



Evolution, adaptation, diversity II

Dr Laura van Holstein

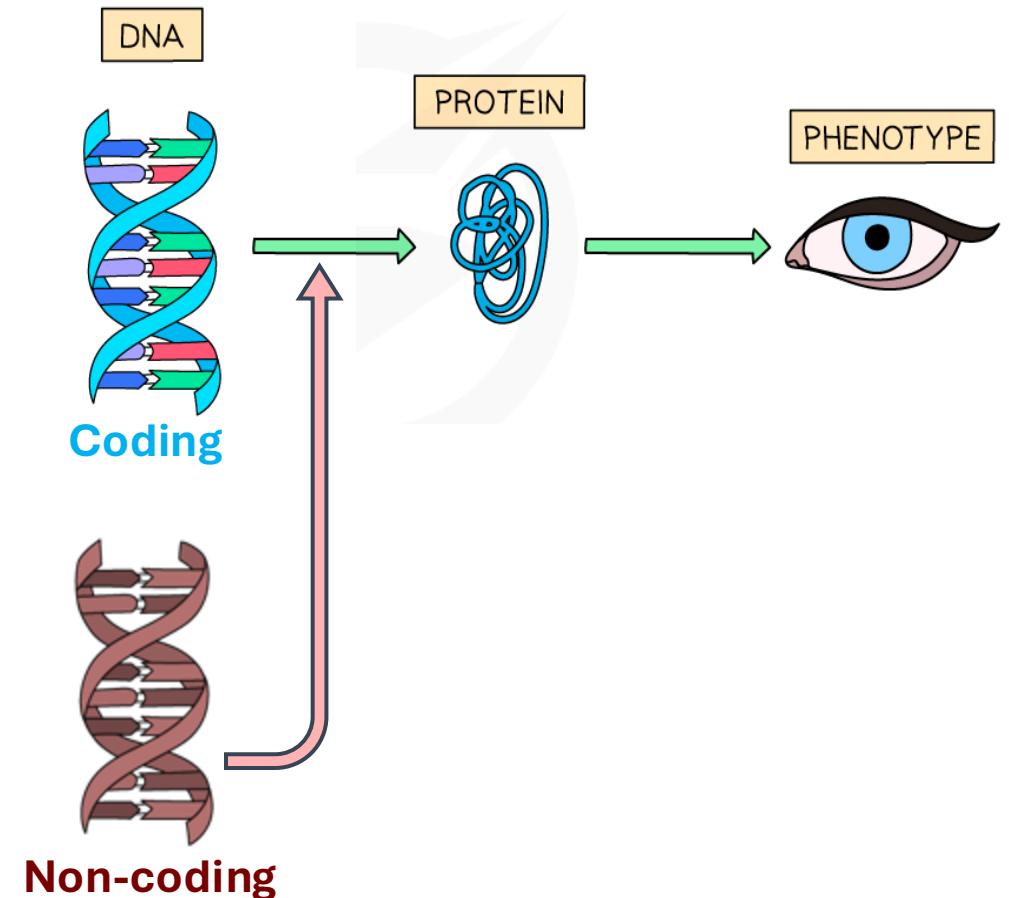
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Anthropology 215

Office hours: Wednesdays 9-10.30AM

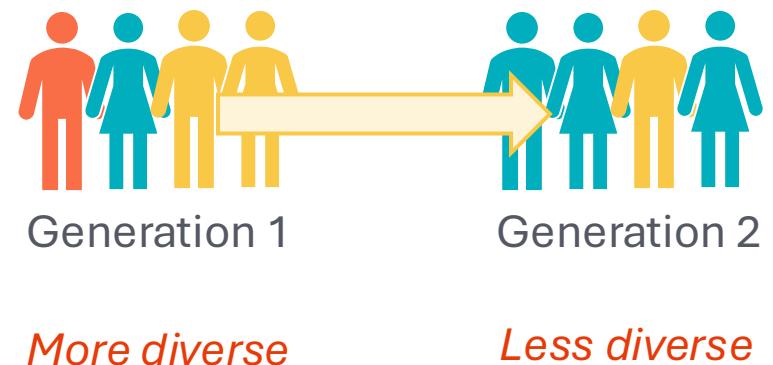
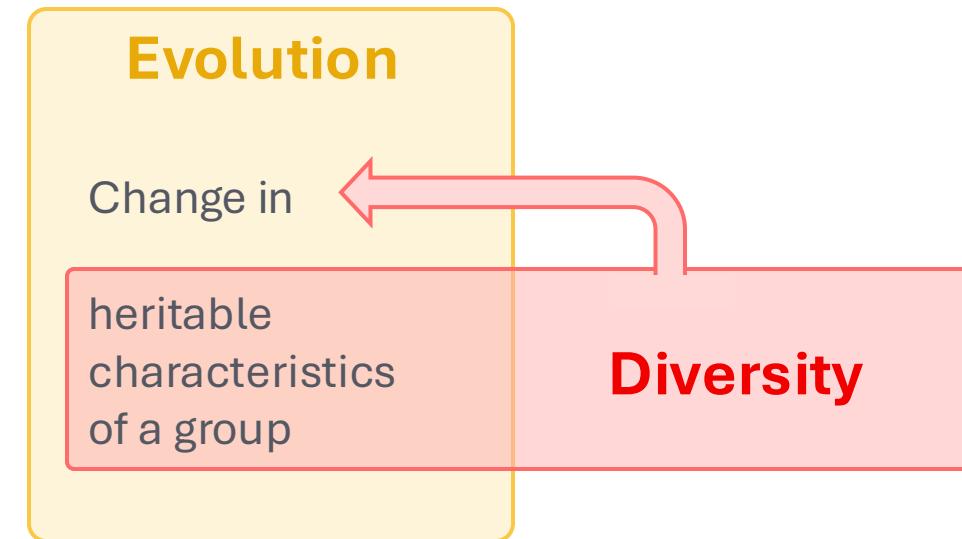
Foundational knowledge covered in the last lecture

- Includes autosomal (4-22) and X-linked (female) DNA
Nuclear DNA inherited from all (theoretically)
only inherited from direct maternal line*
- Some sections of DNA & mtDNA code for proteins
Proteins produce phenotype
 - Other sections do not
*Non-coding DNA
E.g., sections contributing to the regulation of gene expression*
 - Mutations in DNA can be as simple as one SNP, or as big as insertions, deletions, etc.
 - In coding regions, mutations can lead to change in phenotype (*nonsynonymous*) or not (*synonymous*)
Nonsynonymous mutations Synonymous mutations
 - In non-coding regions, mutations may also lead to change in phenotype



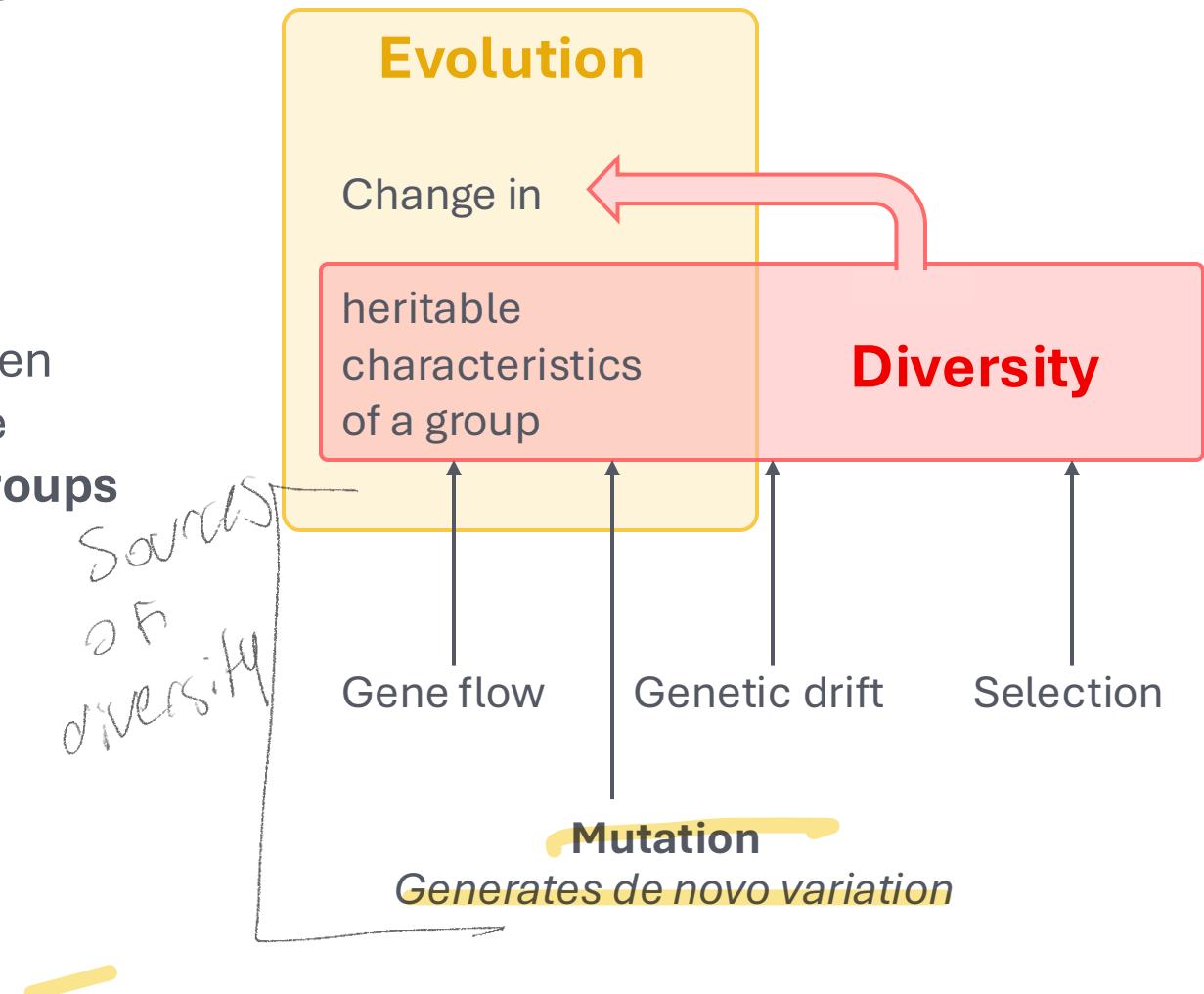
The big takeaways from last lecture

1. Use the big frameworks as handrails/anchors throughout the course
2. Evolution is **change, over time, 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**

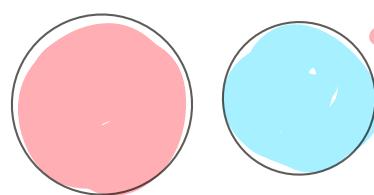


The big takeaways from last lecture

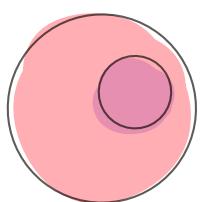
1. Use the big frameworks as handrails/anchors throughout the course
2. Evolution is **change, over time, in heritable characteristics of a group**
3. Genetic variation refers to differences between genomes; **diversity** is a term to describe (the amount of) **variation within and between groups**
4. Evolution (and changes in diversity) happens through **mutation and gene flow, drift, and selection**; these latter three change the frequencies of mutations.



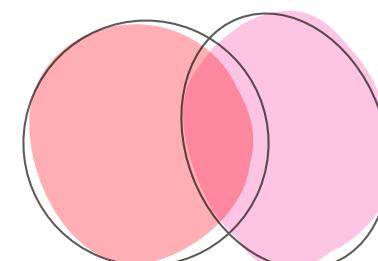
When poll is active respond at PollEv.com/lauravanholstein822



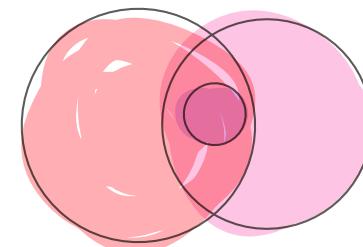
Evolution vs development
not synonymous



Evolution + natural selection



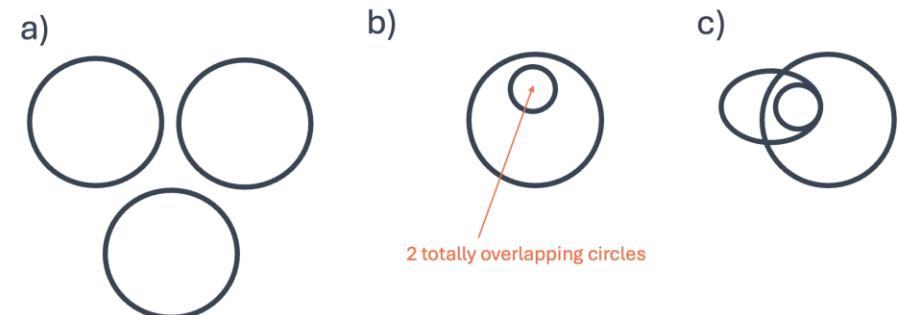
Evolution
and adaptation



Natural selection
+
evolution +
adaptation

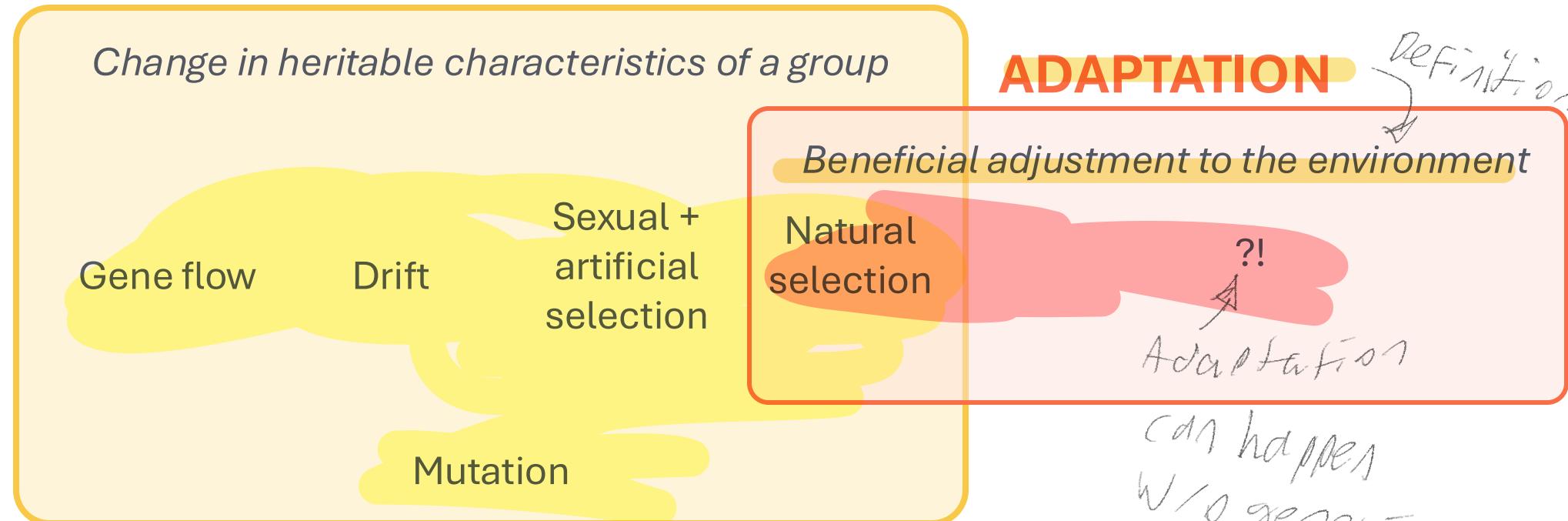
Roadmap for today

1. Considering *how* selection works in some more detail
2. Considering what adaptation is, how adaptation works, and how selection may – or may not! – play a part
3. Putting this all together, and examining how genetic *and* phenotypic diversity may be generated by gene flow, drift, (natural) selection, and other adaptive processes



A visual framework for this lecture

EVOLUTION



Selection operates on fitness

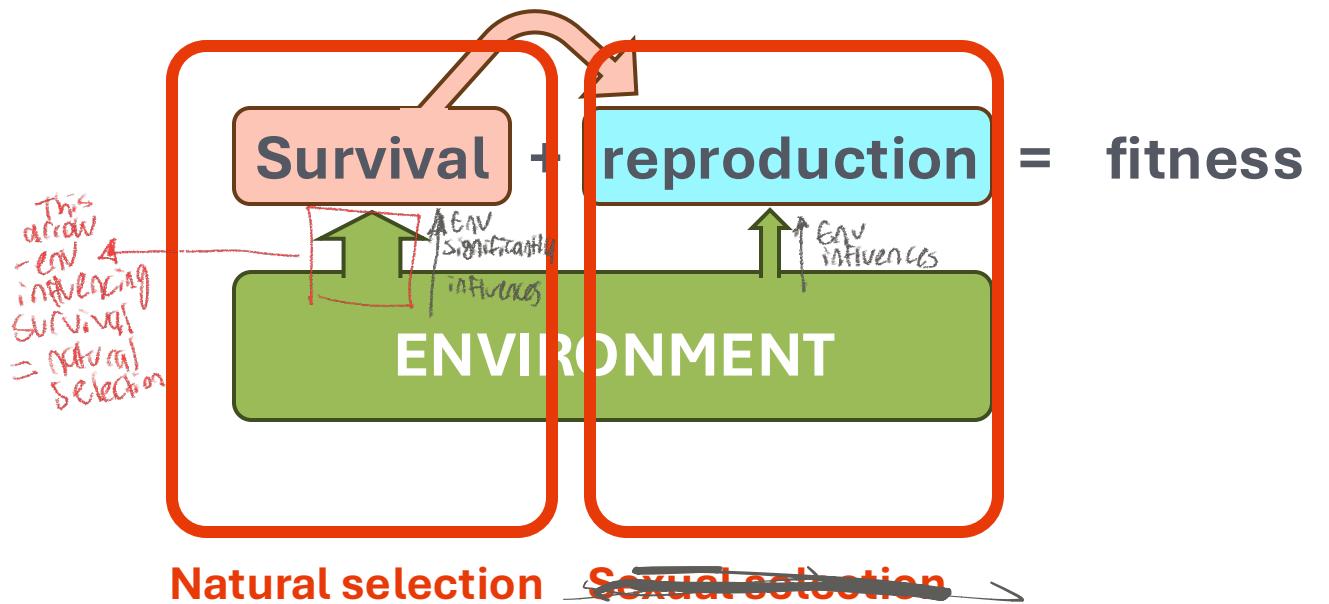
Fitness: The ability of organisms to survive and reproduce in the environment in which they find themselves

Survival + reproduction = fitness



Selection operates on fitness

Fitness: The ability of organisms to survive and reproduce in the environment in which they find themselves



Selection operates on fitness, which means it operates only on phenotype



Natural Selection



Same outcome, because no difference in phenotype

Selection operates on fitness, which means it operates only on phenotype



Making something to impress mate

Behavior is the same so mate is equally impressed/unimpressed



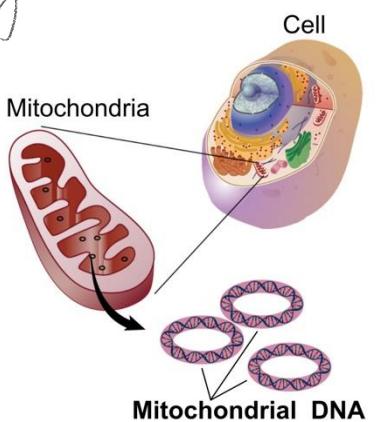
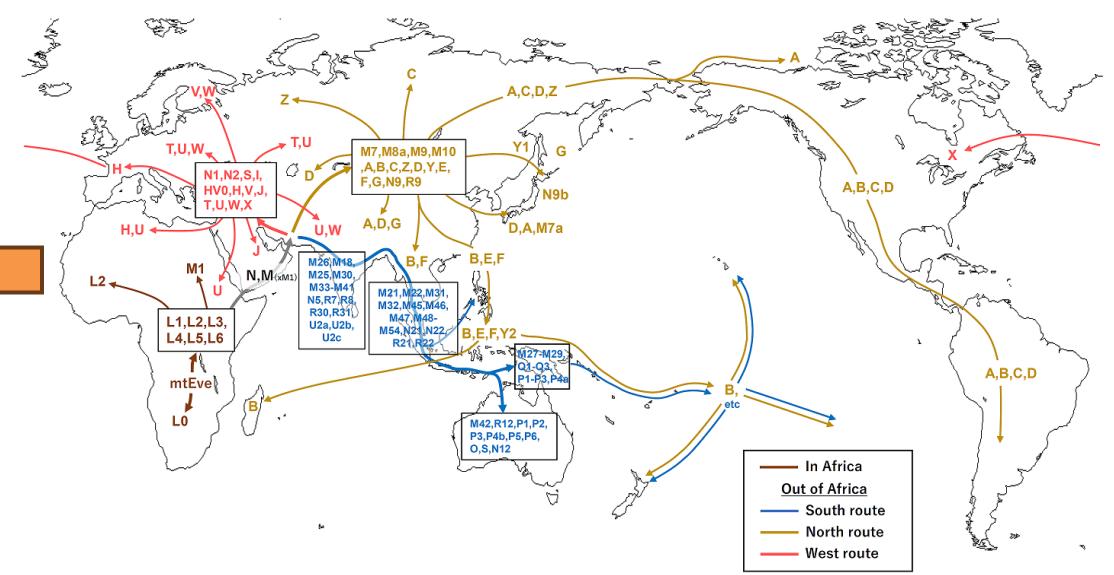
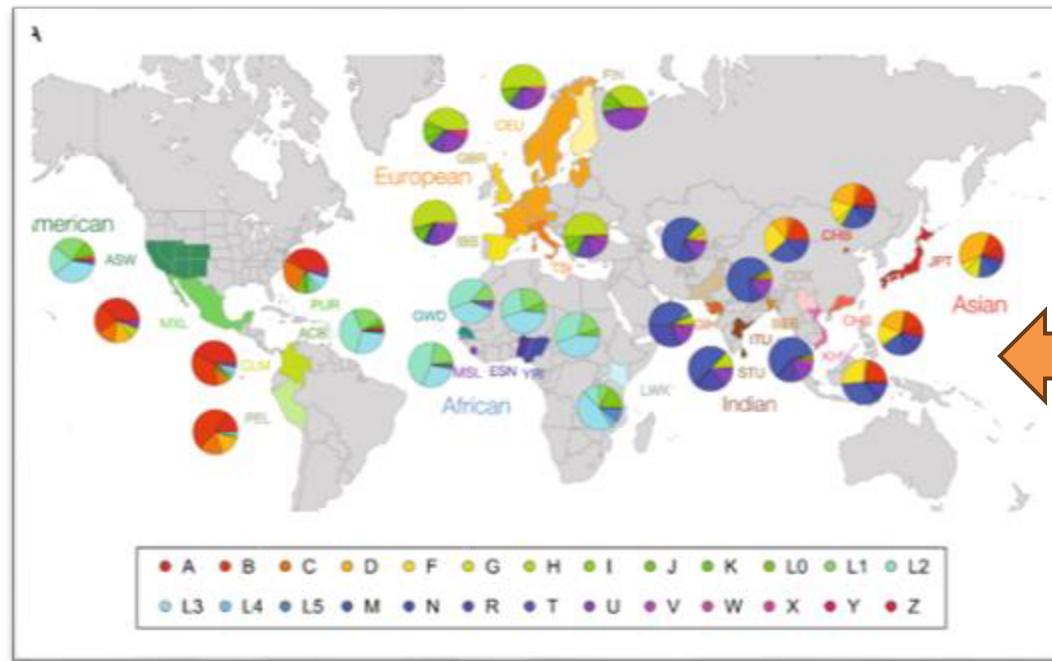
Same outcome, because no difference in phenotype
Sexual Selection

Selection operates on fitness, which means it operates only on phenotype

phenotype
Neutral markers used to infer migration & gene flow

In humans:

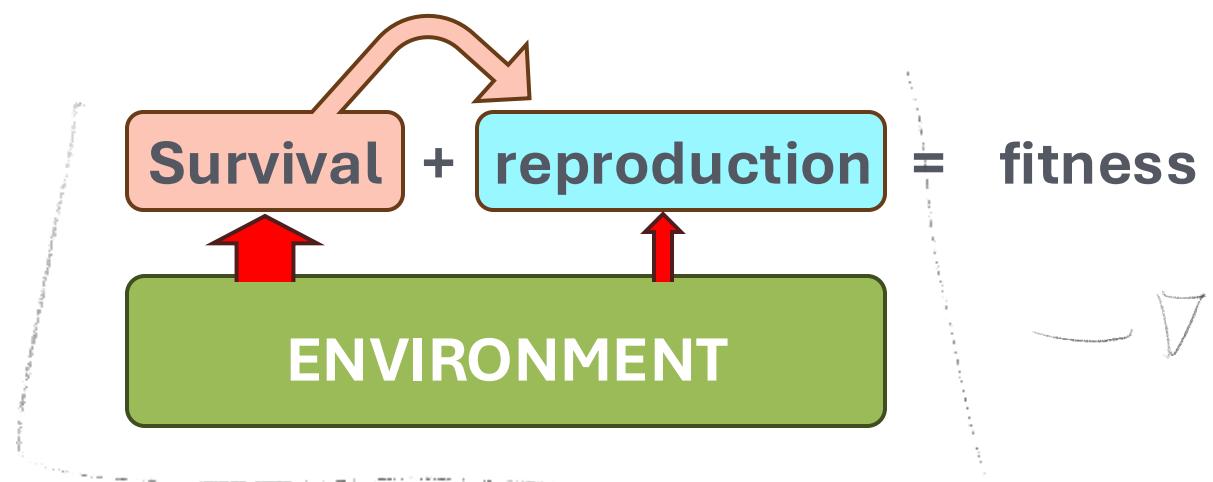
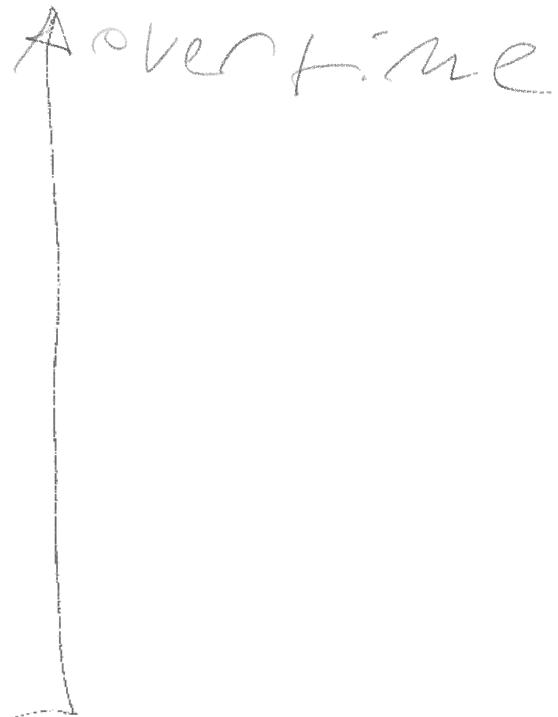
- Synonymous SNPs in hypervariable regions of mitochondria define different haplogroups (*Marker von Haplogrupps*)
 - No effect on mitochondrial function; not expressed in **phenotype**
 - Distribution is entirely predicted by gene flow & migration – **no selection**



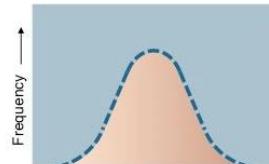
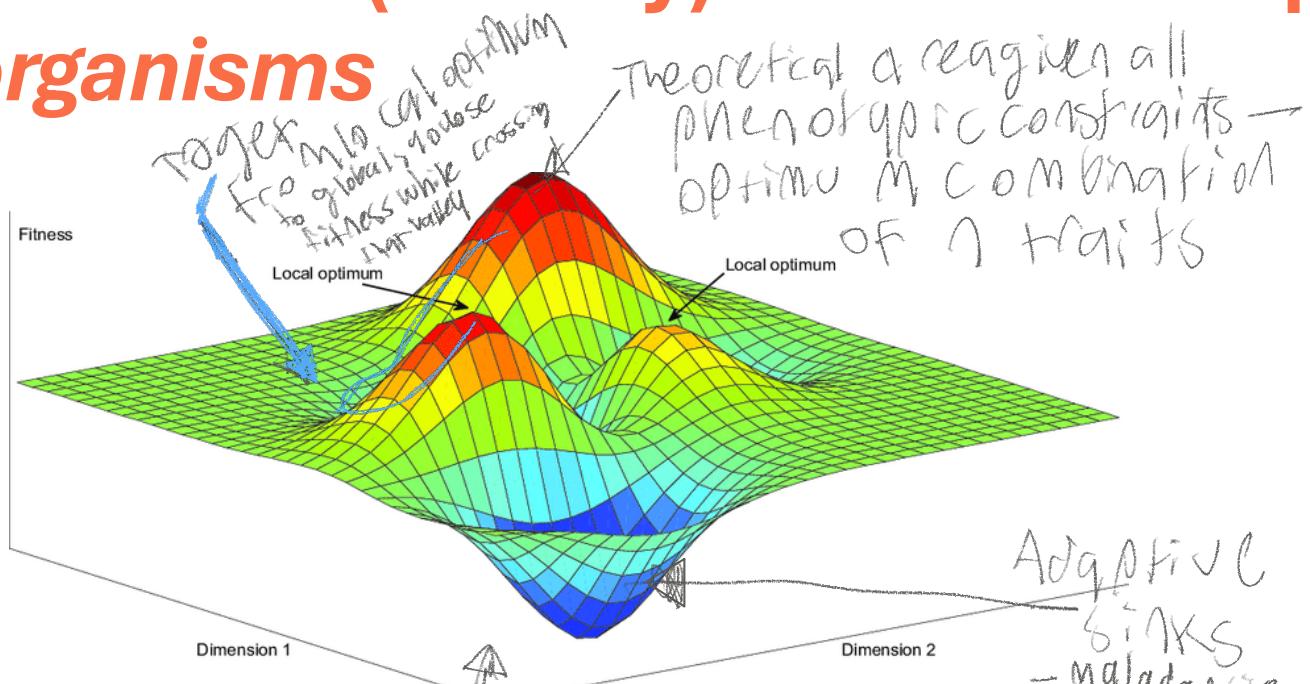
Selection (usually) results in adaptation*

*Beneficial adjustment to the environment

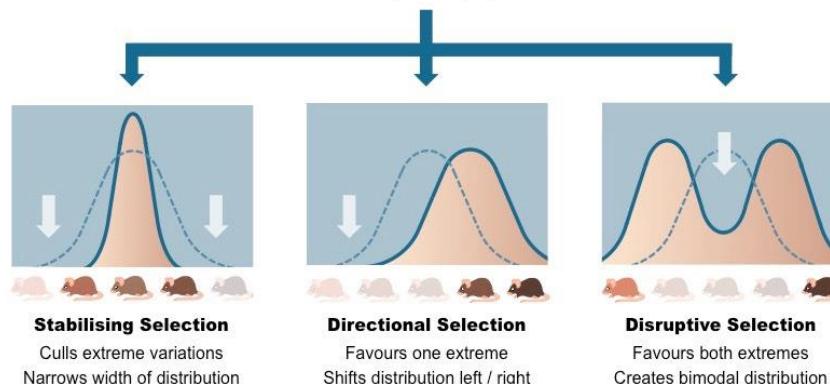
- Environment exerts selective pressures on survival and reproduction
- Fittest individuals *in that environment* contribute most to genetic makeup of the next population



Selection (usually) results in adaptation of whole organisms

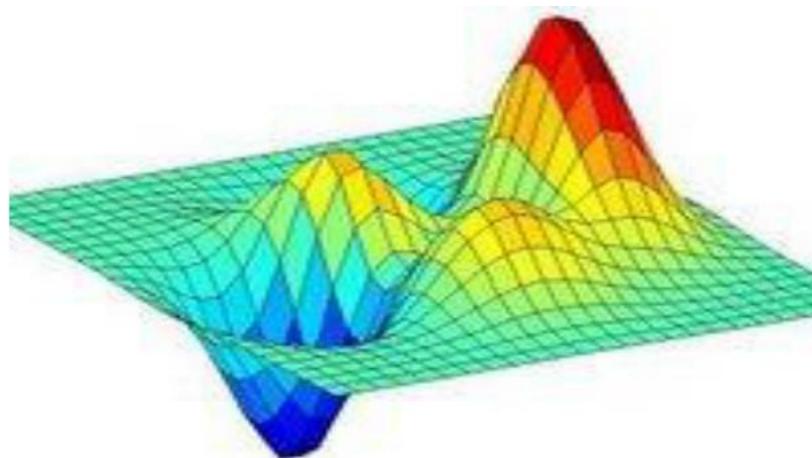
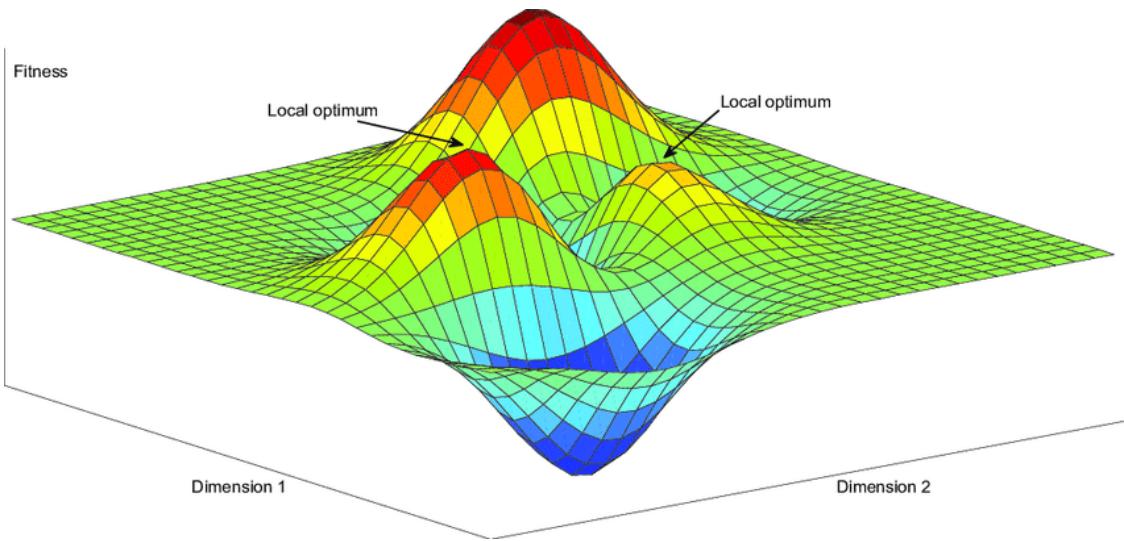


Normal Distribution
Gaussian (bell-shaped) trend



Key

Selection (usually) results in adaptation *of whole organisms* to a specific environment



Selection

Adaptation

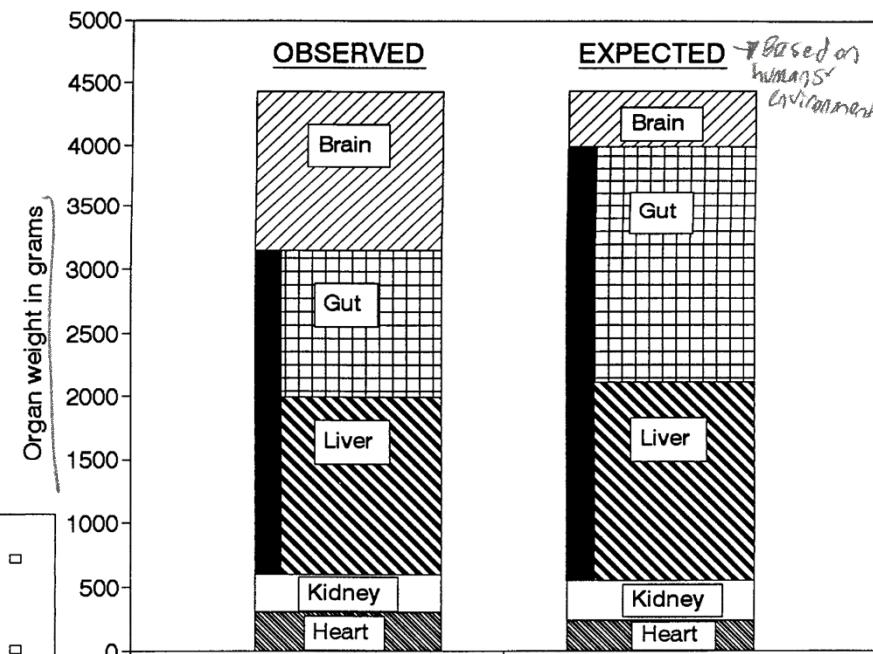
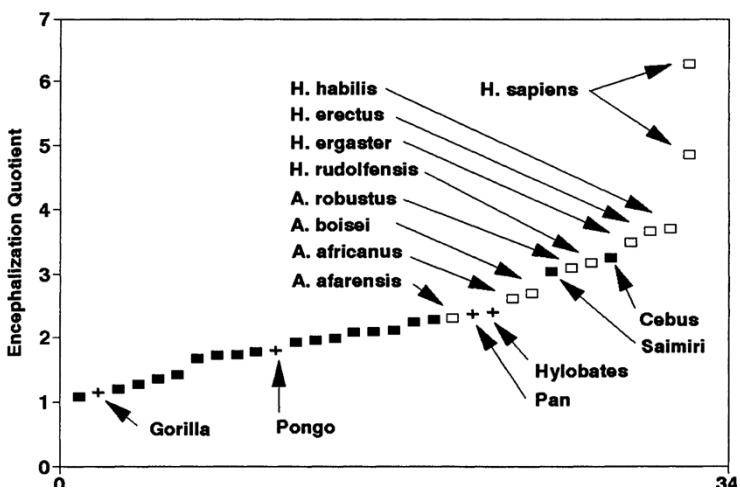
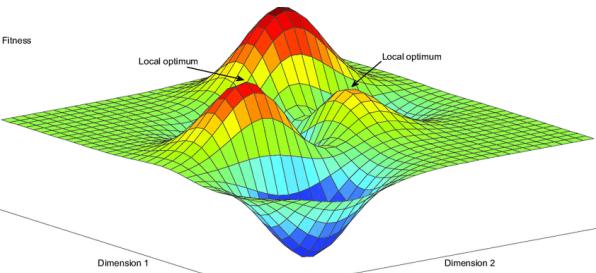
Diversity

Selection (usually) results in adaptation of whole organisms to a specific environment over time

Adds variation happens over along time because, ...



2) Costs and tradeoffs



Humans traded off gut size for brain size as shown here

Aiello & Wheeler 1995

A framework for this lecture

EVOLUTION

Change in heritable characteristics of a group

Gene flow

Drift

Sexual +
artificial
selection

Natural
selection

Mutation

A framework for this lecture

EVOLUTION

Change in heritable characteristics of a group

Gene flow Drift

Mutation

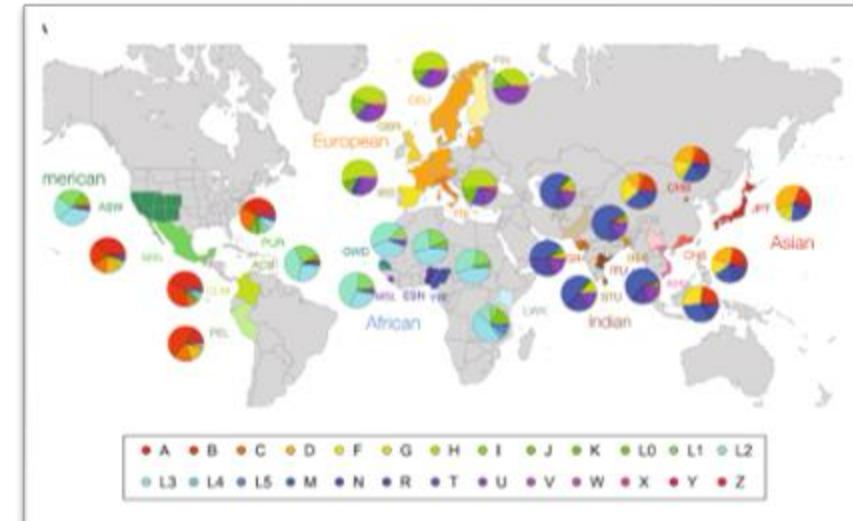
Sexual +
artificial
selection

Natural
selection

Can produce **selectively neutral** variation/evolution

Can have **no effects** on phenotype

E.g., mtDNA haplotypes



A framework for this lecture

EVOLUTION

Change in heritable characteristics of a group

Gene flow

Drift

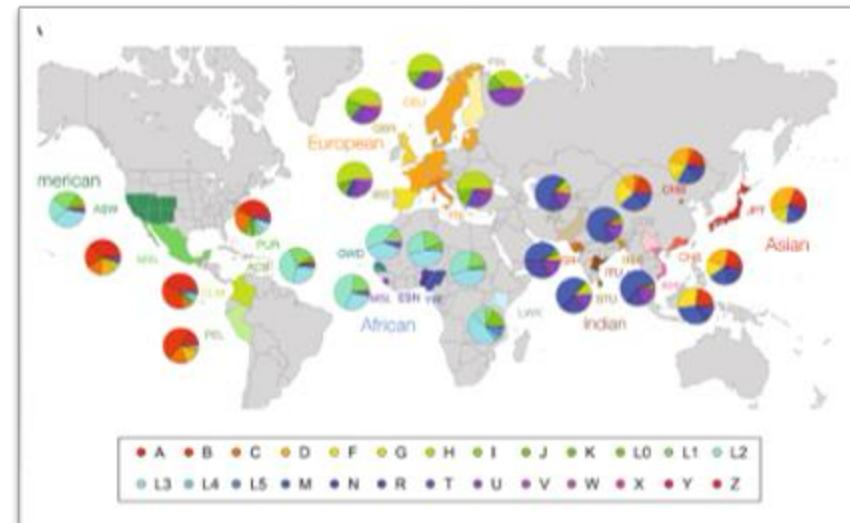
Mutation

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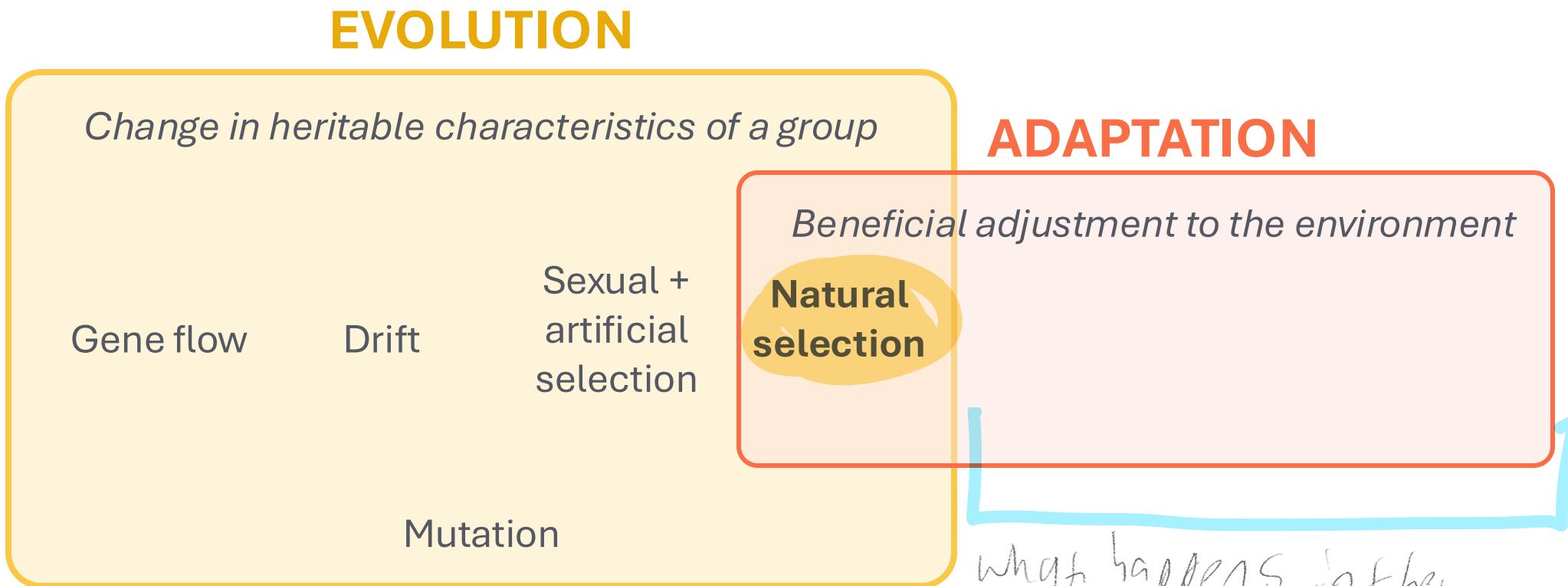
Natural
selection

- Special cases of evolution
- Can only act on phenotype, because they operate on fitness (and neutral effects have no consequence for fitness)

E.g., mtDNA haplotypes – **distribution not result of selection**

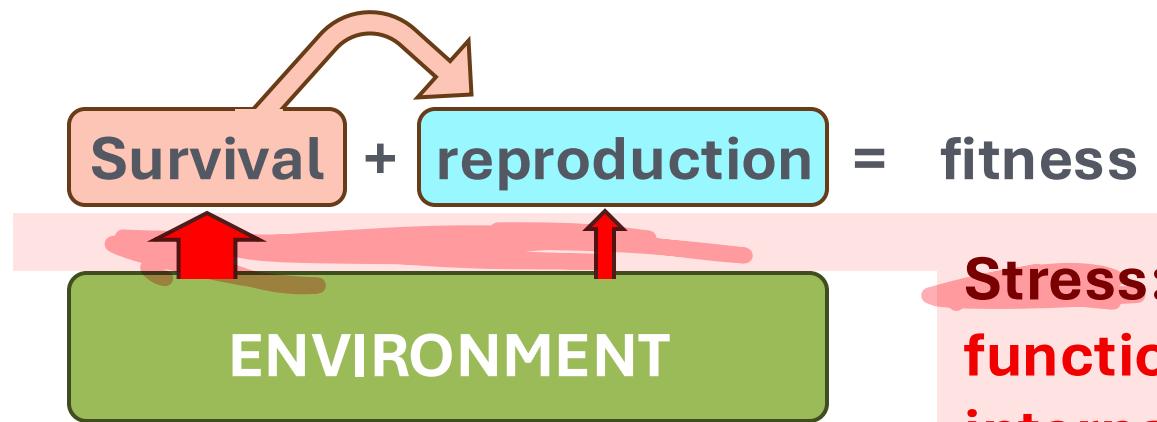


A framework for this lecture



- Imposed by environment (not other members of species, as in sexual selection) on survival
- Results in adaptation to the environment

Adaptation is necessitated by stress



Stress is
VARIABLE

- Intensity
- Timescale
- Risk



Physical stressors

- Temperature extremes
- Altitude
- Humidity - Shapes how we adapt to temperature extremes
- Light - Affects biological clocks and such
- Radiation
- Pollutants



VARIABLE:

- Intensity
- Timescale
- Risk

Biological stressors

- Predators
- Parasites
- Pathogens
- Deficiency or excess of specific nutrients

VARIABLE:

- Intensity
- Timescale
- Risk



Social/cultural stressors

- Resource competition
- Conflict

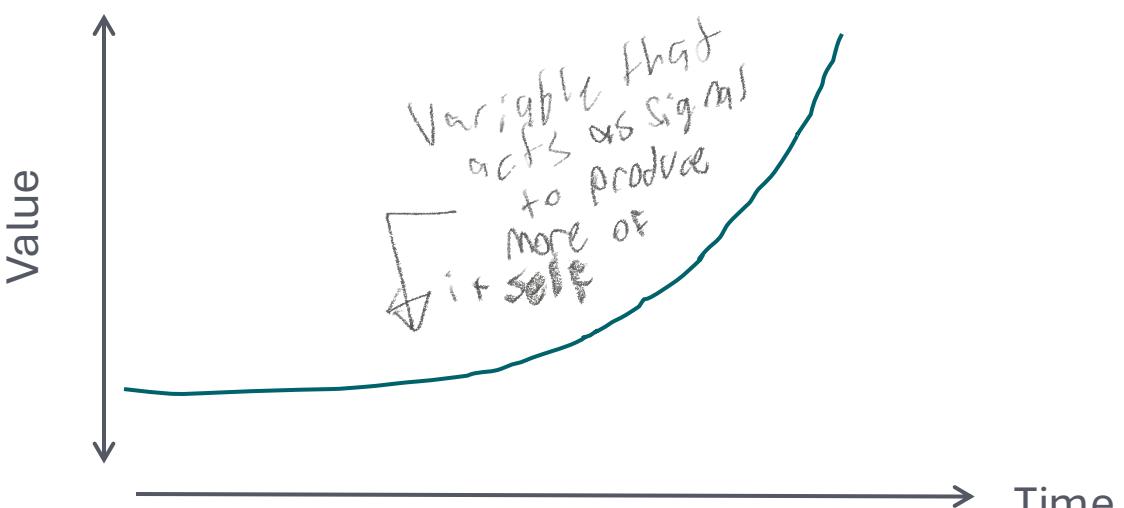
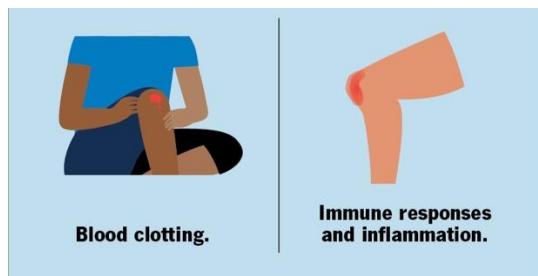
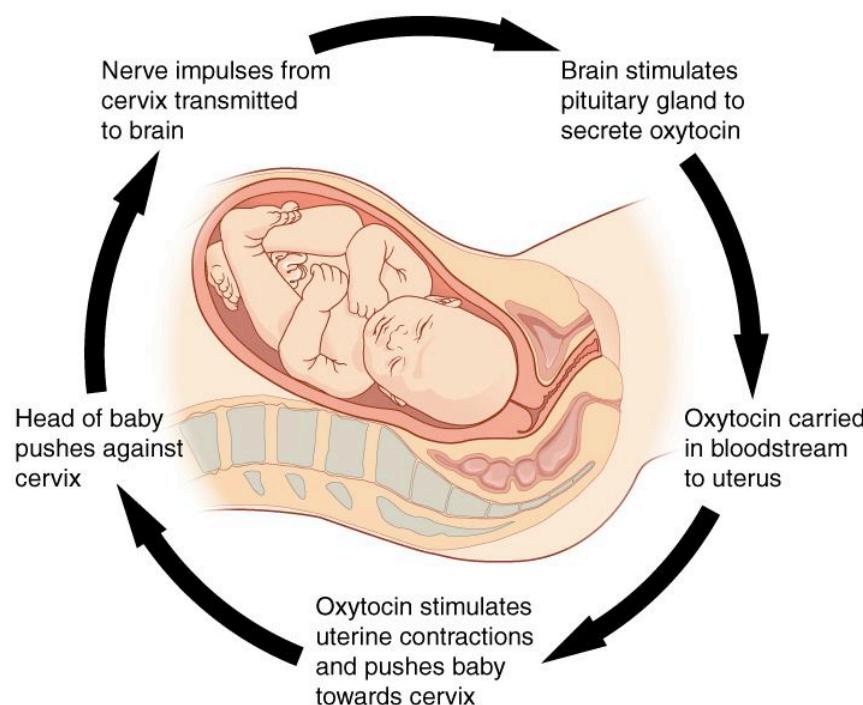


VARIABLE:

- Intensity
- Timescale
- Risk

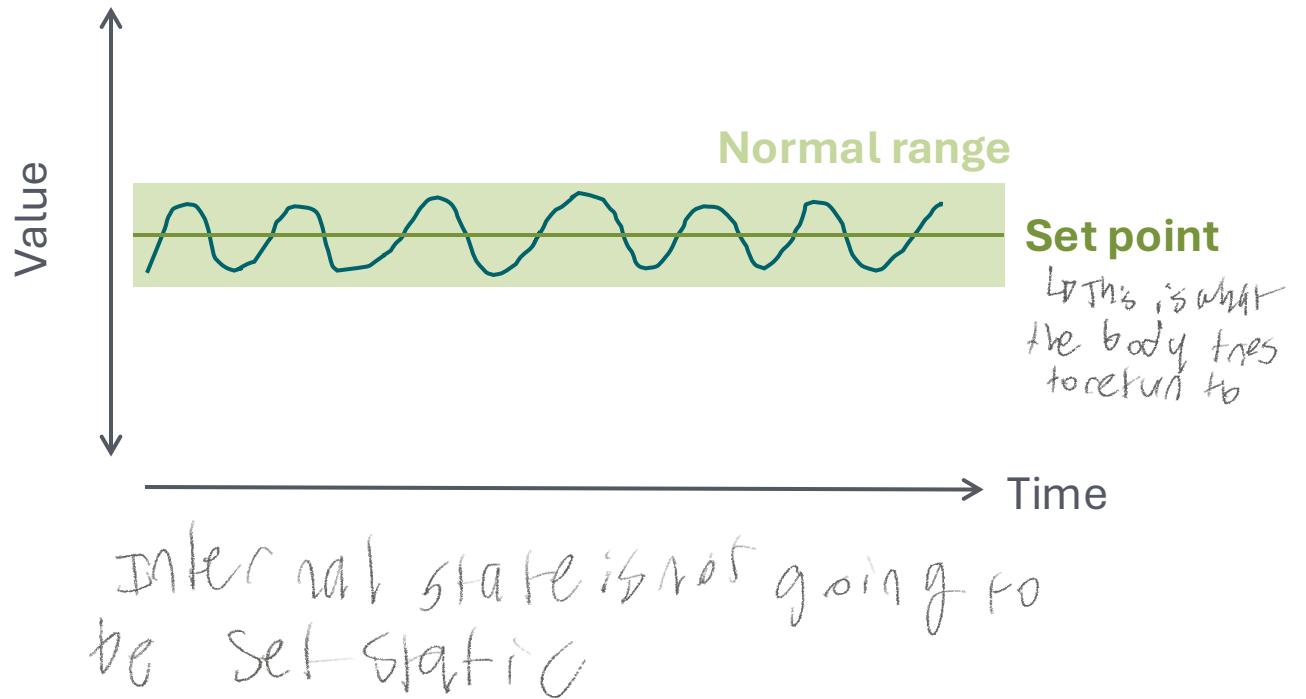
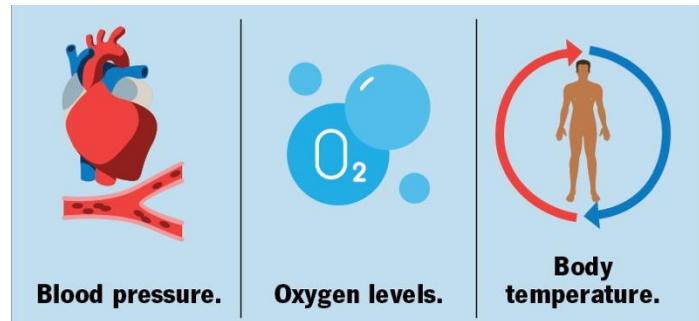
Homeostasis

Positive feedback:



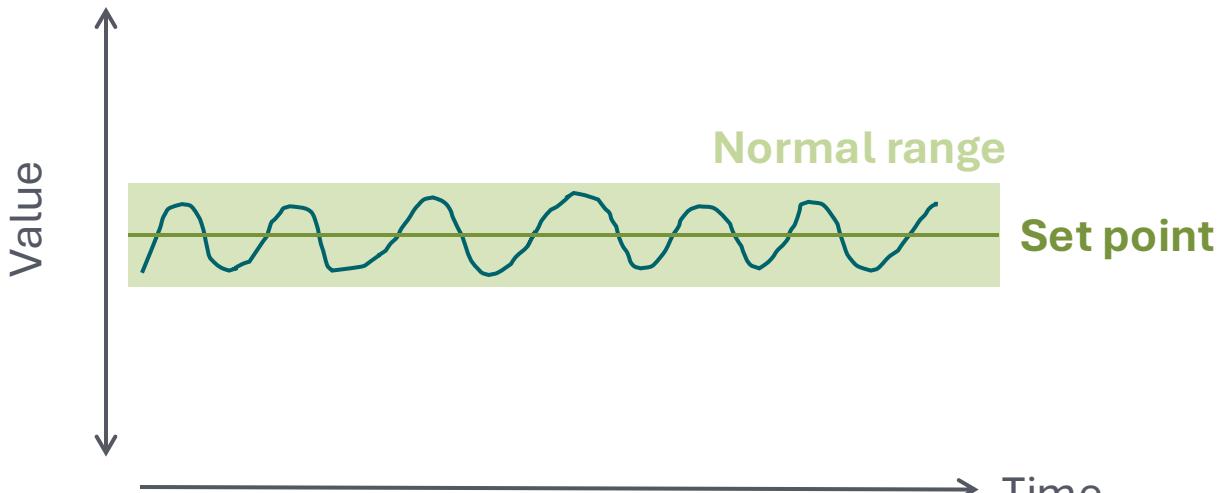
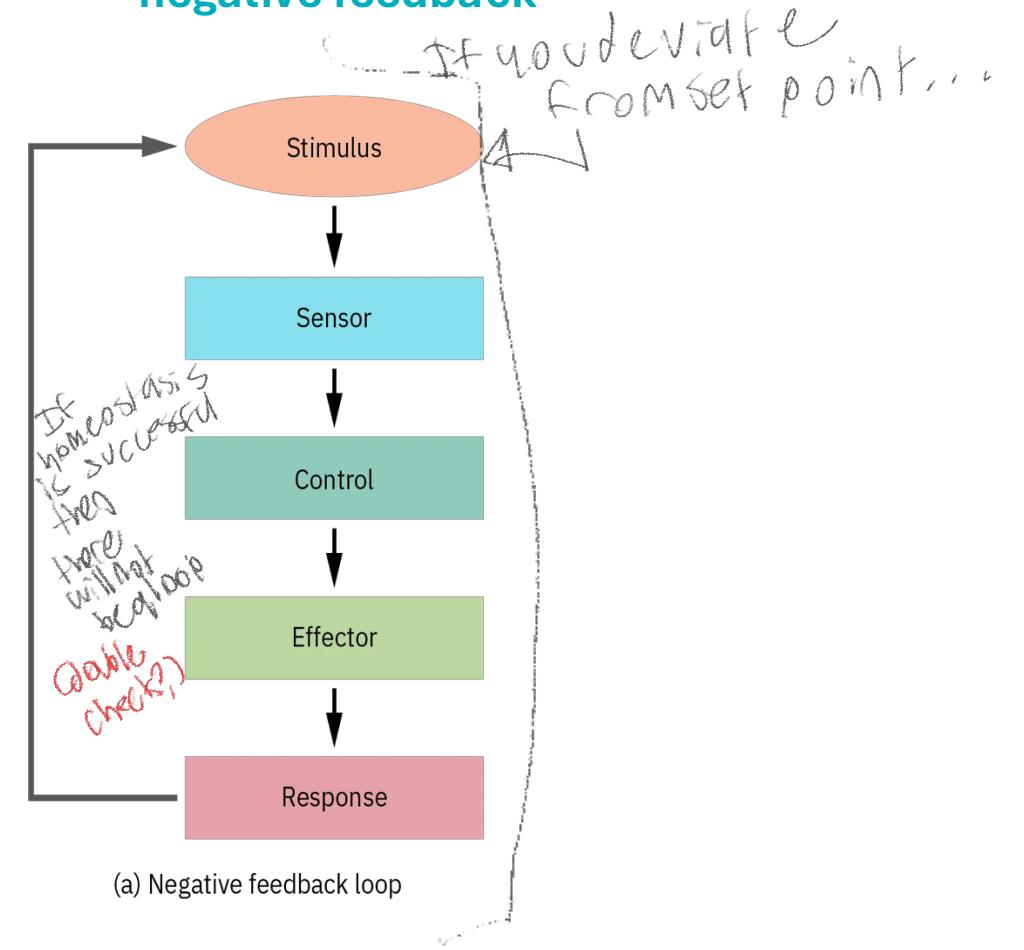
Homeostasis

Primary mechanism:
negative feedback



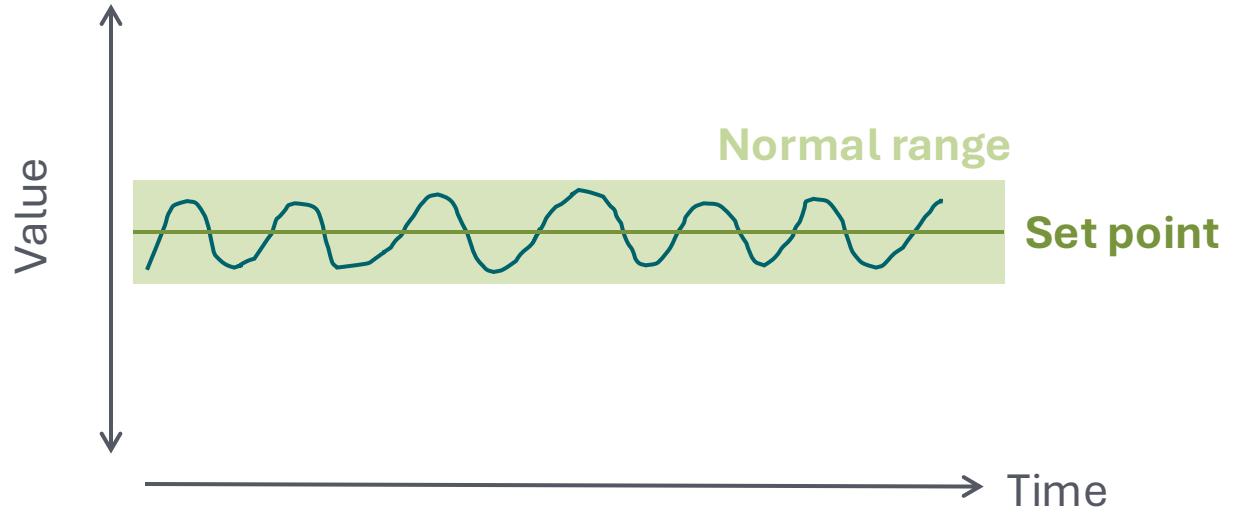
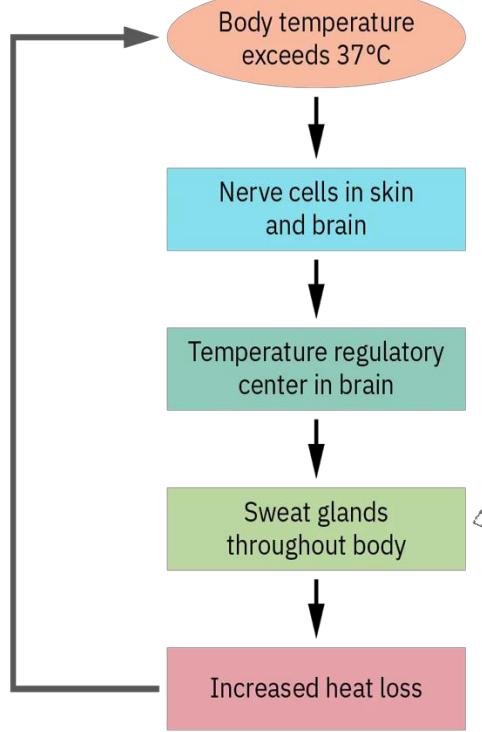
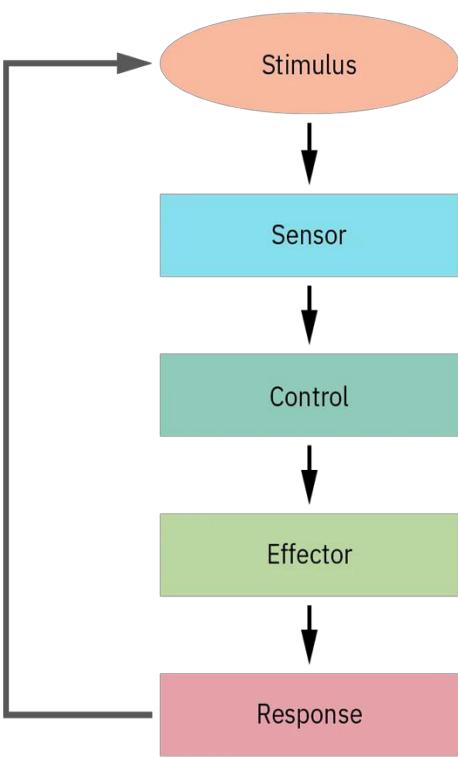
Homeostasis

Primary mechanism:
negative feedback

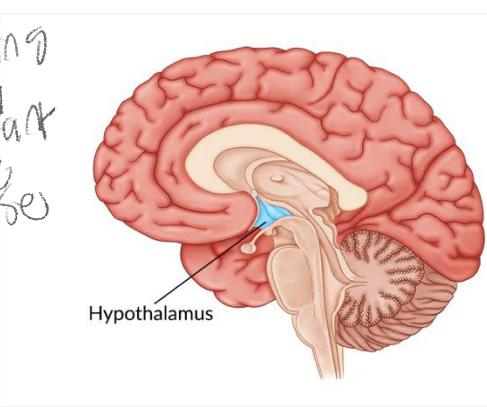


Homeostasis

Primary mechanism:
negative feedback

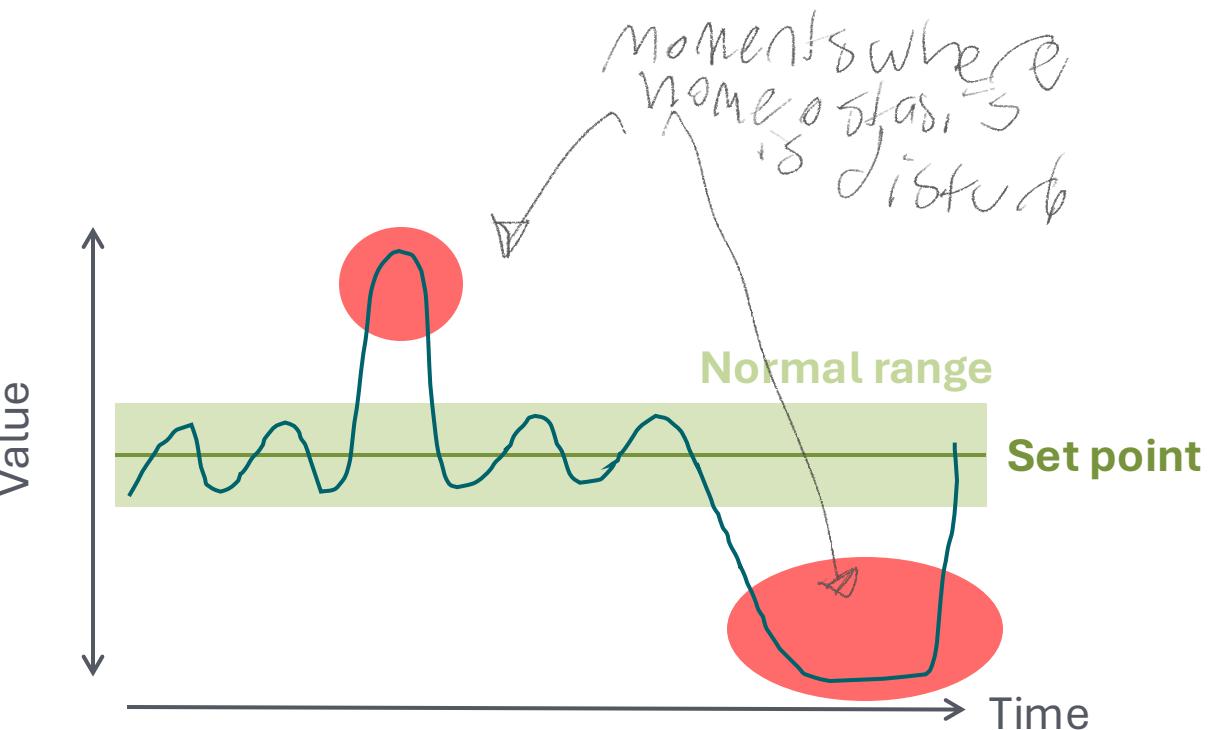


*→ sweating
is very
important
adaptive
response*



Homeostasis

Primary mechanism:
negative feedback



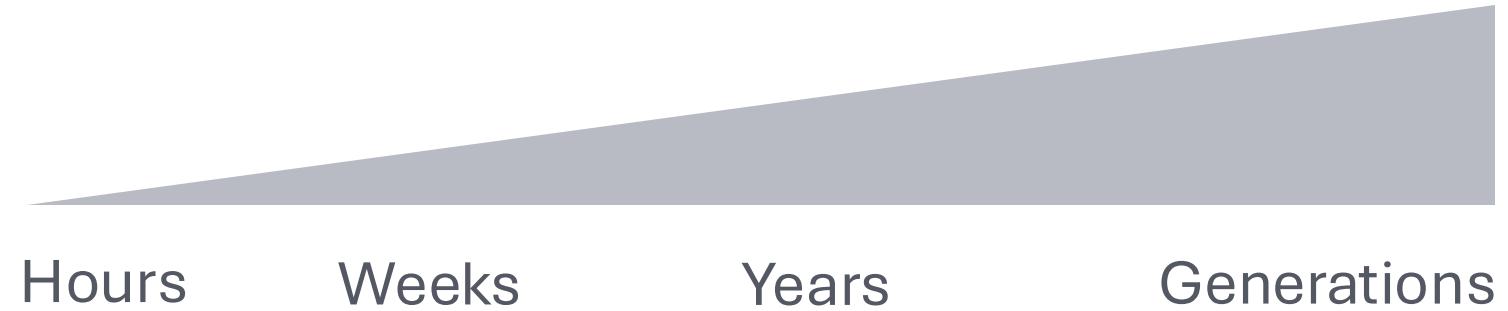
Stressor: any stimulus that disturbs the normal functioning of an organism (i.e., that disturbs internal homeostasis).

These exert selective pressures on fitness

To trigger adaptive processes, stress doesn't need to be constant – just intense enough to threaten survival and reproduction

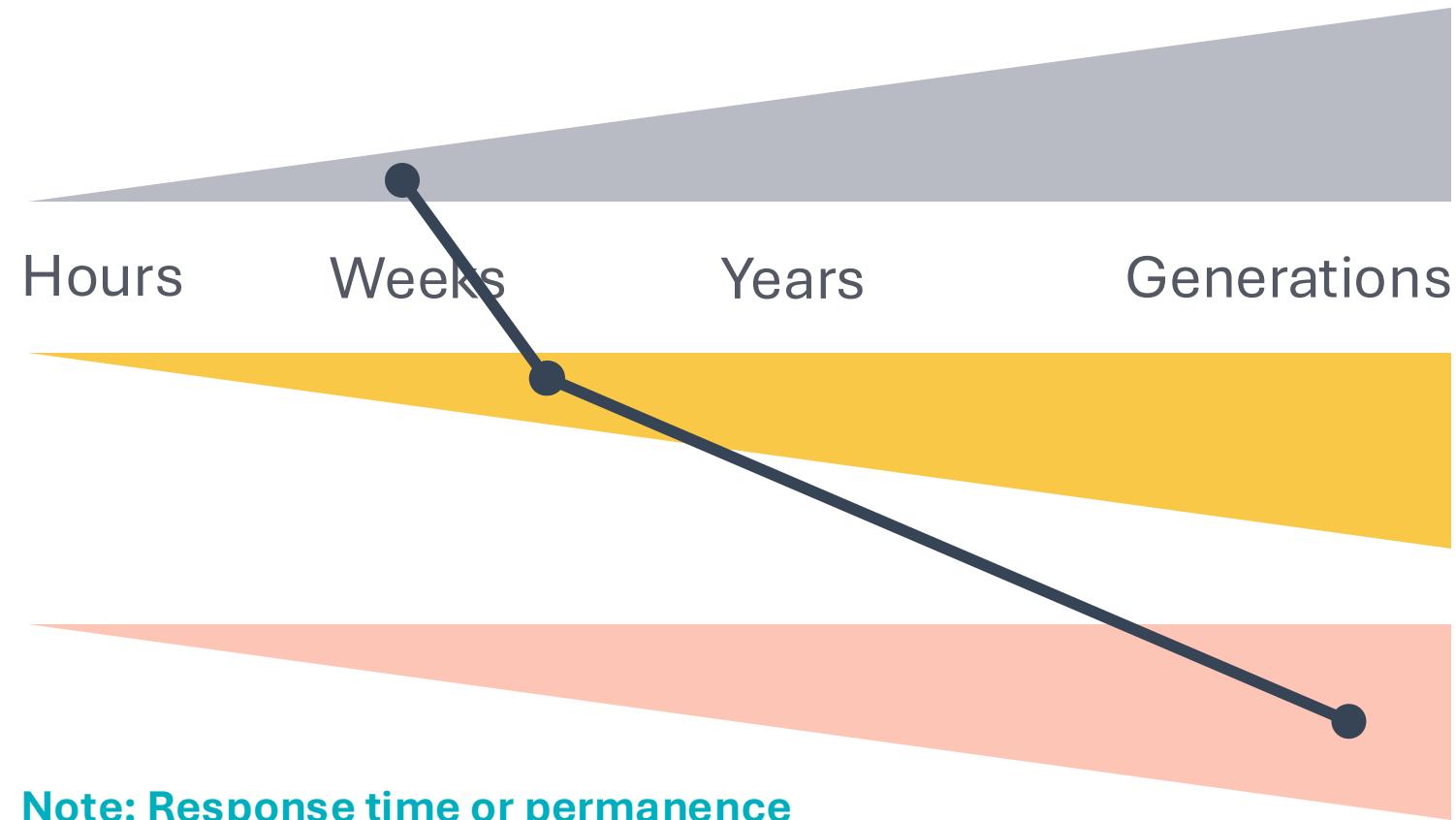
Disruptions of homeostasis occur across different durations

Duration of stress



Disruptions of homeostasis occur across different durations... and thus, so too do adaptive responses

Duration of stress

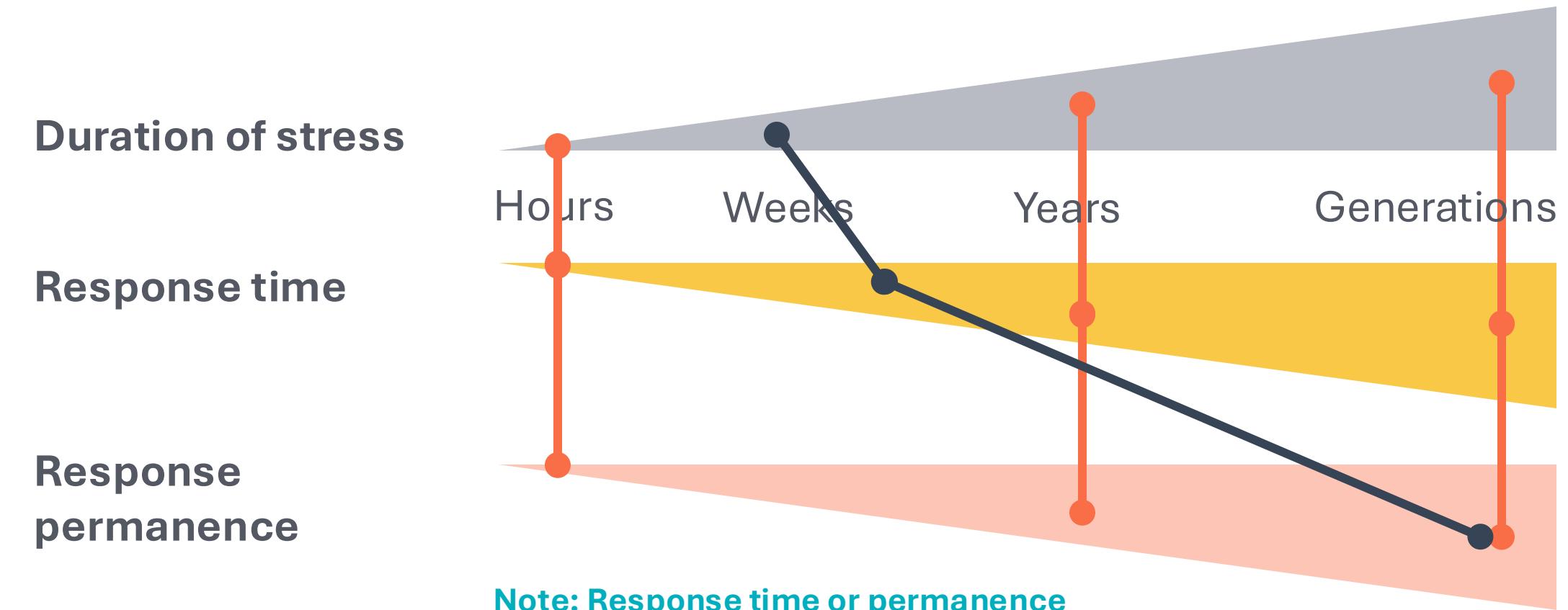


Response time

Response permanence

Note: Response time or permanence
need not correspond to duration of
stress: these correlate more strongly
with *intensity* and *risk*

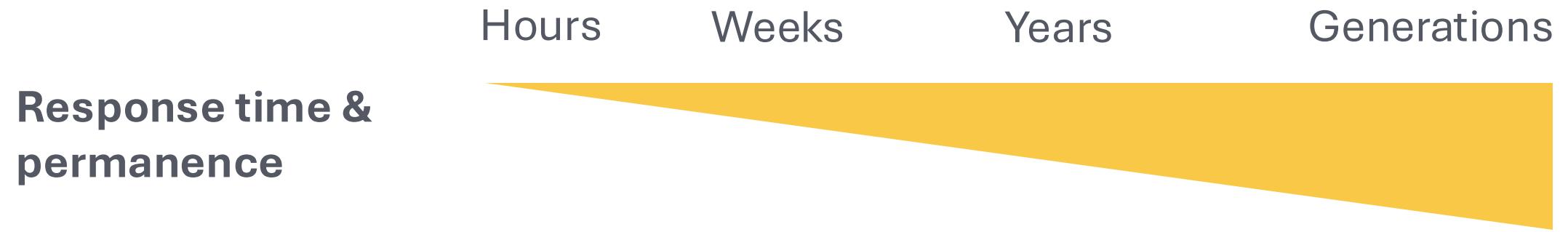
Disruptions of homeostasis occur across different durations... and thus, so too do adaptive responses



Note: Response time or permanence
need not correspond to duration of
stress: these correlate more strongly
with *intensity and risk*

But: generally speaking, they do!

Adaptive responses



Adaptive responses

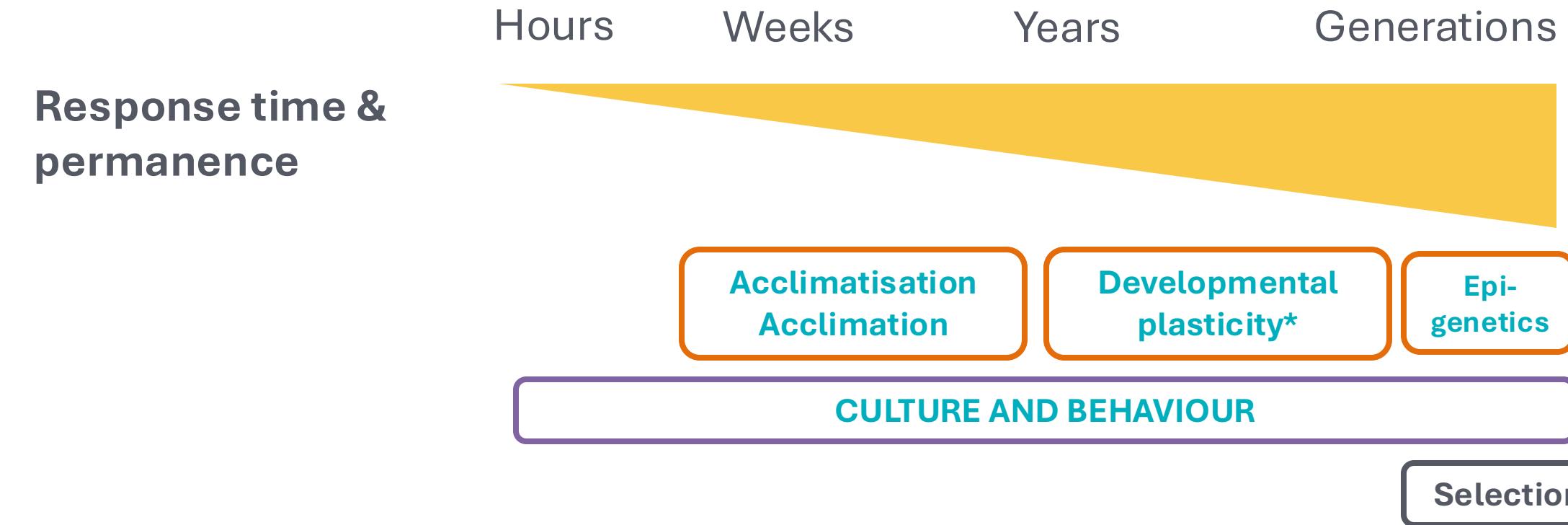


Key:



Plasticity

Adaptive responses



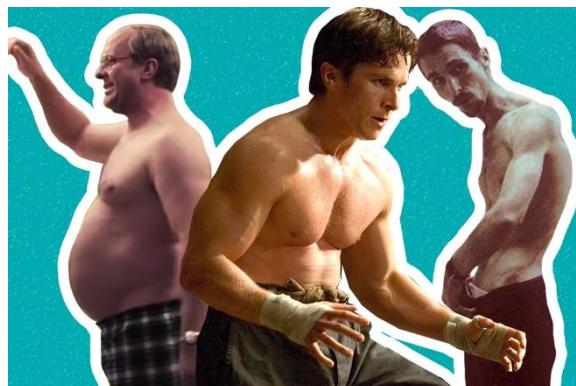
Key:



Plasticity: one genotype > many phenotypes, depending on environment

ABC

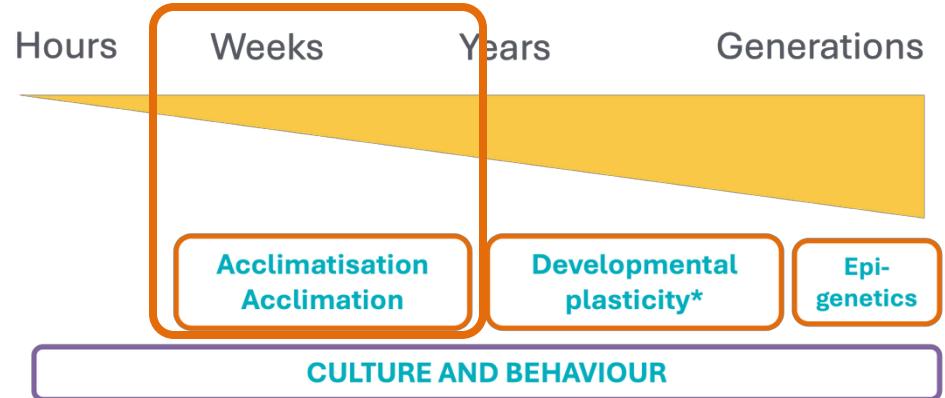
No genetic change (no evolution)



Acclimation and acclimatization

Relatively short-term, often reversible, types of plasticity

Tends to modify homeostatic responses



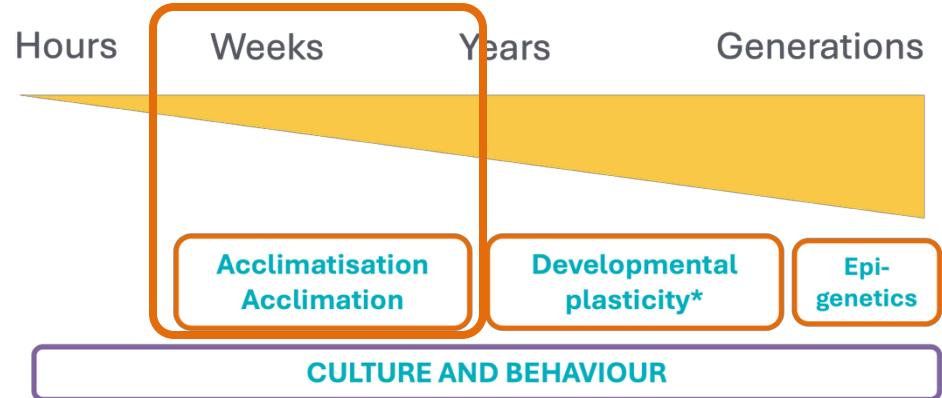
Example: Heat stress in hot & dry vs hot & humid macroenvironments



Acclimation and acclimatization

Relatively short-term, often reversible, types of plasticity

Tends to modify homeostatic responses



Example: Heat stress in **hot & dry** vs **hot & humid** macroenvironments



Highly efficient & fast: With 30 minutes of exposure a day

- These changes occur within 2 weeks
- Maximum attained in 8-12 weeks
- Can be lost in a few weeks (reversible!)

Sweating

- Increased
- Initiates at lower temperature
- Redirected to limbs
- Size of sweat glands increases

entails a cost
causes dehydration
which means FIGHT OR FEE...

Increased plasma volume

- Reservoir for sweat
- Prevents blood volume dropping due to vasodilation

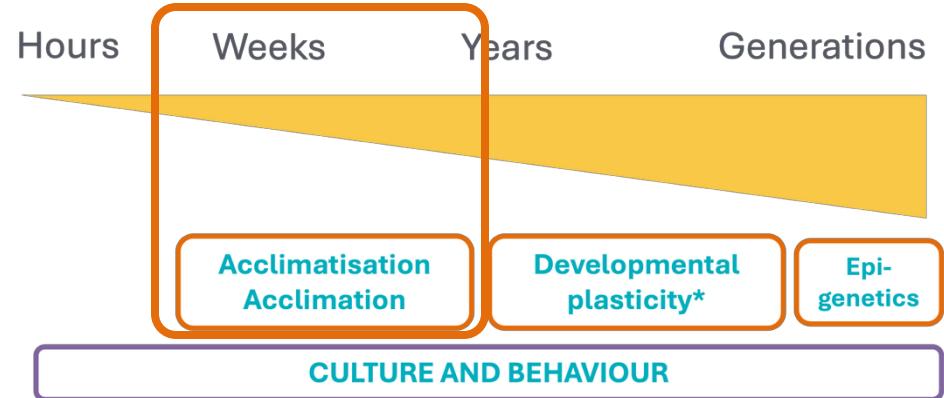
Decreased

- Salt content in sweat (to prevent dehydration)
- Skin and core temperature

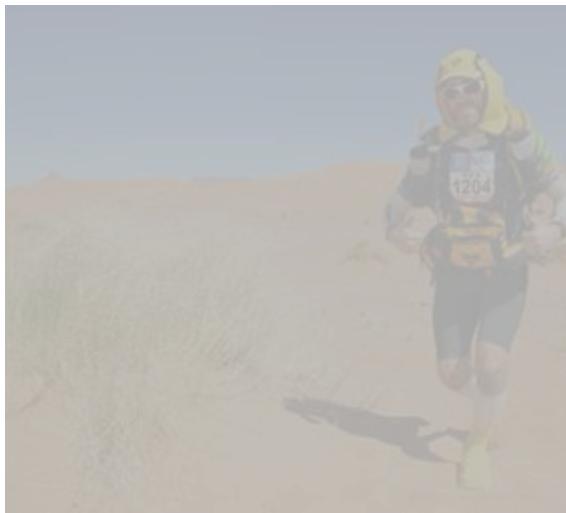
Acclimation and acclimatization

Relatively short-term, often reversible, types of plasticity

Tends to modify homeostatic responses



Example: Heat stress in hot & dry vs **hot & humid** macroenvironments



Extremely inefficient: sweating ineffective at lowering body temperature

WHY
MIGHT
THESE RESPONSES
MAKE IT DIFFICULT
TO ACCLIMATIZE
TO HOT + HUMID ENVIRONMENTS?

Sweating

- Increased
- Initiates at lower temperature
- Redirected to limbs
- Size of sweat glands increases

Increased plasma volume

- Reservoir for sweat
- Prevents blood volume dropping due to vasodilation

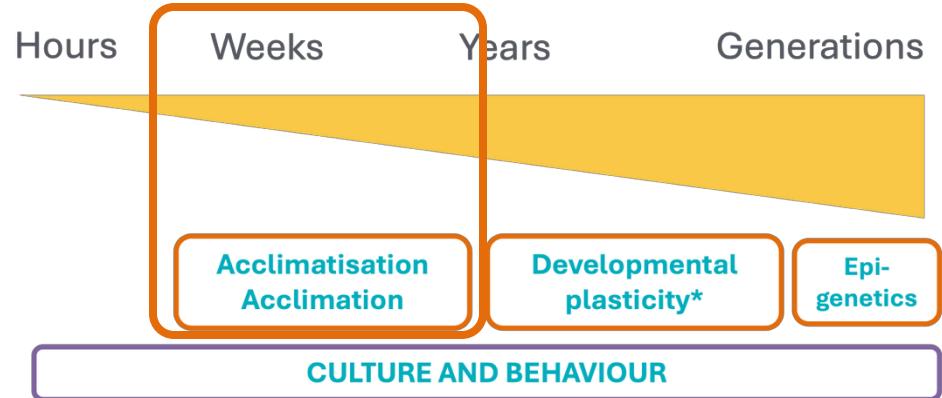
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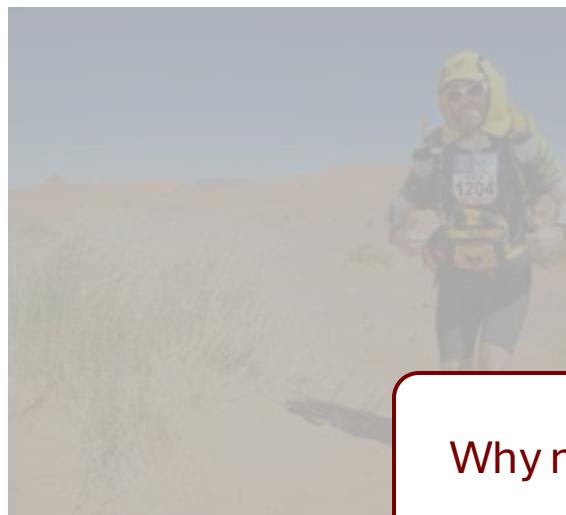
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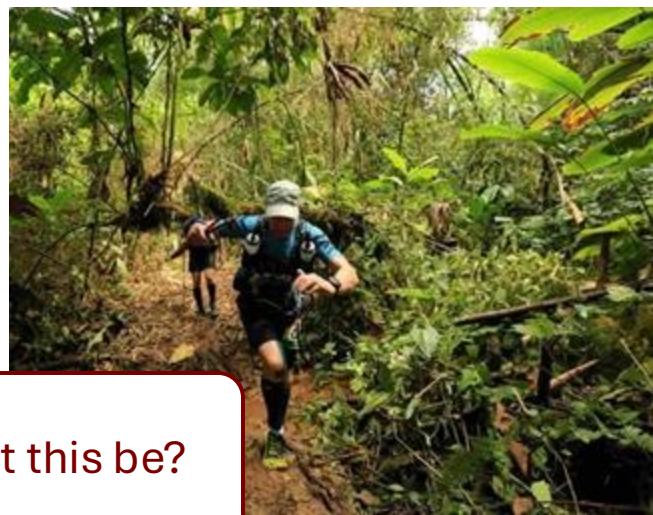
Tends to modify homeostatic responses



Example: Heat stress in hot & dry vs hot & humid macroenvironments



Why might this be?



Extremely inefficient: sweating ineffective at lowering body temperature

Sweating

- Increased
- Initiates at lower temperature
- Redirected to limbs
- Size of sweat glands increases

Increased plasma volume

- Reservoir for sweat
- Prevents blood volume dropping due to vasodilation

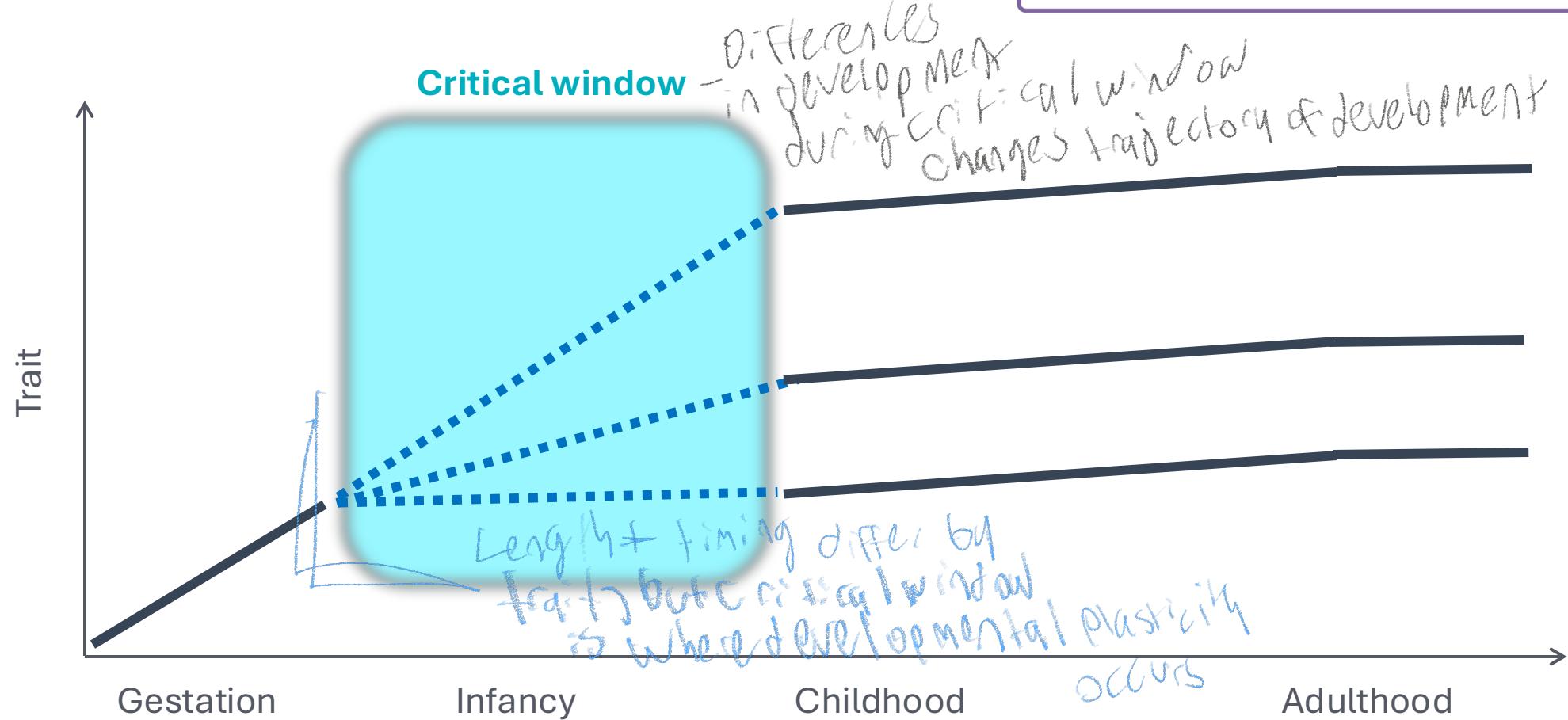
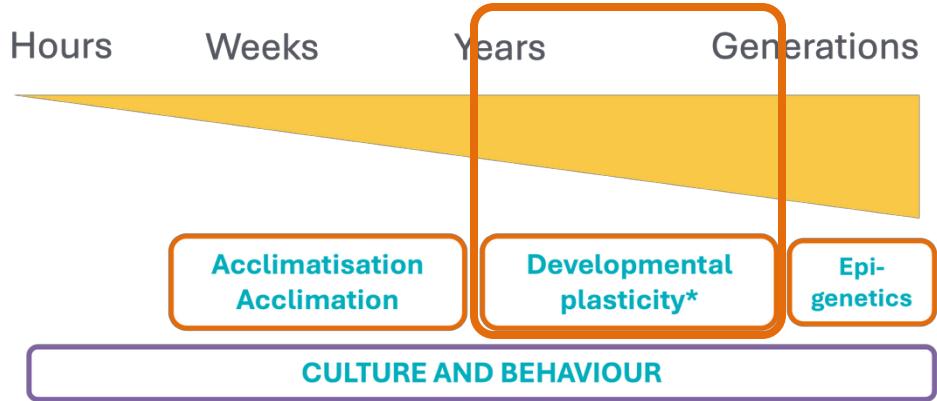
Decreased

- Salt content in sweat (to prevent dehydration)
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Developmental plasticity

Long-term, usually not reversible

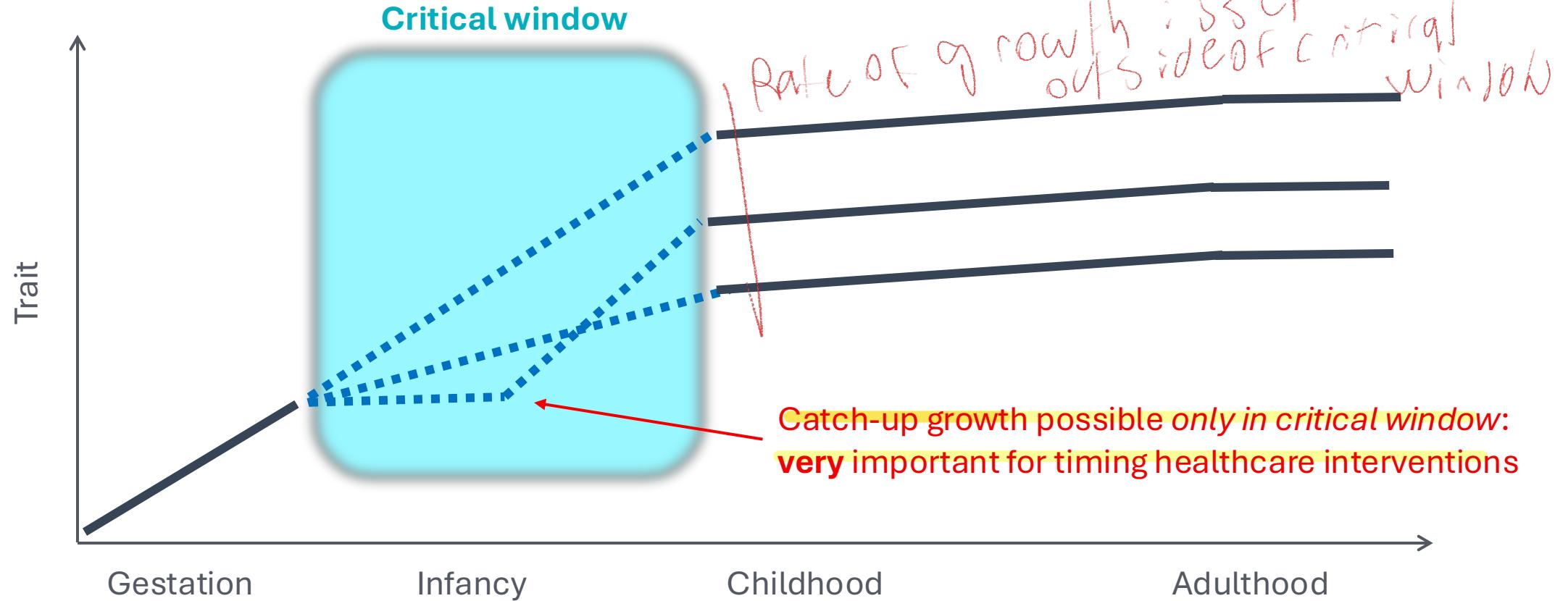
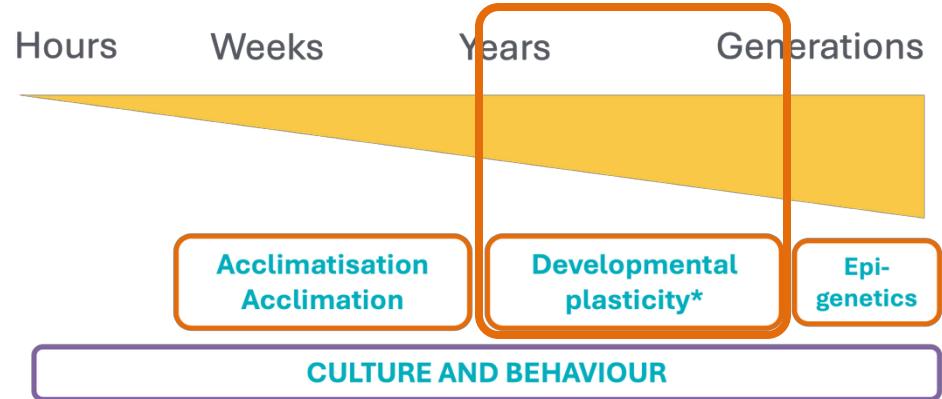
Sometimes called developmental acclimatisation



Developmental plasticity

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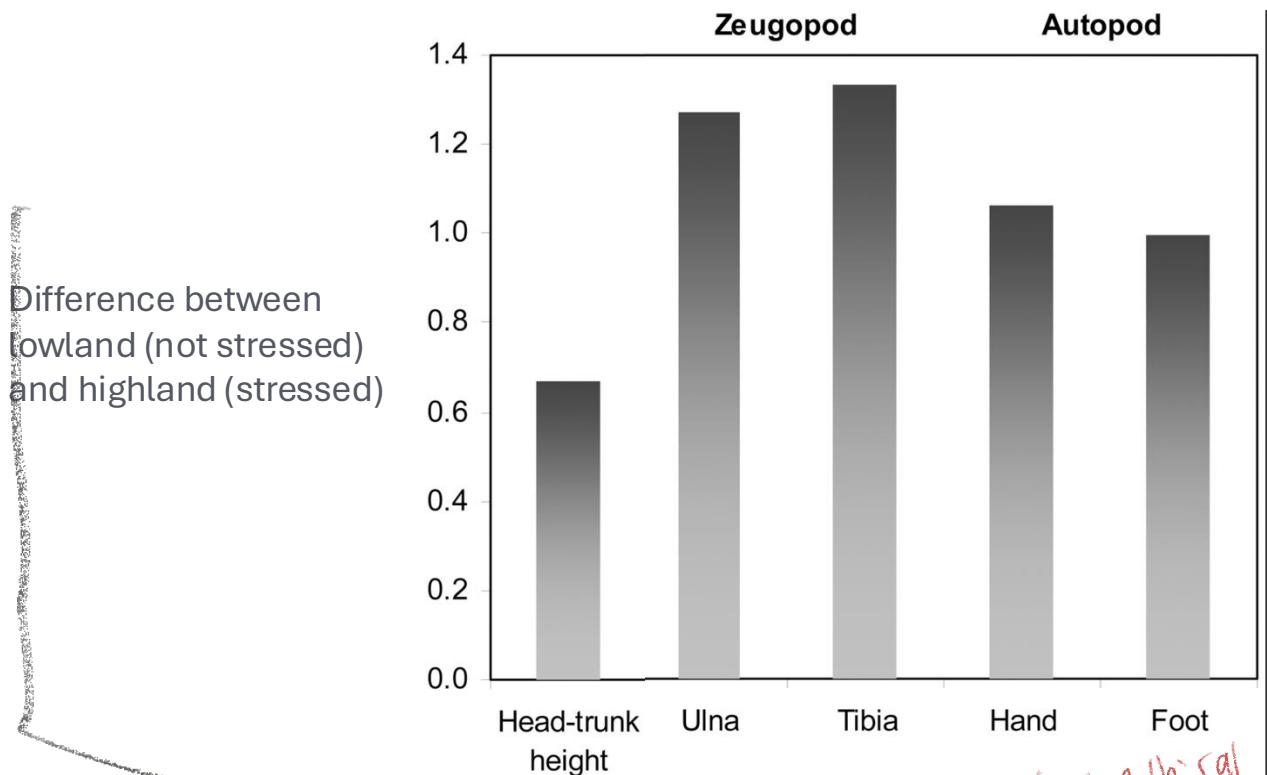
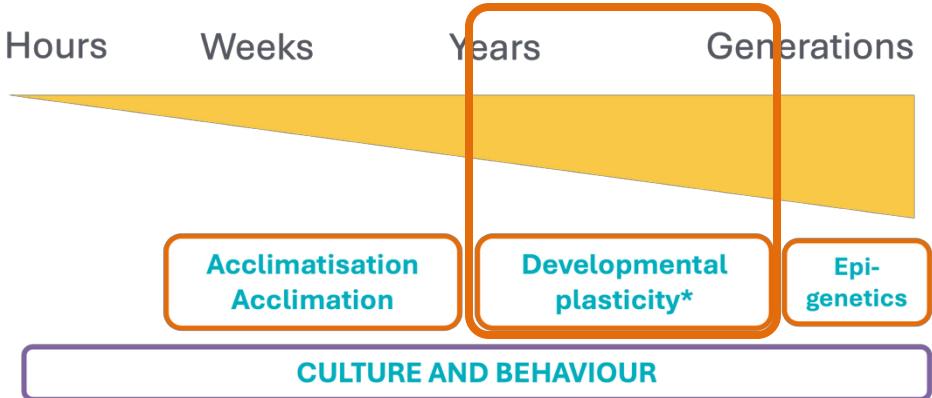
Sometimes called developmental acclimatisation



Developmental plasticity

Long-term, usually not reversible

Sometimes called developmental acclimatisation



It would be unethical to put identical twins in different environments to test so it's hard

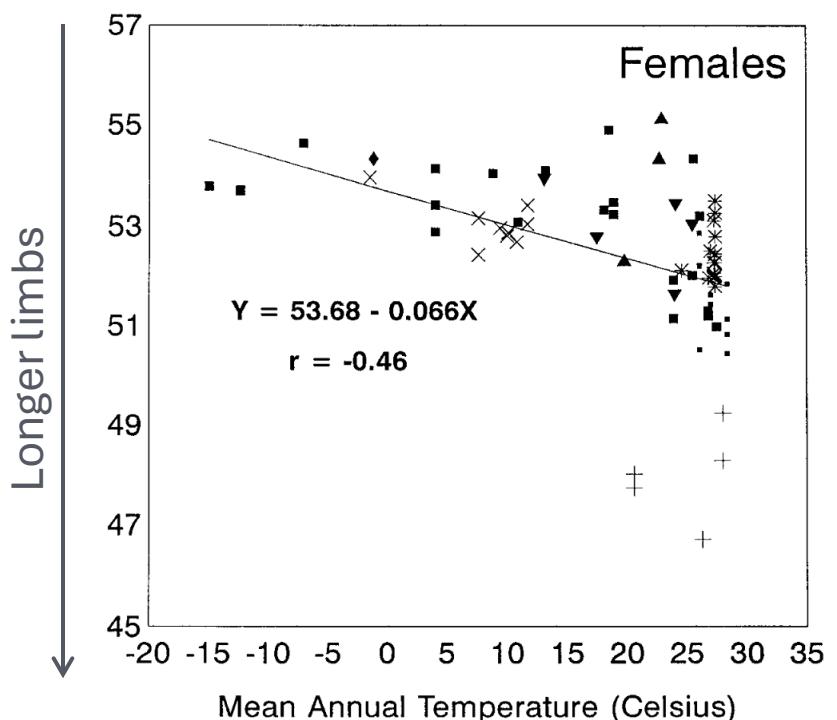
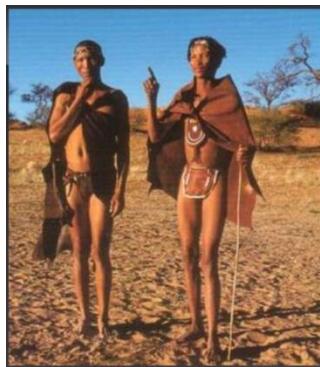
Hard to test whether this is developmental plasticity or an effect of longer-term adaptation!



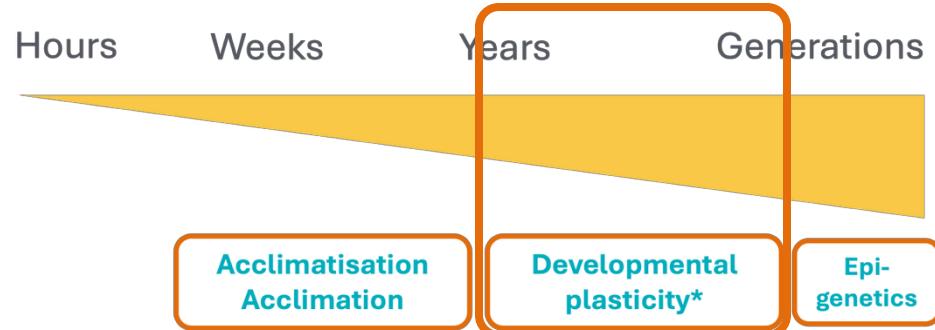
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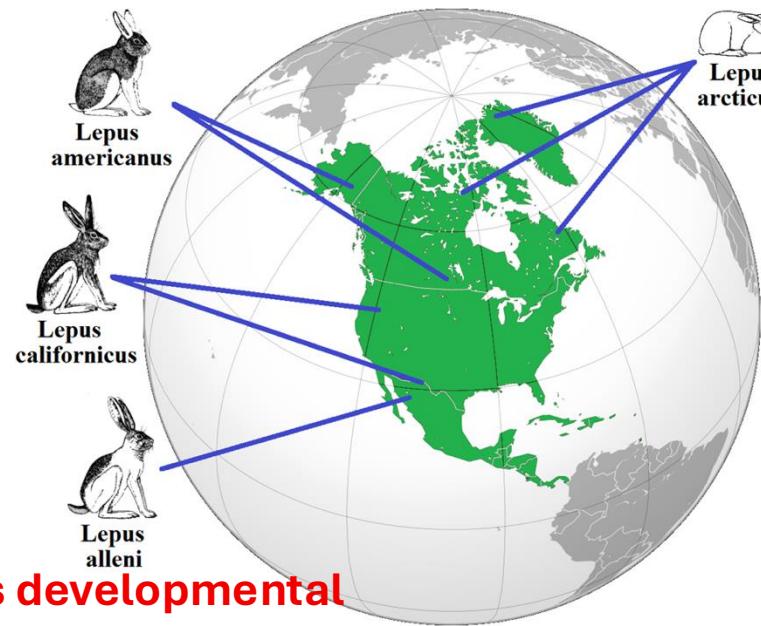
Sometimes called developmental acclimatisation



Hard to test whether this is developmental plasticity or an effect of longer-term adaptation!



These are fake examples of developmental plasticity but considering that these are Longer extremities: poorer heat retention (Allen's rule)

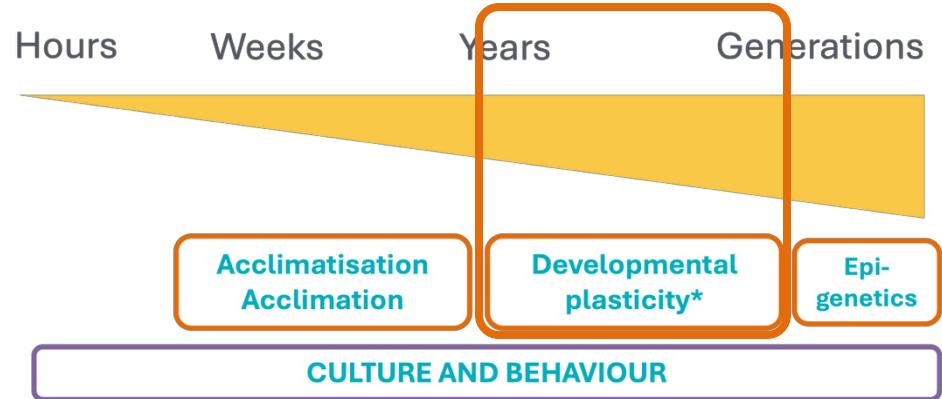


different body parts
that work
live longer
differences
in now
behaviour

Developmental plasticity

Long-term, usually not reversible

Sometimes called developmental acclimatisation



Effective if... developmental environment = adult environment!





Epigenetics

Regulatory changes that can be passed down multiple generations



Dutch hunger winter (1944-45)

People conceived during the famine: epigenetic changes, esp. affecting IGF2 (insulin-like growth factor 2).

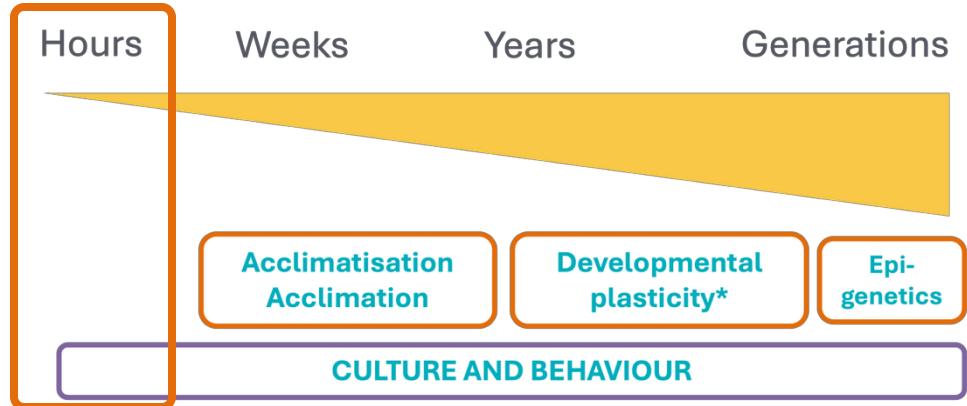
- *Early gestation exposure*: strongest and longest-lasting epigenetic effects. Risk of diabetes, overweight, etc.
- *Mid-to-late gestation exposure*: more associated with immediate birth outcomes (e.g., low birth weight), but less persistent epigenetic changes. Risk of diabetes, overweight, etc.



Some effects may reflect developmental plasticity, rather than epigenetics

Culture and behaviour

Immediate behavioural changes



seeking shade
or resting
it's hot

Culture and behaviour

Creating microenvironments

Clothing: effective

- Inhibits convective heating from hot winds
- Permeable to water to allow for evaporative cooling
- Light, reflective colours reduce radiative heat gain
- Loose clothes promote convection

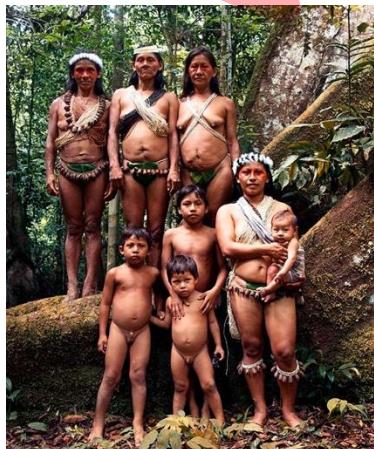
Shelters: effective

- Thick walls to delay the heat absorption (day) and loss (night)
- Minimal surface area to volume ratio
- Whitewash to reflect sun
- Evaporative cooling, courtyards

Hot day



Hot humid



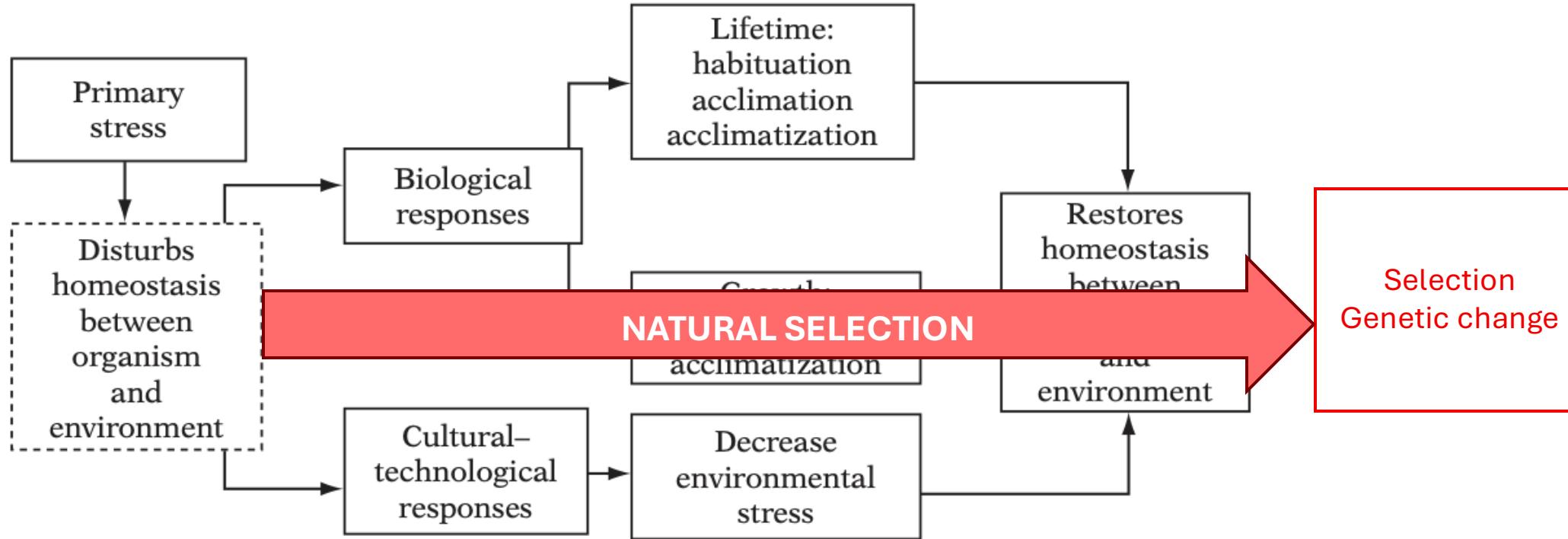
Clothing: ineffective

- General strategy: as little as possible

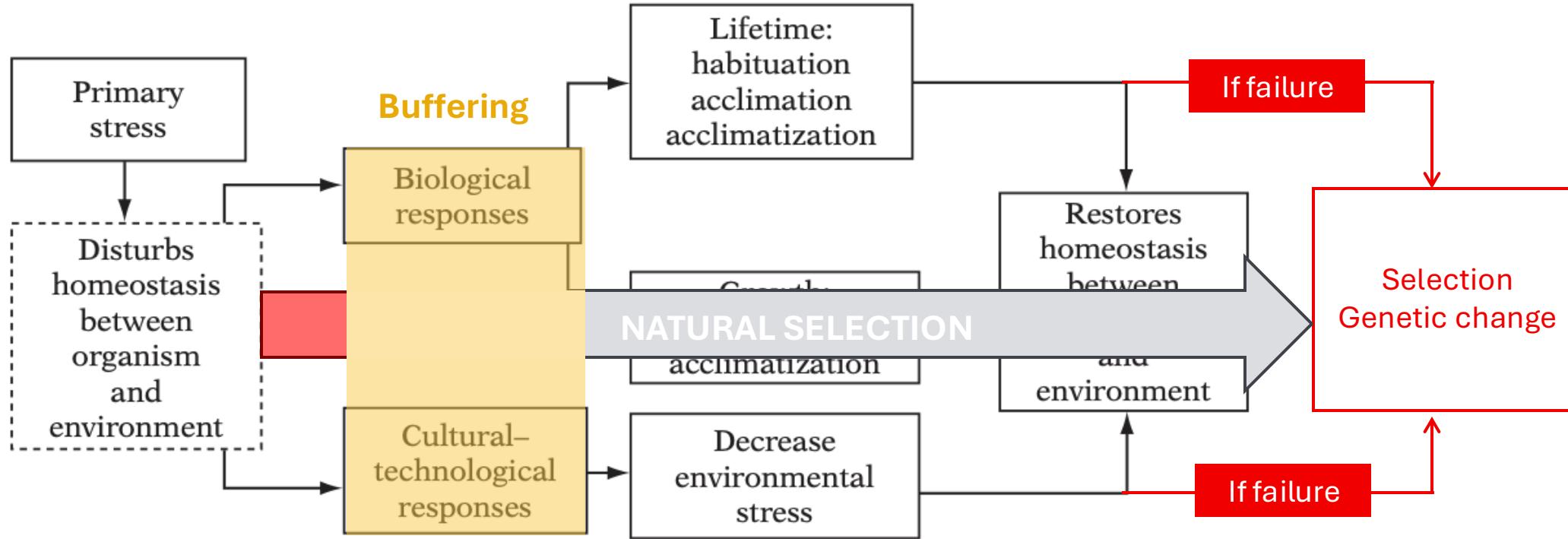
Shelter: ineffective (unless AC!)

- Primarily just shelter from rain
- Air circulation

Buffering

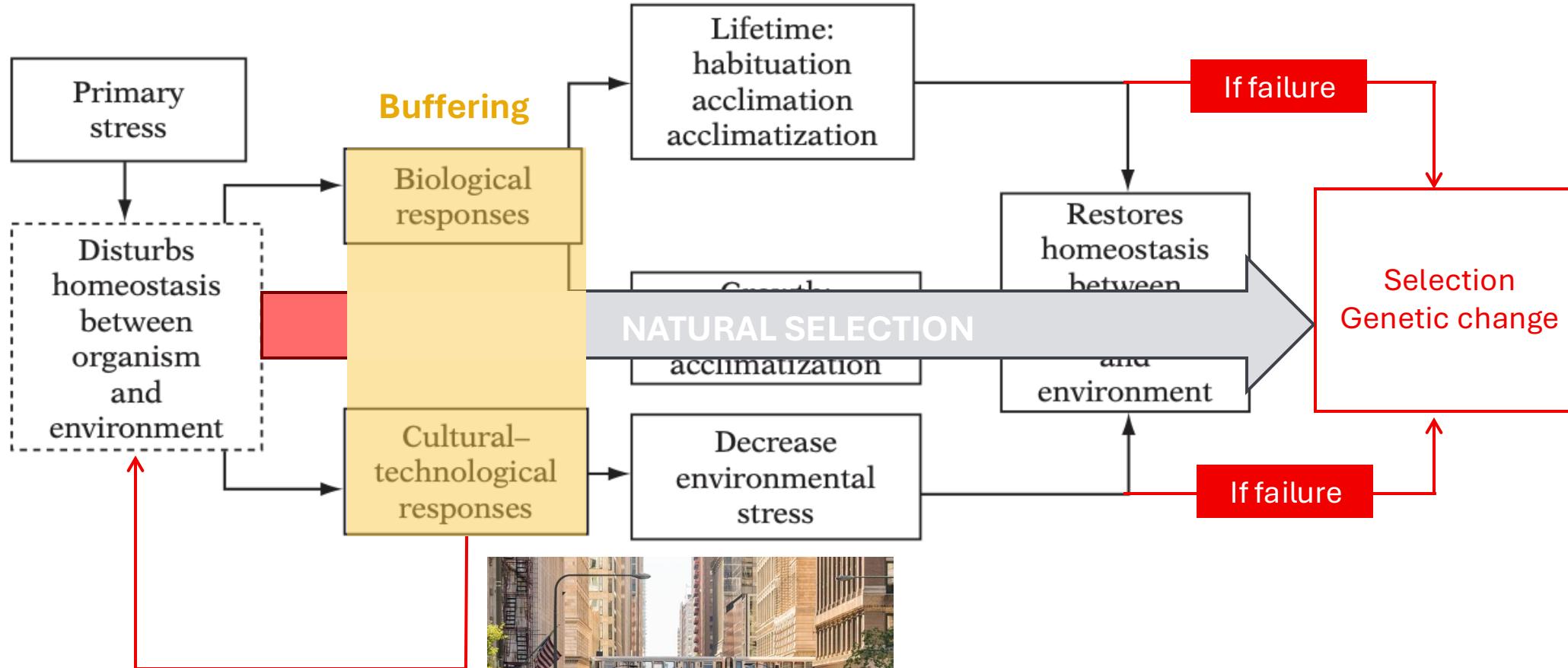


Buffering

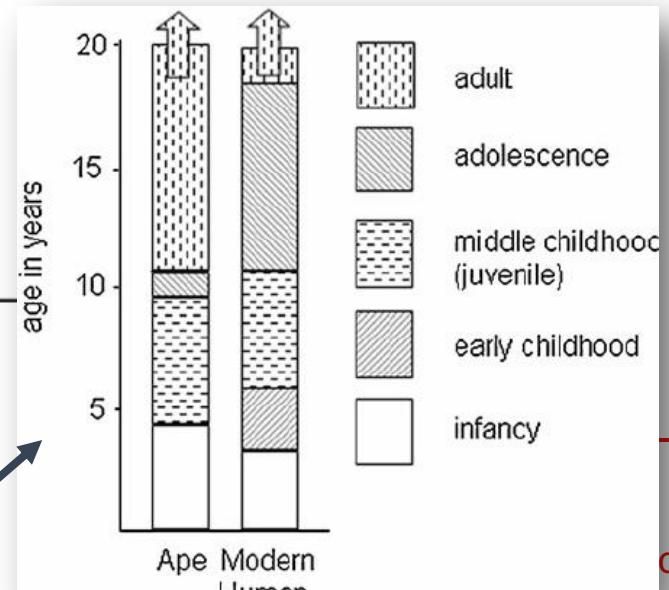
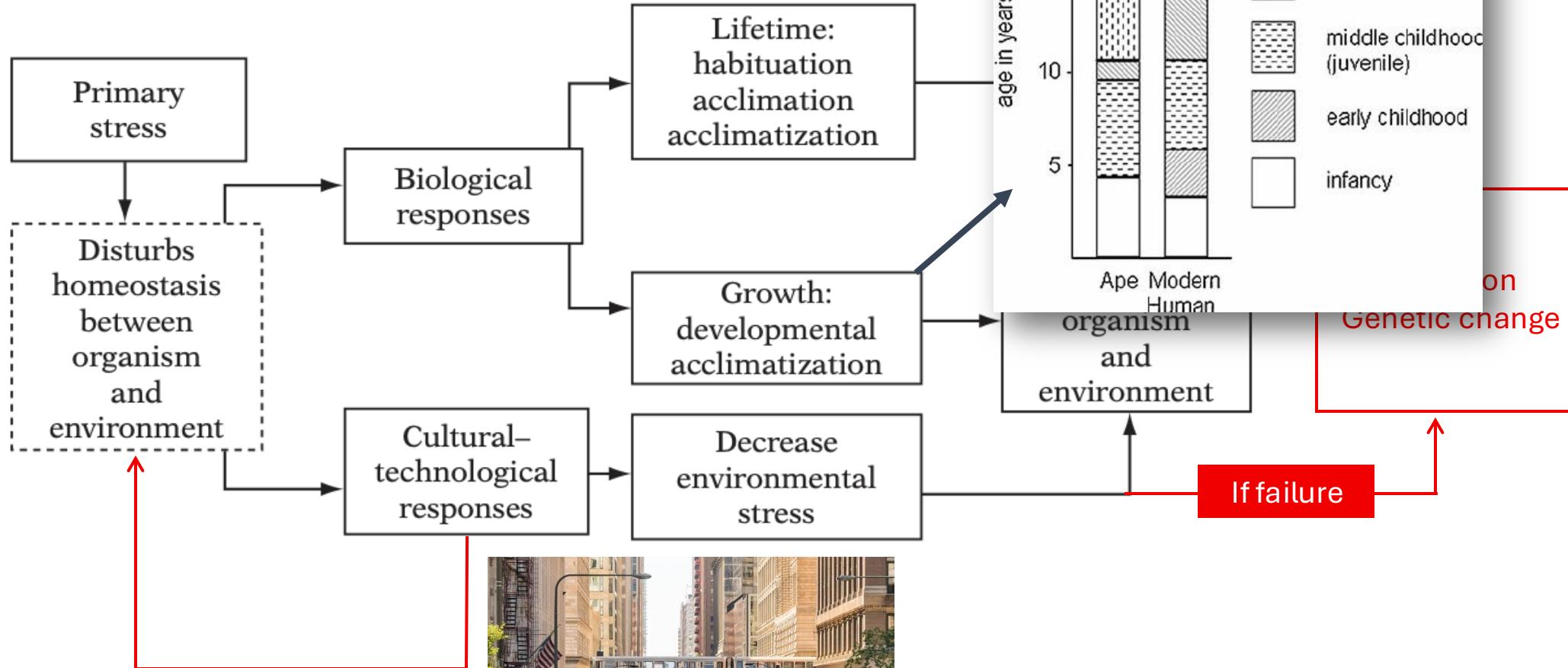


- Reduces genetic diversity
- Increases phenotypic diversity

Buffering



Human uniqueness?



on
Genetic change

If failure

Summary of today

1. Selection operates on fitness, and can therefore only operate on phenotypes.
2. Natural selection (tends to) result in long-term adaptation of populations to their ecosystems.
3. Adaptative processes are necessitated when homeostasis is disrupted.
4. Adaptation can also occur through acclimatisation, developmental plasticity, epigenetics, and behaviour (culture).

These:

- Tend to operate on shorter timescales than natural selection
- Can buffer the genome entirely from selection
- But vary in effectiveness (mostly depending on environment)

Going forward...

When does adaptation become *maladaptation*?

Can you predict a relationship between timescale of adaptive process and maladaptation?