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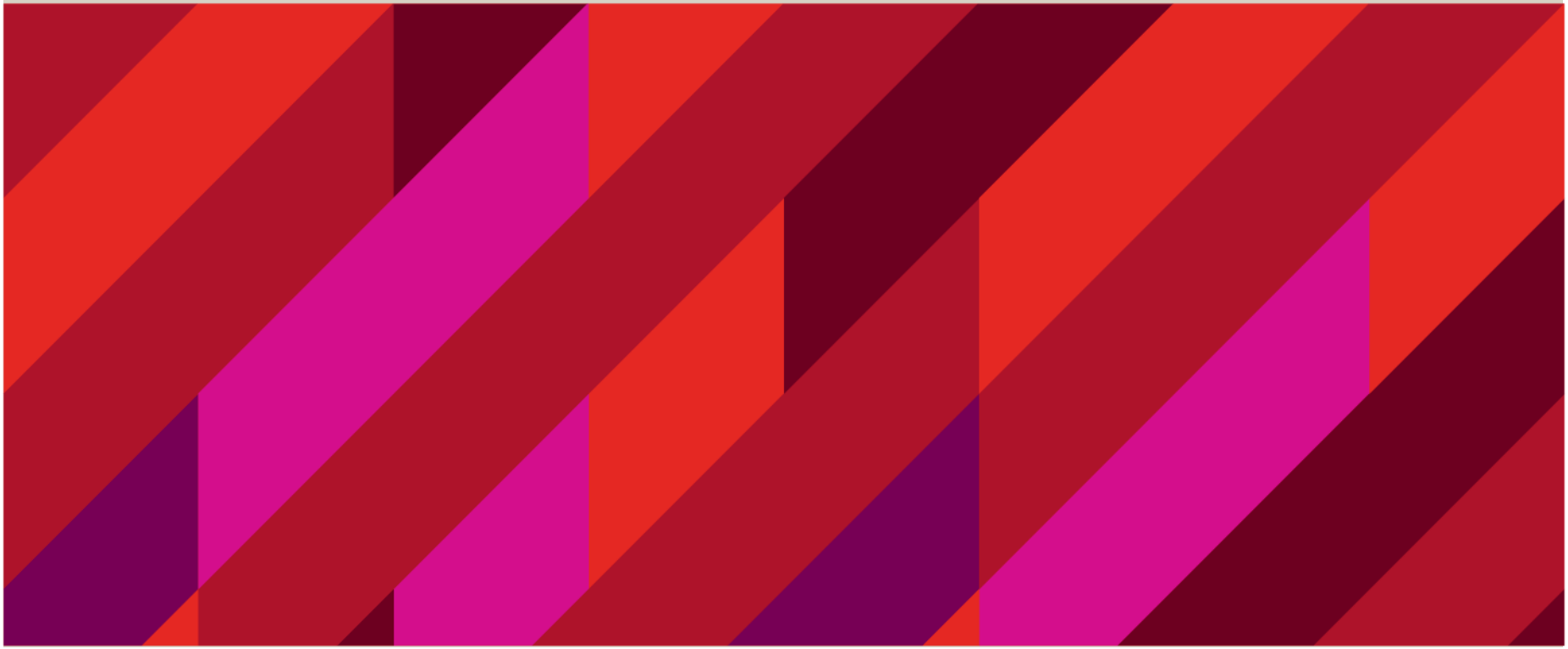
# BIOL3110 Conservation & Ecological Genetics

## 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.

# Mutation, Migration & Selection

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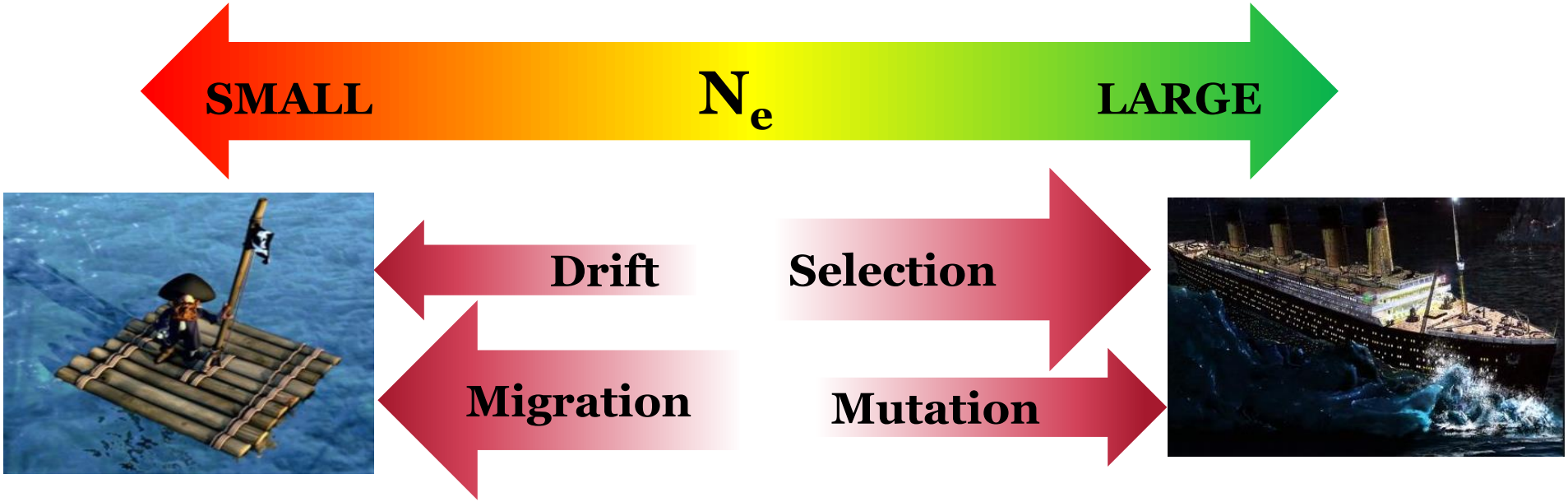
MORE DETAIL NEXT WEEK:

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



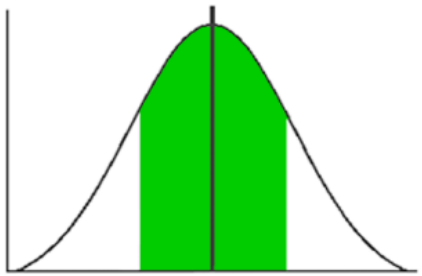
# Mutation, Migration & Selection

## TYPES OF SELECTION (I)

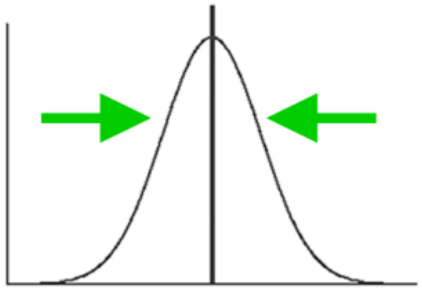
Favoured

### Stabilizing

Before selection:



After selection:



Distribution of phenotypes in the population

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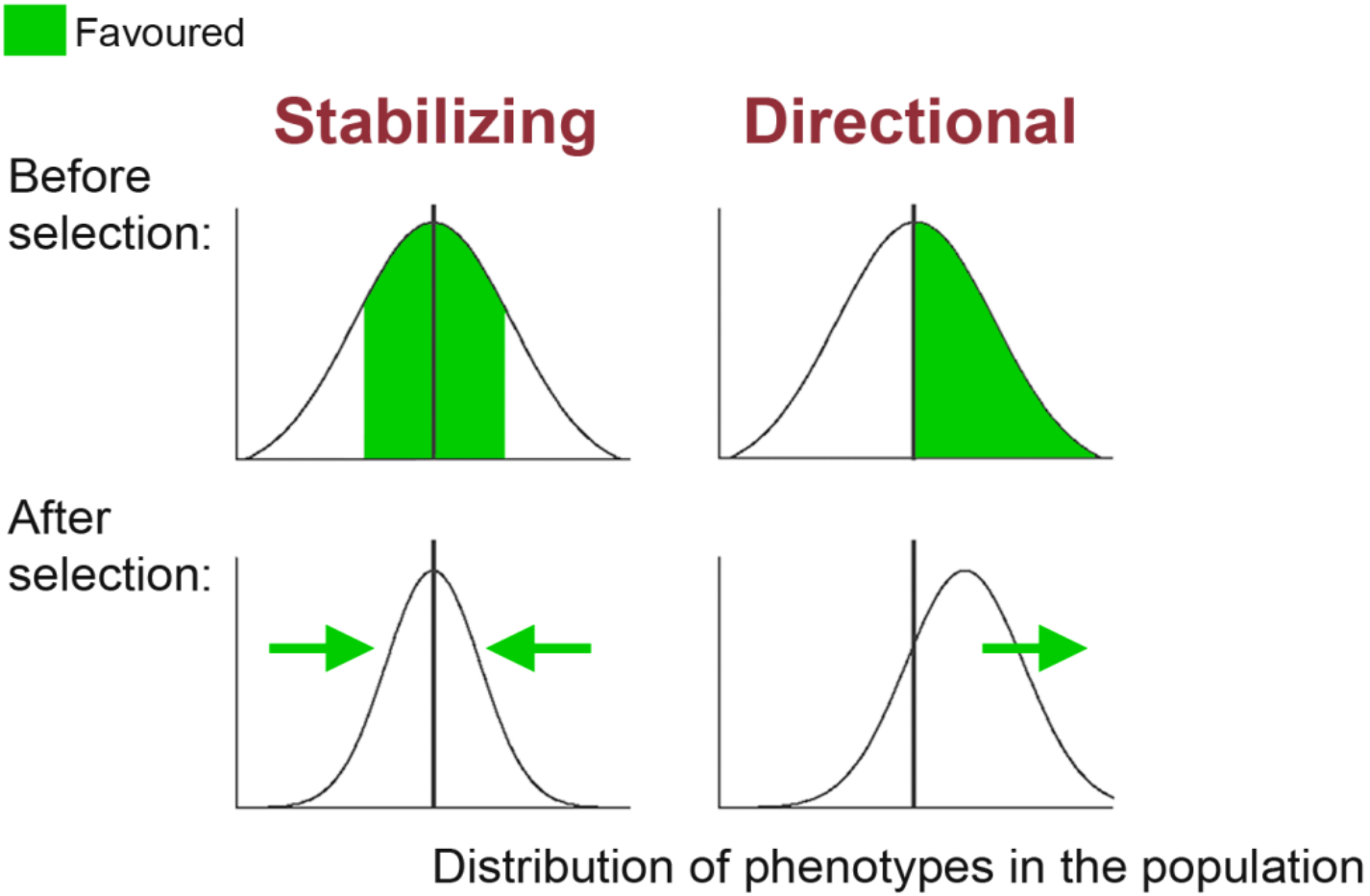
## TYPES OF SELECTION (II)



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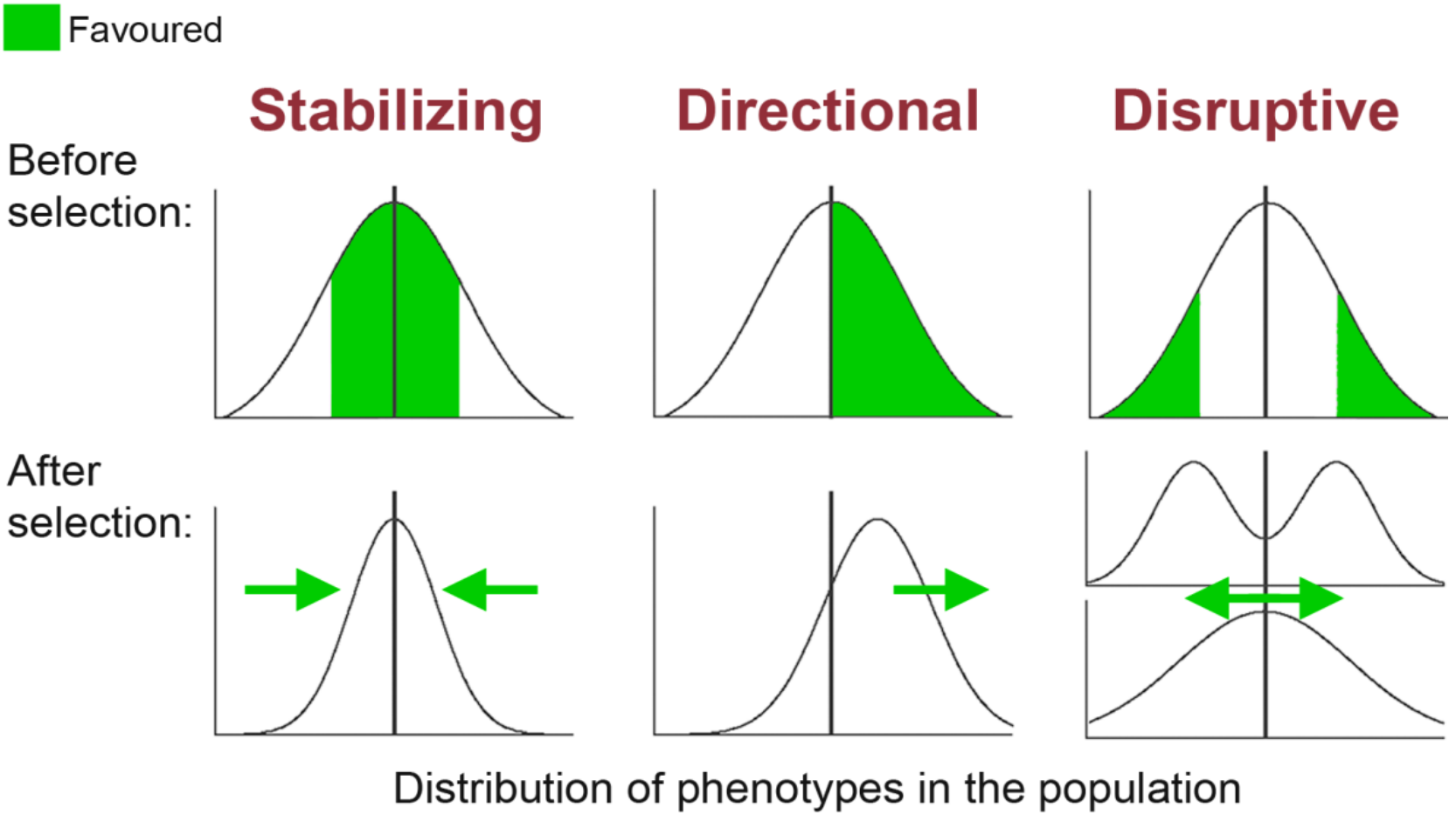
## TYPES OF SELECTION (III)



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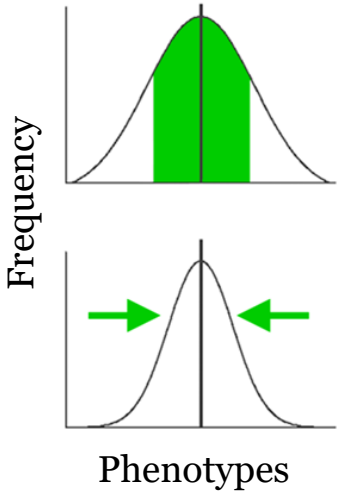
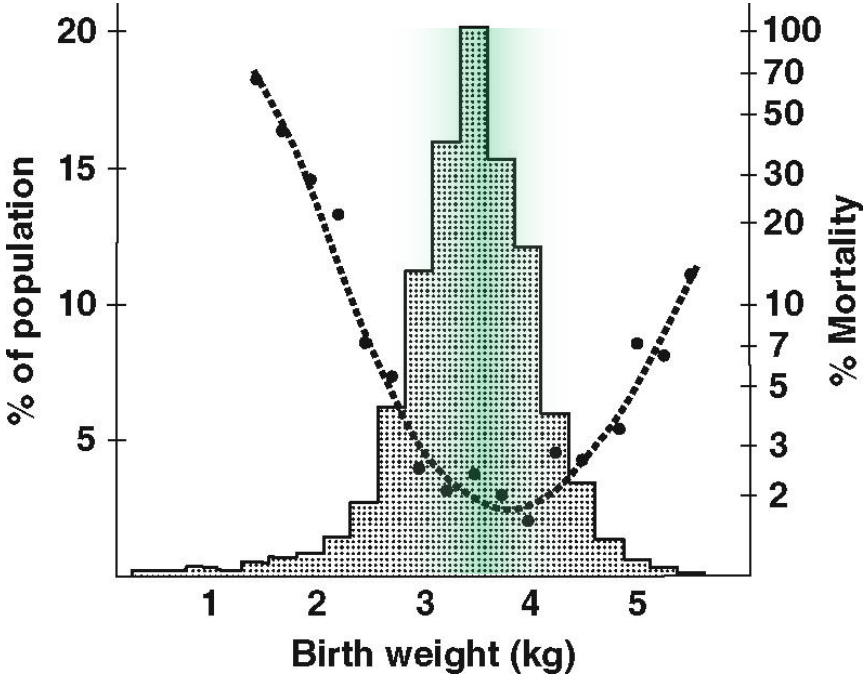
## STABILIZING SELECTION

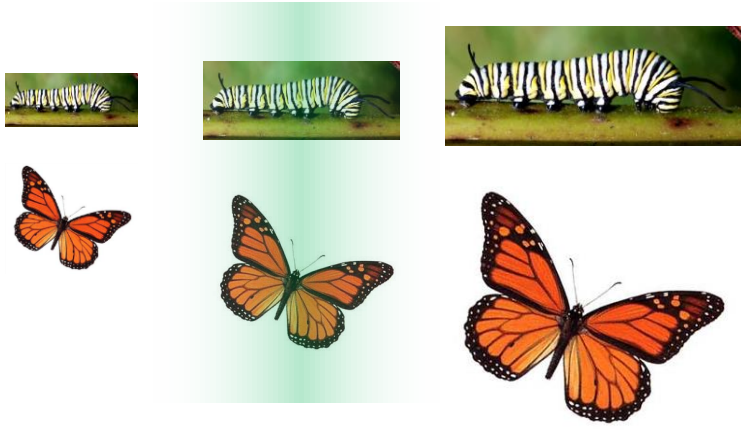
Fitness is under directional selection, BUT:

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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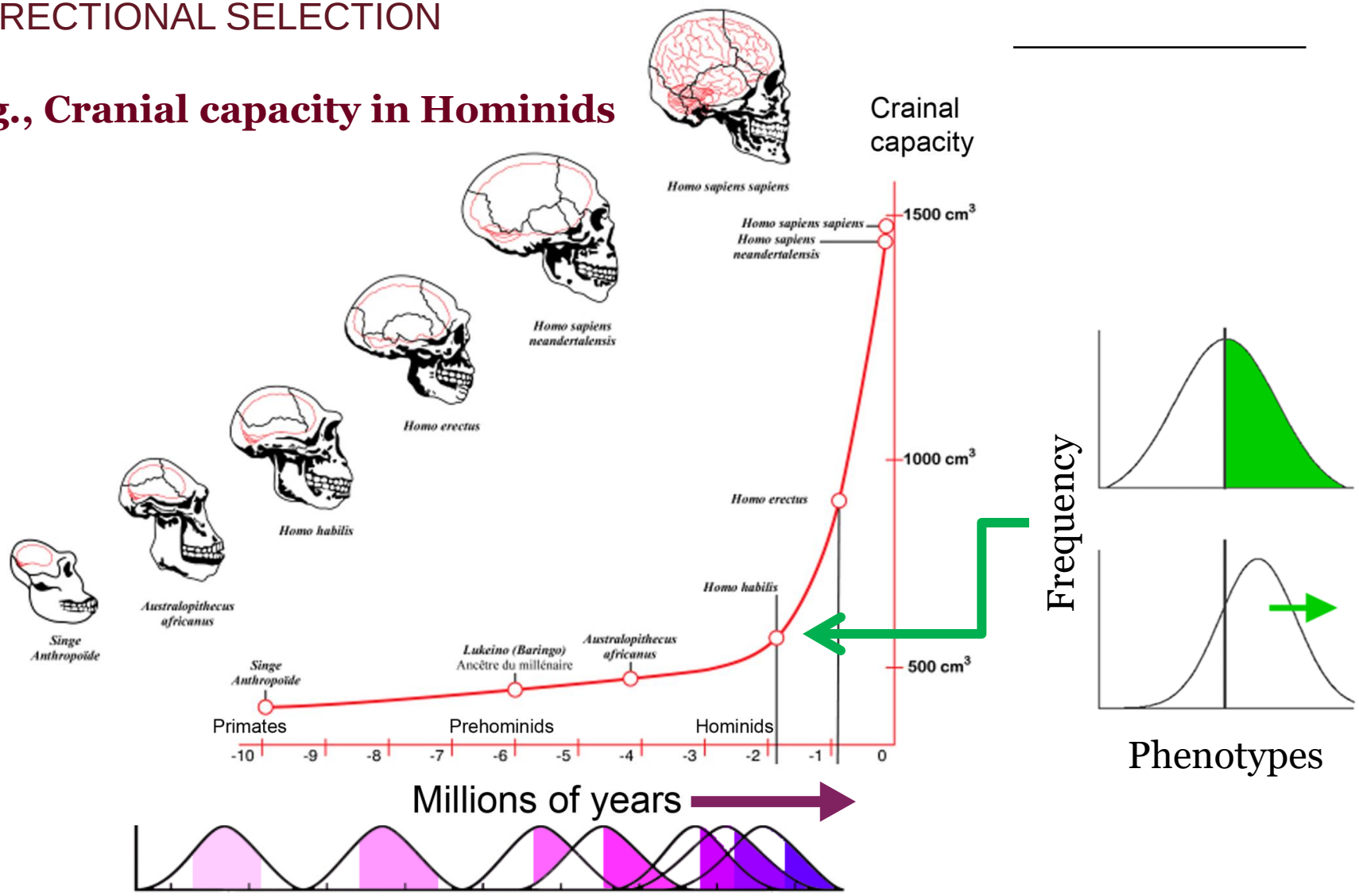
## DIRECTIONAL SELECTION

### E.g., Cranial capacity in Hominids



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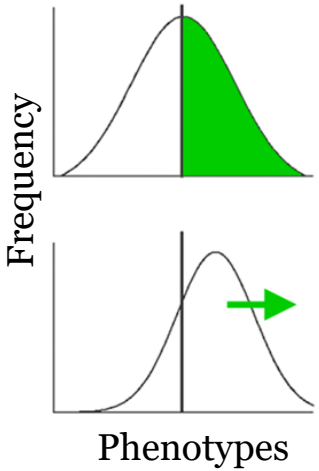
## DIRECTIONAL SELECTION

### E.g. Sexual selection




# Mutation, Migration & Selection

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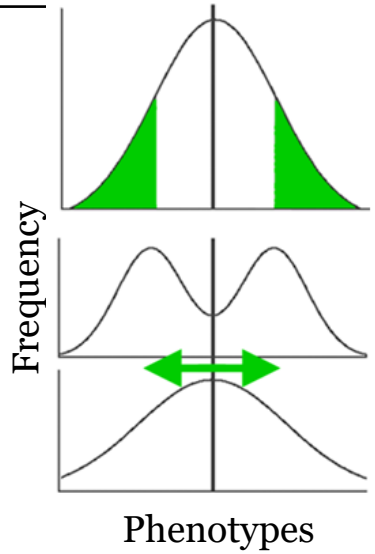
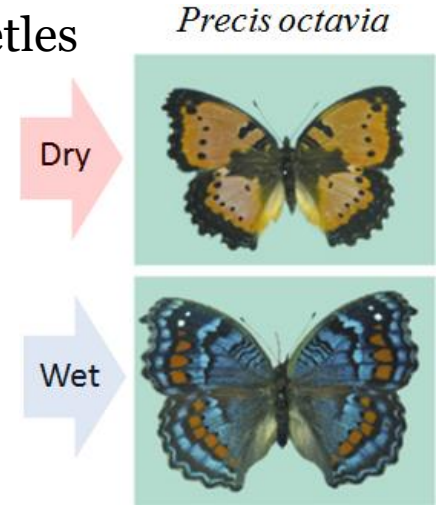
## DISRUPTIVE SELECTION

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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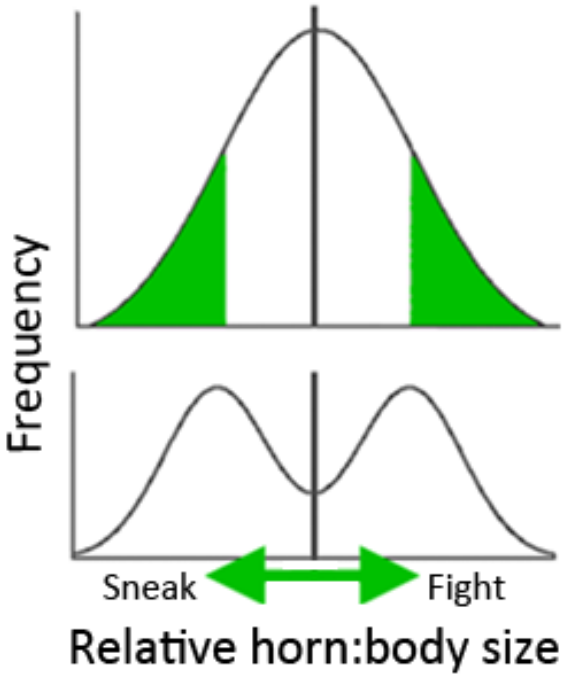
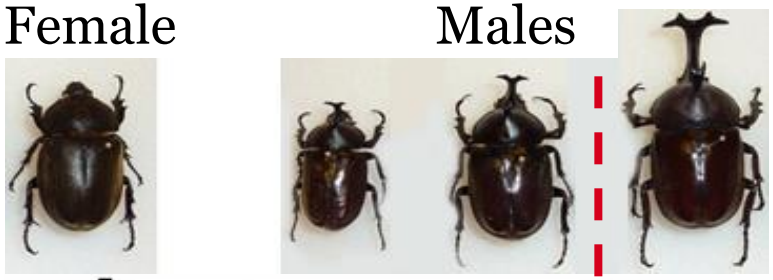
## DISRUPTIVE SELECTION

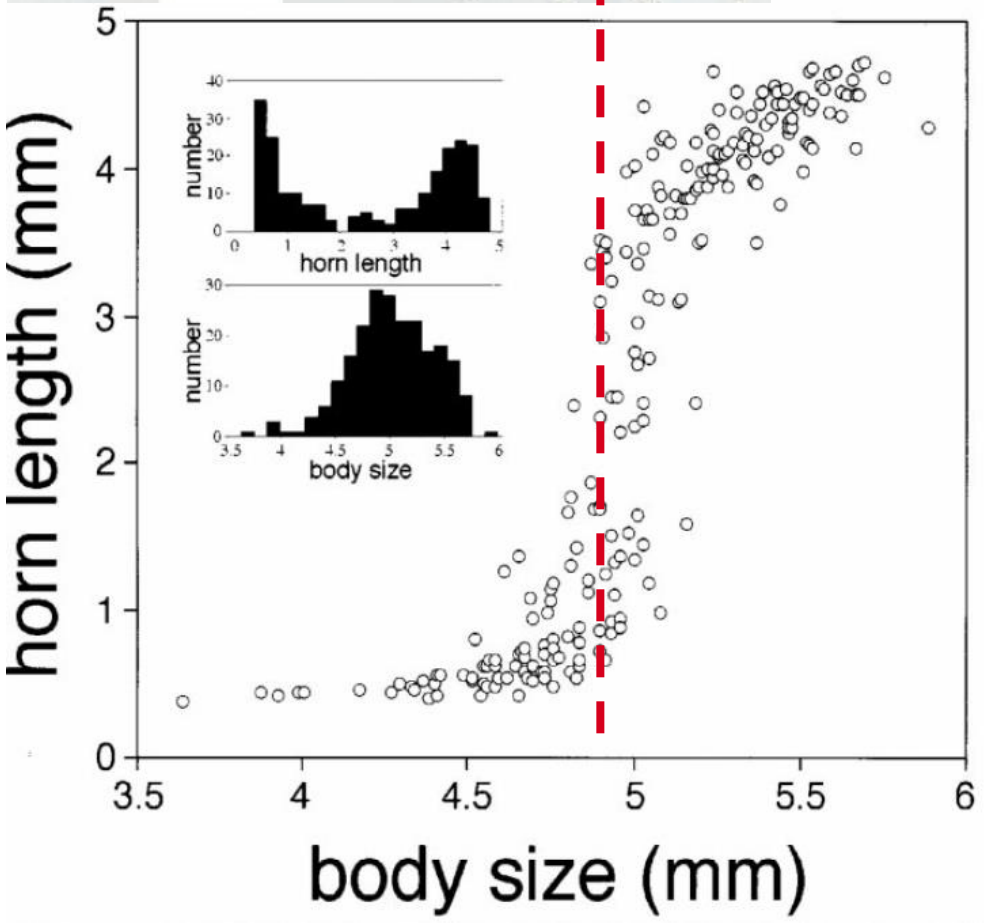
Example:
Horn polyphenism in male
*Onthophagus taurus*




Female

Males





# Mutation, Migration & Selection

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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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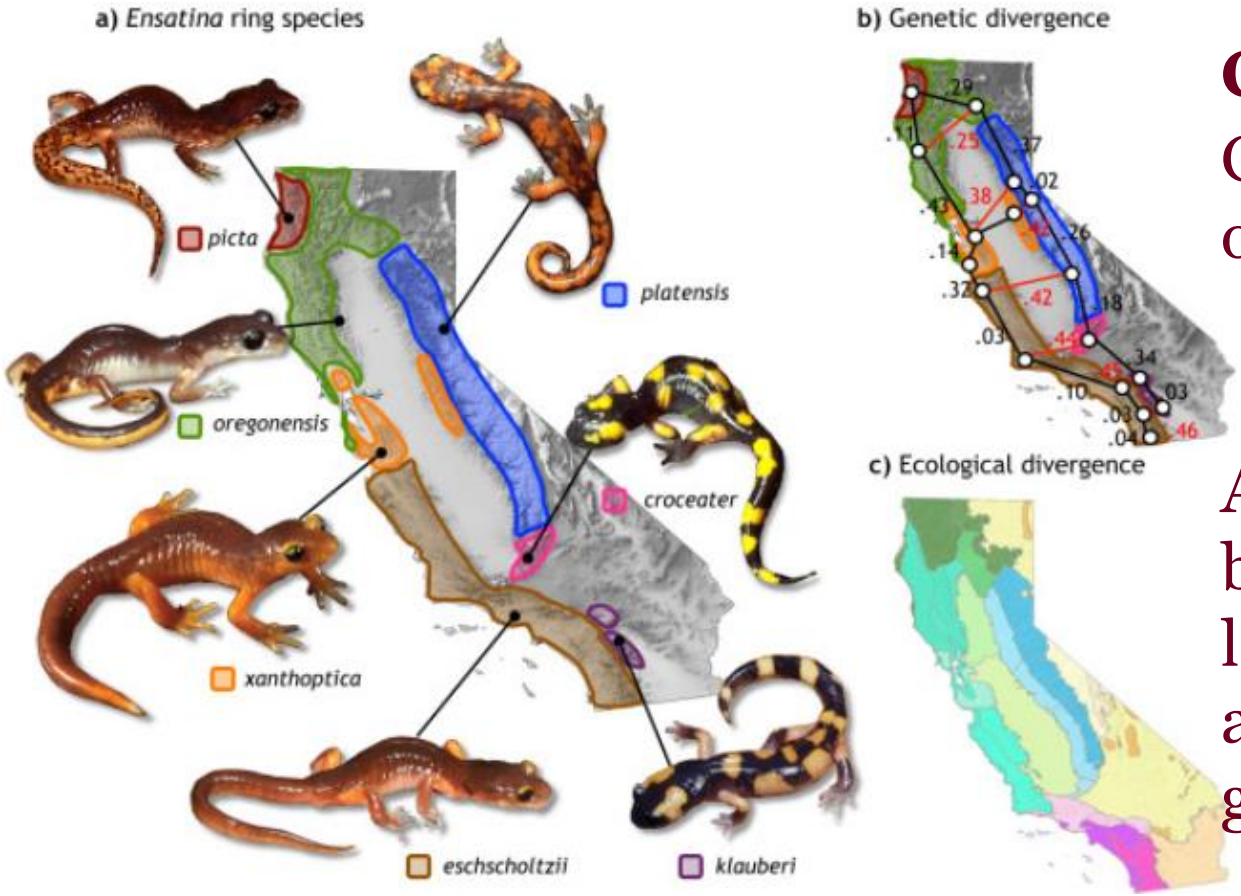
## MIGRATION versus SELECTION




**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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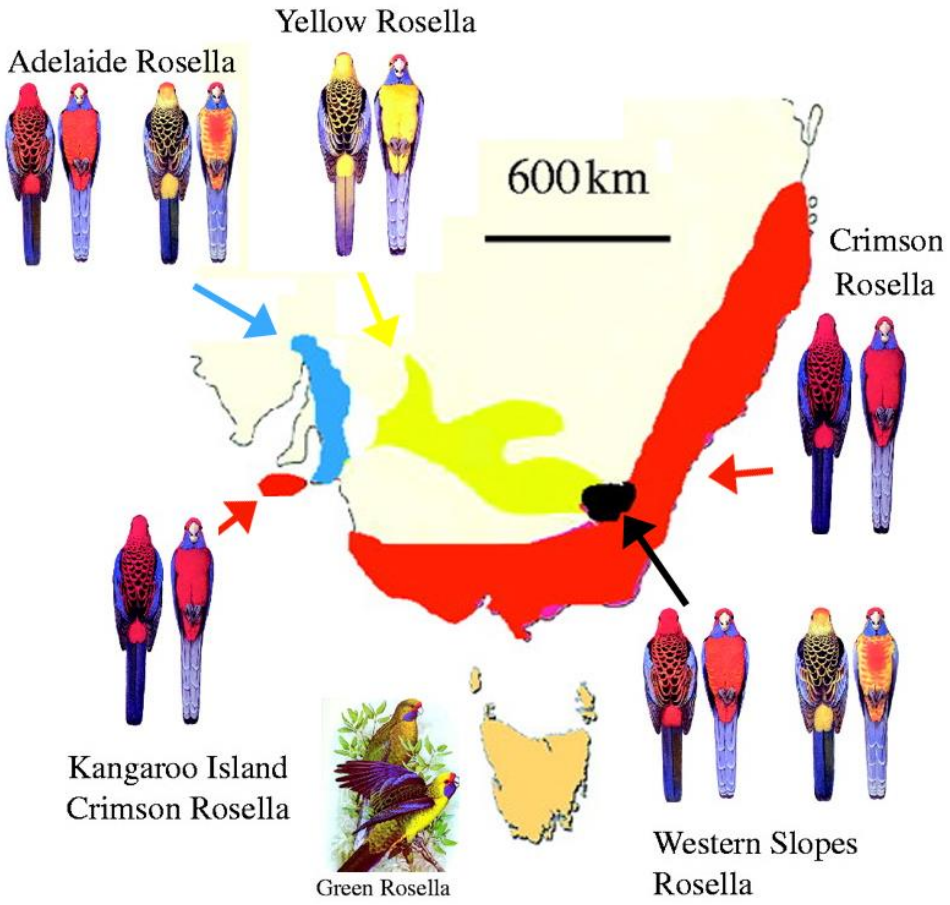
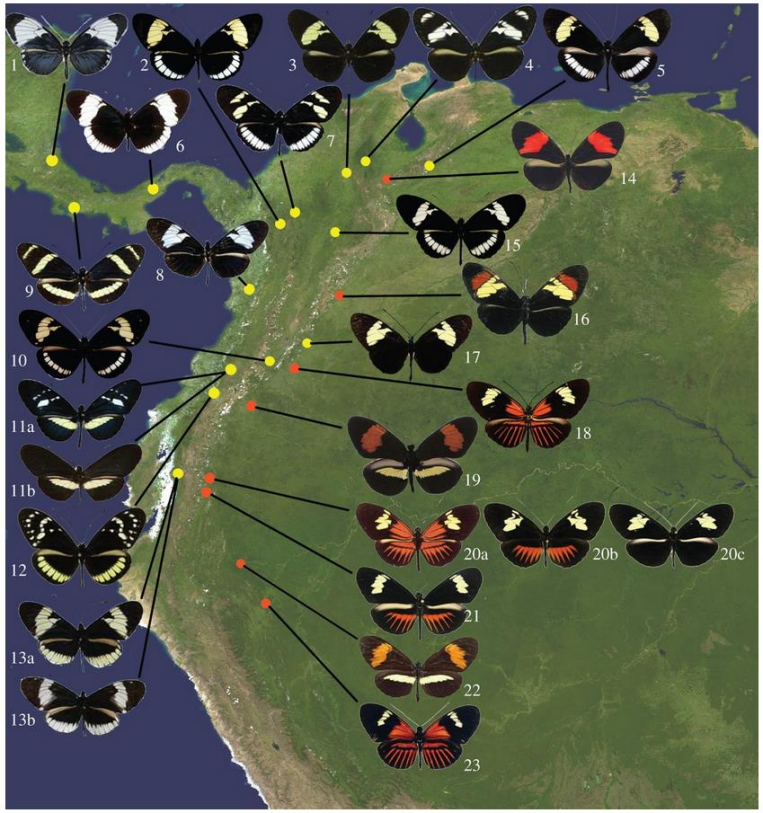
## MIGRATION versus SELECTION




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




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

# Mutation, Migration & Selection

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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**

# Mutation, Migration & Selection

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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:

# Mutation, Migration & Selection

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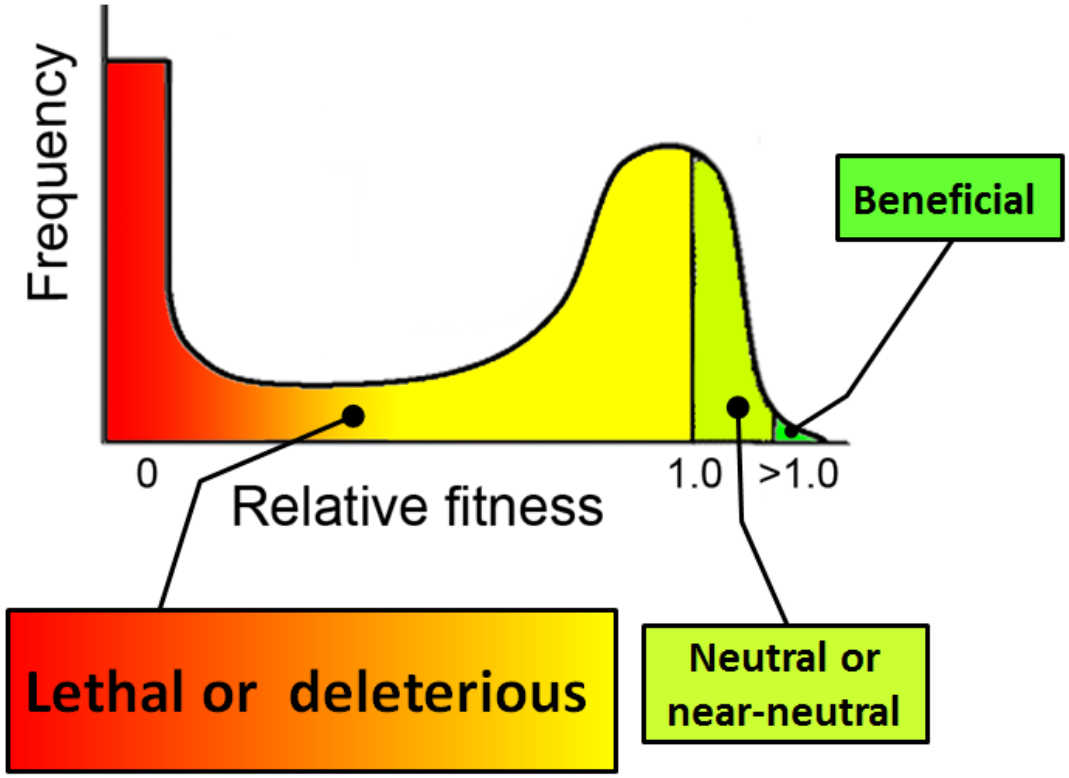
## MUTATION

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

Most mutations deleterious

Eliminated quickly by selection **unless recessive**…



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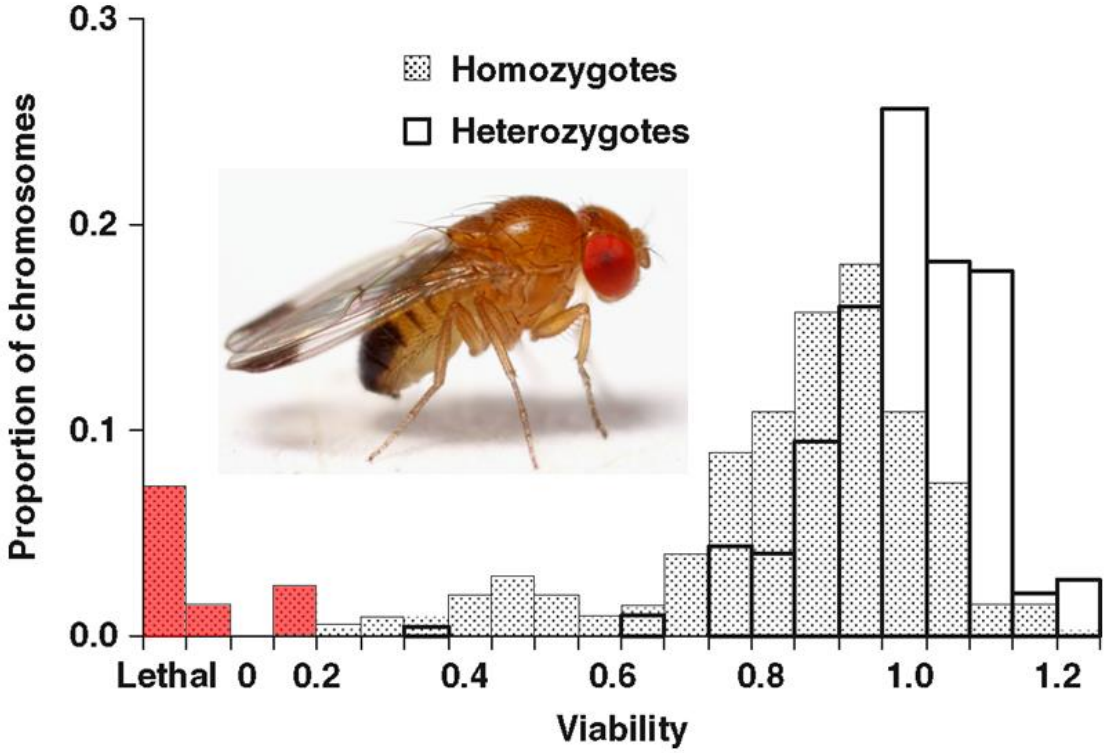
## MUTATIONAL LOAD

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):



# Mutation, Migration & Selection

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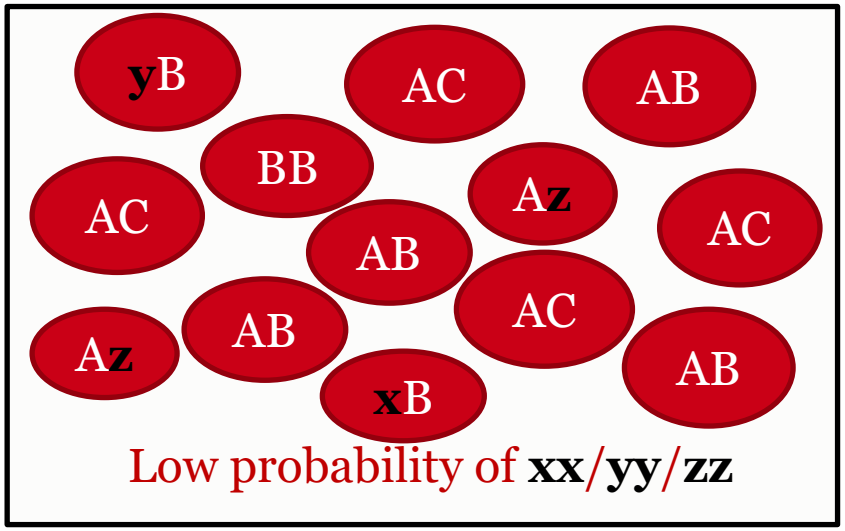
## MUTATIONAL LOAD

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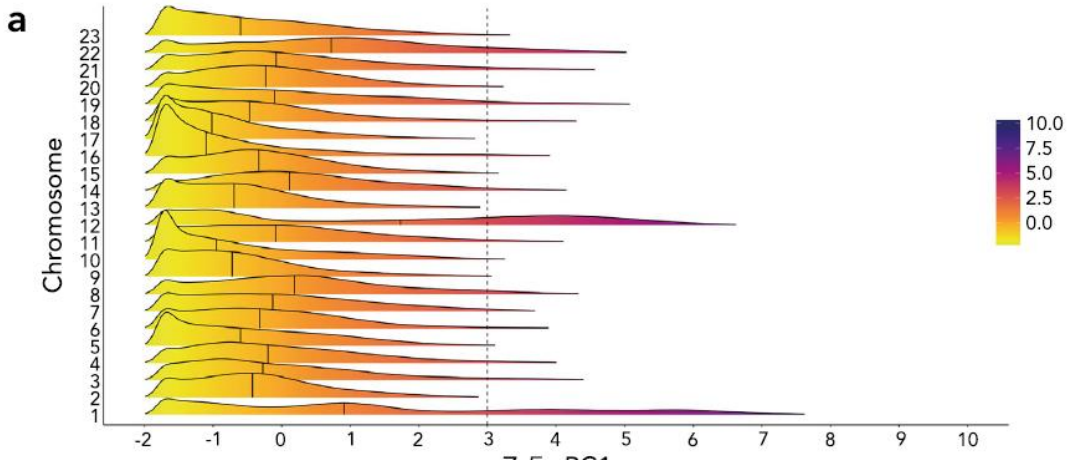
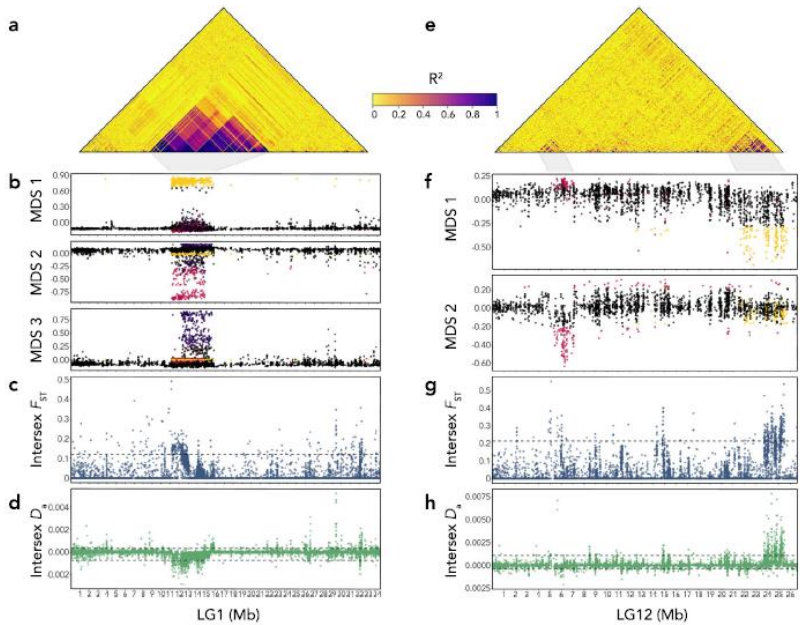
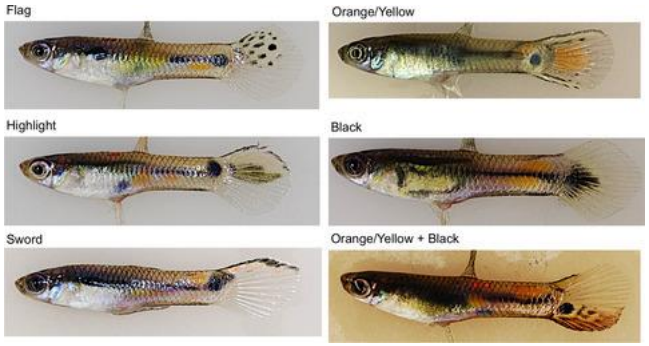
Chromosome 1 (autosome) and 12 (Y chromosome) sig differentiated – cr 1 more so




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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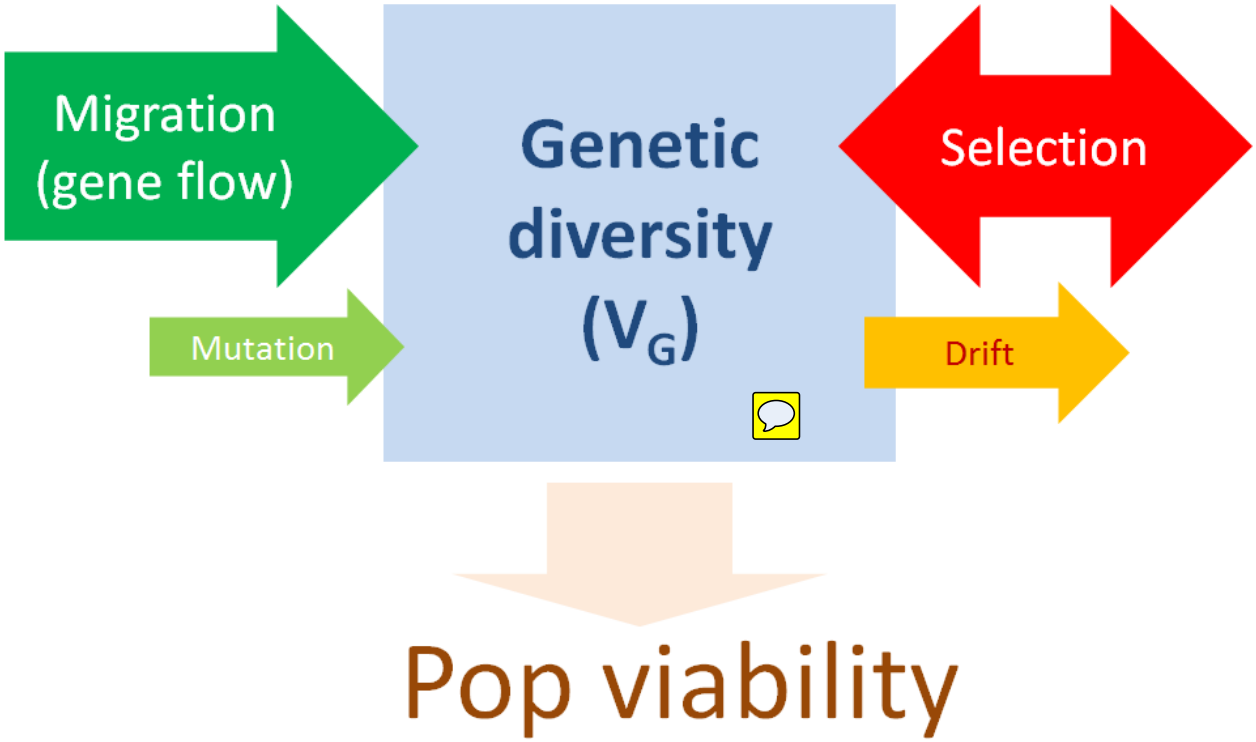
MORE ON THIS NEXT WEEK…

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




Increasingly **stable** with increasing N.

Long-term accumulated negative mutations revealed by small N.