Evolution, adaptation, diversity I

Dr Laura van Holstein

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Anthropology 215

Office hours: Thursdays 10-11.30AM. Come chat!

Before we start…

1. **New students:**
   Welcome! Come chat if you need help catching up.
2. **Office hours – vote on timing:**
   Thursday 10-11.30 (current), Tuesday 10-11.30, or Wednesday 9-10.30?
3. **Your course - vote on content:**
   Applied human biology (Section 4): more on evolutionary psychiatry?

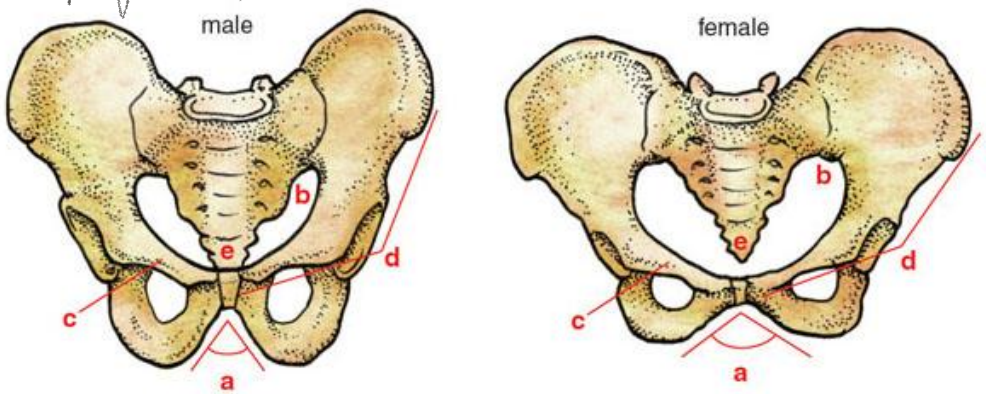
Tinbergen's separation of the proximate and ultimate

a	How?	Why?
	Proximate	Ultimate
Contemporary	Causation	Current Utility
Historical	Ontogeny	Evolution

Right Now

Long-term

Generally applying to genotypic + phenotypic traits



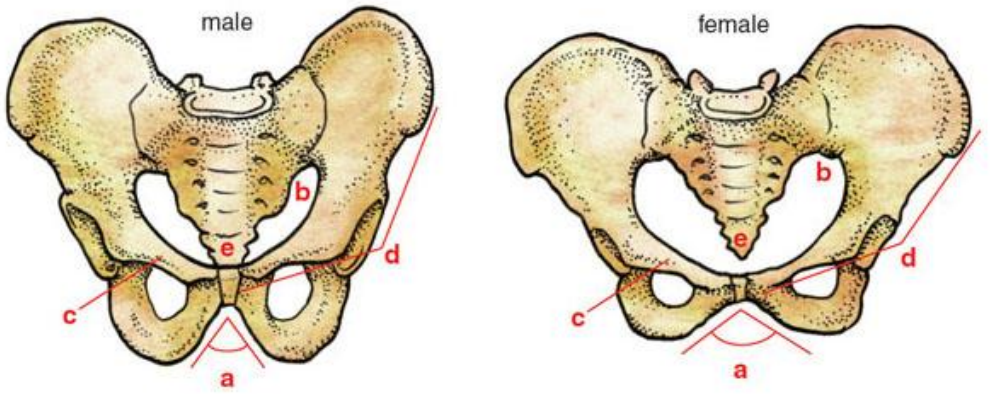
Applying to hips

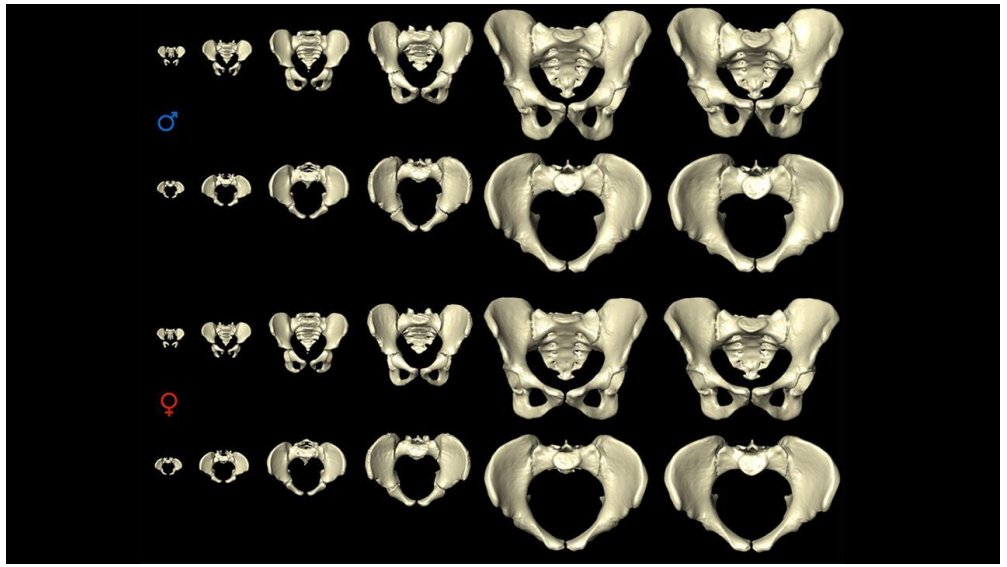
Matrix from Kapheim (2019) *Behavioral Ecology and Sociobiology*

Tinbergen's separation of the proximate and ultimate

a	*How?* Proximate	*Why?* Ultimate
Contemporary	Causation	Current Utility
Historical	Ontogeny	Evolution

Why might there be these differences WRT development?





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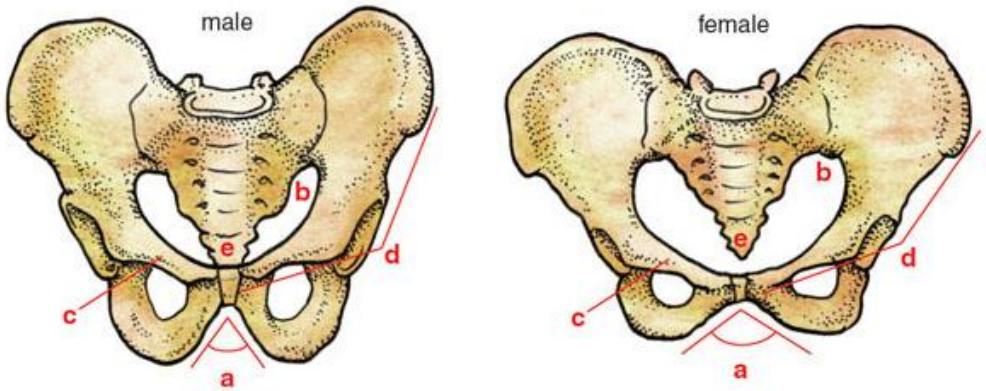
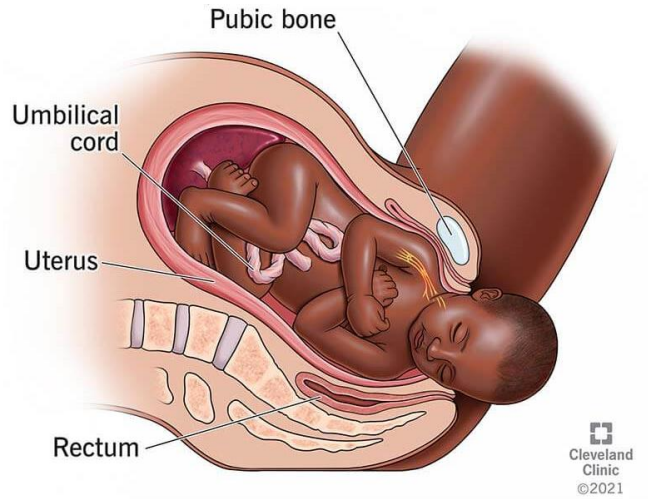
The current purpose - female rounder pelvis for giving birth





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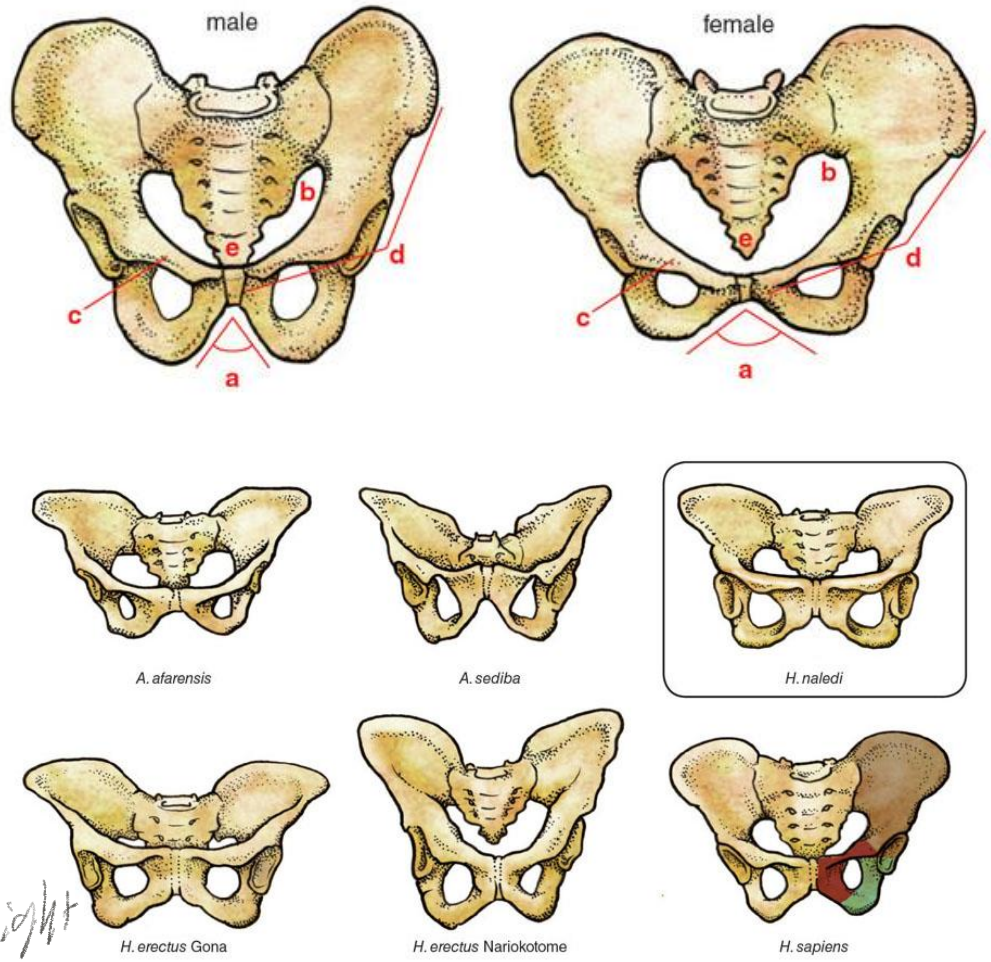
How did the pelvis differences evolve? Btwn species? Why might that be?



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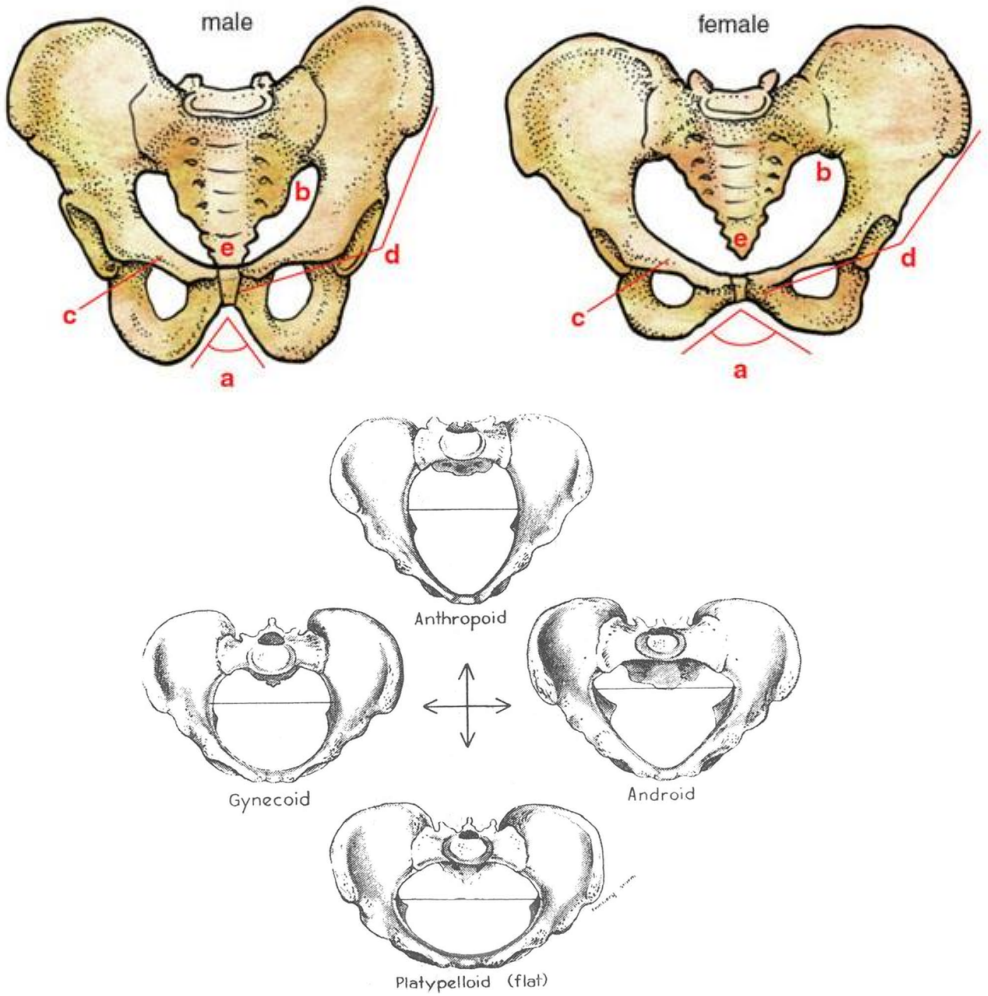

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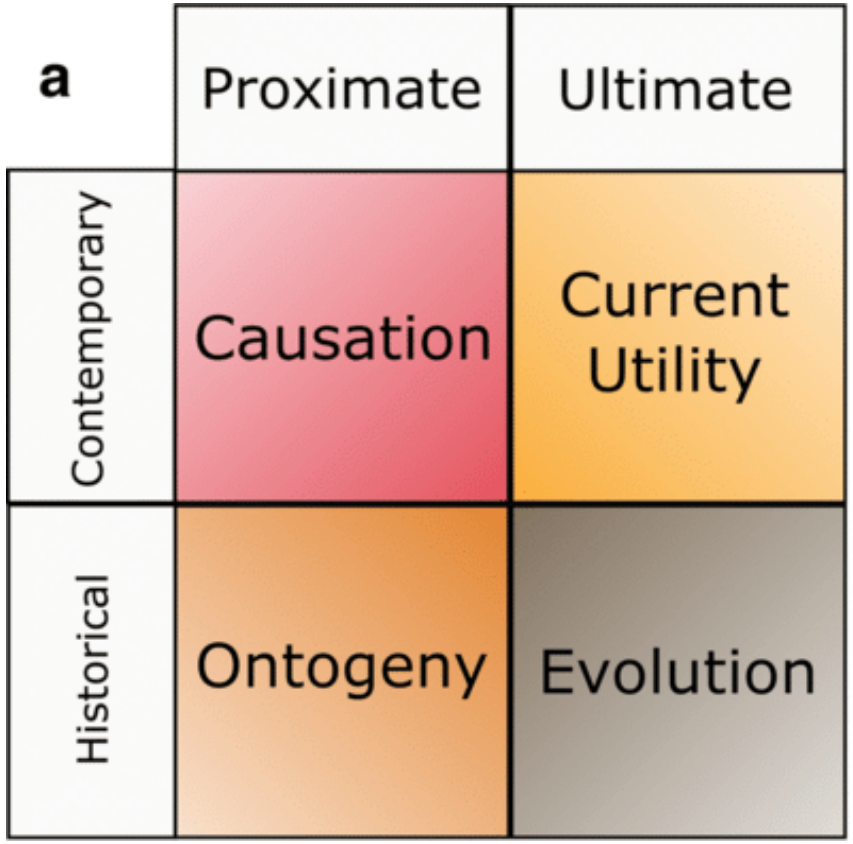
Key

Tinbergen's four questions



- We will be considering most of these for most traits we discuss, but I will not always make it explicit which of these is most applicable.
- **Keep this in the back of your head as you make notes and revise: it is a very useful way to organise this knowledge!**

Tinbergen's four questions

Key

causation + current utility

causation ontogeny

current utility evolution

evolution utility

ontogeny + causation

a

	Proximate	Ultimate
Contemporary	Causation	Current Utility
Historical	Ontogeny	Evolution

b

	Proximate	Ultimate
Contemporary	Causation: How does genotype map to phenotype? How does phenotype map to fitness?	Current Utility: How does evolutionary history influence current utility?
Historical	How does development influence mechanisms of behavior? What are the mechanisms that create developmental environments?	How does current utility influence evolutionary trajectory?
	Ontogeny: How does developmental plasticity evolve? How does developmental plasticity influence evolution?	Evolution

Formal frameworks to structure our thinking

1. Tinbergen's four questions
2. **Tradeoffs**
3. Populations, not races

Tradeoffs

The bottom line of evolution:
Life is about converting energy to offspring

Why species are different to each other: different **energy conversion strategies**

But why not have big, smart (sorry...!) babies, like orangutans?

But why not have many offspring, like guinea pigs?

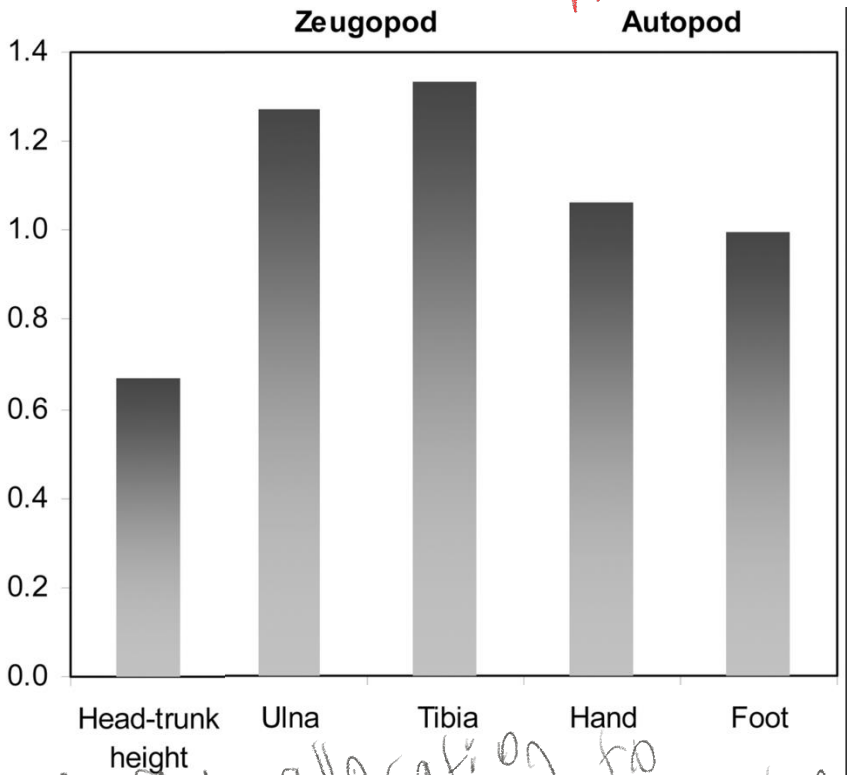
Tradeoffs arise because energy is finite

Tradeoff between offspring quantity and quality

= put large amount of finite energy into having many small babies that don't require much post-birth, or having one big baby that requires a ton of investment

Tradeoffs during human development can explain differences in stature

Difference between lowland (not stressed) and highland (stressed)



- Nutritional and hypoxic stress exposes tradeoffs
- Body can't devote energy to maximum potential growth to all aspects of the skeleton: **growth of different parts are traded off against each other**
- Allocation follows functionality

Pomeroy et al. (2012) *PLoS ONE*

Key

The traits ‘traded off’ can vary, but the principle is important to consider throughout the course

Key areas:

- **Life history** (growth, maintenance, reproduction)
- **Development** (growth of critical versus less critical traits)
- **Health** in early versus later life

Formal frameworks to structure our thinking

1. Tinbergen's four questions
2. Tradeoffs
3. Populations, not races

When considering a trait at the species, population, or individual level: ask **whether you are analysing *why* or *how*** (Tinbergen) and whether the *why* or *how* can be explained by **tradeoffs**

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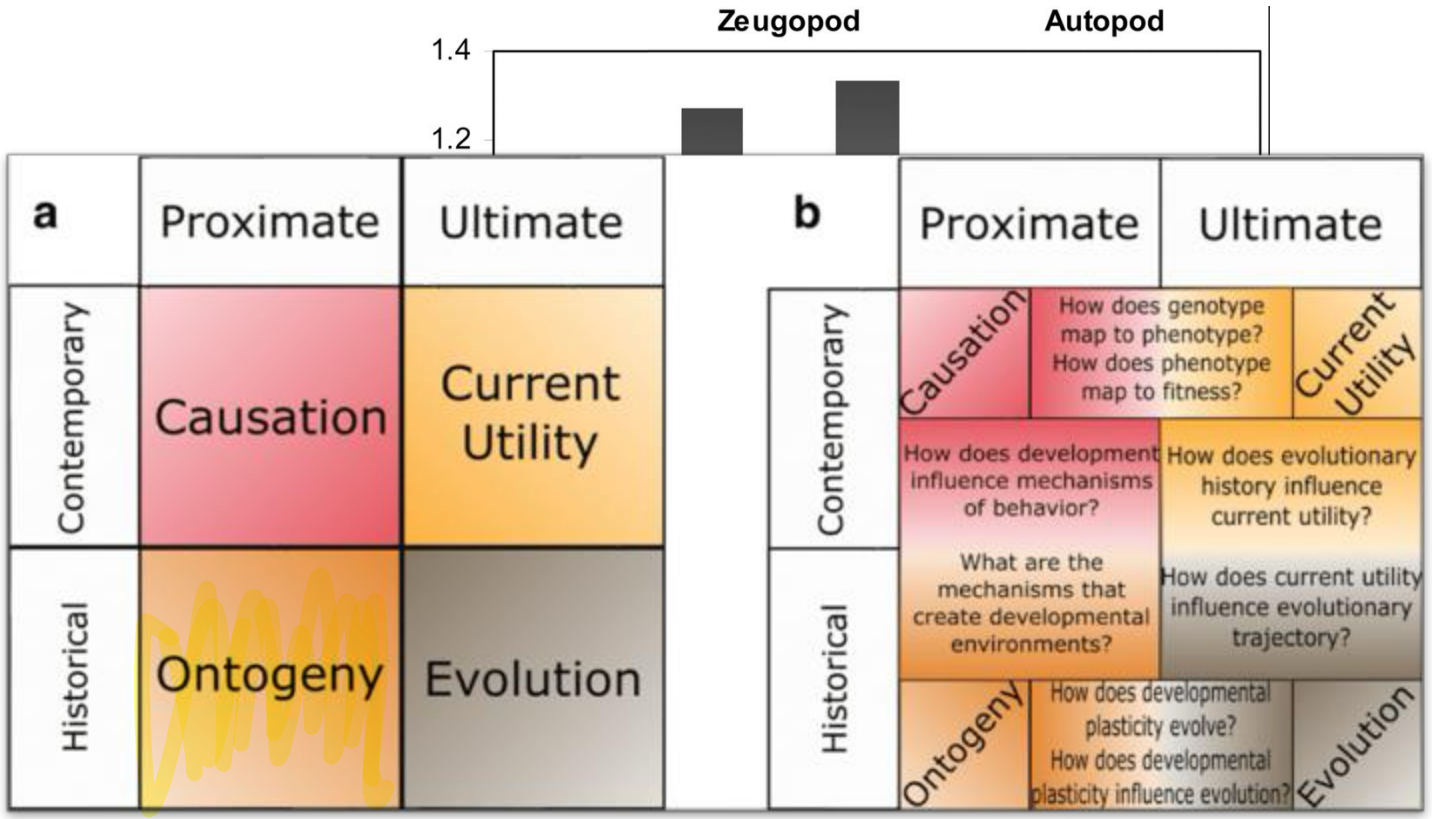

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Formal frameworks to structure our thinking

1. Tinbergen's four questions
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3. **Populations, not races**

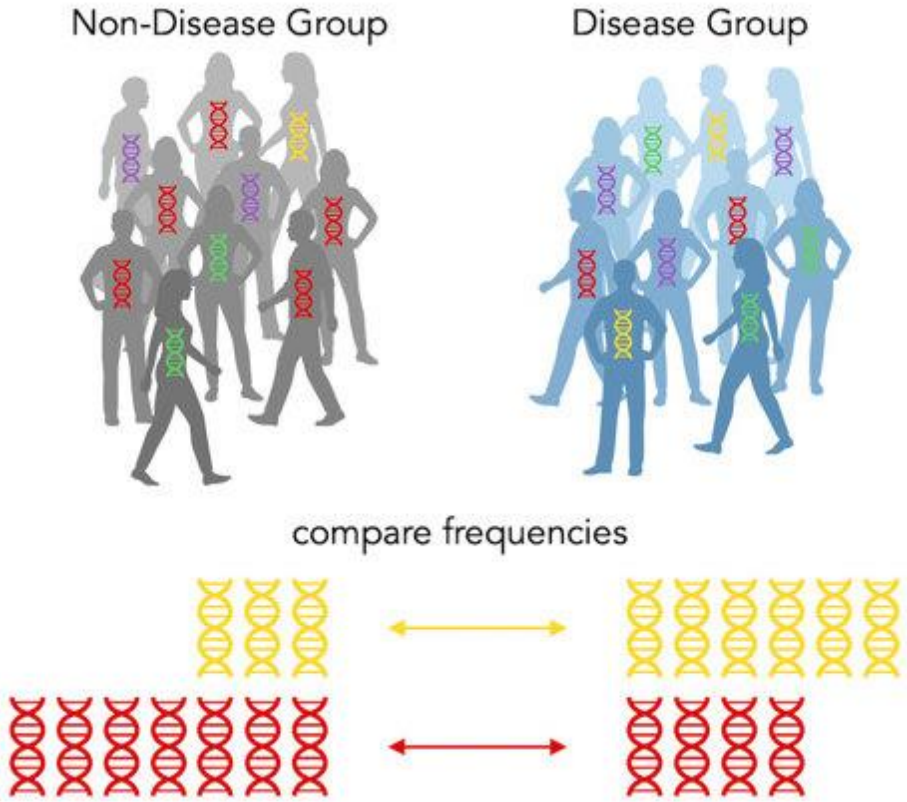
Populations, not races

Human biological variation is *continuous*, *clinal*, and *nonconcordant*:
no biological foundation for race.

not a set of traits that go together -- blood type won't correlate to hair type

Populations, not races

- But grouping people is often necessary to study patterns and/or causes of these patterns
- How, then, do we draw lines between populations?
  - **Groupings vary according to the trait being studied**
  - Lines are often fuzzy – and that is OK!



Is this evolution?

Join by Web
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Is this evolution?

Yes - there have been genetic changes overtime ✓

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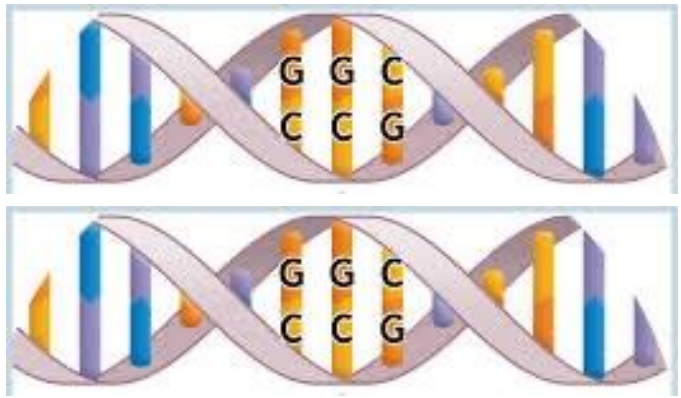
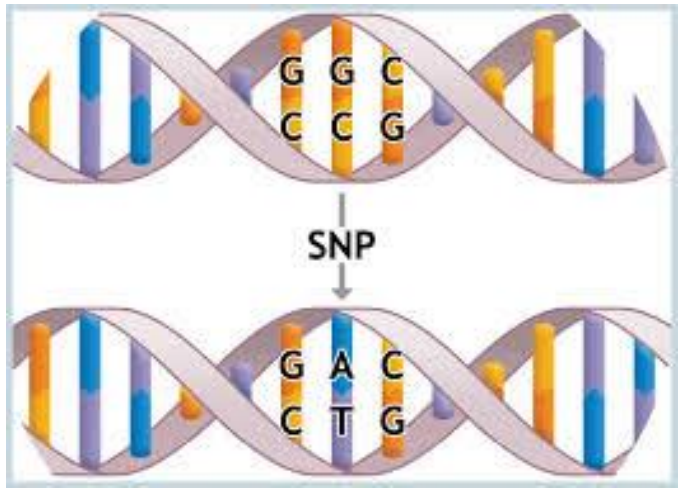
Is this evolution?





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✓ yes, it doesn't have to be expressed in phenotype

Is this evolution?

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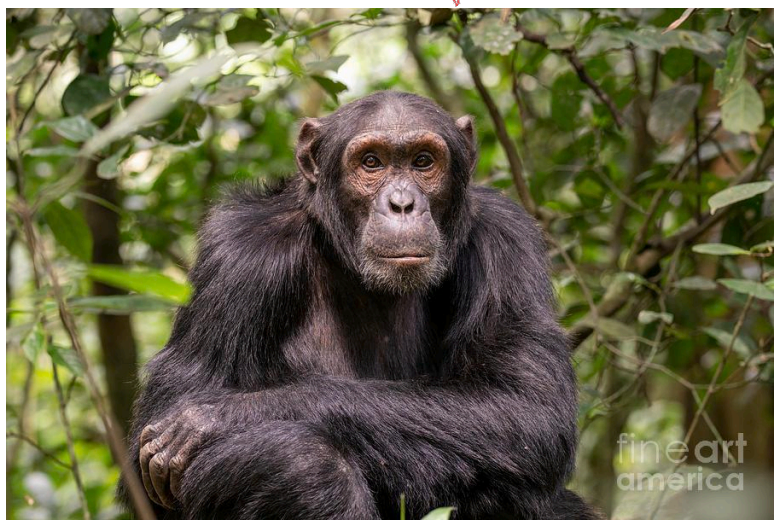
× No - just observing differences

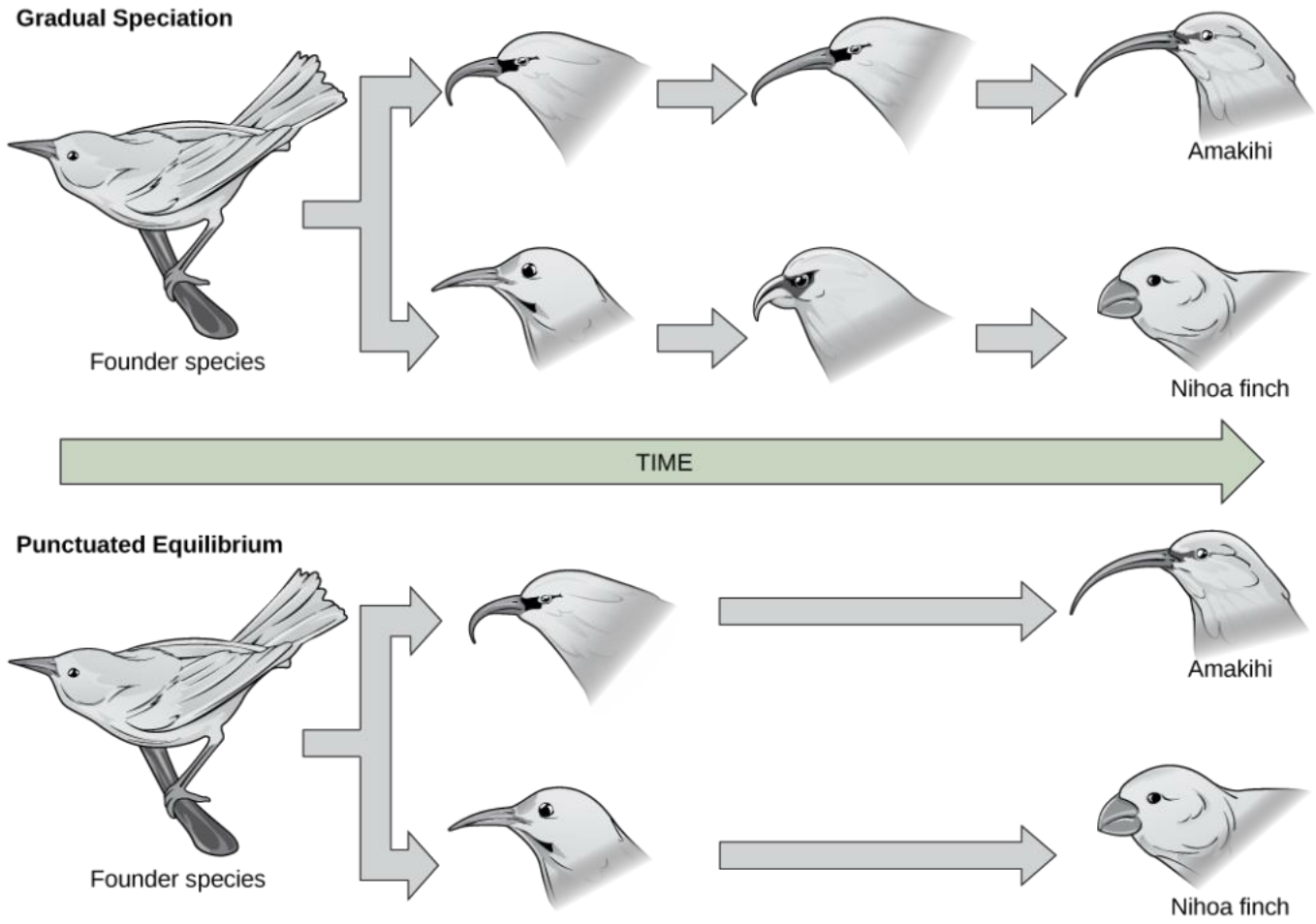


≠ evolution

evolution would be changes over time causing these differences

Is this evolution?

yes, both of the early theories



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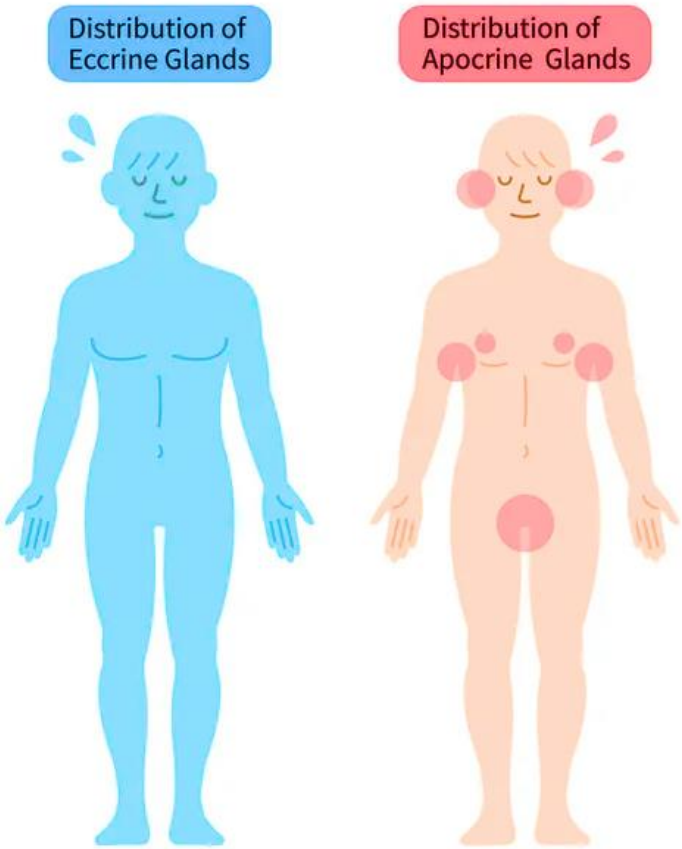
Is this evolution?

X No



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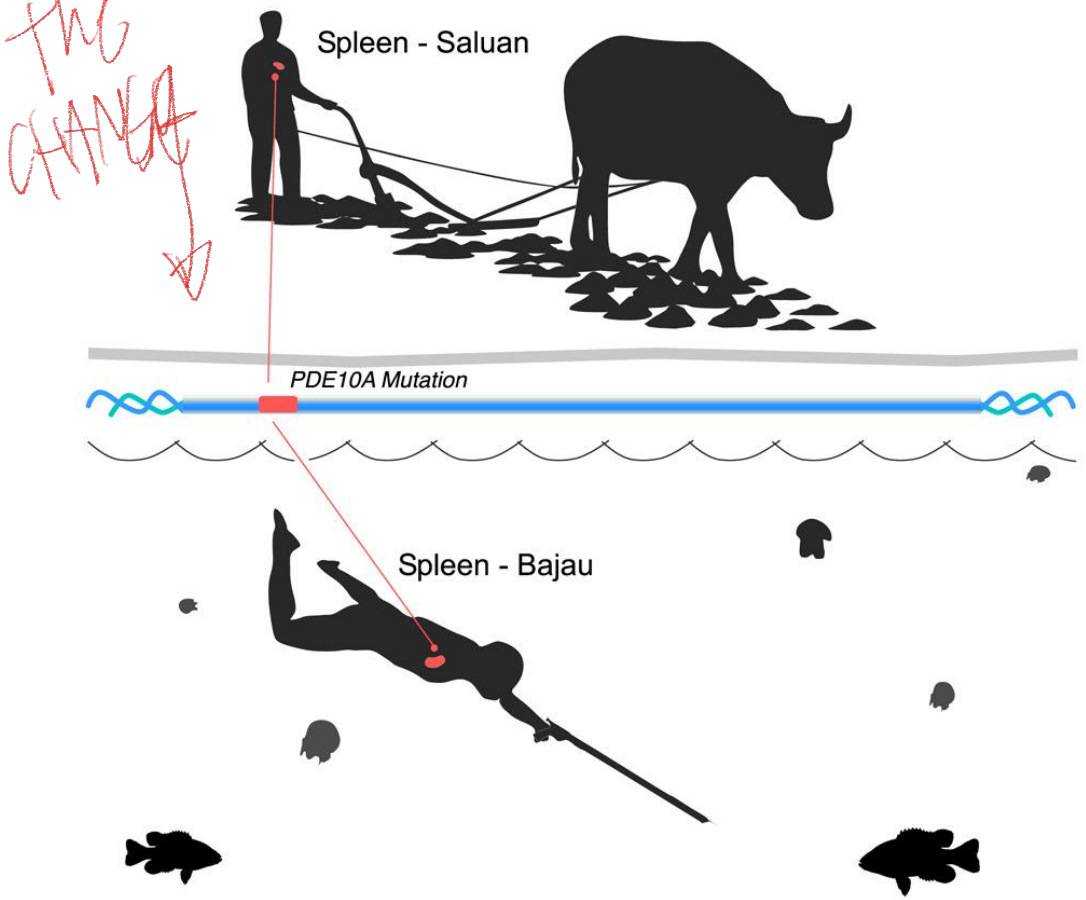

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What is evolution?

"…changes in the genetic constitution of a population…"
(Futuyma in HEB chapter 1)

"…changes in the heritable traits of a population…"
(National Academies)

"…evolution simply means that a species undergoes genetic change over time. That is, over many generations a species can evolve into something quite different, and those differences are based on changes in the DNA, which originate as mutations. The species of animals and plants living today weren't around in the past, but are descended from those that lived earlier."
(Coyne, 2009)

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CHANGE OVER TIME

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CHANGE OVER TIME

in HERITABLE INFORMATION*

*in biological evolution, this happens through DNA

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Key

CHANGE OVER TIME

in HERITABLE INFORMATION*

of a GROUP

not an individual!

*in biological evolution, this happens through DNA

Speciation is actually not implied…

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Microevolution versus macroevolution

Macroevolution:
Evolution *above* the species level

- Speciation
- Extinction

CHANGE OVER TIME

in HERITABLE INFORMATION*

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not an individual!

Cavia tschudii

Cavia porcellus

*in biological evolution, this happens through DNA

CHANGE OVER TIME

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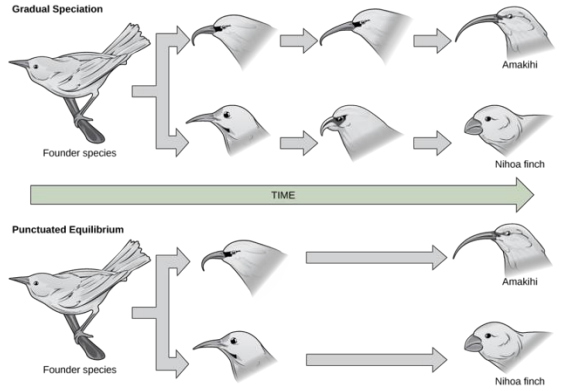

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What is required for evolution?

- Heritable variation
- Time

- Differential reproduction (or selection)

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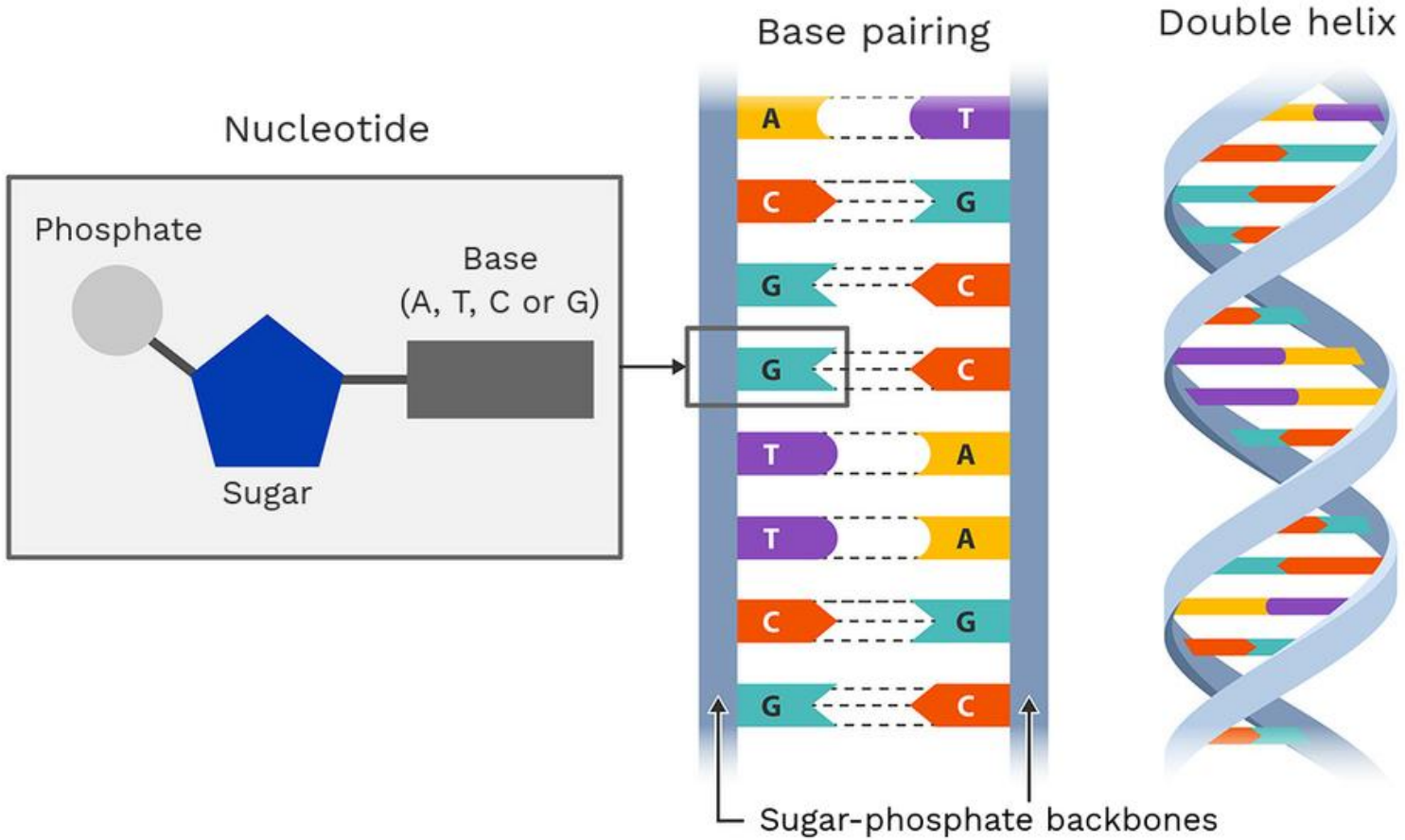
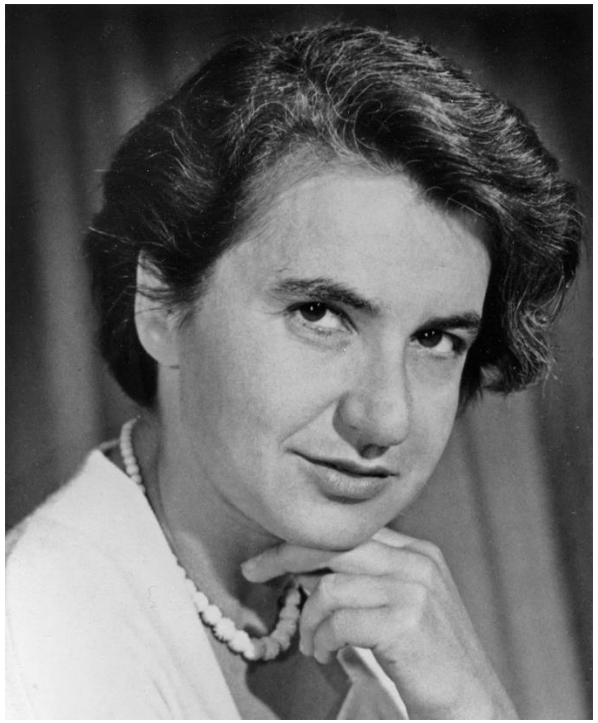
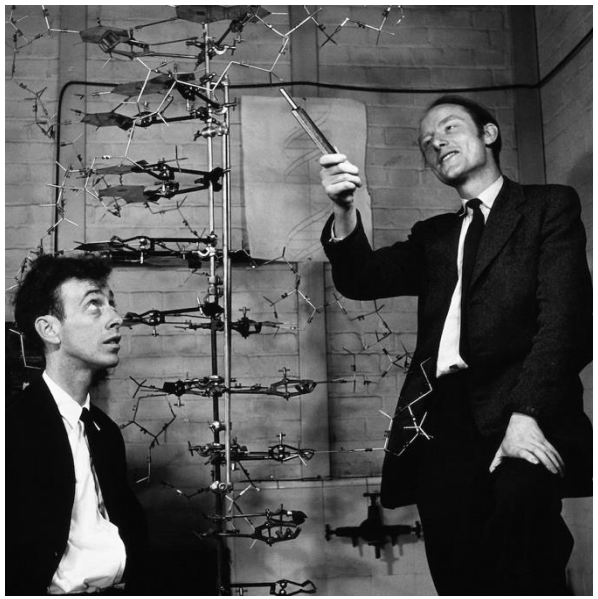
Heritable variation: DNA

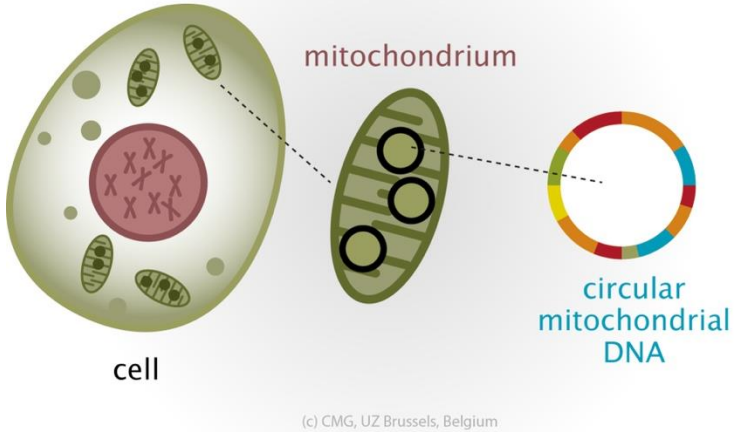






Fantastic profile on Rosalind Franklin:
http://profiles.nlm.nih.gov/spotlight/kr/feature/biographical

mtDNA

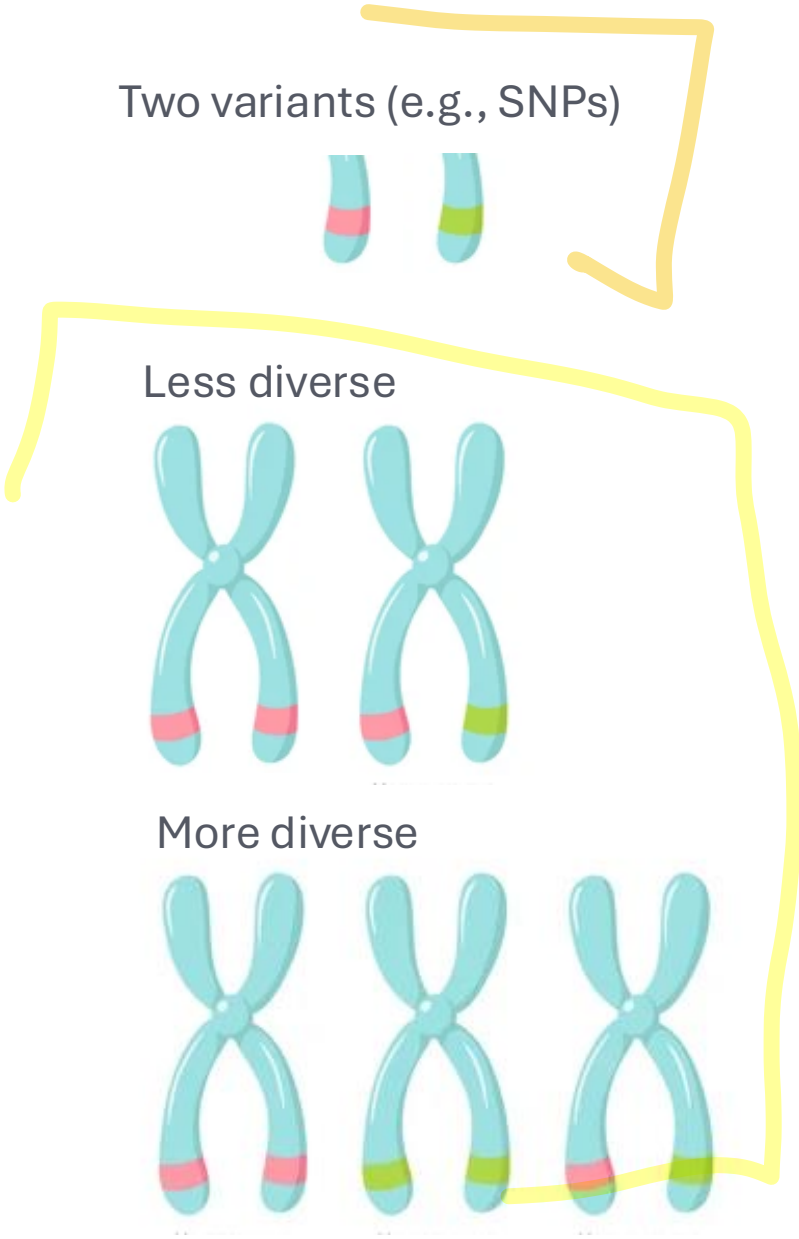

mitochondrium
circular mitochondrial DNA
cell
(c) CMG, UZ Brussels, Belgium


Nuclear DNA has a maternal and paternal inheritance
Mitochondrial DNA is inherited maternally

Genetic variation and diversity

- **Variation:** The differences between **genomes**
  - Encompasses a wide range of scales: from single nucleotide polymorphisms (SNPs) through to structural variation involving millions of base pairs
- **Diversity:** A **summary** of variation at group level
  - Many measures: heterozygosity, population mutation parameter theta (θ), proportioning of diversity within and between groups (F_{ST})…

*"Diversity as a measure of individual variation within a population is widely agreed to reflect the **number of different types** in the population, taking into account their **frequencies**." (Gregorius,1987, Theor. Appl. Genet)*



Genetic variation arises through mutation

Key

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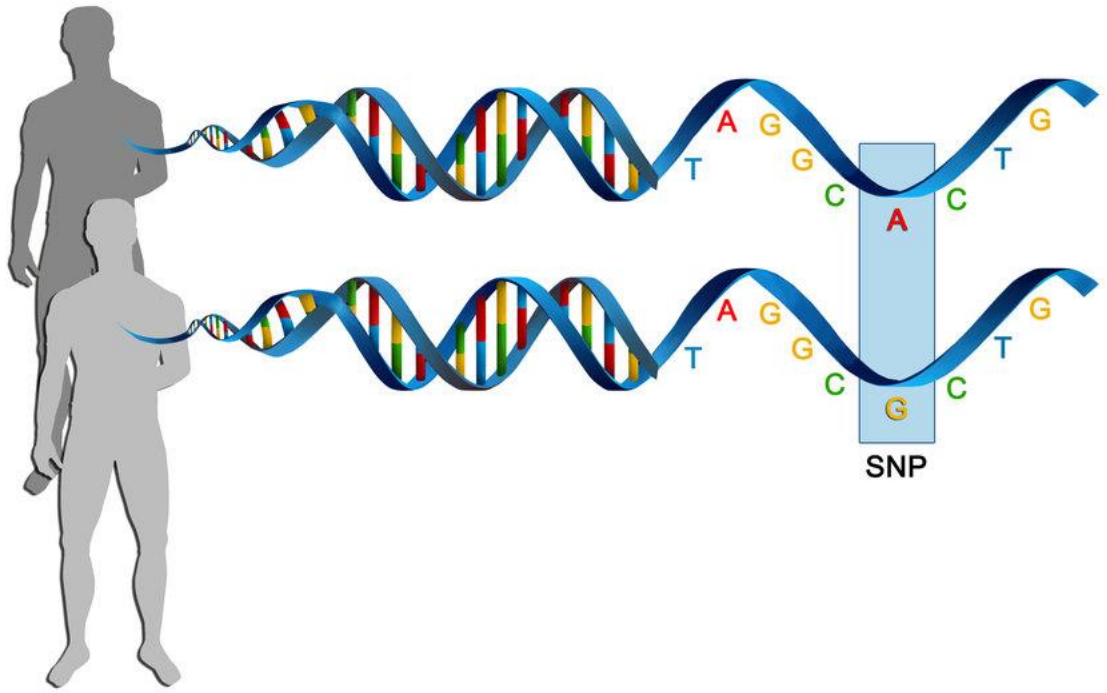

coding SNPs
synonymous
vs
nonsynonymous

Genetic variation arises through mutation

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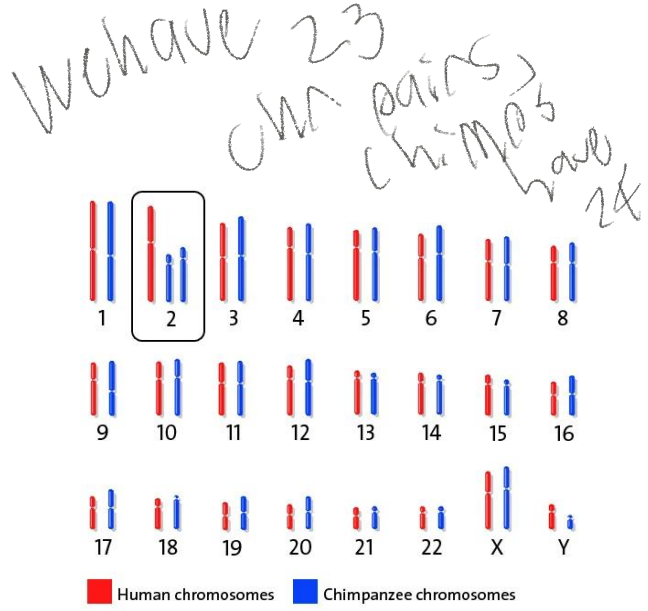
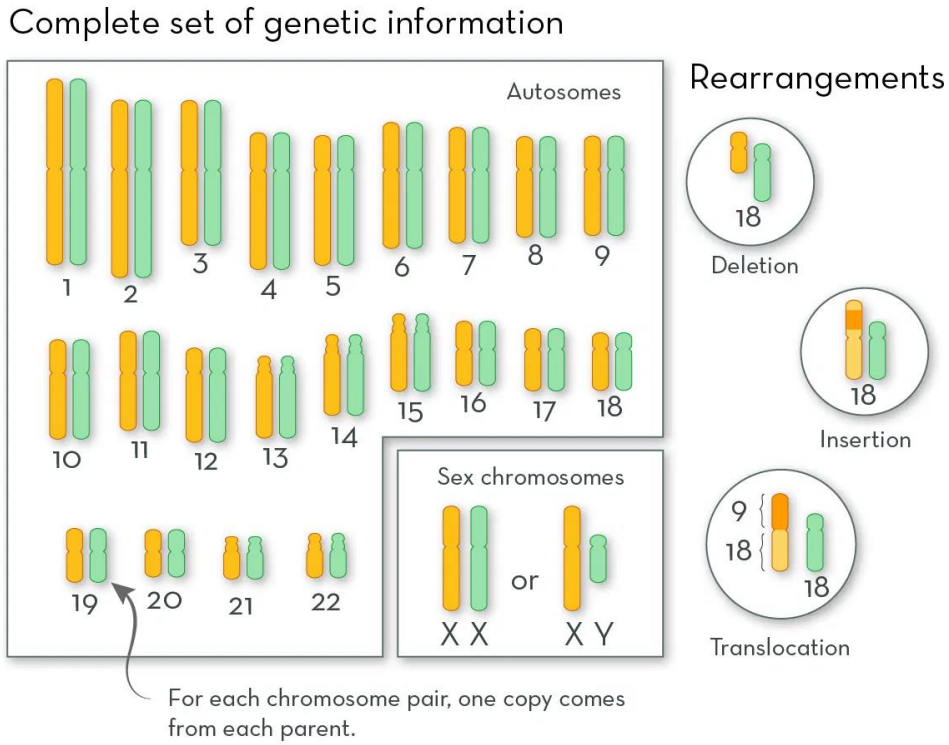
    E.g., insertions, deletions, rearrangements, changes in ploidy





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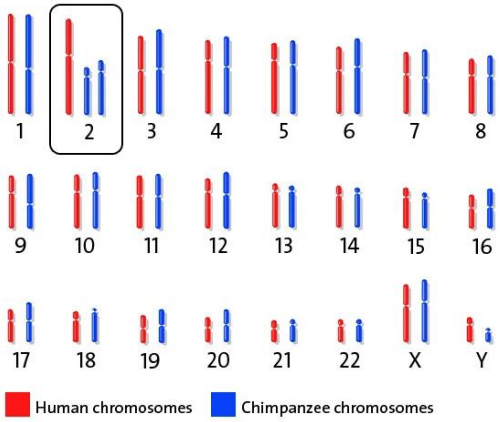
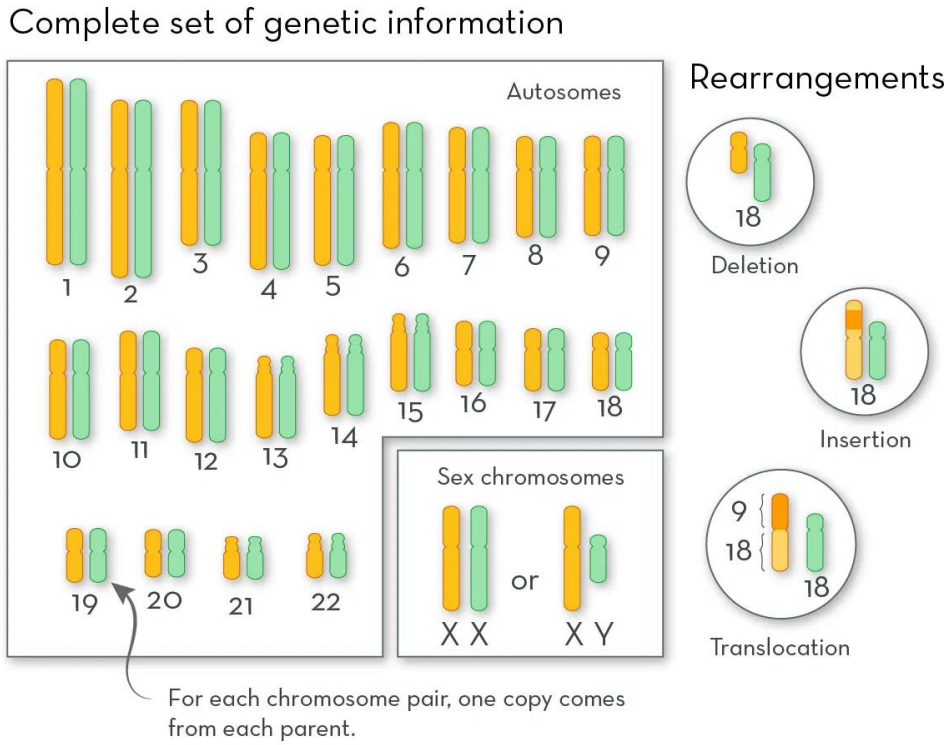
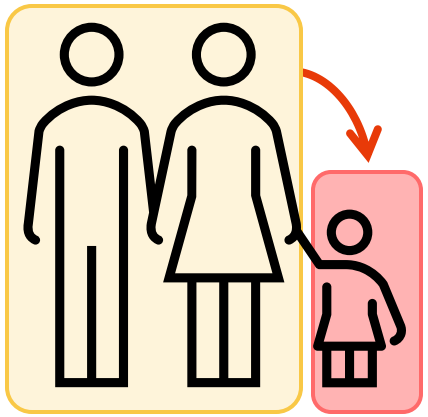




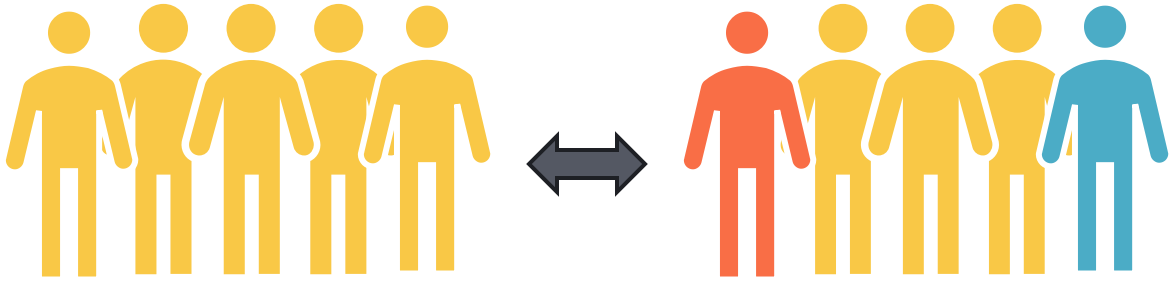


Mutation

Generation of novel genetic variants

Fundamental process that drives evolution

You need mutations to have variation on which natural selection can act



CHANGE OVER TIME

in HERITABLE INFORMATION*

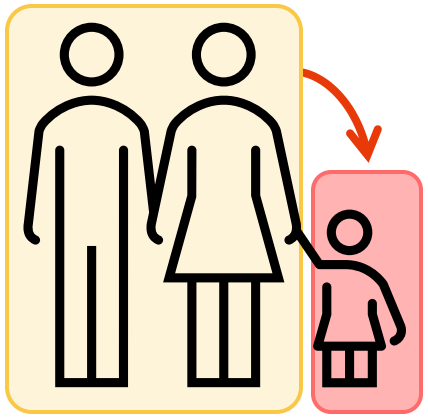
of a GROUP

not an individual!

3 other processes* at group level

*secondary to mutation

*in biological evolution, this happens through DNA



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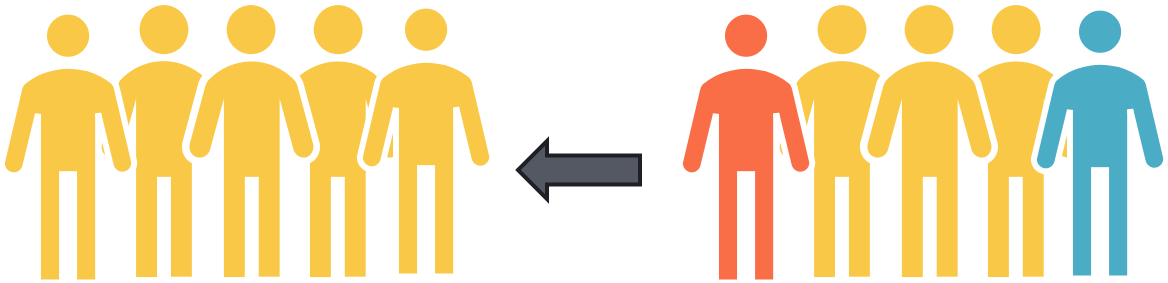
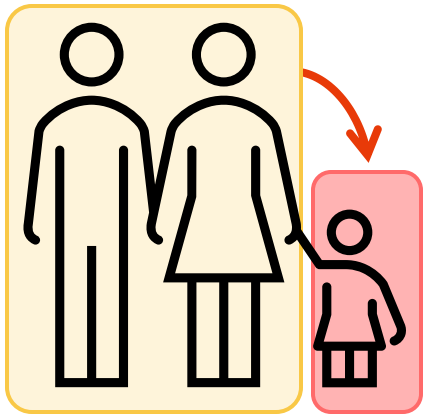
Generation of novel genetic variants

1) Gene flow: introduces new mutations



Population of interest

Population of interest



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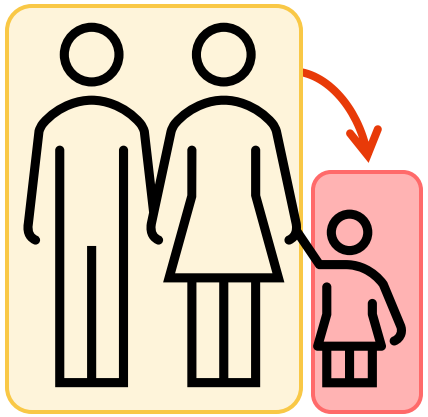

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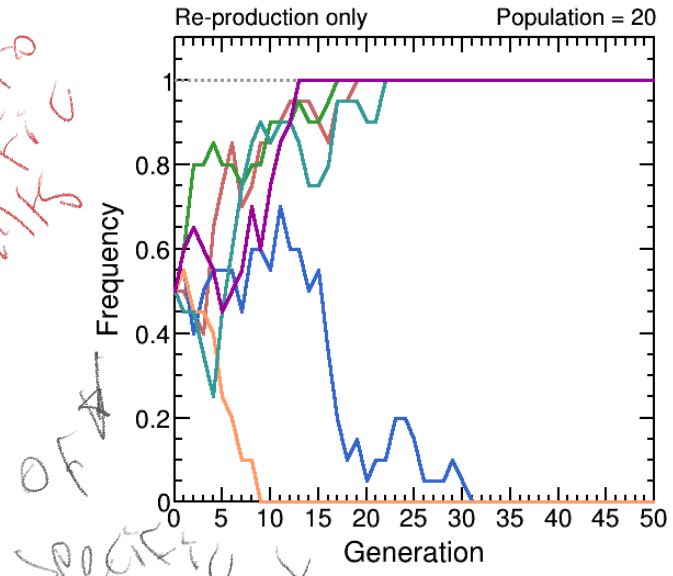
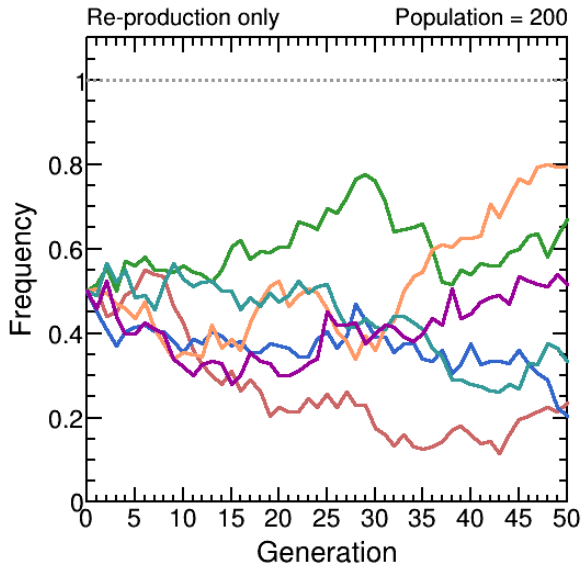
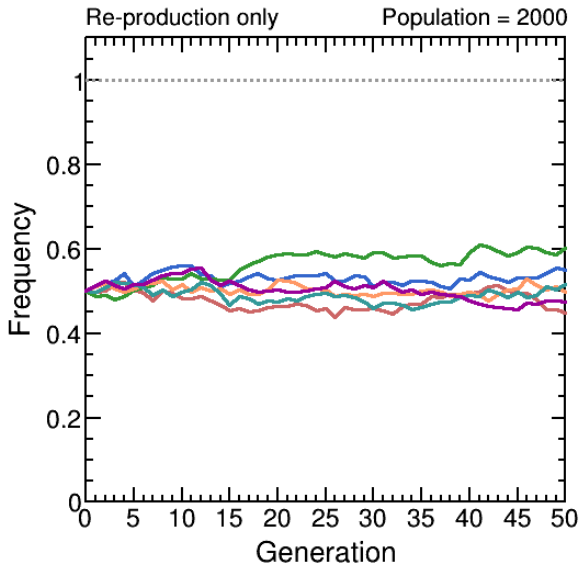
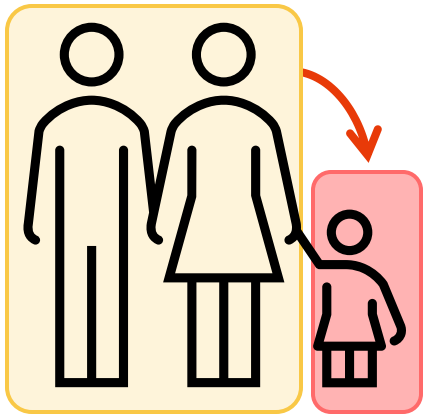






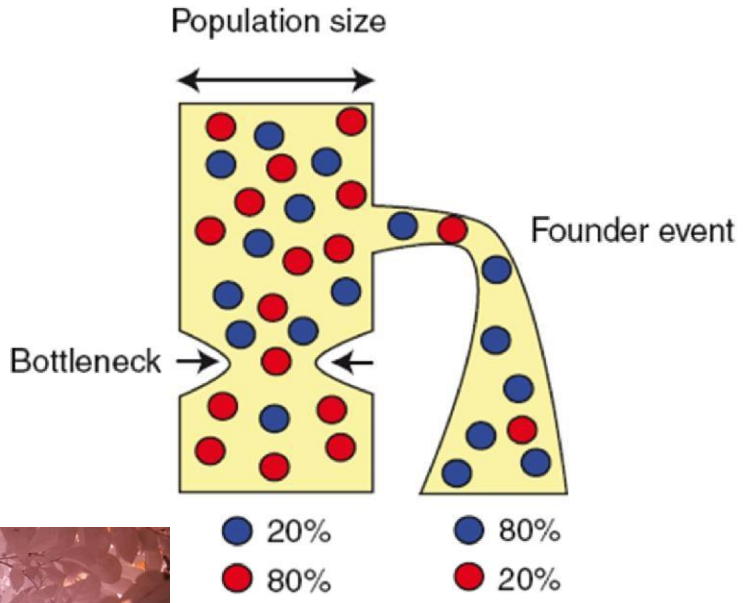


Mutation

Generation of novel genetic variants

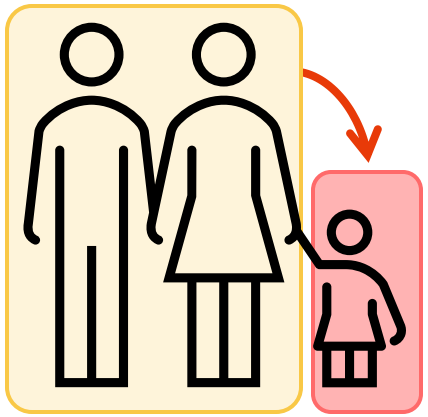
1) **Gene flow:** introduces new mutations

2) **Drift:** removes diversity randomly



Bottleneck:
Pingelapese population (Pingelap Island in the Pacific), catastrophic typhoon in 1780, only a small number of survivors
One of the nine surviving males carried an achromatopsia allele (Chr 8), now unusually high frequency (5–10%) of color blindness on the island.

But this was random



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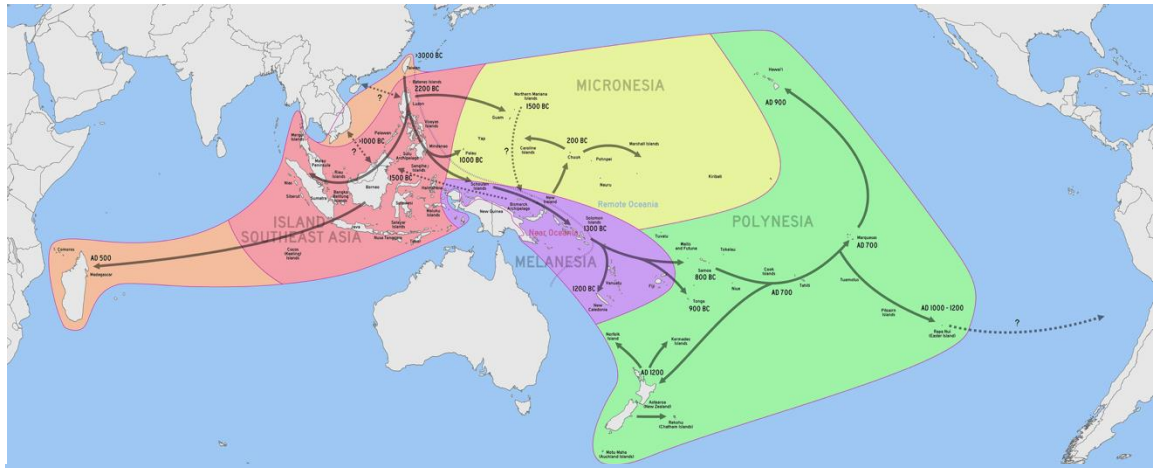

Founder effect:
high frequency of mtDNA haplogroup B4a1a1 in most Polynesian populations ascribed to a small initial effective population size of the Austronesian-speaking ancestral population that expanded in the Pacific a few thousand years ago.

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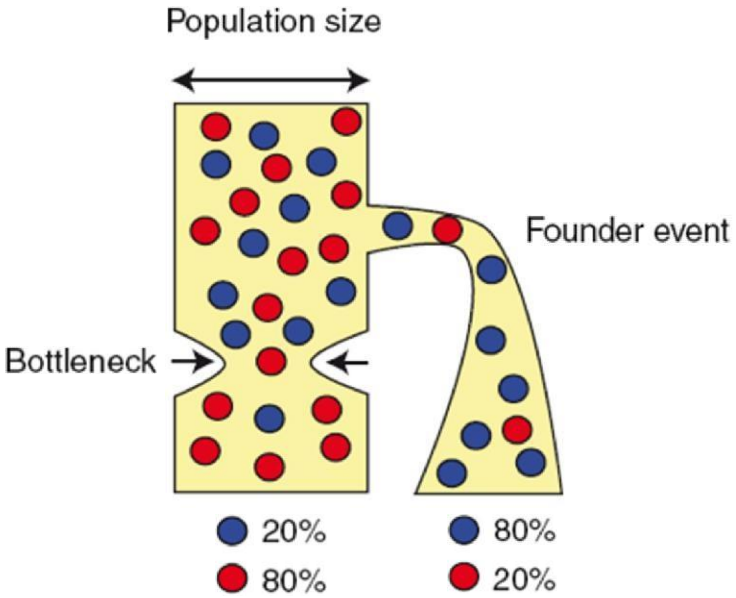

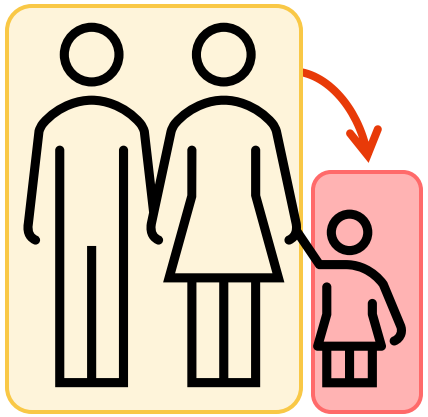

Mutation

Generation of novel genetic variants

1) **Gene flow:** introduces new mutations
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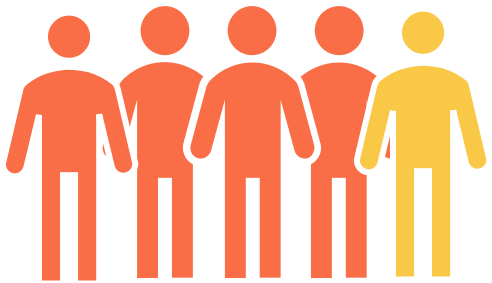
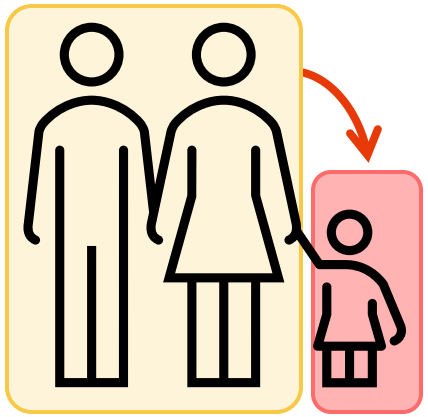
3) **Selection**

Population of interest



Population of interest

(Natural) selection and **evolution** are often used as synonyms, but this is not accurate! **Selection is one of four processes by which evolution can happen**, and relies on (arguably) the most important of those four: mutation.



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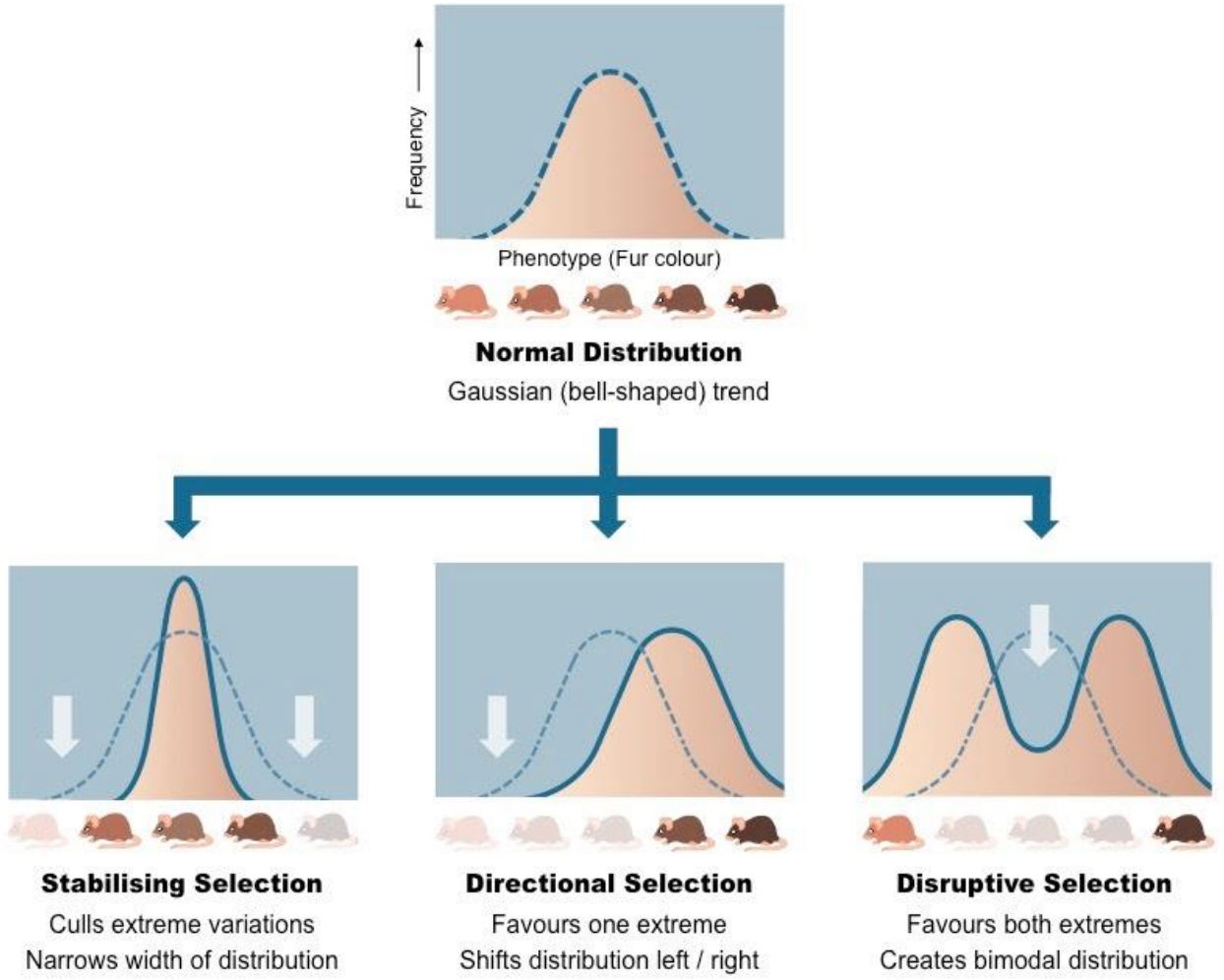

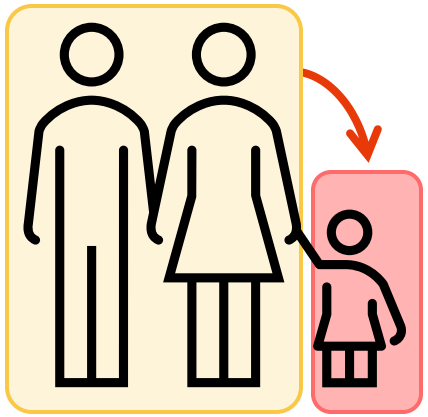

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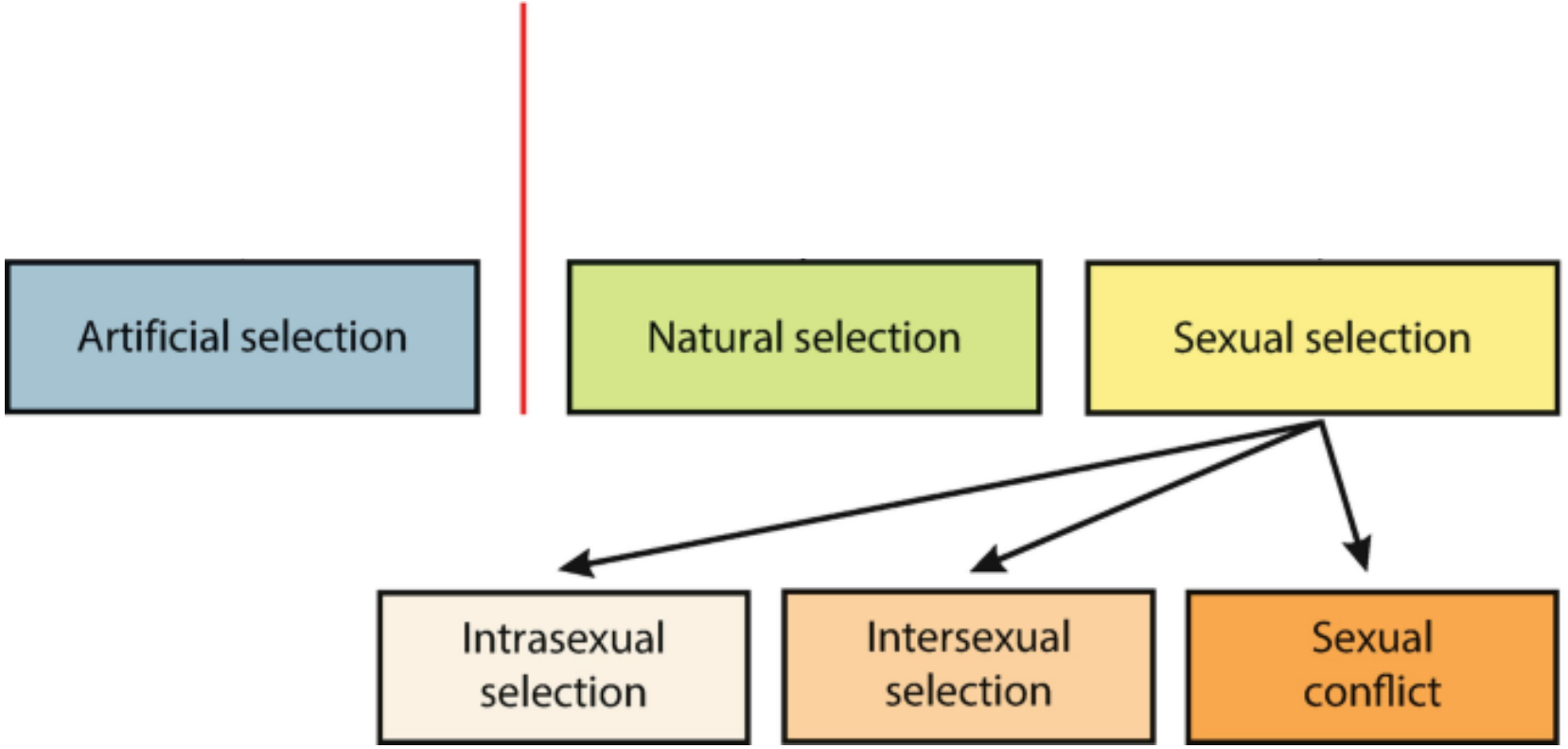

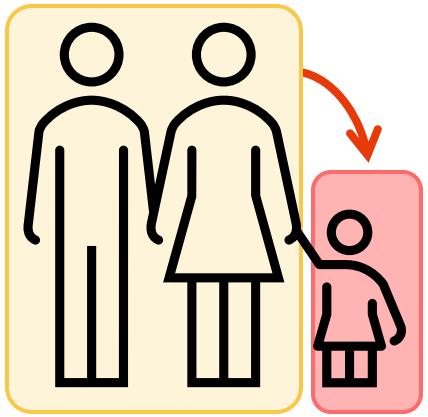

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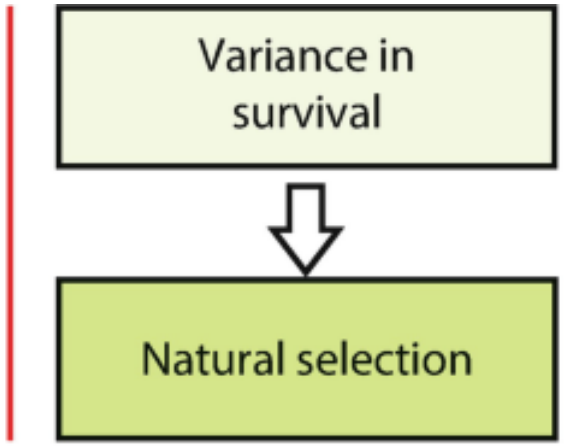

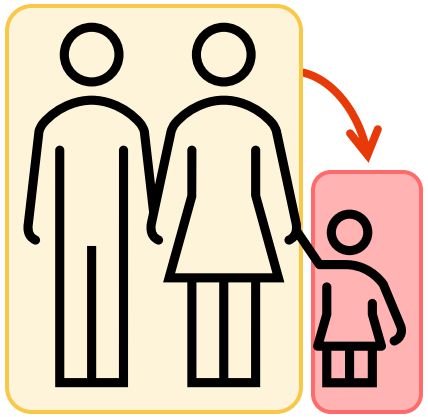

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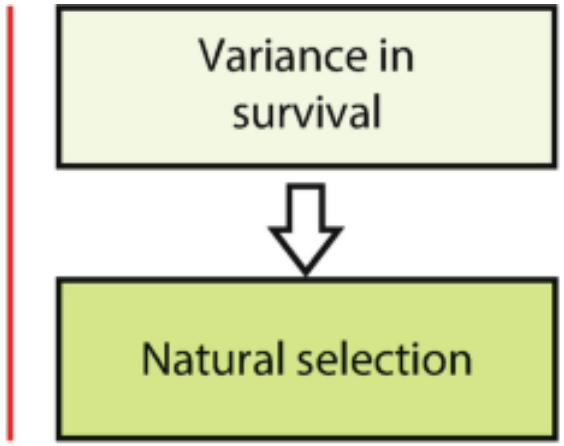

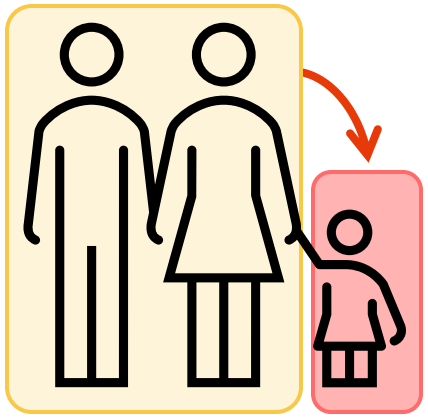

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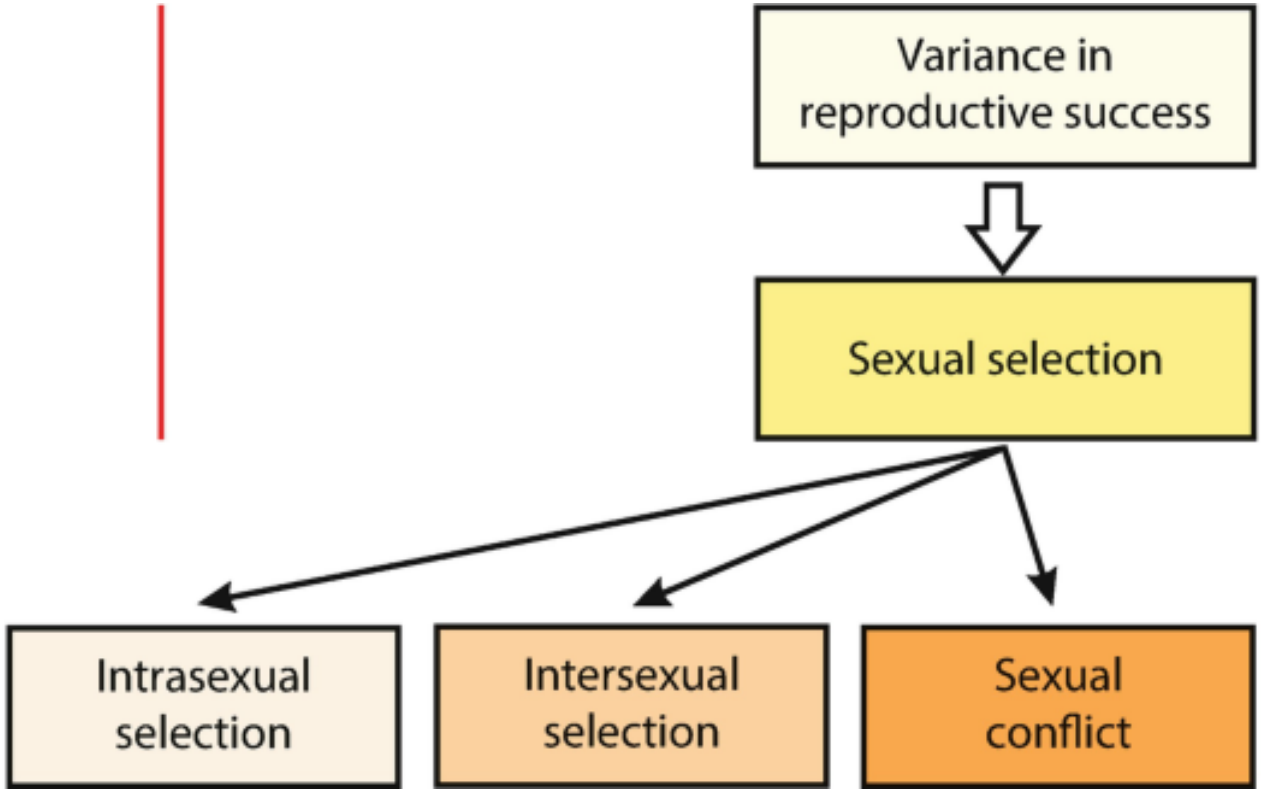

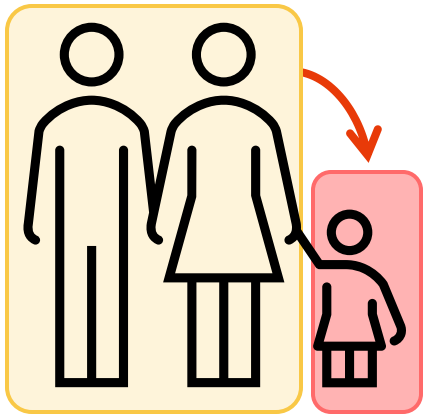

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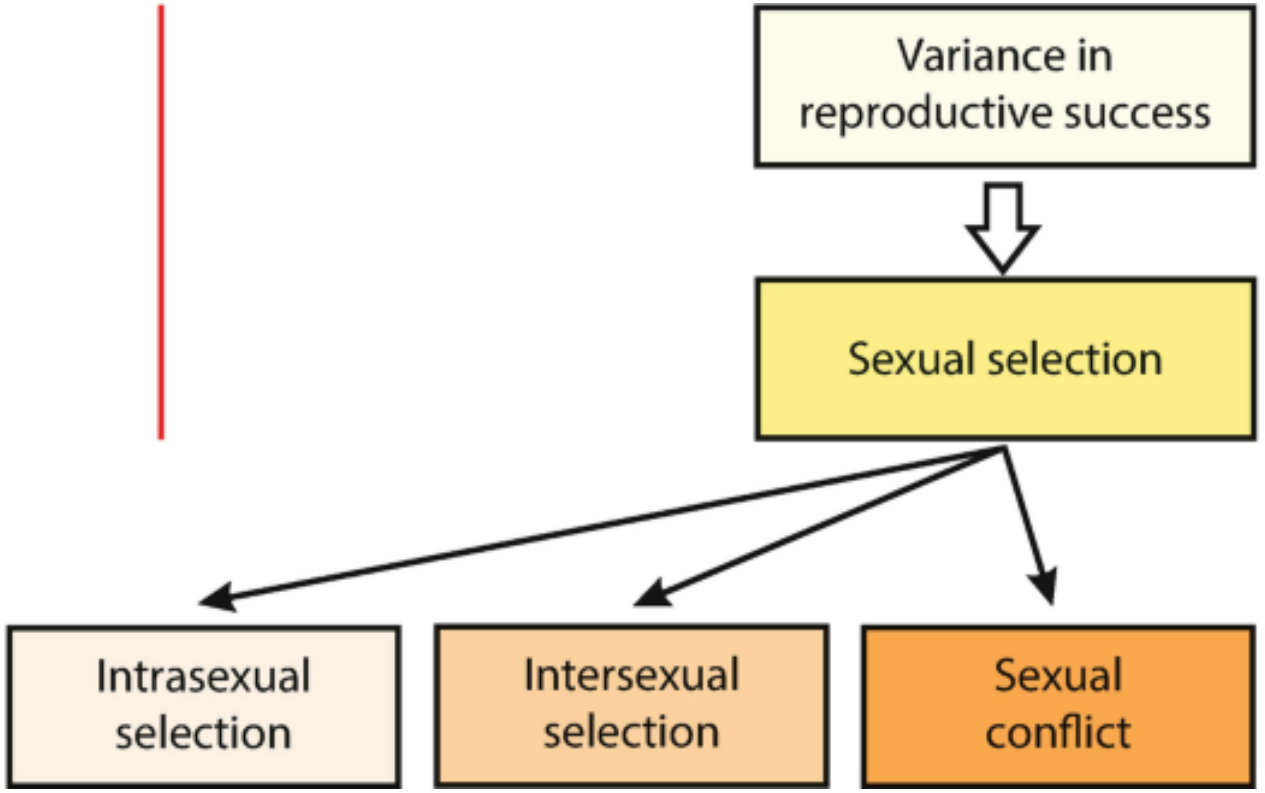

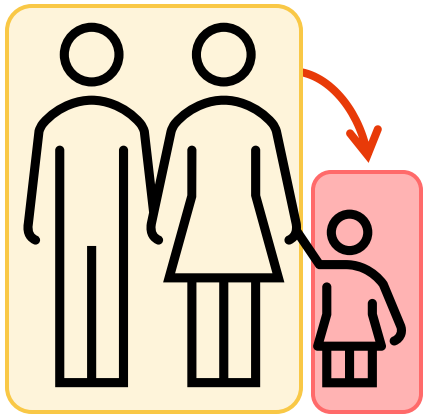

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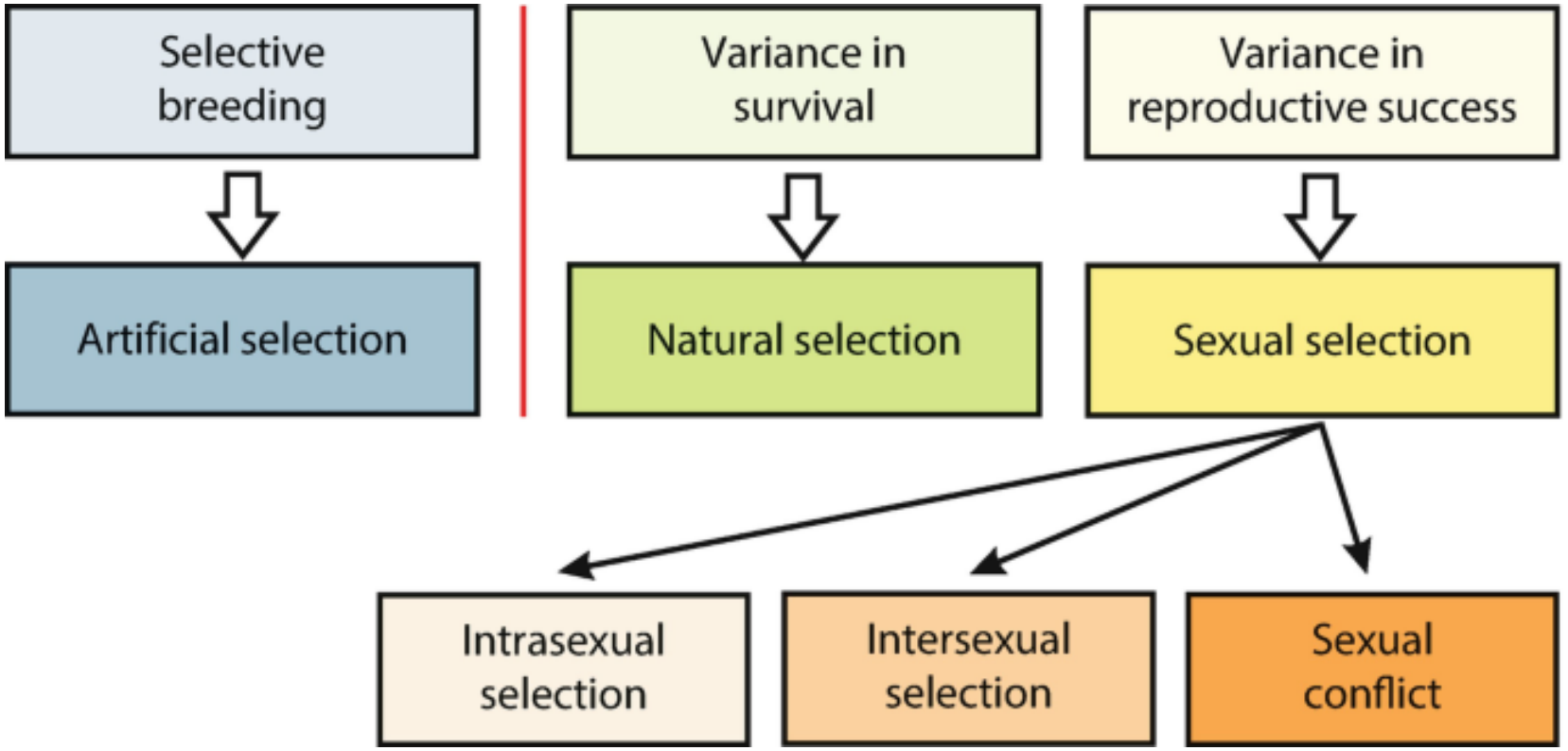

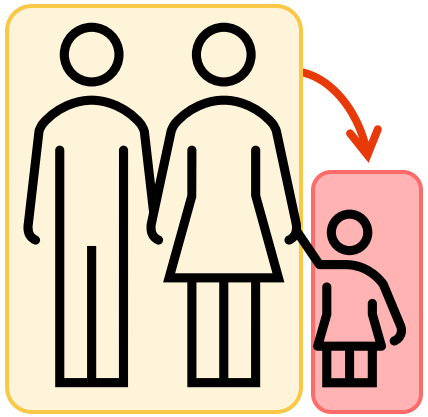

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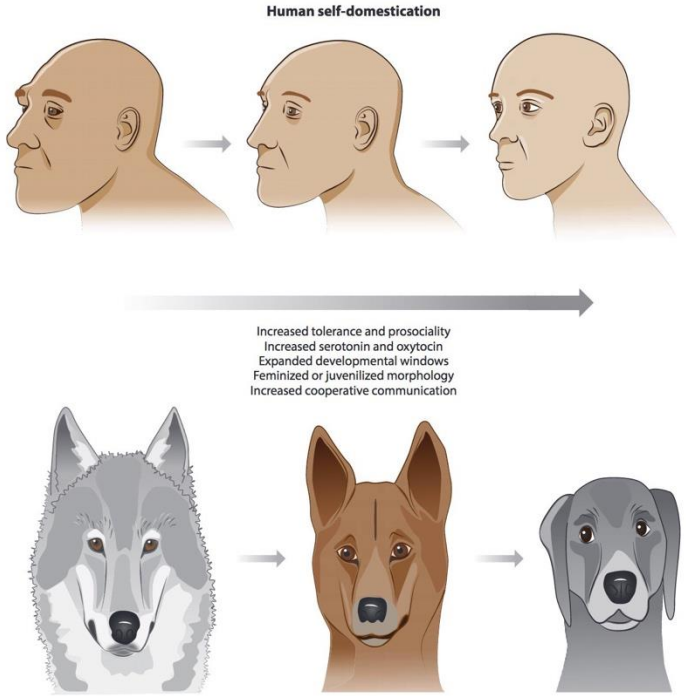
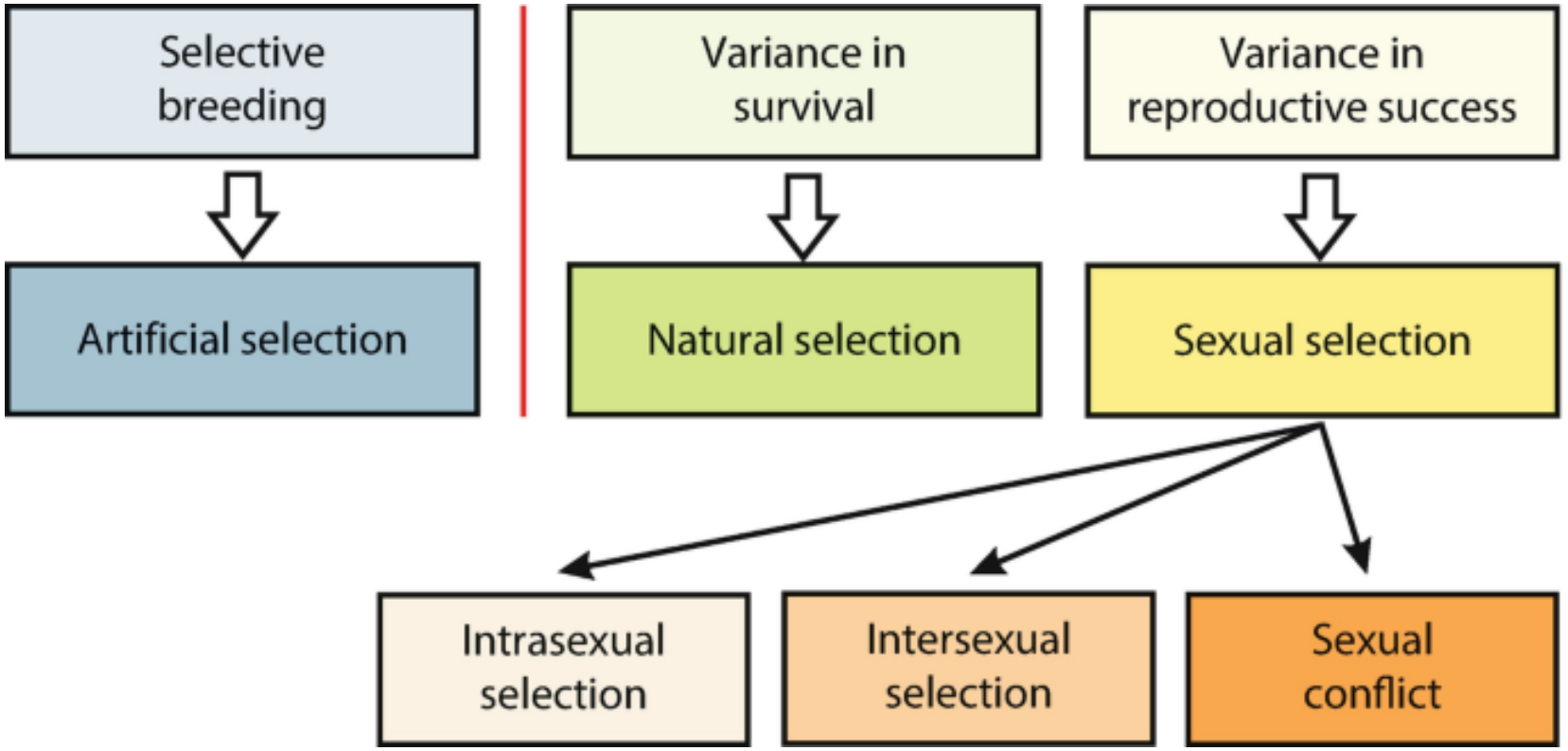




Key

So: the processes that drive changes in diversity* are:

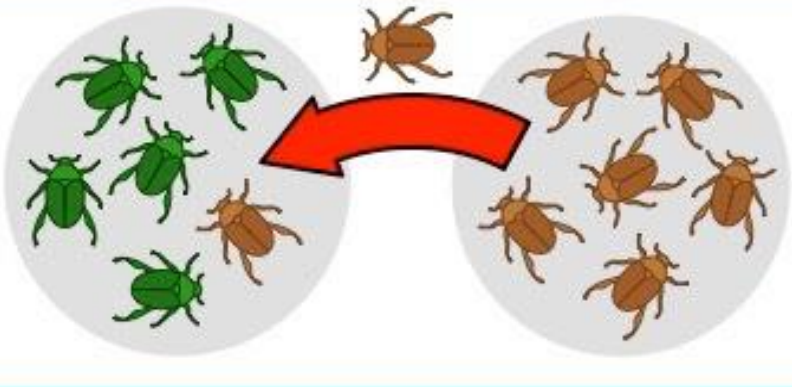
*group-level attribute!

THE OG

All other processes change frequencies of mutations

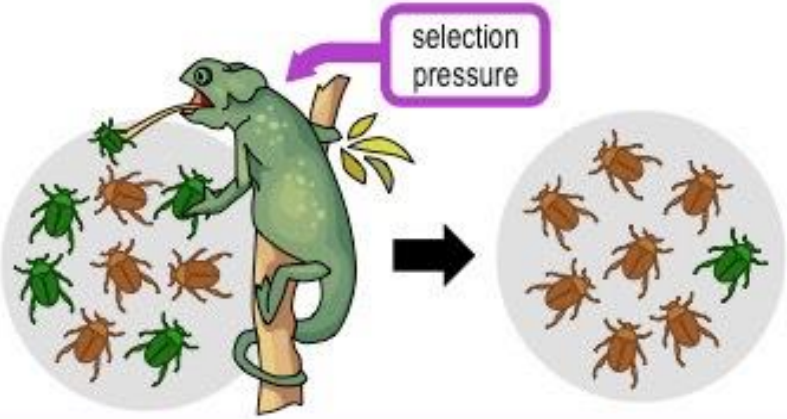
Generates new variation that is acted upon by other processes

Mutation



Gene Flow

Genetic Drift



Selection

So: the processes that drive changes in diversity* are:

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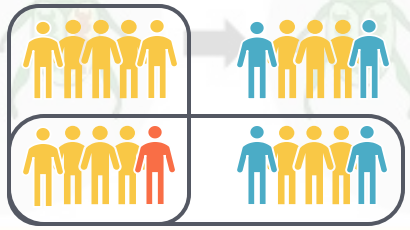
Key

Mutation

WITHIN
Increases

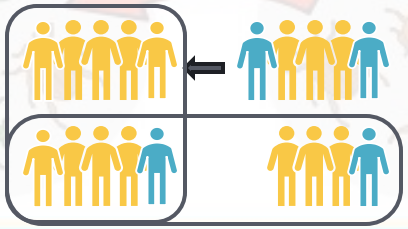
BETWEEN
Increases



Gene Flow

WITHIN
Increases

BETWEEN
Decreases



Genetic Drift

WITHIN
Decreases

BETWEEN
Increases

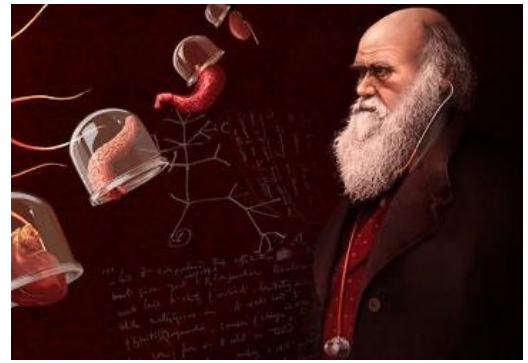
Selection

WITHIN
Increases
Decreases
Maintains

BETWEEN
Increases
Decreases
Maintains

Depends on the type of selection (and its distribution!)

Evolution/ultimate+historical perspectives in the course



Part 1:

- Introduction
- Human biology at the species level

Part 2:

- Patterns and drivers of genotypic and phenotypic variation

Part 3:

- Individual life course

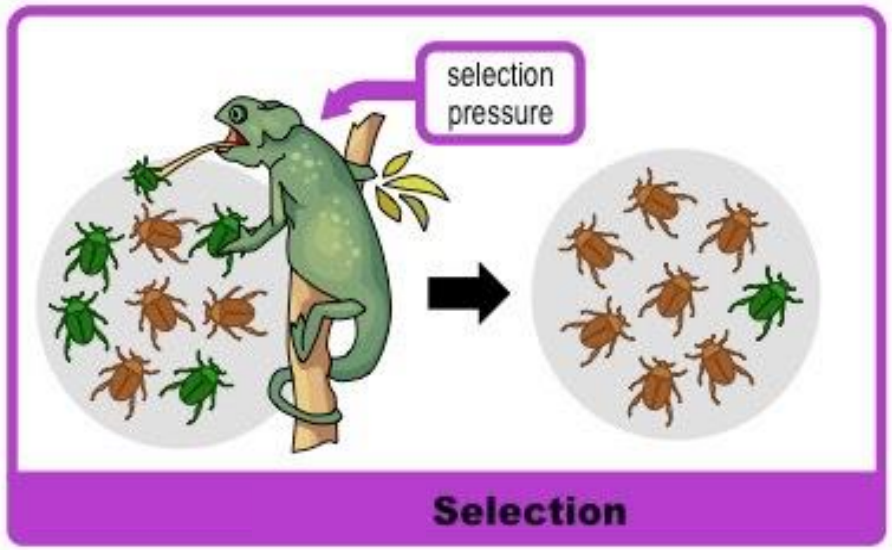
Part 4:

- Applied human biology

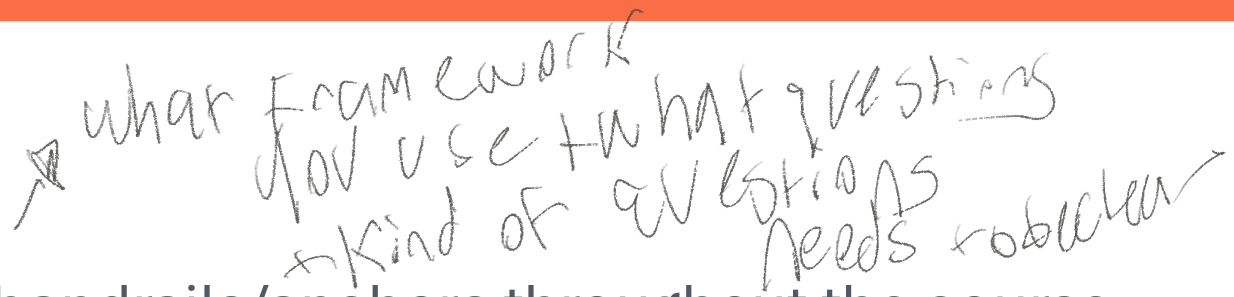
Adaptation and natural selection

Key

Natural selection and **adaptation** are often used as synonyms, but this is not accurate! **Natural selection is a process by which populations can adapt**.



The big takeaways



1. Use the big frameworks as handrails/anchors throughout the course

2. Evolution is **change in heritable characteristics** of a **group**

3. Genetic variation refers to differences between genomes; **diversity** is a term to describe (the amount of) **variation within and between groups**
    - Evolution therefore involves changes in genetic diversity within and between groups

4. **Evolution** (and changes in diversity) **happens through mutation *and* gene flow, drift, and selection**; these latter three change the frequencies of mutations.

After the credits...

Evolution as fact and theory