# Introduction to Infectious Diseases in a Global Health Setting

UChicago Center in Paris

Paris, France

January 2025

# Goals for this lecture

- To explain what we're doing here

# Goals for this lecture

- To explain what we're doing here
- To introduce global health

# Goals for this lecture

- To explain what we're doing here
- To introduce global health
- To introduce infectious disease

# Goals for this lecture

- To explain what we're doing here
- To introduce global health
- To introduce infectious disease
- To introduce methods for the study of infectious diseases

# Goals for this lecture

- To explain what we're doing here
- To introduce global health
- To introduce infectious disease
- To introduce methods for the study of infectious diseases

# What is global health?

# What is global health?

- the health of the populations in the worldwide context (WHO 2006)

# What is global health?

- the health of the populations in the worldwide context (WHO 2006)
- an area of study, research, and practice that places a priority on improving health and achieving equity in health for all people worldwide

# What is global health?

- the health of the populations in the worldwide context (WHO 2006)
- an area of study, research, and practice that places a priority on improving health and achieving equity in health for all people worldwide
- focus on problems that transcend national borders or have a global political and economic impact are often emphasized (reduction of disparities, protection against global threats)
  - e.g. COVID (vaccination), polio eradication

# What is global health?

- the health of the populations in the worldwide context (WHO 2006)
- an area of study, research, and practice that places a priority on improving health and achieving equity in health for all people worldwide
- focus on problems that transcend national borders or have a global political and economic impact are often emphasized (reduction of disparities, protection against global threats)
  - e.g. COVID (vaccination), polio eradication
- Different from international health, the branch of public health focused on foreign aid efforts led by high income countries to improve health improve health in low- and middle-income countries (LMICs)

# What are the major threats to global health?

(e.g. globally, the leading causes of death)

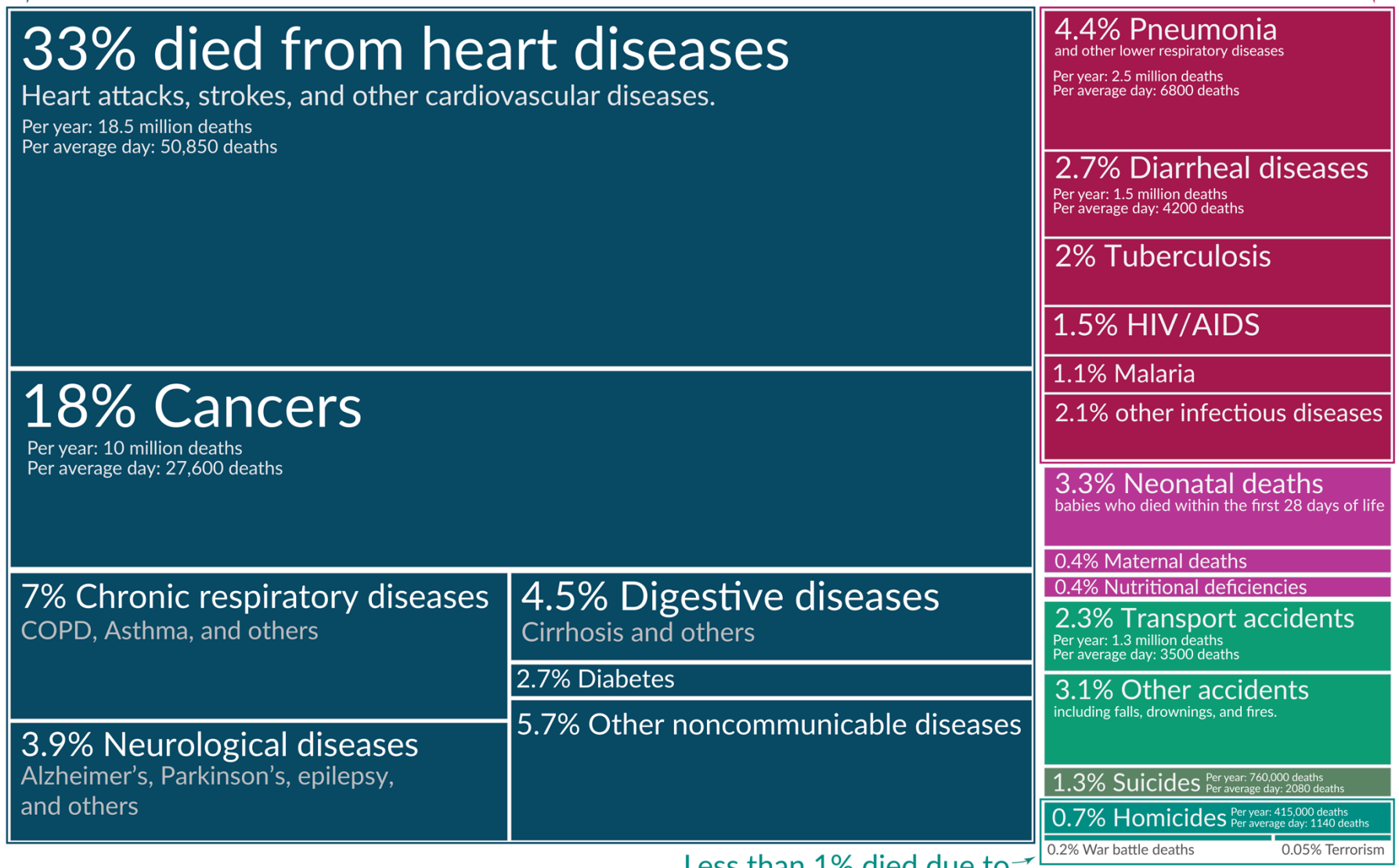
# What do people die from? Causes of death globally in 2019

The size of the entire visualization represents the total number of deaths in 2019: 55 million.
Each rectangle within it is proportional to the share of deaths due to a particular cause.

Our World in Data

74% died from noncommunicable diseases

14% died from infectious diseases




Less than 1% died due to interpersonal violence

Data source: IHME Global Burden of Disease and Global Terrorism Database
OurWorldinData.org – Research and data to make progress against the world's largest problems.

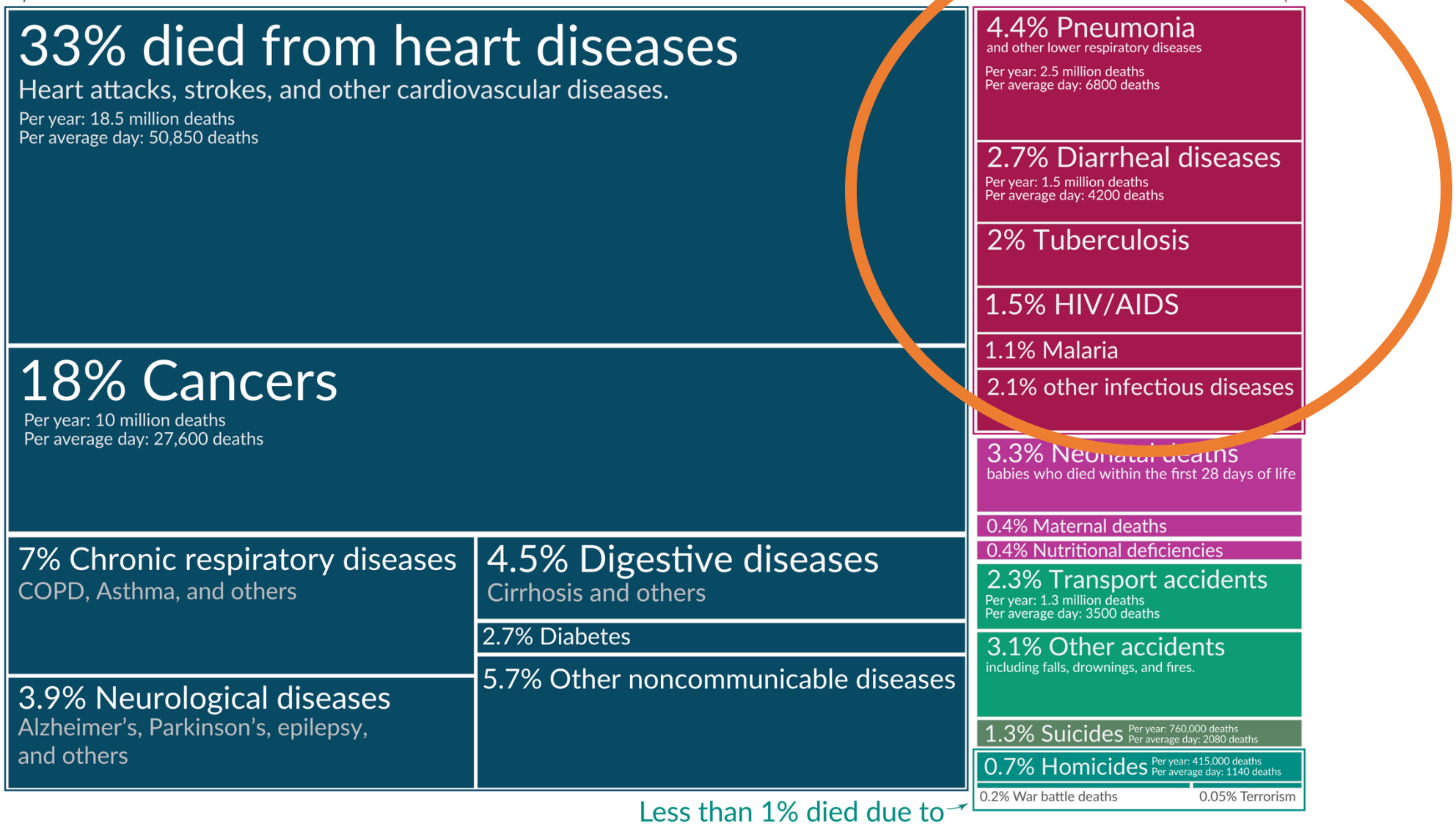
# What do people die from? Causes of death globally in 2019

The size of the entire visualization represents the total number of deaths in 2019: 55 million.
Each rectangle within it is proportional to the share of deaths due to a particular cause.

Our World in Data

74% died from noncommunicable diseases

14% died from infectious diseases




Less than 1% died due to interpersonal violence

Data source: IHME Global Burden of Disease and Global Terrorism Database

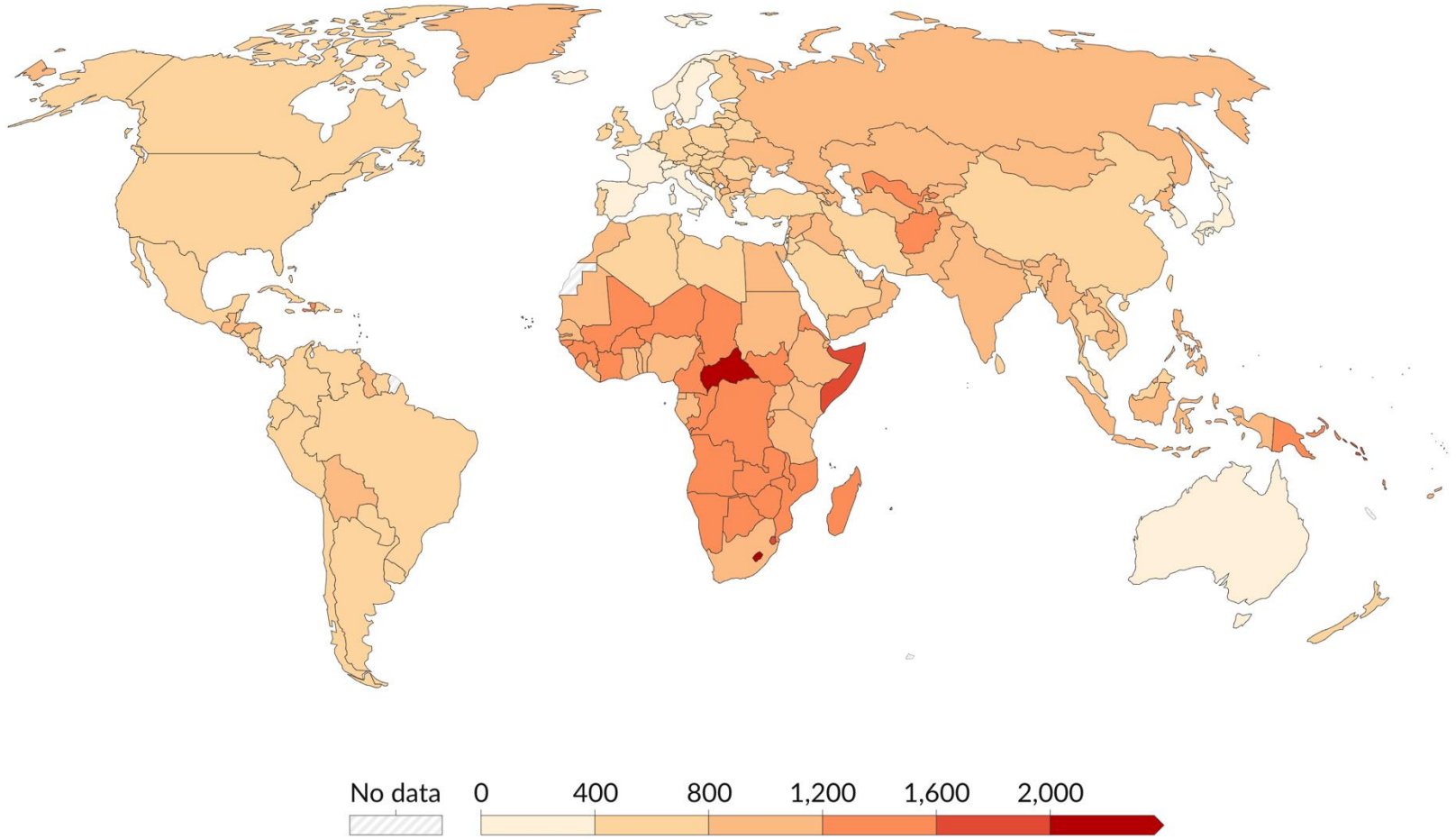
OurWorldinData.org – Research and data to make progress against the world's largest problems.

# Global death rates are far from equitable.

## Annual death rate from all causes, 2019

The estimated annual death rate from all causes per 100,000 people.

Our World in Data




**Data source:** IHME, Global Burden of Disease (2019)

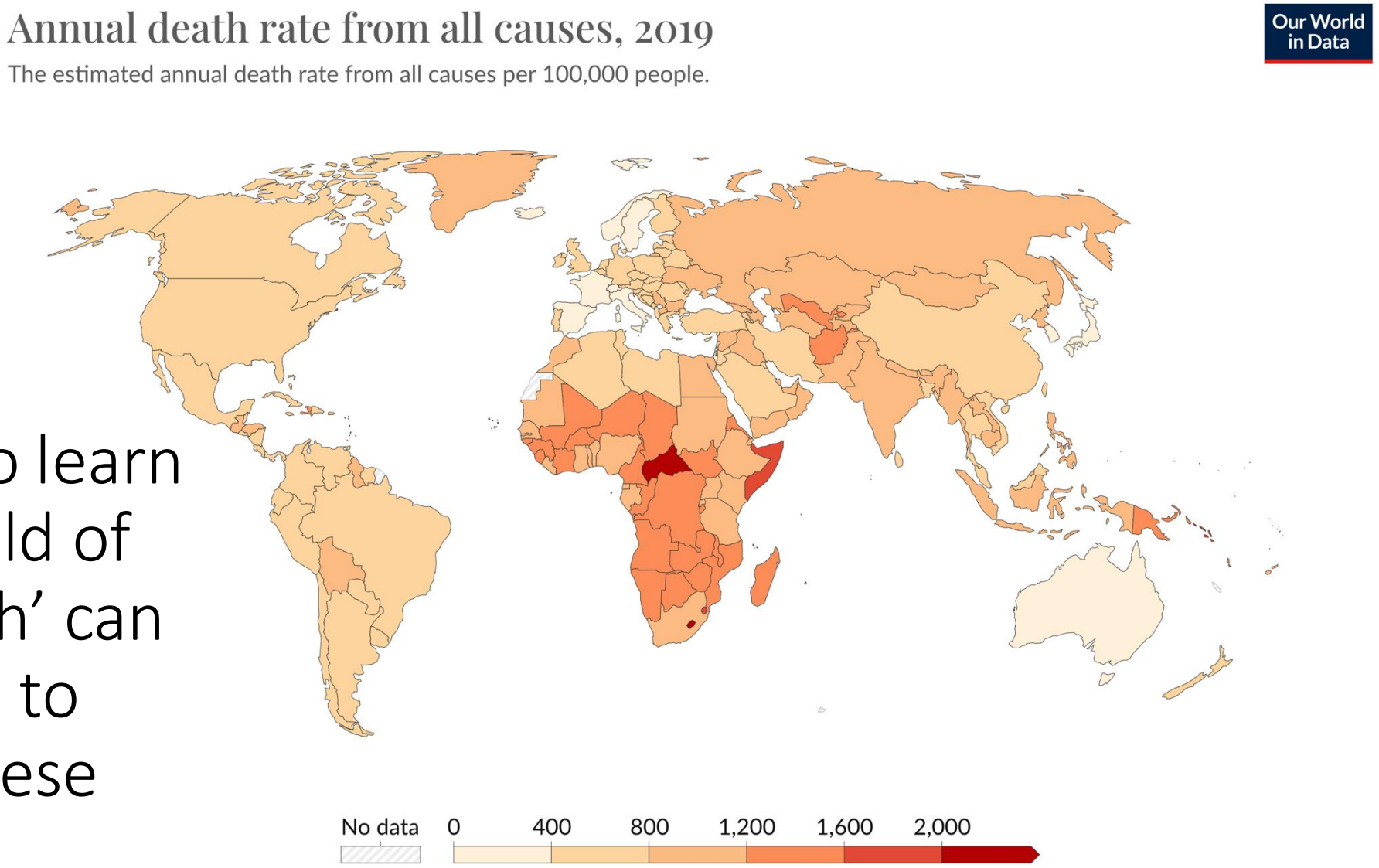
OurWorldInData.org/causes-of-death | CC BY

**Note:** To allow for comparisons between countries and over time, this metric is age-standardized[1].

**1. Age standardization**: Age standardization is an adjustment that makes it possible to compare populations with different age structures by standardizing them to a common reference population. Read more: How does age standardization make health metrics comparable?

Global death rates are far from equitable.

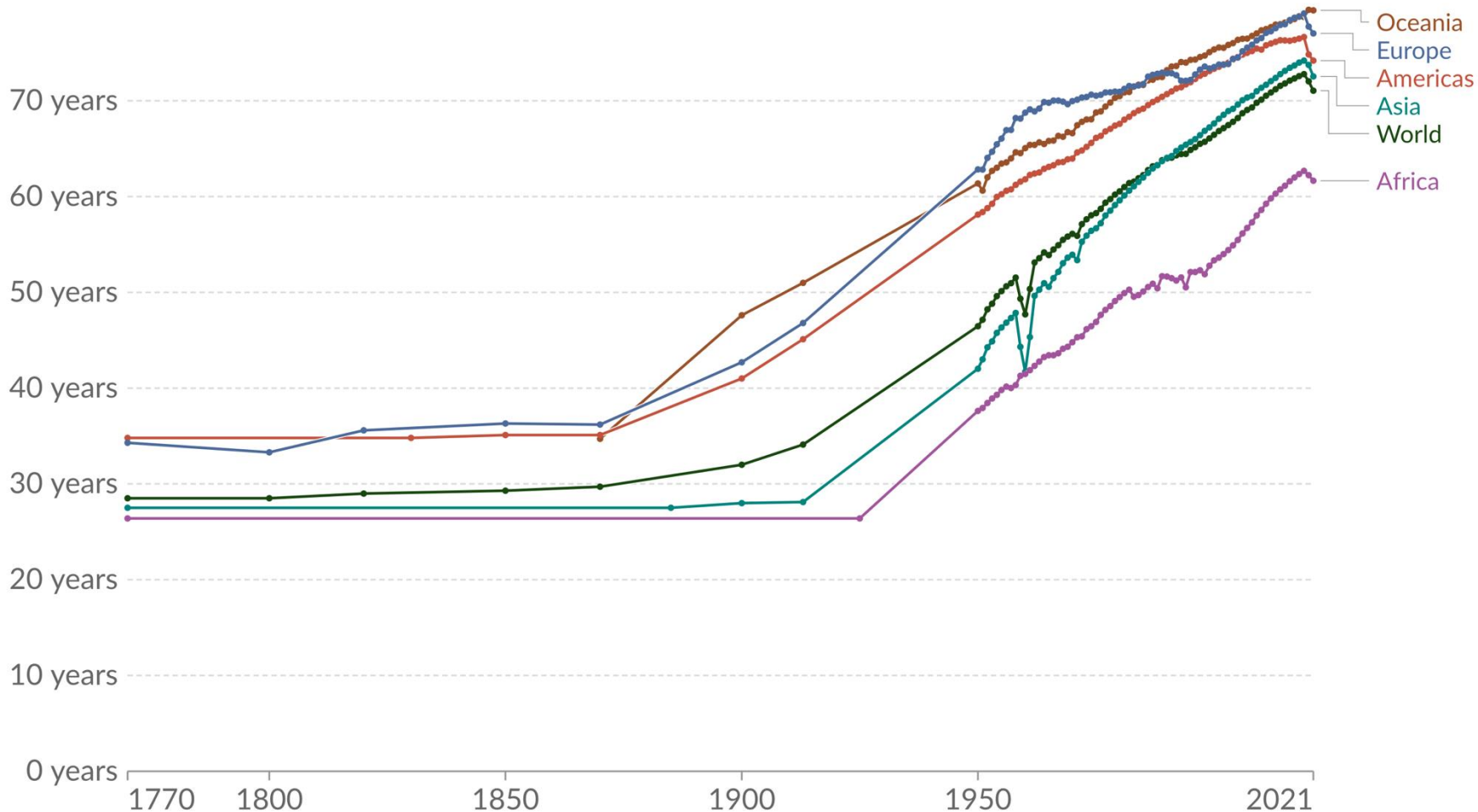
We're here to learn how the field of 'global health' can intervene to reverse these trends.



# Life expectancy

The period life expectancy[1] 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?

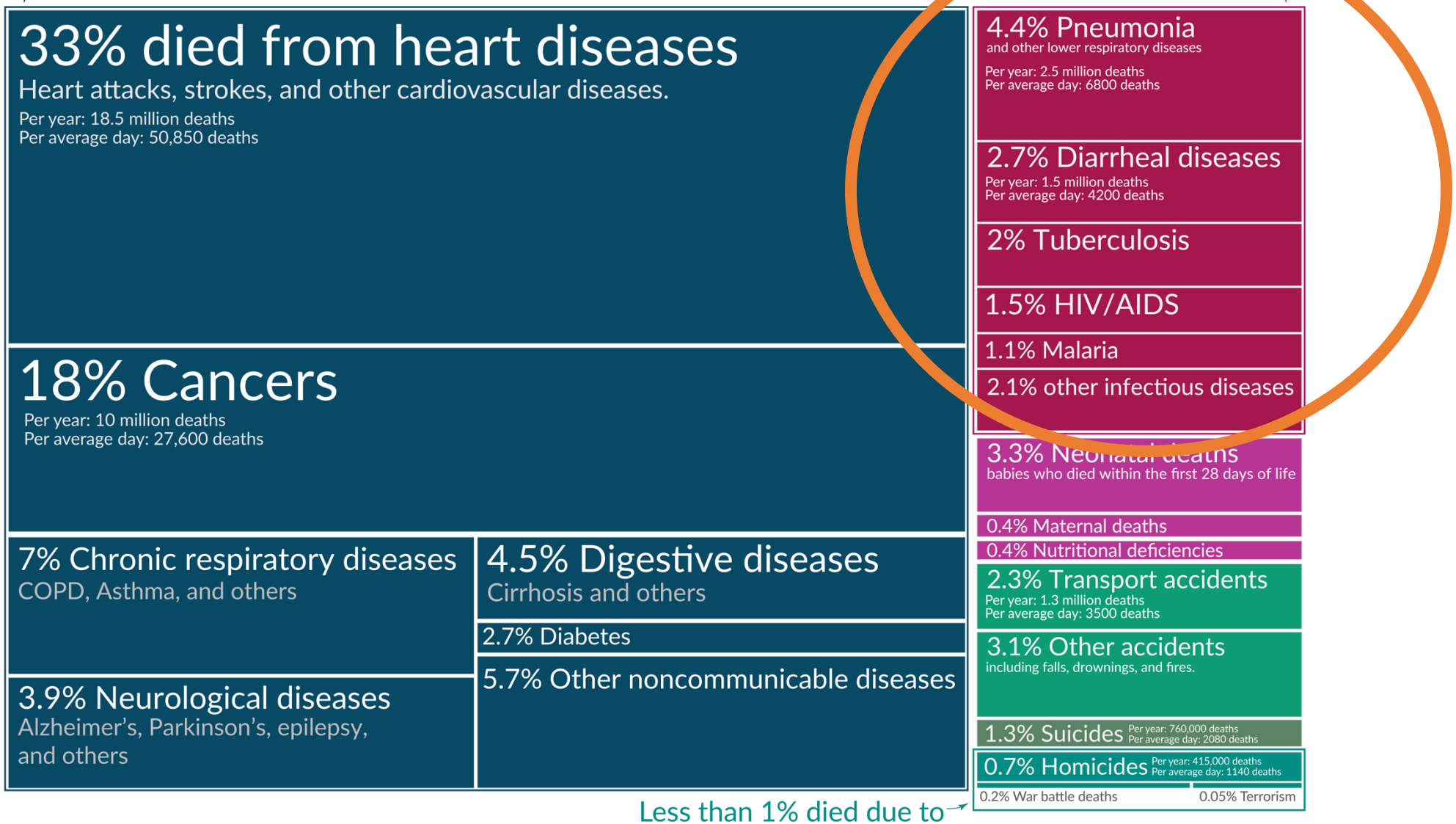
# What do people die from? Causes of death globally in 2019

The size of the entire visualization represents the total number of deaths in 2019: 55 million.
Each rectangle within it is proportional to the share of deaths due to a particular cause.

Our World in Data

74% died from noncommunicable diseases

14% died from infectious diseases

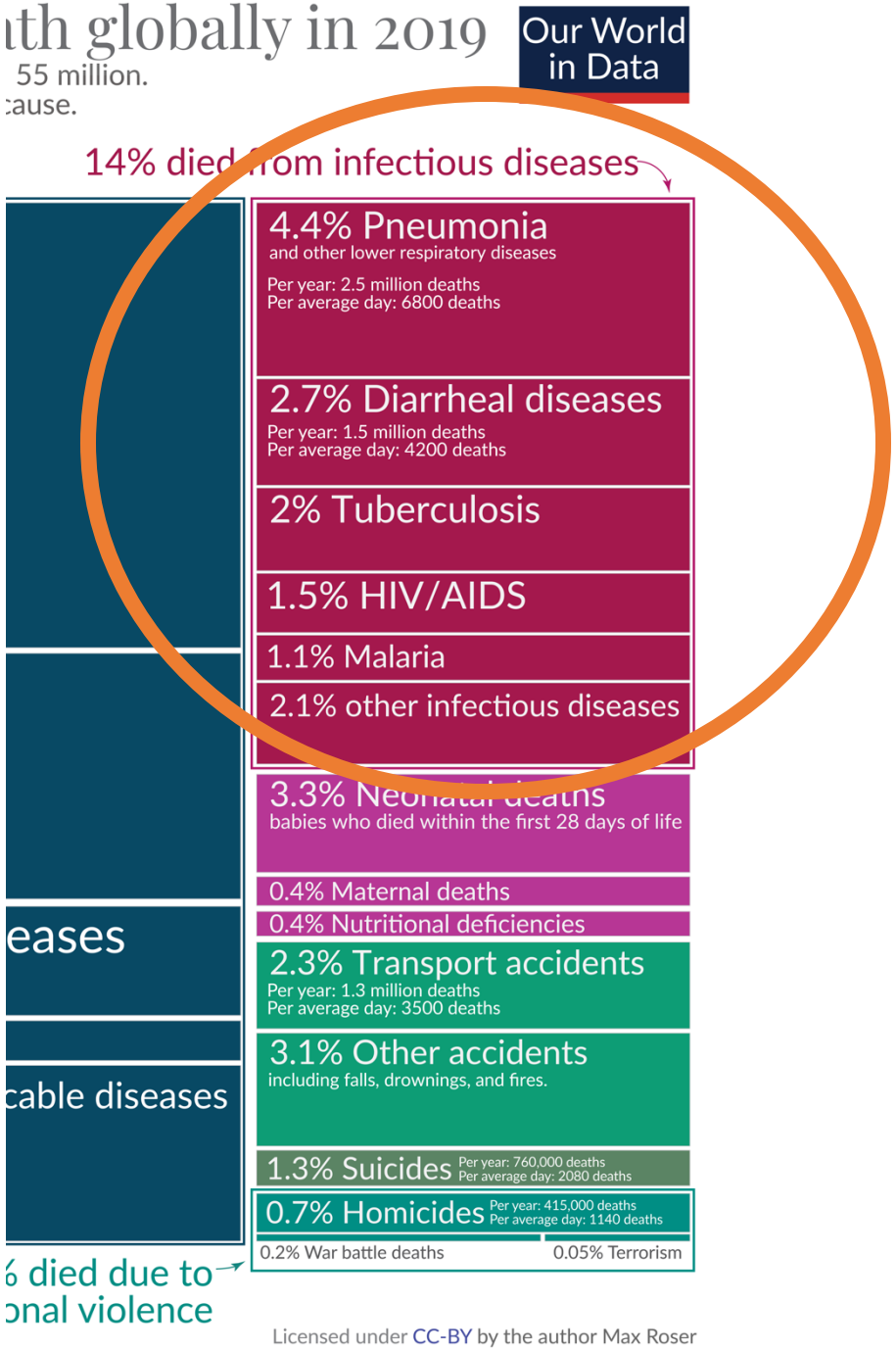


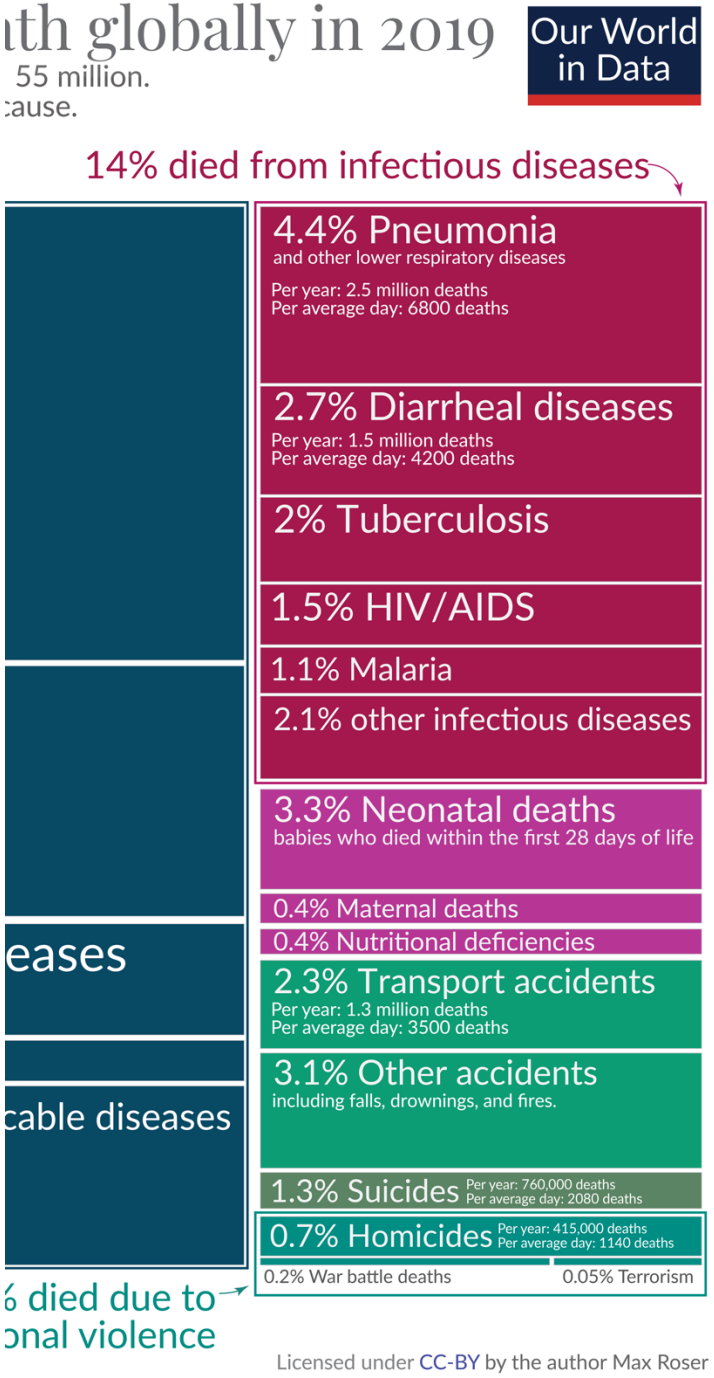

Less than 1% died due to interpersonal violence

Data source: IHME Global Burden of Disease and Global Terrorism Database

OurWorldinData.org – Research and data to make progress against the world's largest problems.

# BIOS27815:
# Infectious Diseases



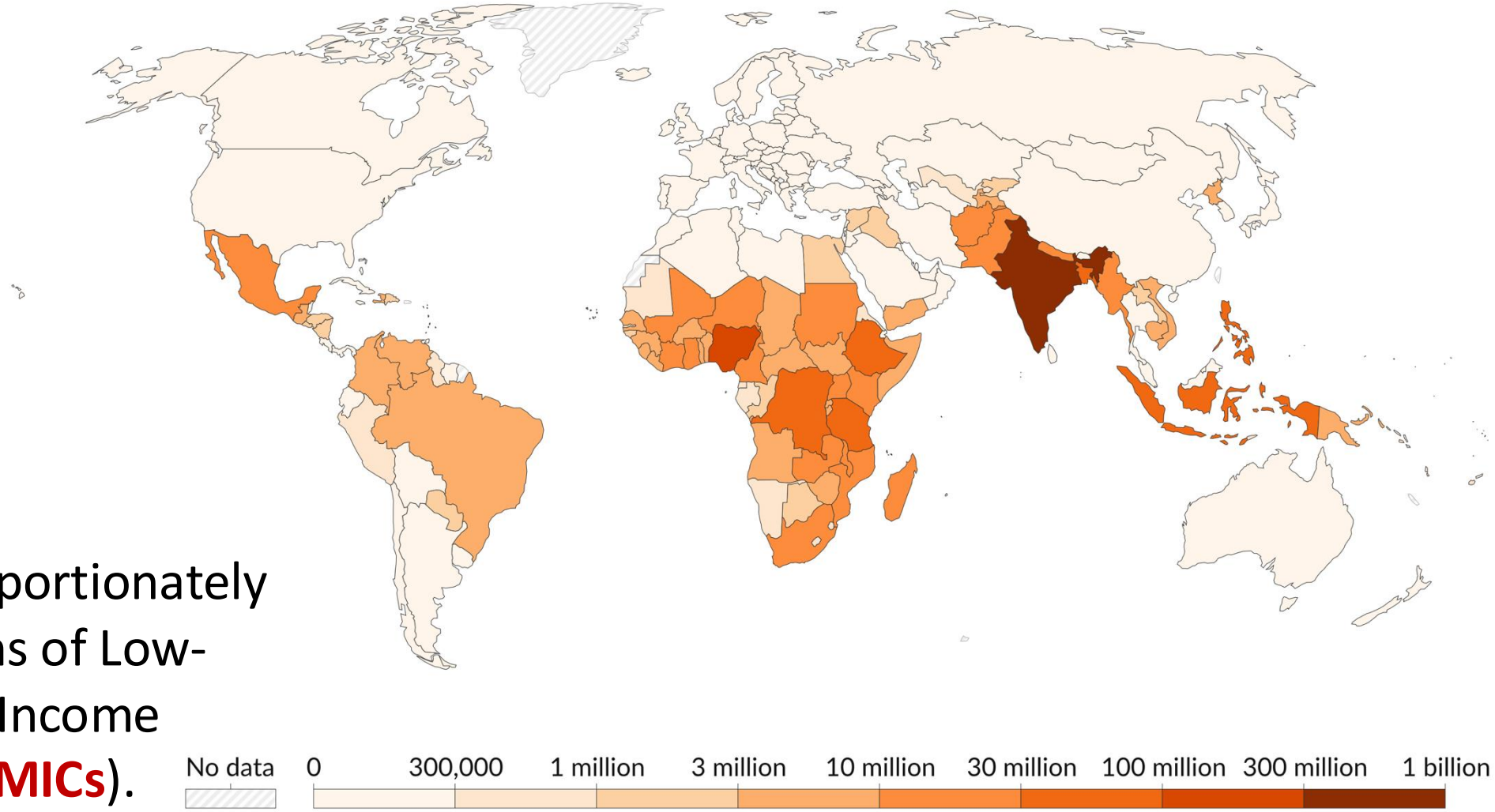



- The '**Big Three**' (**malaria, TB,** and **HIV**) are the three top single infectious disease killers globally, accounting for >2.7 million annual deaths.
- They disproportionately affect citizens of Low- and Middle-Income Countries (**LMICs**).
- They receive the bulk of US and international global health funding, including through **The Global Fund**, a Geneva-based non-profit to fight HIV, TB, and malaria, with a ~$5 billion annual budget.

# Number of people requiring treatment against neglected tropical diseases, 2021

Our World in Data

Estimated number of people requiring medical treatment for neglected tropical diseases (NTDs)[1].

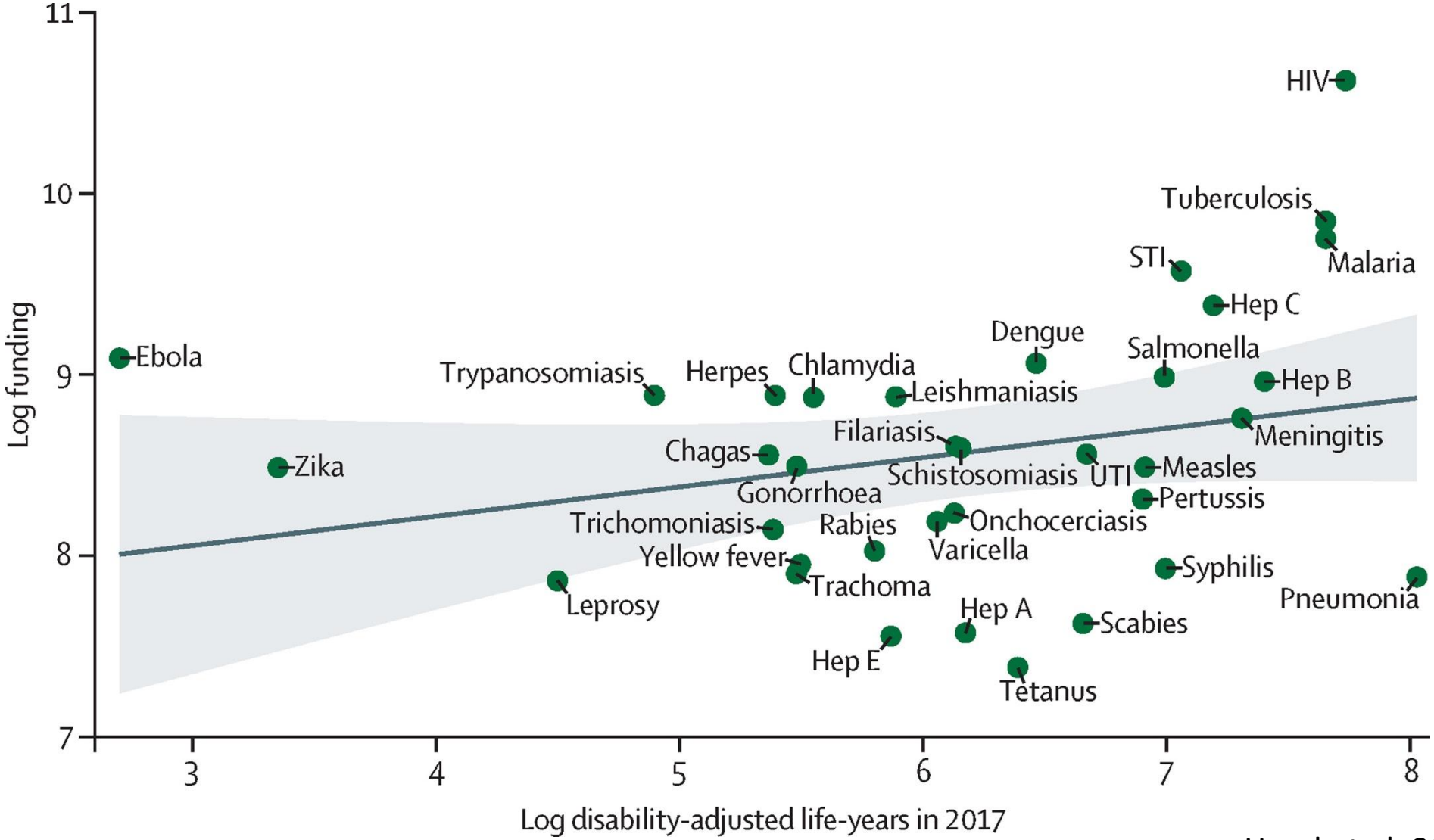



NTDs disproportionately affect citizens of Low- and Middle-Income Countries (**LMICs**).

**Data source:** World Health Organization - Global Health Observatory (2024)

OurWorldinData.org/burden-of-disease | CC BY

# The funding dominance of the '**Big Three**' means that **many** high burden infectious diseases are **neglected** every year.




*1 DALY = the loss of the equivalent of one year of full health*

Head et al. 2020. *The Lancet.*

# Neglected Tropical Diseases (NTDs).

- **NTDs** are diseases mainly prevalent among impoverished communities in tropical areas (though some have a larger geographical distribution) which are **under-resourced as compared to the Big Three**.
- NTDs affect more than 1 billion people globally
- **WHO recognizes 21 NTDs**:

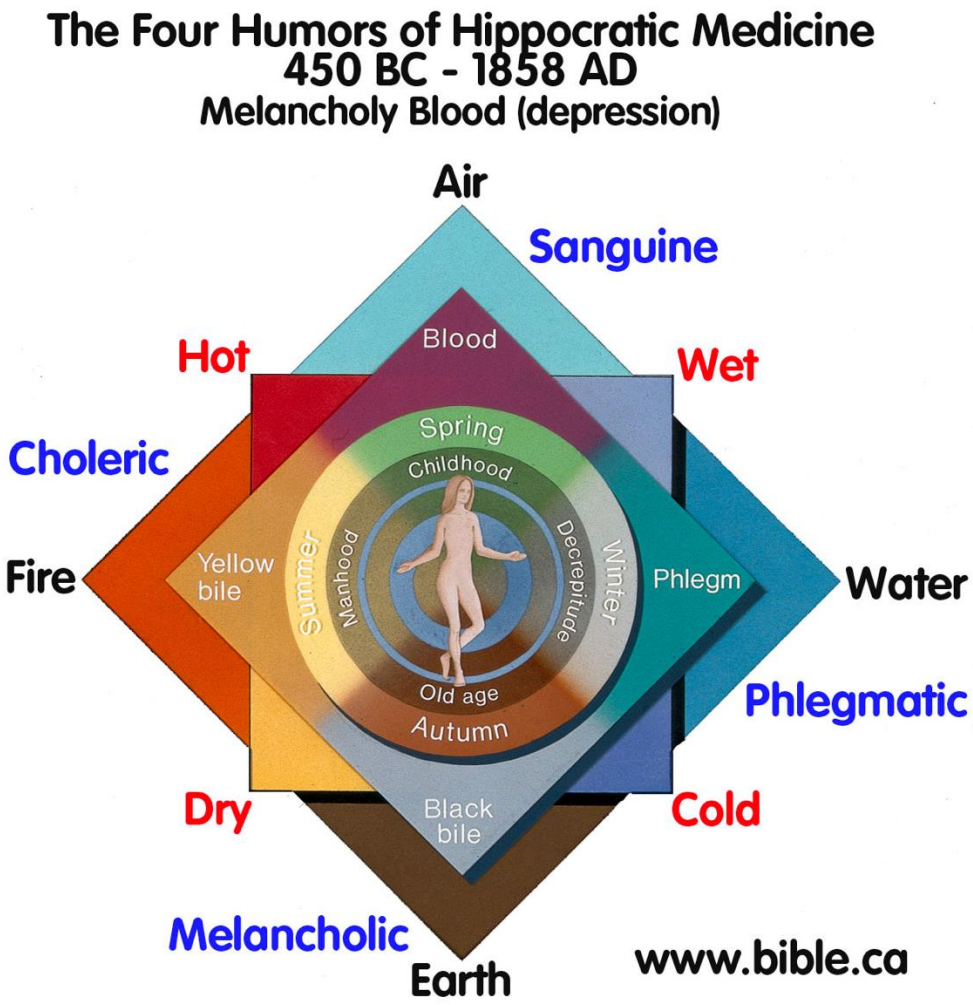
1. Buruli ulcer
2. Chagas disease
3. dengue and chikungunya
4. Dracunculiasis
5. echinococcosis
6. foodborne trematodiases
7. human African trypanosomiasis
8. leishmaniasis
9. leprosy
10. lymphatic filariasis
11. mycetoma, chromoblastomycosis
12. noma
13. onchocerciasis
14. rabies
15. scabies, ectoparasitoses
16. schistosomiasis
17. soil-transmitted helminthiases
18. snakebite envenoming
19. taeniasis/cysticercosis
20. trachoma
21. yaws

# Goals for this lecture

- To explain what we're doing here
- To introduce global health
- To introduce infectious disease
- To introduce methods for the study of infectious diseases

# What causes disease?
## *Perspectives through the ages*

1. **<u>Four Humors:</u>** Hippocrates (c. 400 BC) wrote that disease results from an imbalance of the four humors

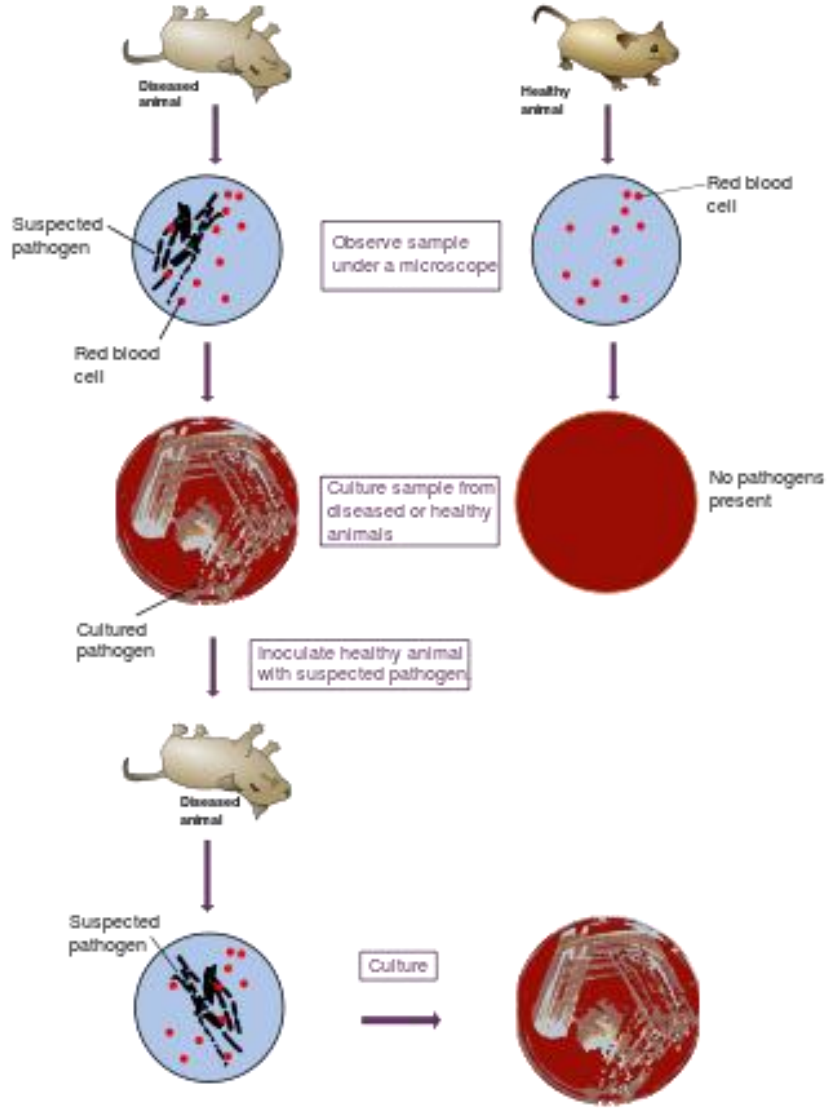


# What causes disease?
## *Perspectives through the ages*

1. **<u>Four Humors:</u>** Hippocrates (c. 400 BC) wrote that disease results from an imbalance of the four humors
2. **<u>Miasmatic Theory:</u>** Extension of Hippocrates that lasted through the 1800s – idea that disease was caused by bad air. Popularized by Florence Nightengale

# What causes disease?
## *Perspectives through the ages*

1. **<u>Four Humors:</u>** Hippocrates (c. 400 BC) wrote that disease results from an imbalance of the four humors
2. **<u>Miasmatic Theory:</u>** Extension of Hippocrates that lasted through the 1800s – idea that disease was caused by bad air.
   - Popularized by Florence Nightengale
3. **<u>Germ Theory of Disease:</u>** Idea that disease results from germs
   - Leuwenhoek's microscope (1675)
   - Koch's postulates (1890)

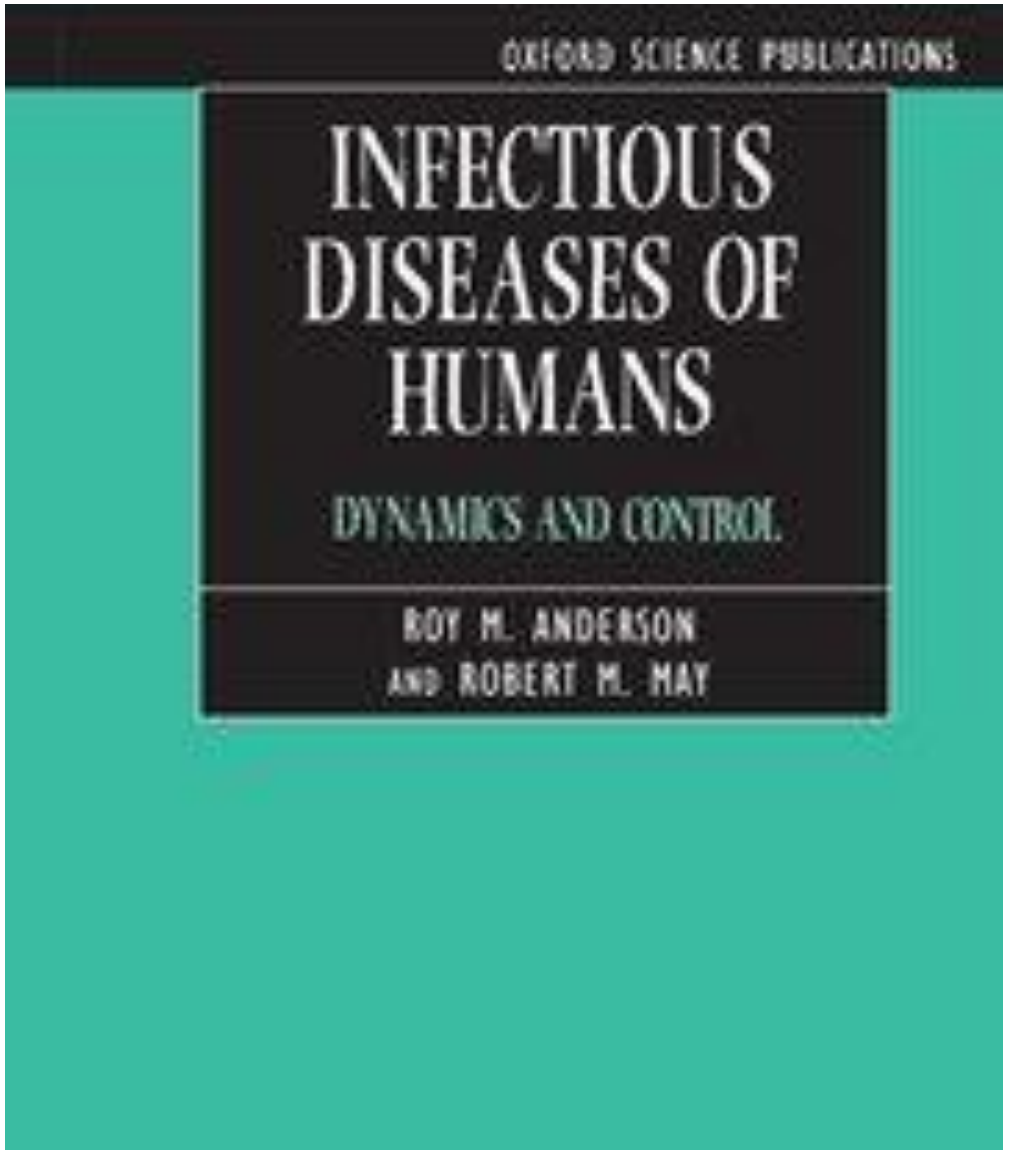


# What causes disease?
## *Perspectives through the ages*

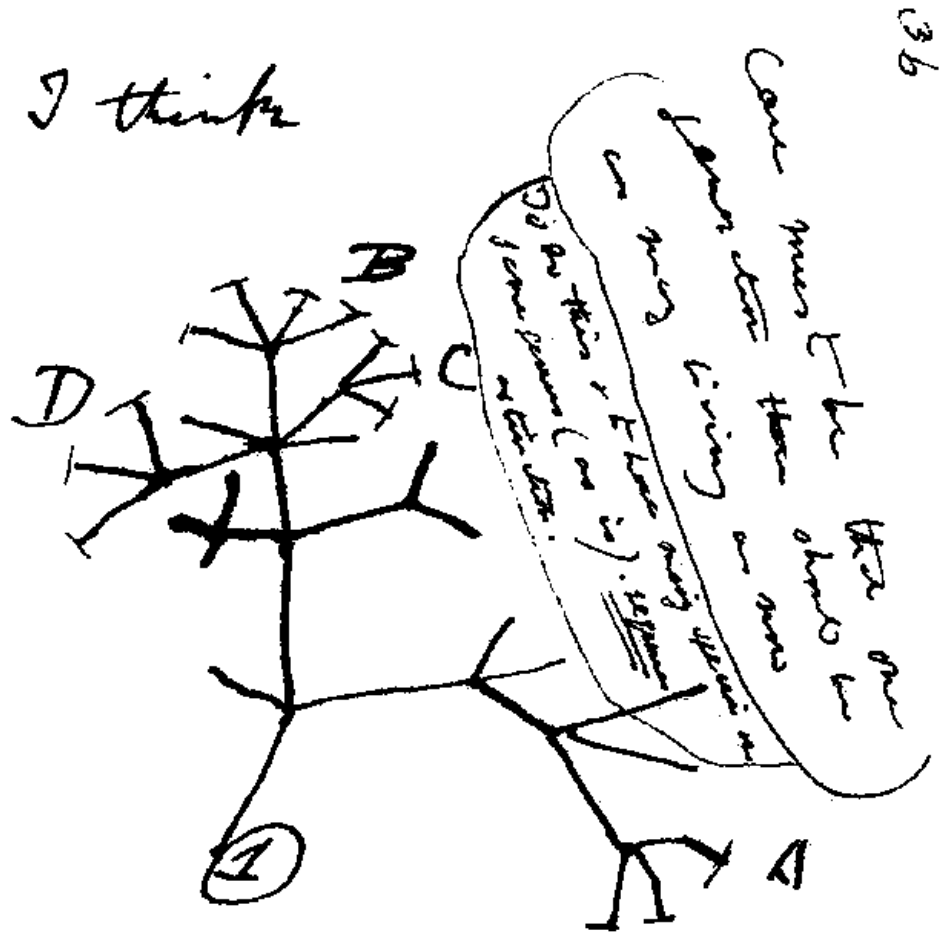
1. **<u>Four Humors:</u>** Hippocrates (c. 400 BC) wrote that disease results from an imbalance of the four humors
2. **<u>Miasmatic Theory:</u>** Extension of Hippocrates that lasted through the 1800s – idea that disease was caused by bad air.
   - Popularized by Florence Nightengale
3. **<u>Germ Theory of Disease:</u>** Idea that disease results from germs
   - Leuwenhoek's microscope (1675)
   - Koch's postulates (1890)
4. **<u>Classic epidemiology</u>**
   - Risk factors for disease = John Snow (1854)

# What causes disease? *Perspectives through the ages*

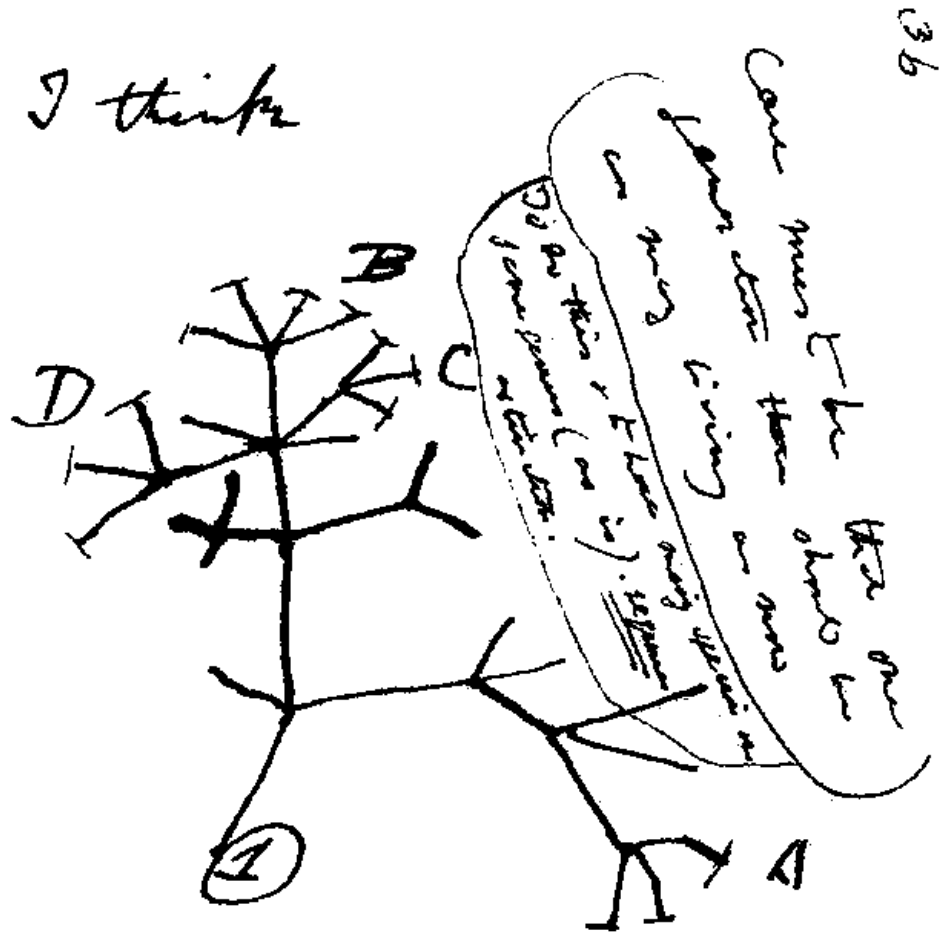
1. **Four Humors:** Hippocrates (c. 400 BC) wrote that disease results from an imbalance of the four humors
2. **Miasmatic Theory:** Extension of Hippocrates that lasted through the 1800s – idea that disease was caused by bad air.
   - Popularized by Florence Nightengale
3. **Germ Theory of Disease:** Idea that disease results from germs
   - Leuwenhoek's microscope (1675)
   - Koch's postulates (1890)
4. **Classic epidemiology**
   - Risk factors for disease = John Snow (1854)
5. **Population biology of infectious disease**
   - Understanding the *process* of infectious disease *transmission.* = Kermack and McKendrick (1927); Anderson and May (1991).



# What is this?

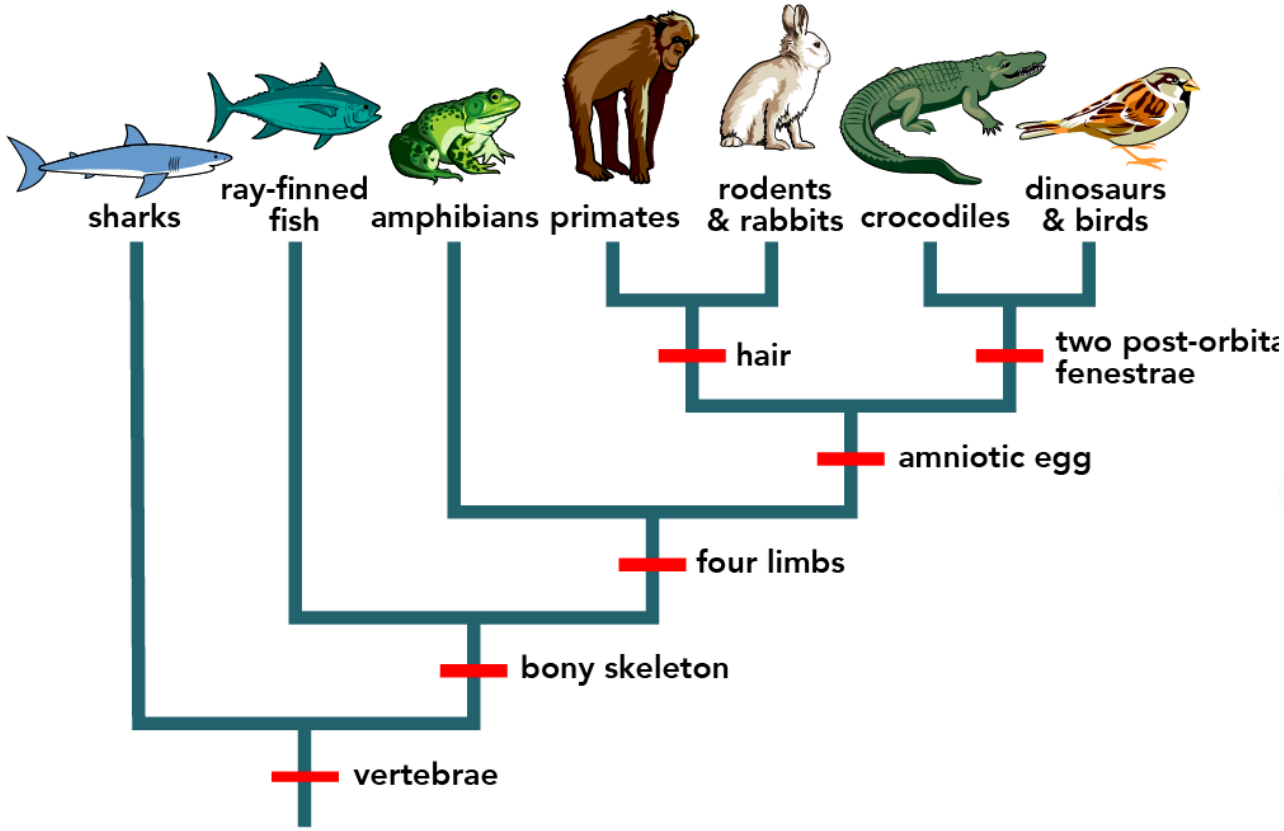


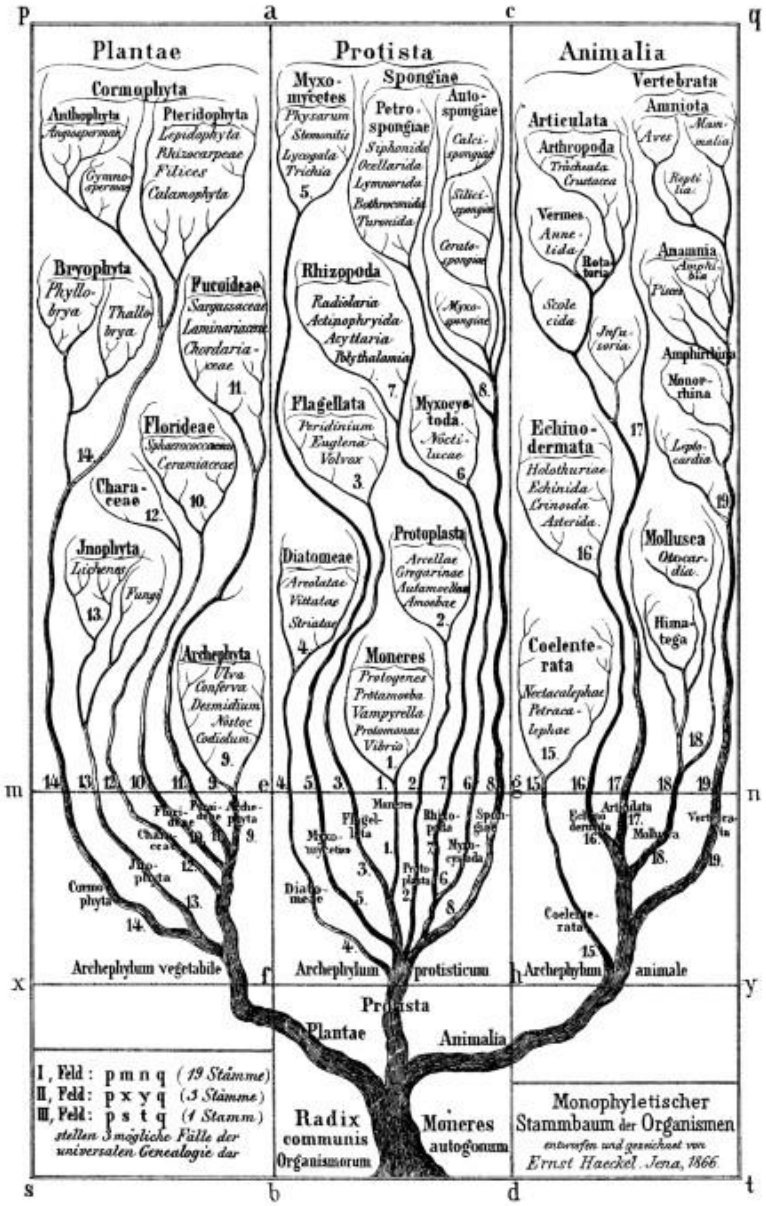
# What is this?




Charles Darwin's notes – world's first phylogenetic tree !

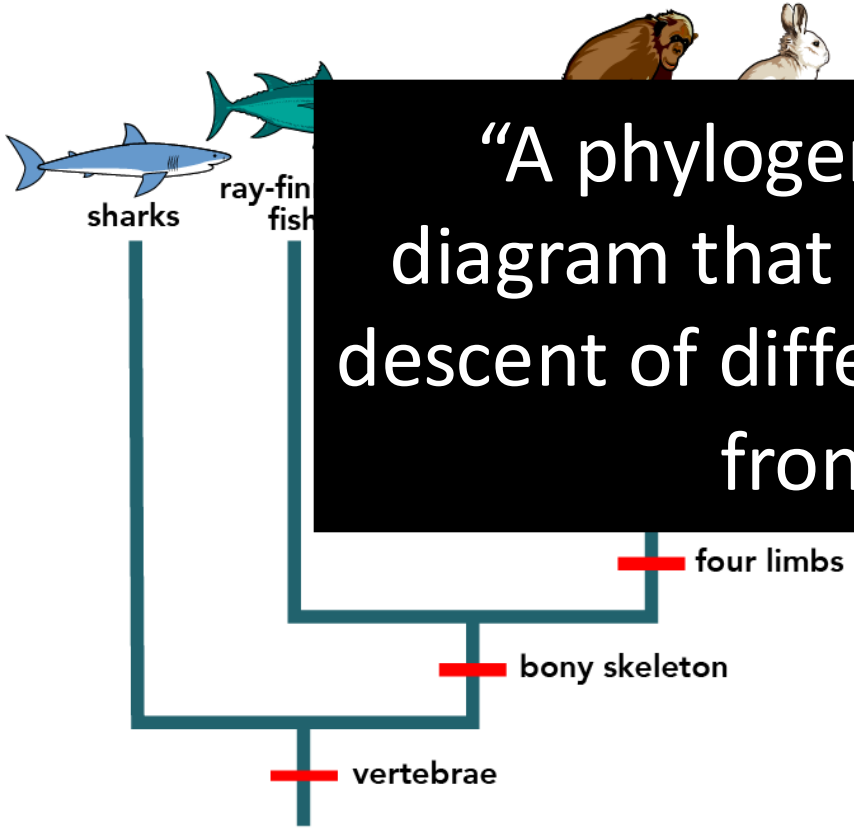
# What is a phylogeny?



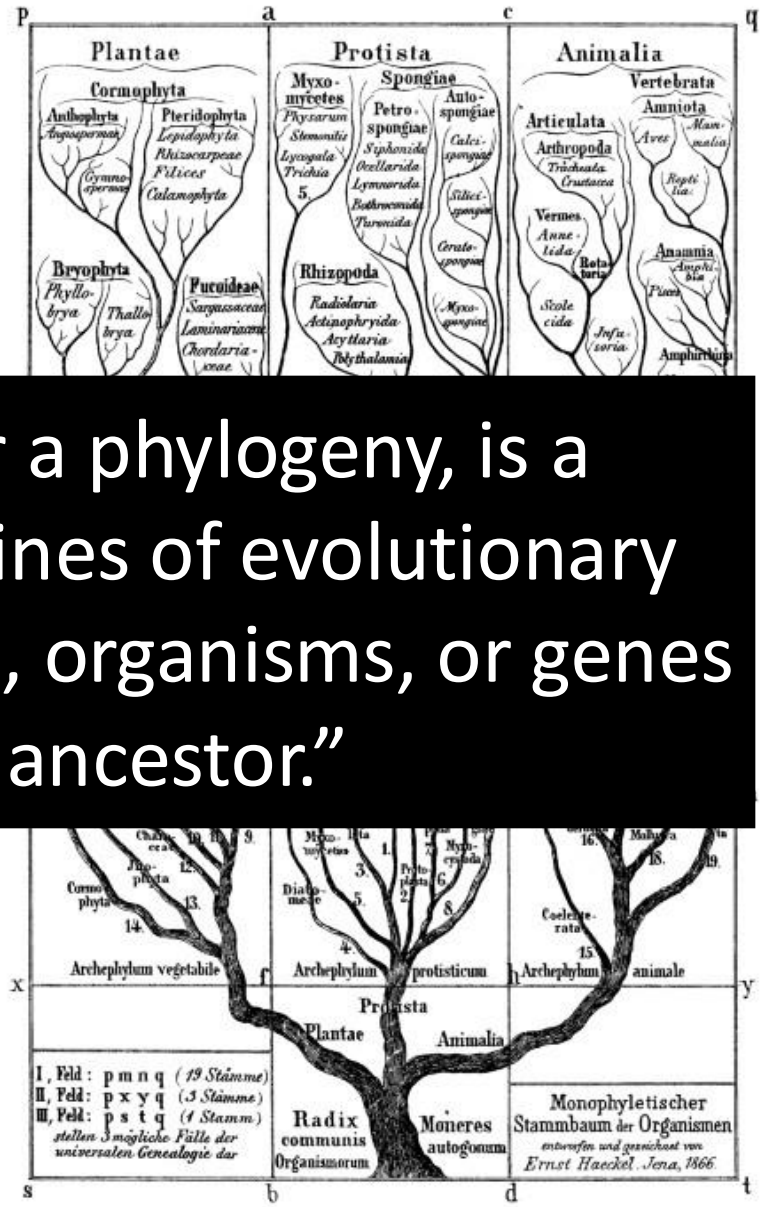




Baum et. al, Nature, 2008
Hossfeld and Levit, Nature, 2016

# What is a phylogeny?



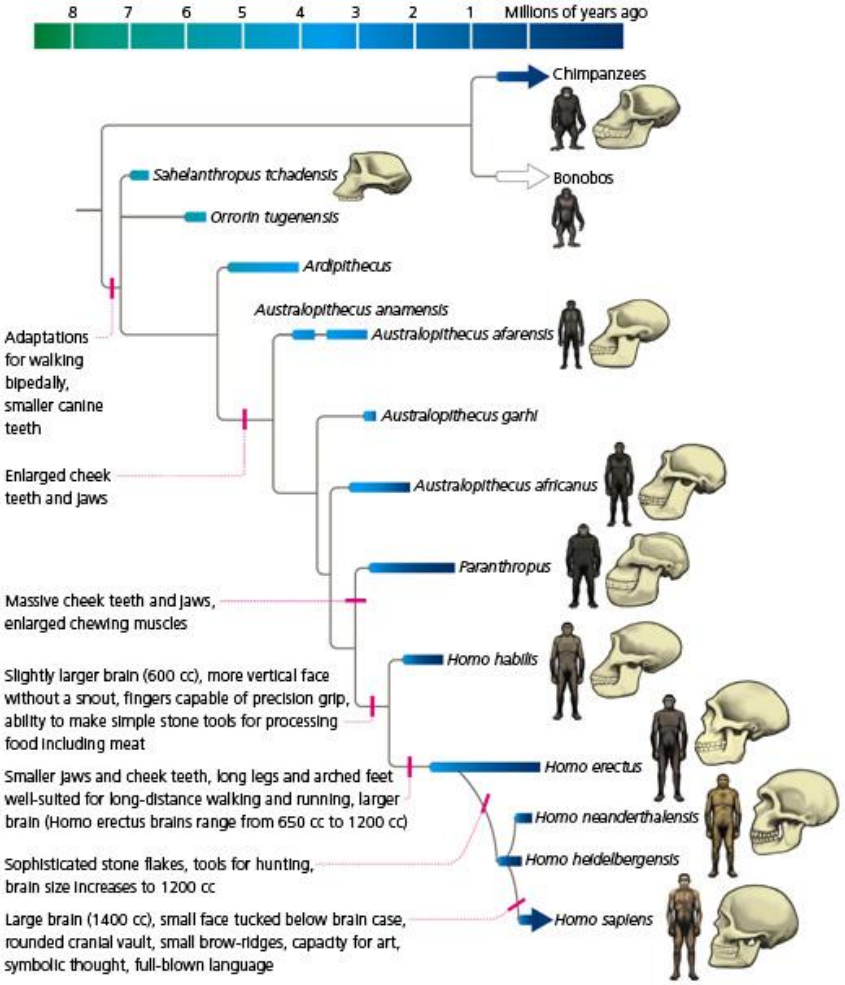

"A phylogenetic tree, or a phylogeny, is a diagram that depicts the lines of evolutionary descent of different species, organisms, or genes from a common ancestor."



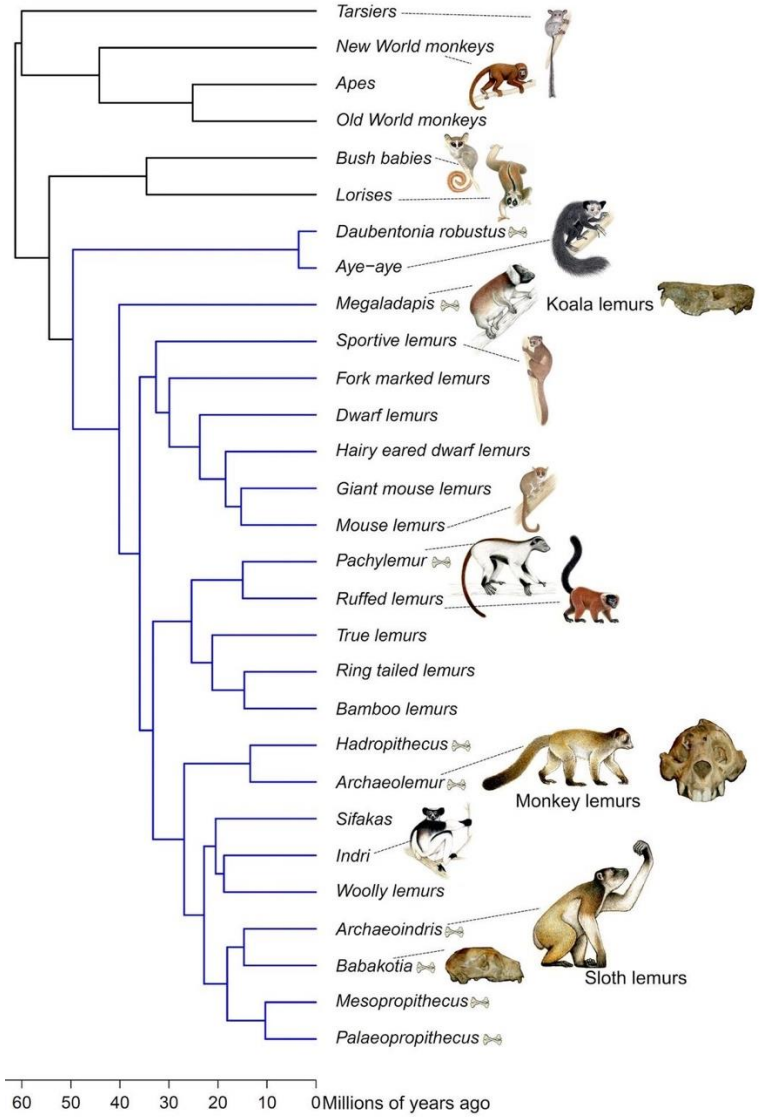

Baum et. al, Nature, 2008

Hossfeld and Levit, Nature, 2016

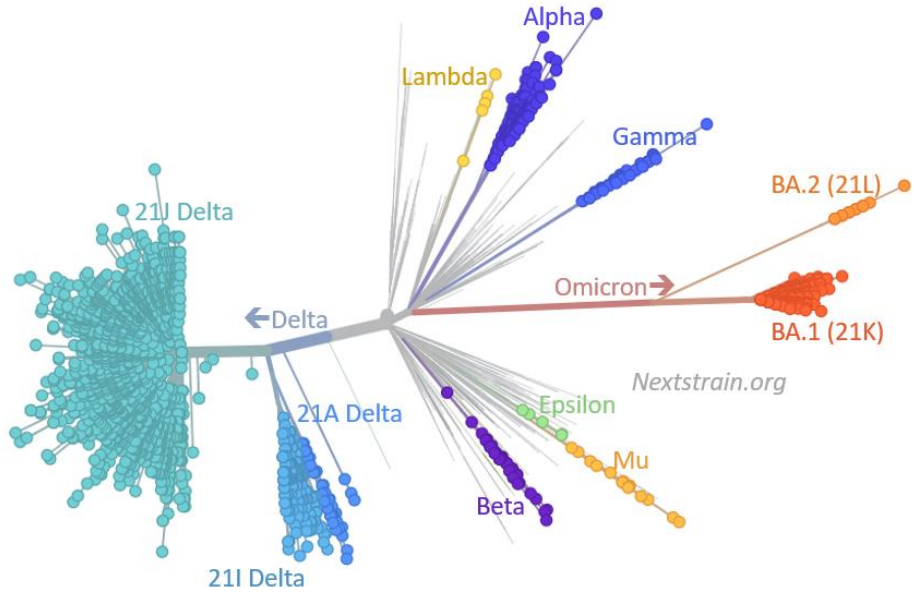
# What can you do with phylogenies?




UC Museum of Paleontology

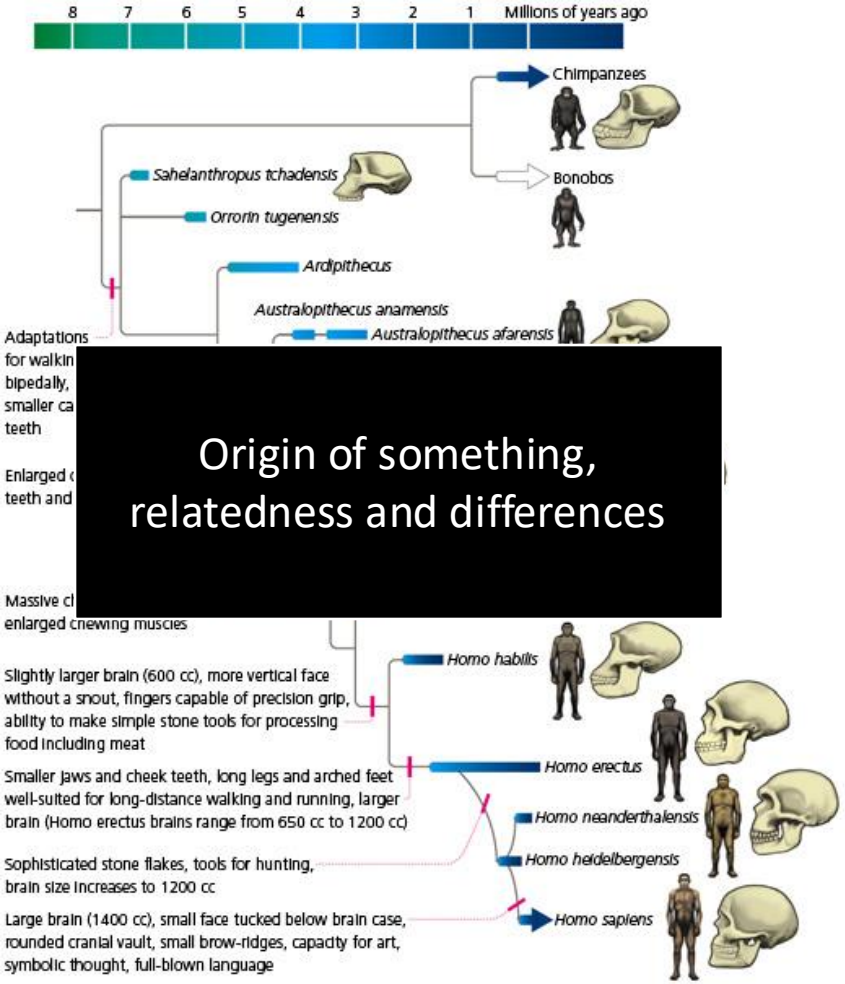



Herrera et al 2016

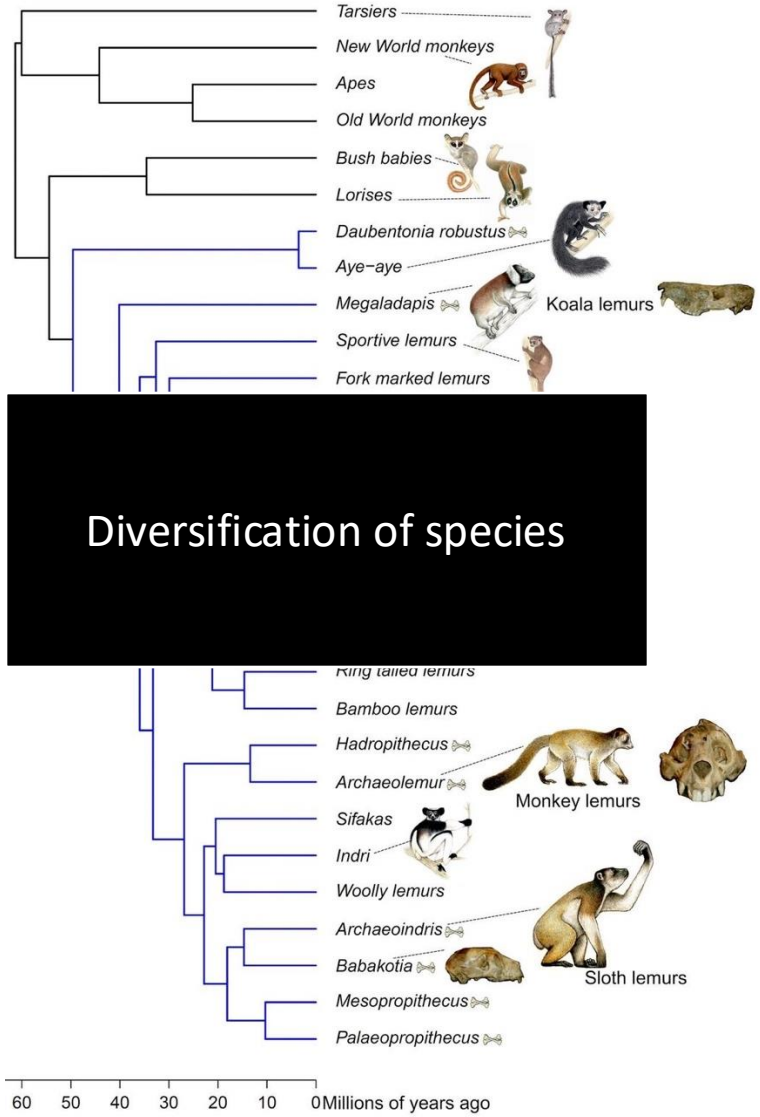



Lowe 2022

# What can you do with phylogenies?




Origin of something, relatedness and differences




Diversification of species

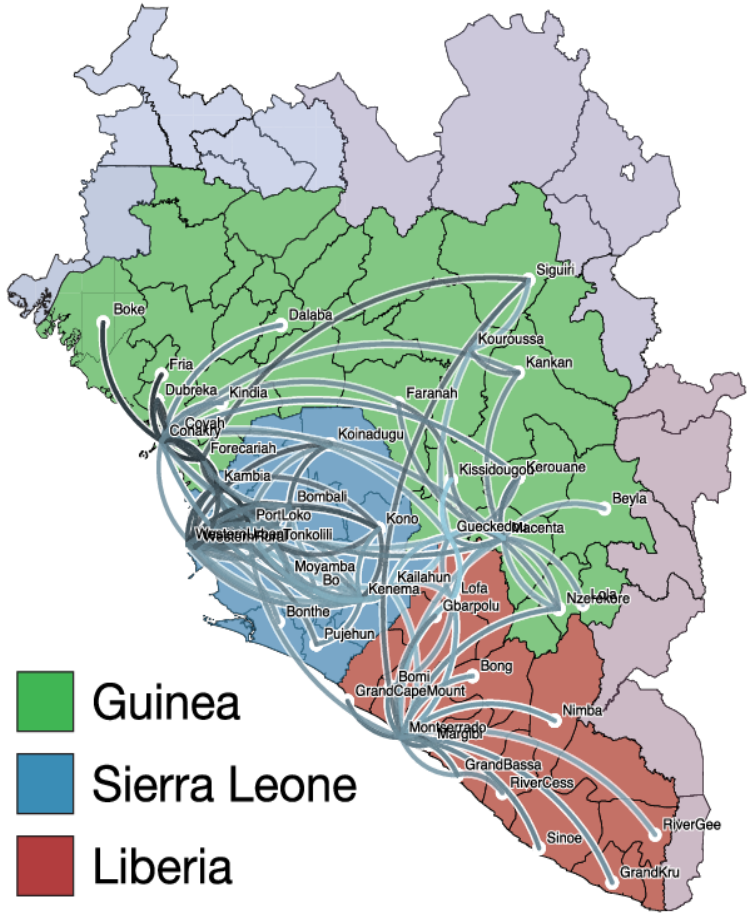

Changes in real time

UC Museum of Paleontology

Herrera et al 2016

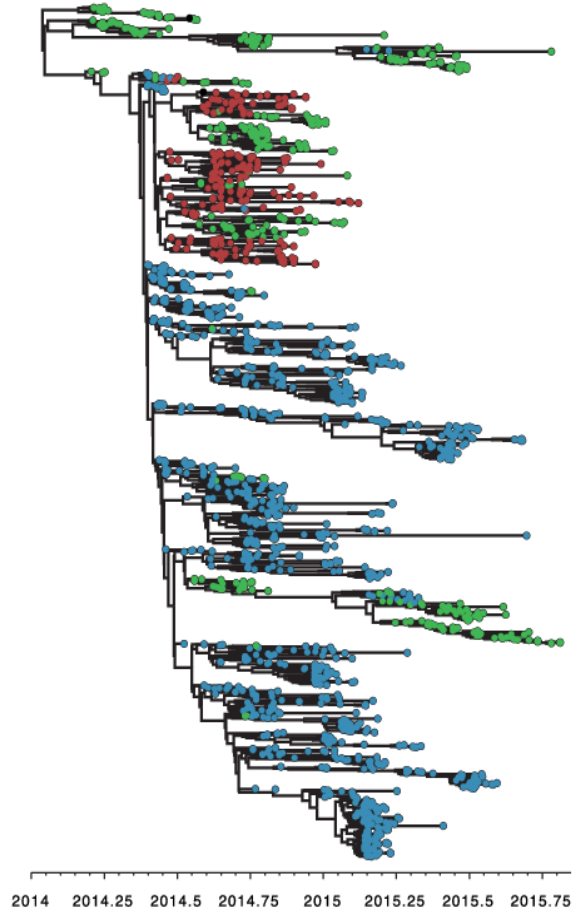
Lowe 2022

## Phylodynamics



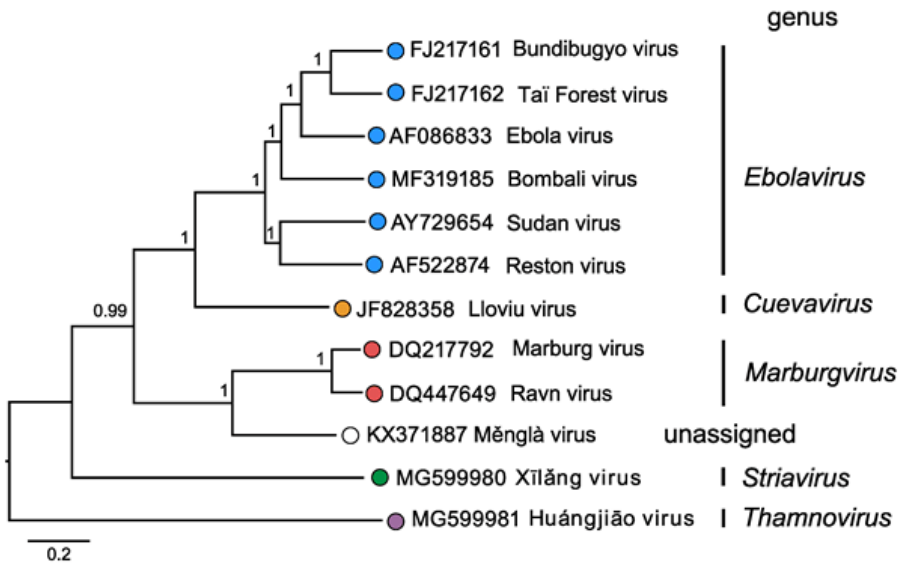

WHERE does it go?

## Bayesian trees




WHEN is the most recent common ancestor?

## Maximum likelihood

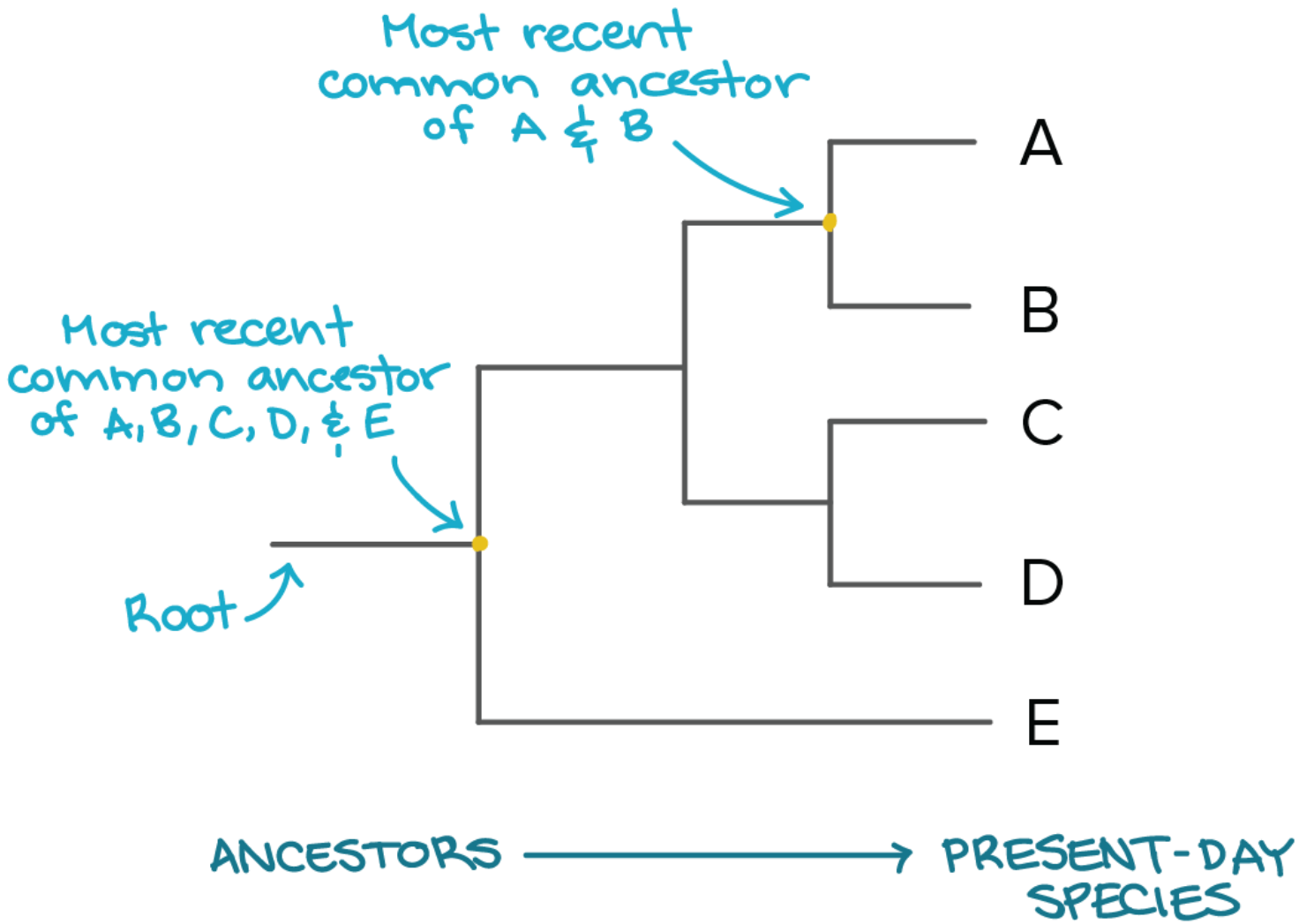



HOW different is it to what's known?

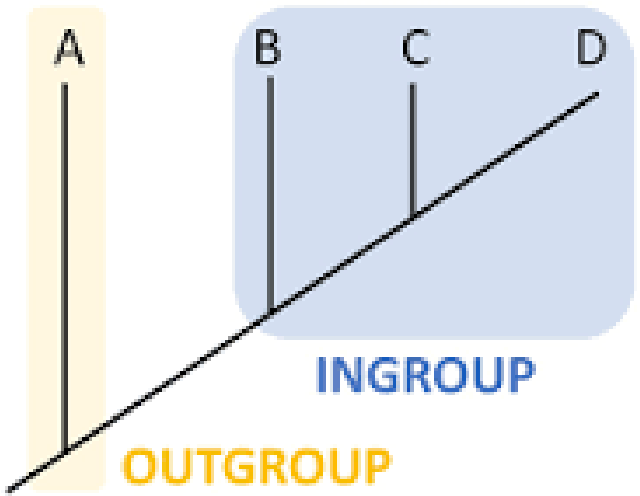
Changes in real time

Suchard et al. 2018
Kuhn et al. 2019

# CONFIDENCE




| BOOTSTRAP VALUE | |
|---|---|
| STRONGLY SUPPORTED | >90% |
| WELL SUPPORTED | 70%-90% |
| WEAKLY SUPPORTED | 50%-70% |
| NOT SUPPORTED | <50% |

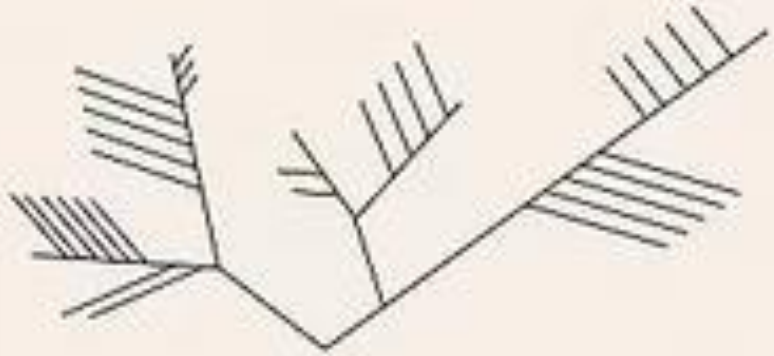


# CLADOGRAM

– the relationships are ***hypothetical***

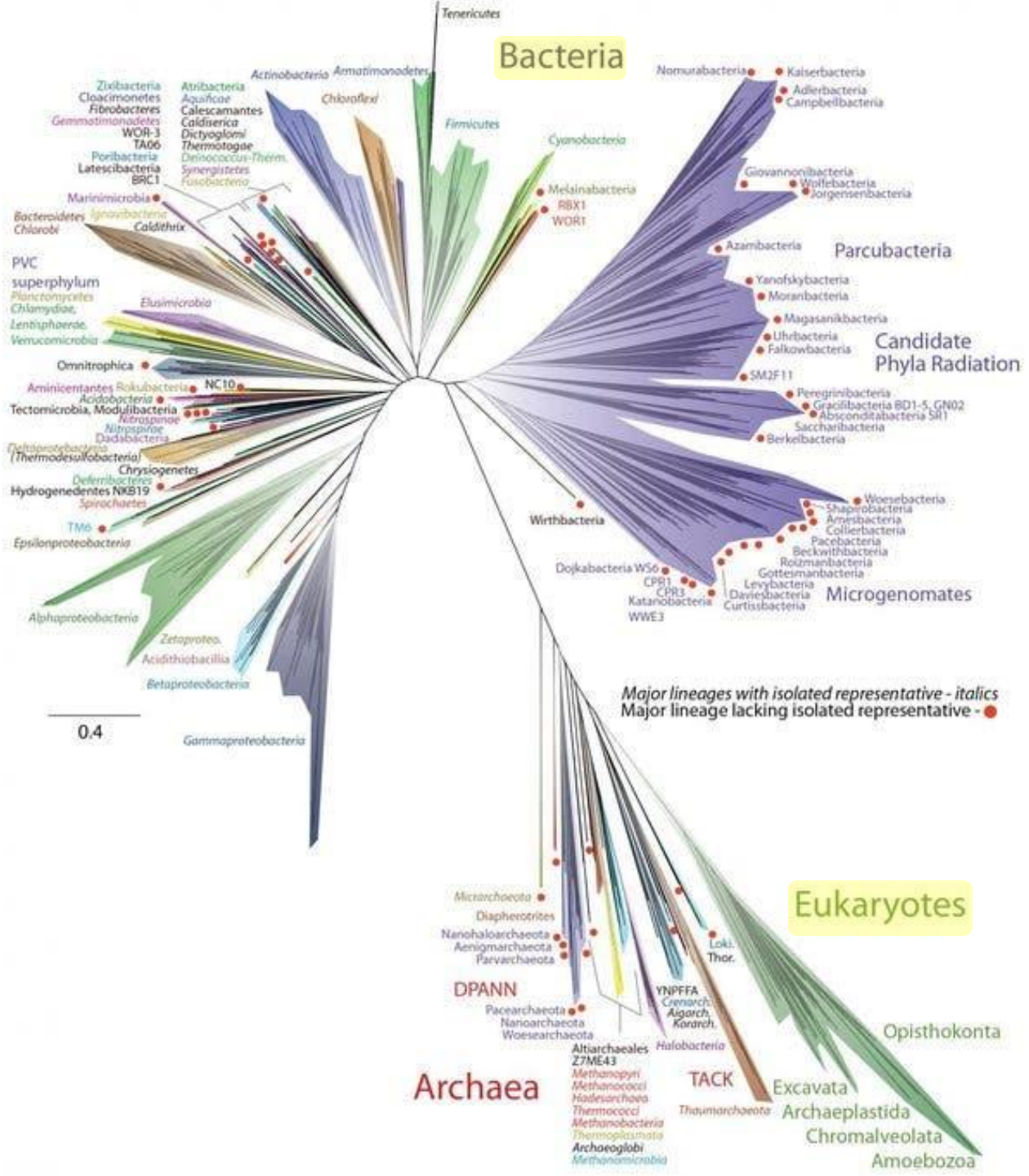
– you can easily make on your own

# PHYLOGENETIC TREE

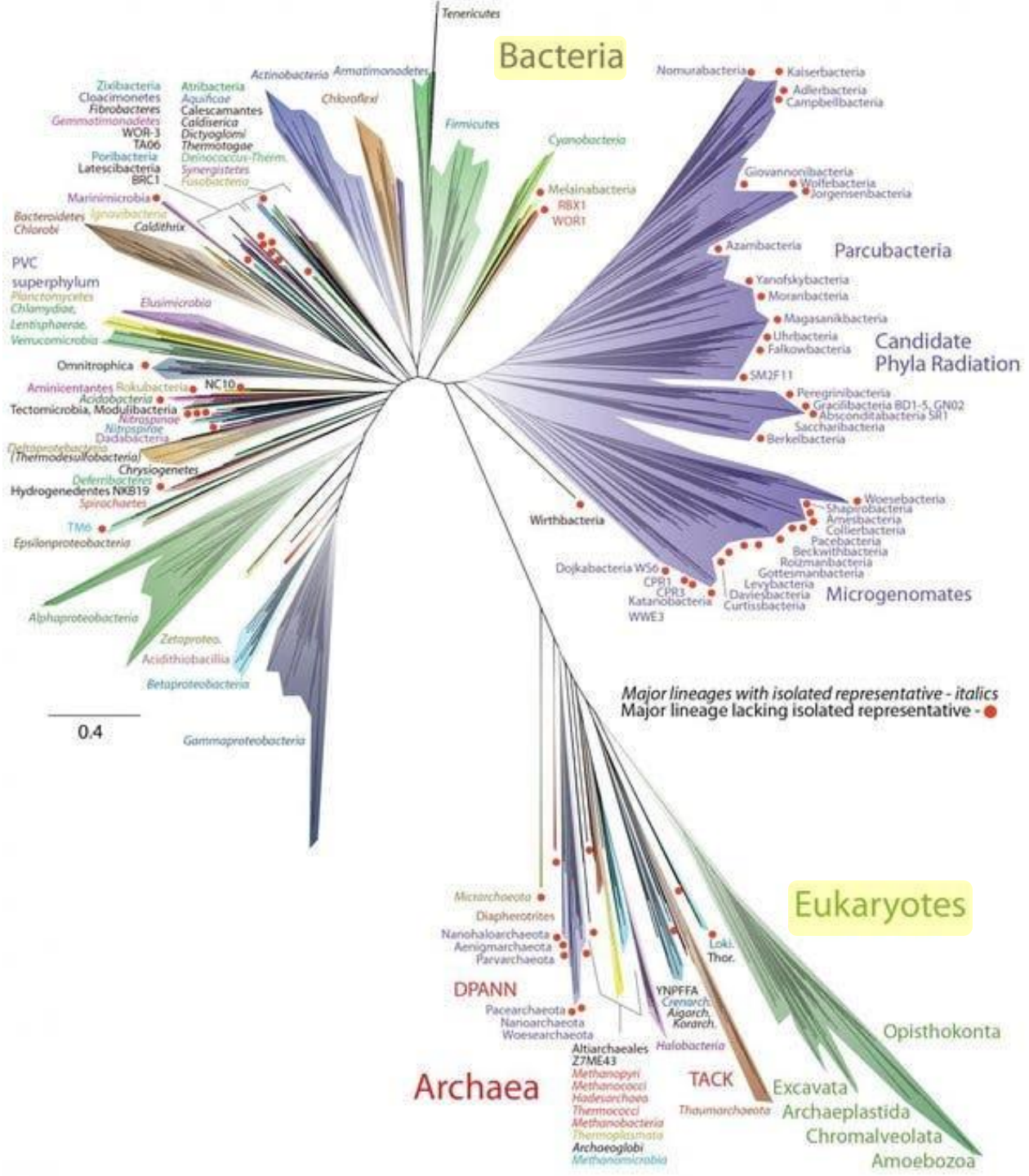


– the relationships are ***backed by molecular evidence***

– should have access to DNA or other molecular data



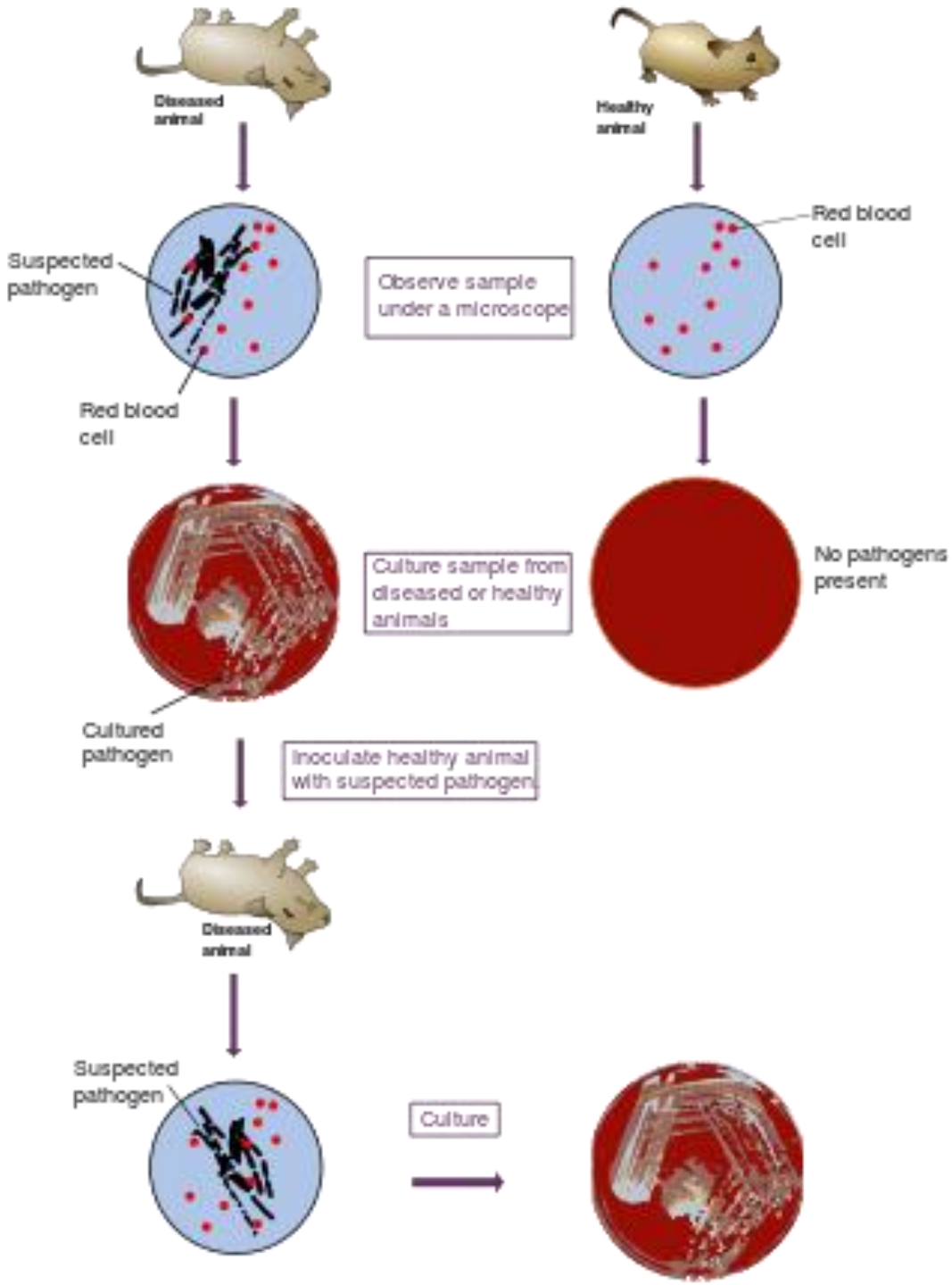

# The parasite and pathogen tree of life




# The parasite and pathogen tree of life

viruses???

# Infectious diseases manifest from *infection* with a *parasite* or *pathogen*



# The parasite and pathogen tree of life

- Parasite: an organism that lives in or on another organism and benefits at the expense of others (***these are eukaryotes***).
  - Ex: helminths (parasitic worms: tapeworms, roundworms, hookworms), ectoparasites (ticks, fleas)

# The parasite and pathogen tree of life

- Parasite:  an organism that lives in or on another organism and benefits at the expense of others (***these are eukaryotes***).
  - Ex: helminths (parasitic worms: tapeworms, roundworms, hookworms), ectoparasites (ticks, fleas)
- Pathogen: a microorganism that can cause disease.
  - Ex: bacterium ***(prokaryote)***, ***virus***, protozoan ***(eukaryote)***

# The parasite and pathogen tree of life

- Parasite:  an organism that lives in or on another organism and benefits at the expense of others (***these are eukaryotes***).
  - Ex: helminths (parasitic worms: tapeworms, roundworms, hookworms), ectoparasites (ticks, fleas)
- Pathogen: a microorganism that can cause disease.
  - Ex: bacterium ***(prokaryote)***, ***virus***, protozoan ***(eukaryote)***

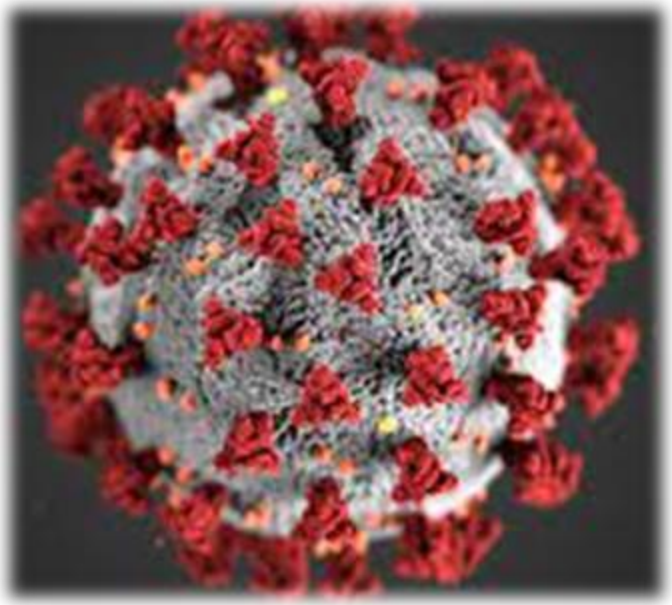
Pathogen: *Yersinia pestis*
Disease: Plague

# The parasite and pathogen tree of life

- Parasite:  an organism that lives in or on another organism and benefits at the expense of others (***these are eukaryotes***).
  - Ex: helminths (parasitic worms: tapeworms, roundworms, hookworms), ectoparasites (ticks, fleas)
- Pathogen: a microorganism that can cause disease.
  - Ex: bacterium ***(prokaryote)***, ***virus***, protozoan ***(eukaryote)***

Pathogen: *Yersinia pestis*
Disease: Plague

Pathogen: SARS-CoV-2
Disease: COVID-19



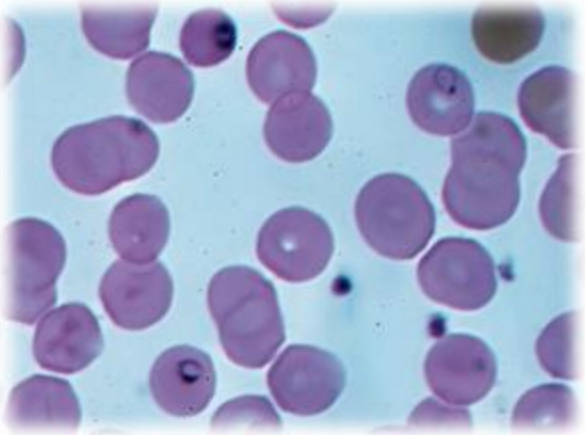
# The parasite and pathogen tree of life

- Parasite: an organism that lives in or on another organism and benefits at the expense of others (***these are eukaryotes***).
  - Ex: helminths (parasitic worms: tapeworms, roundworms, hookworms), ectoparasites (ticks, fleas)
- Pathogen: a microorganism that can cause disease.
  - Ex: bacterium ***(prokaryote)***, ***virus***, protozoan ***(eukaryote)***

Pathogen: *Yersinia pestis*
Disease: Plague

Pathogen: SARS-CoV-2
Disease: COVID-19

Pathogen: *Plasmodium falciparum, P. vivax, P. malariae, P. ovale, P. knowlesi*
Disease: malaria

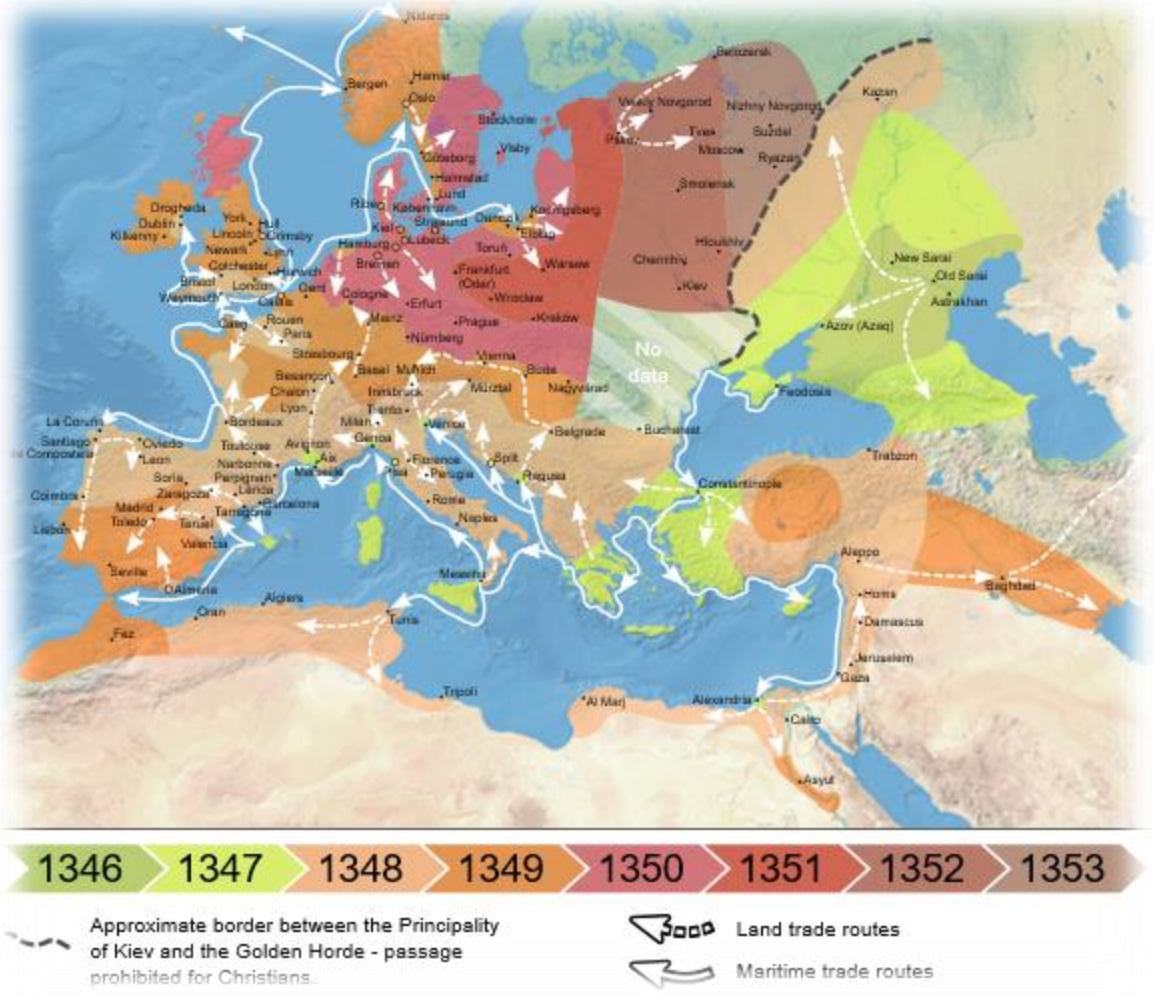


# Parasites and pathogens have shaped human history.

- Plague of Justinian (541-549 AD)
  - First historically recorded pandemic of *Yersinia pestis*
  - Launched the ‘first plague pandemic’ resulting in the deaths of 15-100 million people, 25-60% of Europe’s population at the time

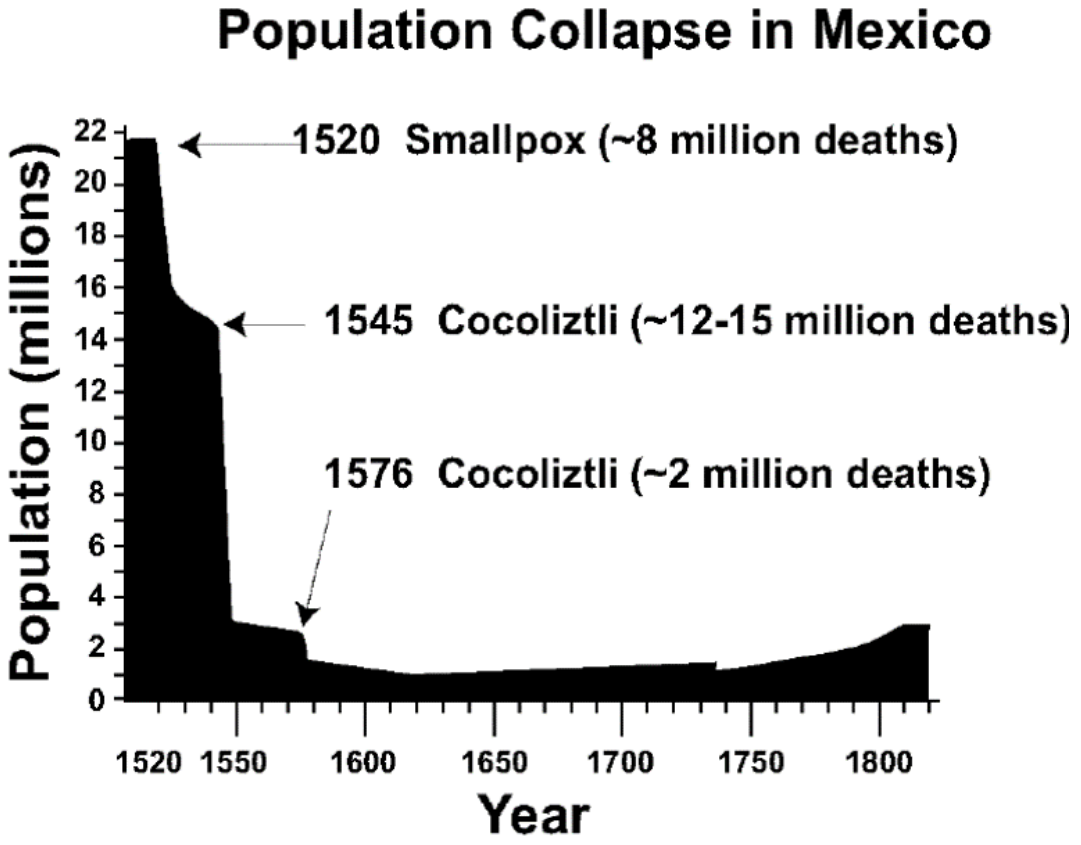
# Parasites and pathogens have shaped human history.

- Plague of Justinian (541-549 AD)
- Black Death (1346-1353 AD)
  - Most fatal pandemic in human history, resulting in deaths of 75-200 million people
  - Killed 30-60% of Europe's population at the time; 17-54% of global population



# Parasites and pathogens have shaped human history.

- Plague of Justinian (541-549 AD)
- Black Death (1346-1353 AD)
- Cocoliztli (1545-1548)
  - Pathogen still unknown! Maybe viral hemorrhagic fever, maybe bacterium
  - Killed 80% of the population of Mexico

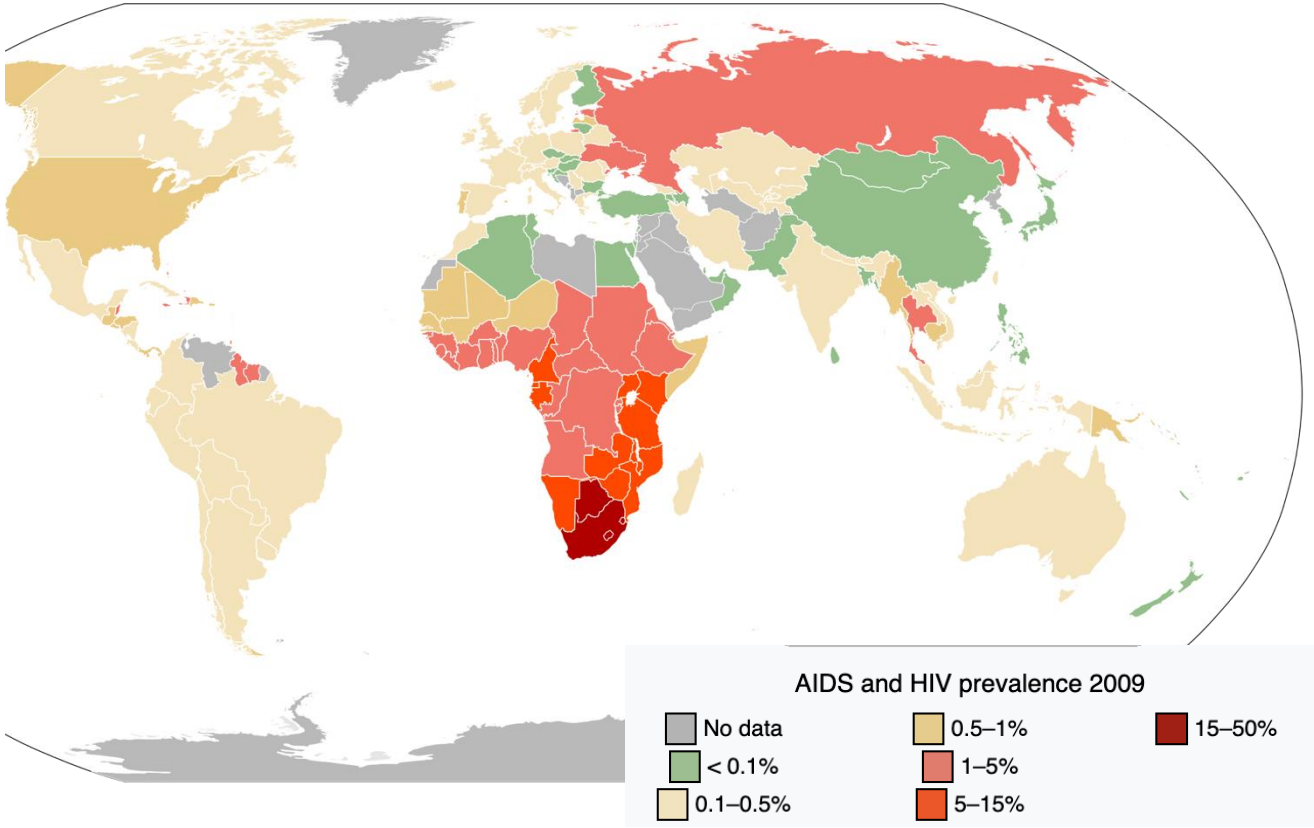


# Parasites and pathogens have shaped human history.

- Plague of Justinian (541-549 AD)
- Black Death (1346-1353 AD)
- Cocoliztli (1545-1548)
- Spanish Influenza (1918-1920)
  - 17-100 million deaths worldwide.
  - 1-5% of global population
  - 2nd-most devastating pandemic in history (after Black Death)

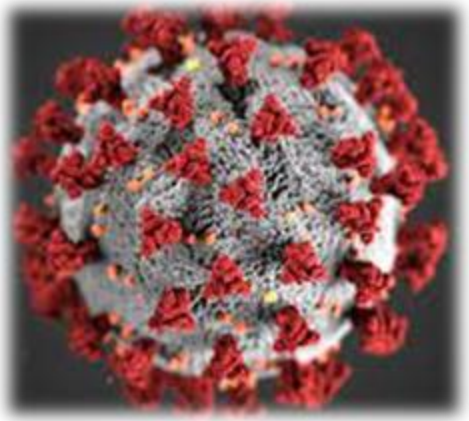
# Parasites and pathogens have shaped human history.

- Plague of Justinian (541-549 AD)
- Black Death (1346-1353 AD)
- Cocoliztli (1545-1548)
- Spanish Influenza (1918-1920)
- HIV (~1960-now)
  - >40 million deaths and counting
  - Prevalence still >20% in some countries in southern Africa



# Parasites and pathogens have shaped human history.

- Plague of Justinian (541-549 AD)
- Black Death (1346-1353 AD)
- Cocoliztli (1545-1548)
- Spanish Influenza (1918-1920)
- HIV (~1960-now)
- COVID-19 (2019-now)
  - ~7-30 million deaths worldwide and counting
  - ~0.1-0.4% of population

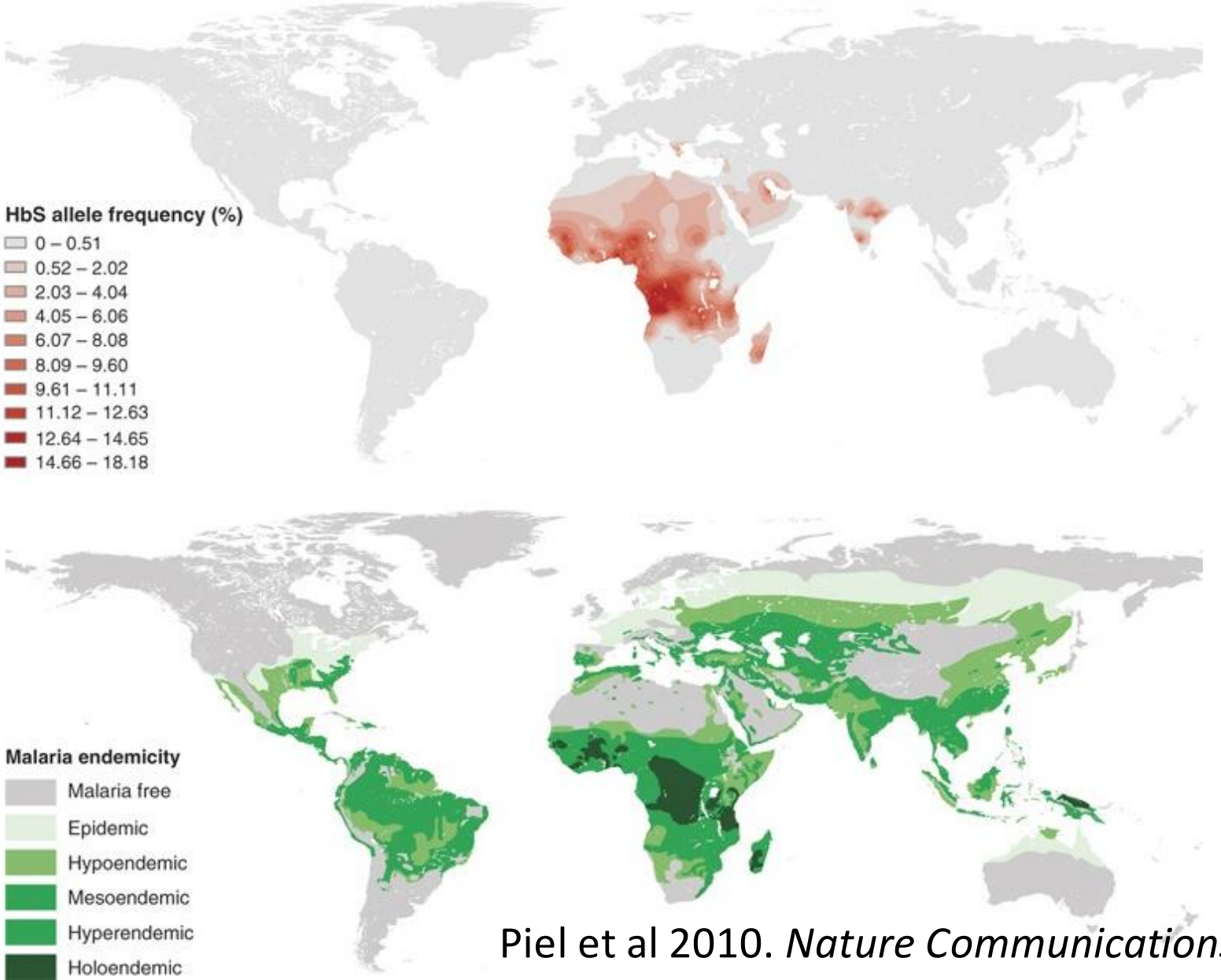


Parasites and pathogens have also shaped human DNA.

# Parasites and pathogens have also shaped human DNA.

## Sickle cell anemia

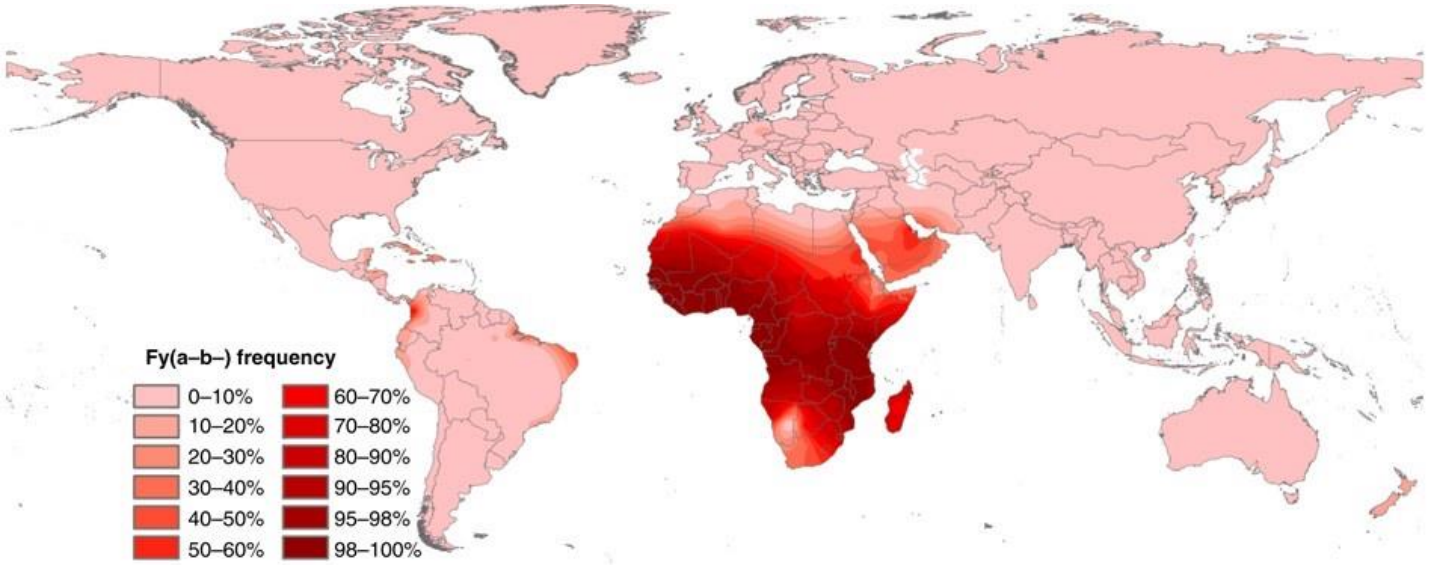
- The HbS allele confers resistance to malaria but also results in sickle cell anemia when homozygous.
- Natural selection has favored this trait in malaria-endemic regions of the planet.
- As of 2021, WHO estimates 247 million malaria cases worldwide and >600,000 deaths, 95% in Africa.
- Children <5 account for 80% of malaria deaths.



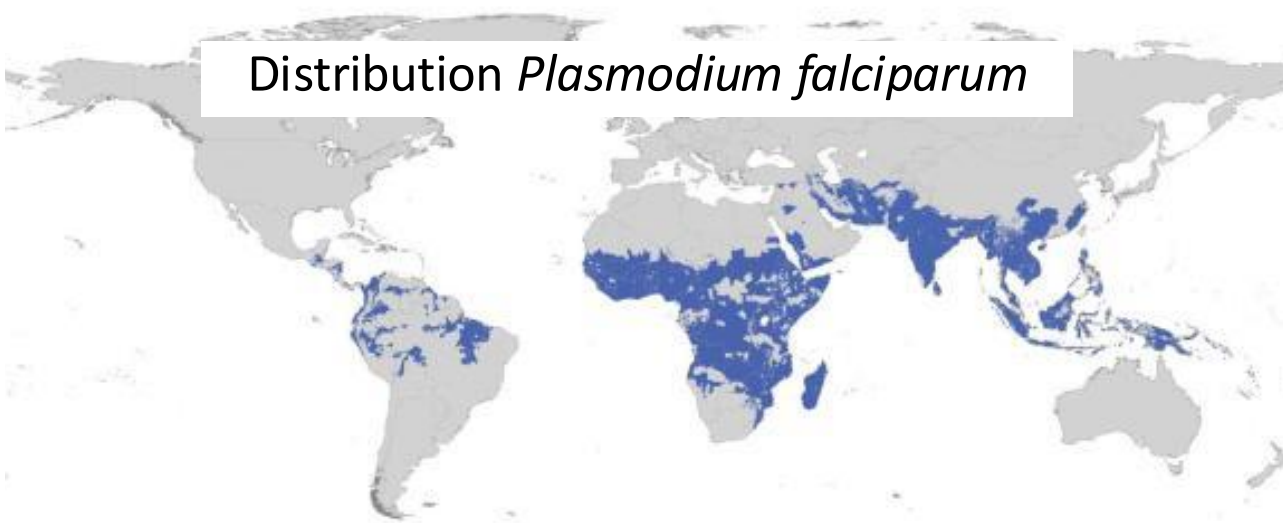

Piel et al 2010. *Nature Communications.*

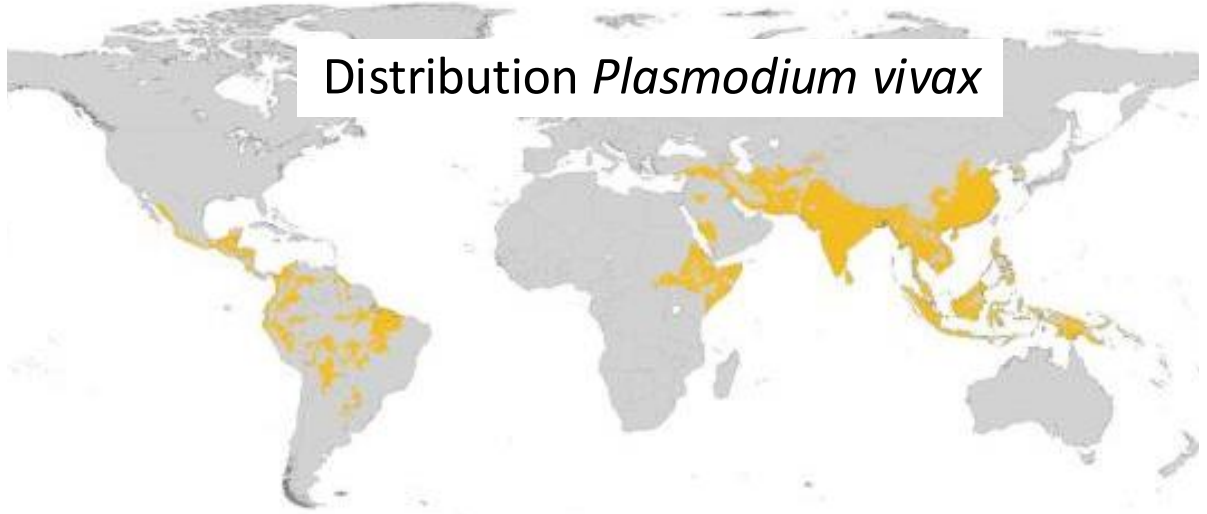
# Parasites and pathogens have also shaped human DNA.

**Duffy antigen**




- Modeled distribution of Duffy-negative human population




Guerra et al. 2006. *Trends in Parasitology*
Howes et al 2011. *Nature Communications.*

# Goals for this lecture

- To explain what we're doing here
- To introduce global health
- To introduce infectious disease
- To introduce methods for the study of infectious diseases

# Epidemiology vs. Population Biology (Disease Dynamics)

# Epidemiology vs. Population Biology (Disease Dynamics)

- Epidemiology = “the study of **what** is on the people”
  - Coined by Spanish physician Villalba in 1802

- Population biology/Disease ecology = the study of **how** a disease spreads
  - Emphasis on the **interactions** of organisms with each other and the environment…when interactions result in disease

# Epidemiology vs. Population Biology (Disease Dynamics)

- Epidemiology = “the study of **what** is on the people”
  - Coined by Spanish physician Villalba in 1802
- Emphasis on the study and analysis of the **distribution and determinants** of health and disease (“risk factors”)
  - Including chronic diseases!

- Population biology = the study of **how** a disease spreads
  - Emphasis on the **interactions** of organisms with each other and the environment…when interactions result in disease
- Emphasis on understanding the **transmission dynamics** of infectious disease

# Epidemiology vs. Population Biology (Disease Dynamics)

- Epidemiology = "the study of **what** is on the people"
  - Coined by Spanish physician Villalba in 1802
- Emphasis on the study and analysis of the **distribution and determinants** of health and disease ("risk factors")
  - Including chronic diseases!
- Often uses **cross-sectional** data to demonstrate associations of variables with outcome (disease)

- Population biology = the study of **how** a disease spreads
  - Emphasis on the **interactions** of organisms with each other and the environment…when interactions result in disease
- Emphasis on understanding the **transmission dynamics** of infectious disease
- Typically involves fitting dynamical (population) models to **time series** data

# Epidemiology vs. Population Biology (Disease Dynamics)

- Epidemiology = "the study of **what** is on the people"
  - Coined by Spanish physician Villalba in 1802
- Emphasis on the study and analysis of the **distribution and determinants** of health and disease ("risk factors")
  - Including chronic diseases!
- Often uses **cross-sectional** data to demonstrate associations of variables with outcome (disease)
- More statistical (y=mx+b)
  - **Pattern**

- Population biology = the study of **how** a disease spreads
  - Emphasis on the **interactions** of organisms with each other and the environment…when interactions result in disease
- Emphasis on understanding the **transmission dynamics** of infectious disease
- Typically involves fitting dynamical (population) models to **time series** data
- More mathematical (dN/dt)
  - **Process**

# Some important epidemiological terminology

- R0, Reff, force of infection, herd immunity, critical vaccination threshold
- Review dynamical fever

# $R_o$

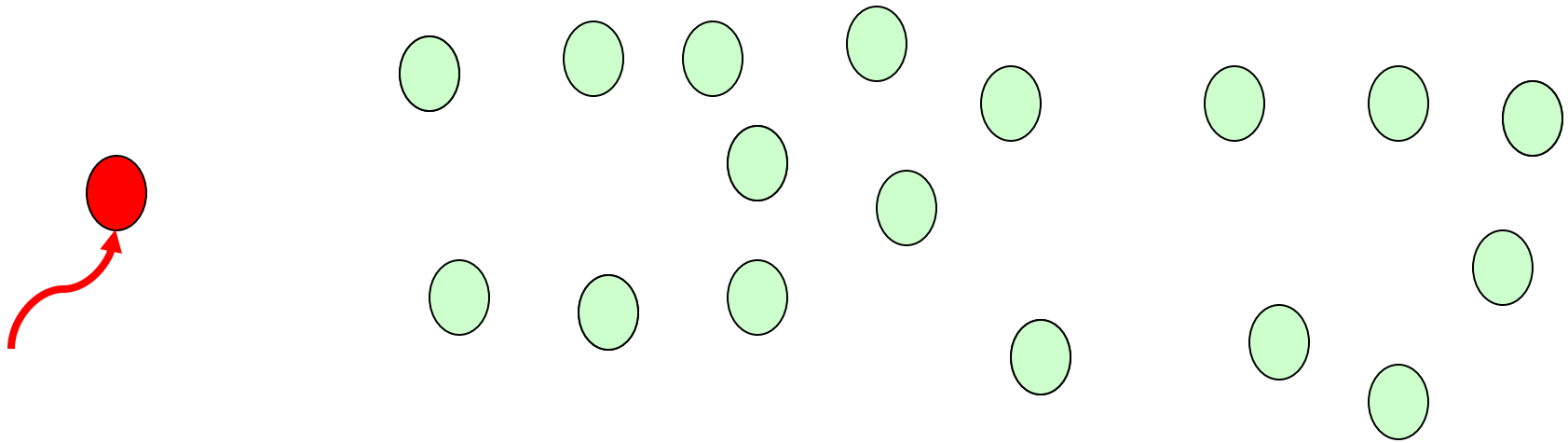
- The **basic reproduction number** for a pathogen

# $R_o$

- The **basic reproduction number** for a pathogen
- Defined as: the number of new cases caused by one infectious case in a **completely susceptible** population

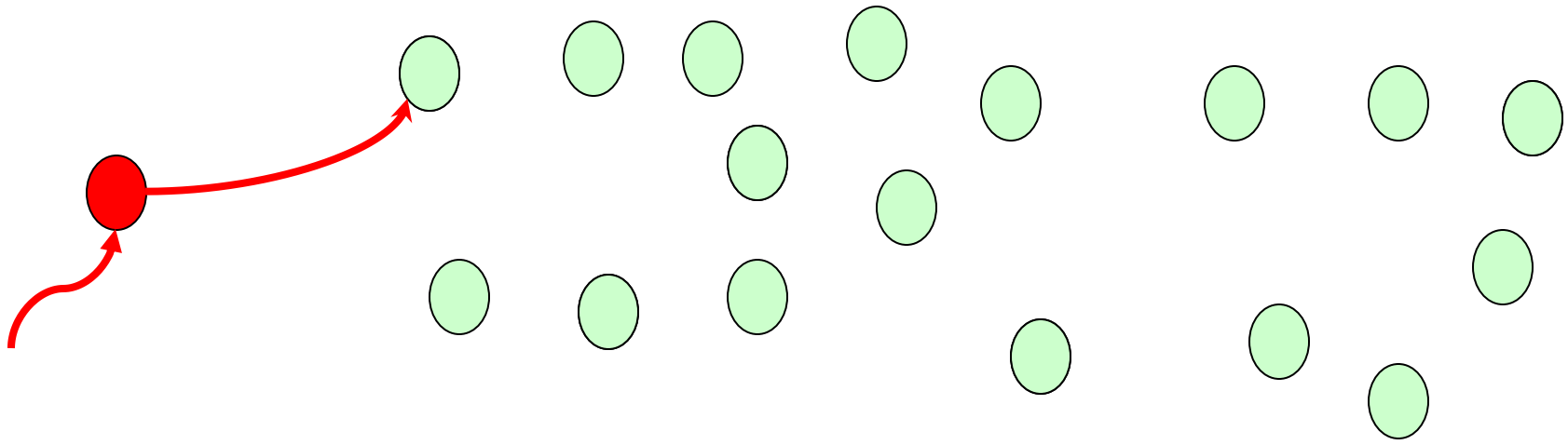
# $R_o$

- The **basic reproduction number** for a pathogen
- Defined as: the number of new cases caused by one infectious case in a **completely susceptible** population



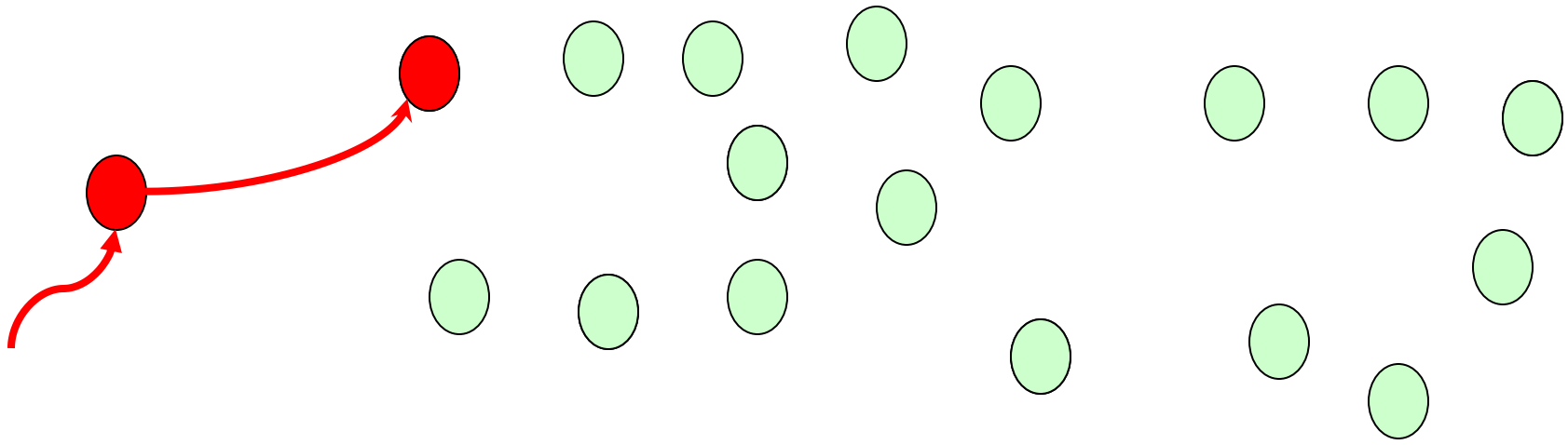
# $R_o$

- The **basic reproduction number** for a pathogen
- Defined as: the number of new cases caused by one infectious case in a **completely susceptible** population



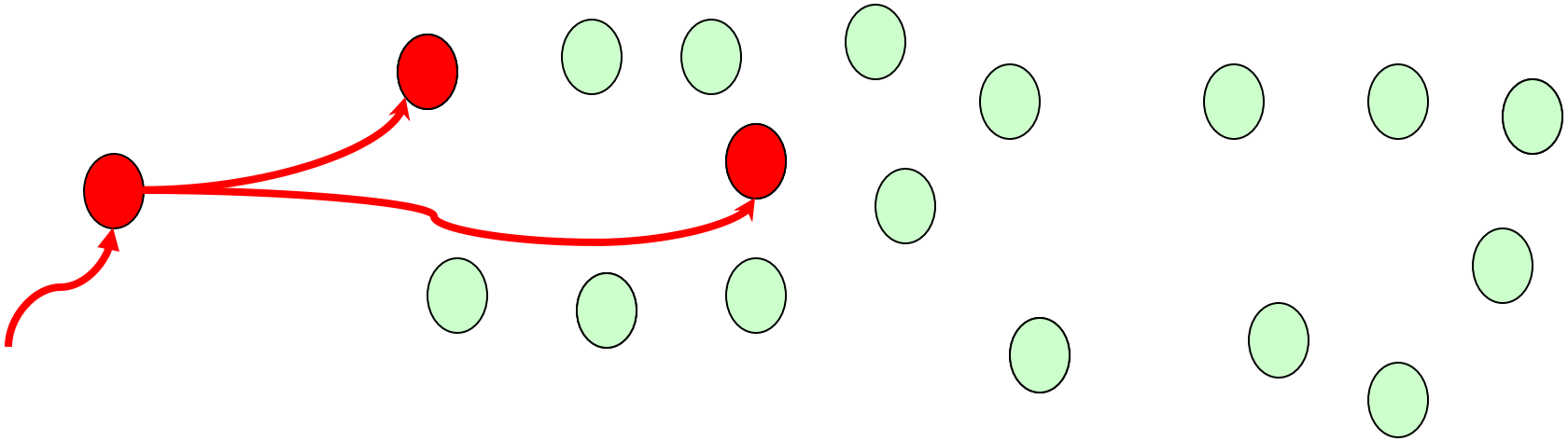
# $R_o$

- The **basic reproduction number** for a pathogen
- Defined as: the number of new cases caused by one infectious case in a **completely susceptible** population



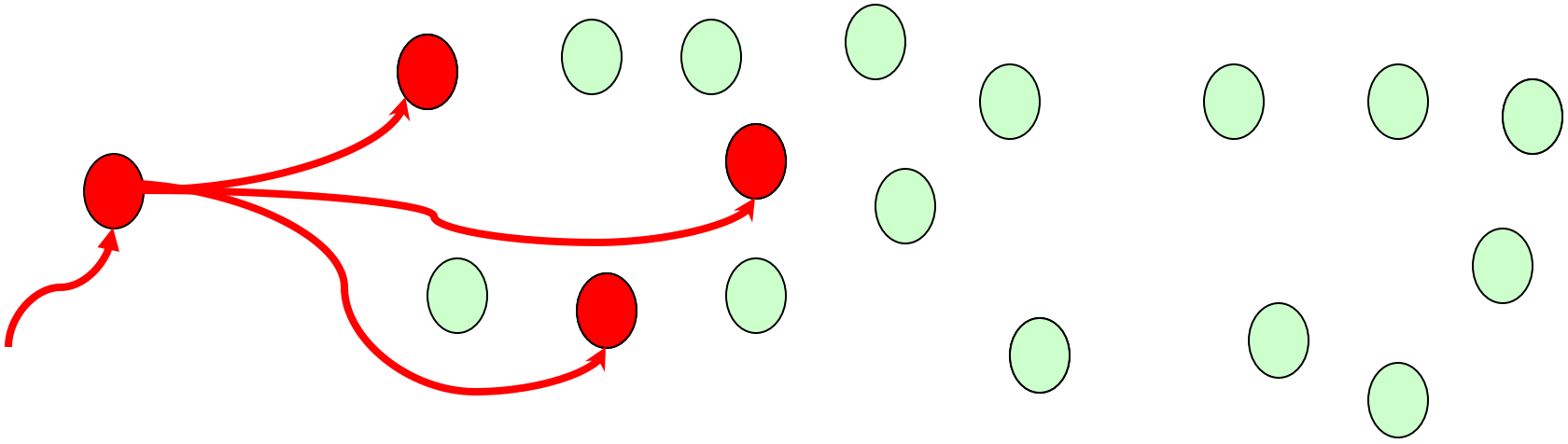
# $R_o$

- The **basic reproduction number** for a pathogen
- Defined as: the number of new cases caused by one infectious case in a **completely susceptible** population



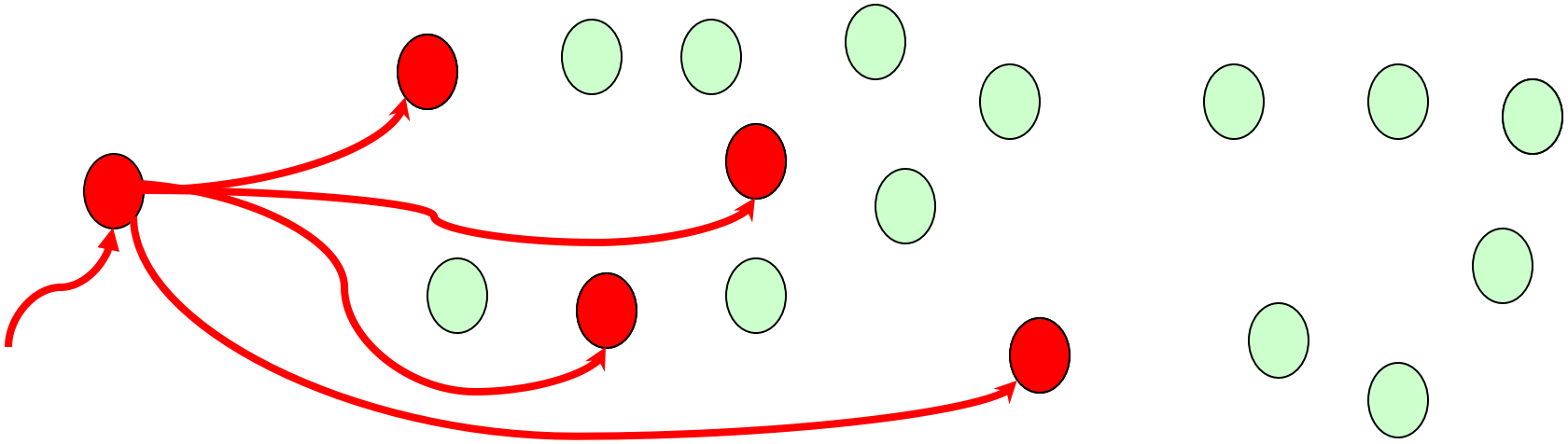
# $R_o$

- The **basic reproduction number** for a pathogen
- Defined as: the number of new cases caused by one infectious case in a **completely susceptible** population



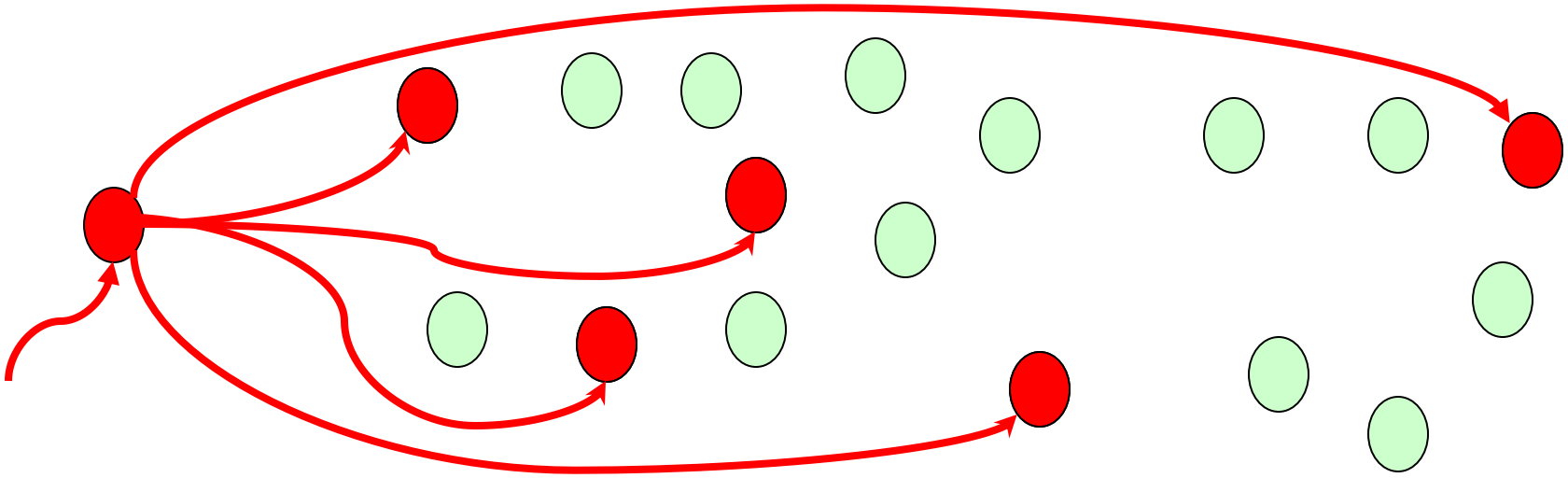
# $R_o$

- The **basic reproduction number** for a pathogen
- Defined as: the number of new cases caused by one infectious case in a **completely susceptible** population



# $R_o$

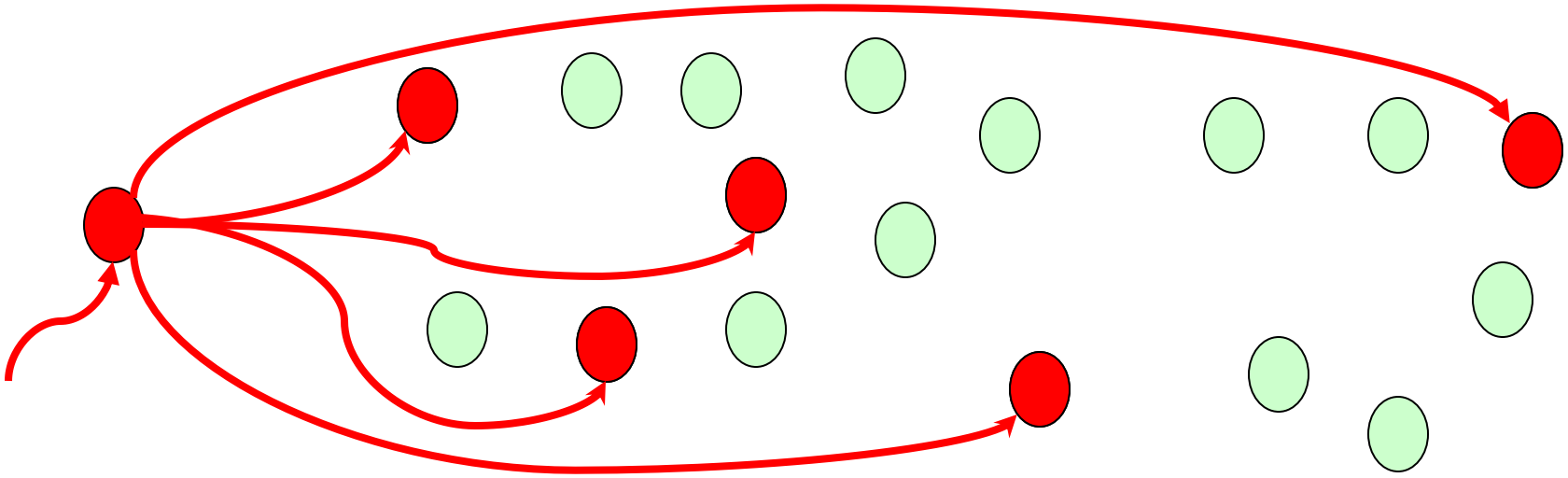
- The **basic reproduction number** for a pathogen
- Defined as: the number of new cases caused by one infectious case in a **completely susceptible** population



What is $R_o$?

# $R_o$

- The **basic reproduction number** for a pathogen
- Defined as: the number of new cases caused by one infectious case in a **completely susceptible** population

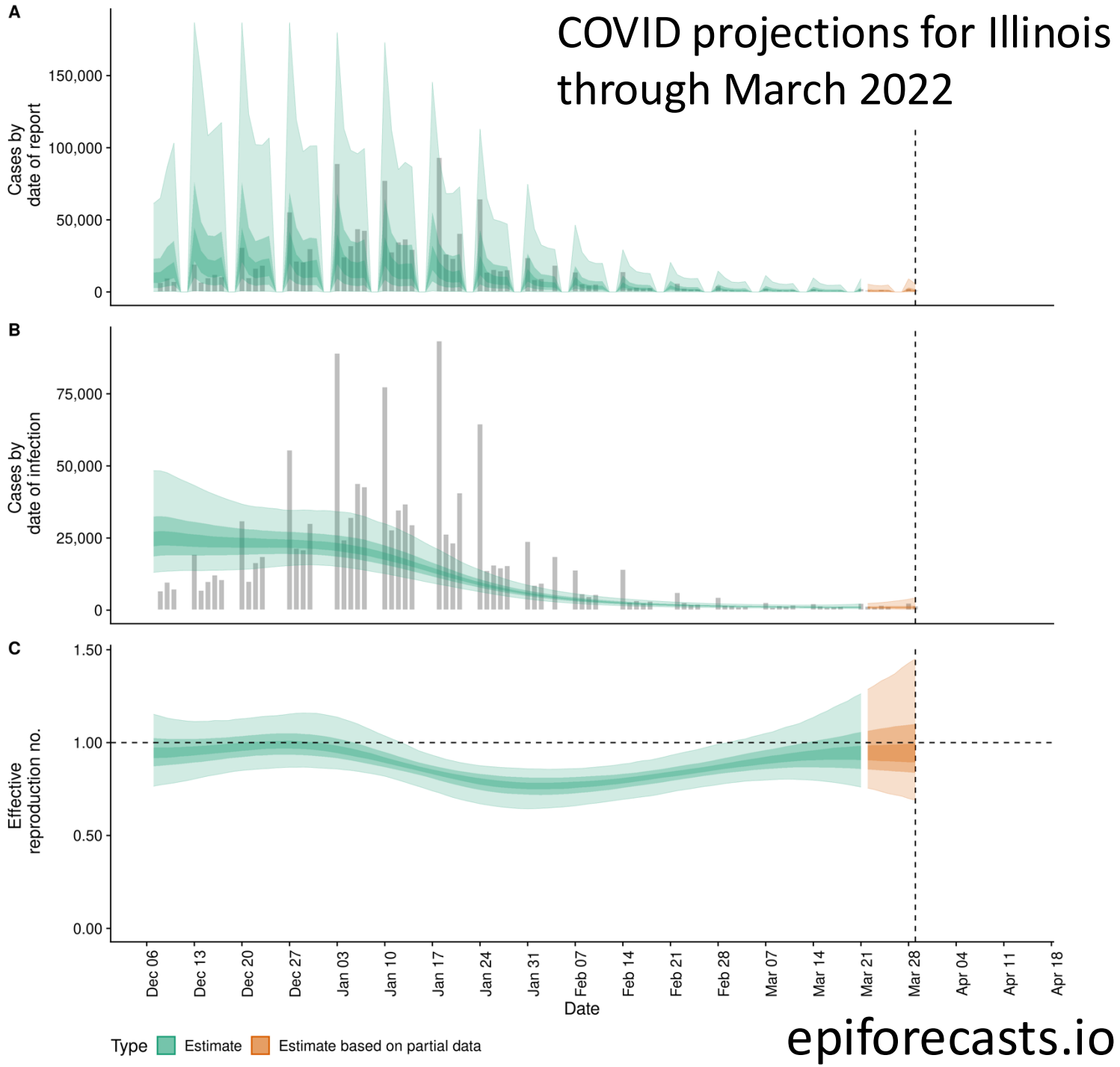


What is $R_o$?

$R_o$ = 5

# $R_E$ OR $R_t$

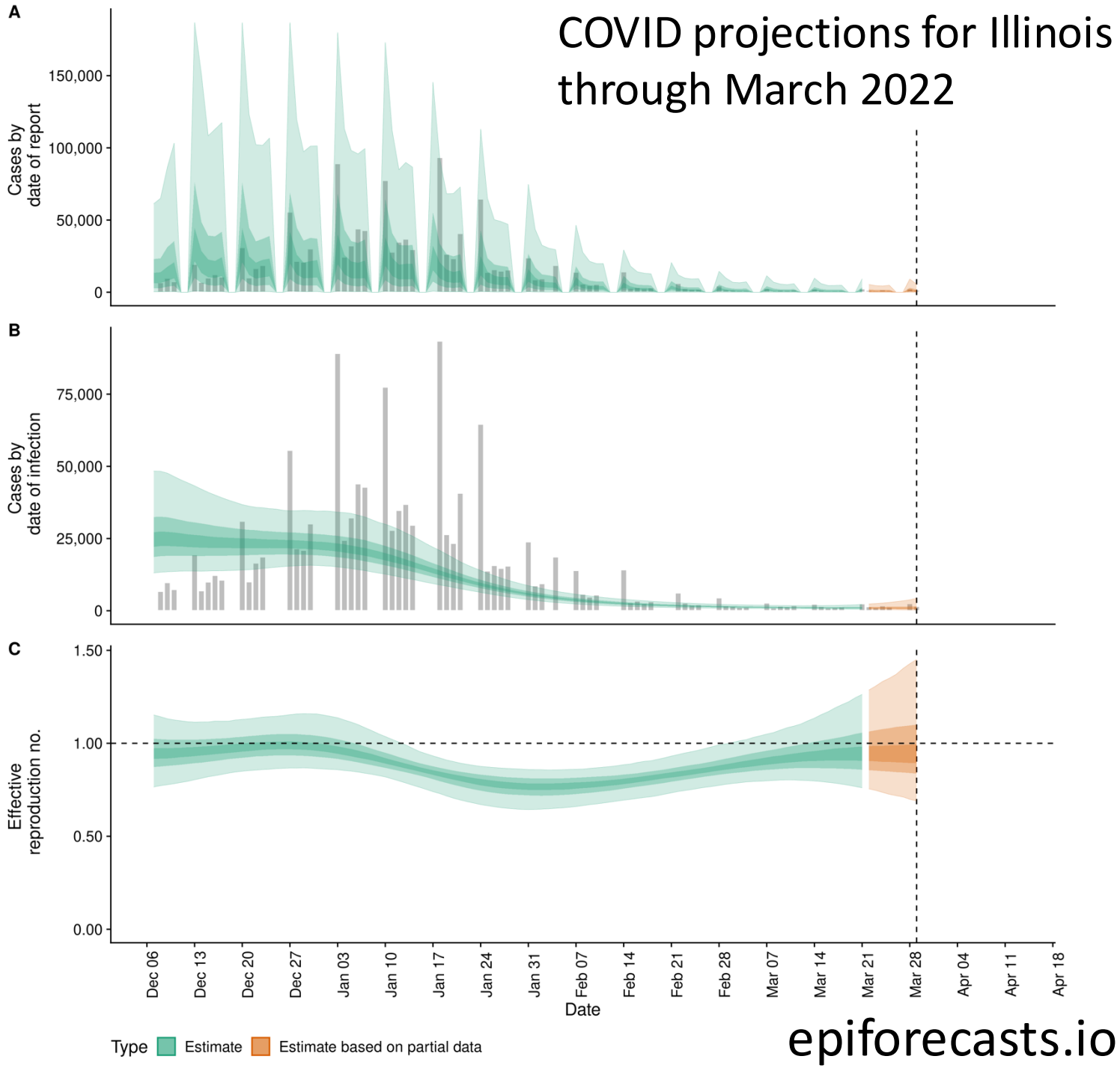
- The **effective reproduction number** for a pathogen




epiforecasts.io

# $R_E$ OR $R_t$

- The **effective reproduction number** for a pathogen
- Defined as: the number of new cases caused by one infectious case in a **partially susceptible** population

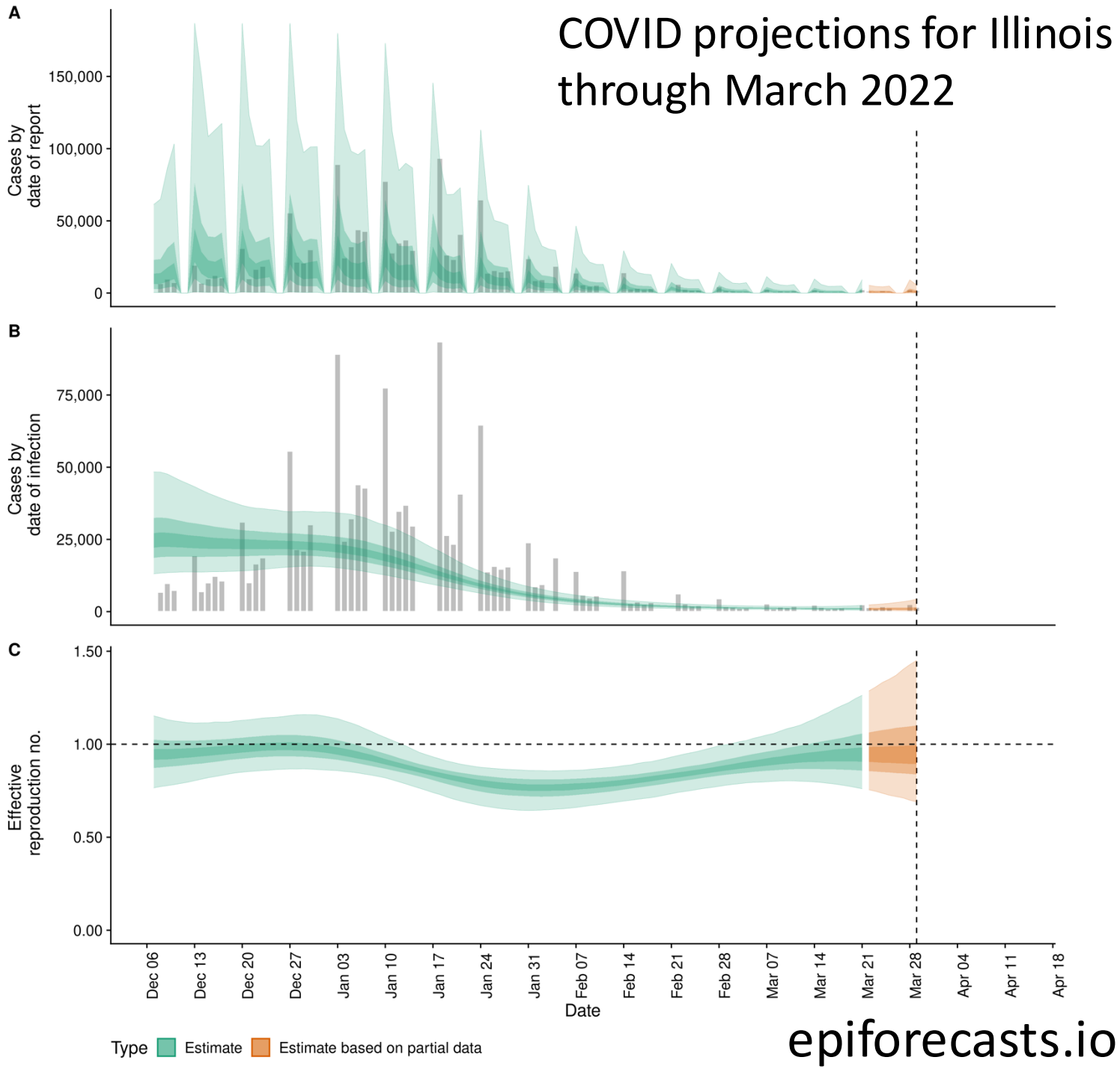



epiforecasts.io

# $R_E$ OR $R_t$

- The **effective reproduction number** for a pathogen
- Defined as: the number of new cases caused by one infectious case in a **partially susceptible** population
- Calculated as R0*proportion susceptible

$$\mathbf{R_E = R_0 \frac{S}{N}}$$



# **Public health interventions** can be employed to reduce both $R_0$ and $R_E$

## $R_0$ interventions

- Social distancing
- Masking
- Limits to gathering sizes
- Drugs that shorten the infectious period

# **Public health interventions** can be employed to reduce both $R_0$ and $R_E$

## $R_0$ interventions

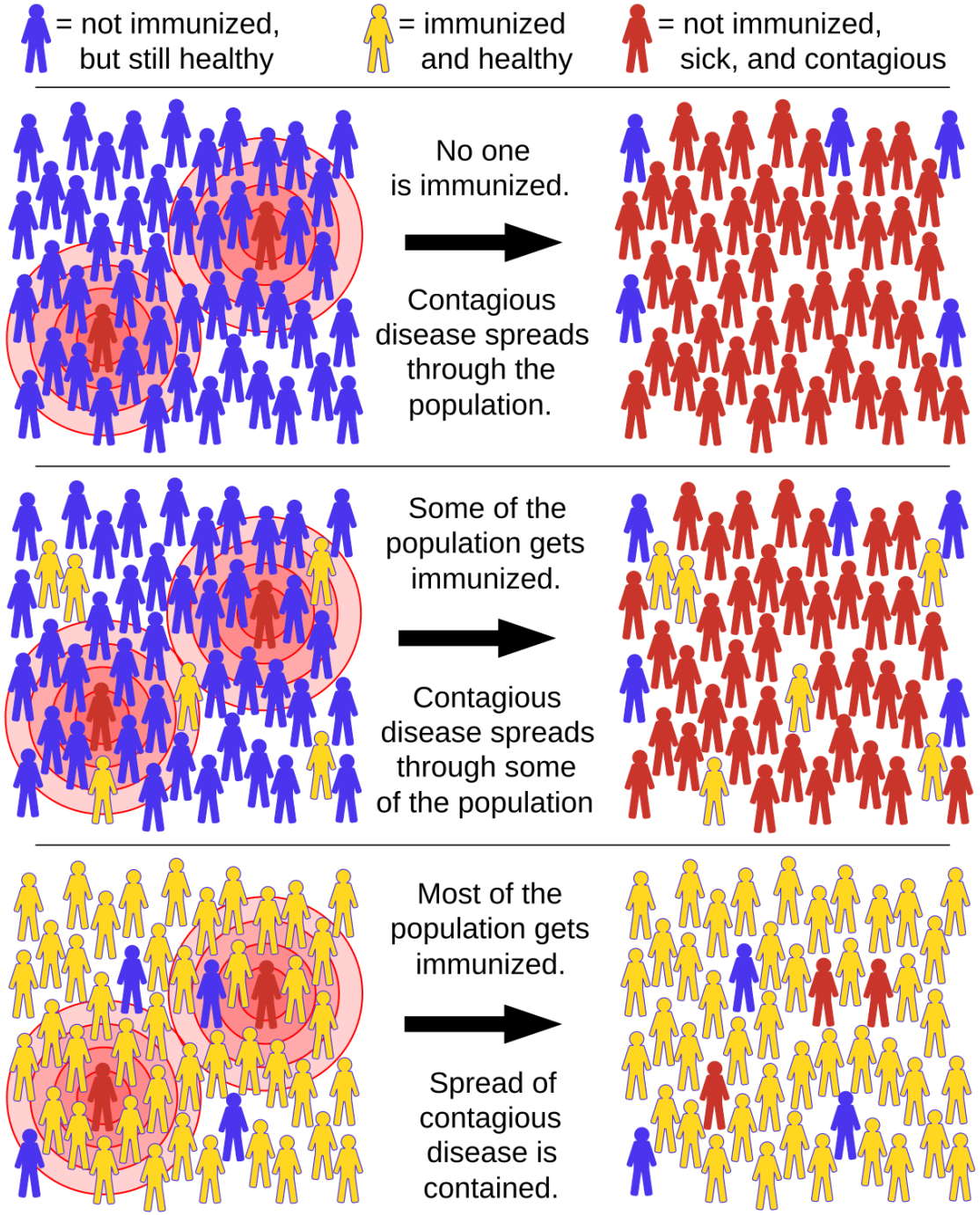
- Social distancing
- Masking
- Limits to gathering sizes
- Drugs that shorten the infectious period


## $R_E$ interventions

- Vaccination

# Vaccination and Herd Immunity

# Vaccination and Herd Immunity



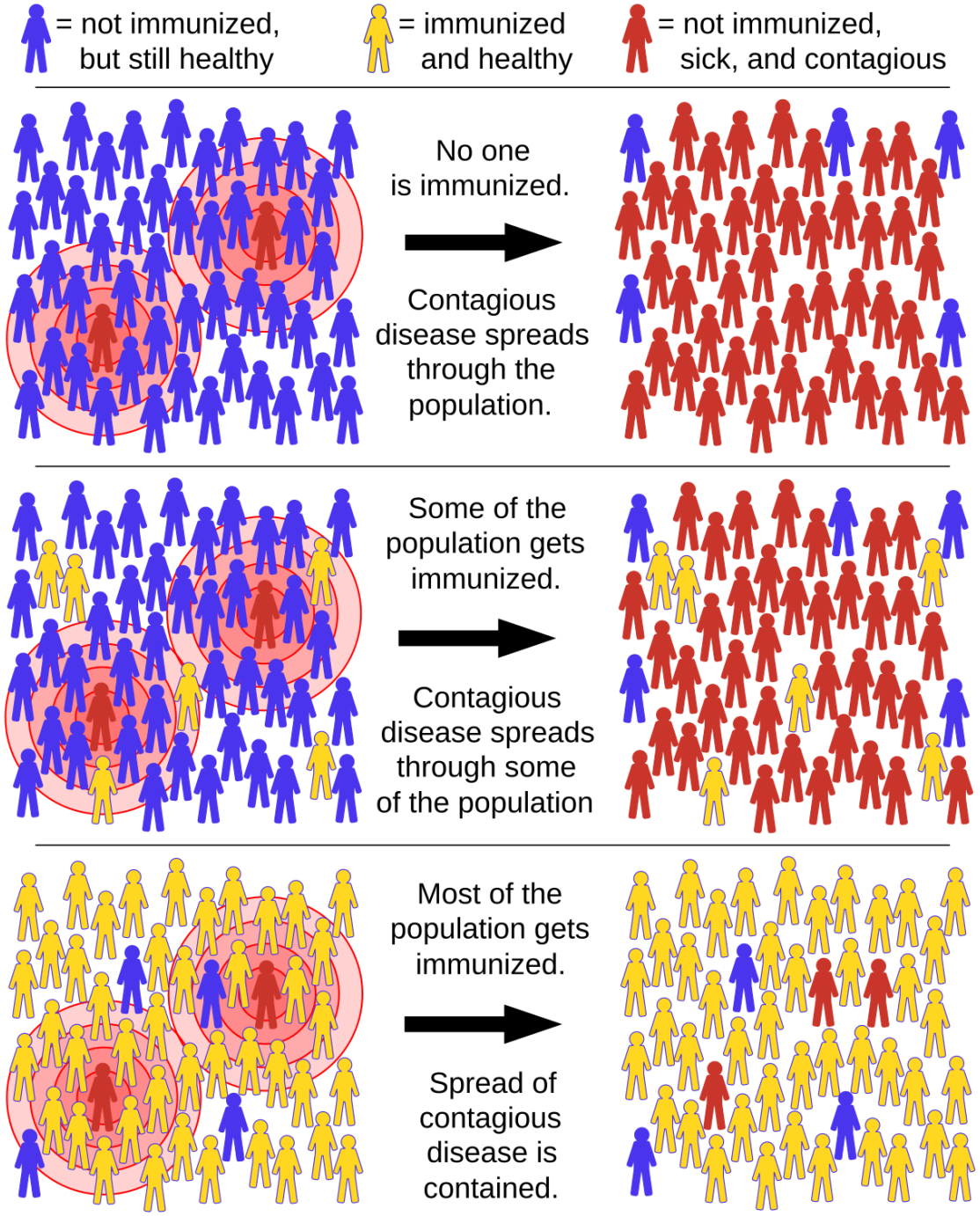
# Vaccination and Herd Immunity

**herd immunity threshold:**

$$P_V > 1 - \frac{1}{R_0}$$

$P_V$ = *proportion needed to vaccinate*

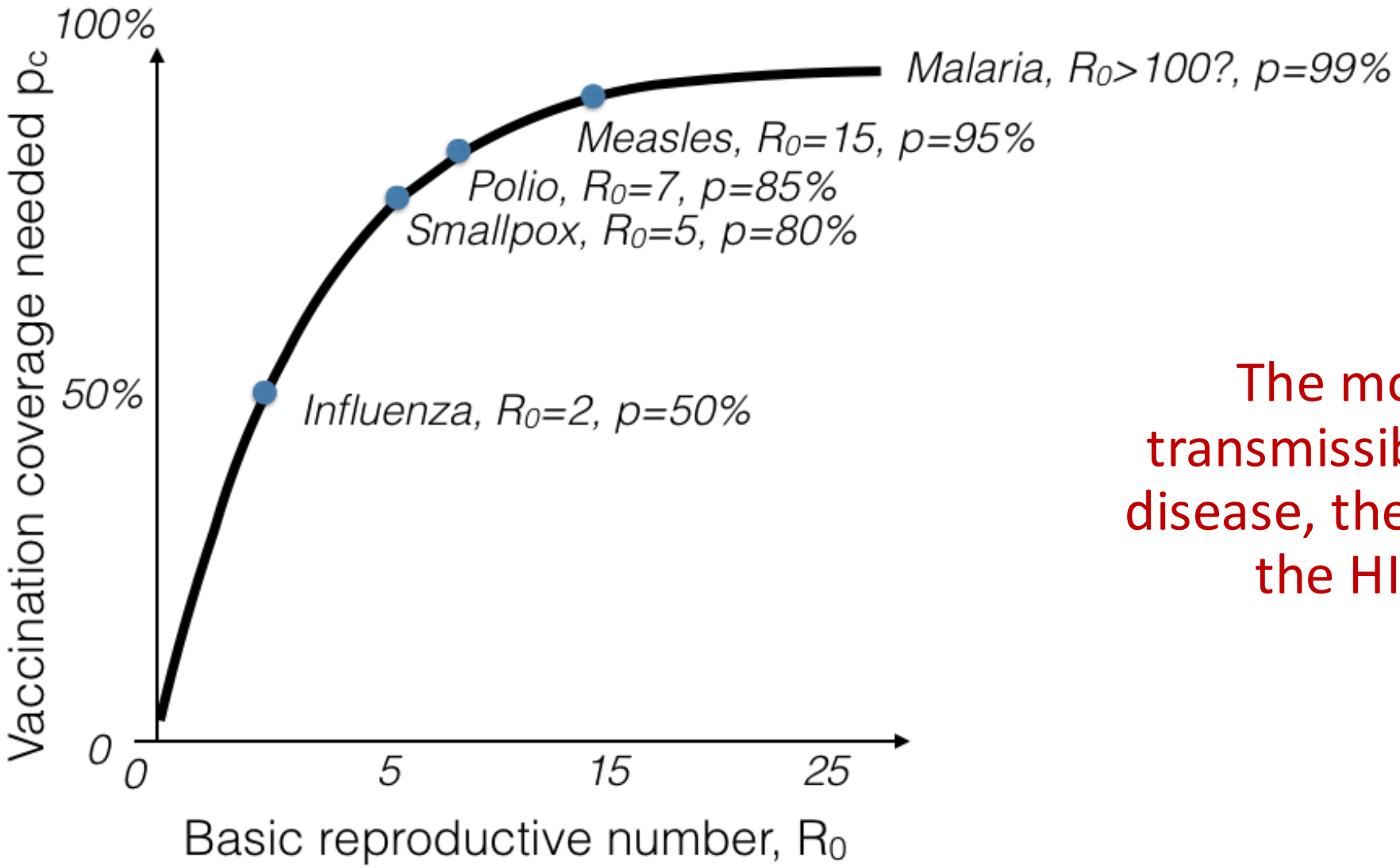
- Vaccination aims to reduce the host population below **critical community size** (**CCS**) for the pathogen of interest.
- CCS, the **minimum number of hosts needed to maintain endemic transmission of a pathogen indefinitely into the future**, varies based on the transmissibility of the pathogen.



# Vaccination and Herd Immunity

**herd immunity threshold:**

$$P_V > 1 - \frac{1}{R_0}$$




The more transmissible the disease, the higher the HIT!

# Mechanisms of disease transmission

# Mechanisms of disease transmission

- **Directly-transmitted** diseases – transmitted via exchange of bodily fluids
  - Droplet (> 5 microns ) spread or direct contact, includes sexually-transmitted pathogens
  - Ex: Smallpox *(Variola* spp.), HIV, Mononucleosis (*Epstein Barr virus*)
- **Indirectly-transmitted** diseases – transmitted via droplets retained in air
  - Droplets < 5 microns in diameter
  - Ex: Measles, COVID (*SARS-CoV-2*)

# Mechanisms of disease transmission

- **Directly-transmitted** diseases – transmitted via exchange of bodily fluids
  - Droplet (> 5 microns ) spread or direct contact, includes sexually-transmitted pathogens
  - Ex: Smallpox *(Variola* spp.), HIV, Mononucleosis (*Epstein Barr virus*)
- **Indirectly-transmitted** diseases – transmitted via droplets retained in air
  - Droplets < 5 microns in diameter
  - Ex: Measles, COVID (*SARS-CoV-2*)
- **Vertically-transmitted** pathogens – transmitted mother-to-child *in utero*
  - Ex: HIV, *Herpes simplex virus*, *Cytomegalovirus*, Rubella, Zika

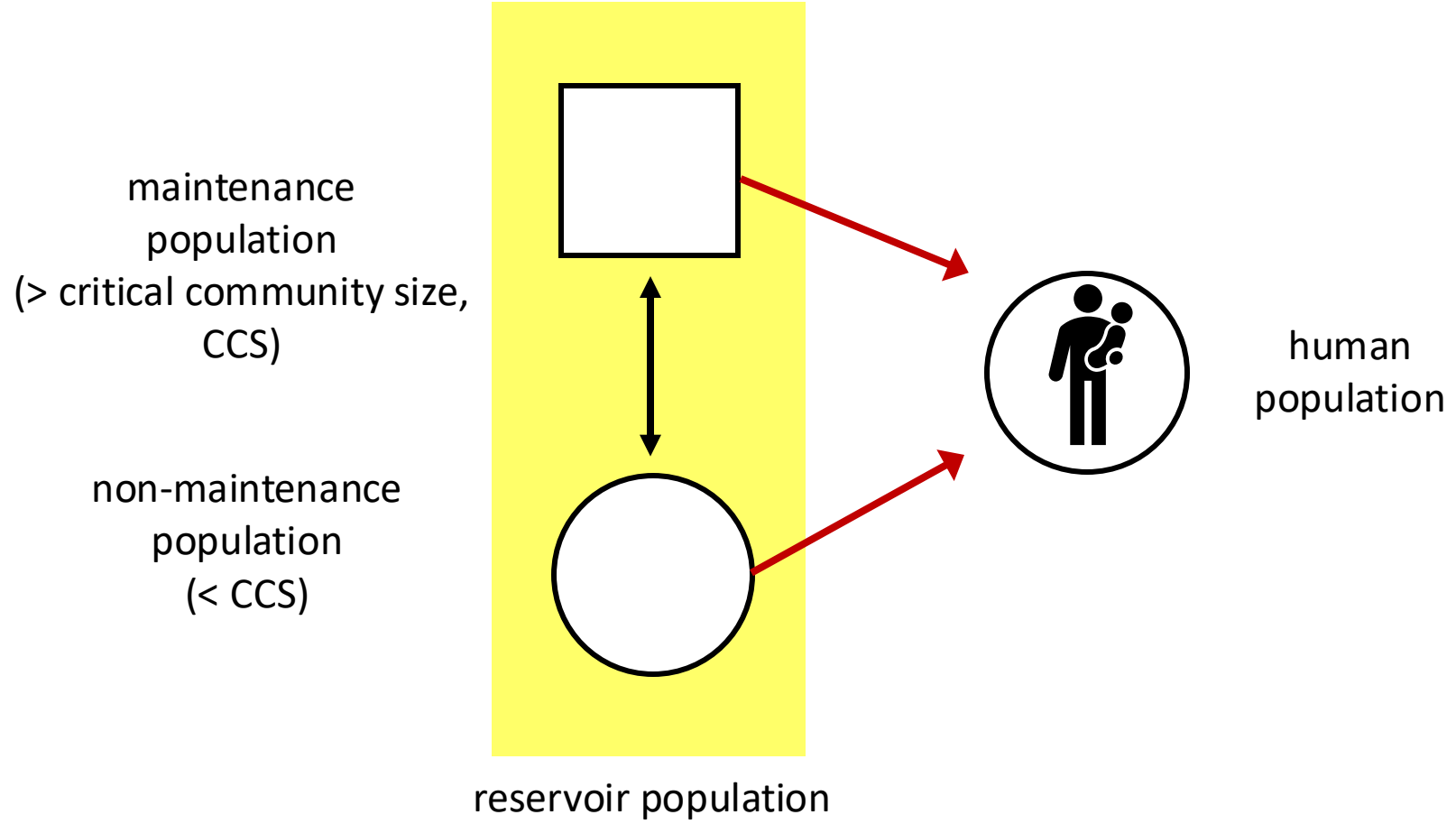
# Mechanisms of disease transmission

- **Directly-transmitted** diseases – transmitted via exchange of bodily fluids
  - Droplet (> 5 microns ) spread or direct contact, includes sexually-transmitted pathogens
  - Ex: Smallpox *(Variola* spp.), HIV, Mononucleosis (*Epstein Barr virus*)
- **Indirectly-transmitted** diseases – transmitted via droplets retained in air
  - Droplets < 5 microns in diameter
  - Ex: Measles, COVID (*SARS-CoV-2*)
- **Vertically-transmitted** pathogens – transmitted mother-to-child *in utero*
  - Ex: HIV, *Herpes simplex virus*, *Cytomegalovirus*, Rubella, Zika
- **Environmentally-transmitted** pathogens – transmitted outside host (e.g. water, food)
  - Ex: Cholera *(Vibrio cholerae*), Salmonellosis (*Salmonella* spp. bacteria)

# Mechanisms of disease transmission

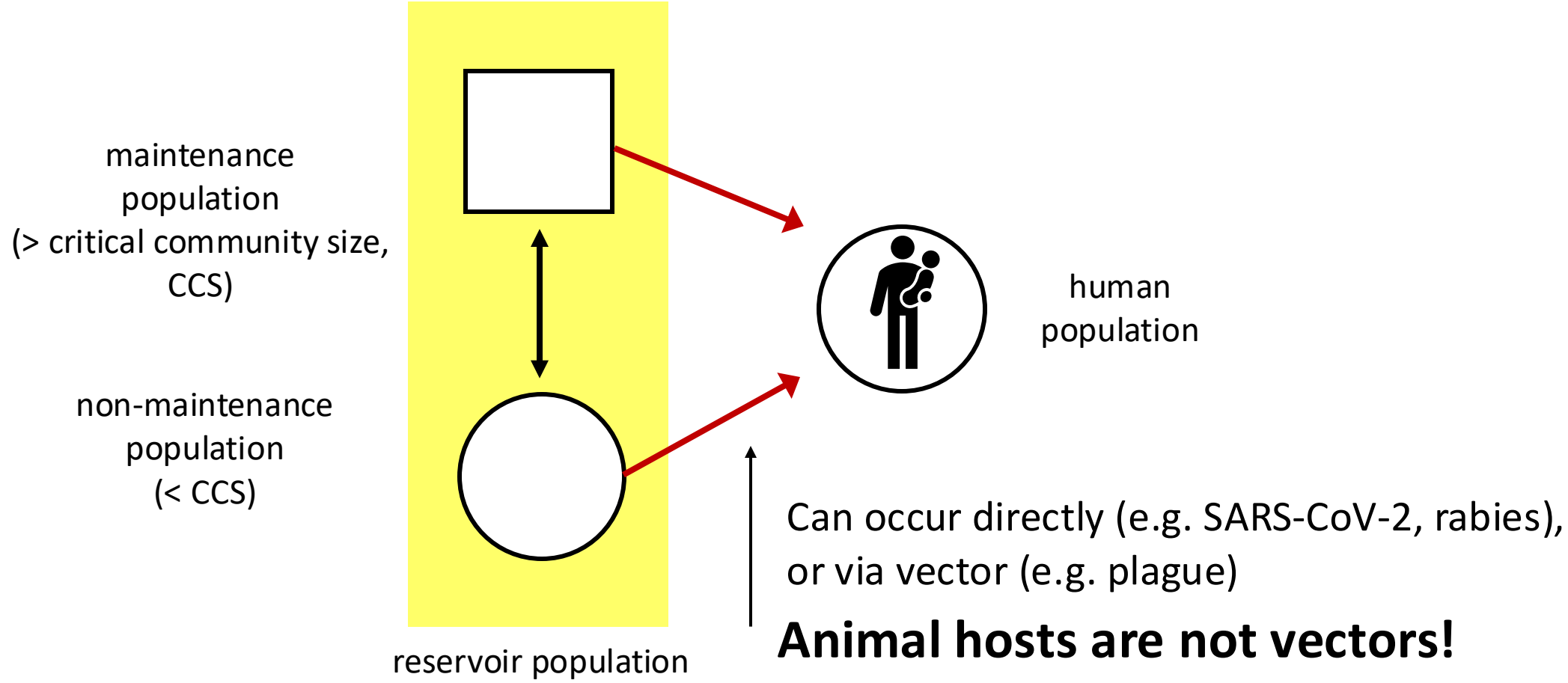
- **Directly-transmitted** diseases – transmitted via exchange of bodily fluids
  - Droplet (> 5 microns ) spread or direct contact, includes sexually-transmitted pathogens
  - Ex: Smallpox *(Variola* spp.), HIV, Mononucleosis (*Epstein Barr virus*)
- **Indirectly-transmitted** diseases – transmitted via droplets retained in air
  - Droplets < 5 microns in diameter
  - Ex: Measles, COVID (*SARS-CoV-2*)
- **Vertically-transmitted** pathogens – transmitted mother-to-child *in utero*
  - Ex: HIV, *Herpes simplex virus*, *Cytomegalovirus*, Rubella, Zika
- **Environmentally-transmitted** pathogens – transmitted outside host (e.g. water, food)
  - Ex: Cholera *(Vibrio cholerae*), Salmonellosis (*Salmonella* spp. bacteria)
- **Vector-borne** diseases (a type of indirect transmission) are transmitted via blood-feeding arthropod (mosquitoes, ticks, fleas)
  - Ex: malaria, arboviruses (dengue, yellow fever), sleeping sickness, plague

# **Zoonosis** is the transmission of a pathogen from a **wildlife reservoir host** to a **human target host** population.



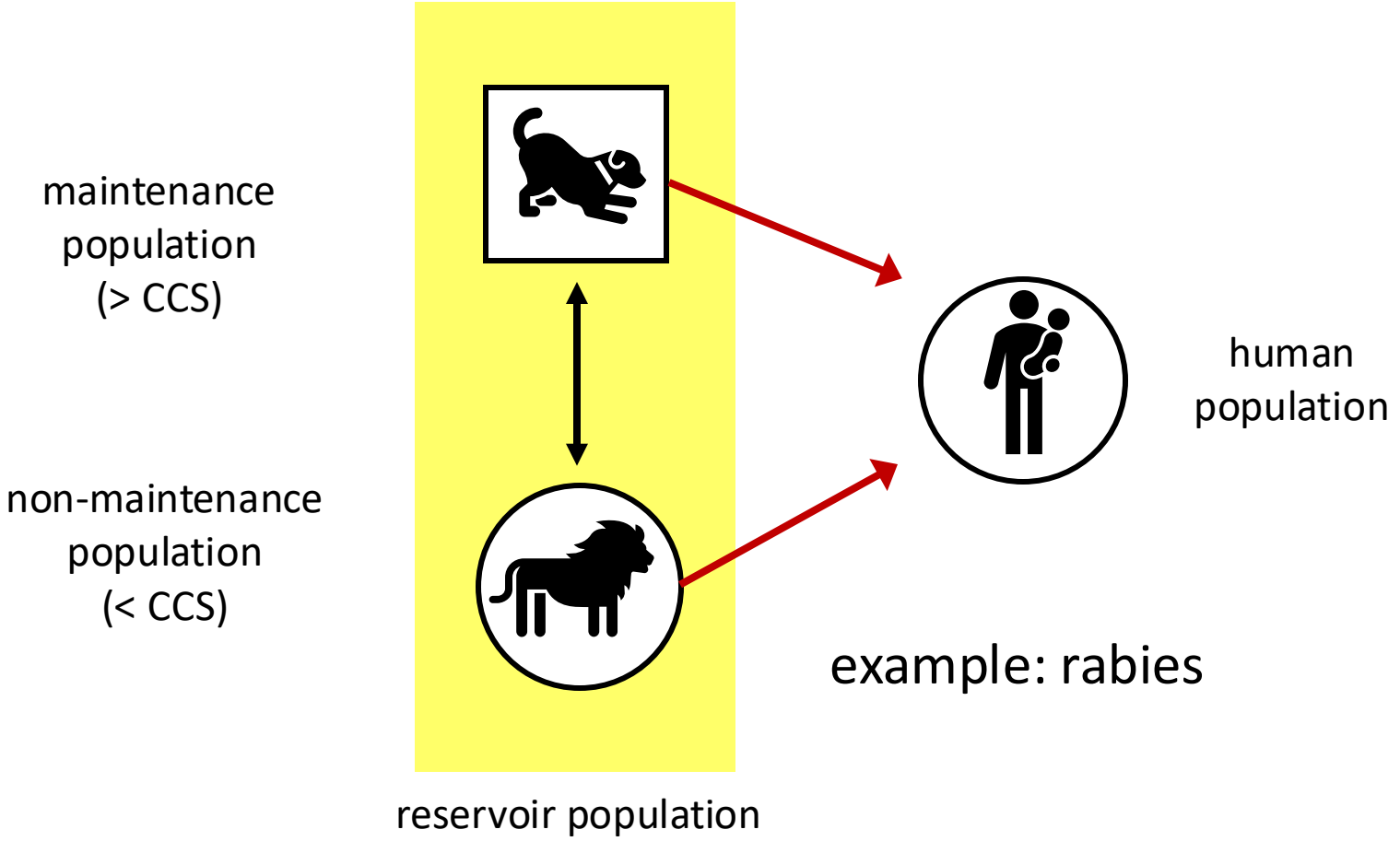

Lembo et al. 2008. *Journal of Animal Ecology*
Haydon et al. 2002. *Emerging Infectious Diseases.*

# **Zoonosis** is the transmission of a pathogen from a **wildlife reservoir host** to a **human target host** population.




Lembo et al. 2008. *Journal of Animal Ecology*
Haydon et al. 2002. *Emerging Infectious Diseases.*

**Zoonosis** is the transmission of a pathogen from a **wildlife reservoir host** to a **human target host** population.




Lembo et al. 2008. *Journal of Animal Ecology*
Haydon et al. 2002. *Emerging Infectious Diseases.*