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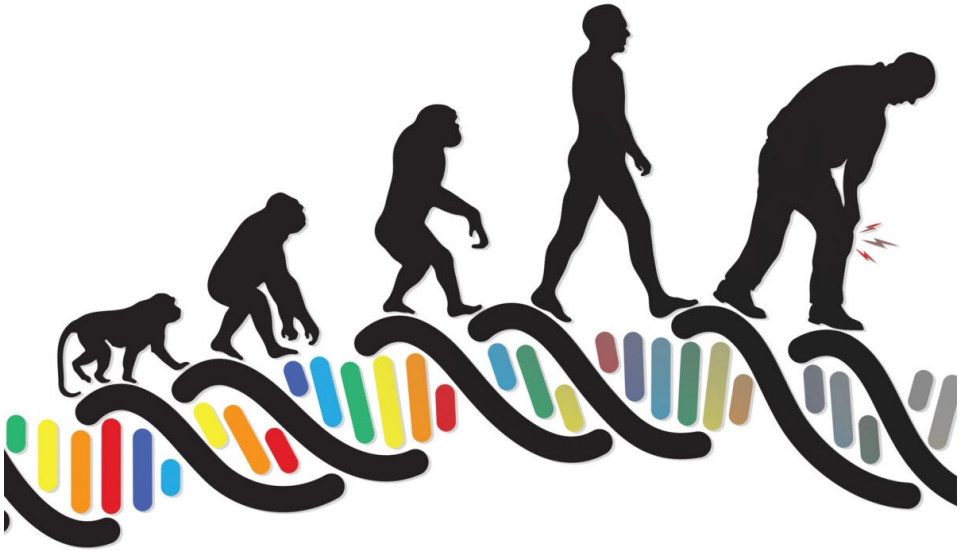
Introduction to Evolutionary Medicine

BIOL3120 – LECTURE 2

What is evolutionary medicine?



- Uses evolutionary biology to understand, prevent, and treat disease
- Evo Med, uses the knowledge that we and our pathogens are the product of evolution, to understand how we were put together, how we work, and how disease manifests

Book recommendation

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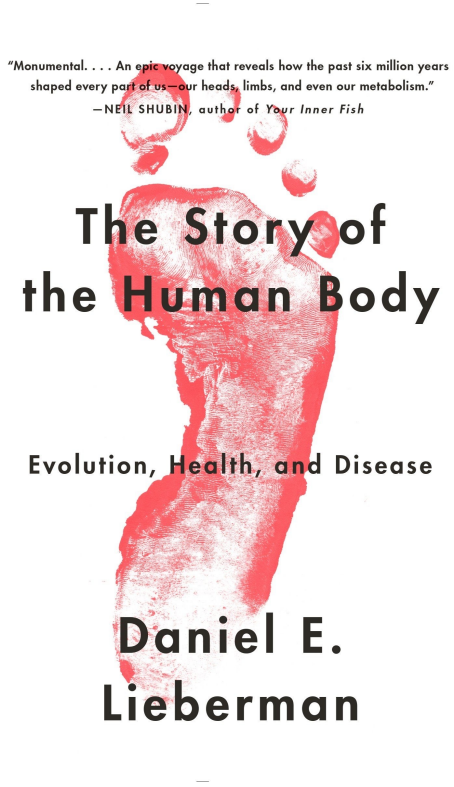
- Accessible book that looks at human evolution and how it impacts on human health

- Great read if you have some down time through the semester



Evo Med – ted talk

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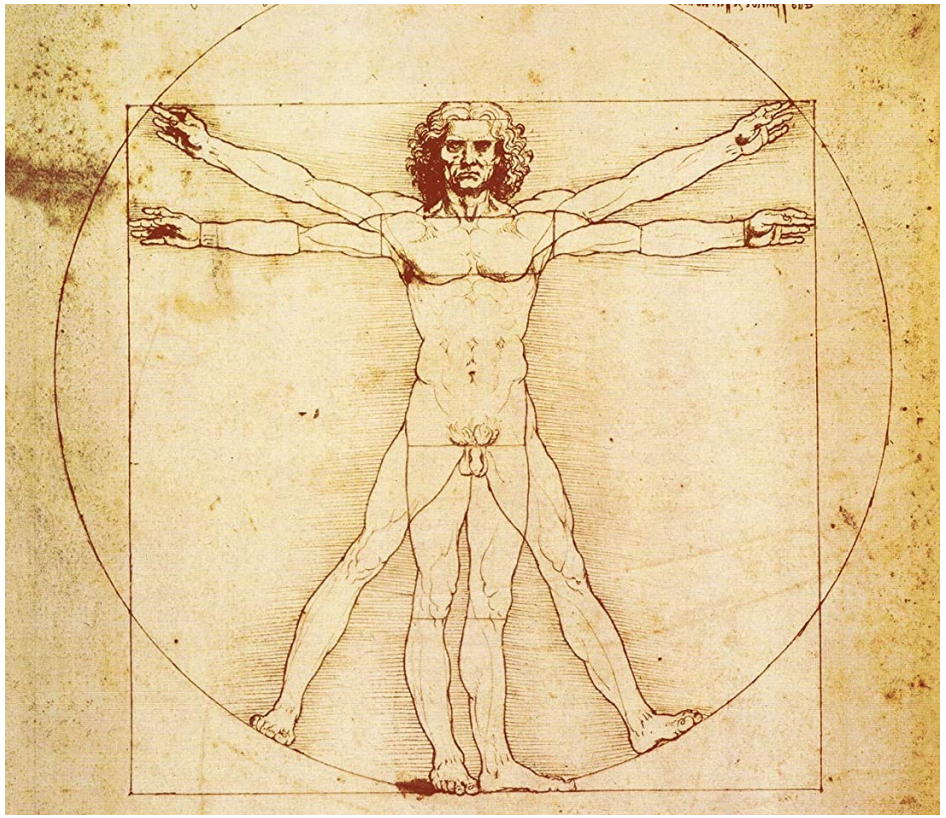
Ultimate vs. proximate understanding of disease

Some evolutionary principles

- Natural selection acts slowly
- There are limitations to what evolution can produce
- We are optimized for reproductive success, not health

Constant arms race with pathogens



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ORIGINAL RESEARCH ARTICLE

EVOLUTION, MEDICINE, & PUBLIC HEALTH

Core principles of evolutionary medicine

A Delphi study

Daniel Z. Grunspan,[1,2] Randolph M. Nesse,[1,2] M. Elizabeth Barnes[2] and Sara E. Brownell*[1,2]

Topic	Core principle
Types of explanation (question framing)	Both proximate (mechanistic) and ultimate (evolutionary) explanations are needed to provide a full biological understanding of traits, including those that increase vulnerability to disease.
Evolutionary processes (evolution I)	All evolutionary processes, including natural selection, genetic drift, mutation, migration and non-random mating, are important for understanding traits and disease.
Reproductive success (evolution I)	Natural selection maximizes reproductive success, sometimes at the expense of health and longevity.
Sexual selection (evolution I)	Sexual selection shapes traits that result in different health risks between sexes.
Constraints (evolution I)	Several constraints inhibit the capacity of natural selection to shape traits that are hypothetically optimal for health.
Trade-offs (evolutionary trade-offs)	Evolutionary changes in one trait that improve fitness can be linked to changes in other traits that decrease fitness.
LHT (evolutionary trade-offs)	Life history traits, such as age at first reproduction, reproductive lifespan and rate of senescence, are shaped by evolution, and have implications for health and disease.
Levels of selection (evolution II)	Vulnerabilities to disease can result when selection has opposing effects at different levels (e.g. genetic elements, cells, organisms, kin and other levels).
Phylogeny (evolution II)	Tracing phylogenetic relationships for species, populations, traits or pathogens can provide insights into health and disease.
Coevolution (evolution II)	Coevolution among species can influence health and disease (e.g. evolutionary arms races and mutualistic relationships such as those seen in the microbiome).
Plasticity (evolution II)	Environmental factors can shift developmental trajectories in ways that influence health and the plasticity of these trajectories can be the product of evolved adaptive mechanisms.
Defenses (reasons for vulnerability)	Many signs and symptoms of disease (e.g. fever) are useful defenses, which can be pathological if dysregulated.
Mismatch (reasons for vulnerability)	Disease risks can be altered for organisms living in environments that differ from those in which their ancestors evolved.
Cultural practices (culture)	Cultural practices can influence the evolution of humans and other species (including pathogens), in ways that can affect health and disease (e.g. anti-biotic use, birth practices, diet, etc.).

Core principles of evolutionary medicine

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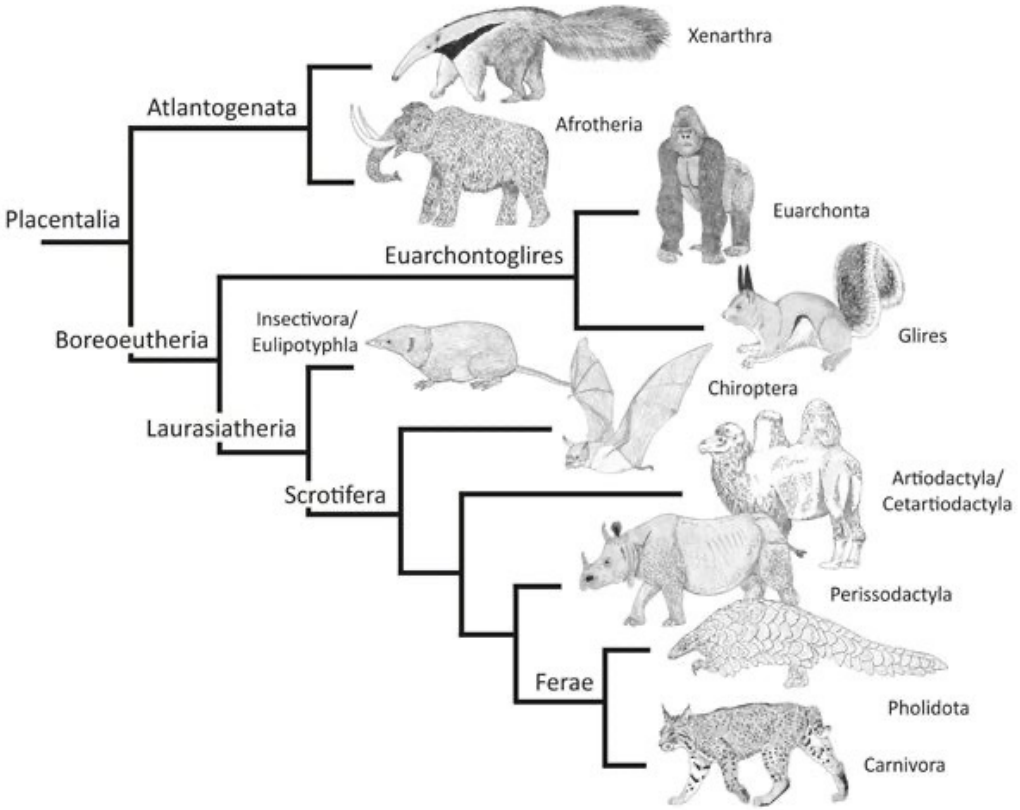
- Evolutionary understanding is required to fully understand traits including disease susceptibility
- Evolutionary processes shape traits and disease
- Natural selection maximises for reproductive success not health
- Evolution has trade offs
- Many signs and symptoms of disease are useful defenses (e.g. fever)



Darren Naish

Evolutionary understanding is required to fully understand traits including disease susceptibility

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- Our bodies are the product of evolution, so to truly understand health, we must know how we were put together

- Ultimate vs. proximate

- Type II Diabetes
  - **Proximate cause**: fat and muscle become insulin resistant and pancreas can't produce enough insulin
  - **Ultimate cause**: changes in diet and exercise regime after agriculture and industrialisation of society

Evolutionary processes shape traits and disease

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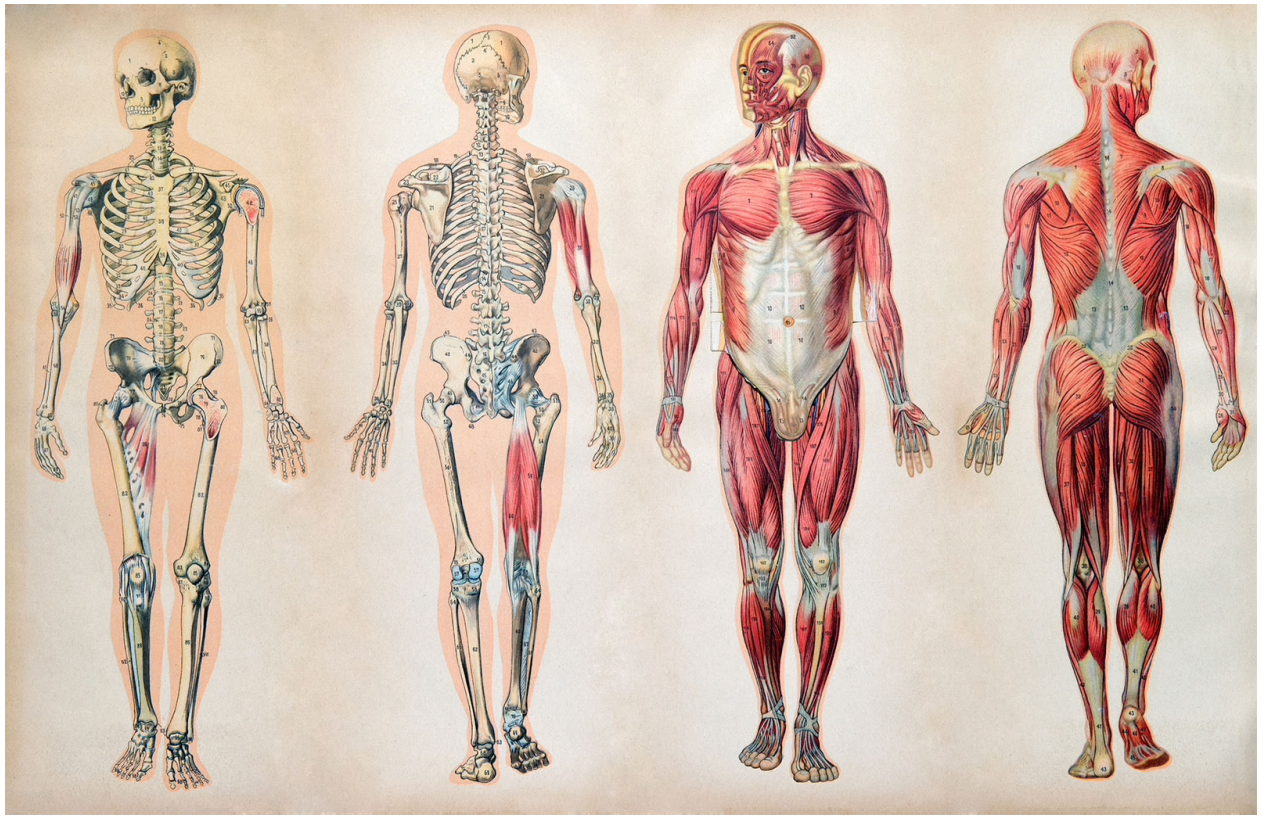


Natural selection maximises for reproductive success not health

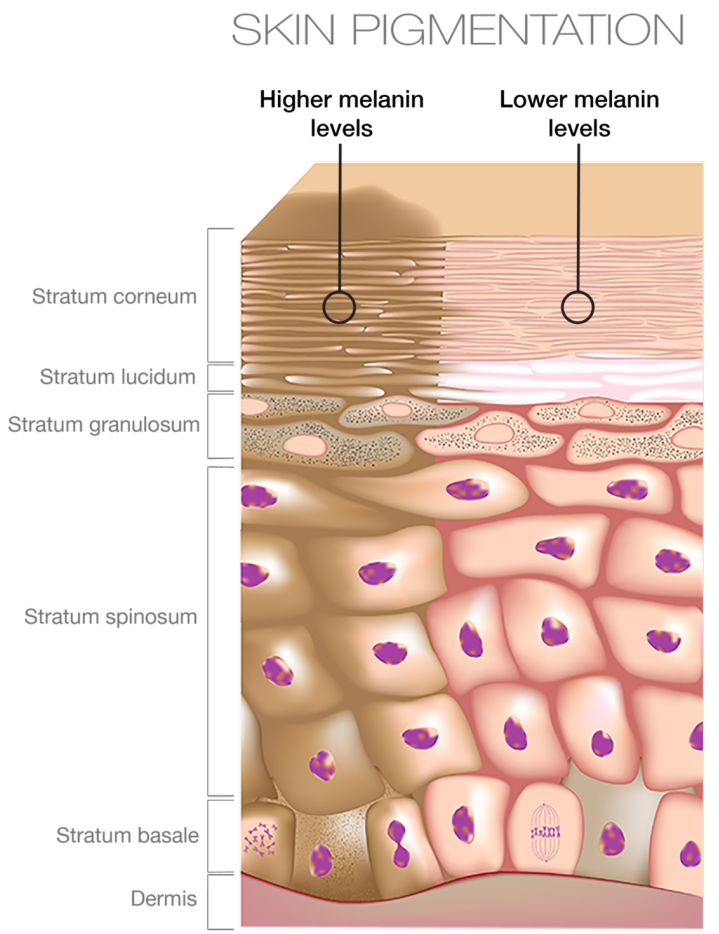
- No where is this more evident than in the brown antechinus

- Males live for just 1 year
- They can re-produce in a short 2 week breeding season each year
- During the breeding season males spend all their time fighting to gain access to females
- This produces so much stress hormones that their body gives up the ability to fight disease and otherwise function
- At the end of the breeding all males in the population die

Evolution has trade offs

- Fitness advantages often come at a cost in other areas of our physiology

- Loss of melanin leads to greater vitamin D synthesis in cooler climates, but leads to increased susceptibility to skin cancer



Many signs and symptoms of disease are useful defenses (e.g. fever)

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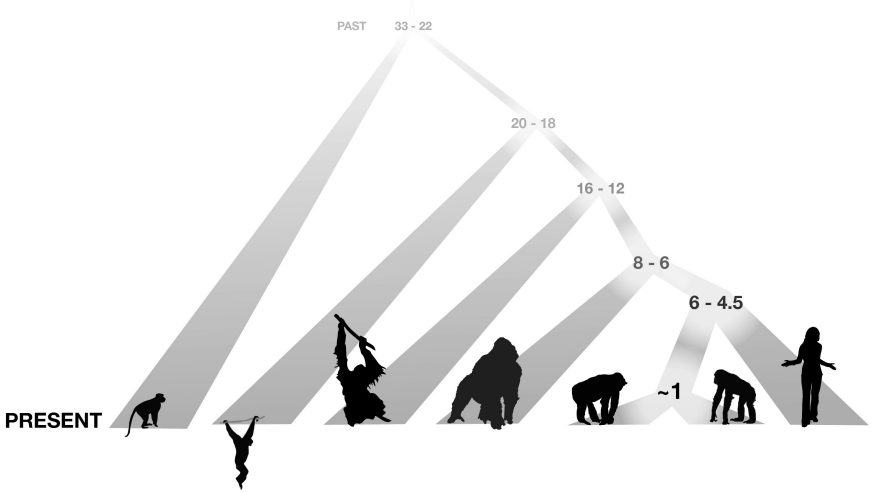
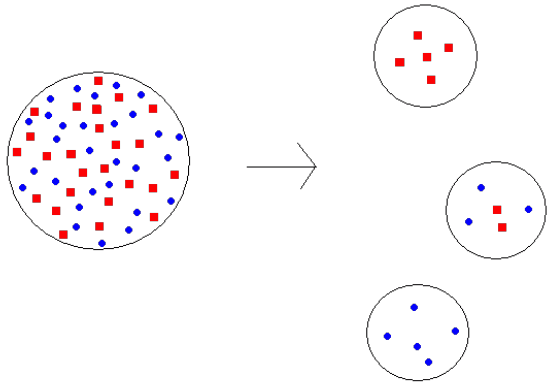
- Tissue damage and infection results in pro-inflammatory signals
- Inflammation recruits the immune system, leads to swelling, and fever
- Inflammation is painful and uncomfortable
- Managing inflammation is often done to decrease discomfort
- Inflammation is a necessary part of immune system to promote healing and eliminate pathogens

Tools of evolutionary biology



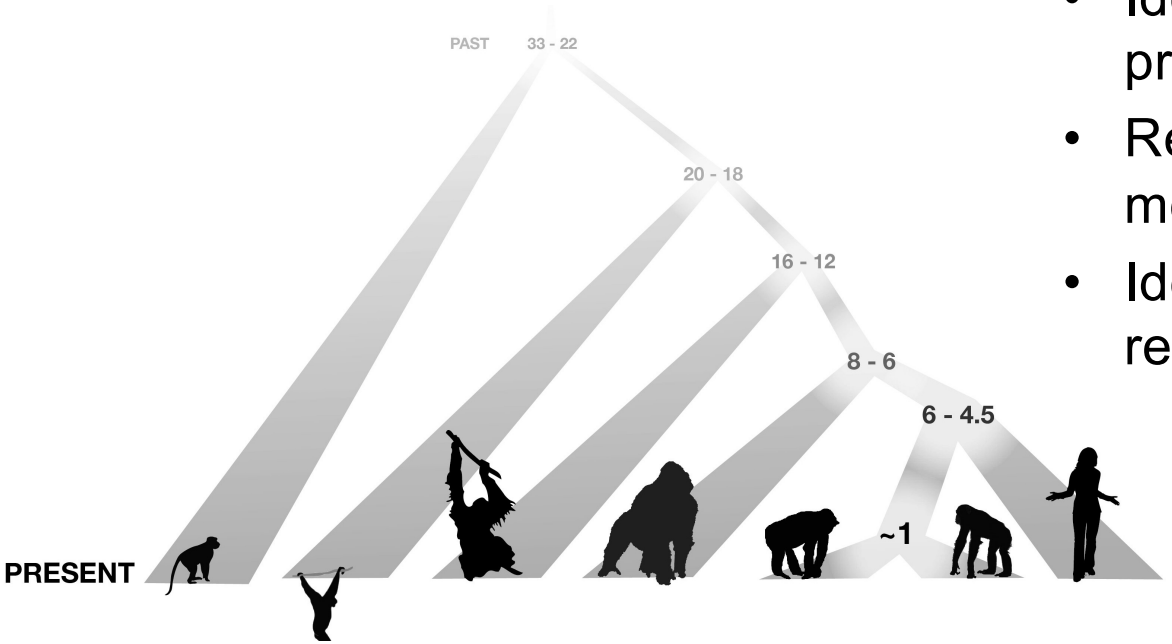
Phylogenetics & ancestral state reconstruction



Population genetics

Evo-Devo
Evolutionary developmental biology

Applications of evolutionary tools



Phylogenetics

- Identify evolutionary relationship of species
- Identify the timeline of evolutionary processes
- Required to evaluate animal models
- Identify the evolutionary relationship of pathogens

Applications of evolutionary tools

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Population genetics

- Field of genetics that identifies frequency of genes within and between populations
- Required to identify genes associated with disease phenotypes
- Identify difference in disease susceptibility between populations

Applications of evolutionary tools

Evo devo

- Compares developmental process between organisms, to identify how development has shaped our evolutionary history
- Vulnerabilities of development
- Understand vestigial structures
- Understand quirks of human anatomy

SARS-CoV-2

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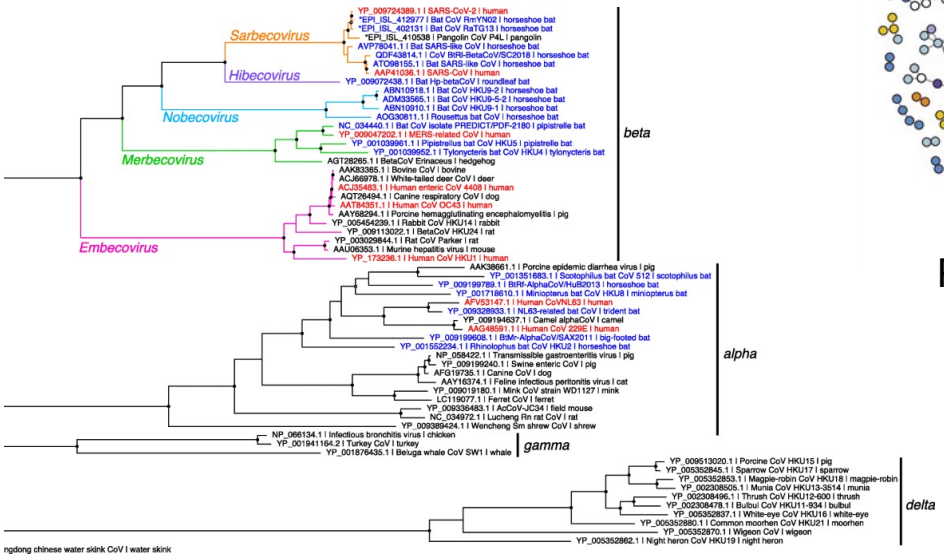
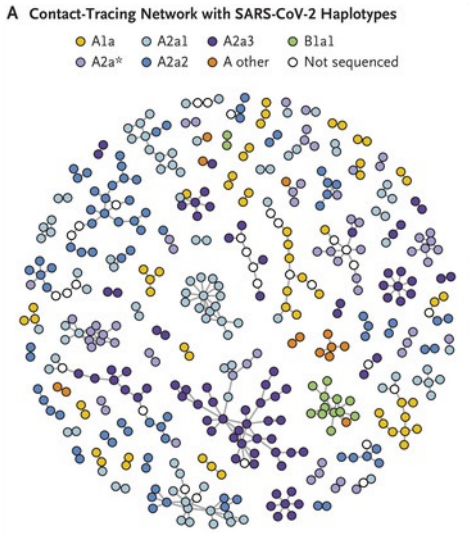
Phylogenetics





Population genetics

Evo-Devo