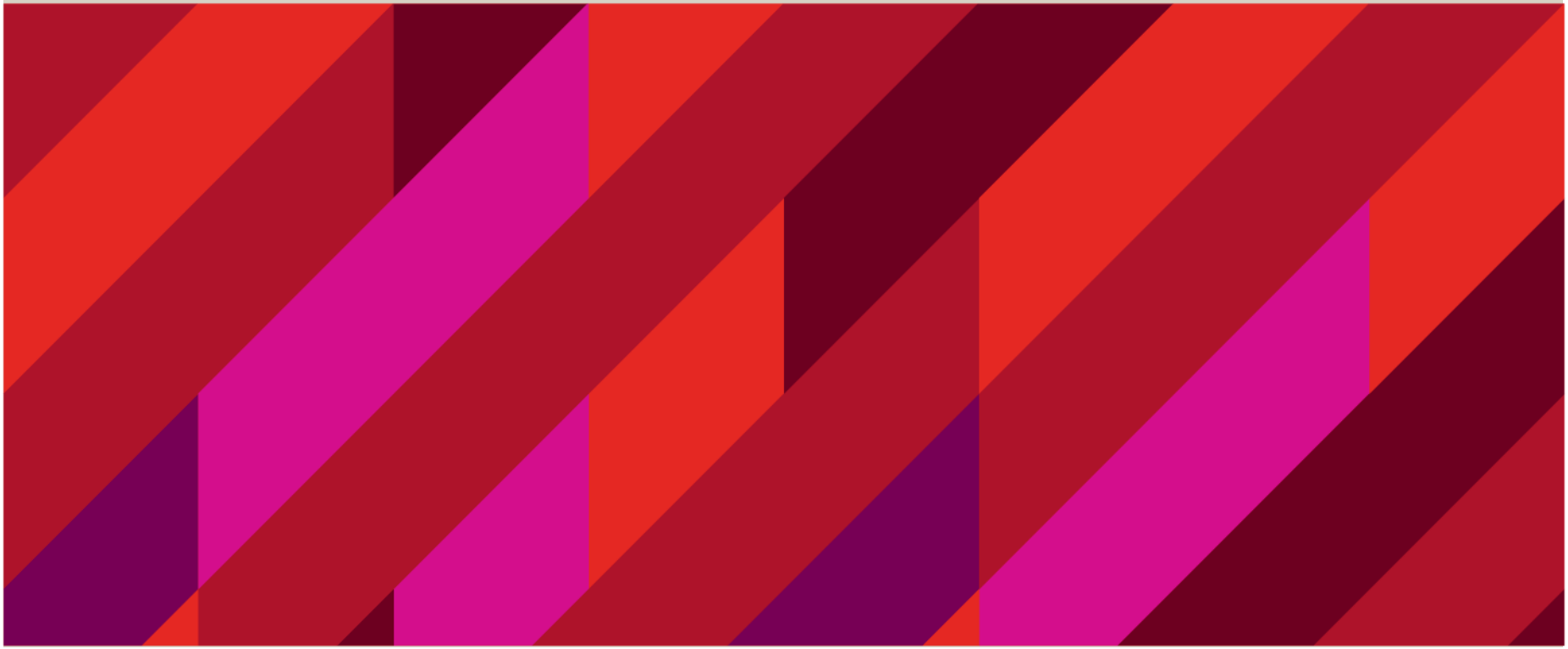
MACQUARIE University

BIOL3110 Conservation & Ecological Genetics

LECTURE 19: ADAPTIVE POTENTIAL 2



Case Study: Research by Jeffrey Good

University of Montana

Climate change and the evolution of seasonal camouflage

Research to understand

1) the evolution of seasonal camouflage and

2) genomic responses to climate change in mammals

using population and functional genomic approaches

SUMMER

WINTER

Snowshoe hare seasonal camouflage

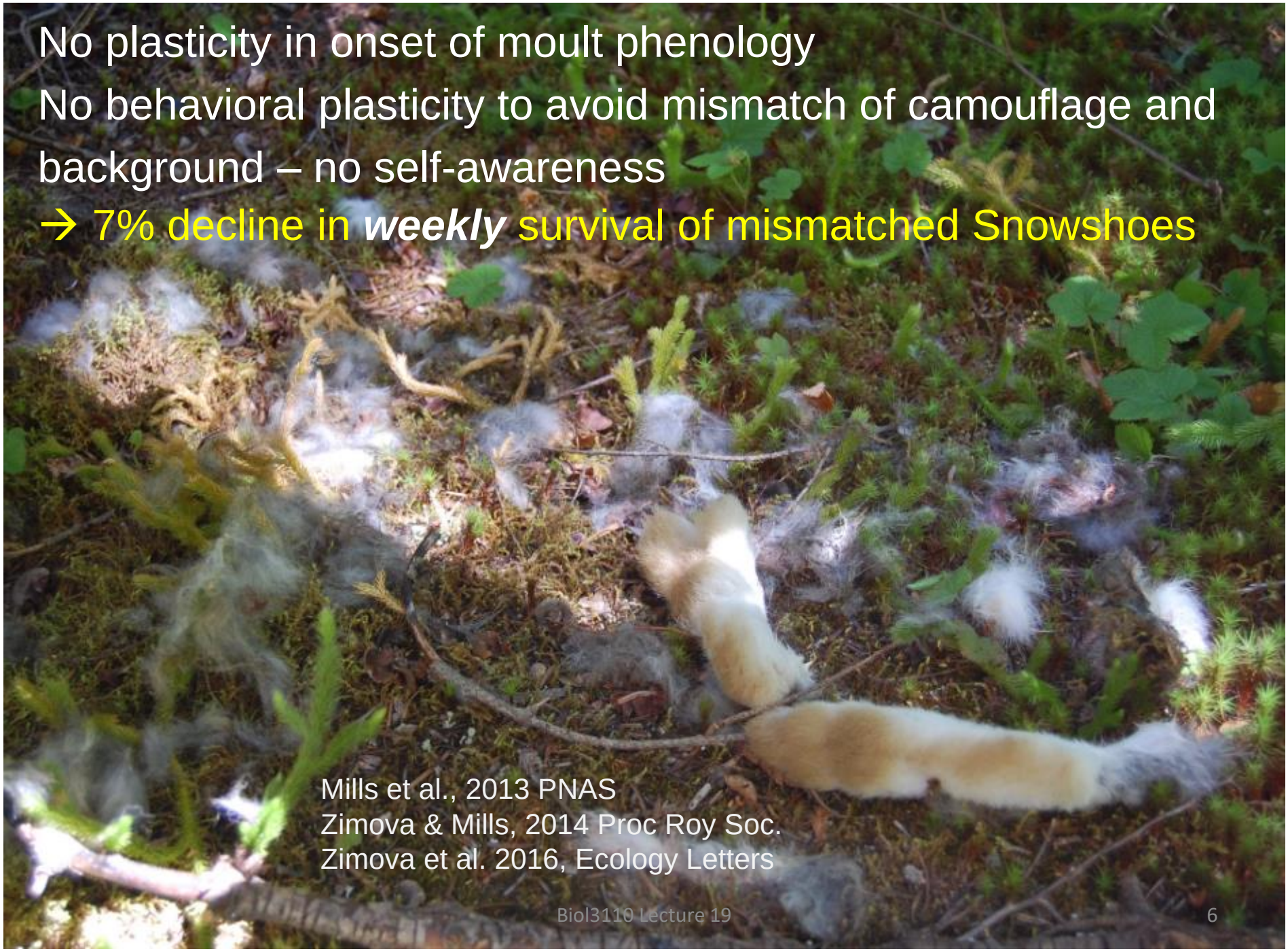
Rapid environmental change (eg climate change) can make these systems break down

Photoperiod may be an increasingly unreliable predictor of snow cover

No plasticity in onset of moult phenology

No behavioral plasticity to avoid mismatch of camouflage and background – no self-awareness

→ 7% decline in ***weekly*** survival of mismatched Snowshoes



Mills et al., 2013 PNAS
Zimova & Mills, 2014 Proc Roy Soc.
Zimova et al. 2016, Ecology Letters

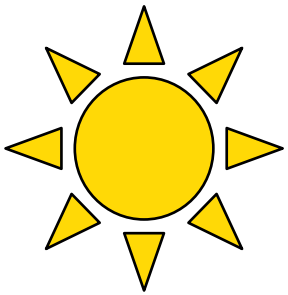
How does seasonal change in phenotype (phenology) happen?

Animals need a cue that warns them of the upcoming season, eg when there will be snow on the ground

Often use photoperiod (daylength), detected by a molecular receptor system (e.g. melatonin) that communicates with the systems that cause phenotypic seasonal change

e.g. photoperiod connects to systems of circadian rhythm ('clock') genes, controlling expression of many genes, driving changes in phenotype

Coat color change is tied to seasonal signaling molecules



Changes in:
Thermoregulation
Reproduction
Behavior

↑ melatonin

summer

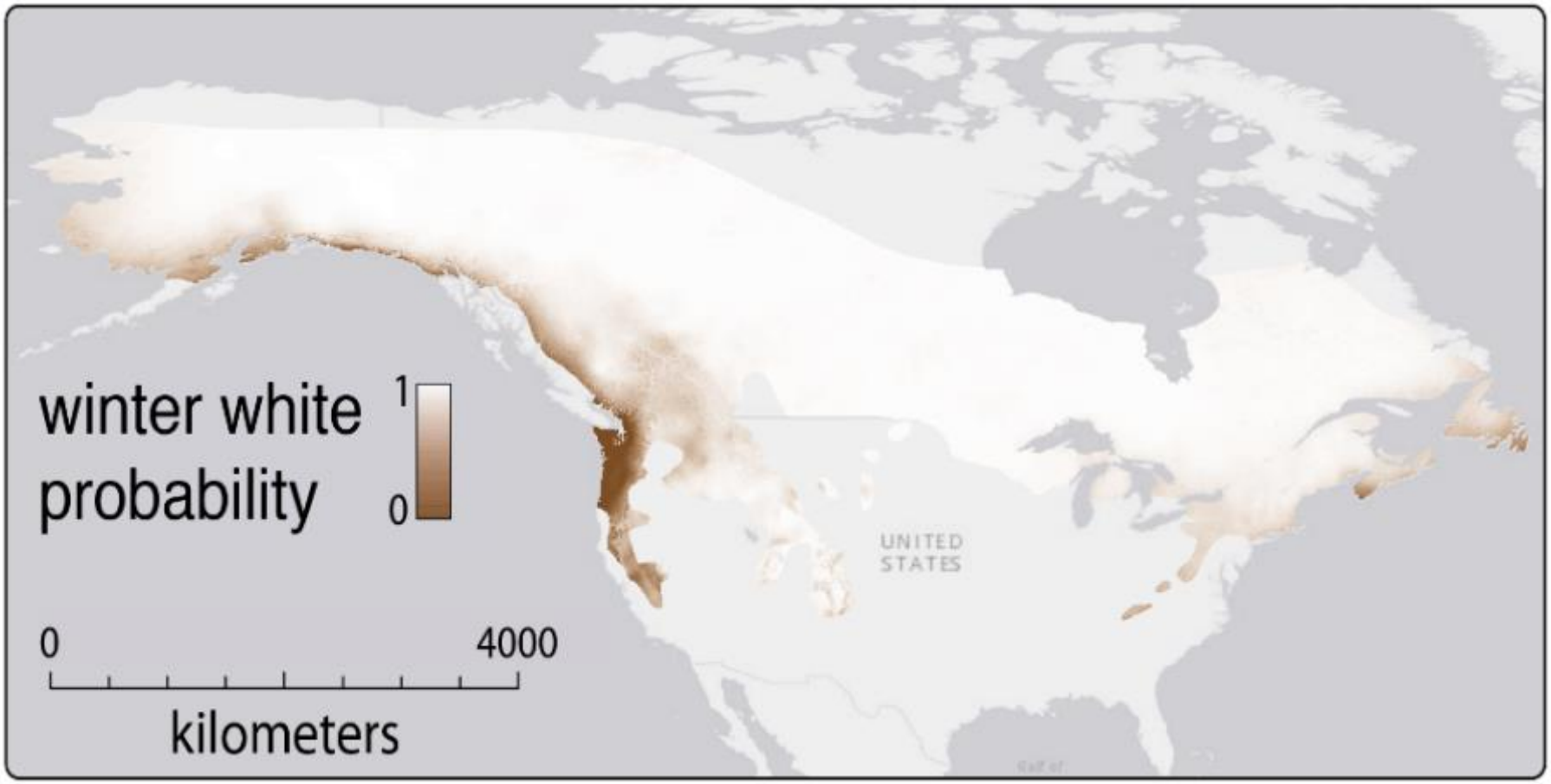
autumn

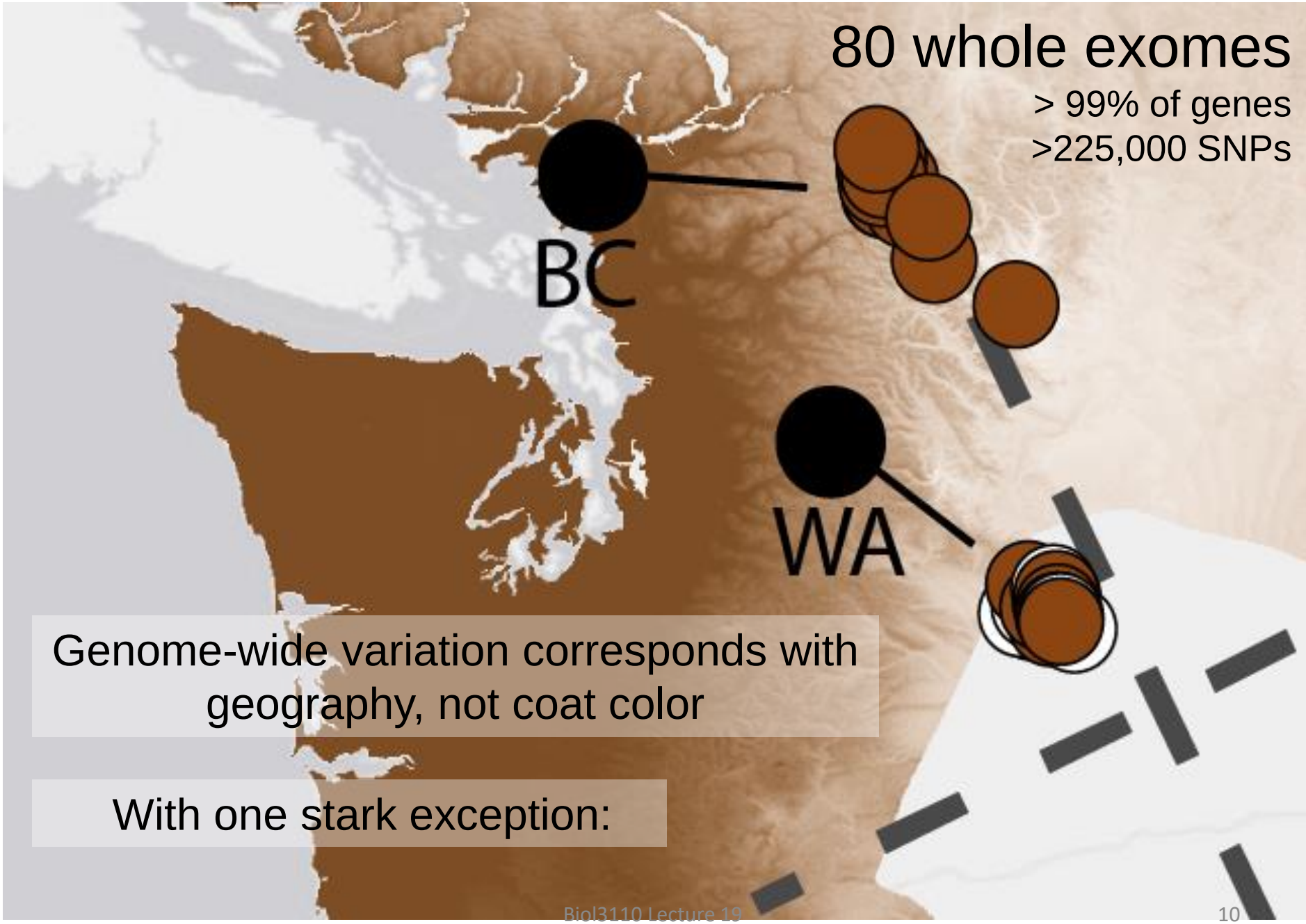
winter

day length threshold

Two components of variation:

- *If* change colour
- *When* to change colour

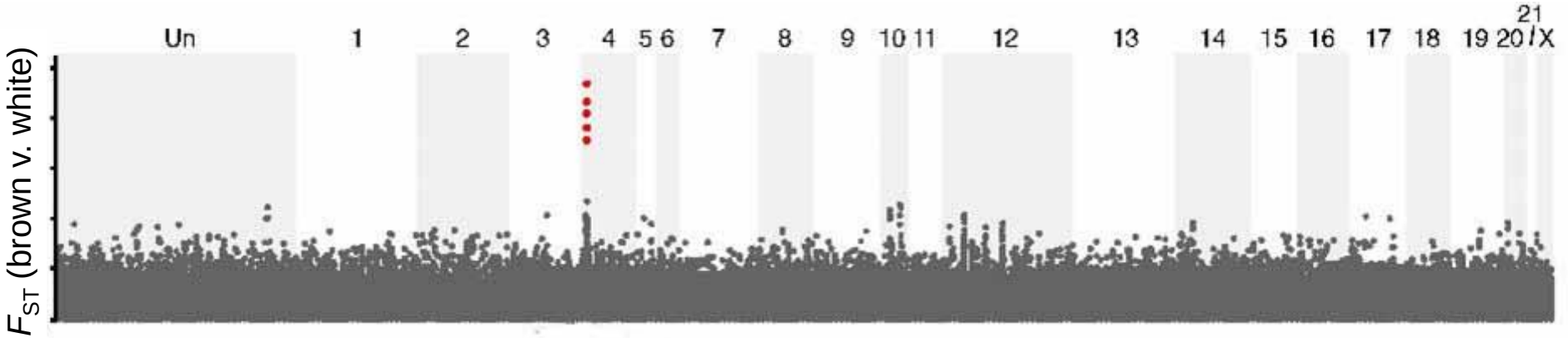


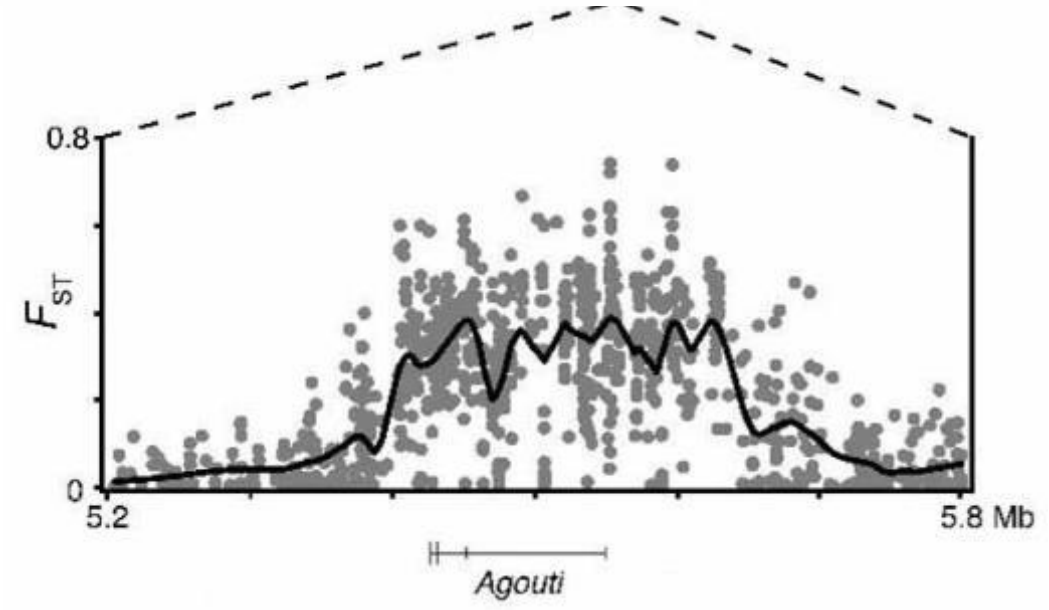


Genome-wide variation corresponds with geography, not coat color

With one stark exception:

Agouti is perfectly associated with winter colour





Manhattan plot

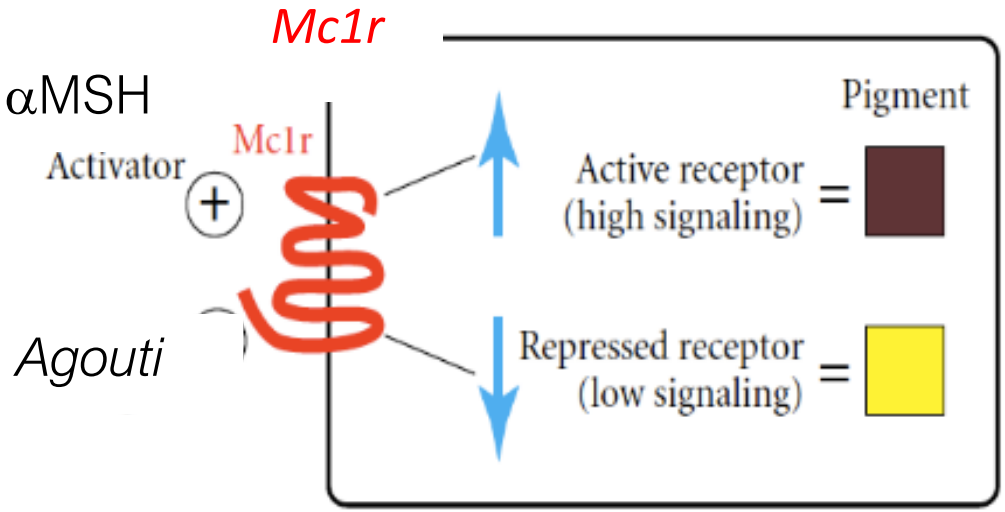
The *Agouti* gene determines winter coat colour

aa
(*a* recessive)

AA *Aa*
(*A* dominant)

How does *Agouti* determine winter colour?

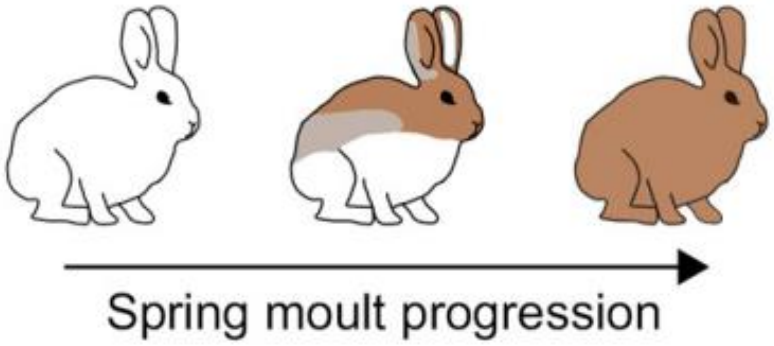
Agouti influences coat colour by reducing the binding of the melanocortin-1 receptor (MC1R), impeding the action of α-melanocyte-stimulating hormone (αMSH) that would cause production of dark eumelanin

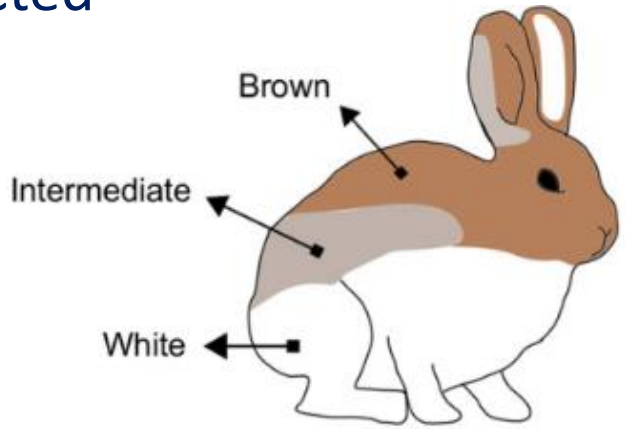


From which you would predict that  is associated with seasonal upregulation of *Agouti – was that true?*

Finding genes that have different seasonal expression to do with coat colour

Progressive moult over the body allowed sampling of cells containing expressed genes, so that the changes in gene expression leading to differences in coat colour could be detected

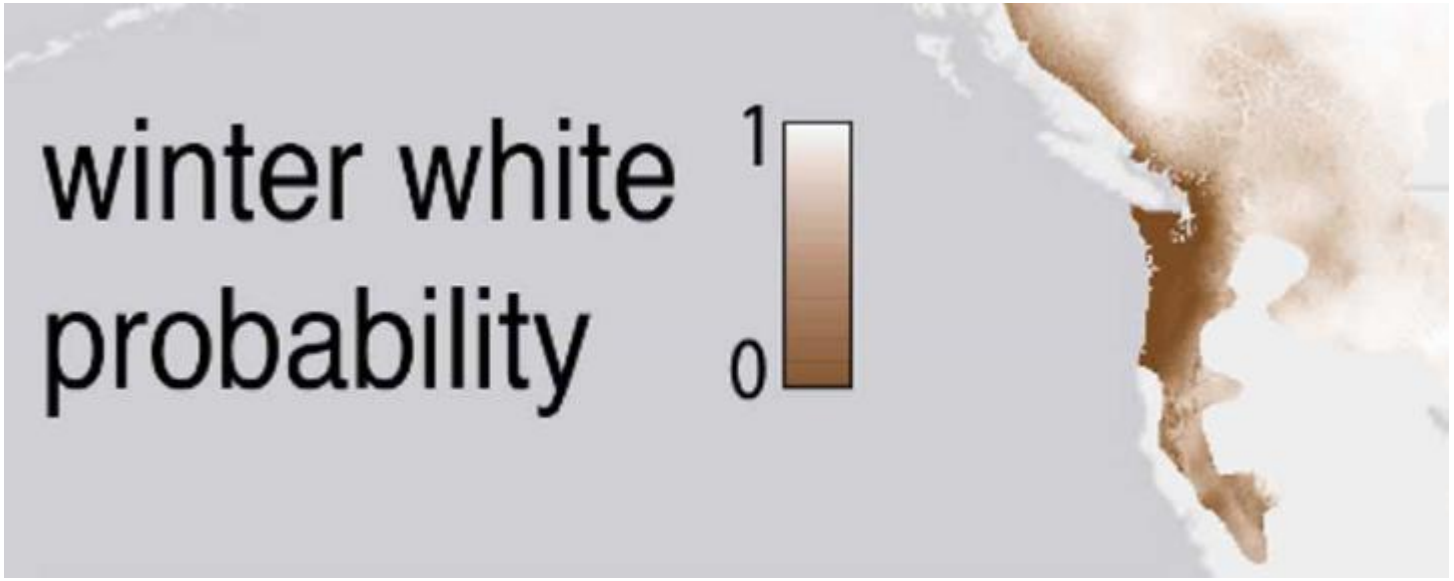




Gene expression tested using RNAseq (RNA sequencing, i.e. transcriptomics) to estimate the abundance of gene transcripts in different-coloured areas of Snowshoes – result: The Agouti Signalling Peptide (ASIP) gene was upregulated in white hares.

How did the warm coastal Pacific Northwest populations evolve to never become white?

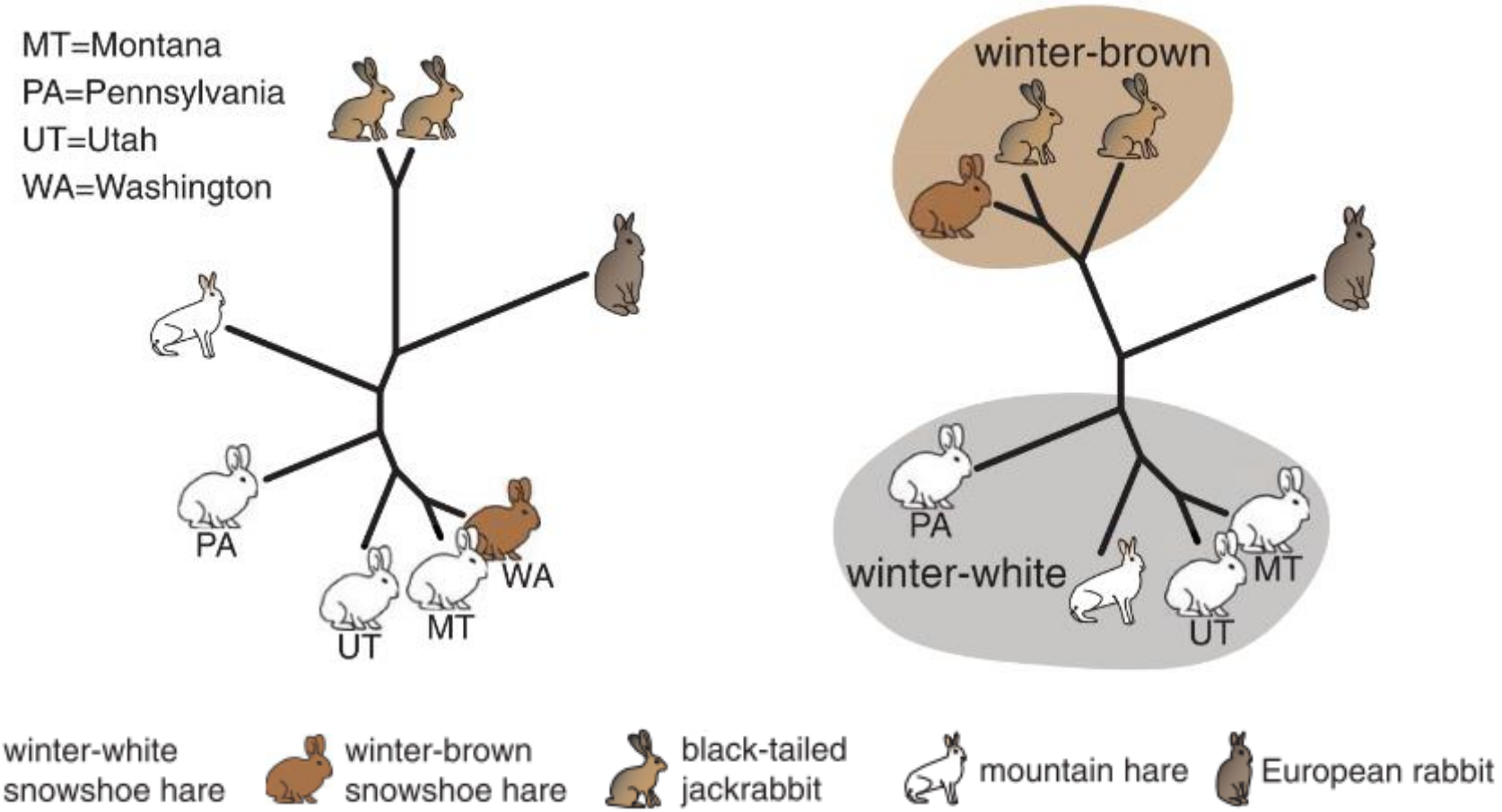
(they moult, but from summer brown to winter brown)



Species tree

Based on whole genome sequencing

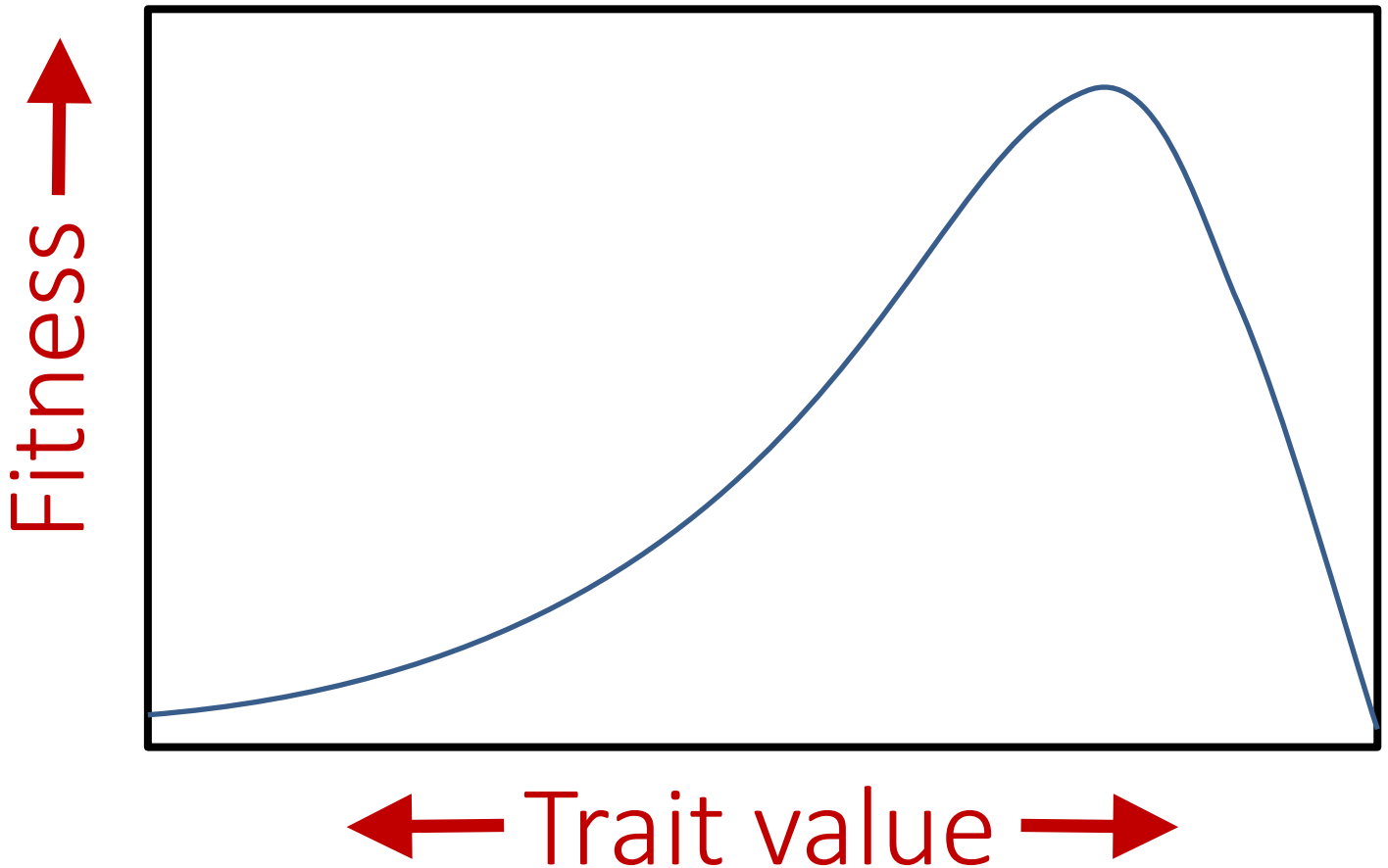
Agouti tree



i.e. the 'brown' gene moved by hybridization from Black-tailed jackrabbit into Pacific Northwest Coast hares - adaptive introgression

“Fitness landscape” concept

If we think of how a single trait relates to fitness:



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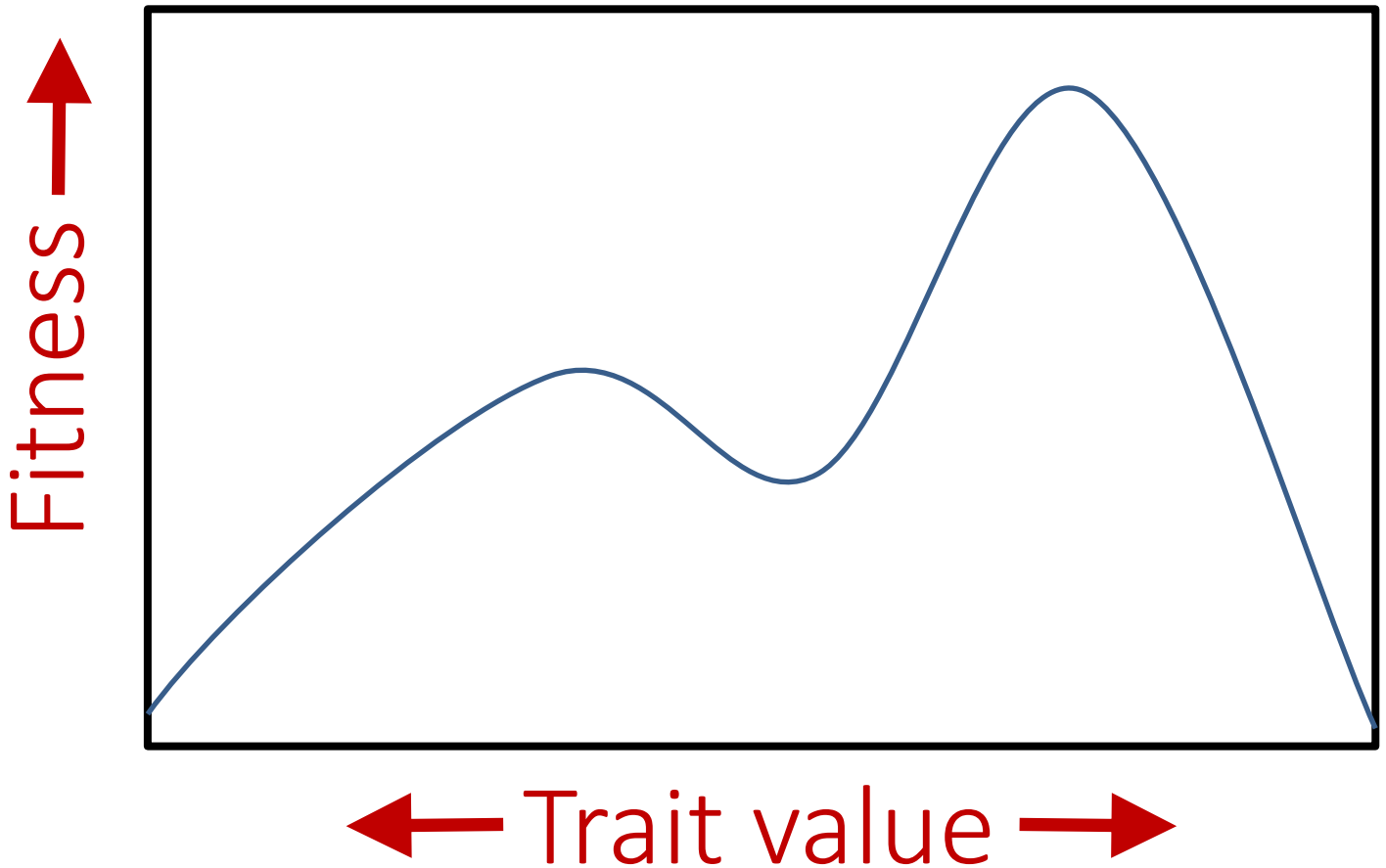
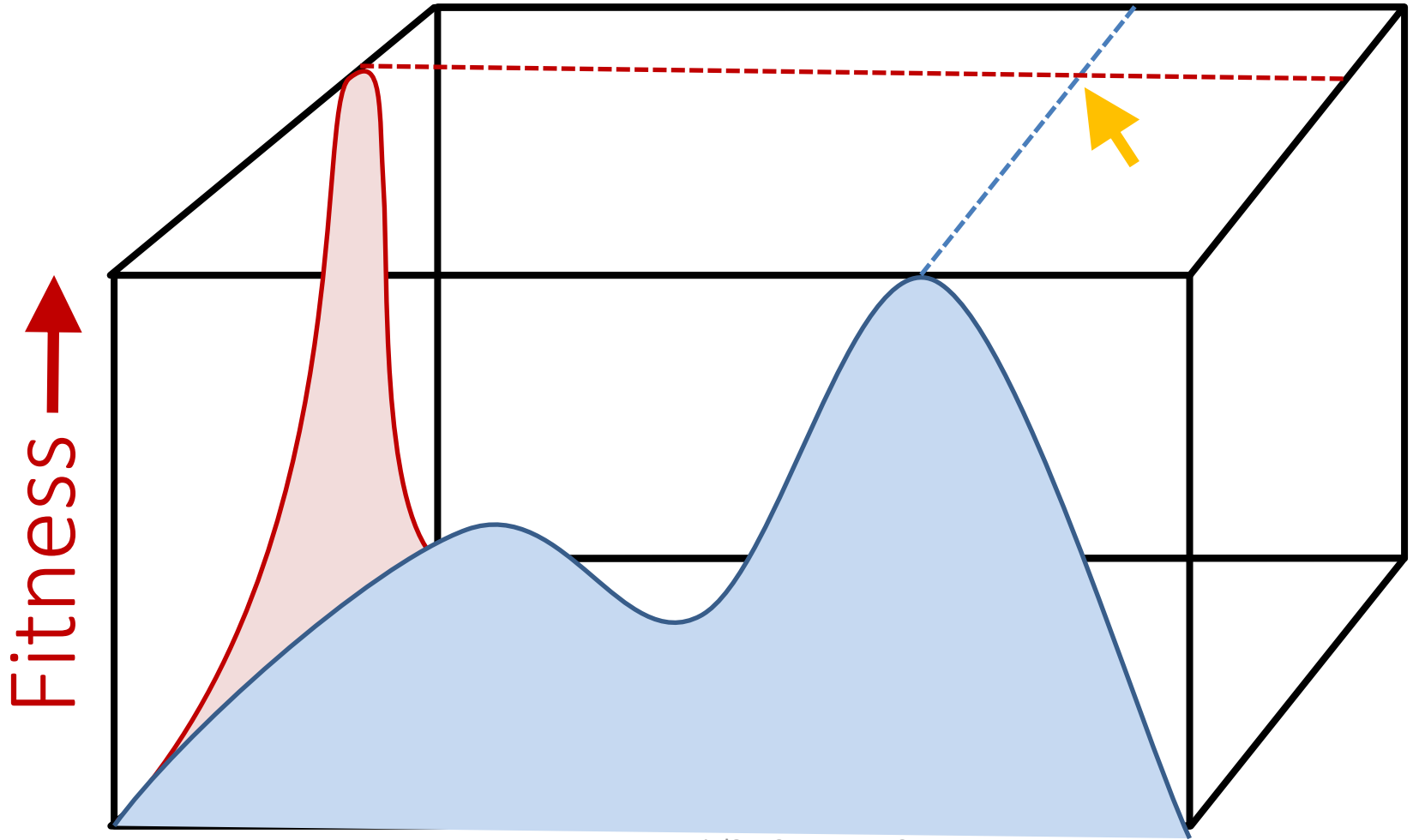


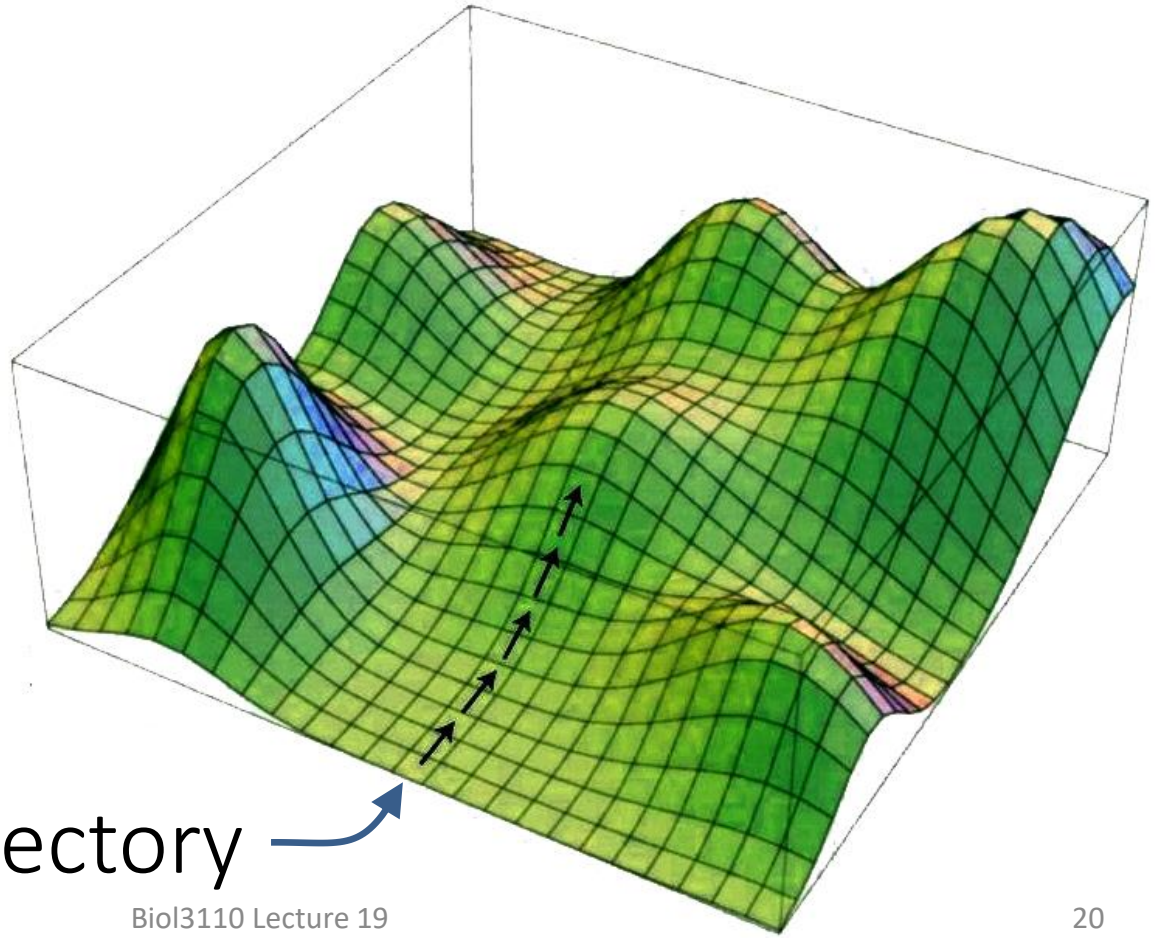
“Fitness landscape” concept

If we think of how **multiple traits** relate to fitness:



“Fitness landscape” concept

Sewall Wright: Species evolve to localised adaptive “peaks” in an n-dimensional “landscape”



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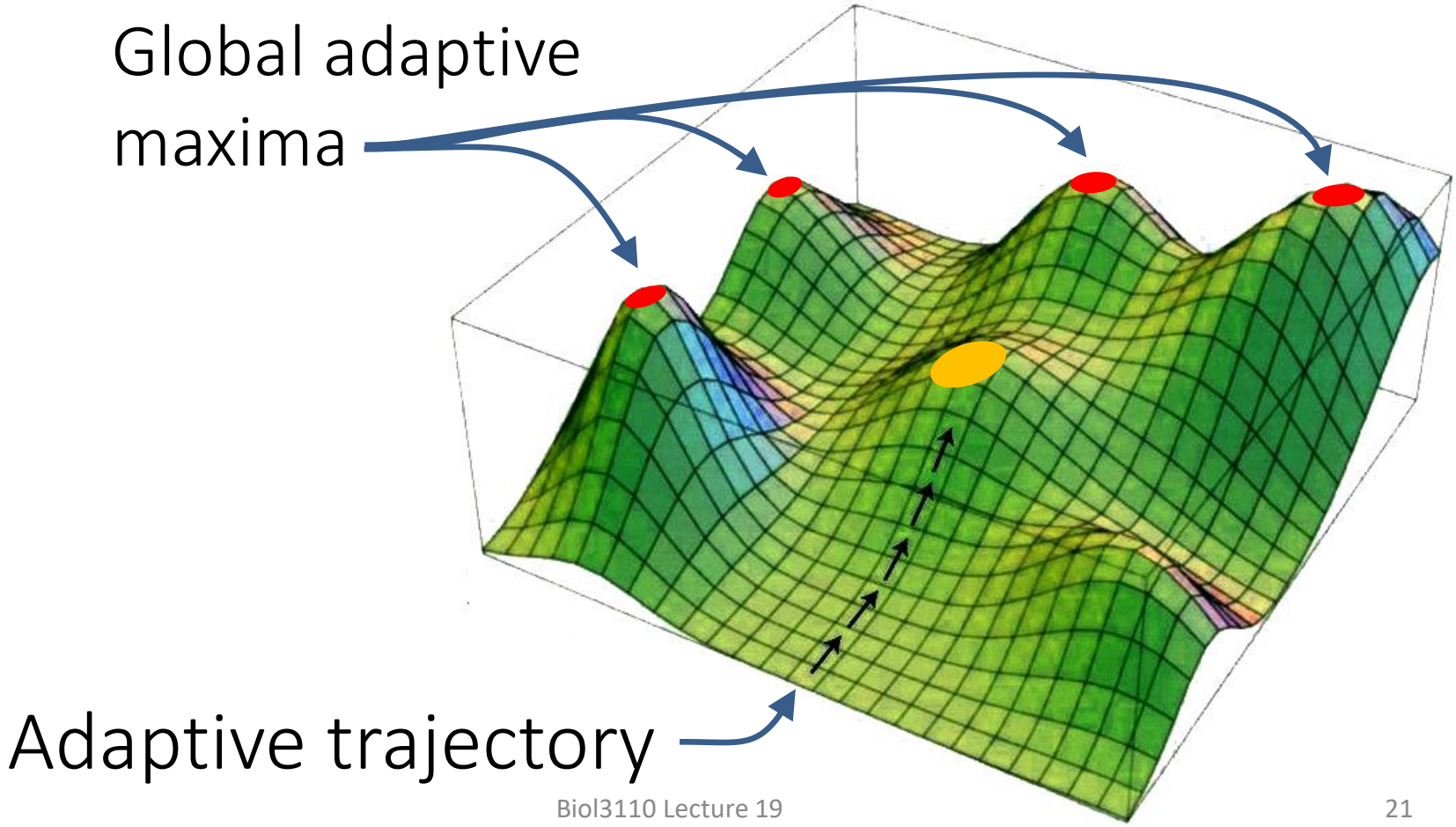
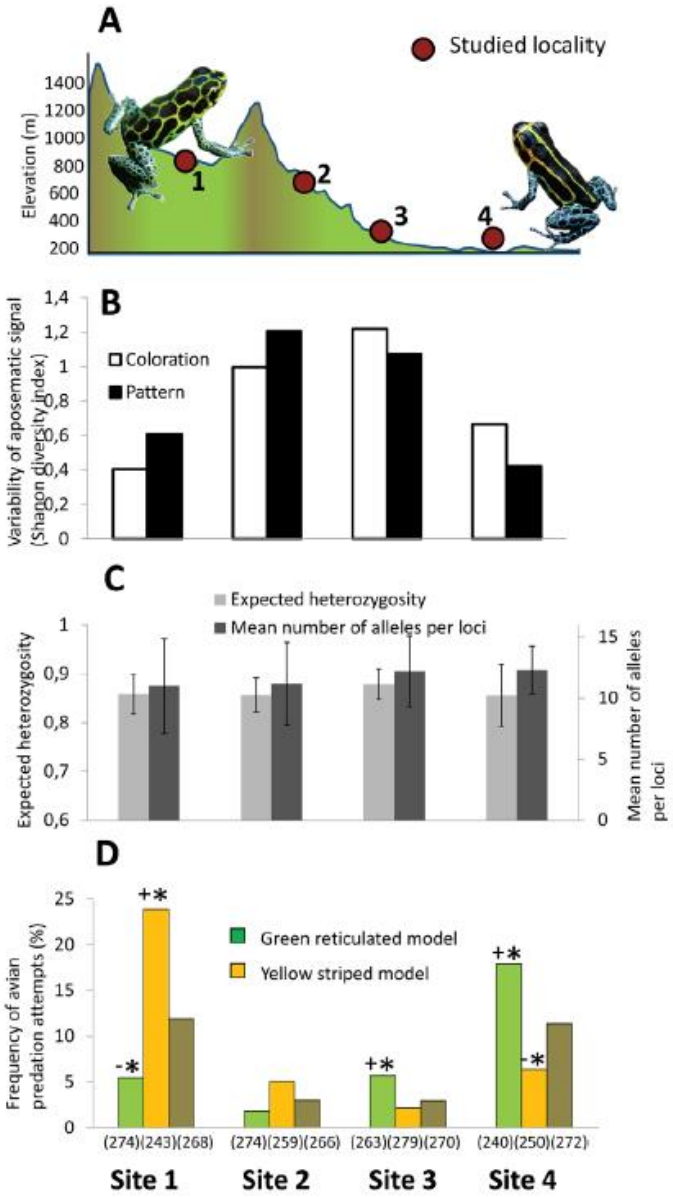


Choteau & Angers PloS One 2012

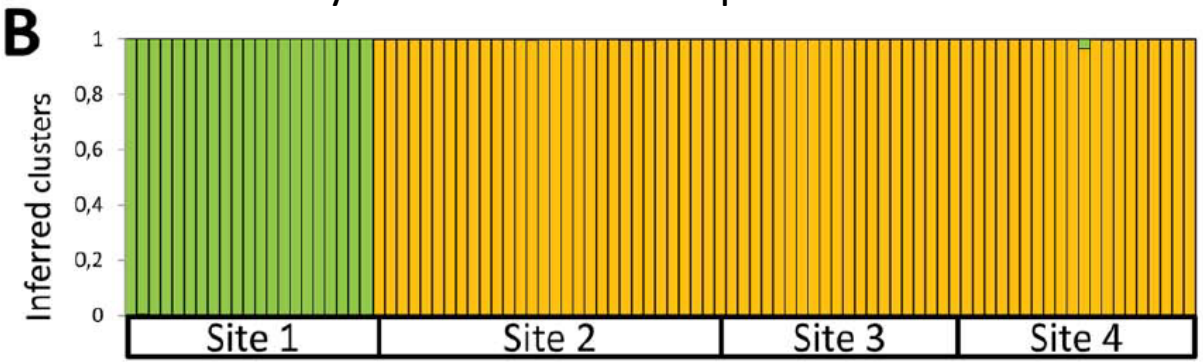


Wrights shifting balance theory – relaxation of selection + drift can allow for polymorphisms

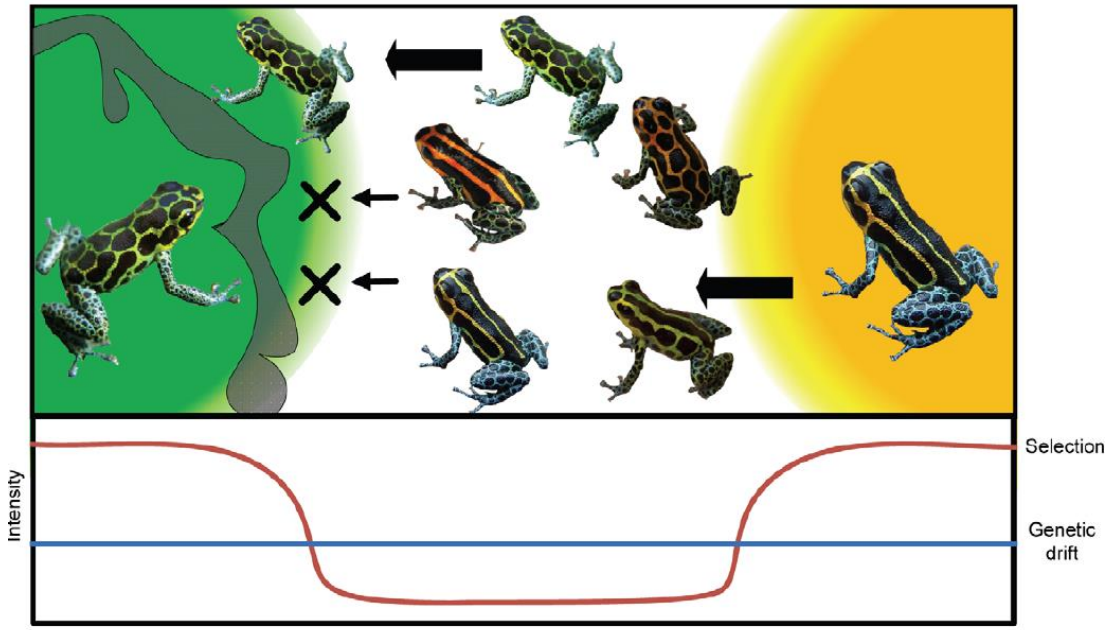
→ High variability sites 2 & 3

→ Low rates of predation sites 2 & 3

Hybridisation can't explain the variation



Wrights shifting balance theory – relaxation of selection + drift can allow for polymorphisms that then 'compete' across the fitness landscape



Next Lecture

Social influences on connectivity