

APRIL 16, 2020 | APPEARED IN **VOLUME 98, ISSUE 15**

In a Post-COVID World:

New Metaphors? Paradigms?

CITCOM
Canaries in the Coal Mine

SENSEW
Sensors in the Sewer
Seawater
Wastewater

abcnews.go.com/Health/us-struggles-lack-coronavirus-testing-researchers-sewage-clues/story?id=69955

abc NEWS VIDEO LIVE SHOWS 2020 ELECTIONS CORONAVIRUS

As the US struggles with lack of coronavirus testing, researchers look to our sewage for clues

Coronavirus may be tracked by where it shows up in wastewater.

By Dr. Nancy A. Anoruo

April 6, 2020, 2:24 PM • 6 min read

MIT begins testing wastewater to help detect Covid-19 on campus

The pilot project is designed to determine if wastewater testing can provide early signals about the spread of the virus.

Watch Video

Zach Winn | MIT News Office
October 2, 2020

innovation.mit.edu/pathway-post/biobot-labs/

MIT innovation initiative

Students/Community | Infrastructure | Diversity | Ventures | Corporate/Government | News/Events

Answers to urban health problems are right under our feet. Sewers carry a reservoir of information on human health and behavior. Scientists and engineers at MIT are on a mission to create real-time public health profiles of urban areas by sampling sewer/wastewater using tools from bio-chemistry, genomics, robotics, data analytics.

BIO BOT

https://www.biobot.io/

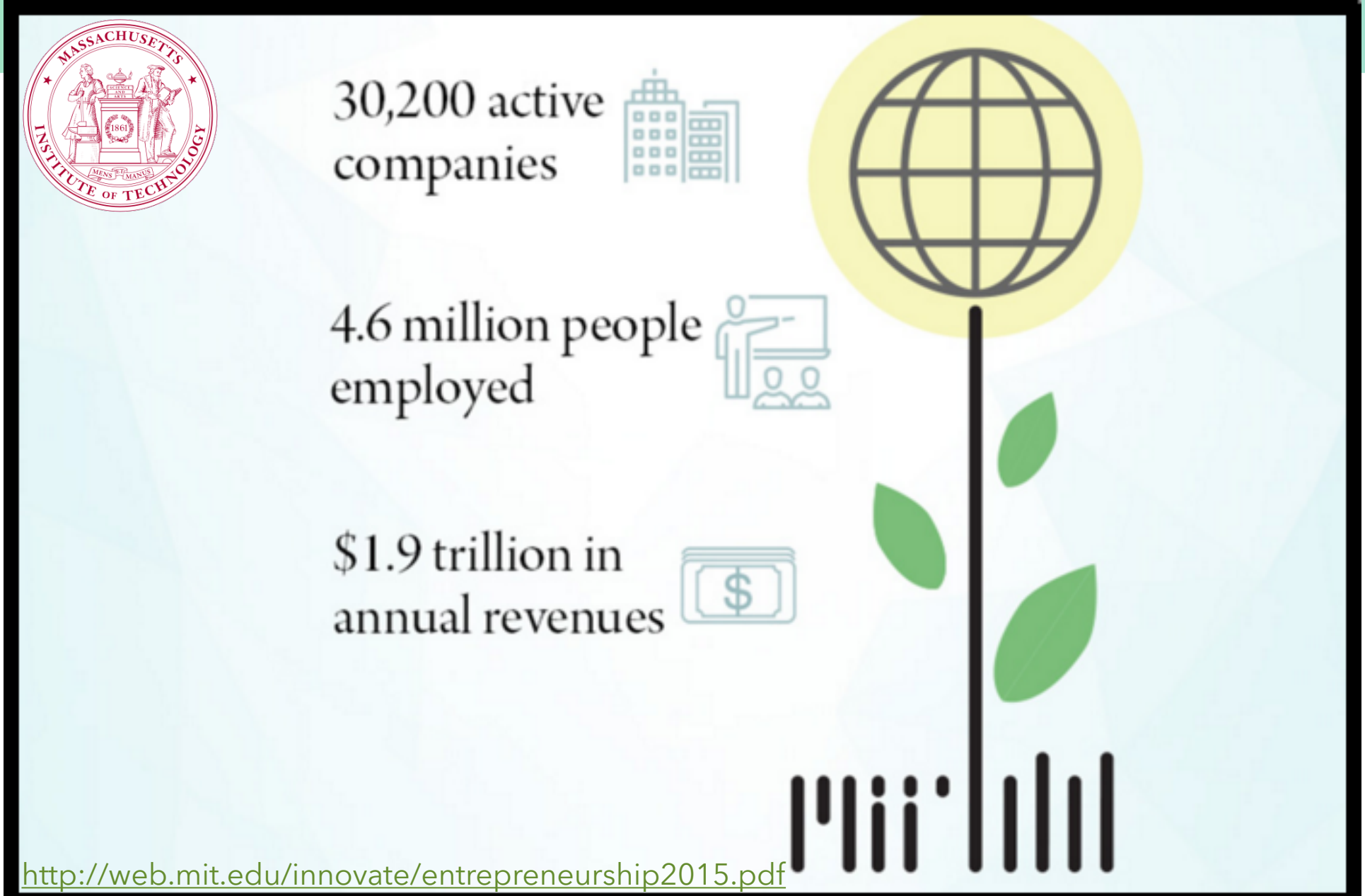
Biobot Labs

Newsha Ghaeli

Mariana G. Matus

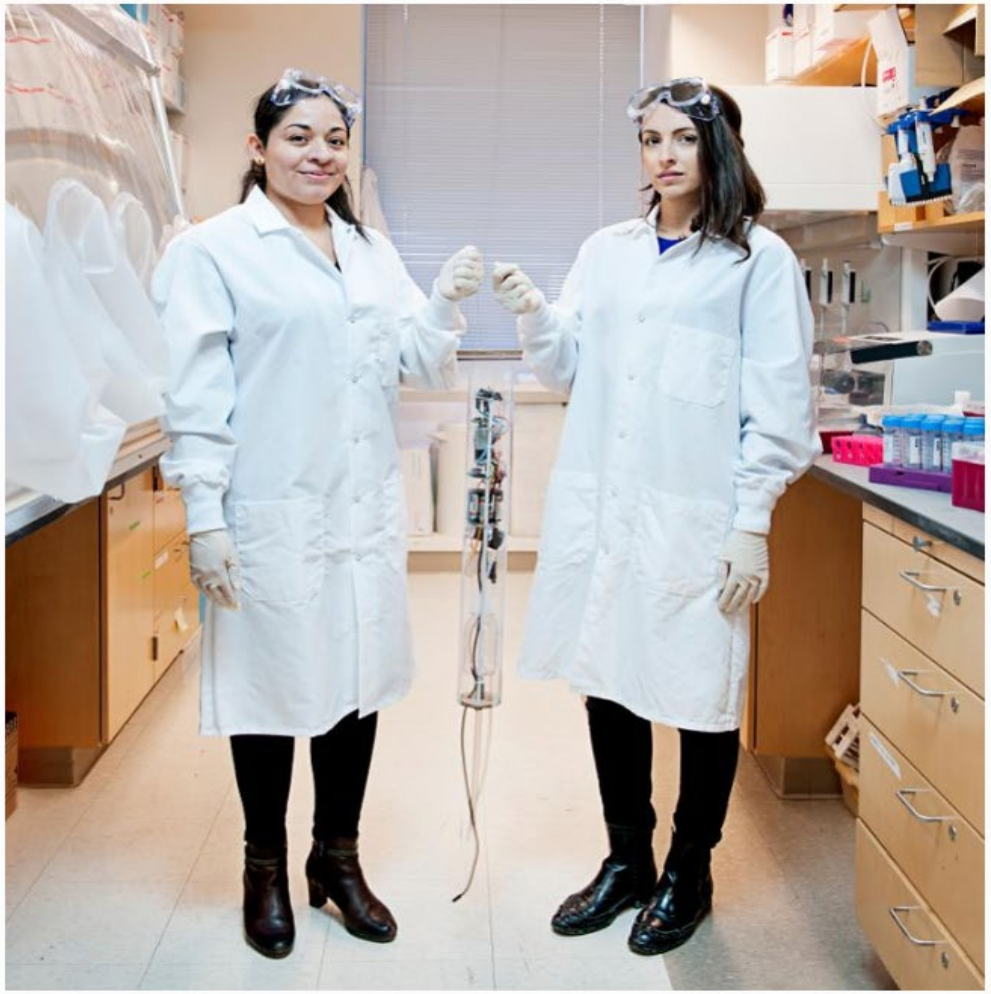
Carlo Ratti

Eric Alm



A new report estimates that, as of 2014, MIT alumni have launched 30,200 active companies, employing roughly 4.6 million people, and generating roughly $1.9 trillion in annual revenues.

Katie Jennings Forbes Staff
Healthcare
I am a staff writer covering health care. Email me at kjennings@forbes.com.



Biobot Analytics co-founders Mariana Matus (L) and Newsha Ghaeli (R) in their lab in Somerville, MA. BIOBOT ANALYTICS

Mariana Matus says she learned firsthand what it meant not to have access to healthcare services

Forbes

EDITORS' PICK | 4,558 views | Apr 24, 2020, 04:25pm EDT

MIT Spinoff Raises $4.2 Million To Estimate Scope Of Coronavirus Cases By Analyzing Poop

Katie Jennings Forbes Staff
Healthcare
I am a staff writer covering health care. Email me at kjennings@forbes.com.

vice.com/en_us/article/m7qygn/your-poop-might-be-key-for-predicting-the-end-of-the-pandemic

www.newsweek.com/coronavirus-traces-massachusetts-wastewater-levels-higher-expected-1497141

Your Poop Might Be Key For Predicting End of the Pandemic

Looking for the new coronavirus in wastewater could give us a heads up about where the outbreak is spreading – and when it has started to dissipate.

By Shayla Love

Apr 8 2020, 4:55pm Share Tweet Snap

PAOLO CORDONI / EYEEM | GETTY

On March 5, there had not yet been a clinical diagnosis of COVID-19 in Amersfoort, a Dutch city of more than 150,000 people to the east of Amsterdam. But underneath Amersfoort's streets, dotted with Medieval buildings, the sewage pipes containing people's fecal matter told another story.

In a Post-COVID World: New lines of business – pay per pee healthcare

medrxiv.org/content/10.1101/2020.04.05.20051540v1.full.pdf

Title: SARS-CoV-2 titers in wastewater are higher than expected from clinically confirmed cases

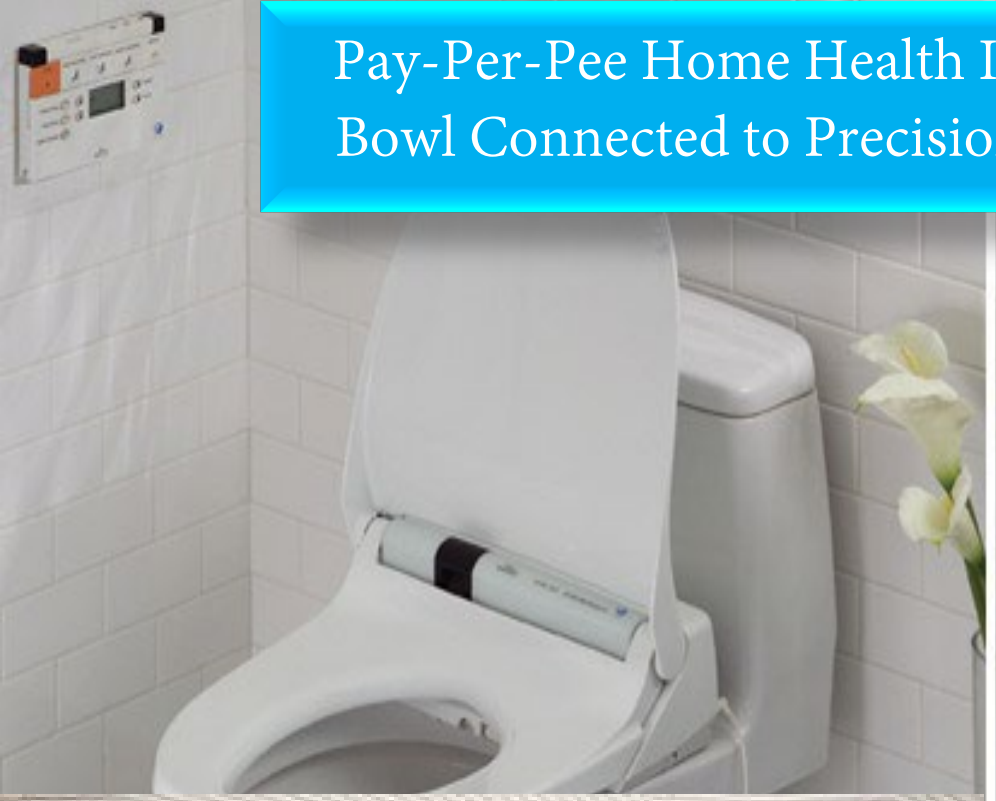
Authors: Wu FQ(1); Xiao A(1); Zhang JB(1); Gu XQ(2); Lee WL(2); Kauffman K (3); Hanage WP(4); Matus M (5); Ghaeli N(5); Endo N(5); Duvallet C(5); Moniz K(1); Erickson TB(6); Chai PR (6); Thompson J(7); Alm EJ(1,2,5)

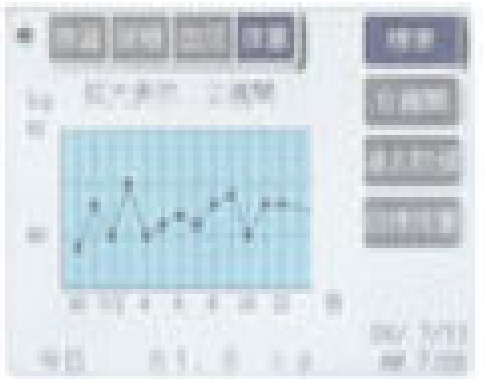
1: Center for Microbiome Informatics and Therapeutics, Departments of Biological Engineering and Civil & Environmental Engineering, Massachusetts Institute of Technology
2: Singapore-MIT Alliance for Research and Technology, National University of Singapore
3: University at Buffalo, The State University of New York
4: Center for Communicable Disease Dynamics, Department of Epidemiology, Harvard T. H. Chan School of Public Health, Boston
5: Biobot Analytics, Cambridge MA
6: Division of Medical Toxicology, Department of Emergency Medicine, Brigham and Women's Hospital
7: Singapore Center for Environmental Life Sciences Engineering, Asian School of the Environment, Nanyang Technological University, Singapore

Abstract. Wastewater surveillance may represent a complementary approach to measure the presence and even prevalence of infectious diseases when the capacity for clinical testing is limited. Moreover, aggregate, population-wide data can help inform modeling efforts. We tested wastewater collected at a major urban treatment facility in Massachusetts and found the presence of SARS-CoV-2 at high titers in the period from March 18 - 25 using RT-qPCR. We then confirmed the identity of the PCR product by direct DNA sequencing. Viral titers observed were significantly higher than expected

www.medrxiv.org/content/10.1101/2020.04.05.20051540v1.full.pdf

Pay-Per-Pee Home Health IoT Wireless Toilet Bowl Connected to Precision Public Health IT



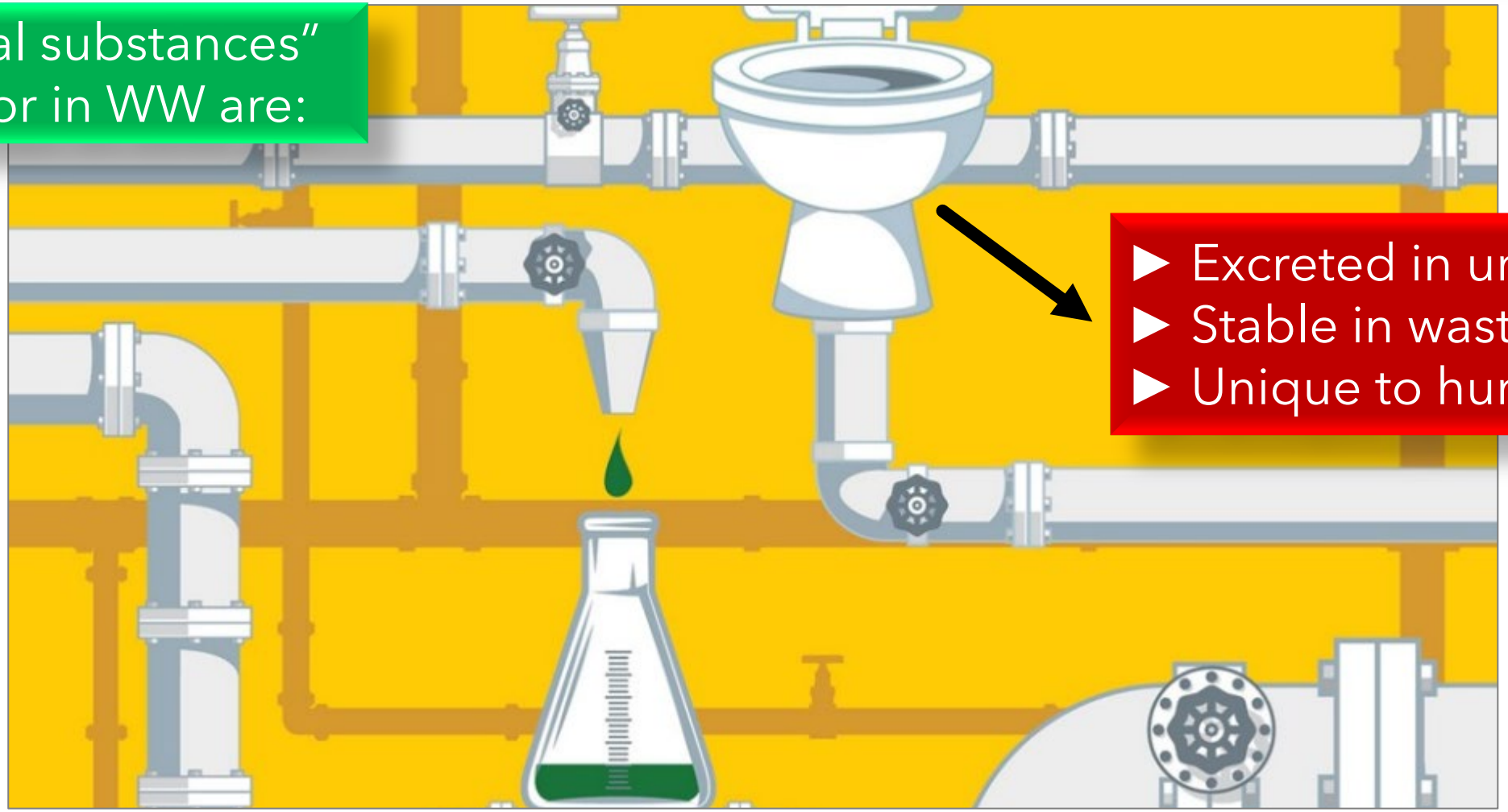


https://dspace.mit.edu/handle/1721.1/56251

Weigh-scale, BMI, FOBT, urine analysis, fecal matter (microbe), 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.

Wastewater based Epidemiology

The "ideal substances" to monitor in WW are:



- Excreted in urine/feces
- Stable in wastewater
- Unique to human

Arnaud, Celia (2018) To monitor the health of cities' residents, look no further than their sewers. *Chemical & Engineering News* **96** (18) 30-38 ► https://cen.acs.org/environment/water/monitor-health-citiesresidents-look-further/96/i18

Sanitation & Healthcare

INEXTRICABLY LINKED ??

Discussion: Snippets of Examples

Number 5

https://www.youtube.com/watch?v=ZbZSe6N_BXs

H	Healthcare

Your contribution to society matters.

Science and Scientists for Society

The division between “rich” versus “poor” may be less applicable to healthcare because human welfare and practices which may alleviate human suffering, diseases and morbidity may benefit all humans

But there are exceptions …

Diseases neglected by the affluent world

The World Health Organization has established a list of 17 “official” neglected tropical diseases (NTDs): Buruli ulcer, Chagas disease, cysticercosis, dengue, dracunculiasis, echinococcosis, endemic treponematoses, foodborne trematode infections, human African trypanosomiasis, leishmaniasis, leprosy, lymphatic filariasis, onchocerciasis, rabies, schistosomiasis, soil-transmitted helminthiases, and trachoma. These 17 diseases were chosen because of their adverse impact, relative obscurity, and the lack of availability of tools to combat them (because they are uncommon in the affluent world).

https://www.ncbi.nlm.nih.gov/books/NBK62516/

Diseases neglected by the affluent world

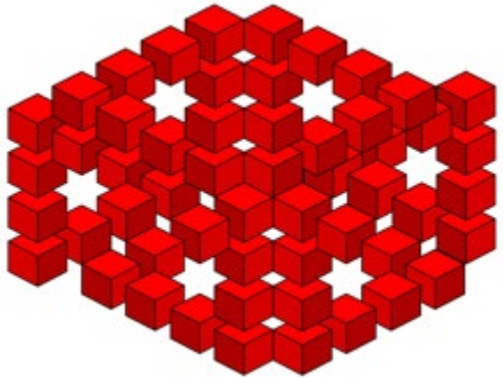
*The good news is that the **science** and **engineering** expertise we need in order to address the neglected diseases are similar in terms of their **foundation**, for almost any disease, neglected or not.*

https://www.ncbi.nlm.nih.gov/books/NBK62516/

Therefore, our discussion in the healthcare segment will address healthcare in general.

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

HEALTHCARE ISSUES



Dr Shoumen Palit Austin Datta

Research Affiliate, MIT Auto-ID Labs, Department of Mechanical Engineering, School of Engineering, Massachusetts Institute of Technology shoumen@mit.edu

Senior Scientist, MDPnP Lab, Medical Device Interoperability & Cybersecurity Program, Department of Anesthesiology, Massachusetts General Hospital, Harvard Medical School sdatta8@mgh.harvard.edu

1989 • (Department of Medicine) Massachusetts General Hospital, Harvard Medical School

Dr J Larry Jameson MD PhD Molecular Endocrinology / Neuro-Endocrinology Dr Ann Klibanski MD

One decade ago, my research group at the University of Tokyo created a flexible electronic mesh and wrapped it around the mechanical bones of a robotic hand. We had dreamed of making an electronic skin, embedded with temperature and pressure sensors, that could be worn by a robot. If a robotic health aide shook hands with a human patient, we thought, this sensor-clad e-skin would be able to measure some of the person's vital signs at the same time.

Today we're still working intensively on e-skin, but our focus is now on applying it directly to the human body. Such a bionic skin could be used to monitor medical conditions or to provide more sensitive and lifelike prosthetics.

http://spectrum.ieee.org/biomedical/bionics/bionic-skin-for-a-cyborg-you

Where does this fit in your future?

Photo: Someya-Sekitani Group

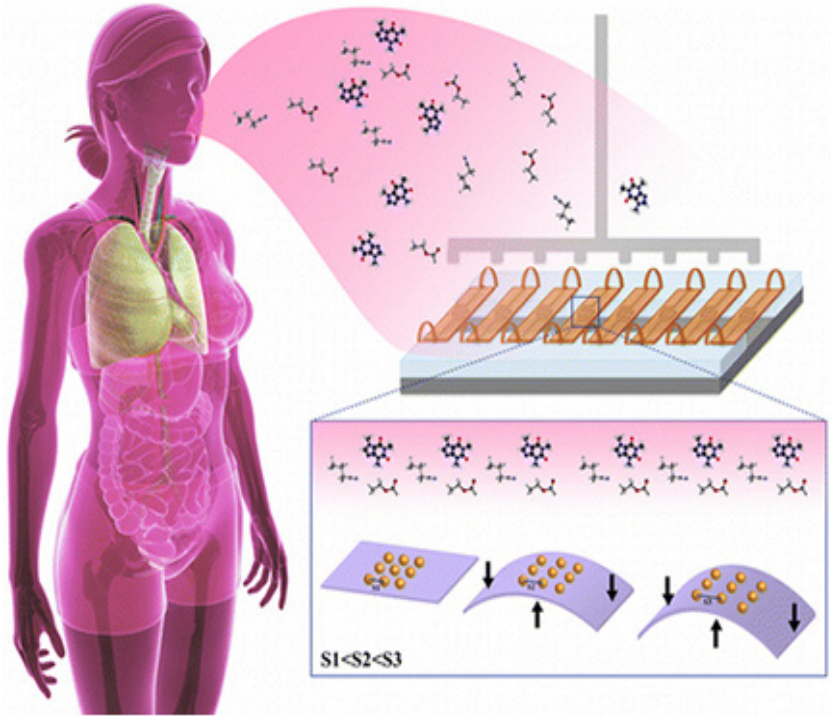
Gilded skin: Takao Someya's latest e-skin material is one-tenth the thickness of plastic kitchen wrap, and it can conform to any body shape.

Electronic Nose Sniffs Out Ovarian Cancer in Exhaled Breath

OCTOBER 6TH, 2015 EDITORS NANOMEDICINE, ONCOLOGY

Where does this fit in your future?

We know that exhaled breath contains biomarkers that point to presence of existing disease, including cancer, but their detection is challenging without bulky and expensive equipment. Building specialized devices that detect volatile organic compounds linked to disease requires large sensor arrays, a limitation that has made them currently impractical. Now researchers at Technion –Israel Institute of Technology and Carmel Medical Center in Haifa, Israel have developed tiny flexible sensors that are each able to replicate the work of many. In a study testing the breath of 43 volunteers that included 17 ovarian cancer patients, their sensors achieved an 82% accuracy of detection.



The sensors are flexible and are made of gold nanoparticles that have molecules onto which volatile organic compounds (VOCs) attach to. When captured, the different VOCs bend the sensors at different angles depending on their nature and provide more information than simply whether they're there or not.

Dynamic Nanoparticle-Based Flexible Sensors: Diagnosis of Ovarian Carcinoma from Exhaled Breath

Nicole Kahn†, Ofer Lavie‡, Moran Paz‡, Yakir Segev‡, and Hossam Haick*†
† Department of Chemical Engineering and Russell Berrie Nanotechnology Institute, Technion–Israel Institute of Technology, Haifa 3200003, Israel
‡ Gynecological Oncology and Surgery Unit, Carmel Medical Center, Haifa 3436212, Israel

Nano Lett., Article ASAP
DOI: 10.1021/acs.nanolett.5b03052
Publication Date (Web): September 9, 2015

*E-mail: hhossam@technion.ac.il.

Malaria Diagnosis Using a Mobile Phone Polarized Microscope

Casey W. Pirnstill & Gerard L. Coté

Scientific Reports **5**, Article number: 13368 (2015)
doi:10.1038/srep13368

Received: 19 March 2015
Accepted: 14 July 2015
Published online: 25 August 2015

Poverty magnifies the need for health care while shrinking the capacity to finance it. Low-income countries face 56 percent of the global disease burden but account for only 2 percent of global health spending (World Bank 2005; Mathers, Lopez, and Murray, forthcoming). With spending levels of some $30 per capita on average, over half of it out of pocket, low-income countries face severe challenges in providing their

http://siteresources.worldbank.org/INTHSD/Resources/topics/Health-Financing/HFRChap7.pdf

ENTREPRENEURS 8/01/2015 @ 7:00AM | 1,215 views

The Leapfrog Opportunity In The World's Underserved Health Care Markets

President Uhuru Kenyatta of Kenya

+ Comment Now

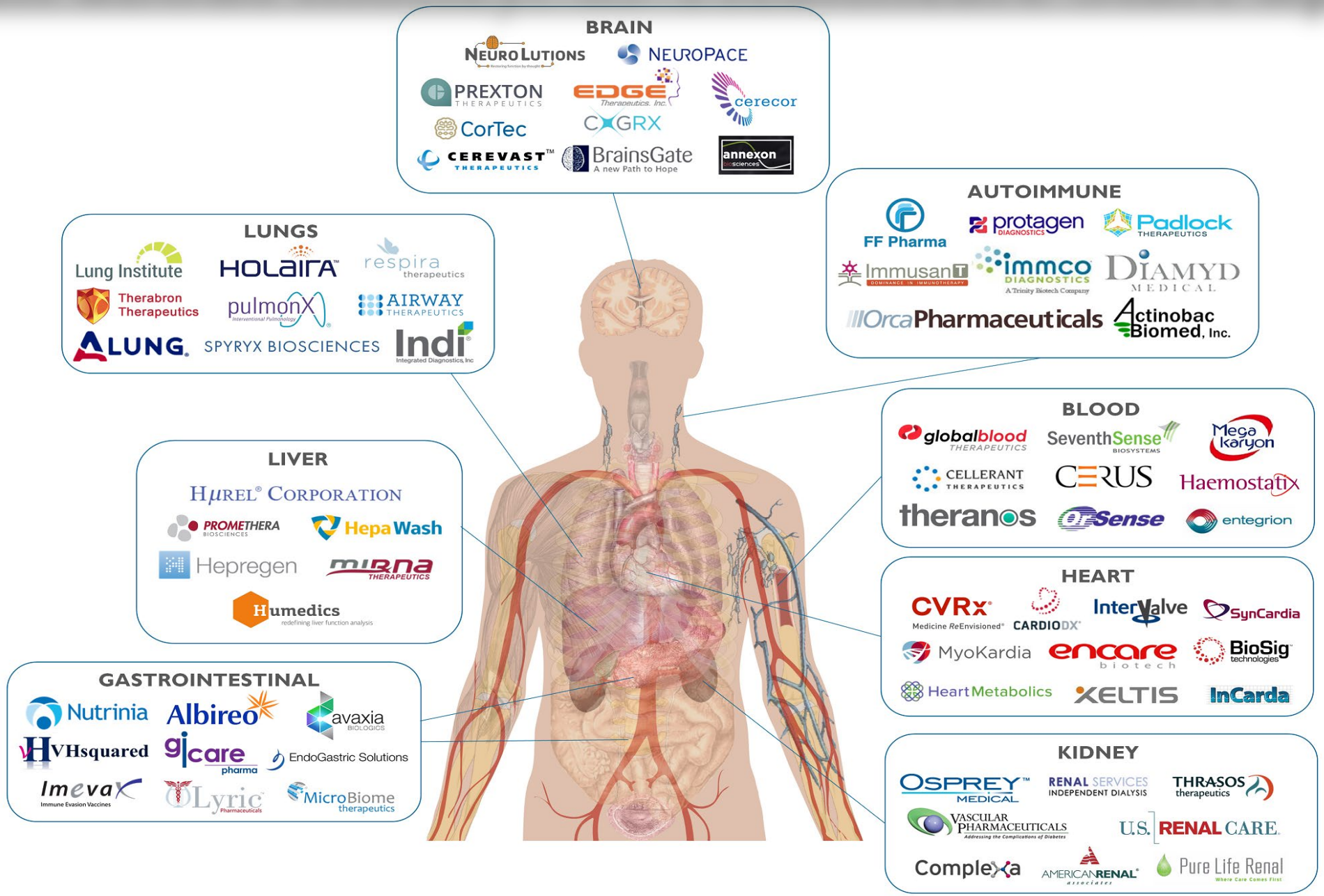
In Sub-Saharan Africa, traditional banking infrastructure has never quite gained a foothold. That's because instead of brick and mortar vaults, the region has seen sweeping use of mobile banking. Microfinancing and transfers, all from your cell phone, offered simplified, safer banking solutions for a fraction of the cost.

This is an example of "leapfrog" innovation and the same paradigm is beginning to emerge in health care in Africa, Asia and Latin America, creating a global opportunity for health innovators.

This past week President Obama was in Africa at the Global Entrepreneurship Summit calling on entrepreneurs and industry leaders to ignite growth on that continent and beyond. The question is will the leaders in today's largest health care markets seize the moment? Or will upstarts leap over them by bringing radically less expensive and more accessible healthcare options to the rest of the world?

http://onforb.es/1IQ1pSQ

Is it all about money? 69 Healthcare Start-ups (Yes)



Does US Abhor Low-Cost Healthcare?

How the healthcare system discourages creating low-cost solutions

http://jama.jamanetwork.com/article.aspx?articleid=2429454

The U.S. leads the world in creating new drugs and healthcare tech, but the system discourages inventors from creating cost-lowering technologies in favor of ones with a healthy return on investment, according to an article at the *Journal of the American Medical Association*.

"In the United States, the surest way to generate a healthy return on investment is to increase health care spending, not reduce it," says the authors, from the Uniformed Services University of the Health Sciences and Yale School of Medicine.

They use as an example a low-cost, once-a-day pill to treat cardiovascular disease, with the estimated potential to reduce the incidence of myocardial infarction and stroke by more than 80 percent.

MIT Technology Review

When curing a disease with gene therapy is bad business

A drug giant turns over its pipeline of miracle drugs to a startup.

by **Antonio Regalado** April 12, 2018

An analyst at Goldman Sachs asked a troubling question this week about gene therapy.

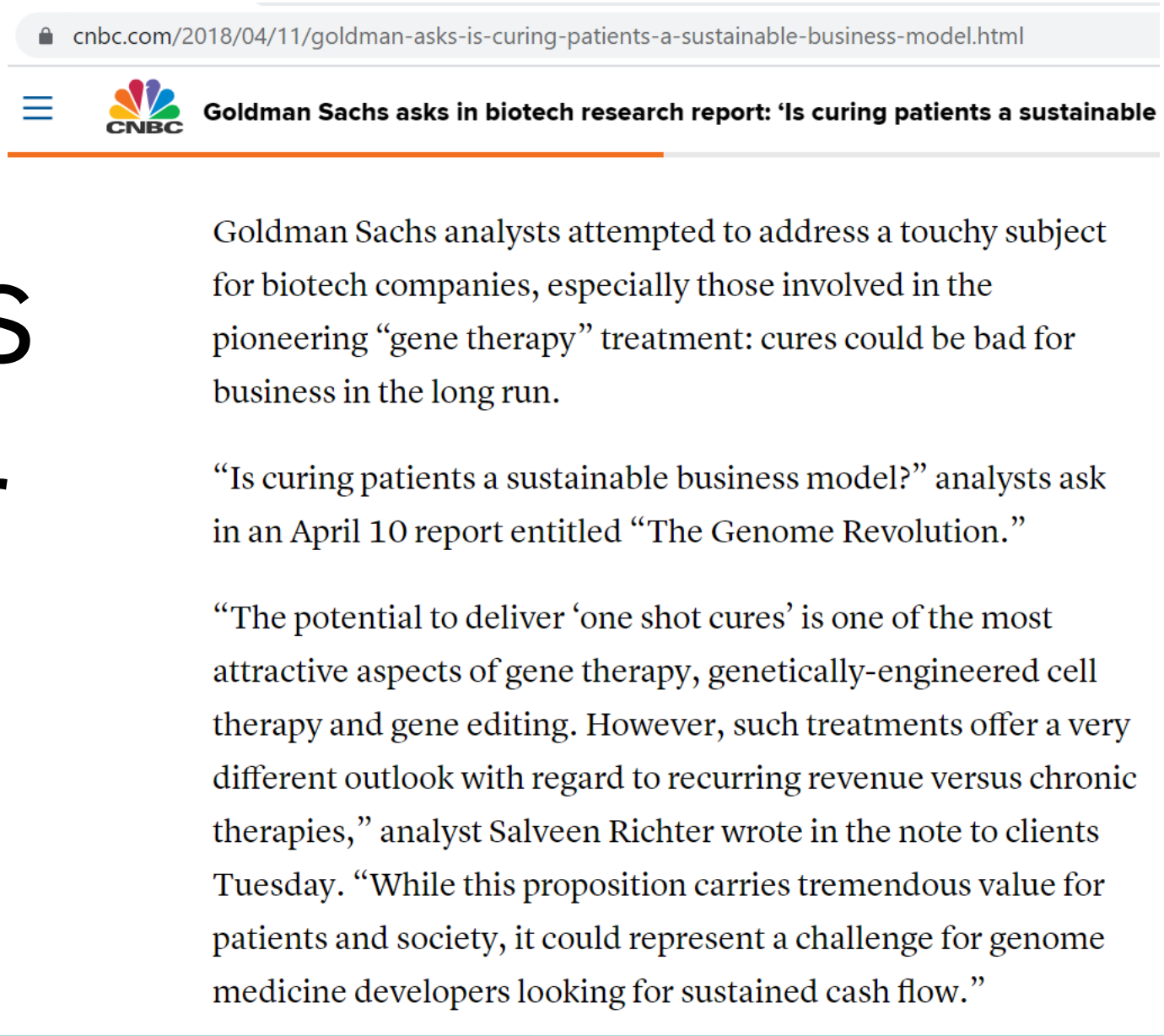
"Is curing patients a sustainable business model?"

In social media, reactions were quick and sharp. "Cold and immoral."

https://www.technologyreview.com/2018/04/12/143913/the-gene-therapy-that-cures-bubble-boy-disease-isnt-worth-it-to-glaxo/


cnbc.com/2018/04/11/goldman-asks-is-curing-patients-a-sustainable-business-model.html
CNBC
MARKETS
BUSINESS
INVESTING
TECH
POLITICS
CNBC TV
Goldman Sachs asks in biotech research report: 'Is curing patients sustainable business model?'
PUBLISHED WED, APR 11 2018•3:15 PM EDT | UPDATED WED, APR 11 2018•7:20 PM EDT

“medicine developers looking for sustained cash flow”



cnbc.com/2018/04/11/goldman-asks-is-curing-patients-a-sustainable-business-model.html

CNBC

Goldman Sachs asks in biotech research report: ‘Is curing patients a sustainable

Goldman Sachs analysts attempted to address a touchy subject for biotech companies, especially those involved in the pioneering “gene therapy” treatment: cures could be bad for business in the long run.

“Is curing patients a sustainable business model?” analysts ask in an April 10 report entitled “The Genome Revolution.”

“The potential to deliver ‘one shot cures’ is one of the most attractive aspects of gene therapy, genetically-engineered cell therapy and gene editing. However, such treatments offer a very different outlook with regard to recurring revenue versus chronic therapies,” analyst Salveen Richter wrote in the note to clients Tuesday. “While this proposition carries tremendous value for patients and society, it could represent a challenge for genome medicine developers looking for sustained cash flow.”

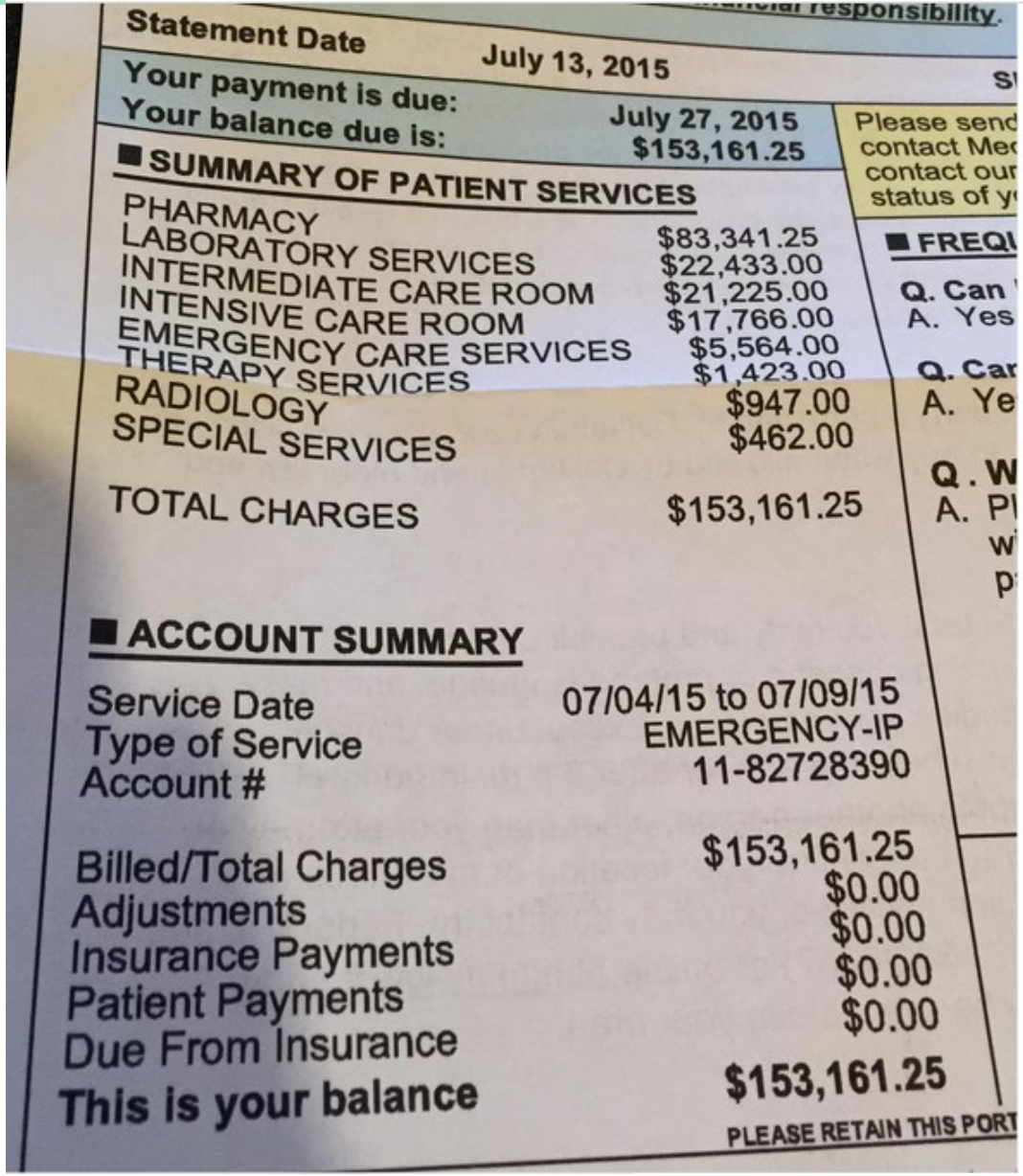
Understanding the principle of transaction cost economics

Transaction Cost

Ronald Coase (Nobel Prize in Economics, 1991)

American Healthcare

wp This $153,000 rattlesnake bite is everything wrong with



Statement Date July 13, 2015

Your payment is due: July 27, 2015
Your balance due is: $153,161.25

SUMMARY OF PATIENT SERVICES

PHARMACY	$83,341.25
LABORATORY SERVICES	$22,433.00
INTERMEDIATE CARE ROOM	$21,225.00
INTENSIVE CARE ROOM	$17,766.00
EMERGENCY CARE SERVICES	$5,564.00
THERAPY SERVICES	$1,423.00
RADIOLOGY	$947.00
SPECIAL SERVICES	$462.00
TOTAL CHARGES	$153,161.25

ACCOUNT SUMMARY

Service Date	07/04/15 to 07/09/15
Type of Service	EMERGENCY-IP
Account #	11-82728390
Billed/Total Charges	$153,161.25
Adjustments	$0.00
Insurance Payments	$0.00
Patient Payments	$0.00
Due From Insurance	$0.00
This is your balance	**$153,161.25**

PLEASE RETAIN THIS PORT

Dan Haggerty
@10NewsHaggerty

US AV PER CAPITA INCOME <$55,000

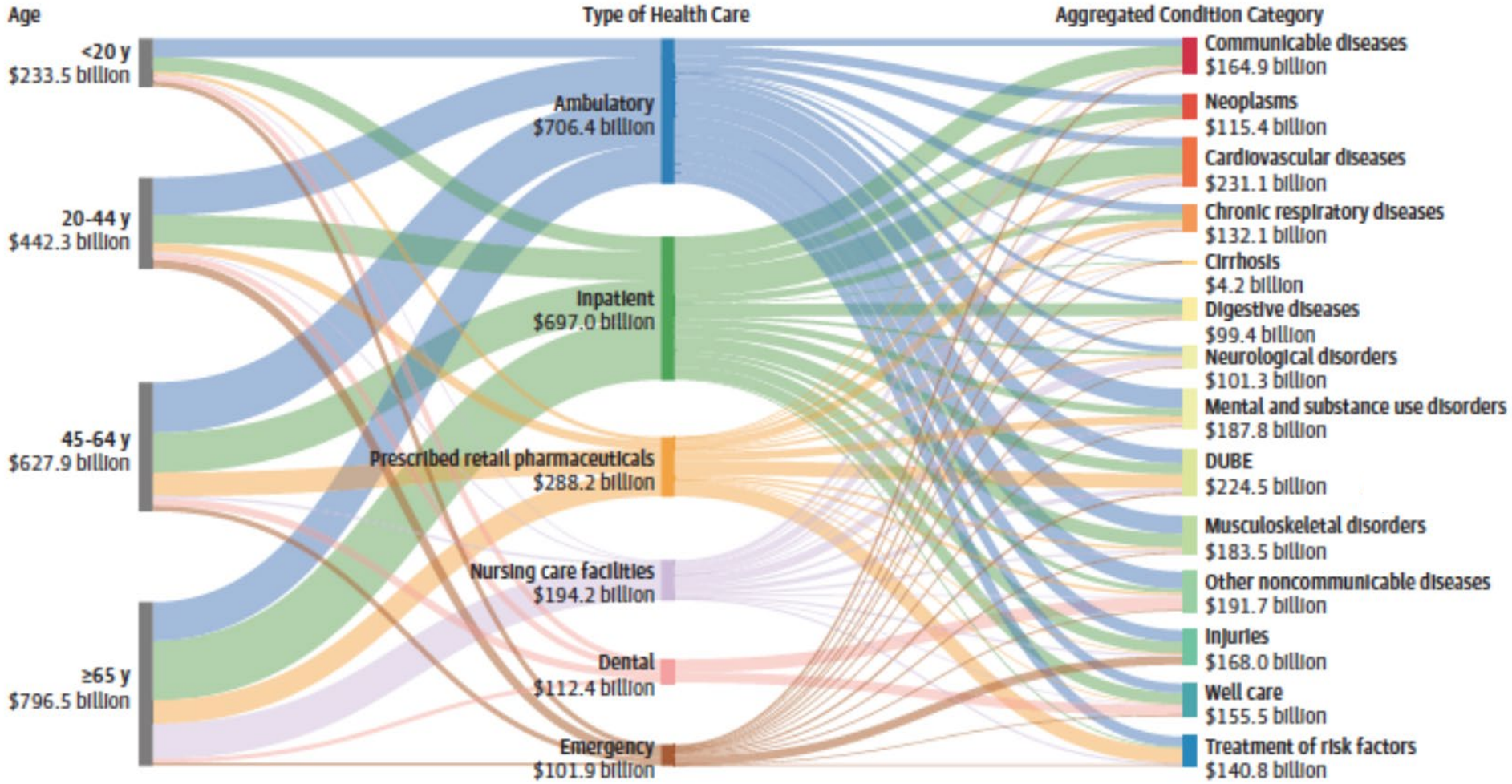
http://bit.ly/US-MEDICAL-WASTE

$153,161.25

US Hospital charges for

Treatment of Snake Bite

Personal Health Care Spending in the United States by Age Group, Aggregated Condition Category, and Type of Health Care, 2013



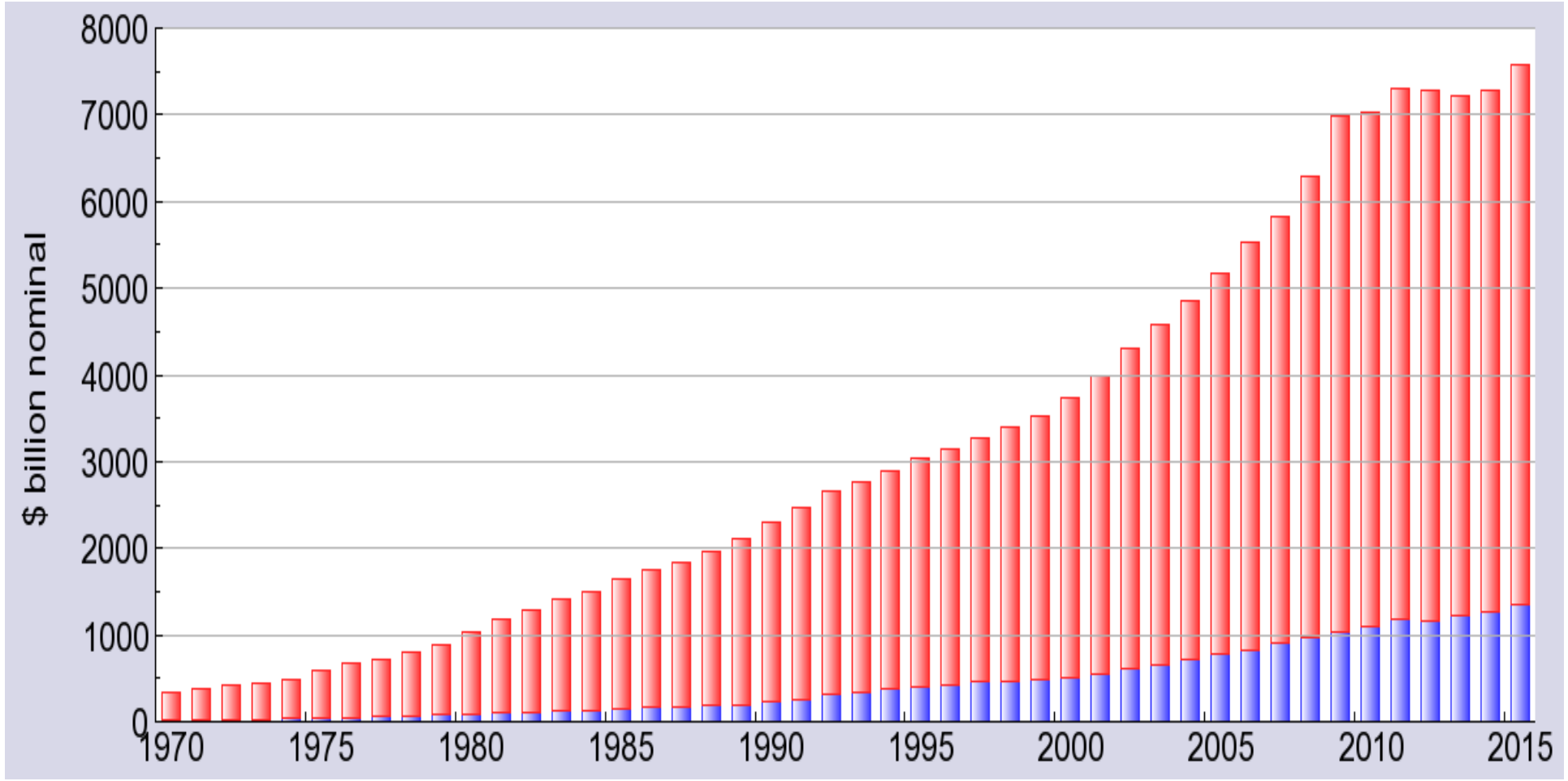
http://jamanetwork.com/journals/jama/fullarticle/2594716

https://image-store.slidesharecdn.com/8250a975-308d-40a7-a573-e4c1ab8d791b-original.png

DUBE indicates diabetes, urogenital, blood, and endocrine diseases. Reported in 2015 US dollars. Each of the 3 columns sums to the $2.1 trillion of 2013 spending disaggregated in this study. The length of each bar reflects the relative share of the $2.1 trillion attributed to that age group, condition category, or type of care. Communicable diseases included nutrition and maternal disorders. Table 3 lists the aggregated condition category in which each condition was classified.

Joseph L. Dieleman, PhD[1]; Ranju Baral, PhD[2]; Maxwell Birger,

TOTAL US HEALTHCARE SPENDING 1970-2015



www.usgovernmentspending.com/spending_chart_1970_2015USb_16s2li111

Forbes

EPIC GREED

http://onforb.es/KWJHJF

BUSINESS 6/18/2012 @ 7:59AM | 98,482 views

The Staggering Cost Of An Epic Electronic Health Record Might Not Be Worth It

Judy Faulkner once walked into a roomful of hospital CIOs, tossed her macramé handbag on a table, and announced she came to decide who she wanted as customers. Faulkner doesn't do marketing. The formidable founder of electronic health records Epic Systems boasts an enviable roster of customers made up of prestigious hospitals and academic centers. She has quietly convinced them that her product is best: a single, seamless database—the fruit of a company that has grown organically, and shunned acquisitions. And, because it is no small task to deploy, she is there all the way to hand-hold jittery CIOs, and help them get millions of dollars in government subsidies by showing meaningful use of her EHR.

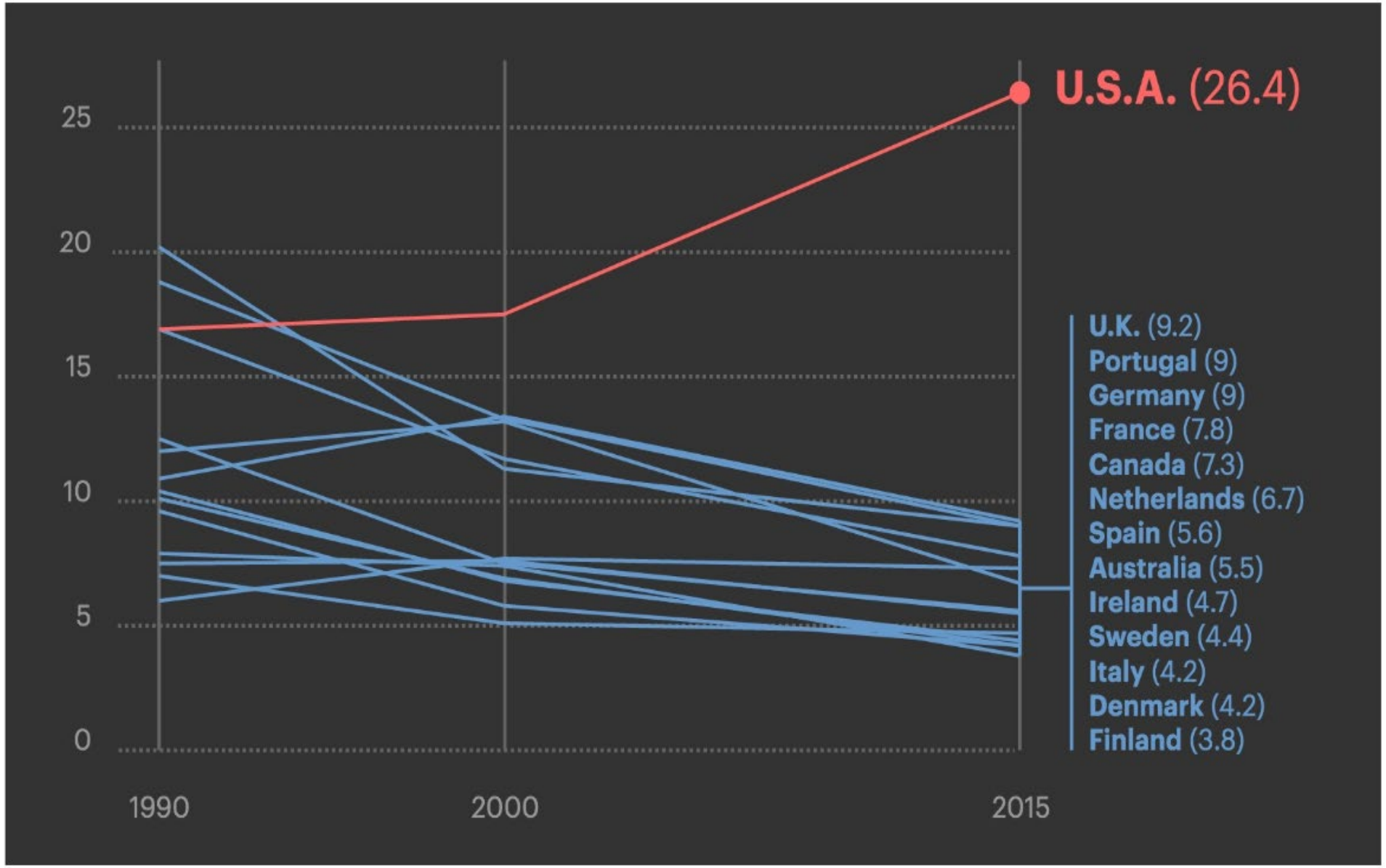
Her not-for-profit clientèle will need every penny of those taxpayers' dollars, but they won't cover anywhere near the staggering cost of an Epic EHR. Duke University Health System will shell out $700 million, so will Boston-based Partners HealthCare; University of California, San Francisco will pay $150 million.

$700 million

The “care” in healthcare

Where is it ??

Maternal Mortality Is Rising in the U.S. As It Declines Elsewhere



Per 100,000 live births. Source: "Global, regional, and national levels of maternal mortality, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015," The Lancet. Note: Only data for 1990, 2000 and 2015 was made available in the journal.

Leading causes of death in the USA (annual data)

1. 597,689 Heart Disease
2. 574,743 Cancer
3. 138,080 Chronic lower respiratory diseases
4. 129,476 Stroke
5. 120,859 Accidents
6. 83,494 Alzheimer's disease
7. 69,071 Diabetes
8. 56,979 Influenza &Pneumonia
9. 47,112 Kidney diseases
10. 41,149 Suicide

www.cdc.gov/nchs/fastats/deaths.htm

• 2010 • OIG HHS bad hospital care deaths ~180,000 patients in Medicare alone (in 1 year).

Patient Safety **2013**
Exploring Quality of Care in the U.S.

How Many Die From Medical Mistakes in U.S. Hospitals?

A New, Evidence-based Estimate of Patient Harms Associated with Hospital Care

John T. James, PhD

98,000
deaths due to error

210,000 – 440,000 deaths

400,000 deaths due to medical mistakes – shared with the US Senate

Deaths by medical mistakes hit records

Tejal Gandhi, MD, president of the National Patient Safety Foundation and associate professor of medicine, Harvard Medical School, spoke at the hearing.

The way IT is designed remains part of the problem

WASHINGTON | July 18, 2014

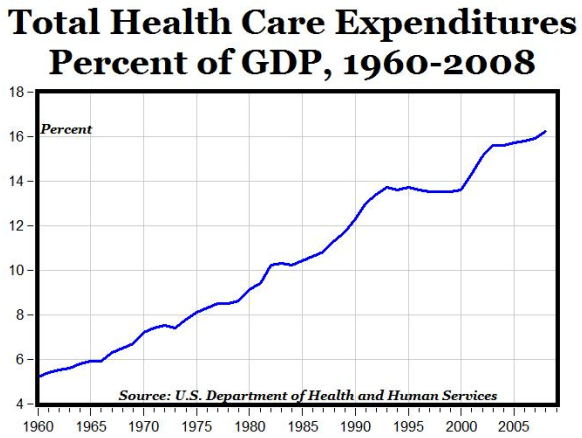
It's a chilling reality – one often overlooked in annual mortality statistics: Preventable medical errors persist as the No. 3 killer in the U.S. – third only to heart disease and cancer – claiming the lives of some 400,000 people each year. At a Senate hearing Thursday, patient safety officials put their best ideas forward on how to solve the crisis, with IT often at the center of discussions.

Hearing members, who spoke before the Subcommittee on Primary Health and Aging, not only underscored the devastating loss of human life – more than 1,000 people each day – but also called attention to the fact that these medical errors cost the nation a colossal $1 trillion each year.

"The tragedy that we're talking about here (is) deaths taking place that should not be taking place," said subcommittee Chair Sen. Bernie Sanders, I-Vt., in his opening remarks.

3rd Leading cause of death in the USA ?

1. 597,689 Heart Disease
2. 574,743 Cancer
3. ***Deaths Due to Medical Errors (180,000 - 210,000 - 440,000)***
4. 138,080 Chronic lower respiratory diseases
5. 129,476 Stroke
6. 120,859 Accidents
7. 83,494 Alzheimer's disease
8. 69,071 Diabetes
9. 56,979 Influenza &Pneumonia
10. 47,112 Kidney diseases
11. 41,149 Suicide



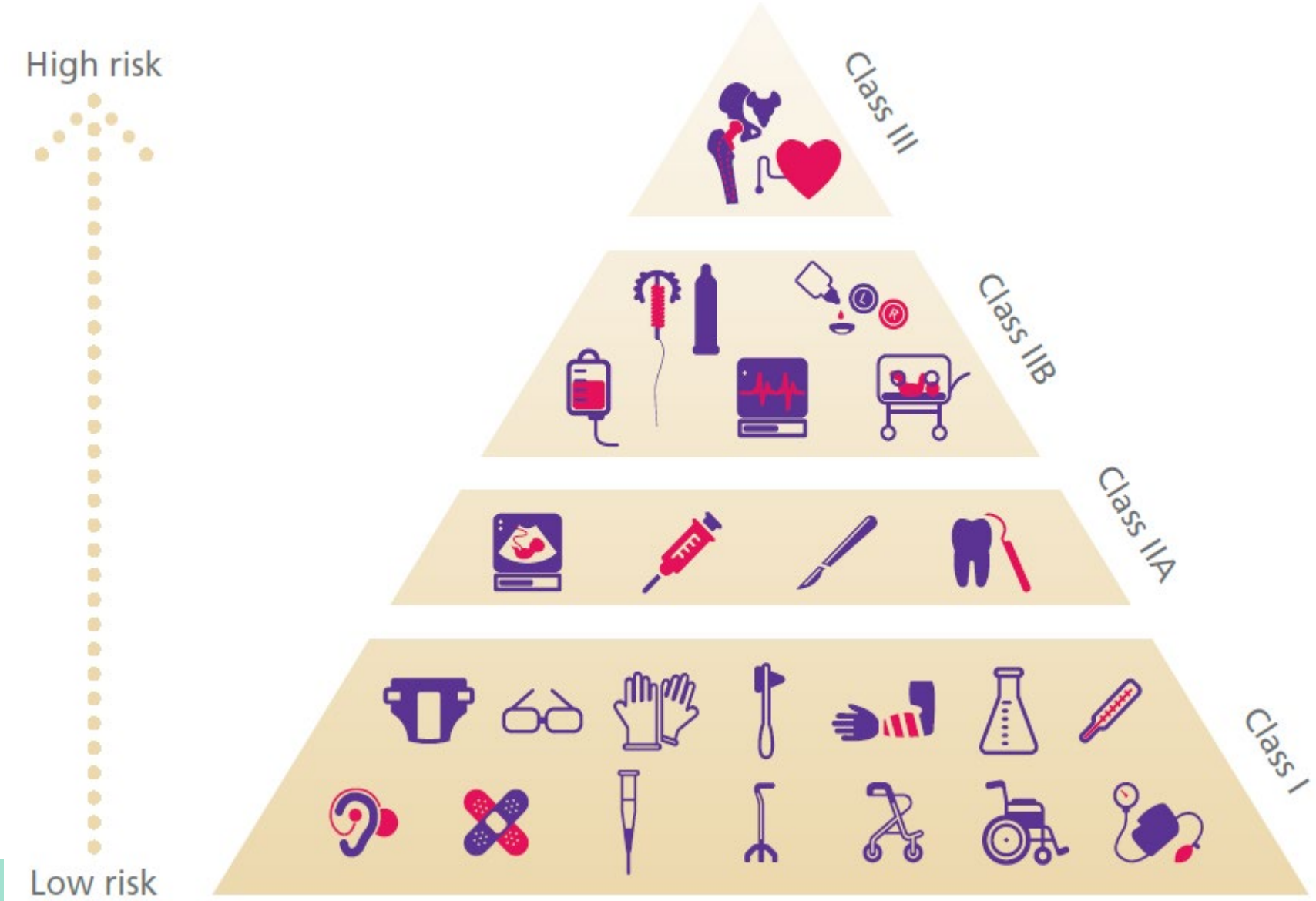
Equivalent to at least one 747 Jumbo Jet airplane crash every day

Medical Devices Today

stand alone, unintegrated, not patient-centric, proprietary data

- Philips Intellivue Series Monitors
- GE Solar 8000x / Dash 4/5000
- Dräger Apollo / EvitaXL / V500
- Nonin Bluetooth OnyxII 9650 / WristOx 3150
- Oridion Capnostream20
- Ivy 450C
- Nellcor N-595
- Masimo Radical-7

Device Manufacturers Builds Things – not Patient Care Systems



SOLUTIONS APPROACH

Devices that can talk to each other and synthesize data to present an integrated physiological status that is patient centric and updates patient medical records without locking raw data.

Autonomous Control of Morphine Infusion Pump – Medical Device Integration Model

Infusion Pump

Capnometer

Patient Simulator
Ventilator

Intelligent Monitor

Vital Signs Monitor

Simulator connected to vital signs monitor

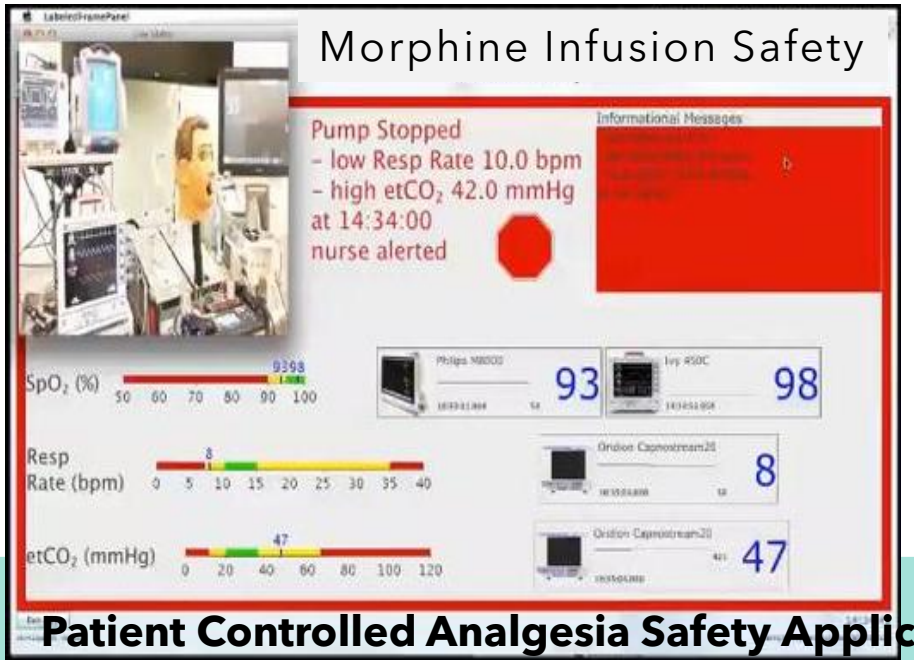
Fluke ProSim 8 connected to intelligent monitor

↓ O_2 Saturation

↓ Respiratory Rate

↑ end-tidal CO_2

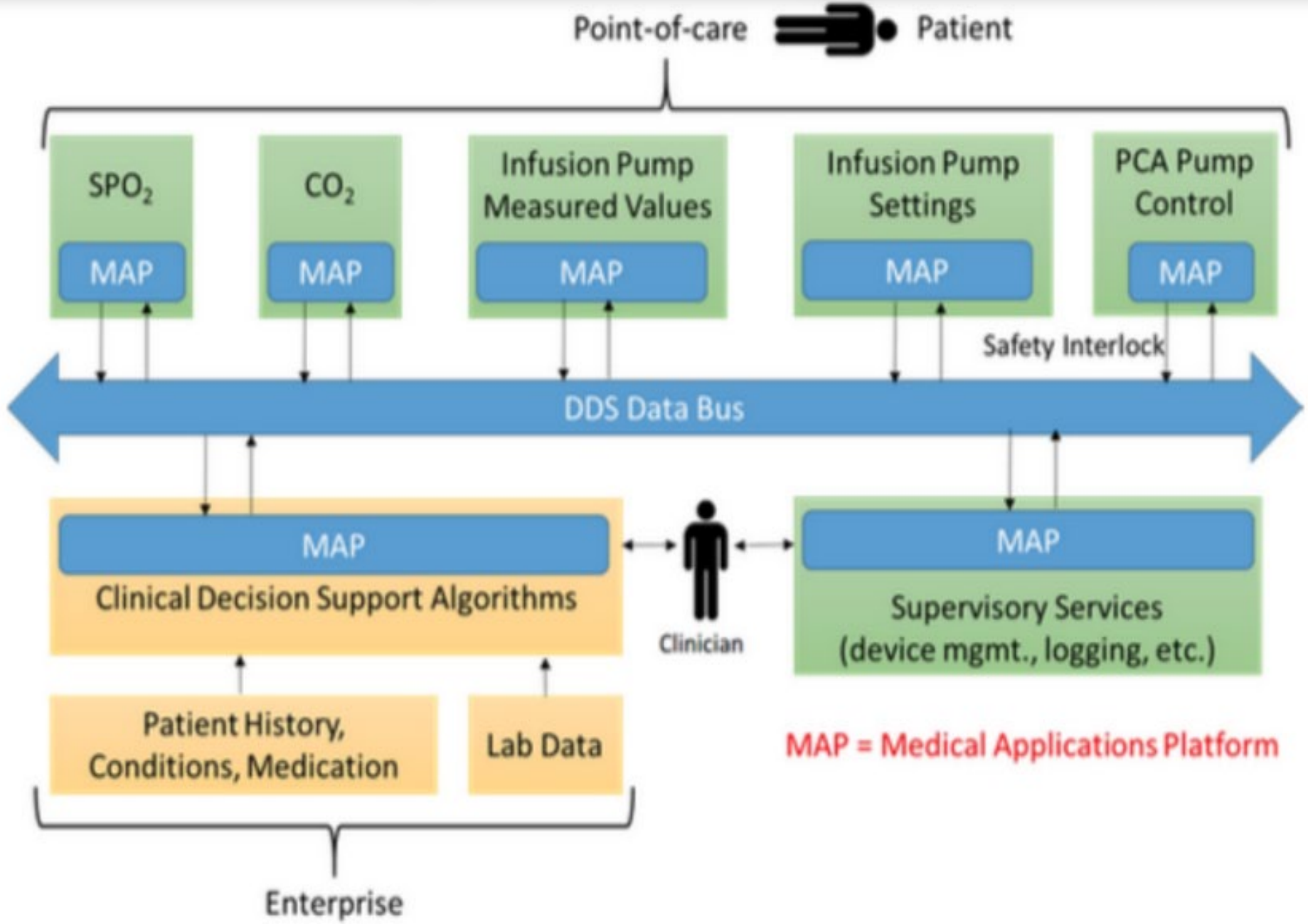
Connected Data
Collective Analysis
Automated Response



Patient Controlled Analgesia Safety Application

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

Autonomous Control of Morphine Infusion Pump – Medical Device Data Integration



PROOF OF CONCEPT

Response to White House Call for Ebola Management

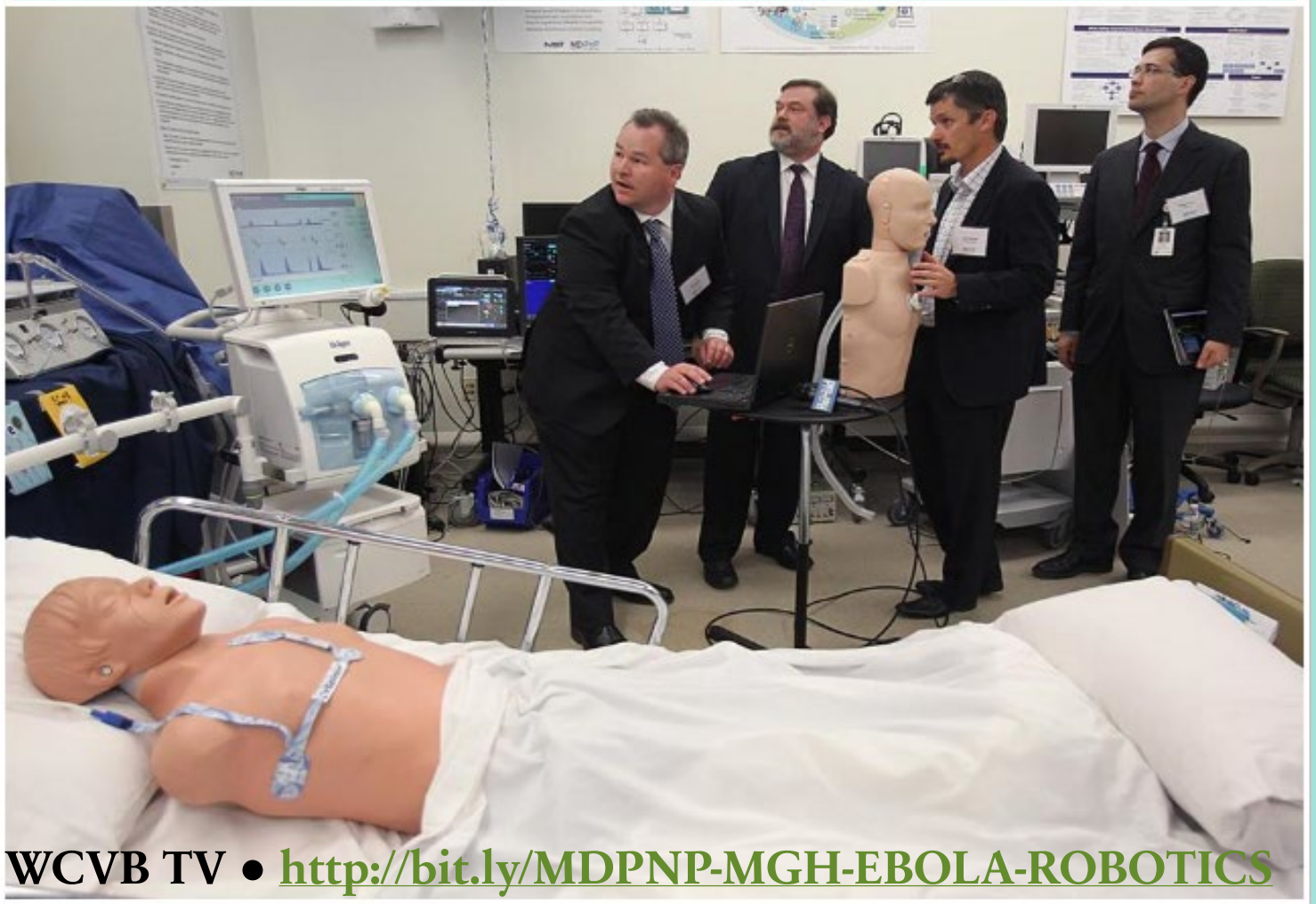
https://vimeo.com/111314176

Is there a need for Integrated Healthcare Platforms?

Ebola spurs rethinking of devices at MGH

By Carolyn Y. Johnson
| GLOBE STAFF NOVEMBER 07, 2014

You cannot buy a TV without a remote. You cannot buy a medical device with a remote. Dr Julian M Goldman, MGH



WCVB TV • http://bit.ly/MDPNP-MGH-EBOLA-ROBOTICS

SUZANNE KREITER/GLOBE STAFF

Health officials demonstrated treating an Ebola patient remotely in a mock ICU. Pictured, left to right: Eric Lynn, Julian M. Goldman, Brian Russell, and Dave Arney.

Robotic Tools in Infectious Diseases Management
Need for Medical Device Interoperability Platform

www.gereports.com/post/104422691785/hospital-hack-a-thon-attacks-ebola-with-robots

E
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A

COLLABORATORS

PARTNERS HEALTHCARE
FOUNDED BY BRIGHAM AND WOMEN'S HOSPITAL AND MASSACHUSETTS GENERAL HOSPITAL
MD PnP Getting Connected for Patient Safety
MGH 1811
HARVARD MEDICAL SCHOOL
FDA Center for Devices and Radiological Health
smiths medical bringing technology to life
Lyntek
FCC FEDERAL COMMUNICATIONS COMMISSION USA
IEEE
DOCBOX
Zephyr
COVIDIEN
TATRC
GE Healthcare
RESPIRATORY MOTION INC. INSPIRED INNOVATION
WPI
PHILIPS
Dräger
intel
IIC MEMBER industrial internet CONSORTIUM

MD PnP MedTech Hackathon Open Medical Device and Data Integration Platforms to Support the Management of Ebola

Will FDA drown medical device interoperability efforts through conventional regulatory acts?

☑ Yes ? ☒ No ?

Dr. Shuren received his B.S. and M.D. degrees from Northwestern University under its Honors Program in Medical Education. He completed his medical internship at Beth Israel Hospital in Boston, his neurology residency at Tufts New England Medical Center, and a fellowship in behavioral neurology and neuropsychology at the University of Florida. He received his J.D. from the University of Michigan.

Participation of the US FDA CDRH was a powerful incentive for medical device manufacturers to explore innovative medical technology solutions, especially those benefiting from interoperability between manufacturers

DEPARTMENT OF HEALTH & HUMAN SERVICES

Food and Drug Administration
10903 New Hampshire Avenue
Room 5447, Building 66
Silver Spring, MD 20993-0002

November 3, 2014

Julian M. Goldman, MD
Director, Medical Device Interoperability Program
65 Landsdowne Street
Cambridge, MA 02139

Dear Dr. Goldman,

Thank you for reaching out to the Center for Devices and Radiological Health (CDRH) via our Emergency Preparedness/Operations and Medical Countermeasures (EMCM) Program.

We understand that The Medical Device "Plug-and-Play" (MD PnP) Interoperability Program, under your coordination, has been asked by the White House Office of Science and Technology Program to mobilize resources among medical device manufacturers and the clinical community, so as to design and demonstrate proof of concept for an interoperable platform that would enable critical care of Ebola-infected patients in an isolation environment with reduced exposure to health care workers.

FDA recognizes the importance of implementing strategies that minimize direct exposure of clinical personnel to patients infected with Ebola virus. We understand that MDPNP, along with its collaborators, are developing potential approaches that would include comprehensive data access and potential remote control of medical devices in the isolation environment, thereby reducing the risk of healthcare worker exposure to the virus.

CDRH recognizes the importance of these efforts and is ready and willing to collaborate with you, the clinical community and your industry partners to demonstrate the potential of this technology in serving this particular public health emergency. We are eager to observe the demonstration taking place Friday November 7th for OSTP, and we look forward to participating in the development of next steps with MDPNP and your medical device partners so as to do our part in enabling advancement of technology that can protect our healthcare workers who put themselves on the front line to promote the public health mission.

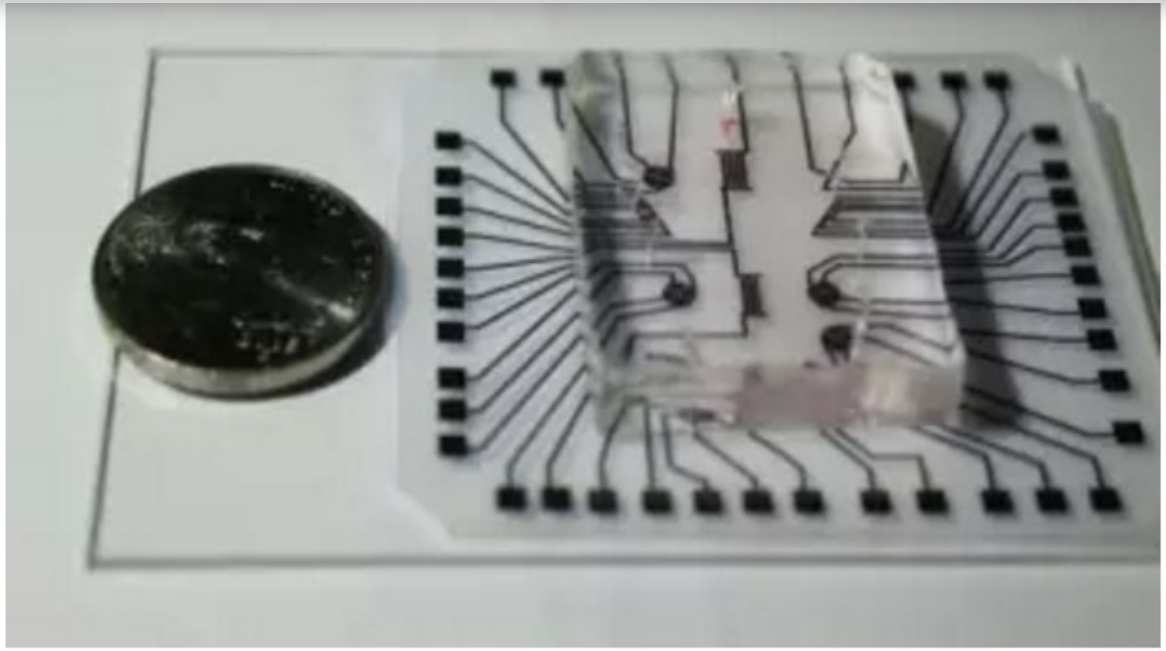
Sincerely,

Jeffrey Shuren, M.D., J.D.
Director
Center for Devices and
Radiological Health

Plethora of healthcare tools

What's stopping them from providing services for humanity?

IS HEALTHCARE A HUMAN RIGHT ? IS IT FOR THE BILLIONS ?



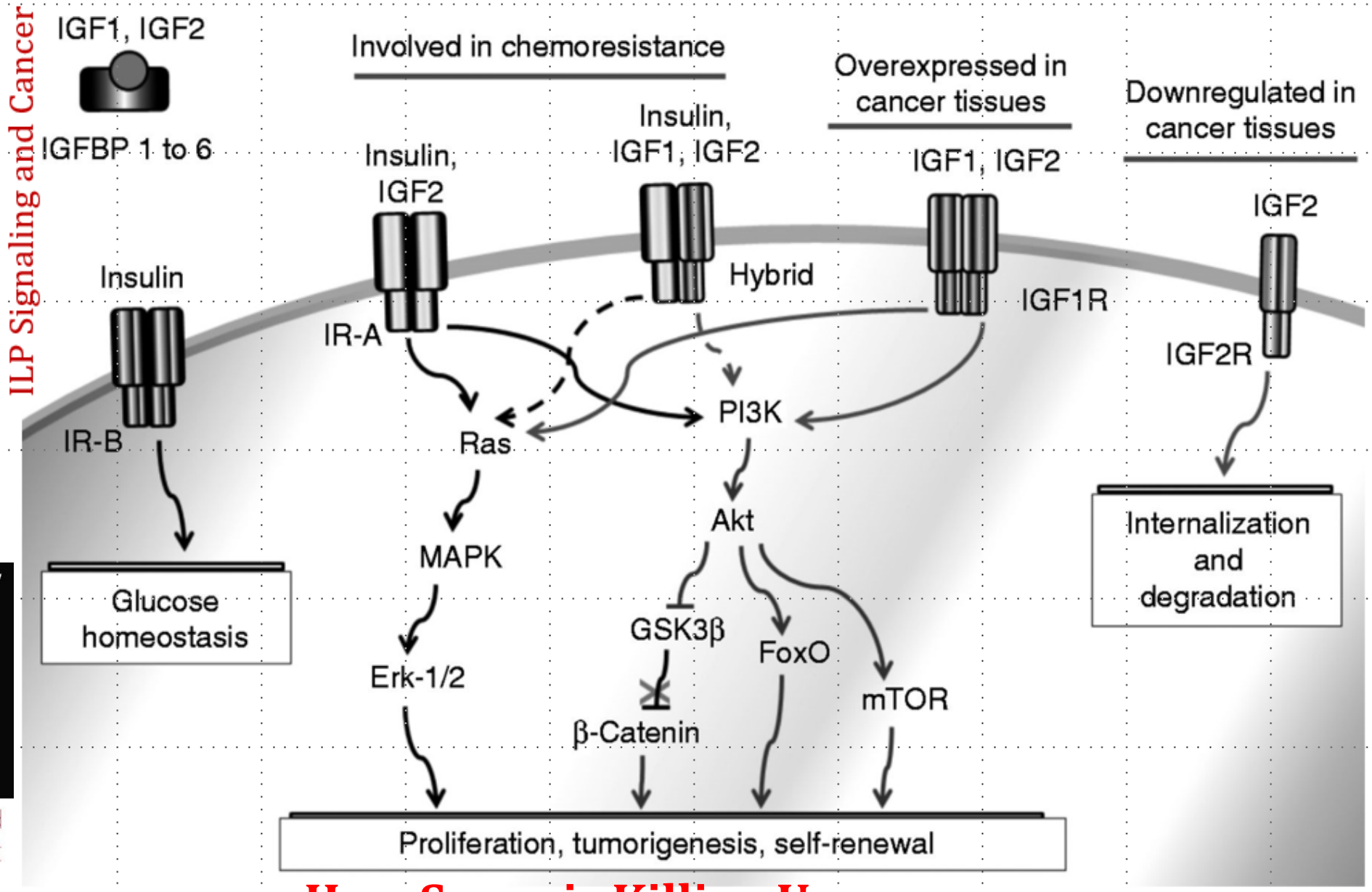
This device costs one cent to make and could help deliver critical diagnostic care to remote, impoverished areas of the globe. (Image courtesy of Stanford.)

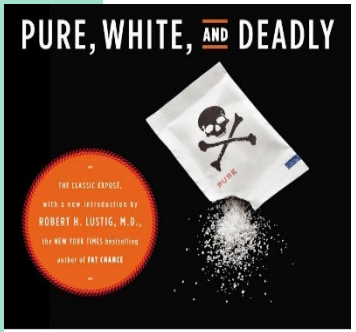
Multifunctional, inexpensive, and reusable nanoparticle-printed biochip for cell manipulation and diagnosis

Rahim Esfandyarpour[a,b], Matthew J. DiDonato[c], Yuxin Yang[d], Naside Gozde Durmus[a,b], James S. Harris[d], and Ronald W. Davis[a,b,1]

https://www.pnas.org/content/pnas/114/8/E1306.full.pdf

Insulin Resistance and Cancer



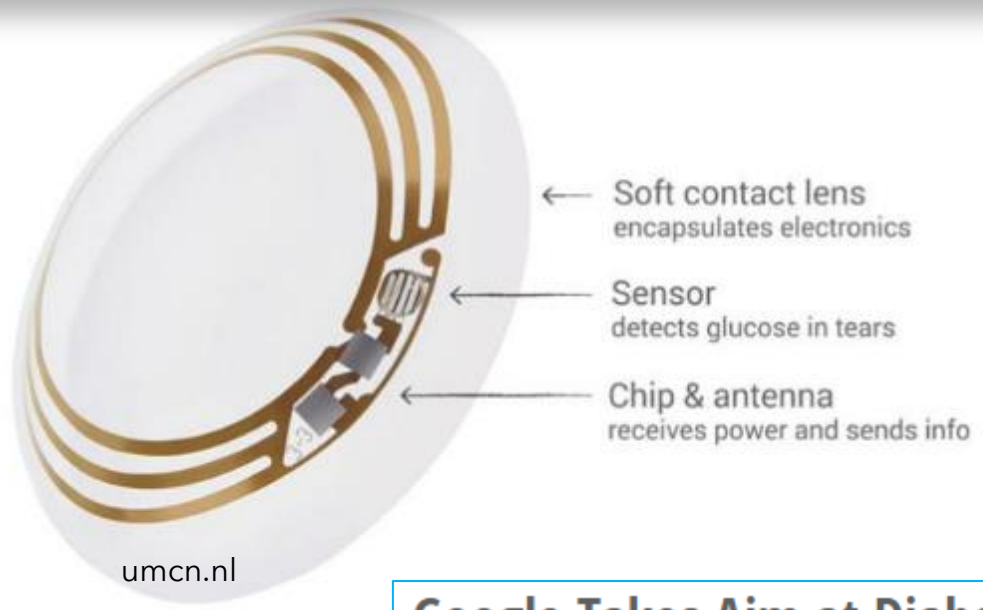


How Sugar is Killing Us

www.ncbi.nlm.nih.gov/pubmed/23207292

http://jamanetwork.com/journals/jamainternalmedicine/article-abstract/2548255

DIABETES - The next pandemic?



umcn.nl

Google, DexCom to Make Glucose Monitoring Devices for Diabetes Patients

by Robin Sinha , 13 August 2015

Soon after the announcement of its new CEO Sundar Pichai and a holding company called Alphabet, the Google Life Sciences team has teamed up with a healthcare firm DexCom to build blood glucose monitoring devices for diabetes patients that are smaller and less expensive than current technologies.

Google Takes Aim at Diabetes with Big Data, Internet of Things

By **Jennifer Bresnick** on August 31, 2015

SANOFI

HARVARD MEDICAL SCHOOL

ABOUT HMS | EDUCATION

Joslin Diabetes Center

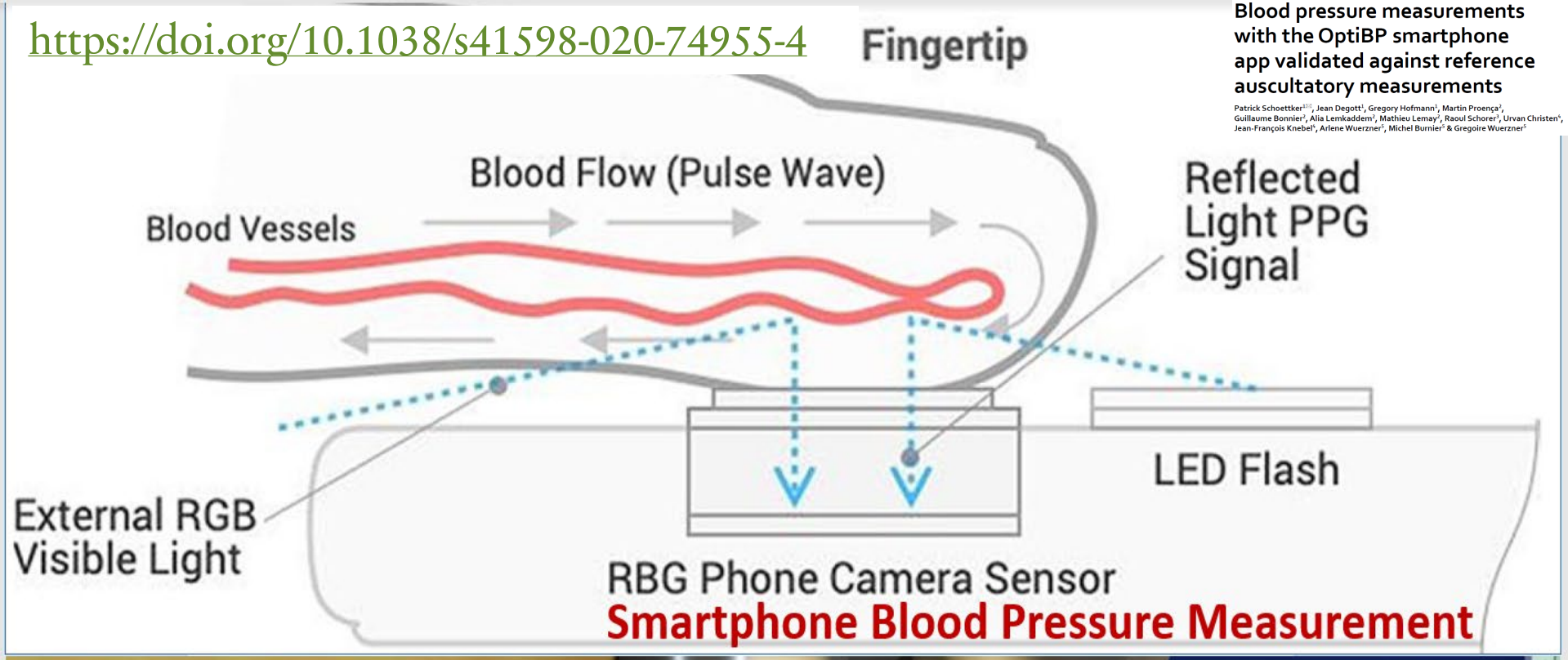
Freshly revitalized after Google's much-discussed reorganization under the **Alphabet** umbrella, the tech giant's life science team is once again **planning to tackle diabetes** with the help of big data analytics and innovative Internet of Things technologies.

With the formation of a new partnership that enlists the aid of the Joslin Diabetes Center and Sanofi, a multinational pharmaceutical developer, Google hopes to reduce the burden of Type 1 and Type 2 diabetes on both patients and providers.

https://doi.org/10.1038/s41598-020-74955-4

Blood pressure measurements with the OptiBP smartphone app validated against reference auscultatory measurements

Patrick Schoettker[1✉], Jean Degott[1], Gregory Hofmann[1], Martin Proença[2], Guillaume Bonnier[2], Alia Lemkaddem[2], Mathieu Lemay[2], Raoul Schorer[3], Urvan Christen[4], Jean-François Knebel[4], Arlene Wuerzner[3], Michel Burnier[3] & Gregoire Wuerzner[3]



Smartphone Blood Pressure Measurement

Non-invasive Blood Glucose Monitoring

BLOOD-FREE NON-INVASIVE BLOOD HEMOGLOBIN ??

Laser excitation of oxy-hemoglobin generates highly specific resonance (Raman spectra) which could be exploited in the development of non-invasive tool.

This statement is made by the author. It is merely a suggestion.

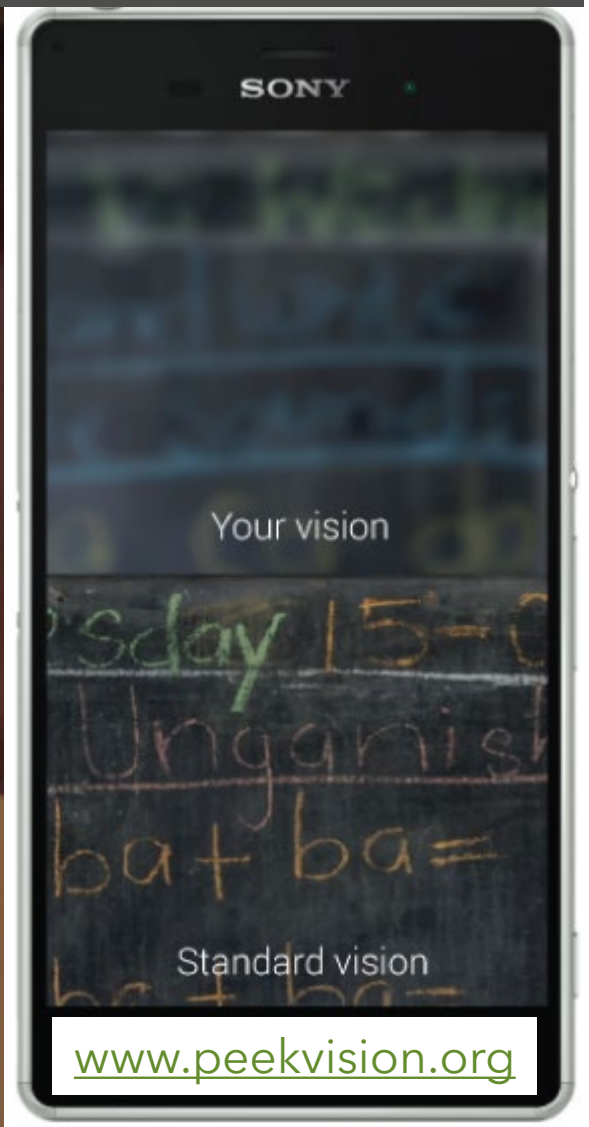
Wrig Nanosystems, a medical technology startup company which develops and markets a hemoglobin measurement device, has attracted financial interest from different investors in the product. The company has made an investment of up to 15 cr to commercialise and further develop the product and Avendus Wealth Management acted as the advisor to Wrig on this deal.

The list of investors includes Flipkart co-founders Sachin and Binny Bansal, Malvinder and Shivinder Singh (former Ranbaxy and Fortis promoters), Gurpreet Singh (Round Glass Partners) and others.

Optics for the Masses

- View the retina with high quality imaging
- See cataracts clearly for classification
- Simulates a patient's eyesight on screen
- Visual acuity tests for eyesight
- Colour and contrast tests

The Peek Retina adapter is being developed through a collaboration between the University of Strathclyde, where Dr Mario Giardini heads the engineering design; the London School of Hygiene & Tropical Medicine; and the Glasgow Centre for Ophthalmic Research of NHS Greater Glasgow and Clyde.



OPTICIAN'S CLINIC-IN-A-POCKET

A woman from Nakuru, Kenya, having a cataract scan with the Peek smartphone tool. This portable eye testing kit can diagnose eye problems in remote areas, where access to clinics is limited. ©Peek

www.bbc.com/news/health-22553730

What we hope is that it will provide eye care for those who are the poorest of the poor

Dr Andrew Bastawrous, London School of Hygiene and Tropical Medicine

What the phone app can do for eyes

Peek can diagnose a vast range of eye problems, blindness and vision impairments,

- Glaucoma
- Cataracts
- Macular degeneration
- Diabetic retinopathy
- Other retinal and optic nerve diseases.

MIT News
ON CAMPUS AND AROUND THE WORLD

https://news.mit.edu/2017/cardiio-app-screens-arrhythmia-smartphone-camera-0329

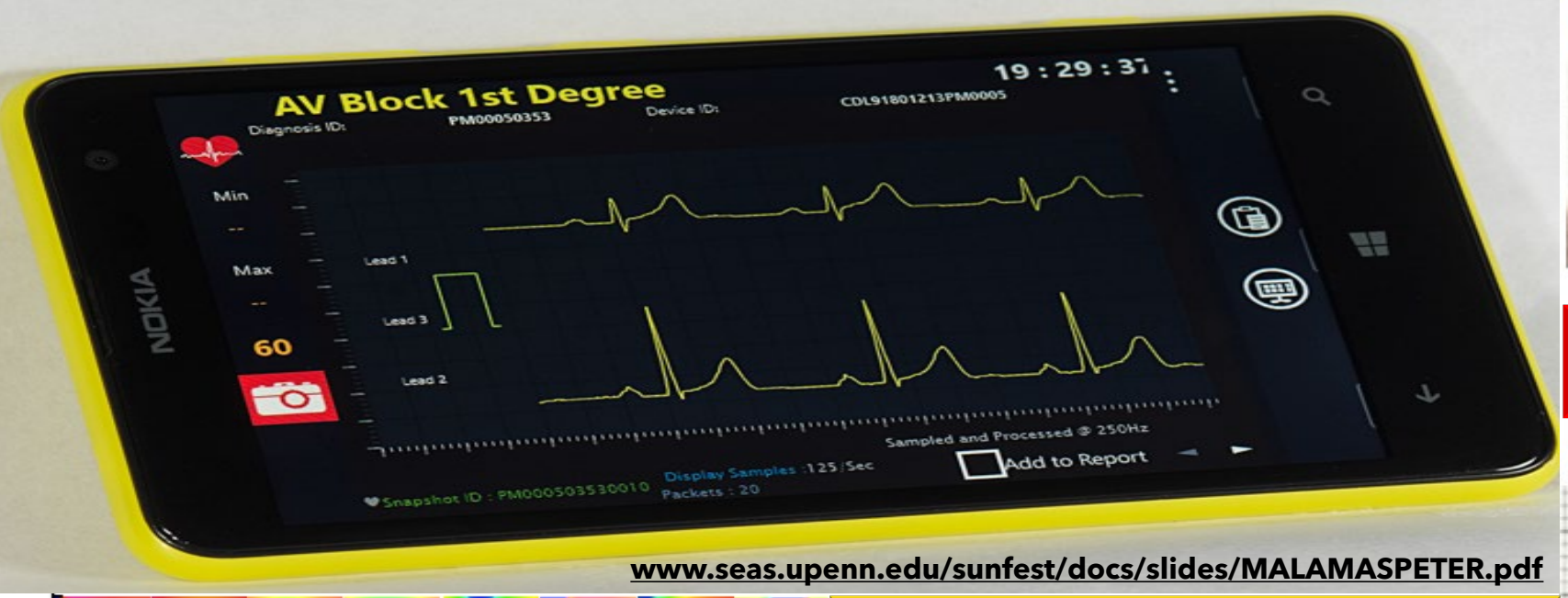
MIT Media Lab spinout Cardiio has developed a mobile app that uses a smartphone camera to detect facial signs of a heart arrhythmia associated with strokes.

Courtesy of Cardiio

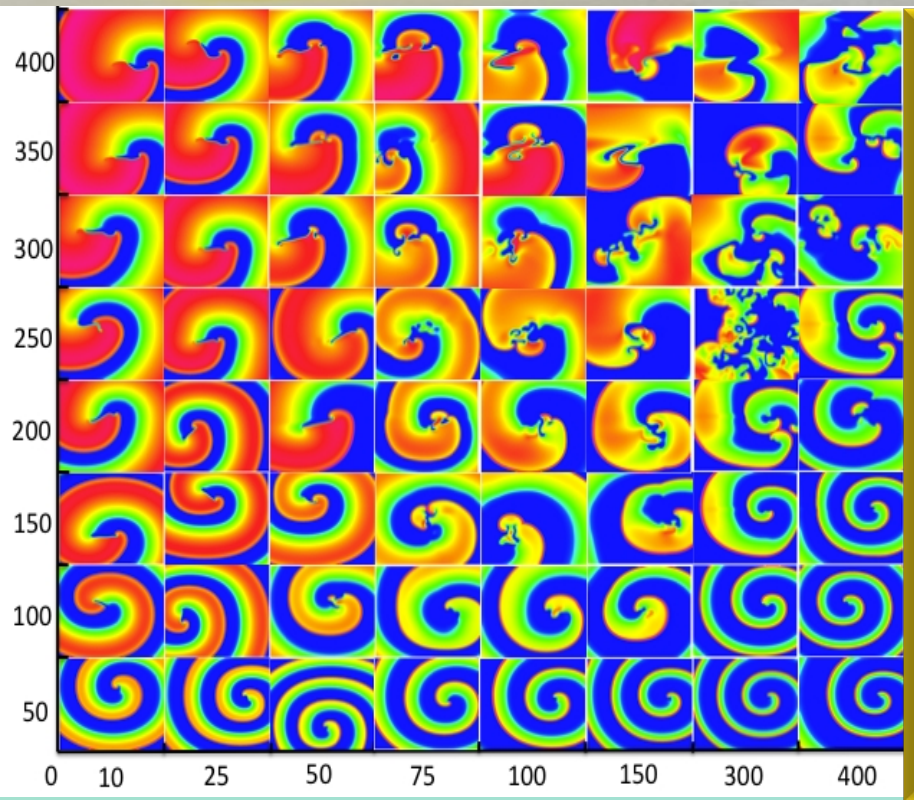
App screens for arrhythmia using smartphone

Dr Leslie Saxon, University of Southern California

PHONE ECG DETECTS IRREGULAR HEARTBEAT



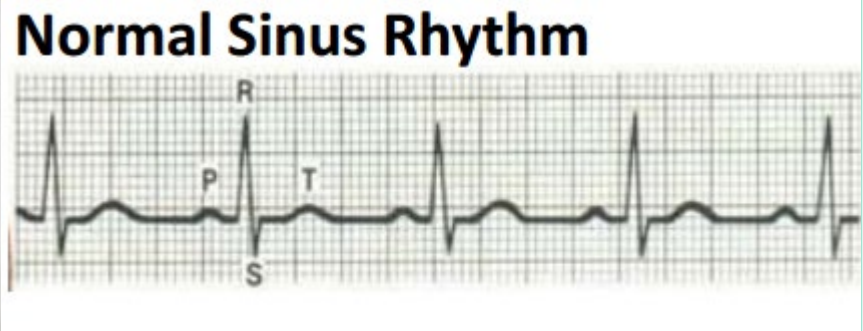
www.seas.upenn.edu/sunfest/docs/slides/MALAMASPETER.pdf



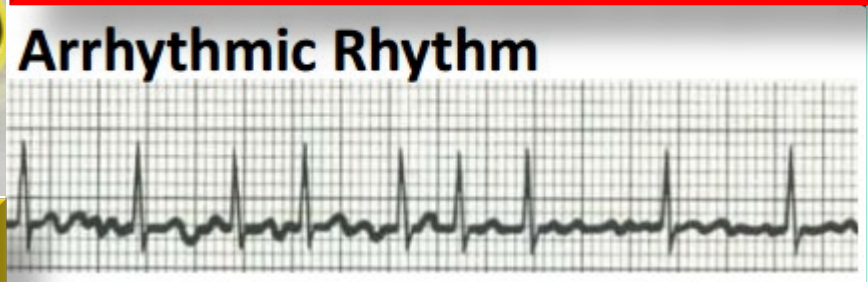
CARDIAC ARRHYTHMIA

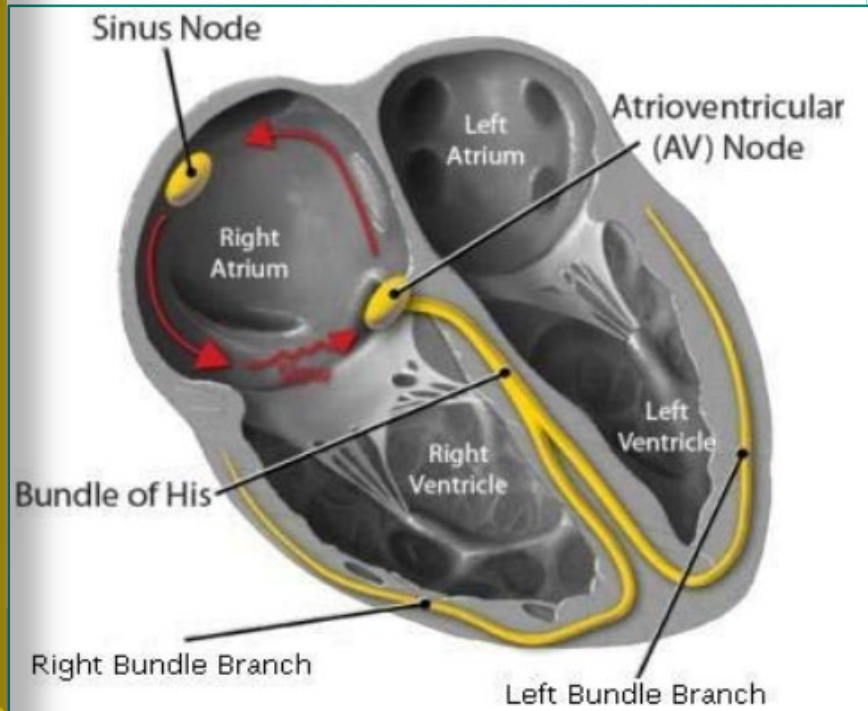
DIAGNOSIS & REPORTING

CARDIOLOGIST-in-a-POCKET

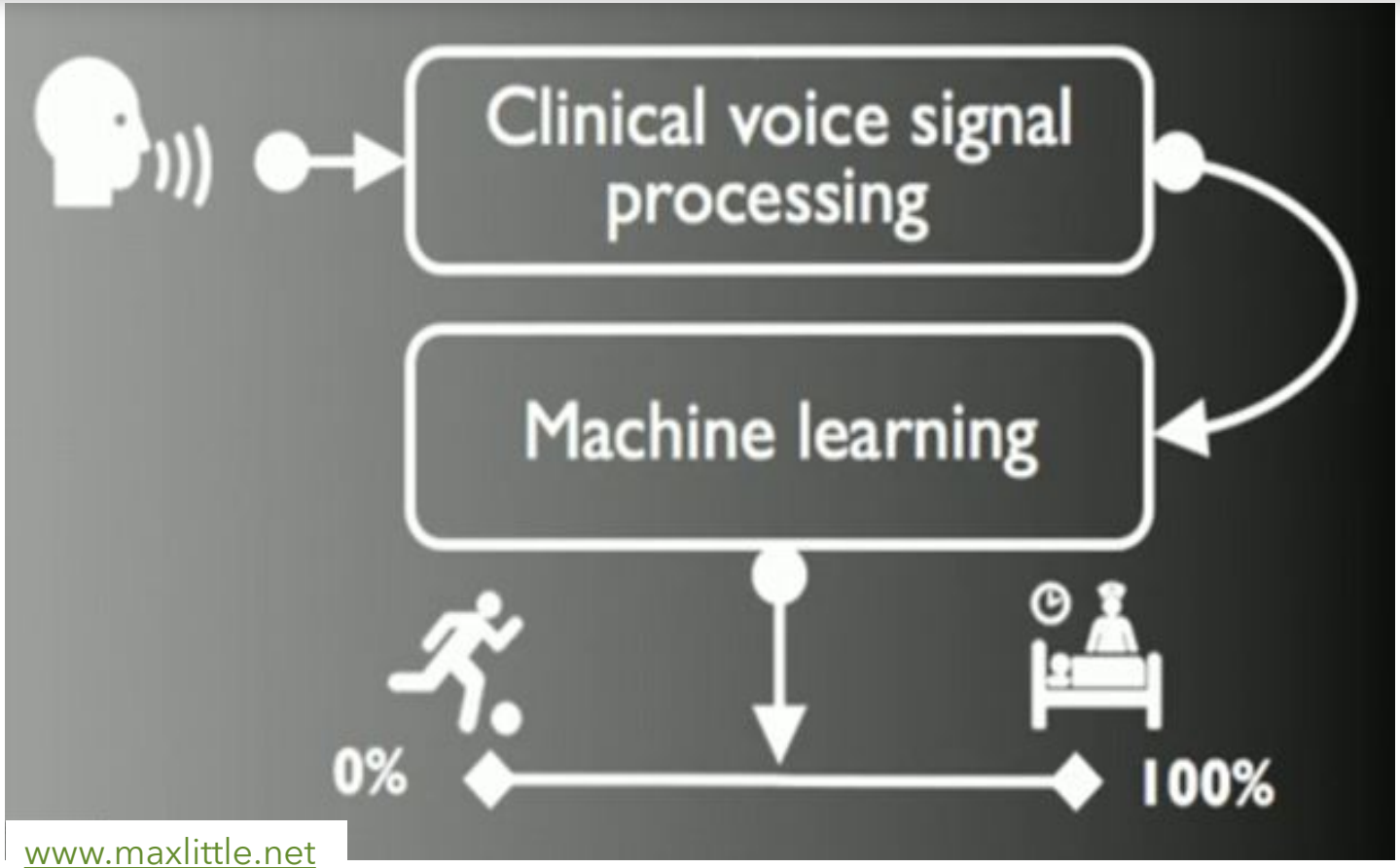


Circular pathways in the heart conduction System is a common cause of arrhythmias





How reliable is the detection of Parkinson's Disease using a smartphone?



www.maxlittle.net

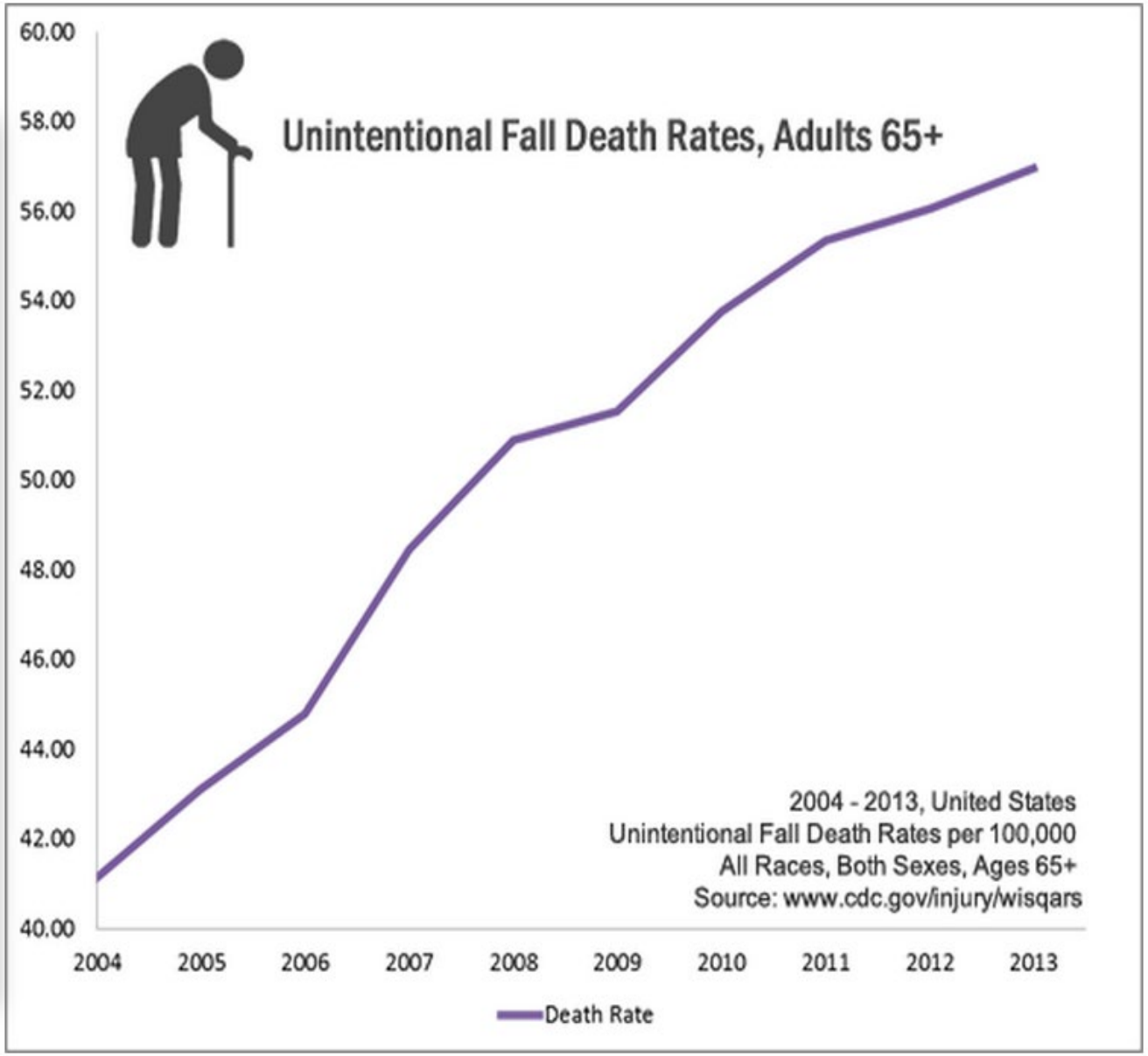
Acoustic signal processing data may be used to detect Parkinson's Disease with a smartphone or predict torrential rainfall or used in hydrogeomorphology apps.

2.5 million falls, 2013

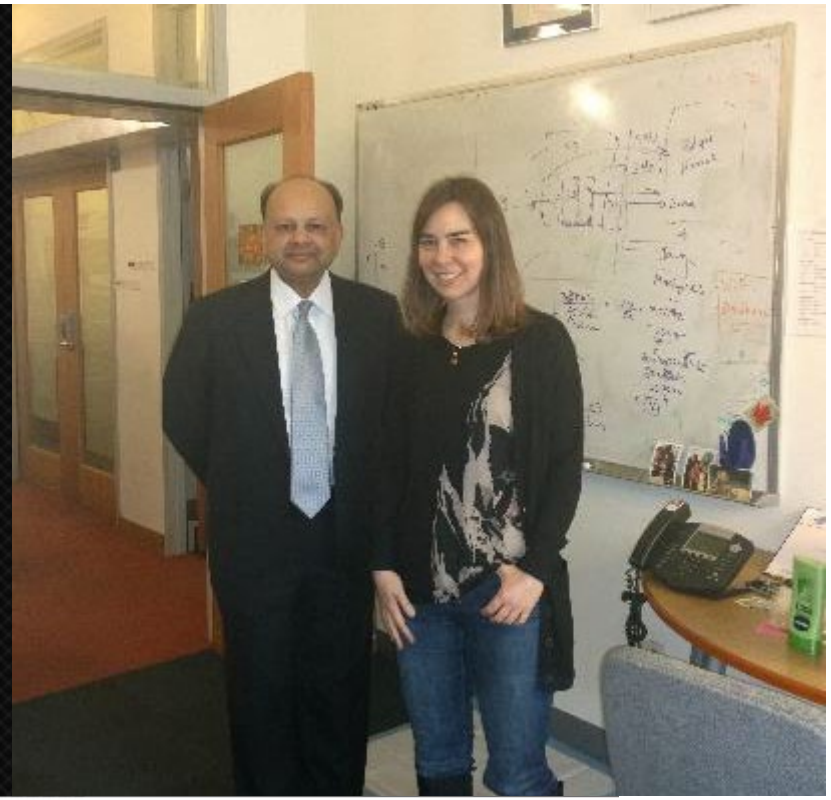
734,000 hospitalized

25,500 died from fall

$34 billion direct cost



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

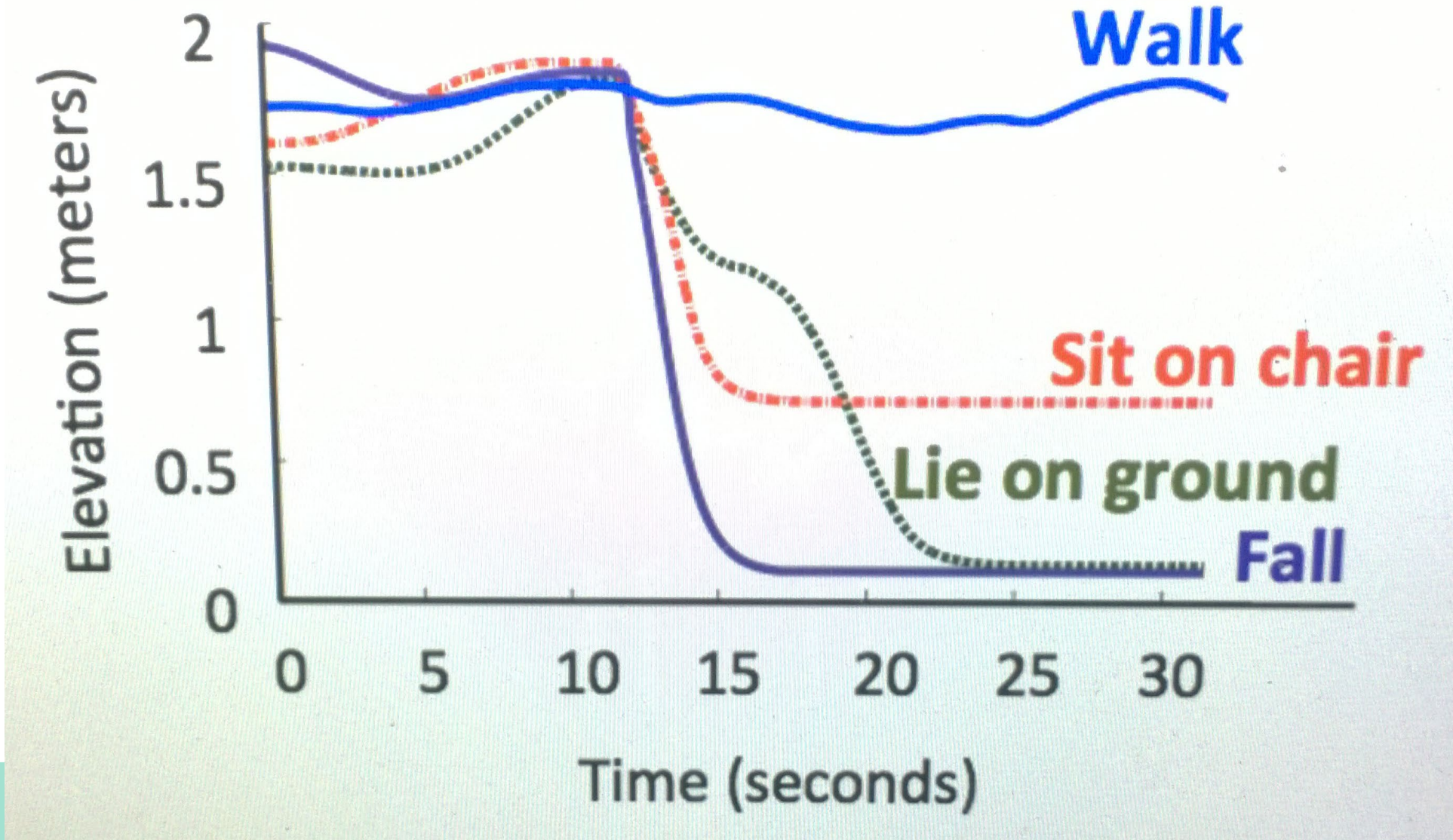


President Obama invites MIT entrepreneurs to give demo at the White House http://bit.ly/President-Obama-with-Dina-Katabi

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

Fall Detection – Wire less, Sensor less, Without any Wearable

RF Reflection Data from Prof Dina Katabi, Wireless Center, CSAIL, MIT

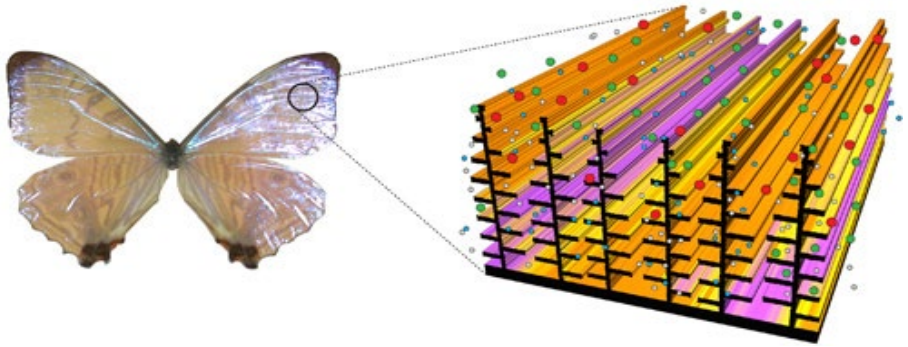


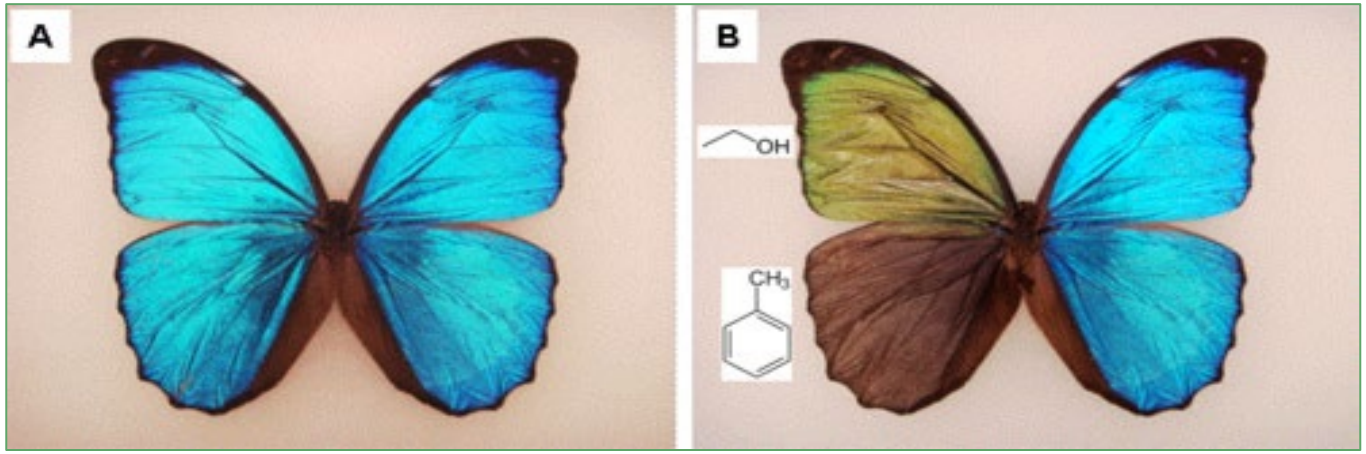
Digital Health and Advances in Diagnostic Tools / Systems

How relevant is it for the less affluent world?

Preventive Medicine • Diagnostic Devices with High Performance Sensitive Nano-Sensors

Swiss engineer George de Mestro invented Velcro after his dog came home covered with thistle burrs, Speedo learned from sharkskin to make faster swimsuits, and chemical companies designed self-cleaning paint after studying lotus leaves.



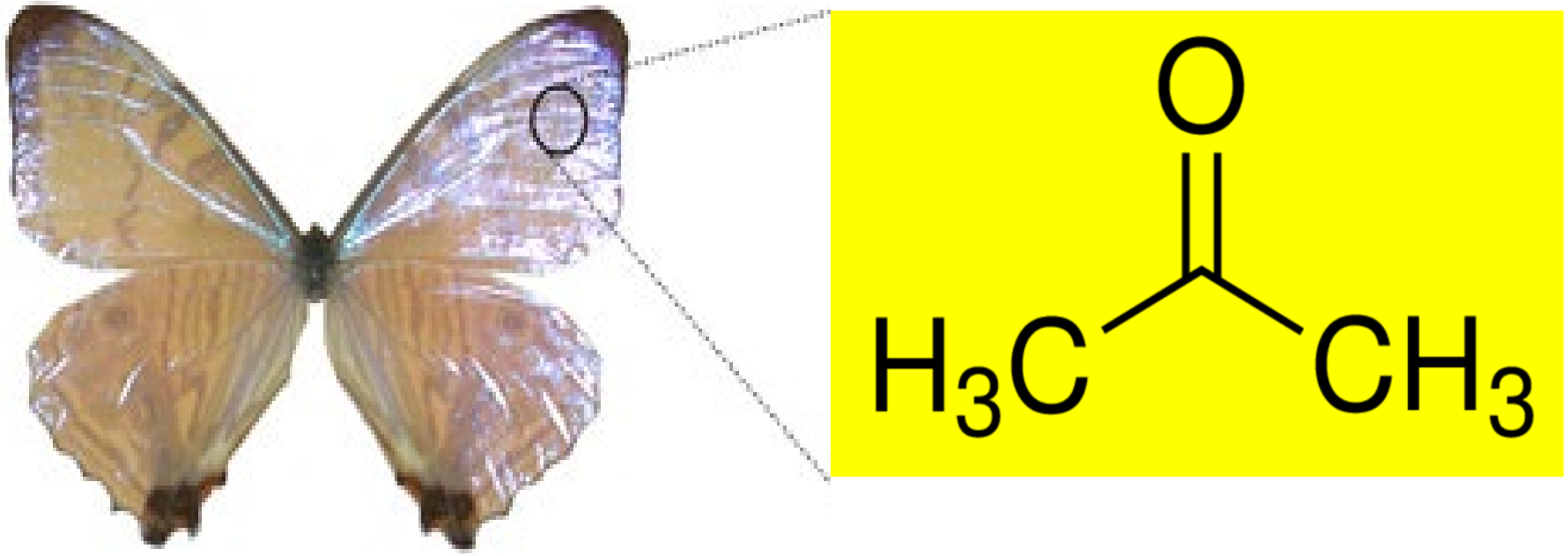


GE scientists observed that *Morpho* wings change their color when they come into contact with heat, gases and chemicals. The normal iridescent blue color of butterfly wings (A) changes when exposed to ethanol (panel B top) or toluene (panel B bottom). These findings may lead to the development of fast, ultra-sensitive thermal and chemical imaging sensors for applications in night vision goggles, super-sensitive surveillance cameras, handheld or wearable medical diagnostic devices.

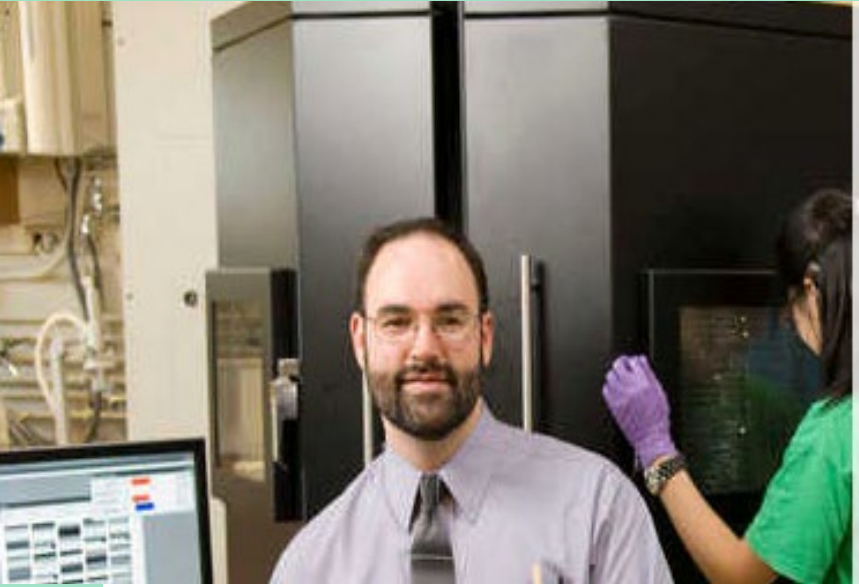
www.gereports.com/post/80985289914/like-a-butterfly-out-of-hell-the-next-wave-of

Can Butterflies Help Prevent Diabetes?

This is a suggestion by the author (Shoumen Datta) and not a fact or system which is under investigation or is available at present.



Dual Acetone Sensors on a single chip may differentiate between acetone in the environment vs acetone in the blood, breath or urine of diabetics. Subtractive analysis alerts to blood ketones. Occurs when body uses fat instead of glucose. It signals insulin dysfunction. If undiagnosed, it may lead to diabetic ketoacidosis (DKA) which may result in diabetic coma and may be fatal. The acetone (ketone bodies) sensors may be able to detect trace levels (nano milli moles eq) and may help preventive care to stem the clinical onset of type II diabetes mellitus (glucose >120 mg/dl).



Michael S. Strano

Carbon P. Dubbs Professor of Chemical Engineering

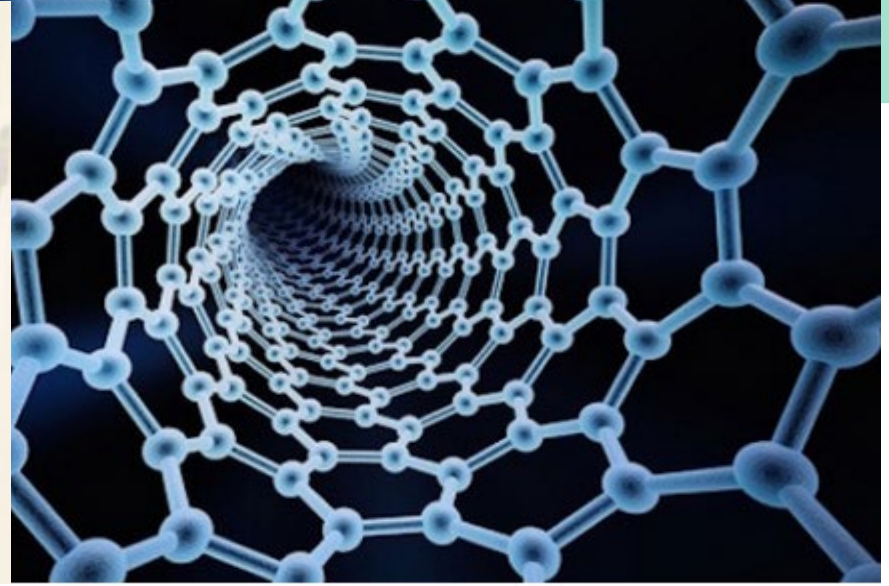
Department of Chemical Engineering

Massachusetts Institute of Technology

Room 66-570B

77 Massachusetts Ave

Cambridge MA 02139 USA



Embedded nano-sensors and nano-radios will transmit data from inside the body using ad hoc mesh networks (nano-com). They may coordinate actions of nano-bots and nano-drones introduced through nasal inhalation or epidermal patches to optimize time-dependent drug delivery, radio/laser ablation, magnetic monitoring or surgically remove abnormal growth. Real-time internal data will help manage external support, such as printed stem cell therapy or assembly of pre-synthetic peptides to form active proteins (think printed insulin in your medicine cabinet).

NANOTUBES

IMPLANTED NANOTUBE SENSOR DIAGNOSTICS

AUGUST 24, 2015 LISAWEINER

MIT researchers are developing tiny devices made from polymer wrapped carbon nanotubes that detect insulin, nitric oxide and fibrinogen — simplifying and automating diagnostic tests.

Past efforts to develop implantable sensors have failed, due to the body's inclination to protect itself and recycle biological material. Devices can become wrapped in scar tissue, or their components can be broken down. The team believes that the nanotube sensors can be effective for the long term.

Peptoid nanosheets exhibit a new secondary-structure motif

Ranjan V. Mannige, Thomas K. Haxton, Caroline Proulx, Ellen J. Robertson, Alessia Battigelli, Glenn L. Butterfoss, Ronald N. Zuckermann & Stephen Whitelam

Affiliations | Contributions | Corresponding authors

Nature (2015) | doi:10.1038/nature15363

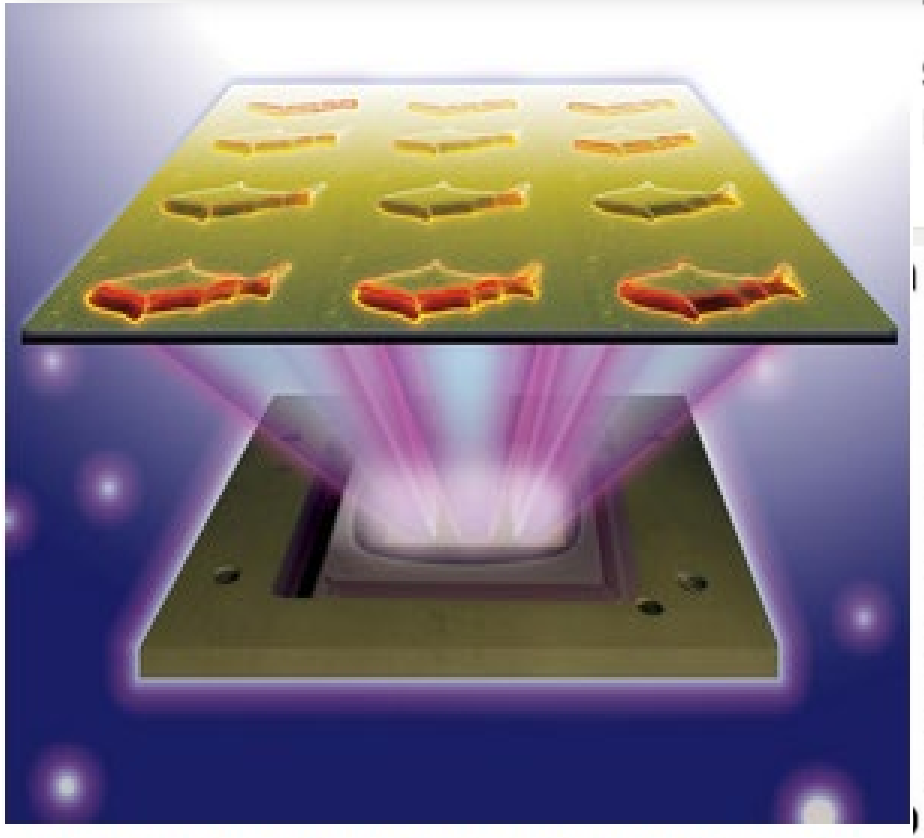
Received 20 April 2015 | Accepted 27 July 2015 | Published online 07 October 2015

A promising route to the synthesis of protein-mimetic materials that are capable of complex functions, such as molecular recognition and catalysis, is provided by sequence-defined peptoid polymers[1, 2]—structural relatives of biologically occurring polypeptides. Peptoids, which are relatively non-toxic and resistant to degradation[3], can fold into defined structures through a combination of sequence-dependent interactions[3, 4, 5, 6, 7, 8]. However, the range of possible structures that are accessible to peptoids and other biological mimetics is unknown, and our ability to design protein-like architectures from these polymer classes is limited[9]. Here we use molecular-dynamics simulations, together with scattering and microscopy data, to determine the atomic-resolution structure of the recently discovered peptoid nanosheet, an ordered supramolecular assembly that extends macroscopically in only two dimensions. Our simulations show that nanosheets are structurally and dynamically heterogeneous, can be formed only from peptoids of certain lengths, and are potentially porous to water and ions. Moreover, their formation is enabled by the peptoids' adoption of a secondary structure that is not seen in the natural world. This structure, a zigzag pattern that we call a Σ('sigma')-strand, results from the ability of adjacent backbone monomers to adopt opposed rotational states, thereby allowing the backbone to remain linear and untwisted. Linear backbones tiled in a brick-like way form an extended two-dimensional nanostructure, the Σ-sheet. The binary rotational-state motif of the Σ-strand is not seen in regular protein structures, which are usually built from one type of rotational state. We also show that the concept of building regular structures from multiple rotational states can be generalized beyond the peptoid nanosheet system.

Printed Proteins ?

Insulin ?

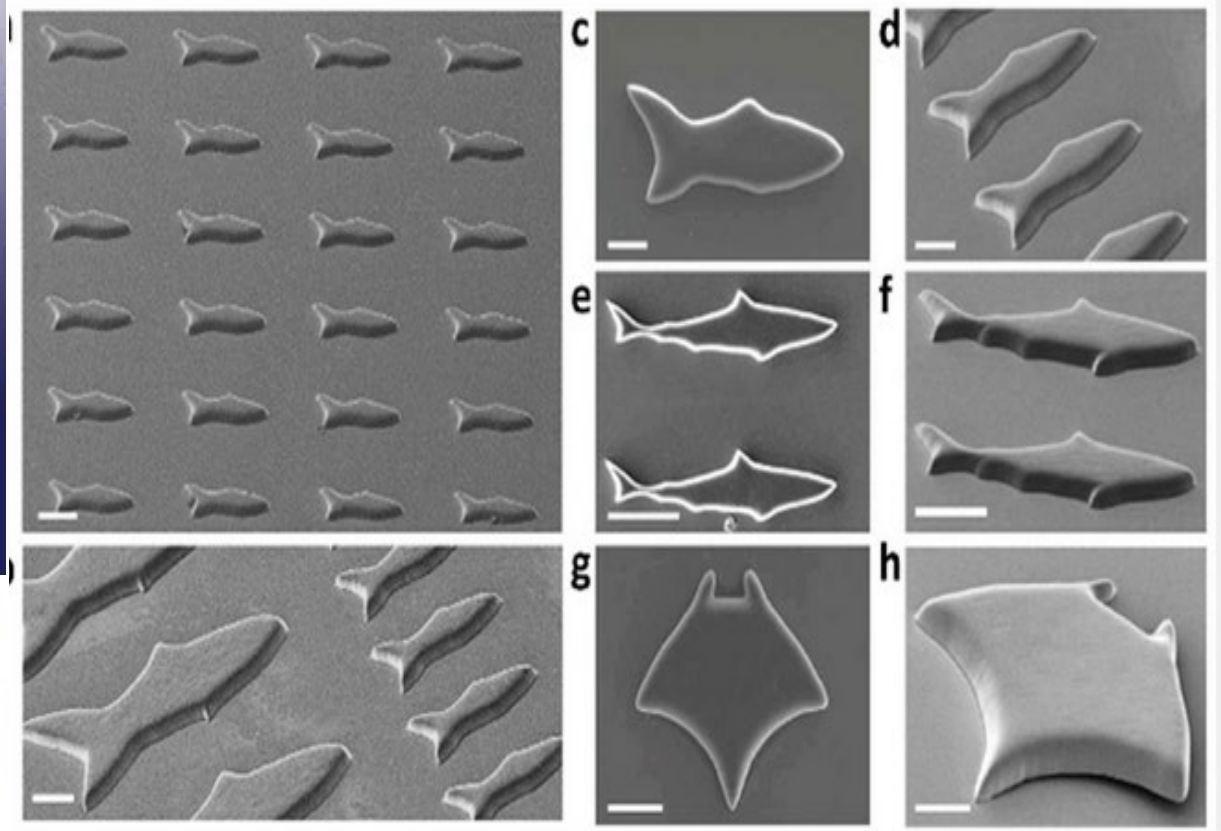
Conceptual Convergence of Material Genome with the Human Genome?



3D-printed microfish contain functional nanoparticles that enable them to be self-propelled, chemically powered and magnetically steered. The microfish are also capable of removing and sensing toxins. Image

"With our 3D printing technology, we are not limited to just fish shapes. We can rapidly build micro-robots inspired by other biological organisms such as birds," said Zhu.

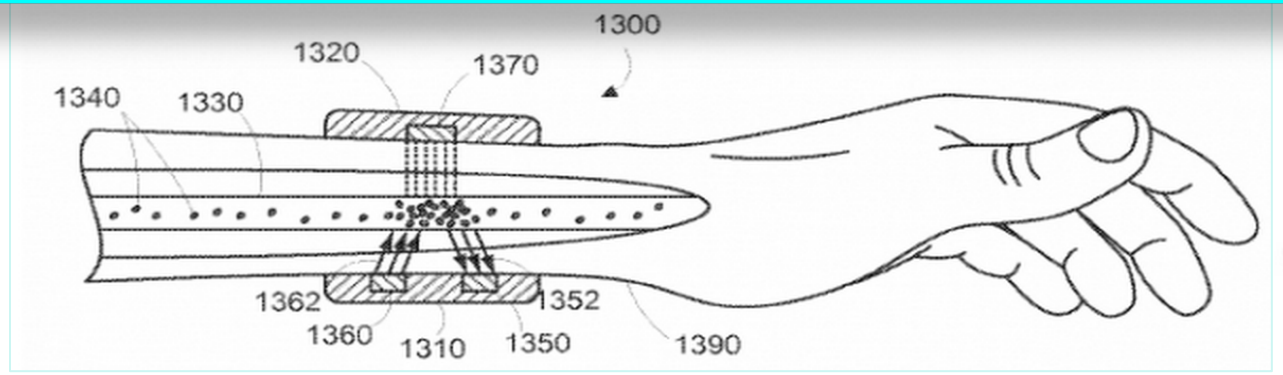
Professor Shaochen Chen & Joseph Wang, NanoEngineering Dept, UCSD

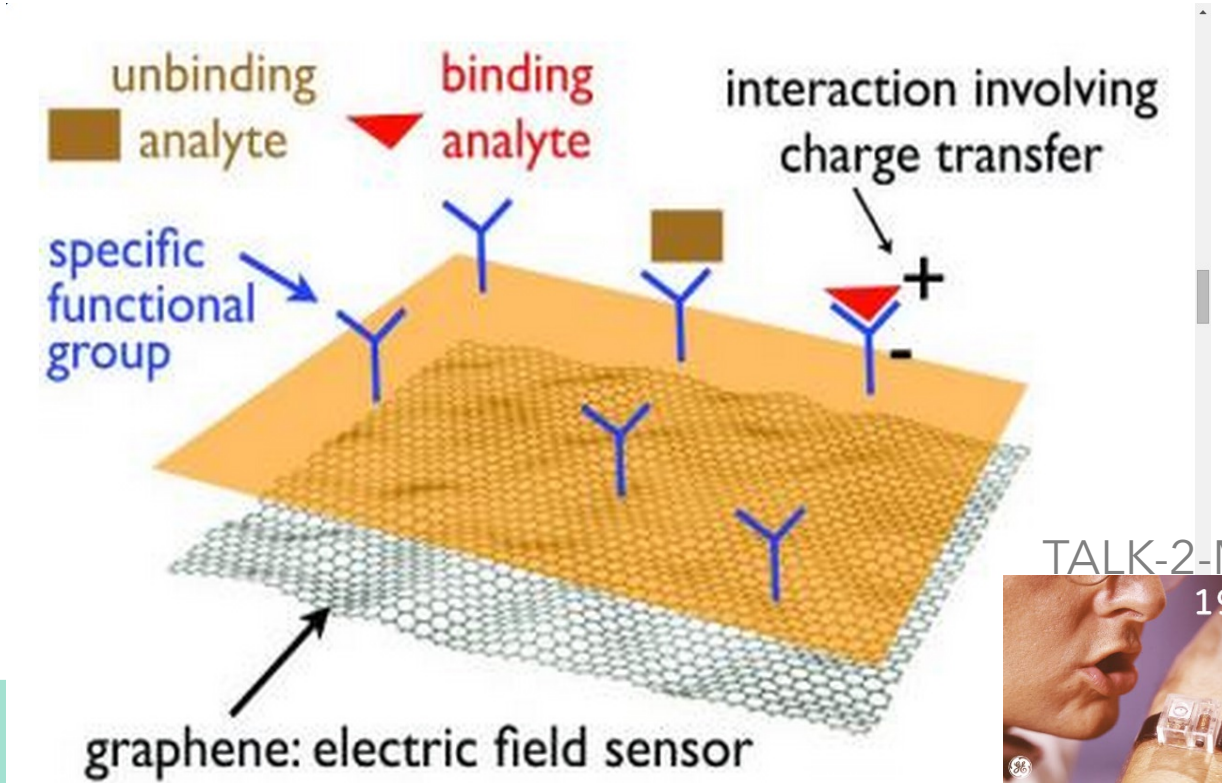


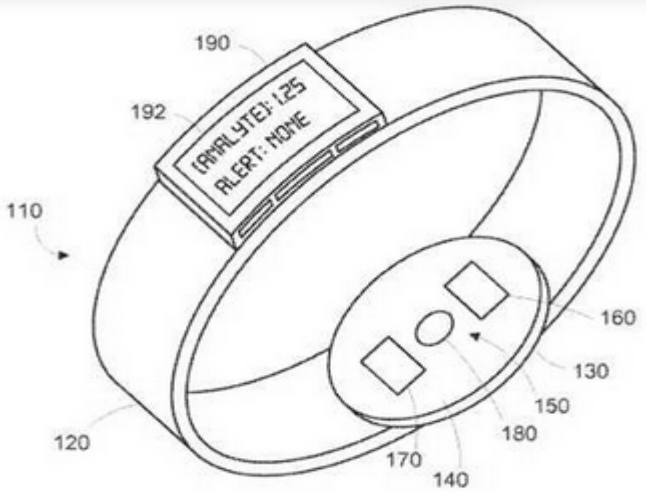
3D printed robots from iron oxide, which can be magnetically guided; platinum, which can be chemically guided; and polydiacetylene (PDA) which can be used for neutralising harmful toxins.

http://bit.ly/POTUS-REPORTS

Target Specific Analytes in Detection, Monitoring and Treatment







New test can predict cancer up to 13 years before disease develops

People who develop cancer have shorter telomeres, the caps at the end of chromosomes which protect the DNA

Target Specific Analytes in Detection, Monitoring & Treatment

ANALYTES ??
Cohesin ?
Shelterin ?
Condensin ?

http://bit.ly/SHELTERIN-ANALYTE-FOR-TELOMERE

http://genesdev.cshlp.org/content/19/18/2100.full.pdf+html

Lower Cost of Healthcare in India leaves billions in the dust without access to healthcare

Cancer Treatment

$2,900 HCG Oncology, India

$22,000 U.S. average

Kidney Dialysis

$12,000 Deccan Hospital, India

$66,750 U.S. average

http://hbr.org/2013/11/delivering-world-class-health-care-affordably/ar/1

Fast Forward FEWSH →
Pay A Penny Per Use (PAPPU)

$1 - Bone density

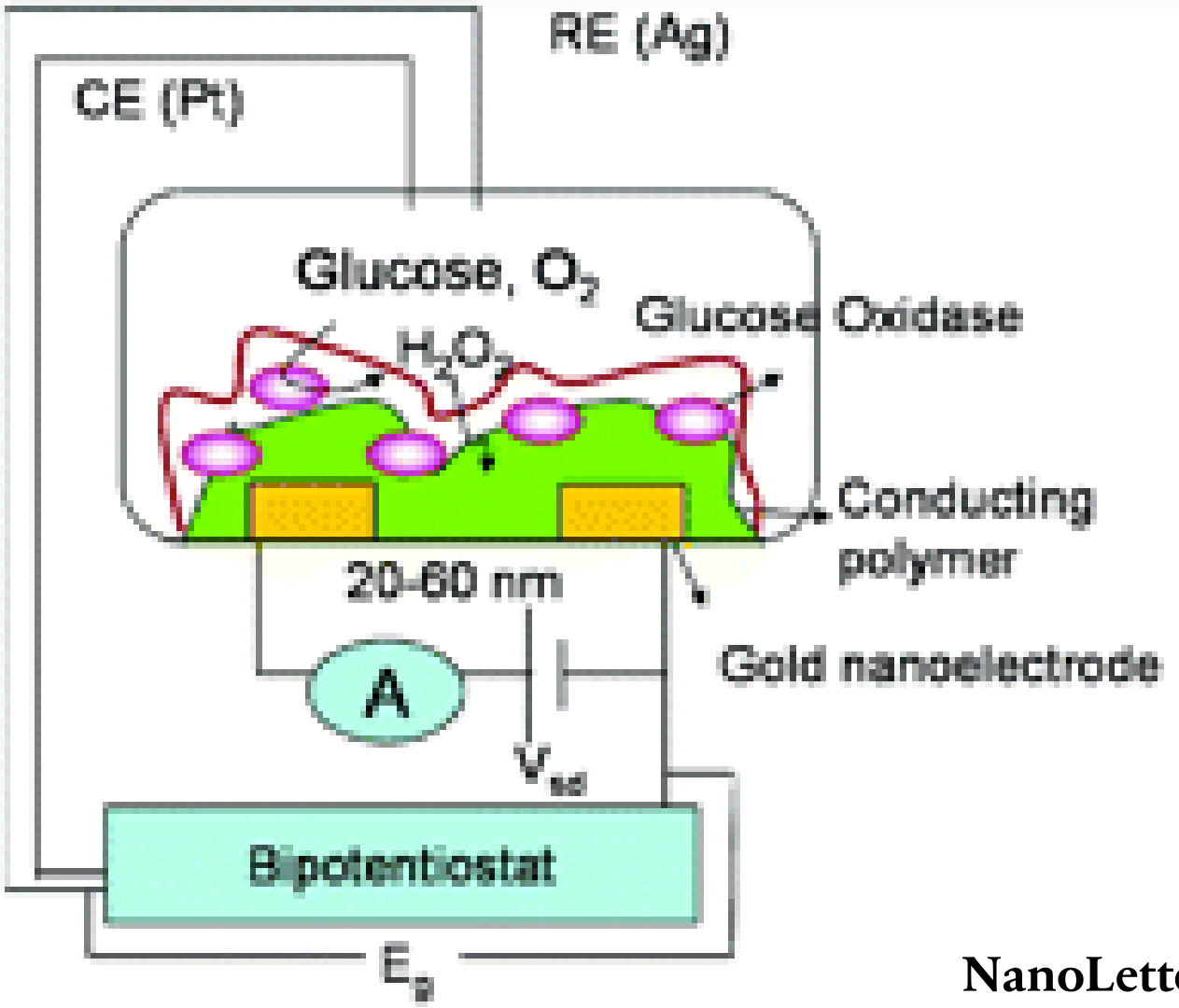
$1 - Mammogram

at the corner of Happy and Healthy in every zip code in India, China, Indonesia

data transmitted to specialists and reports sent to individuals, doctor and clinic

A very old idea

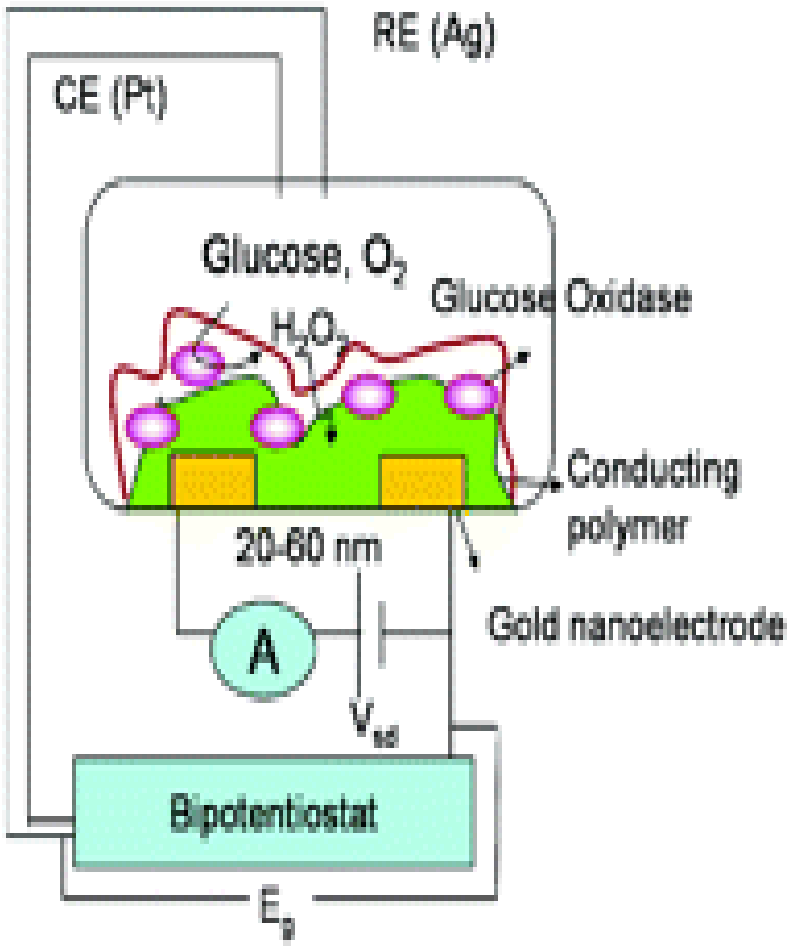
Glucose NanoSensor



NanoLetters (2004) 4 1785-1788

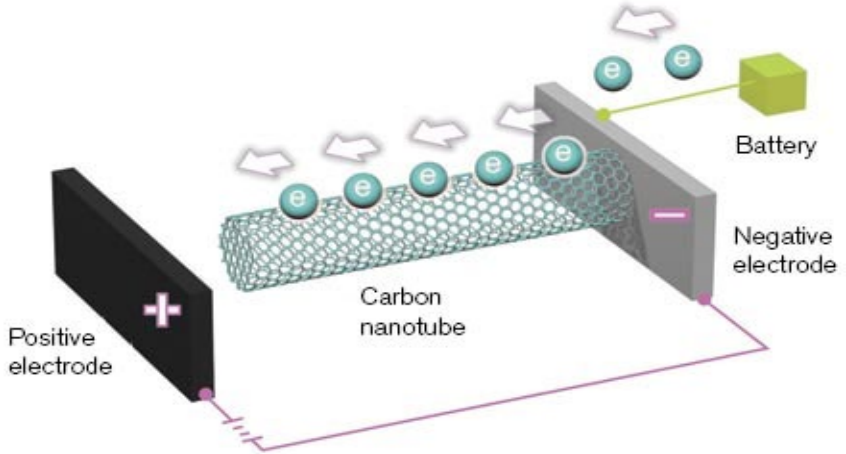
https://pubs.acs.org/doi/abs/10.1021/nl049080l

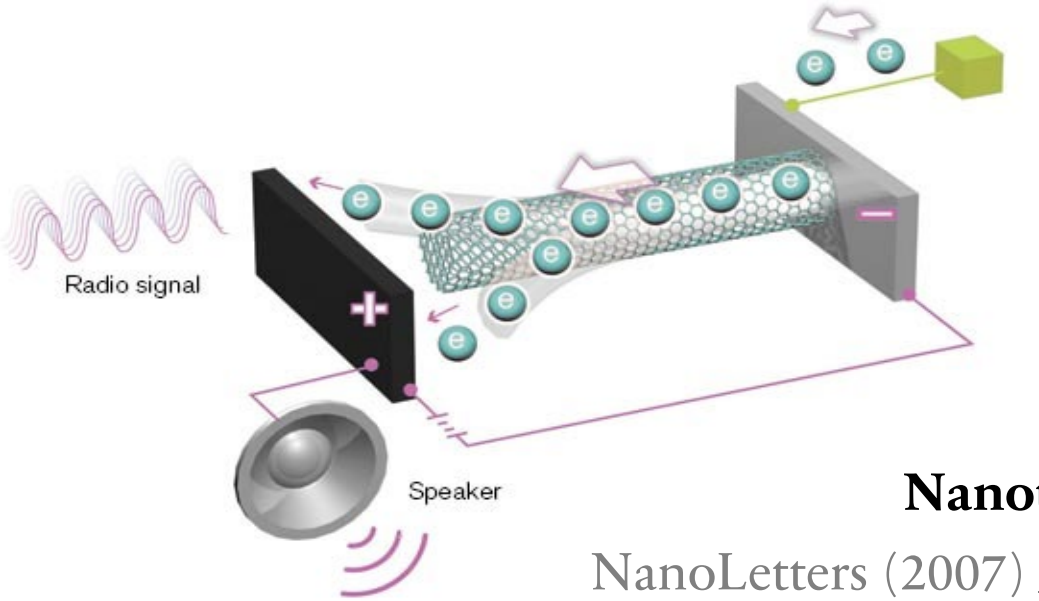
Convergence ?



Blood Glucose Nano-sensor

NanoLetters (2004) 4 1785-1788

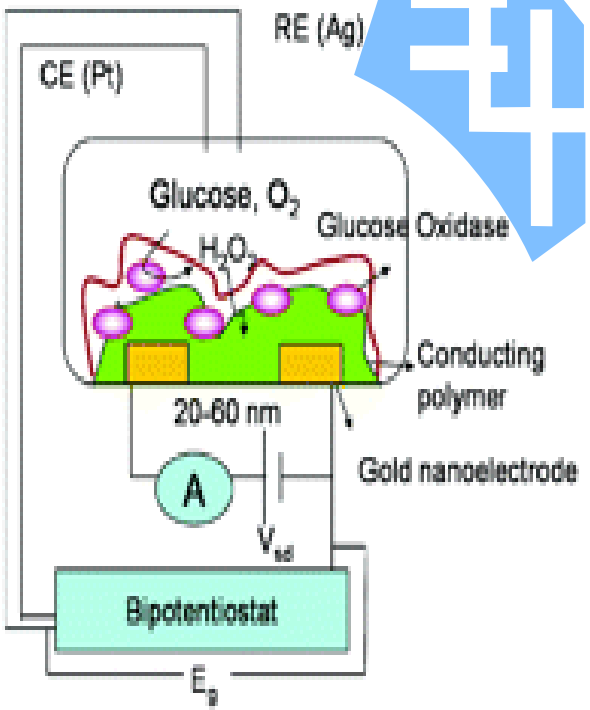




Nanotube Radio

NanoLetters (2007) 7 3508-3511

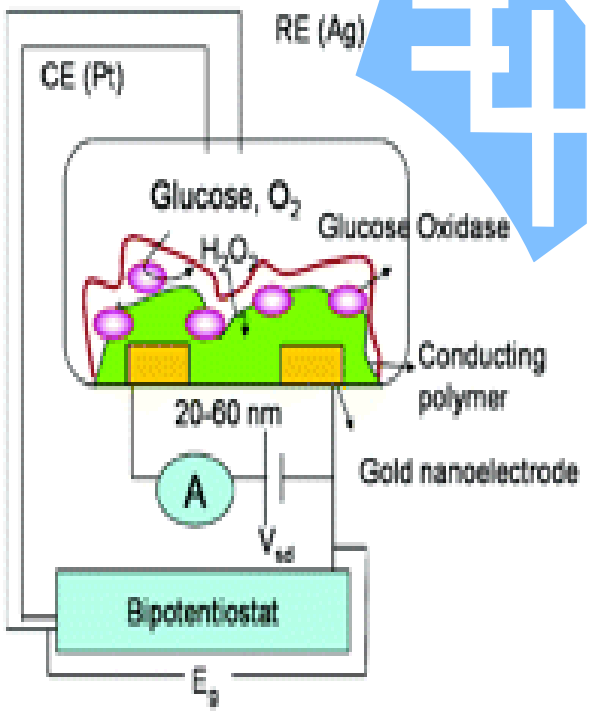
Integrated Glucose NanoSensor NanoRadio



www.cdc.gov/diabetes/pubs/pdf/ndfs_2011.pdf

Hypothetical proposal (S. Datta)

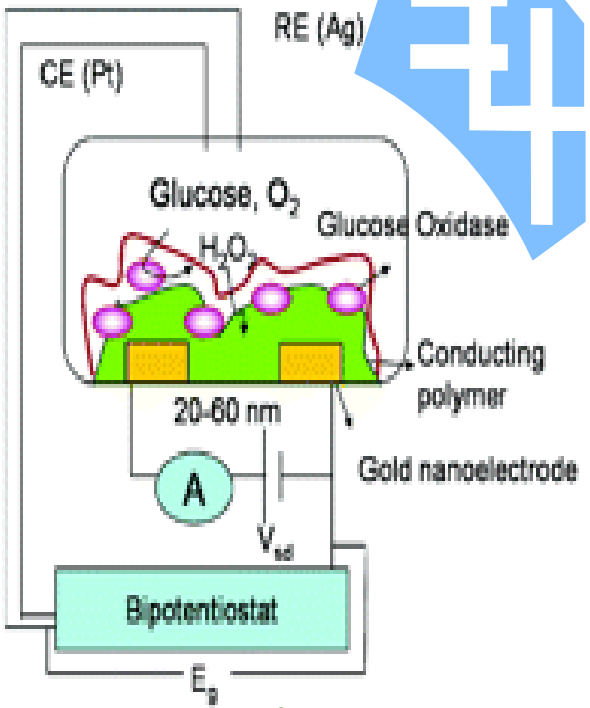
Diabetes - Remote Heath Monitoring ?



May I implant a glucose nano-sensor nano-radio chip on your shoulder? Are you an obese diabetic?

Prime Minister Bertie Ahern (Taoiseach)
Prime Minister of Ireland, 2005 Trinity College

Glucose NanoSensor NanoRadio: Ecosystem of healthcare monitoring?



www.cdc.gov/nchs/fastats/diabetes.htm

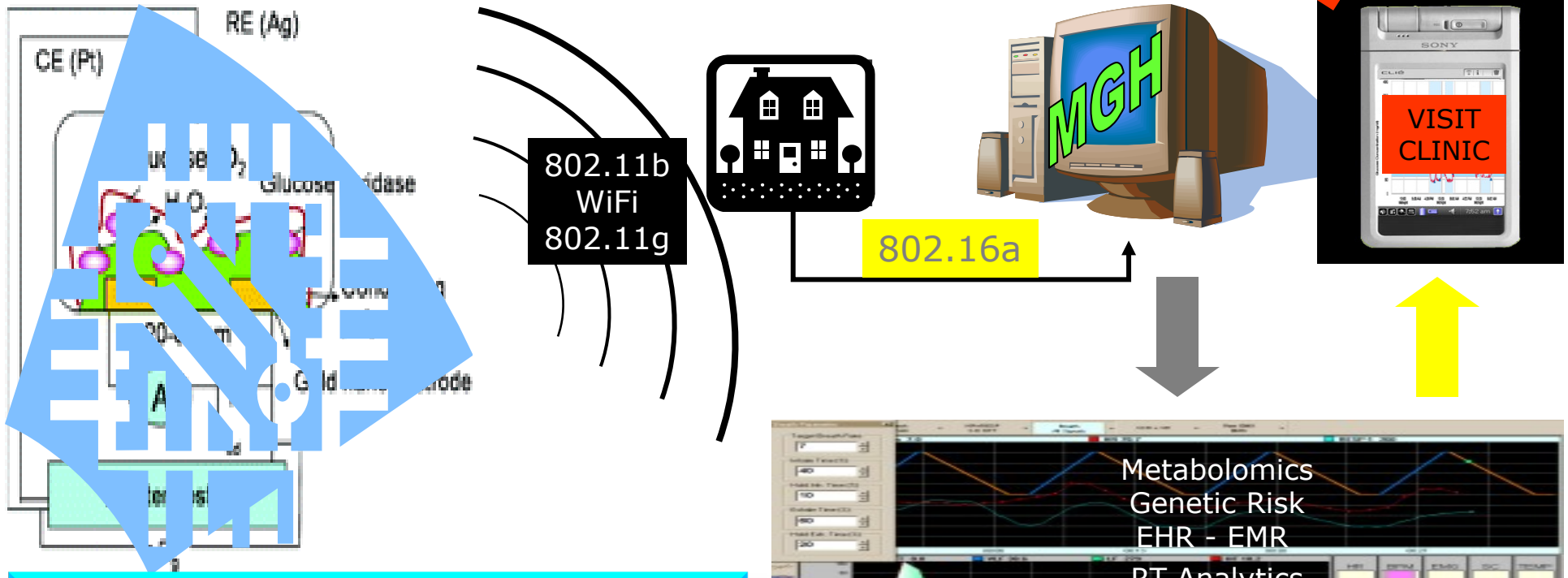
~30 million individuals in US affected by diabetes

1. Implanted wireless sensor transmits blood glucose data from home or office or airport (WiFi/WAN/gateway)

2. Data travels from you to your hospital or clinic (MAN)

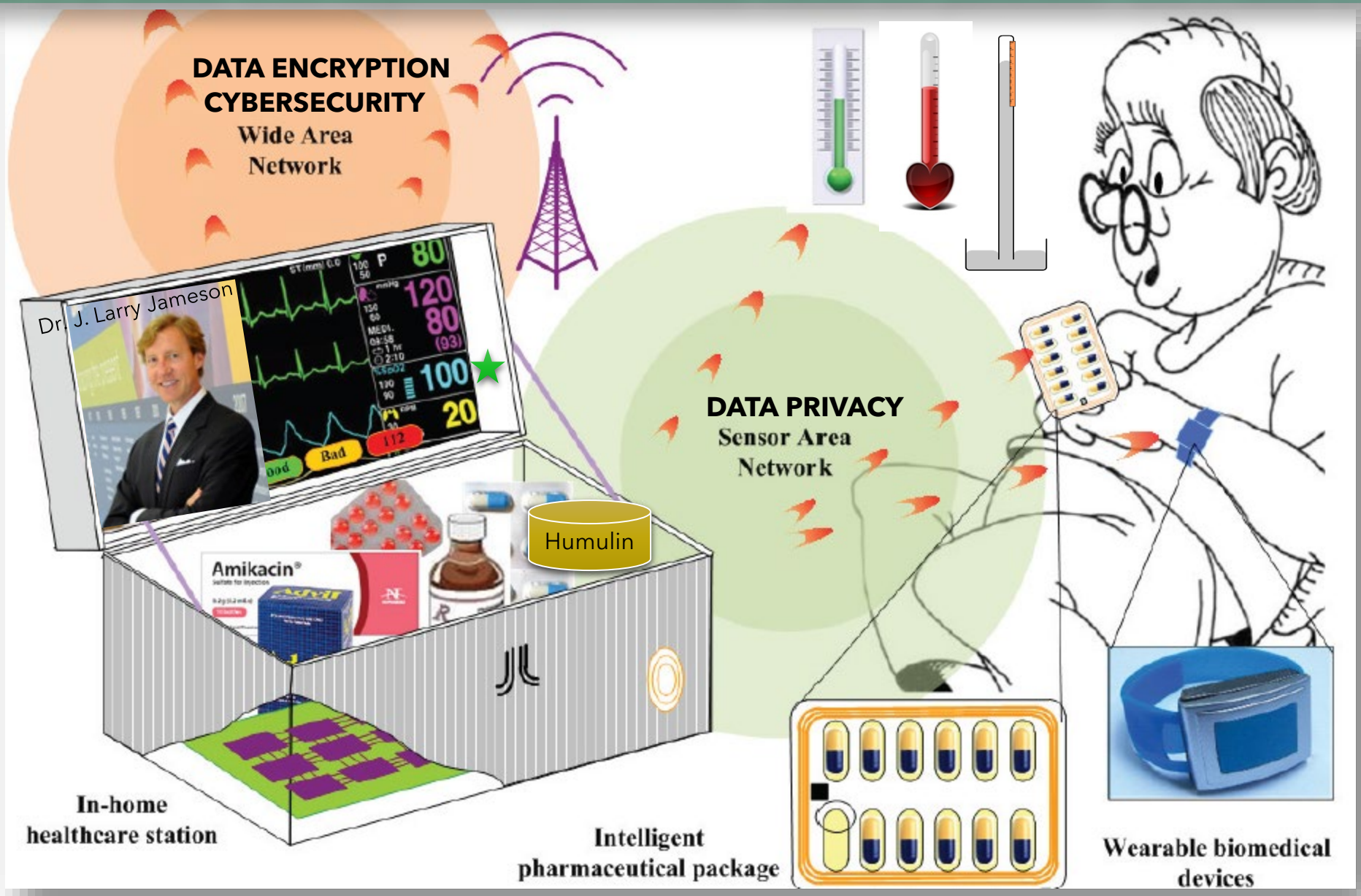
3. Blood glucose data updates risk and patient profile

4. If you need medical attention or insulin or other treatment then auto-responder sends message or calls



Improved healthcare services, savings, create jobs from new products, new services and potential to create as well as capture new emerging markets of billions (BRICS)

Larry Gold is at home with hypercholesterolemia: Hello Dr Jameson - Do I need Lipitor today?



Dr Larry Jameson: Avoid KFC. Your LDL-VLDL ratio looks good. No Lipitor.

Congestive Heart Failure (CHF)

- About 5.1 million people in the United States have heart failure.
- About half of people with CHF die within 5 years of diagnosis.
- CHF costs the nation an estimated $32 billion each year.

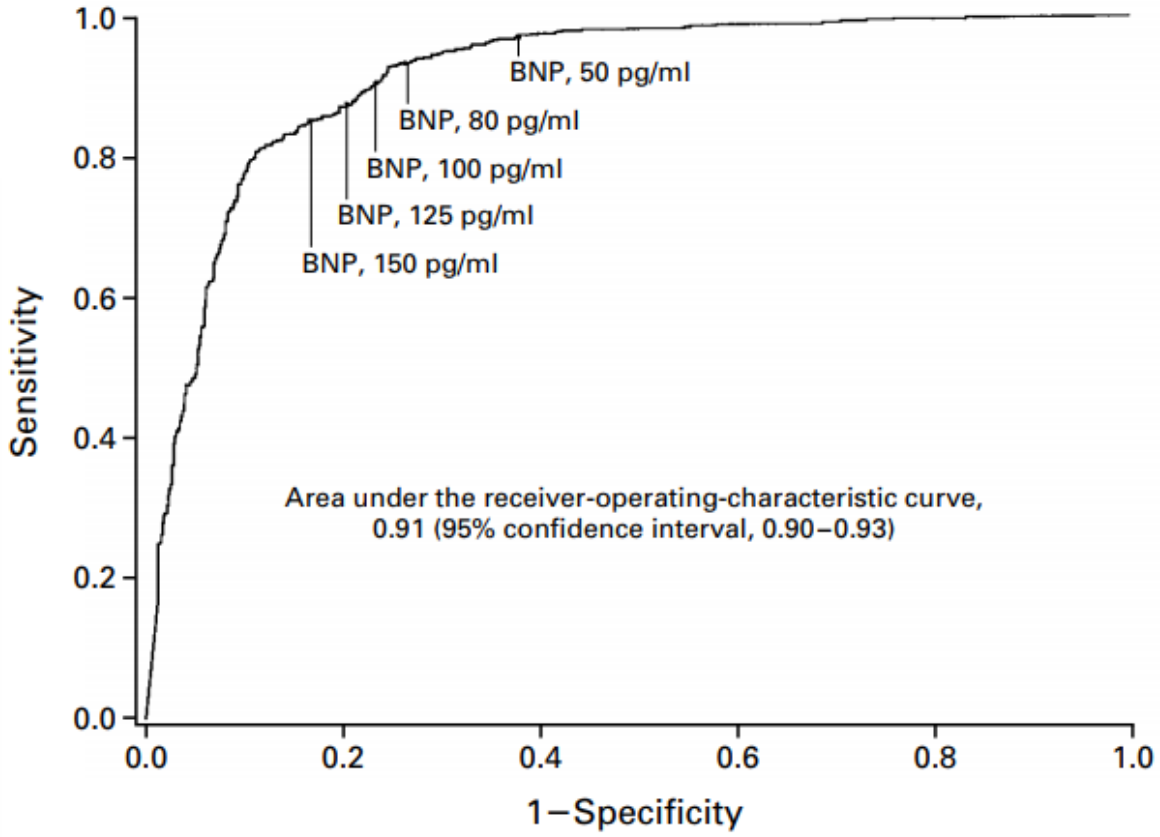
Abundance of prognostic biochemical markers –

- C-reative protein (CRP5 / CRP6) – 1954 and Framingham Heart Study
- Tumour necrosis factor alpha (TNFα)
- Brain Natriuretic Peptide (1981) BNP <100 pg/ml unlikely & >400 pg/ml CHF likely
- N-terminal (NT) pro-BNP <300 pg/ml unlikely & >400-900 pg/ml CHF likely (age?)

48,629 patients of acute decompensated heart failure found linear correlation between BNP levels and in hospital mortality. Failure of BNP to decline during hospitalization predicts death and re-hospitalization while discharge levels of 250pg/ml or less predicts event free survival.

http://medind.nic.in/jac/t10/i4/jact10i4p282.pdf www.cdc.gov/dhdsp/data_statistics/fact_sheets/fs_heart_failure.htm

BNP as a key biochemical marker in coronary syndromes and congestive heart failure (CHF)

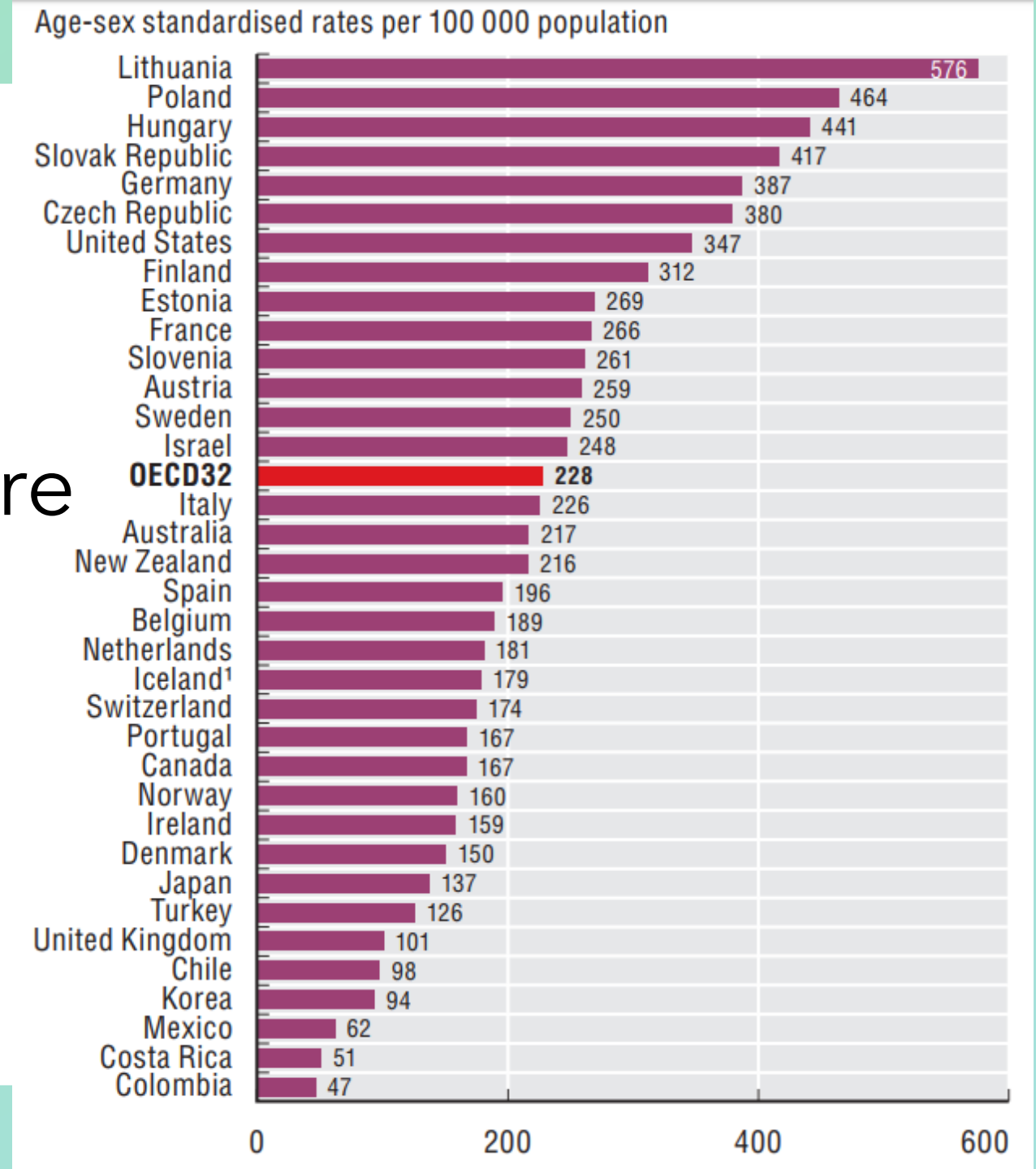


BNP pg/ml	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Accuracy
	(95 percent confidence interval)				
50	97 (96–98)	62 (59–66)	71 (68–74)	96 (94–97)	79
80	93 (91–95)	74 (70–77)	77 (75–80)	92 (89–94)	83
100	90 (88–92)	76 (73–79)	79 (76–81)	89 (87–91)	83
125	87 (85–90)	79 (76–82)	80 (78–83)	87 (84–89)	83
150	85 (82–88)	83 (80–85)	83 (80–85)	85 (83–88)	84

Figure 3. Receiver-Operating-Characteristic Curve for Various Cutoff Levels of B-Type Natriuretic Peptide (BNP) in Differentiating between Dyspnea Due to Congestive Heart Failure and Dyspnea Due to Other Causes.

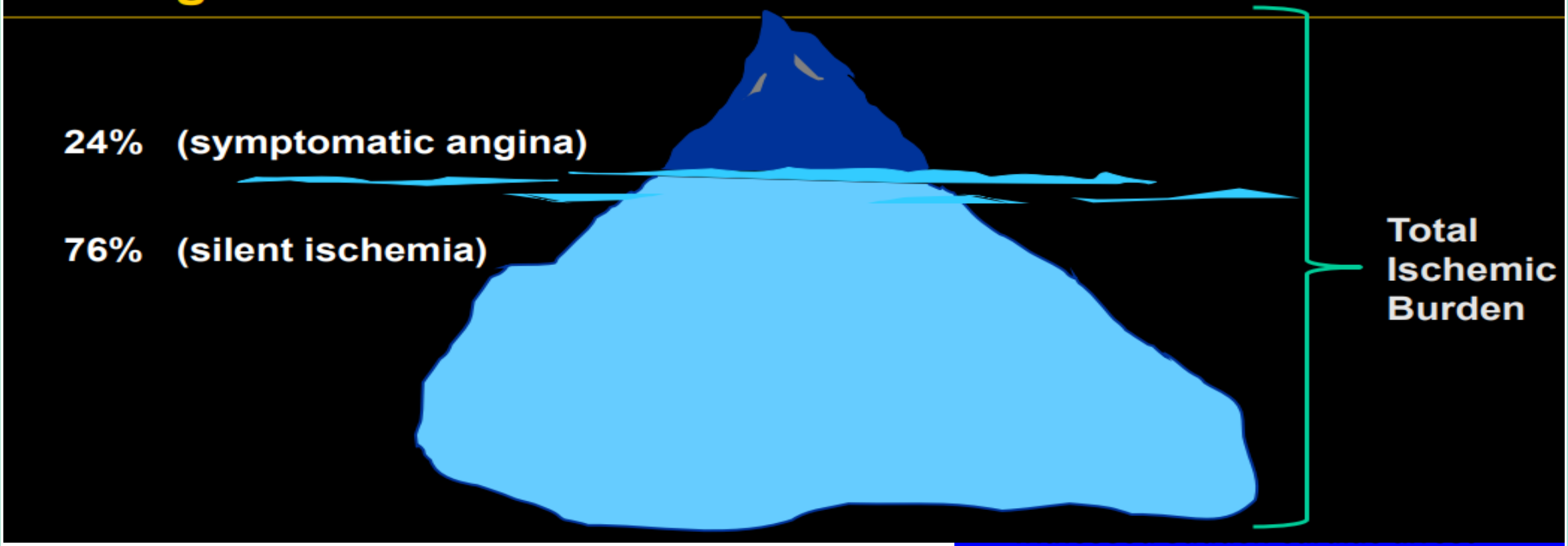
www.nejm.org/doi/pdf/10.1056/NEJMoa020233

Congestive heart failure hospital admission (2015)



OECD Health Statistics 2017
http://dx.doi.org/10.1787/888933603507

Symptomatic Angina: The Tip of the Ischemic Iceberg

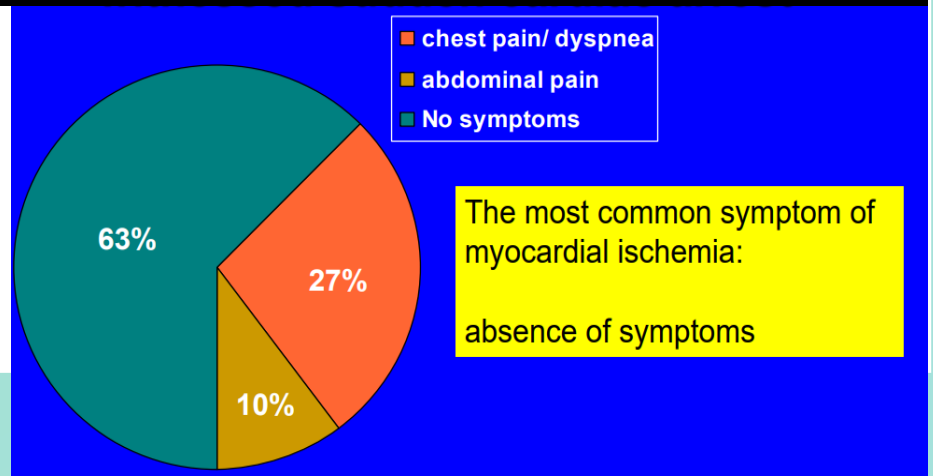


If you cannot sense, you cannot detect.

If you cannot predict, you cannot prevent.

If you cannot measure, you do not have metrics.

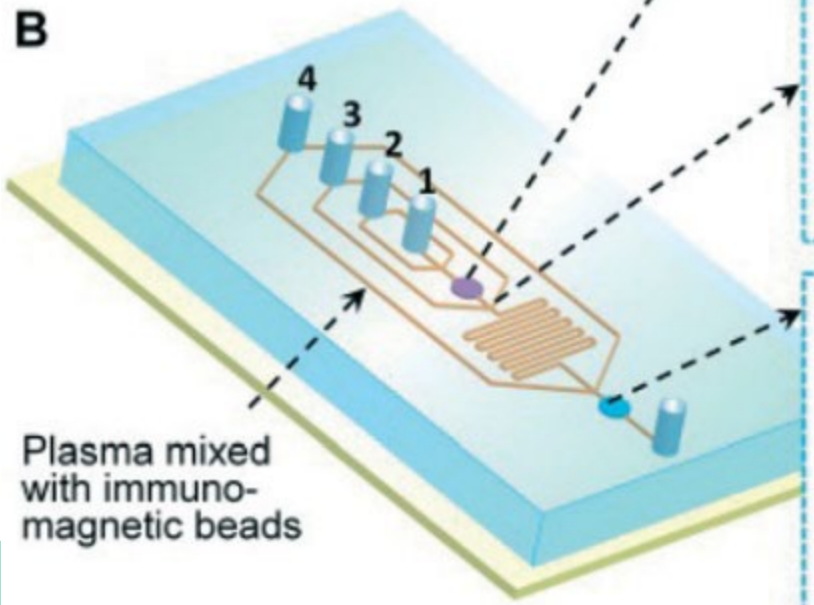
If you do not have data, you cannot take a decision.

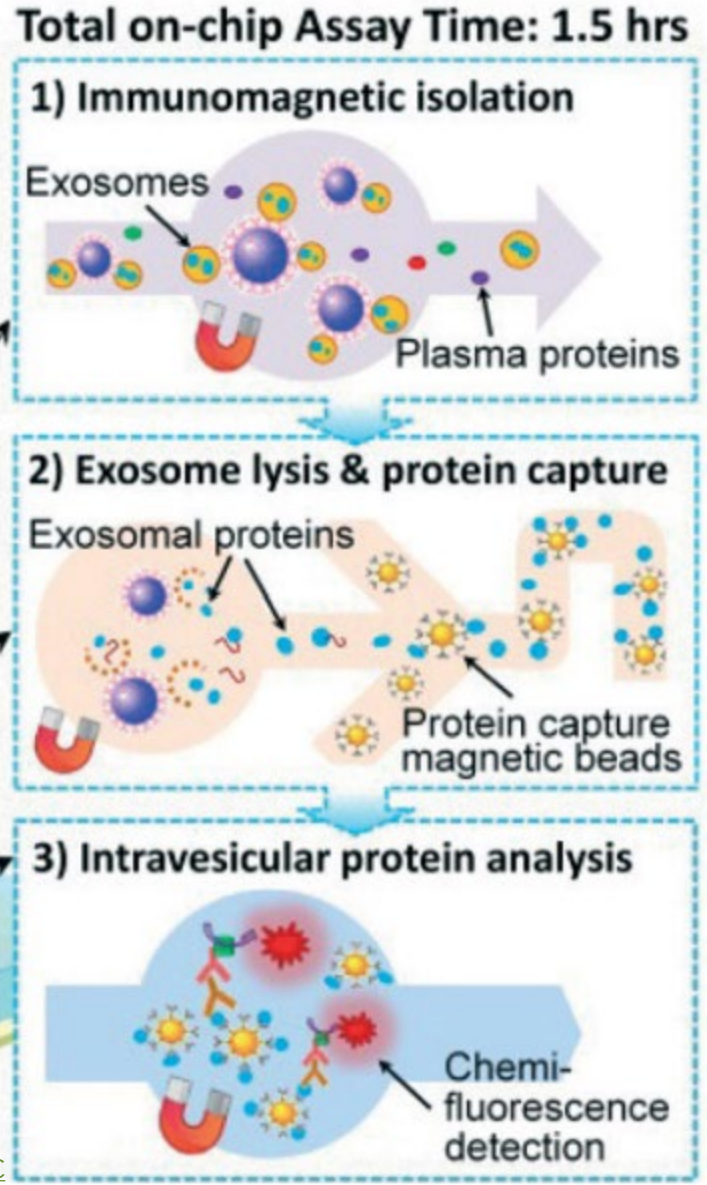


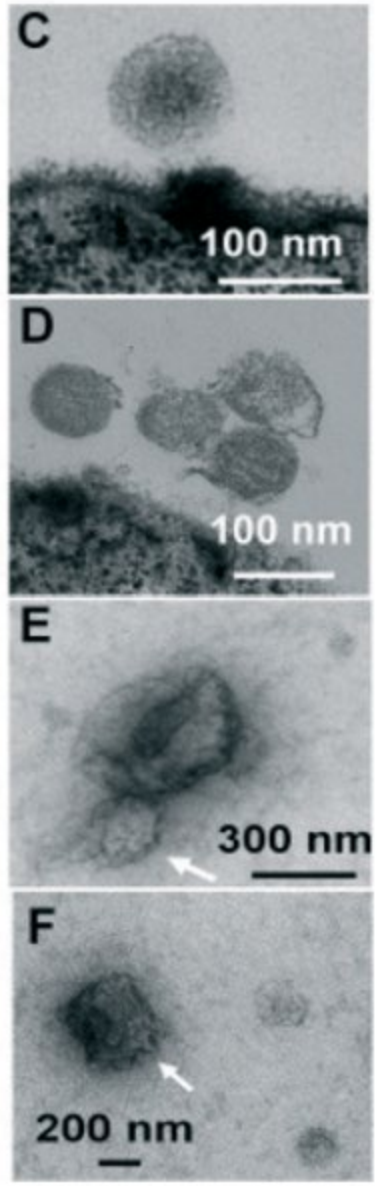
https://dspace.mit.edu/handle/1721.1/107893

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

Lab on a Chip - Detection of Non-Small Cell Lung Cancer (C) and Ovarian Cancer (D)







http://pubs.rsc.org/en/content/articlepdf/2014/LC/C4LC00662C

Miniaturized, biopsy-implantable chemical sensor with wireless, magnetic resonance readout

C. C. Vassiliou,†[ab] V. H. Liu[ab] and M. J. Cima*[ac]

Author affiliations

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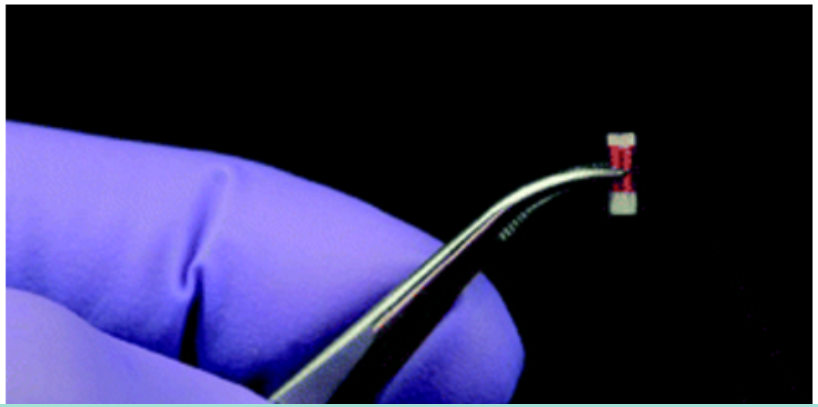
[b] Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, Cambridge, MA 02139, USA

[c] Department of Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139, USA

Biopsy is an important diagnostic tool for a broad range of conditions. Cancer diagnoses, for example, are confirmed using tissue explanted with biopsy. Here we demonstrate a miniaturized wireless sensor that can be implanted during a biopsy procedure and return chemical information from within the body. Power and readout are wireless *via* weak magnetic resonant coupling to an external reader. The sensor is filled with responsive nuclear magnetic resonance (NMR) contrast agents for chemical sensitivity, and on-board circuitry constrains the NMR measurement to the contents. This sensor enables longitudinal monitoring of the same location, and its simple readout mechanism is ideal for applications not requiring the spatial information available through imaging techniques. We demonstrated the operation of this sensor by measuring two metabolic markers, both *in vitro* and *in vivo*: pH in flowing fluid for over 25 days and in a xenograft tumor model in mice, and oxygen in flowing gas and in a rat hind-limb constriction experiment. The results suggest that this *in vivo* sensing platform is generalizable to other available NMR contrast agents. These sensors have potential for use in biomedicine, environmental monitoring and quality control applications.



Single-molecule detection of protein efflux from microorganisms using fluorescent single-walled carbon nanotube sensor arrays

Markita Patricia Landry, Hiroki Ando, Allen Y. Chen, Jicong Cao, Vishal Isaac Kottadiel, Linda Chio, Darwin Yang, Juyao Dong, Timothy K. Lu & Michael S. Strano

Affiliations | **Contributions** Department of Chemical Engineering, Massachusetts Institute of Technology

Nature Nanotechnology (2017) | doi:10.1038/nnano.2016.284

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Hiroki Ando, Allen Y. Chen, Jicong Cao & Timothy K. Lu

MIT Synthetic Biology Center, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA
Hiroki Ando, Allen Y. Chen, Jicong Cao & Timothy K. Lu

Biophysics Program, Harvard University, Cambridge, Massachusetts 02138, USA
Allen Y. Chen

The Rowland Institute at Harvard University, Cambridge, Massachusetts 02142, USA
Vishal Isaac Kottadiel

A distinct advantage of nanosensor arrays is their ability to achieve ultralow detection limits in solution by proximity placement to an analyte. Here, we demonstrate label-free detection of individual proteins from *Escherichia coli* (bacteria) and *Pichia pastoris* (yeast) immobilized in a microfluidic chamber, measuring protein efflux from single organisms in real time.

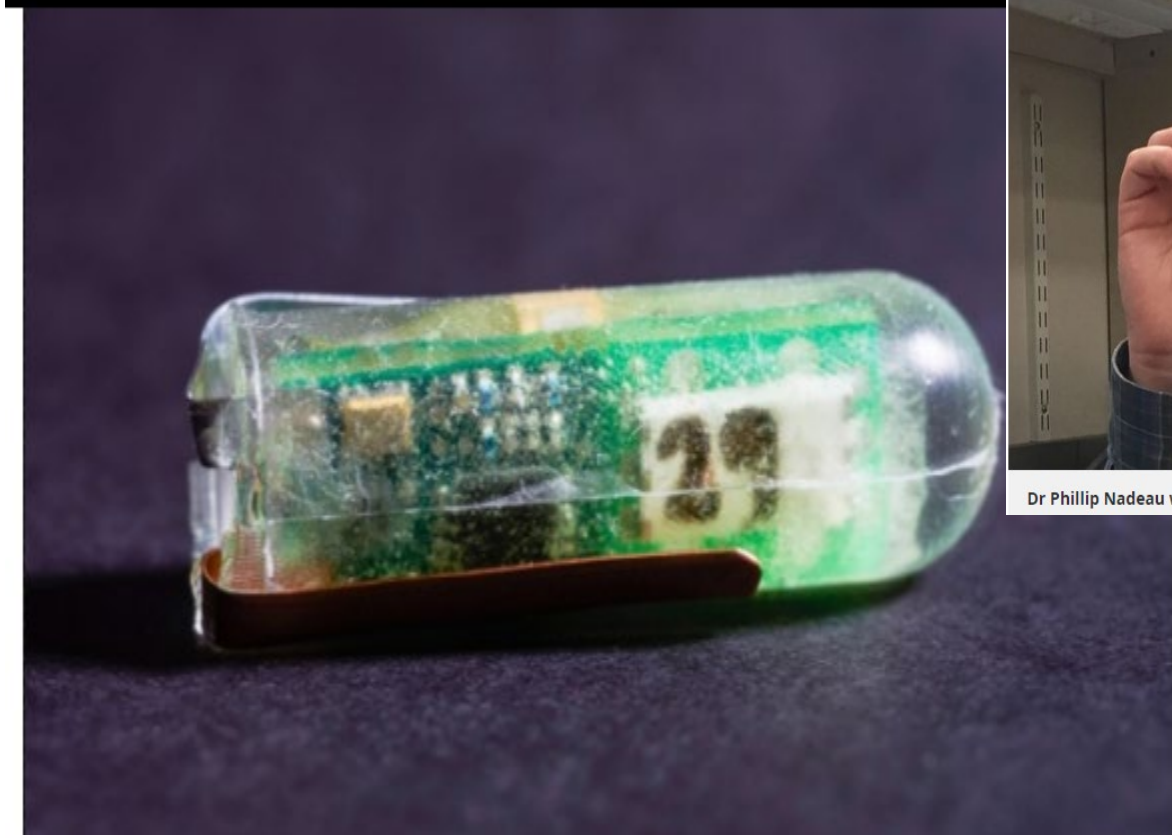
Secure | https://www.theguardian.com/science/2017/jan/22/stroke-detector-biosensor-diagnosis-nicholas-dale--breakthrough?utm

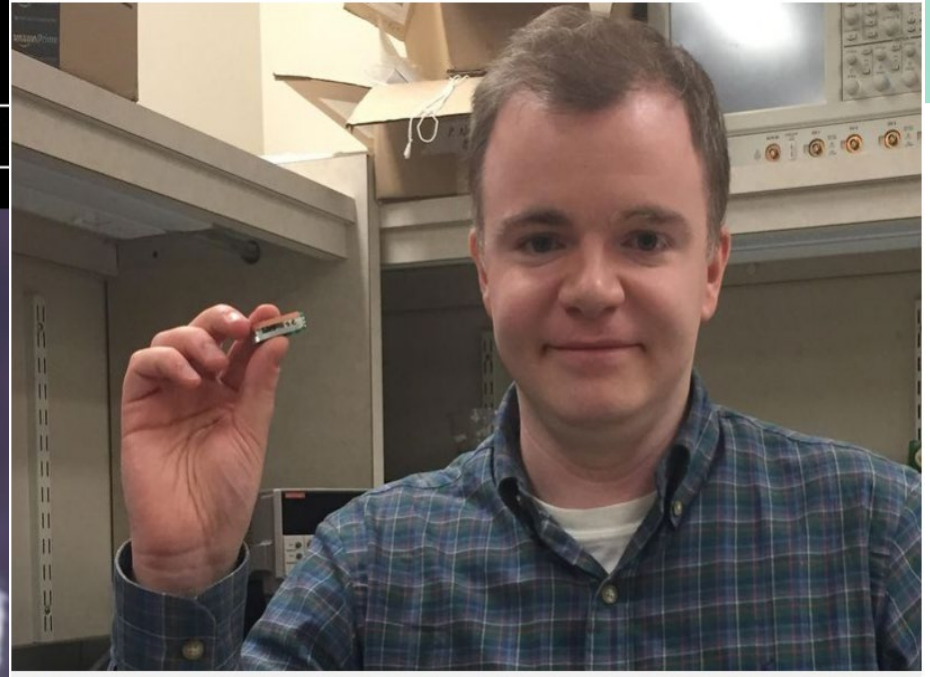
Nicholas Dale with his SMARTchip

STROKE DETECTOR – BIOSENSOR

MIT News

ON CAMPUS AND AROUND THE WORLD





Dr Phillip Nadeau with the "silver bullet" device, which could revolutionise medical treatment (Photo: Andrew

Researchers at MIT and Brigham and Women's Hospital have designed and demonstrated a small, ingestible voltaic cell that is sustained by the acidic fluids in the stomach.

Photo: Diemut Strebe

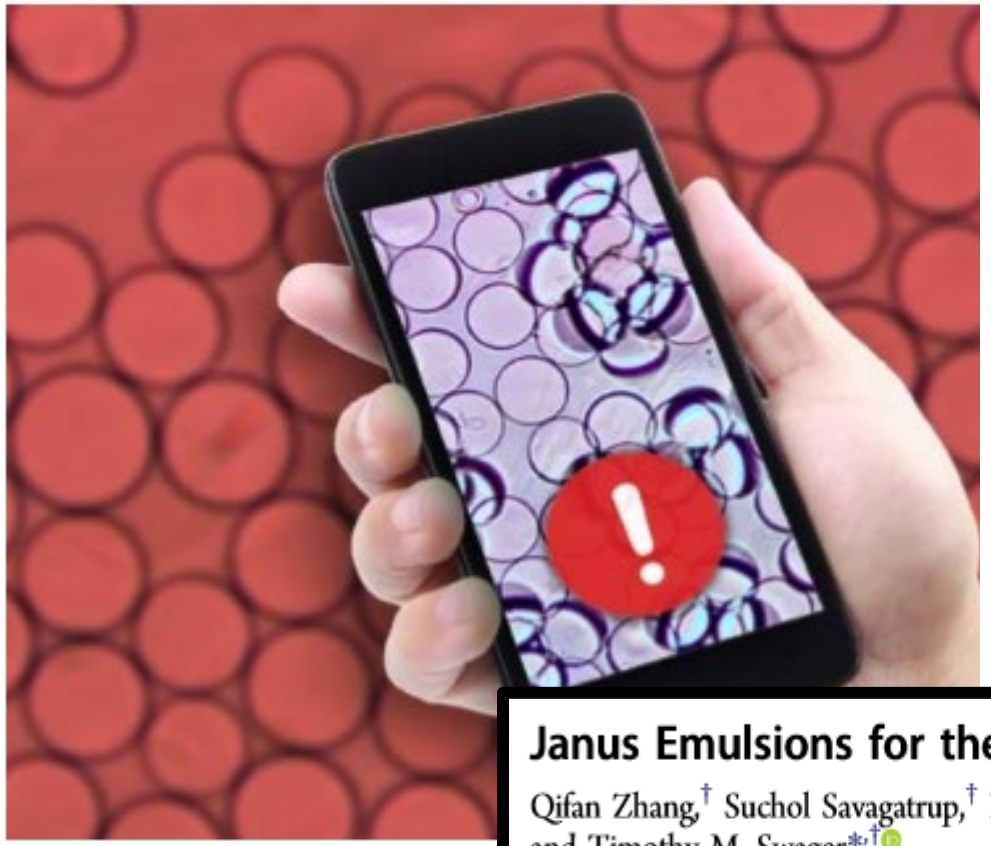
http://news.mit.edu/2017/engineers-harness-stomach-acid-power-tiny-sensors-0206

Engineers harness stomach acid to power tiny sensors

Ingestible electronic devices could monitor physiological conditions or deliver drug

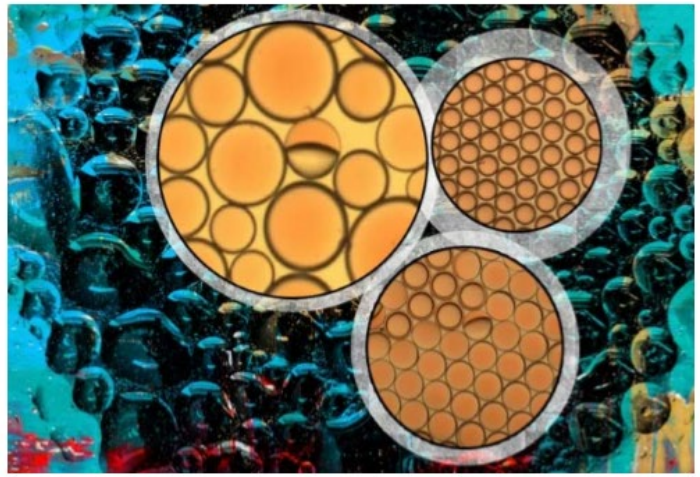
MIT News

ON CAMPUS AND AROUND THE WORLD



MIT News

ON CAMPUS AND AROUND THE WORLD



A simple way to make and reconfigure complex emulsions

Anne Trafton | MIT News Office
February 25, 2015

Food Testing. Blood Testing? Sputum? Mucus? Fluids?

Janus Emulsions for the Detection of Bacteria

Qifan Zhang,[†] Suchol Savagatrup,[†] Paulina Kaplonek,[‡,§] Peter H. Seeberger,[*,‡,§] and Timothy M. Swager[*,†]

[†]Department of Chemistry and Institute for Soldier Nanotechnologies, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139, United States

[‡]Department of Biomolecular Systems, Max Planck Institute of Colloids and Interfaces, Am Mühlenberg 1, 14476 Potsdam, Germany

[§]Institute of Chemistry and Biochemistry, Free University Berlin, Arnimallee 22, 14195 Berlin, Germany

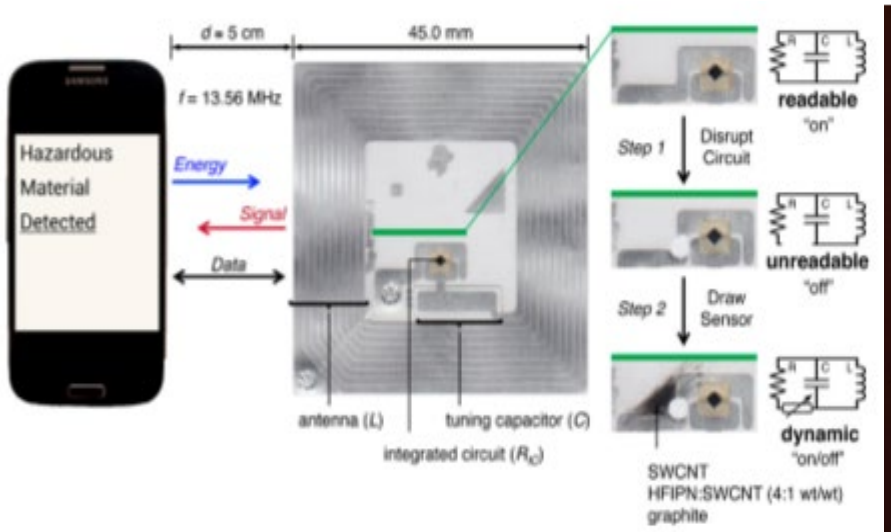
Specialized droplets interact with bacteria and can be analyzed using a smartphone.

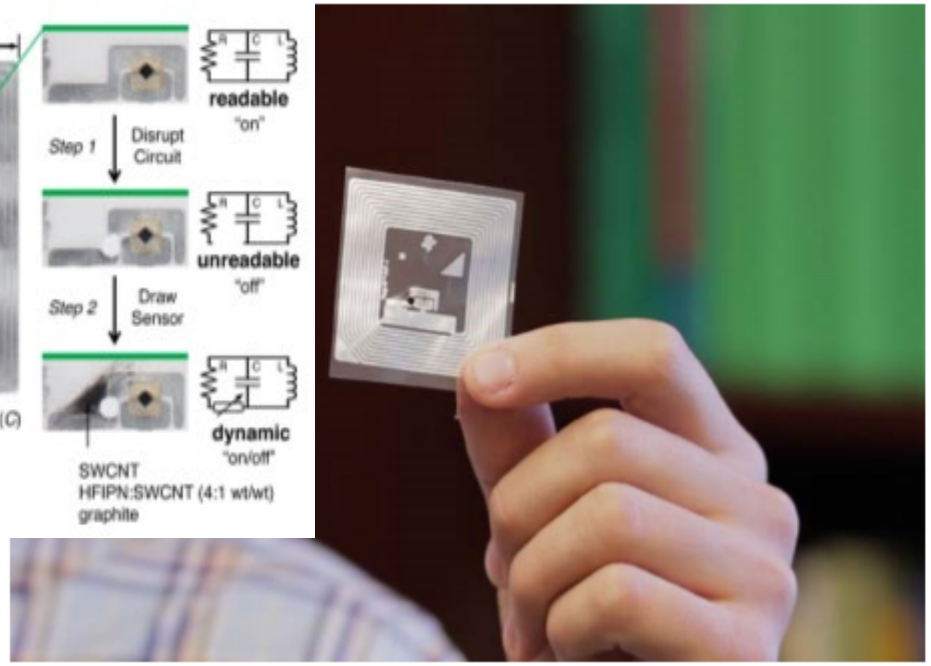
Anne Trafton | MIT News
April 5, 2017

http://pubs.acs.org/doi/abs/10.1021/acscentsci.7b00021

MIT News

ON CAMPUS AND AROUND THE WORLD





The MIT researchers' wireless chemical sensor.

Photo: Melanie Gonick

MIT News

ON CAMPUS AND AROUND THE WORLD

Detecting gases wirelessly and cheaply

New sensor can transmit information on hazardous chemicals or food spoilage to a smartphone.

Wireless gas detection with a smartphone via rf communication

Joseph M. Azzarelli, Katherine A. Mirica, Jens B. Ravnsbæk[1], and Timothy M. Swager[2]

Department of Chemistry, Massachusetts Institute of Technology, Cambridge, MA 02139

Edited by Chad A. Mirkin, Northwestern University, Evanston, IL, and approved November 5, 2014 (received for review August 10, 2014)

Wireless, wearable toxic-gas detector www.pnas.org/content/111/51/18162.full.pdf

Pay A Penny Per Use – PAPPU Analytics, Apps, Data Distribution Service

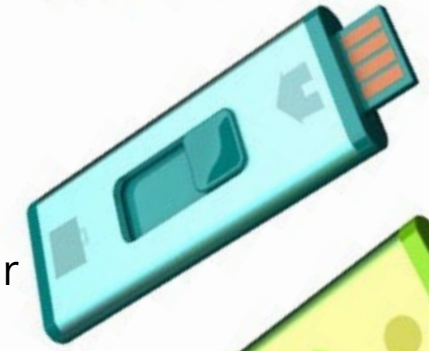
Glucose Sensor

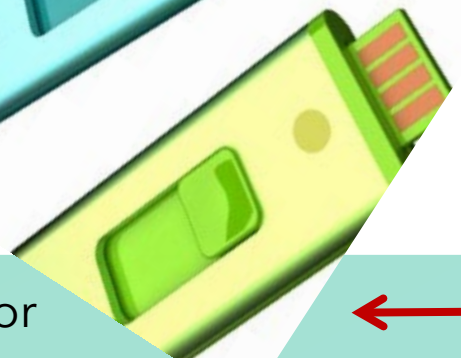
Cholesterol Sensor

BNP Sensor

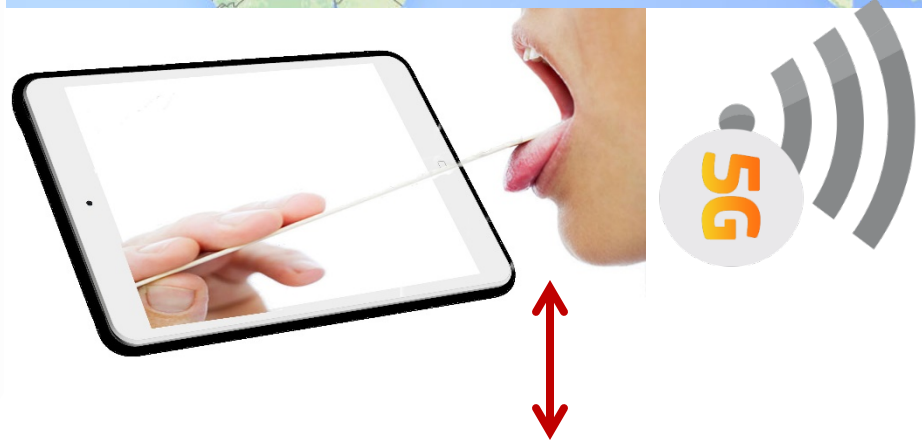
SARS-CoV-2 Sensor

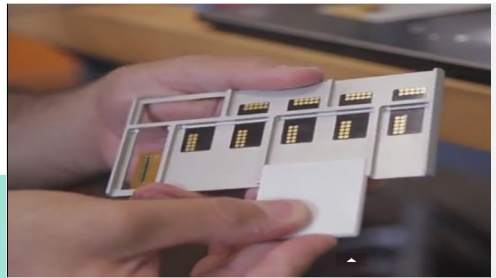
Ebola Virus Sensor





What does the data suggest about my health?





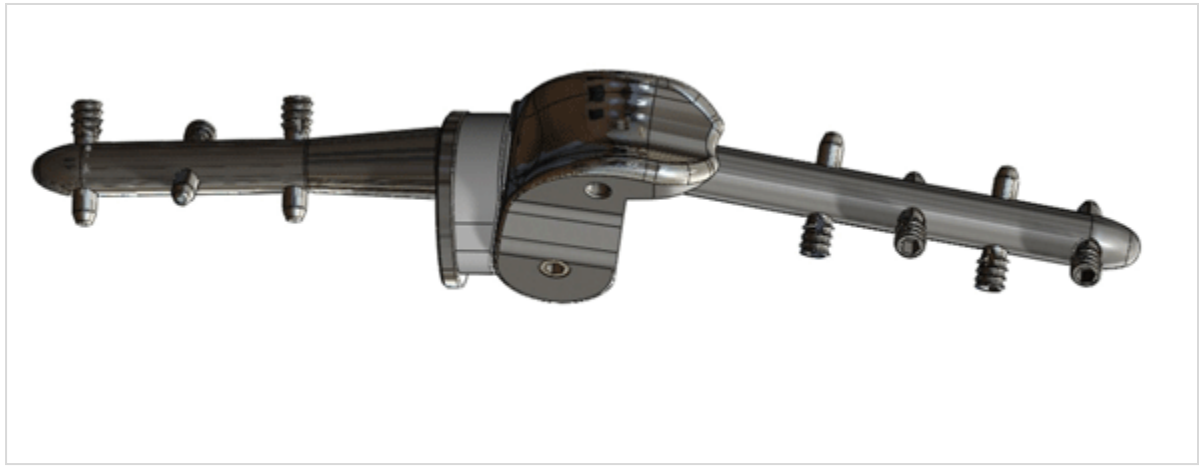
Hot swappable, modular, smart

NK Labs
ARA Prototype

Made-on-Demand ▪ Made-to-Design

3D Printed Spare Parts – specifically designed for each patient

3-D Printing
Design of Prosthetics and Orthopedic Imaging

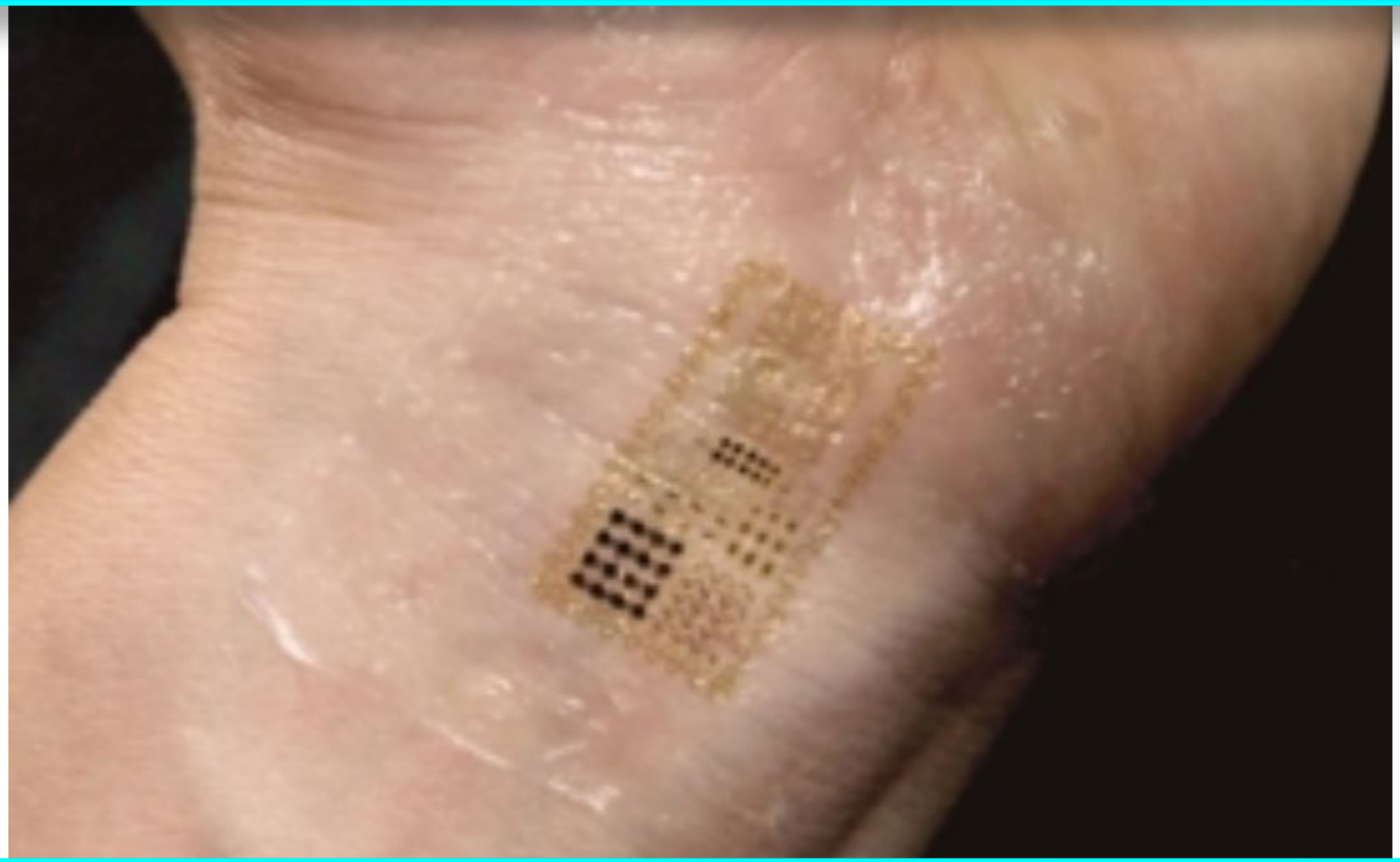


Cyrano L. Catte II (above) is the first feline to receive a total knee arthroplasty (TKA). Femoral and tibial components were created with direct metal laser sintering (EOS).

3-D Printing of Fitted Parts on Demand

http://bit.ly/3D-Print-A-Tooth
http://bit.ly/3D-Print-Medical-Devices

Artificial Skin with embedded sensory surface talks to smart phone via capacitive sensing using Touchcode adapted for printed i-Skin

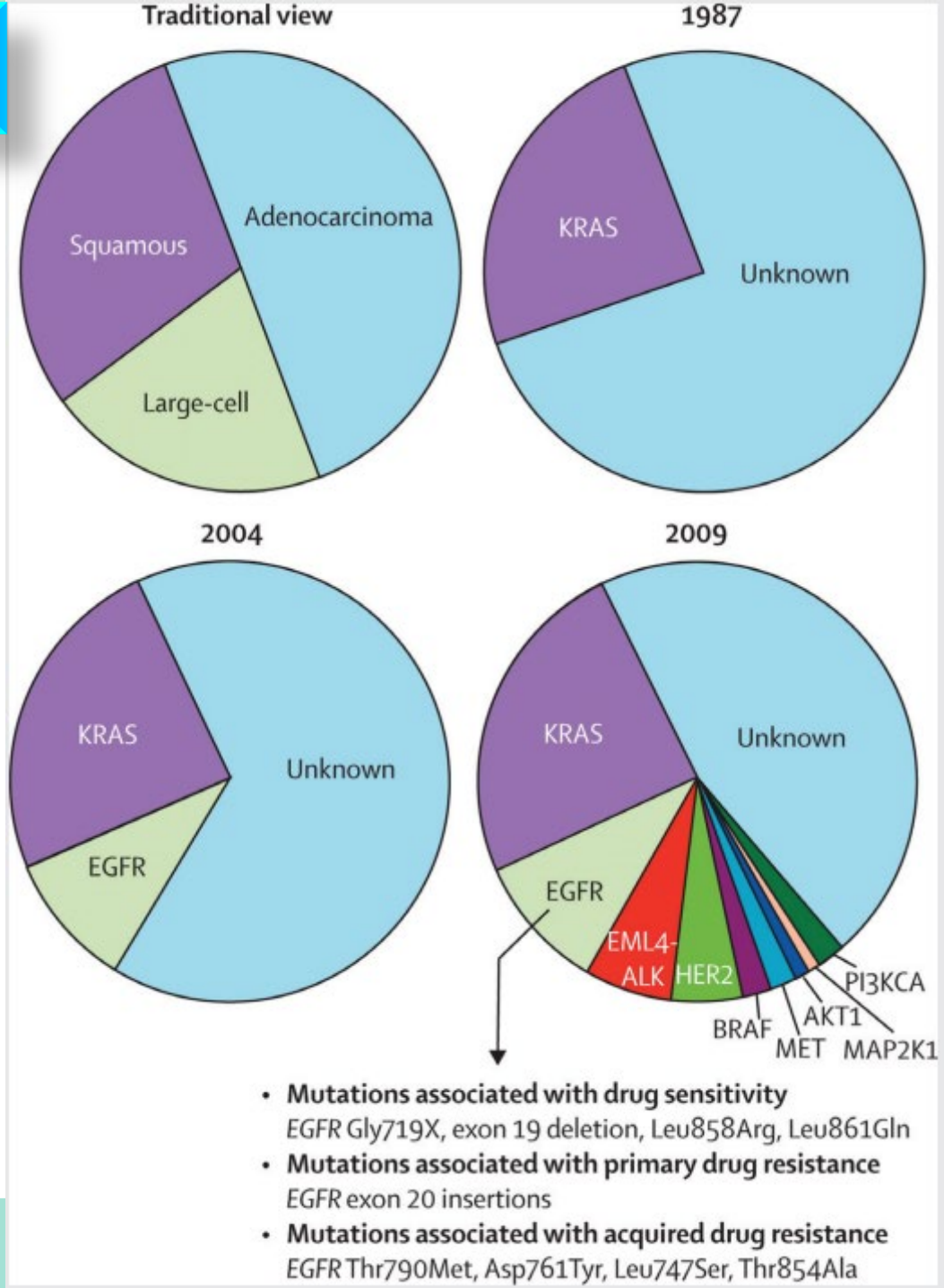


Your medicine can inform your doctor about its kinetics, bio-availability and side effects. It can alert your pharmacist about potential over-dose if multiple medications contain same or similar active ingredients. Your medicine can query your physician and even adjust dosage.

The Final Frontier or Excessive Greed ?

Precision Medicine

Non-Small Cell Lung Carcinoma



http://bit.ly/PRECISION-MEDICINE

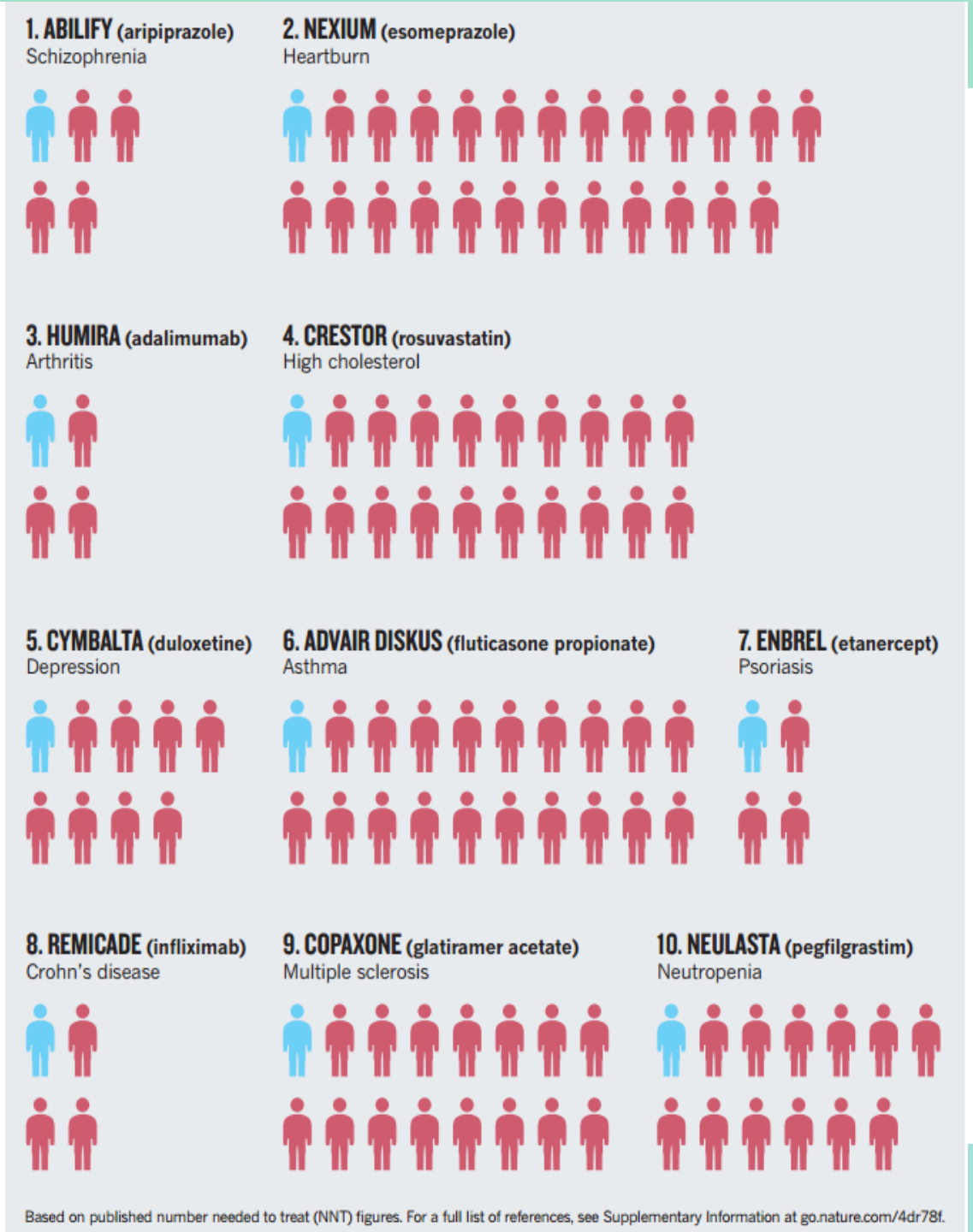
new ones and identifying appropriate disease biomarkers, such as tumour DNA circulating in the bloodstream. It will also require a cultural shift on many levels — in regulatory agencies, in pharmaceutical companies and, most of all, in the clinic.

A WORLD OF DIFFERENCE

Discovering that an intervention works well in certain groups happens relatively rarely and often by chance. Researchers typically get disappointing results with a drug in large, population-based trials. This leads them to conduct ad hoc post-trial analyses, to try to identify the factors that cause some of the people in the trial to seem to be responsive[3].

For instance, the drug Gleevec (imatinib) was found to double survival rates of leukaemia patients[4] with a chromosomal abnormality in their tumours called the Philadelphia translocation. Similarly, it turns out that Erbitux (cetuximab) improves the survival of people with colorectal cancer whose tumour cells carry a mutated *EGFR* gene but not a mutated *KRAS* gene[5].

This approach to discovery is inefficient at best. Conventional phase III trials involve thousands of people. The intervention being tested is often given at random to one group while another group receives a sham treatment, such as a sugar pill or the standard treatment that physicians would give such patients. Because scant data are collected on factors such as genetics, lifestyles and diets, the results of these trials often indicate the need for yet another study to validate the effectiveness of the intervention among the apparent responders and to establish the



Based on published number needed to treat (NNT) figures. For a full list of references, see Supplementary Information at go.nature.com/4dr78f.

Precision Medicine – Drug Development

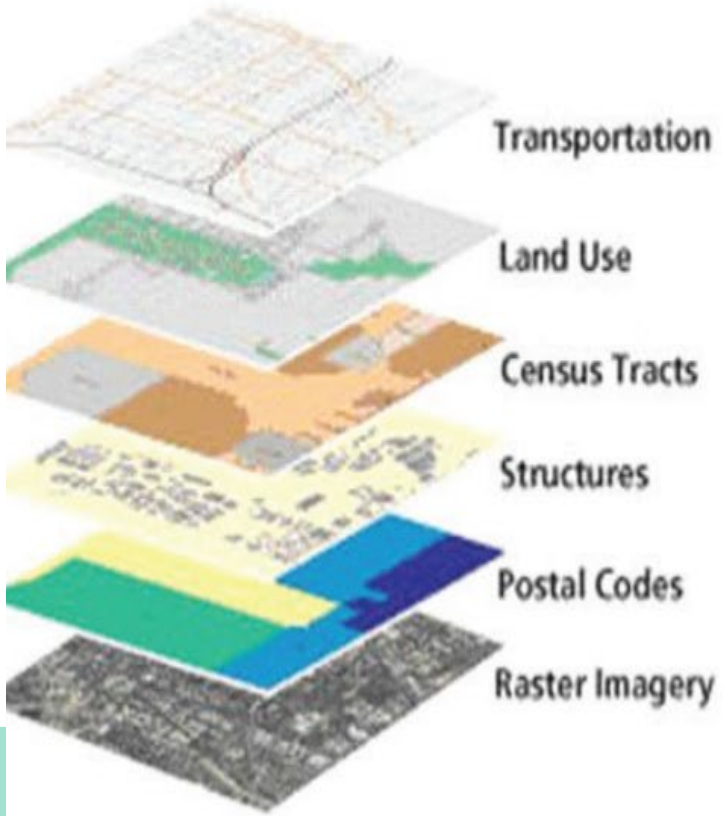
A successful example of the precision medicine approach to drug development involves the drug Crizotinib, an inhibitor of the MET and ALK kinases, which began clinical development in a broad population of patients with lung cancer (Kwak et al. 2010). During the early stages of the initial Crizotinib clinical trial conducted by pharmaceutical industry scientists, an independent group of academic scientists published their discovery that a particular chromosomal translocation involving the gene encoding ALK drives tumor growth in a subset of non-small cell lung cancer patients (Soda et al. 2007). Access to this knowledge allowed the pharmaceutical industry scientists to modify their clinical trial to look specifically at a cohort of patients with this translocation, and the results were dramatic. For those patients who had the translocation, the median disease-free survival with Crizotinib was a year, compared to just a few months with the standard of care. Thus, even in a trial that involved only a small number of patients that were compared to historical controls, it was obvious that the drug was active. In contrast, in an unselected patient population, most patients did not benefit from this drug and it was unclear whether the drug had any activity.

(Crizotinib is expected to receive regulatory approval for treatment of ALK translocation-positive lung cancer within the next year.)

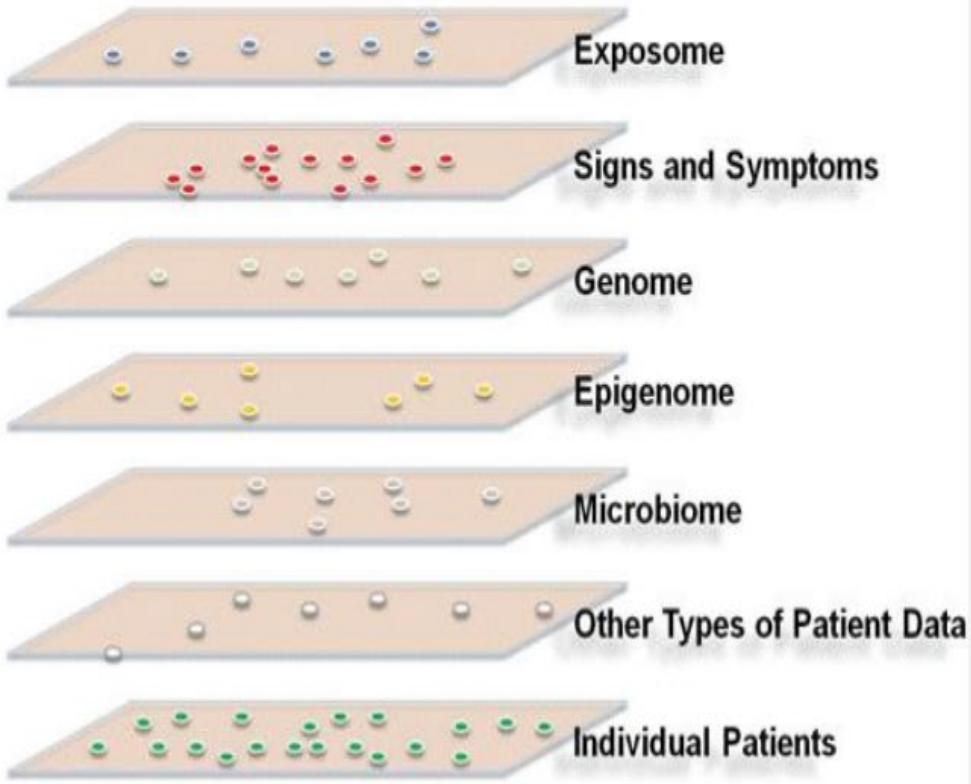
http://bit.ly/PRECISION-MEDICINE

The principle of GIS helped to organize patient-centric information layers

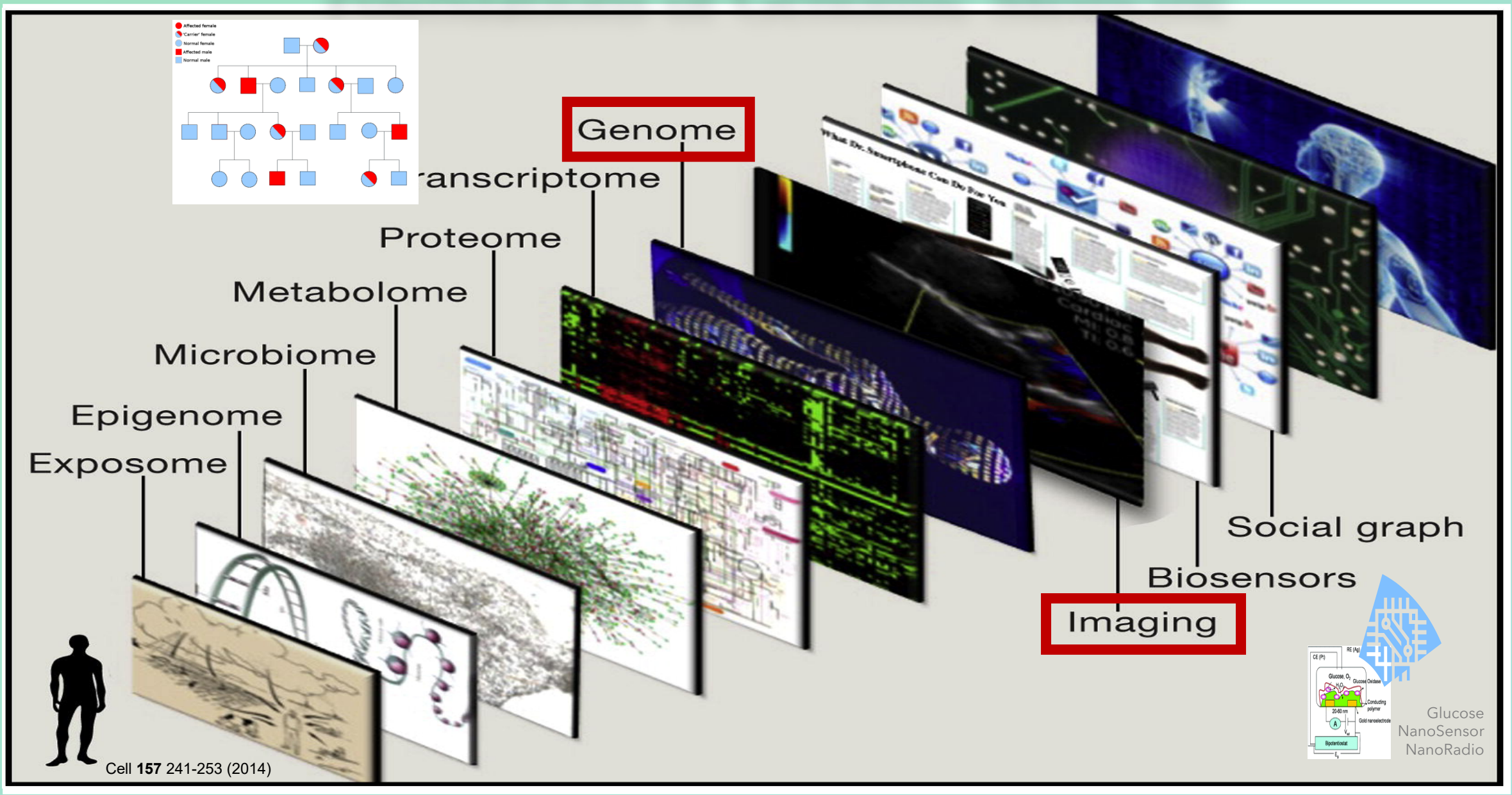
Google Maps: GIS layers
Organized by Geographical Positioning



Information Commons
Organized Around Individual Patients



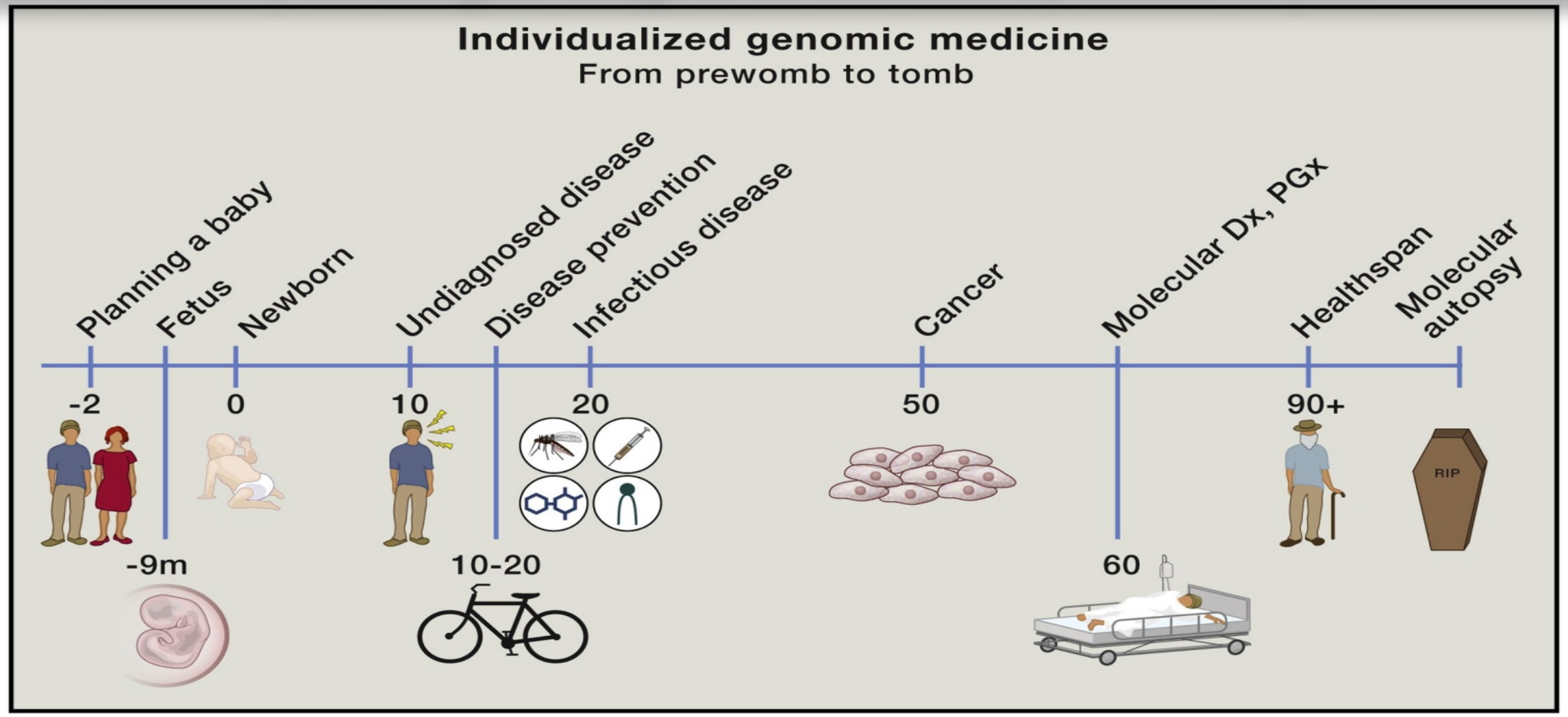
Foundations of Genomic Medicine



Mendelian Inheritance in Man: A Catalog of Human Genes and Genetic Disorders by Victor A. McKusick

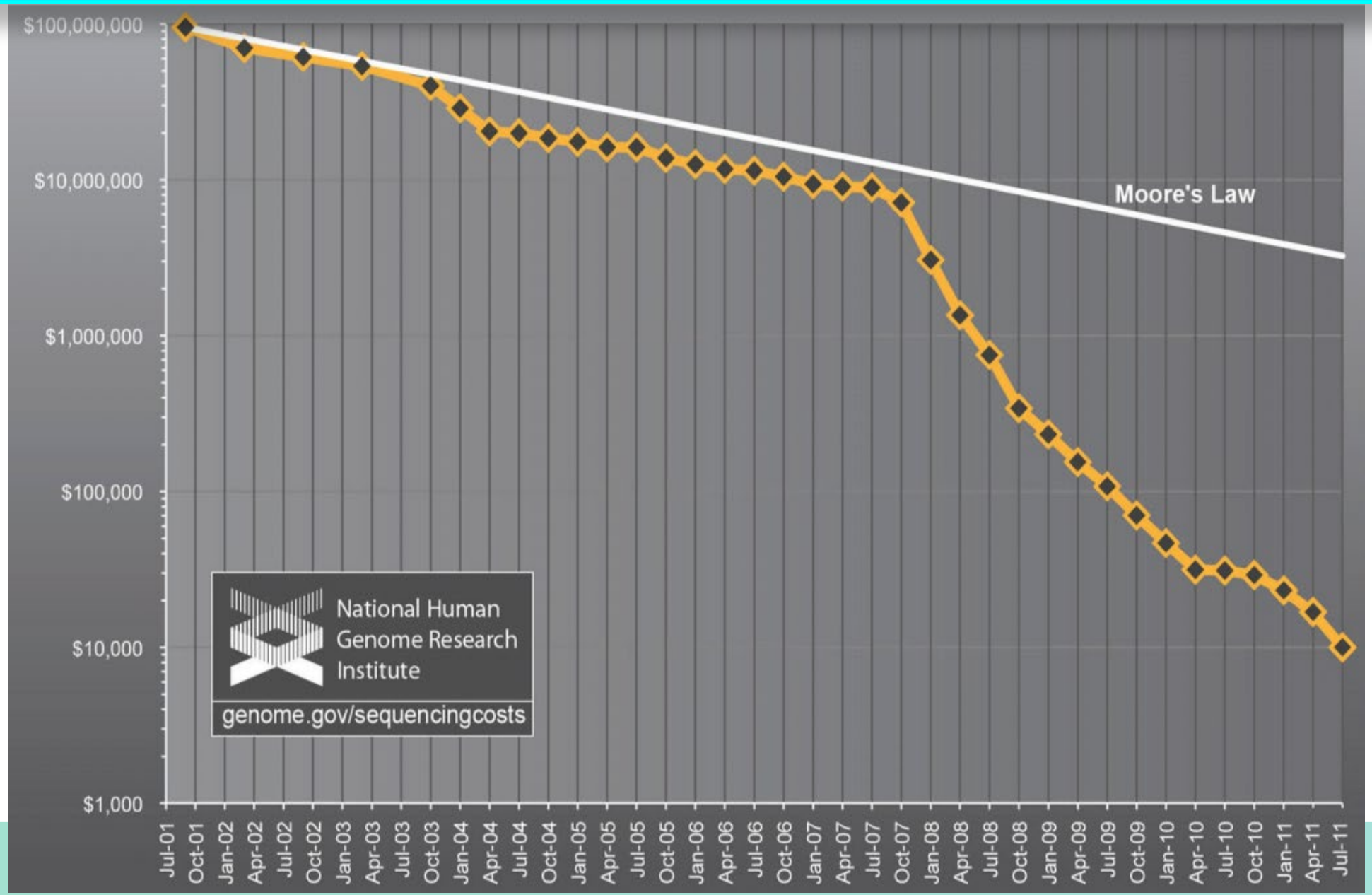
Human Genomics in the Age of Precision Medicine: Is it irrational exuberance?

Is it necessary for designer drugs to be delivered by drones to your bedroom?



Cell **157** 241-253 (2014) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3995127/pdf/nihms-572802.pdf

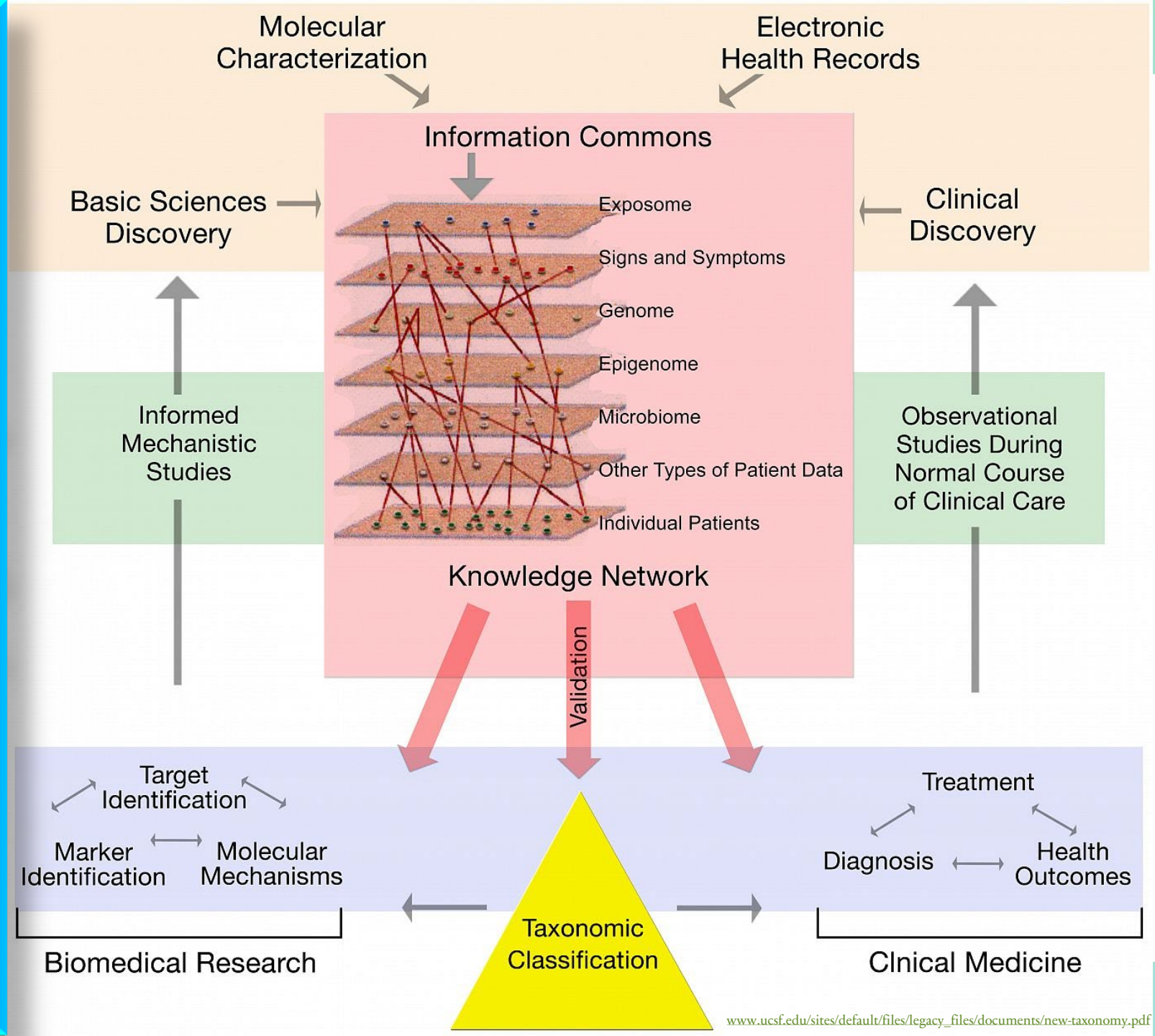
Plummeting cost of complete genome sequencing – is there information of value in the data ?



MinION USB stick gene sequencer finally comes to market

By John Hewitt (http://www.extremetech.com/author/jhewitt) on September 19, 2014 at 2:10 pm

How do we integrate data and information from these systems with diverse open source healthcare platforms?



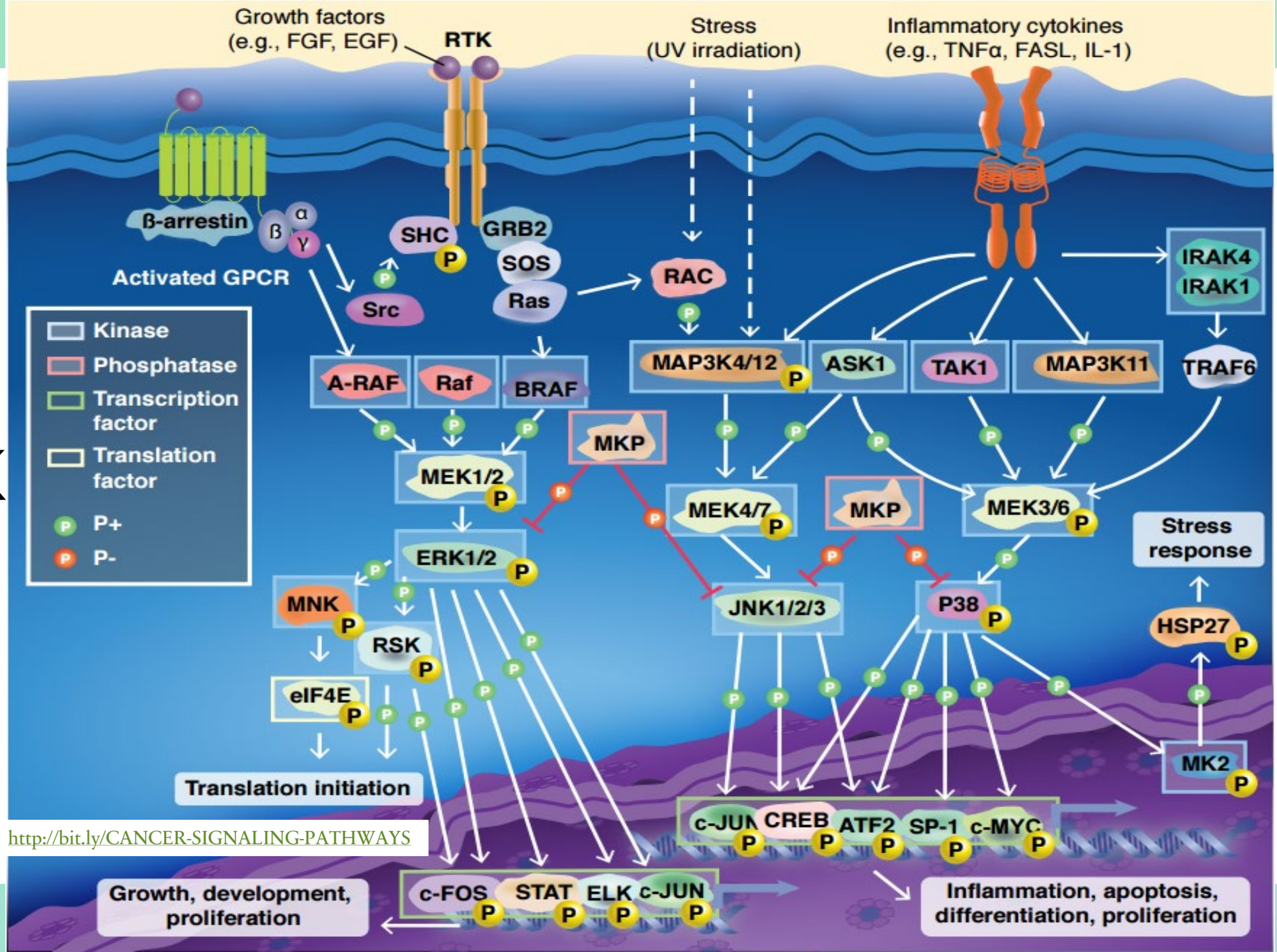
www.ucsf.edu/sites/default/files/legacy_files/documents/new-taxonomy.pdf

What is the challenge of precision medicine?

Avoid the hyperbole

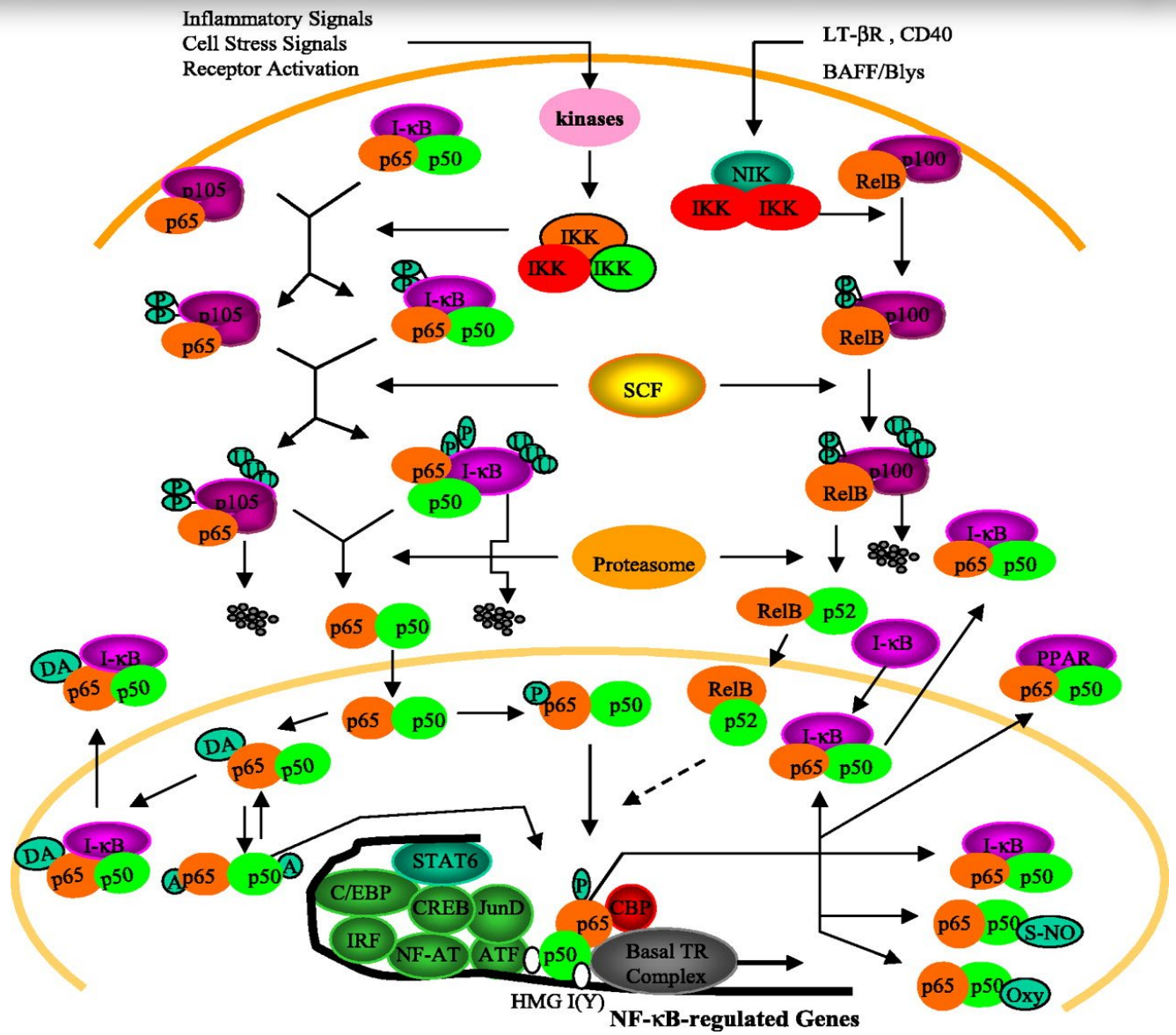
How close are we to the “knowledge network” of biological/disease networks?

MAPK



http://bit.ly/CANCER-SIGNALING-PATHWAYS

NF-κB activation cascade in the canonical pathways

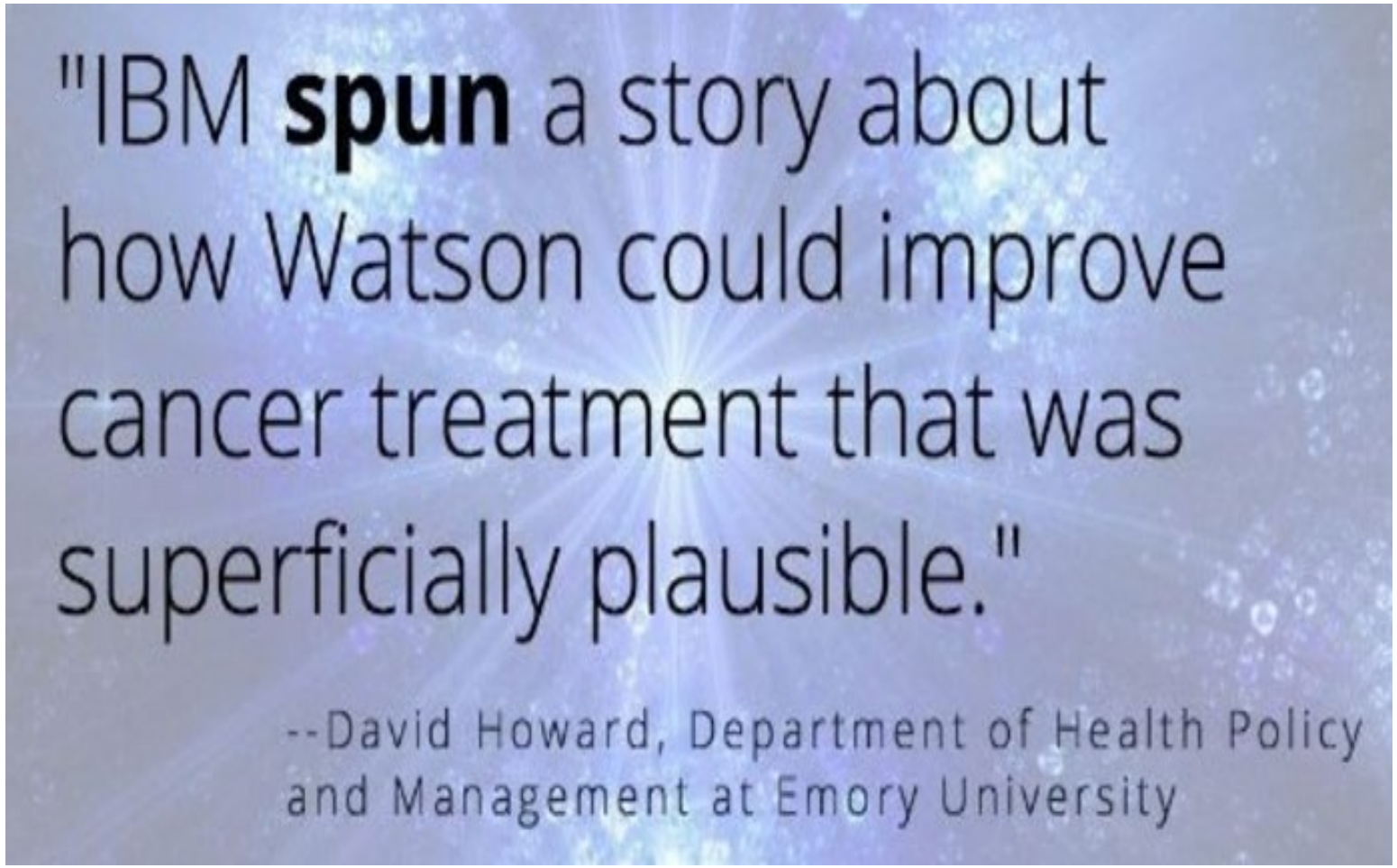


Shu Fang Liu and Asrar B. Malik (2006) American J Physiol Lung Cell Mol Physiology **290** L622-L645

How close are we to the "knowledge network" of biological/disease networks?

We know so little that only those who are egotistical, stupid and braggadocious will venture to claim knowledge about "knowledge networks" in biology and/or diseases.

Healthcare garbage from IBM and others. How tabloid fodder is promoted from rubbish to veritable truth.



www.healthnewsreview.org/2017/02/md-anderson-cancer-centers-ibm-watson-project-fails-journalism-related

Far flung future frontier …

http://bit.ly/Terahertz-Imaging

Proteins are Radios

We can detect, diagnose and correct RF radiation.

Can we?

Protein Electrodynamics

Nature Vol. 267 16 June 1977

articles

Dynamics of folded proteins

J. Andrew McCammon, Bruce R. Gelin & Martin Karplus

Department of Chemistry, Harvard University, Cambridge, Massachusetts 02138

The dynamics of a folded globular protein (bovine pancreatic trypsin inhibitor) have been studied by solving the equations of motion for the atoms with an empirical potential energy function. The results provide the magnitude, correlations and decay of fluctuations about the average structure. These suggest that the protein interior is fluid-like in that the local atom motions have a diffusional character.

The Nobel Prize in Chemistry 2013
Martin Karplus, Michael Levitt, Arieh Warshel

The Nobel Prize in Chemistry 2013

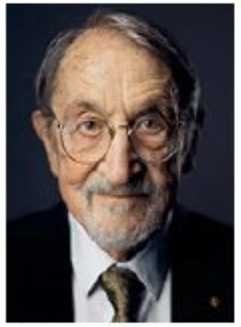


Photo: A. Mahmoud
Martin Karplus
Prize share: 1/3

Photo: A. Mahmoud
Michael Levitt
Prize share: 1/3

Photo: A. Mahmoud
Arieh Warshel
Prize share: 1/3

The Nobel Prize in Chemistry 2013 was awarded jointly to Martin Karplus, Michael Levitt and Arieh Warshel *"for the development of multiscale models for complex chemical systems"*.

Seminal contribution to the field of protein electrodynamics by Martin Karplus, Harvard University

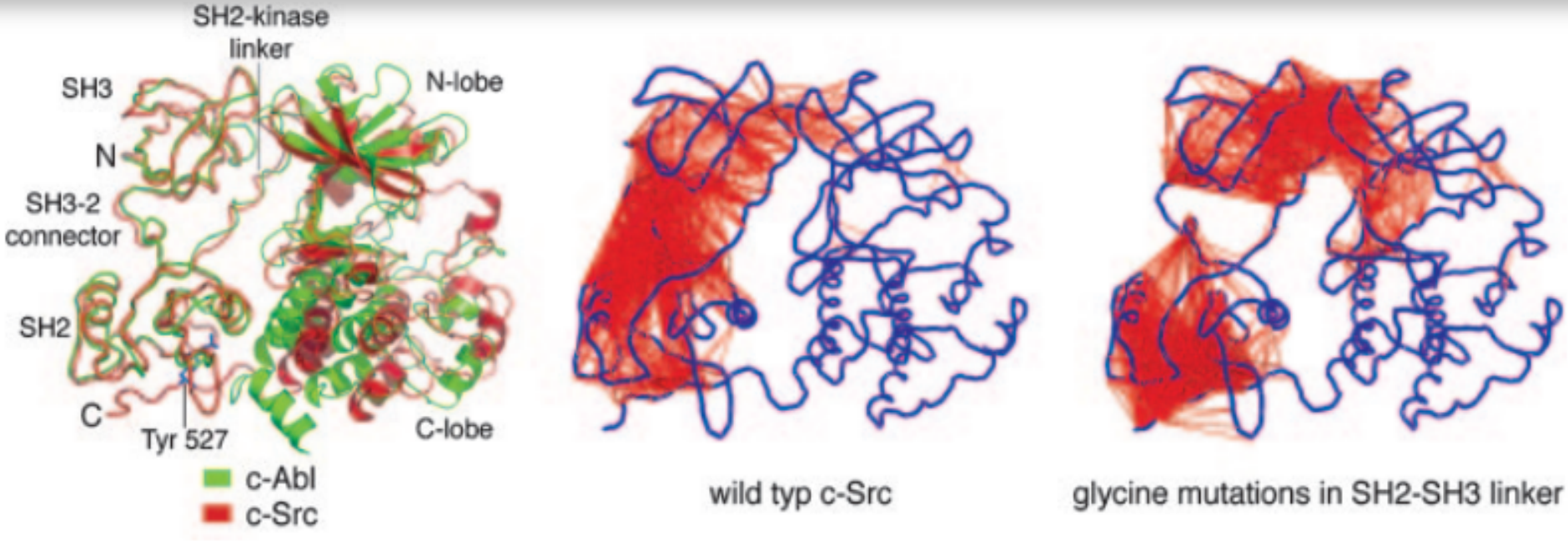
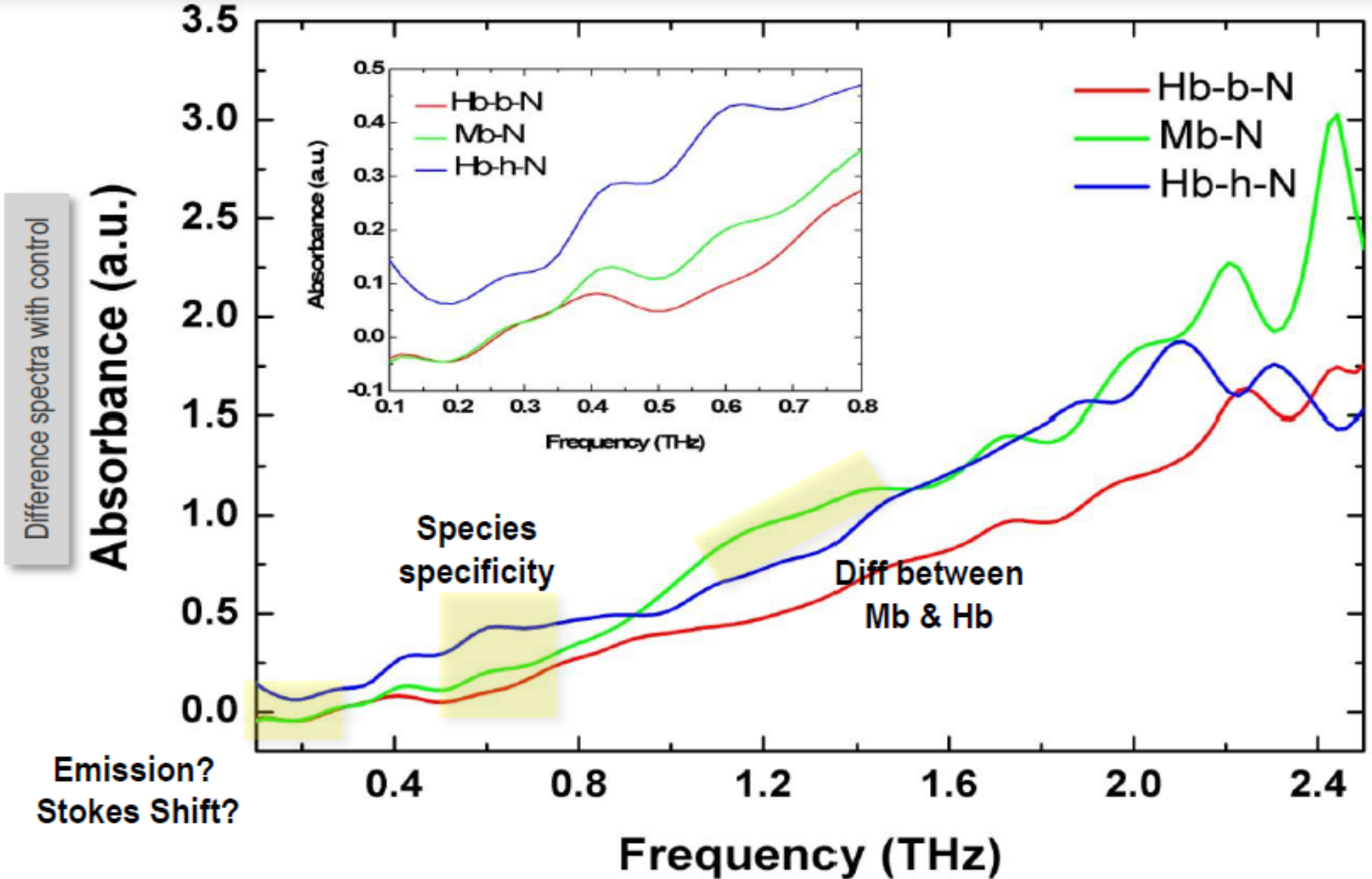


Fig. 5. Structure and dynamics of the Src and Abl kinases. (*Left*) The structures of c-Abl (green) and c-Src (red) are shown superimposed on their SH2 and SH3 domains (69, 70, 75). Note the dissimilarity in the conformation of the kinase domains. (*Center* and *Right*) The results of unbiased molecular dynamics simulations of c-Src. Residues in different domains that move in a correlated manner in the simulation are linked by a red line. These correlations were calculated by superimposing each instantaneous structure in the simulation on the C-terminal lobe of the kinase domain, and motions that are correlated to the C-terminal lobe are removed by this procedure. (*Right*) The mutation of residues in the SH2–SH3 linker to glycine reduces the correlation in the dynamics of these domains. Similar results were obtained for c-Abl. (Modified from refs. 8 and 75.)

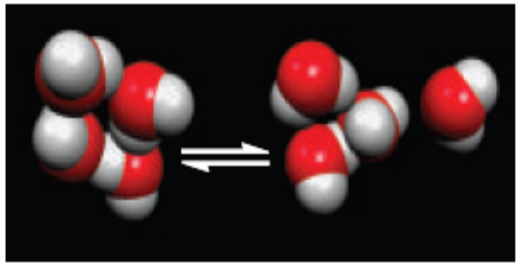
Proteins Absorb Radio Frequency (RF) at the TeraHertz (THz) Range



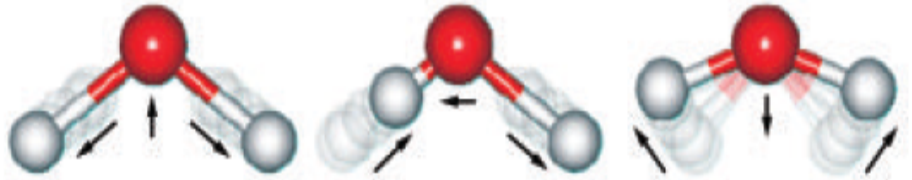
Terahertz Spectroscopy – A Tool ??

TERAHERTZ SPECTROSCOPY 101

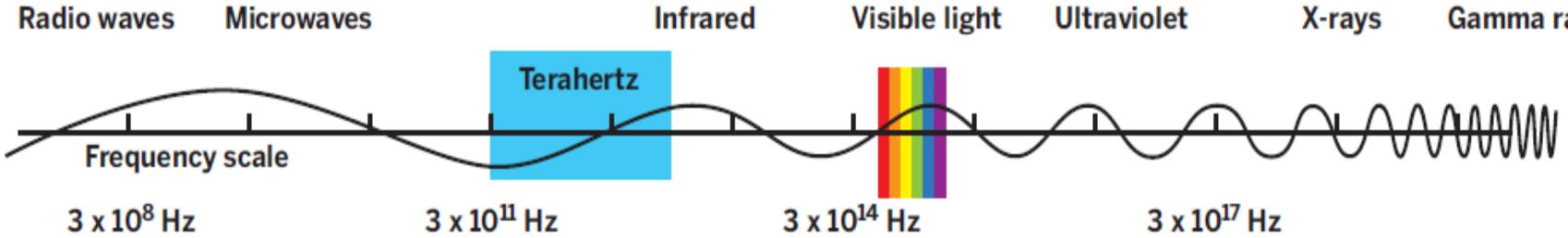
Light with submillimeter wavelengths and a frequency range of roughly 0.1 to 10 THz, or 3 to 300 cm^{-1}, is known as terahertz radiation. It can penetrate plastics, paper, and textiles, but it is absorbed strongly by water, making it a sensitive probe of biological tissue. Unlike the relatively high-frequency stretching and bending motions that infrared light induces in individual water molecules (above), THz light causes groups of water molecules to coalesce and disassemble repeatedly (left).



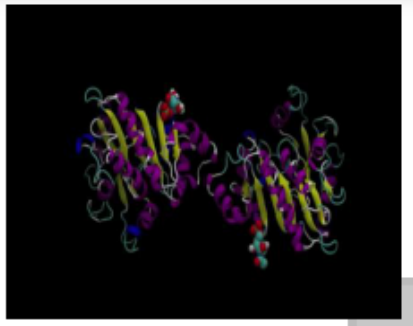
MATTHIAS HEYDEN/ RUHR UNIVERSITY BOCHUM



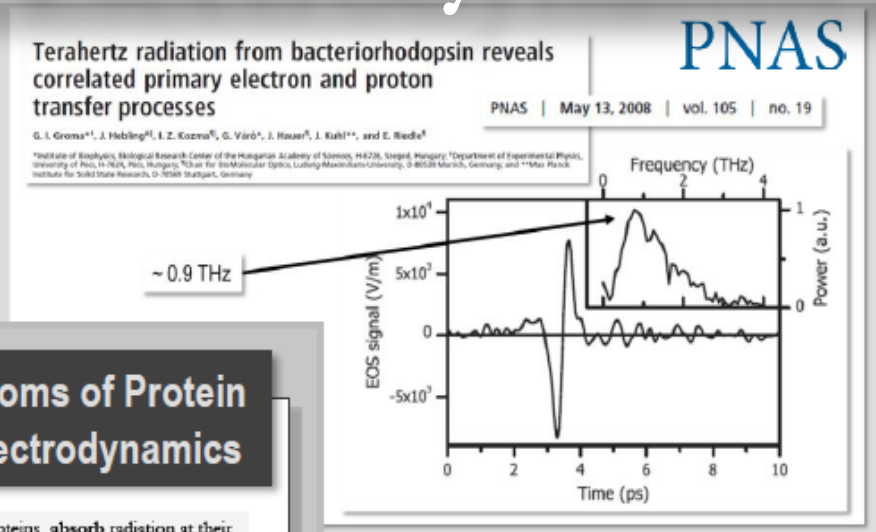
MARTIN CHAPLIN/ LONDON SOUTH BANK U.



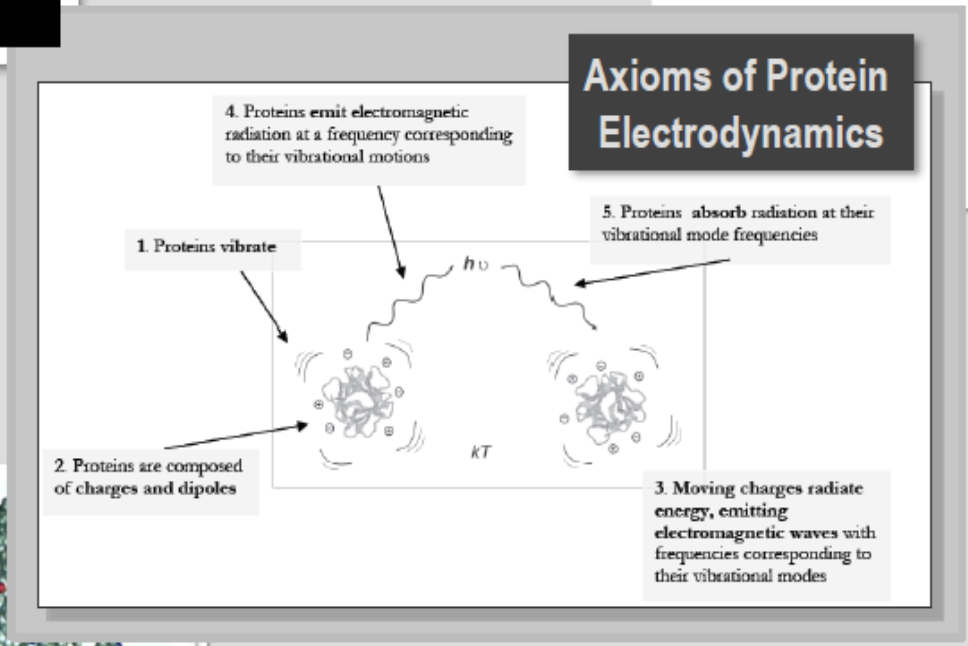
Axioms of Protein Electrodynamics



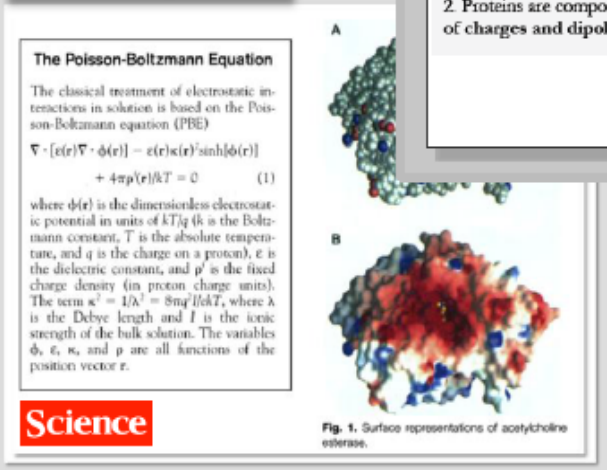
1. Proteins Vibrate



4. Proteins emit THz radiation



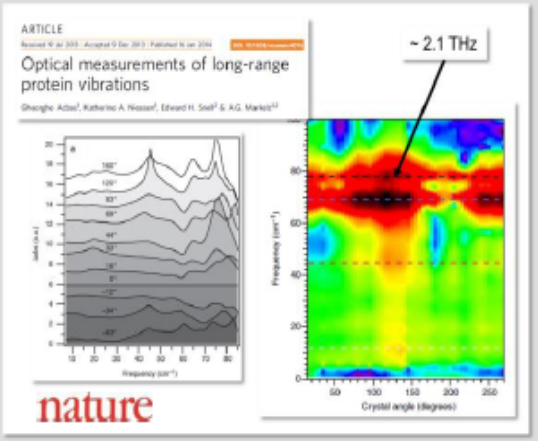
2. Proteins Are Charged



3. Maxwell's Equations

$$\nabla \cdot \mathbf{E} = 0 \qquad \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t},$$

$$\nabla \cdot \mathbf{B} = 0 \qquad \nabla \times \mathbf{B} = \frac{1}{c^2}\frac{\partial \mathbf{E}}{\partial t}.$$



5. Proteins absorb THz radiation

Absence of Protein • Absence of Vibration

Concept of protein vibration as a signature

Police Tool Targets Guns

Kelly Says 'T-Ray' Can Indicate a Firearm Under Clothing

By TAMER EL-GHOBASHY

Jan. 23, 2013 9:20 p.m. ET

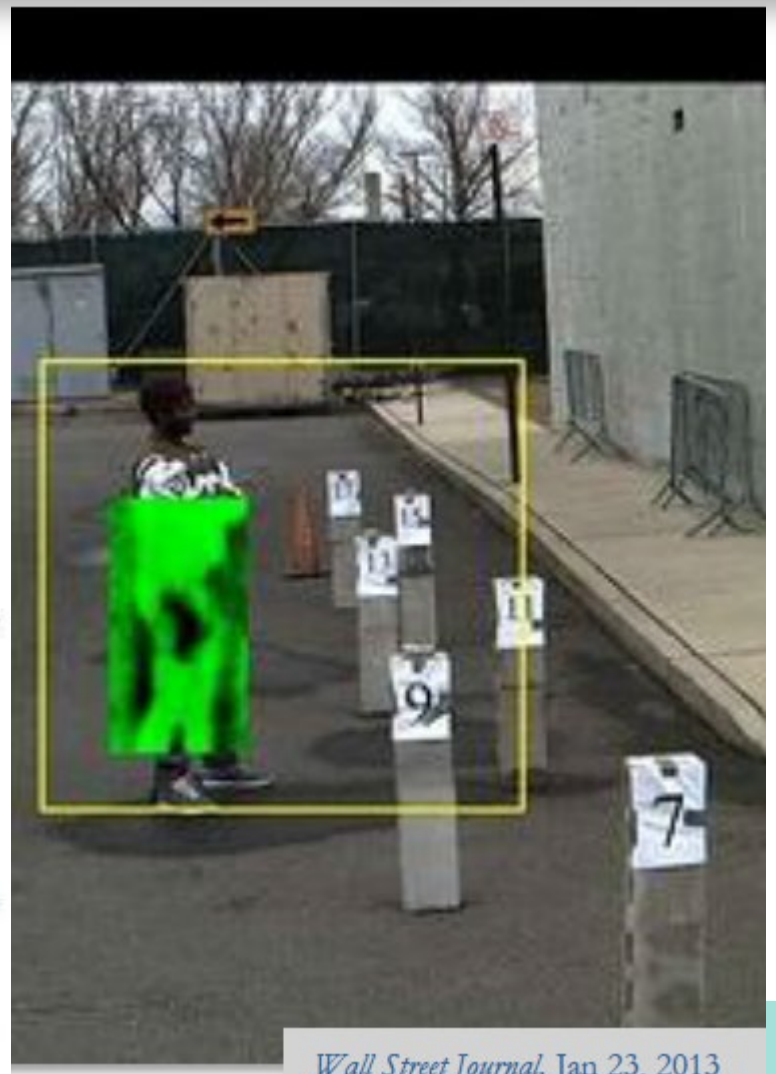
The New York Police Department is testing a new device it says can detect firearms concealed beneath layers of clothing, a high-tech crime-fighting tool seemingly torn from the pages of science fiction.

The so-called T-Ray machine detects terahertz radiation, a high-frequency electromagnetic natural energy that is emitted by people and can penetrate many materials, including clothing.

The T-Ray machine. *NYPD*

"If something is obstructing the flow of that radiation, for example a weapon, the device will highlight that object," said Commissioner Raymond Kelly, who described the device Wednesday in a speech at the Waldorf-Astoria Hotel.

News of the device prompted concerns from privacy advocates, though they also saw a potential benefit: It might render unnecessary the legally disputed police policy of stopping and frisking people who haven't been first identified as suspects in crimes.

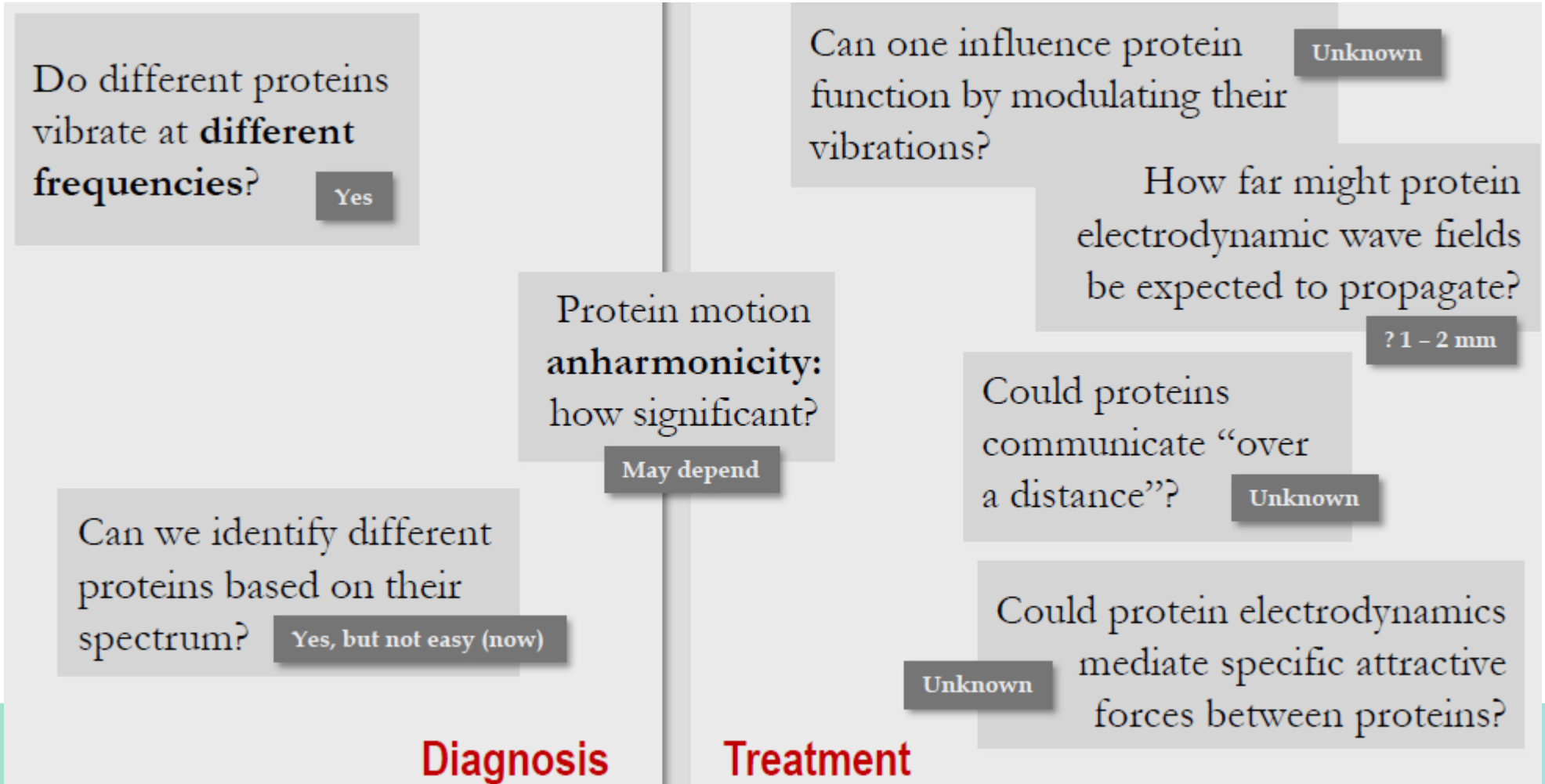


Wall Street Journal, Jan 23, 2013

TeraHertz Medicine

Concept of protein vibration as a signature

- Is the protein signature sufficiently specific as a tool for protein structure, conformation and configuration?
- Can it be used for diagnosis to differentiate between normal and mutant proteins or degraded products/peptides?
- Can RF modulation reconfig protein structure to activate normal function or detect/deactivate harmful proteins?



Key technical challenges in TeraHertz Medicine

Concept of protein vibration as a signature is clouded by water

The “noise” from RF vibration of water molecules may significantly distort the TeraHertz profile.

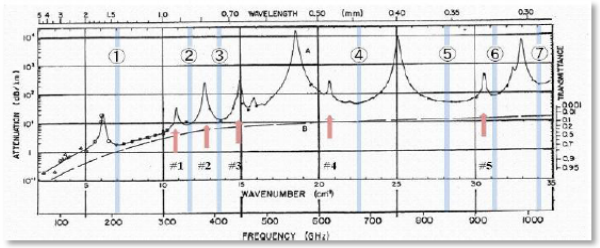
How do we correct the error due to this (Shannon) “noisy channel” related to water?

Is this a signal processing issue? Can novel algorithms subtract the “noise” due to water?

What about the application of the principles of (Shannon, Kalman-Bucy) error correcting algorithms?

https://en.wikipedia.org/wiki/Kalman_filter
http://news.mit.edu/2010/explained-shannon-0115
http://www.cs.cmu.edu/~guyb/realworld/errorcorrecting.html
http://www.cs.cmu.edu/~aarti/Class/10704/lec16-shannonnoisythrm.pdf

- **Range: 0.2 – 1THz** for biomedical applications (e.g. proteins)
- **Tunability: CW** spectroscopy (water windows)
- **Pulsed: (~ 10 ps)** Minimize water relaxation effects
- **High power:** Beer-Lambert, etc.



Optics Express (2011), 19(9)

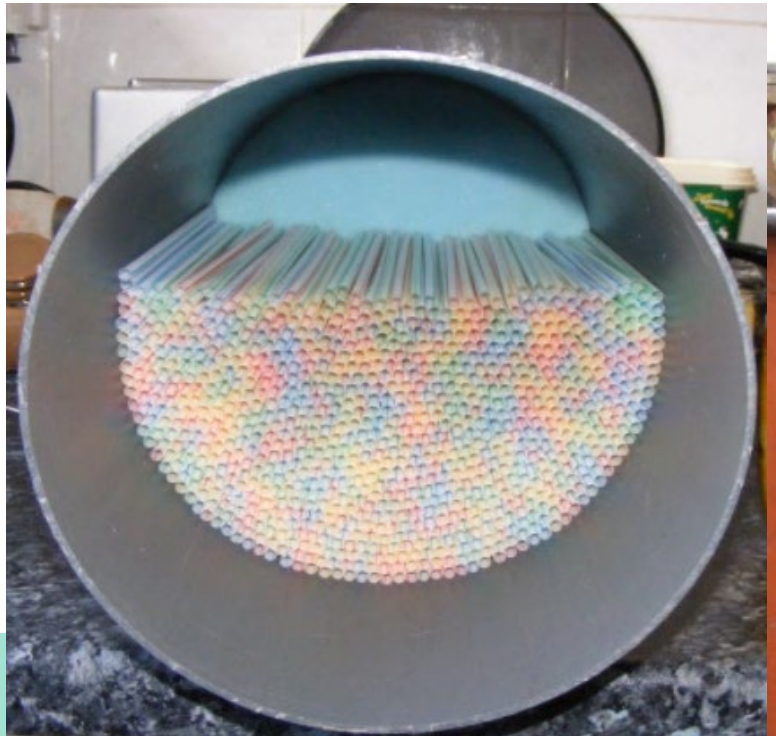
Data Curation Concepts from Laminar Flow in TeraHertz Medicine?
Can we subtract RF vibration due to water from protein vibration?

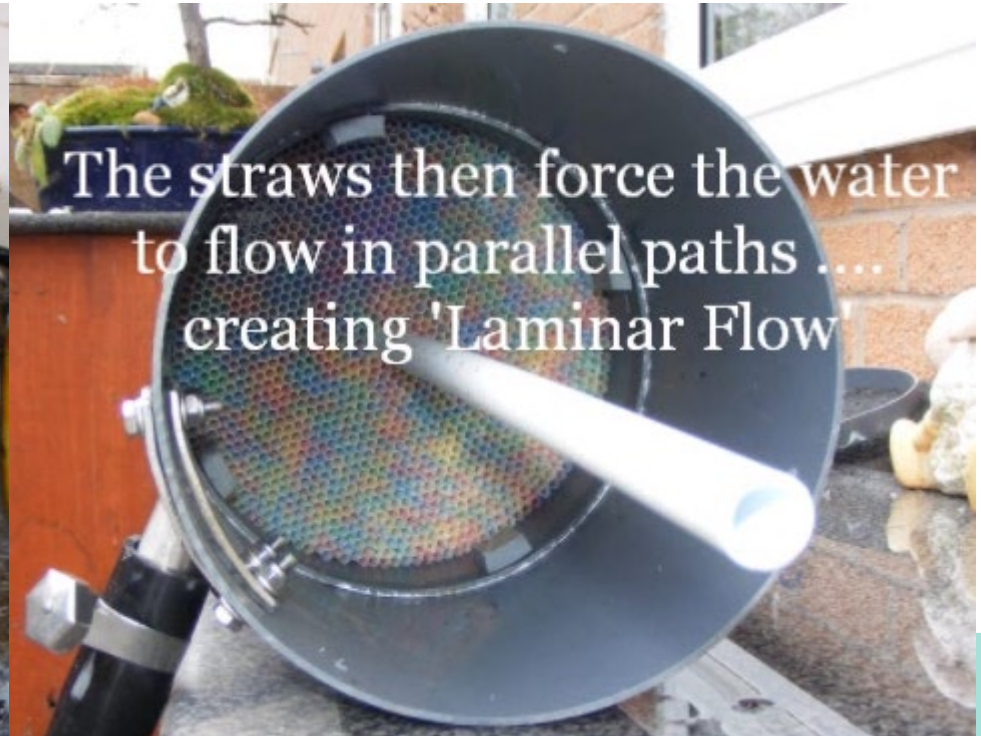
The data (TeraHertz profile) is a mix of RF due to water and protein (which needs to be separated).

Is this a data curation problem? Are we observing related signal/noise issues in data analytics?

Are there any concepts related to data curation which may be triggered by laminar flow?

http://bit.ly/LAMINAR-FLOW-DATA-CURATION-CONCEPT





www.eecs.berkeley.edu/~christos/classics/shannon-report.pdf

www.princeton.edu/~verdu/reprints/IT44.6.2057-2078.pdf

http://web.mit.edu/6.933/www/Fall2001/Shannon1.pdf

http://web.mit.edu/6.933/www/Fall2001/Shannon2.pdf

http://home.ustc.edu.cn/~zhanghan/cs/Gallager01.pdf

www.pnas.org/cgi/doi/10.1073/pnas.1517384113

www.pnas.org/cgi/doi/10.1073/pnas.1013529108

www.essrl.wustl.edu/~jao/itrg/shannon.pdf

A Mathematical Theory of Communication

By C. E. SHANNON

Introduction

THE recent development of various methods of modulation such as PCM and PPM which exchange bandwidth for signal-to-noise ratio has intensified the interest in a general theory of communication. A basis for such a theory is contained in the important papers of Nyquist[1] and Hartley[2] on this subject. In the present paper we will extend the theory to include a number of new factors, in particular the effect of noise in the channel, and the savings possible due to the statistical structure of the original message and due to the nature of the final destination of the information.

The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. Frequently the messages have *meaning*; that is they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. The significant aspect is that the actual message is one *selected from a set* of possible messages. The system must be designed to operate for each possible selection, not just the one which will actually be chosen since this is unknown at the time of design.

If the number of messages in the set is finite then this number or any monotonic function of this number can be regarded as a measure of the information produced when one message is chosen from the set, all choices being equally likely. As was pointed out by Hartley the most natural choice is the logarithmic function. Although this definition must be generalized considerably when we consider the influence of the statistics of the message and when we have a continuous range of messages, we will in all cases use an essentially logarithmic measure.

The logarithmic measure is more convenient for various reasons:

1. It is practically more useful. Parameters of engineering importance

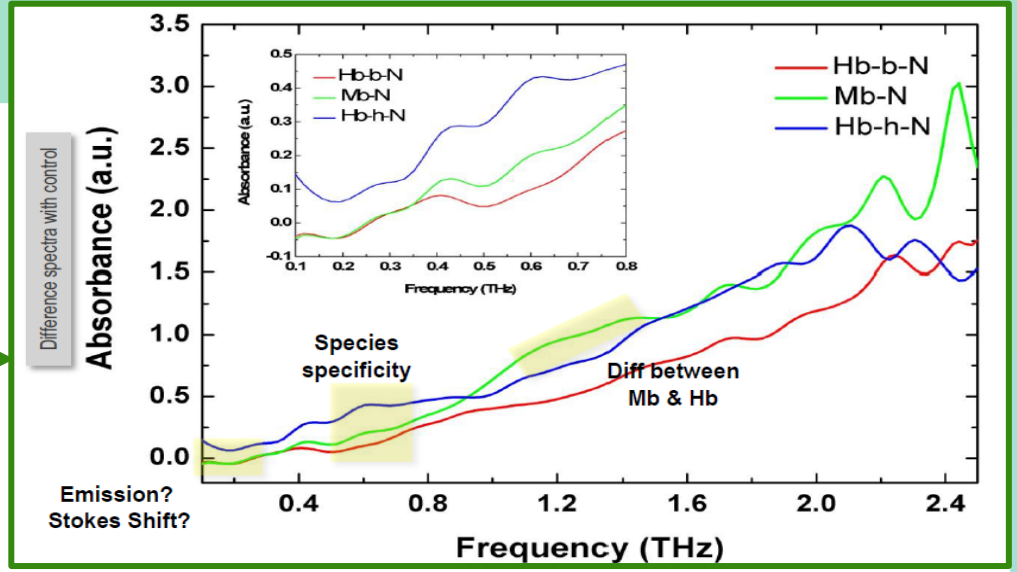
[1] Nyquist, H., "Certain Factors Affecting Telegraph Speed," *Bell System Technical Journal*, April 1924, p. 324; "Certain Topics in Telegraph Transmission Theory," *A. I. E. E. Trans.*, v. 47, April 1928, p. 617.

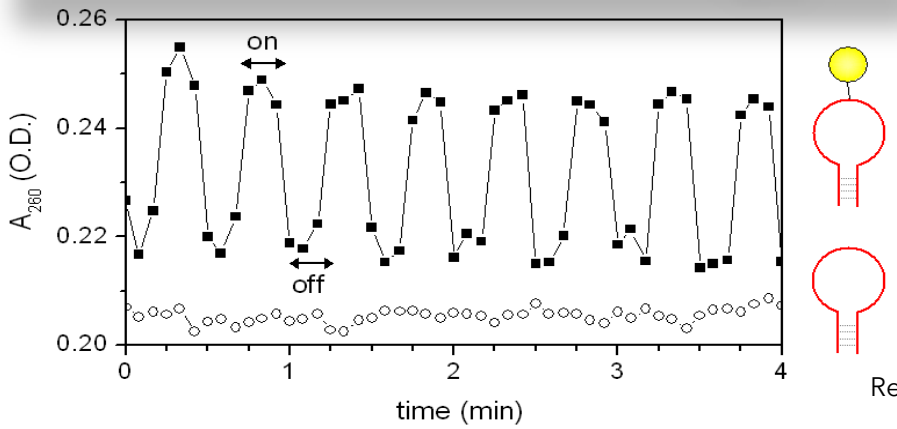
[2] Hartley, R. V. L., "Transmission of Information," *Bell System Technical Journal*, July 1928, p. 535.

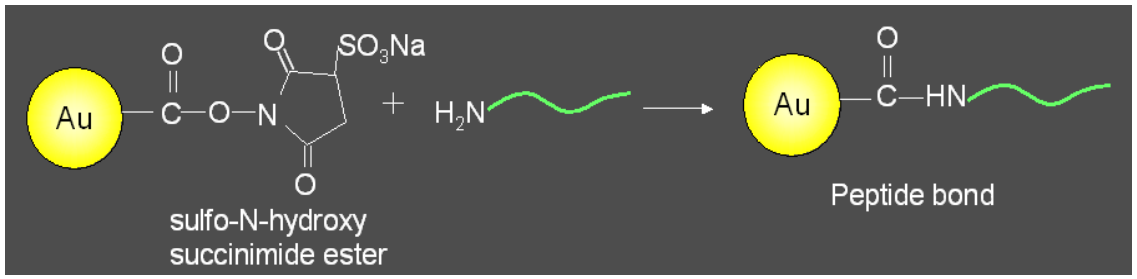
Published in The Bell System Technical Journal
Vol. 27, pp. 379-423, 623-656, July, October, 1948

MONOGRAPH B-1598
Reissued December, 1957

Convergence (?) of TeraHertz Medicine (proteins are radios) & RF Nano Biology?



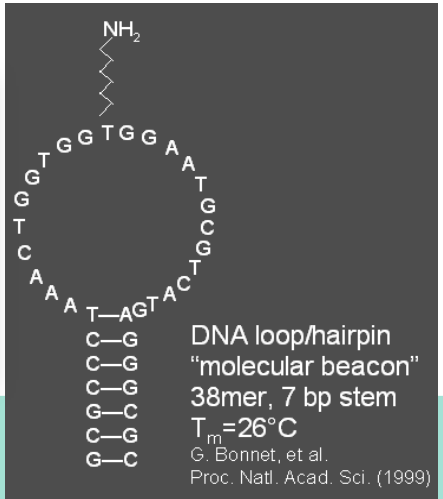


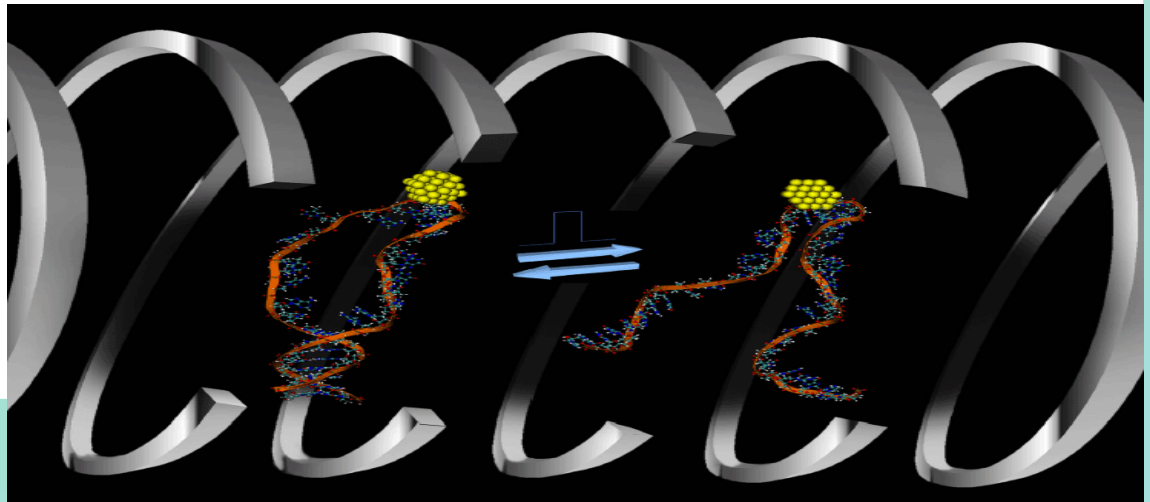


Remote Electronic Control of DNA Hybridization Through Inductive Coupling to an Attached Metal Nanocrystal Antenna
Kimberly Hamad-Schifferli, J J Schwartz, A T Santos, S G Zhang and J M Jacobson [Nature (415) 152-155, 2002]

Beyond the horizon ?

Close at hand ?





Leapfrogging healthcare ??

In at least one vein of healthcare … hip and knee replacements

Due to my ignorance, this is an US-centric scenario but it can be Implemented, anywhere.

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

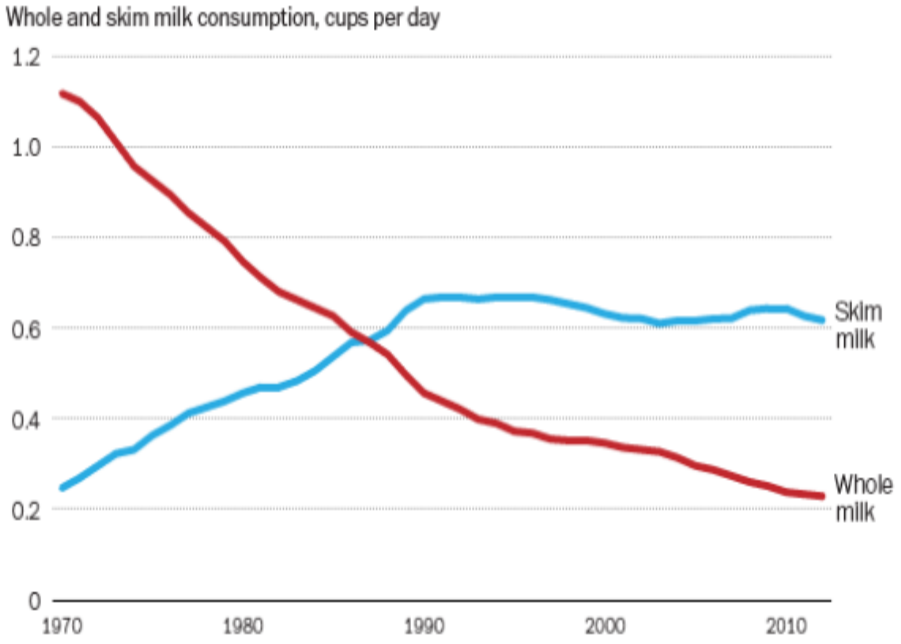
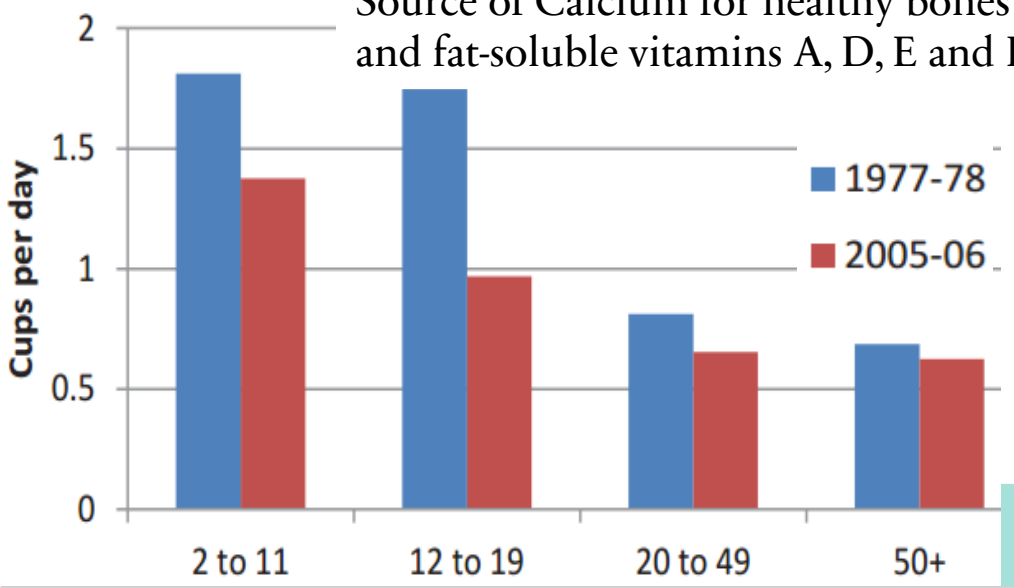


Figure 2: Mean Intake of Fluid Milk

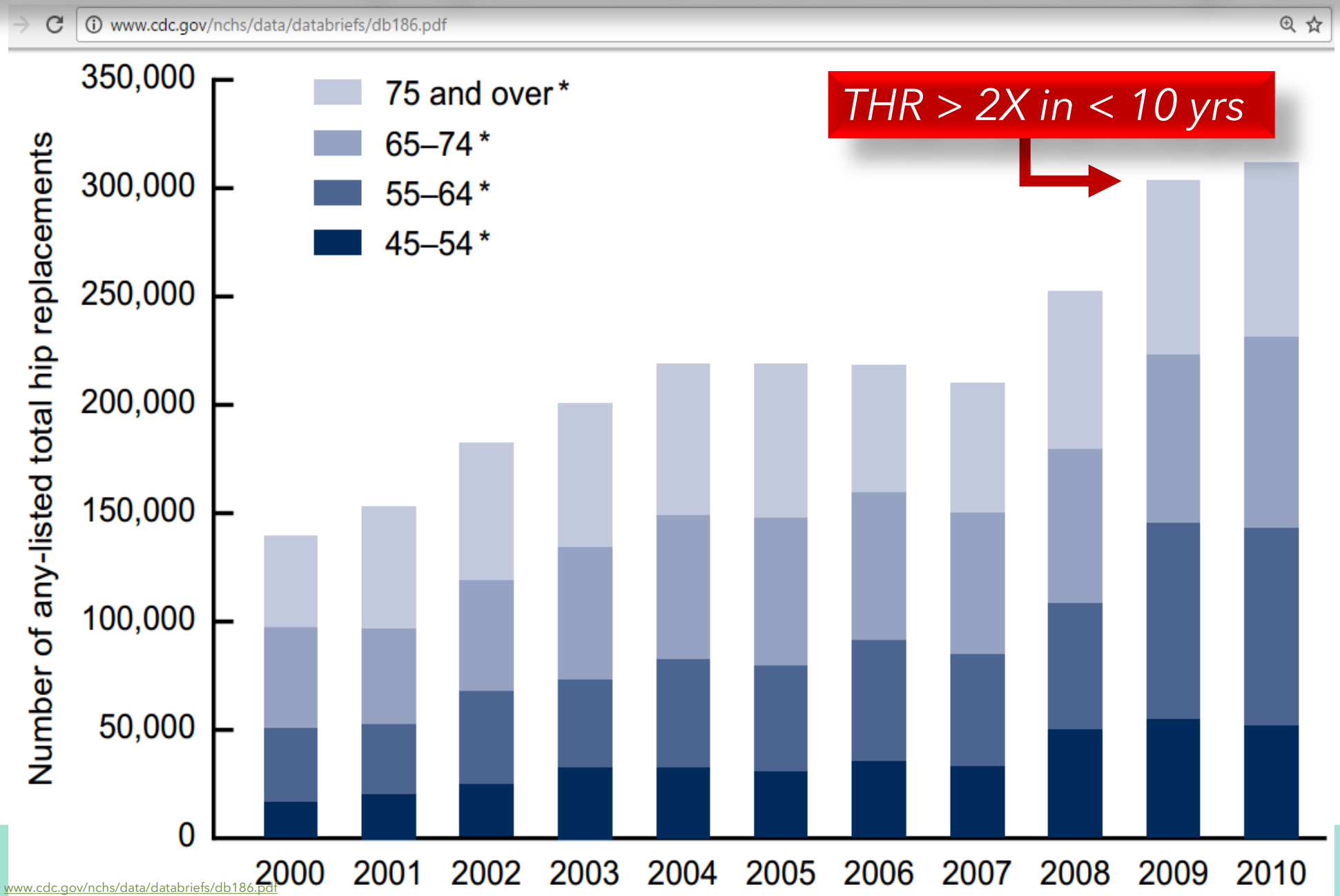
Source of Calcium for healthy bones and fat-soluble vitamins A, D, E and K



Causality

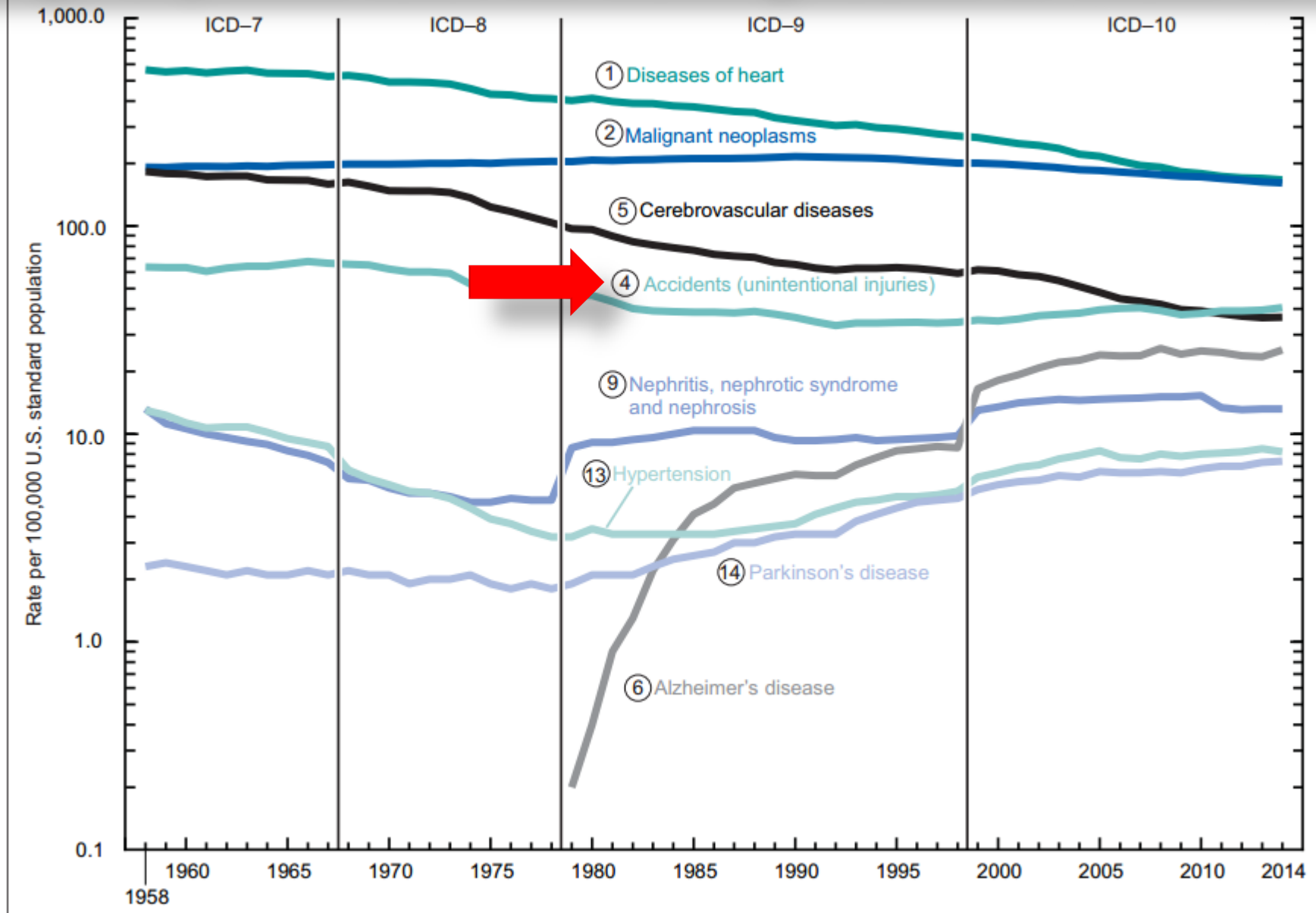
significant correlation?

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



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

Age-adjusted rates for leading causes of death in US

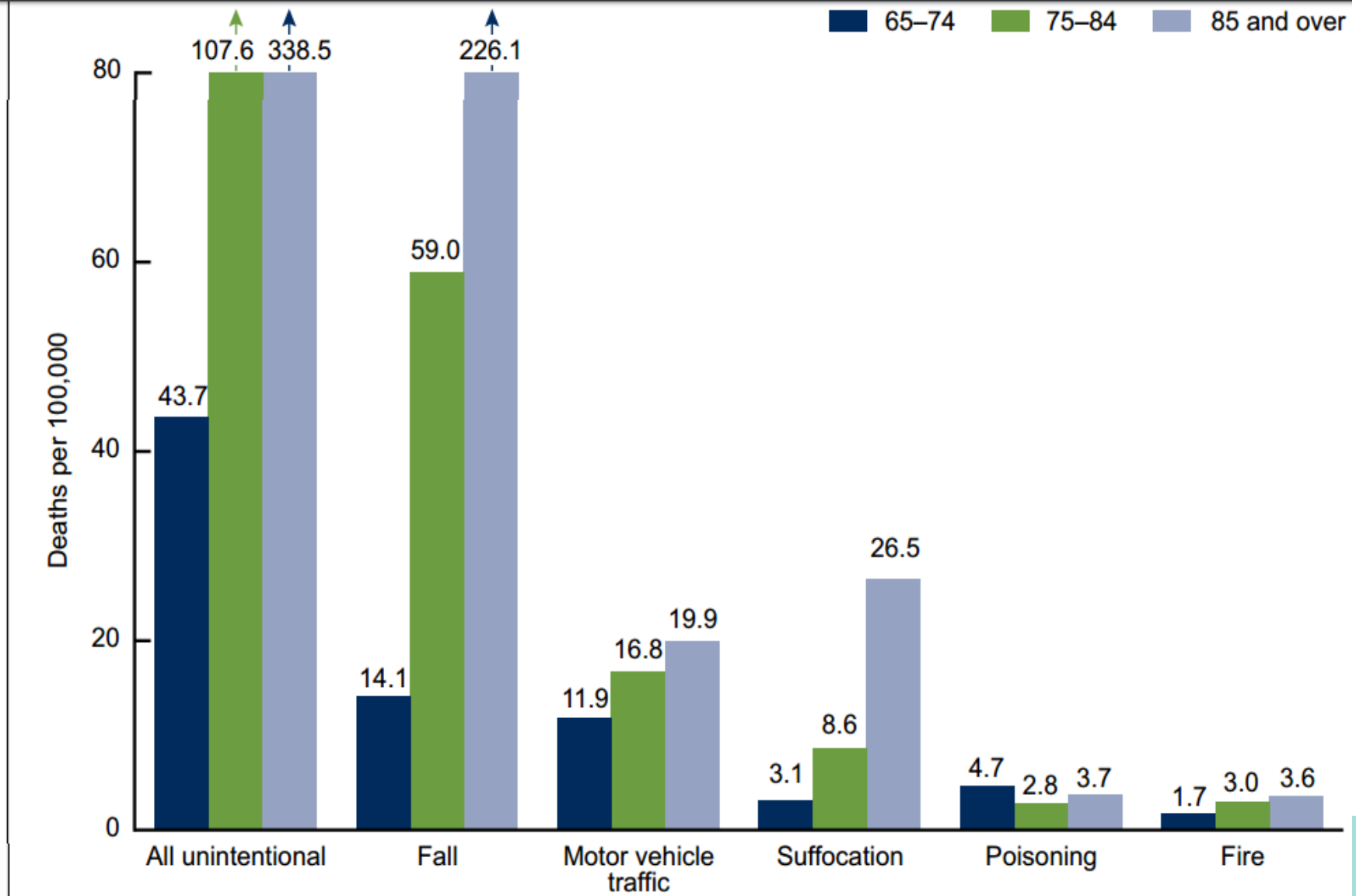


NOTES: ICD is the *International Classification of Diseases*. Circled numbers indicate ranking of conditions as leading causes of death in 2014.
SOURCE: NCHS, National Vital Statistics System, Mortality. http://www.cdc.gov/nchs/data/nvsr/nvsr65/nvsr65_04.pdf

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

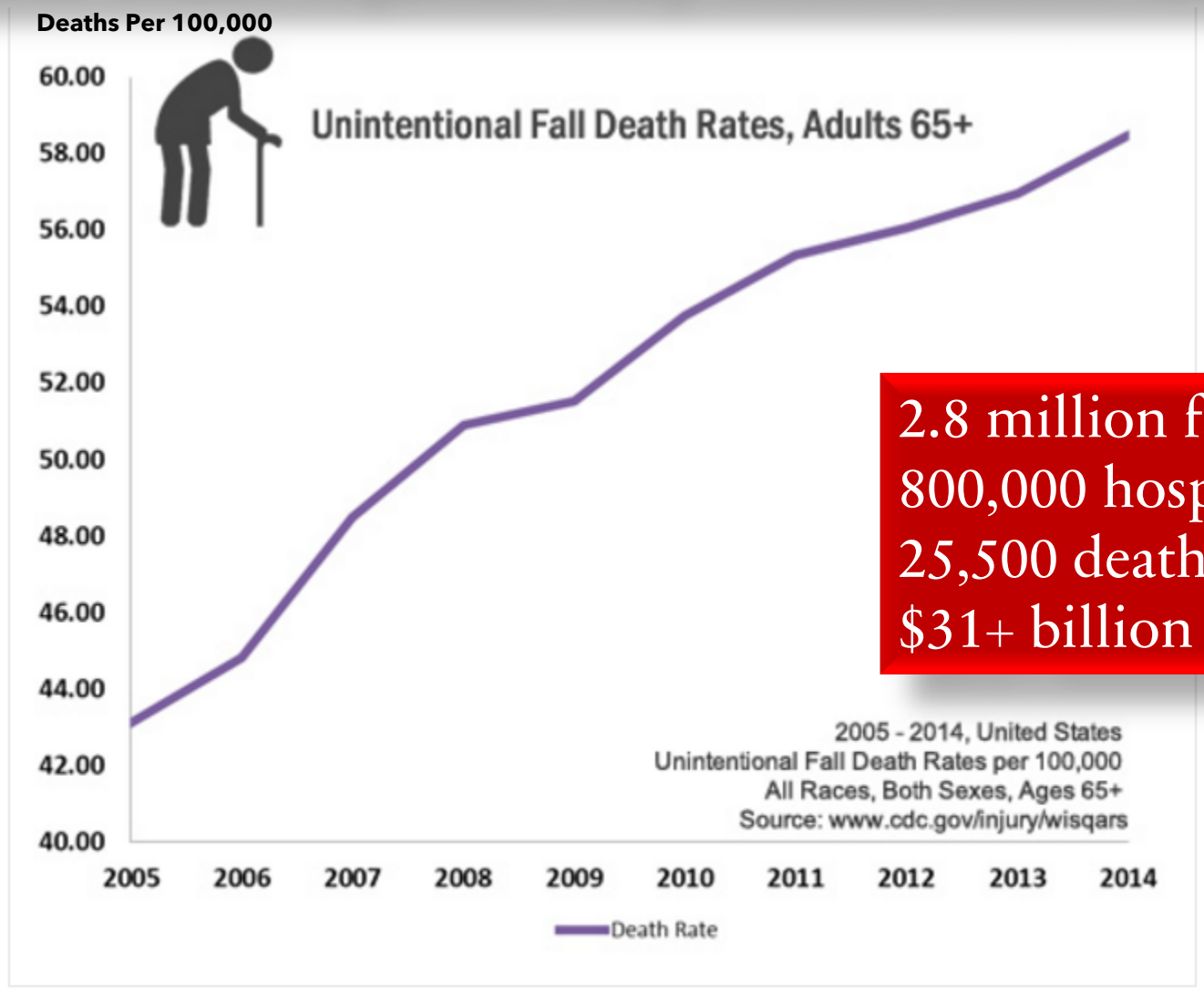
www.cdc.gov/nchs/data/databriefs/db199.pdf

NCHS Data Brief, Number 199, May 2015 3 / 8



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.



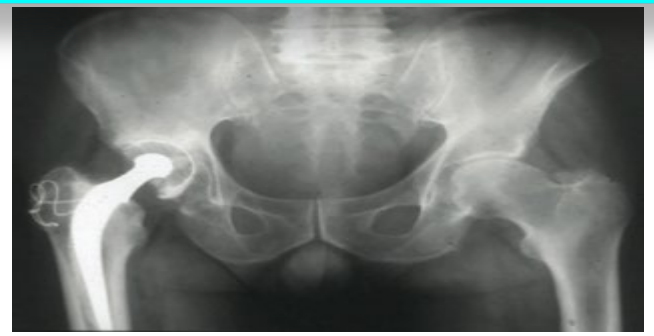
2.8 million falls in 2014
800,000 hospitalized
25,500 deaths due to fall
$31+ billion direct costs

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

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			



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

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

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%

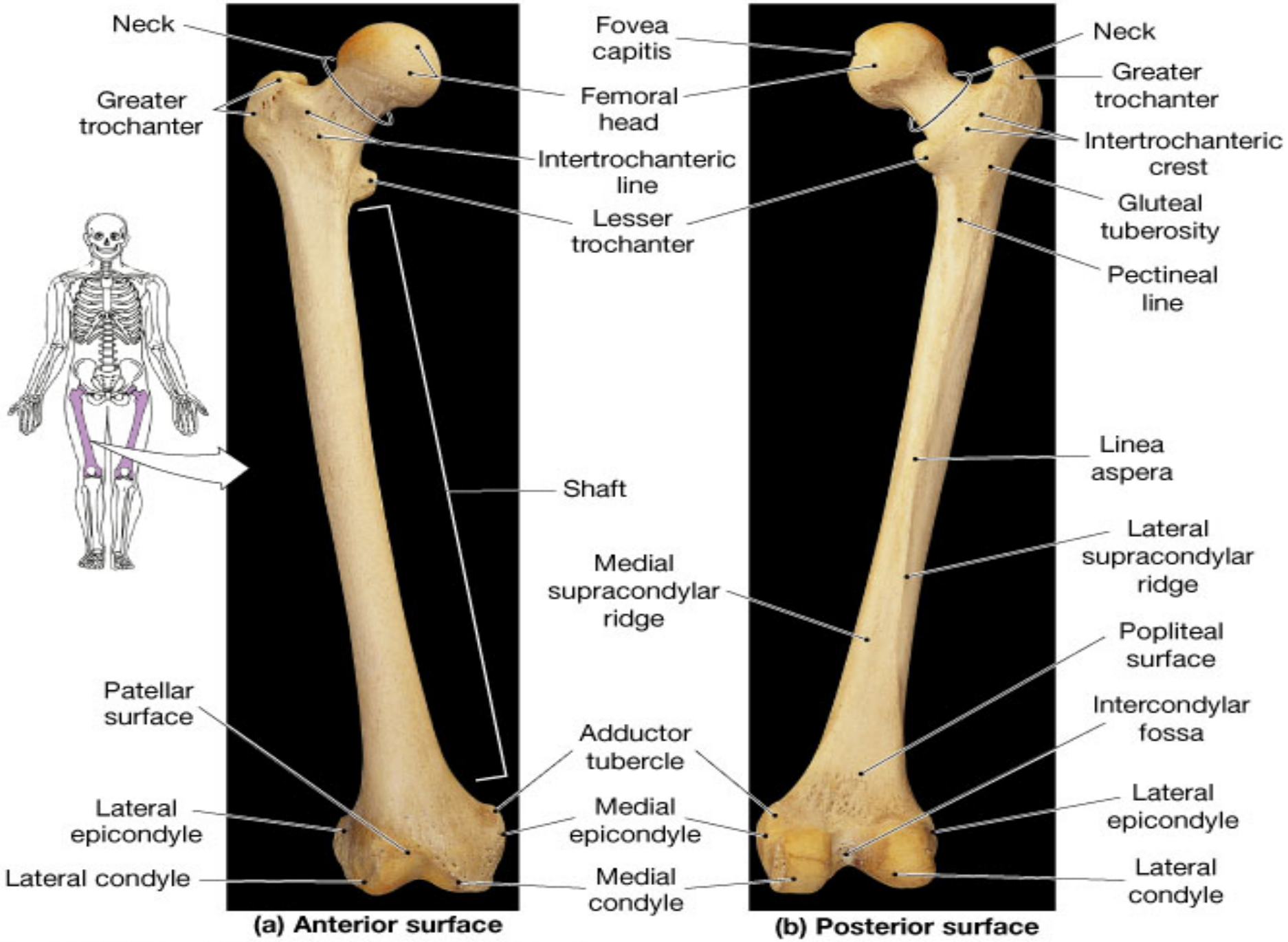
- 4.7 million (3.0 million women, 1.7 million men) individuals with total knee replacement in 2010

Total Hip Replacement (THR)

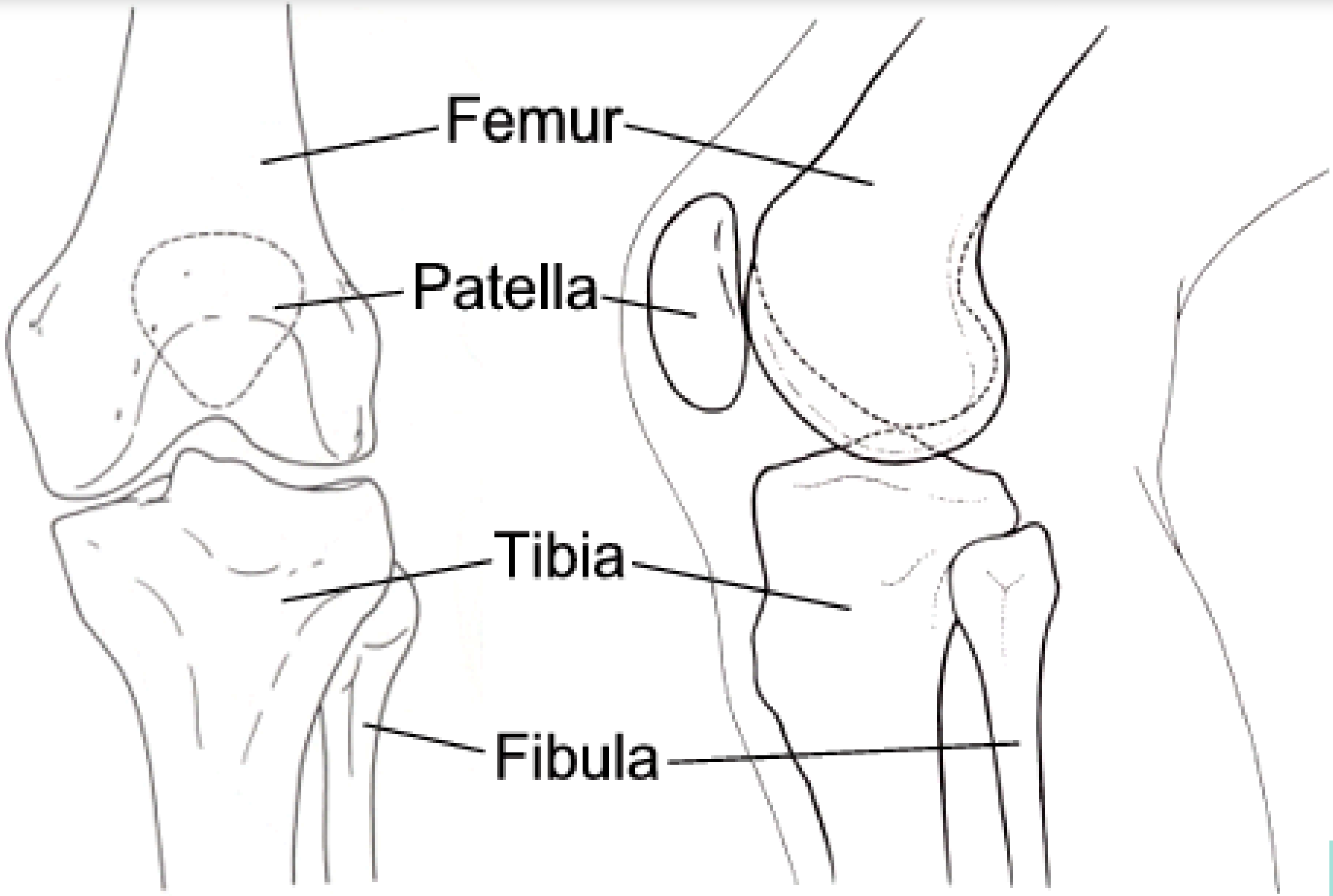
Age group	Female	Male
<50	0.1%	0.1%
50-59	0.8%	1.0%
60-69	2.1%	2.1%
70-79	4.4%	3.8%
80-89	6.3%	4.8%
90+	6.1%	4.8%

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

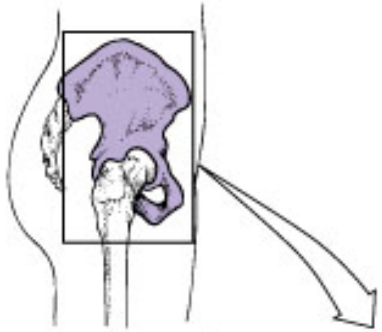
www.mayoclinic.org/medical-professionals/clinical-updates/orthopedic-surgery/study-hip-knee-arthroplasty-shows-7-2-million-americans-living-with-implants

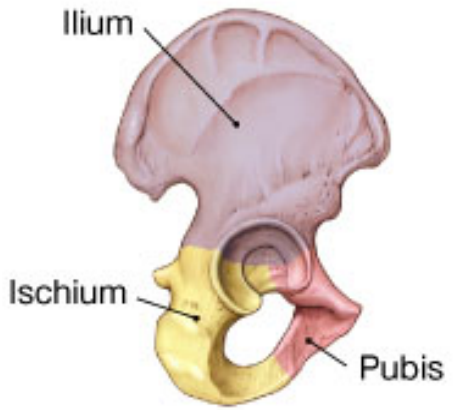


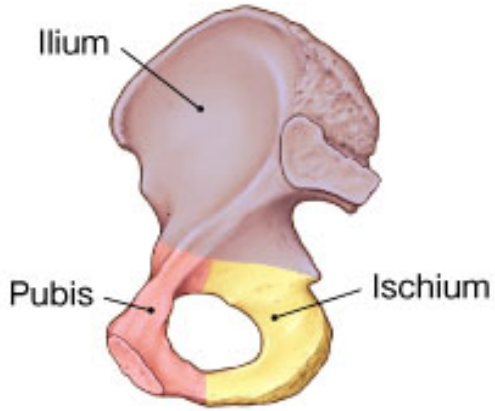
Anatomy of Knee Joint

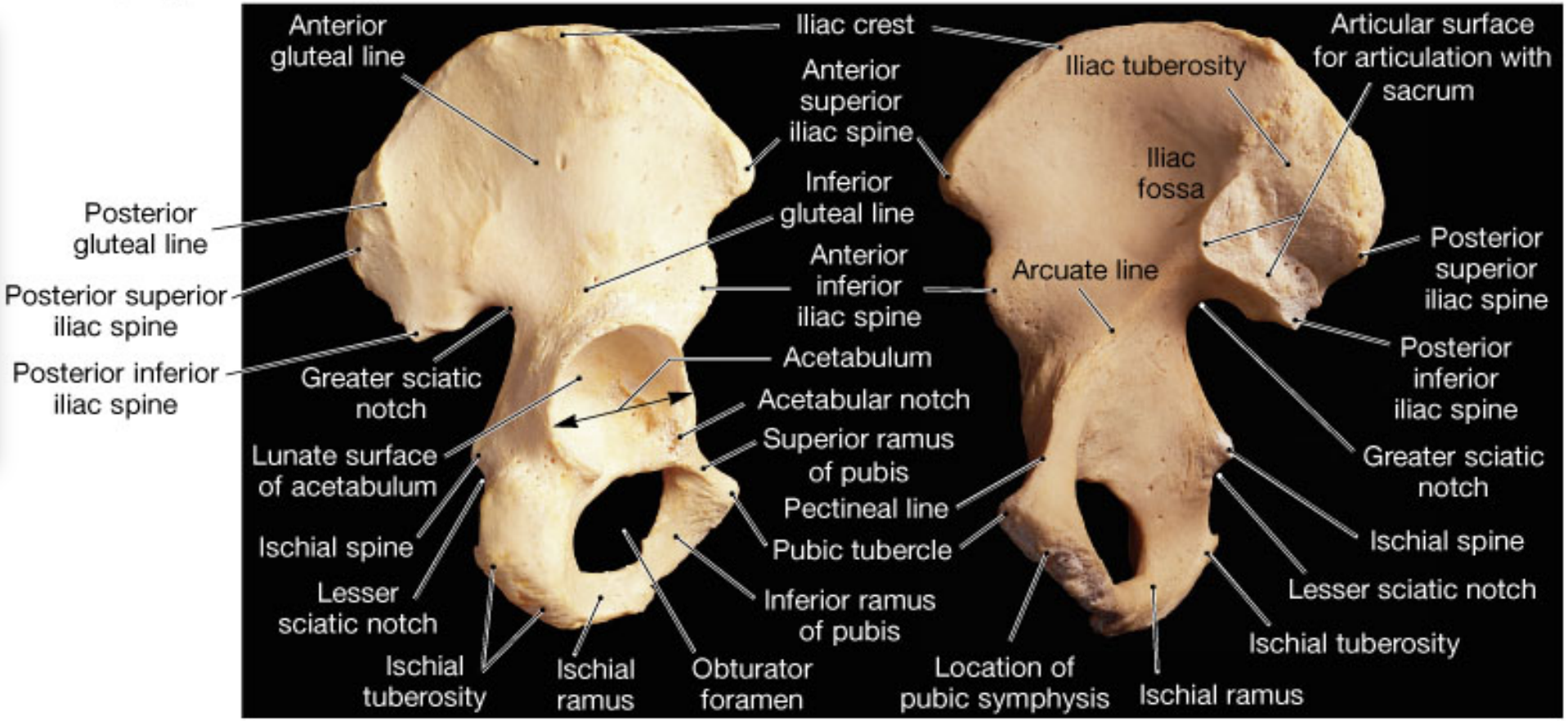


Anatomy of Hip Joint



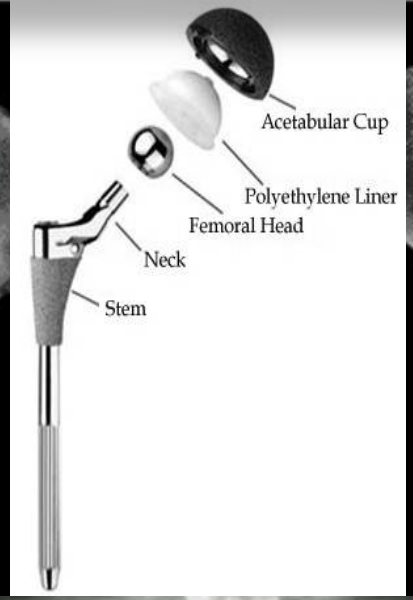


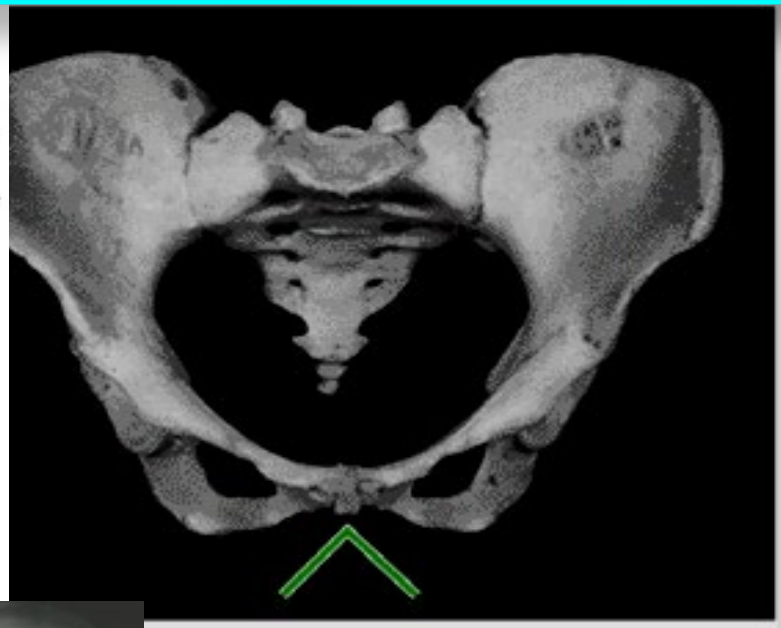


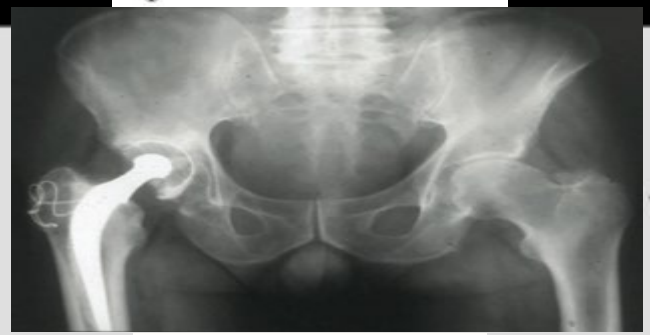


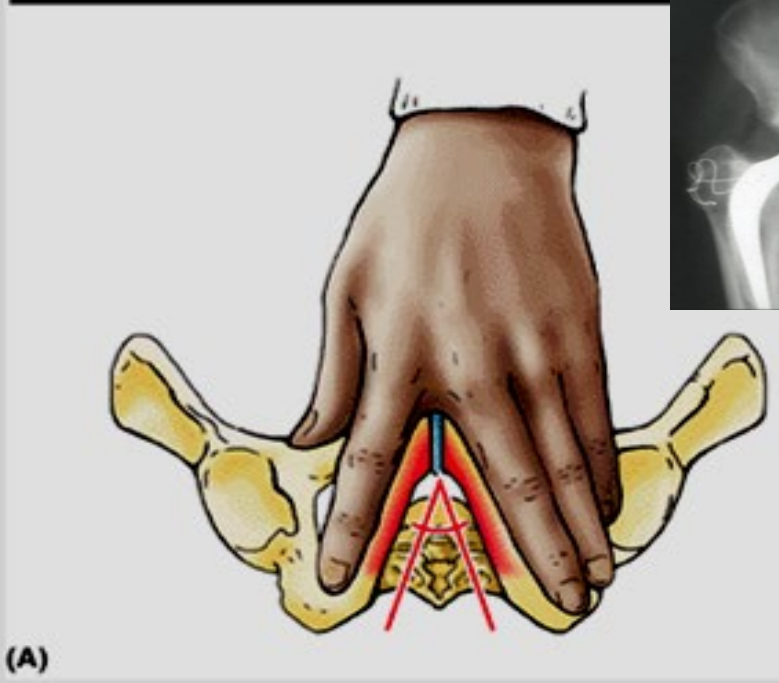
(a) Right os coxae, lateral view (b) Right os coxae, medial view

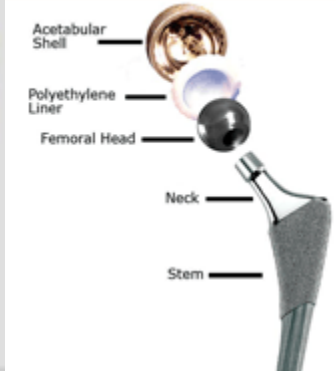
Total Hip Arthoplastry - Are All Acetabular Caps Created Equal?

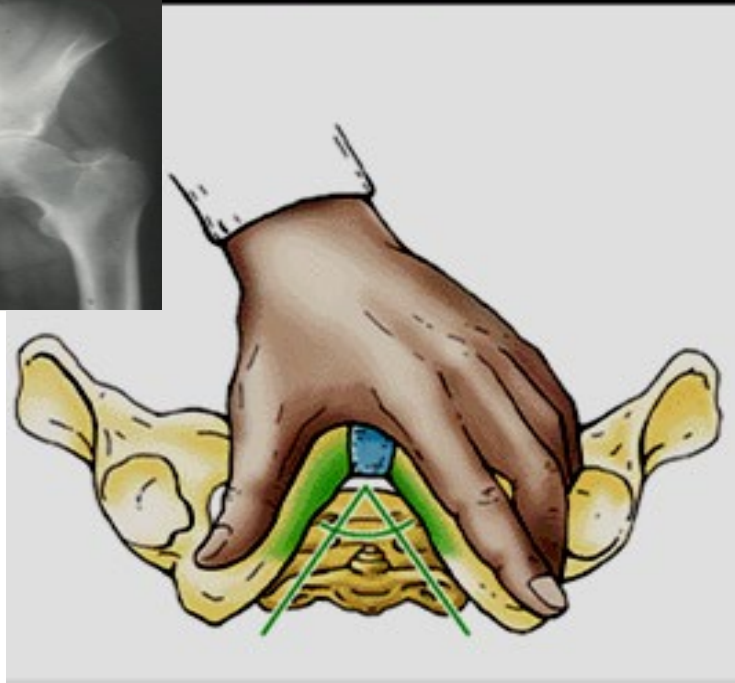




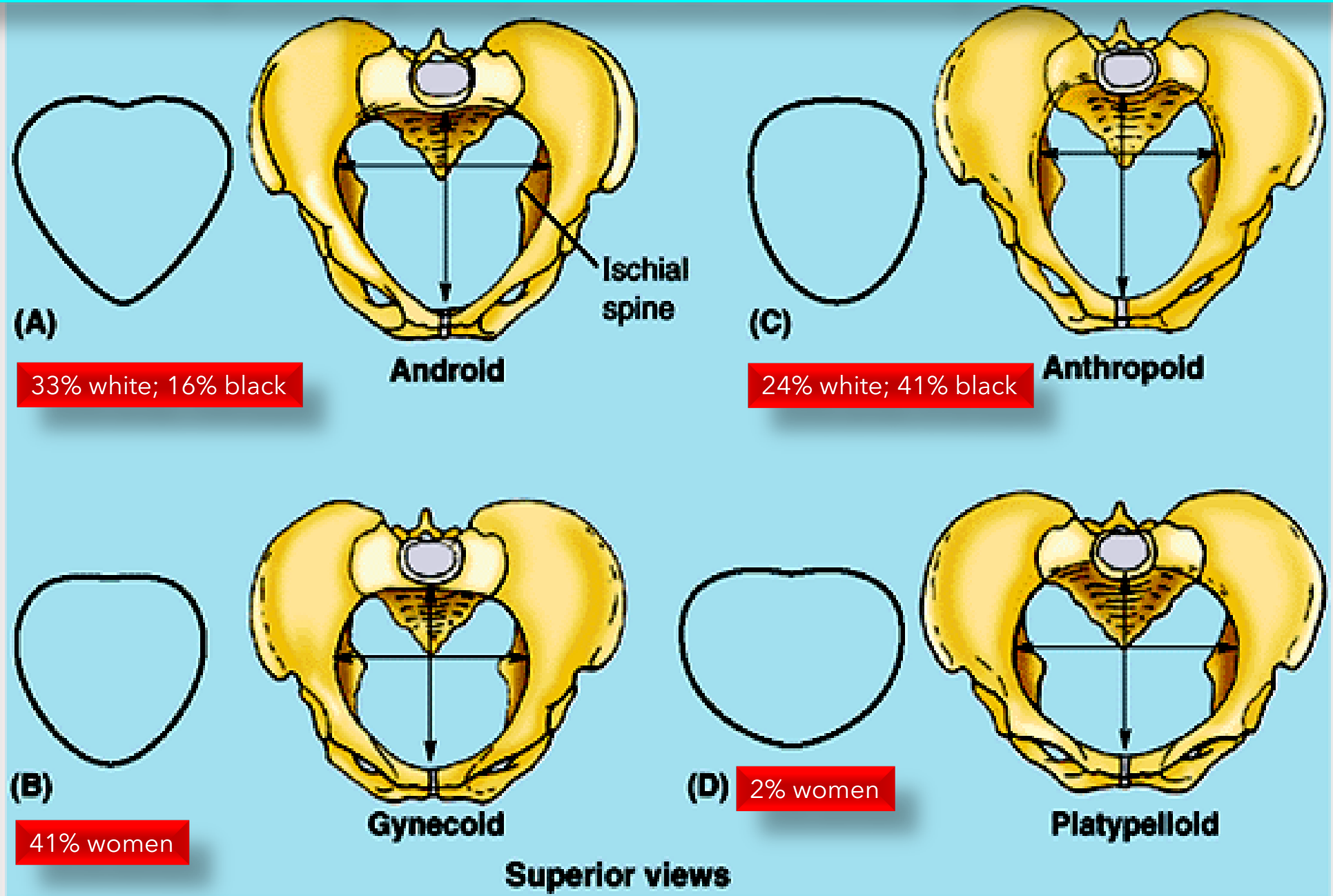








Total Hip Arthoplastry - Are All Female Hips Created Equal ?



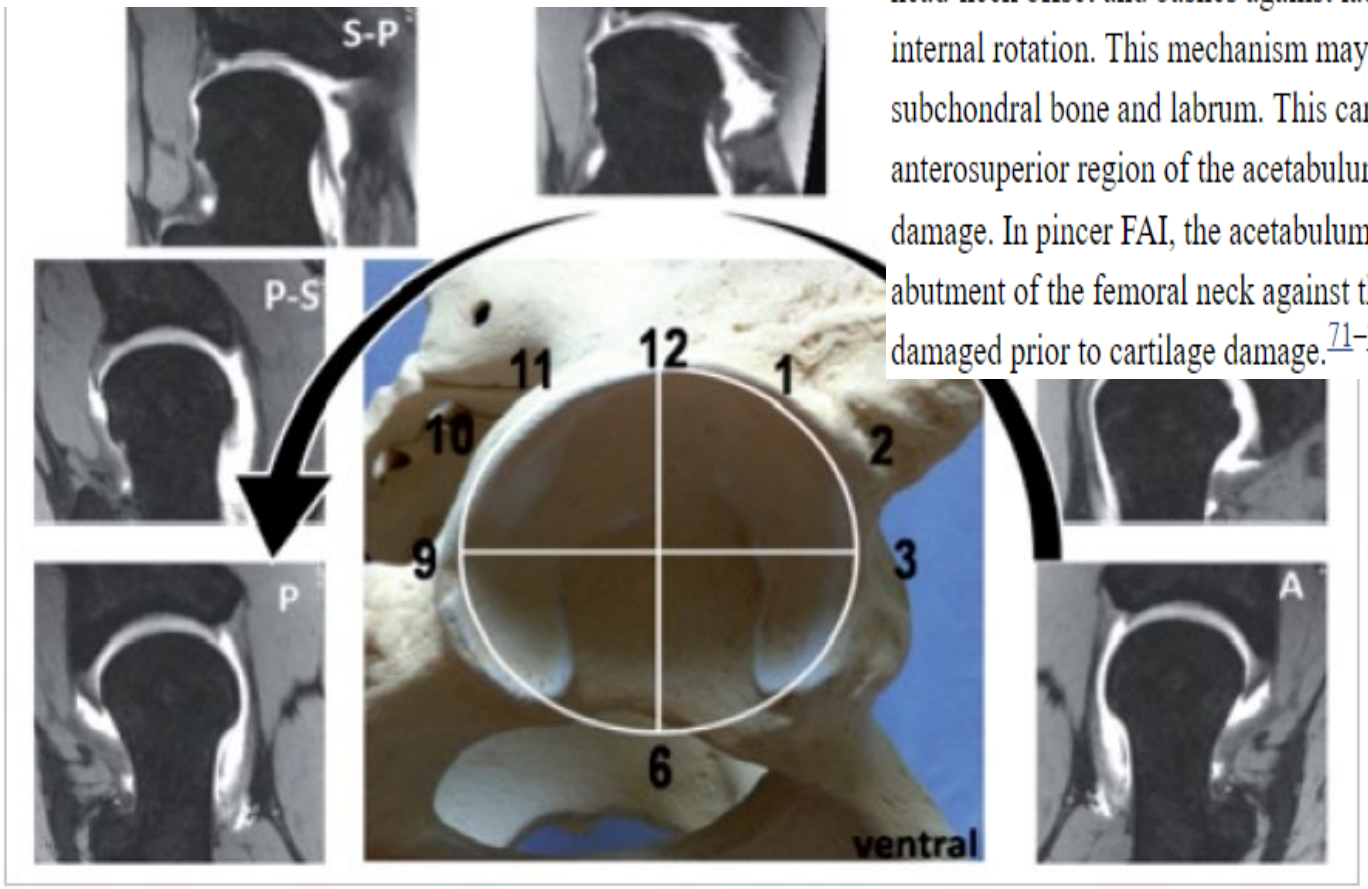
One shoe doesn't fit all !!

FEMOROACETABULUM

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

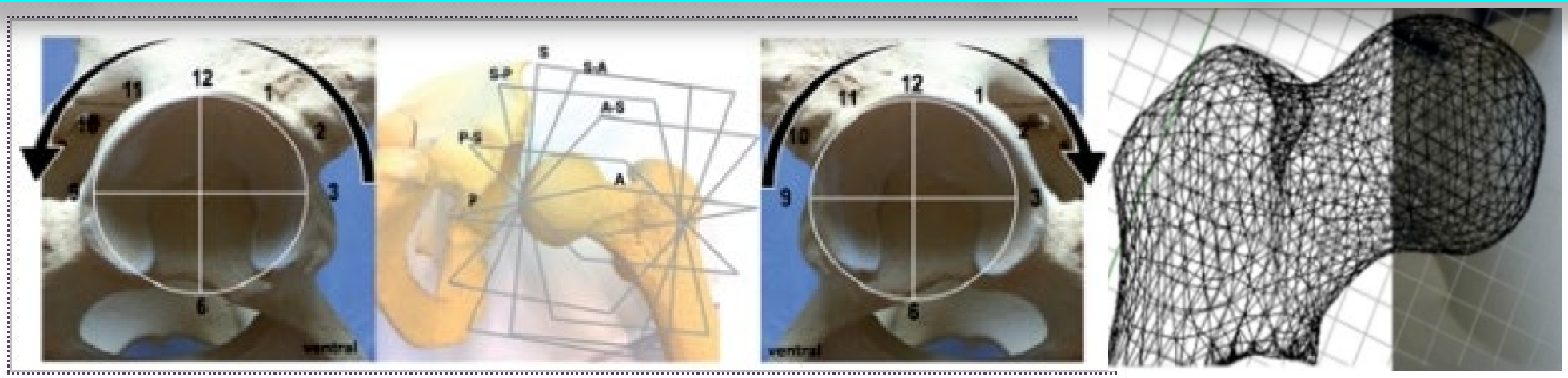


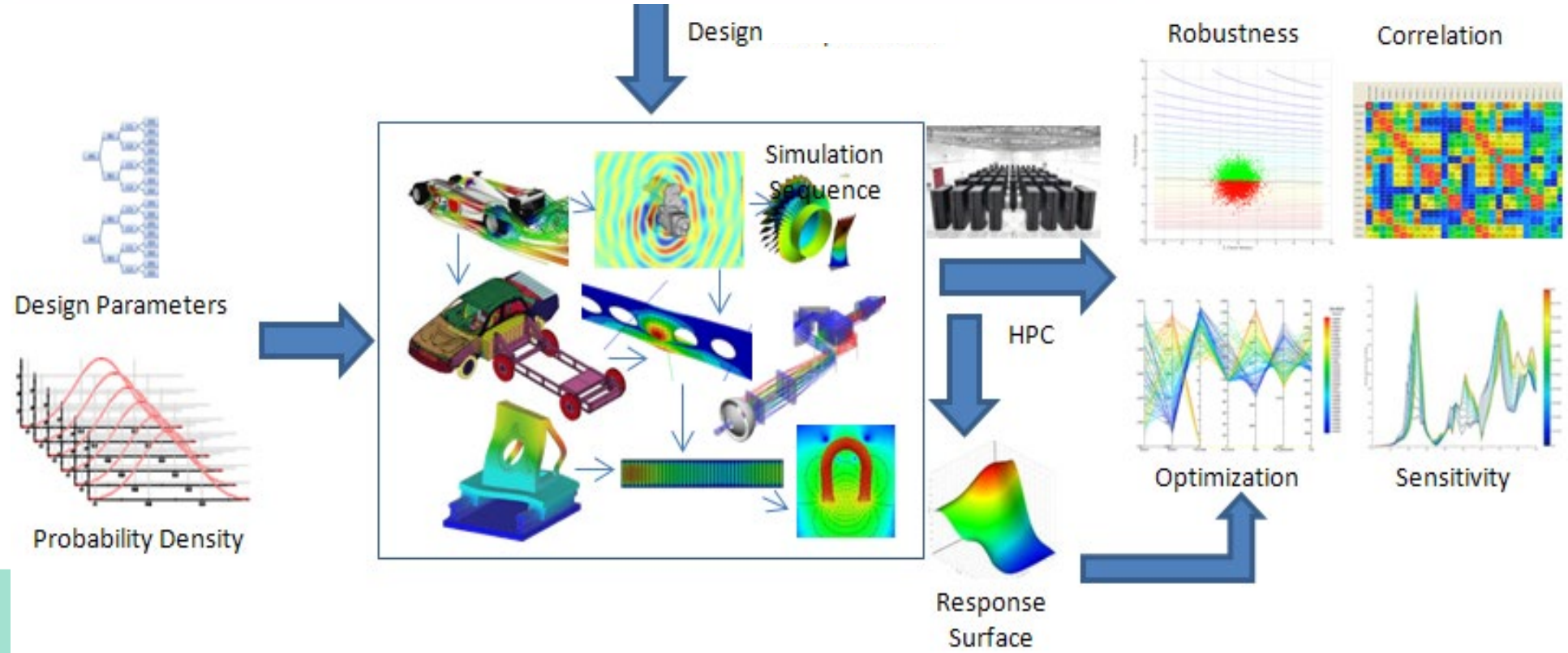
Radial images in a hip dysplasia patient.

Rev (Pavia) — Orthop Rev (Pavia)

Connect ➲ Converge ➲ Compile

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



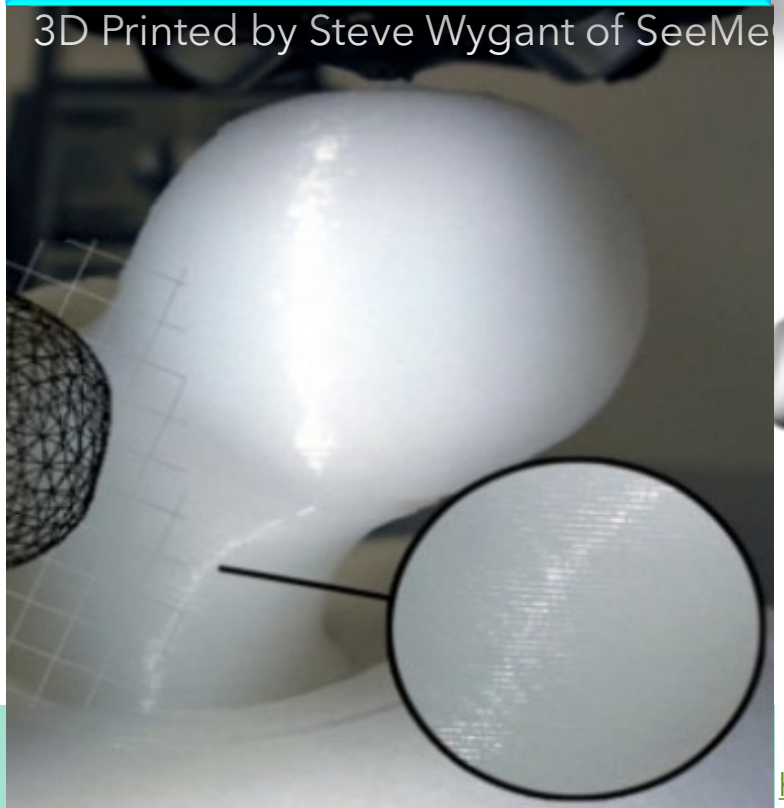


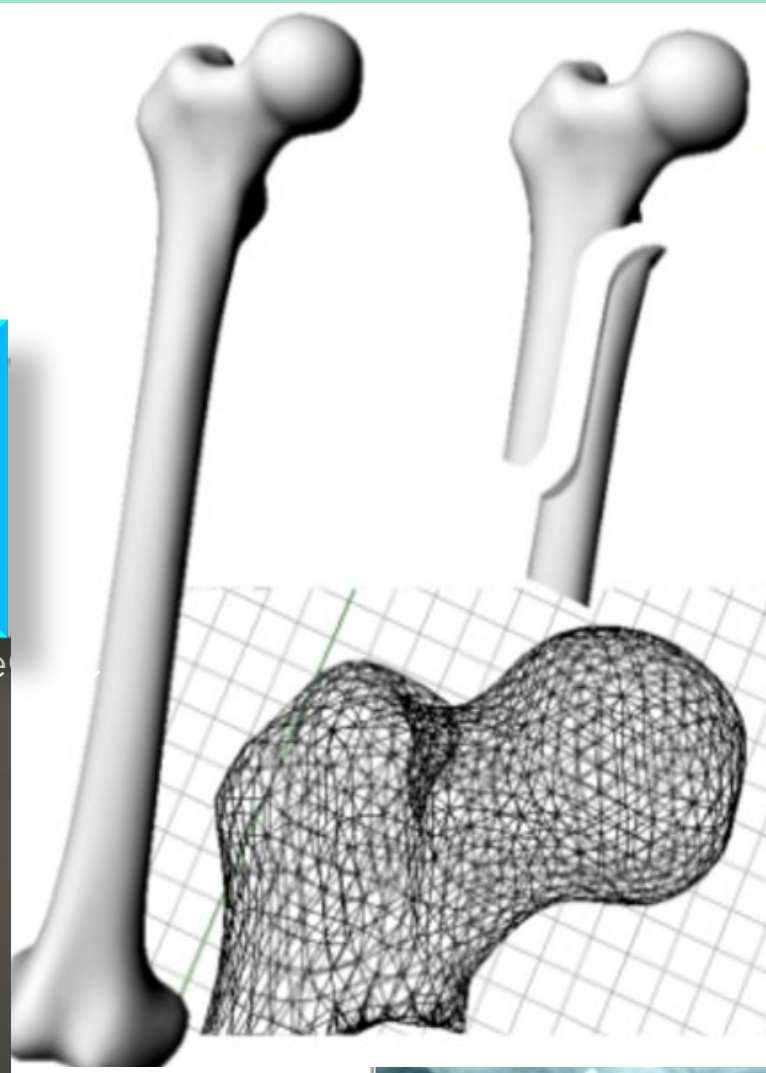
Connect ➲ Converge ➲ Communicate to 3D Printer

Upper Femur

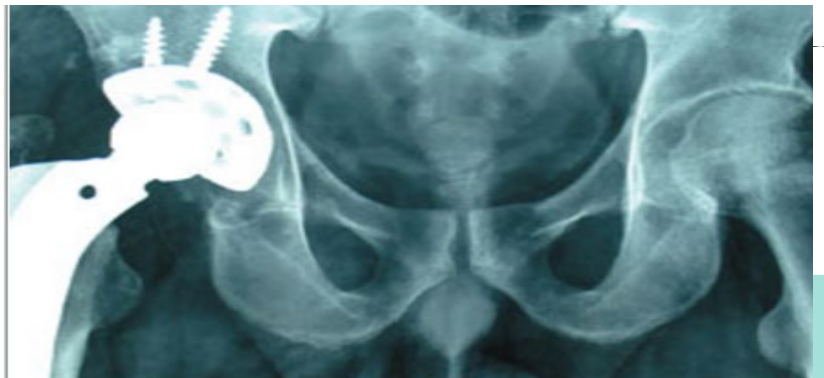
3D Printed with 9572 psi tensile strength 618 nylon co-polymer

3D Printed by Steve Wygant of SeeMe





http://bit.ly/AAOS-2014



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

Can it happen in Asia, Africa ?

Can it happen in Asia, Africa ?

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).

Can it happen in Asia, Africa ?

CYMAC

CyberManufacturing of Orthopedic Parts and Prosthetic Joints

It can happen anywhere, with a little bit of effort and enthusiasm


DESIGN, MANUFACTURING, AND ANALYSIS SOFTWARE TOOLS (CAx)
• Cloud-computing Enabled Multi-User.
• Template-driven Design.
• Embedded Social Media, VoIP, and Skype.
• Design Rules and Analysis tools for Optimization.
• High-fidelity Physical Models.
RAPID MANUFACTURING TECHNOLOGY
• Design Next-generation LAMP equipment.
• Process control architecture.
• Mold Material Systems for Diverse Alloys
• Process chains for optimized Castings.
• Technology Transition and Continuous Upgrades.
DESIGN
DEVELOP
DEMONSTRATE
QUALIFY
CyMAC
RAPID QUALIFICATION
• Digital Inspection Systems
• Laser, White-light, Blue-light Scanning
• Computed Tomography
• Metallography
• Flow Testing
• Natural Frequency and Modeshape Analysis.
• CFD Model Calibration with Hot Cascade Crystals.
MANUFACTURING DEMONSTRATION FACILITY
• World's first CyMAC demonstration facility.
• Initially based on LAMP beta machine built at Georgia Tech.
• Pilot production line.
• Install Commercial machine.
• Operational 6 months from start and open to OEMs 1 year of start.
• Produce and qualify challenge parts

CYMAC

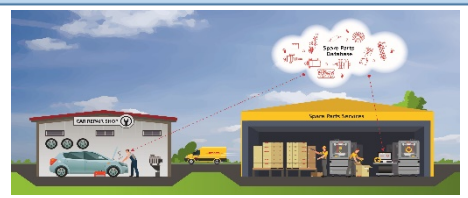
The Future Vision of a CeMS-DDM based Digital Factory

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

Down to earth, present reality …

http://bit.ly/IOT-MIT explore HEALTHCARE

After #covid19, thankfully we can shift from BS innovation to BB (Back to Basics) innovation that really serves humanity.

Juicero offering refunds to all customers after people realize $400 juicer is totally unnecessary

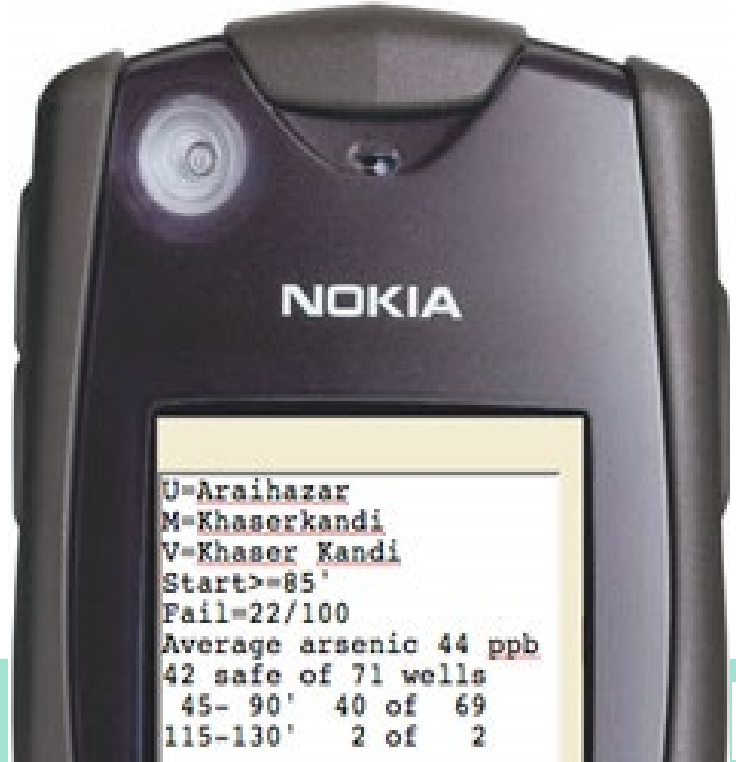
« The best brains in the world are busy solving the problems of the rich, who really don't have problems »

Solve real problems

Reality Check ☑ Arsenic in Water (Bangladesh)

Healthcare Internet of Things - Impact of Clean Water

Nokia ‘sensor as a service’ can improve lives ☑ Internet of Things (IoT) Tool - Arsenic in water



http://news.mit.edu/2016/faculty-profile-rohit-karnik-0901

Can't conclude **HEALTHCARE** without discussing SARS-CoV-2/CoVID-19

Please refer to these discussions (see PDFs).
Please download PDFs from the MIT Library.

PDF from May 19th, 2021

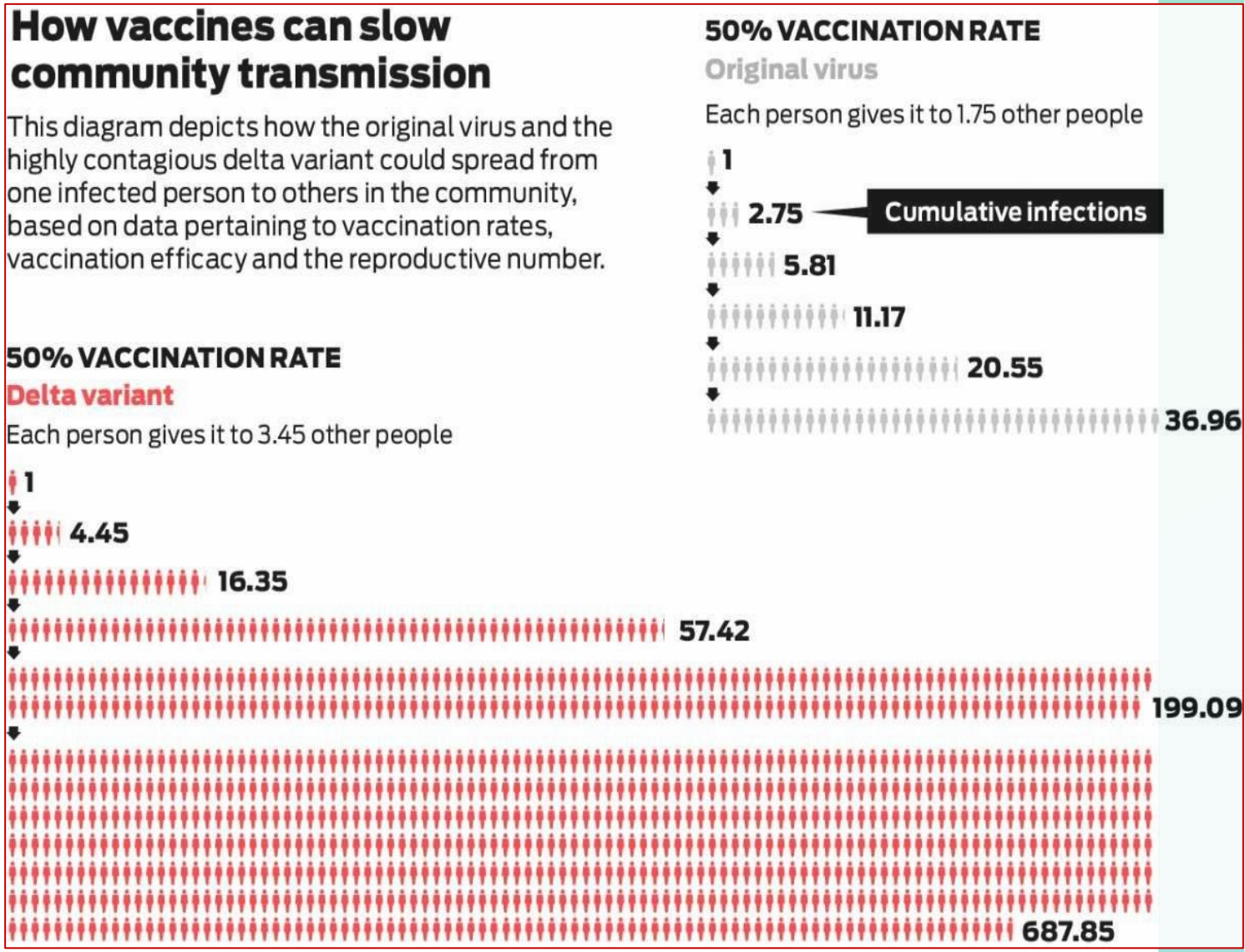
- https://bit.ly/PART-ONE-MAY-19

PDF from May 21st, 2021

- https://bit.ly/PART-TWO-MAY-21

Articles and essays from the MIT Library

- https://dspace.mit.edu/handle/1721.1/128017



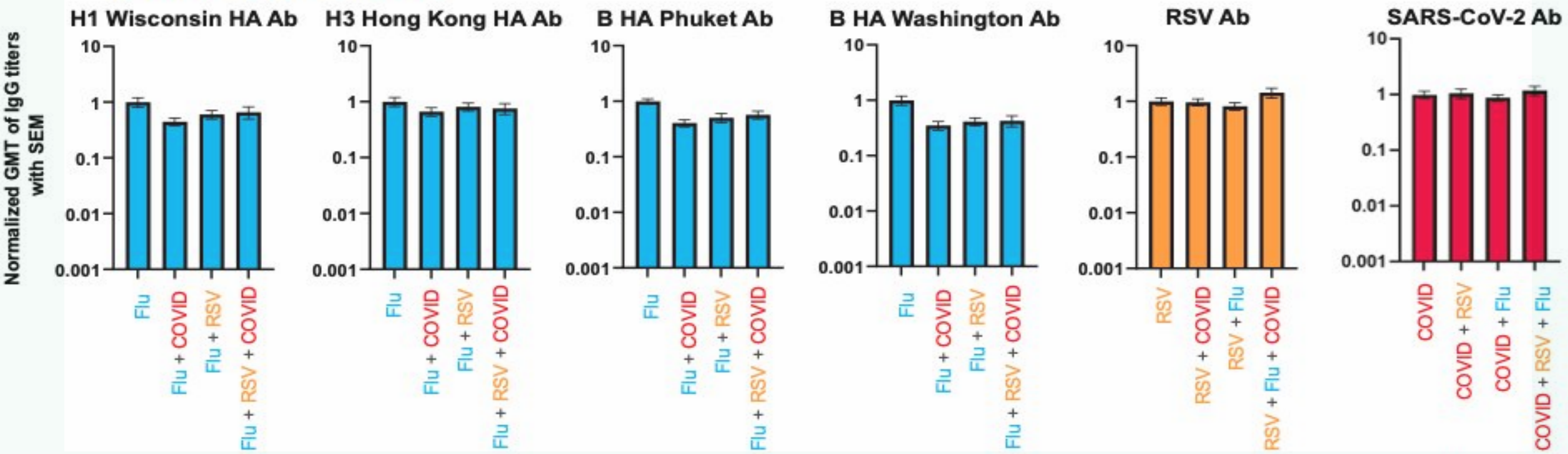
www.sfchronicle.com/bayarea/article/Here-s-when-the-Bay-Area-delta-COVID-surge-is-16370982.php

Long way to go …

A Flu, RSV and SARS-CoV-2 combo vaccine induces robust antibody responses to all components in mice

Flu vaccine (mRNA-1010) encodes for **4 antigens** (HA)	COVID-19 vaccine (mRNA-1273) encodes for **1 antigen** (spike protein)	RSV vaccine (mRNA-1345) encodes for **1 antigen** (prefusion F protein)

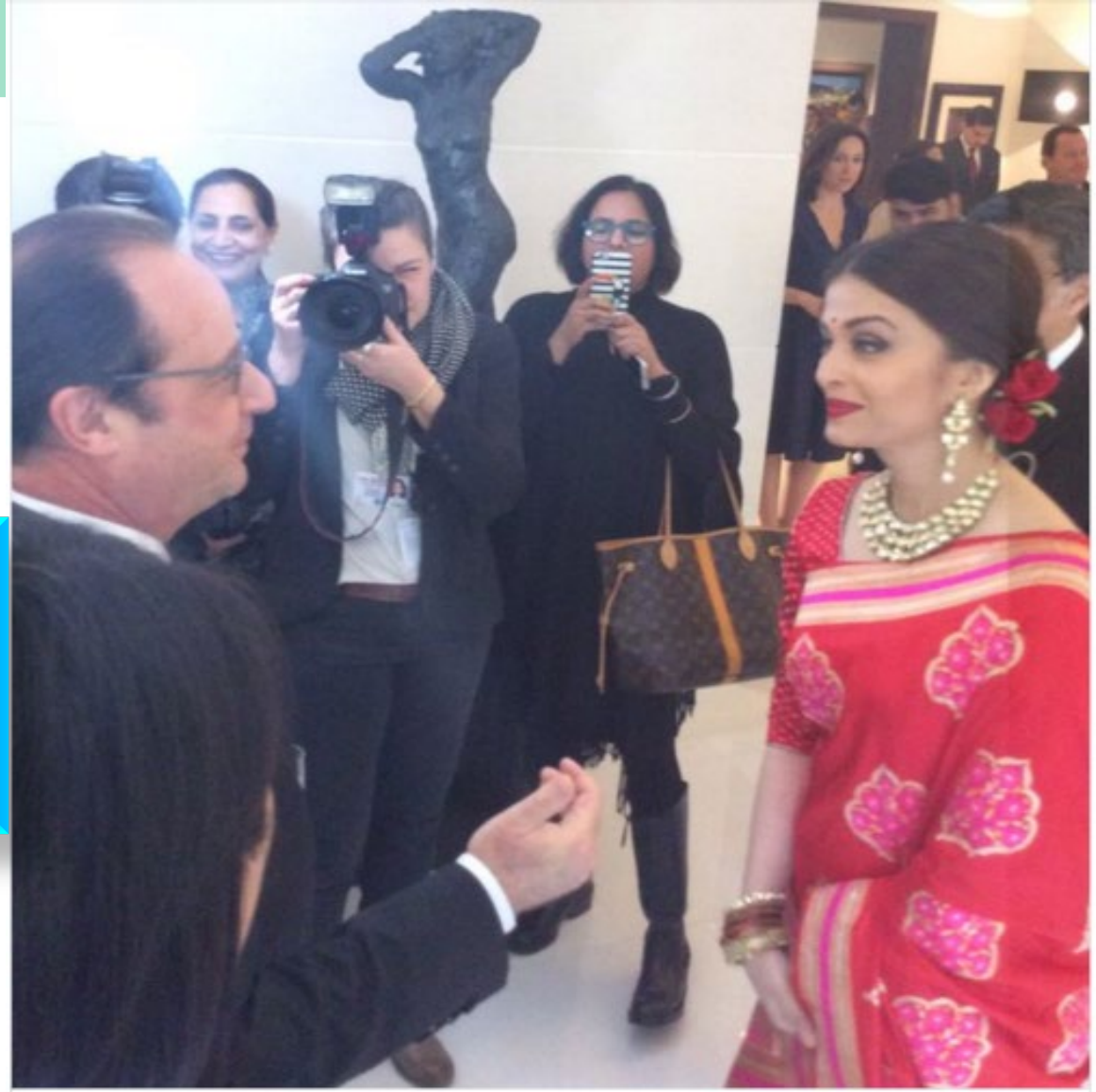
or mRNA-1010 + mRNA-1345 + mRNA-1273



Species: Mice; Shots on Day 0 and Day 21; Results from Day 36

moderna

Resist Tweeter-ionic disinformation



Élysée
@Elysee

Follow

.@fhollande rencontre plusieurs personnalités indiennes francophiles, dont l'actrice Aishwarya Rai #IndePR

2:10 AM - 26 Jan 2016

Twitter is not a data analysis tool: data in science is 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.

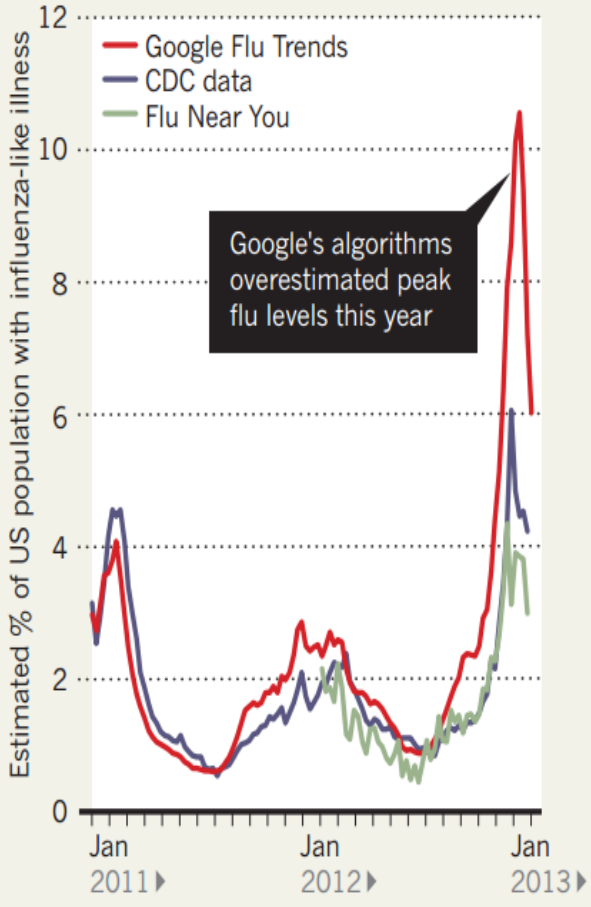
"It is hard to think today that one can provide disease surveillance without existing systems," says Alain-Jacques Valleron, an epidemiologist at the Pierre and Marie Curie University in Paris, and founder of France's Sentinelles monitoring network. "The new systems depend too much on old existing ones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



Raison d'être

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. http://bit.ly/GENDER-INEQUALITY

Take time to peruse, read and reflect

Be patient with large files and zipped folders. It may take a while to download.

If you enjoy reading, find free books in zipped folders – please download:

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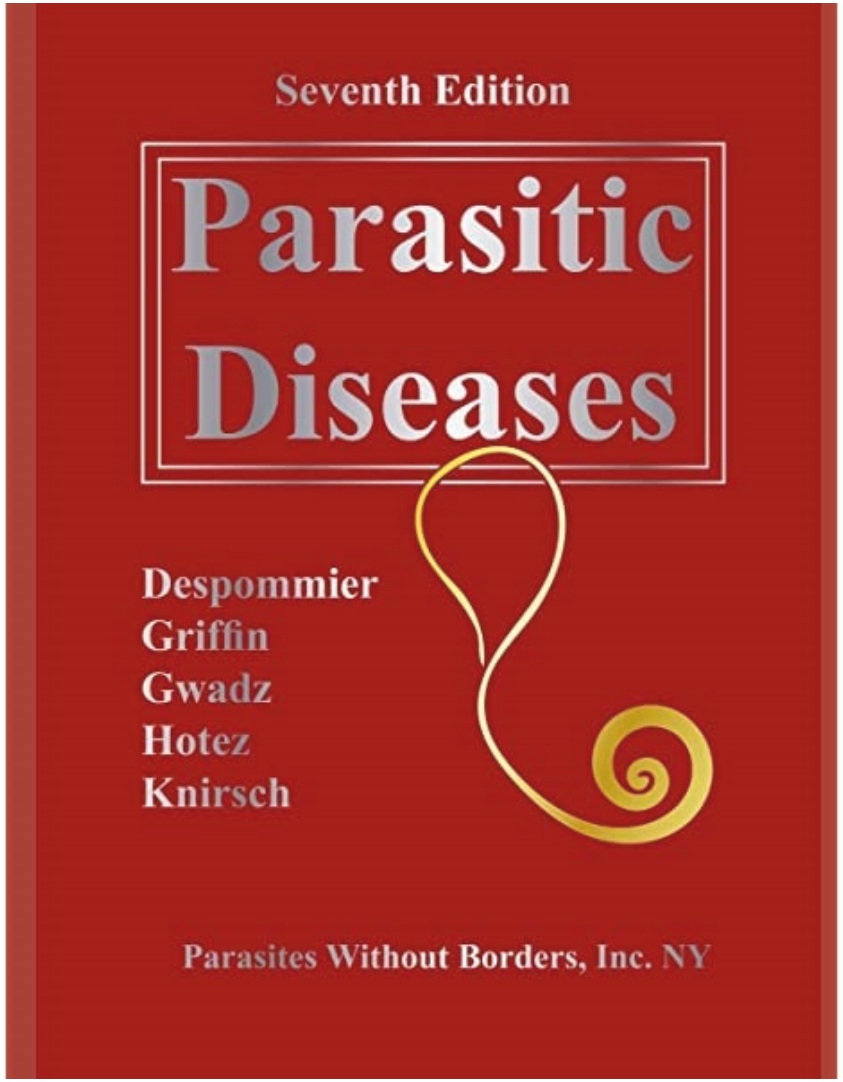
If you want a specific non-fiction book or text-book, please ask shoumen@mit.edu or sdatta8@mgh.harvard.edu (if I can, I will help)

Suggested non-fiction books . . .



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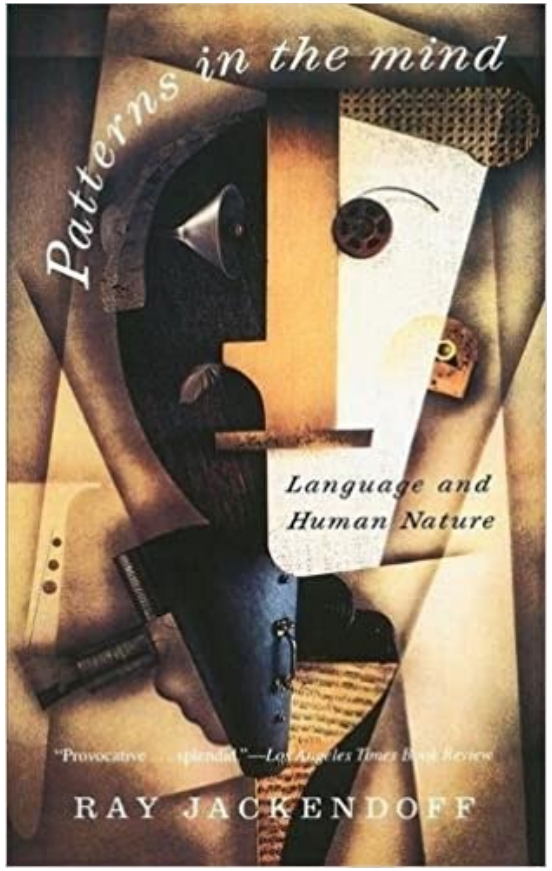

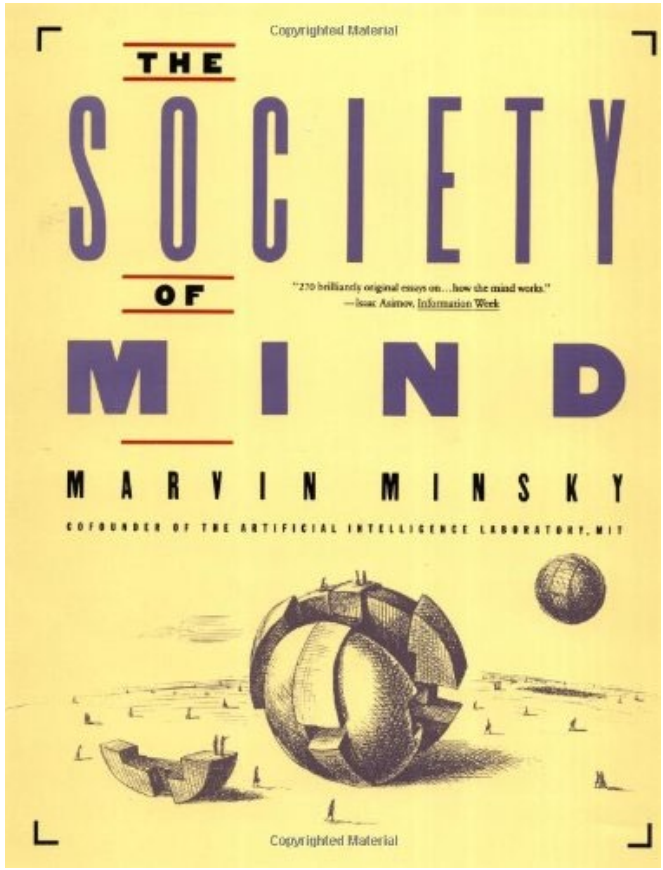

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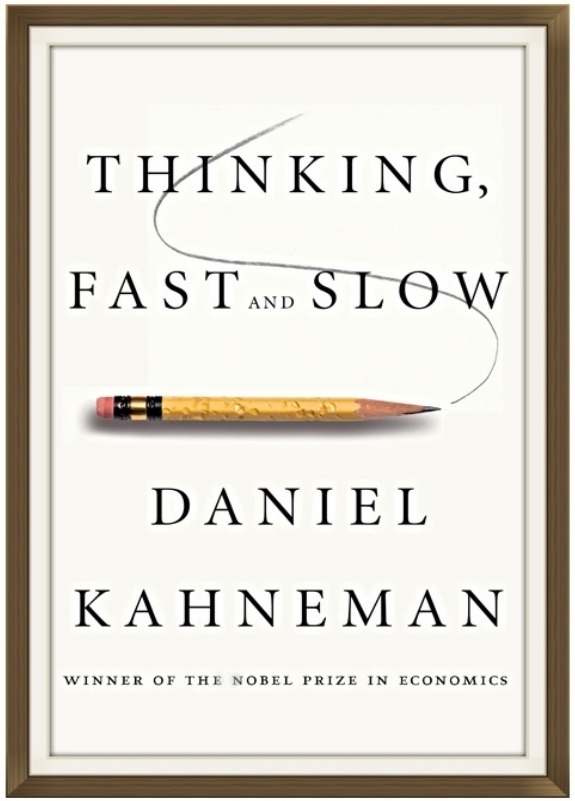

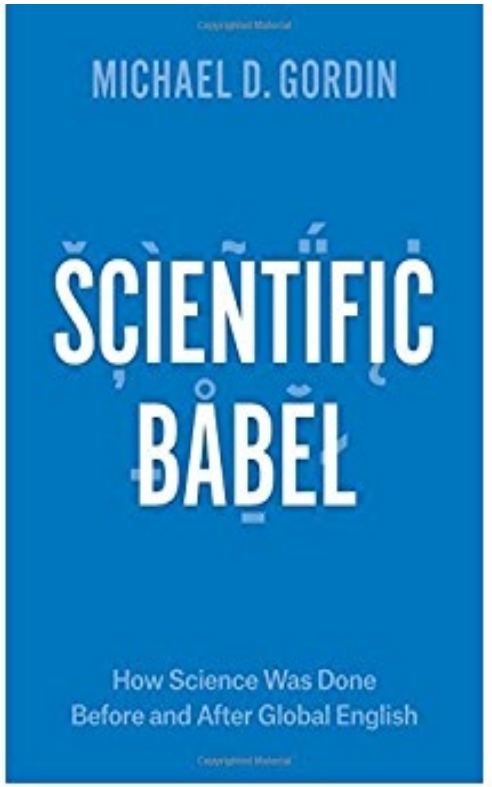

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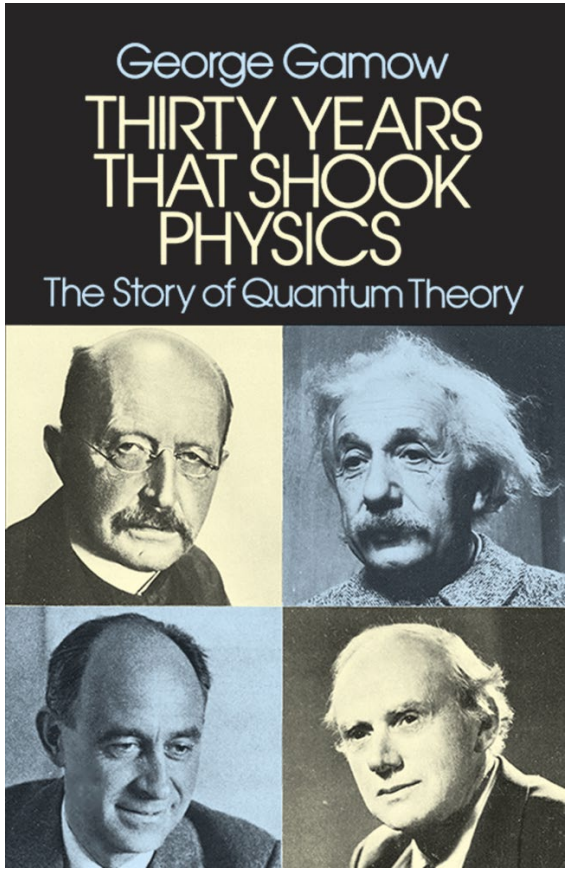

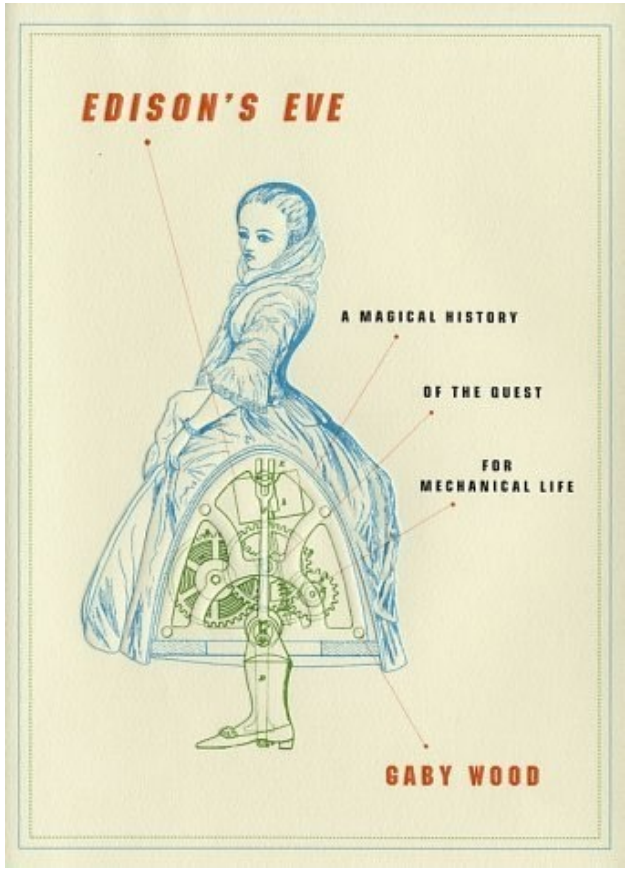

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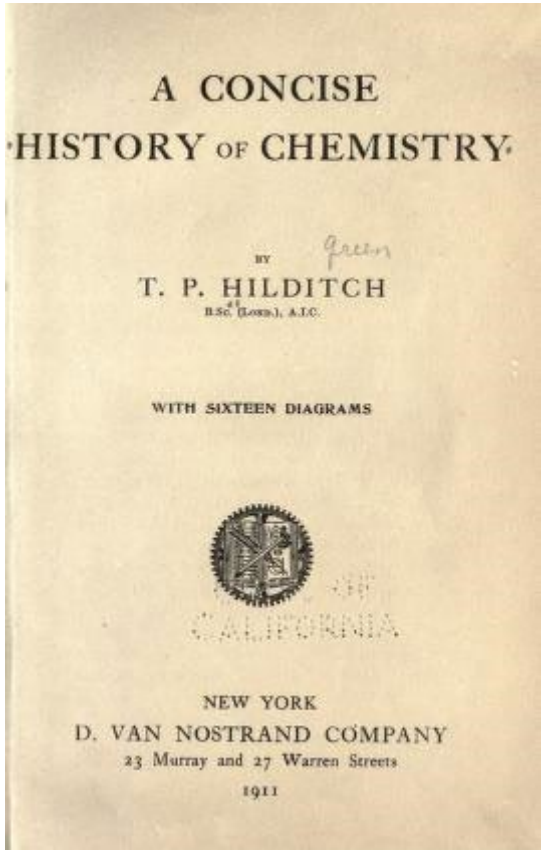

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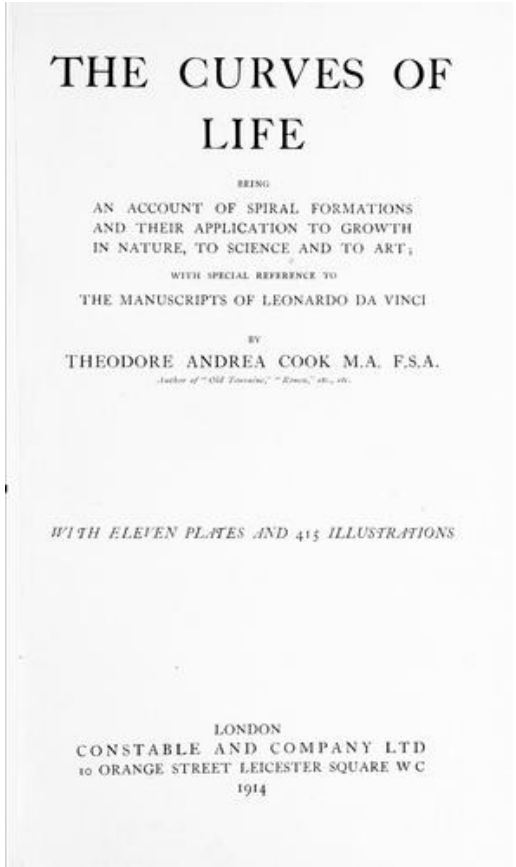

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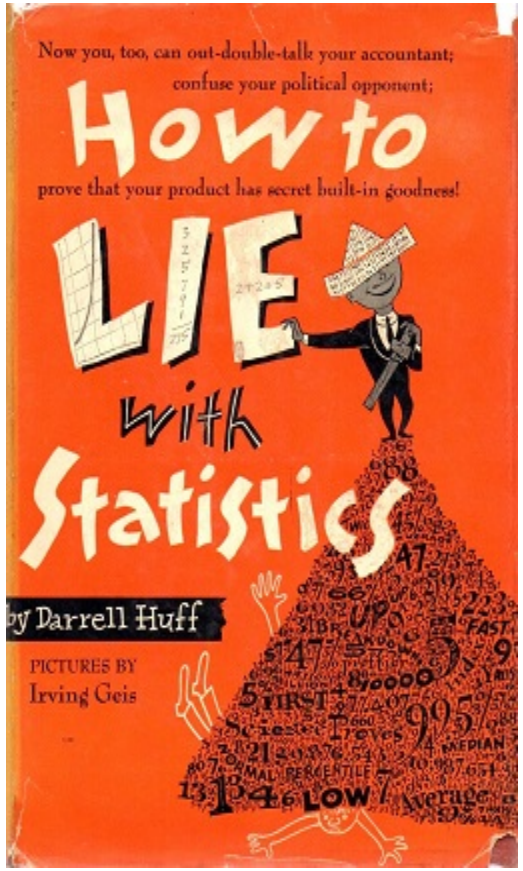

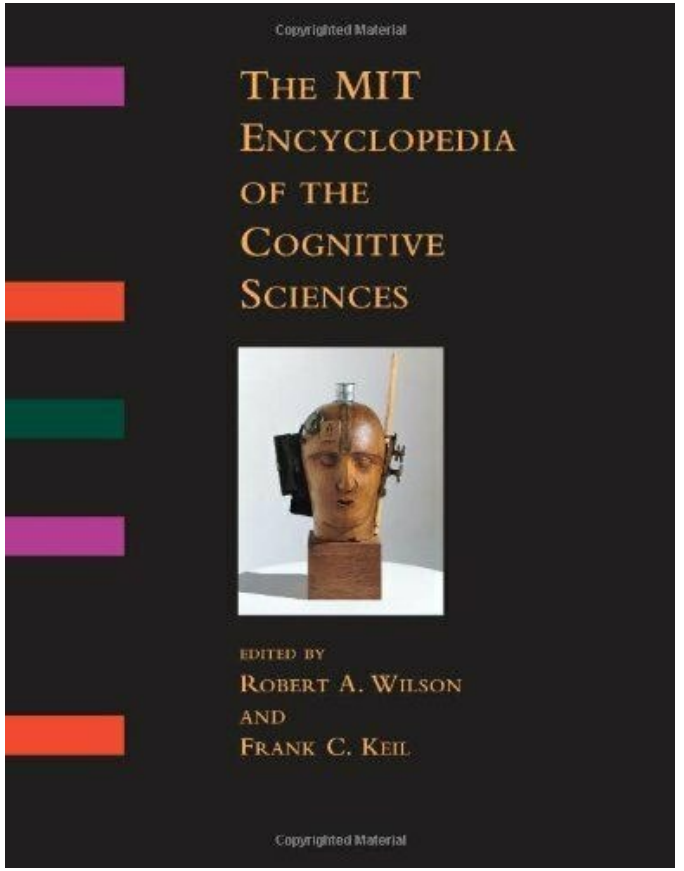

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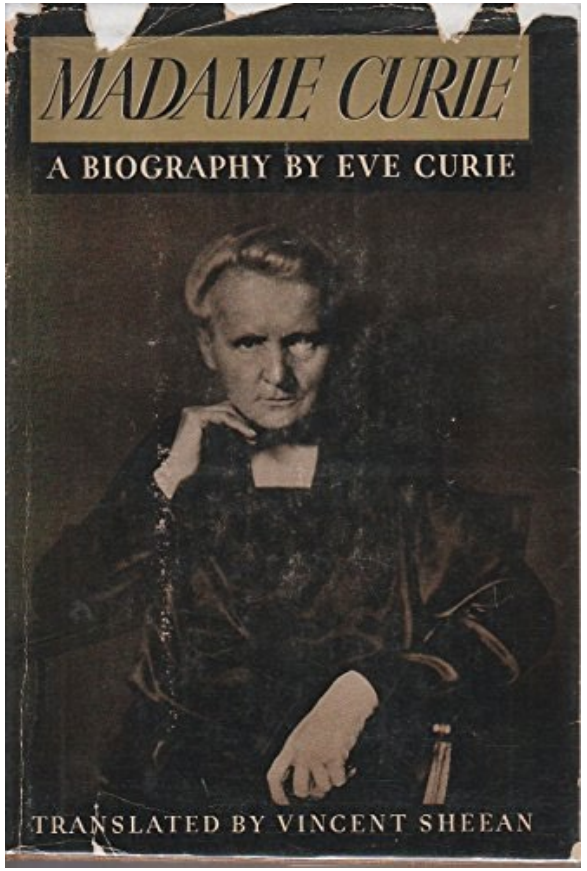

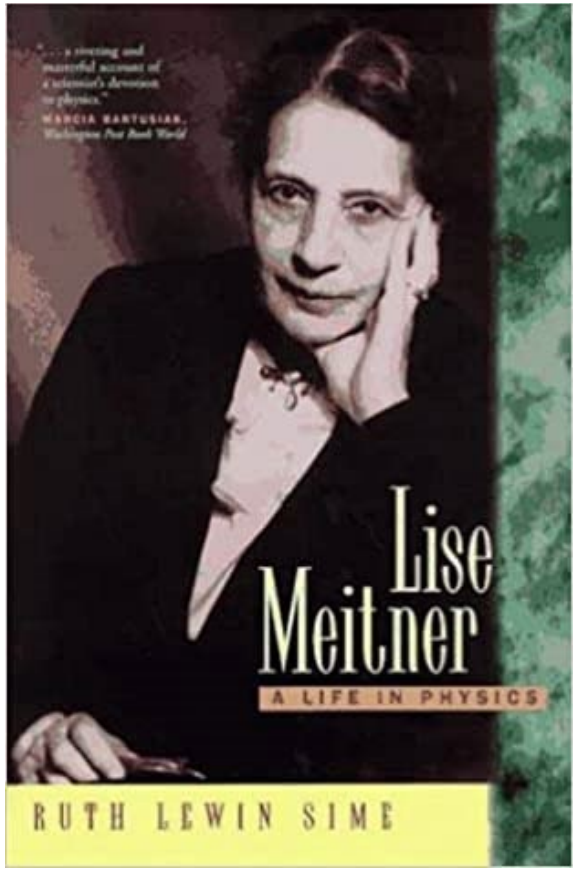

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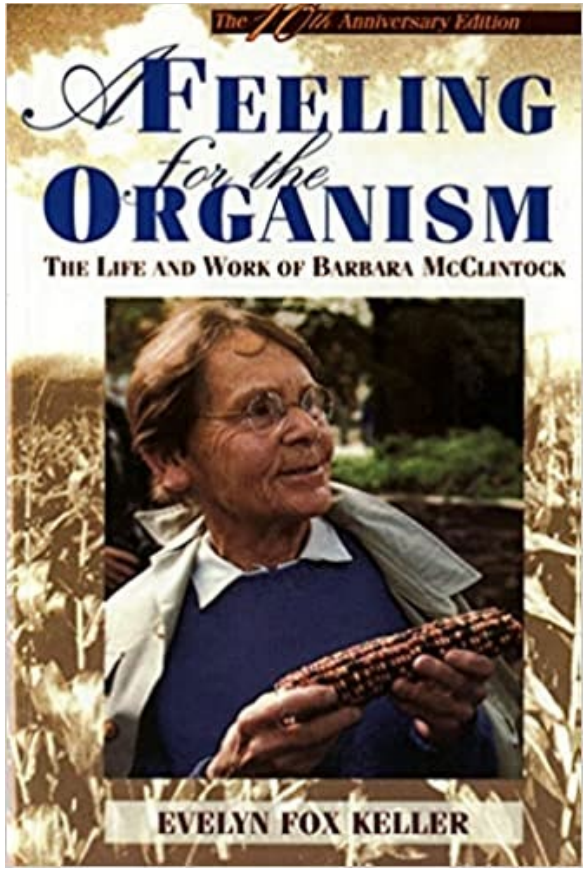

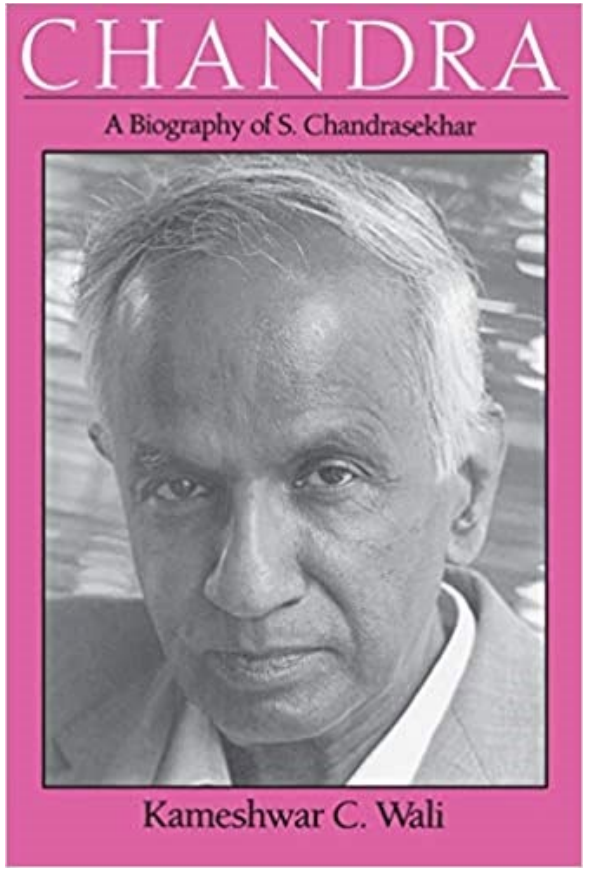

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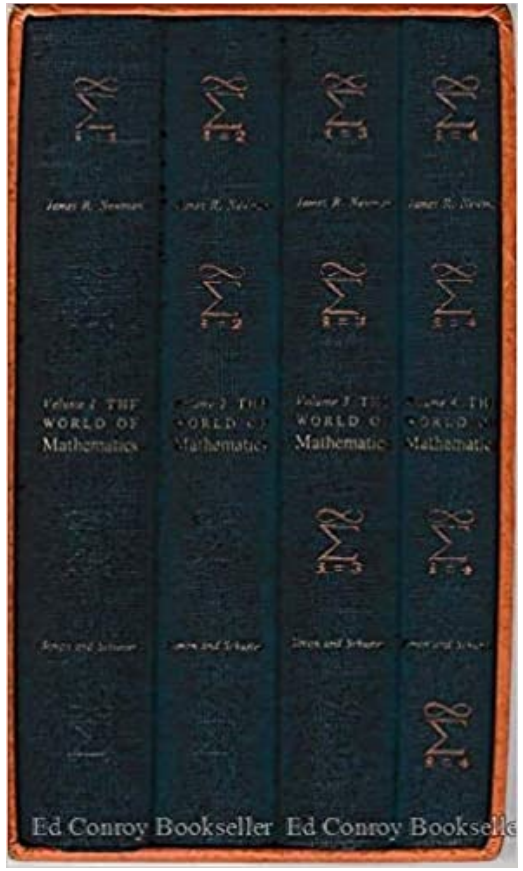

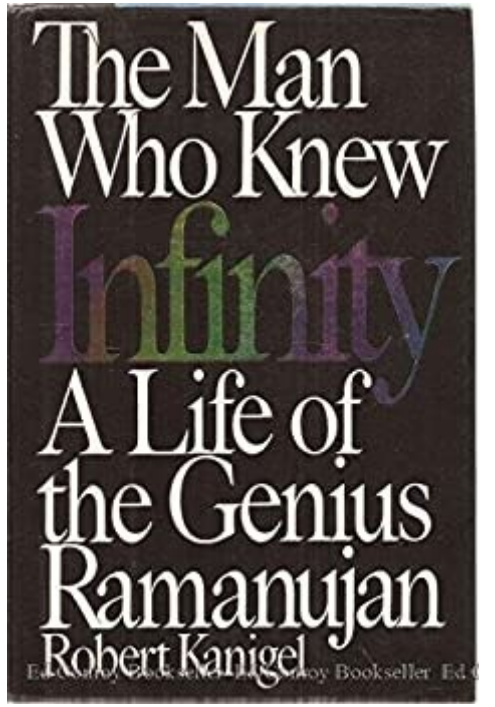

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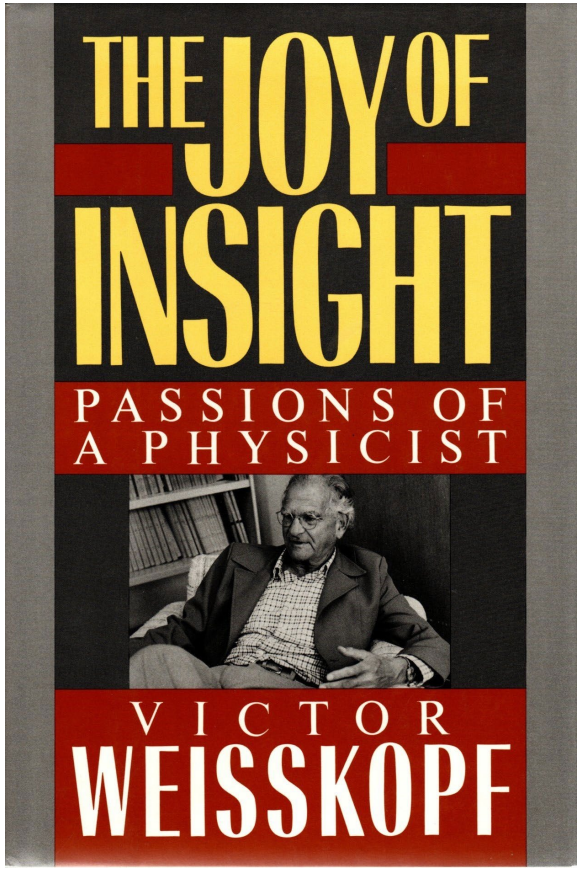

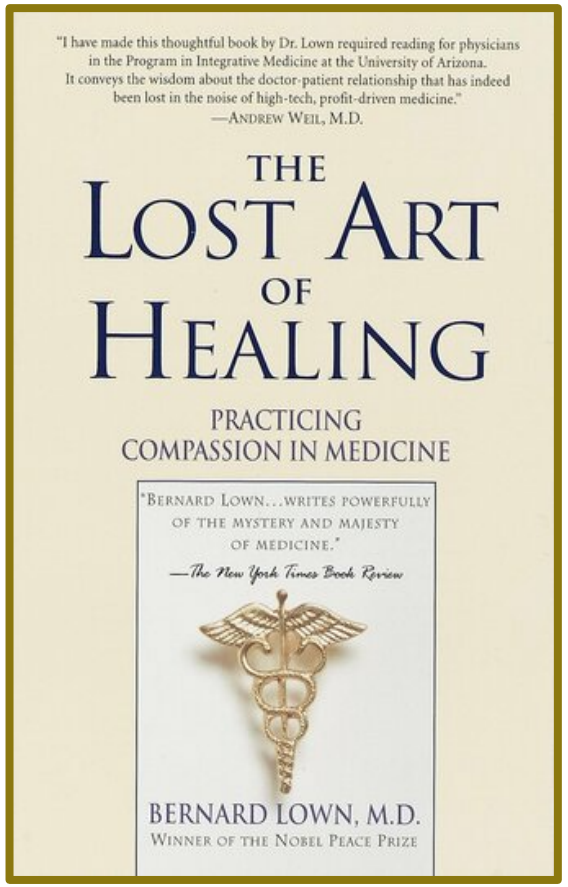

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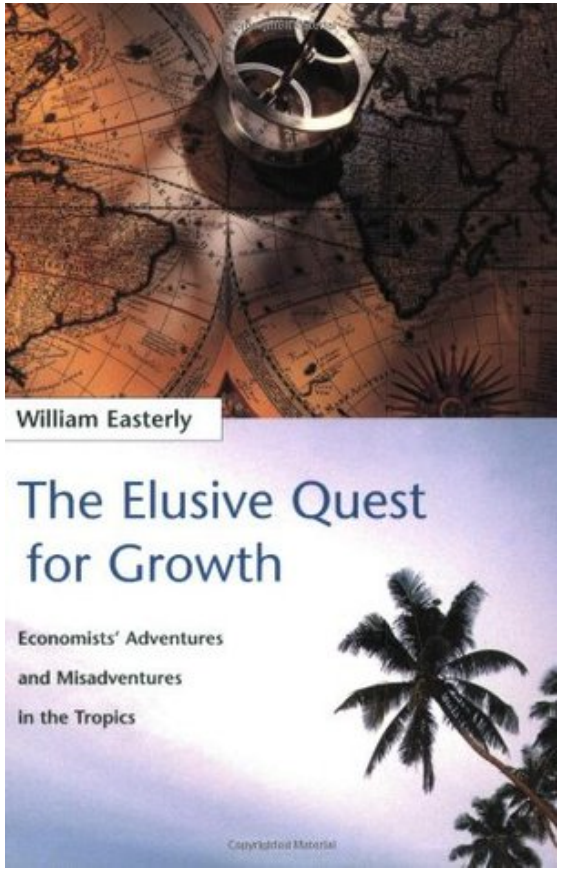

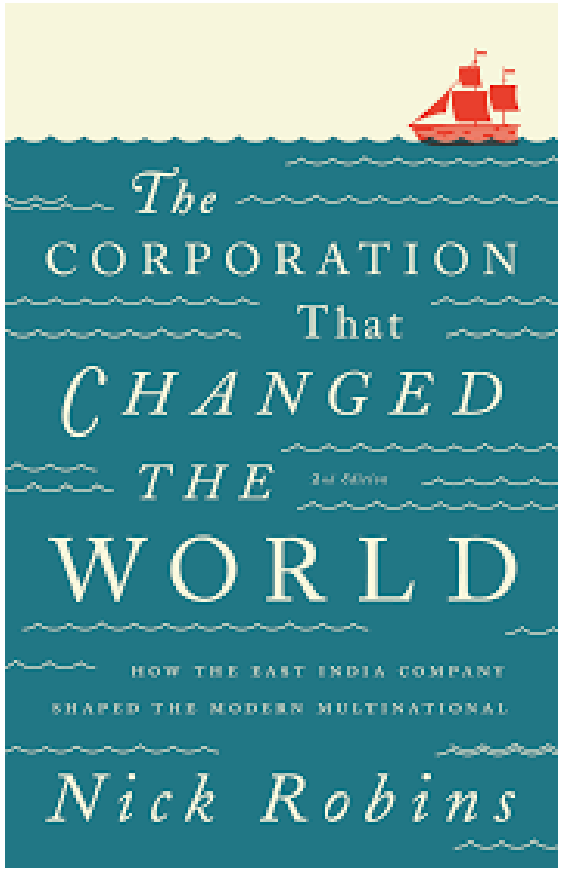

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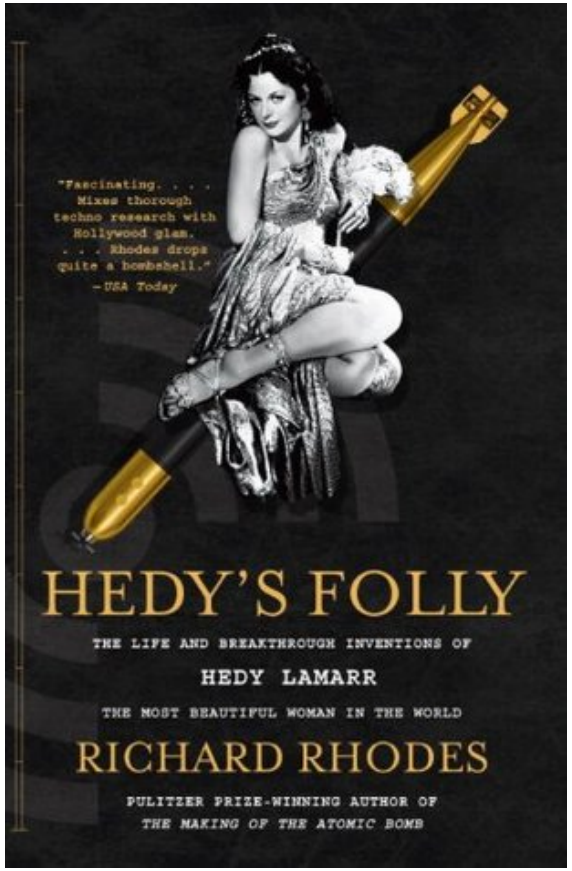

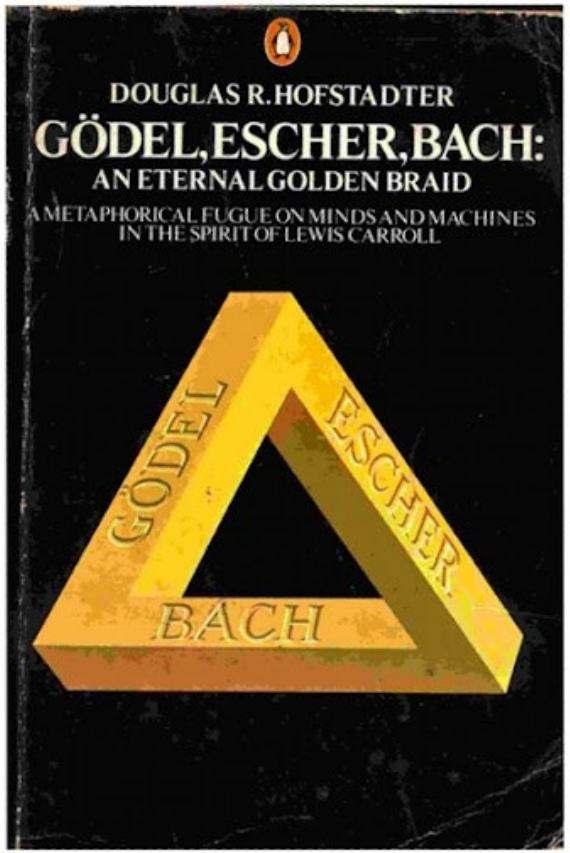

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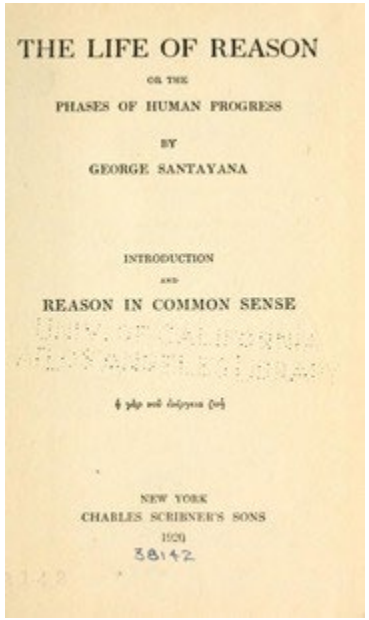
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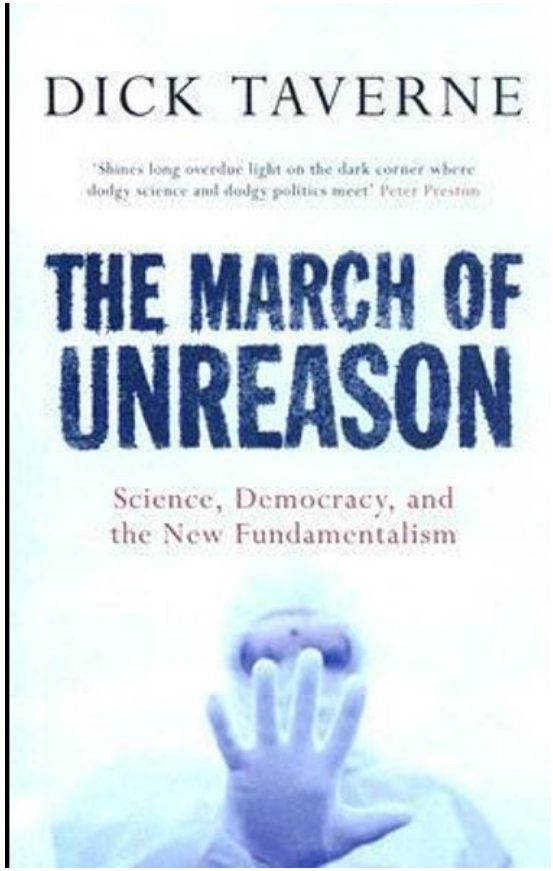

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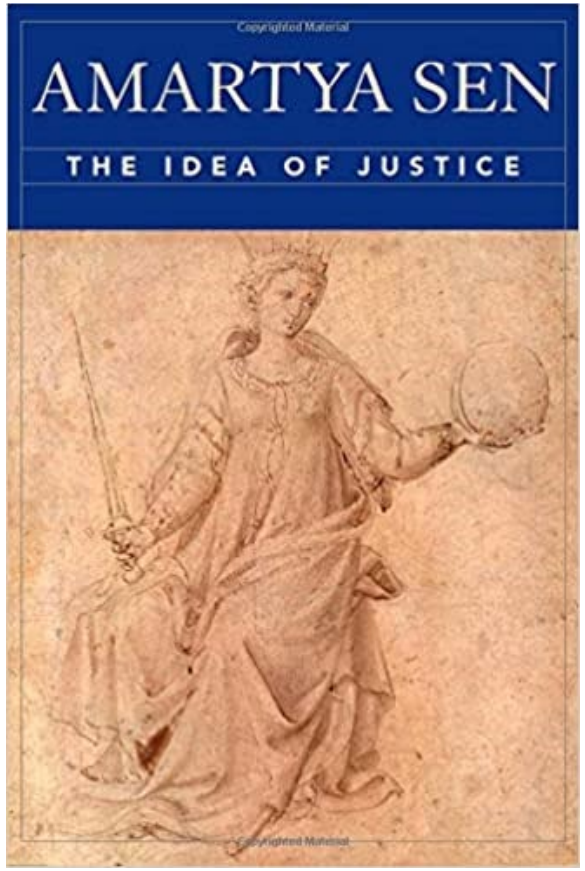

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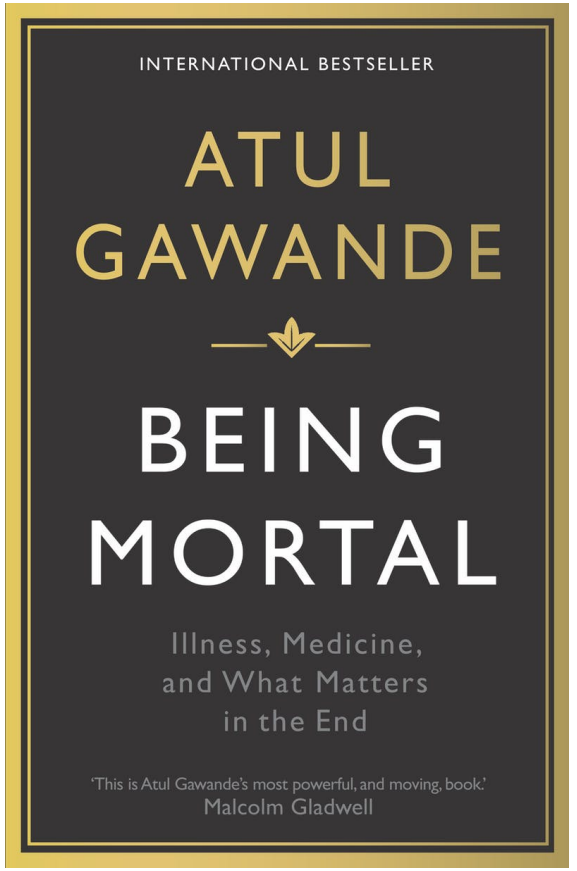
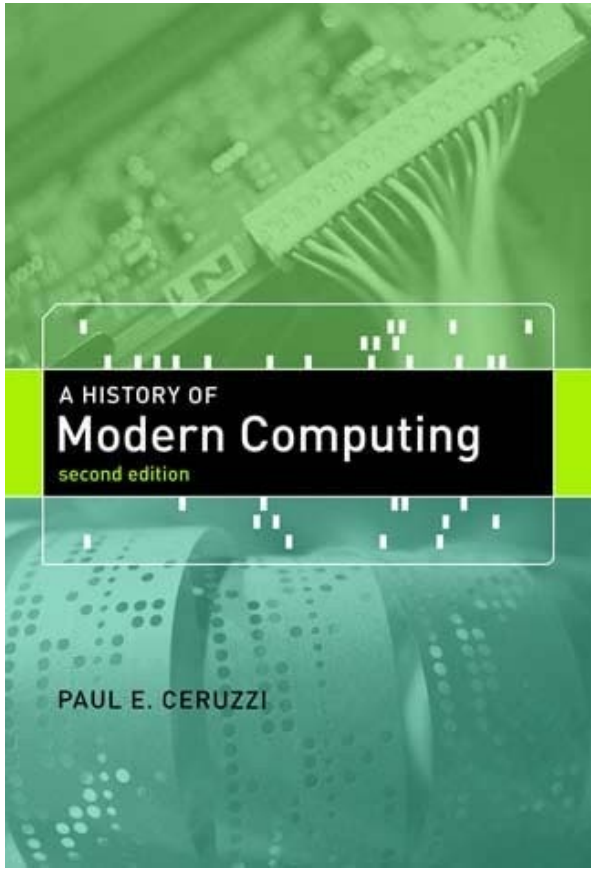
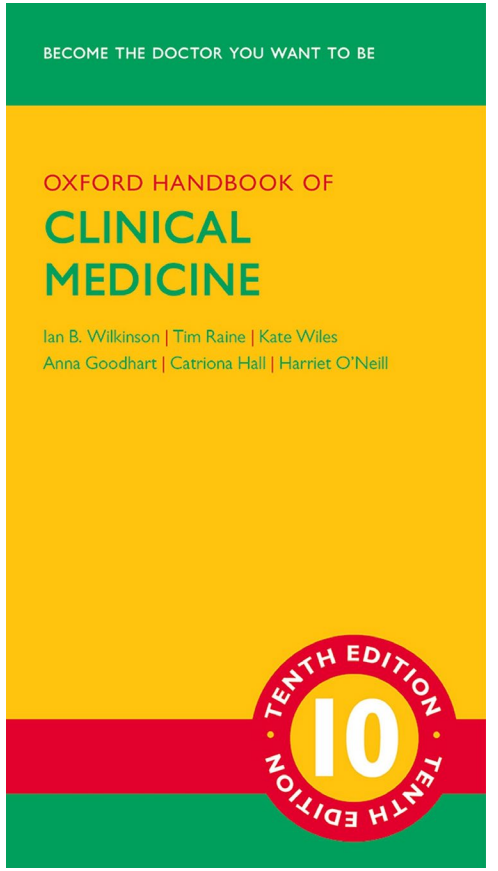






Temporary Conclusion …

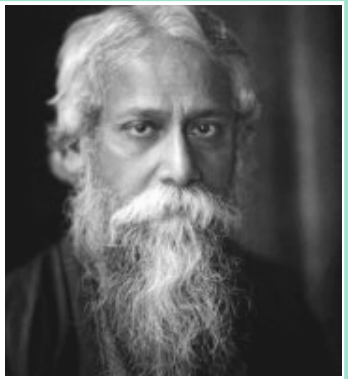
Did I bore you to sleep ?

Your contribution to society matters. Enabling engineering and science to serve society requires preparation. The road ahead is not a bed of roses. You can complain that rose bushes have thorns or rejoice because thorny bushes also grow roses. In ***your*** design of ***your*** sense of the future, the "rose" is a metaphor for sign-posts you are likely to encounter on this long journey. Finding your mental compass to navigate your direction is quintessential. Your family, friends, teachers and academia are your sources of values, virtues and vices. Yet, ultimately, it is your aspiration, ambition and your courage to discover not only knowledge, but the wisdom you must inculcate, to re-shape your destiny.

This talk is just a tiny point in the pragmatic philosophical fabric of life, whose quality depends on what you are weaving. I aim to mention a few elements of scientific significance pertaining to 5 strands (FEWSH) of global public goods which acts as purveyors of civilization. We are not indulging in the hubris, extravagance and waste which is in abundance in the West. We aim to discuss how the fruits of science may lift lives of people who are down-trodden, forgotten or misbegotten. What can you do to help 80% of the world's population? Does your plight include lifting many boats or just a few yachts?

Prepared for discussion with students ◆ Brief bio-sketch of speaker may be downloaded from http://bit.ly/BIO-SD

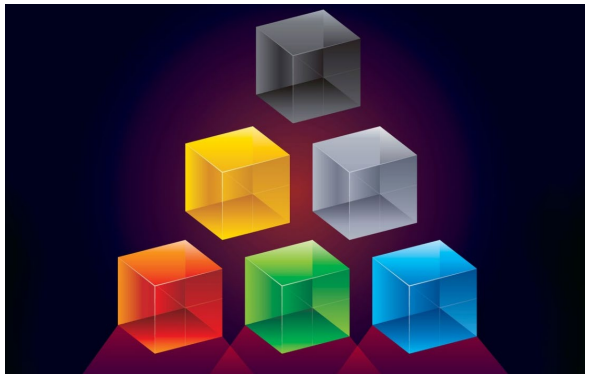
"What we do in life echoes in eternity" *(Attributed to Maximus Decimus Meridius)*



The child ever dwells in the mystery
of an ageless time
unobscured by the dust of history.

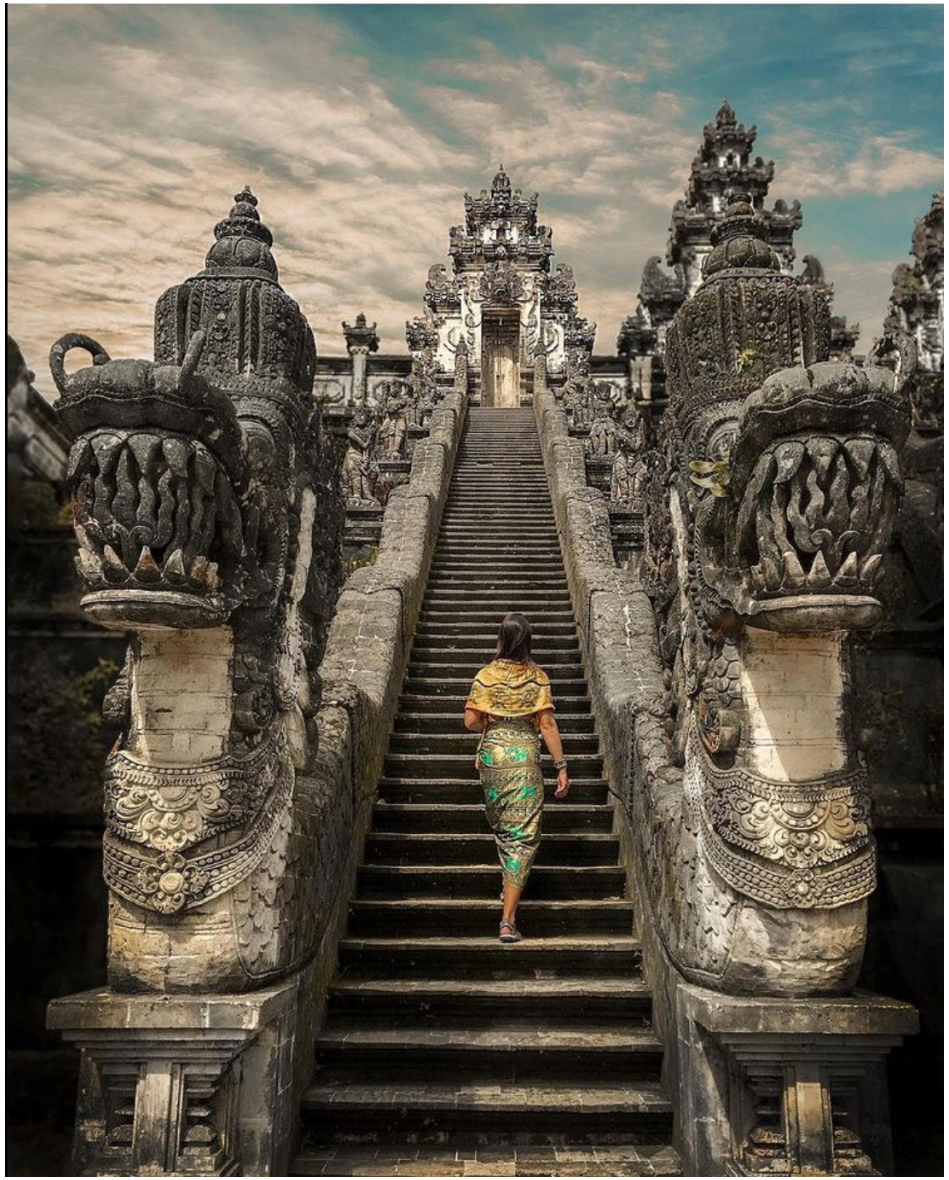
Photo from https://terebess.hu/english/tagore5.html ❖ Quote from page 53 https://terebess.hu/english/Lekhan.pdf

"Nobody has the power to take two steps together; you can take only one step at a time."



Build back better

Shoumen Palit Austin Datta



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