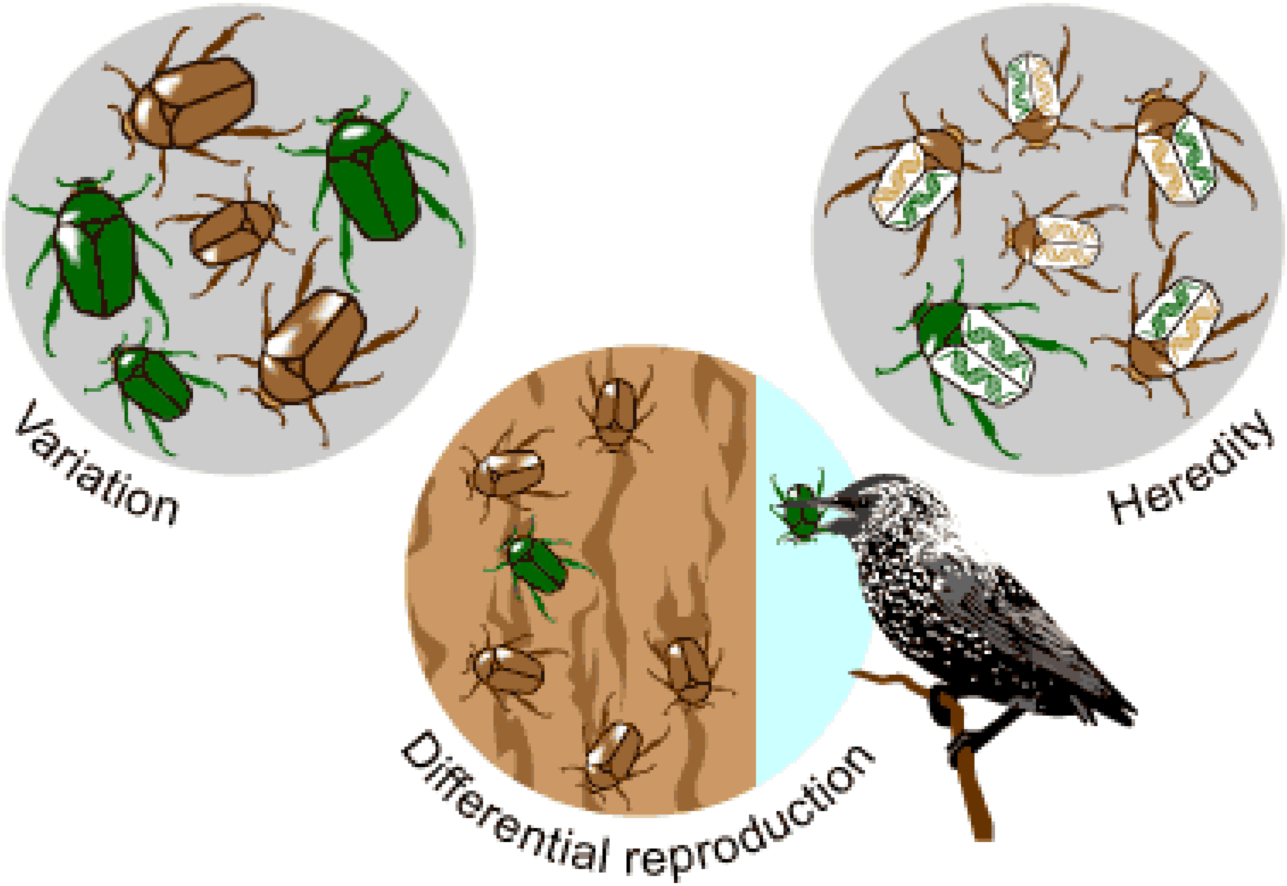
Today's Class – Natural selection (cont.), Adaptations & Sexual Selection (start)



https://www.mrgscience.com/yr11-topic-5-natural-selection-and-evolution.html

Upcoming assignments…

Due this Sunday, February 19th @ 11:59 pm

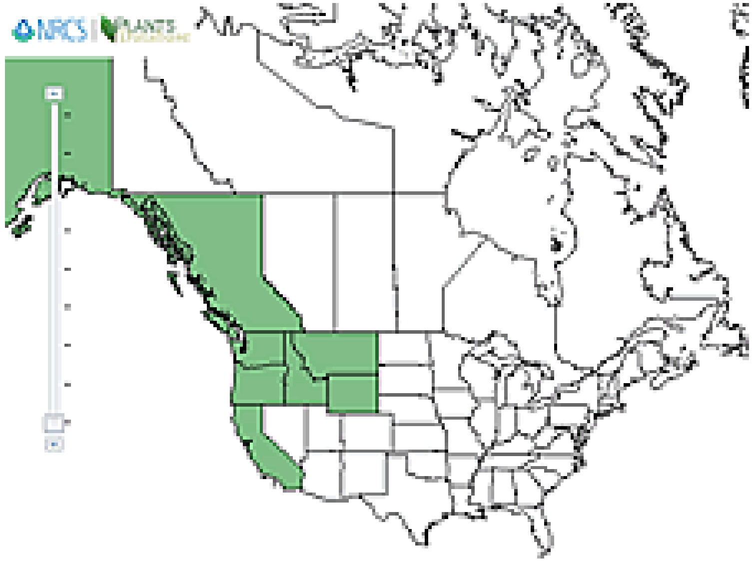
- Quiz 5 – Evolution by natural selection

Due next Sunday, February 26th @ 11:59 pm (but submissions will be accepted until Sunday, March 5th with no penalty).

- Group Project Proposal Survey
- Unofficial teaching feedback survey #1 (1% of grade)

Organism of the Day – Western Skunk Cabbage *(Lysichiton americanus)*

- Found in wet areas (e.g. along streams, wet meadows and swamps) from Alaska to California. And east to Montana, Wyoming and Utah.



https://www.fs.usda.gov/wildflowers/plant-of-the-week/Lysichiton-americanus.shtml

https://en.wikipedia.org/wiki/Lysichiton_americanus

Organism of the Day – Western Skunk Cabbage *(Lysichiton americanus)*

- One of its distinguishing features is it’s smell. It has a distinctive “skunky” odor when it blooms in the Spring (hence it’s common name).

- The “carrion” scent is a way to attract pollinators (i.e. rove beetles, *Pelecomalium testaceum*), which are searching for food or egg laying sites. So, the plant is being deceptive (tricking the beetles).

- While some plants mimic a reward without supplying one, the western skunk cabbage actually does reward the rove beetles with food (pollen) and a mating site.   In return, the beetles transfer the pollen (which contains the male gametes) to other flowers during its movement. (i.e., it is a mutualistic relationship – both taxa have a fitness benefit).

Original Paper | Published: 09 May 2018

Identification and field testing of floral odorants that attract the rove beetle *Pelecomalium testaceum* (Mannerheim) to skunk cabbage, *Lysichiton americanus* (L.)

Bekka S. Brodie, Asim Renyard, Regine Gries, Huimin Zhai, Steven Ogilvie, Jennifer Avery & Gerhard Gries

Arthropod-Plant Interactions **12**, 591–599 (2018) | Cite this article

543 Accesses | **6** Citations | **5** Altmetric | Metrics

https://bugguide.net/node/view/503019

Organism of the Day – Western Skunk Cabbage *(Lysichiton americanus)*

- An individual plant can live to be more than 80 years old.
- Most animals avoid skunk cabbage because the leaves contain chemical compounds (oxalic acid) that cause pain in the mouth and throat region.
- But skunk cabbage is sometimes called bear weed because bears will eat young skunk cabbage after emerging from hibernation. Why?
- Prior to entering hibernation bears ingest leaves, dirt, hair, etc. to form a fecal plug up to 1m long in their intestine.
- When the bears wake up they need to become “unplugged”. Young skunk weed acts as a laxative.

Organism of the Day – Western Skunk Cabbage *(Lysichiton americanus)*

- Skunk cabbage is important to the Indigenous peoples of the Pacific Northwest.

- In the early Spring, when winter food stores were running low, people would roast/boil the roots of the skunk cabbage. Cooking the roots destroyed the oxalic acid.

- The large leaves (which could grow over 1 m in length) were/are used to wrap food and as a layer in earth ovens to preserve moisture. *https://www.oregonencyclopedia.org/articles/skunk-cabbage/*

- Some indigenous peoples are use skunk cabbage as a topical medicine, e.g. skin conditions and respiratory illnesses.

A different skunk cabbage

- Some people mistakenly believe that the western skunk cabbage can generate its own heat. This is not true.

- The EASTERN skunk cabbage (*Symplocarpus foetidus*) – same family (Araceae), but different genus, can generate its own heat (with the help of a mitochondrial enzyme, AOX or alternative oxidase). Instead of generating energy for growth, it generates heat, which helps to melt snow. This allows the plant to take advantage of early pollinators.

https://www.inaturalist.org/taxa/48961-Symplocarpus-foetidus

iClicker question

Natural selection and evolution are the same thing?

A. True
B. False

Answer

Natural selection and evolution are the samething?

A. True
B. False

Evolution is defined as a changes in allele frequencies in a population over time (pattern); natural selection is a process that results in changes in allele frequencies

iClicker Question

If you see a change in the frequency of a phenotype in a population of organisms over time, can you assume that natural selection has occurred?

A. Yes

B. No

Answer

If you see a change in the frequency of a phenotype in a population of organisms over time, can you assume that natural selection has occurred?

Reminder: phenotype can also be affected by the environment

A. Yes

B. No

3 criteria that must be met for natural selection to occur

1. Trait is heritable (so, coded for by a gene/genes)

2. Variation in phenotype in the population

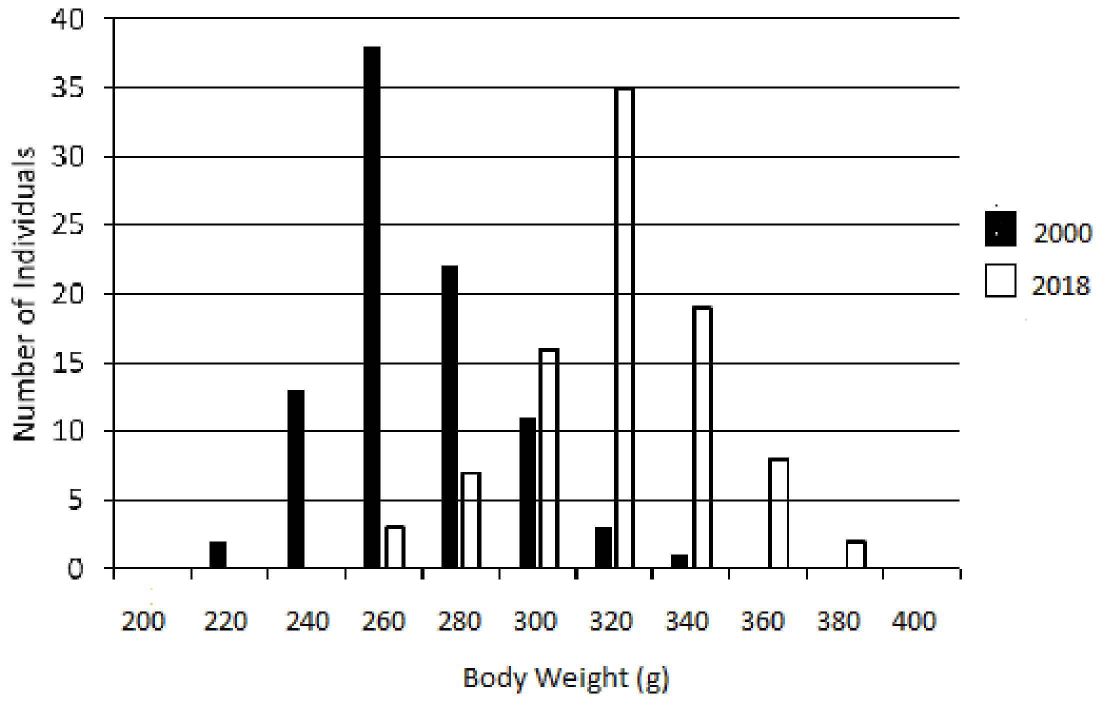
3. Fitness differences associated with different phenotypes

Natural Selection – Explanation Activity

Data on the body size of campus pigeons (*Columbia livia*) has been collected at UBC for the past two decades and was recently analyzed to determine if there has been any morphological change in the birds over time. The data for two of those years are presented in the graph below.

Your friend thinks that the change in the body size of the pigeon is a result of natural selection. Do you agree with your friend's claim. Use the claim, evidence, reasoning format to explain your answer.

2 minutes to write an answer



Sample Answer

No, I do not agree with my friend's claim that the change in body size of the pigeons at UBC from 2000 to 2018 can be explained by natural selection (or I cannot conclude with certainty that ….). (1 mark)

There is variation in this trait, which is a requirement for natural selection. Specifically, in 2000 the weight of the pigeon ranged from approximately 220g to 340g (1 mark). However, there is no evidence that body size is heritable or that differences in body size result in fitness differences, i.e. differences in reproductive success, which are also requirements for natural selection (2 marks).

Therefore, I cannot be certain that the change in body size with the pigeons between 2000 and 2018 is due to natural selection. *There are other plausible answers (e.g. differences in food availability).*

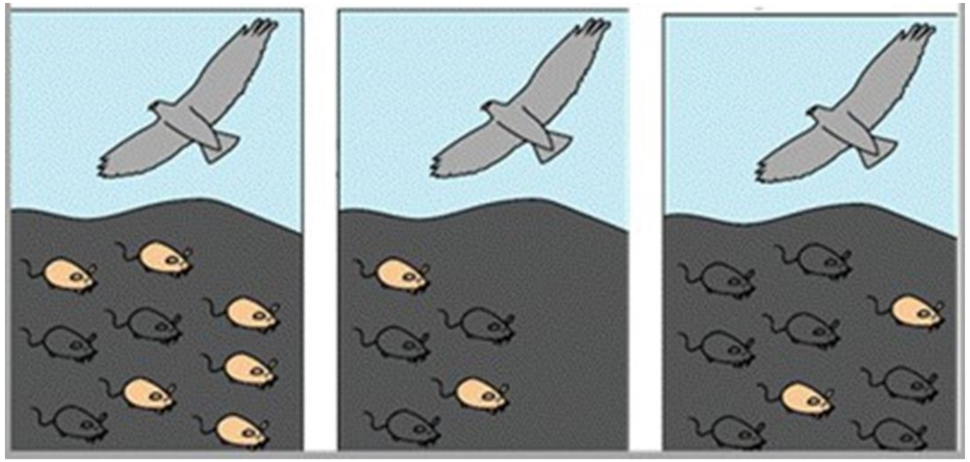
Natural Selection (mechanism #3)

Natural selection is a <u>process</u> that results in changes in allele frequencies in a population over time (generations).

Natural selection occurs when individuals with a certain genotype (and phenotype) are more likely than individuals with other genotypes/phenotypes to survive and reproduce, and thus pass more alleles to the next generation.

This results in an increase in frequency of individuals with the advantageous genotype/phenotype over generations, and an increase in the beneficial allele (and a decrease in frequency of the less beneficial allele).

The population becomes more well adapted to the environment over generations.   But, if the environment changes, so can the direction of selection.



Source: unknown

Non-random differences in survival and reproduction

Although the origin of a new allele (via mutation) is random with respect to the fitness of an organism, the probability of that allele being passed on to the next generation <u>is not random</u>, if it affects the survival and reproduction of the organism with that allele.

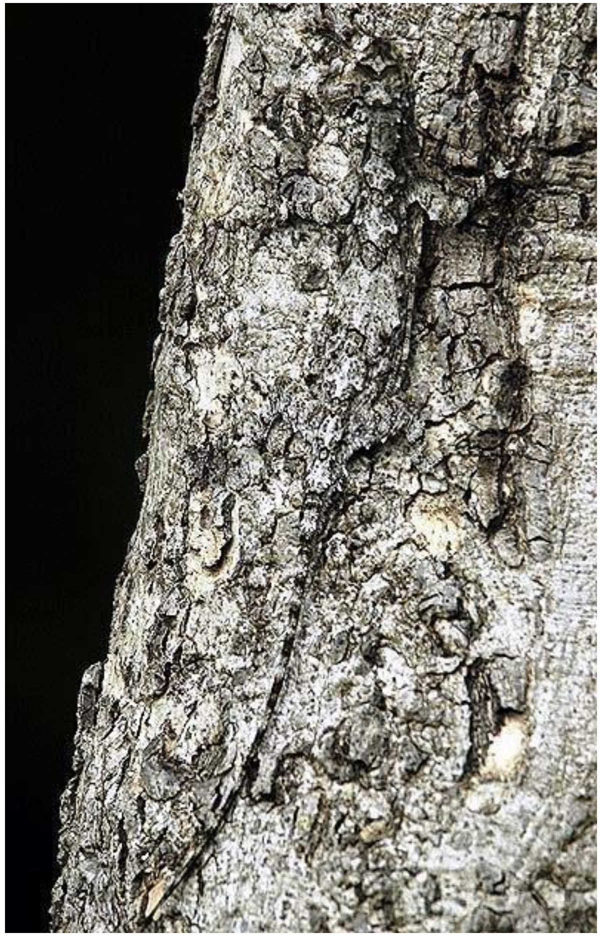
New term - Adaptations (or AdaptiveTraits)

In the literature, I have seen the term adaptation used two ways:

1. To refer to a process in which populations become more well adapted to the environment as a result of mutations and natural selection.

2. To refer to a HERITABLE (adaptive) trait that increases the ability of an individual to survive and reproduce compared to individuals without that trait.

Adaptations can be structural



https://en.wikipedia.org

Adaptations can be physiological

https://www.youtube.com/watch?v=pLPeehsXAr4

Source: https://www.youtube.com/watch?v=mrL2A7my1fc

https://www.flickr.com/photos/brewbooks/2485147738

Adaptations can also be behavioural

Source: https://www.straight.com/news/684401/anne-murray-peep-showcases-shorebird-migration-roberts-bank

Source: https://www.youtube.com/watch?v=OOmUBuaMjzw

A trait is not an adaptation if it is …

- not heritable; or

- not functional; or

- does not positively affect an individual's fitness

(e.g. male nipples)

- note: no requirement for variation in population; all members of population can have phenotype.

Cool Adaptation - Mr. Jamie Foxx's character (Art)

Superpower:

He can super heat the air around him and create shock waves.

Pistol Shrimp

- Real life animal with those powers Pistol Shrimp
  (*Alpheus cedrici*)
- Small marine animal
- Only 4 cm in length (approx.)
- Enlarged left claw for snapping

- Snapping their claw super-heats the water near them to ~4,800°C, which is similar to the temperature at the surface of the sun
- Sound produced by the snap (~ 218 db) is louder than a bullet (~ 140 db)
- Temperature + sound + pressure changes stuns/kill other organisms (for food/protection)

  - http://large.stanford.edu/courses/2017/ph240/nag2/#:~:text=The%20internal%20low%20pressure%20causes,over%20a%20very%20small%20area.

Bad guy on Project Power (Knifebones)

Can break his own bones and use them for protection

The wolverine or hairy frog (*Trichobatrachus robustus*) breaks it own bones to produce claws when threatened

https://www.newscientist.com/article/dn13991-horror-frog-breaks-own-bones-to-produce-claws/

Learning Goals

Natural Selection: Given a scenario, predict, describe and/or explain how natural selection could affect allele or phenotypic frequencies in a population and justify your explanation with specific evidence.

New: Also be able to explain whether or not a change in phenotype could be due to natural selection or not (e.g. pigeon example).

Natural Selection: Be able to described the 3 requirements for natural selection to occur.

Adaptations: Identify traits that are likely adaptations and given a scenario, determine if a trait could be considered an adaptation and provide a logical justification for your conclusion supported by evidence from a scenario.

- Be able to describe the 3 requirements for a trait to be considered an adaptation (a bit different from natural selection).

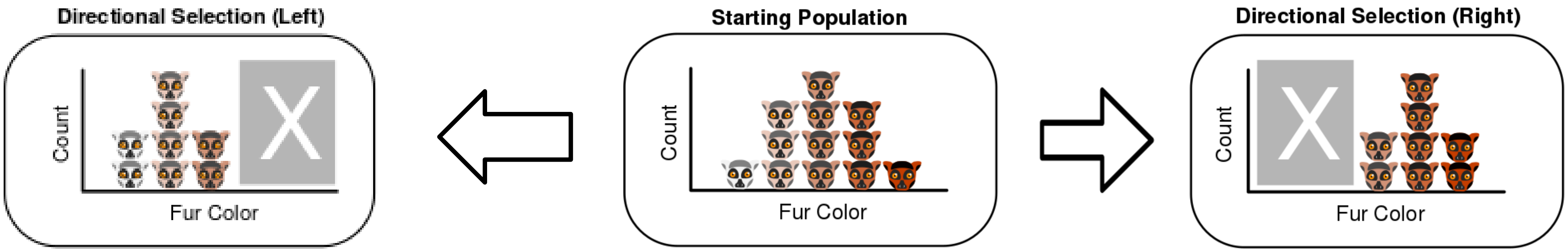
3 Types of Natural Selection

To understand phenotypic effects of natural selection – need to consider 3 modes of natural selection:

- Directional
- Stabilizing
- Disruptive

1. Directional Selection

- favours individuals with a phenotype at one end of the distribution of a trait, e.g. darker fur, shorter wings, faster running speed, higher metabolic rates.
- outcome: the frequency distribution of the trait in the subsequent generation is shifted in one direction from where it was in the parental generation.

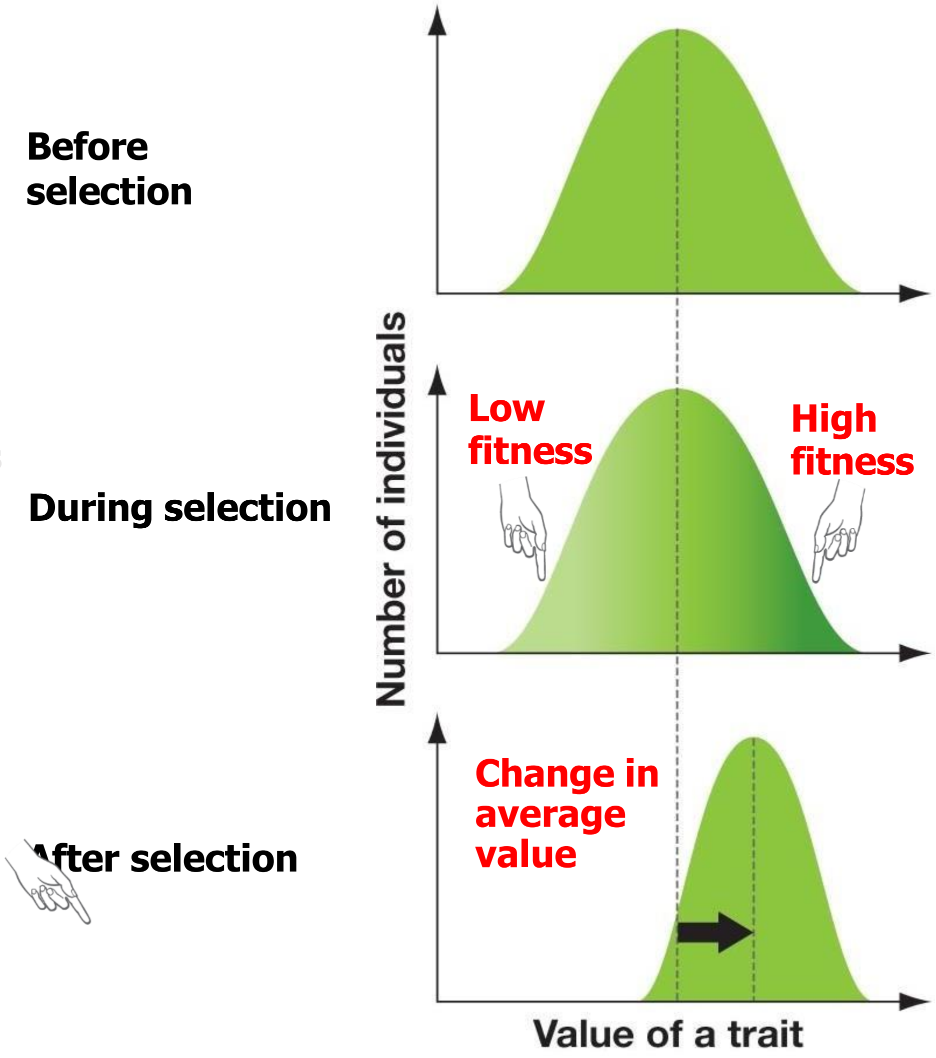


https://commons.wikimedia.org/wiki/File:Directional_Selection_(Right).svg

Directional Selection - outcome

Changes the average value for a trait in the population (increases or decreases).

Variation tends to decrease.



Classic example of directional selection – Pepper moths in England

Peppered Moth (*Biston betularia*)

These moths are active at night and during the day seek refuge from predators (mostly birds) by resting on tree trunks.

Wing colour varies (black to white body with black and brown speckles)

Wing colour determined by *cortex* gene (so heritable).

Prior to the Industrial Revolution, most moths of this species had light coloured wings. Dark morphs were rare.

https://branchcollective.org/?ps_articles=nathan-k-hensley-and-john-patrick-james-soot-moth-biston-betularia-and-the-victorian-end-of-nature

During the Industrial Revolution, soot (from the burning of coal) darkened tree trunks. Light morphs became far less common, and dark morphs more common.

Cause of phenotype change = selective pressure by birds (predation)

https://branchcollective.org/?ps_articles=nathan-k-hensley-and-john-patrick-james-soot-moth-biston-betularia-and-the-victorian-end-of-nature

Evidence of directional selection

Kettlewell (1956) mark-recapture study in England (Dorset region):

Biologists released:

- 584 moths – both morphologies into industrial woods (tree trunks darkened by soot)
- 969 moth – both morphologies into unpolluted woodland (tree trunks not darkened)
- Moths marked with small dot on underside of wing

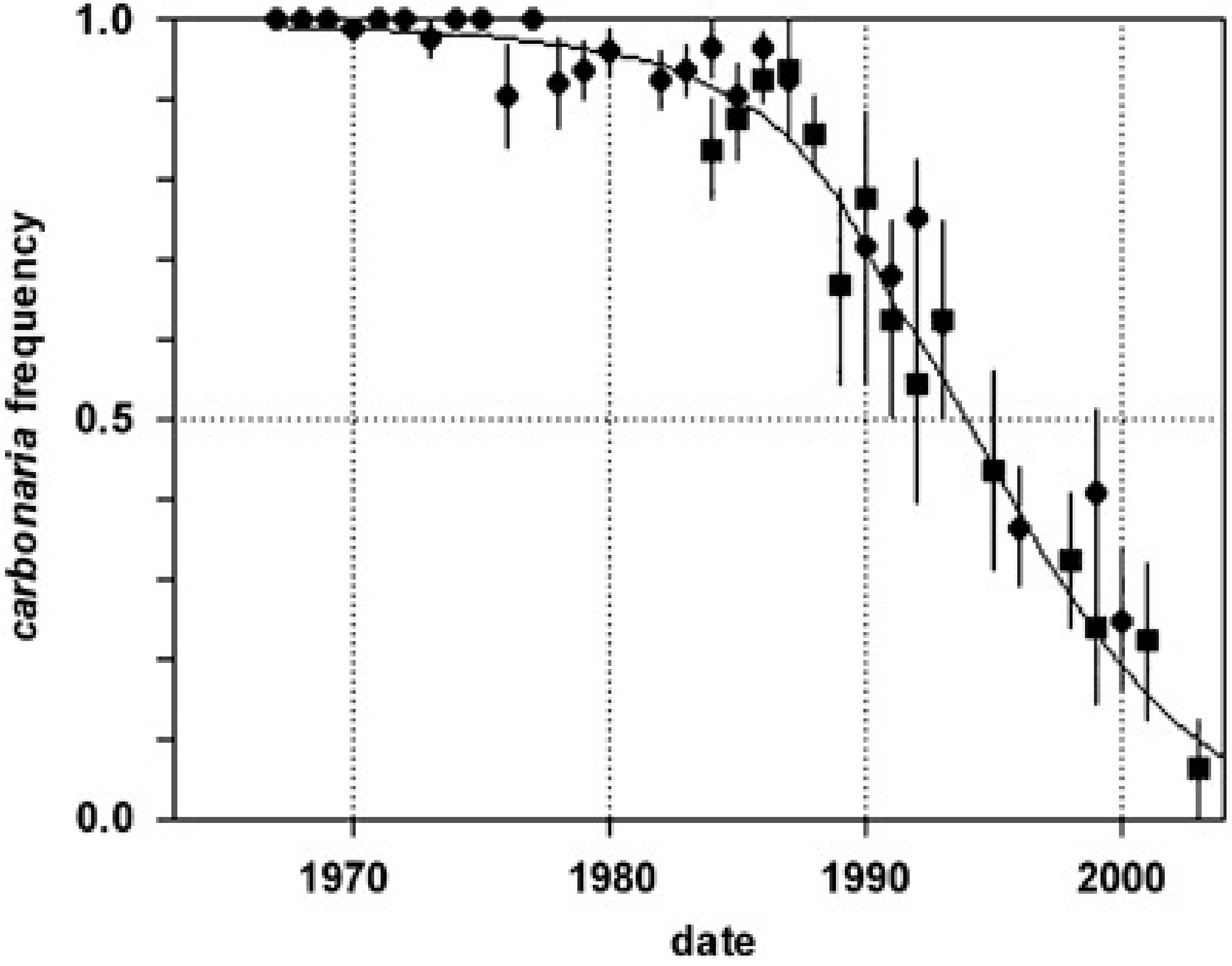
Recapture Success

	light moth	dark moth
non-industrial woods	14.6 %	4.7 %
industrial woods	13 %	27.5 %

https://www.globalchange.umich.edu/globalchange1/current/lectures/selection/selection.html

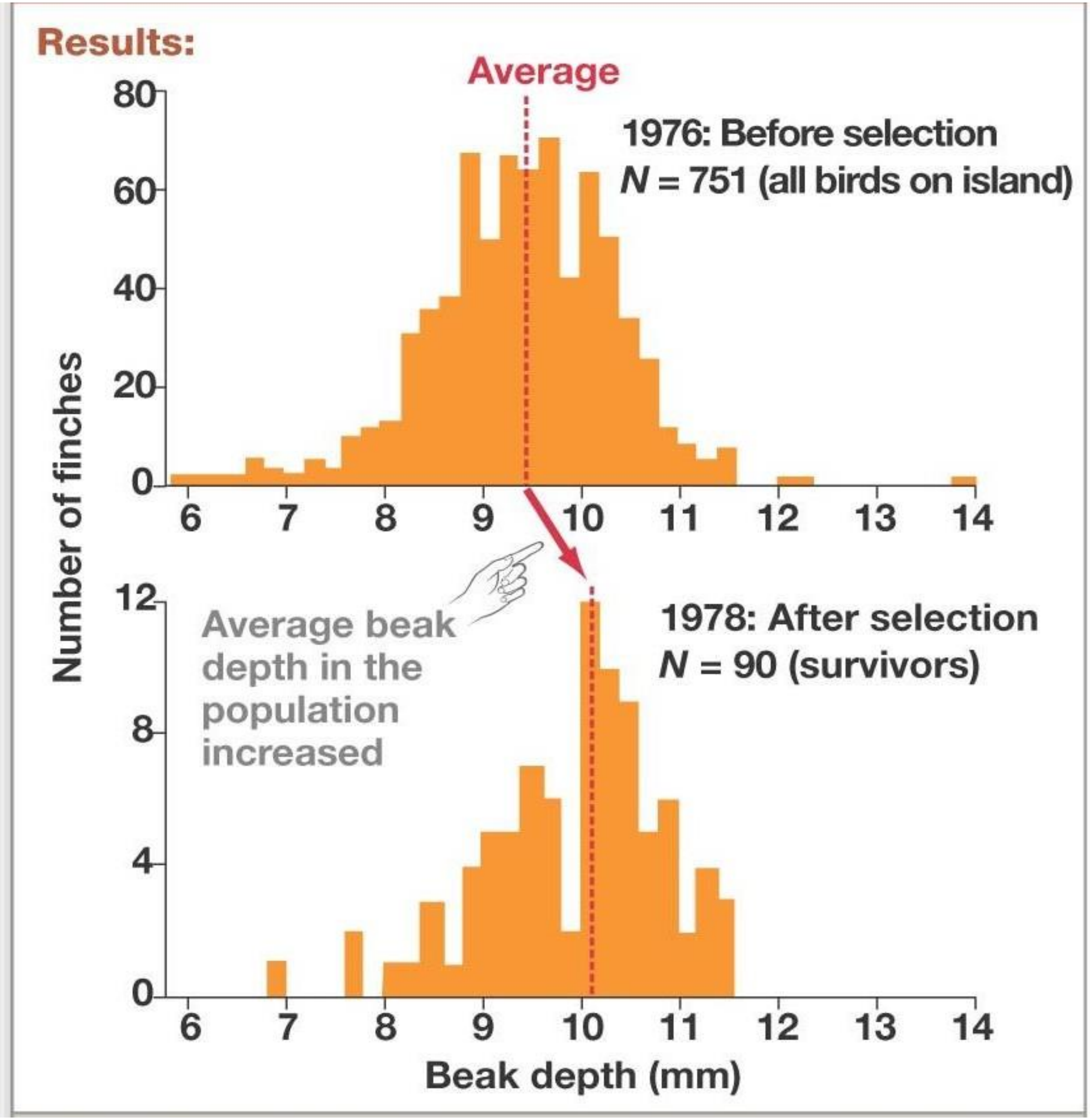
Direction of selection can change

Change in frequency of dark morph (*carbonaria*) in Leeds, England after air became cleaner due to clean air acts.



Example #2: Research on finches by Peter & Rosemary Grant

- Daphne Major Island – Galapagos Islands
- 1977 severe drought
- Vegetation withered
- Seeds became scarce
- Small, soft seeds were quickly exhausted by the birds on the island leaving mainly large tough seeds that the birds typically ignore.
- Beak size is heritable (**HMGA2 gene)**
- Natural selection favoured the birds (finches) with large, tough beaks that could crack the shells of these tough seeds.
- Most small finches with less powerful beaks either emigrated or perished from starvation ☹.

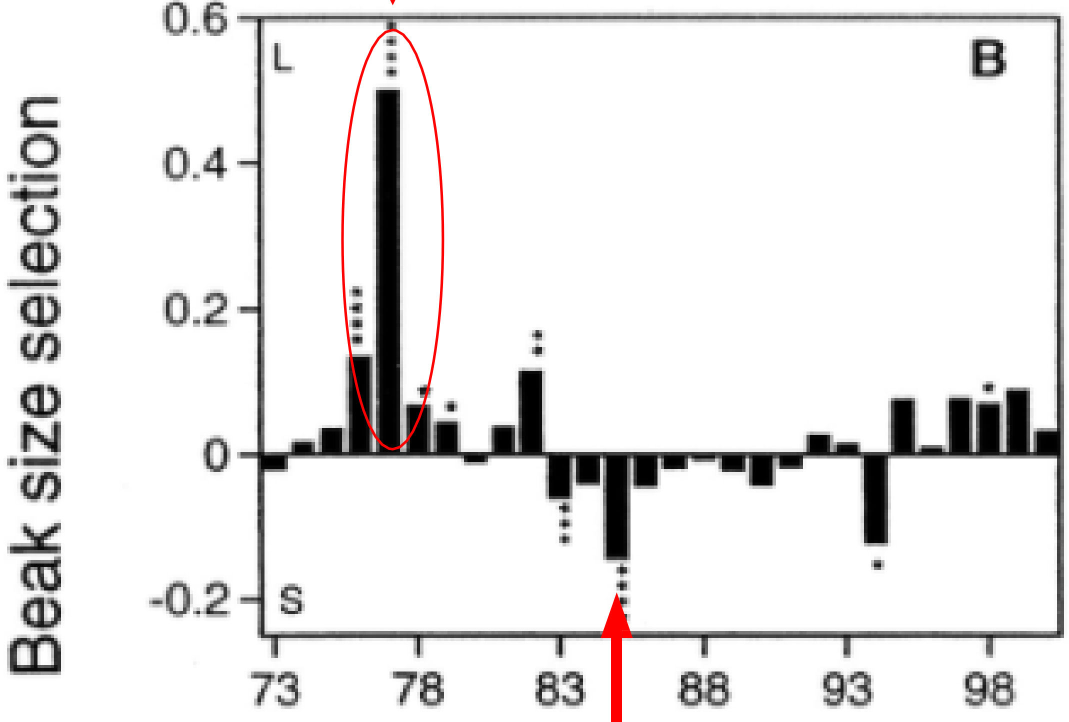


Selective force = food availability (biotic factor)

Notice change in average value of trait (beak depth) and reduction in ranges of beak size (less variation).

Keep in mind - the direction and strength of selection can change as the environment changes

1977 - larger beaks favoured by natural selection due to drought in 1977



1995 - larger beaks once again favoured (thought not as strongly)

~ 7 years later (1986), El Ninio – lots of rain; smaller seeds more abundant; small beaks favoured over large beaks

Unpredictable Evolution in a 30-Year Study of Darwin's Finches

Peter R. Grant and B. Rosemary Grant

Example #3 - Humans as a selective force (biotic)

Tim the Tusker, African Geographic

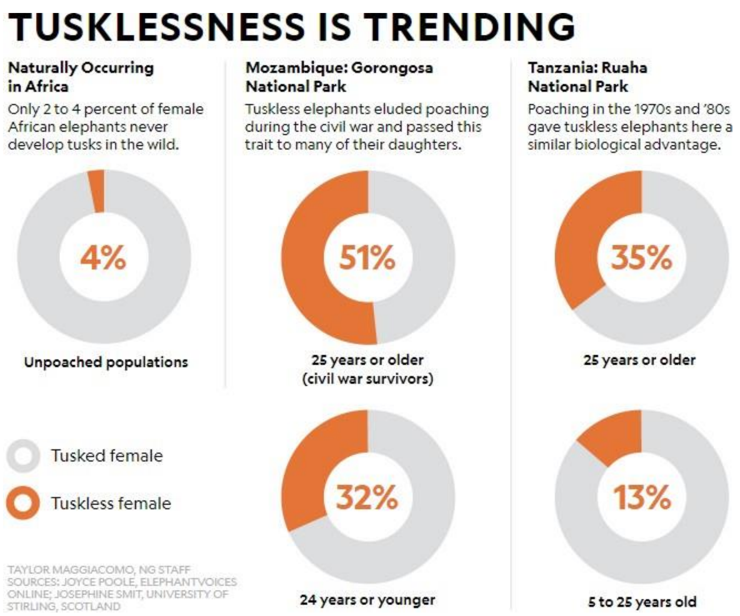
New: Scientist have identified two likely candidate genes for tusklessness: *AMELX* and *MEP1a*.

- In people, these genes are involved in the growth of incisors (equivalent of elephant tusks).
- Likely X-linked
- The fact that there are no tuskless males suggest this may be a lethal trait for males.

NEWS | 21 October 2021

Ivory hunting drives evolution of tuskless elephants

In Mozambique, the selective poaching of elephants with tusks has led to a higher number of females being born without them.

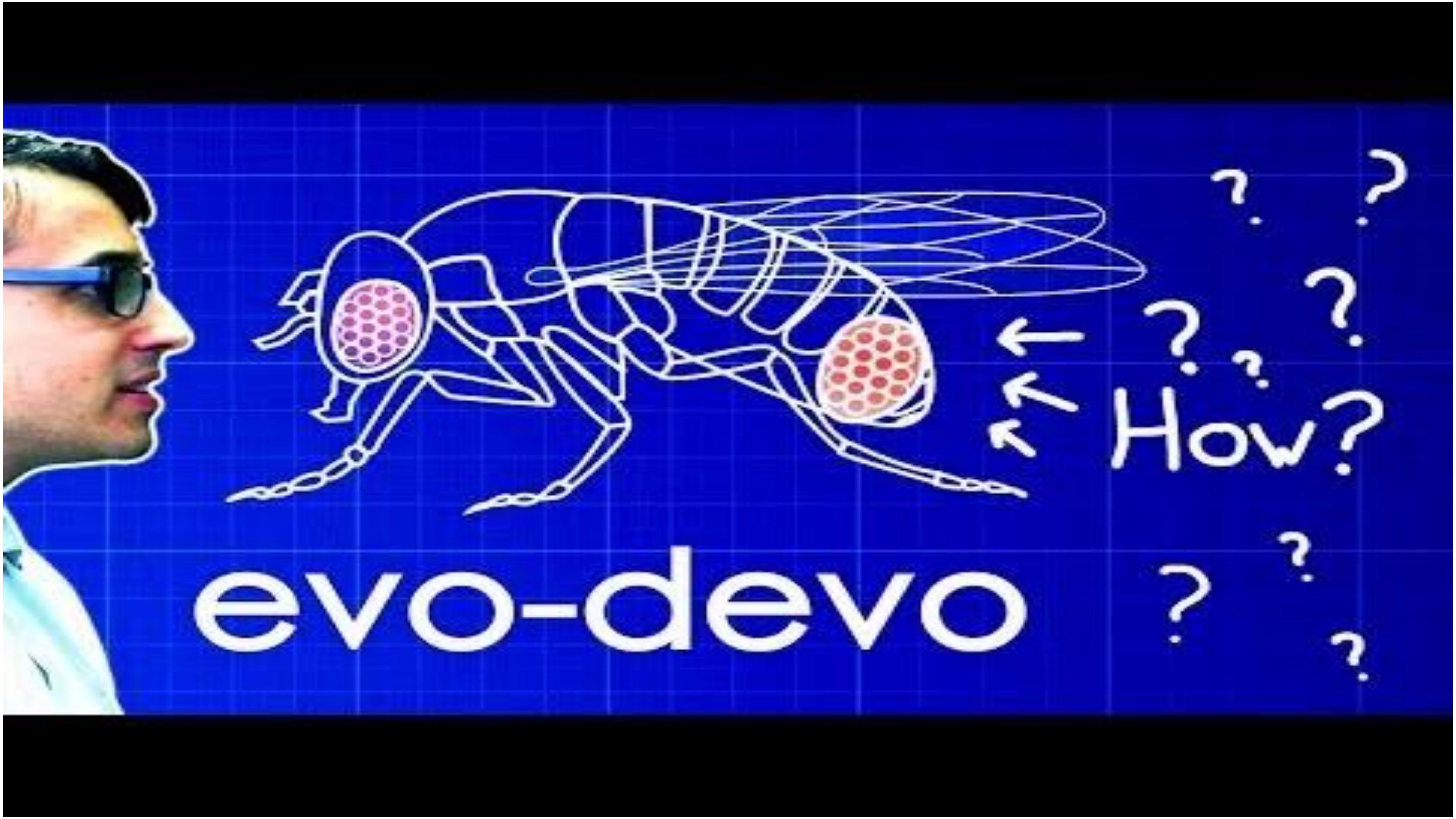


Also - size of tusks is getting smaller in males (21%) and females (27%)

Comparison of elephants from 1960s to those born after 1995

Duke University Study

4-minute break

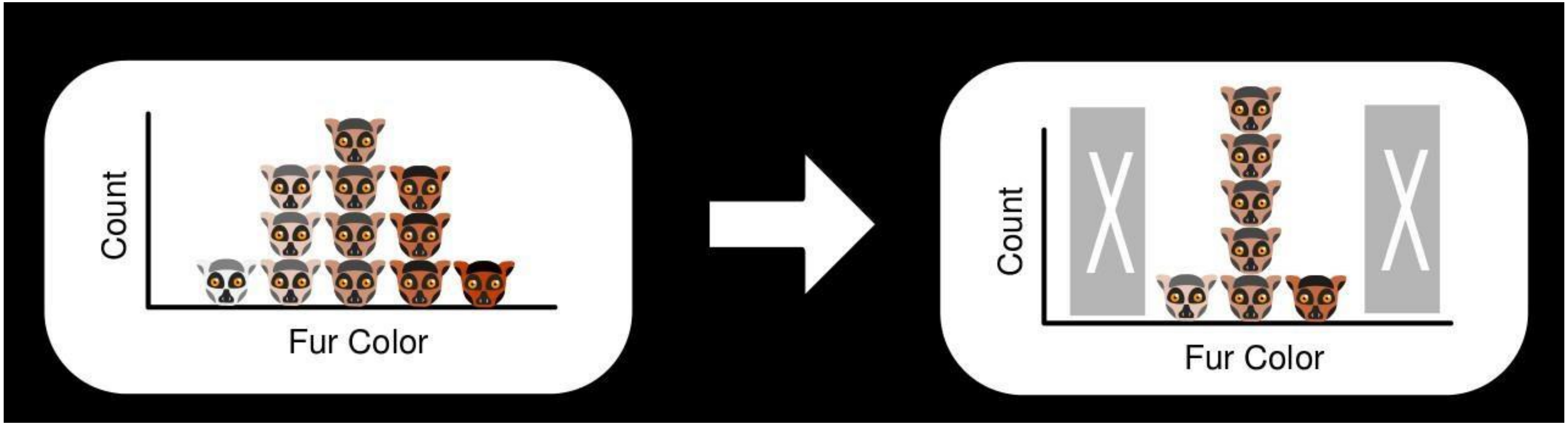


https://www.youtube.com/watch?v=ydqReeTV_vk

If you have a song or video you would like me to show during break, please just send me an email with the link

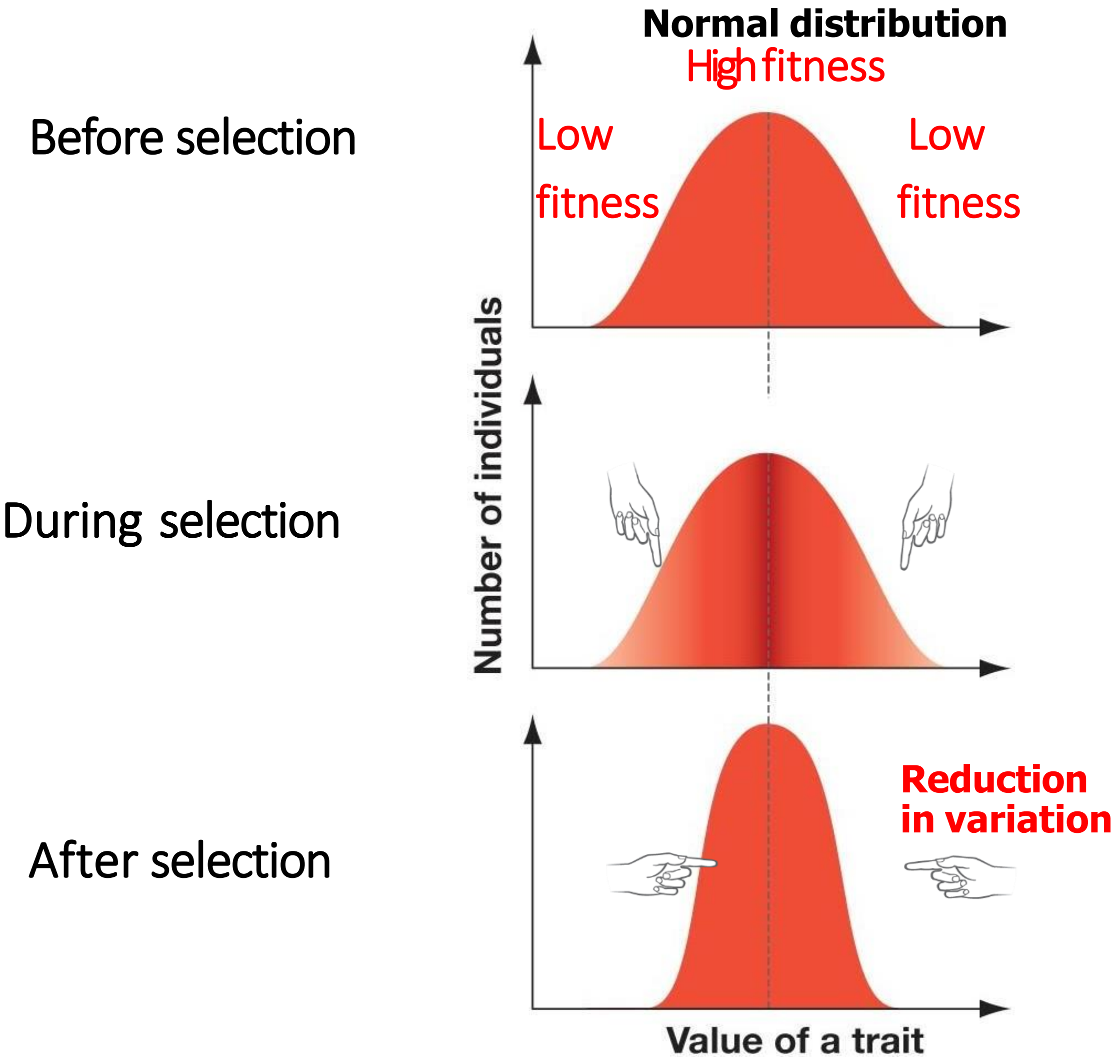
2. Stabilizing Selection

- Selects against extreme phenotypes at both ends of the frequency distribution.
- Selection favours intermediate phenotypes



Stabilizing Selection

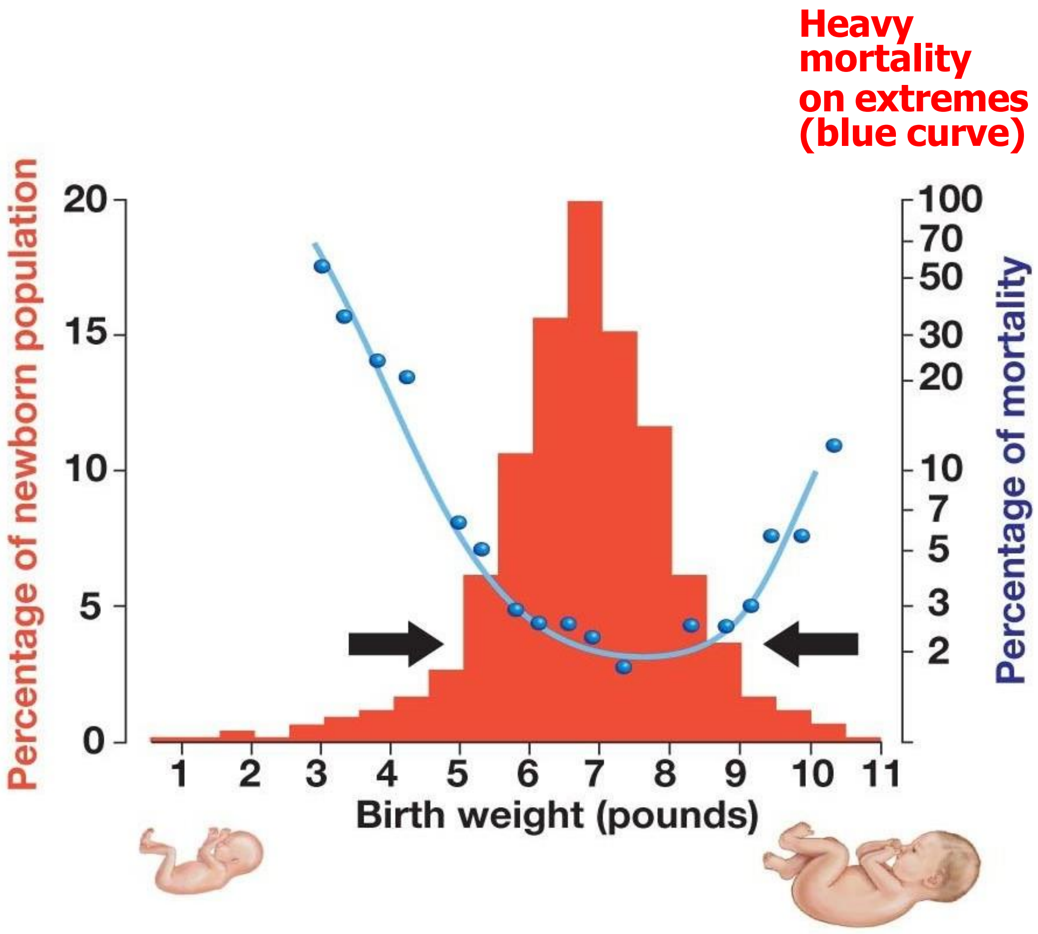
Average value of the trait remains the same
Phenotypic/genotypic variation is reduced



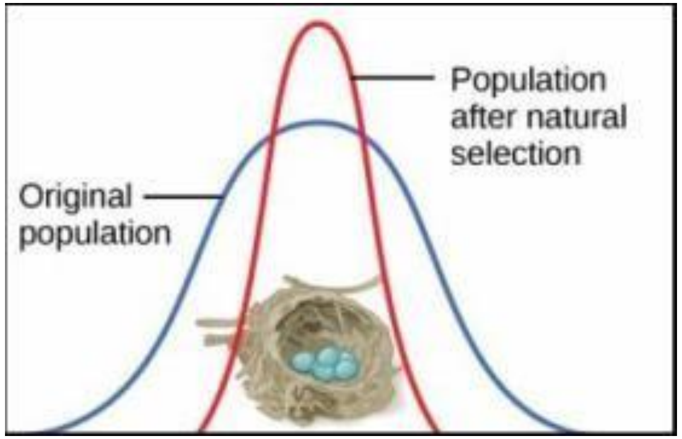
Favours intermediate phenotypes
Removes extreme phenotypes

Example - Stabilizing Selection – weight of newborns

For example, very small and very large babies have a higher mortality risk (blue curve), leaving a narrower distribution of birth weights.



Stabilizing Selection – number of robin eggs



Robin's typically lay 4 eggs.

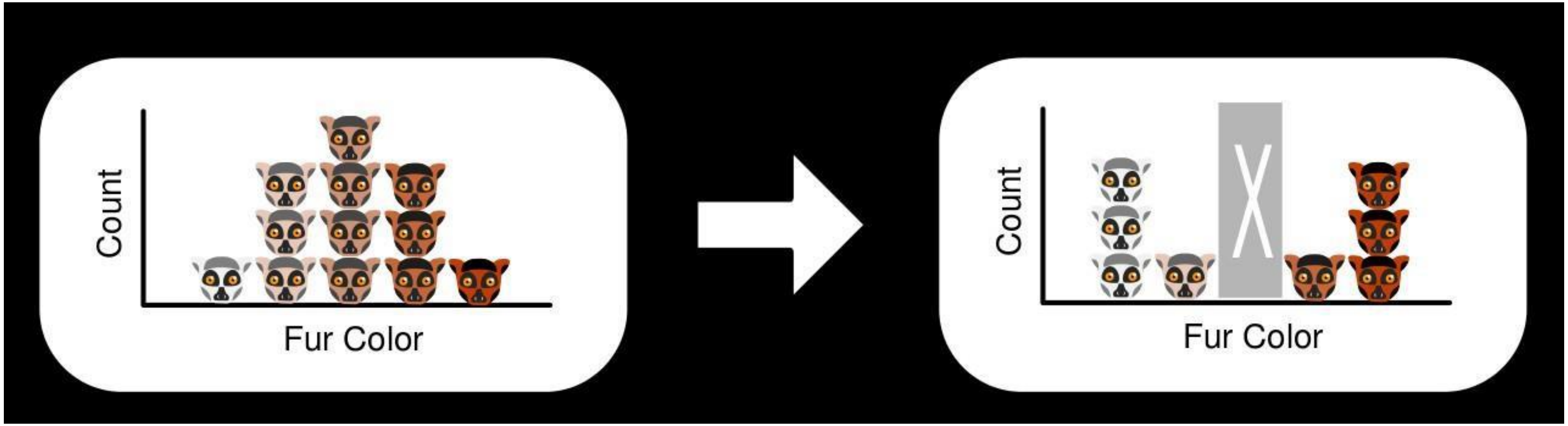
> 4 eggs, not all chicks may be fed sufficiently (e.g. chicks are malnourished)

< 4 eggs, risk that no offspring will survive (e.g. due to predation)

http://rachelbio11.weebly.com/evolution--taxonomy.html

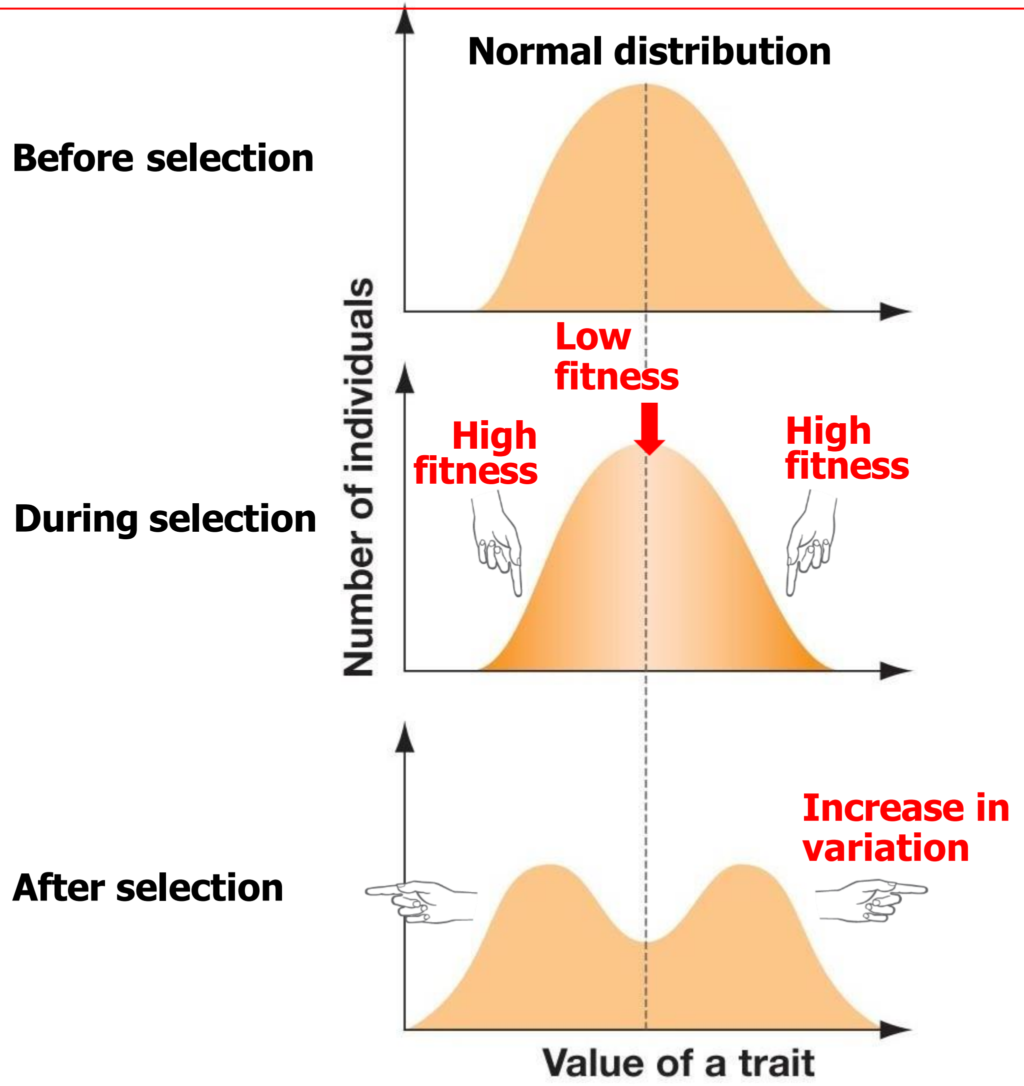
3. Disruptive Selection

Both extremes are favoured at the expense of intermediate phenotypes



Disruptive Selection

Average value of the trait remains the same.
Increase in variation (differences between individuals in a population)

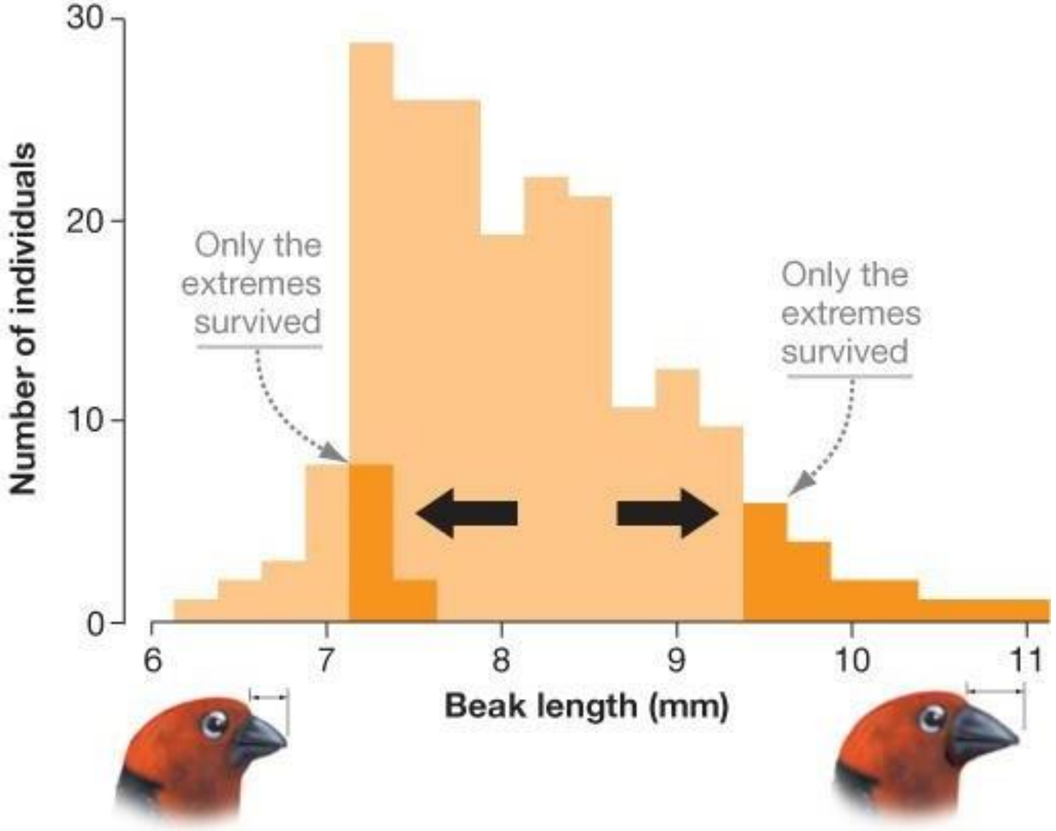


Often drives speciation.

We will return to this point in the lecture on speciation.

Example - Disruptive Selection

Black-bellied seedcrackers have two distinct beak sizes, large and small. They specialize on different seeds to reduce competition for food. (Smith 1993)

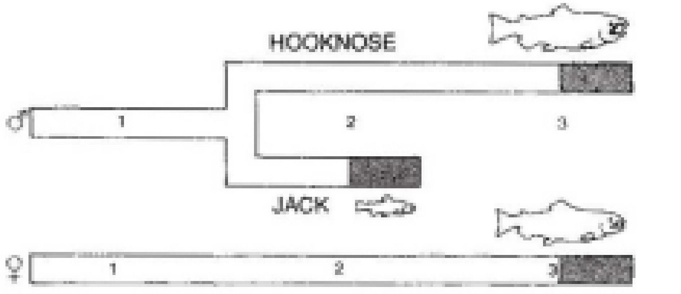


Disruptive selection on life history strategies of chinook salmon

Two strategies for when male chinook salmon become sexually mature:

1. Some males become sexually mature at 2 years old, when the fish is relatively small = jack salmon (be a sneaky male); see shaded area in figure below.
2. Some males wait until 3 years old to become sexually mature = larger hooknose males (be a strong competitor)

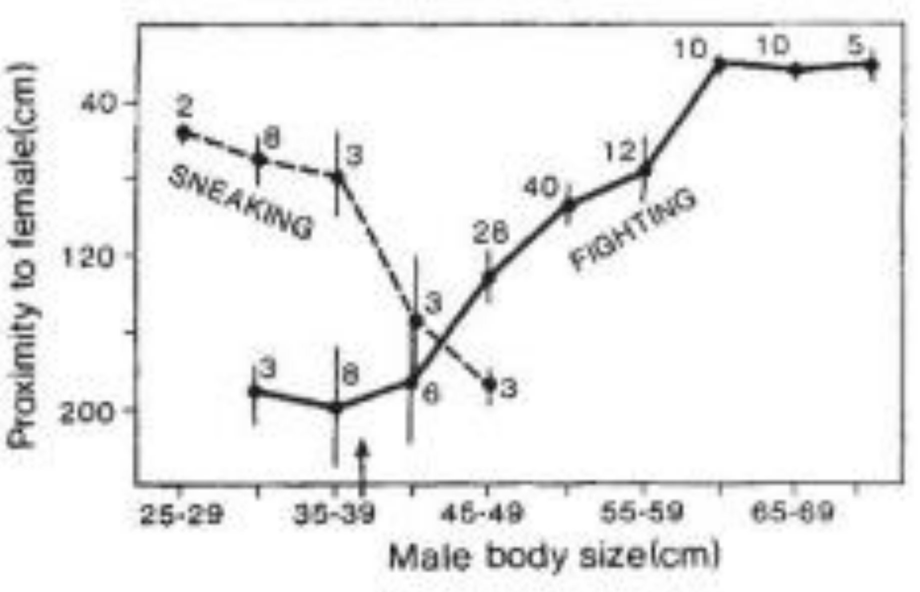
Intermediate-sized fish have lower fitness; not big enough to be competitive; and not small enough to be sneaky



Disruptive selection for alternative life histories in salmon

Mart R. Gross

Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia, Canada V5A 1S6



See slides on chinook salmon later in lecture,

iClicker Question

In 1996, a six-day cold spell killed thousands of cliff swallows in Nebraska, and reduced the population size by 53%

The figure on the right shows the distribution of body sizes in this population before (light green) and after (dark green) this cold snap.

Is this an example of:

A. Directional selection

B. Stabilizing selection

C. Disruptive selection

D. I am not sure

E. I can't resist ☺ .

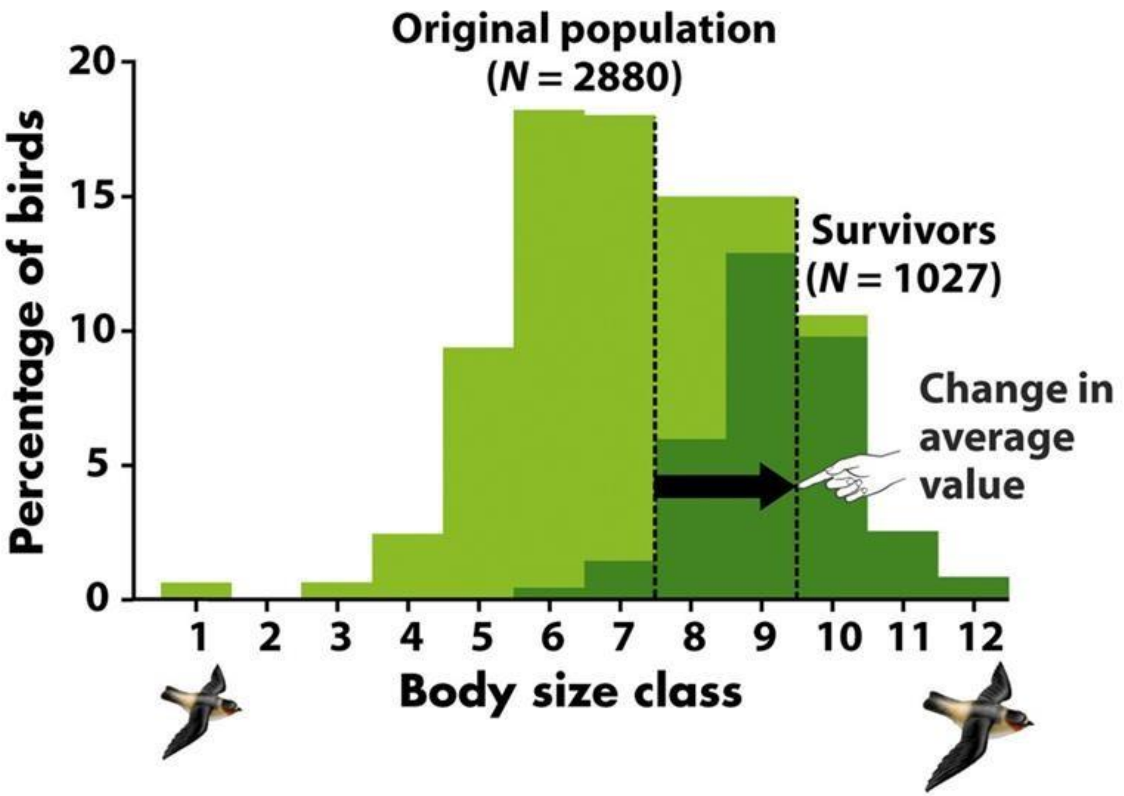


Figure 24-2b Biological Science, 2/e

Answer

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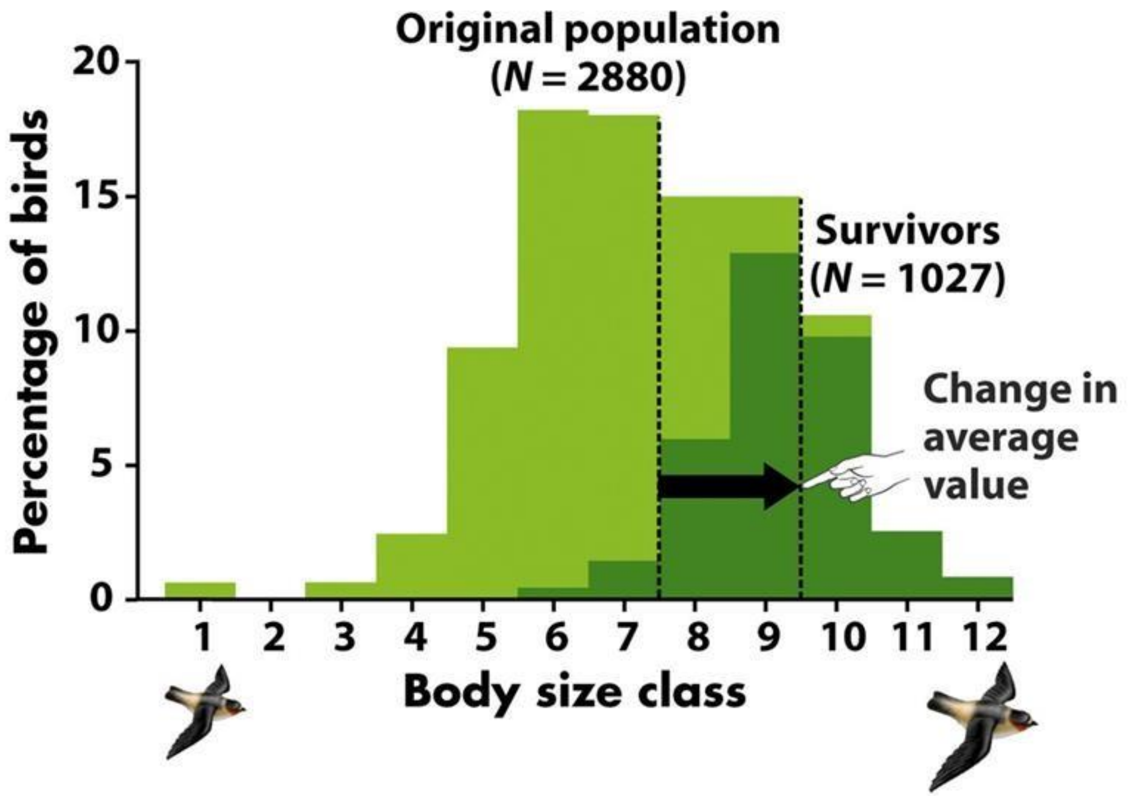

Figure 24-2b Biological Science, 2/e

iClicker Question

Reindeer calves are typically born in the spring.

If calves are born earlier in the year sufficient vegetation may not be available for the calves to feed upon, and the mothers may not be able to compensate completely with her milk.

If calves are born in the summer, plants become harder to digest later in summer; so, calves born later may have difficulty obtaining sufficient energy and nutrient to grow before their first winter.

What type of selection do you think may be acting on the birth date of the calves?

A. Directional selection
B. Stabilizing selection
C. Disruptive selection
D. I am not sure

iClicker Question

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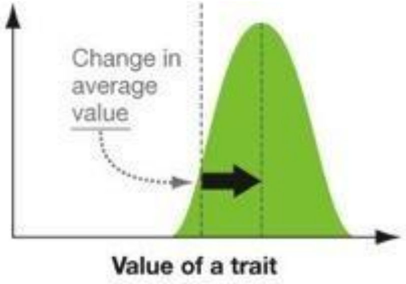
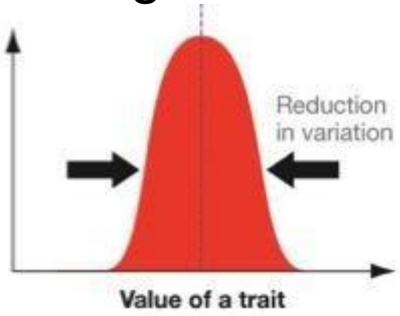
A. Directional selection
B. Stabilizing selection
C. Disruptive selection
D. I am not sure

Type of Selection:	Average trait value:	Phenotypic variation:
Directional	Increases or decreases	Reduced
Stabilizing	Does not change	Reduced
Disruptive	Does not change	Increased

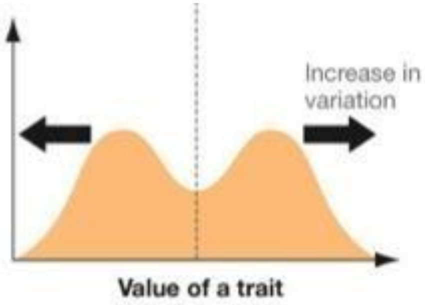
Directional



Stabilizing



Disruptive



Up to this point….

- Natural Selection: Ecological Selection
  - the environment largely determines which alleles get passed on to the next generation (e.g. water availability, environmental temperatures, food availability, predators, competitors)

Charles Darwin's Theory of Sexual Selection

- Darwin recognized that his Theory of Natural Selection could not explain certain traits, particularly traits that were found only in males (and not females).

- In some species, there are distinct differences in size/appearance/behaviour/physiology between males and females. This is called sexual dimorphism.

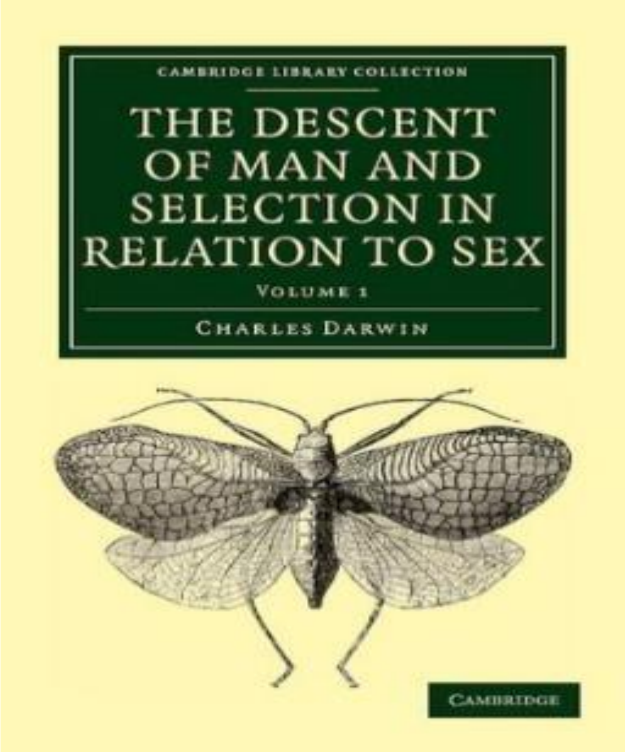
- Darwin recognized that some of these sexually dimorphic traits had the potential to decrease the survivorship of the individuals that bore them, e.g. by:
  - increasing the risk of being spotted by a predator;
  - making it more difficult to evade a predator; and
  - requiring a lot of energy to produce and/or maintain

https://www.pinterest.ca/pin/435441857723876538/

https://www.judithhand.net/sexual-dimorphism.html

Charles Darwin's Theory of Sexual Selection

- In an 1871 publication, Darwin suggested that another evolutionary force was at work.
- He called this force <u>sexual selection</u>.



Natural Selection - Sexual Selection

Darwin argued that:

- sexually dimorphic traits could be explained by the struggle for mates/mating opportunities.

- certain conspicuous traits (e.g. large size, bright colouration, intricate dances) that potentially decrease survival could be selected for if they gave an individual an advantage in the struggle for reproduction, either by:
  - enabling an individual to outcompete rivals for access to a mate; or
  - increasing the likelihood that an individual would be able to woo a prospective mate.

Darwin recognized two mechanisms of sexual selection

(i) Competition for mates (intrasexual selection): male-male interactions (mostly)

(ii) Mate choice (intersexual selection): female mate choice (mostly)

iClicker Question – Sexual Selection

Is a male's fitness, in part, a function of how often they mate?

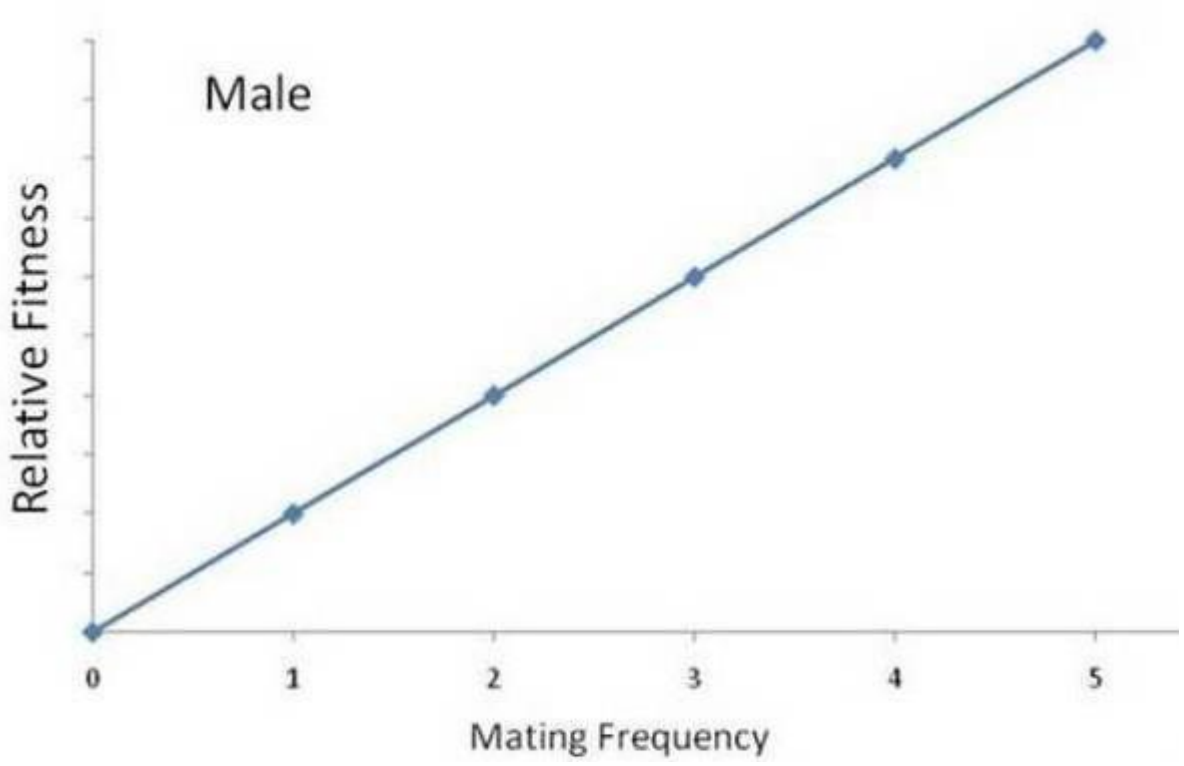
A. Yes
B. No
C. Not sure

Answer

Is a male's fitness, in part, a function of how often they mate?

A. Yes
B. No
C. Not sure

The more times that a male can mate the greater the number of eggs that he can potentially fertilize; and the more of his alleles are being passed to the next generation.



https://www.nature.com/scitable/knowledge/library/mating-systems-in-sexual-animals-83033427/

Competition for mates - direct male-male interactions

- Males may physically combat each other
- Males may evolve:

- "weapons" that give them an advantage in a fight

www.Wikipedia.org

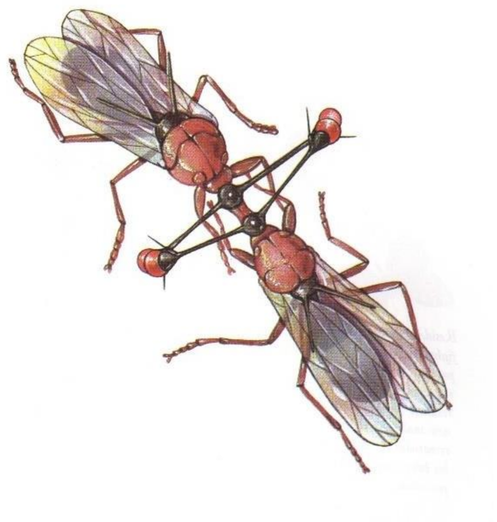
https://www.springfieldnewssun.com/news/deer-bucks-lock-horns-front-porch-california-home/3IrYFSWpFQV2P09WNUdX4H/

Physical combat can be costly to both males

http://www.youtube.com/watch?v=DU4xW79ASsg

Male-male interactions do not always involve direct combat

- Males evolve ornaments and/or behaviours that signal to the other males their “fighting ability”.



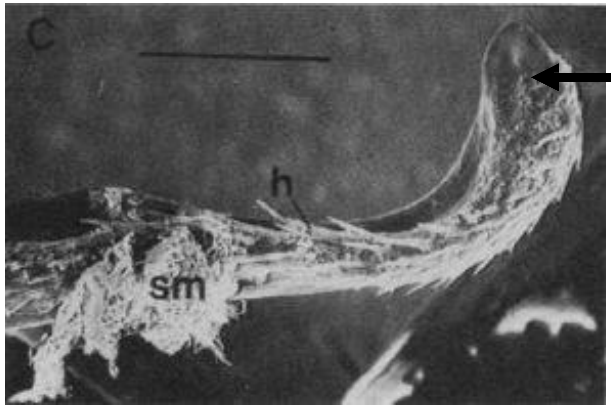
Male stalk-eyed fly

Gorillas:
Reveal teeth when yawning.
Large body size.

Other “sneaky” tactics males use to avoid direct combat

https://www.whatsthatbug.com/2009/07/01/mating-ebony-jewelwings-4/

https://www.livescience.com/48212-animal-sex-snakes.html



Spoon-shaped penis to scoop out competitors sperm – damselflies and dragonflies

http://ccsbio.blogspot.ca/2010/04/i-googled-dragonfly-penis-so-you-dont.html

http://www.iflscience.com/plants-and-animals/male-snakes-invest-lots-energy-producing-mating-plugs/

Other indirect tactics

Tiger salamander males mimic the female's dance to attract a mate, then destroy the genetic material of the other male.

A male fruit fly less than one-tenth of an inch long. Note the black bristles on his front legs, which he uses to stroke the female during courtship.

Drosophila melanogaster males marks a female with the scent of a male to make her less attractive to other males.

Woodlice – some males mimic females to get closer to the females

Next class (Tuesday after Reading Week)

- Finish sexual selection (finish male-male interactions, female mate choice)
- Mechanism #4 – Genetic Drift
- Start Hardy-Weinberg Equilibrium – if time (very unlikely).