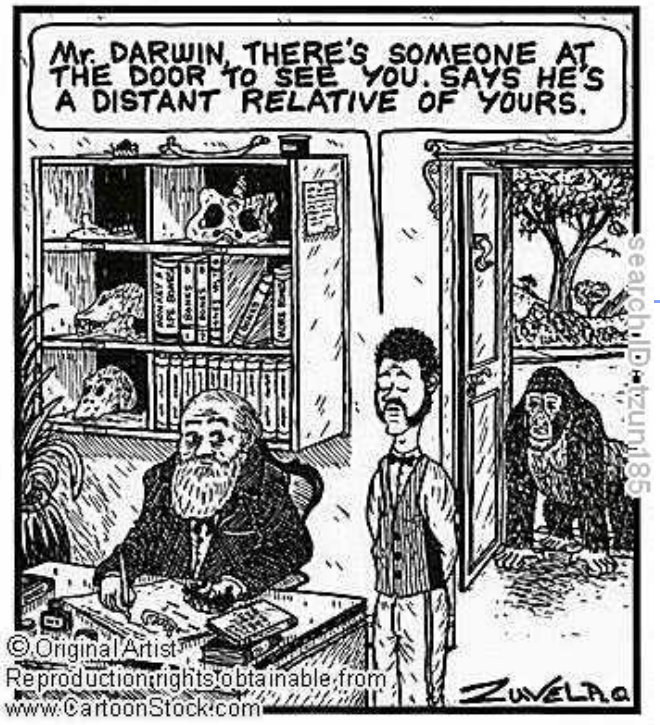
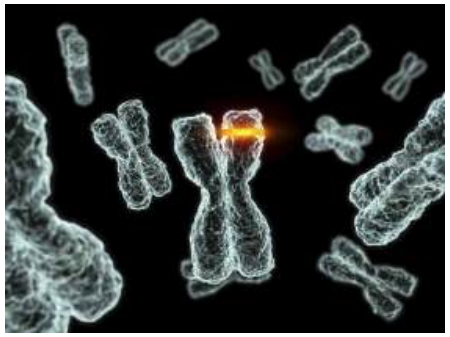
Measuring Evolution of Populations

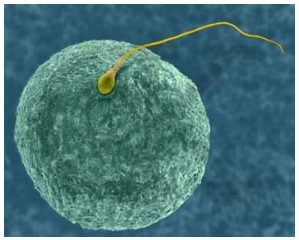


Variation in a population

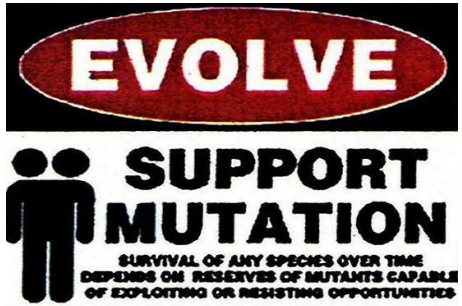


Mutations and sexual reproduction produce the genetic variation that makes evolution possible

- **Mutations: Changes in the nucleotide sequence of an organisms DNA - *original source of all gene variation***
  - **Must occur in cell lines that produce gametes to be passed on to offspring and the next generation**
- **Three mechanisms that occur during sexual reproduction shuffle existing alleles into new combinations**



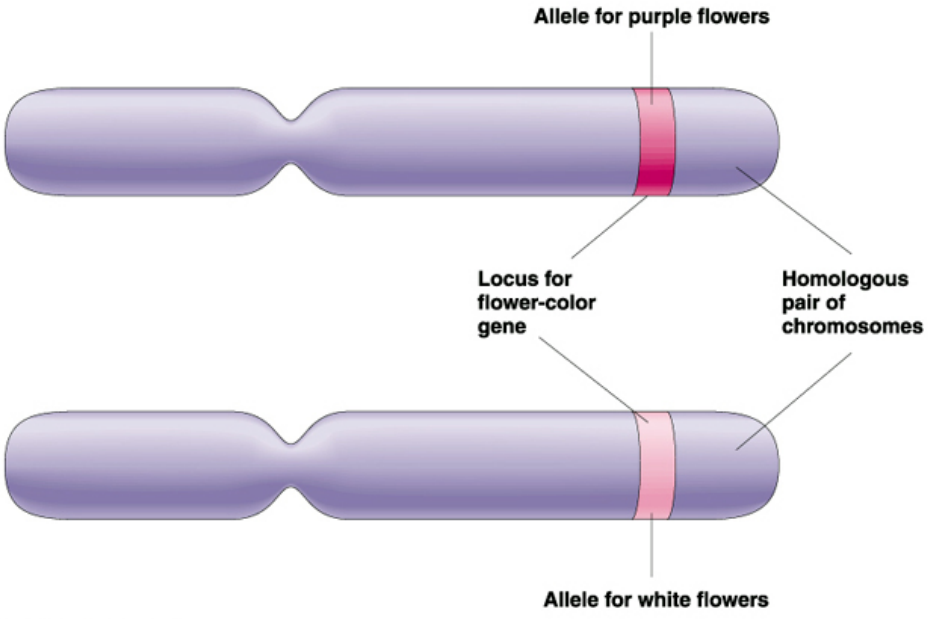
1. **Crossing over**
2. **Independent assortment of chromosomes**
3. **Fertilization**



- **Remember though that all the differences between alleles originally arose from past mutations.**
  - **Mutations are the Ultimate source of genetic variation!**

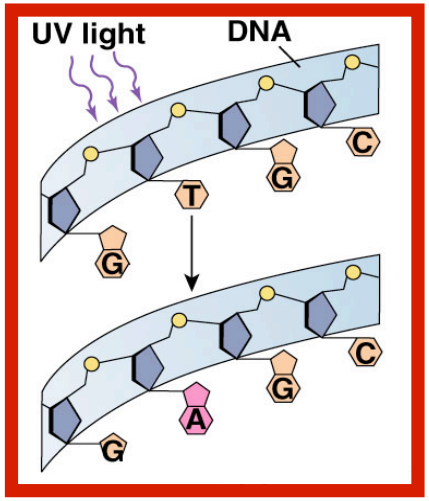
Variation in a population

- **Concepts to remember:**
  - a **population** is a localized group of interbreeding individuals
  - **gene pool** is the **collection of alleles** in the population
    - remember the difference between **alleles** & **genes**!
  - **allele frequency** is how common is that allele in the population
    - how many **A** vs. **a** in whole population

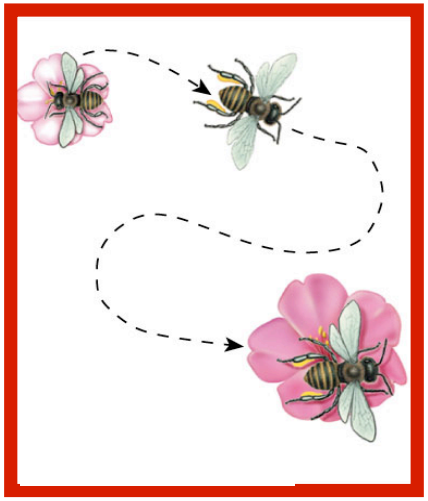


5 Agents of evolutionary change

(3 of which are the main forces behind changes in allele frequencies)

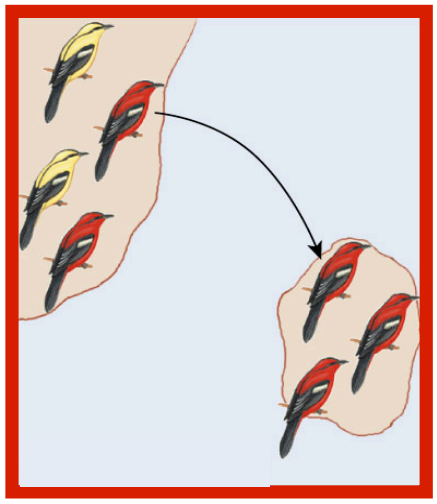


Mutation

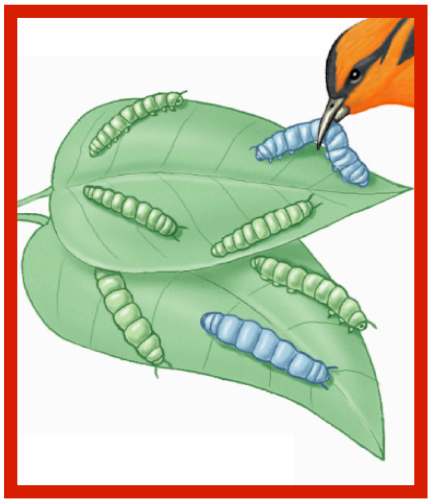


Gene flow

Nonrandom Mating



Small Population Sizes



Natural Selection

ONLY natural selection improves the match between organisms and the environment, a process called ADAPTIVE EVOLUTION

Evolution of populations

- **Evolution** = change in allele frequencies in a population
  - **Hypothetically speaking: what conditions would cause allele frequencies to not change?**
    - Non-evolving population experience NO agents of evolutionary change
      1. very large population size (no genetic drift - chance changes in gene pool)
      2. no migration (no gene flow - movement of genes in or out of a population)
      3. no mutation (no genetic change)
      4. random mating (no sexual selection - ability for everyone to mate is equally likely)
      5. no natural selection (everyone is equally fit - makes equal contribution to the gene pool of the next generation)

Hardy-Weinberg equilibrium

- **Hypothetical, non-evolving population**
  - **preserves allele frequencies from generation to generation.**
    - **Frequencies REMAIN CONSTANT if evolution NOT occurring!**
- **The H-W Equation Serves as a model *(null hypothesis)***
  - **natural populations are rarely in H-W equilibrium!!!**
    - **useful model to measure if evolutionary forces are acting on a population!!!**
      - **Their formula predicts the EXPECTED genotype frequencies using the allele frequencies in a diploid Mendelian population IF A POPULATION IS NOT EVOLVING**
      - **Next you can compare the expected to the ACTUAL frequencies to see if there HAS BEEN EVOLUTIONARY CHANGE**

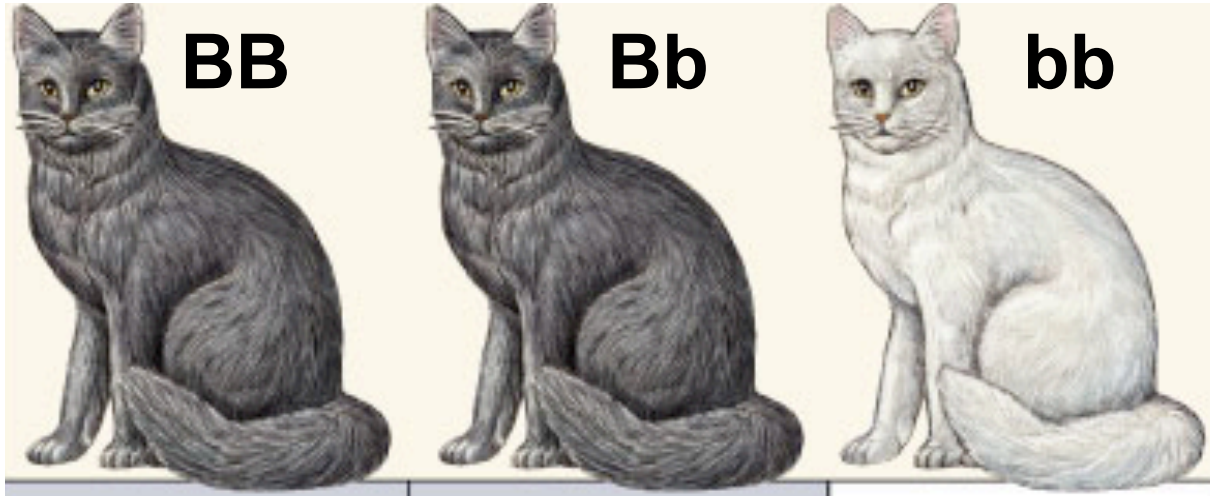
G.H. Hardy
mathematician

W. Weinberg
physician

Hardy-Weinberg theorem

- **Alleles**
  - assume 2 alleles = B, b
  - frequency of dominant allele (B) = *p*
  - frequency of recessive allele (b) = *q*
    - frequencies must add to 100%, so:

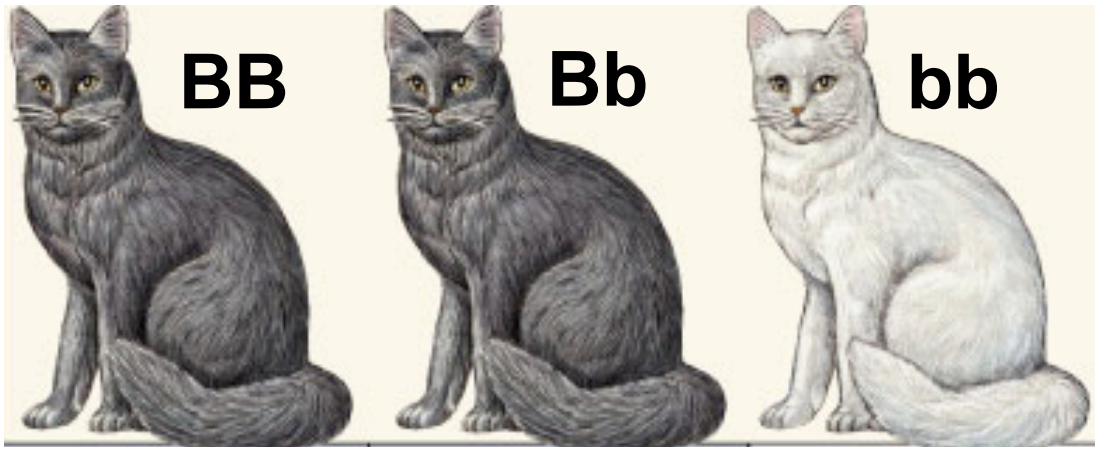
$$p + q = 1$$



Hardy-Weinberg theorem

- **Possible genotypes of Individuals:**
  - frequency of homozygous dominant
    (of having dominant AND dominant): $p \times p = p^2$
  - frequency of homozygous recessive
    (of having recessive AND recessive): $q \times q = q^2$
  - frequency of heterozygotes
    (dominant AND recessive OR recessive AND dominant):
    $(p \times q) + (q \times p) = 2pq$
    - frequencies of all individuals must add to 100%, so:

$$p^2 + 2pq + q^2 = 1$$



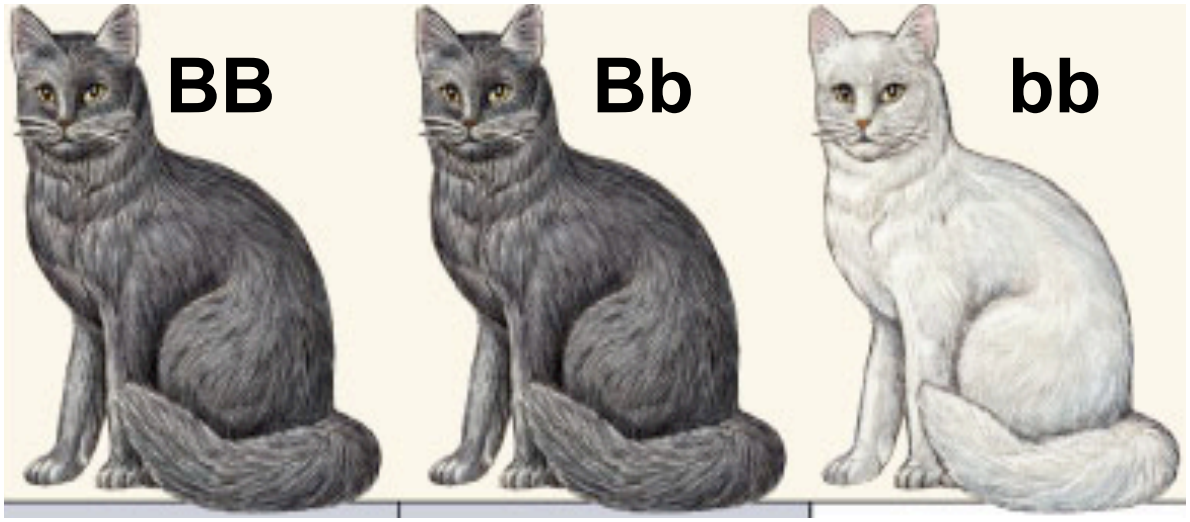
H-W formulas

- **Allele Frequencies:** $p + q = 1$

B b

- **Genotype Frequencies:** $p^2 + 2pq + q^2 = 1$

BB Bb bb



Using Hardy-Weinberg equation

Population: 100 cats

- 84 black
- 16 white

How many of each genotype exist?

q^2 (bb): 16/100 = .16

q (b): $\sqrt{.16}$ = **0.4**

p (B): 1 - 0.4 = **0.6**

p^2=.36
36 black

$2pq$=.48
48 black

q^2=.16
16 white

Must assume population is in H-W equilibrium!

Using Hardy-Weinberg equation

Assuming H-W equilibrium

p^2=.36 | $2pq$=.48 | q^2=.16

Null hypothesis

Sampled data

p^2=.74 | $2pq$=.10 | q^2=.16

How do you explain the data?

1. Hybrids are in some way weaker.
2. Immigration in from an external population that is predominantly homozygous B
3. Non-random mating... white cats tend to mate with white cats and black cats tend to mate with black cats.

Using Hardy-Weinberg equation

Assuming H-W equilibrium

Null hypothesis

p^2=.36 | $2pq$=.48 | q^2=.16

Sampled data

How do you explain the data?

p^2=.10 | $2pq$=.80 | q^2=.10

Heterozygote advantage.

Summary: Hardy-Weinberg Equations

- **Hardy-Weinberg equilibrium states that the amount of genetic variation in a population will remain constant from one generation to the next in the absence of disturbing factors.**
  - ***In a population with no mutations, no natural selection, no gene flow, large population size, & random mating***
- **To estimate the frequency of alleles in a population** *(where only 2 alleles exist for a gene)*, **we can use the Hardy-Weinberg equation:**
  - p = the frequency of the dominant allele, A
  - q = the frequency of the recessive allele, a
  - **For a population in genetic equilibrium:** $p + q = 1.0$
    - ***Remember, evolution occurs when the frequency of alleles change!***
- **Expected frequencies of the three possible genotypes can also be calculated using** $p^2 + 2pq + q^2 = 1$
  - p^2 = frequency of *AA* **(homozygous dominant)**
  - $2pq$ = frequency of *Aa* **(heterozygous)**
  - q^2 = frequency of *aa* **(homozygous recessive)**

Summary: Hardy-Weinberg Equations

- **In population genetics studies, the Hardy-Weinberg equation, $p^2 + 2pq + q^2 = 1$, can be used to measure whether the observed genotype frequencies in a population differ from the genotype *(and phenotype)* frequencies predicted by the equation.**
  - **We can also then measure if the individual allele frequencies have changed from one point in time to another using $p + q = 1.0$**
    - **Even if there is population growth, as long as the five conditions hold true, p and q values should not change since no evolution has occurred.**
    - **If the population is evolving, the allele frequencies p and q are changing and the population is NOT in equilibrium.**

Application of H-W principle

- Sickle cell anemia
  - inherit a mutation in gene coding for one of the hemoglobin polypeptides
    - Hemoglobin = oxygen-carrying blood protein
      - recessive allele = H^s
      - normal allele = H^b
  - Hemoglobin sticking to each forming crystals causes RBC to sickle
    - breakdown of RBC
    - clogging small blood vessels
    - damage to organs
  - often lethal

Sickle cell frequency

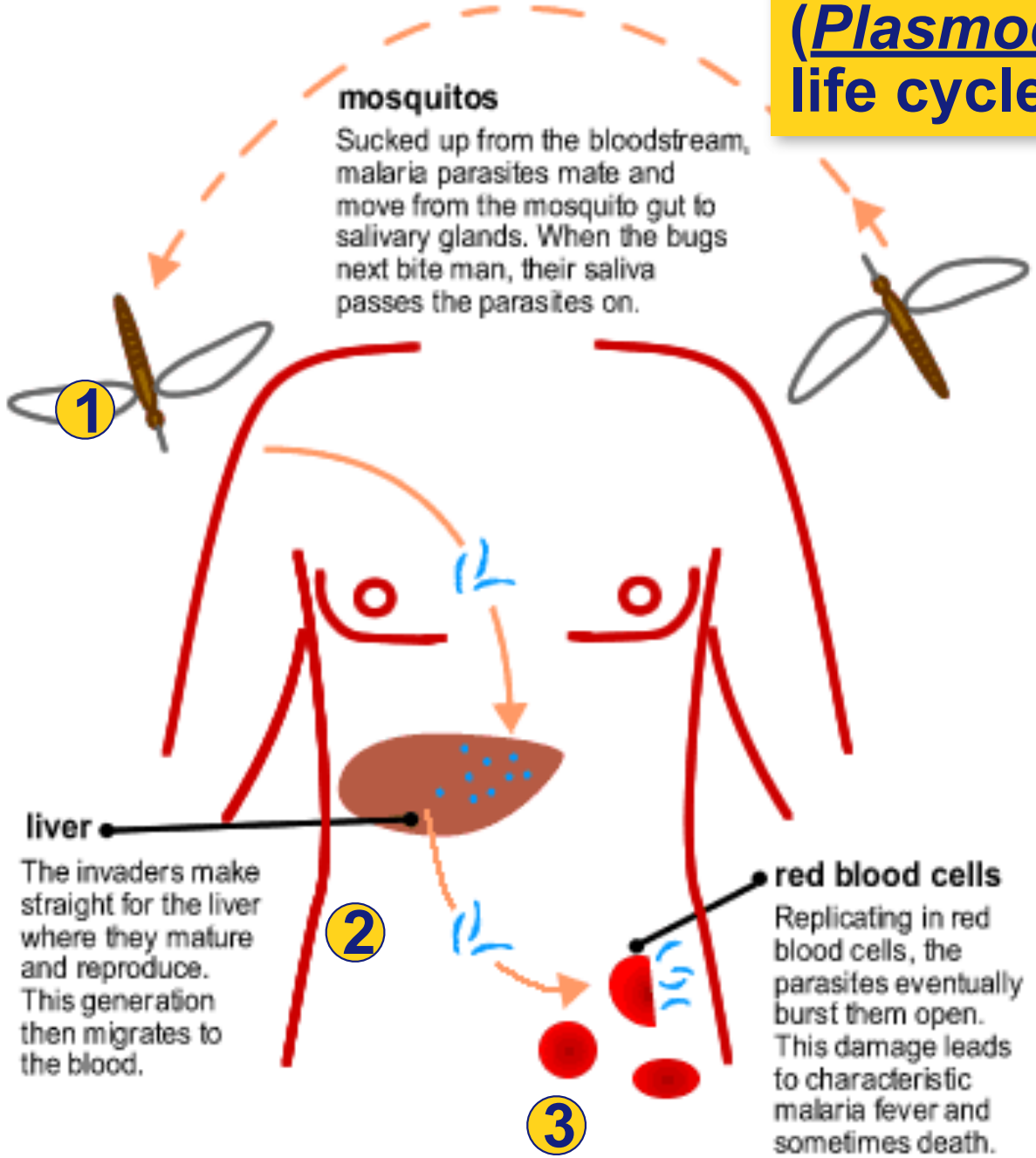
- There's a high frequency of heterozygotes found in sub-Saharan Africa compared to other areas.
  - 1 in 5 in Central Africans = H^bH^s
  - unusually high for allele with severe detrimental effects in homozygotes
    - This leads to high disease cases too (1 in 100 = H^sH^s)
      - usually die before reproductive age.

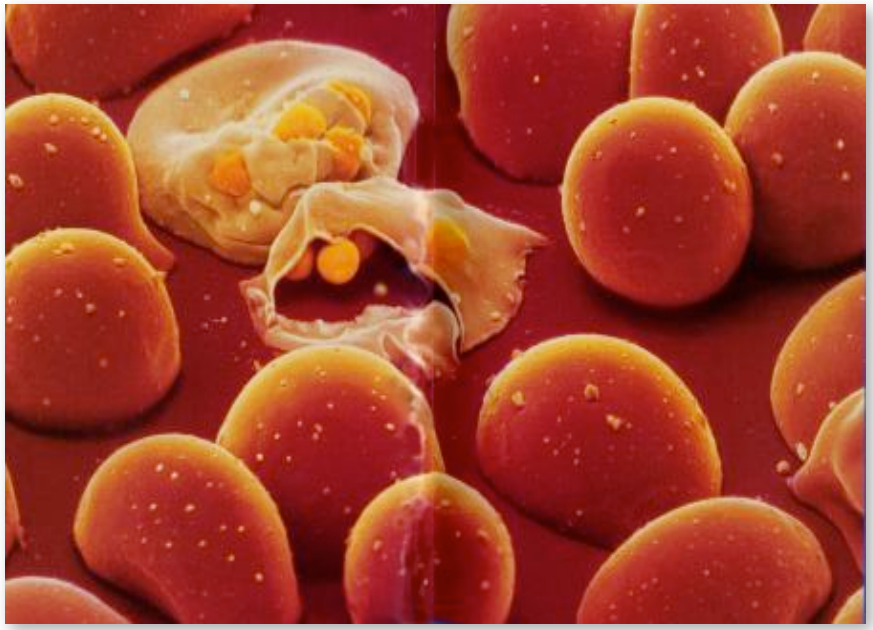
Why is the H^s allele maintained at such high levels in African populations?

Suggests some selective advantage of being heterozygous…

Malaria

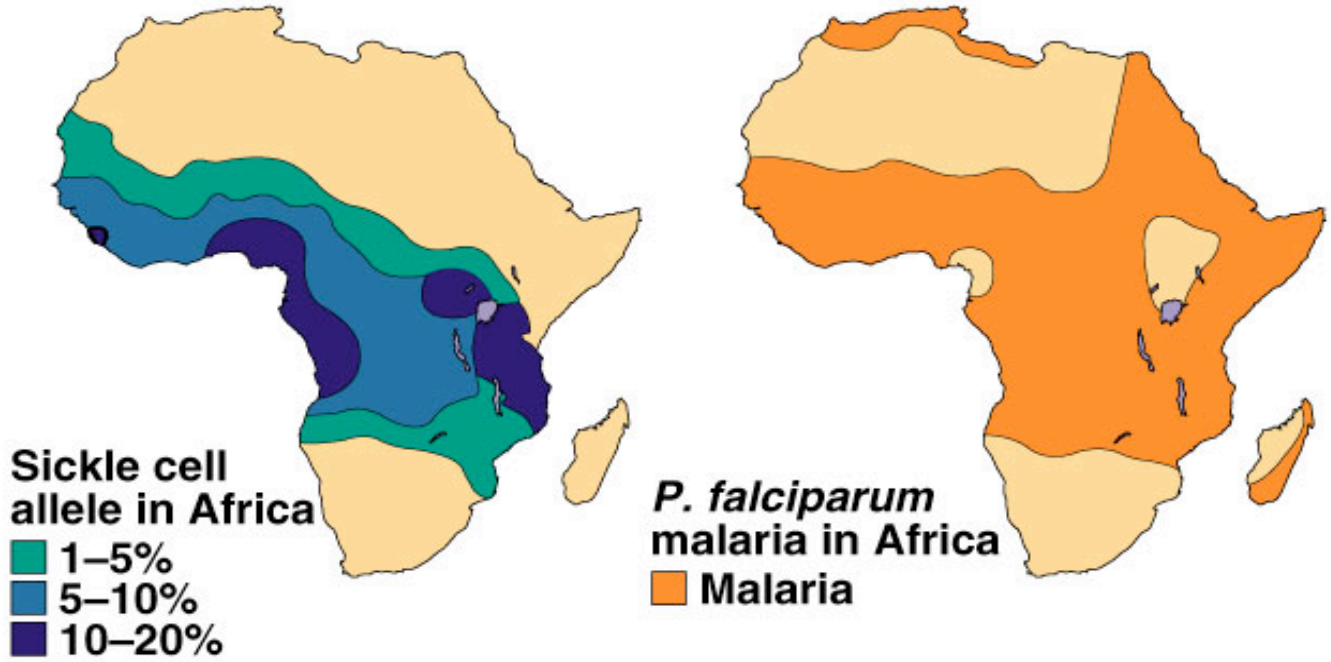
Single-celled eukaryote parasite (*Plasmodium*) spends part of its life cycle in red blood cells





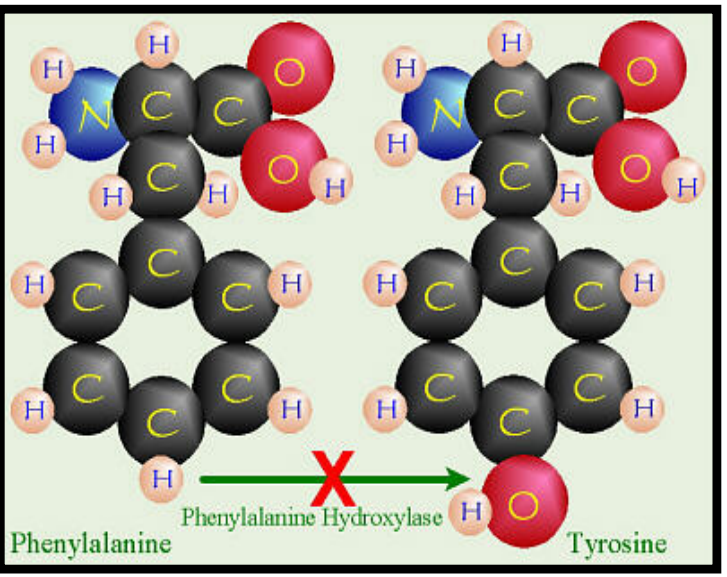
Heterozygote Advantage

- In tropical Africa, where malaria is common:
  - homozygous dominant (normal)
    - die or reduced reproduction from malaria: H^bH^b
  - homozygous recessive
    - die or reduced reproduction from sickle cell anemia: H^sH^s
  - heterozygote carriers are relatively free of both
    - survive & reproduce more so *heterozygotes are more common in this population:* H^bH^s



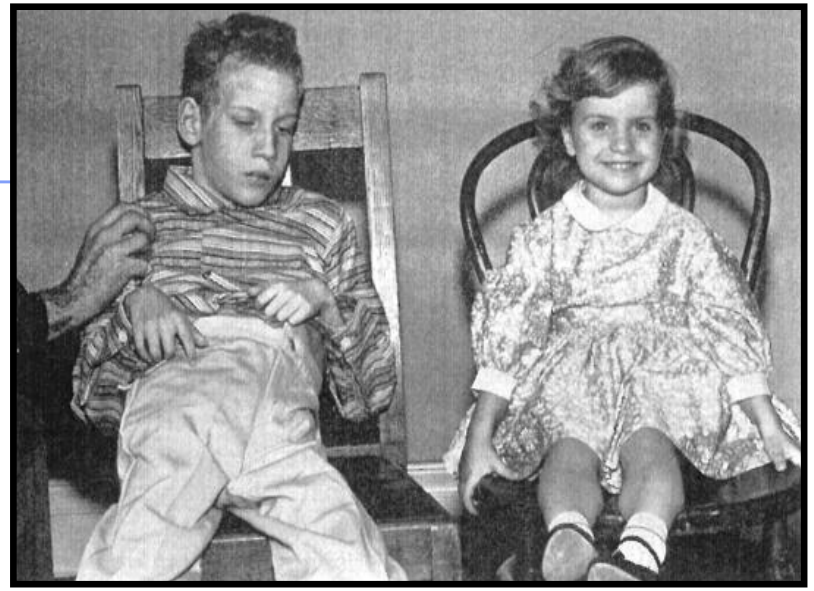
Real world application of H-W

- PKU (phenylketonuria) is a rare, inherited metabolic disease that results in mental retardation and other neurological problems
- The disease arises from the absence of a single enzyme (phenylalanine hydroxylase).
  - This enzyme normally converts the essential amino acid, phenylalanine, to another amino acid, tyrosine.



- Failure of the conversion to take place results in a buildup of phenylalanine.
- Through a mechanism that is not well understood, the excess phenylalanine is toxic to the central nervous system and causes the severe neurological problems normally associated with PKU.

PKU

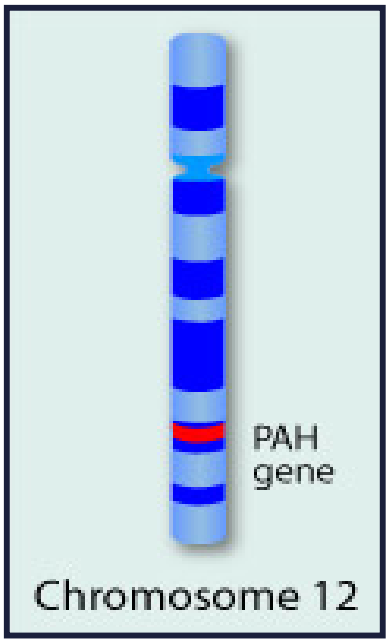


- When a very strict diet is begun early and well-maintained with no phenylalanine in it, affected children can expect normal development and a normal life span.

- PKU is an autosomal recessive genetic disorder.
  - The incidence of carriers in the general population is approximately one in fifty people, but the chance that two carriers will mate is only one in 2,500.
  - Carrier tests are available only through PKU treatment programs.

- What is we wanted to know the frequency of this allele in the human population?

PKU and Hardy-Weinberg



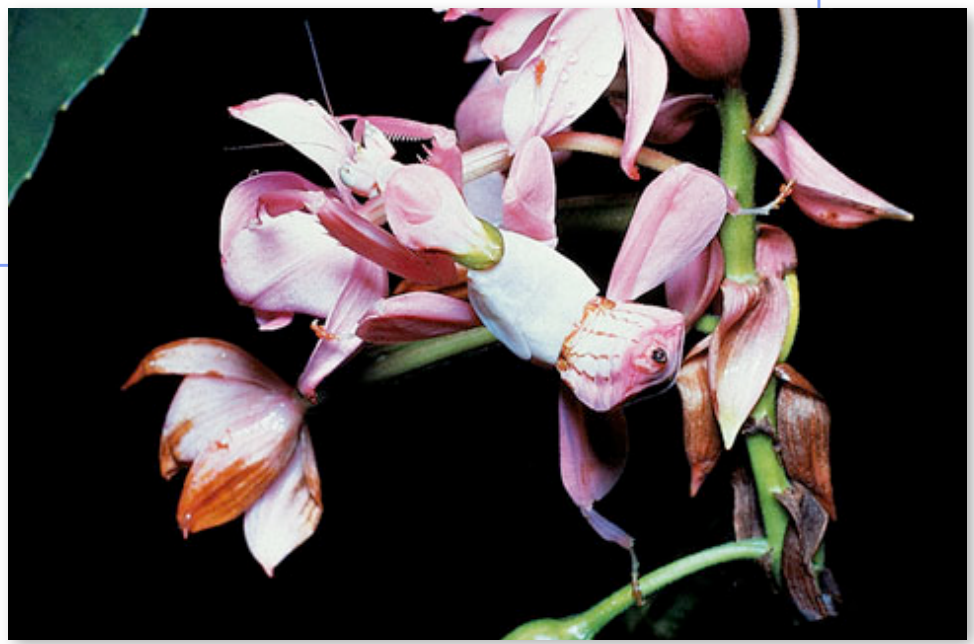
- What % of human population carries allele for PKU?
  - ~ 1 in 10,000 babies born in the US is born with PKU
    - disease is caused by a recessive allele

- **PKU = homozygous recessive (aa) genotype**
  - frequency of homozygous recessive individuals
    - q^2 (aa) = 1 in 10,000 = 0.0001
  - frequency of recessive allele (*q*):
    - $q = \sqrt{0.0001} = 0.01$
  - frequency of dominant allele (*p*):
    - *p* (A) = 1 – 0.01 = 0.99
  - frequency of carriers, heterozygotes:
    - 2pq = 2 x (0.99 x 0.01) = 0.0198 = ~2%
  - ~2% of the US population carries the PKU allele
    - 300,000,000 x .02 = 6,000,000

Any Questions??

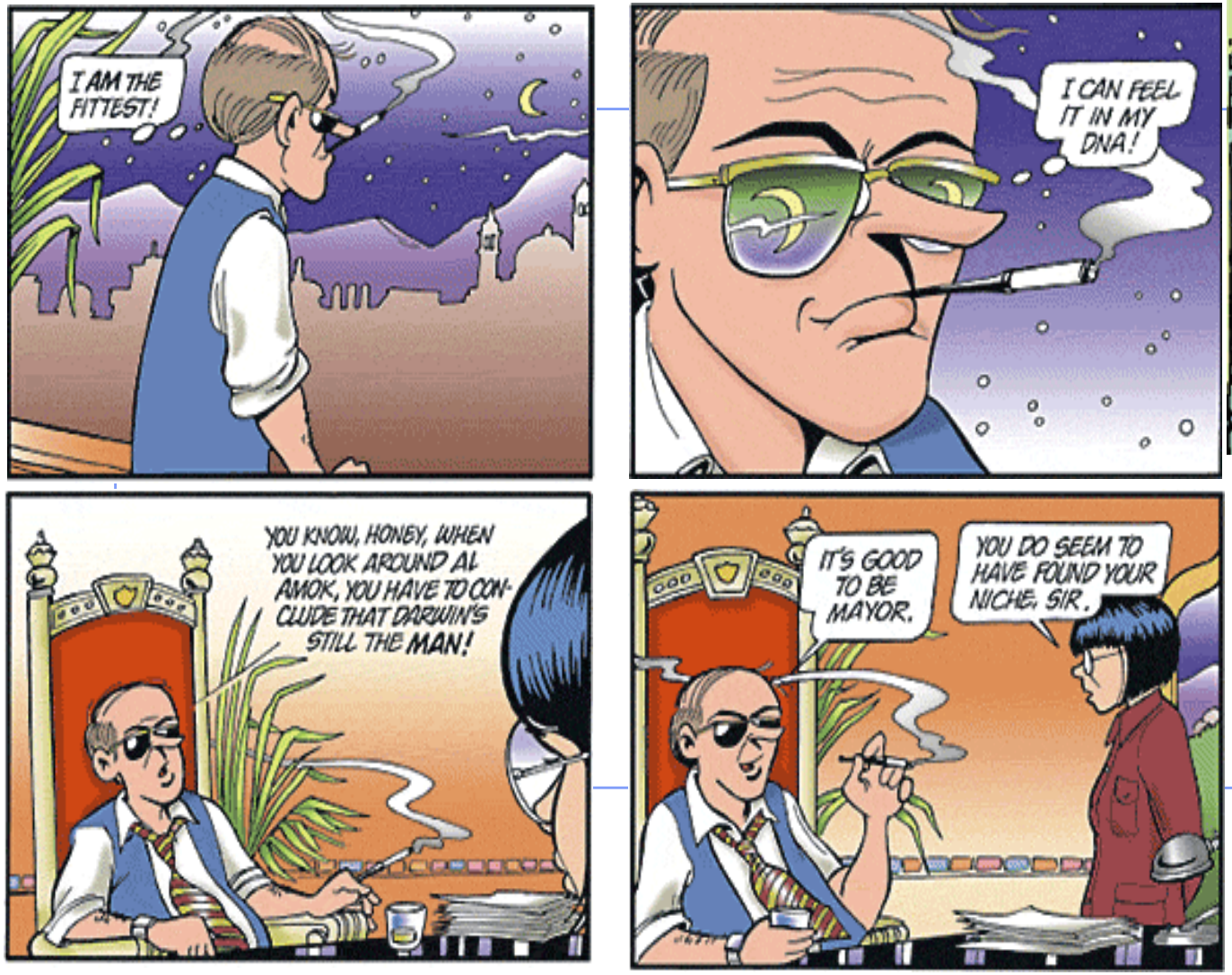
Evolutionary Forces

What changes populations?

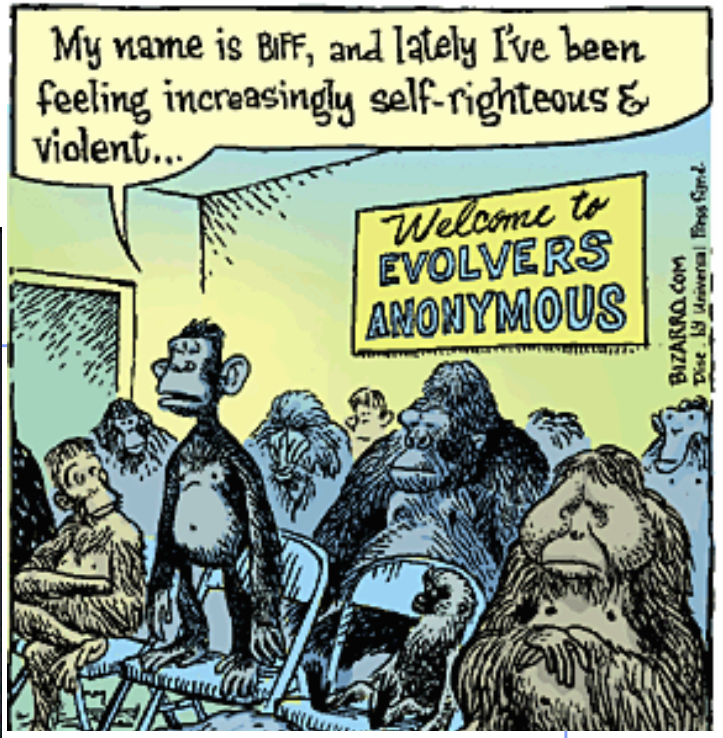


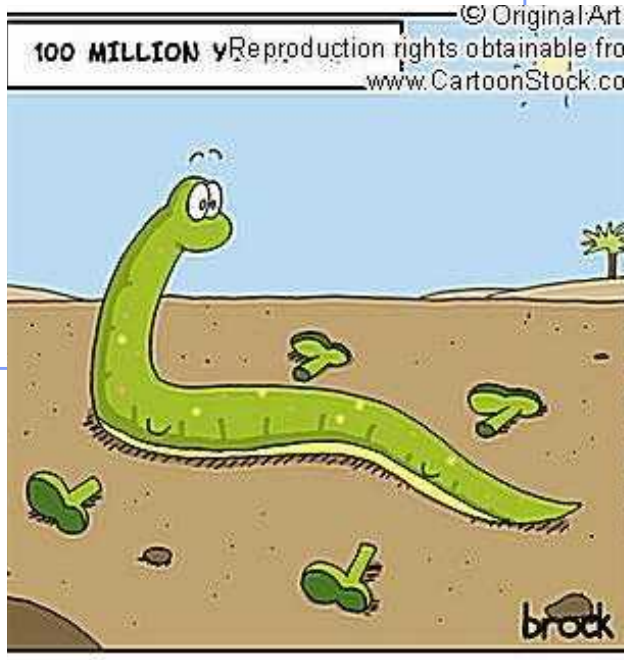
Evolution of Populations

Evolution of Populations



Doonesbury - Sunday February 8, 2004





And just like that, Larry Lizard found he'd evolved into a snake.

Evolving of populations violate one of the conditions of the H-W Equilibrium

- **Non-evolving population experience NO agents of evolutionary change**

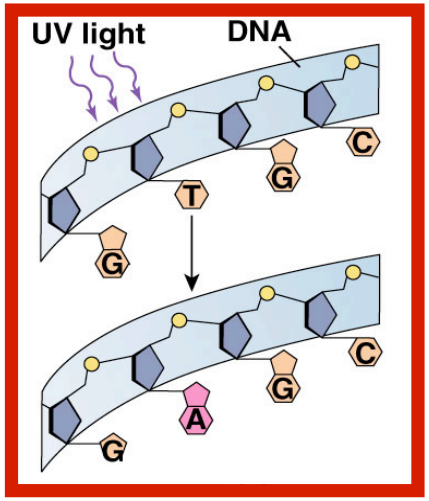
1. very large population size (no genetic drift - chance changes in gene pool)
2. no migration (no gene flow - movement of genes in or out of a population)
3. no mutation (no genetic change)
4. random mating (no sexual selection - ability for everyone to mate is equally likely)
5. no natural selection (everyone is equally fit - makes equal contribution to the gene pool of the next generation)

Evolution = change in allele frequencies in a population

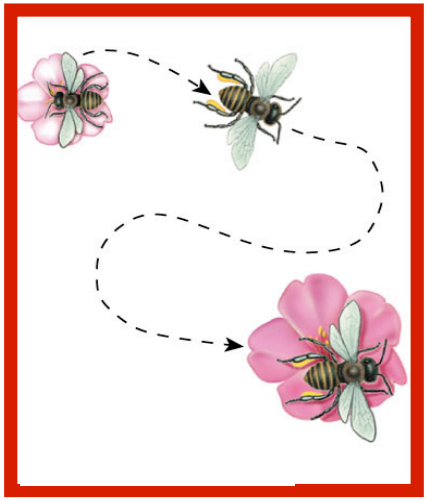
Changes can occur because of the following 5 events...

5 Agents of evolutionary change

(3 of which are the main forces behind changes in allele frequencies)

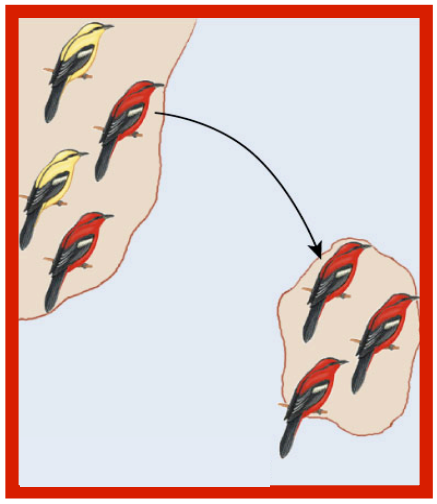


Mutation



Gene flow

Nonrandom Mating



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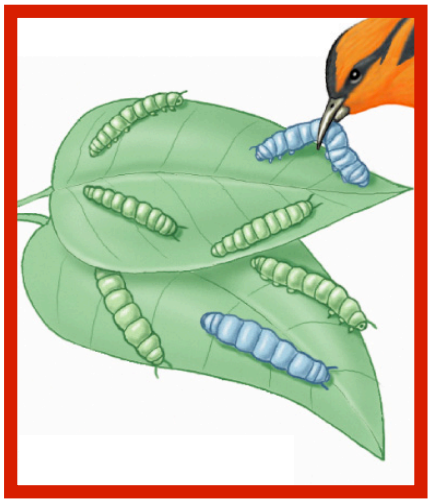
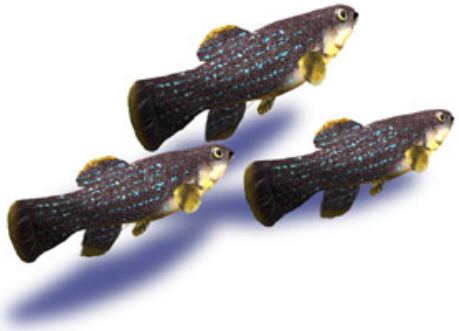


Natural Selection

ONLY natural selection improves the match between organisms and the environment, a process called ADAPTIVE EVOLUTION

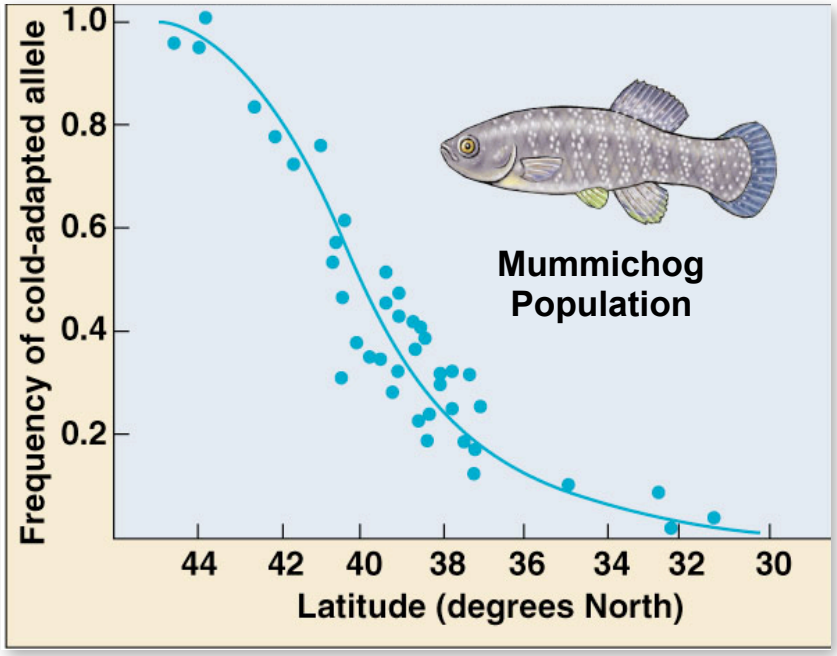
Populations evolve



- **Natural selection acts on: individuals**
  - differential survival
    - "survival of the fittest"
  - differential reproductive success
    - who bears more offspring

- **Populations evolve**
  - genetic makeup of population changes over time
  - favorable traits *(organisms with greater fitness)* become more common

Presence of lactate dehydrogenase allele Ldh-B^b which codes for a form of the enzyme that is a better catalyst in cold water



  - **Relative Fitness:** contribution an individual makes to the gene pool of the next generation relative to the contributions of other individuals

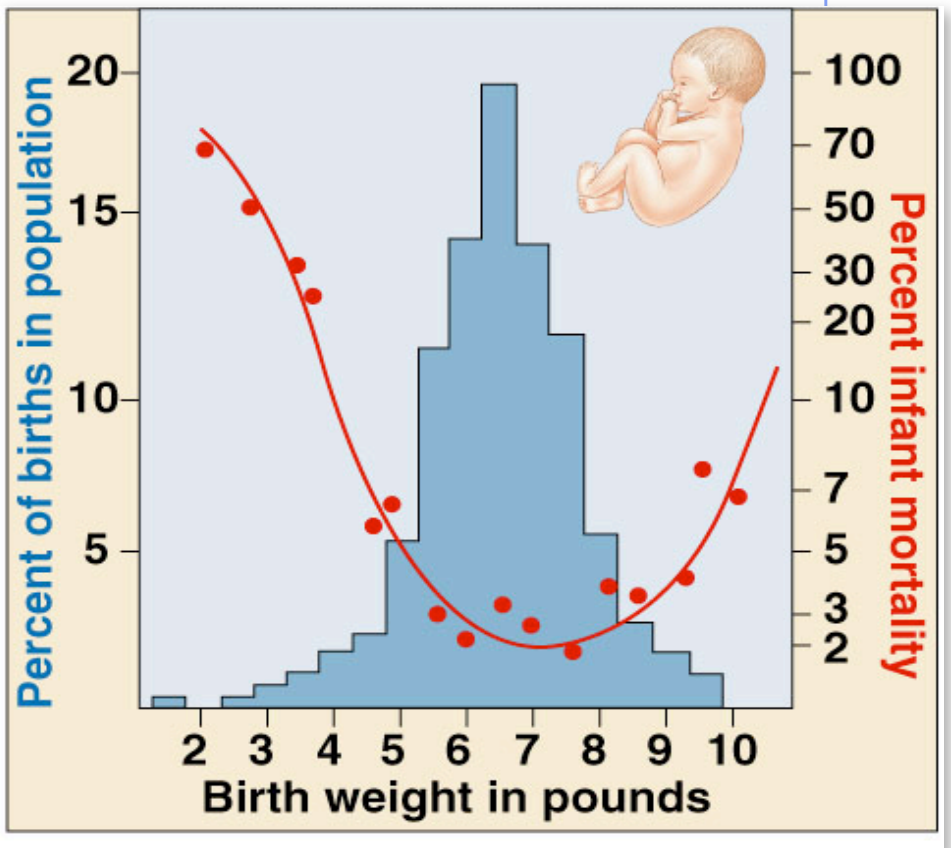
Individuals DON'T evolve…

Individuals survive or don't survive…

Individuals reproduce or don't…

Individuals are selected

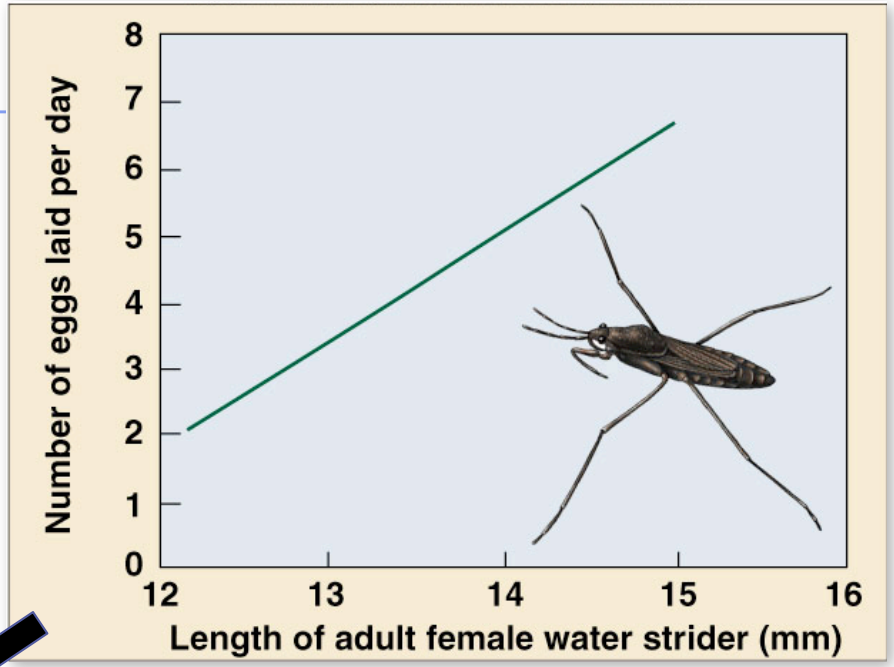
Populations evolve

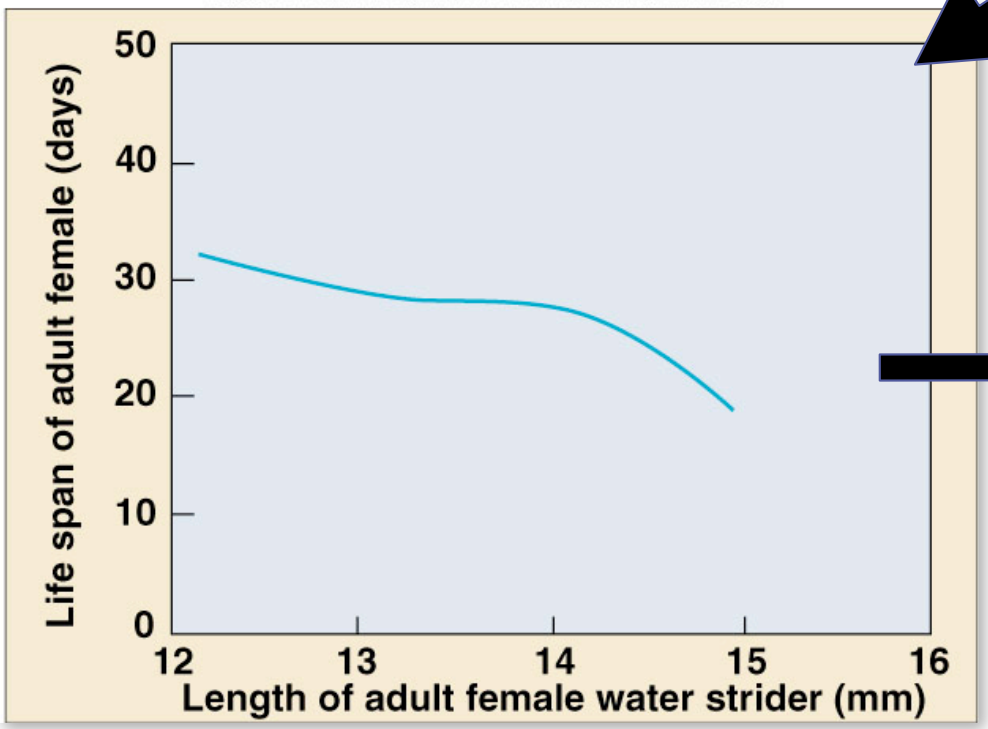


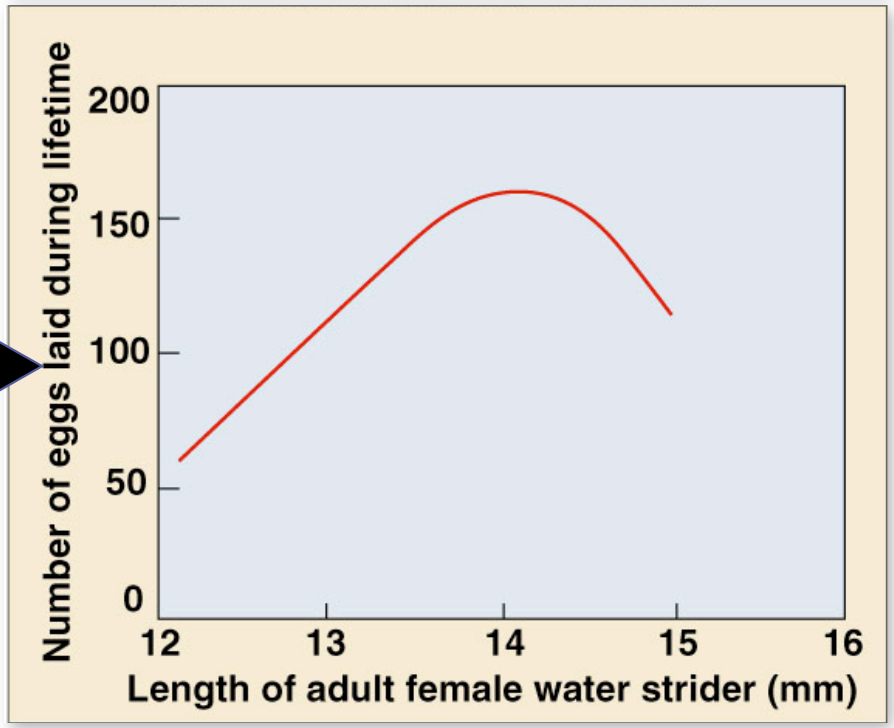
Fitness

- **Survival & Reproductive success**
  - **individuals with one phenotype leave more surviving offspring**
    - **If this phenotype is heritable, then this phenotype will be selected for**

Body size & egg laying in water striders



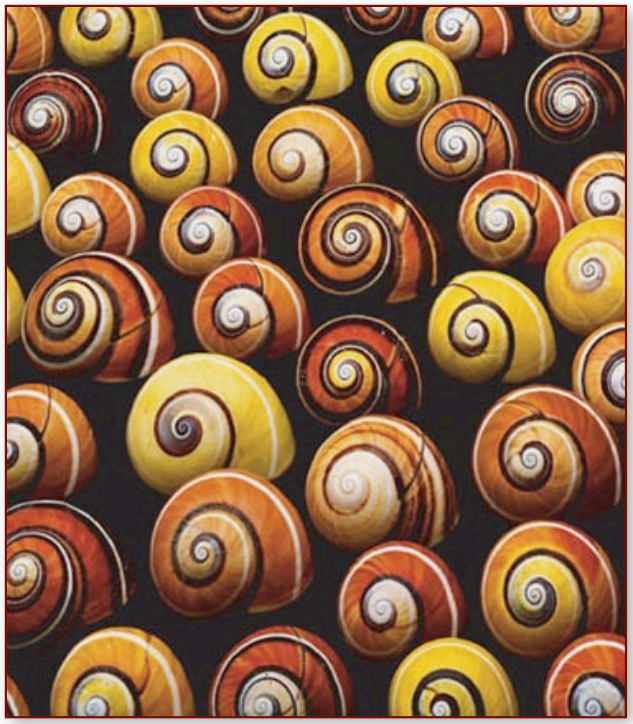




AP

Variation & natural selection

- **Variation** is the raw material for natural selection
  - there have to be differences within population
    - ultimate source of new variation = DNA mutations
      - sex shuffles alleles of genes into new combinations
  - some individuals must be more fit than others

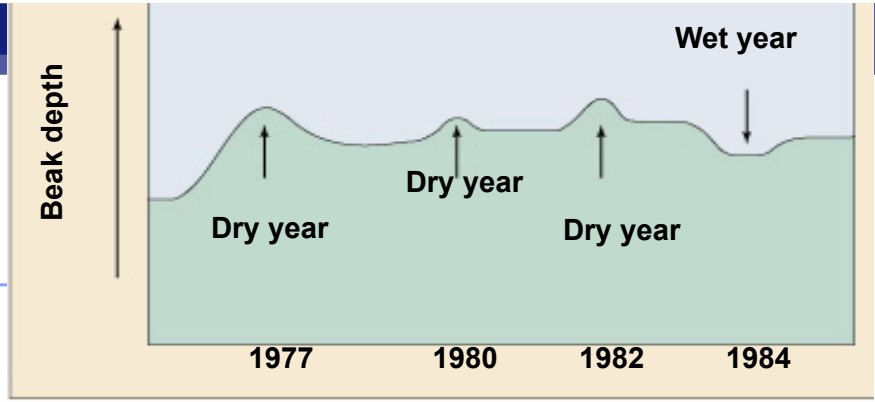


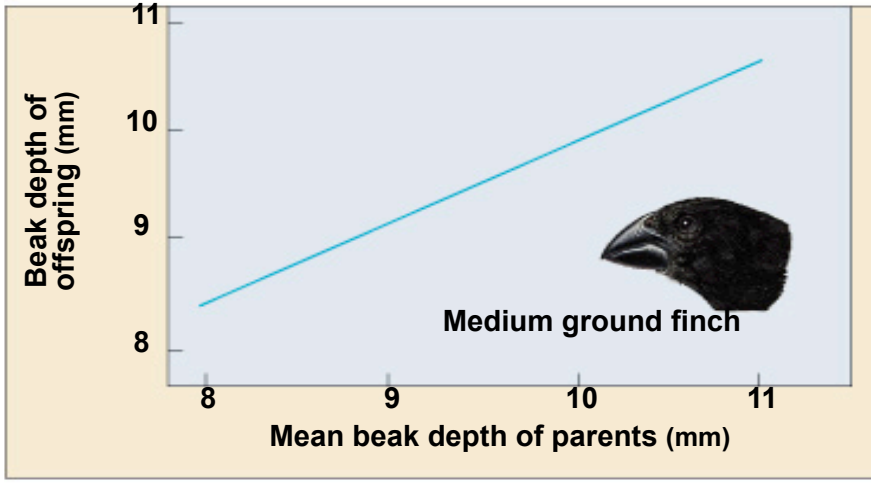
Where does VARIATION come from? 3 sources

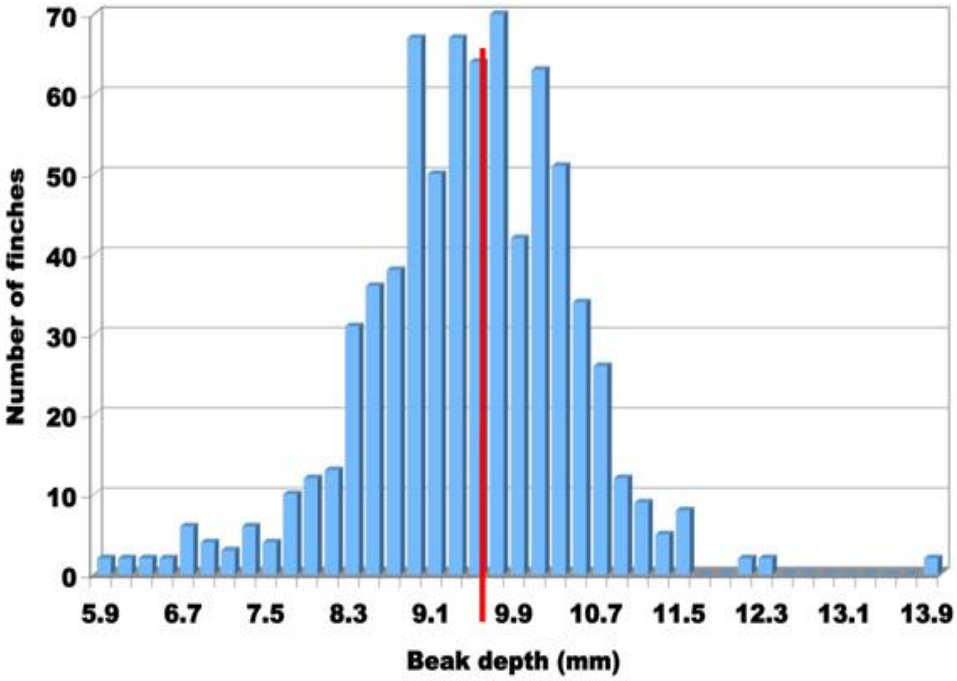
1. **Mutation - ULTIMATE source** (in sexual and asexual reproducing organisms)
   - random changes in the nucleotide sequence of DNA
     - errors in mitosis & meiosis
     - environmental damage

2. **Sexual Reproduction in Eukaryotes**
   - Causes a systematic mixing of alleles (through crossing over & independent assortment during meiosis and random fertilization of gametes from two parents)
     - recombination of alleles
       - new arrangements in every offspring
     - new combinations = new phenotypes
   - spreads variation vertically
     - offspring inherit traits from both parent

3. **Asexual Processes in Prokaryotes**
   - Conjugation, Transformation, & Transduction when possible
     - New cells can at times acquire new genes or new alleles of genes

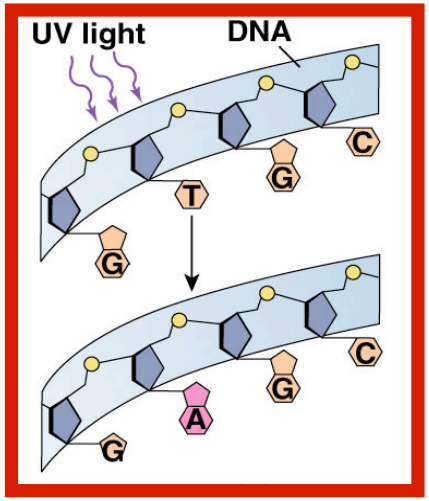




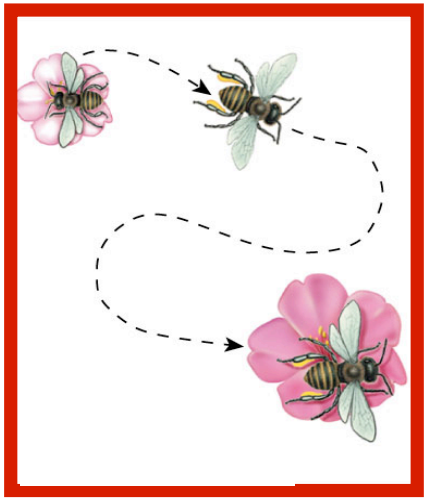


5 Agents of evolutionary change

(3 of which are the main forces behind changes in allele frequencies)

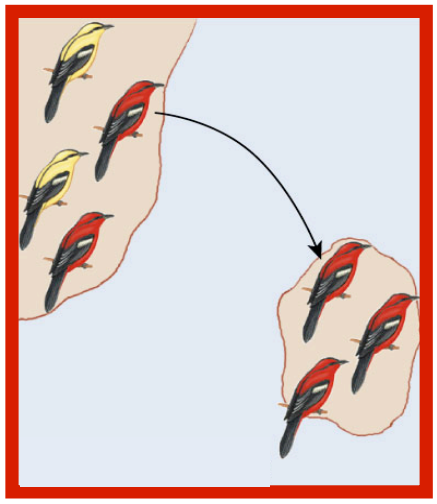


Mutation

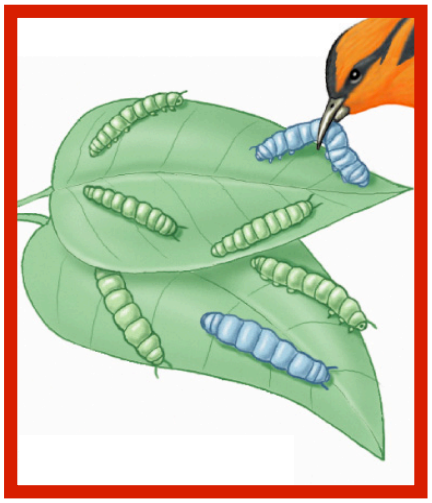


Gene flow

Nonrandom Mating



Small Population Sizes

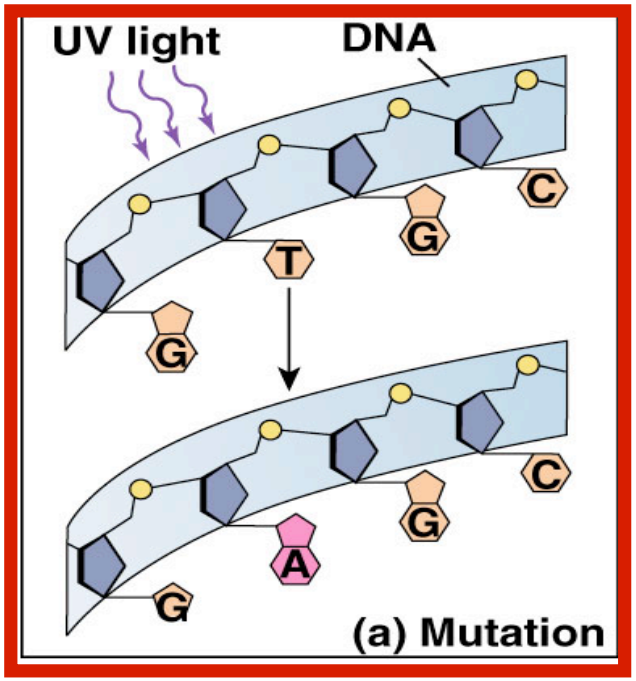


Natural Selection

ONLY natural selection improves the match between organisms and the environment, a process called ADAPTIVE EVOLUTION

1. Mutation

- Mutation creates & Variation variation
  - new mutations are constantly appearing
- Mutation changes DNA sequence
  - A change in the DNA may alter the codon in mRNA
    - This may change an amino acid in a polypeptide
    - This may change the protein
      - May change structure
      - May changes function
        - changes in protein may change phenotype & therefore change fitness



1. Mutation - rarely affect the next generation: Have more of an effect when they influence fitness in very positive or negative ways

Wild type allele:

Amino acids: M D D Q S R M L Q T L A G V N L

DNA codon: atggacgatcaatccaggatgctgcagactctggccggggtgaacctg

silent (third base pair) mutation:

M D D Q S R M L Q T L A G V N L

atggacgatcaatccaggatgctgcaaactctggccggggtgaacctg

point mutation (missense):

M D D Q S R M L K T L A G V N L

atggacgatcaatccaggatgctgaagactctggccggggtgaacctg

This mutation may alter polypeptide 3D folding, active site function, etc…

point mutation (nonsense):

M D D Q S R M L stop

atggacgatcaatccaggatgctgtagactctggccggggtgaacctg

frameshift leading to premature termination:

M D D Q S R M L R L W P G stop

atggacgatcaatccaggatgctgagactctggccggggtgaacctg

1. Mutation

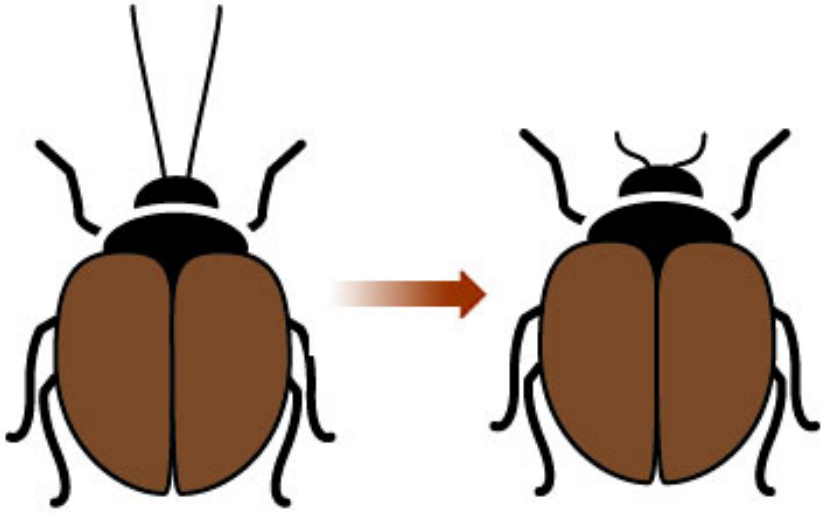
Lack of mutations in a population limits genetic change because no old alleles are turned into new alleles.

- **The frequency of all alleles remains the same.**
- **Once an inheritable mutation occurs, the allele frequency is changed.**

Mutations add to the genetic variability of populations over time and are thus the ultimate source of variation for evolution.

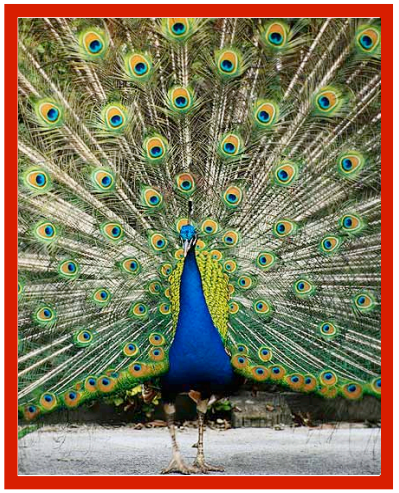
- **Mutations increase genetic variability that can be acted on by natural selection.**

In this way, mutations increase the opportunity for evolution of adaptations different from characteristics of the ancestral population.



2. Non-Random Mating

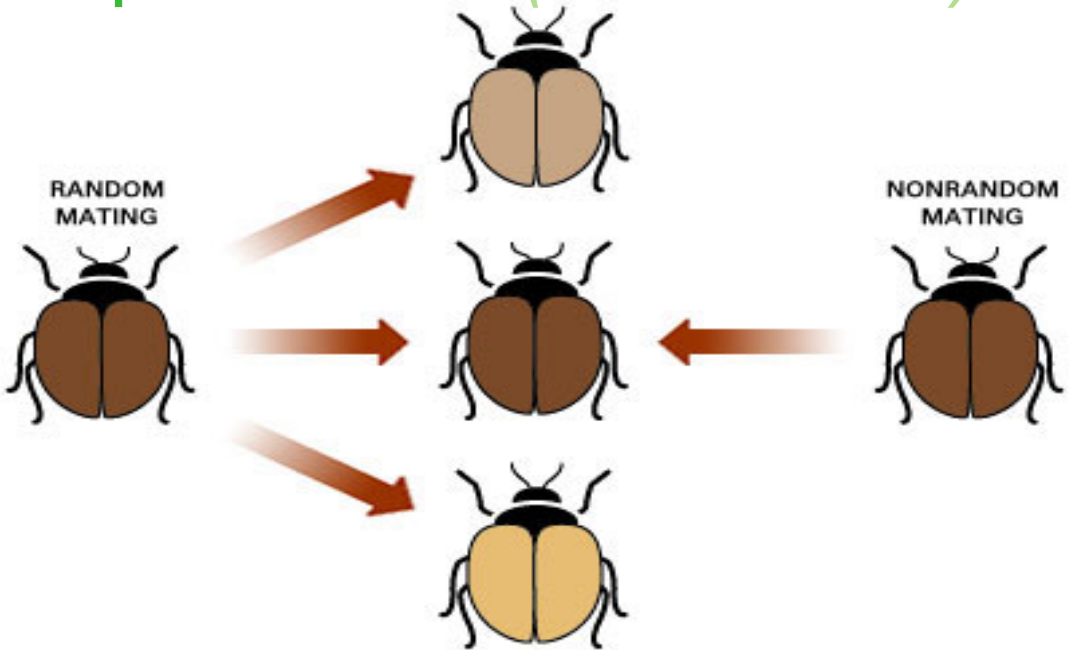
Non-random mating



Result: Some individuals have more opportunity to mate than others and thus produce more offspring (and more copies of their genes) than others.

Random mating works against evolutionary change by guaranteeing that the genes of a population are thoroughly mixed among the members of the next generation.

Random mating is unlikely: It is simply easier to mate with a nearby individual, as opposed to one that is farther away. Also, especially in animals, individuals compete for mates and active selection of mating partners occurs *(sexual selection).*

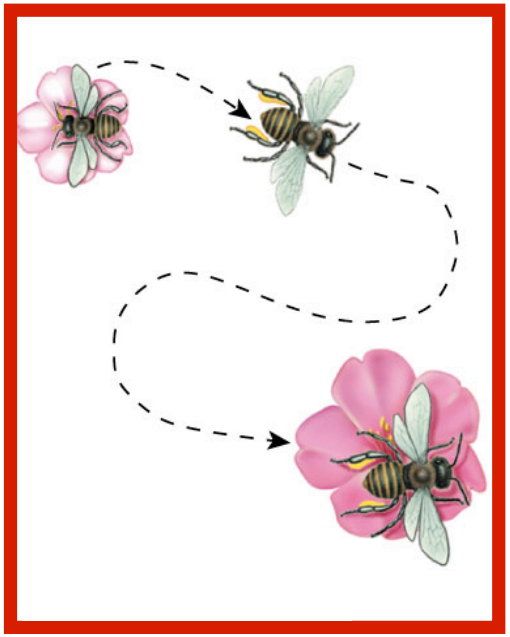


- Often affects the frequencies of homozygous and heterozygous genotypes but usually has little effect on allele frequencies in a gene pool

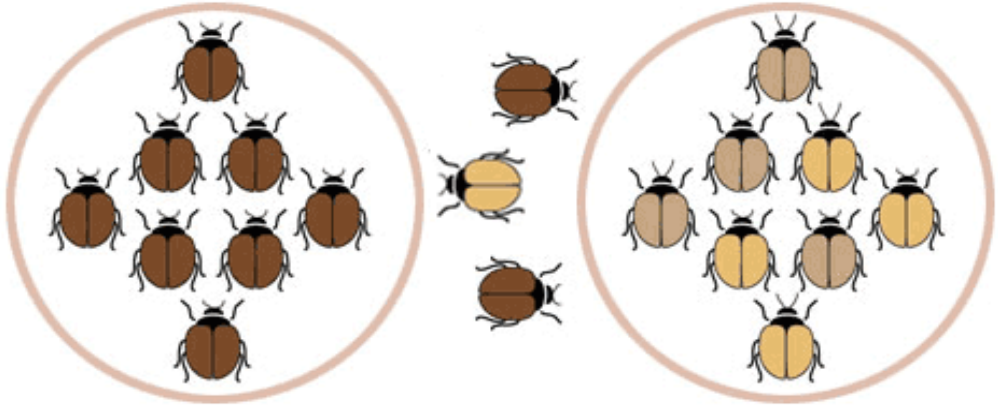
- If allele frequencies are affected though, evolution has occurred

3. Gene Flow

- **The transfer of alleles into or out of a population due to the movement of fertile individuals or their gametes.**
  - **Ex: seed & pollen distribution by wind & insect leads to gene flow**



  - **Ex: migration of animals**
    - sub-populations may have different allele frequencies
    - causes genetic mixing across regions
    - reduce differences between populations



Changes in populations

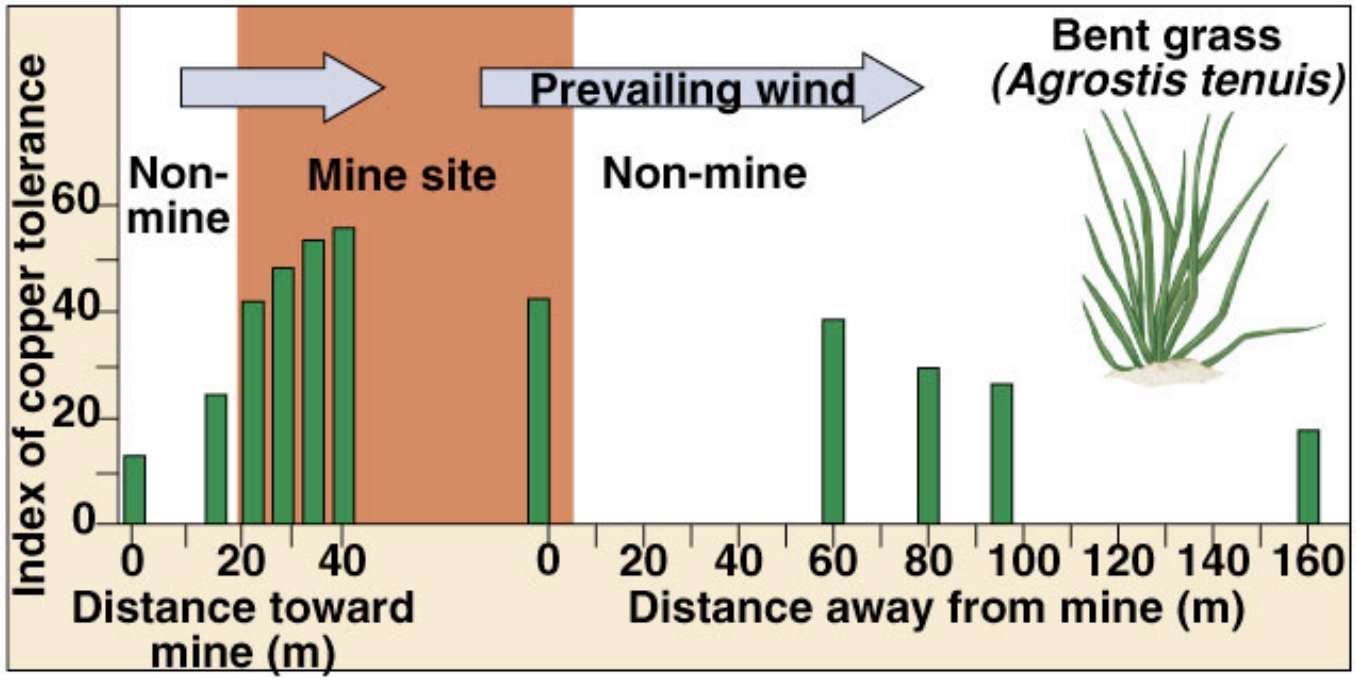
Like mutation, gene flow introduces new alleles into a population

Unlike mutation, this occurs at a much higher rate with gene flow

After allele is introduced, NATURAL SELECTION may increase or decrease its frequency.

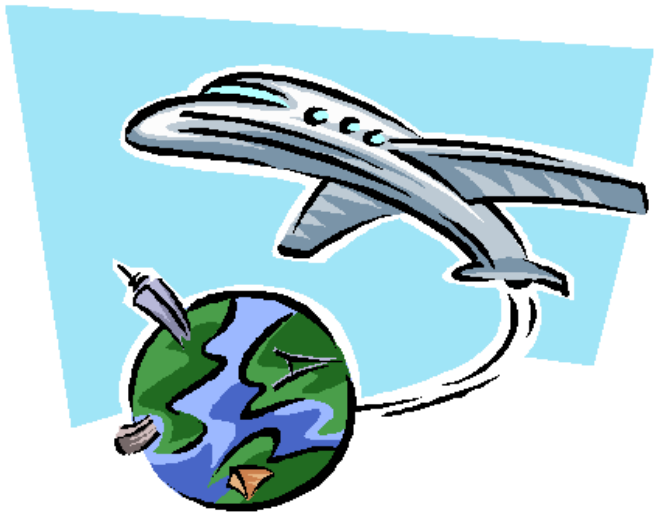
Expect copper tolerance trait to be present in 100% of the population living in copper rich soils but close to 0% in non-copper rich soils.

This grass is wind pollinated and so gene flow results and copper tolerant plants are found downwind in non-copper-rich soils.



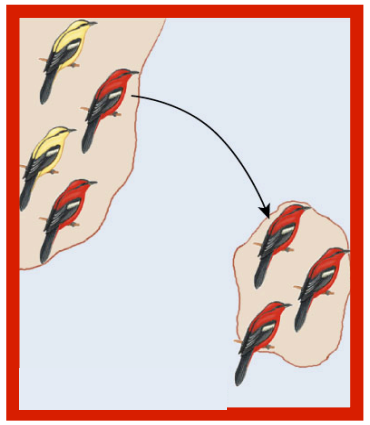
Human evolution today

- **Gene flow in human populations is increasing today**
  - **Humans are transferring alleles between populations at a much faster rate than ever before**
  - **Gene flow decreases differences between populations**



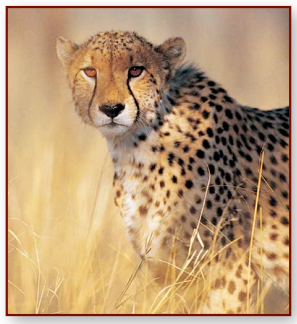
Are we moving towards a blended world?

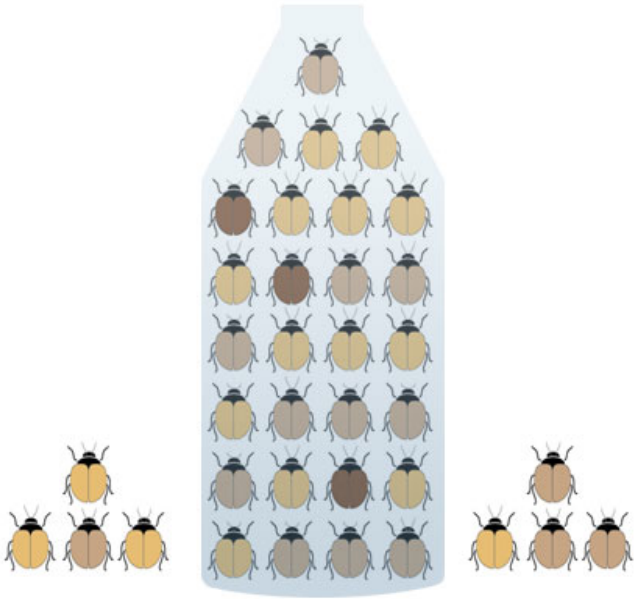
4. Genetic drift



- **The unpredictable fluctuation in allele frequencies - *fluctuations due to chance***
  - **Has a large effect especially is small populations**
    - **For ex: By chance alone the sperm and eggs pair in a way to give offspring carrying more of one allele than another or an accident results in the death of random individuals**
  - **Effect of chance events**

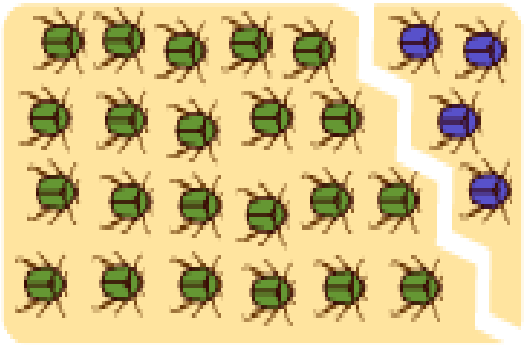
- **Circumstances that can result in genetic drift as well are:**
  1. **founder effect**
     - **small group splinters off & starts a new colony**
  2. **bottleneck**
     - **some factor (disaster)randomly reduces population to small number & then population recovers & expands again**





Founder effect

- When a new population is started by only a few individuals whose gene pool differs from that of the source population
  - some rare alleles may be at high frequency; others may be missing
  - This occurrence can skew the gene pool of new population
    - Ex: human populations that started from small group of colonists



- There is less genetic variation between Americans and Chinese than between two African populations
- All white people around the world are descended from a small group of ancestors that left Africa 80,000 years ago

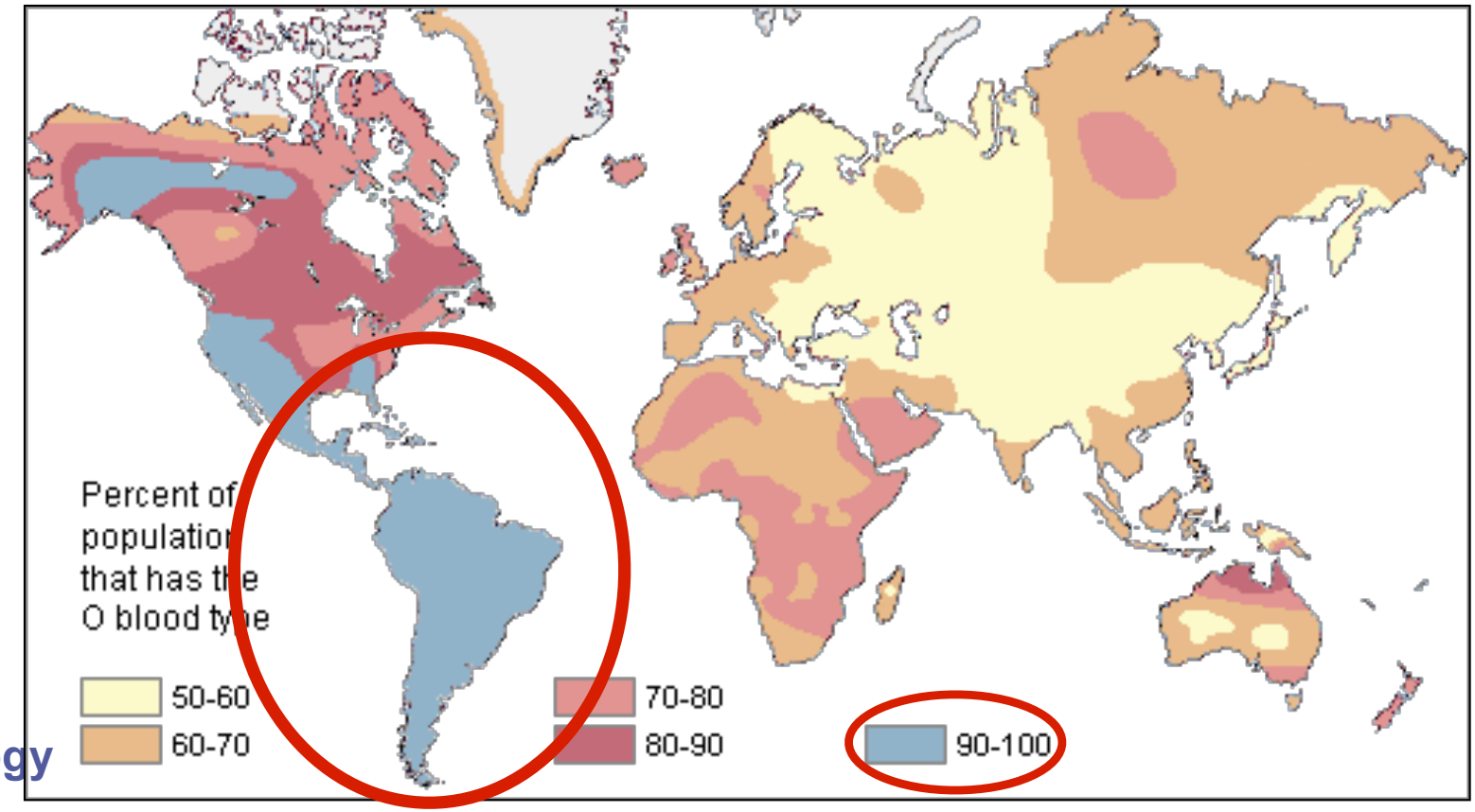
Founder effect

- Polydactyly = extra fingers or sometimes toes
  - One symptom of Ellis-van Creveld syndrome.
    - The syndrome is commonly found among the Old Order Amish of Pennsylvania, a population that experiences the "founder effect."

- Traced back to one couple, Samuel King and his wife, who came to the area in 1744.
  - The mutated gene that causes the syndrome was passed along from the Kings and their offspring, and today it is many times more common in the Amish population than in the American population at large.
    - If individuals in the group tend to marry within it, there's a greater likelihood that the recessive genes of the founders will come together in the cells that produce offspring.

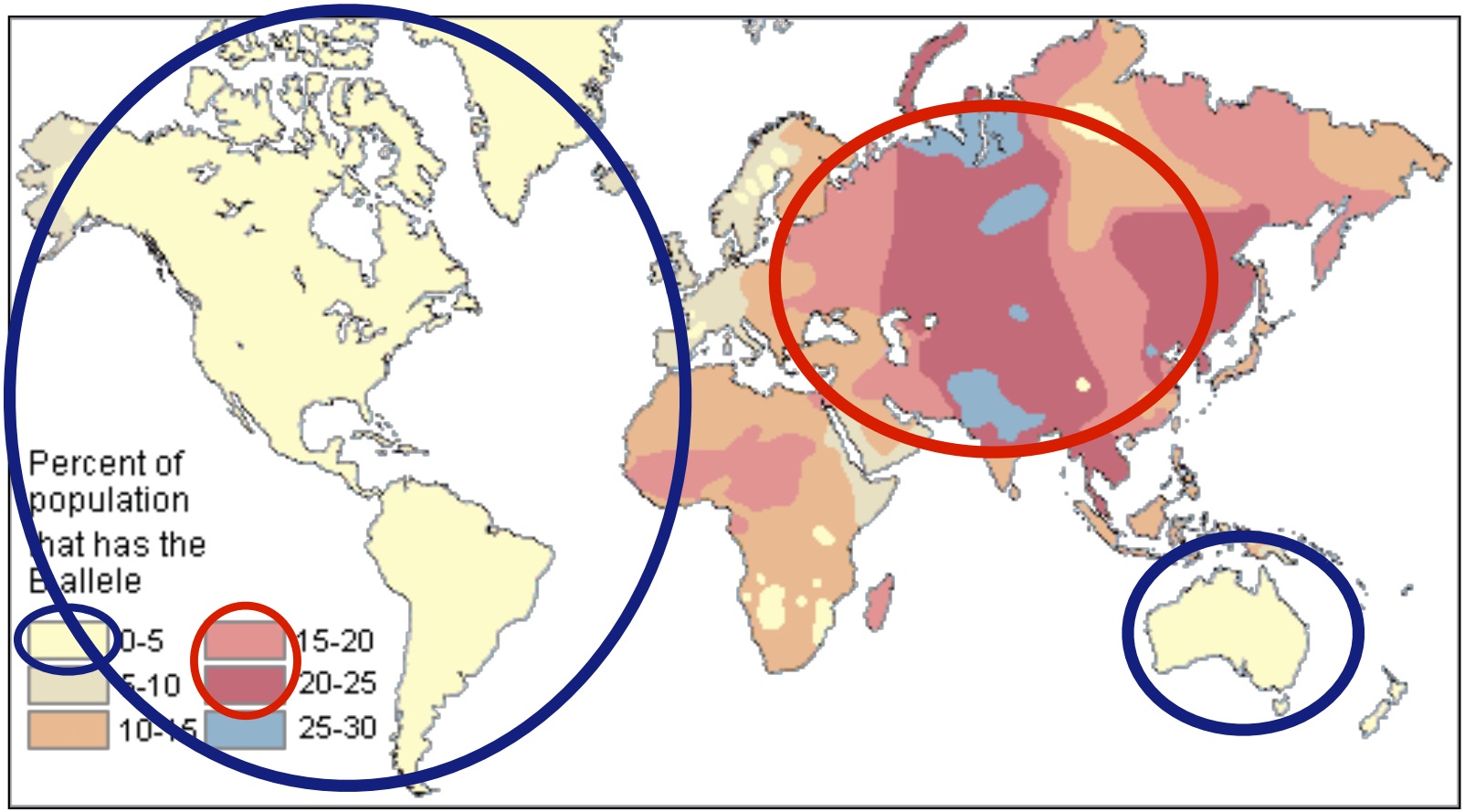
Distribution of blood types

- Distribution of the O type blood allele in ***native*** populations of the world reflects original settlement
  - South & Central American Indians were nearly 100% type O for the ABO blood system
    - Descendants of a small band of closely related "founders" who also shared this blood type



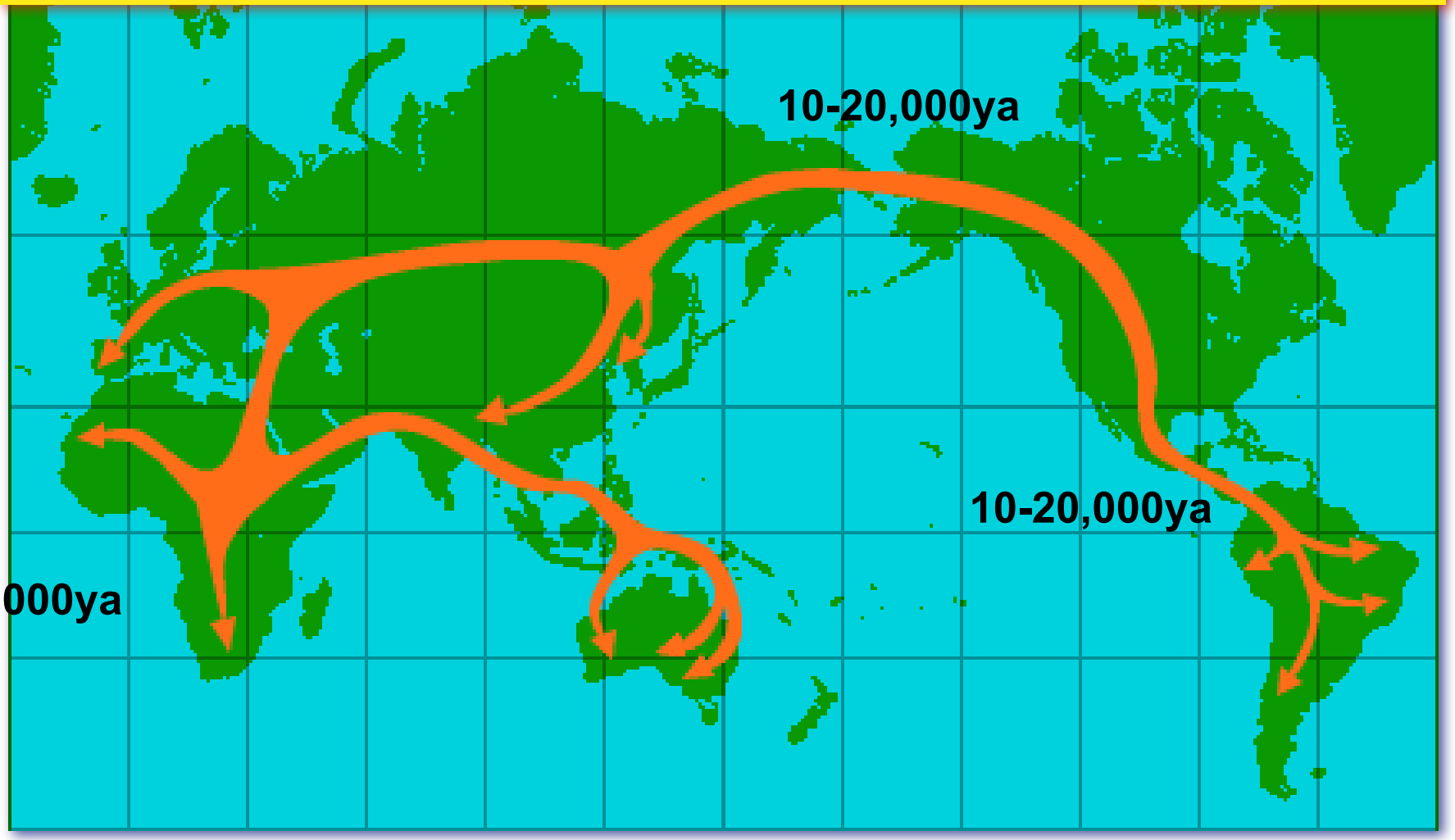
The global frequency patterns of the type B

- Distribution of the **B type** blood allele in ***native*** populations of the world reflects original migration
  - From Africa to central Asia
    - Note that it is highest in central Asia and lowest in the Americas and Australia.
    - However, there are relatively high frequency pockets in Africa as well.



Out of Africa Hypothesis - modern man originated in Africa and from there colonized the world

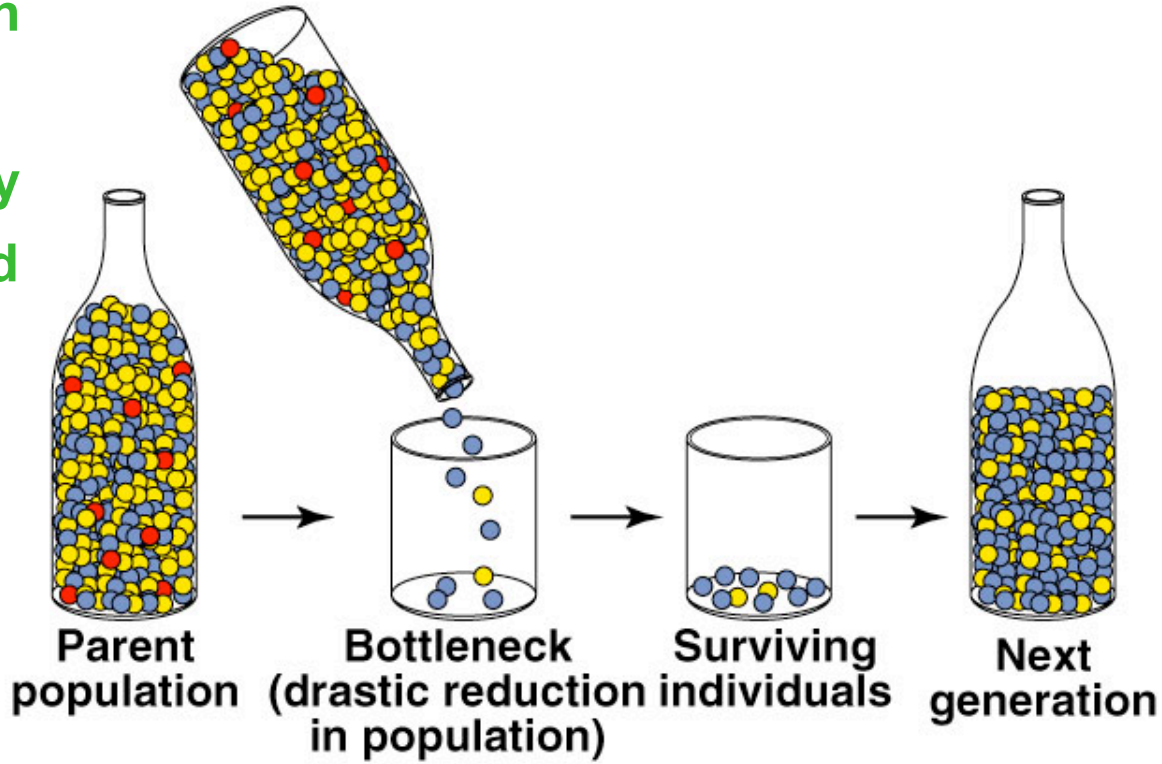
Likely migration paths of humans out of Africa



Many patterns of human traits reflect this migration

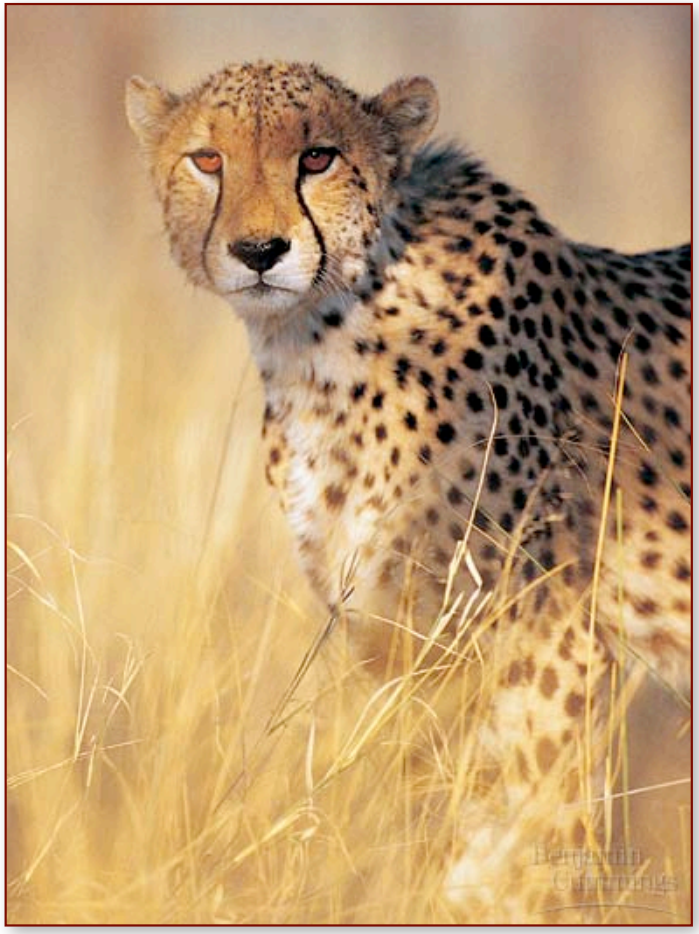
Bottleneck effect

- When large population is drastically reduced in size
  - Could be because of a disaster
    - famine, natural disaster, loss of habitat…
  - loss of variation by chance event
    - By chance alone some alleles may be lost from or underrepresented in the gene pool
    - Or some alleles may be overrepresented
      - NOT due to fitness
  - narrows the gene pool



Cheetahs

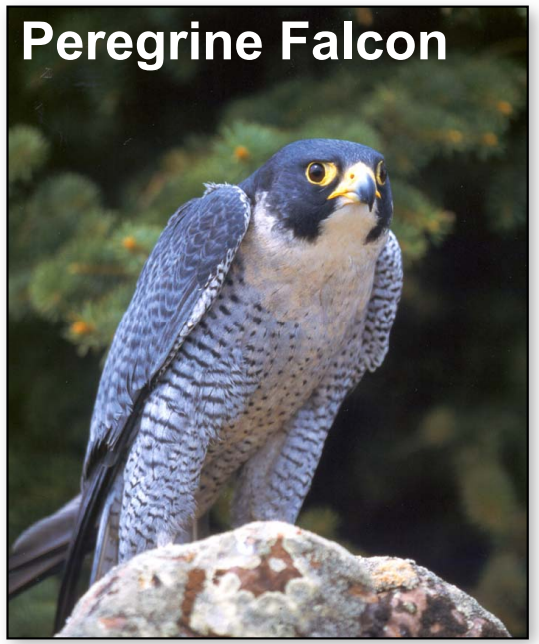
- All cheetahs share a small number of alleles
  - less than 1% diversity
  - as if all cheetahs are identical twins



- 2 bottlenecks occurred in their history
  - 10,000 years ago
    - Ice Age
  - last 100 years
    - Poaching & loss of habitat

Conservation issues

- Bottlenecking is an important concept in conservation biology of endangered species
  - When populations get small there is a loss of alleles from gene pool
    - This reduces variation reduces adaptability



Breeding programs must consciously outcross

5. Natural selection

- Differential survival rates due to current and changing environmental conditions lead to differential reproductive success of organisms in a population
  1. Because of variations in phenotype within the members of a population, some individuals will survive better than others.
  2. Those that survive better, have more chances to pass down their versions of genes (alleles) because they live longer and get to reproduce or reproduce more often compared to those that may die without reproducing as much as they would have had they lived.

Natural selection

- Survivability rates differ because:
  - climates & environmental conditions change in time
  - nutrients availability differs
  - competition for limited resources exists
  - predators, parasites, pathogens cause bodily harm
  - toxins may accumulate in areas

- Survival rates influence reproductive rates!!! *They influence organisms' biological fitness.*
  - Those combinations of alleles that provide "fitness" - that increase the chance of SURVIVAL & REPRODUCTION - will thus increase in the population over time
    - *ONLY* natural selection consistently increases the frequency of alleles that provide a survival advantage and thus a reproductive advantage as a consequence
      - This type of evolution is termed adaptive evolution

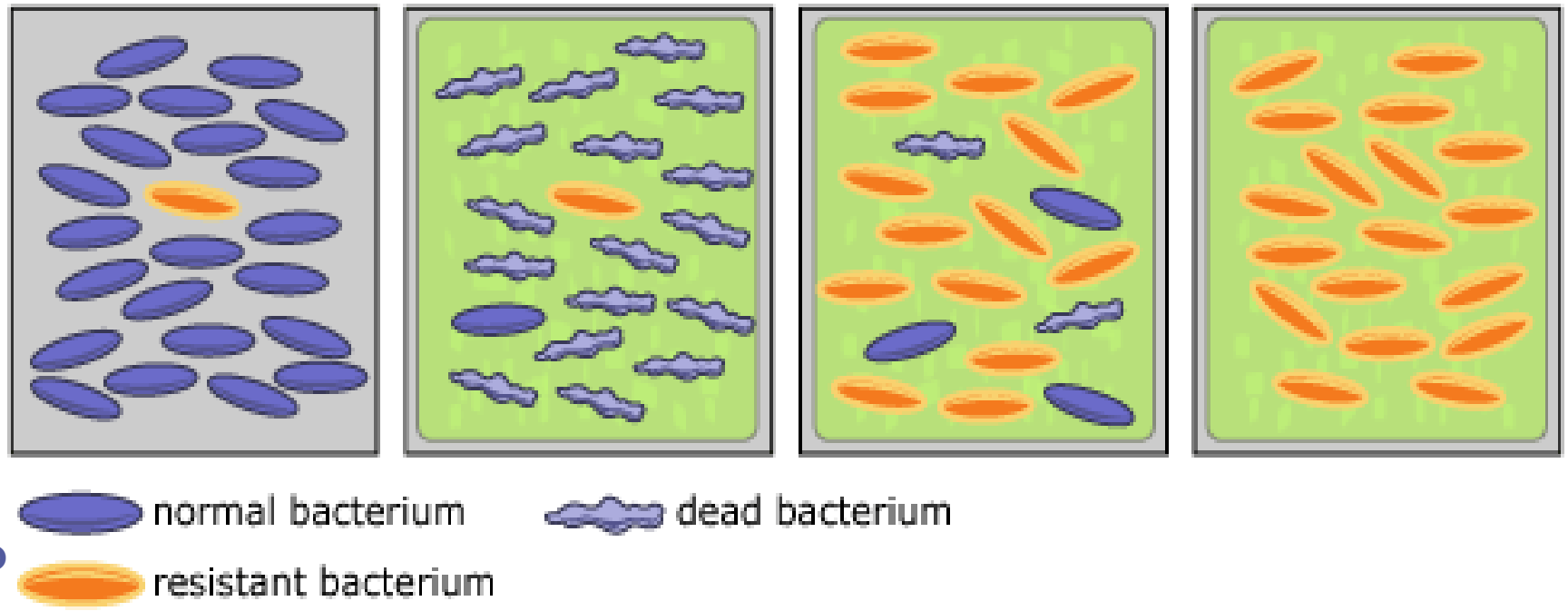
Comparing change in populations

- **Natural selection**
  - traits that improve survival and. reproduction will accumulate in the population
    - ADAPTIVE change (nonrandom)
      - Cause the evolution of adaptations within populations (a characteristic that helps that species survive and reproduce in that environment)

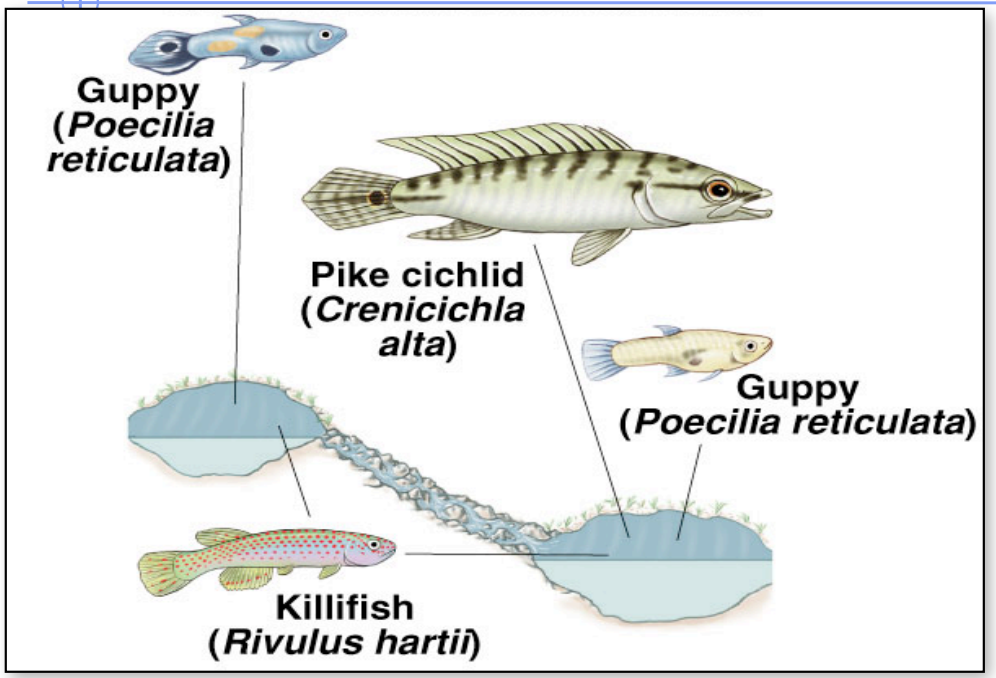
- **Genetic drift**
  - frequency of traits can change in a population due to chance events
    - random change
- **Gene Flow**
  - Movement of alleles into or out of a population
    - Nonrandom but not adaptive

Natural selection

- **LEADS TO ADAPTIVE EVOLUTION**
  - **The rise of adaptations in a populations**
    - ***Heritable traits that increase the fitness of a population***
      (ability to survive and reproduce)

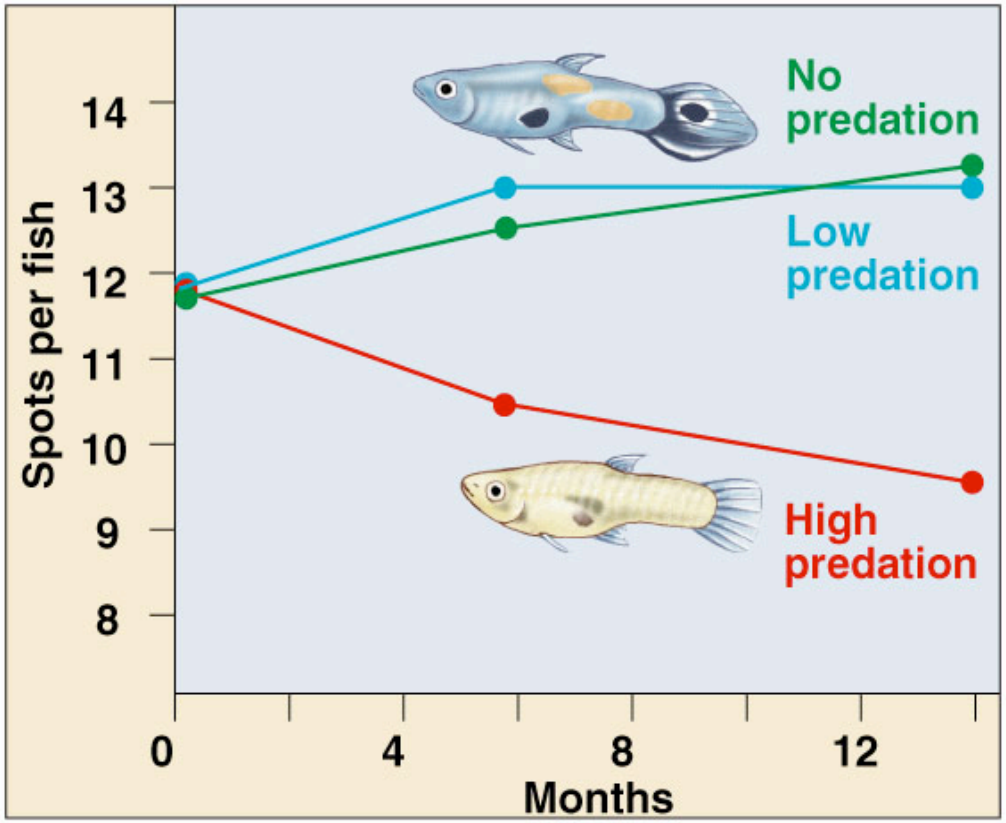


Adaptive evolution



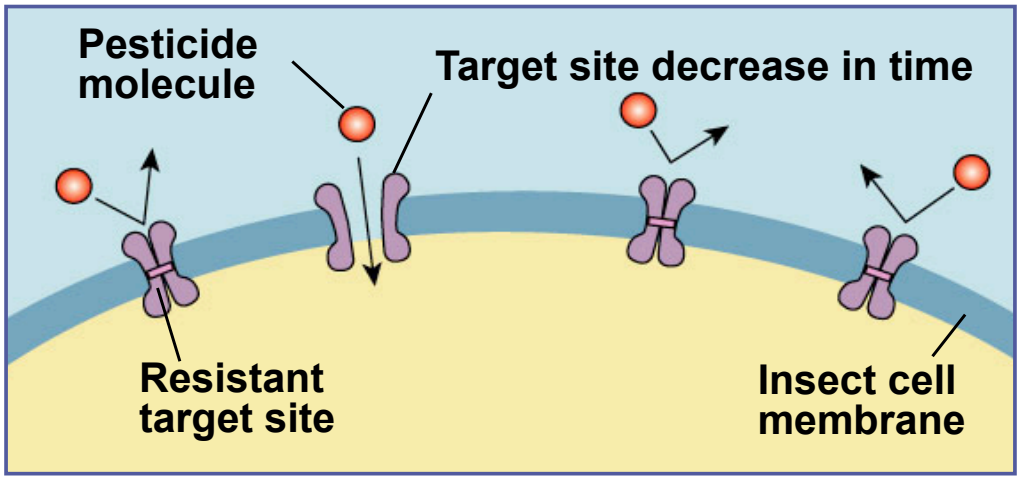
Cichlid preyed on guppies with more spots, but male guppies with spots tend to have more success in finding mates

AP

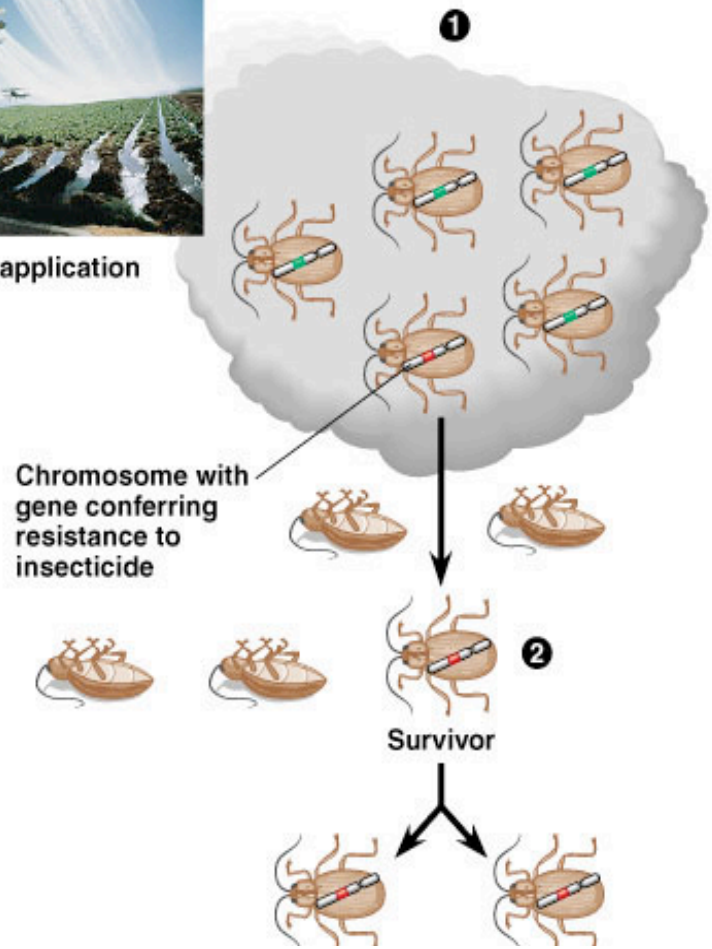


Changes in populations

Pocket Mice in desert lava flows



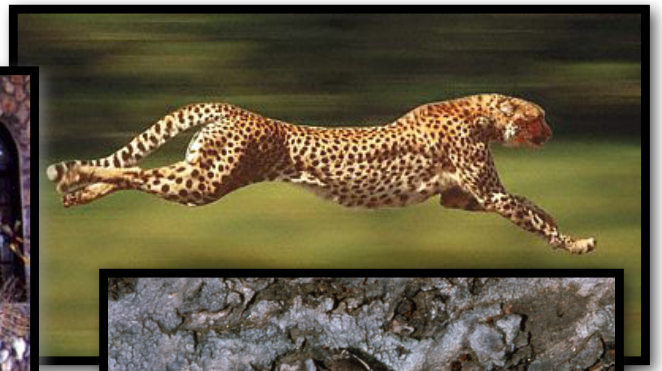

Insecticide application

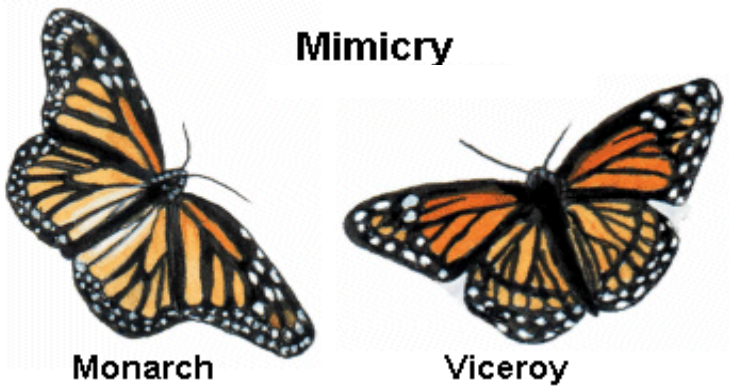


Insecticide resistance

Natural Selection

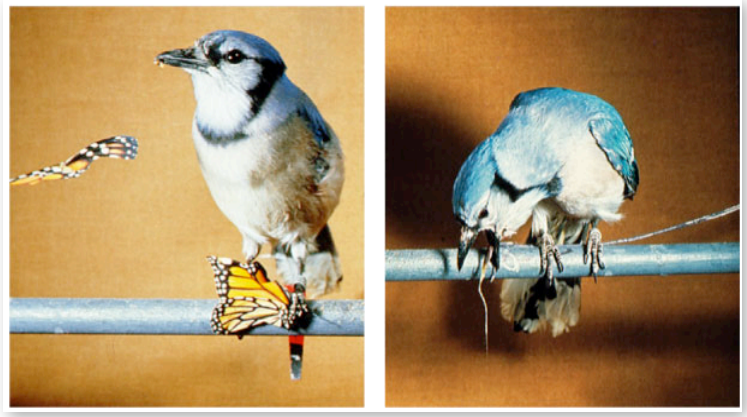
- **Selection acts on any trait that affects survival & reproduction**
  - **Darwin stressed survivability as playing a key role in which traits get passed down best.**
    - **Since then, we have have gained a better understanding of which factors influence reproductive success *(surviving in the face of competition for limited resources, for example, is not the only factor affecting reproductive success)***
  - **Selection processes today can be subdivided to emphasize different aspects that still lead to reproductive success:**
    - **predation selection**
    - **physiological selection**
    - **sexual selection**





Predation selection

- act on both predator & prey
  - Predators affect the evolution of prey & prey affect the evolution of predators
    - Affects the evolution of behaviors
    - Causes evolution of camouflage/mimicry
    - Affects the evolution of speed, hunting, or evasion tactics
    - Causes the evolution of defenses (physical & chemical)



Physiological Selection

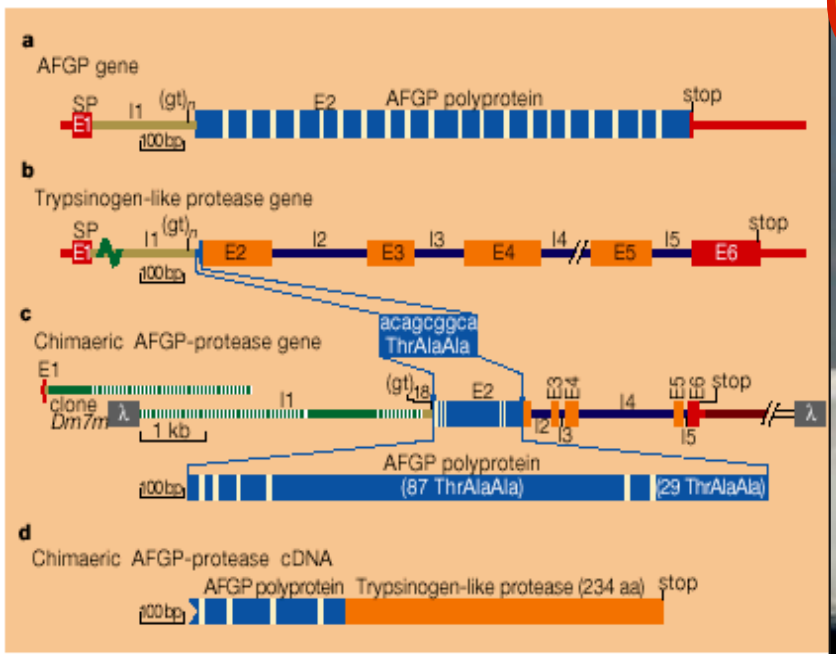
- **Bodily function & chemistry influence who survives best to reproduce**
  - disease resistance may be favored.
  - physiology efficiency (using oxygen, food, water) may spread through future populations.
  - biochemical versatility increases in populations.
  - ways to protect or recover from injury may be selected for.

Evolution of an antifreeze glycoprotein

A blood protein that keeps Antarctic fish from freezing arose from a digestive enzyme.

The ice-binding antifreeze glycoprotein (AFGP) that circulates in the blood of Antarctic notothenioid fishes enables them to avoid freezing in their perpetually icy environment[1]. This crucial survival protein probably arose from a functionally unrelated pancreatic trypsinogen-like protease[2]. We have now discovered an important intermediate in this evolutionary process — transcriptionally active chimaeric genes that encode both an AFGP polyprotein and the protease, confirming the protease origin of AFGP and indicating how it was created.

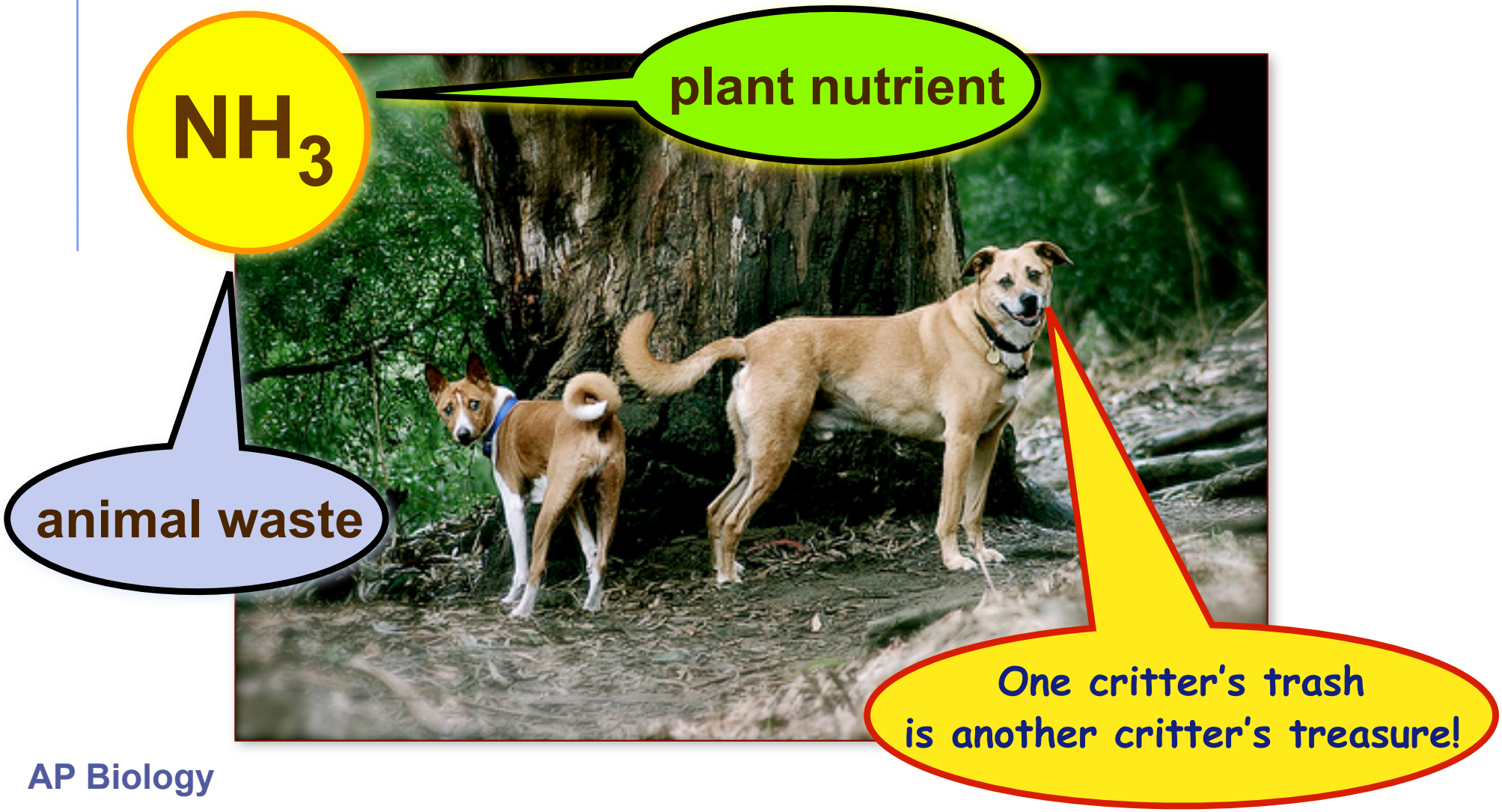
AFGP binds to and arrests the growth of ice crystals that enter the fish, thereby preventing the fish from freezing. There are at least eight forms of the protein of different sizes (AFGP 1–8), all composed of repeats of a simple glycotripeptide monomer (Thr-Ala/Pro-Ala-) with a disaccharide attached to each threonine



HOT STUFF!
Some fish had the variation of producing anti-freeze protein

Physiological selection

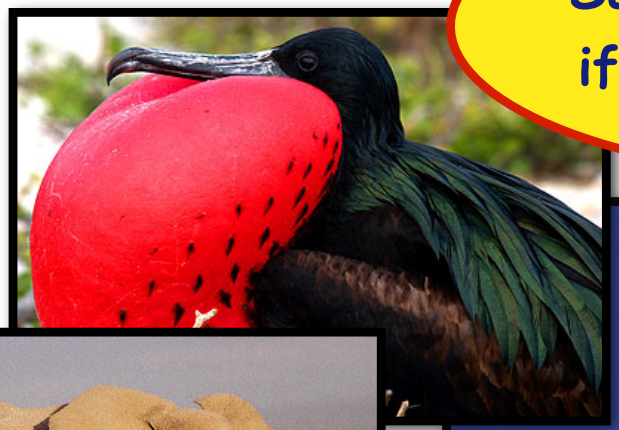
Dogs pee on trees…Why don't trees pee on dogs?

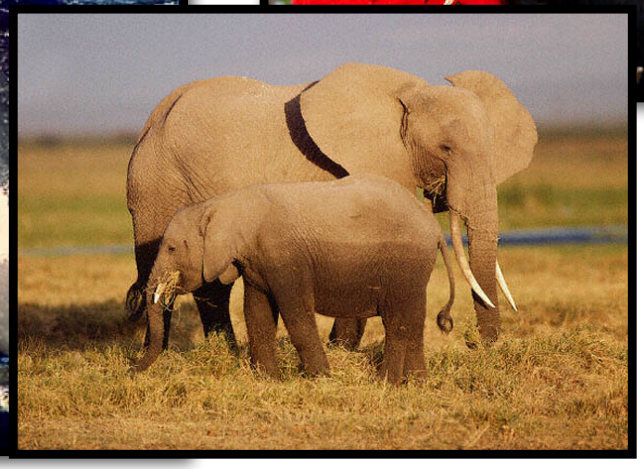


Sexual Selection - nonrandom mating

- **Acts on reproductive success**
  - attractiveness to potential mate influences which alleles pass down
  - fertility of gametes alters which allele pass down
  - Phenotypes that lead to the successful rearing of offspring are favored

Survival doesn't matter if you don't reproduce!





Sexual selection

In these species:
It's FEMALE CHOICE, baby, that affects the evolution of male features!

The lion's mane…

Science magazine

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Sexual Selection, Temperature, and the Lion's Mane

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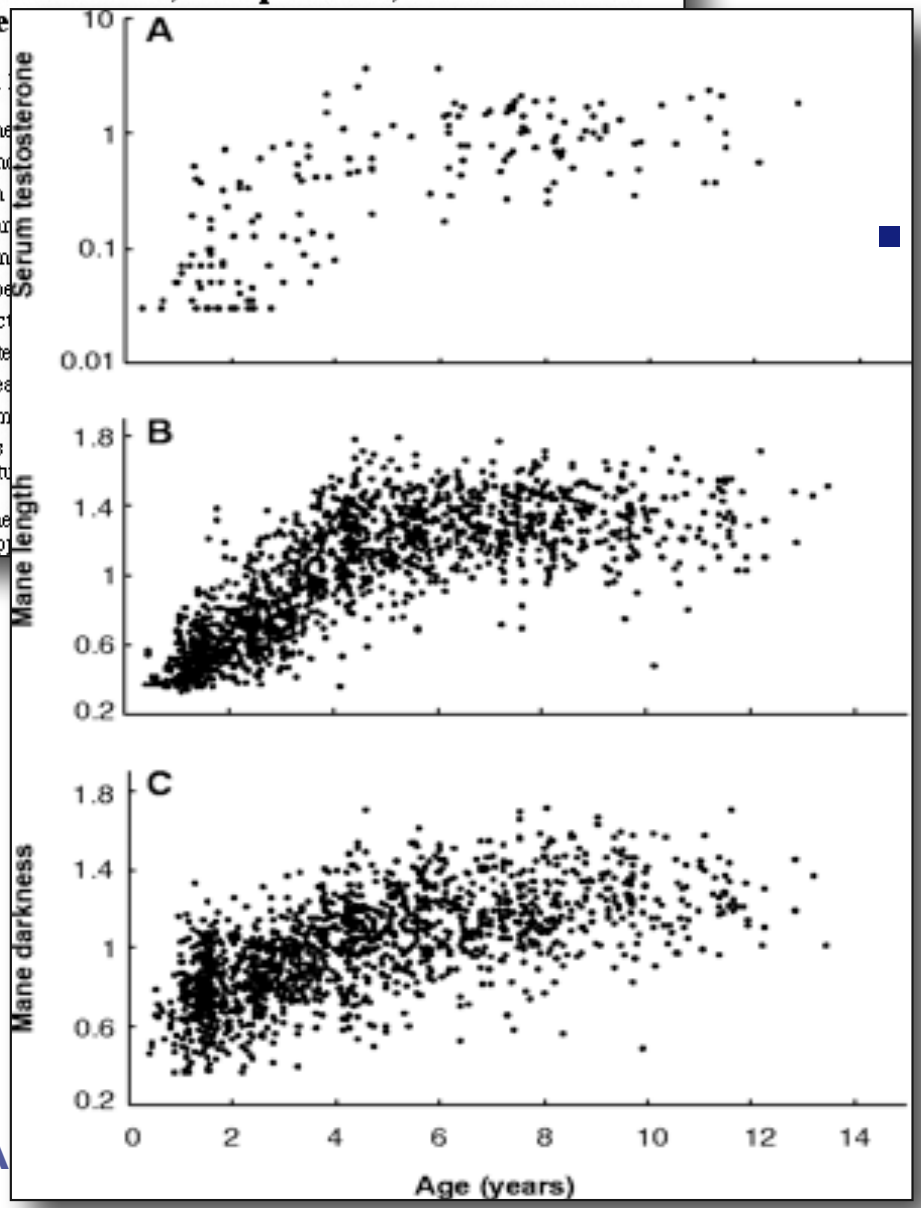
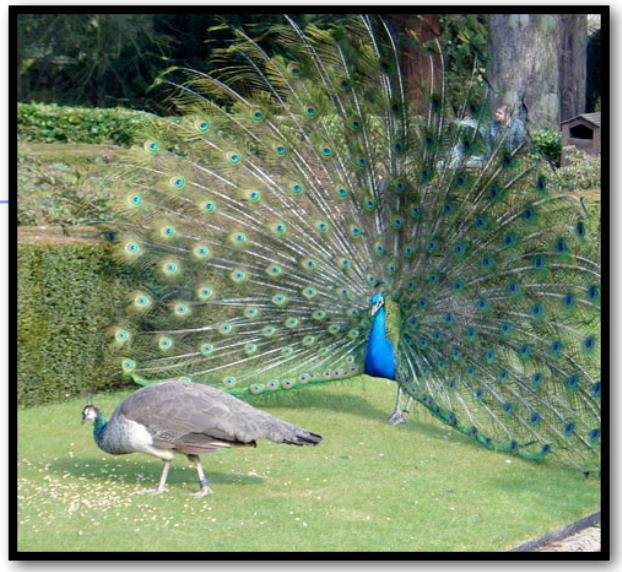


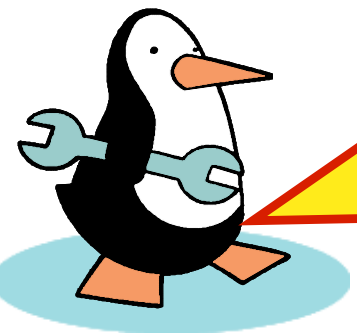
- **Females are attracted to males with larger, dark manes**
  - Correlates with higher testosterone levels
    - better nutrition & health
    - more muscle & aggression
    - better sperm count / fertility
    - longer life
  - But imposes a cost to male
    - **Manes are HOT! Is it worth it??**
    - **YES!**
      - Females who evolved to prefer these males have healthier young and a greater chance of passing on the trait of being attracted to longer darker manes to daughters and longer darker manes to sons

Sexy = fitness markers

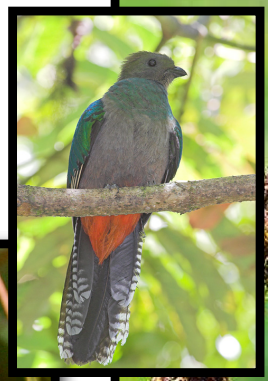
Sexual selection *(animals select their mate and do not mate with just anyone)*



- Acts in all sexually reproducing species
- Sexually reproducing species often engage in <u>NONRANDOM MATING</u>
  - traits exist that get you mates more successfully because the opposite sex favors certain phenotypes or a phenotype gives you an advantage in competing for access to a mate
    - <u>sexual dimorphism</u> = systematic difference in form between individuals of different sex in the same species
      - influences both morphology & behavior
  - sexual selection results in phenotypes being favored in one sex which may seem opposite to the phenotypes natural selection would favor



There are compromises sometimes between survivability and reproduction. Both are part of the process of passing your genes on to the next generation

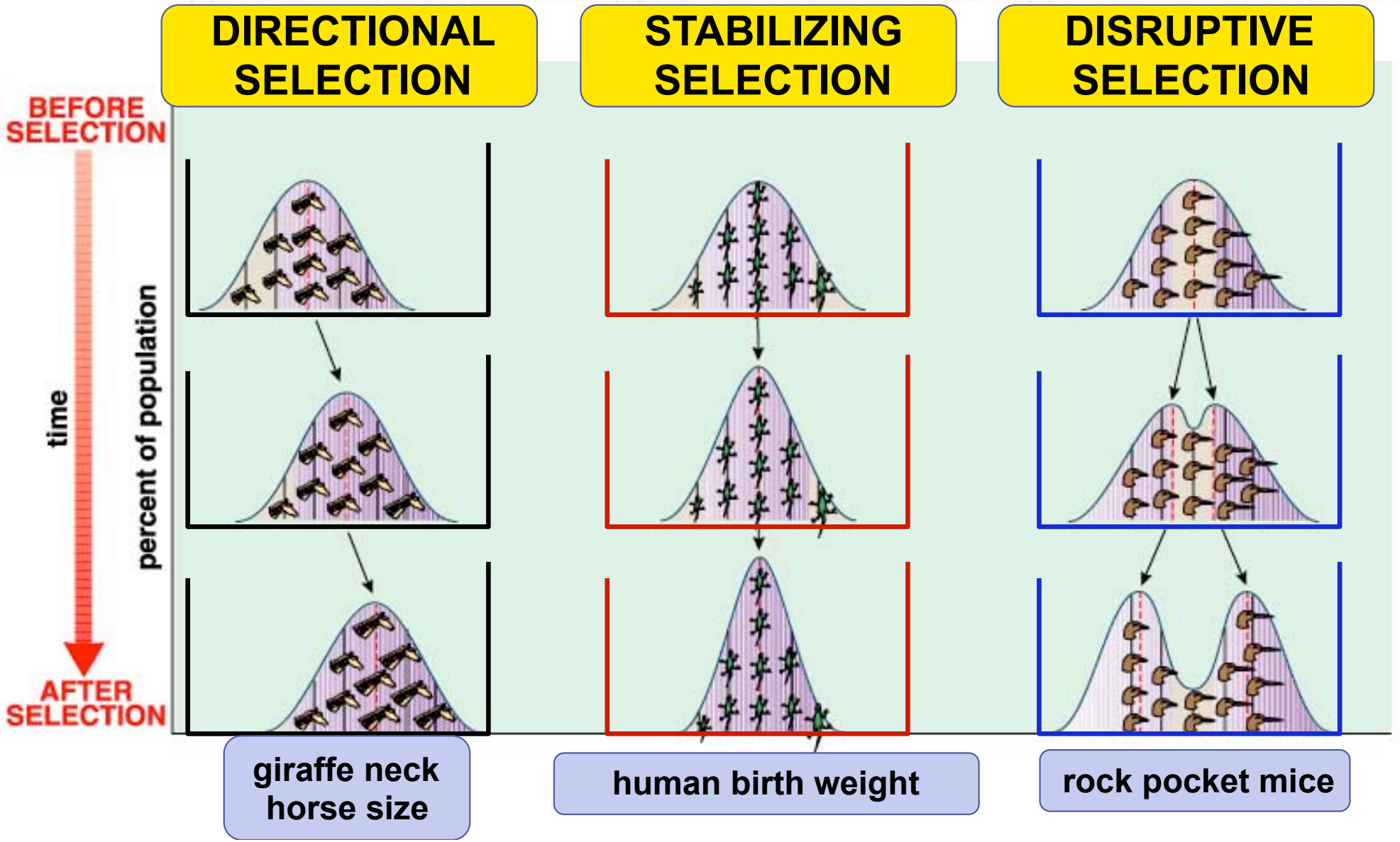


Operation of Sexual selection

- Intrasexual Selection
  - Selection within the same sex of s species
  - When individuals of one sex compete directly for mates of the opposite sex
    - Ex: males may fight for females attention
    - Ex: Males often perform ritualized displays to warn competitor and avoid injury
- Intersexual Selection
  - A.K.A. *Mate Choice*
  - Individuals of one sex (often females) are choosy in selecting their mates from the other sex
    - Often female interest depends on behavior or look of male
    - Male showiness is not adaptive in any other way other than that it gets him a mate to pass down his genes with way and may even be a risk for surviving
      - Ex: Male peacock tries to impress a pea hen long colorful flowers that makes flying and running harder and makes him stand out more easily to predators

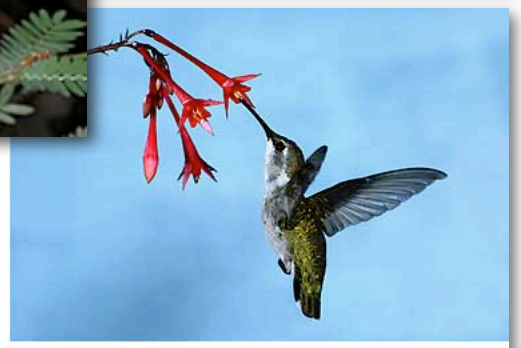
The Effects of Selection

- Changes the average trait of a population in three ways:



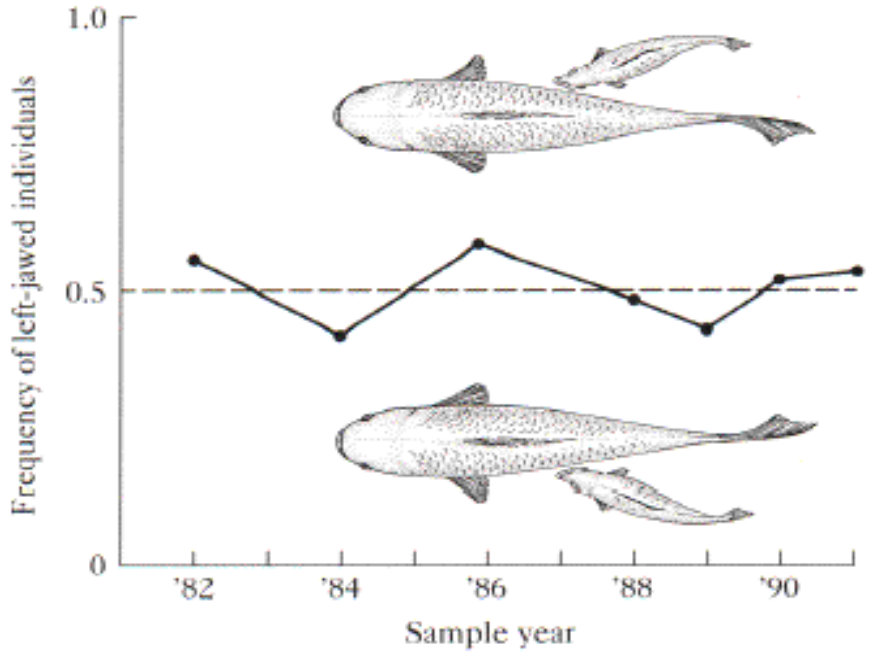
Coevolution

- Two or more species reciprocally affect each other's evolution
  - predator-prey
    - disease & host
  - competitive species
  - mutualism
    - pollinators & flowers



Why does natural selection not reduce genetic variability by deleting all unfavorable alleles from a gene pool?

- **Diploidy** - Most eukaryotes are diploid
  - Genetic variation is hidden in the form of recessive alleles
  - Natural selection only acts on these alleles when an organism is homozygous for both alleles - Heterozygotes hide these alleles
- **Balancing Selection**
  - When natural selection maintains two or more phenotypes in a population
- **Heterozygote Advantage**
  - When heterozygous individuals have greater fitness than both homozygotes
    - Natural selection now maintains two alleles at that locus
- **Frequency Dependent Selection**
  - Fitness of a phenotypes declines if it becomes too common in a population
    - Scale-Eating fish attack from behind and pull off scales of fish
    - Right mouthed fish is dominant over left mouthed fish
    - Right mouthed fish attack from the left
    - Prey species guard against attack from the phenotypes most common
    - The phenotype selected for alternates over time



- **Neutral Variation**
  - Nucleotide differences that cause no benefit or harm to organisms
    - Over time the frequencies of any of such alleles may change because of genetic drift

Any Questions??