Epidemics, Pandemics and Plagues: Oh My!

A history of infectious disease

PHILIP MADVIG, M.D., M.S.

A History of Infectious Diseases

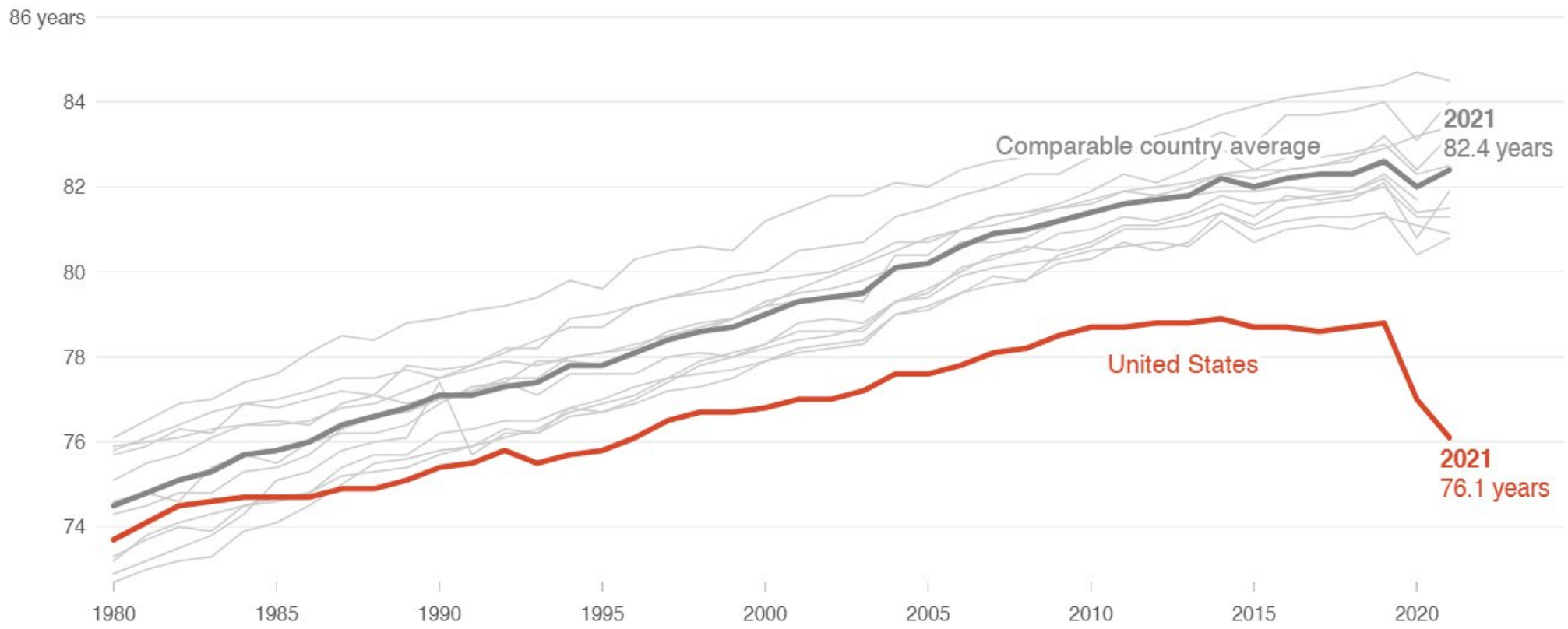
1. Introduction-why are we talking about this?
2. The Great Escape from short life
3. What are these things that infect us? A brief bit of (micro)biology
4. Historic theories of disease: Gods, humors and miasmas
5. Major epidemics in history and their impact
6. The discovery of germs
7. Germ theory consequences: public health, vaccines, antibiotics
8. Where we are today: vaccine and science skepticism, climate change, globalization, war…new pandemics

Why Study the History of Infectious Disease?

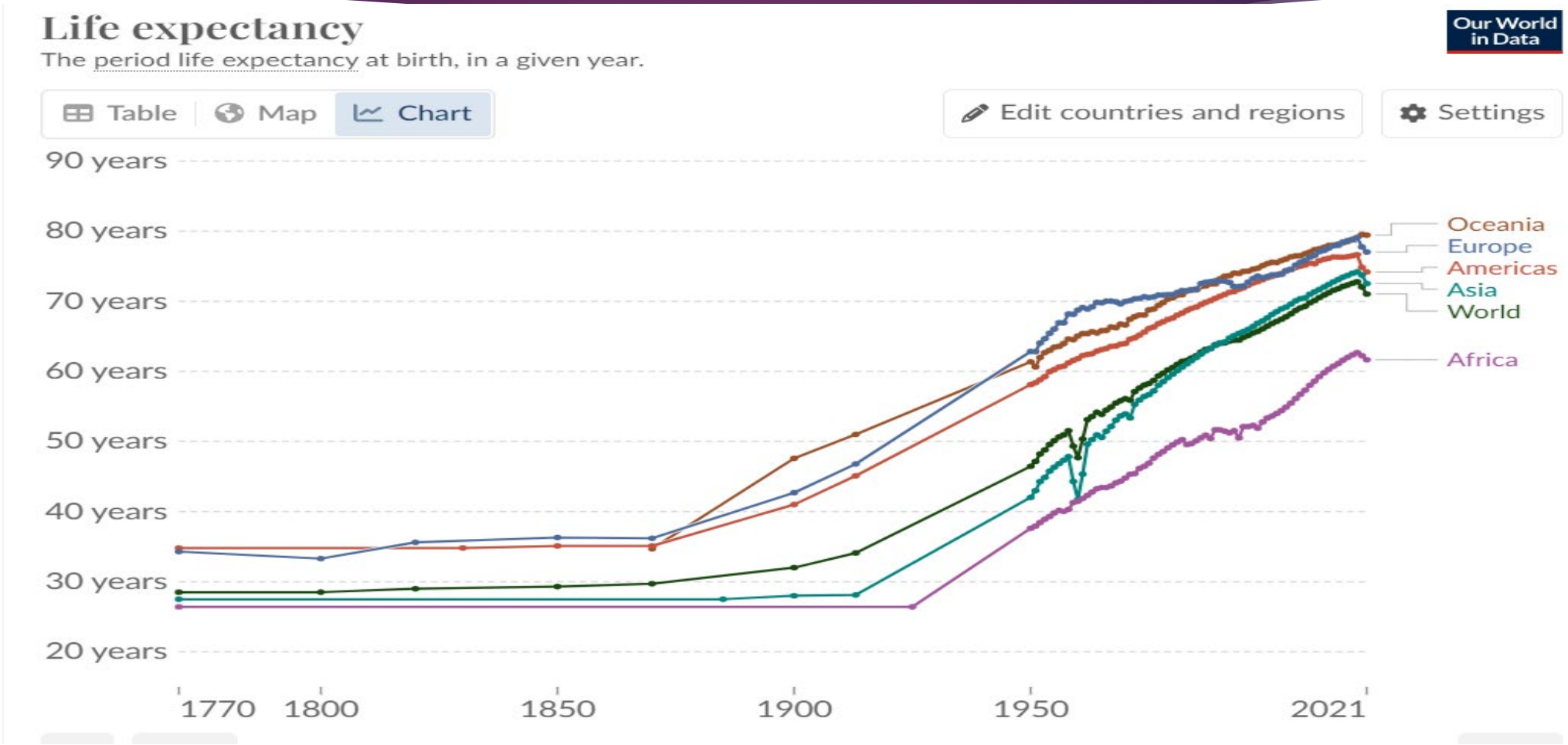
Why study the history of infectious disease?

Because we are not done with infectious diseases. Or, more accurately, infectious diseases are not done with us!

An American Tragedy



Life Expectancy Doubled in 20th Century



Lessons from Covid

As Covid-19 Cases Tick Higher, Conspiracy Theorists Stoke New Fears

Scamdemic
Plandemic
Vaccines with microchips
Bleach therapy

Balancing Liberty and Public Health: Civil Liberties in a Time of Pandemic

The First Pandemic?

THE ANTONINE PLAGUE

The Roman Empire: The Pax Romana

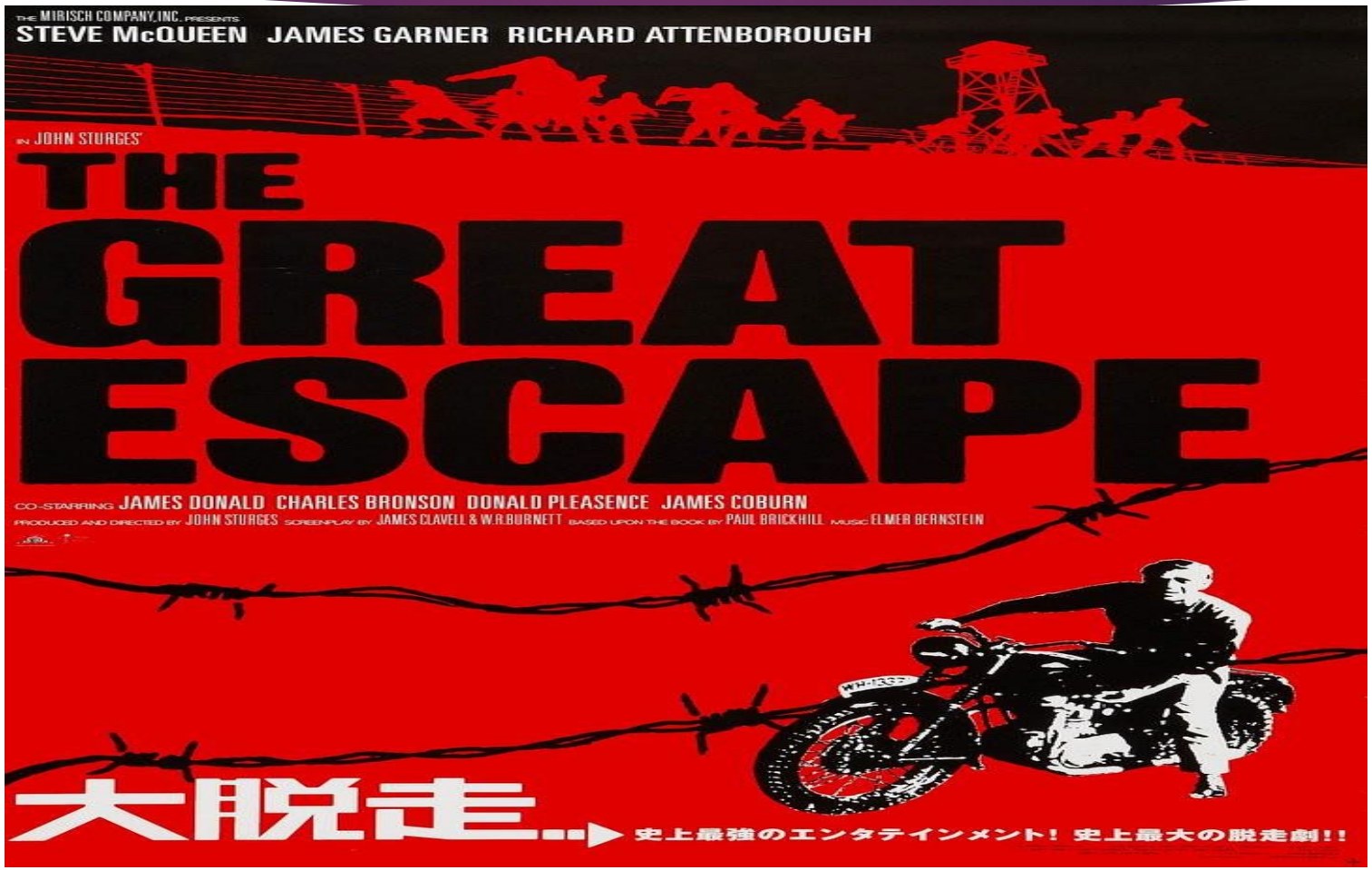
The Antonine Plague

- Marcus Aurelius, last of the Five Good Emperors
- ¼ of world population lived in Roman Empire- 75 million people
- Towns and trade
- Wealth did not equal health
- Army returning from battle in Persia and first "super spreader" event
- Spread rapidly, killing 10% of population (7-10 million)
- Probably smallpox
- Substantial contributor to decline of the Roman Empire
- "Pox" Romana

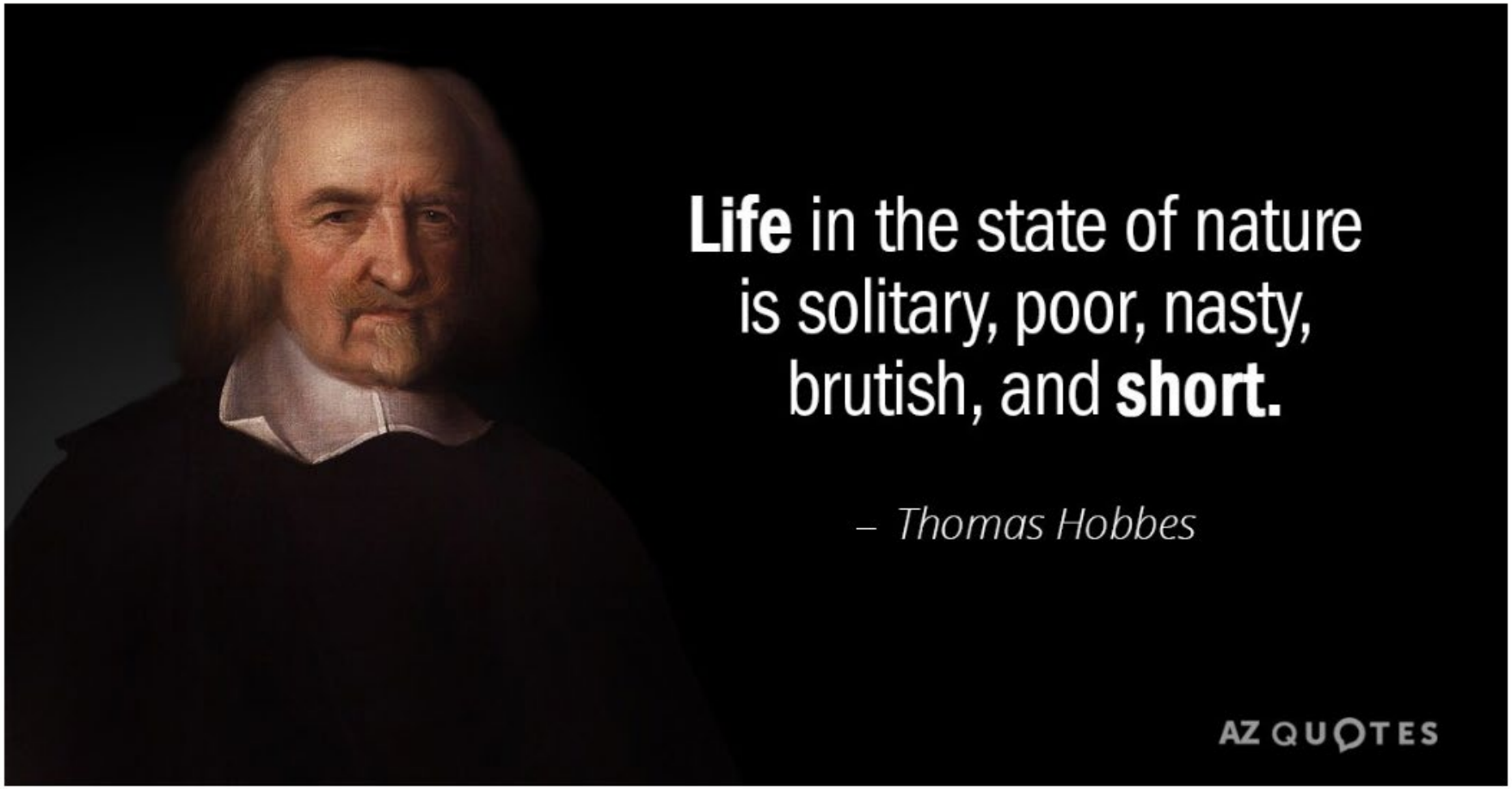
The Great Escape

HOW HUMANITY OVERCAME SHORT LIFE AND MISERY

The Great Escape



Looking back in history….



Causes of death US 1900 and 2022

- **Major causes of death 1900**:
  1. Pneumonia and influenza
  2. Tuberculosis
  3. GI infections

➢ **Major causes of death 2022:**

1.Heart disease

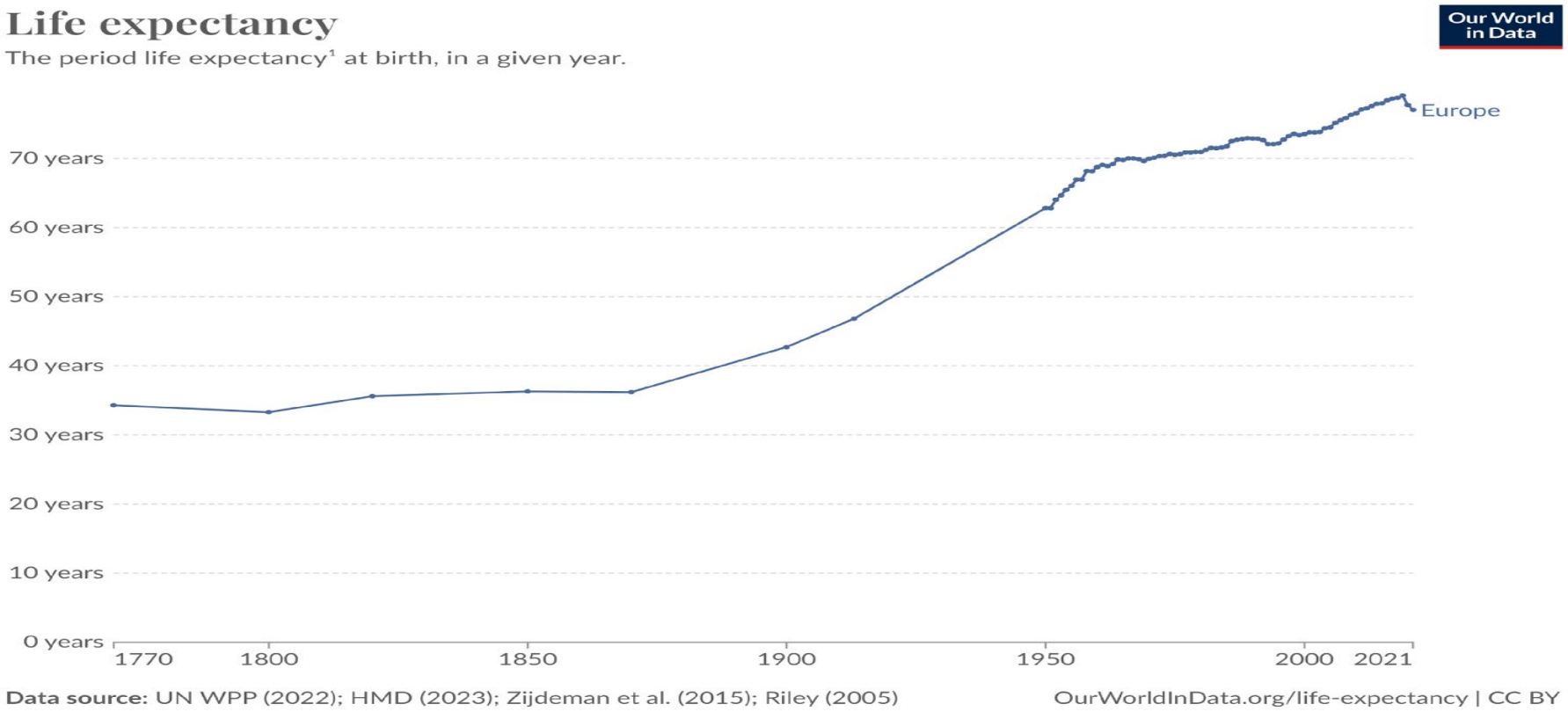
2.Cancer

3.Accidents

4.COVID-19

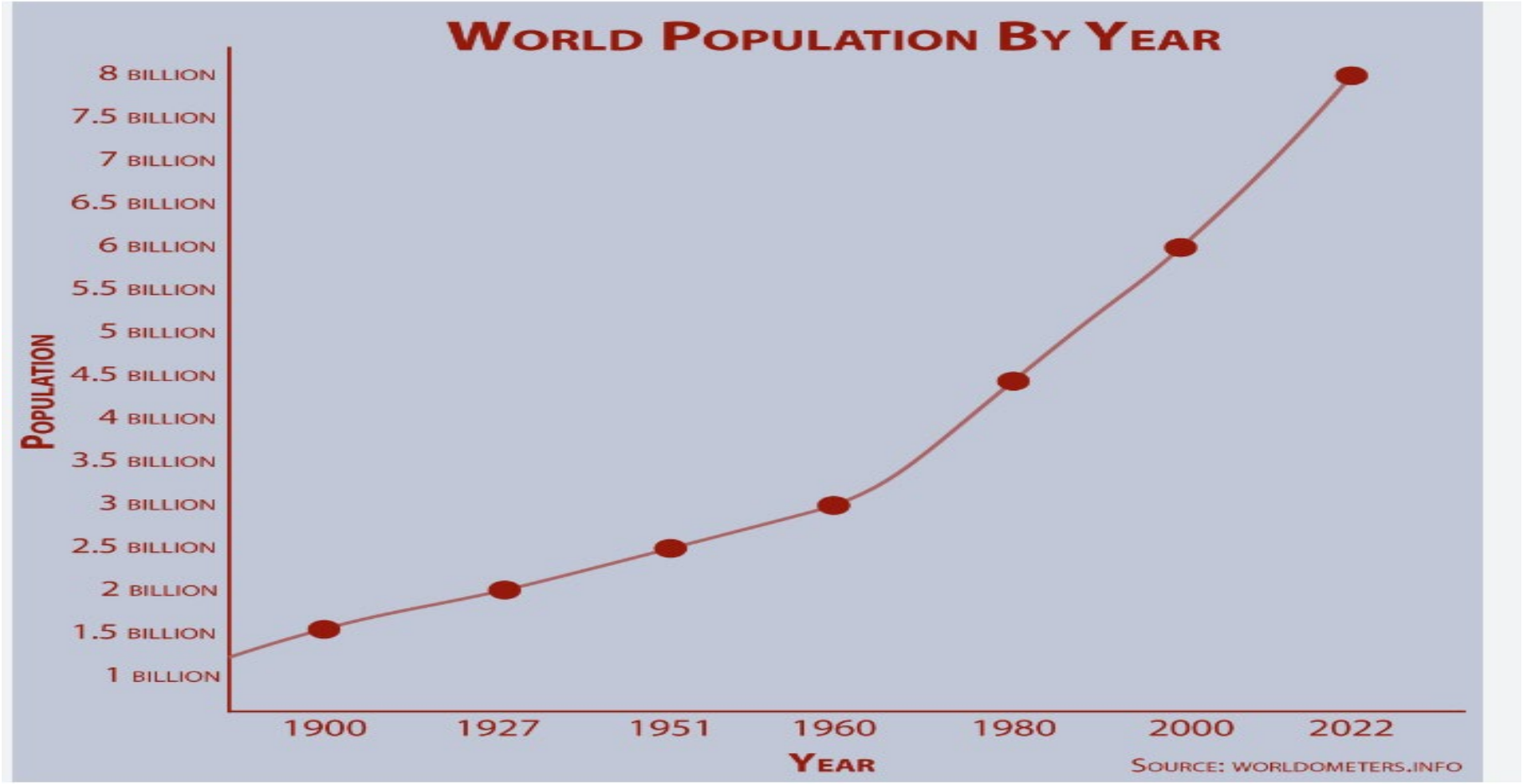
<2% of deaths were children under 5

The Most Remarkable Improvement in Human Health Ever



1. Period life expectancy: Period life expectancy is a metric that summarizes death rates across all age groups in one particular year. For a given year, it represents the average lifespan for a hypothetical group of people, if they experienced the same age-specific death rates throughout their whole lives as the age-specific death rates seen in that particular year. Learn more in our article: "Life expectancy" – What does this actually mean?

The Great Acceleration



The Great Acceleration

"Human beings have multiplied deliriously not because they suddenly started breeding like rabbits, It is just that we stopped dying like flies"

Peter Adamson

What Causes Infectious Disease?

A BRIEF COURSE IN MICROBIOLOGY

What causes infections?

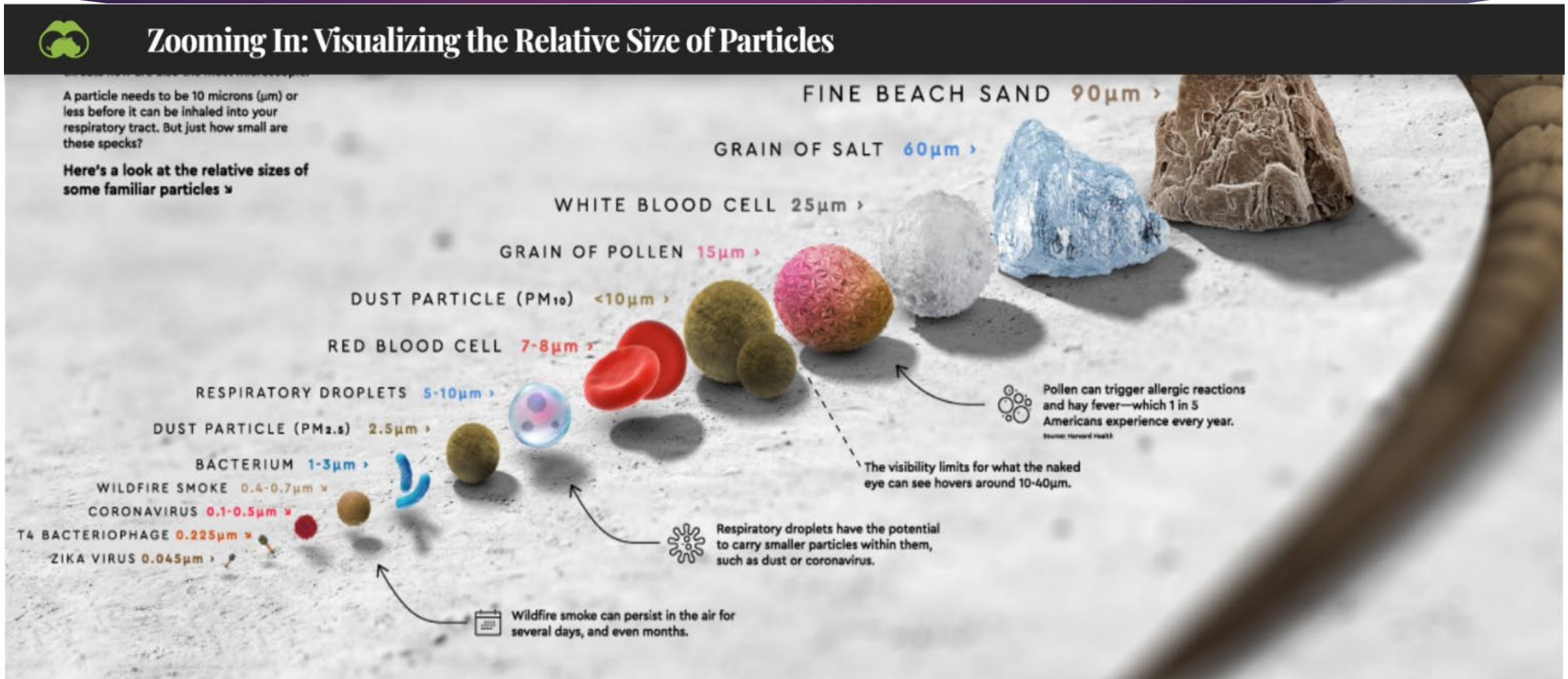
- **Basic requirements of living things:**
  - Energy
  - Ability to reproduce
- **Parasitism**
  - "One who eats at the table of another"
- **Pathogen**
  - An organism that causes disease

Pathogenic Microorganisms

- **Microorganisms:** Living things too small to be seen by the naked eye
- Major human pathogens, about 300 species of:

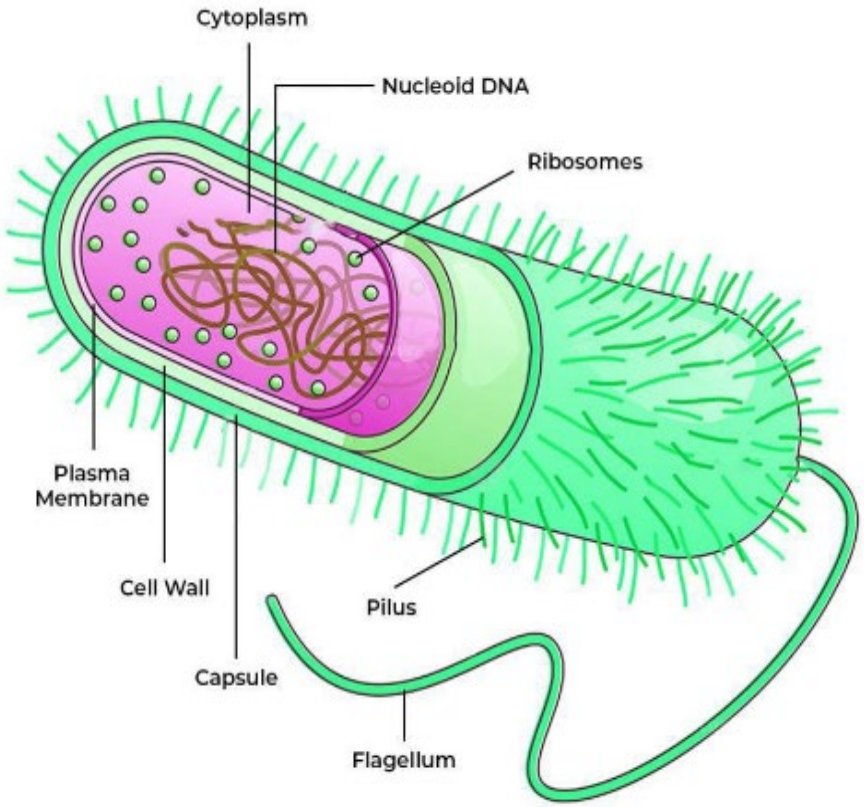
- Bacteria
- Viruses
- Protozoa
- Others: fungi, worms, prions

Microorganisms



Bacteria

- Single cell organism
- No nucleus; DNA floats freely in the cytoplasm
- Ubiquitous; probably many billion species
- Many benign or beneficial bacteria on and in humans
- A very small number are pathogenic



Bacteria: Salmonella Invading Intestine

Bacteria

- Pathogenic bacteria:
  - Anthrax
  - Plague
  - Whooping Cough
  - Tetanus
  - Tuberculosis
  - Gonorrhea
  - Syphilis
  - Cholera

Pathogenic Bacteria

- Streptococci
- Staphylococci
- Clostridum difficile
- Escherichia coli
- Typhoid
- Typhus

Bacteria

- When conditions are favorable some bacteria like *Escherichia coli* can divide every 20 minutes.
- This means that in just seven hours one bacterium can generate 2,097,152 bacteria.
- After one more hour the number of bacteria will have risen to a colossal 16,777,216. That's why we can quickly become ill when pathogenic microbes invade our bodies.

Viruses

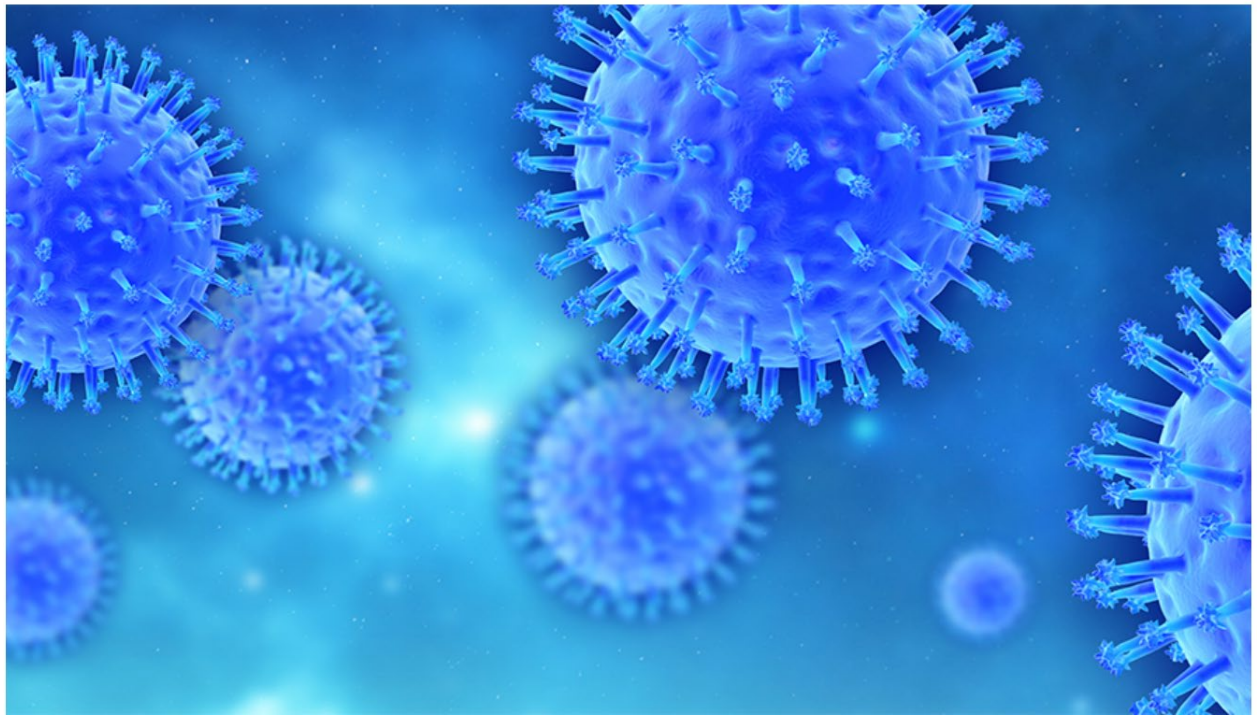
"A piece of bad news wrapped up in protein"

DNA or RNA, surround by a capsid

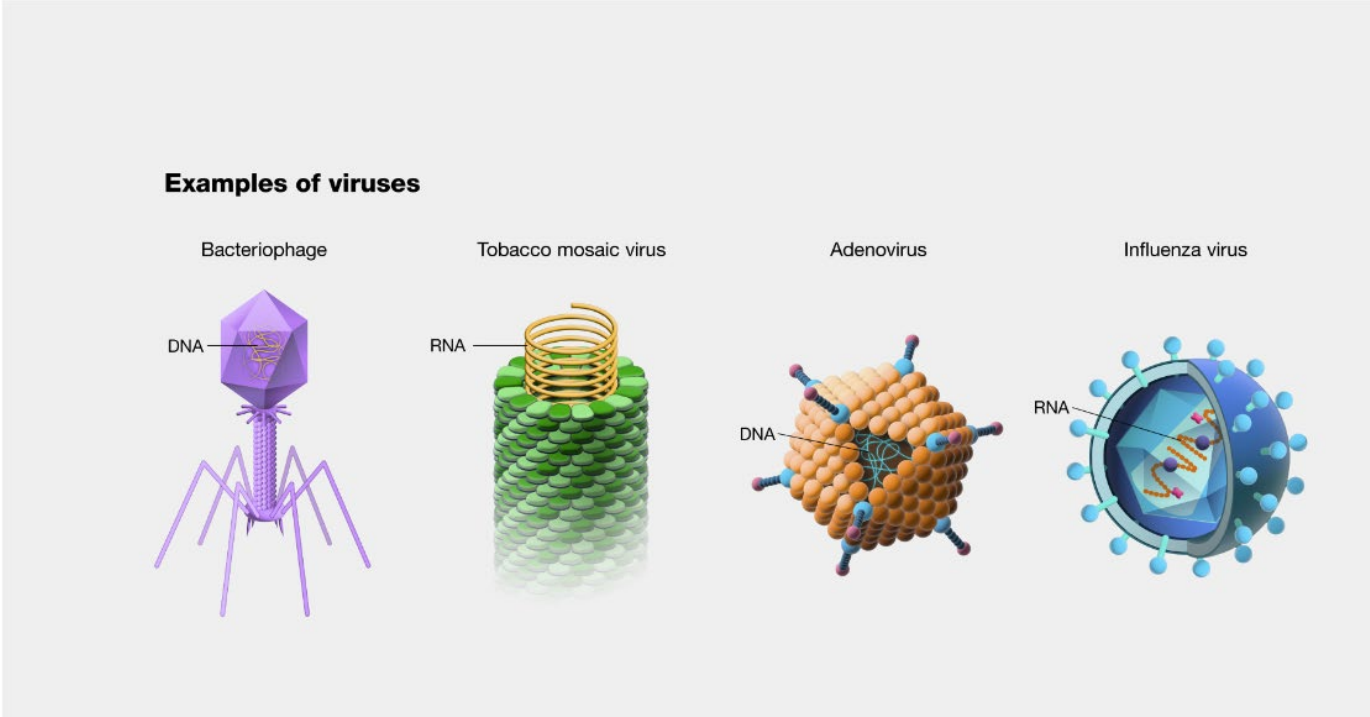
Obligate intracellular parasite
--can't do anything on their own, except:

Attach
Penetrate

The host cell then:
Synthesis
Assembly
Release



Viruses


Examples of viruses
Bacteriophage
Tobacco mosaic virus
Adenovirus
Influenza virus
DNA
RNA
DNA
RNA

Viral Pathogens

- Herpes
- AIDS
- COVID
- Influenza
- Smallpox
- Chickenpox
- Measles
- Dengue

Viral Pathogens

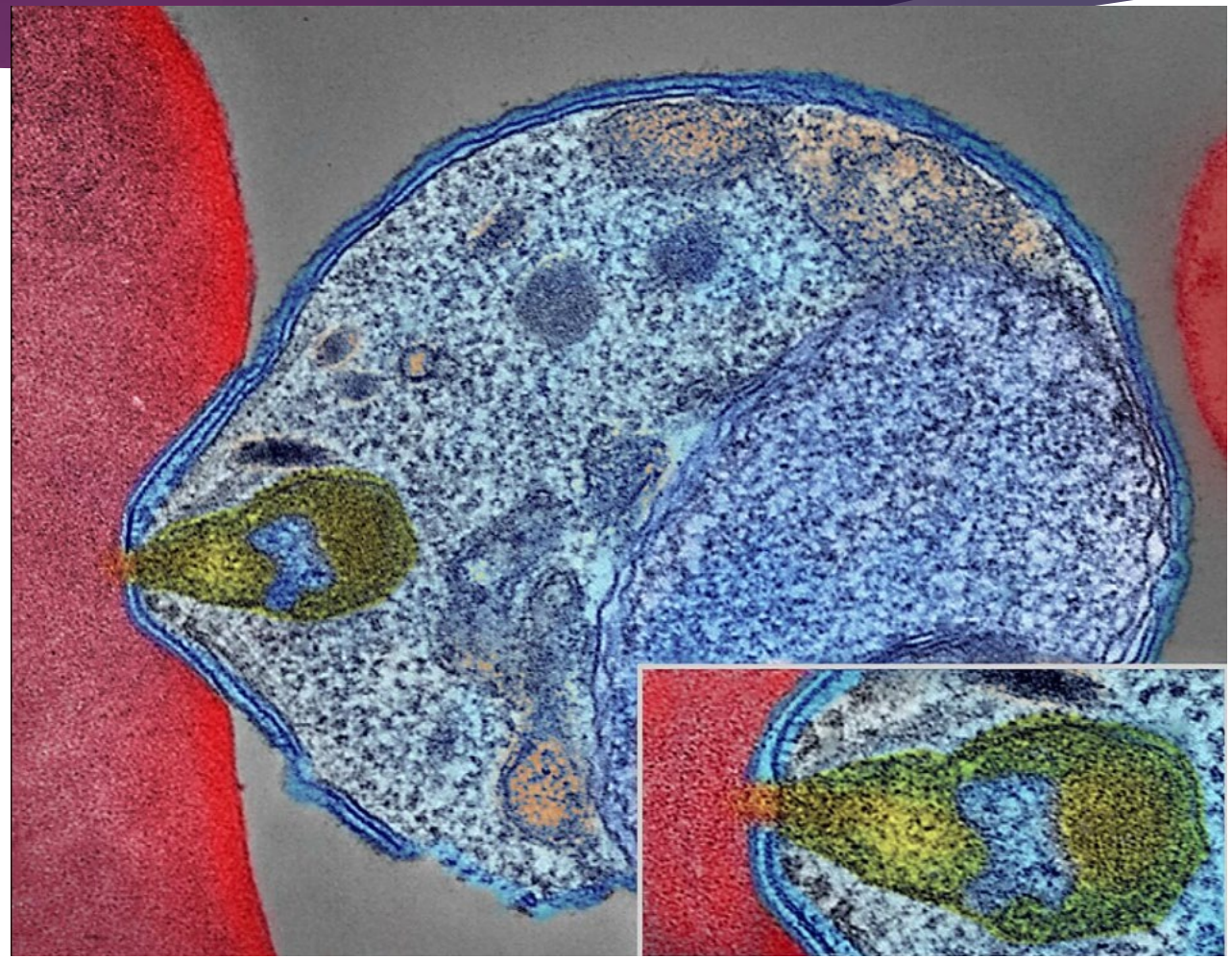
- Rabies
- Chikungunya
- Hepatitis A,B,C…
- Epstein Barr
- Rhinovirus
- M pox
- Norovirus
- Polio

Viruses: two more things

- Cancer
  - Cervical, oral, liver, lymphoma,
- Rapid evolution due to high error rate and short generation time
  - “Every generation is a chance at evolution”

Protozoa

- Single celled, have a nucleus
- Malaria
- Amoebic dysentery
- Leishmaniasis



Vectors

- A problem for all parasites: How to get from one host to another
- Insects:
  - Fleas: Plague
  - Mosquitoes: Malaria, Dengue, West Nile, Yellow Fever
  - Ticks: Lyme, Rocky mountain Spotted Fever
  - Lice: Typhus
- Snails: Schistosomiasis, Rat lungworm

Reservoirs

- Animals
  - Bats
  - Rodents
  - Livestock
  - Humans
- Water

Immune Defenses

- Physical barriers
  - Skin
  - Mucosa
  - Microbiome
- Innate immune system
  - Rapid, non-specific; respond to “foreign” substances
  - White blood cells, enzymes, cytotoxins
- Adaptive immune system
  - Slower, but specific.
  - Memory
  - T-cells, B-cells, Antibodies

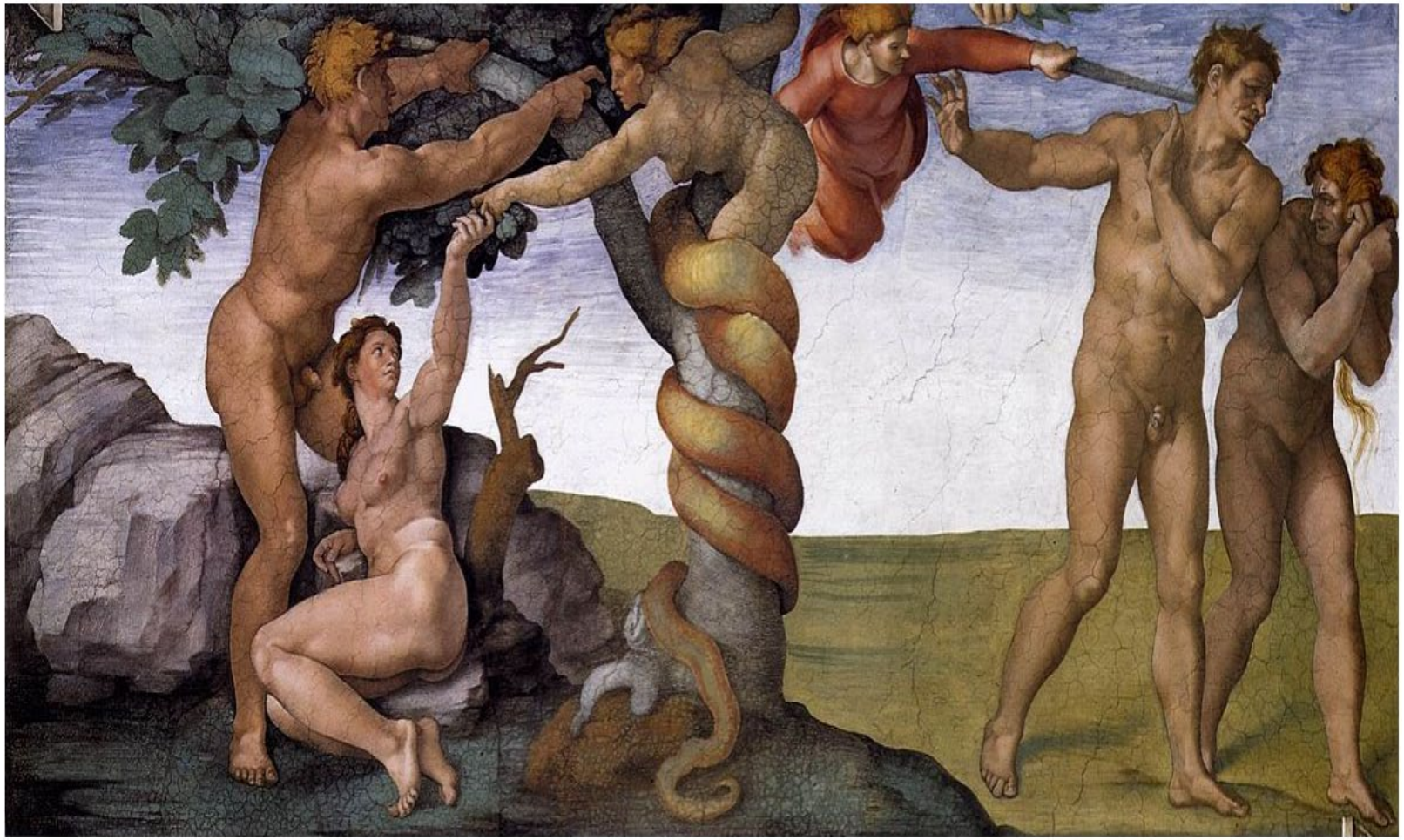
Historic Theories of Disease

Theories of Disease

- Divine
- Astrologic
- Humoral
- Miasmal
- Germ

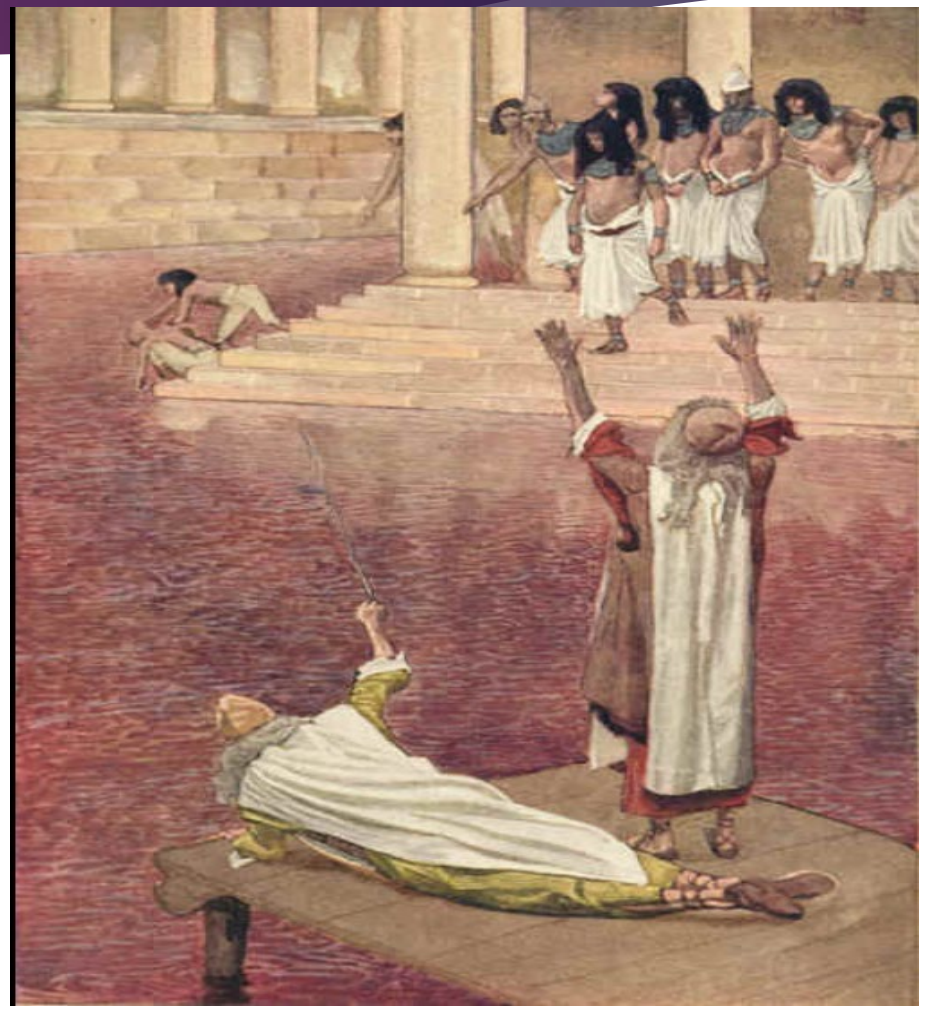
Divine Theories of Illness: A Punishment by the Gods

Genesis: God condemns mankind to suffer disease and experience mortality, as punishment for eating the forbidden fruit



Illness as Divine Punishment

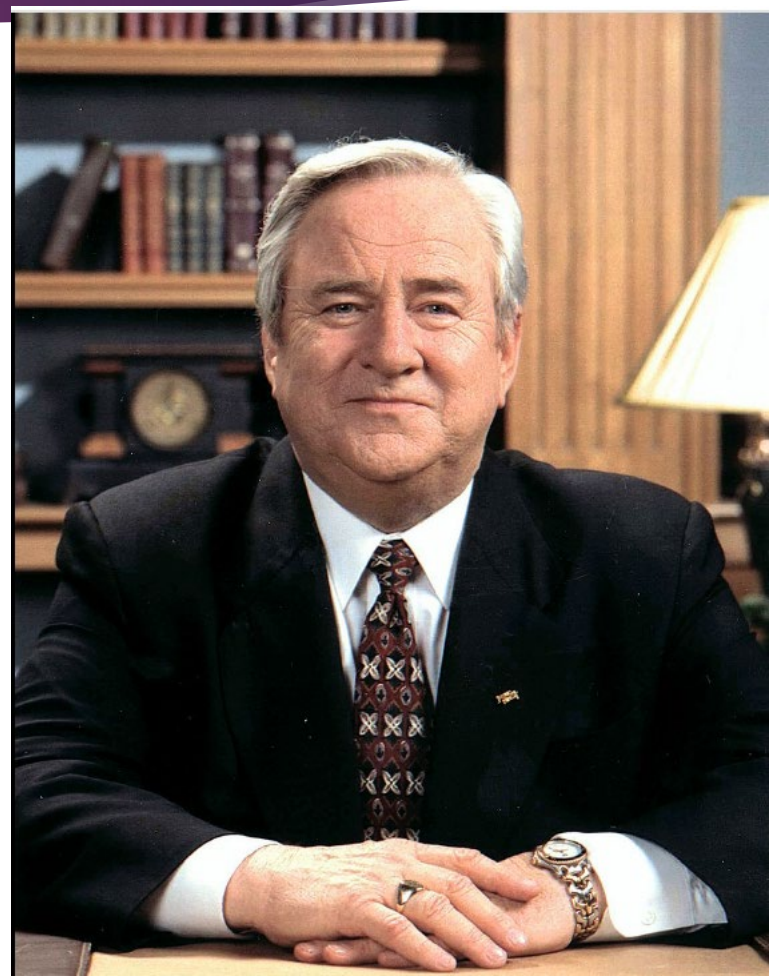
Exodus: When Pharoh refuses to free the Israelites, God sends a series of plagues upon the Egyptians



Illness as Divine Punishment

"AIDS is not just God's punishment for homosexuals; it is God's punishment for the society that tolerates homosexuals."

Jerry Falwell



Humoral theory

- Greek philosophers (and others) believed there were Four Elements
  - Earth, Water, Air, Fire
  - Each is either dry or wet, and either hot or cold
- And Four Seasons
- And Four Cardinal Directions
- And Four Ages of Man

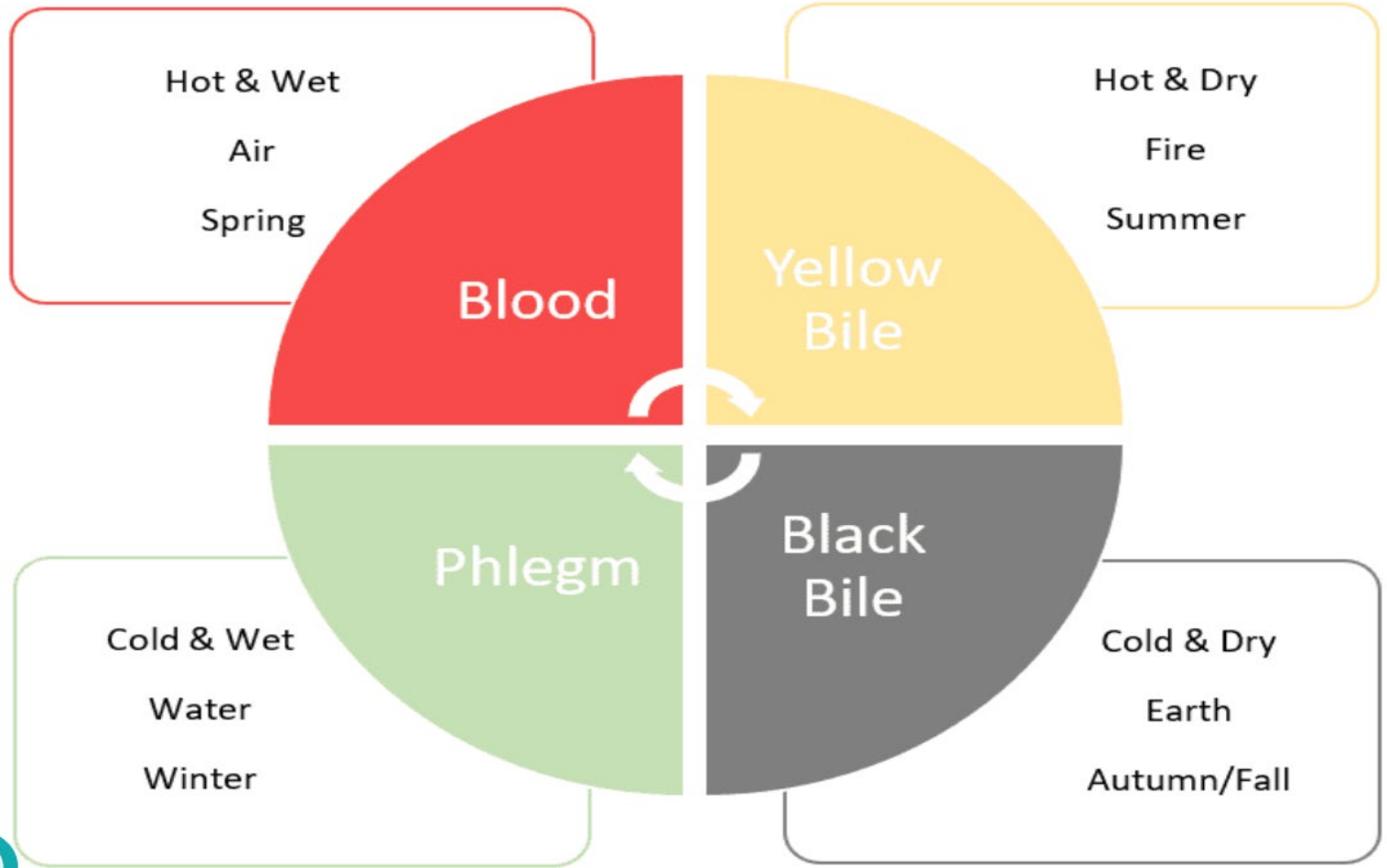
Humoral Theory: The Hippocratic Breakthrough

- Hippocrates described disease as naturalistic, not divine
- "It is thus with the disease called sacred: It appears to me to be nowise more divine nor more sacred than other diseases, but has a natural cause. Men regard its nature and cause as divine from ignorance and wonder"
- If disease is postulated as divine, then scientific progress is impossible.

Humoral theory

- Hippocrates sought harmony between nature and the body thus describing the four humors:
- “The Human body contains blood, phlegm, yellow bile, and black bile. These are the things that make up its constitution and cause its pains and health. Health is primarily that state in which these constituent substances are in the correct proportion to each other.”

Hippocrates “On The Nature of Man”


Hot & Wet
Air
Spring
Blood
Hot & Dry
Fire
Summer
Yellow Bile
Phlegm
Cold & Wet
Water
Winter
Black Bile
Cold & Dry
Earth
Autumn/Fall

Humoral Theory

- Eucrasia: A state of balance among the four humors
- Dyscrasia: Imbalance among the humors resulting in disease (and specific tempermant)
- Causes of dyscrasia: “perturbations”
  - Food
  - Exercise
  - Passions
  - Bad air

Treatments based on humoral theory

- "opposites treat opposites"
  - e.g. too much black bile (cold and dry) treated by foods that are hot and wet
- Addition/subtraction
  - Phlebotomy or purging

Miasma Theory

Miasma was considered to be a poisonous vapor or mist filled with particles from decomposed matter (miasmata) that caused illnesses. The miasmatic position was that diseases were the product of environmental factors such as contaminated water, foul air, and poor hygienic conditions. Such infection was not passed between individuals but would affect individuals within the locale that gave rise to such vapors. It was identifiable by its foul smell

Miasma Theory

- Toxic vapors, generated in the soil and marshes, an exhalation from the landscape
- Malaria="bad air"
- Night air
- Influence on sanitary movement

A History of Infectious Diseases

DAY TWO

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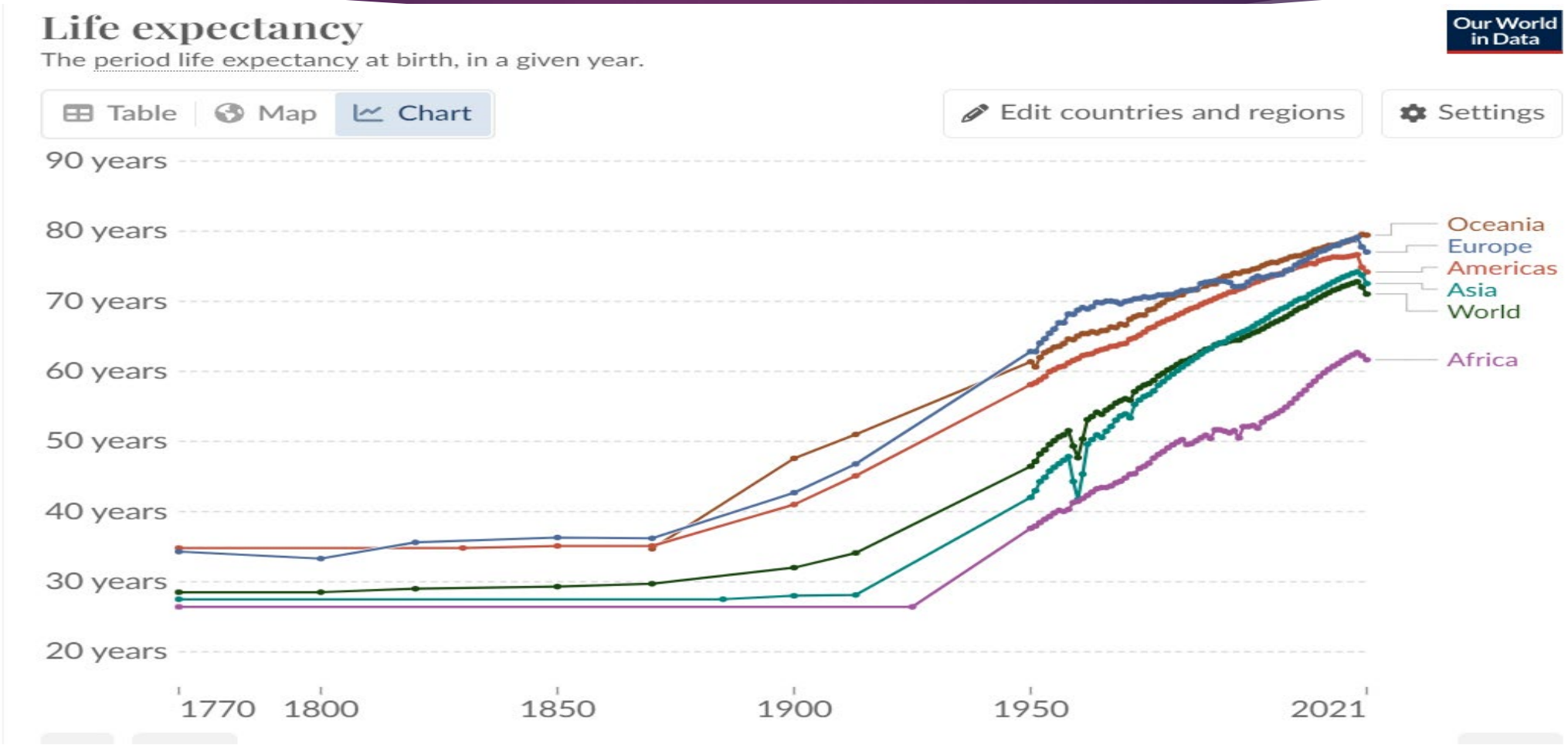
Life Expectancy Doubled in 20th Century



Why did Asian and World Life Expectancy Dip in 1959-1961?

- Mao initiated the Great Leap Forward, intended to industrialize China
- Millions of peasants were forced to abandon food production and contribute to steel production
- Grain production, constituting 80% of China's food energy, plummeted
- At least 30 million people starved to death, the largest famine in history

Do masks work to decrease spread of COVID?

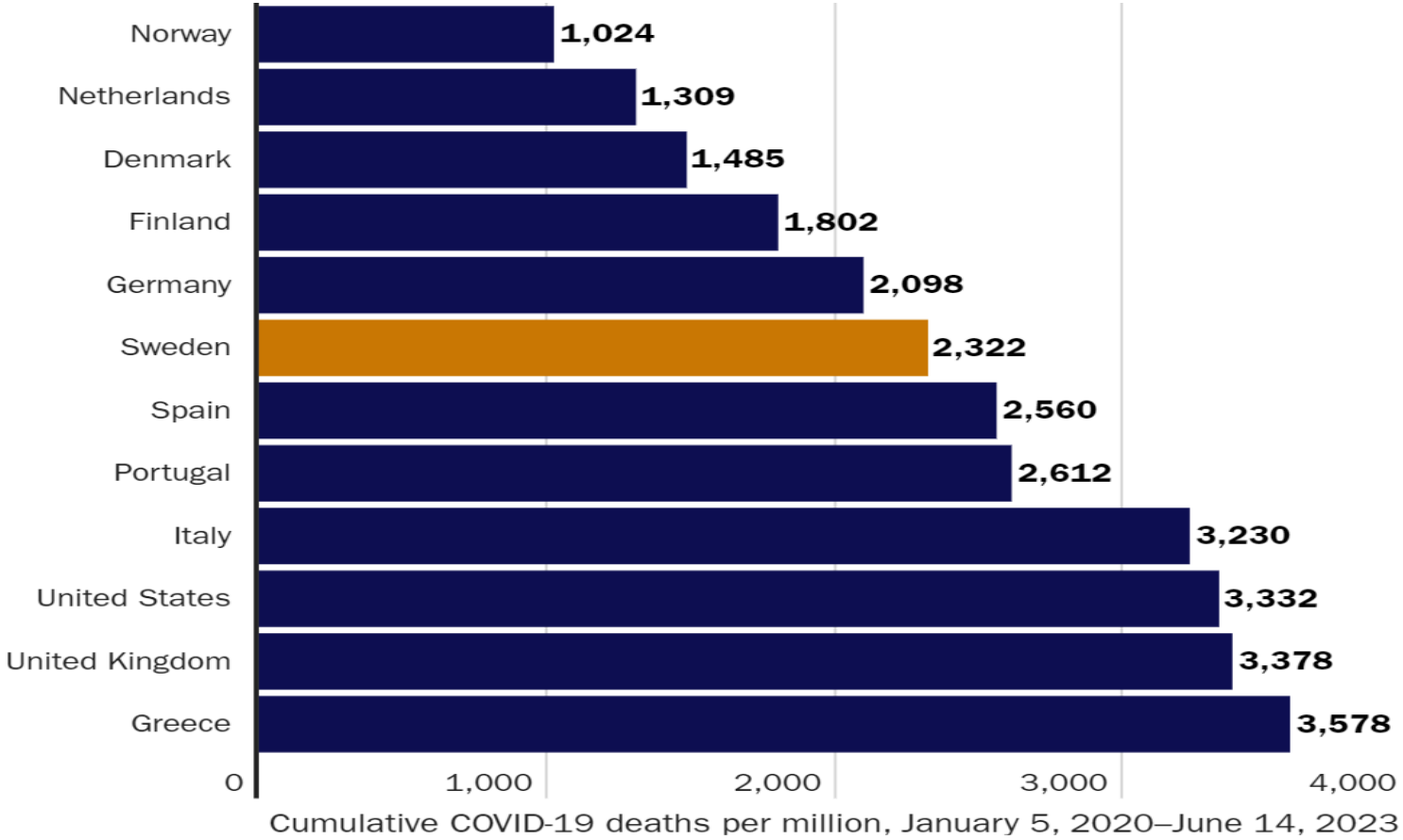
It's complicated…

- Masks and respirators work if and to the extent that they are well-designed, well-fitting and actually worn.
- Mask mandates are, overall, effective in reducing community transmission of respiratory pathogens including COVID
- The pore size of N95 masks is much larger than COVID virus size, but most virus is carried on aerosol droplets, and further, mask filtration is augmented by electrostatic and other properties that trap vary small particles

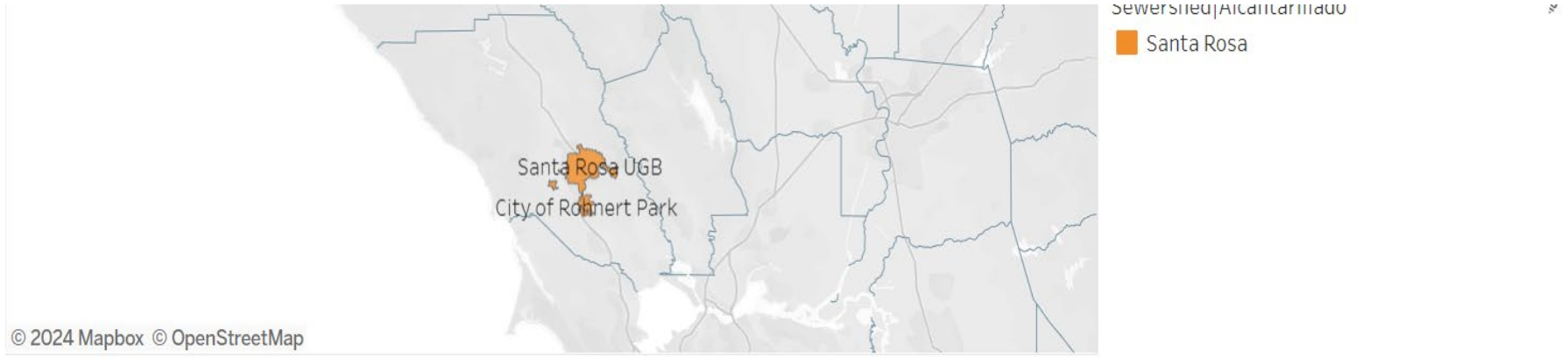
What was COVID experience in Sweden?

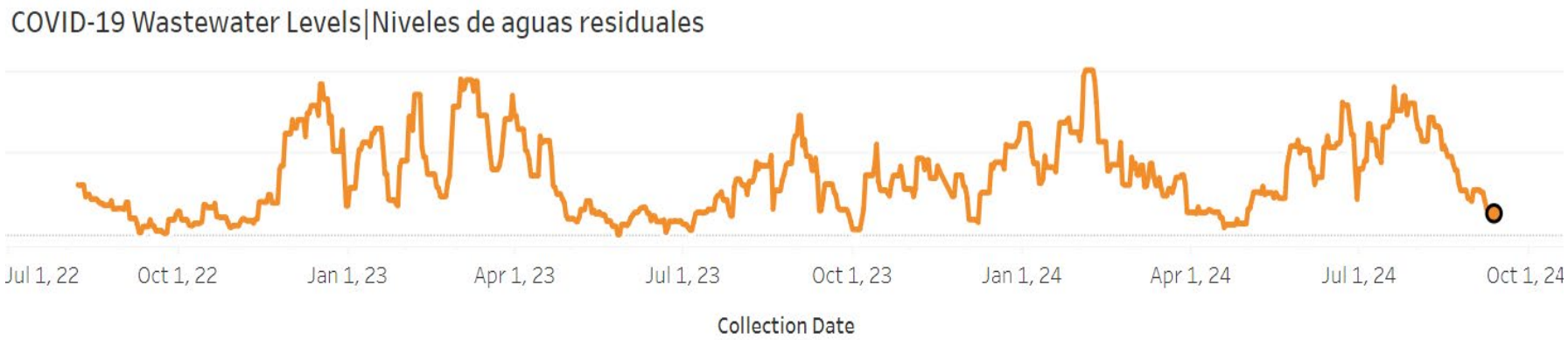
- Sweden advocated for voluntary mitigation measures, and Swedes had high compliance rates for social distancing, masking etc.
- Sweden kept schools open and did not implement most other "lockdowns", except banning large gatherings
- Initial excess mortality in Sweden was higher than neighboring Nordic countries, especially among elderly
- As the pandemic progressed, Swedish mortality more closely approximated that of neighboring Nordic countries and remained lower than most European countries and US

How did Sweden do?



COVID Wastewater Trends Santa Rosa

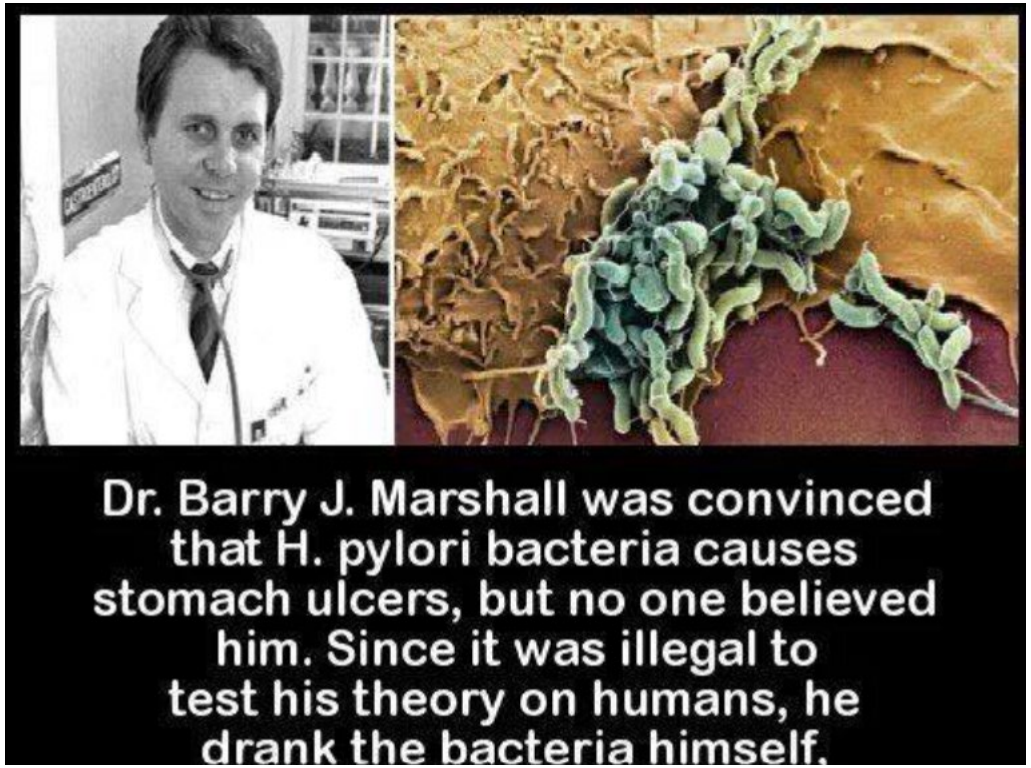




COVID Wastewater Trends Marin

Helicobacter pylori

- Once assumed major cause of ulcers and gastritis was stress
- Marshall and Warren in Australia noted bacteria in biopsies of gastritis and ulcer patients (1984)
- Proposed infectious cause of ulcers and stomach cancer; dismissed by medical establishment.
- Infected himself with H. pylori and developed gastritis; showed ulcer could be treated with antibiotics
- Awarded Nobel Prize 2005



Melting Glaciers and Permafrost

Major Epidemics

Focus on plague and smallpox

- The Three Bubonic Plagues had profound impact
- Smallpox was target of first vaccination and is only human infection to be eradicated and
- Malaria, Cholera, HIV, Tuberculosis, Yellow Fever… just not enough time

What is plague?

- Infection with a bacterium called Yersinia pestis, leading to bubonic, pneumonic and/or septic plague.
- Endemic in rodent populations
- Transmitted from rodent to human by fleas
- None of this was known until 1890s
- Extremely high case fatality rate (CFR) historically 50-80%

Plague transmission

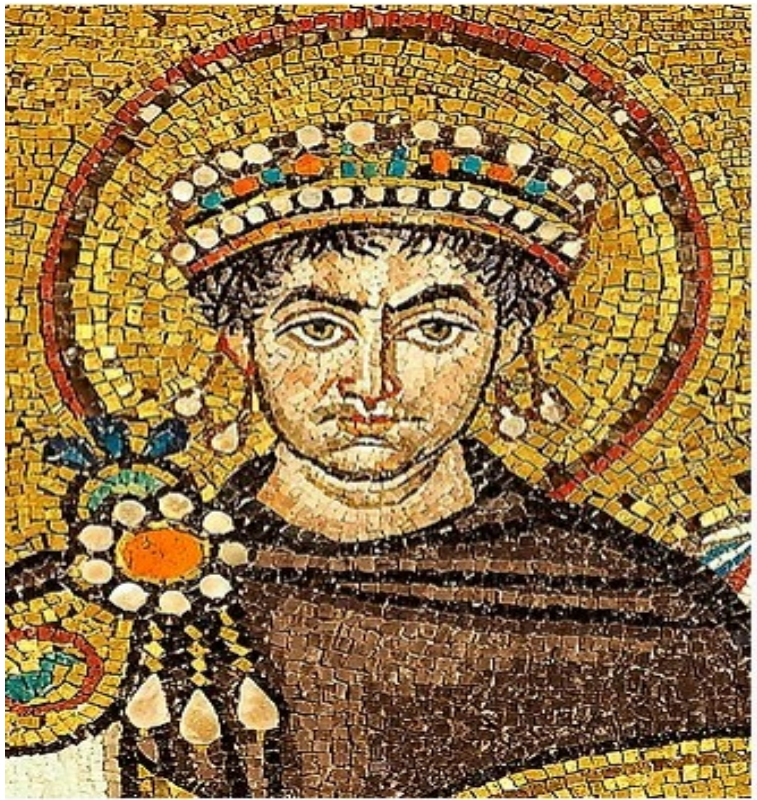
- Rats go everywhere, fleas go with them
- Flea bites infected rat
- Plague bacteria cause obstruction in flea gut, so
- Doesn't feel sated and continues to bite, loading up more bacteria
- Regurgitates bacteria as it bites thereby efficiently infecting next host
- When rat dies, flea seeks new host
- When a whole colony of rats die, fleas move en masse, explaining explosive nature of plague outbreaks

Three Plague Pandemics

- Plague of Justinian: 540-755 AD
- Black Death: 1330-1830, but especially 1347-1353
- Modern Plague: 1855-1910

Plague of Justinian

Justinian I, Byzantine Emperor, 527-565



- Attempted restoration of the Roman Empire
- Corpus Juris Civilis
- Hagia Sophia

Hagia Sophia

- Completed 537
- Largest Cathedral in the world for 1000 years
- First pendentive dome
- Converted to mosque in 1453 when Constantinople fell to the Ottomans
- Converted to museum in 1935
- Restored to mosque 2019

Plague of Justinian

- Originated in the Nile Delta 541 AD
- " This was pestilence by which the whole human race was near to being annihiliated" – Procopius
- Unknown number of deaths and impact
- 18 successive waves over 200 years
- Disappeared in 755
- DNA extracted from dental pulp from a sixth century cemetery confirm Yersinia pestis

The Black Death

- Originated in Asia, arrived by boat to Sicily in 1347
- From Sicily spread first to mainland Italy and then rapidly to all of Europe
- Conditions favored spread: urban centers, crowding, poverty, crop failures
- First wave, 1347 to 1353 killed 50% of European population
- Subsequent waves over 400 years included the Great Plague of London 1665-1666
  - Daniel Defoe: A Journal of the Plague Year
  - Samuel Pepys Diaries

Samuel Pepys

"The Towne grows very sickly"

"I did in Drury Lane see 3 houses marked with a red cross upon the doors an "God Have Mercy" writ there"

"Nobody but poor wretches in the streets; no boats upon the river"

"Little noise about the city but the tolling of bells"

Impact of Plague

- Population decline
- Terror, loss of humanity
- Flight
- Cleansing
- Self-defense
- Violence
- Piety and cults
- Public health

Terror and Loss of Humanity

- Powerless and overwhelmed religious and medical institutions
- Abandonment
- Loss of *ars moriendi* and *memento mori*
- *Vanitas and the Triumph of Death*

The Triumph of Death

- Peter Bruegel the Elder, 1563
- Unrelenting Death
- Transience of Life
- Egalitarian nature of death

Flight and Cleansing

- Fleeing to escape disease
  - Miasmal and humoral theories
- Fleeing to escape catastrophe
- Cleansing with water, smoke, aromatics

Self-defense

- Miasmatic vapors
- Physical barriers
- Aromatics and herbs
- Rubies, diamonds
- Plague “costumes”
- Maintaining humoral balance

Plague Doctor Halloween Costume

Nicexx Plague Doctor Mask Costumes Set 6 in 1 Halloween Beak Mask Plague Dr Outfit for Adults

4.3 ★★★★½ 607 ratings | Search this page

100+ bought in past month

-20% $39.99

List Price: ~~$49.99~~

prime One-Day

FREE Returns

Size:

Medium

Product details

Fabric type	Polyester
Country of Origin	China

About this item

- Halloween costumes for men 6 IN 1 : Package

Violence, piety and cults

- Purges: Prostitutes, Jews, foreigners
  - Strasbourg 1349
  - Milan 1630
- The Flagellants
- Veneration of Saint Sebastian
- Marianism

Violence, piety and cults

Public Health

- Anti-plague measures first adopted in Italian cities
- Although rooted in ignorance of the nature of the disease, and sometimes counterproductive, they were ultimately effective and likely contributed to the eradication of plague from Europe.
- Because they were effective, they justified significant state power and authority over individuals
- They provided the rationale and underlying structure for modern public health structures

Public Health-Anti-plague Measures

- Plague regulations enforced by “health “ magistrates or plague commissioners
- Boards of health
- Quarantines, lazarettos and sanitary cordons
- Confinement in pest houses
- Disposal of dead

What caused plague to disappear?

- Anti-plague measures
- Brown rat (Rattus norvegicus) displaced Black rat (Rattus rattus)
- Climate –Little Ice Age
- Improved hygiene and sanitation

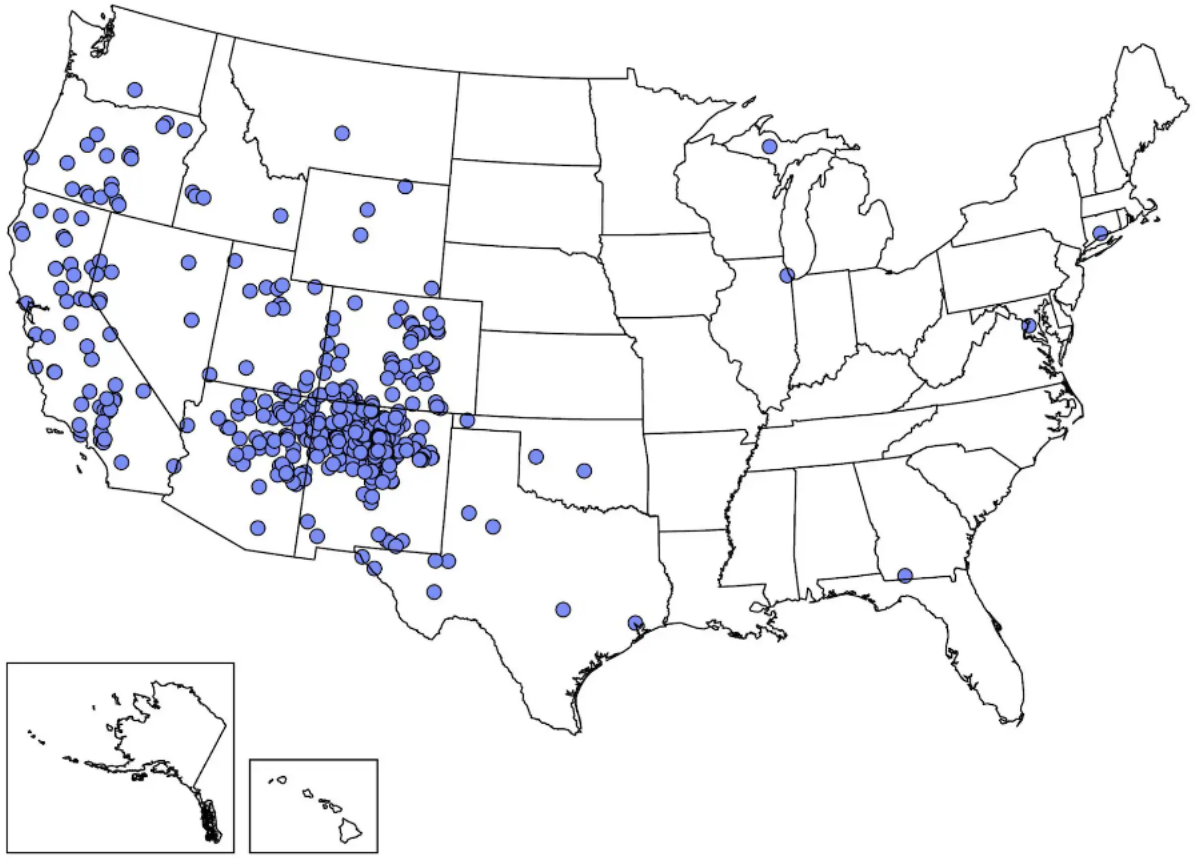
Modern Plague

- Initial outbreak in China 1855
- Spread to Hong Kong 1894, then to trading partners including San Francisco, and eventually to India 1898
- Largest impact in India: 15 million deaths
- Only 500 US deaths, but
- Established endemic reservoir of plague in Western US in ground squirrels and other rodents

Unraveling Plague

- Yersinia pestis shown to be causative agent in 1894 in Hong Kong
- Rats and fleas discovered as vectors for human disease
- Resulted in knowledge-based public health measures targeting the vectors:
  - Insecticides
  - Rat abatement
- A few human plague cases each year in US. Curable with antibiotics

Plague in US



1 dot placed within state of residence for each reported case

Smallpox

Smallpox

- Viral illness: Variola major
- Humans are only host
  - No animal reservoir or vector
- Transmitted by exhaled droplets, fomites or transplacentally
- Only human disease to have been eradicated: "Smallpox was a disease…"

Smallpox symptoms

- Lengthy incubation
- General malaise, fever, headache
- Widespread rash
- Central nervous system
- Case Fatality Rate of 30-40%
- Significant disfigurement and other consequences
- Lifelong immunity for survivors

Smallpox rash and scarring

Smallpox over time

- Some evidence of smallpox since 1500 B.C.
  - Ramses V died 1157 B.C
- Spread to India by Egyptian traders
- China approx. 200 B.C.
- Antonine plague 160 AD
- Periodic epidemics in Europe; endemic by 15th century
- Prominent cause of death 16th through 18th centuries, especially children

The Columbian Exchange

- Columbus landed Hispaniola 1492. Indigenous population was 1 million
  - By 1520 indigenous population 15,000
  - Loss of labor facilitated African slave trade
- Cortes invaded Mexico 1519, and was nearly defeated before smallpox ravaged Aztecs
- Massachussets 1617
- French and Indian War : "Could it not be contrived to send smallpox among these disaffected tribes of Indians?" –Jeffrey Amhurst, Commander of Bristish Army
- Washington inoculated his troops

Prominent victims of smallpox

- Queen Mary II of England
- Emperor Joseph I of Austria
- Tsar Peter II of Russia
- King Louis XV of France
- Francis Folger Franklin
- Janet Parker

Smallpox historic treatment

- Red Therapy
  - Practiced throughout Asia, India and Africa
  - Red cloth and clothing for smallpox patients
  - Queen Elizabeth I, dressed in red clothing and blanket
  - Niels Finsen advocated red light therapy to reduce scarring
    - Nobel Prize 1903
    - Largely abandoned by 1930s
- Variolation
- Vaccination

Variolation

- Based on observation that survivors of smallpox were "protected" from the disease for life. Therefore inducing a mild case, with high odds of recovery, could provide similar protection.
- Material from a patient with an active smallpox lesion is placed under the skin of another person. Produces a mild case of smallpox with high rate of recovery (but sometimes more severe or even fatal 1-2%)
- Entrance through the skin may attenuate the virus
- Historic practice in China and India, introduced to Turkey 1670
- Lady Mary Wortley Montagu brought practice to England 1721

Vaccination

- Well-observed that milkmaids seldom got smallpox
- Benjamin Jesty 1774 inoculated his family with cowpox
  - “Neighbors feared their metamorphosis into horned beasts"
- Edward Jenner 1796 inoculated his gardeners son with cowpox; later exposed him to smallpox repeatedly and he remained well
  - Jenner anticipated eradication
- Controversial from the start
  - Civil liberty, religious objection,

Eradication of Smallpox

- Feasible due to no animal or other reservoir, and lifelong immunity
- Globally organized effort started 1959
- Last naturally acquired case Bangladesh 1975
- Janet Parker, medical photographer in England died of smallpox 1978
- Smallpox virus stocks in CDC, Atlanta and in virus institute Koltsovo, Russia
- Full genome elucidated and published (available online!)

The Discovery of Germs

Germ Theory: A saga of independent thinkers

- van Leeuwenhoek
- Semmelweis
- Snow
- Louis Pasteur
- Koch
- Lister

Early ideas

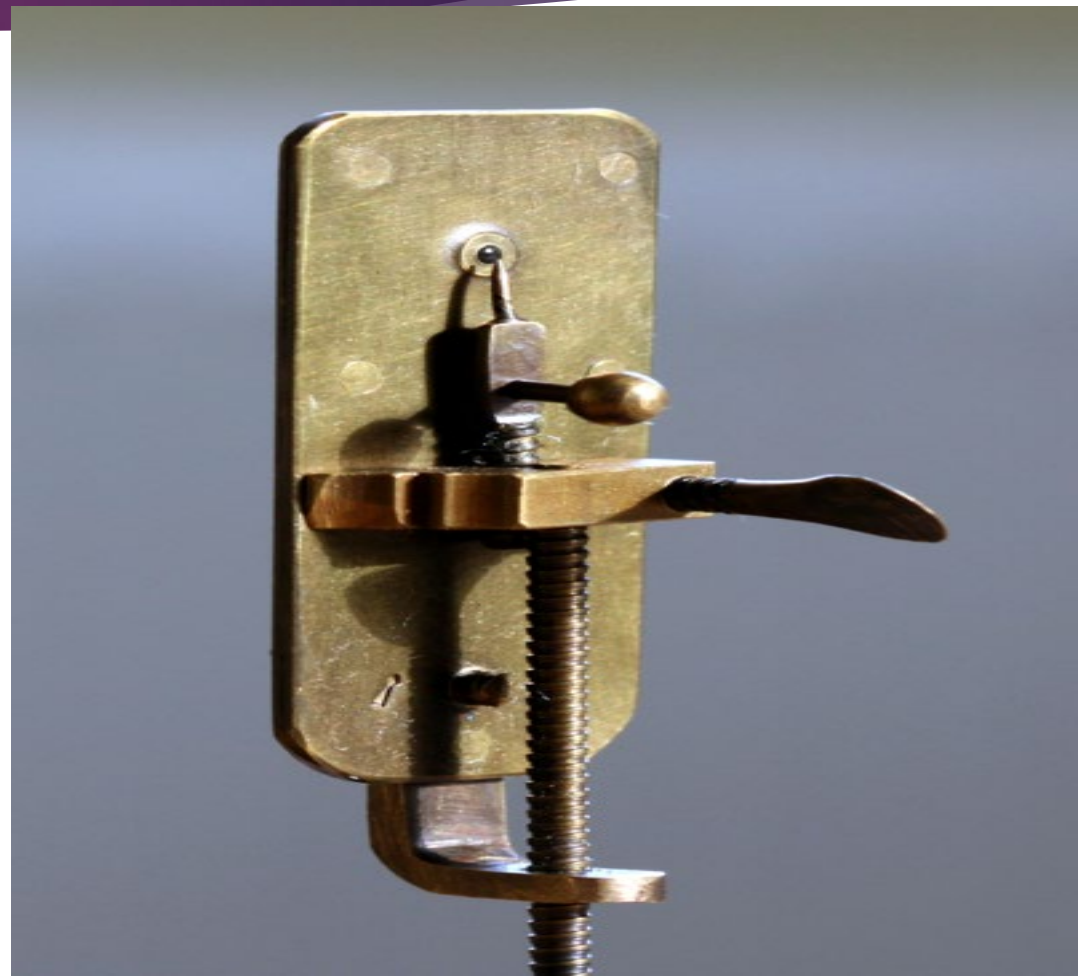
- "Precautions must also be taken in the neighborhood of swamps... because there are bred certain minute creatures which cannot be seen by the eyes, which float in the air and enter the body through the mouth and nose and there cause serious diseases." [Marcus Varro, 36 BC
- "seeds of disease" Girolamo Fracastoro 1536
- Athanius Kircher saw “worms” in blood from plague victims through his microscope, postulated they were cause of disease 1658
- Antonie van Leeuwenhook “animalcules” 1694

Van Leeuwenhoek 1632-1723

- Dutch draper; self-taught
- Made his own lenses used to examine quality of cloth
- Built a single lens microscope capable of 275x magnification
- Identified “animalcules” in rainwater, saliva in 1674
- Corresponded to Royal Society of London 1676 (in Dutch)

Antonie van Leeuwenhoek

- Skeptical reception by Royal Society
- But he kept at it, writing 190 letters, never published a real scientific paper
- Eventually a delegation came to see for themselves and were convinced
- Van Leeuwenhoek was elected a Fellow of the Royal Society in 1680. He never attended a meeting.



Germ Theory: Semmelweis and childbed fever

- Obstetrician in Vienna 1847
- Noted excessive maternal mortality from puerperal fever in ward staffed by doctors, compared to midwives
- Noted doctors often came to deliver babies directly from autopsies
- Postulated contagious “cadaveric particles” as cause
- Instituted hand washing with dramatic success
- Scorned, reviled and ostracized
- Died in a mental institution, probably of sepsis

Germ theory: John Snow the first epidemiologist

- Postulated biological, versus miasmal, cause of cholera with "cells"
  - 'the morbid matter of cholera having the property of reproducing its own kind must necessarily have some sort of structure, most likely that of a cell".
- Advocated boiling and filtering water
- Noted clustering of cases near Broad Street well 1854
- Had pump handles removed; cholera outbreak abated

Louis Pasteur: microbes cause diseases

- Showed that microorganisms were responsible for fermentation and "souring" of milk and other beverages
- "Souring" could be prevented by boiling (Pasteurization)
- Theorized microorganisms caused disease
- Reproduced anthrax and cholera in animals
- Developed vaccine for anthrax and rabies

Robert Koch: Koch's Postulates

- Contemporary and competitor of Pasteur
- "Germs (bacteria) cause specific diseases"
- Isolated anthrax and tuberculosis bacteria
- Articulated Koch's Postulates:
  1. Microorganism is found in diseased organism, and not in healthy ones
  2. The microorganism can be isolated from the diseased organism and grown in clulture
  3. Introduction of the cultured microorganism to a healthy organism produces the disease
  4. The organism can then be re-isolated and shown to be the same as the original

Joseph Lister

- British surgeon Influenced by Pasteur
- Believed germs in air contaminated surgical wounds causing infection
- Devised several ways to protect wounds, disinfect air
- Used carbolic acid to disinfect wounds and proved effective
- Unlike Semmelweis, he was persuasive, and transformed surgical practice
-

Discovery of bacterial pathogens

Discovery of pathogenic bacteria in early modern medicine and the beginning of late modern medicine.

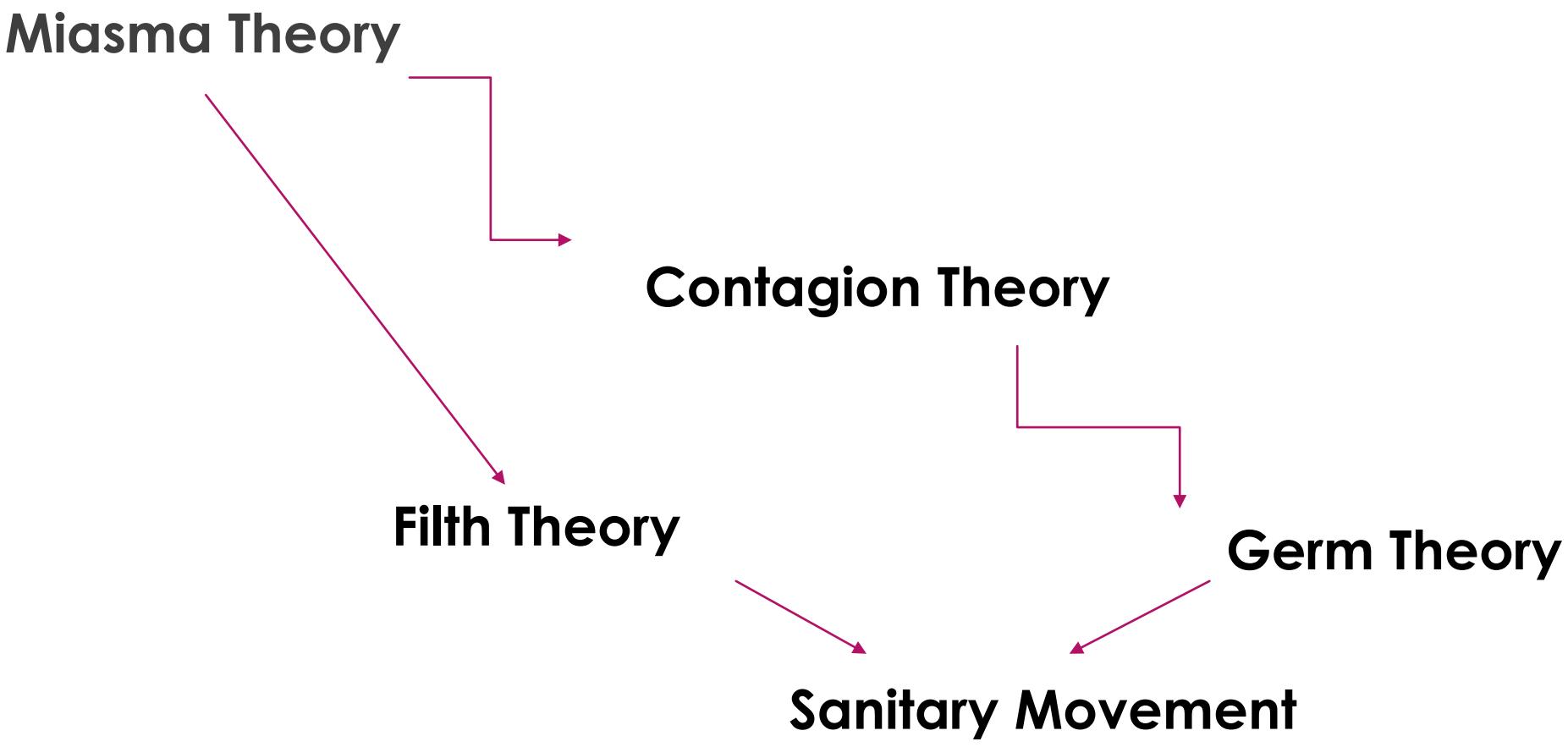
Disease	Pathogen	Year	Discoverer
Leprosy	*Mycobacterium leprae*	1874	Hansen, Gerhard Armauer (Norway)
Anthrax	*Bacillus anthracis*	1876	Koch, Robert (Germany)
Typhoid fever	*Salmonella enterica*	1880	Eberth, Karl Joseph (Germany)
Tuberculosis	*Mycobacterium tuberculosis*	1882	Koch, Robert (Germany)
Cholera	*Vibrio cholerae*	1883	Koch, Robert (Germany)
Diphtheria	*Corynebacterium diphtheriae*	1883	Klebs, Edwin (Switzerland)
Tetanus	*Clostridium tetani*	1884	Nicolaier, Arthur (Germany)
Brucellosis	*Brucella* sp.	1887	Bruce, David (Great Britain)
Plague	*Yersinia pestis*	1894	Yersin, Alexandre (France); Kitasato, Shibasaburo (Japan)
Dysentery	*Shigella dysenteriae*	1897	Shiga, Kiyoshi (Japan)
Syphilis	*Treponema pallidum*	1905	Schaudinn, Fritz; Hoffmann, Erich (Germany)
Whooping cough	*Bordetella pertussis*	1906	Bordet, Jules (France)
Epidemic typhus	*Rickettsia prowazekii*	1909	Nicolle, Charles (France)

Discovery of viral pathogens

The representative pathogenic viruses discovered in late modern medicine.

Disease	Pathogen	Year	Discoverer
Polio (Poliomyelitis)	Poliovirus	1909	Landsteiner, Karl (Austria)
Yellow fever	Yellow fever virus	1928	Stokes, A; Bauer, JH; Hudson, NP (USA)
Influenza	Influenza viruses	1933	Smith, W; Andrews CH; Laidlaw PP (USA)
Japanese encephalitis	Japanese encephalitis viruses	1935	Hayashi, Michitomo (Japan)
Shingles (Herpes zoster)	Varicella zoster virus (VZV)	1953	Weller, Thomas Huckle (USA)
Measles	Measles virus	1954	Edmonston, David (USA)
Rubella	Rubella virus	1962	Parkman, Paul Douglas (USA) Weller, Thomas Huckle (USA)
Hepatitis B	Hepatitis B virus	1966	Blumberg, Baruch Samuel (USA)
gastroenteritis	Noro virus	1972	Kapikian, Albert Z. (USA)
Acquired immunodeficiency syndrome (HIV/AIDS)	Human immunodeficiency virus (HIV)	1983	Gallo, Robert (USA); Montagnier, Luc (France)
			Choo QL, Kuo G, Weiner AJ, Overby LR, Bradley DW, Houghton M

Evolution of Germ Theory



The Sanitary Movement

- Louis-Rene Villerme correlated death rates with geography, income, population density and filth and odor in Paris(1820)
- Edwin Chadwick brought idea to England
  - Urban England suffered from poverty and disease
  - New Poor Law of 1834
  - Sanitary Report of 1842
- Sanitary Reform focused on water –clean water coming in and washing the filth away cleanly: Running water, flushing toilets, sewer systems
- Cleanliness became a way of life

The discovery of germs led to stunning improvements in health

- Public health measures (clean water, sewage disposal…)
- Vaccines
- Antibiotics

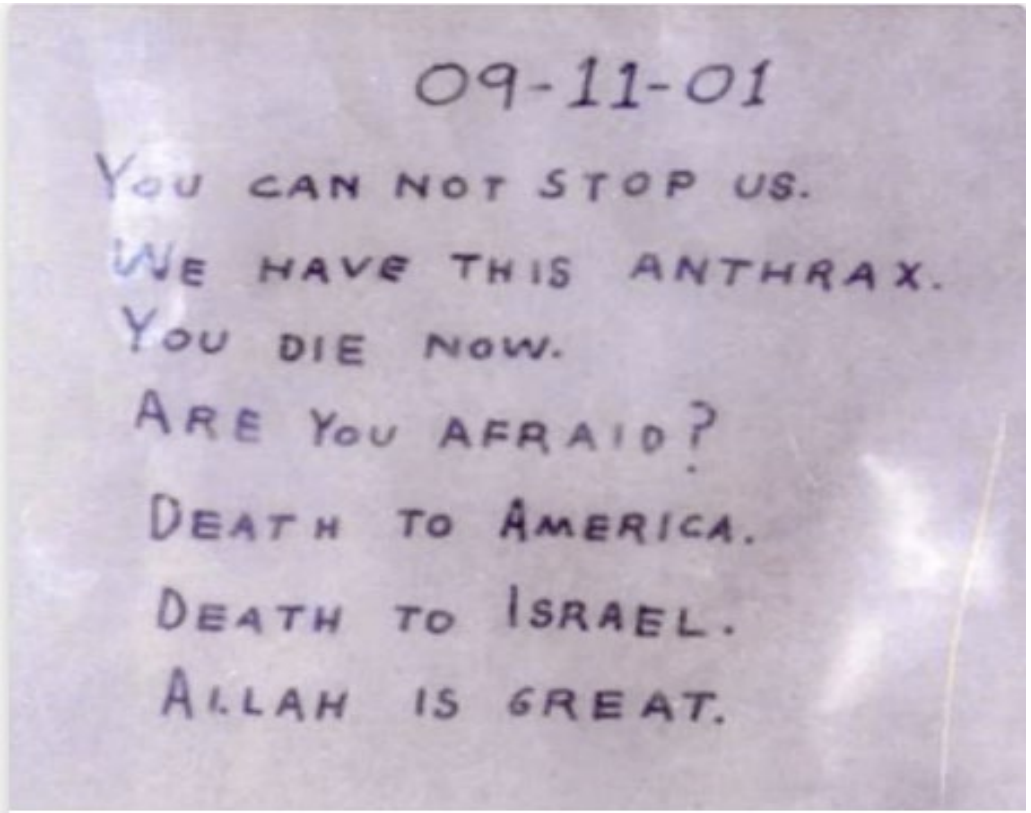
Germ Warfare

- 1346, the bodies of Mongol warriors of the Golden Horde who had died of plague were catapulted over the walls of the besieged Crimean city of Kaffa now Feodosiya
- WW I Anthrax used by Germany
- 1925 Geneva Protocol prohibits first use of biological and chemical agents
- WW II UK and US biological warfare program “weaponized” anthrax and botulism
- Japan had extensive biological warfare program, experimented on prisoners and had a plan to attack West Coast US cities with plague and cholera
- Richard Nixon terminated US Biowarfare program in 1969
- 1972 Biological Weapons Convention 183 signatories

Germ Terrorism: Salmonella in Oregon;

- Rajneesh, Indian mystic, founded colony in Antelope Oregon
- Sought to take over County circuit court leadership by winning 2/3 seats
- To assure victory, planned to cause widespread voter illness
- Used Salmonella typhi added to salad and salsa bars in 10 restaurants
- 750 sickened, 45 hospitalized

Anthrax in Washington DC



October 2001 U.S. Anthrax letter

Anthrax Attack

- October 4, 2001 a photo editor for American Media Inc developed pulmonary anthrax- first US case in 25 years
- Two others at AMI soon became sick and recalled white powder in a letter
- Letters had been sent Sept 18 to several media outlets
- Letters sent in early October to two US Senators contained anthrax spores
- 22 people stricken; 5 died

Public Health Evolution

- 1600s Venetian plague regulations
  - Established role of state acting via "Boards of Health, overriding individual liberty for public health benefit
- 1800s Enforcement of variolation and vaccination for smallpox
- 1800s "The Great Sanitary Awakening"
- 1800s Public responsibility for health
- 1866 First Public Health Departments, New York

Antibiotics

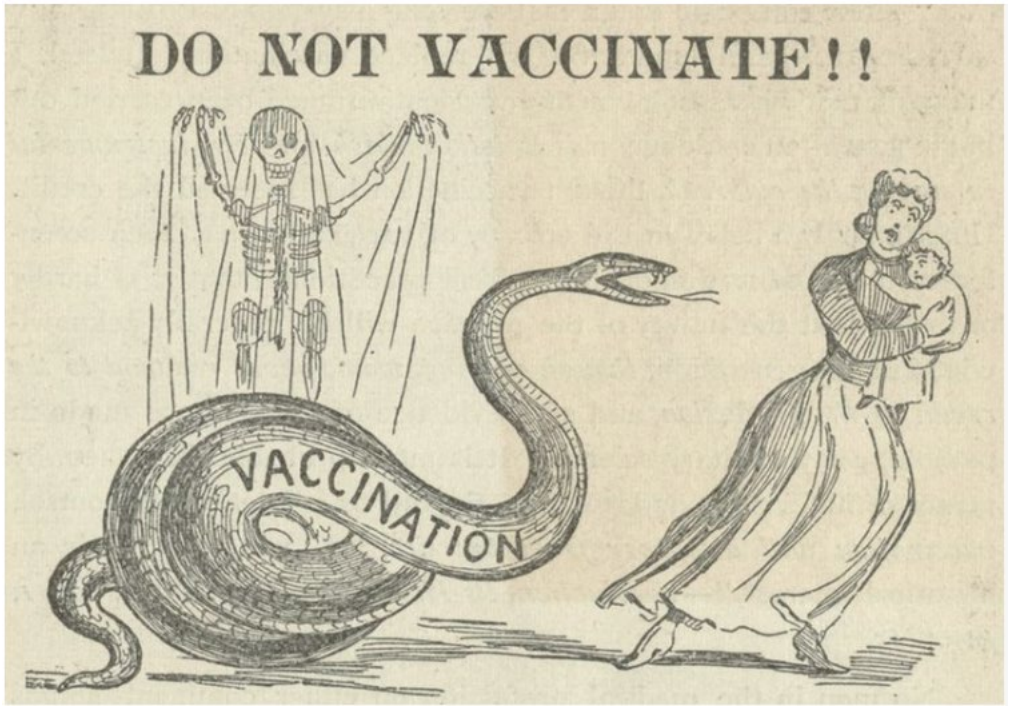
- 1910-Salvarsan Paul Ehrlich "Zauberkugel" (Magic Bullet) 1910
  - Salvarsan (Salvation Arsenic) for syphilis
- 1928-Alexander Fleming Penicillin 1928; first used in human 1941
- 1932-Gerhard Domagk treated his 6 year old daughter for gangrene with sulfonamide
- 1945 Streptomycin for Tuberculosis
- 1945 Tetracycline
- 1949 Chloramphenicol
- Antibiotic resistance often noted within a few years of introduction; 700,00 deaths worldwide/year

Vaccines

- 1796 Smallpox, (Edward Jenner)
- 1813 “An Act to Encourage Vaccination” (James Madison)
- 1879 Chicken Cholera , (Louis Pasteur)
- 1885 Rabies, (Louis Pasteur)
- 1893 Human Cholera (Haffkine)
- 1905 U.S. Supreme Court upholds compulsory vaccination
- 1945 Influenza
- 1954 Polio (Salk)

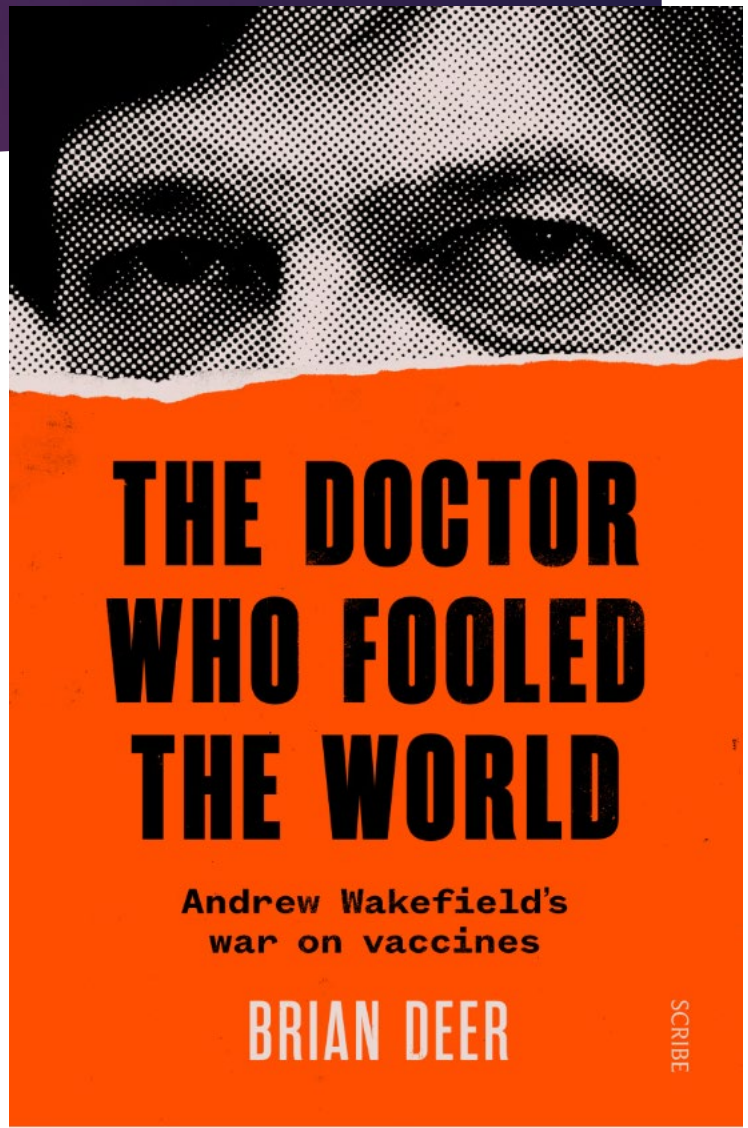
Vaccine Skepticism

- 1790s Smallpox vaccine opposed by variolation "industry", but eventually variolation outlawed in UK in 1840
- 1853 UK Vaccination Act required mandatory vaccination against smallpox
  - Immediate resistance with organized opposition
- 1898 UK allows exceptions



Vaccine Skepticism

- 1905 US Supreme Court says can't forcibly vaccinate, but can limit liberty
- 1921 Mahatma Gandhi "vaccination is a barbarous practice"
- 1930s US polio experiments killed 6 children
- 1955 Cutter incident: 120,000 inadequately inactivated vaccine doses
- 1998 Andrew Wakefield
- 2000s Robert Kennedy



Will our success continue given current challenges? What is coming next?

- Climate change
- Habitat encroachment
- Extensive global travel
- Vaccine and science skepticism
- War
- continued ability of those pesky microorganisms to evolve

Climate Change

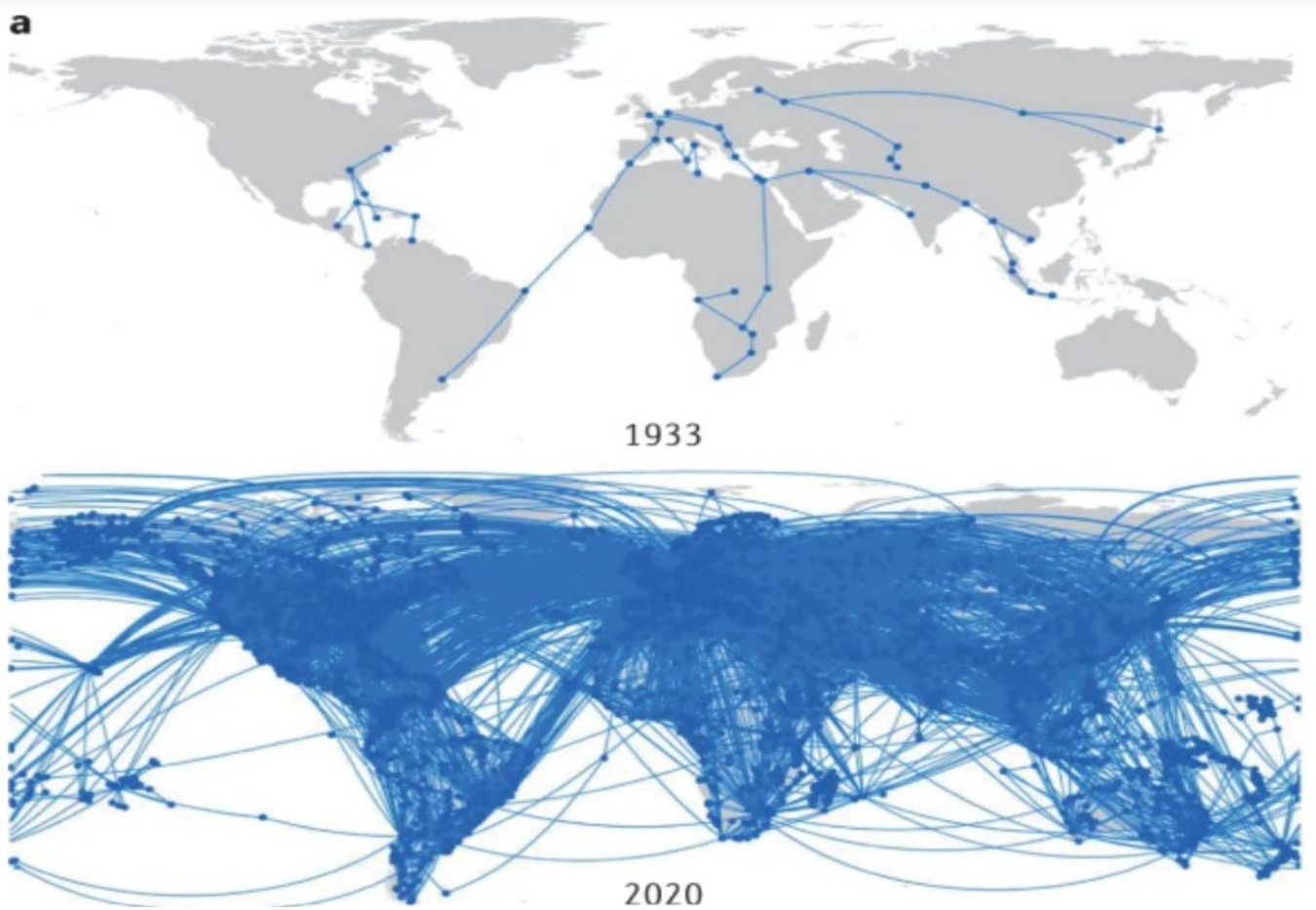
- Expanded range—malaria, Dengue, Valley fever
- Expanded season—Lyme and other tick borne illness
- Wetter, and warmer areas-- cholera
- Dryer areas-Hanta virus

Proximity to wildlife and livestock

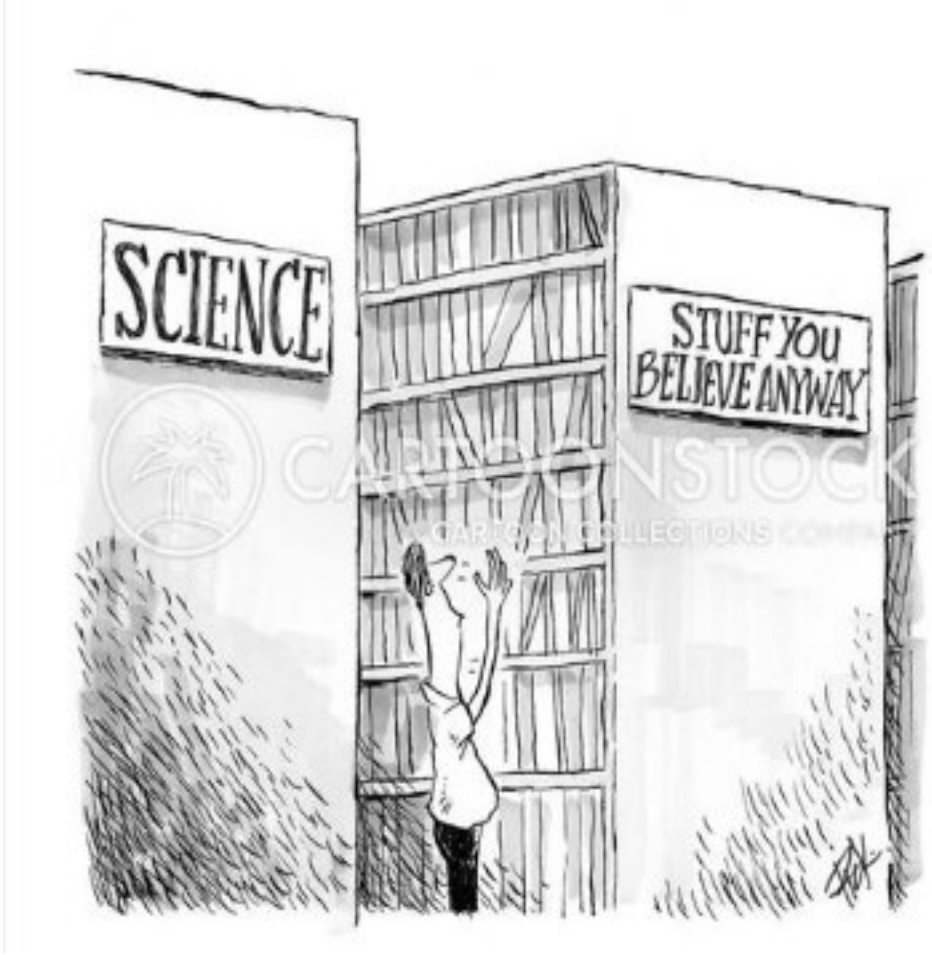
- Habitat encroachment
- Intensified animal trade- Rift Valley fever,
- Livestock management--Avian flu
- Fruit bats-HIV, ?COVID

Globalization

COVID spread across planet in about 3 months



Skepticism of science and expertise



War and infections

- Polio reemergence in Gaza
- Cholera in Sudan
- Due to disruptions of public health infrastructure, crowding, collapse of medical services, interrupted supply chains, malnutrition

Microorganisms Evolve Rapidly

- Short generation time
- Large population
- Duration of epidemic
- High mutation rate
- Horizontal transmission

COVID (SARS-CoV2) Evolution

- Wuhan Dec 2019
- Alpha Sep 2020
- Beta Oct 2020
- Gamma Nov 2020
- Delta Mar 2021
- Omicron Nov 2021
  - XBB, BAA, FLiP, SLiP, FLiRT

COVID Evolution

- 10,000 virions produced from each infected cell; 100 billion/infected person
- 1 million mutations /day/infected population
- Mutations may confer:
- Enhanced cell entry (Increased infectivity)
- Immunity escape
- Decreased effectiveness of therapeutics
- Decreased sensitivity of diagnostic testing
- Specific clinical symptoms including loss of smell and long COVID, milder or more severe illness

What is needed

- Humility!
- Public health leaders who can speak to diverse viewpoints
  - "The public health community must capitalize on this new awareness by embracing the public as partners in health preparedness and response. " Caitlin Rivers
- Investment in surveillance
- Investment in biomedical research, drug and vaccine development