



Epidemics, Pandemics and Plagues: Oh My!

A history of infectious disease

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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



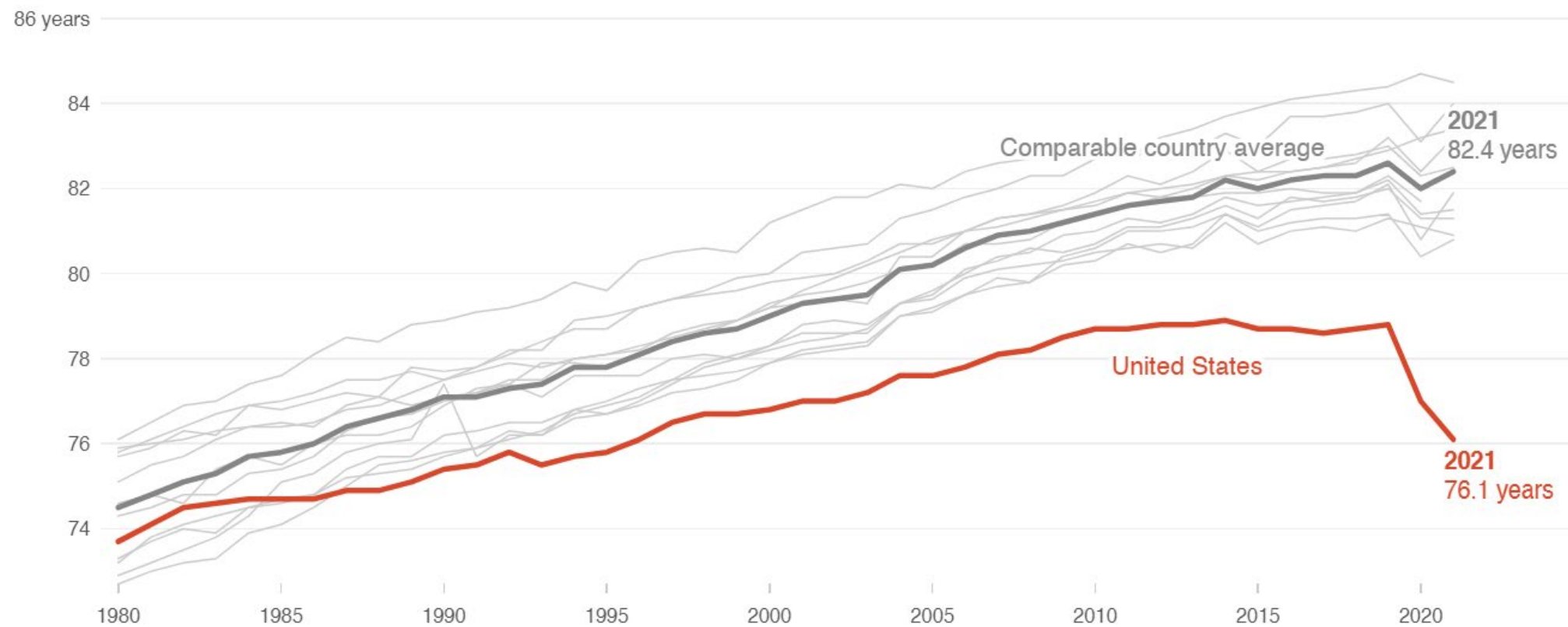
Why Study the History of Infectious Disease?

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

Life expectancy

The period life expectancy at birth, in a given year.

Our World
in Data

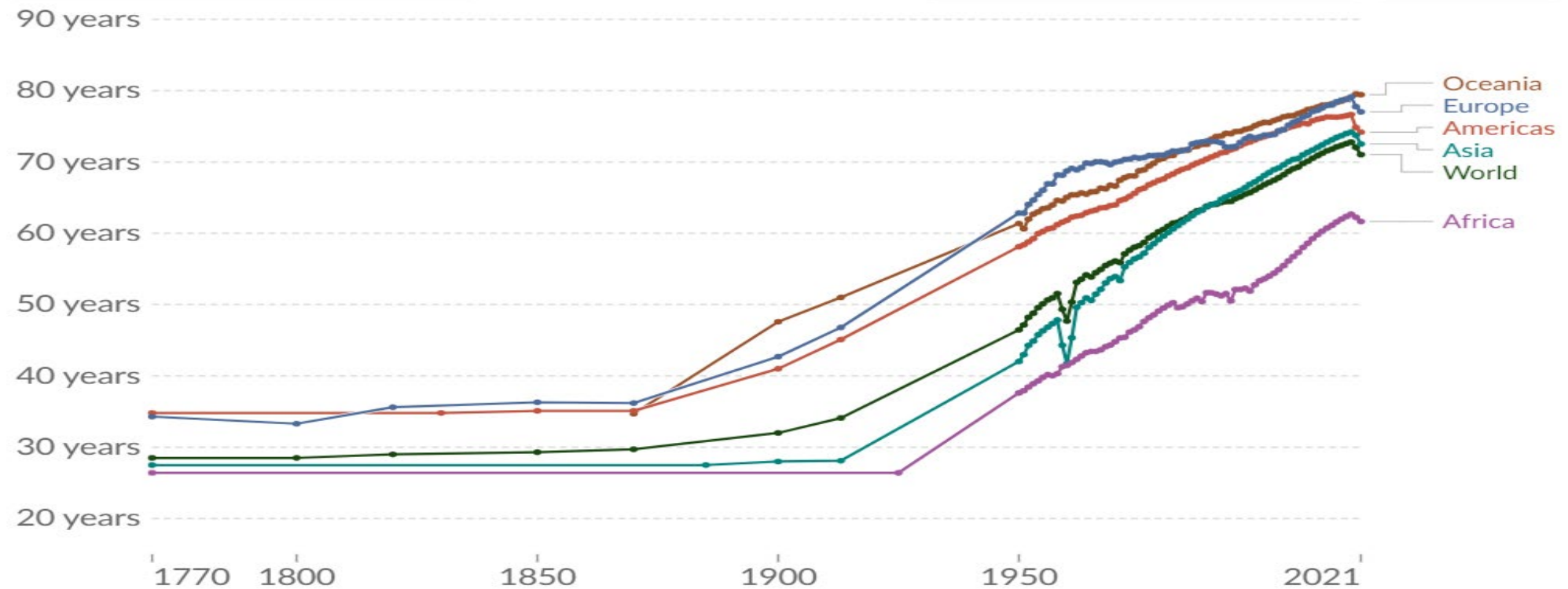
Table

Map

Chart

Edit countries and regions

Settings



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
- 1/4 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



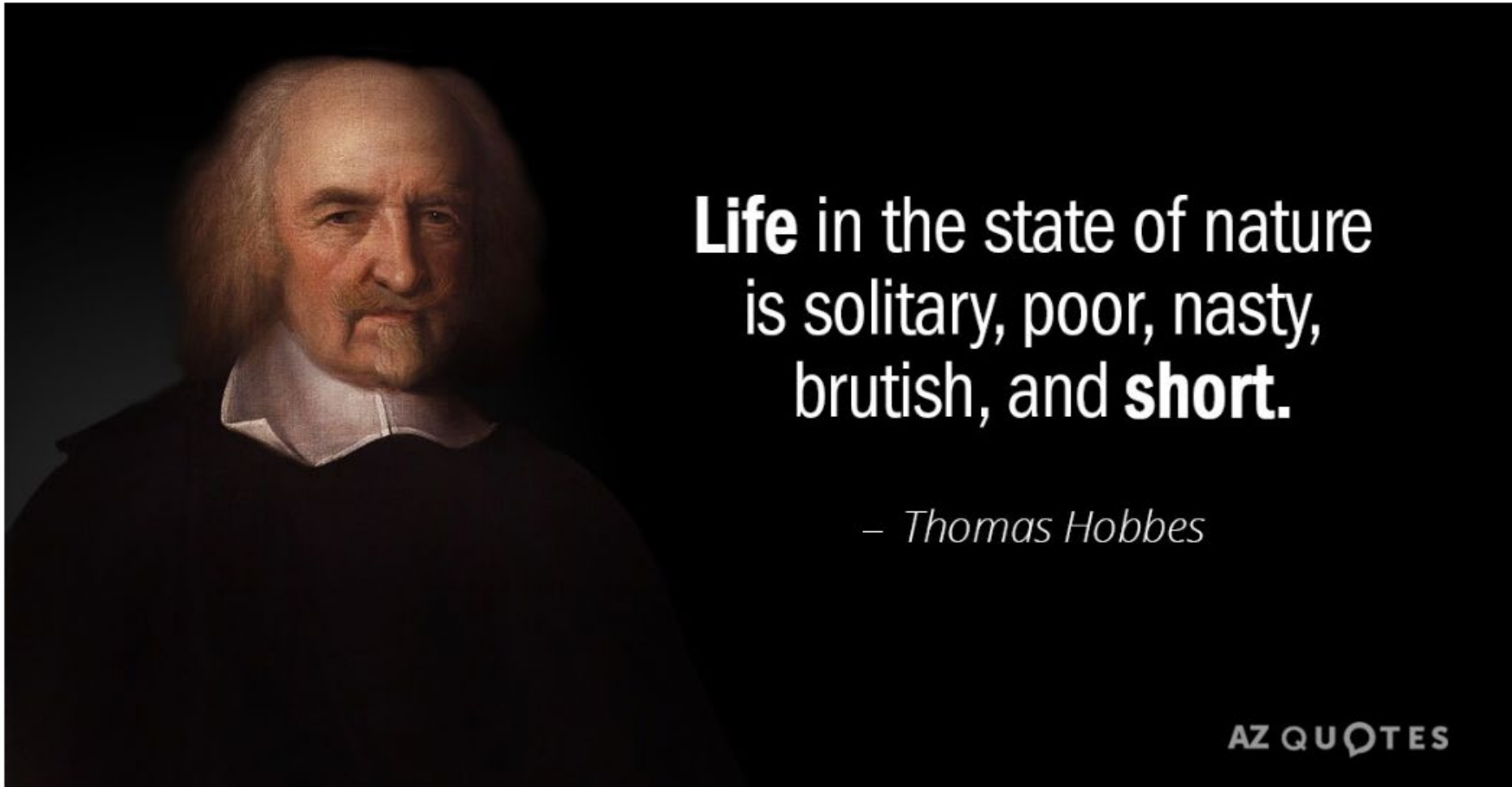
The Great Escape

HOW HUMANITY OVERCAME SHORT LIFE AND MISERY

The Great Escape



Looking back in history....



Life in the state of nature
is solitary, poor, nasty,
brutish, and **short.**

– *Thomas Hobbes*

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

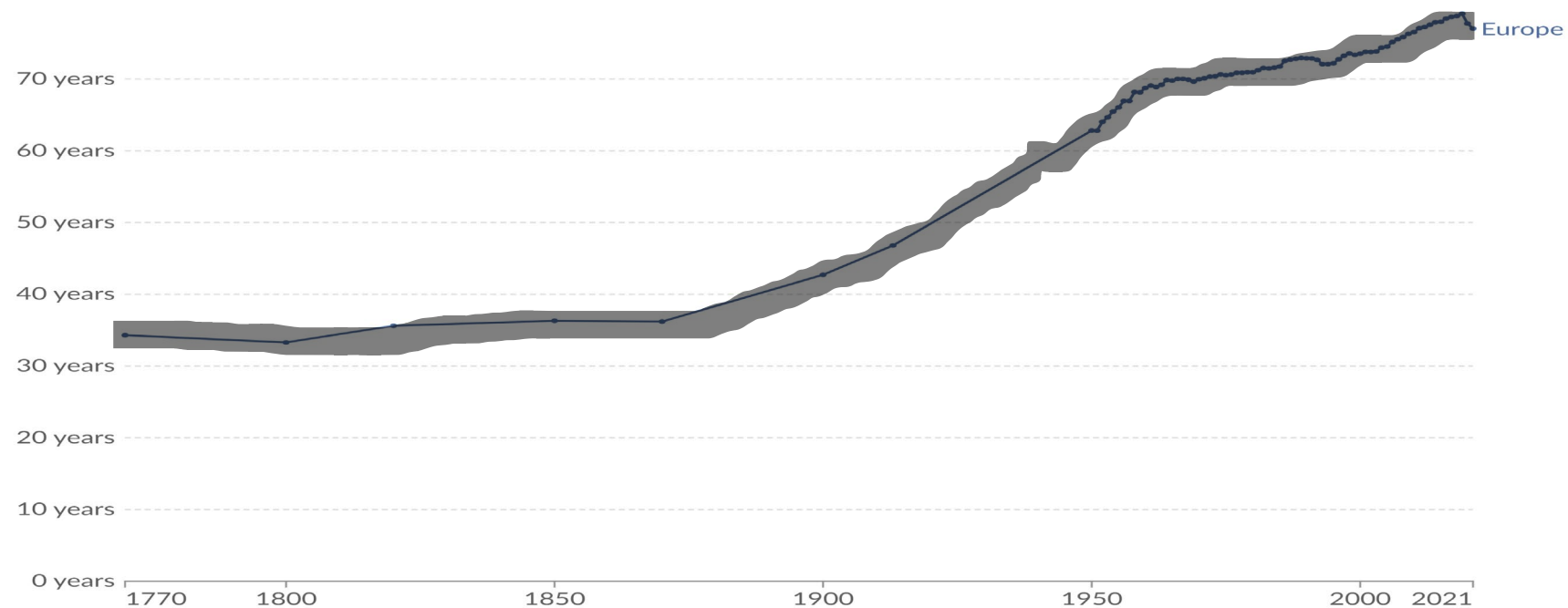
<2% of deaths were children under 5

The Most Remarkable Improvement in Human Health Ever

Life expectancy

The period life expectancy¹ at birth, in a given year.

Our World
in Data

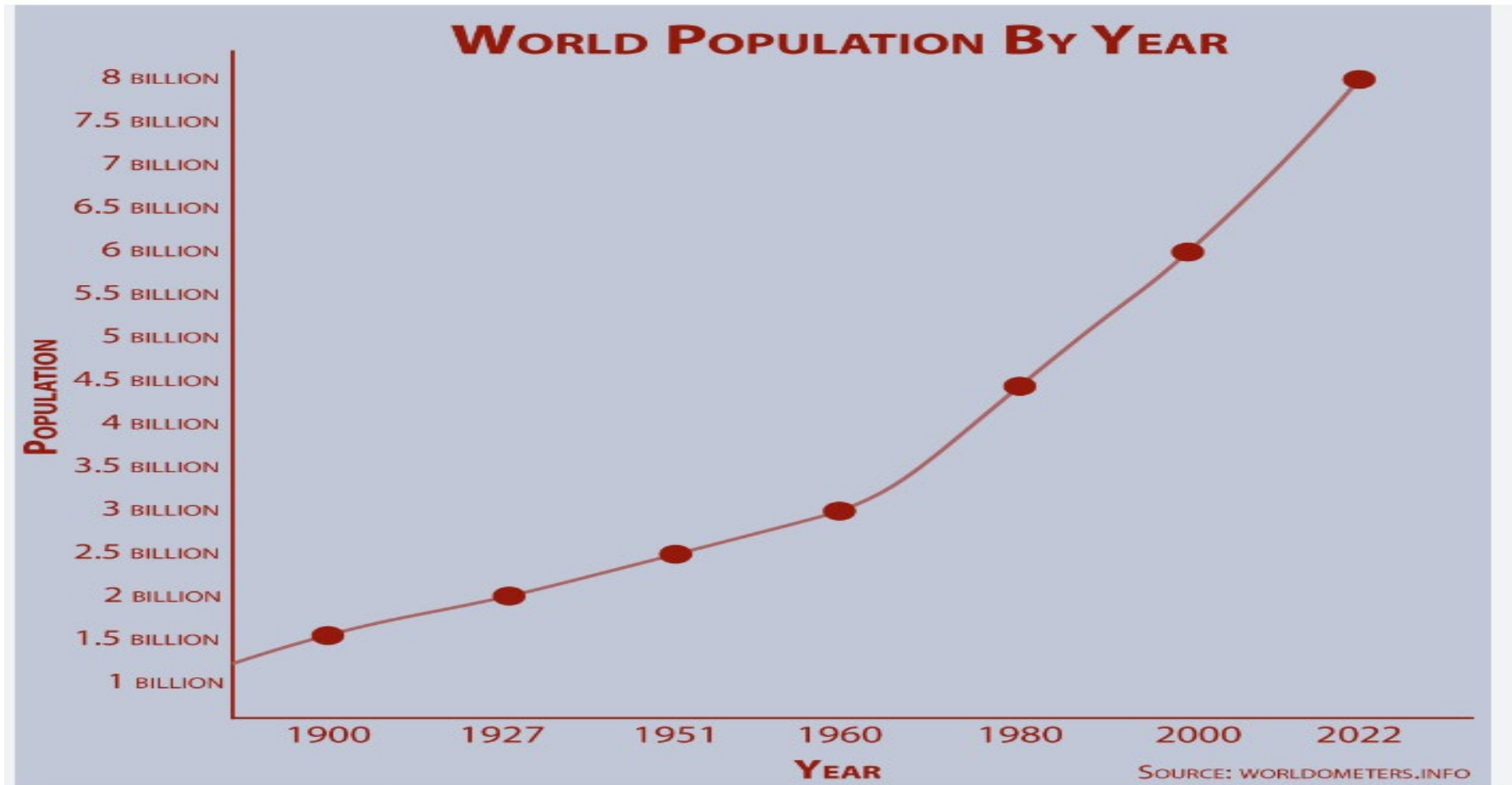


Data source: UN WPP (2022); HMD (2023); Zijdeman et al. (2015); Riley (2005)

OurWorldInData.org/life-expectancy | CC BY

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



Zooming In: Visualizing the Relative Size of Particles

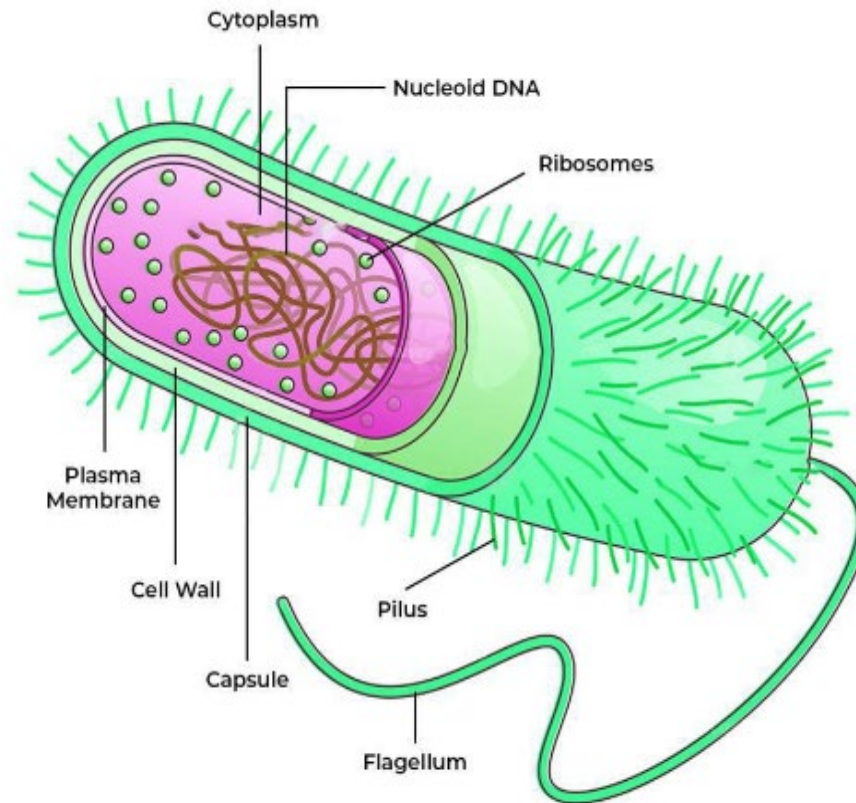
A particle needs to be 10 microns (μm) or less before it can be inhaled into your respiratory tract. But just how small are these specks?

Here's a look at the relative sizes of some familiar particles \blacktriangleright



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
 - ▶ Gonorrhoea
 - ▶ Syphilis
 - ▶ Cholera

Pathogenic Bacteria

- ▶ Streptococci
- ▶ Staphylococci
- ▶ Clostridium 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

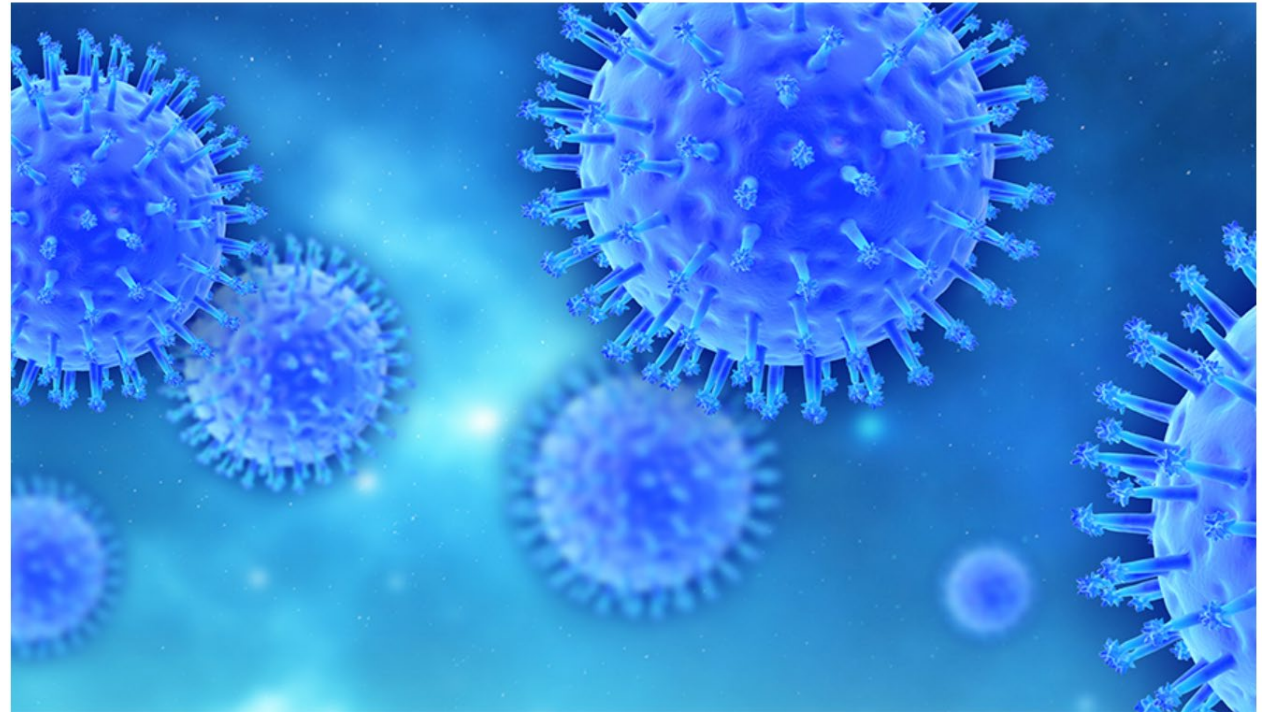
“A piece of bad news wrapped up in protein”

DNA or RNA, surround by a capsid

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

Attach
Penetrate

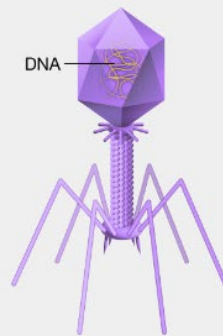
The host cell then:
Synthesis
Assembly
Release



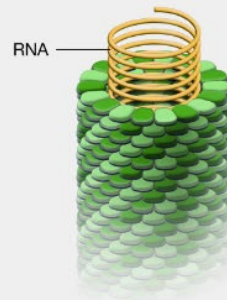
Viruses

Examples of viruses

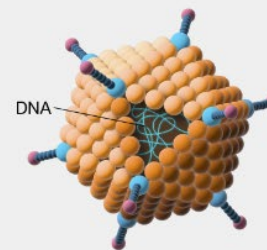
Bacteriophage



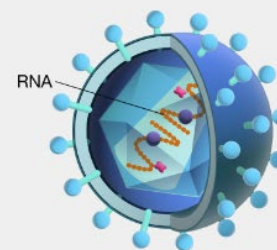
Tobacco mosaic virus



Adenovirus



Influenza virus



Viral Pathogens

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

Viral Pathogens

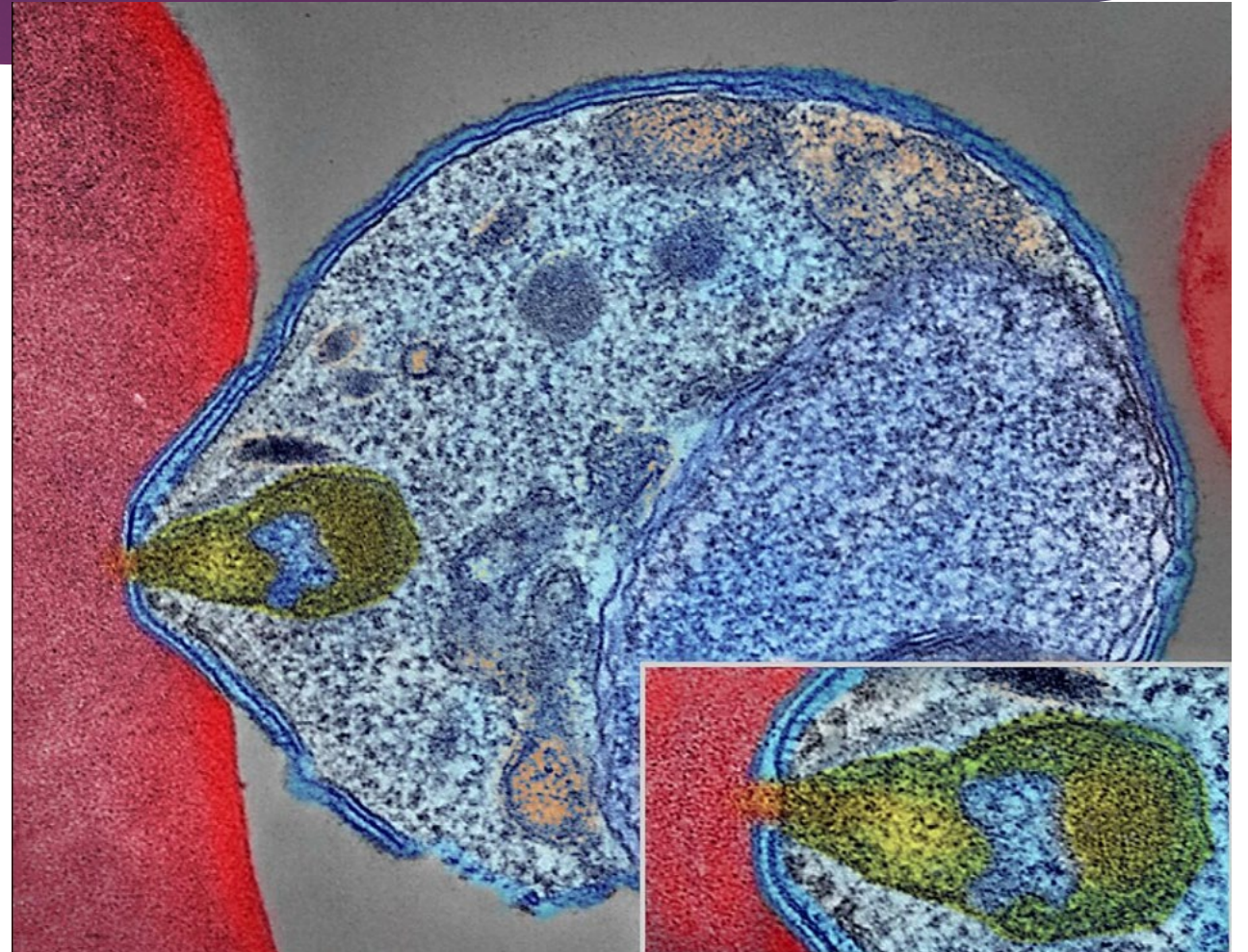
- ▶ Rabies
- ▶ Chikungunya
- ▶ Hepatitis A,B,C...
- ▶ Epstein Barr
- ▶ Rhinovirus
- ▶ M pox
- ▶ Norovirus
- ▶ Polio

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



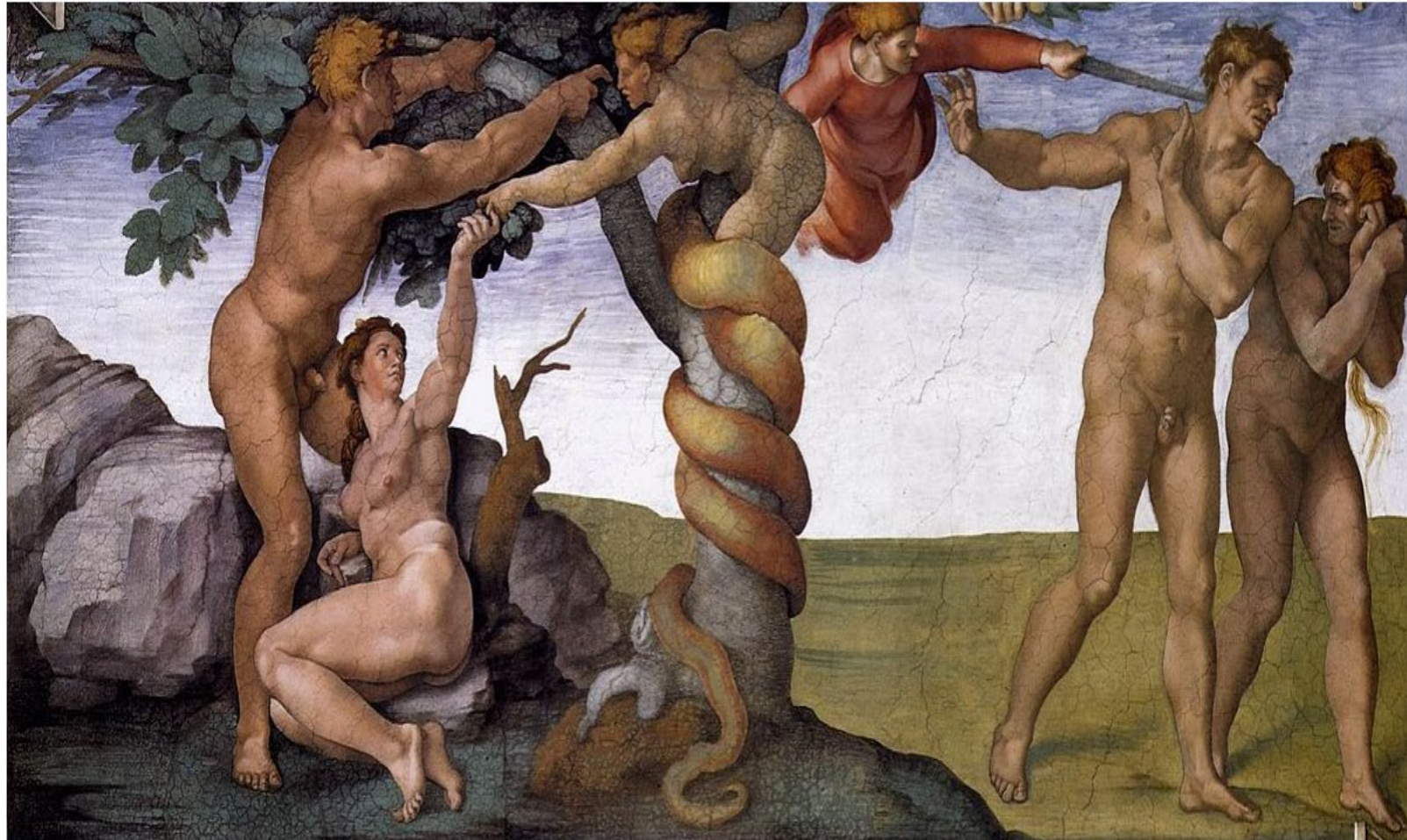
Historic Theories of Disease

Theories of Disease

- ▶ Divine
- ▶ Astrologic
- ▶ Humoral
- ▶ Miasmatal
- ▶ Germ

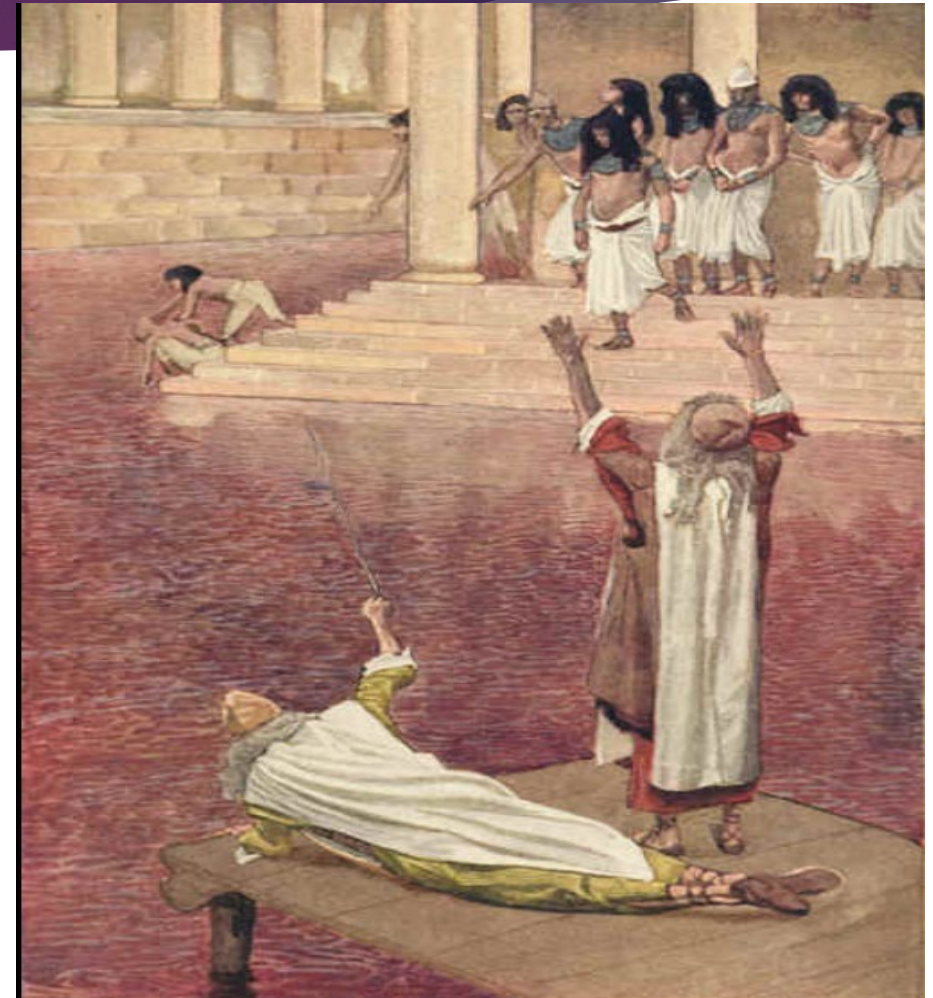
Divine Theories of Illness: A Punishment by the Gods

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



Illness as Divine Punishment

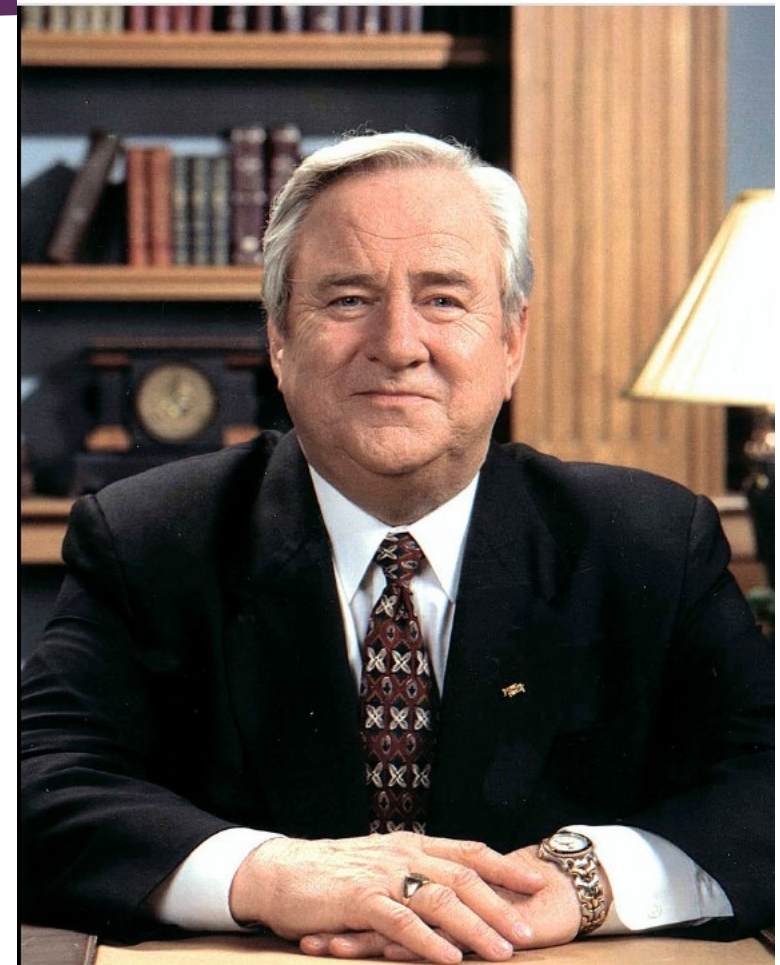
Exodus: When Pharaoh refuses to free the Israelites, God sends a series of plagues upon the Egyptians



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

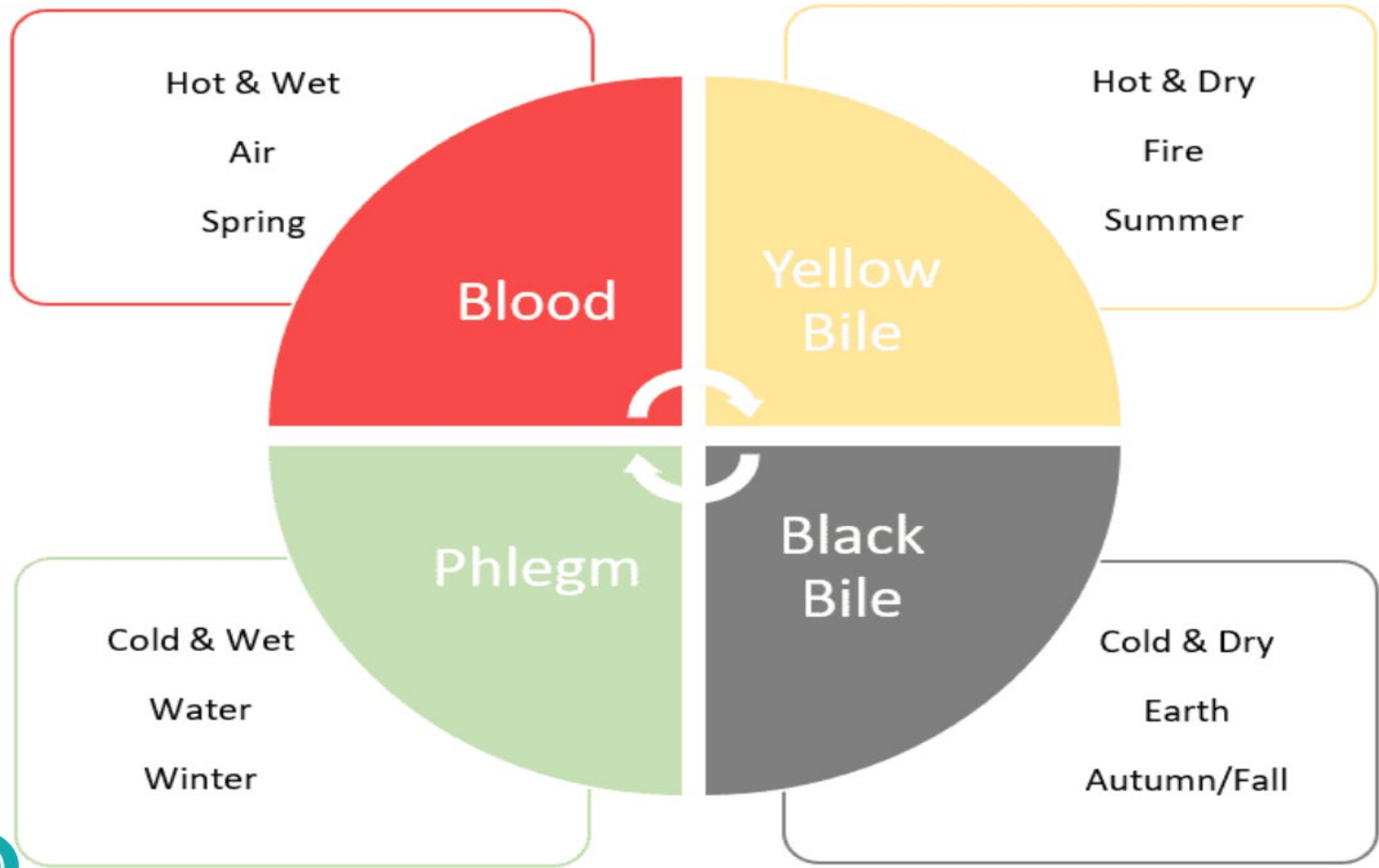
Humoral Theory: The Hippocratic Breakthrough

- ▶ 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

Cold & Wet

Water

Winter

Phlegm

Cold & Dry

Earth

Autumn/Fall

Black
Bile

Humoral Theory

- ▶ Eucrasia: A state of balance among the four humors
- ▶ Dyscrasia: Imbalance among the humors resulting in disease (and specific temperment)
- ▶ 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



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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



CHOLERA TRAMPLES THE VICTOR & THE JANQUISH'D BOTH.

Miasma Theory

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

Microorganisms plagued mankind throughout our history

- ▶ The Black Death killed over 1/3 of Europeans in the 14th century
- ▶ Smallpox allowed Cortes and 700 soldiers to defeat the Aztec Empire and conquer Mexico in 1521
- ▶ The Spanish flu (1918) killed 50 million



Major Epidemics and Their Impact

- ▶ Antonine plague

The three bubonic plagues



The Columbian Exchange

The Spanish Influenza

The discovery of germs led to stunning improvements in health

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

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

- ▶ Climate change
- ▶ Habitat encroachment
- ▶ Extensive global travel
- ▶ Vaccine skepticism
- ▶ Mistrust of...everything
- ▶ The continued ability of those pesky microorganisms to evolve

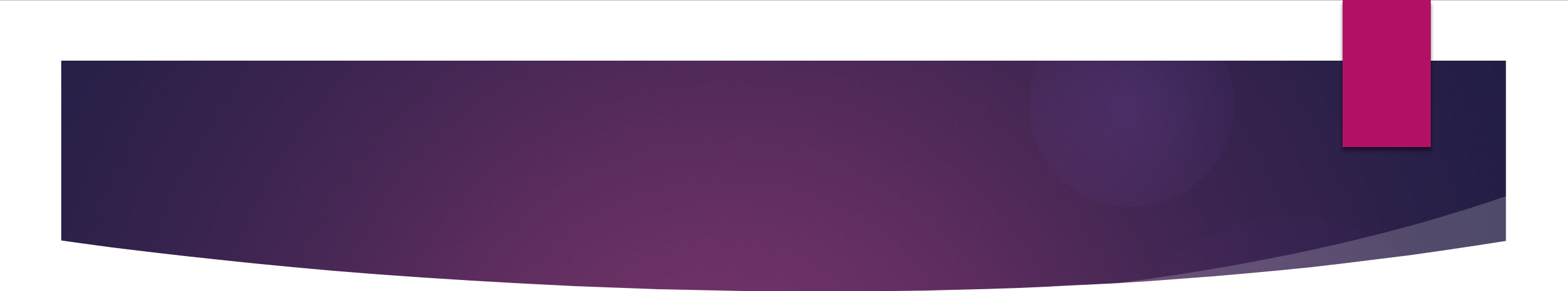


The New York Times

GLOBAL HEALTH

Cholera Deaths Soar Worldwide Despite Being Easily Preventable

Fatalities spiked 71 percent last year, far outpacing the 13 percent rise in cases, the World Health Organization said.

- 
- ▶ Cholera is easy to prevent and costs just pennies to treat, but huge outbreaks have swamped even well-prepared health systems in countries that had not confronted the disease in years.
 - ▶ Much of the increase was driven by conflict and climate change, the W.H.O. report said.
 - ▶ “It reflects the world’s lack of interest in a disease that has plagued humans for thousands of years, afflicting the poorest people who cannot find clean water to drink,”