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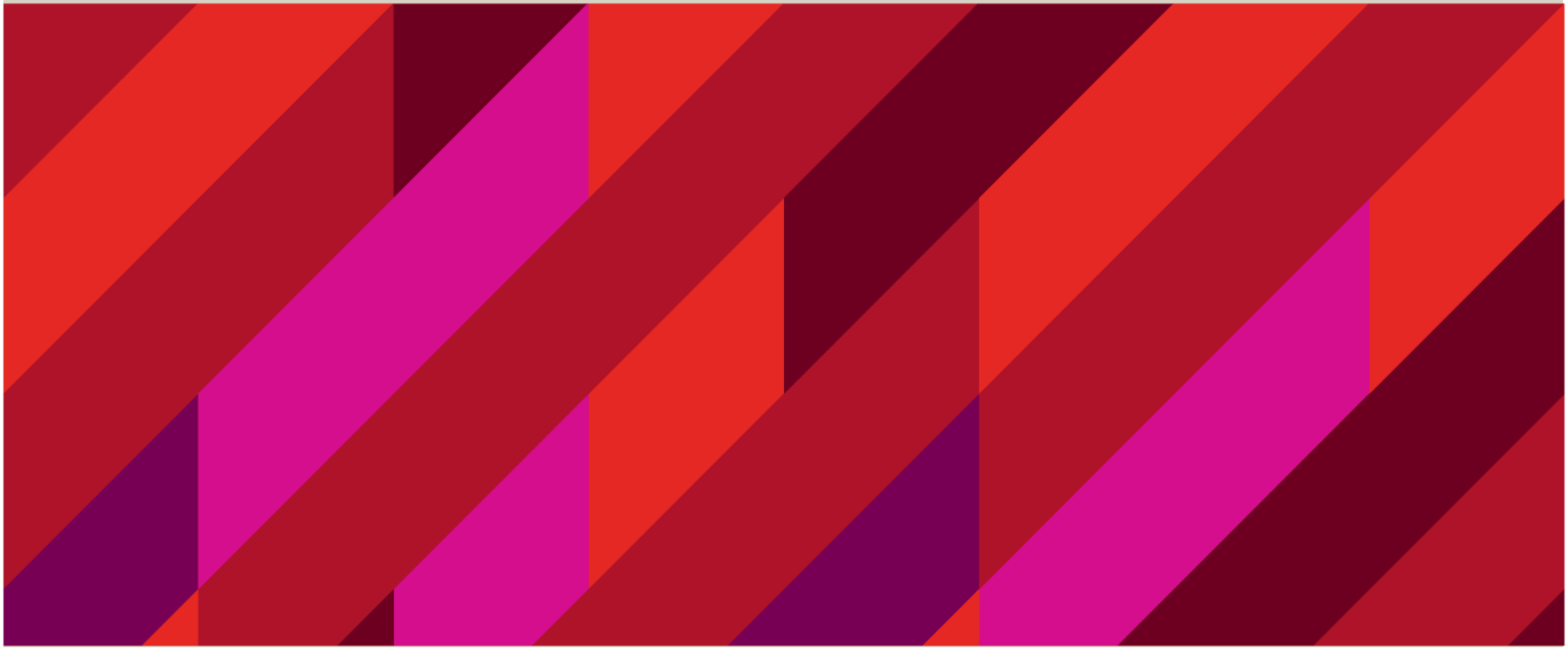
BIOL3110 Conservation & Ecological Genetics

LECTURE 8: MUTATION, MIGRATION & SELECTION



Mutation, Migration & Selection

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DEFINITIONS wrt GENETICS

Mutation: Copying errors – rare (beneficial mutations even rarer). Nevertheless, mutation is the core generator of $\mathbf{V_G}$ for Darwinian evolution.

Migration: among populations – brings new genes in or takes genes out.

Selection: Different forms of selection. Can either reduce or increase $\mathbf{V_G}$ under different circumstances.

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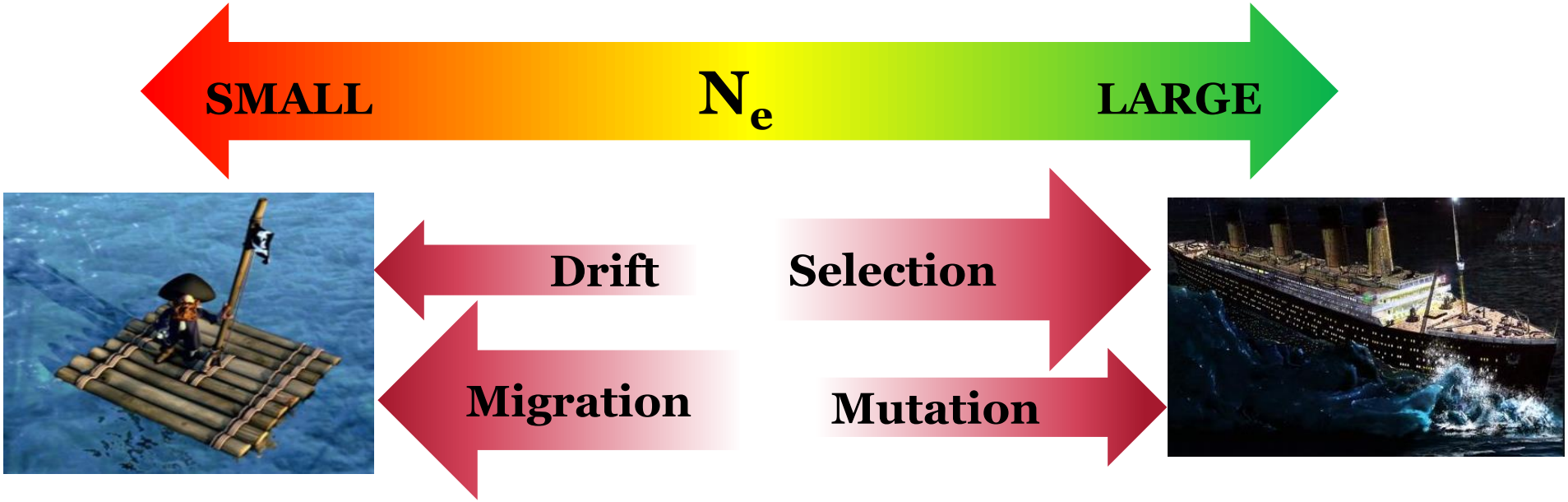
MORE DETAIL NEXT WEEK:

The critical importance of (effective) population size for these parameters.



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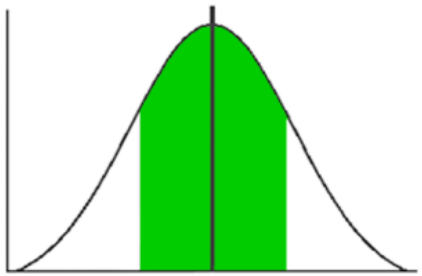
TYPES OF SELECTION (I)

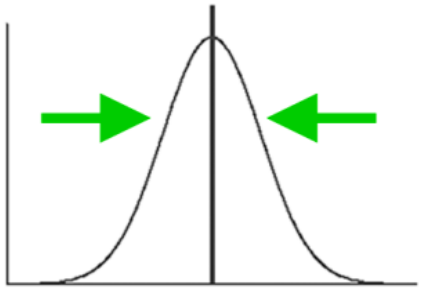
Favoured

Stabilizing

Before selection:



After selection:



Distribution of phenotypes in the population

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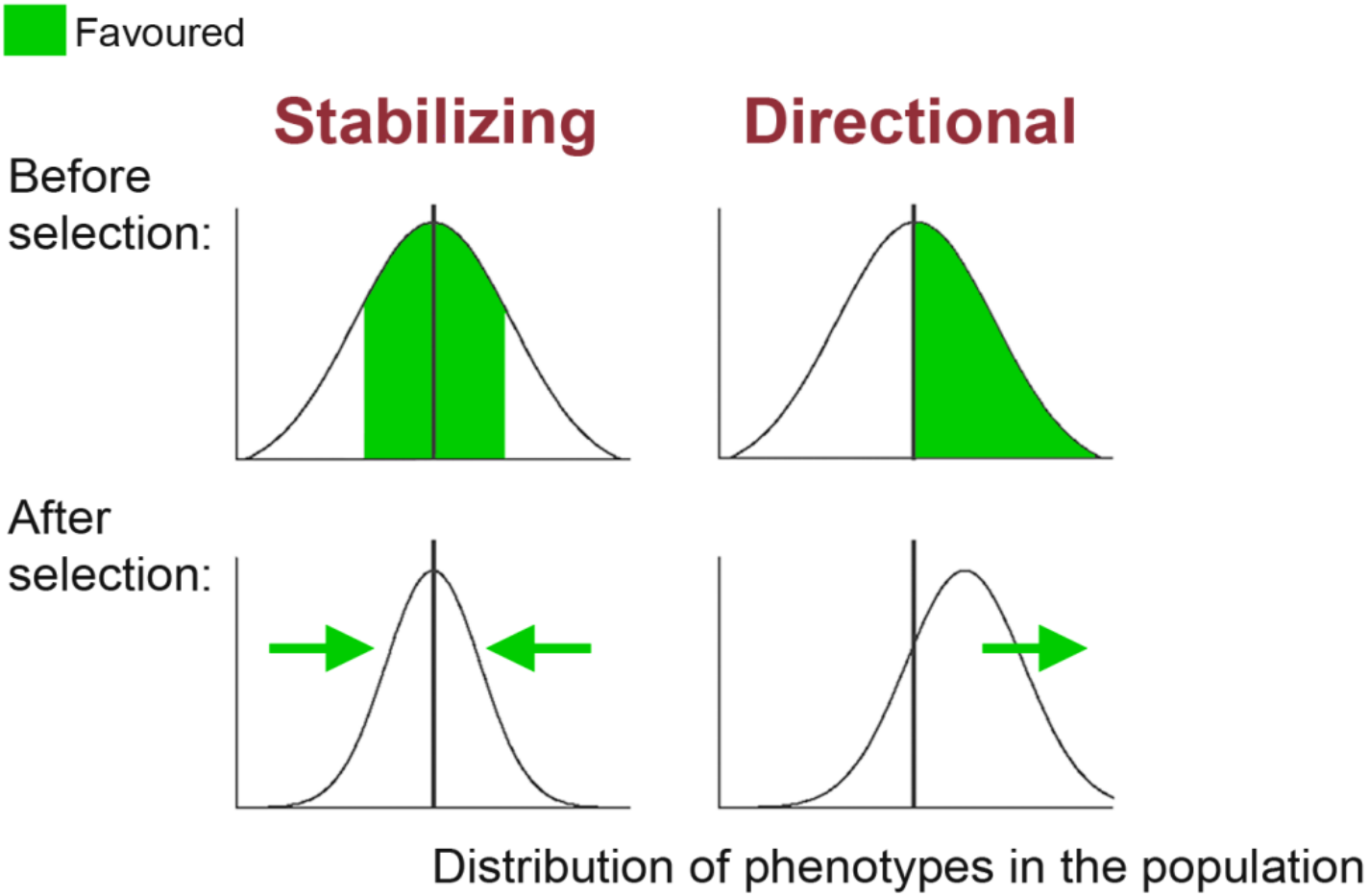
TYPES OF SELECTION (II)



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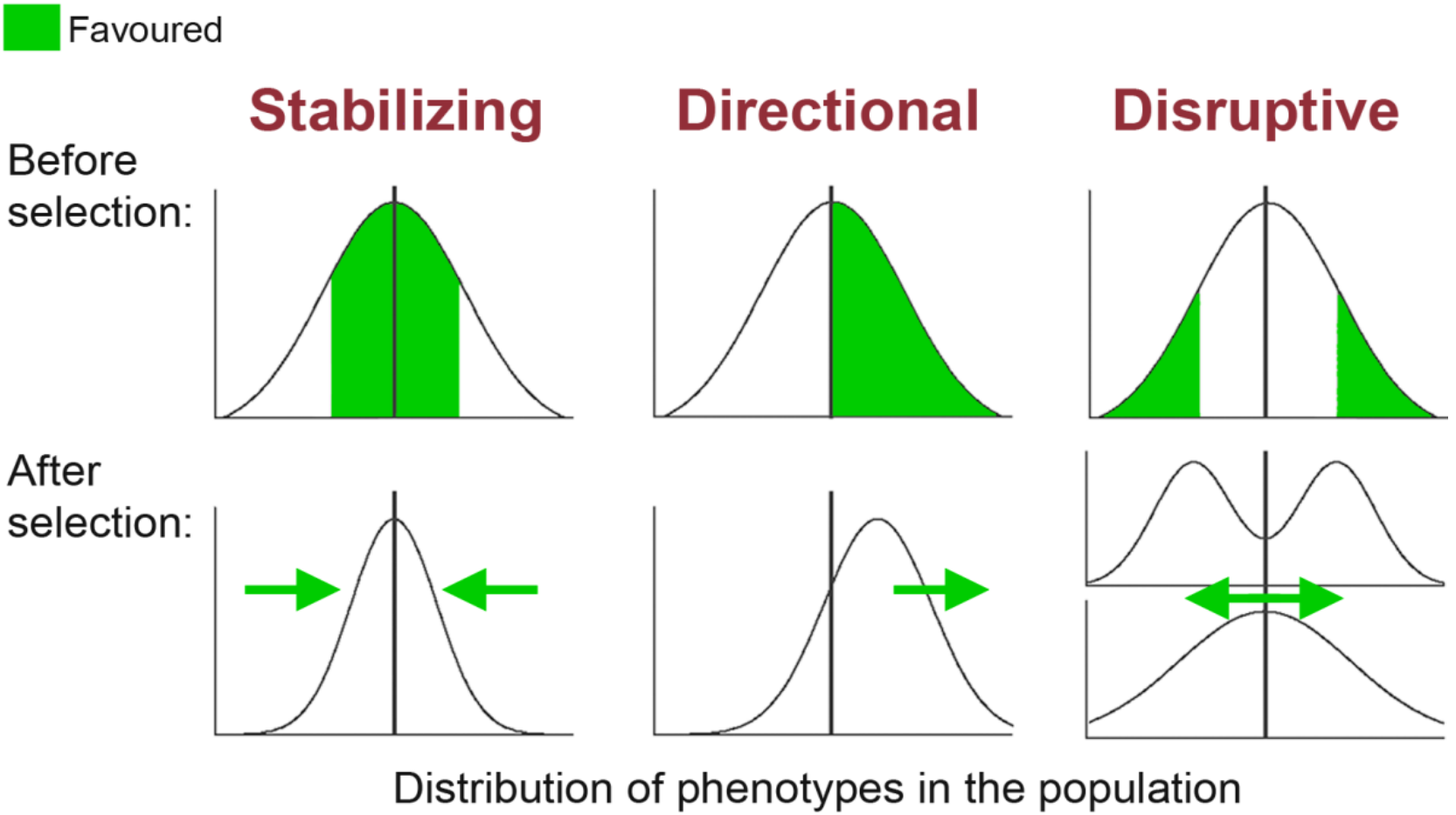
TYPES OF SELECTION (III)



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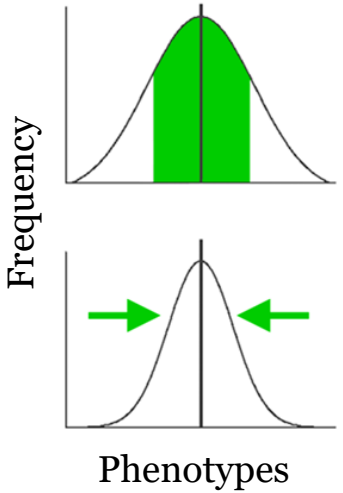
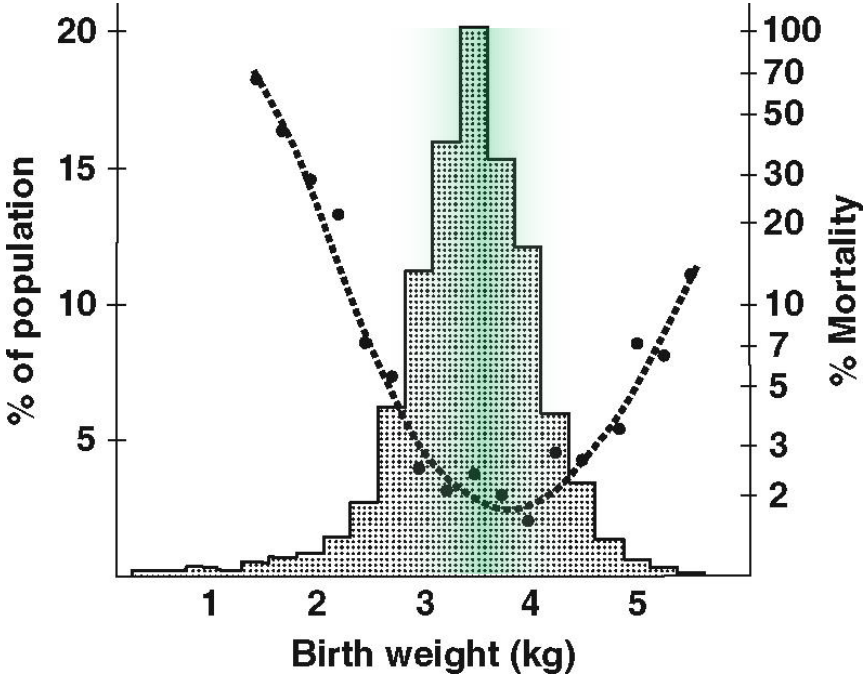
STABILIZING SELECTION

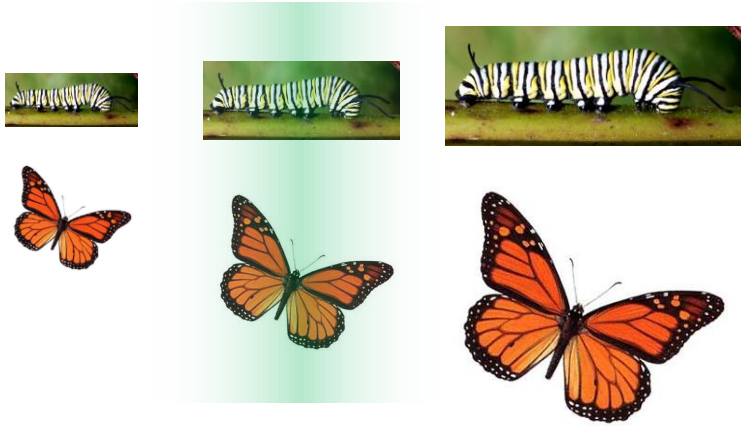
Fitness is under directional selection, BUT:

Most individual traits in wild populations are subject to **NET stabilizing selection**.





E.g. Birth weight in humans



E.g. Size at maturity in insects

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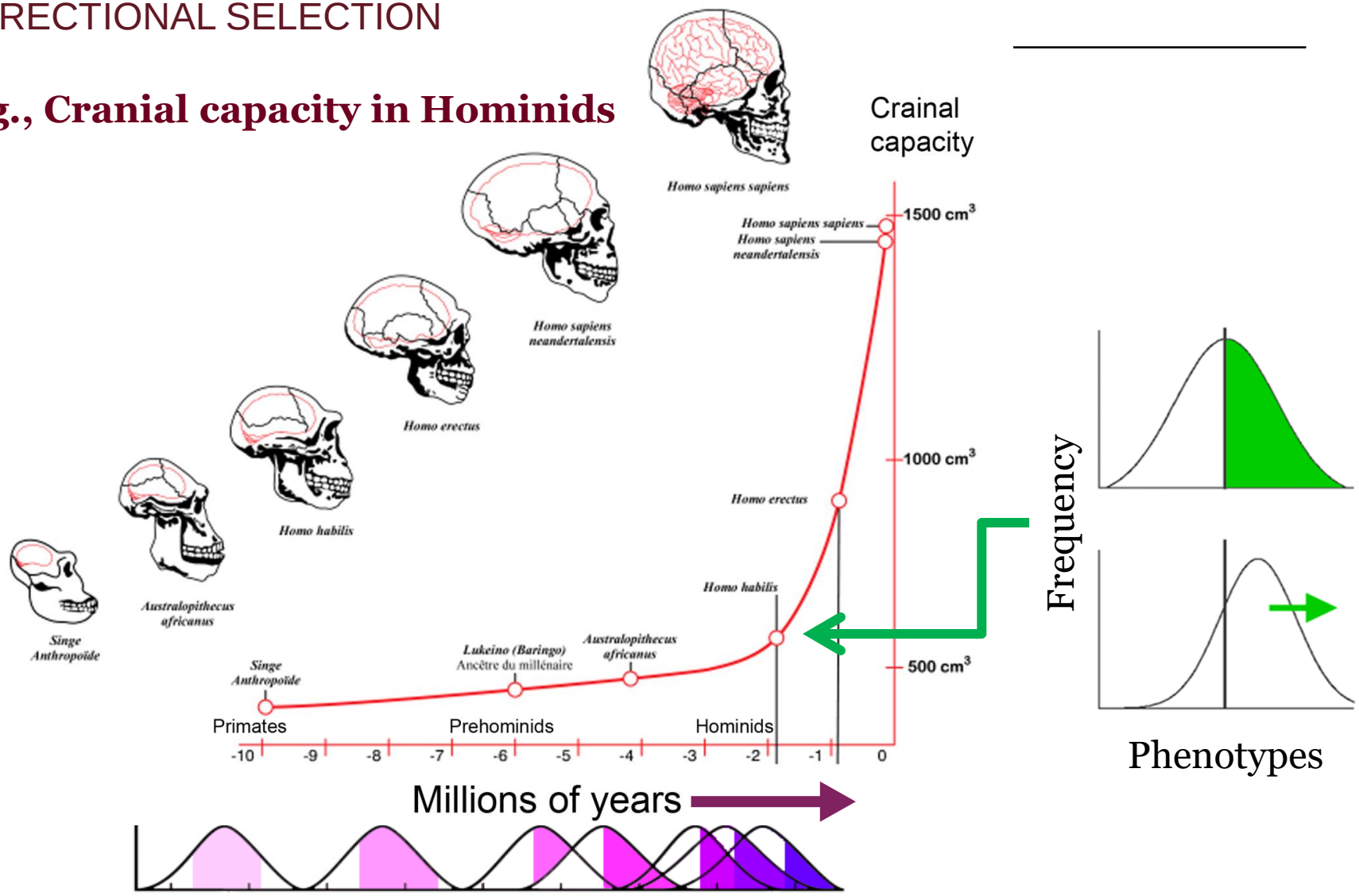
DIRECTIONAL SELECTION

E.g., Cranial capacity in Hominids



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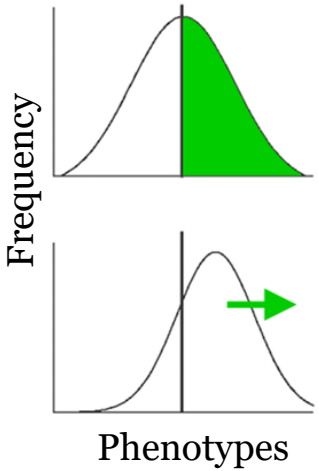
DIRECTIONAL SELECTION

E.g. Sexual selection



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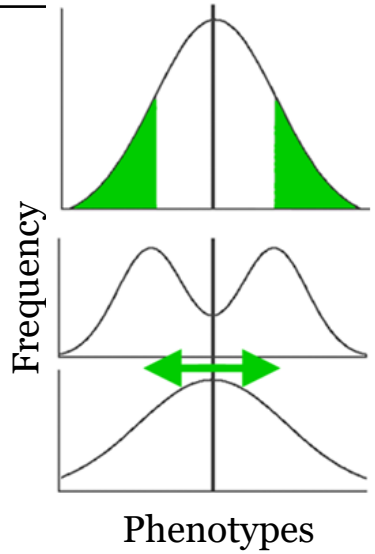
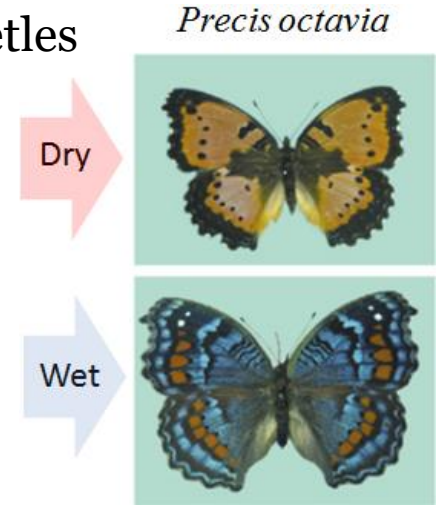
DISRUPTIVE SELECTION

Often maintains V_G. May also favour di-morphism or poly-morphism or phenotypic plasticity.

Sexual dimorphism (e.g. *Eclectus*)

E.g. Dimorphism in Rhino beetles





E.g. Plastic wing color in butterflies

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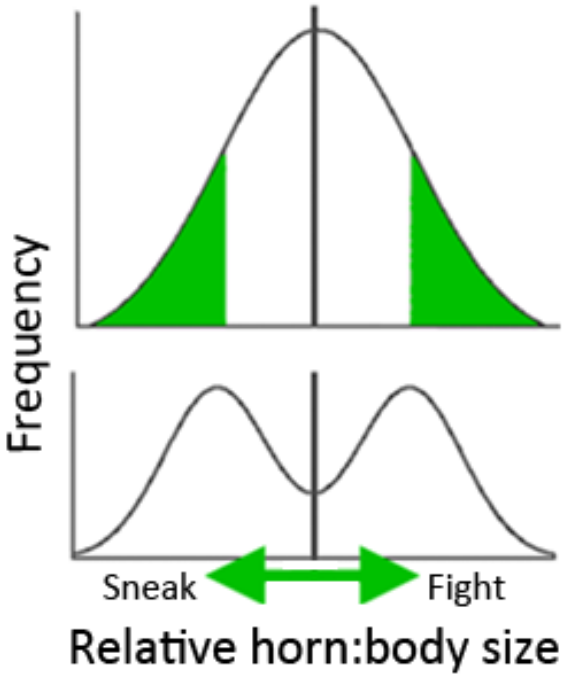
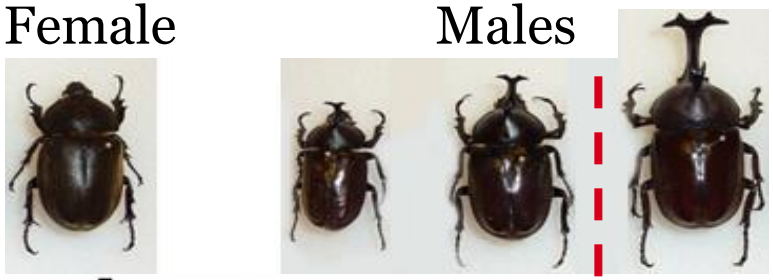
DISRUPTIVE SELECTION

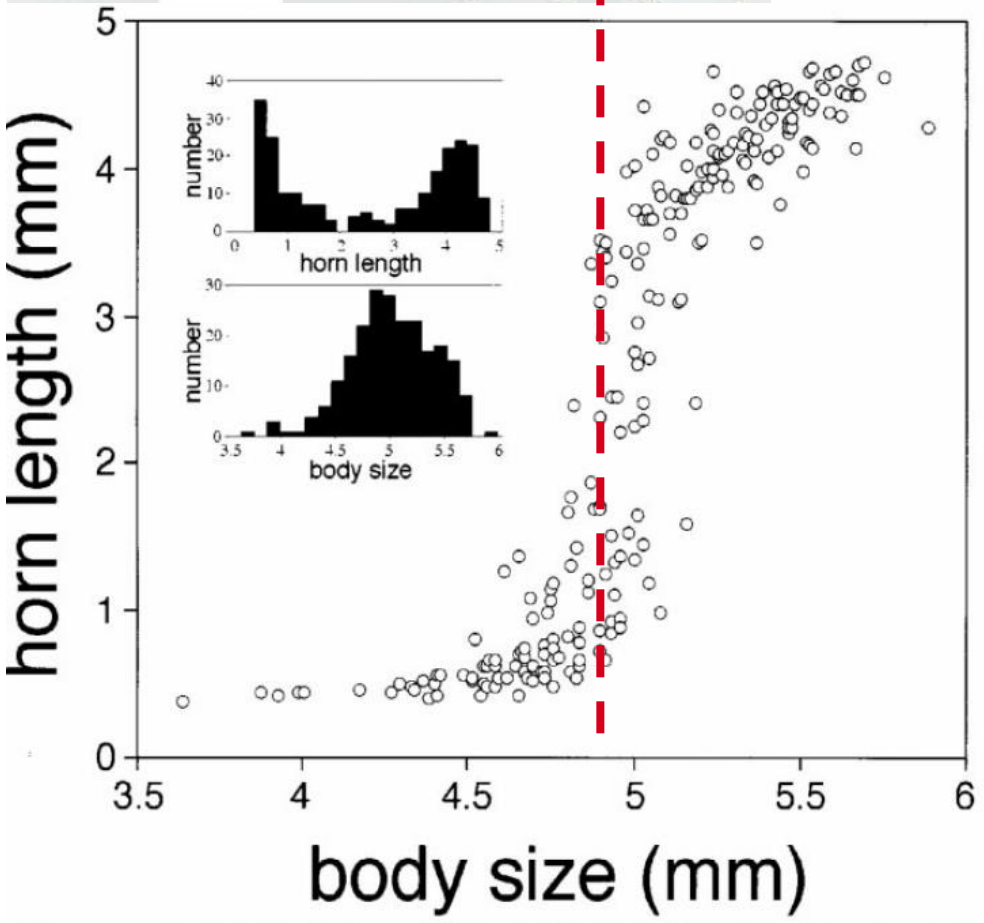
Example:
Horn polyphenism in male
Onthophagus taurus



Female

Males





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MIGRATION

In whole populations:

Among-populations:

Inter-pop migration = **gene flow**

20 individuals contain 95% of V_G

Little gene flow needed to maintain substantial V_G

Higher levels required to maintain rare alleles

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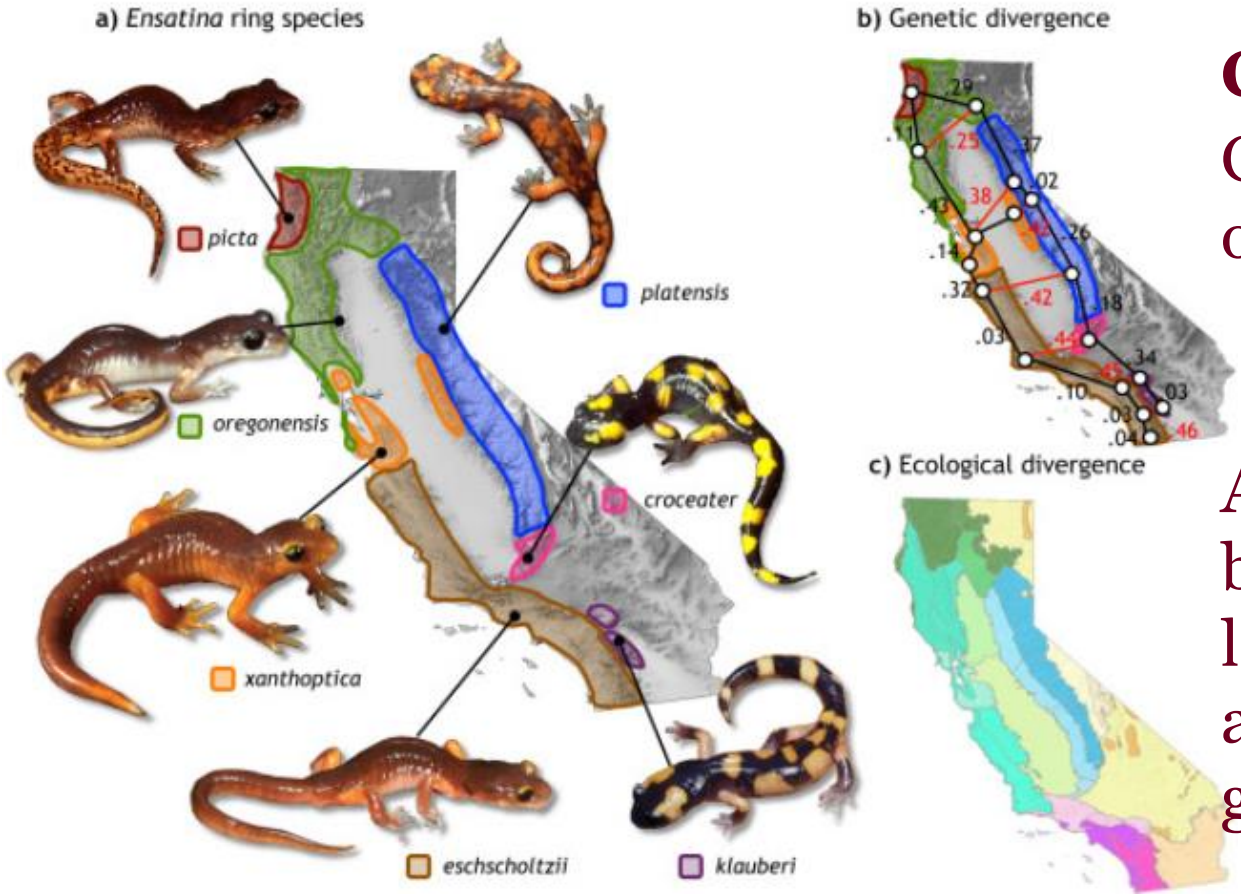
MIGRATION versus SELECTION



Cline:
Geographic gradient of phenotypes

Arises as the balance between selection for localized adaptation and/or drift versus gene flow

e.g. *Ensatina* salamander "ring species" in California

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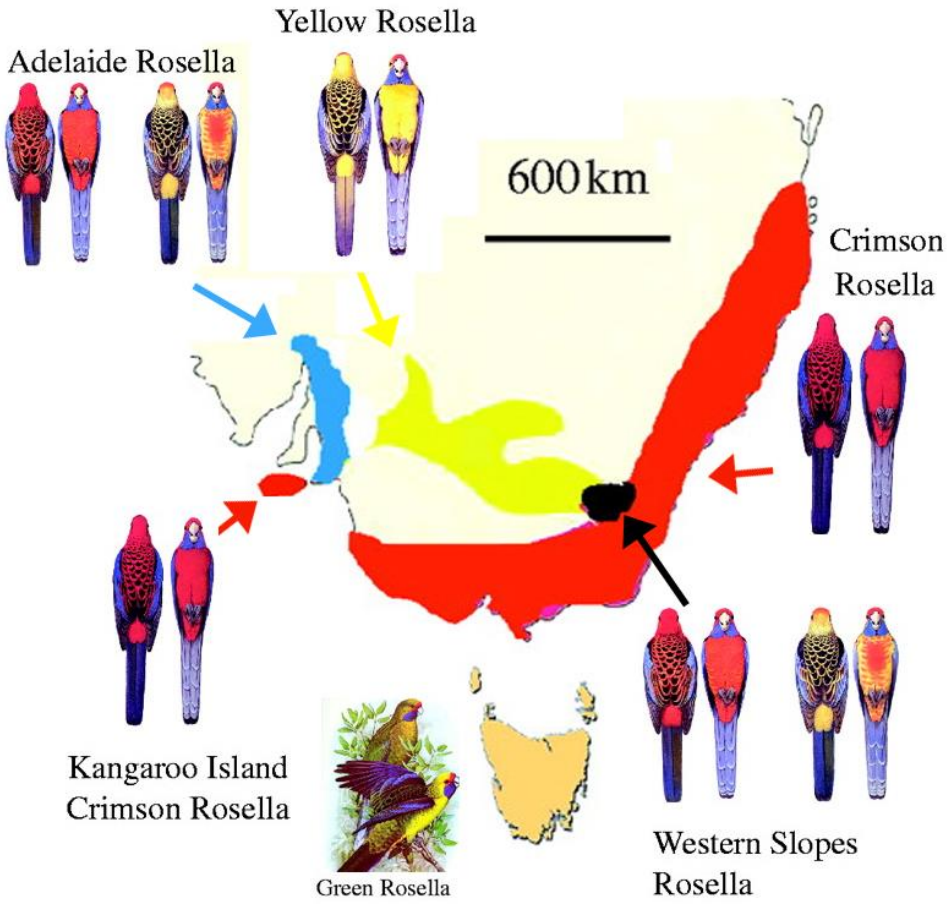
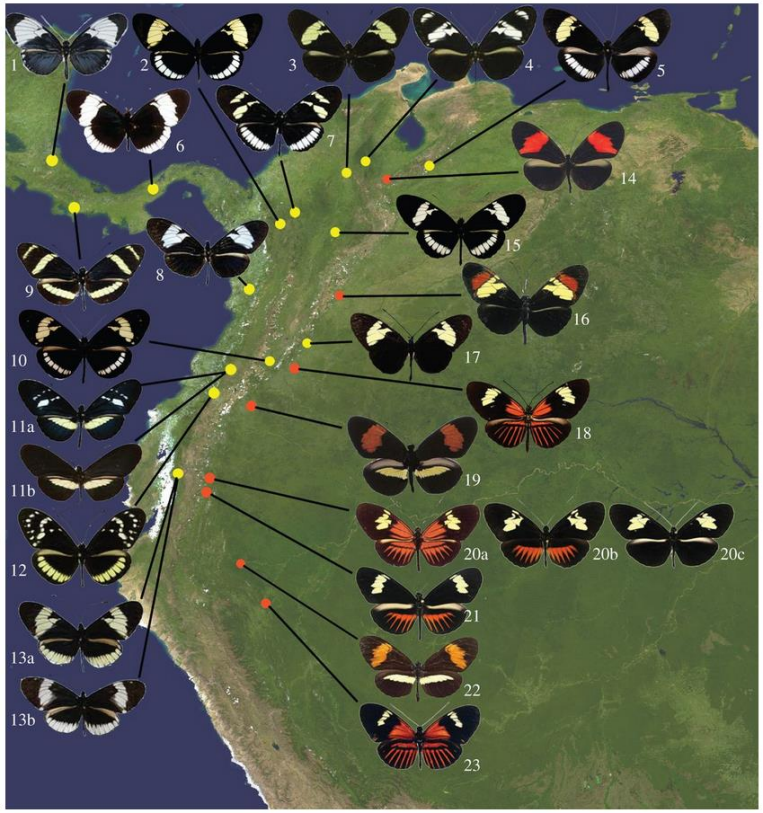
MIGRATION versus SELECTION



Platycercus elegans
Joseph *et al.* (2008) Proc. R. Soc. Lond. (B)



Heliconius cydno
Brower (2012) *Proc. R. Soc. Lond. (B)*

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MUTATION

Copying errors in germ-line replication

At the genomic level:

- Single-Nucleotide Polymorphisms (**SNPs**)
- Additions, deletions & duplications (e.g., microsats)
- Insertion of transposable or "mobile" elements

Rates of point mutation:

1 mutation per locus per 100,000 gametes per generation

= **10 mutations/individual** (typical eukaryote ~1M loci)

Mutation among microsatellites **~10x higher rate**

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MUTATION

Rates of point mutation (1 mutation/locus/100,000 gametes/generation)

Corroboree frog:

250 individuals

16-40 eggs per clutch

250 x 1M loci = 250,000,000 loci

125 pairs x 40 gametes = 5,000 gametes

1 generation per year

= 50,000 (**5 x 10^4**) mutations per year

Bufo marinus:

200,000,000 individuals

30,000 eggs per clutch

2 x 10^{14} loci

3 x 10^{12} gametes

~4 clutches per year

= 1 x 10^{14} mutations per year

A spatial analogy:

$3m^2$ versus:

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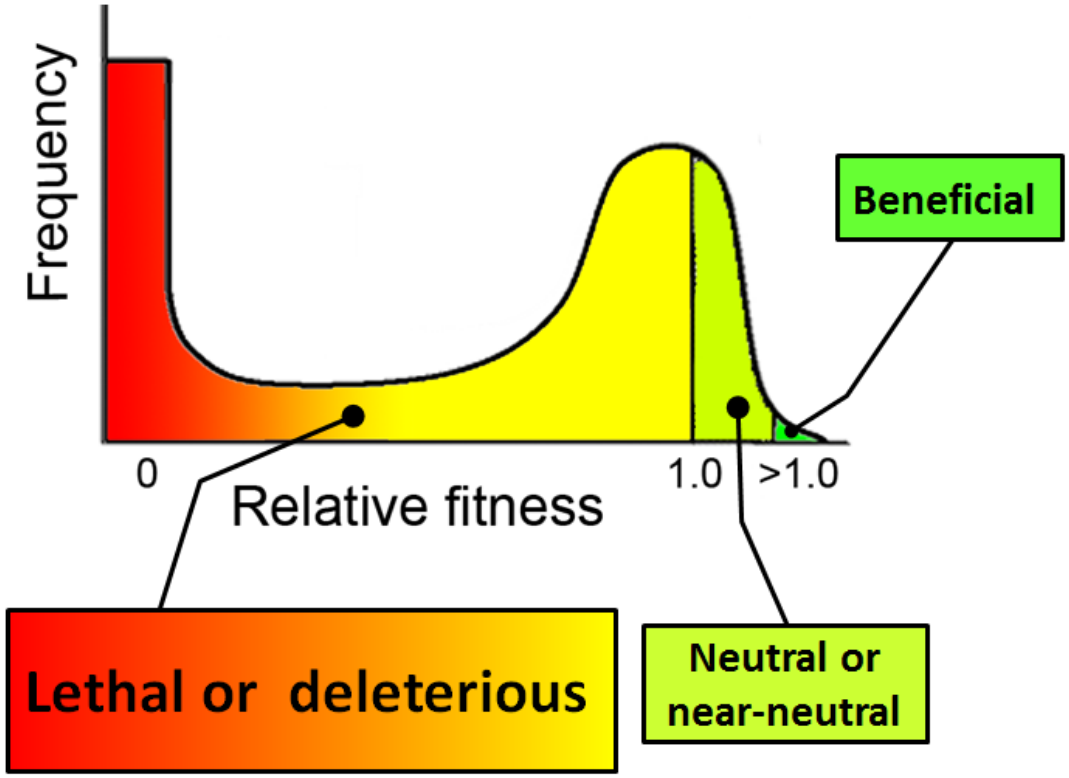
MUTATION

Generates $\mathbf{V_G}$ in the long term

Most mutations deleterious

Eliminated quickly by selection **unless recessive**…



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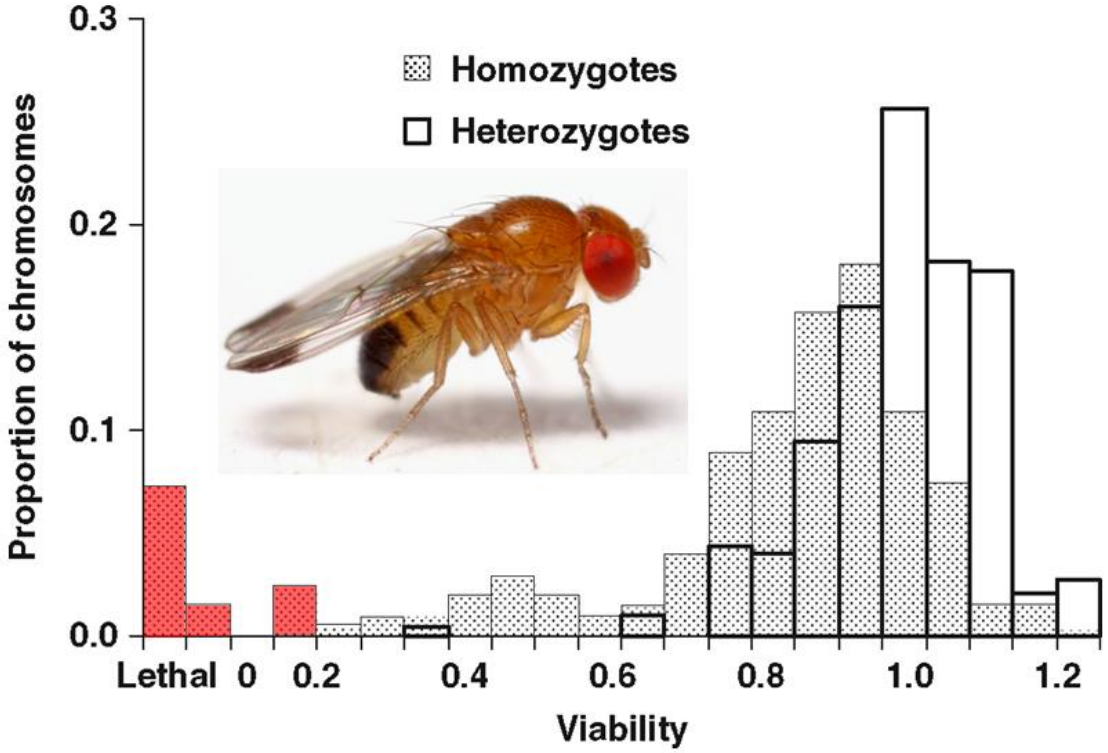
MUTATIONAL LOAD

1. Low frequency (<1% per locus) of deleterious mutations
2. Exist as recessives (rarely exposed)
3. Thought to occur in most species & loci

Sum for population called "Mutational load"

Fitness effects experimentally revealed using inbred lines (=increased homozygotes):



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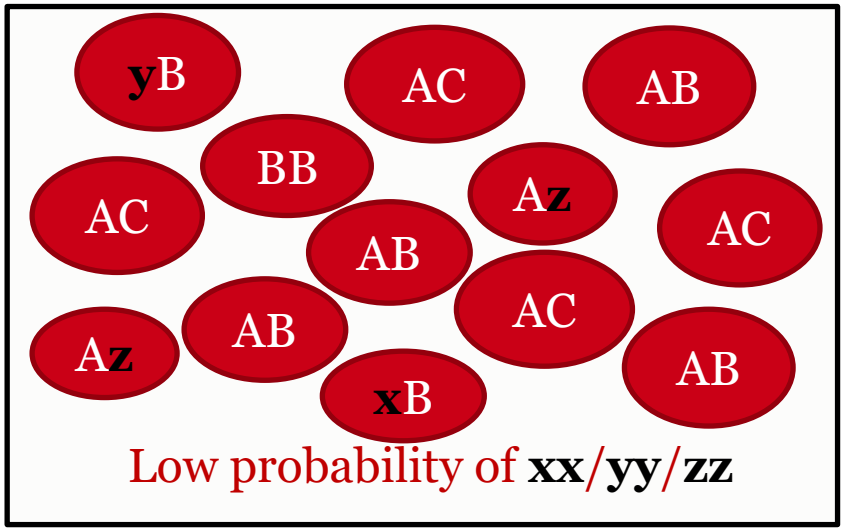
MUTATIONAL LOAD

Mutational load is increasingly revealed as populations become smaller

Via the increased chance of deleterious recessives pairing together, and being expressed

This is the mechanism of inbreeding depression



Size reduction

Paris et al. 2022 Nat com

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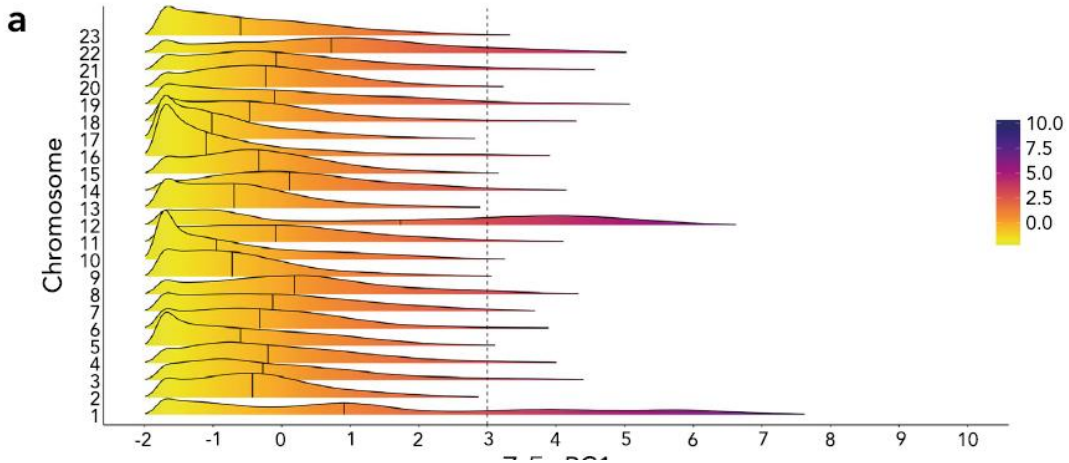
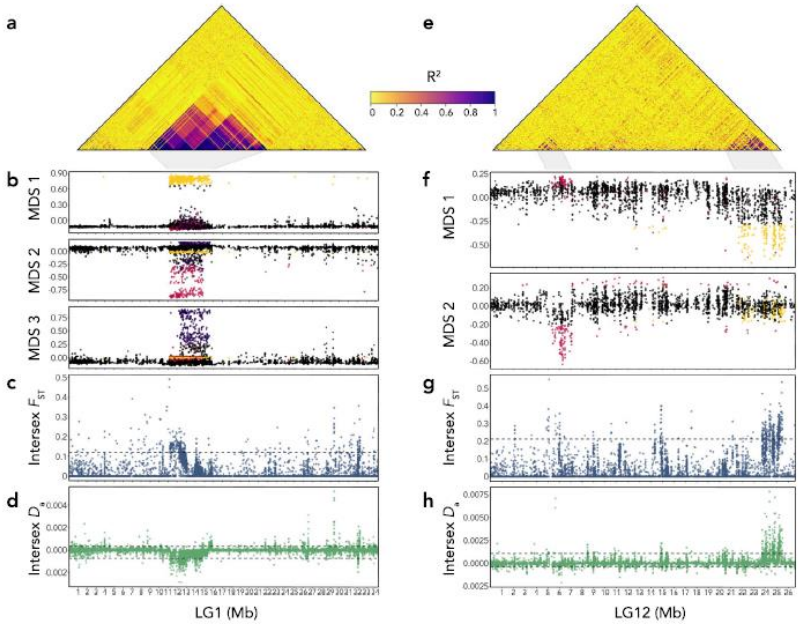
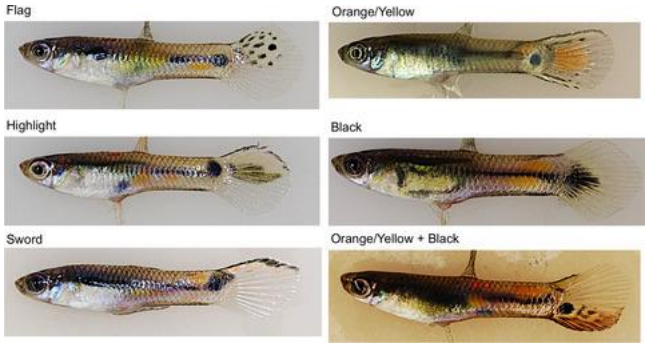
Chromosome 1 (autosome) and 12 (Y chromosome) sig differentiated – cr 1 more so





Trinidadian guppy –
males colorful – 4 'Iso Y lines'
True breeding 40 gen



Differentiation (cr 1 & 12) associated with regions of low recombination – physical linkage – except for intersex comparisons

Epistasis between 1 & 12 – increases diversity & shields Y region diversity from drift

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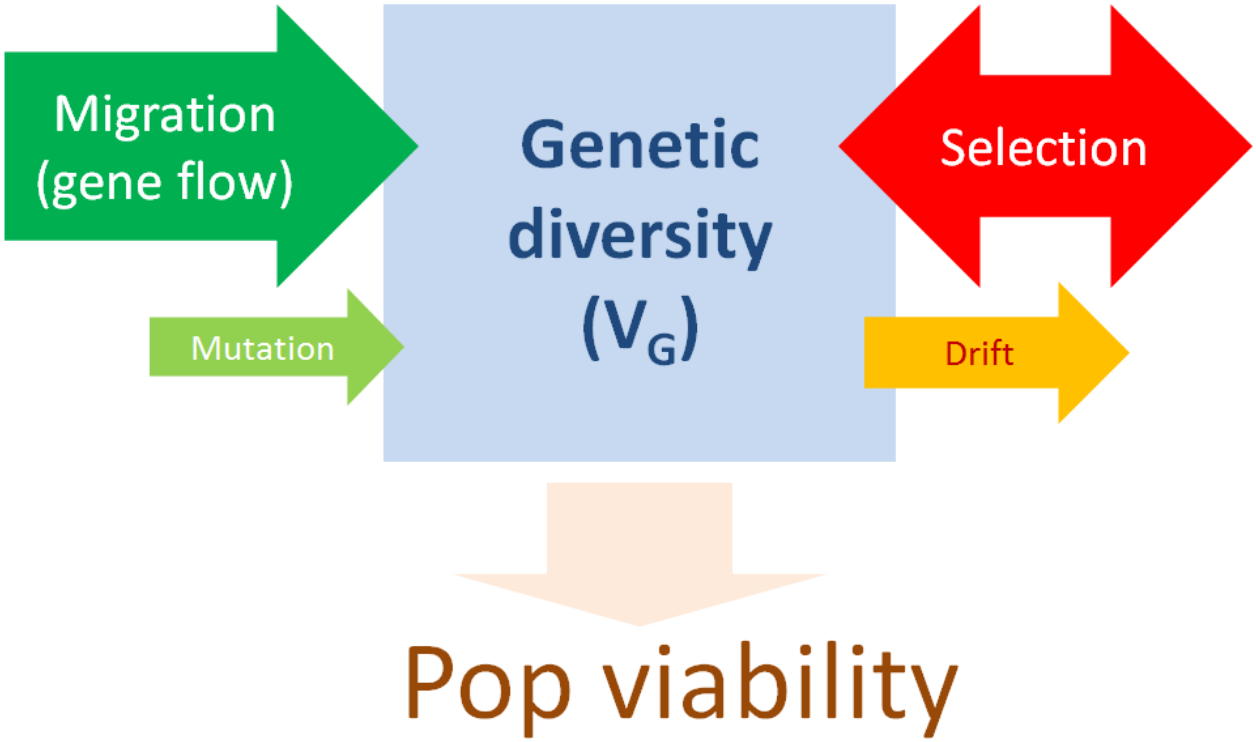
MORE ON THIS NEXT WEEK…

V_G is a **balance** between selection, drift, migration & mutation;



Increasingly **stable** with increasing N.

Long-term accumulated negative mutations revealed by small N.