ROME IS BURNING

Robert M Califf MD
Vice Chancellor for Health Data Science
Duke University
Advisor, Verily Life Sciences
National Health Council
October 29th, 2019

1

LET THEM EAT CAKE…

Robert M Califf MD
Vice Chancellor for Health Data Science
Duke University
Advisor, Verily Life Sciences

2

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TECHNOLOGY ENABLED HEALTHCARE: CAN WE ACHIEVE PERSONALIZED APPROACHES TO CARE?

Robert M Califf MD
Vice Chancellor for Health Data Science
Duke University
Advisor, Verily Life Sciences

3

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CONFLICTS OF INTEREST

- Employment
  - Duke University
  - Verily Life Sciences
- Corporate Board
  - Cytokinetics
- Consulting
  - Astra Zeneca
  - Merck
  - Boehringer Ingelheim
  - Amgen
  - Biogen
  - Genentech/Roche
  - Lilly

4

History of Digital Disruption

Company /Industry	Core Business	Transformational Change	Digital Disruption Enhance Existing Income Model?	Successful Internal Transformation?	Digital Disrupter
Kodak	Photographic Film & Paper	Digital Photography	NO	X	Apple, Motorola, Samsung, Sharp, Sony
Barnes & Noble	Selling Books from Stores	Online Book Orders	NO	X	amazon.com
Chemical Bank	Lending Money	ATMs and Online Banking	YES	✓	All Modern Banks
Blockbuster Video	Video Rental	Digital Streaming	NO	X	Netflix
	Fee-for-Service Health Care	Value-based, Digitally Enabled Medicine	NO	?	?
	Sell more drugs at higher prices	Value based reimbursement	NO	?	?

5

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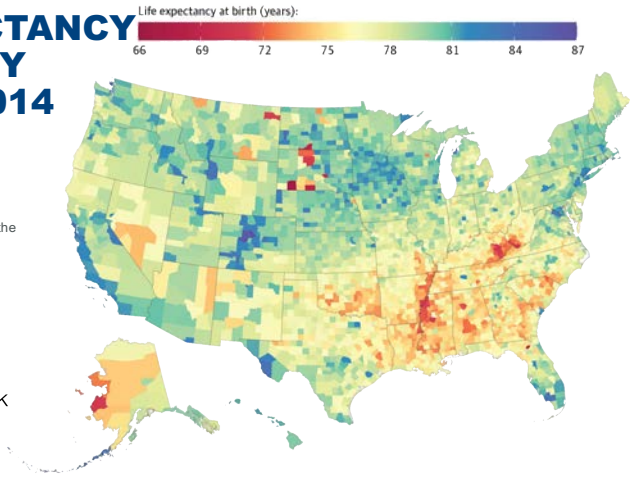
LIFE EXPECTANCY AT BIRTH BY COUNTY, 2014



- Counties in South Dakota and North Dakota had the lowest life expectancy, and counties along the lower half of the Mississippi, in eastern Kentucky, and southwestern West Virginia also had very low life expectancy compared with the rest of the country. Counties in central Colorado had the highest life expectancies.

The JAMA Network

Dwyer-Lindgren L, et al. Inequalities in life expectancy among US counties, 1980 to 2014 - temporal trends and key drivers. JAMA Intern Med. 2017;177:1003-11. doi:10.1001/jamainternmed.2017.0918

6

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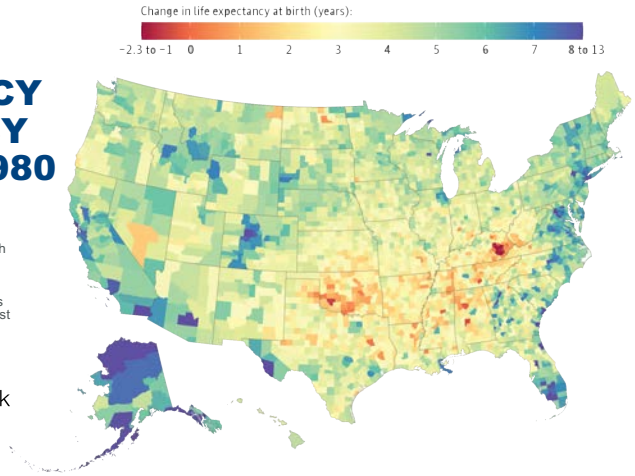
CHANGE IN LIFE EXPECTANCY AT BIRTH BY COUNTY, 1980 TO 2014

- Compared with the national average, counties in central Colorado, Alaska, and along both coasts experienced larger increases in life expectancy between 1980 and 2014, while some southern counties in states stretching from Oklahoma to West Virginia saw little, if any, improvement over this same period.

The JAMA Network



Dwyer-Lindgren L, et al. Inequalities in life expectancy among US counties, 1980 to 2014 - temporal trends and key drivers. JAMA Intern Med. 2017;177:1003-11. doi:10.1001/jamainternmed.2017.0918

7

The JAMA Network

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From: **Inequalities in Life Expectancy Among US Counties, 1980 to 2014Temporal Trends and Key Drivers**

JAMA Intern Med. Published online May 08, 2017. doi:10.1001/jamainternmed.2017.0918

Table 1. Variables Included in the Regression Analysis With Summary Statistics and Bivariate Regression Results

Variable	Summary Statistics, Mean (SD) [Range]	Bivariate Regression Results	
		Coefficient (SE)	R^2
Socioeconomic and race/Ethnicity factors			
Population below the poverty line, %	16.3 (6.4) [3.1-62.0]	−0.24 (0.005)	0.47
Median household income, log $	10.6 (0.2) [9.8-11.6]	6.06 (0.130)	0.41
Graduates, age ≥25 y, %			
High school	83.7 (7.2) [46.3-98.6]	0.20 (0.004)	0.42
College	19.2 (8.6) [4.2-72.0]	0.15 (0.004)	0.34
Unemployment rate, age ≥16 y, %	9.1 (3.2) [2.1-27.4]	−0.29 (0.011)	0.18
Black population, %	9.4 (14.7) [0-85.8]	−0.07 (0.002)	0.24
American Indian, Native Alaskan, and Native Hawaiian population, %	2.3 (7.9) [0-97.2]	−0.06 (0.005)	0.04
Hispanic population, %	8.1 (13.1) [0-95.9]	0.02 (0.003)	0.01
Behavioral and metabolic risk factors, %			
Obesity prevalence, age ≥20 y	37.0 (4.3) [18.0-52.0]	−0.39 (0.006)	0.54
No leisure-time physical activity prevalence, age ≥20 y	27.0 (5.2) [11.7-47.2]	−0.34 (0.005)	0.62
Cigarette smoking prevalence, age ≥18 y	24.7 (4.1) [7.7-42.1]	−0.40 (0.007)	0.54
Hypertension prevalence, age ≥30 y	39.5 (3.6) [27.9-56.4]	−0.49 (0.007)	0.62
Diabetes prevalence, age ≥20 y	14.0 (2.4) [8.1-25.5]	−0.72 (0.011)	0.59
Health care factors			
Insured population, age <65 y, %	81.7 (5.7) [57.3-96.7]	0.15 (0.007)	0.14
Quality index	70.1 (11.5) [0-100]	0.10 (0.003)	0.28
Physicians per 1000 population, No.	1.1 (1.0) [0-4.4]	0.53 (0.039)	0.06

Abbreviation: SE, standard error.

Table Title:

Variables Included in the Regression Analysis With Summary Statistics and Bivariate Regression Results

8

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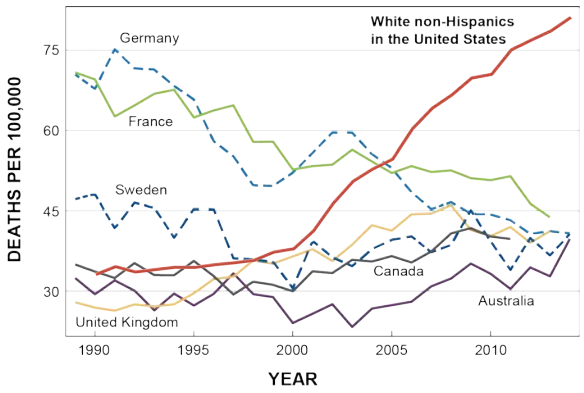
Midlife mortality from "deaths of despair" across countries

Men and women ages 50–54, deaths by drugs, alcohol, and suicide, 1989–2014



B Economic Studies at BROOKINGS

Source: "Mortality and morbidity in the 21st century" by Anne Case and Angus Deaton, Brookings Papers on Economic Activity, Spring 2017.

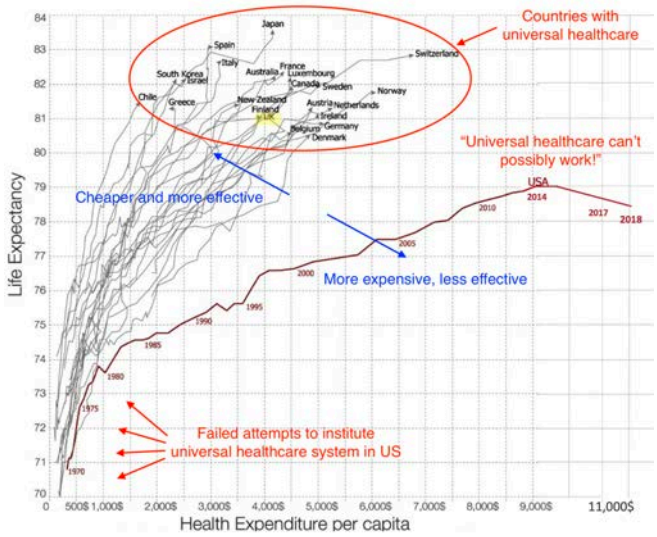
9

Life expectancy at birth (years) in 18 high income countries for women and men during 2010-16 and 1990-2015.

Jessica Y Ho, and Arun S Hendi BMJ 2018;362:bmj.k2562

thebmj

10



11

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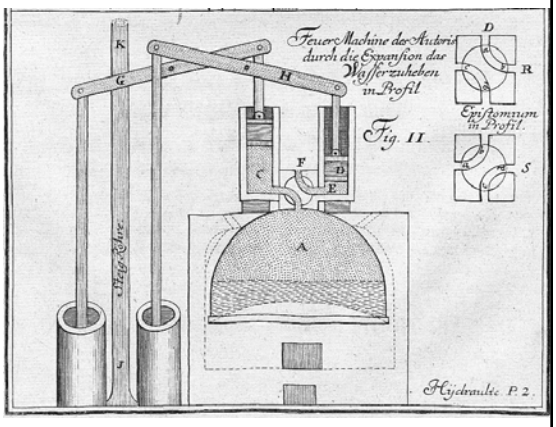
Four industrial revolutions

FIRST
Water and steam power mechanize production.



Jacob Leupold, Steam Engine, in *Theatri Machinarum Hydraulicarum II* (1720)

12

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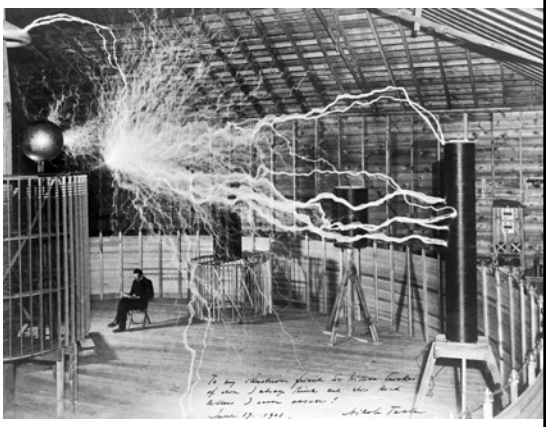
Four industrial revolutions

SECOND
Electric power creates mass production.

2



Photographer: Dickenson V. Alley. CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=36367226

13

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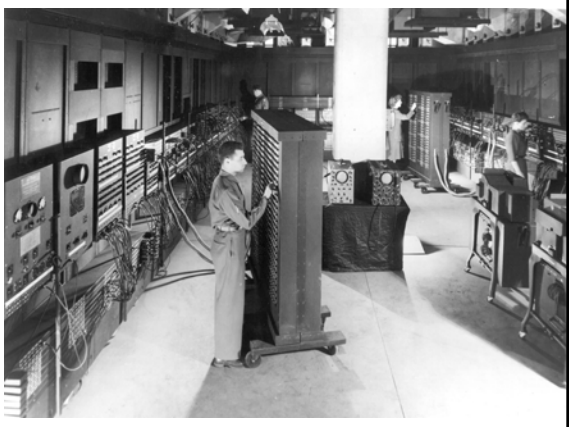
Four industrial revolutions

THIRD
Electronics and information technology automate production.

3



ENIAC digital computer. Unidentified U.S. Army photographer. Public Domain, https://commons.wikimedia.org/w/index.php?curid=9787770

14

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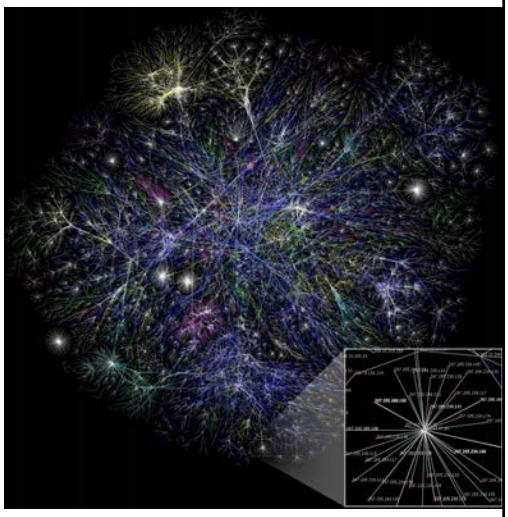
Four industrial revolutions

FOURTH
The digital revolution—characterized by a fusion of technologies—blurs the lines between physical, digital, and biological spheres.



Opte Project. Internet map. https://commons.wikimedia.org/wiki/File:Internet_map_1024.jpg

15

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Qualities of the New Data Environment

- **Volume**
  - —New methods of data storage allow access to huge amounts of data
- **Ubiquity/Liquidity**
  - —Data are available anywhere across geography, social and economic classes
- **Latency**
  - —There is no delay in access to data inherent in the technology
- **Analysis**
  - —Data, information, knowledge, wisdom continuum is being shifted to the right

16

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17

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18

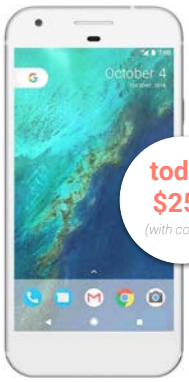
19

16.3M results

in 0.57 second

20

The cost of a smartphone in 1985: $32M



Mobile Phone $9,000 (DynaTAC)	**Text Messaging** $1,105 (fax machine)	**GPS** $6,630 (Magellan GPS)	**Voice Recorder** $110 (Realistic CTA)
Digital Watch $45 (Casio DBC)	**Music Player** $400 (Sony Discman)	**Video Camera** $3,745 (Sony V8)	**Video Player** $1,105 (Sony VCR)
Encyclopedia $2,200 (Encyclopedia)	**Processor** $32M (Cray)	**Portable TV** $665 (Casio Mini TV)	**Video Conference** $110,520 (Future Sys)

21

Project Baseline

WE'VE MAPPED THE WORLD. NOW LET'S MAP HUMAN HEALTH.

www.projectbaseline.com

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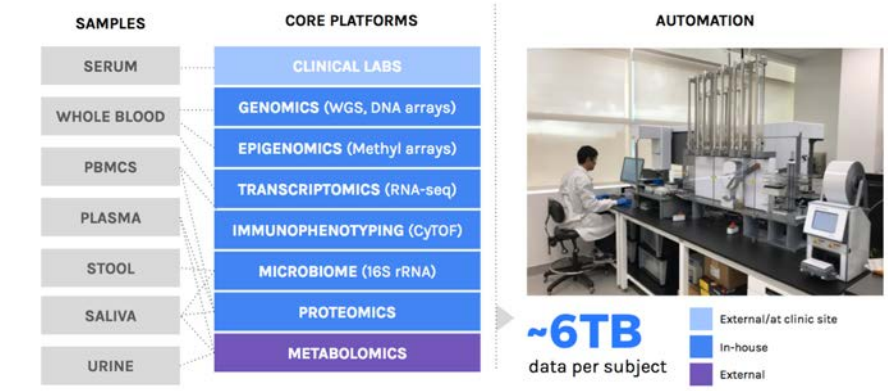
22

DEEP MOLECULAR PROFILING



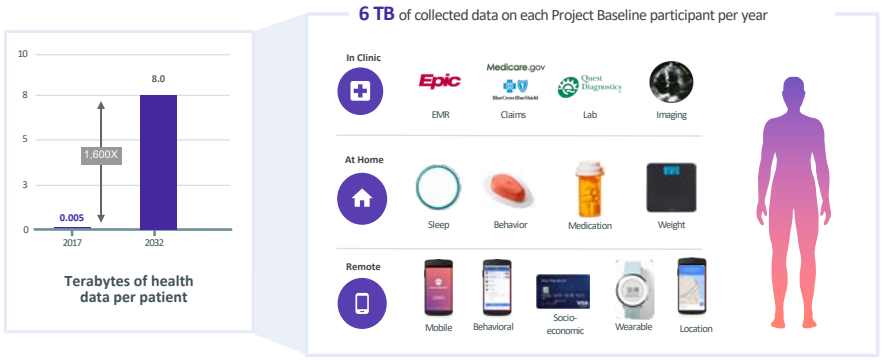
Project Baseline

23

23

Collecting comprehensive health data

Generate tools and technologies to collect diverse, comprehensive health data in-clinic, at-home, and remotely.



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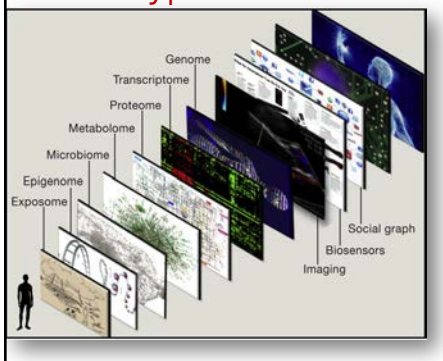
24

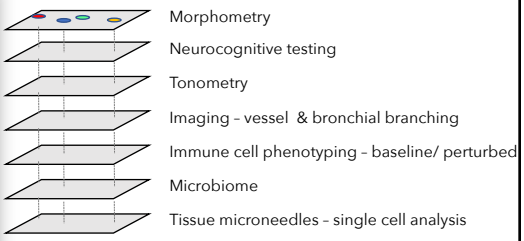
Big Challenges in Biomedicine

- **Lack of significant information over time dimension**
  - Measurements to assess biology and human health are made periodically in visits to healthcare or for research
- **Missing systems biology**
  - When developing concepts of human biology or drug development we make limited measurements focused on specific mechanisms —**we look "under the lamppost"**
- **Missing the opportunity to measure interactions of biology, sociology, environment and decision-making that could enable optimization of individualized and population health**
  - Although we know that health and disease are the product of the interactions of genes, multiple derivative biological systems, environment, social context and personal decisions, we tend to look at one part of the time

25

Phenotype stack





- Integration across scales requires new data, new tools, new taxonomy
- Unifying metadata: **small molecules, biophysical stimuli**
- Breadth vs Depth
- Co-clinical modeling

26