

Engineering Human Health

What will you die of?

Week 4 lecture 1

Statistically, speaking. What do you think?

1. Causes of death in the past and today
2. Which engineering solutions have led to the health outcomes we see today?
3. Challenges in healthcare - role of bioengineering

Causes of death in Boston in 1812

Consumption - pulmonary tuberculosis
Lockjaw - tetanus

Note the fevers, Cholera, Tetanus, TB,
Dysentery, Syphilis

The DEATHS preceding were caused by Diseases and Casualties as follows, viz.

Abscesses	-	-	1	Hernia, or Rupture	-	3
Aneurism	-	-	1	Jaundice	-	10
Apoplexy	-	-	13	Inflammation of the bowels	-	1
Burns or Scalds	-	-	6	----- of the stomach	-	1
Cancer	-	-	5	Killed by lightning	-	1
Casualties	-	-	15	Insanity	-	1
Childbed	-	-	14	Intemperance	-	2
Cholera Morbus	-	-	6	Locked jaw	-	2
Colic	-	-	2	Mortification	-	11
Consumption	-	-	221	Old Age	-	26
Convulsions	-	-	36	Palsy	-	12
Cramp in the stomach	-	-	2	Pleurisy	-	8
Croup	-	-	1	Quinsy	-	15
Debility	-	-	28	Rheumatism	-	1
Decay	-	-	20	Rupture of blood vessels	-	1
Diarrhoea	-	-	15	Small-Pox, (at Rainsford's Island)	-	2
Drinking cold water	-	-	2	Sore throat	-	1
Dropsy	-	-	21	Strasma	-	2
----- in the head	-	-	23	Stillborn	-	49
Drowned	-	-	13	Suicide	-	1
Dysentery	-	-	14	Sudden death	-	25
Dispepsia or Indigestion	-	-	15	Syphilis	-	12
Fever, bilious	-	-	7	Teething	-	15
----- pulmonic	-	-	46	Worms	-	11
----- inflammatory	-	-	24	Whooping Cough	-	14
----- putrid	-	-	6	White swelling	-	2
----- typhus	-	-	33	Diseases not mentioned	-	48
Flux infantile	-	-	57			
Gout	-	-	3			
Hoemorrhage	-	-	4			
				Total,		942

Causes of death in Boston in 1812

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Lockjaw - tetanus

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Dysentery, Syphilis

What don't you see? Cancer,
diabetes, obesity, CV disease....

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NB - we are in the early days of understanding human health

New England Journal of Medicine and Surgery, and the Collateral Branches of Science

- 1812a. Warren JC. Remarks on angina pectoris. 1:1-11.
- 1812b. Jackson J. Some remarks on the morbid effects of dentition. 1:12-25.
- 1812c. Bigelow J. Observations and experiments on the treatment of injuries occasioned by fire and heated substances. 1:52-64.
- 1812d. Warren JC. Cases of apoplexy with dissection. 1:34-41, 154-9.
- 1812e. Of the disease called the spotted fever. 1:228-44.
- 1812f. Wind of cannon balls. 1:309-10.
- 1812g. Spontaneous combustion in manufactories, &c. 1:313-4.
- 1812h. Abstract of the bill of mortality for the town of Boston. 1:320-1.

NB - we are in the early days of understanding human health

Boston Medical and Surgical Journal

1912a. 1911 — A healthful year. 166:28.

1912b. Marshall HW. A few notes upon operative measures for tubercular knee affections. 166:35-43.

1912c. Past, present and future. 166:62-3.

1912d. Fire at the Penikese leper colony. 166:104.

1912e. Kaan GW. The relation of gonorrhea to pelvic disease. 166:556-60.

1912f. American supremacy at the Olympic Games. 167:102.

1912g. Mears JE. A further study of the problem of race betterment. 167:455-61.

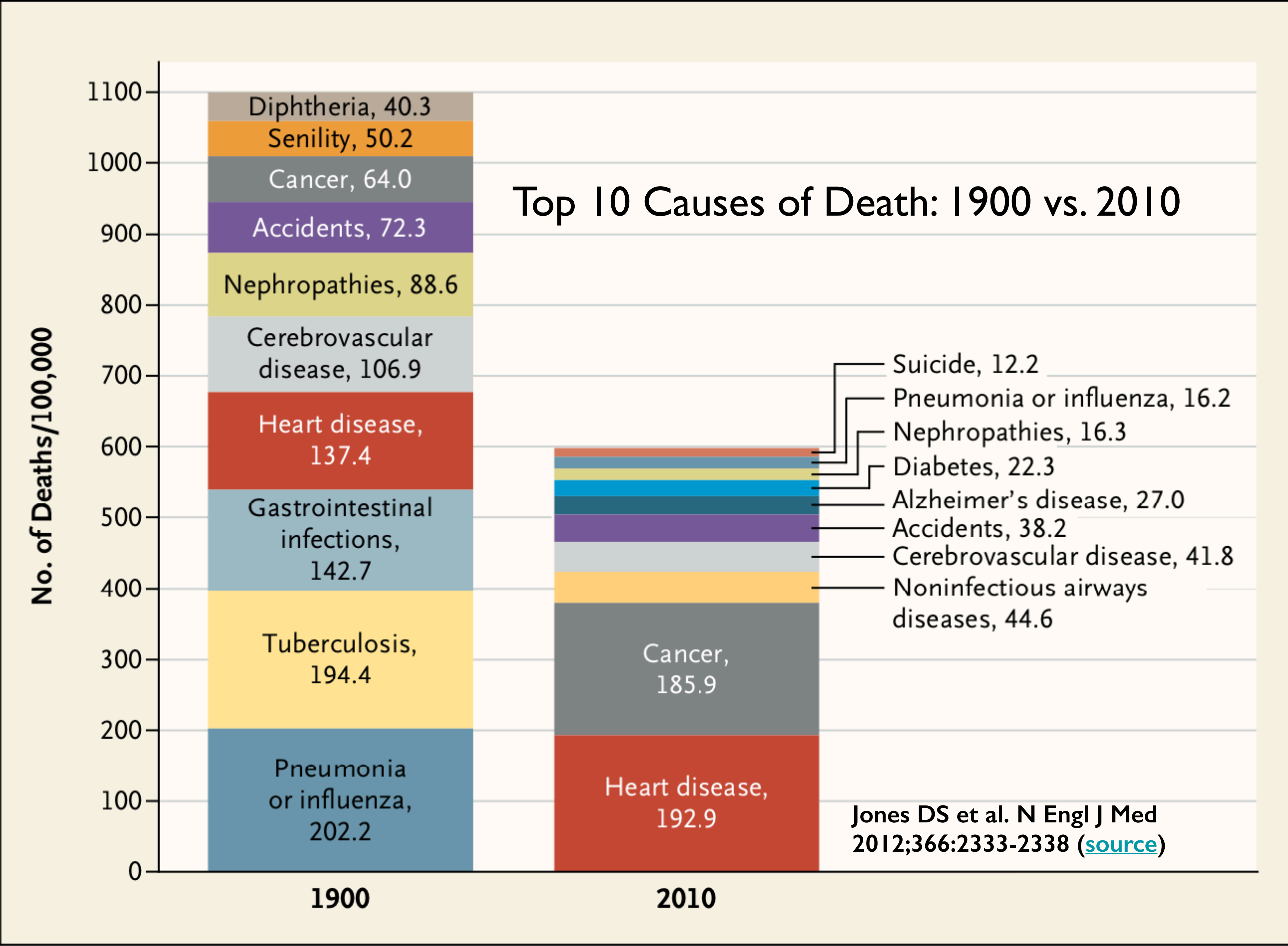
1912h. Conservation and evolution. 167:518-9.

1912i. Knapp PC. Syphilis of the nervous system. 167:614-8.

1912j. The automobile knee. 167:816-7.

The Burden of Disease and the Changing Task of Medicine

<https://www.nejm.org/doi/full/10.1056/NEJMp1113569>

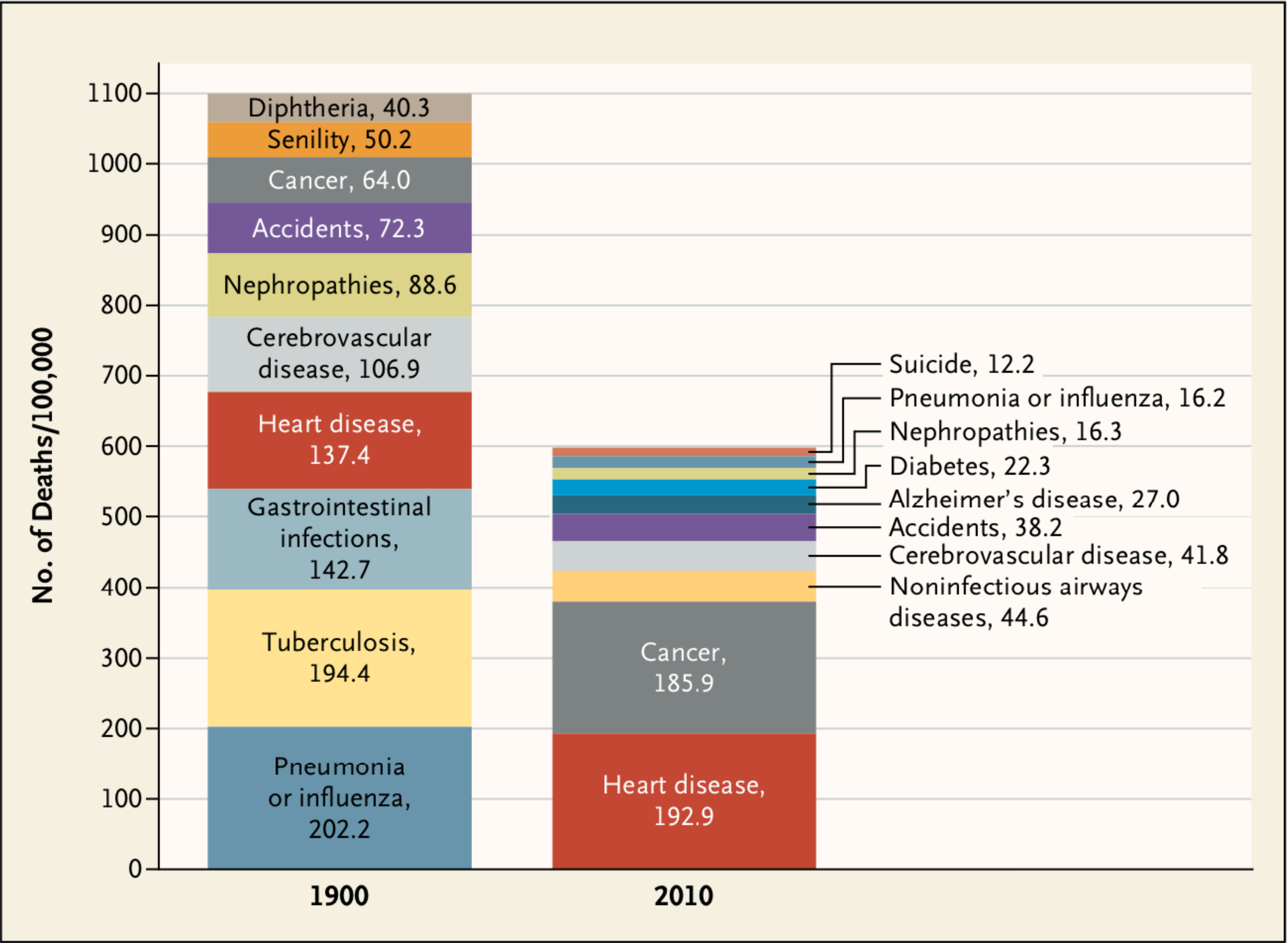


Why has there been an improvement?

Q1. What major changes do you see in this chart from 1900 to 2010?

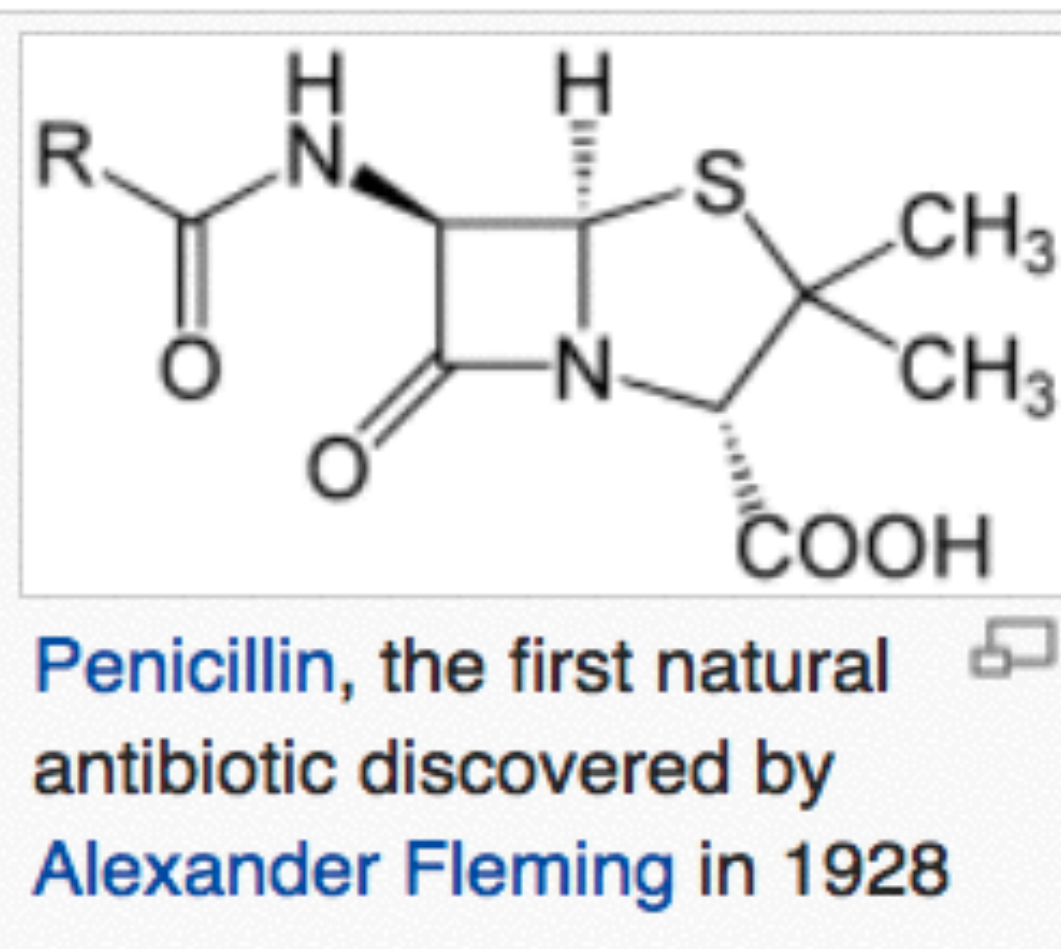
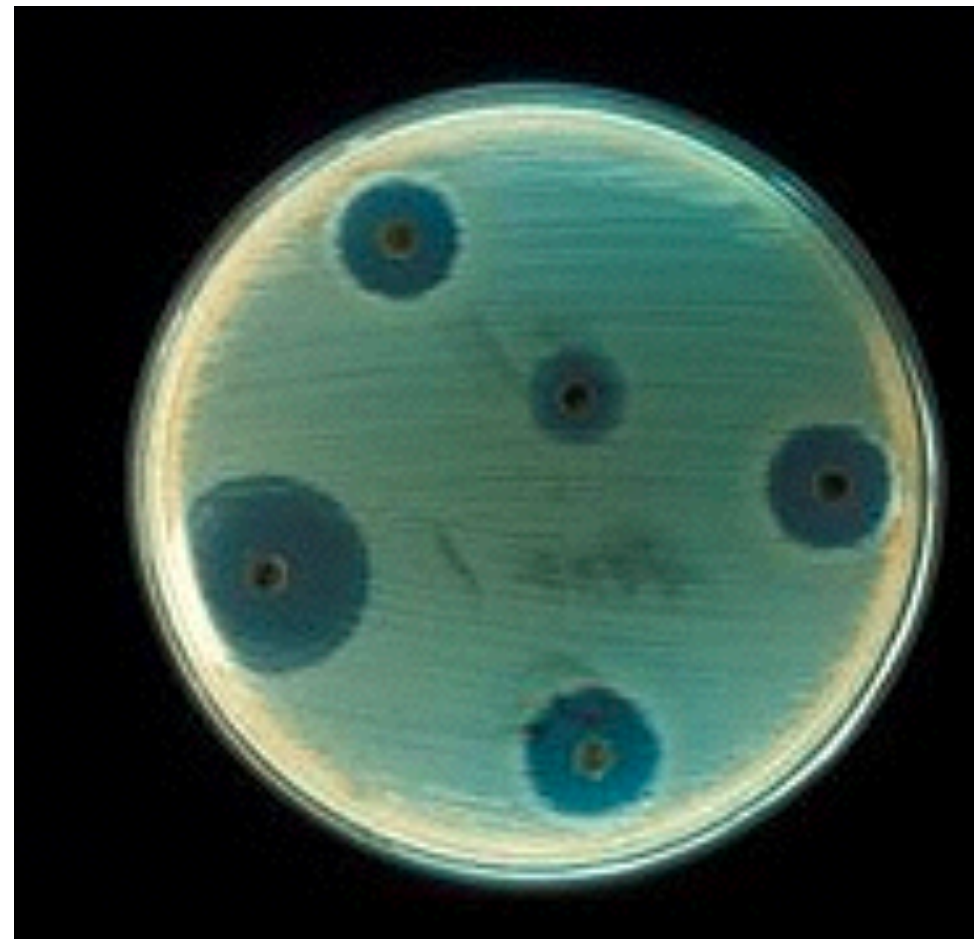
Q2. What engineering or medical innovations have changed the burden of disease to what we see today?

What do you think?



Why has there been an improvement?

1. Public health, sanitation, 'lifestyle' (e.g. anti-smoking)
2. Vaccines (saw week-1: Polio Vaccine)
3. Antibiotics
4. Screening and early detection (e.g. breast self-exam)



Jonas Salk on the Mar. 1954, cover of TIME

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Interesting fact - many of the fancy things you hear about - nano quantum proton holographic gold precision health personalized to your genome is either:

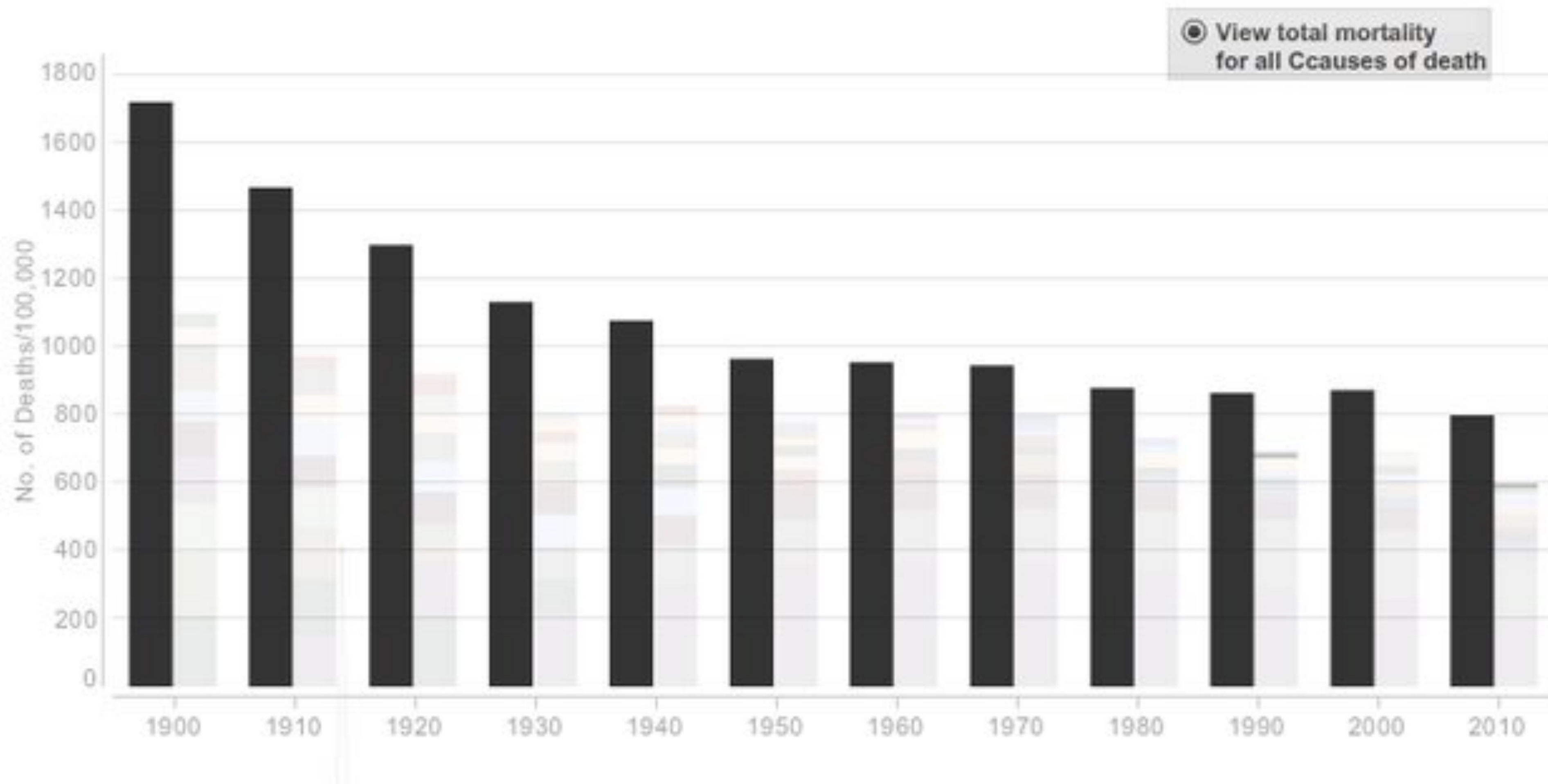
(a) fake marketing speak, or

(b) transformational for a tiny number of people and therefore of little effect on a population scale. Example - cancer immunotherapy - 2000 people treated to date (\$1 Million each), ~10% respond well = 200 people saved

What does health look like today?

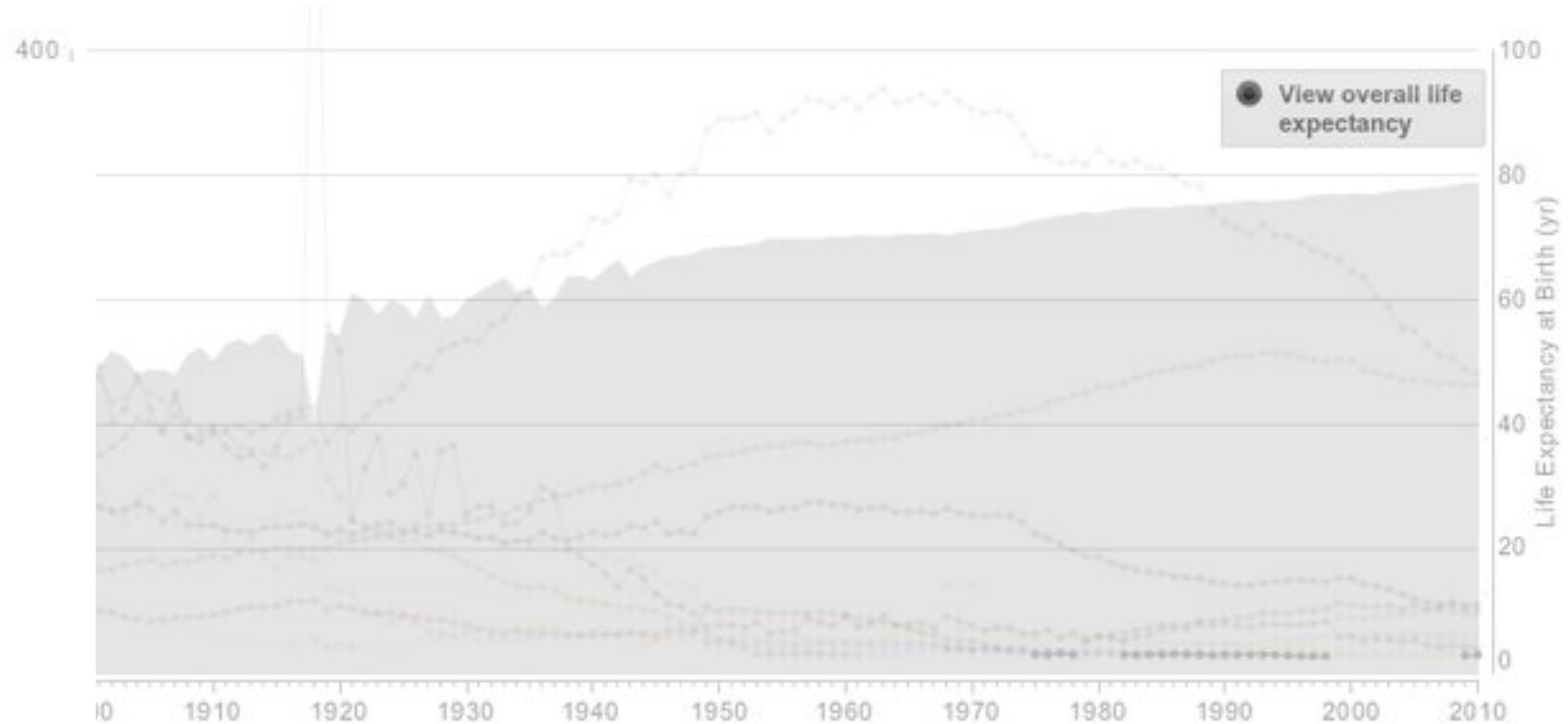
The per capita death rate has decreased over time

So people
live 2x
longer!



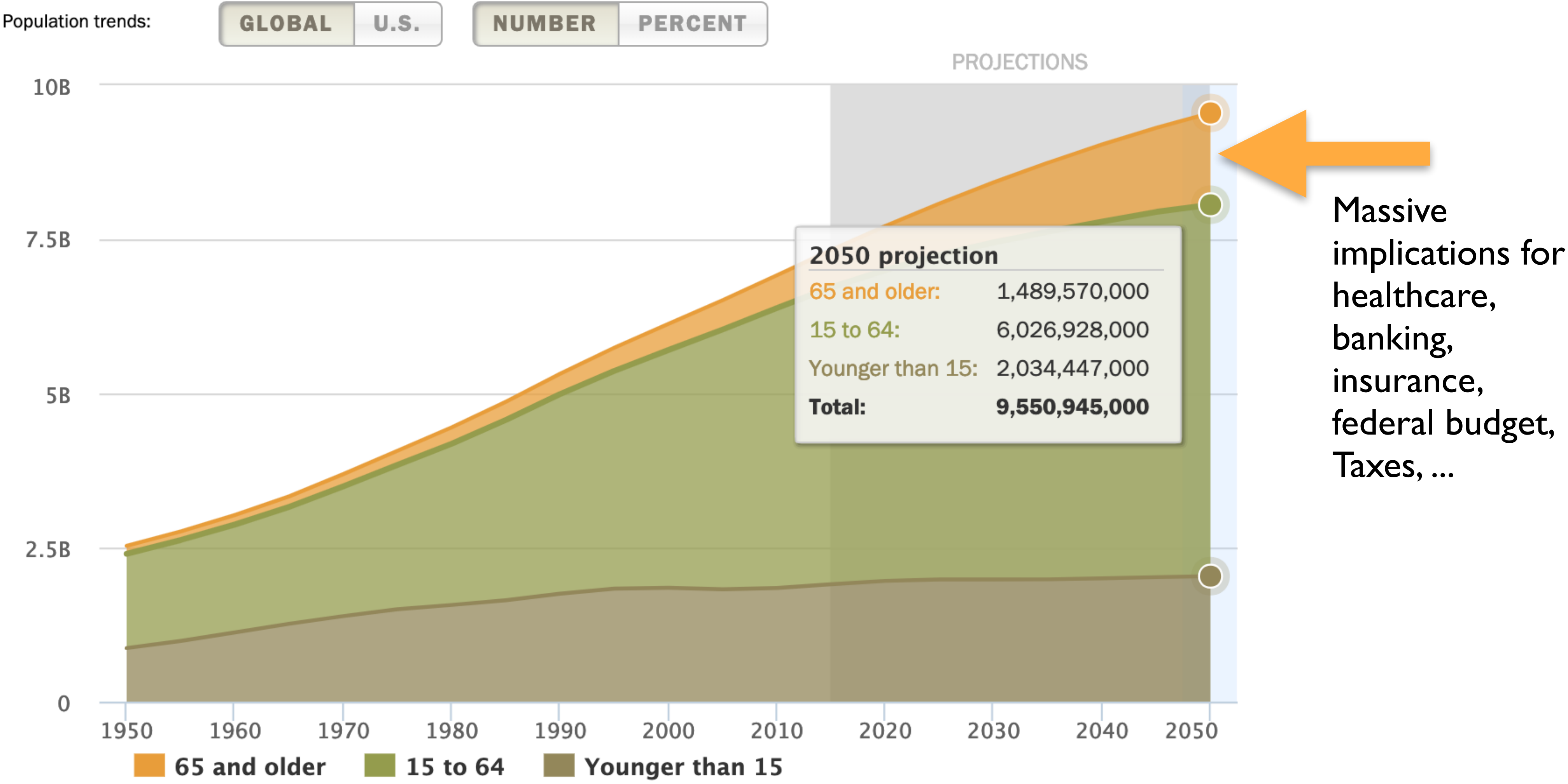
<https://www.businessinsider.com/leading-causes-of-death-from-1900-2010-2012-6?op=1>

Life Expectancy has increased from about 50 to 80 years



<https://www.businessinsider.com/leading-causes-of-death-from-1900-2010-2012-6?op=1>

The global population structure is changing



Source: United Nations, Department of Economic and Social Affairs, [World Population Prospects: 2012 Revision](#), June 2013

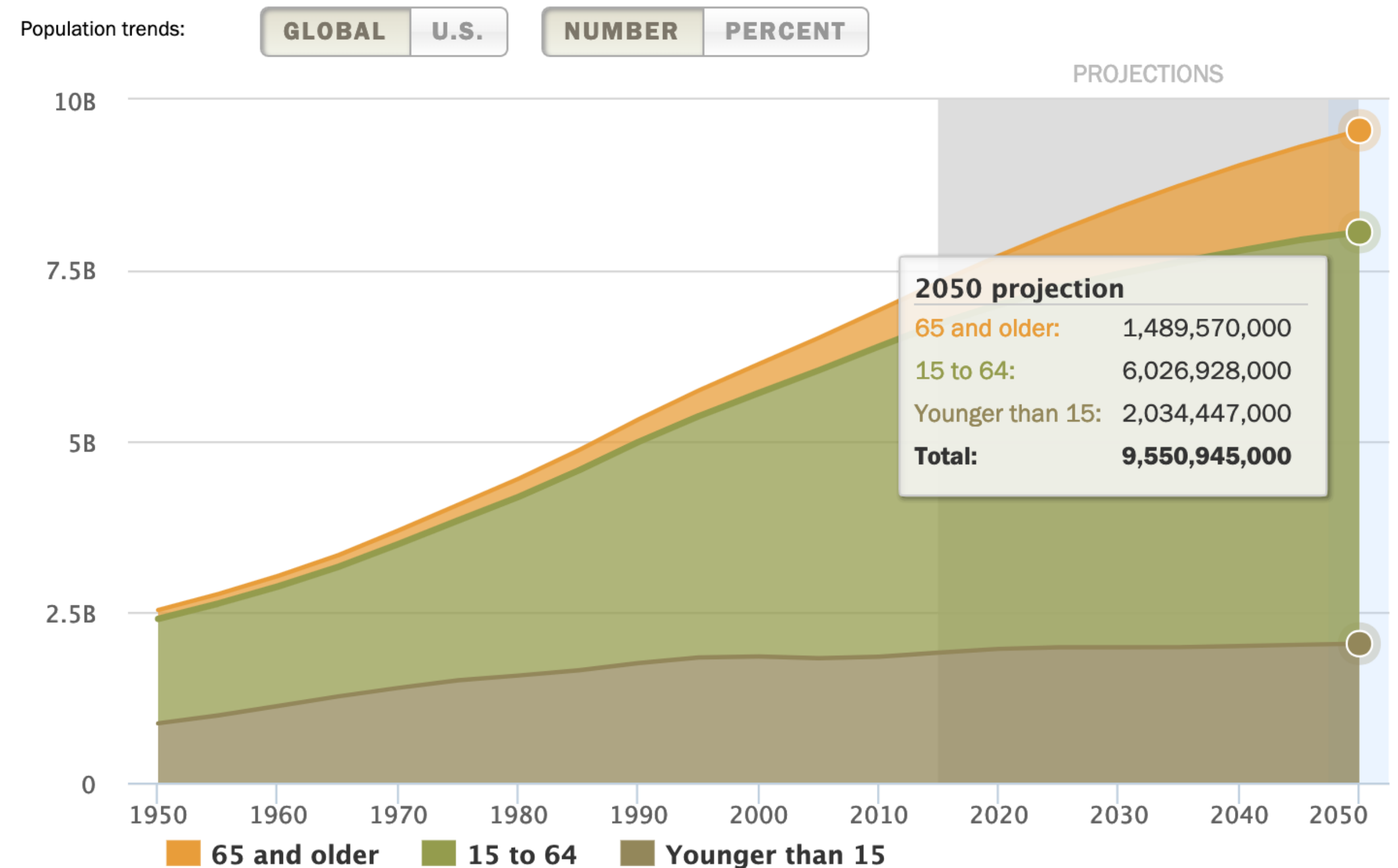
[source](#)

Activity-I: Discussion in Groups (5 mins)

In small groups discuss the following:

Now that people are living longer, what are opportunities and challenges?

How do we prepare for this age structure - individuals, society, and the environment?



Source: United Nations, Department of Economic and Social Affairs, *World Population Prospects: 2012 Revision*, June 2013

Share back to the entire class: pollEv.com/bioe80

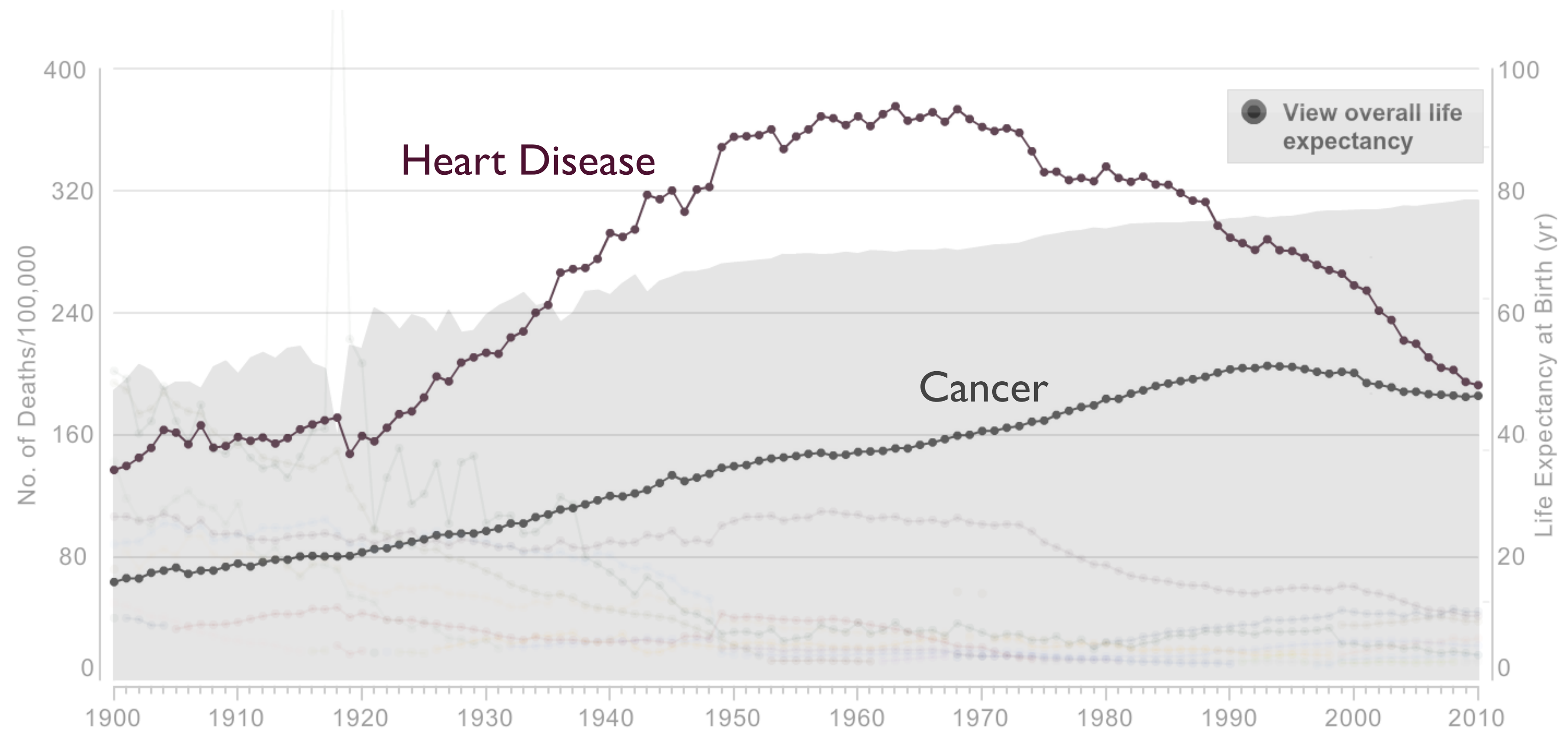
Now that people are living longer, what challenges have arisen?

pollEv.com/bioe80

Major Challenge I

Back then, people died younger, due to things we can now treat/cure

As the world's population ages, we're seeing 'new' diseases of old age (heart disease, cancer, dementia)



[Source](#)

Major Challenge 2

A subtle but important issue!

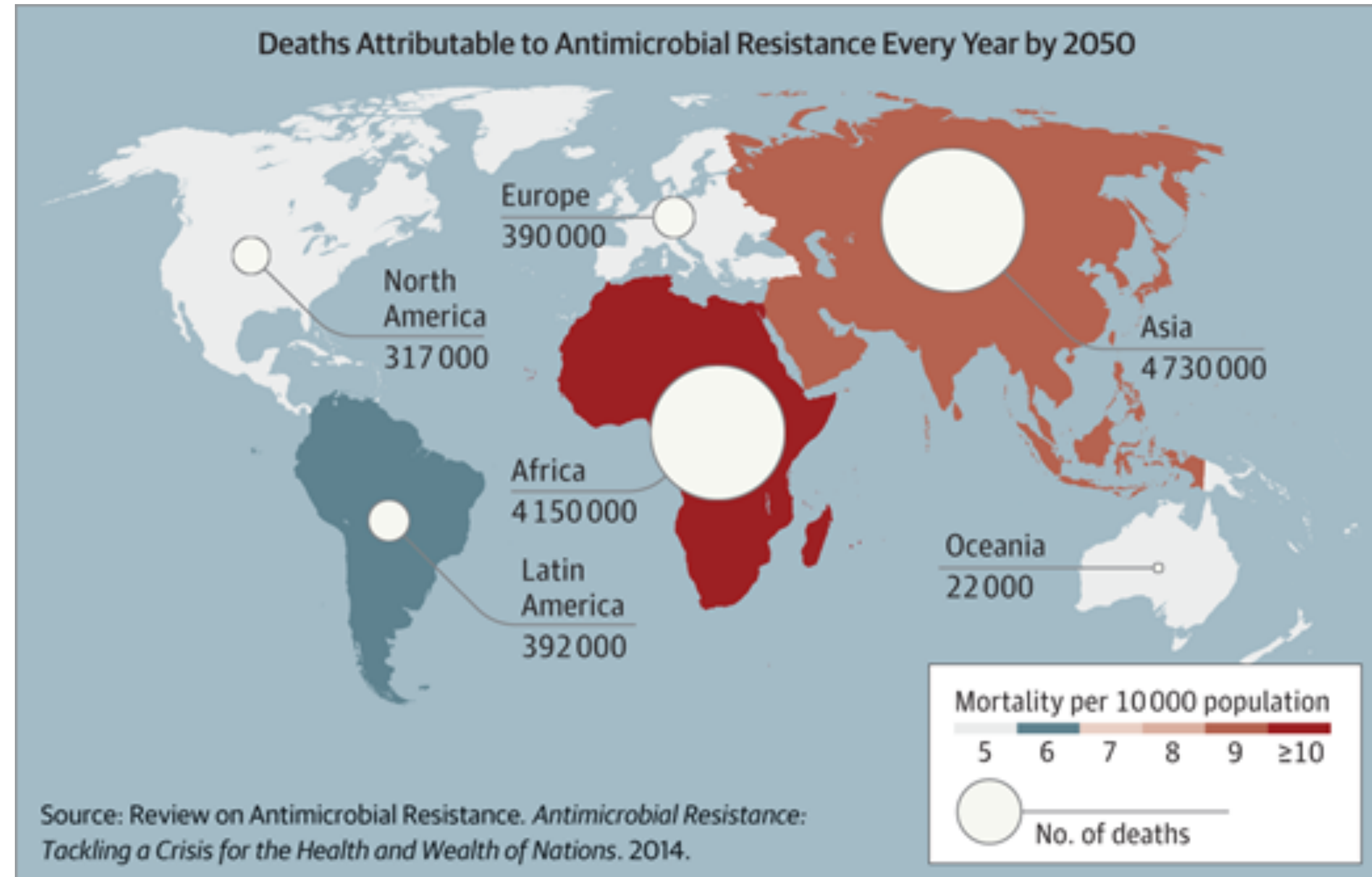
As treatments get better, people live longer,
and then have to live with side effects longer...

Emotional & Physical Effects	
Anemia and Cancer	Managing Medications
Appetite Changes	Nausea
Bleeding and Bruising	Peripheral Neuropathy
Body Image	Neutropenia
Bone Health	Pulmonary Embolism and Cancer
Bowel Management	Oral Care
Chemobrain	Cancer Pain Management
Dehydration	Sexuality and Cancer
Diabetes Management	Skin and Nail Changes
Fatigue	Sleep Loss
Hair Loss	Stress Reduction
Heart Health	Weight Loss
Infections	
Lymphedema	MD Anderson Center

Major Challenge 3

Antibiotic use is widespread and has been critical in decreasing deaths from infections.

But all microbes become resistant...



<https://jamanetwork-com.stanford.idm.oclc.org/journals/jama/article-abstract/2301348>

Activity: Discussion in Groups (5 mins)

In small groups discuss the following:

Can Bioengineering address these challenges? If so, how? Pick one and brainstorm possible solutions.

- Diseases of old age
- Living with side effects
- Microbial antibiotic resistance



<https://jamanetwork-com.stanford.idm.oclc.org/journals/jama/fullarticle/2714542>

Share back to the entire class

How can Bioengineering help with these challenges?

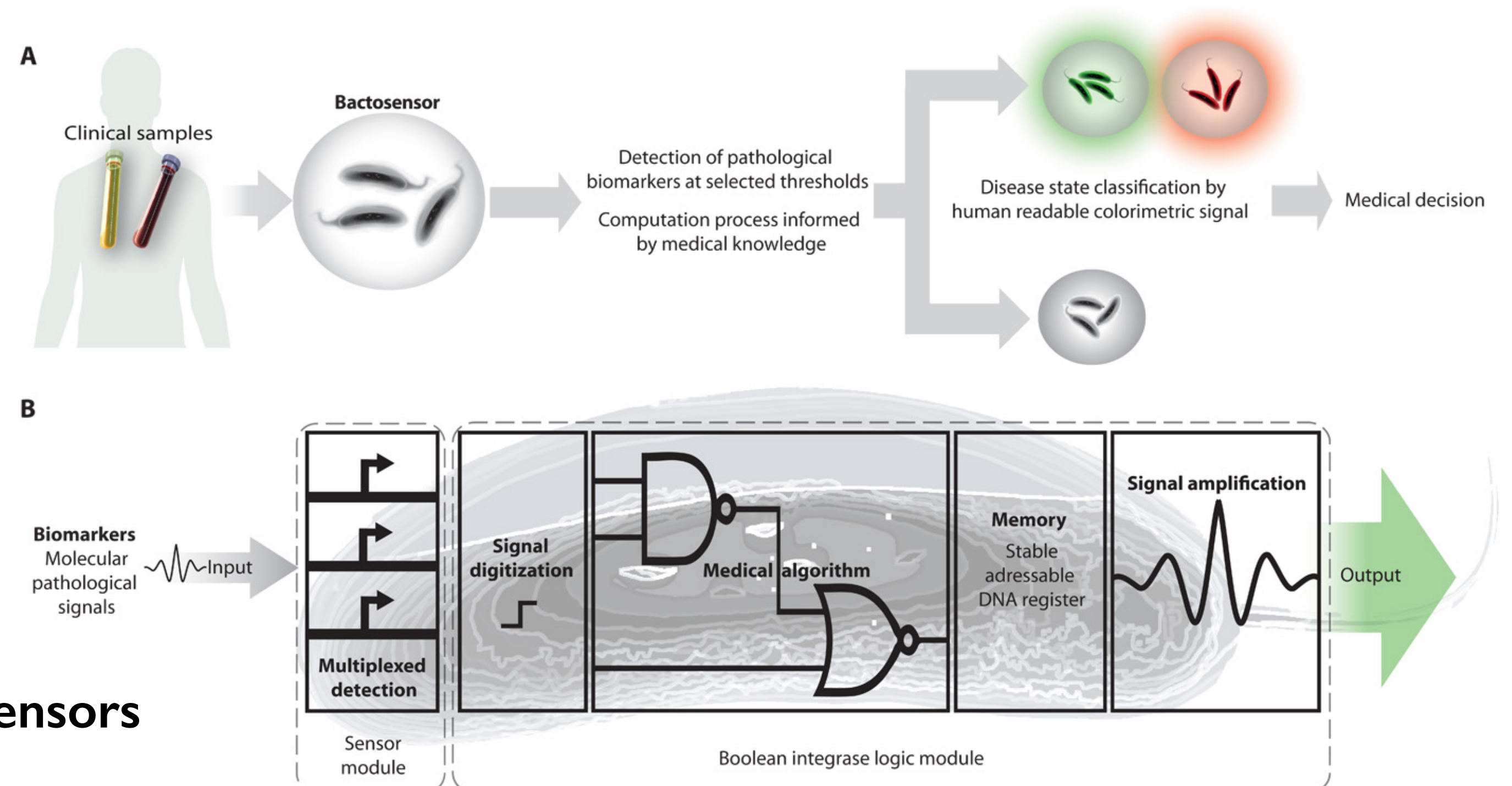
- Development of new antibiotics/treatments for diseases with fewer side effects
- Development of phage that target antibiotic resistant bacteria
- Engineering of microbial communities to strengthen immune response

How can Bioengineering help with these challenges?

Detection of pathological biomarkers in human clinical samples via amplifying genetic switches and logic gates

Alexis Courbet¹, Drew Endy², Eric Renard³, Franck Molina^{1,*} and Jérôme Bonnet^{4,*}

+ See all authors and affiliations

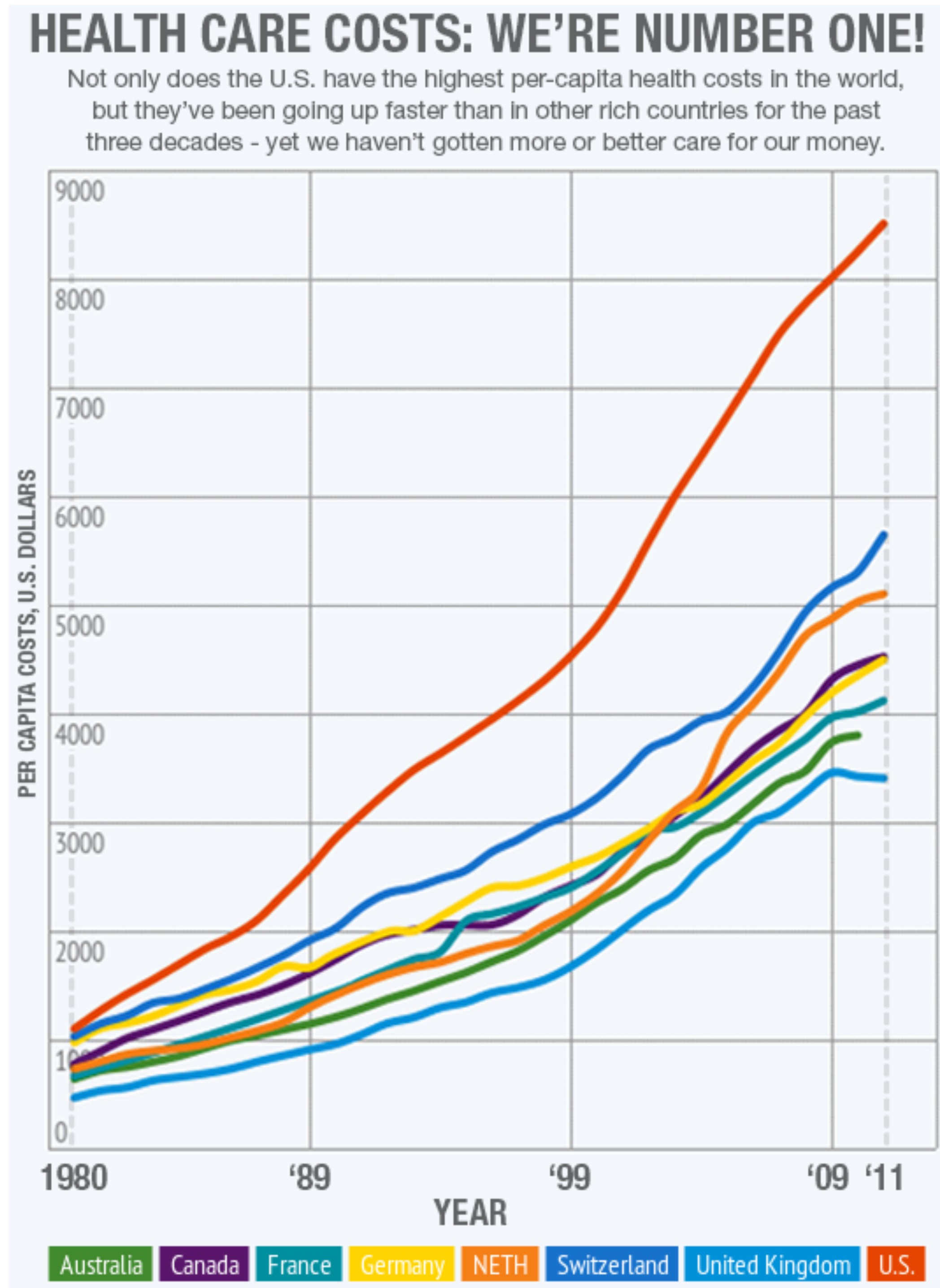


Operational principle and architecture of bactosensors to perform medical diagnoses. [Source](#)

Additional Challenge: Cost

Health care costs have been increasing

<https://www.consumerreports.org/cro/magazine/2014/11/it-is-time-to-get-mad-about-the-outrageous-cost-of-health-care/index.htm>



How is Bioengineering helping us today?

Reproduction/IVF is changing quickly

DNA sequencing leading to ‘personalized*’ therapies (but still early days) - watch for this topic in Week 6!

Technology-enabled* aka Precision* health may allow diseases to be picked up earlier (but overdetected/overdiagnosis)

New ways to intervene - microbiome, cancer immunotherapy¹

New ways to discover drugs - synthetic biology, machine learning²

* Marketing buzzwords, not scientific terms

¹ Works well for some; super expensive

² Should work, but let's wait and see

Looking forward: Some major human health challenges in 2030 to 2050

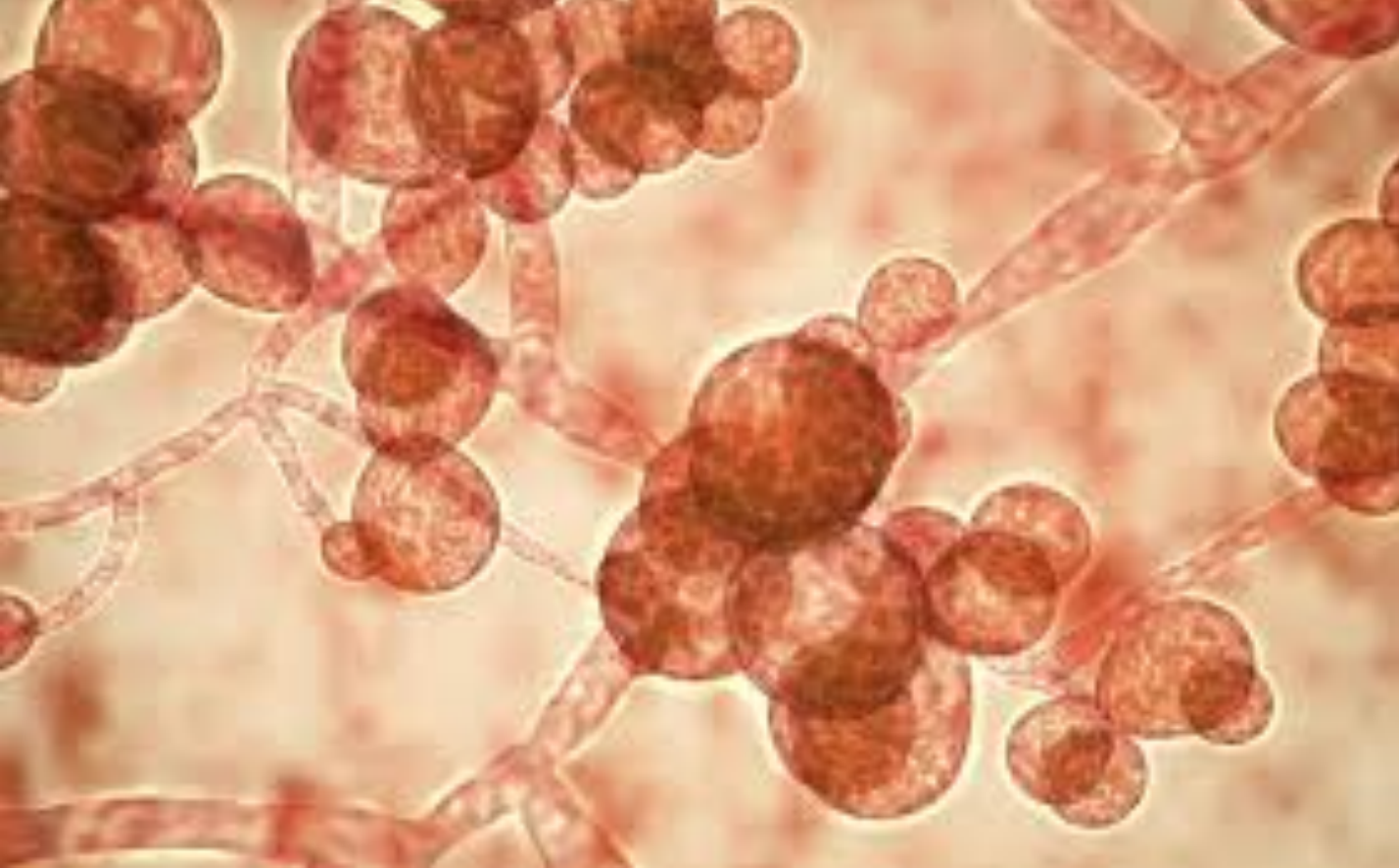
Major unresolved global health challenges

Aging global population - Heart disease, cancer, neurodegenerative diseases

Better treatments - A cancer survivor may need to live with side effects for 40 or 50 years

Loss of key treatments - Will children in 2066 die of similar causes to children in 1666?

Cost - 18% of US GDP goes to healthcare



DEADLY GERMS, LOST CURES

A Mysterious Infection, Spanning the Globe in a Climate of Secrecy

The rise of *Candida auris* embodies a serious and growing public health threat: drug-resistant germs.

April 6, 2019



1635

[Leer en español](#)

Breaking
news #1!

Last May, an elderly man was admitted to the Brooklyn branch of Mount Sinai Hospital for abdominal surgery. A blood test revealed that he was infected with a newly discovered germ as deadly as it was mysterious. Doctors swiftly isolated him in the intensive care unit.

Breaking news #2!

Article | Published: 17 April 2019

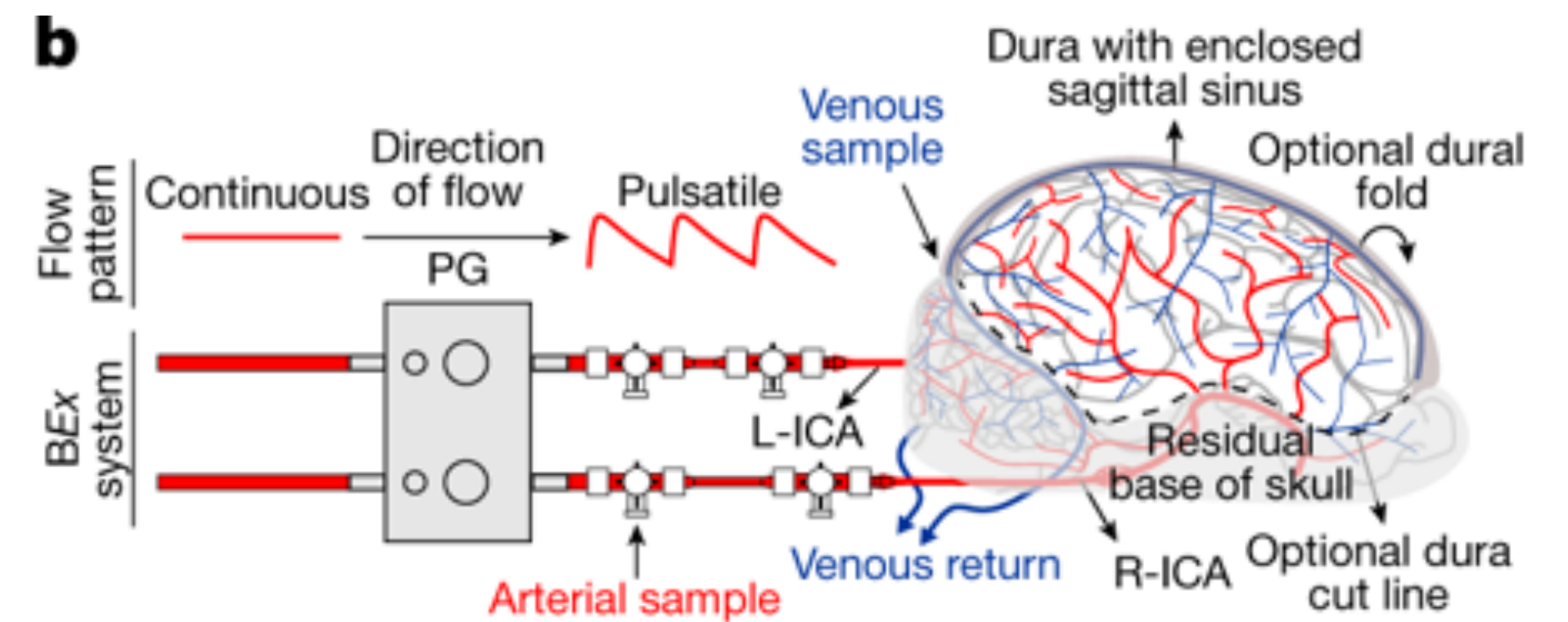
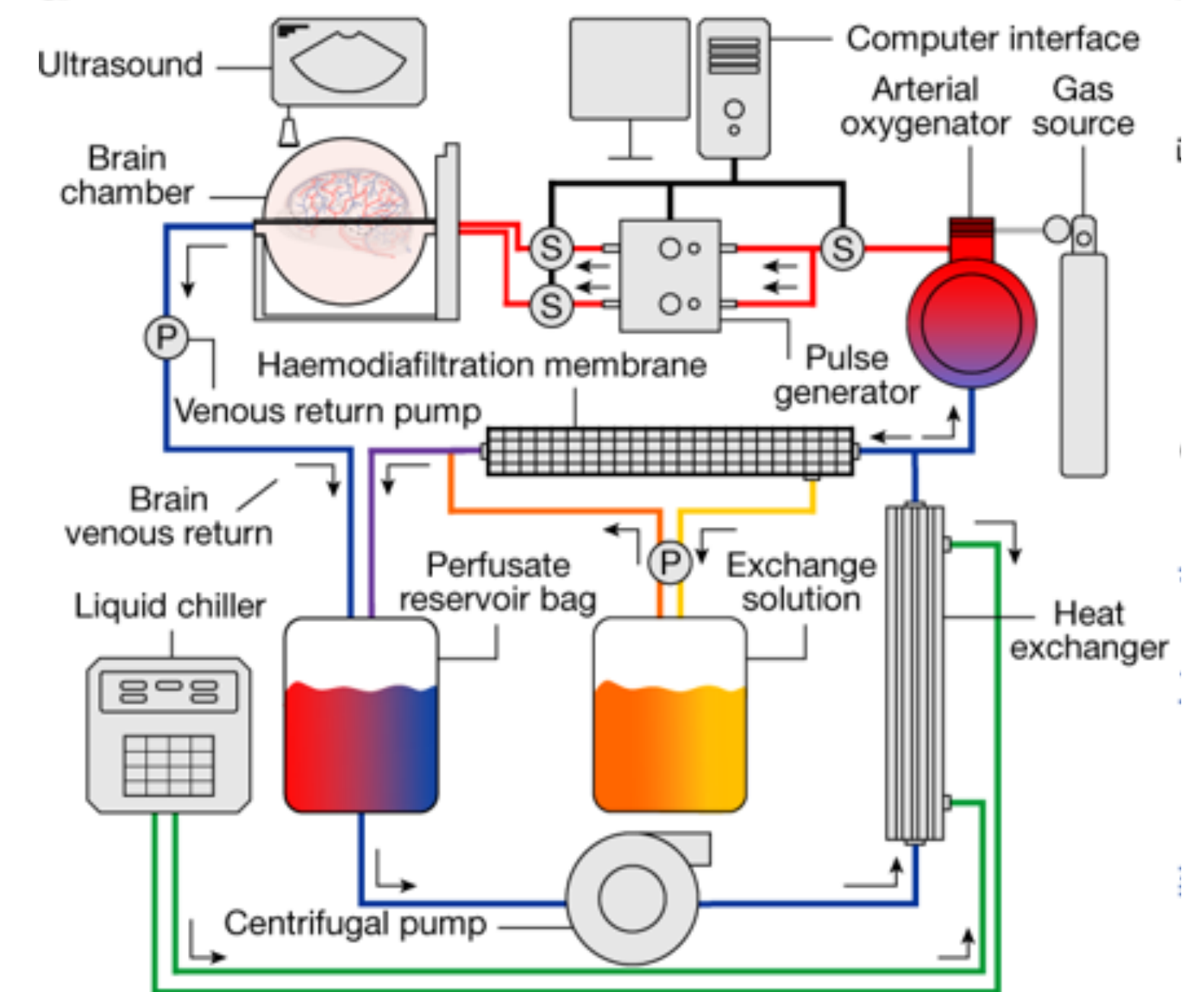
Restoration of brain circulation and cellular functions hours post-mortem

Zvonimir Vrselja, Stefano G. Daniele, John Silbereis, Francesca Talpo, Yury M. Morozov, André M. M. Sousa, Brian S. Tanaka, Mario Skarica, Mihovil Pletikos, Navjot Kaur, Zhen W. Zhuang, Zhao Liu, Rafeed Alkawadri, Albert J. Sinusas, Stephen R. Latham, Stephen G. Waxman & Nenad Sestan ✉

Nature (2019) | Download Citation ↓

Abstract: The brains of humans and other mammals are highly vulnerable to interruptions in blood flow and decreases in oxygen levels. Here we describe the restoration and maintenance of microcirculation and molecular and cellular functions of the intact pig brain under ex vivo normothermic conditions up to four hours post-mortem ...

These findings demonstrate that under appropriate conditions the isolated, intact large mammalian brain possesses an under-appreciated capacity for restoration of microcirculation and molecular and cellular activity after a prolonged post-mortem interval.



<https://www.nature.com/articles/s41586-019-1099-1>

How long has modern medicine (mostly) understood satiety?

How long have we had definitive proof of the connection among eating, obesity, cardiovascular disease, and diabetes?

How long have we known the key target for satiety drugs?

500 years?

50 years?

5 years?

5 days?

Breaking news #3!

The New York Times

This Genetic Mutation Makes People Feel Full — All the Time

Two new studies confirm that weight control is often the result of genetics, not willpower.

"While most MC4R variants caused loss of function, a subset caused gain of function; these variants were associated with significantly lower BMI and lower odds of obesity, type 2 diabetes, and coronary artery disease."

The study subjects had been thin all their lives, and not because they had unusual metabolisms. They just did not care much about food.

They never ate enormous amounts, never obsessed on the next meal. Now, a group of researchers in Britain may have found the reason.

The people [carry a genetic alteration that mutes appetite](#). It also greatly reduces their chances of getting diabetes or heart disease.

The scientists' study, published on Thursday in the journal Cell, relied on data from the U.K. Biobank, which includes a half million people aged 40 to 69. Participants have provided DNA samples and medical records, and have allowed researchers to track their health over years.

Breaking news #1 - Candida auras

Breaking news #2 - Pig brain reawakening

Breaking news #3 - Why you feel full - MC4R

- New, very dangerous threats
- Biology is still very very early! Major advances every week
- General knowledge about human satiety - 4 weeks old!