Meeting Life's Challenges

Why do species go extinct?

- **Short Answer- They were unable to meet life's challenges!**

Recall Living Organisms Must

- Obtain Nutrients
- Obtain & Conserve Water
- Eliminate Wastes
- Exchange Gases
- Sense & Respond to their environment
- Thermoregulate
- Defend themselves
- Reproduce

Why do species go extinct?

- **Long Answer- The environment changes, which in turn effects the species ability to meet one or more of life's challenges and as a group the species is unable to adapt in time to the new conditions.**

Environmental Changes & New Conditions

- Changing Climates
- Habitat Loss
- Being Out-Competed (by better adapted organisms)
- Over-Exploitation & Hunting

How have extant species made it this far?

- **Short Answer- They were ABLE to meet life's challenges!**

- Obtain Nutrients
- Obtain & Conserve Water
- Eliminate Wastes
- Exchange Gases
- Sense & Respond to their environment
- Thermoregulate
- Defend themselves
- Reproduce

How have extant species made it this far?

- **Long Answer- Descent with modification, the population (species) possessed enough variation that at least some organisms in the population were able to meet life's challenges in spite of the changing conditions. As a result these better adapted individuals left more offspring who were also more able to deal with the changing conditions. Over time (descent) a once rare trait in the population becomes more common (modification) and the population consequently is able to meet life's challenges and thus continues to survive through time.**
- **Short Answer- They adapted & Evolved**

How do species continue to meet life's challenges?

- **The population as a whole adapts and changes over time with the inevitable changing conditions...They Evolve!**

Before Charles Darwin...

- **The predominant idea before Darwin- species were created and remained unchanged through time.**

After Charles Darwin...

- **Darwin's book the "Origin of Species" caused paradigm shift as today science views life as changing over time.**

Note: Darwin did not directly address the origin of life itself but rather how life has changed once it was here on earth.

Origin of Species

- **Darwin's idea of organisms adapting and changing over time was not new, but he was succeeded where *<u>others before him</u> failed .**
    - **He had an astonishing amount of evidence and logically sound mechanism (to be explained shortly)**
- ***The idea of evolution was not novel, in fact Darwin's grandfather wrote about this idea of organisms changing over time.***

...others before him?

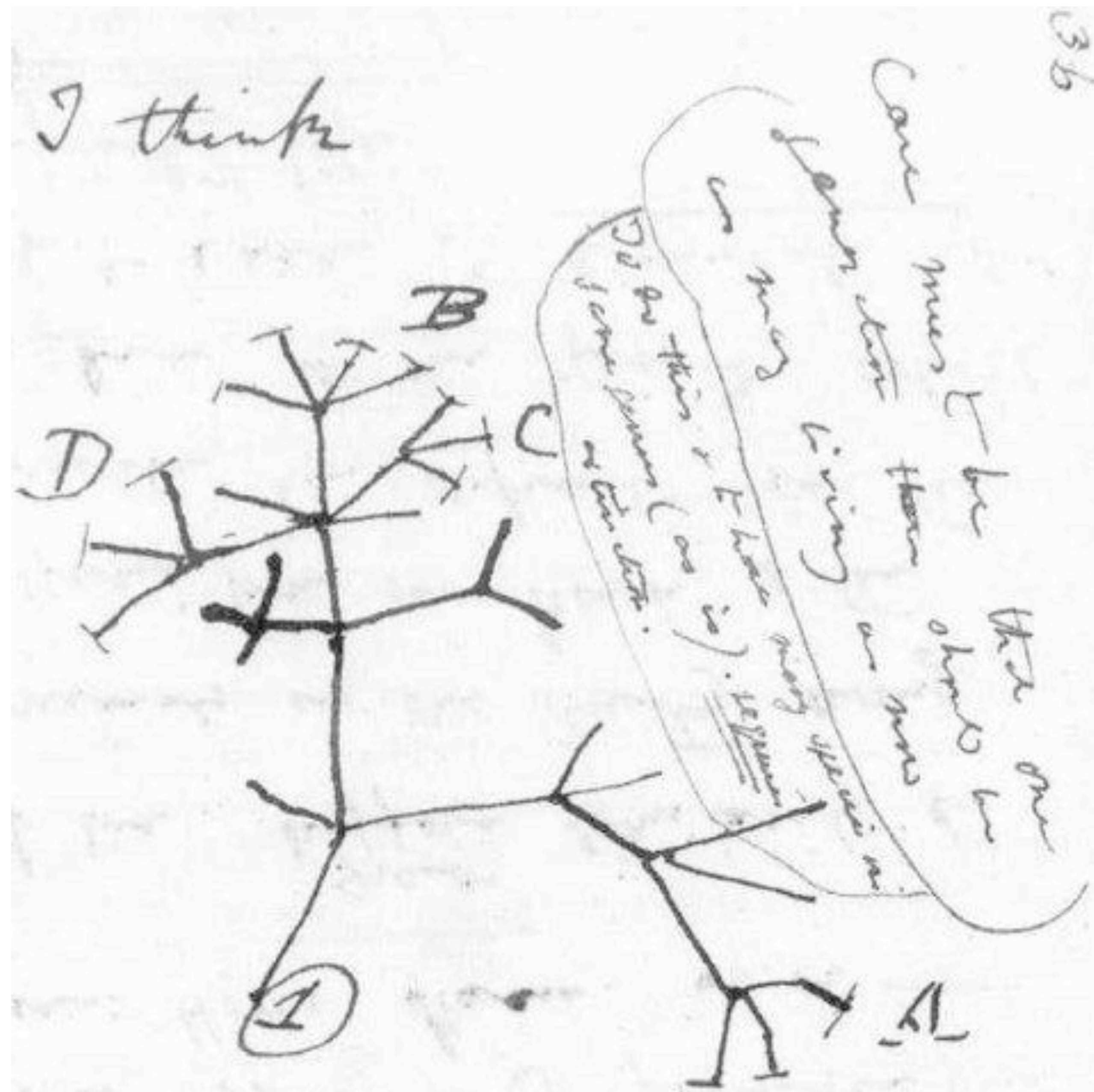
- **Jean-Baptiste de Lamarck proposed the idea of biological evolution before Darwin was even born, but his mechanism was flawed and not widely accepted.**
  - ***Use & Disuse***
    - **body parts not used would deteriorate while those used would become larger/stronger/better**
  - ***Inheritance of Acquired Characteristics***
    - **whatever modifications occurred through use and disuse could then be passed to offspring**

*Lamarck has served as a poster boy for how evolution does not work, almost a counter example if you will however he may have the last laugh. Recent work in the field in epigenetics is revealing that some changes that occur in an organism's in life may in fact be passed on to future generations.

Origin of Species

- **Origin of Species beautifully illustrated life's**
  - **unity**
  - **diversity**
  - **relationships**

Darwin suggested that a "Tree" might best symbolize these ideas

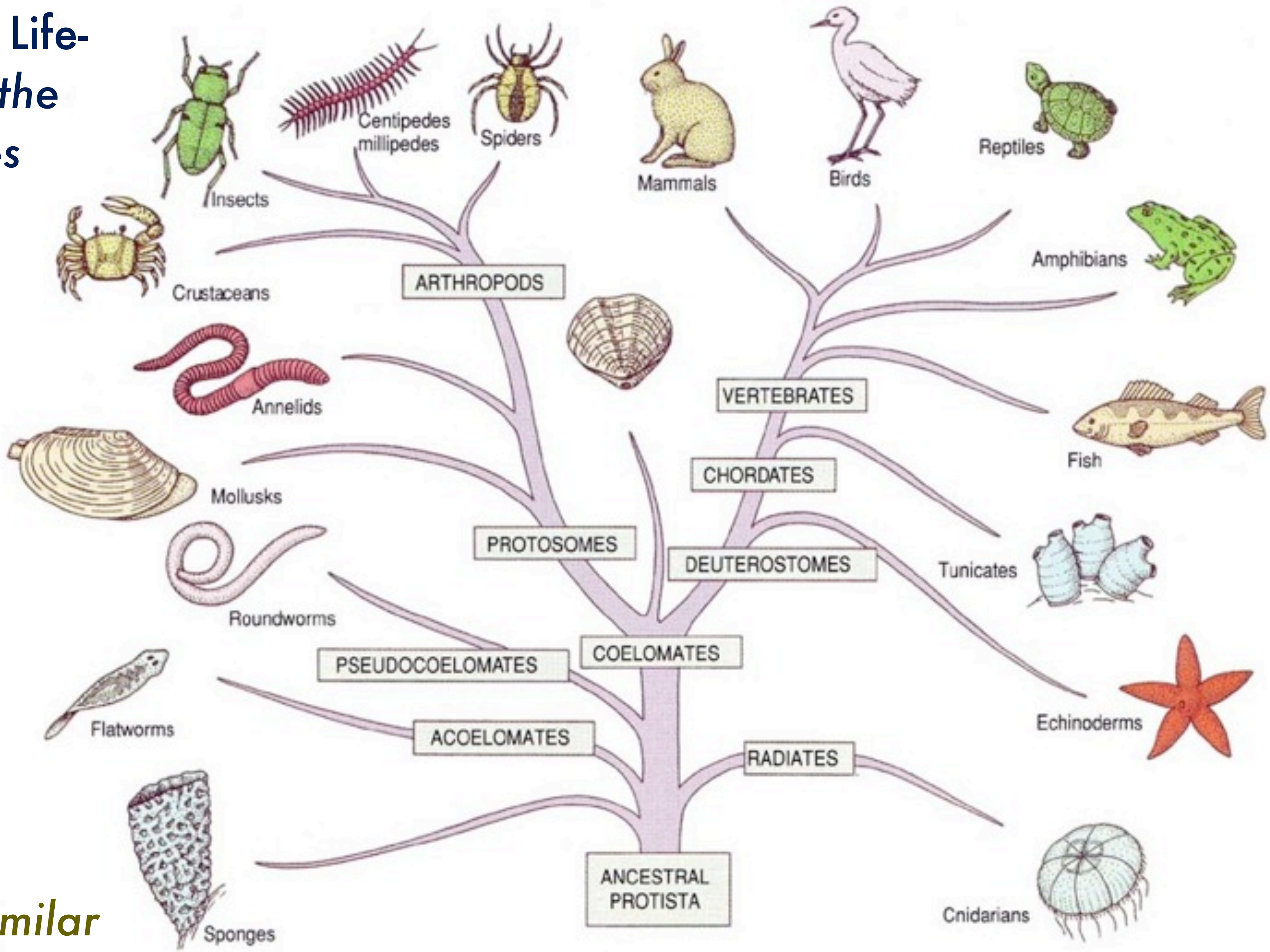


Tree of Life

Diversity of Life- *is seen in the branches*

Forks- *represent common ancestors*

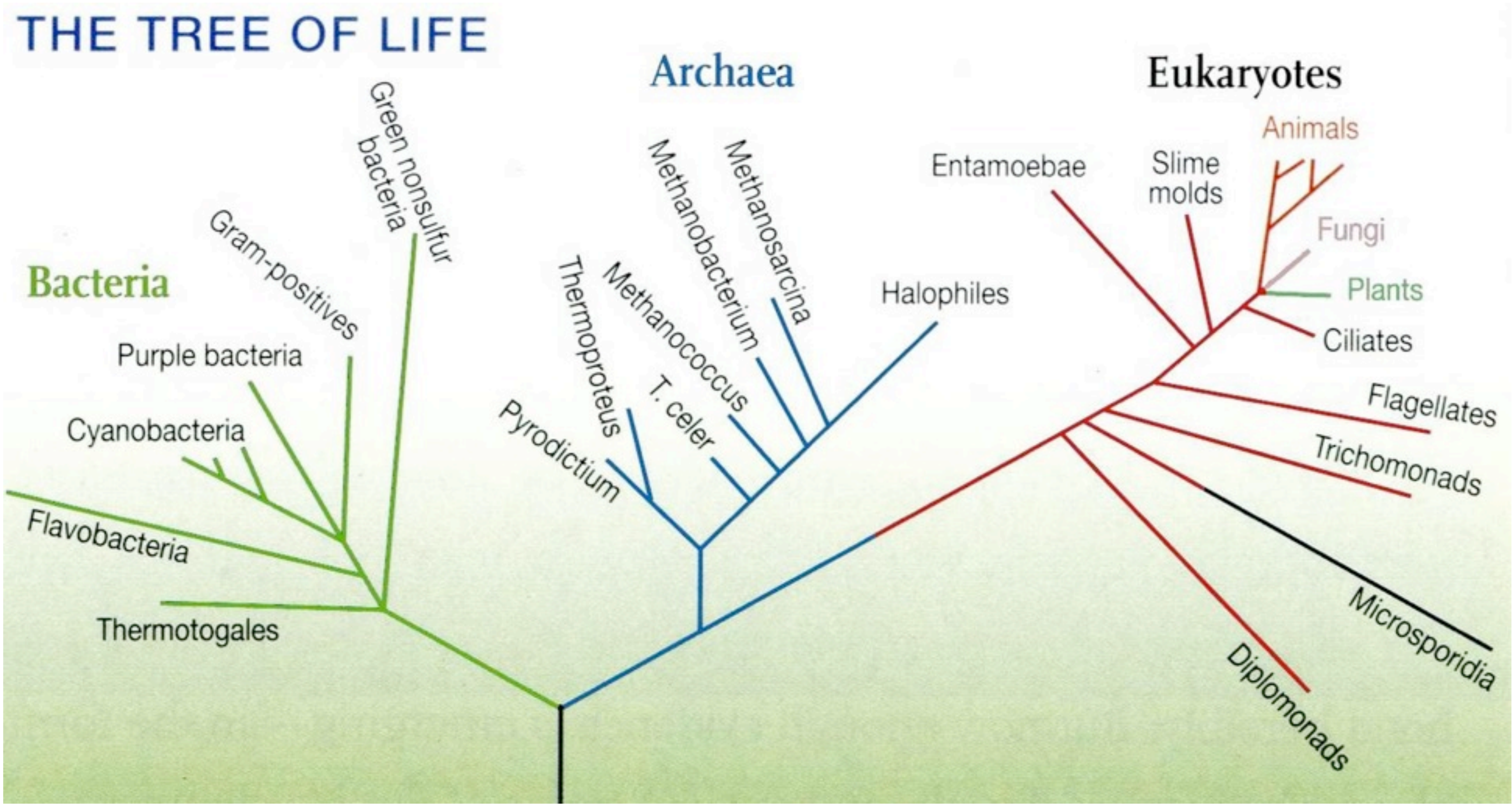
Relationships- *different structures are related to unique/different environments*



Relationships- *similar structures due to common ancestry and similar environments*

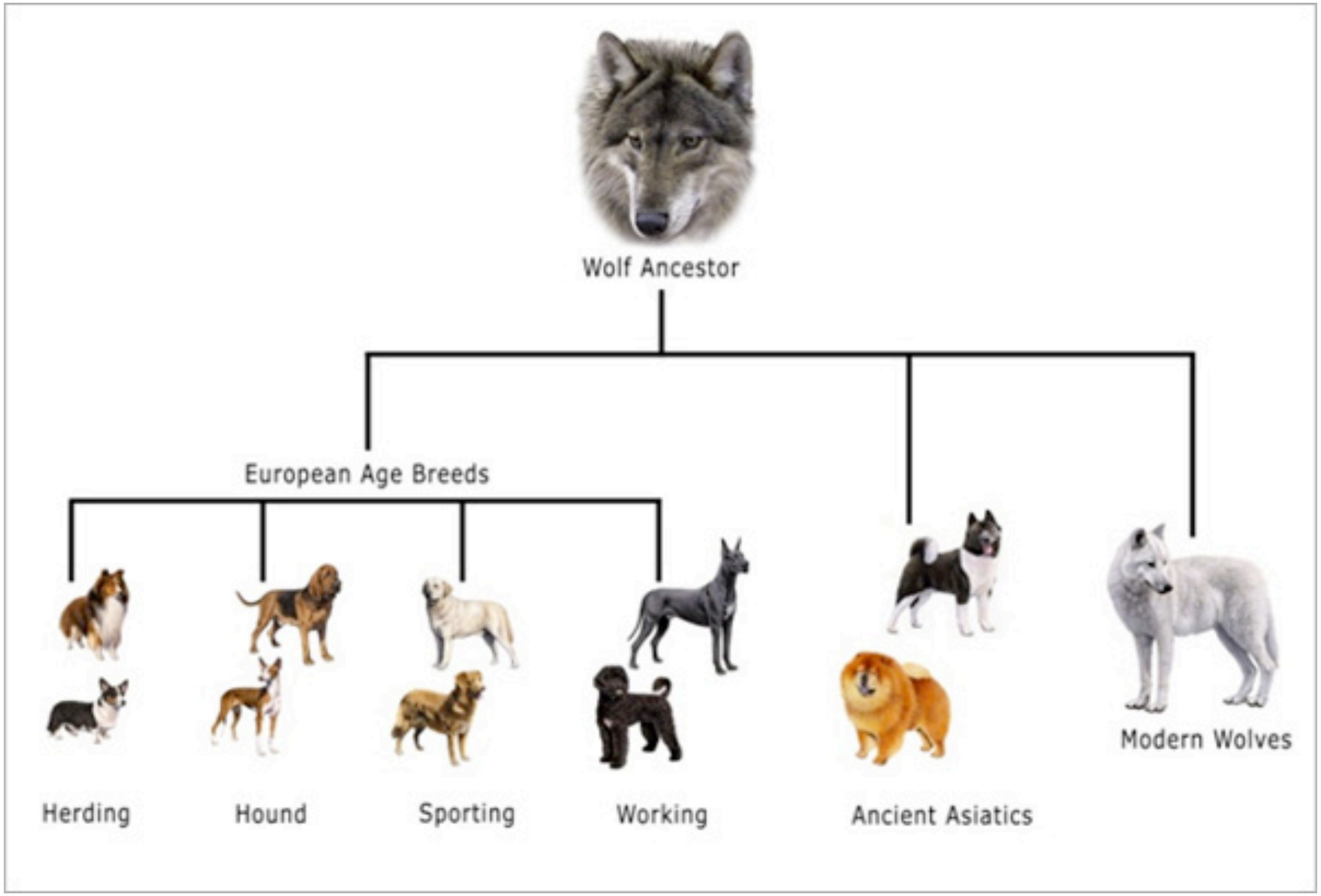
Unity of Life- *is seen in the trunk as single common ancestor*

More Accurate View



Origin of Species

- **Darwin also successfully used selective breeding to further explain and support his mechanisms of natural selection.**



Darwin's Argument

- **Variation exists among individuals in a population!**

Darwin's Argument

- **Populations produce more offspring than the environment can support, thus some will fail to survive and/or reproduce!**

Darwin's Argument

- **Individuals with inherited traits that give them a better chance of surviving and reproducing in a particular environment tend to leave more offspring!**

Darwin's Argument

- **The unequal ability of individuals to survive and reproduce will lead to accumulation of favorable traits and less favorable traits will diminish in the population over *time!**

*Darwin noted that if artificial selection could produce dramatic changes in a relatively short time frame then given enough time nature could fashion the same dramatic changes

Darwin's Mechanism

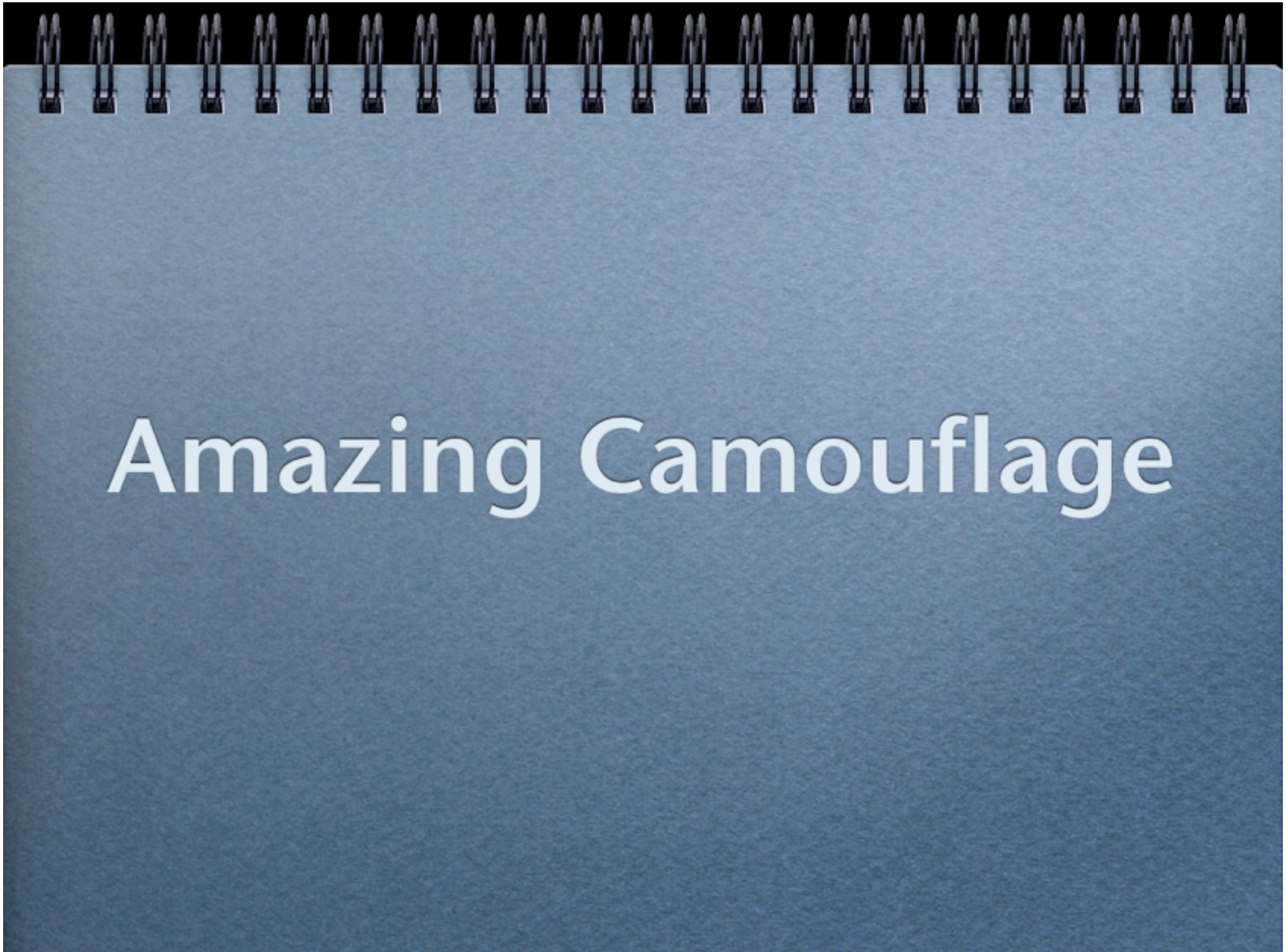
- **NATURAL SELECTION- differential reproductive success!**

- Beneficial traits are subject to the environment, a beneficial trait for one may be deleterious to another.
  (should the environment change so to might the beneficial traits)

- Natural selections can only amplify or diminish the traits that differ in a population.
  (no variation = no selection)

- Populations evolve not individuals.

Natural Selection in Action



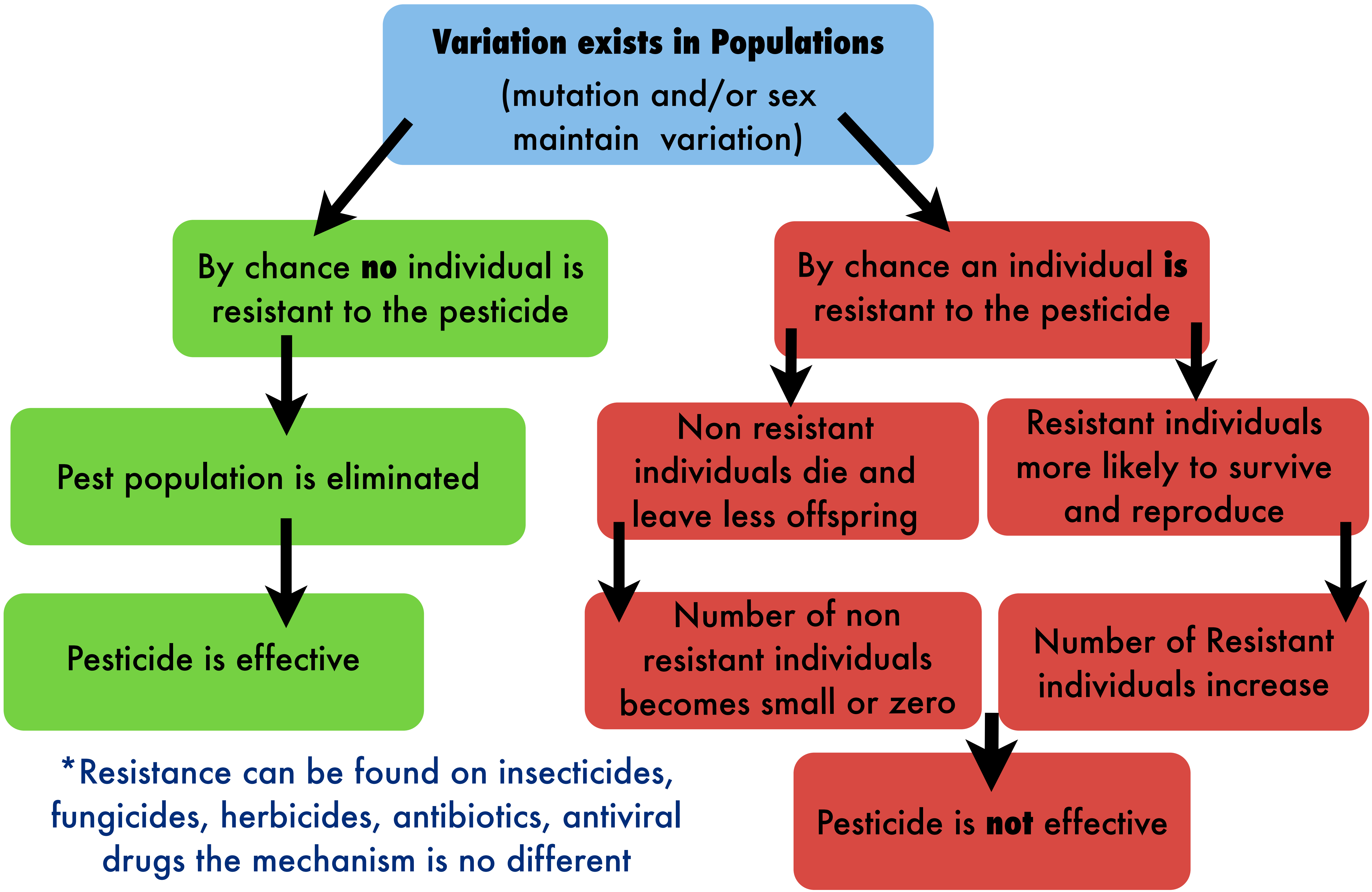
Darwin's Theory

- **The colloquial use of theory would be best described as a possible explanation !**
- **In science however a theory is much more comprehensive.**
  - **1st- theories explains a broad variety of observations and phenomena**
  - **2nd- theories can only continue to stand up through further testing and observations**
  - **3rd- scientific skepticism keeps theories from becoming dogma, and allows them to expand and adapt**

Evidence for Evolution

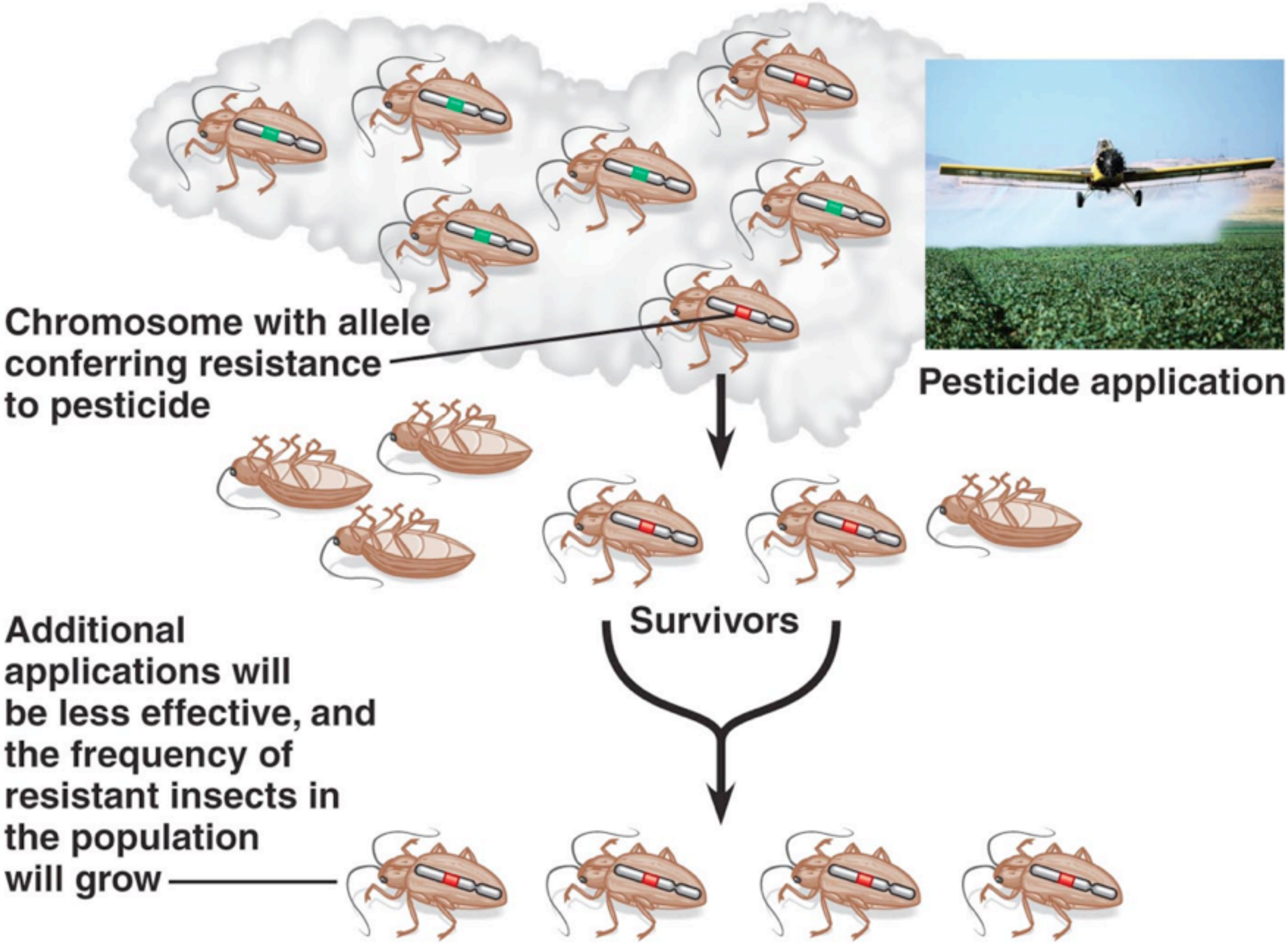
- **What does/can the theory of evolution explain?**
- **What observations does/can the theory of evolution support?**
  - **Pesticide Resistance**
  - **Fossil Record**
  - **Biogeography**
  - **Anatomical Observations**

*Pesticide Resistance

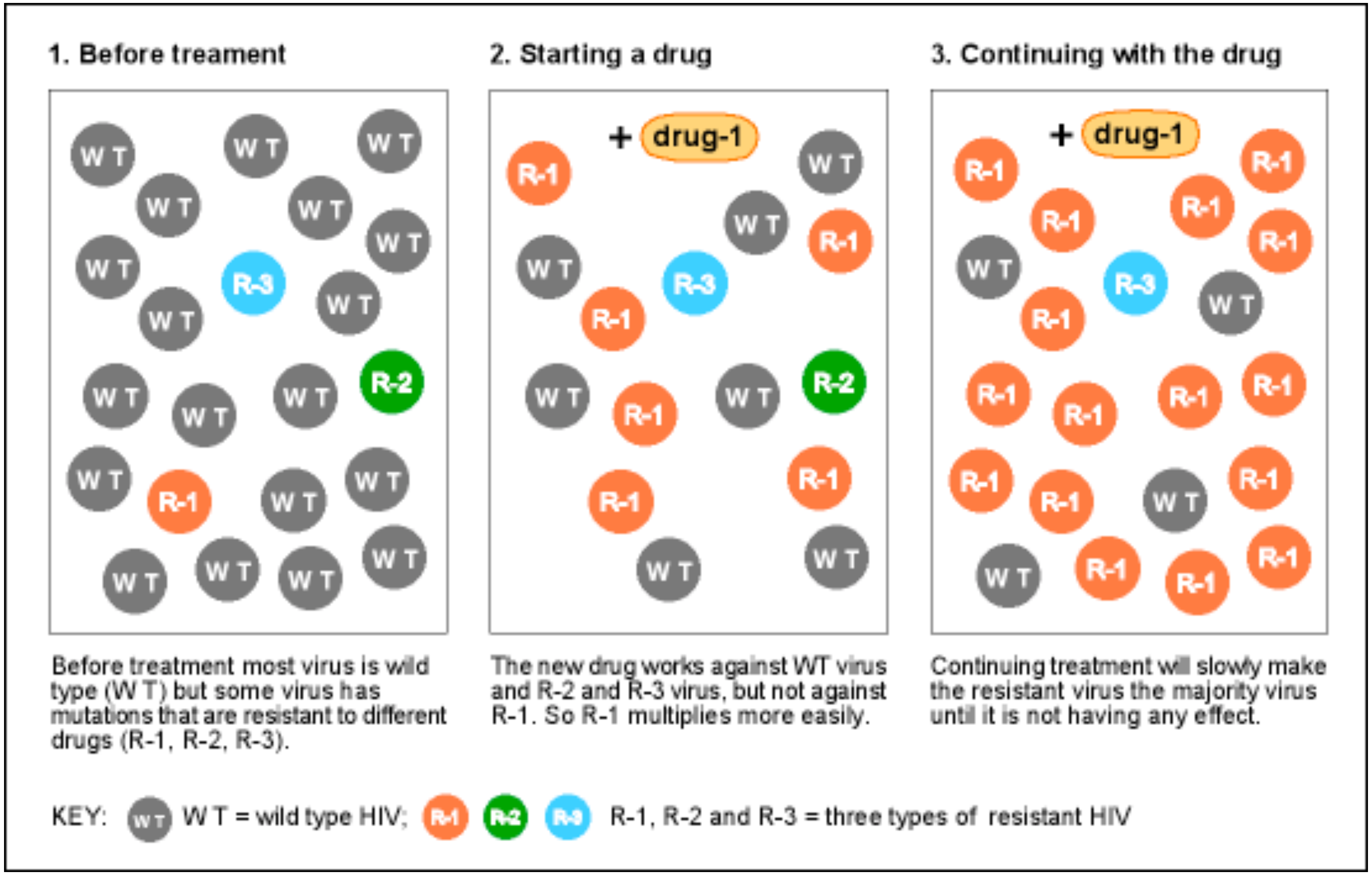


*Resistance can be found on insecticides, fungicides, herbicides, antibiotics, antiviral drugs the mechanism is no different

*Pesticide Resistance



HIV Resistance



What is the selective pressure that changed the make up of the population?

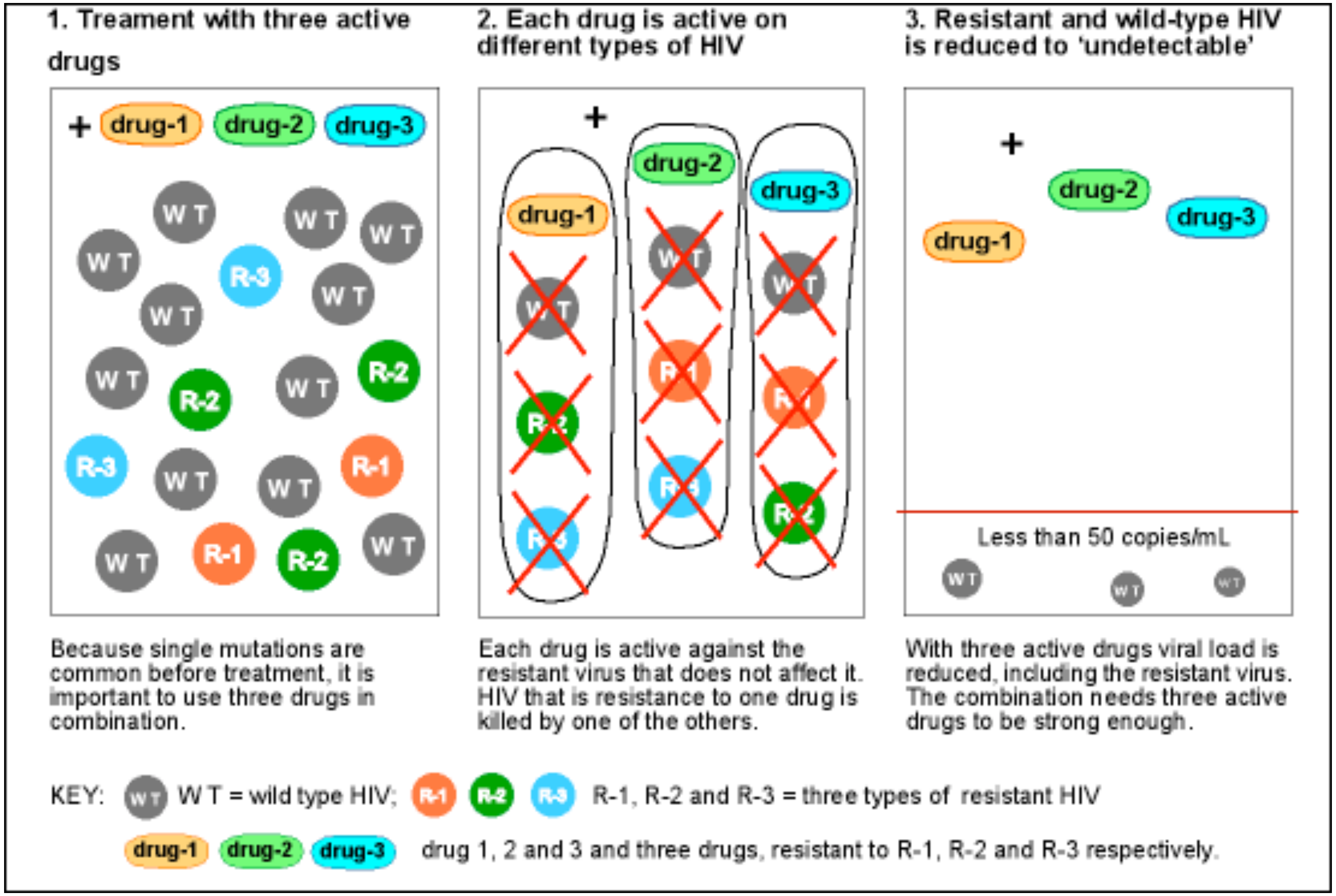
Answer: drug-1

How is the viral load changing from each successive window?

Answer: viral load decreases from window 1 to 2 but increases from 2 to 3.

Use the information above and suggest 2 therapeutic strategies for HIV .

HIV Therapy



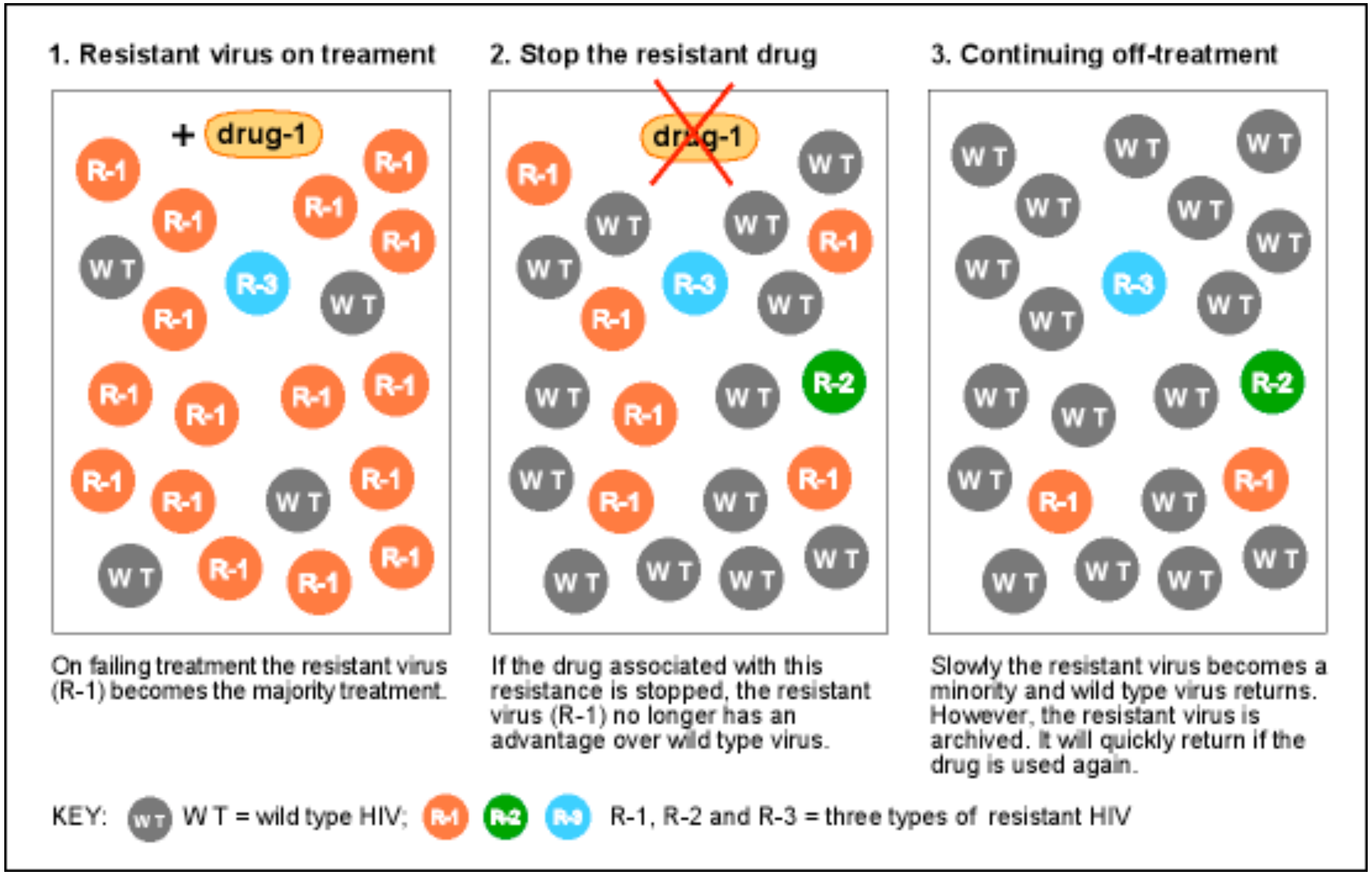
Obviously HIV has not yet been cured, Why is this therapy unable to“cure” HIV.?

Answer: 1. there may be more viral variants then drugs 2. the drugs take time to work & perhaps new variants emerge through mutations during that time 3.see question

Suggest how this therapy might work?

Answer: the new anti-viral drugs inhibit the reproduction of new viruses but we still have no way of eliminating those viruses already present lying dormant in cells

HIV Therapy



Assume that we can keep a person with HIV alive indefinitely if we can keep the viral count low.

Suggest a therapy based upon this information?

Answer: Intermittent use of the drug. The drug will have initial success (lowering viral count), then as resistant form increases remove drug and allow wild type to outcompete the resistant type there by lowering the viral count, next as wild type becomes more common hit them with the drug again...repeat indefinitely.

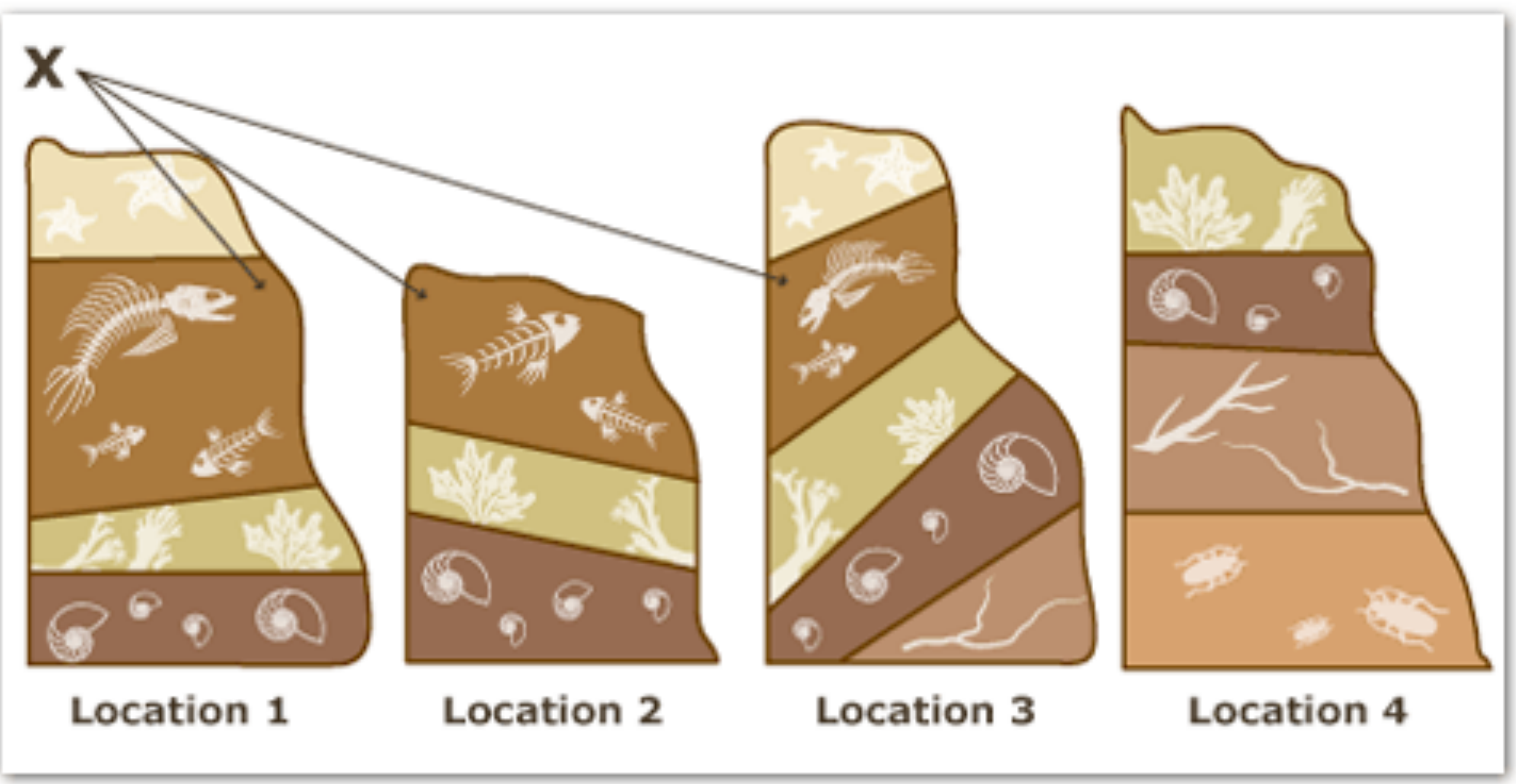
Graph the viral count over time. Indicate on the graph where drug was administered and removed.

Fossil Record

- **Law of Superposition**

- **The lower the strata the older the rock**

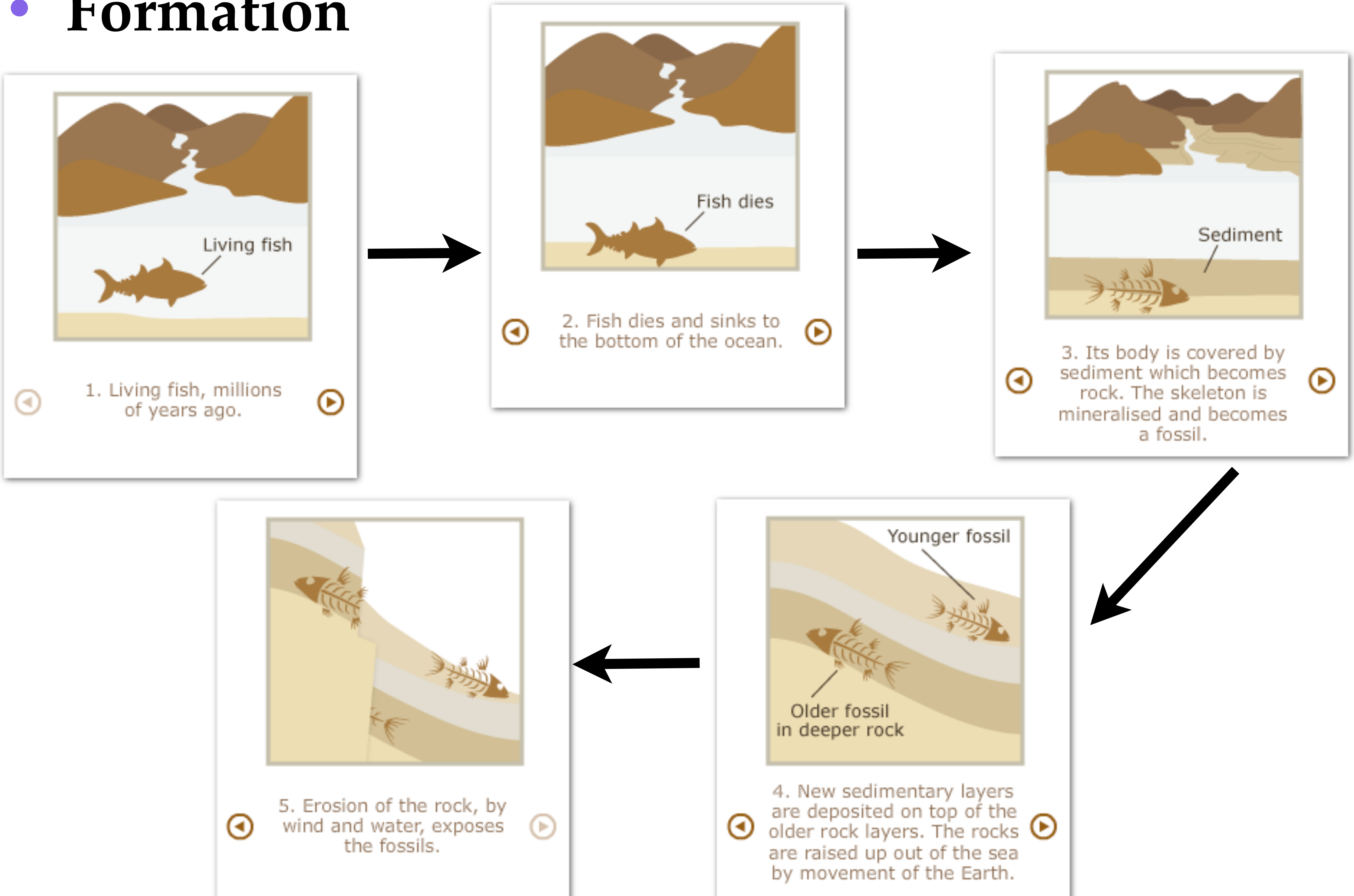
- **General Pattern**



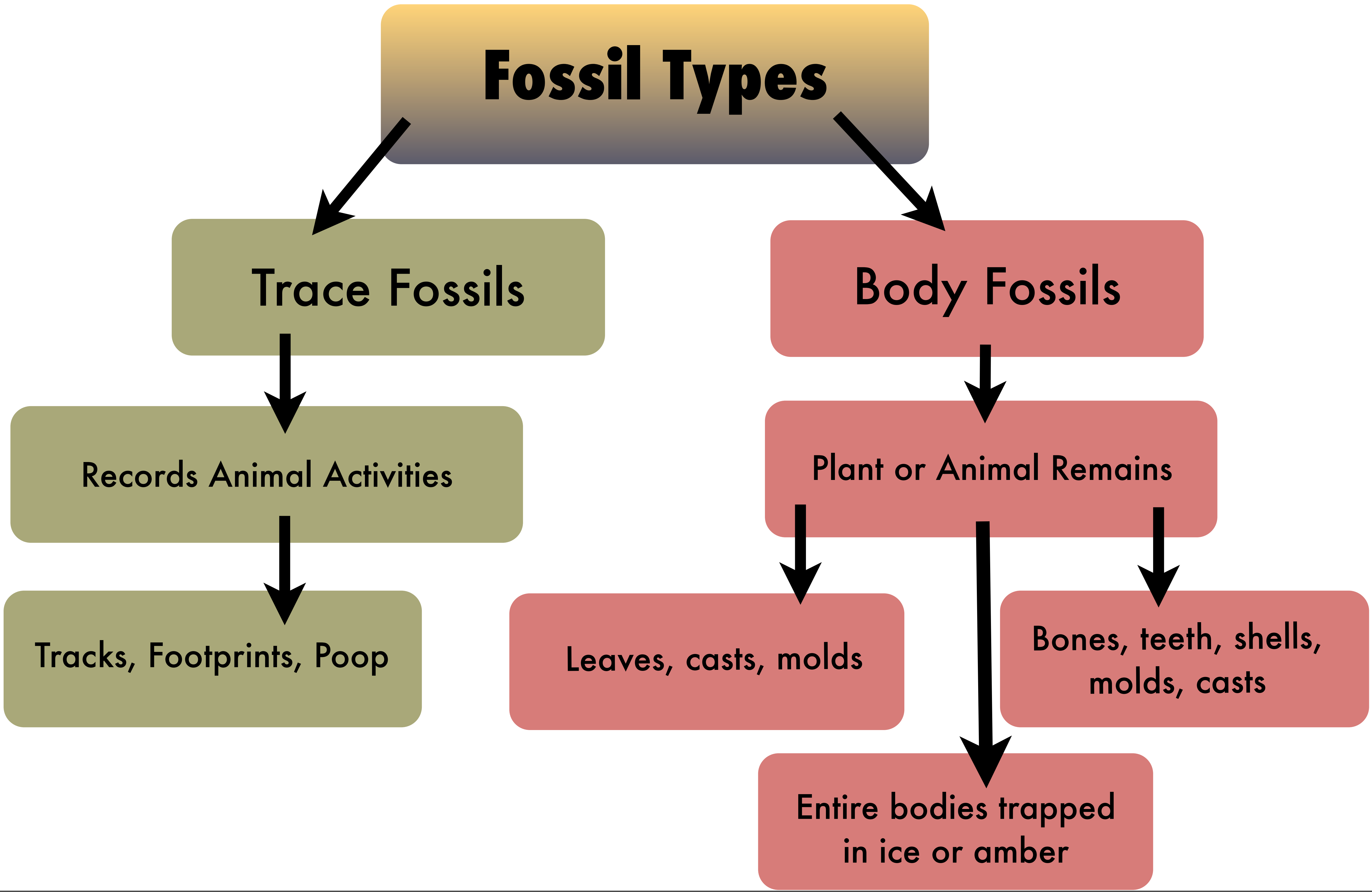
- **Shows a succession of forms**
- **Similar fossils in similar strata**
- **Older Strata, simpler organisms**
- **Newer Strata, more complex organisms**

Fossils

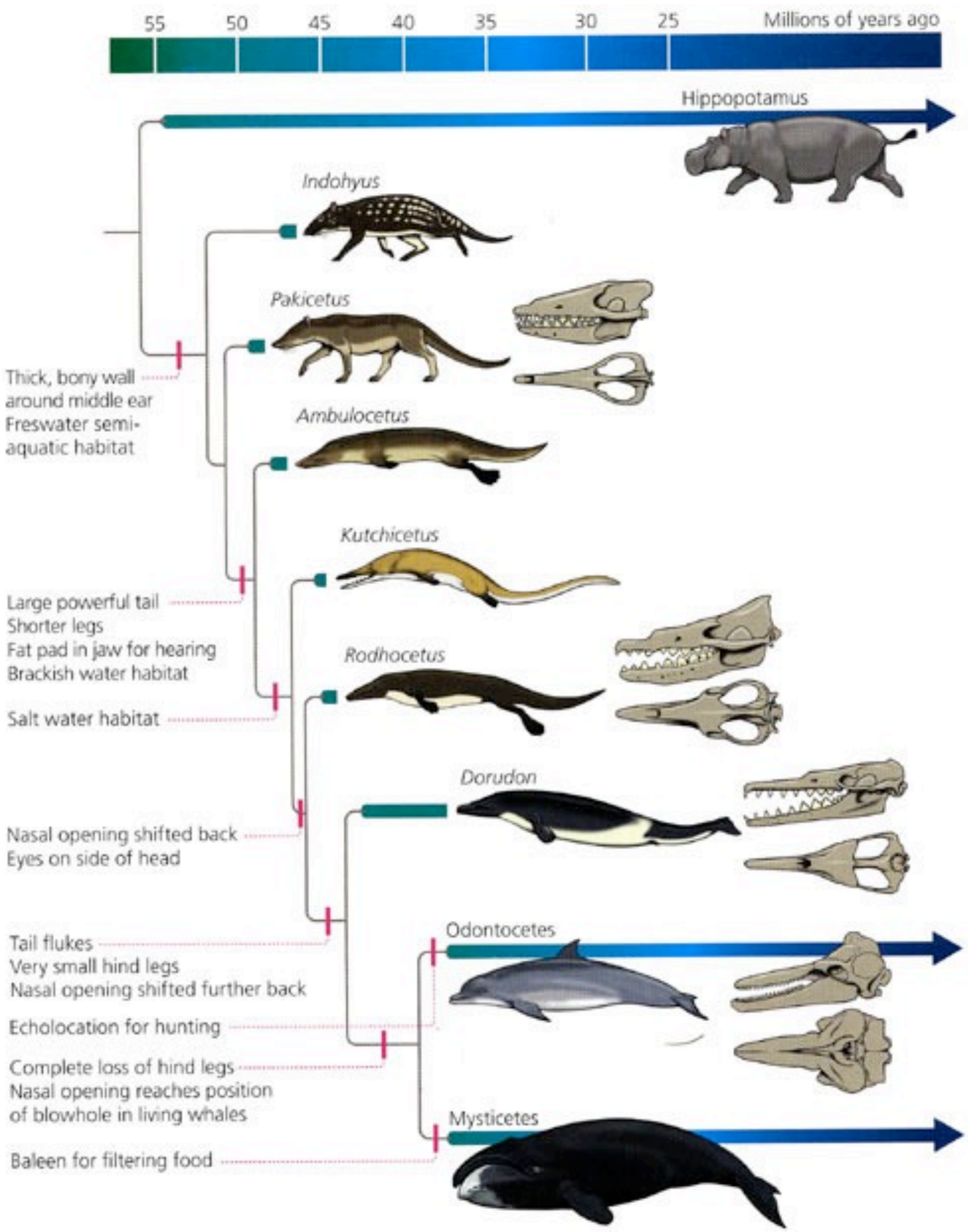
- **Formation**



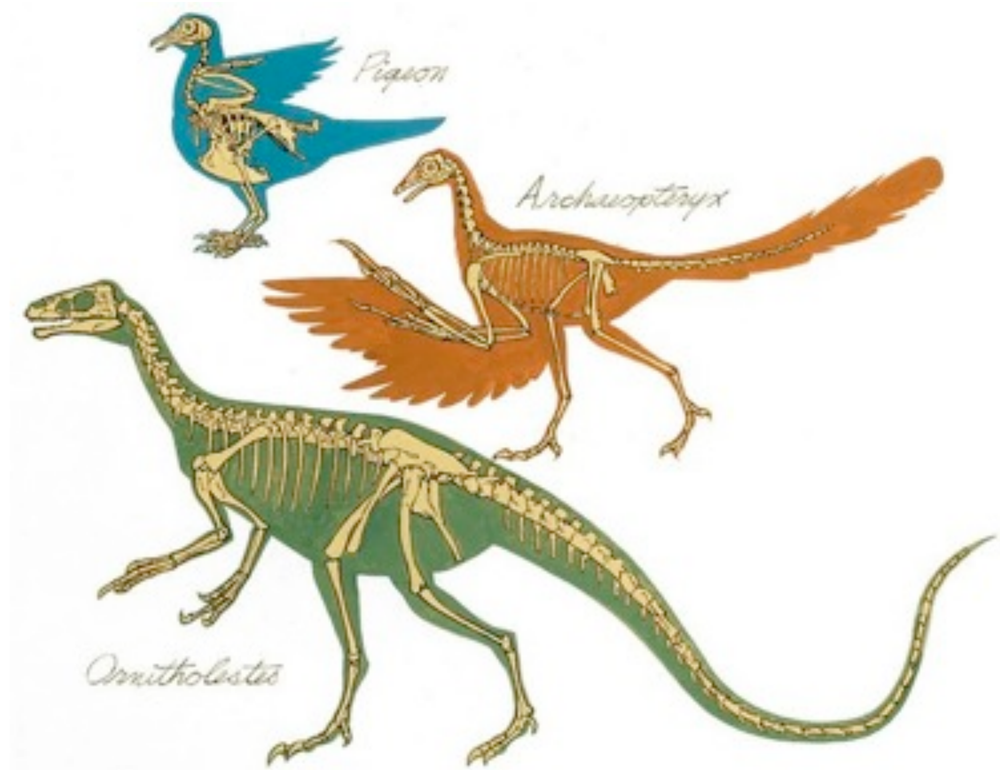
Fossils


Fossil Types
Trace Fossils
Body Fossils
Records Animal Activities
Plant or Animal Remains
Tracks, Footprints, Poop
Leaves, casts, molds
Bones, teeth, shells, molds, casts
Entire bodies trapped in ice or amber

Fossil Record



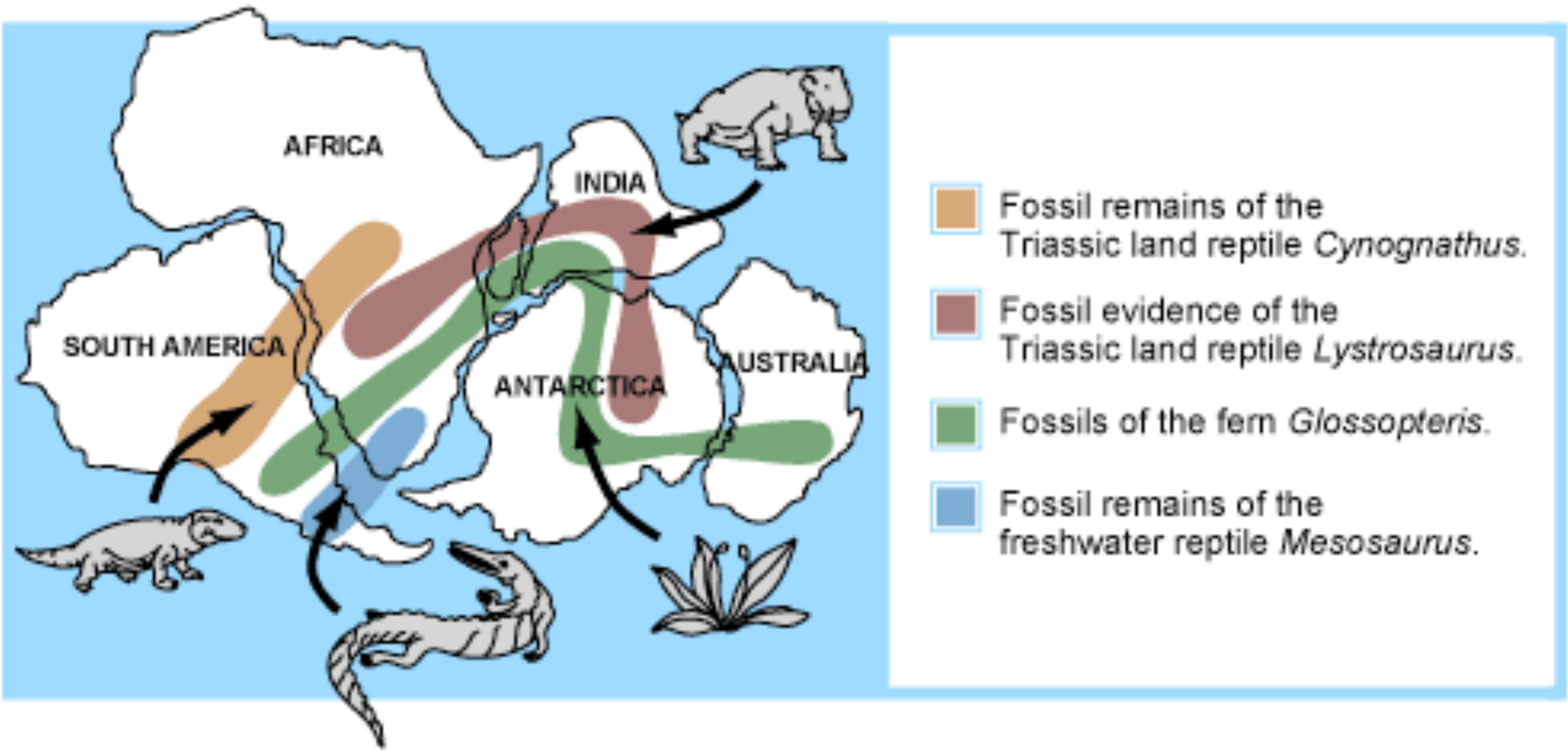
- **Transitional Forms**



Biogeography

- **Biogeography- is record of inheritance,**
  - **specifically the study of geographical distribution of species and how they got that way**

Global →



Wegener found that the distributions of fossils of several organisms supported his theory that the continents were once joined together.

Biogeography

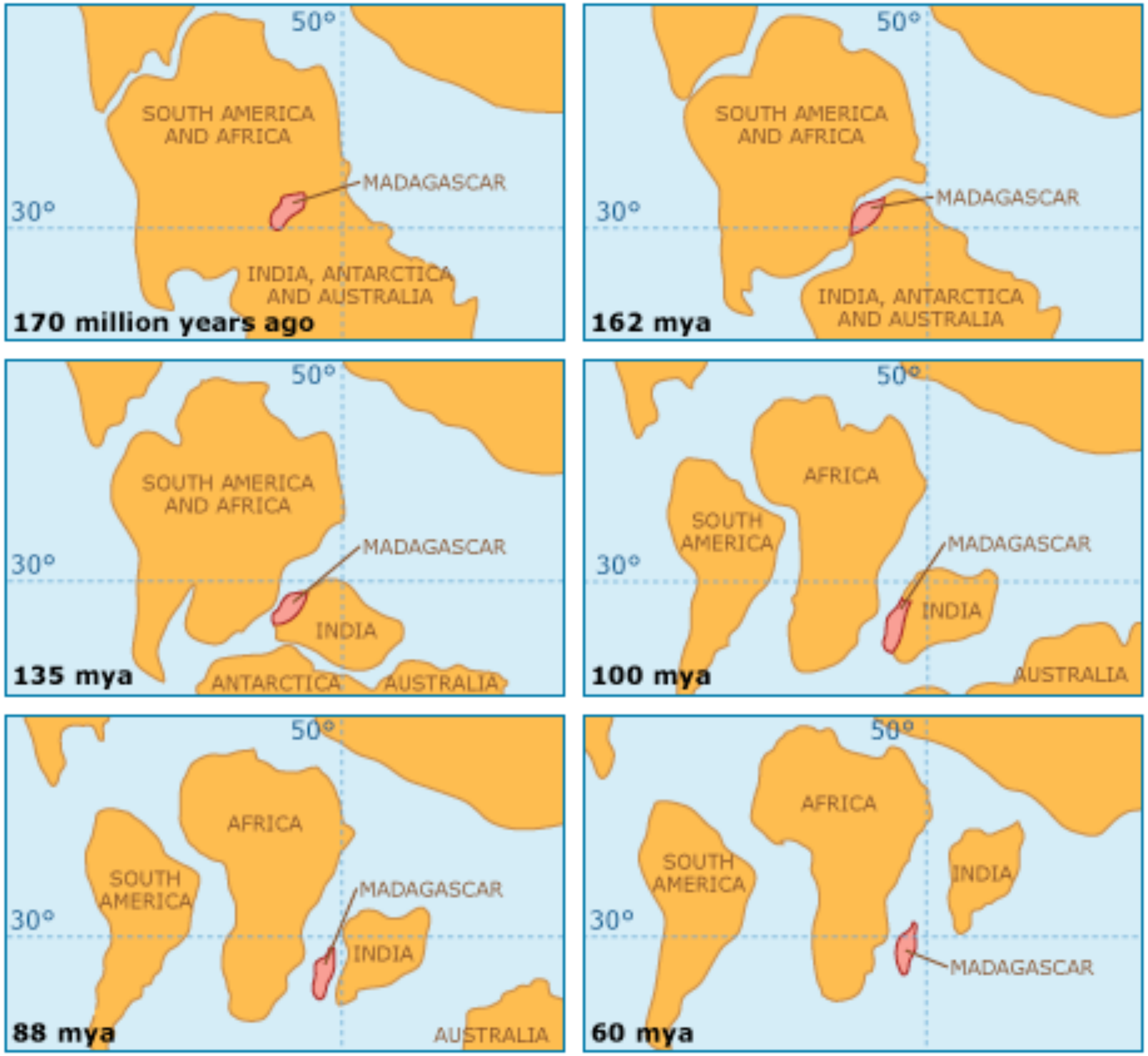
Local

Biogeography

Where did all of Madagascar's species come from?

Vicariance

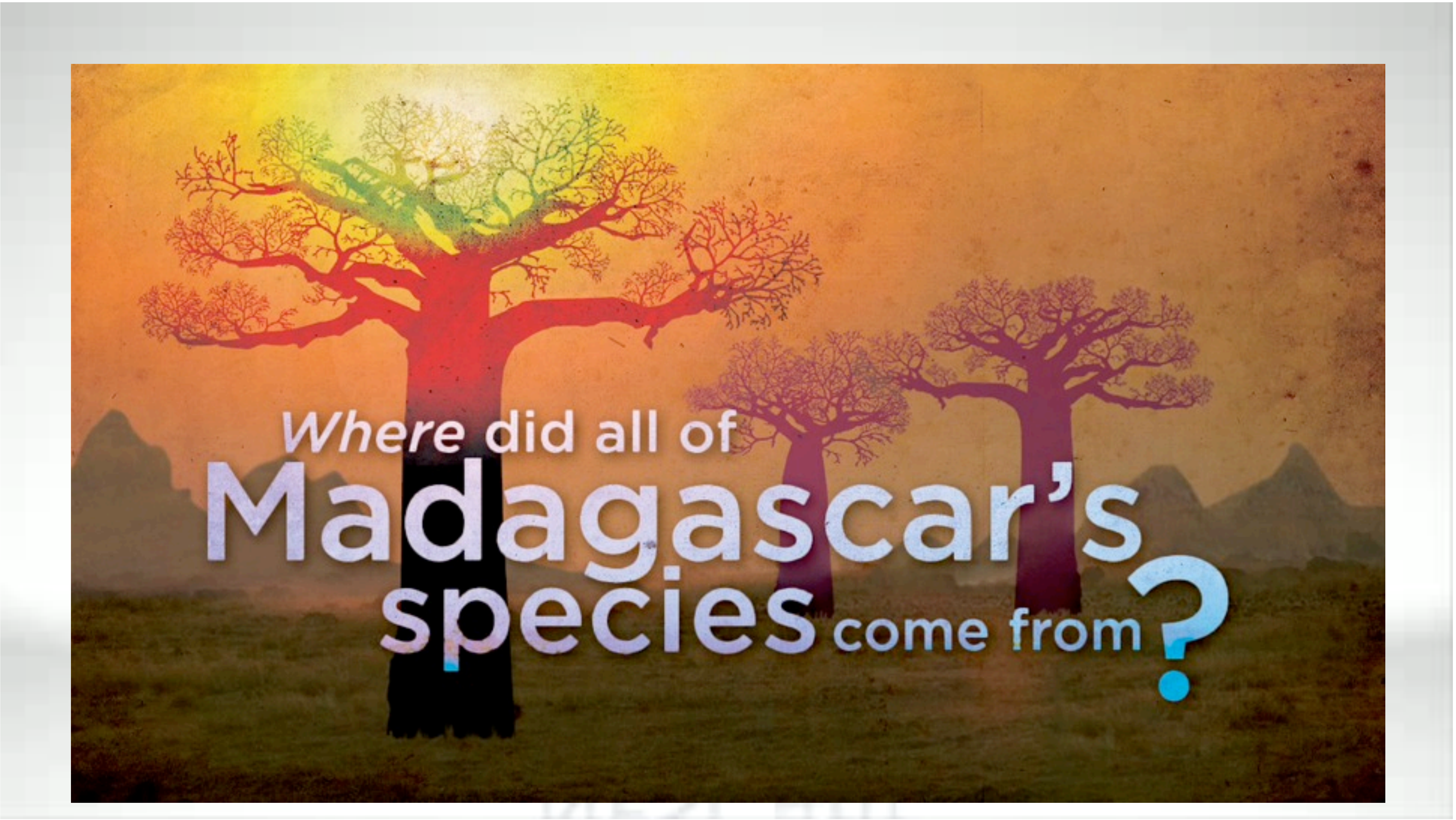
species were there originally, and as land separated they moved with the land



Dispersal

species traveled to the land after it moved

Biogeography

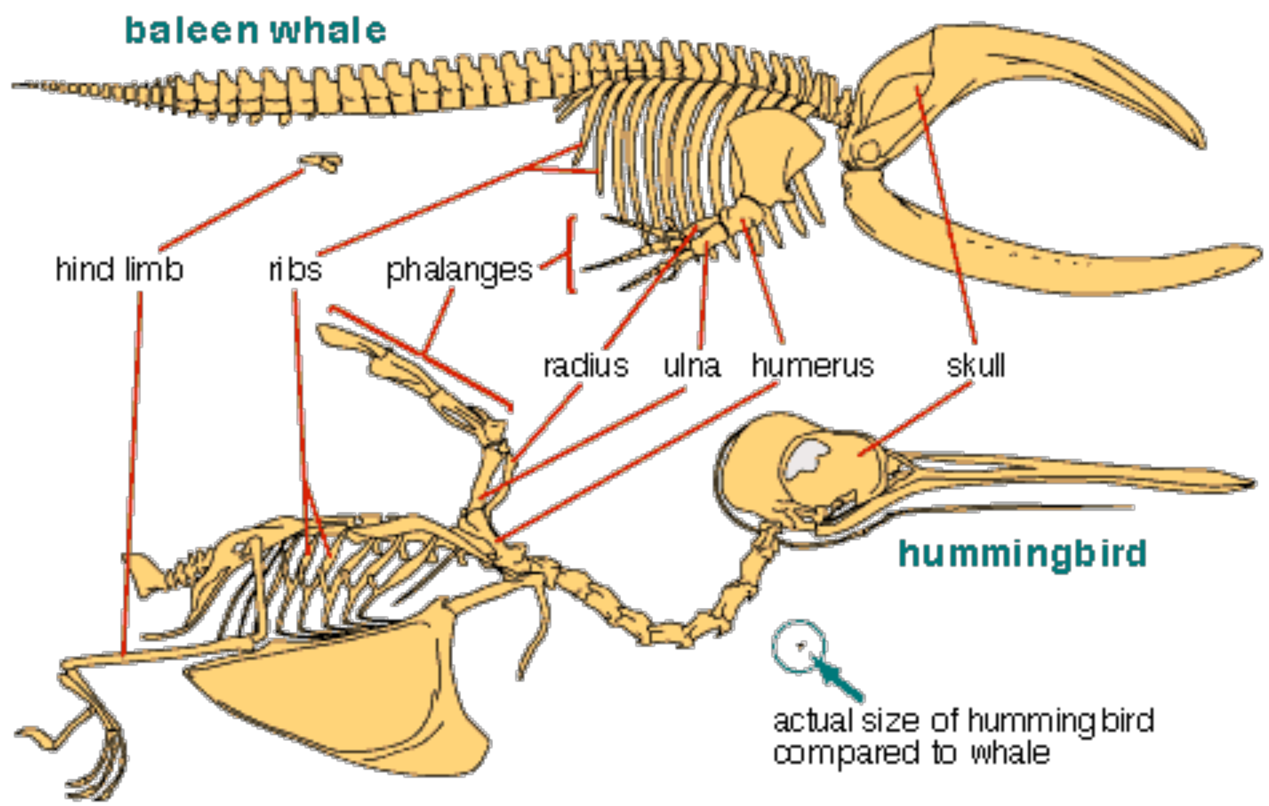


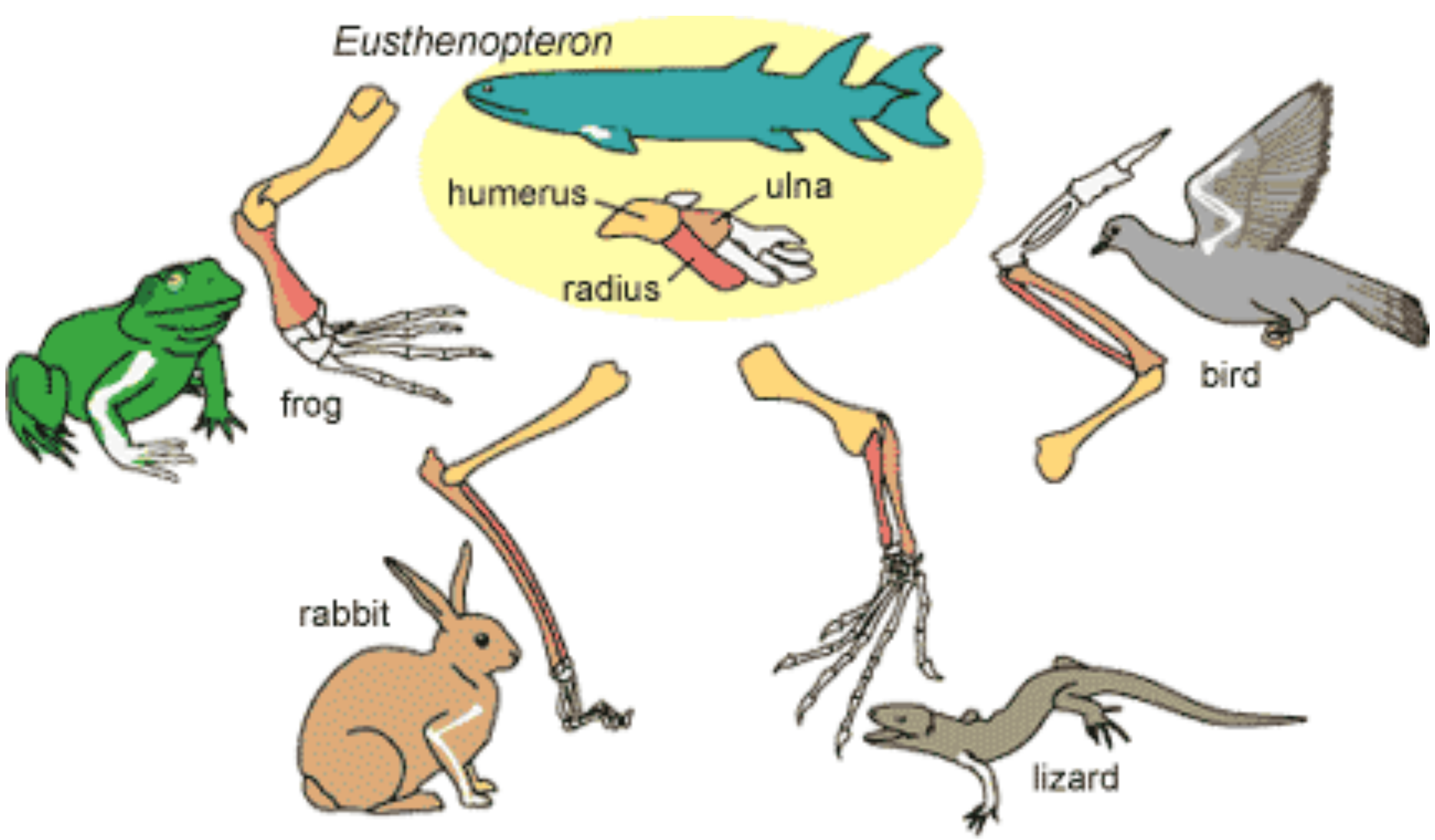
Homology

- **Homology- when related organisms will share certain traits due to common ancestry**
- ***(of course differences in traits are due to divergence as each species adapts to its own environment/challenges)***
    - **Anatomical**
        - **Vestigial Structures**
    - **Embryological**
    - **Cellular**
    - **Molecular**

Anatomical Homology

Although each skeleton appears very different nearly every bone in each has an equivalent in the other

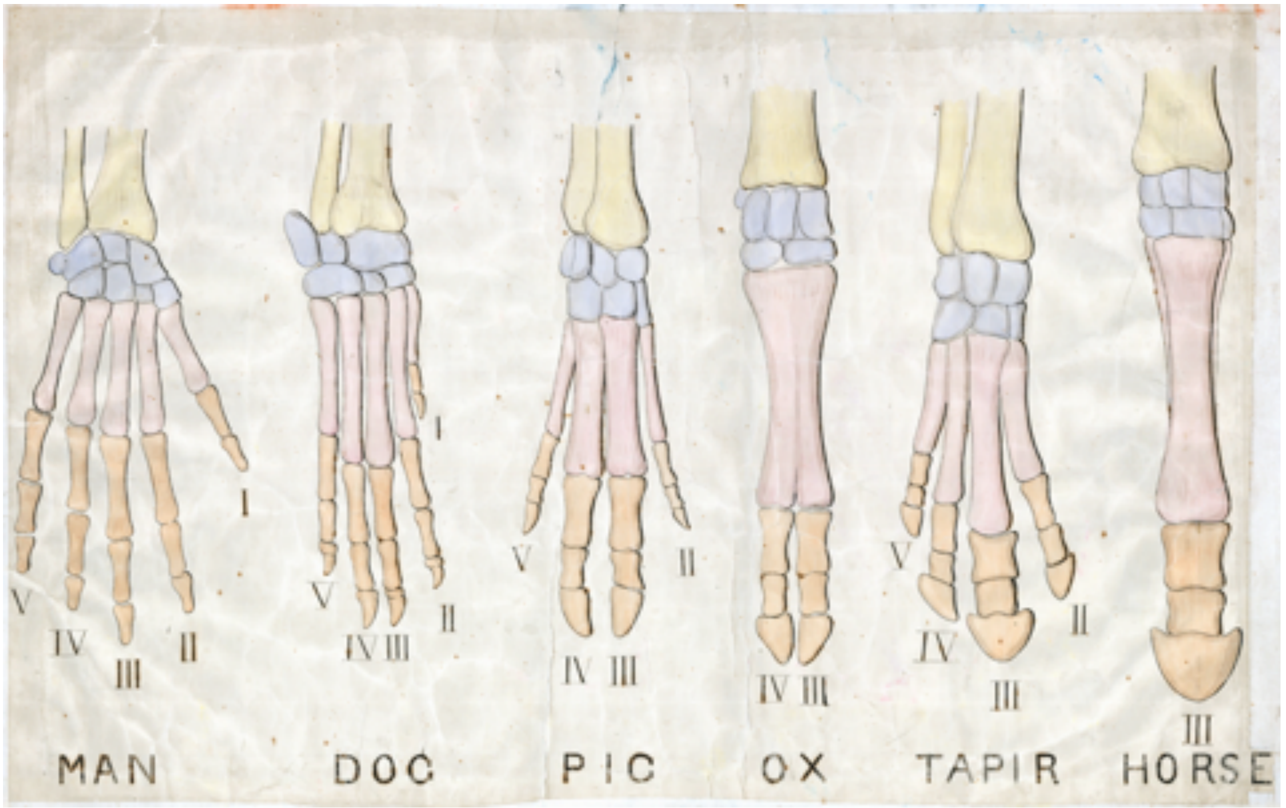




Classic example of tetrapod forelimbs, similar structures, dissimilar functions

Vestigial Structures

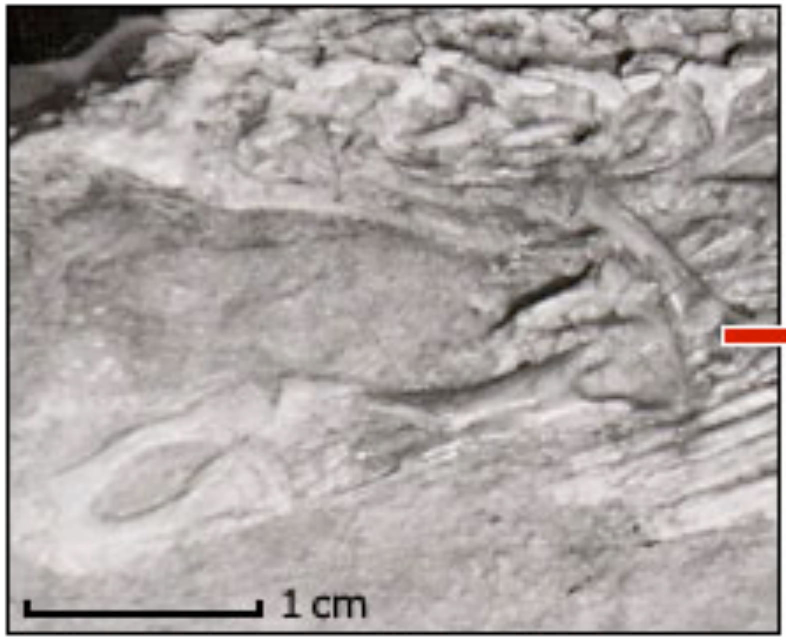
Structures inherited that over time become less functional

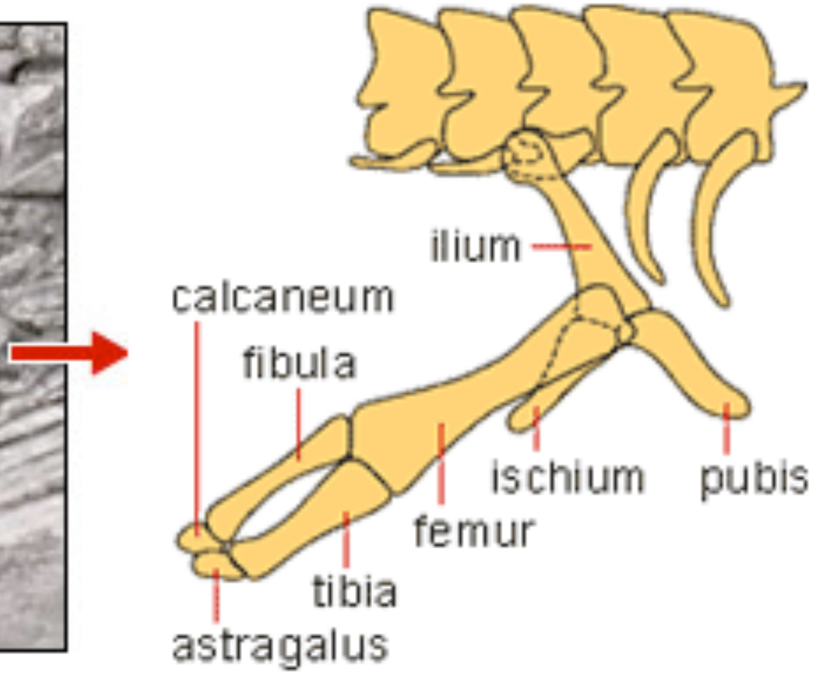


Embryological Homology

Snakes have legged ancestors.

Some species of living snakes have hind limb-buds as early embryos but rapidly lose the buds and develop into legless adults. The study of developmental stages of snakes, combined with fossil evidence of snakes with hind limbs, supports the hypothesis that snakes evolved from a limbed ancestor.



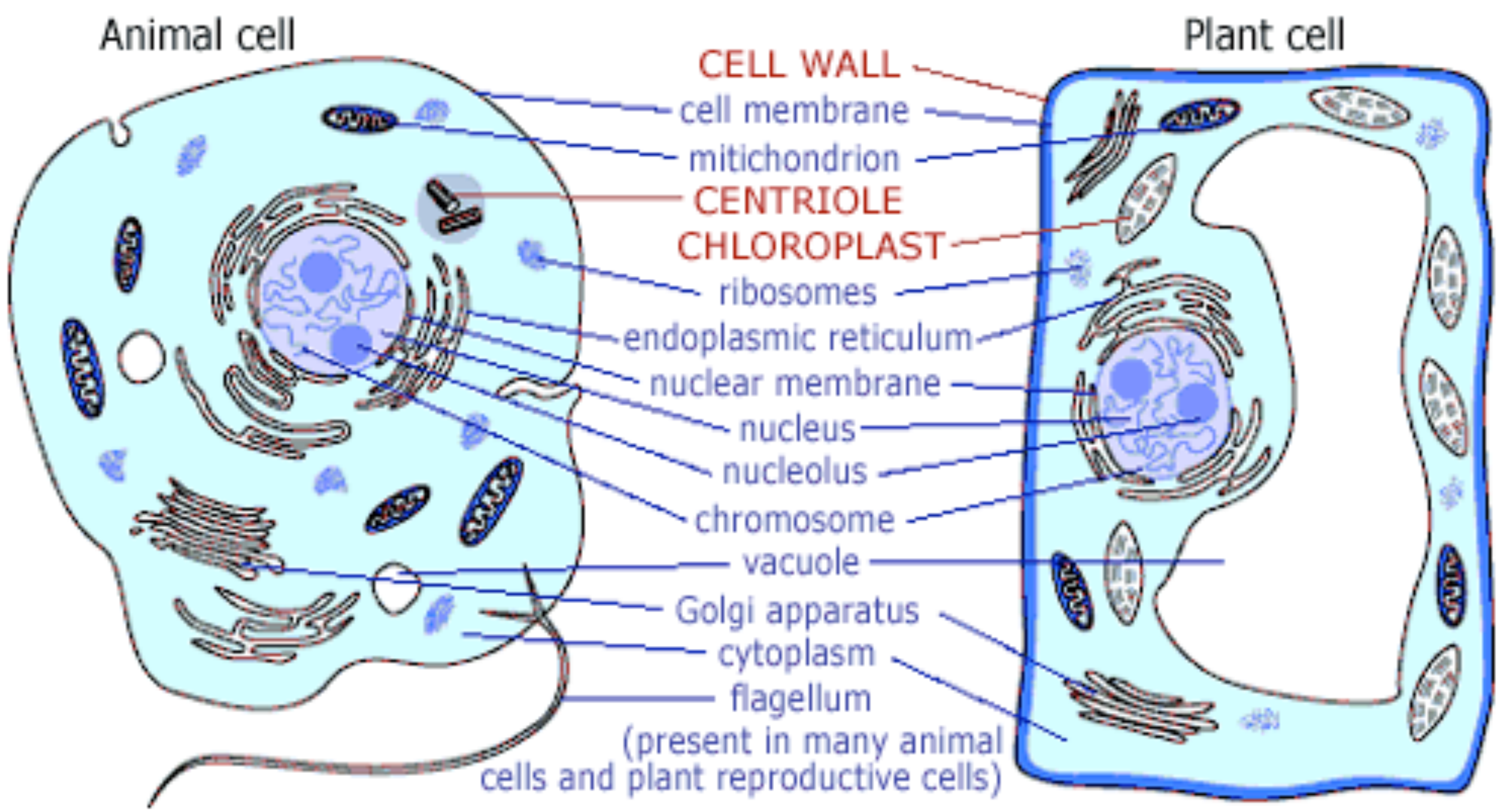


Above left, the Cretaceous snake *Pachyrhachis problematicus* clearly had small hindlimbs. The drawing at right shows a reconstruction of the pelvis and hindlimb of *Pachyrhachis*.

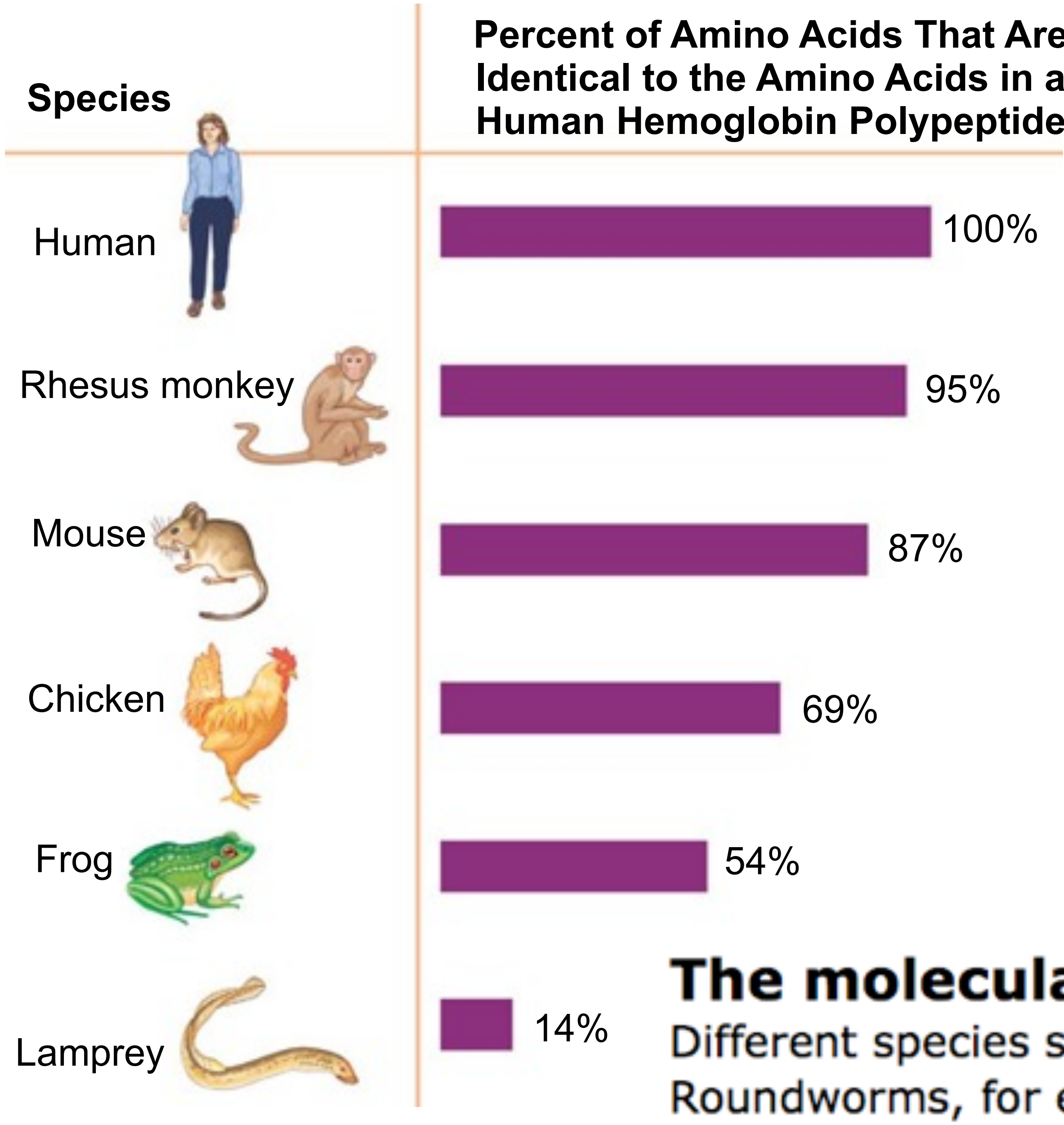
Cellular Homology

The cellular level

All organisms are made of cells, which consist of membranes filled with water containing genetic material, proteins, lipids, carbohydrates, salts and other substances. The cells of most living things use sugar for fuel while producing proteins as building blocks and messengers. Notice the similarity between the typical animal and plant cells pictured below — only three structures are unique to one or the other.



Molecular Homology

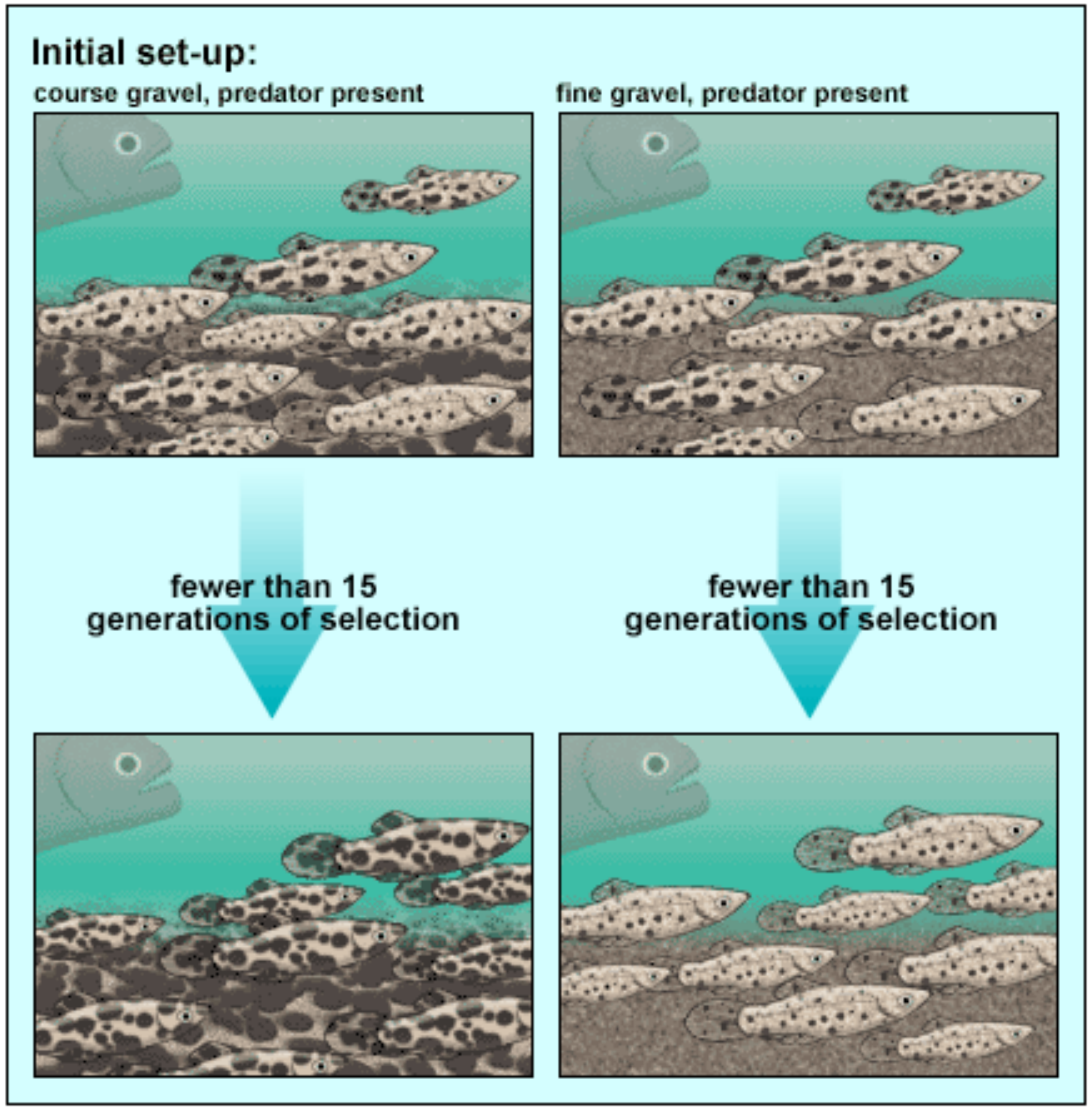


Biologists find homologies in amino acid sequences and nucleotide sequences of both DNA and RNA

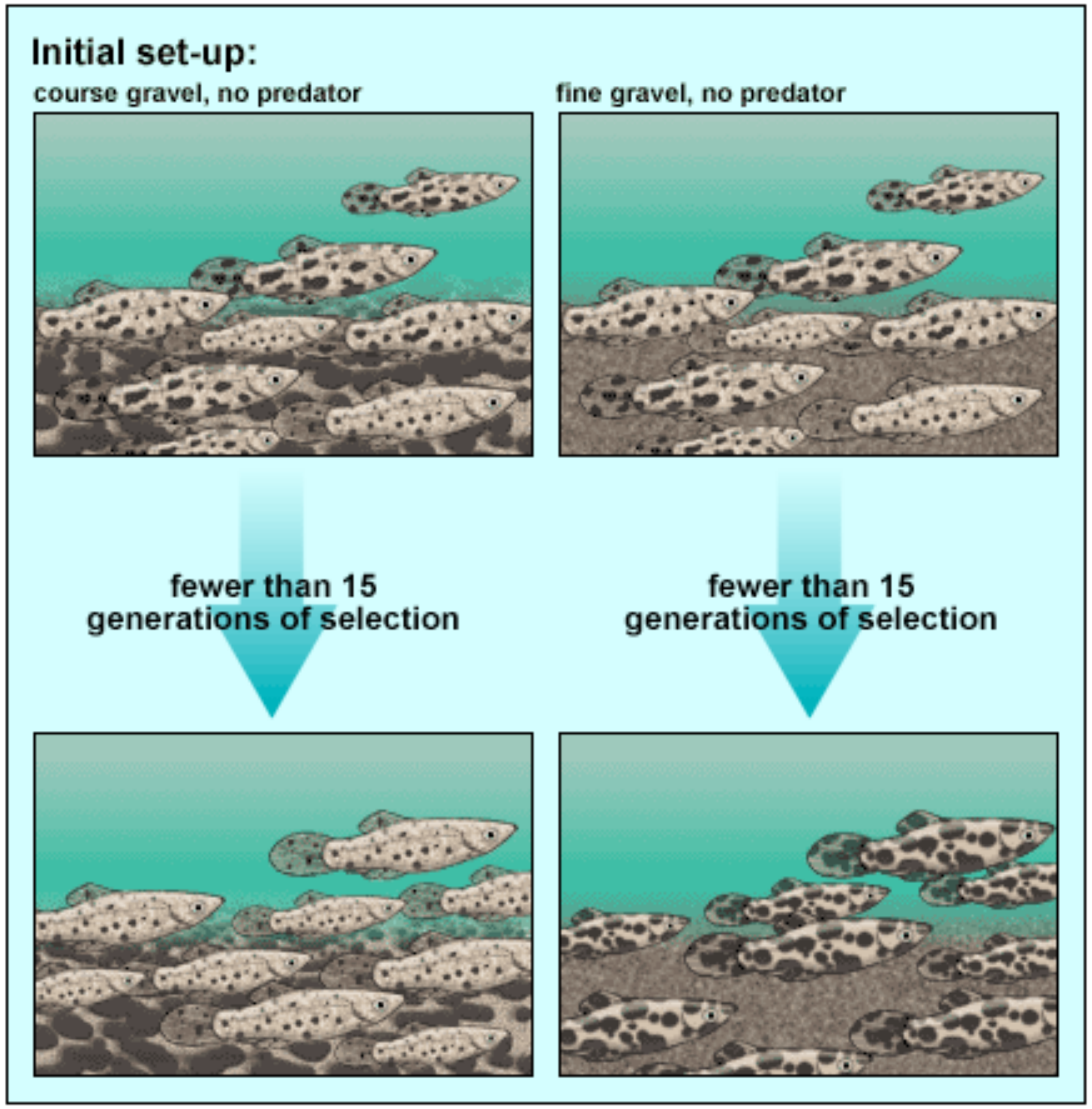
The molecular level

Different species share genetic homologies as well as anatomical ones. Roundworms, for example, share 25% of their genes with humans. These genes are slightly different in each species, but their striking similarites nevertheless reveal their common ancestry. In fact, the DNA code itself is a homology that links all life on Earth to a common ancestor. DNA and RNA possess a simple four-base code that provides the recipe for all living things. In some cases, if we were to transfer genetic material from the cell of one living thing to the cell of another, the recipient would follow the new instructions as if they were its own.

Natural Selection in Action

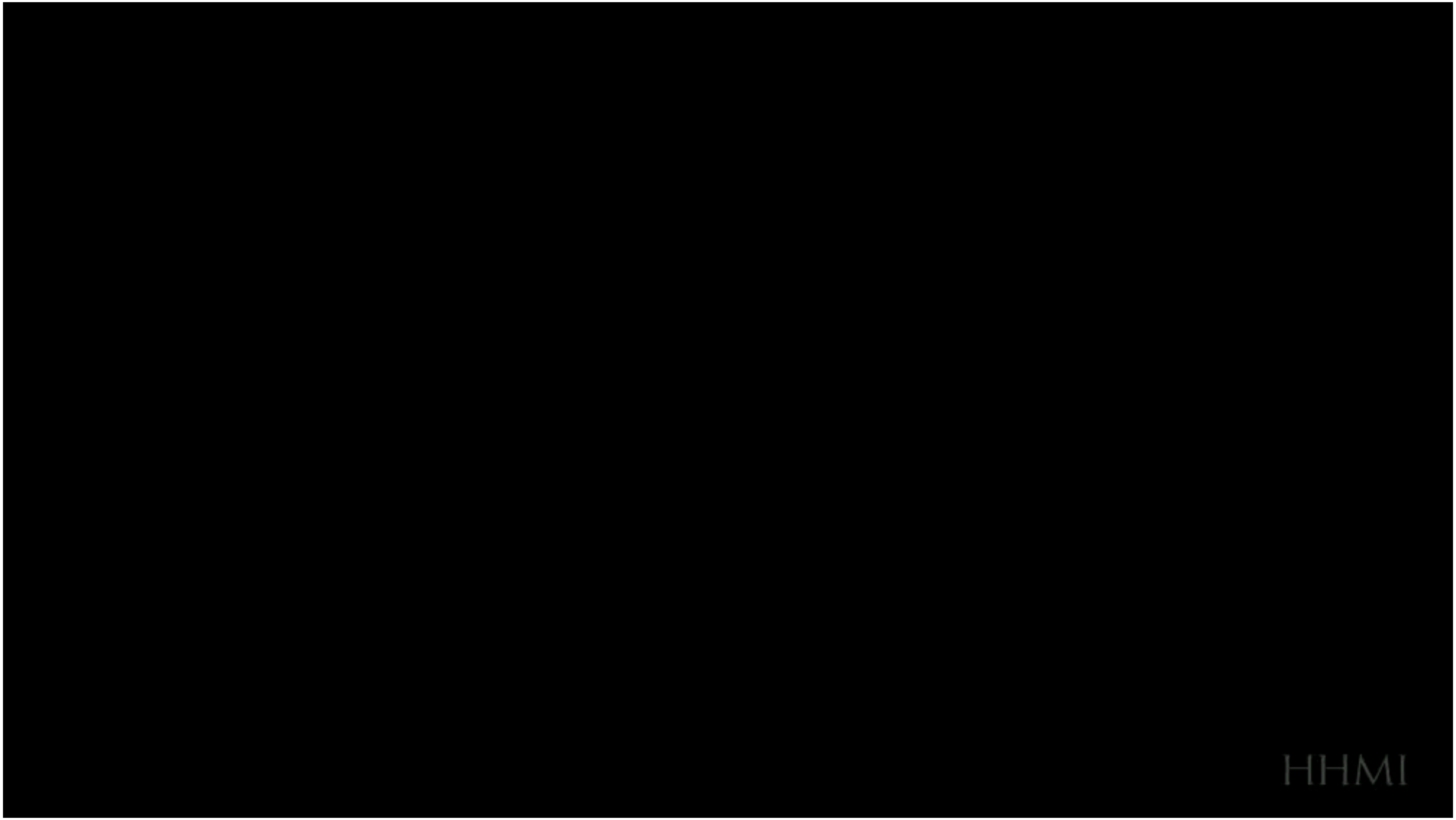


The predator serves as the strongest selective pressure, resulting in a population that blends with its surroundings to avoid being eaten



With predator removed sexual selection serves as the strongest pressure, resulting in a population with males standing out against their surroundings

Natural Selection in Action



What exactly is evolving?

- **The POPULATION as a whole adapts and changes over time with the inevitable changing conditions...POPULATIONS Evolve!**
- **The POPULATION is the smallest unit of evolution.**
    - **The Individual can change through growth and development but only populations evolve.**
    - **Traits effect the survival and reproductive success of individuals but the effects of natural selection are only seen in the larger group over time.**

Evolution

- **Evolution is simply a change in the gene (alleles) frequencies in a population over time!**

  - **3 Things can change gene frequencies**
    - ***Natural Selection**
    - **Genetic Drift**
    - **Gene Flow**

**Only natural selection results better adapted organisms*

Evolution- Ingredients

- **For evolution to occur we need at least two very important ingredients: time & variation.**
- **TIME**
  - **(in general) more time = greater changes**
  - **Darwin's mechanism was slow and gradual, it required vast tracks of time**
  - **Today we think "some" change might happen rapidly in bursts**
- **VARIATION**
  - **remember the force behind evolution is natural selection, the very word itself "selection " implies variation otherwise there is nothing to "select"**

Evolution- Variation

- **Individual variation occurs in all species.**
  - **some variation we can see- hair color**
  - **some variation we can see- blood groups**
- **Individual variation reflect genetic variation.**
  - **different phenotypes result from different genotypes**

When certain traits are favored over others it is in fact the genes, the "blueprints" for those traits that are being being favored. Thus GENES provide the raw material for evolution.

Variation in a Population

- **Biologists can quantify genetic variation at two levels.**
- **Gene Variability**
  - **measures variation among genes themselves**
- **Nucleotide Variability**
  - **measures variation among the nucleotides that make up the genes**

Variation in a Population

- **Gene Variability**
  - **measures *average heterozygosity,* the percent of loci (gene positions) that are heterozygous (Aa as opposed to homozygous AA or aa)**
- **Nucleotide Variability**
  - **compares the DNA sequences of two individuals from a population and averages the differences seen in many of these comparisons**

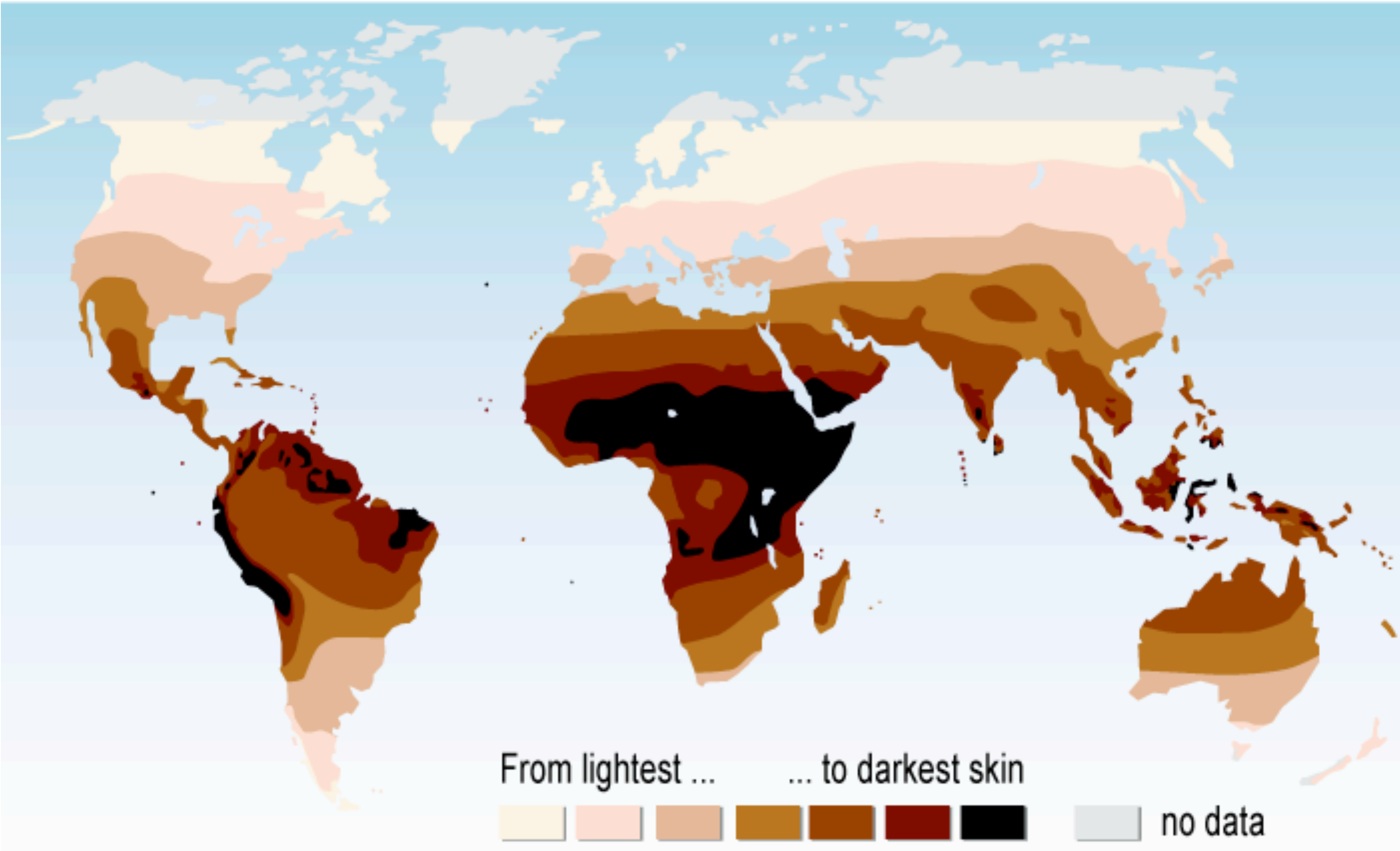
Both of these require biotechnology such as gel electrophoresis, PCR and restriction fragment analysis

Variation Between Populations

- **Biologists can also quantify genetic variation between two different populations... *geographic variation*.**
- **Differences are usually found**
    - **sometimes differences are purely random (genetic drift, discussed shortly)**
    - **other times the differences are likely a result of natural selection favoring certain traits over others**
        - **example- clines**

Skin colour map for indigenous people

Predicted from multiple environmental factors



Source: Chaplin G.©, *Geographic Distribution of Environmental Factors Influencing Human Skin Coloration*, American Journal of Physical Anthropology 125:292–302, 2004; map updated in 2007.

Sources of Variation

- **Recall: Evolution requires variation...**
- **BUT natural selection reduces variation in a population over time...**
- **THUS there must be mechanism(s) that generate(s) variation in a population otherwise populations would lose their ability to evolve**

SEX & MUTATIONS... Generate Variation!

Sex Sex Sex

- **Sexual Reproduction shuffles existing genes (alleles) deals them at random to produce unique individuals.**
- **The "shuffling mechanisms" include...**
  - ***Crossing Over***
  - ***Independent Assortment***
  - ***Random Fertilization***

Ultimately all the different genes that sex reshuffles originated in a population by way of a mutation.

Mutations...gotta have them!

- **Any and all new alleles (genes) arise from mutations.**
- **Mutations- are change in nucleotide sequence in an organisms DNA**
  - **Mutations are random**
    - ***Only mutations that occur in gametes (sperm/eggs) can be inherited and passed generation after generation***
    - ***Somatic (body cells) mutations can not be inherited and thus die with the individual.***

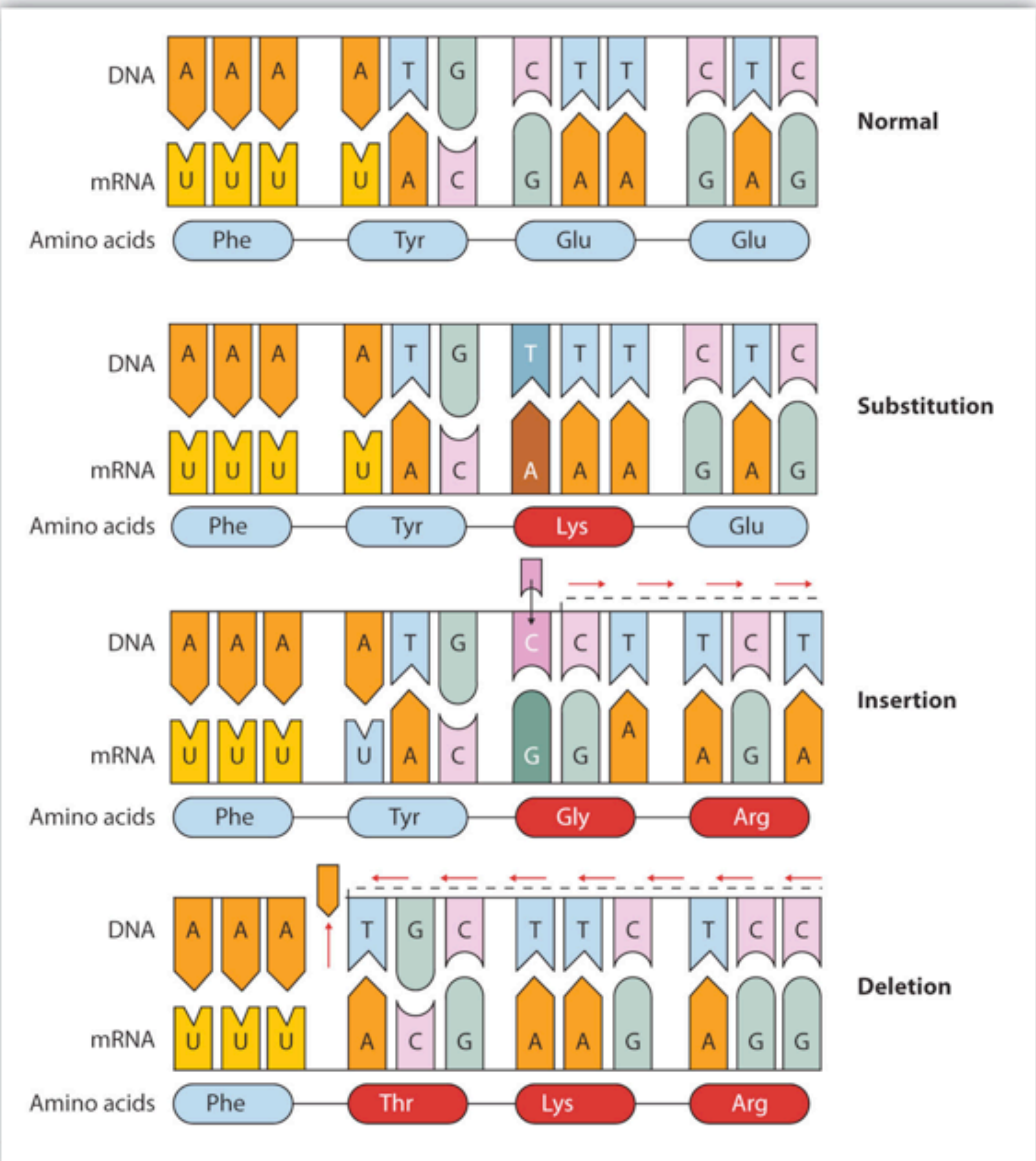
Effects of Mutations

- **Mutations change nucleotide sequences, which in turn changes the protein product, which in turn alters the phenotype (trait).**
- **Most mutations are neutral or perhaps slightly harmful.**
- **On rare occasions a mutation results in a new trait that provides a selective advantage to the individual and should they reproduce to their offspring.**
    - **Over time this new gene becomes more common.**

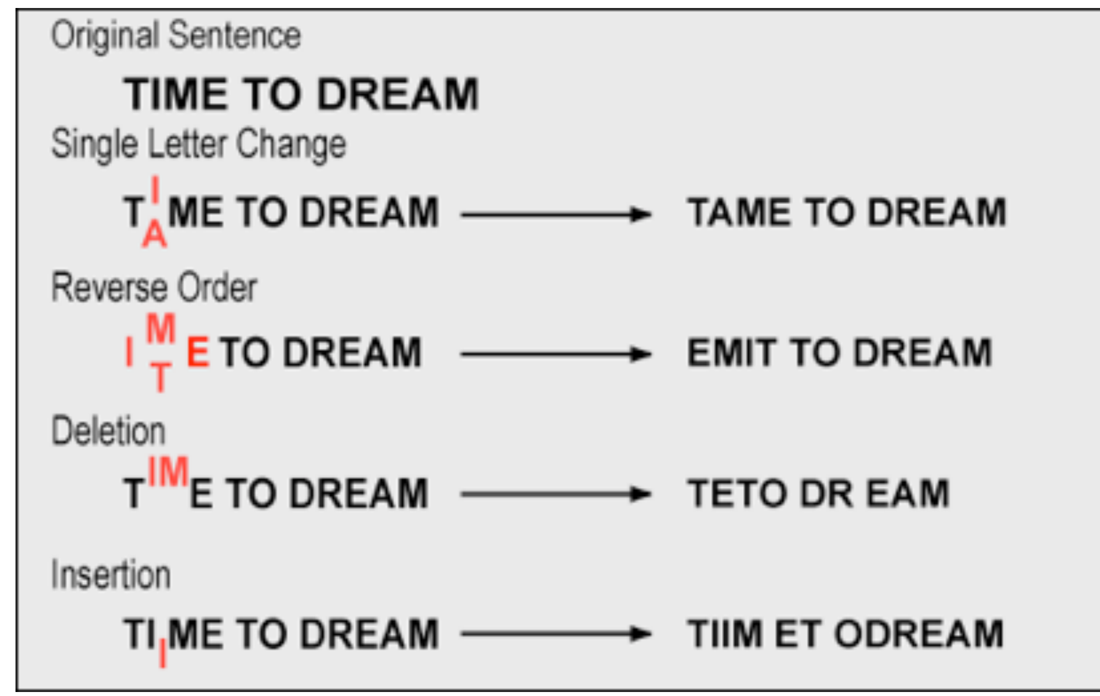
Mutations

- **Mutations can occur in any number of ways.**
  - **Gene Mutations (small scale)**
    - *substituting one nucleotide for another*
    - *adding or deleting a nucleotide*
  - **Chromosomal Mutations (large scale)**
    - *rearranging chromosomal pieces (moving an entire gene or genes) in a genome*
    - *deleting or duplicating chromosomal pieces (deleting or duplicating an entire gene or genes) in a genome*
    - *disrupting an entire gene or genes at one time*

Gene Mutations



The first two are called "point" mutations, it may or may not effect 1 amino acid

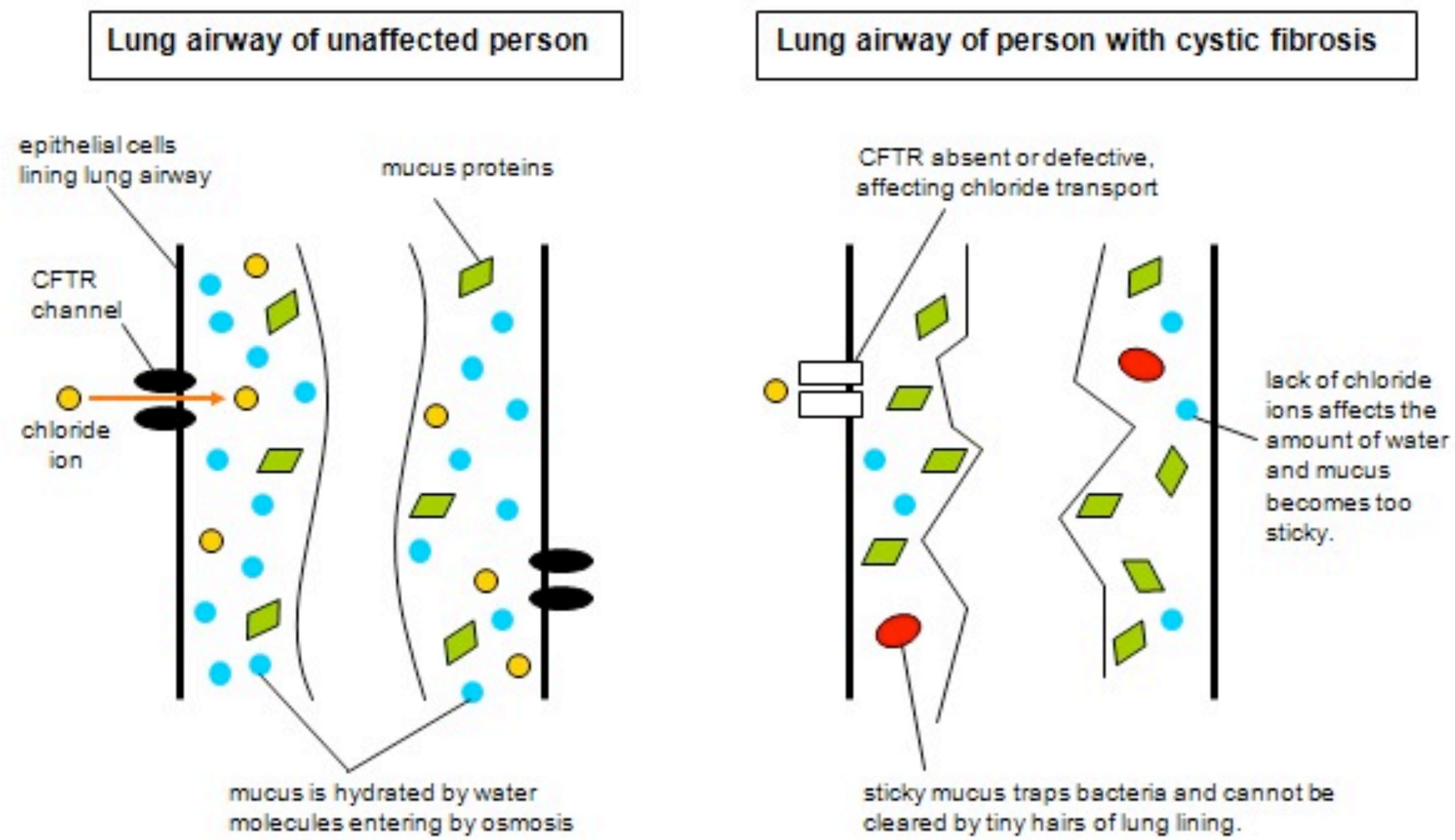


The last two are called "frameshift" mutations, it moves the entire reading frame, they have dramatic effects

Gene Mutations

Most mutations are neutral, have no effect on the fitness of the individual. Occasionally a mutation will provide a selective advantage and other rare times in results in a detrimental phenotype, reducing fitness. Here is an example of such a case

Cystic Fibrosis



1 amino acid is lost out 508 and this results in cystic fibrosis

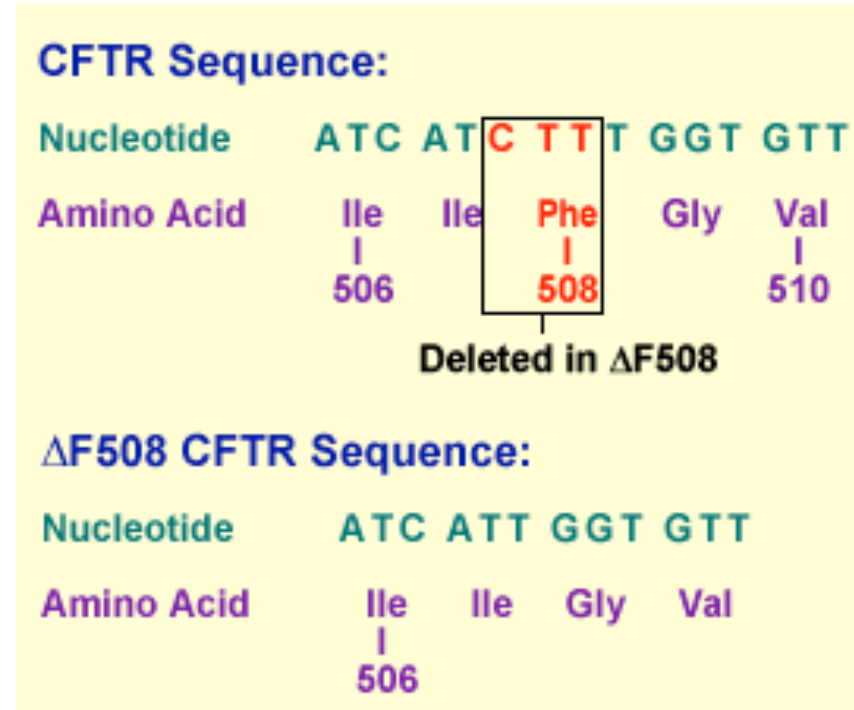
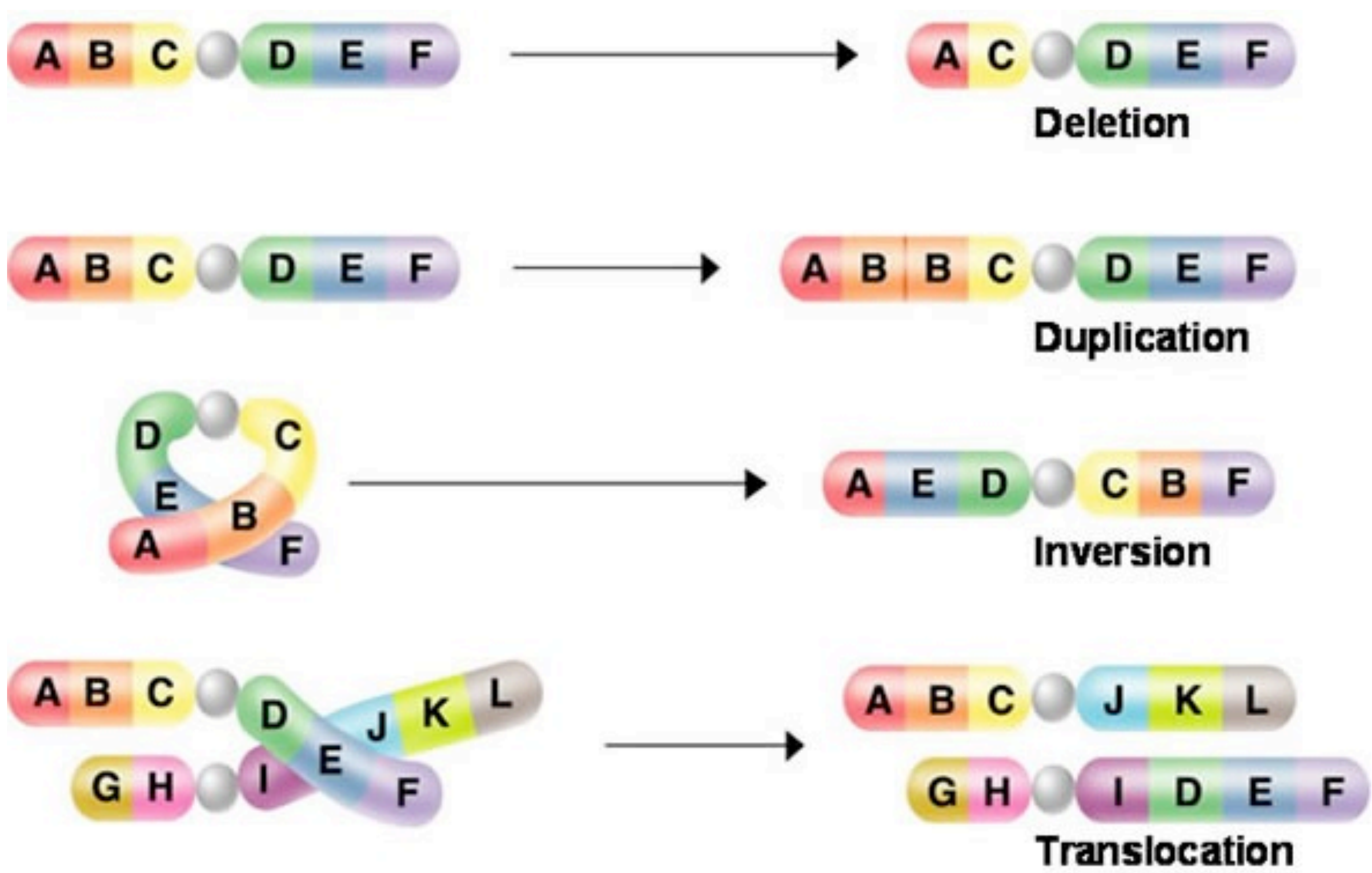


Figure 3: The deltaF508 deletion is the most common cause of cystic fibrosis. The isoleucine (Ile) at amino acid position 507 remains unchanged because both ATC and ATT code for isoleucine

Chromosomal Mutations

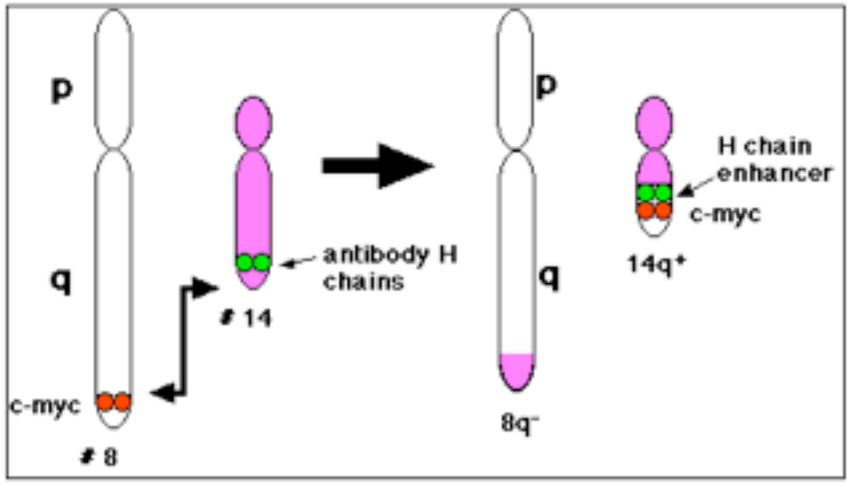


Chromosomal Mutations

Burkitt's Lymphoma

Burkitt's lymphoma is a solid tumor of **B lymphocytes**, the lymphocytes that the immune system uses to make **antibodies**. The genes for making antibodies are located on chromosomes **14** (the heavy [H] chains), **2** (kappa light chains), and **22** (lambda light chains). These genes are expressed only in B lymphocytes because only B cells have the necessary transcription factors for the promoters and enhancers needed to turn these antibody genes "**on**".

In most (approximately 90%) of the cases of Burkitt's lymphoma, a reciprocal translocation has moved the **proto-oncogene** **c-*myc*** from its normal position on chromosome **8** to a location close to the enhancers of the antibody heavy chain genes on chromosome **14**.



Translocation

Seven-year-old Nigerian boy with a several month history of jaw swelling which had been treated with antibiotics. The tumor was ulcerated and draining.

Consider this...

- A long time a mutation occurred in mammals that enabled them to detect volatile chemicals (they could smell)
- Since then this gene has been duplicated and alter so many times that humans have about 1000 olfactory receptors, mice about 1300.
- The mutation rate in mice and humans is roughly equal
- Today about 60% of human olfactory genes are inactive due to mutation but mice have lost only 20%.

1. Why did the original mutation (a mistake) become so numerous and common over time?

2. What can we infer about olfaction between humans and mice today?

Evolution...Measured?

- **Can we determine objectively whether evolution is taking place in a population?**
  - **YES**
- **Can we quantify the rate or degree of evolution in a population?**
  - **YES**
- **Can a population not evolve?**
  - **YES**

Population Genetics

- **Recall: a *population* is a group of organisms of the same species, in the same general area that interbreed successfully.**
- **A *gene pool* represents all genes (alleles), at every locus in all members of a population.**
- **Recall: *evolution* is a change in gene (allele) frequencies in a population over time.**

Population Genetics

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Measuring Allele Frequency

- **To determine that evolution has occurred we must know the allele(s) frequency in a population at a point in time and compare it to the allele(s) frequency at a later time.**
- **This implies/requires that we can measure allele(s) frequencies...but HOW?**
  - *First we must the know the total number of individuals in a population*
  - *Next we must the know the frequency of a trait in a population.*
  - *Lastly we need to which alleles control the trait we are examining*

Genetic structure of parent population

which alleles control the trait

phenotypes

genotypes: *AA* | *Aa* | *aa*

number of moths (total = 500): 320 | 160 | 20

population size

frequency of a trait in a population

genotype frequencies: $\frac{320}{500} = 0.64\ AA$ | $\frac{160}{500} = 0.32\ Aa$ | $\frac{20}{500} = 0.04\ aa$

$\times 2$ | $\times 2$

number of alleles in gene pool (total = 1000): 640 *A* | 160 *A* | 160 *a* | 40 *a*

allele frequencies: $\frac{800}{1000} = 0.8\ A$ | $\frac{200}{1000} = 0.2\ a$

p = frequency of $A = 0.8$ | q = frequency of $a = 0.2$

Bingo!

Measuring Allele Frequency

- **To determine that the moth population is evolving we simply recalculate the allele(s) frequency in the population at a later time.**
  - **If we find that the frequency of A is no longer 0.8 or 80% and a is no longer 0.2 or 20% then the population <u>has evolved</u> because its <u>allele frequencies have changed</u>.**
  - **If we find that the frequency of A remains 0.8 or 80% and a remains 0.2 or 20% then the population <u>has not evolved</u> because its <u>allele frequencies have not changed</u>.**

Evolution…measured?

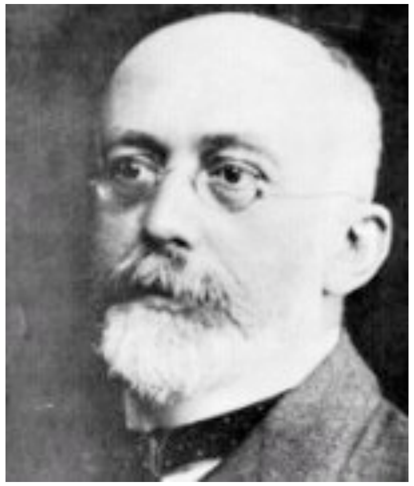
- **The fact of the matter is this... in real populations the allele/gene frequencies DO, in most cases, change over time**
- **Does this mean that allele/gene frequencies that do not change mean that the population is not evolving?**
  - **NO**
    - **The last example only measured one allele in the population, it is possible that an allele is not subject to selection pressures at some point in time.**

So what would a non-evolving population look like?

Non-Evolving Populations

- **A population not evolving would have to have ALL allele/gene frequencies remain constant over time in order for the gene pool itself to remain constant.**
  - **Keep in mind populations have hundreds to thousands of alleles/genes.**
  - **Is it likely or even possible that all allele/gene frequencies remain unchanged over time?...NO**
    - **Never the less we can still ask...Are there conditions where a populations' allele(s)/gene(s) would NOT change?**

Godfrey Hardy & Wilhelm Weinberg



- **A British mathematician and German physician asked this same question and their work tells us...**
    - **Yes it is possible for allele/gene frequencies to remain unchanged in a population, Yes it is possible that a population does not evolve over time.**
    - **However it is only possible provided the population meets certain criteria.**

Hardy-Weinberg Equilibrium

- **This principle describes a hypothetical non-evolving population**
- **In order for a population to maintain the Hardy-Weinberg equilibrium (not change) they must meet all 5 of the following conditions:**

Very large population	No genetic drift can occur.
No emigration of immigration	No gene flow can occur.
No mutations	No new alleles can be added to the gene pool.
Random mating	No sexual selection can occur.
No natural selection	All traits must equally aid in survival.

How likely is it that a population meets these conditions?

Not at all likely, close to impossible!

Hardy-Weinberg Equilibrium

- **This principle describes a hypothetical non-evolving population**
- **When gametes are donated randomly and matings are also random allele frequencies will not change and we can calculate genotypic frequencies from allele frequencies:**
  - **We can summarize the union of gametes in an algebraic equation**

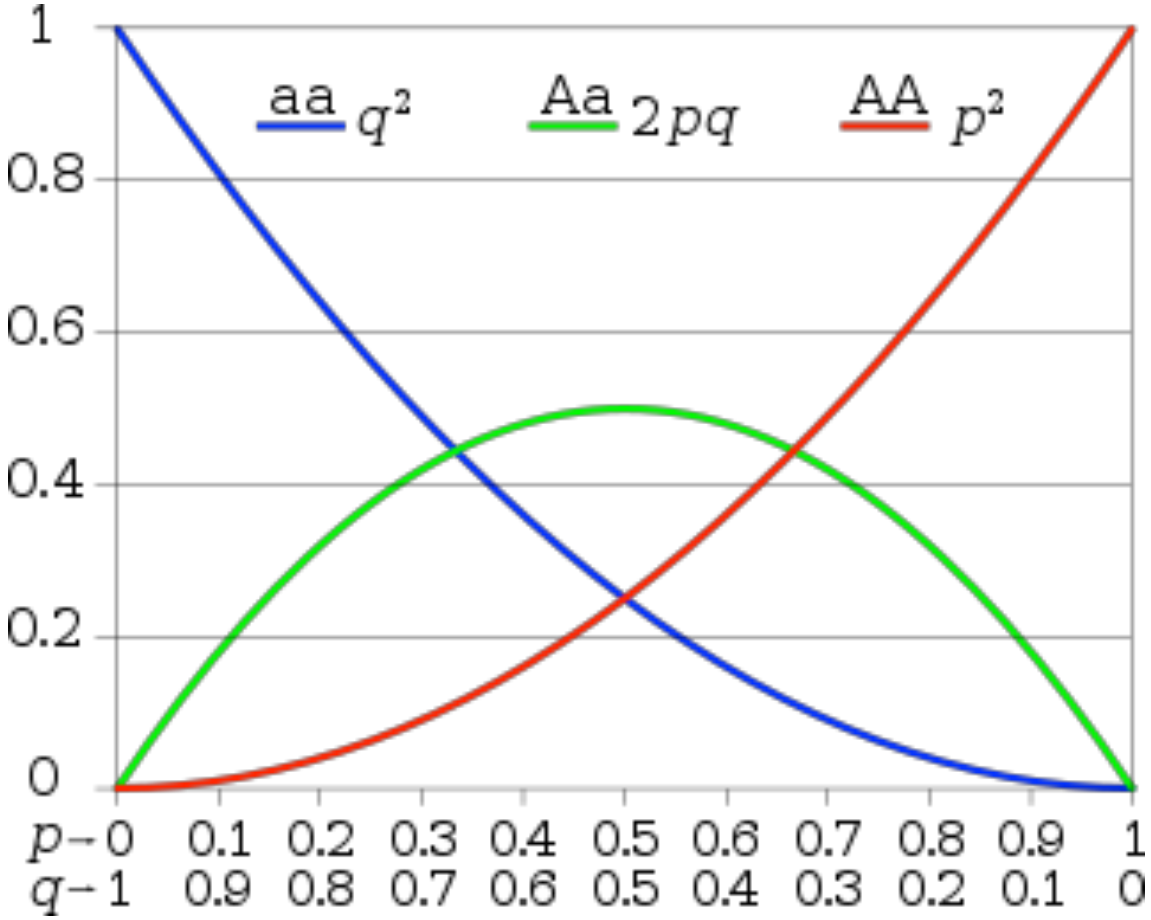
$$(p+q)(p+q) = p^2 + 2pq + q^2 = 1$$

Hardy-Weinberg Equilibrium

Thus a locus with two alleles, the genotypes will appear in the proportions.

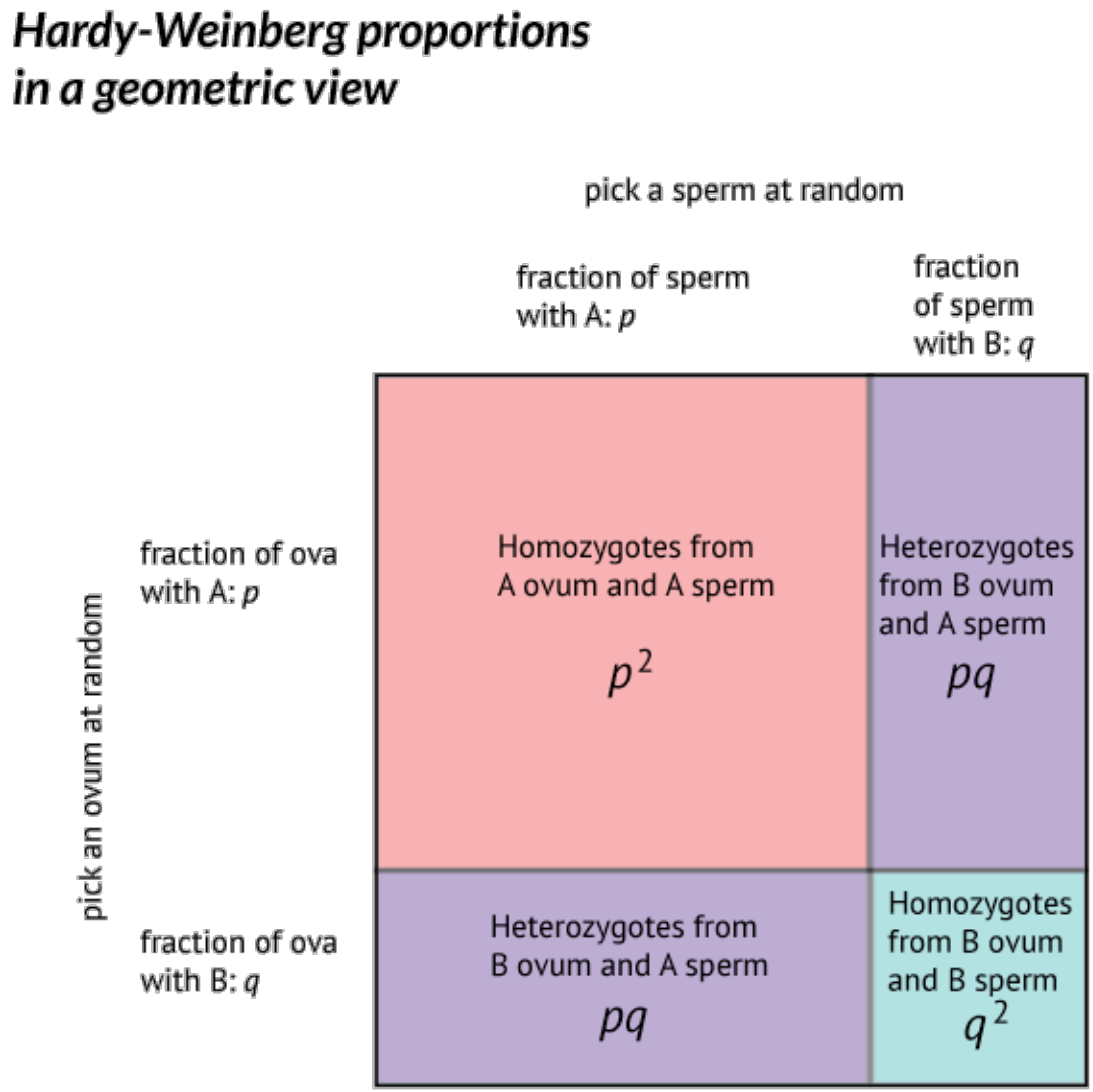
$$p^2 + 2pq + q^2 = 1$$

Here is graphic representation of allele and genotypic frequencies.



Hardy-Weinberg Health Applications

- **The Hardy-Weinberg equation can be used to estimate the percentage of the population that carriers an allele for a disease (among other things as well)**



Solving Hardy-Weinberg Problems

- **Every Hardy-Weinberg problem is essentially the same, you will be given one (or more) of the 5 variables below, you will then use simple algebra to solve for the unknown.**

Know This

p = dominant allele

q = recessive allele

p^2 = AA genotype

2pq = Aa genotype

q^2 = aa genotype

Follow these steps

First- determine the unknown (which of the variables on the left do need to solve for)

Next- determine the known (which of the variables on the left do we have)

Last- using the equations on the right and simple algebra solve for the unknown

Use These

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

$$p + q = 1$$

Hardy-Weinberg Equilibrium

Let's try a tough problem together.

There is a hypothetical population with 100 individuals. There is a trait with two alleles, B and b. 12 people are normal homozygous dominant (BB), 78 people are carriers of a disease (Bb) and 10 people have the disease (bb). Is this population evolving?

OK Where do we start? Well we just learned that the Hardy-Weinberg equation can help us determine (predict) if a population is evolving. $p^2 + 2pq + q^2 = 1$

Before we can predict what a non-evolving population looks, we need to know what the actual population looks like.

Hardy-Weinberg Equilibrium

Start by finding alleles frequencies "p" and "q".

Population with 100 individuals will have 200 alleles.

12 people are normal homozygous dominant (BB) so (12)(2)= 24 B's
78 people are carriers of a disease (Bb) so (64)(1) = 78 B's and 78 b's
10 people have the disease (bb) so (10)(2) = 20 b's

Now 24B + 78B = 102 total B's out of 200 or 102/200 = 0.51 or 51% B's "p"

And 78b + 20b = 98 total b's out of 200 or 98/200 = 0.49 or 49% b's "q"

Remember "p" = dominant allele (B)

Remember "q" = dominant allele (b)

And since there are only two alleles p + q =1

Hardy-Weinberg Equilibrium

OK Now we have p and q let's plug them into the Hardy-Weinberg equation and see what a non-evolving population would look like.

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

$$(0.51)^2 + 2(0.51)(0.49) + (0.49)^2 = 1$$

↓ 0.26BB ↓ 0.50Bb ↓ 0.24bb

Now that we know what a non-evolving population looks like. We have to compare our "predicted" non-evolving population with our "actual" population

Hardy-Weinberg Equilibrium

OK Now we have p and q let's plug them into the Hardy-Weinberg equation and see what a non-evolving population would look like.

Predicted Non-Evolving	Actual Population
(0.26)(100)= 26 BB	12 BB
(0.50)(100)= 50 Bb	78 Bb
(0.24)(100)= 24 bb	10 bb

If they are the same then population is NOT evolving.

If they are different then population IS evolving.

What genotype is being selected for? **Bb**

Changing Gene Pools

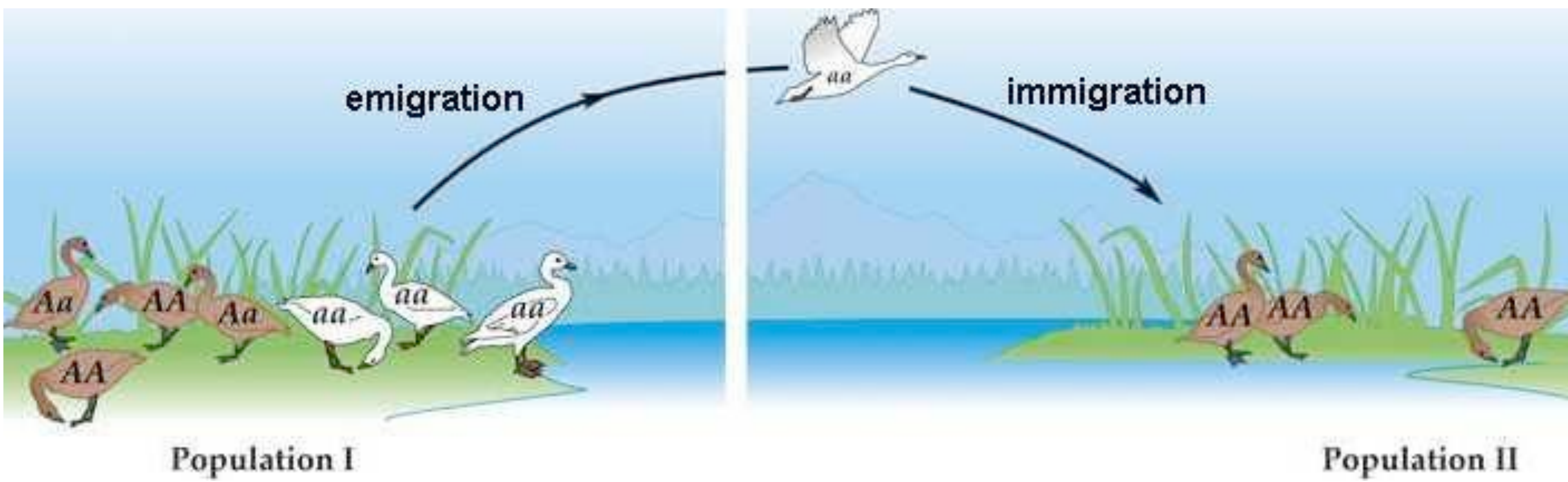
- **A deviation in any of the 5 Hardy-Weinberg conditions will change allele/gene frequencies.**
- **However three processes in particular change gene pools or cause evolution more than anything else.**
  - **Gene Flow**
  - **Genetic Drift**
  - **Natural Selection**

} The smaller the population the greater there effect

Important Note...Natural selection is the only one that results in a population becoming more well adapted to its environment over time.

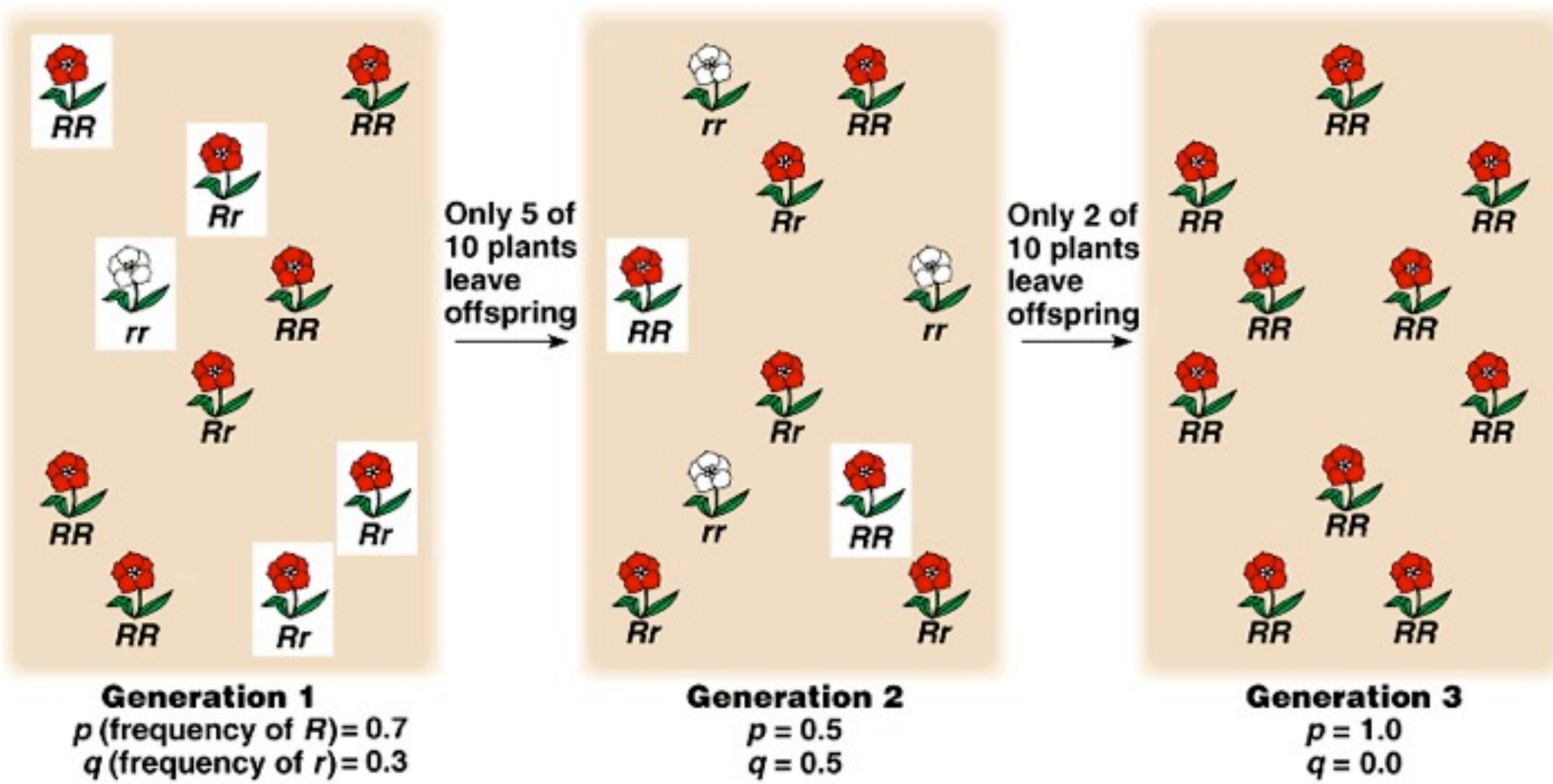
Gene Flow

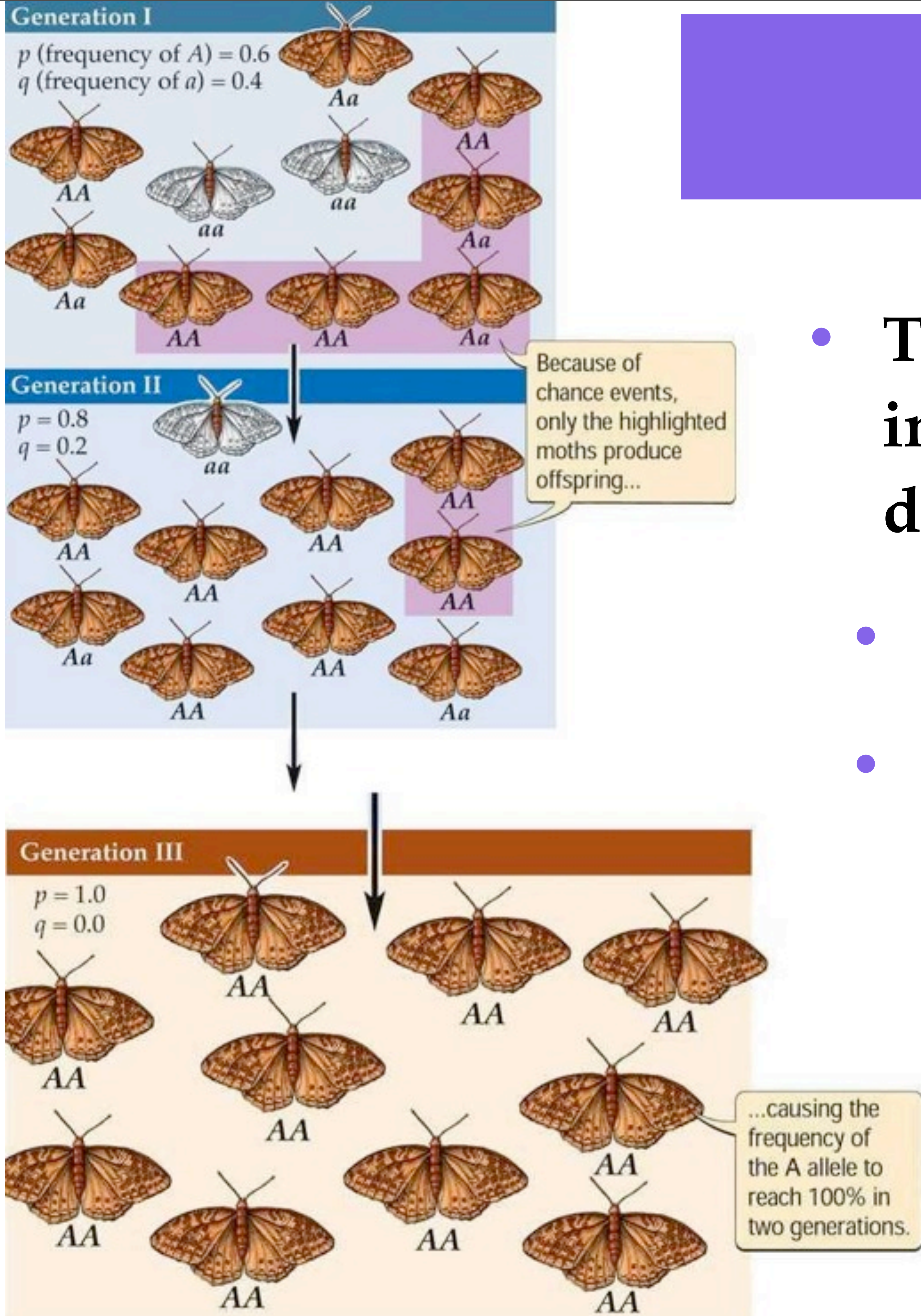
- **Gene Flow- a population can gain or lose alleles/genes as a result of individual or gamete movement.**
- **Gene flow often reduces differences between populations, it can "melt" two populations into one.**



Genetic Drift

- **Genetic Drift- random and unpredictable fluctuations in allele/gene frequencies.**
  - **Genetic Drift will have a greater effect on smaller populations**
  - **Genetic Drift tends to reduce variation**
  - **Genetic Drift can "fix" (100% frequency) harmful alleles**



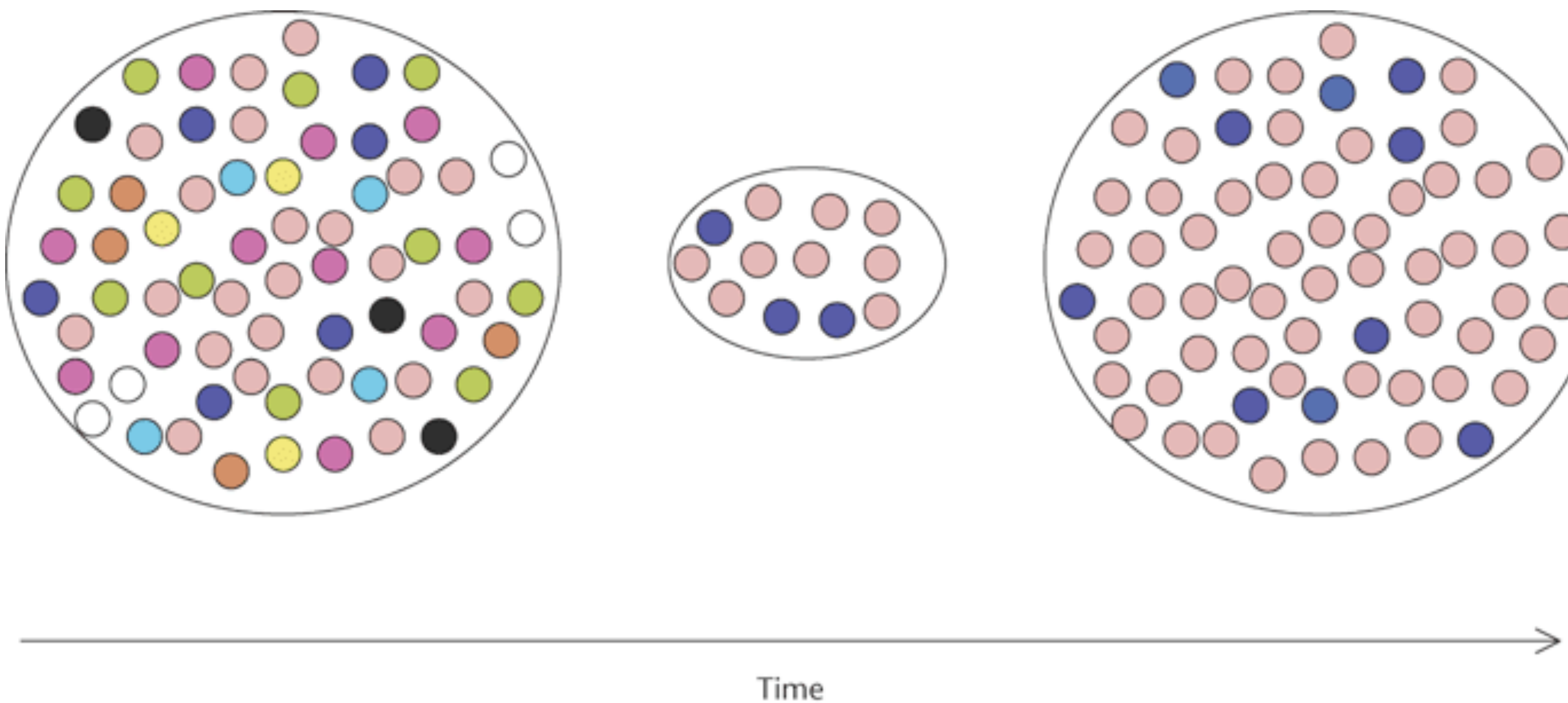


Genetic Drift

- **There are two events that increase the effect of genetic drift.**
  - **A bottleneck effect**
  - **A founder effect**

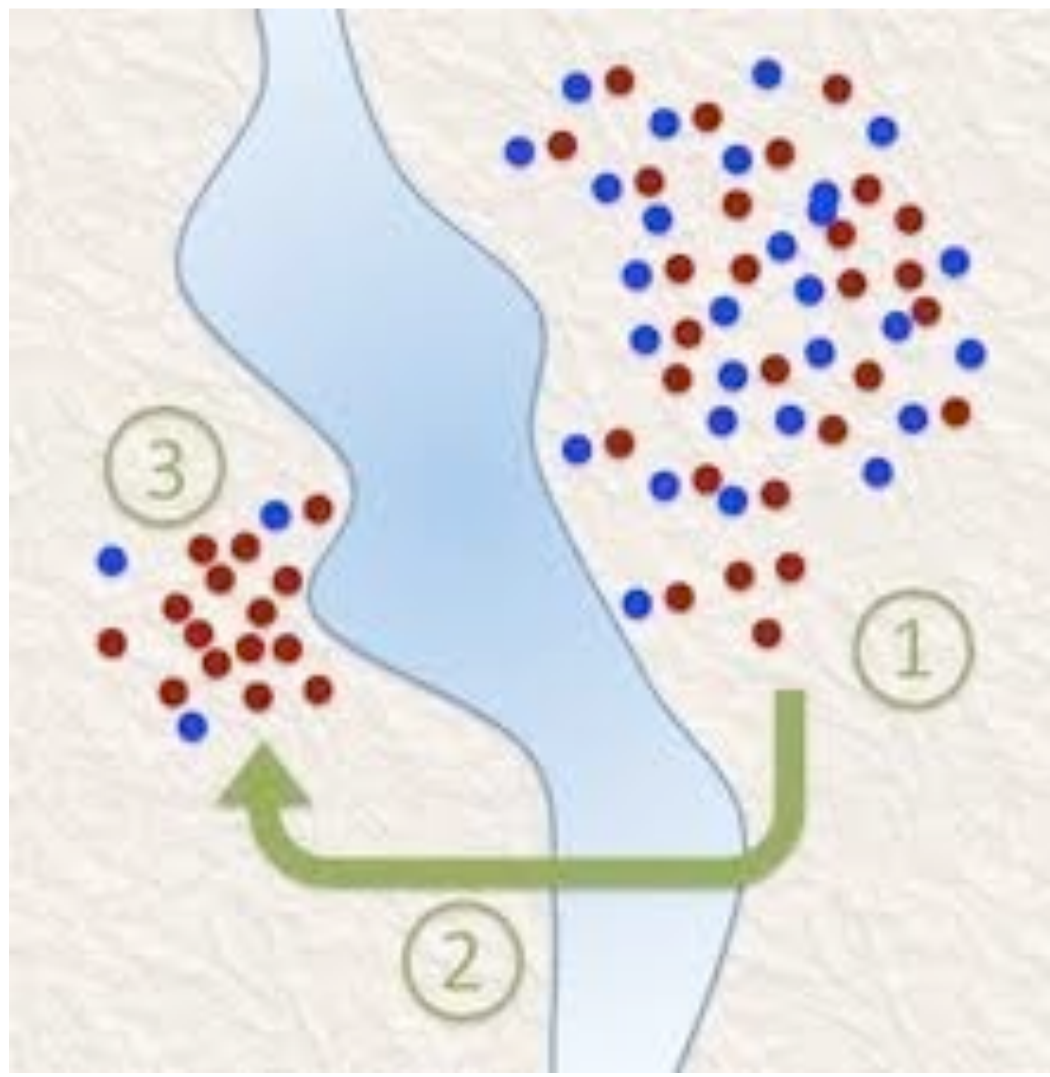
The Bottleneck Effect

- **Bottleneck Effect- can occur when there is large reduction in population size, the survivors may not reflect the composition of the original population.**
  - **can have a lasting effect on populations**



The Founder Effect

- **Founder Effect- when a small group leaves a larger population, establishes a new population that is not representative of the original .**

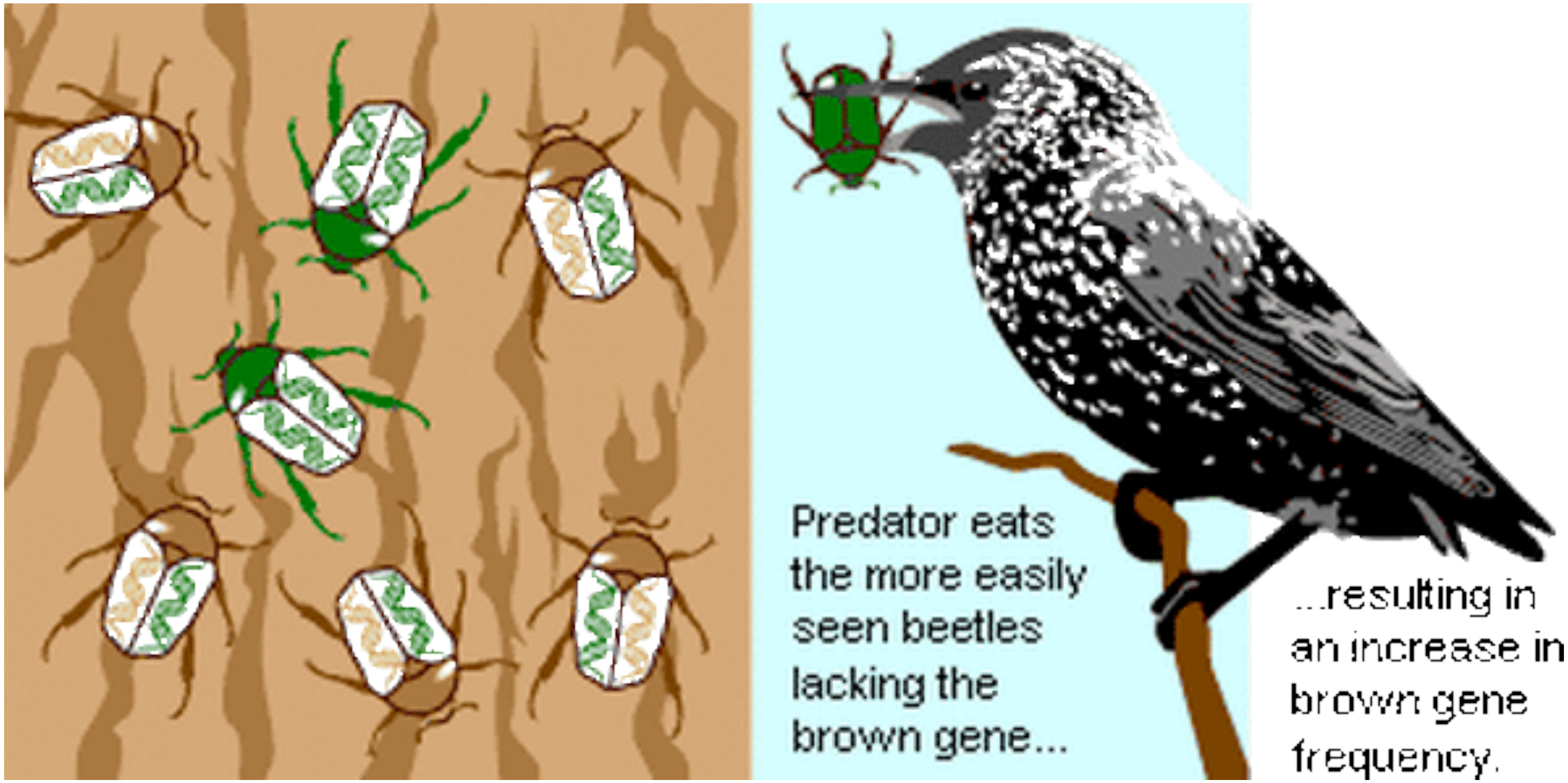


new population

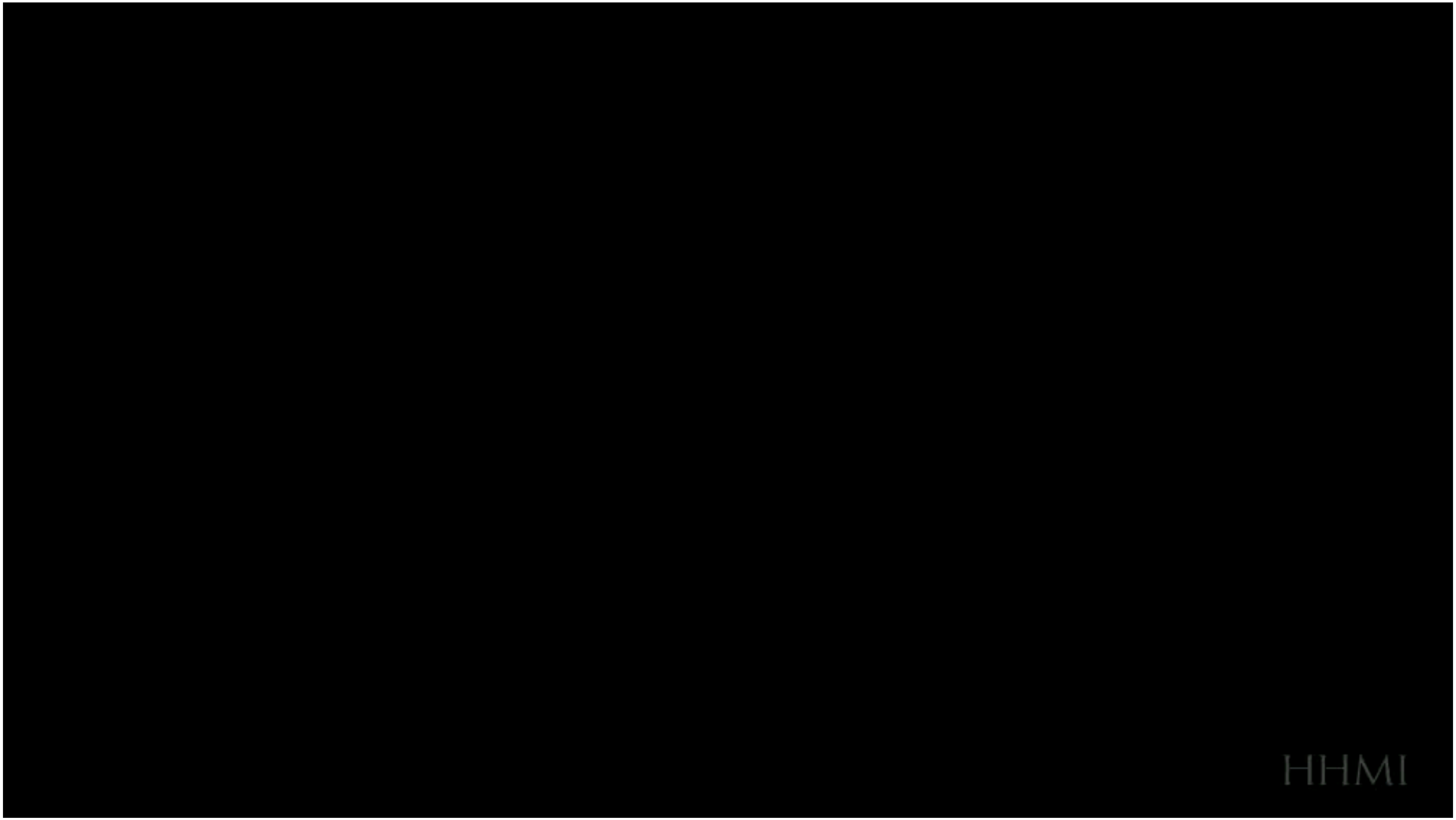
original population

Natural Selection

- **Natural Selection- differential reproductive success.**
    - **Certain favorable traits become more frequent, non favorable traits become less frequent and the population becomes better suited to its environment over time.**

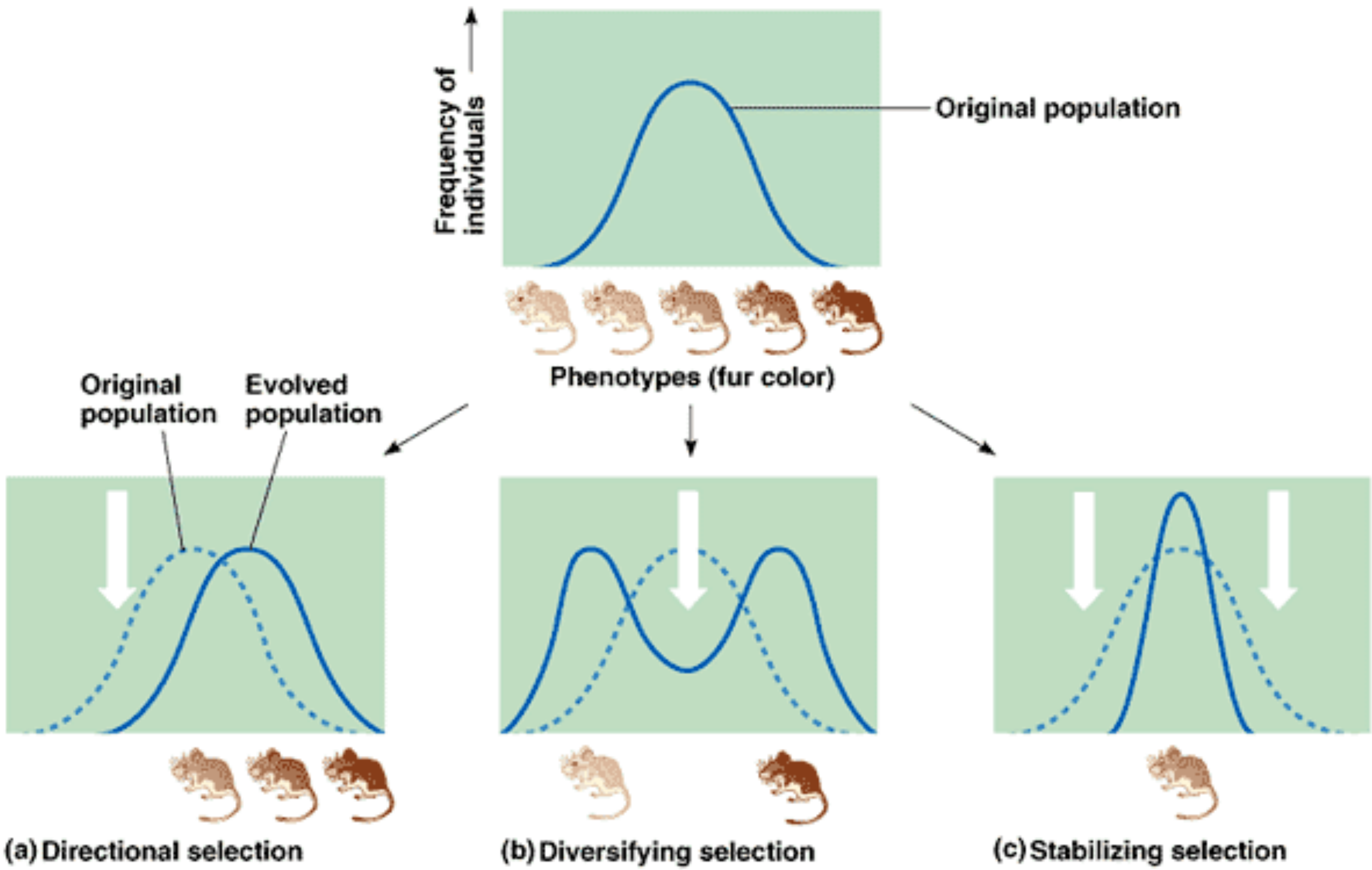


Natural Selection



Natural Selection

- **Natural Selection- can alter frequency distribution of traits in 3 ways.**



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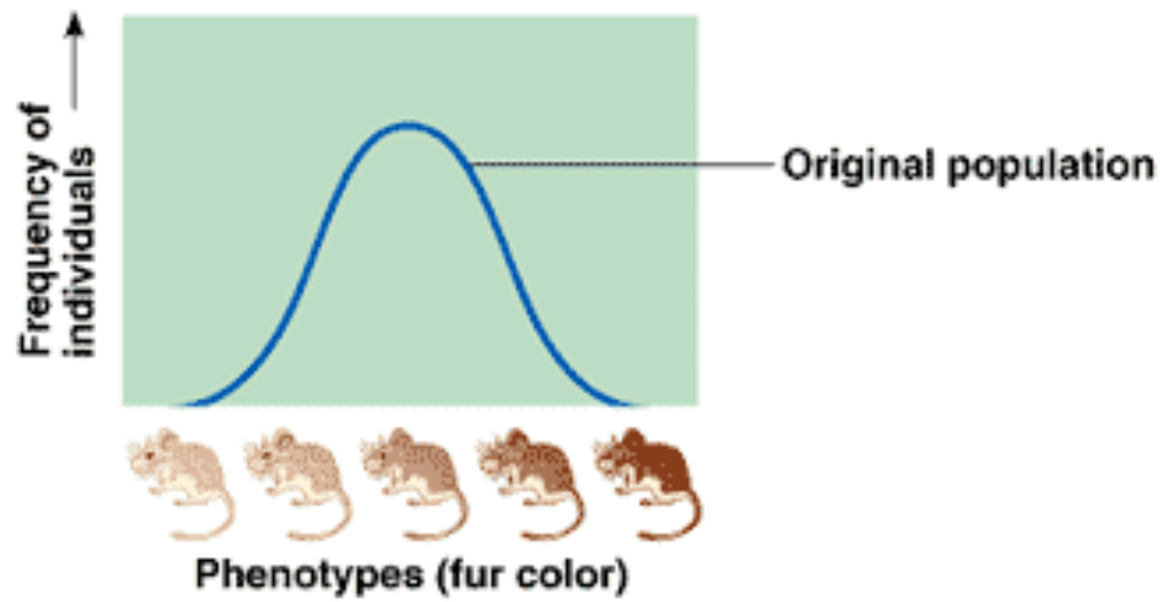
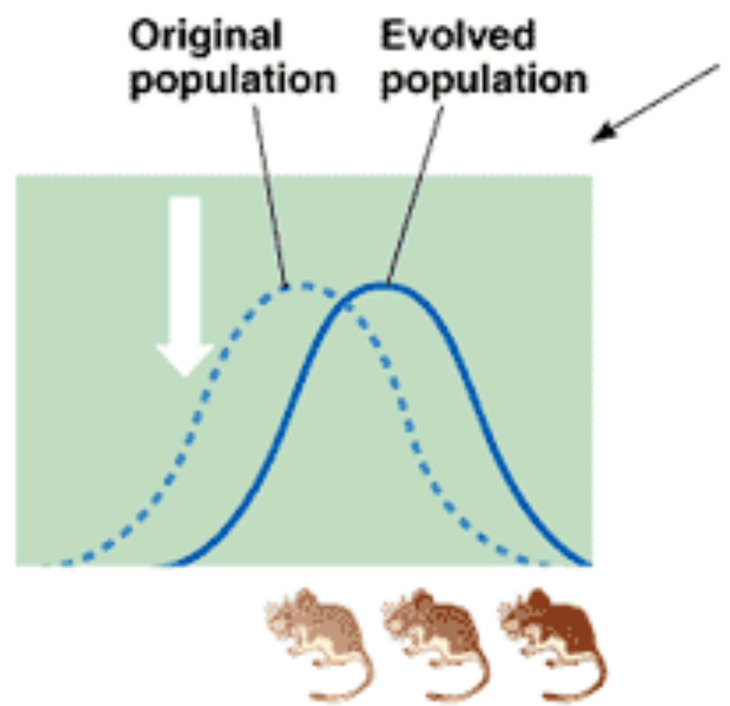




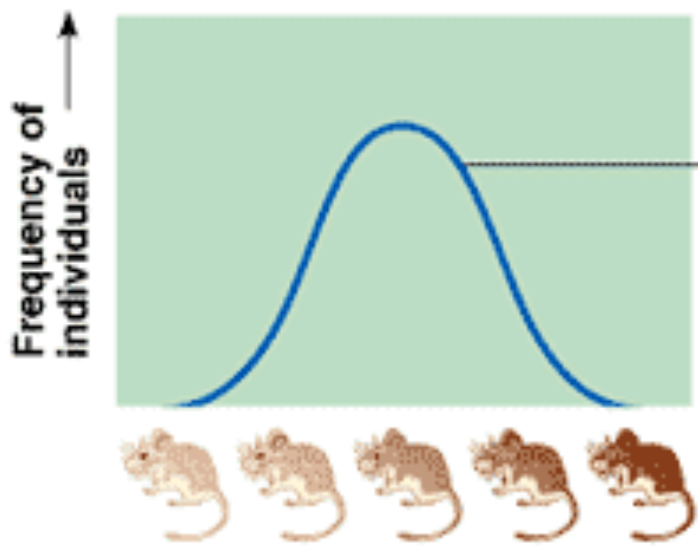
(a) Directional selection

-most common in a new environment

-shifts frequency in one direction and away from the average

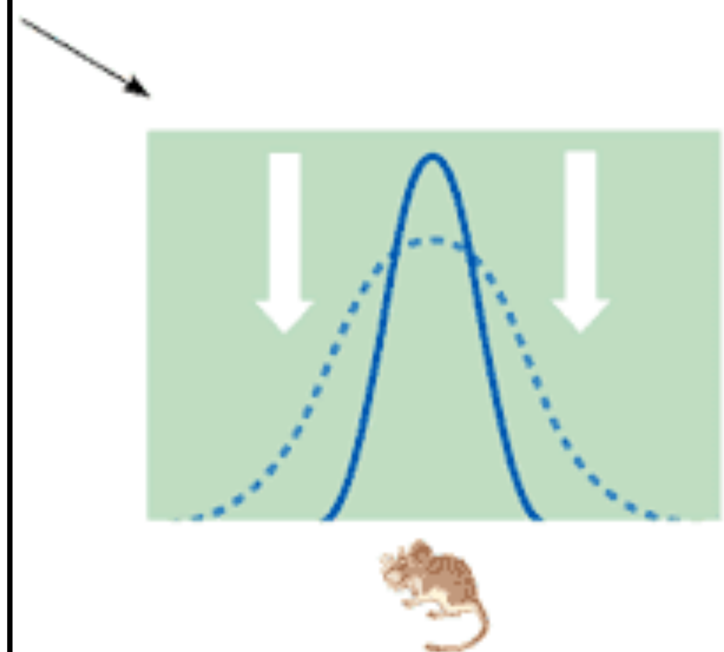
Natural Selection

- **Natural Selection- can alter frequency distribution of traits in 3 ways.**



-reduces variation

-selects the extremes, moderate traits are favored

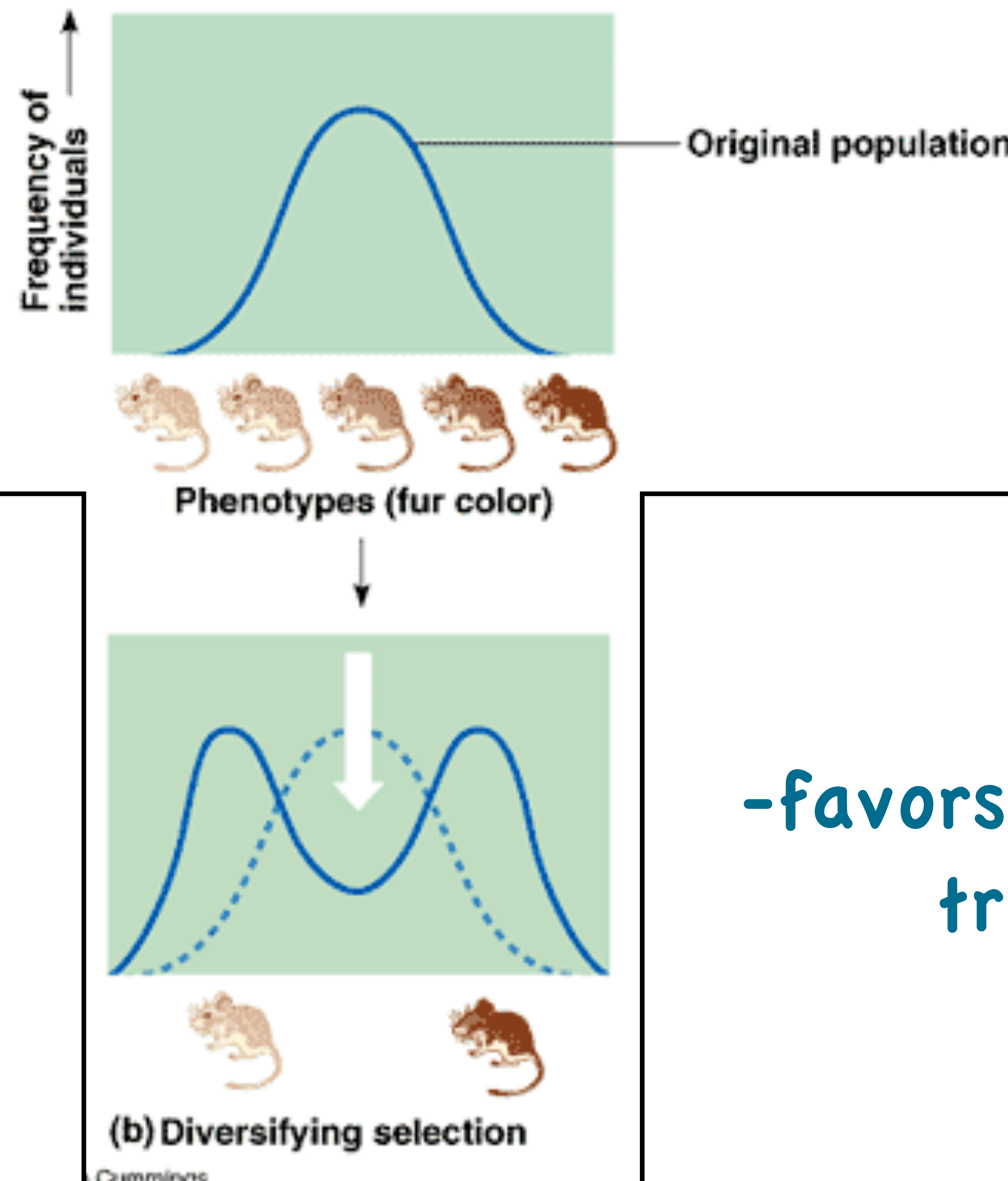


(c) Stabilizing selection

Natural Selection

- **Natural Selection- can alter frequency distribution of traits in 3 ways.**

-can play an important role in speciation



-favors extreme traits

Conserving Variation

- Recall...natural selection reduces variation in a population.
- Recall...sex and mutations generate variation in a population.
- There are also mechanisms that help to preserve, maintain or even restore variation in a population.
  - Diploidy
  - Balanced Selection
    - Heterozygote Advantage
    - Frequency-Dependent Selection

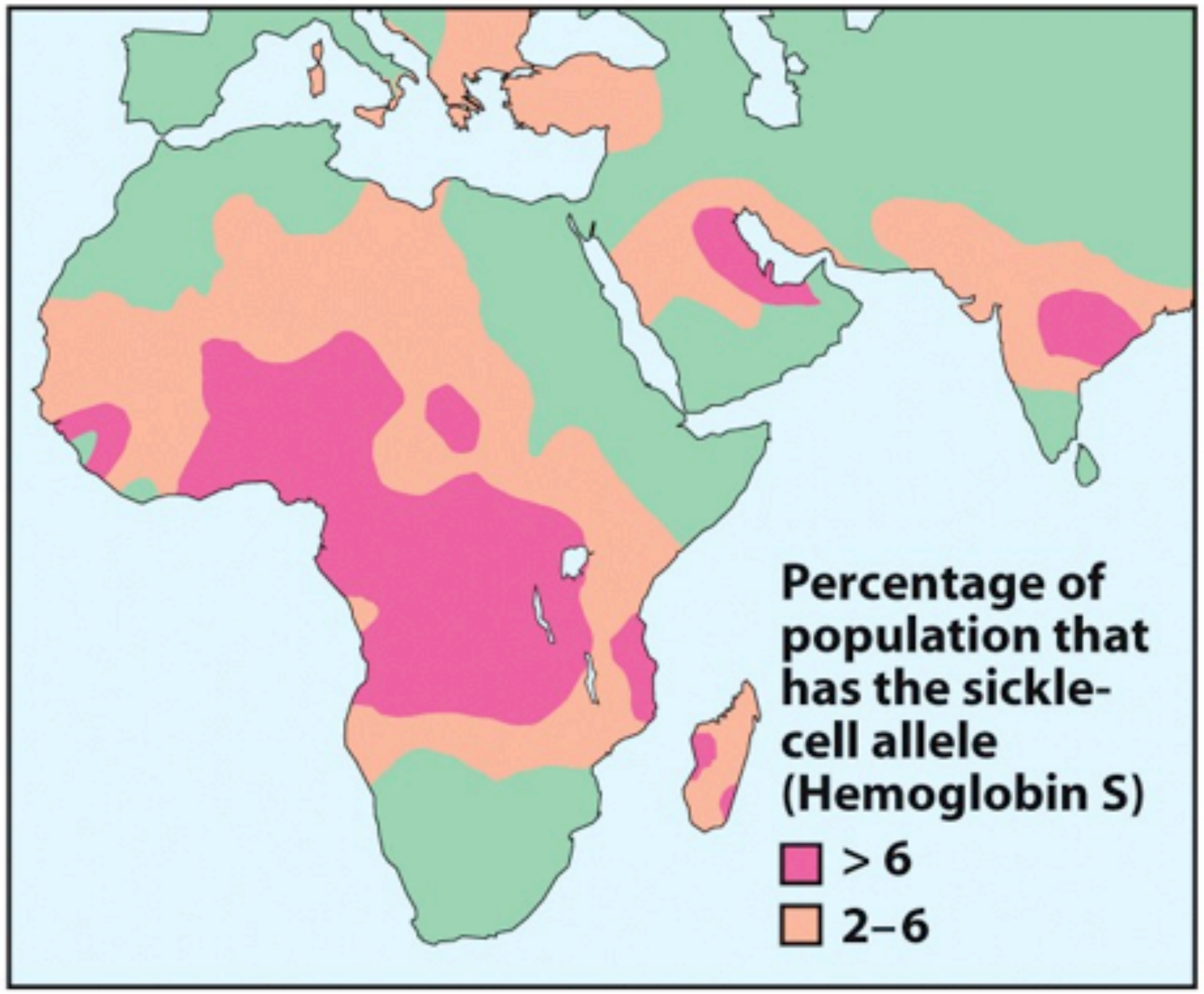
Conserving Variation

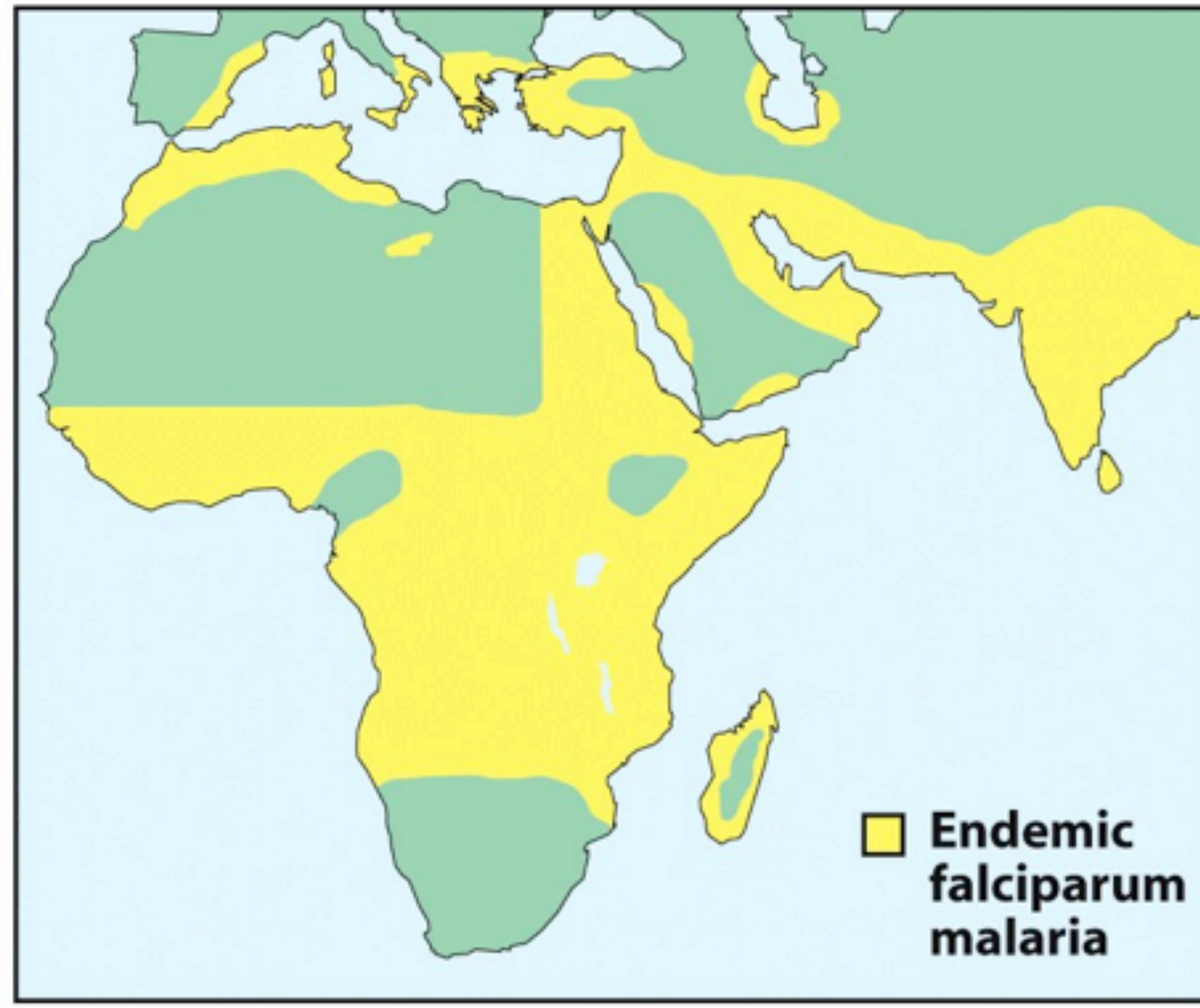
- **Diploidy- having two alleles to control a one trait.**
    - **Recall recessive phenotypes are only expressed when both recessive genes are present.**
    - **Thus recessive genes are often "masked" or hidden behind the dominant gene a heterozygous genotype.**
    - **As a result these recessive genes, even if maladaptive, can persist over time**

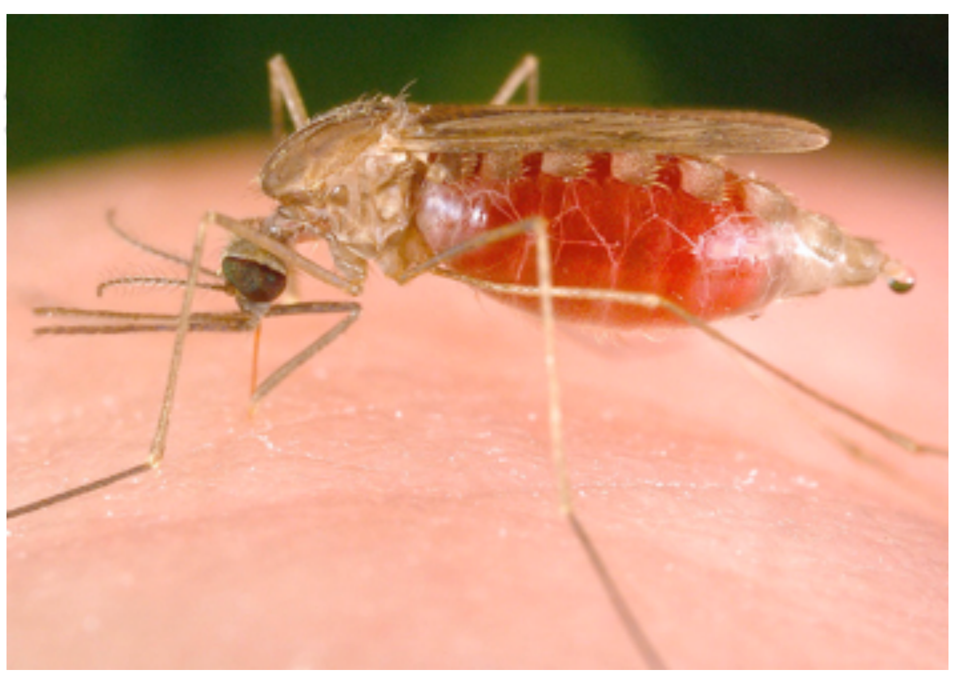
Conserving Variation

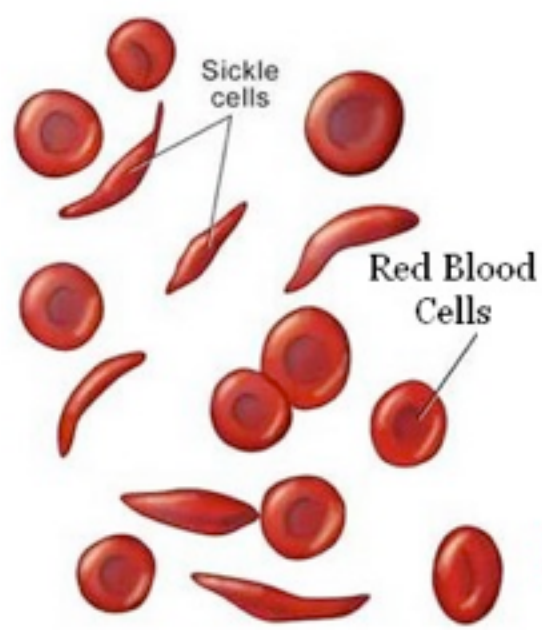
- **Balanced Selection- maintains two or more forms in a population**
    - **Heterozygote Advantage**
        - **When the heterozygous phenotype is selected for, both dominant and recessive genes are maintained**
            - **Ex. Malaria story in Africa (see next slide)**
    - **Frequency-Dependent Selection**
        - **As a phenotype becomes more common it is selected against, less common phenotypes are selected for thus over time the frequency of each oscillates back and forth and neither is eliminated, both persist in population.**

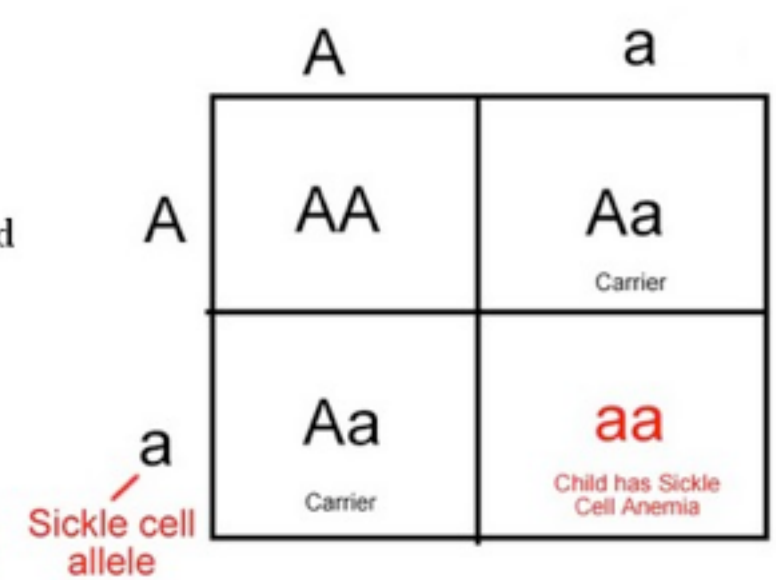
Sickle Cell Trait & Malaria



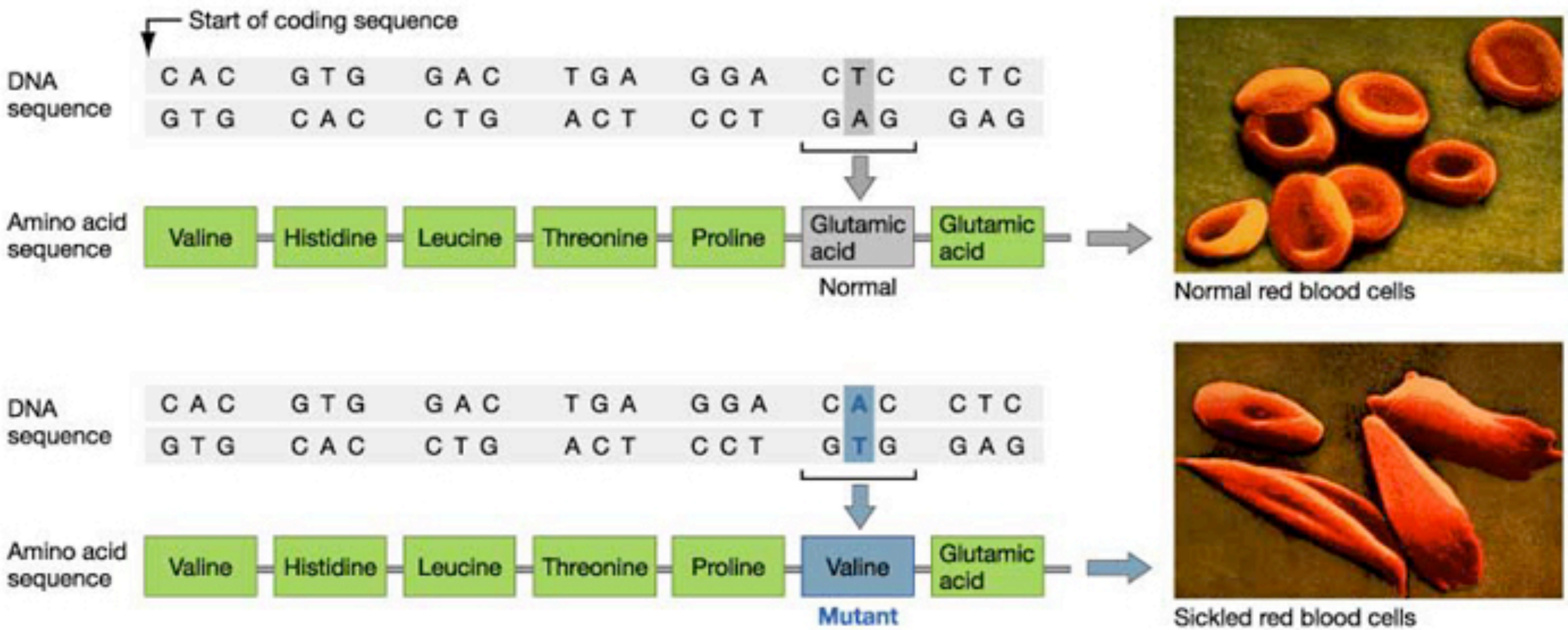








Sickle Cell Trait & Malaria



The change in amino acid sequence causes hemoglobin molecules to crystallize when oxygen levels in the blood are low. As a result, red blood cells sickle and get stuck in small blood vessels.

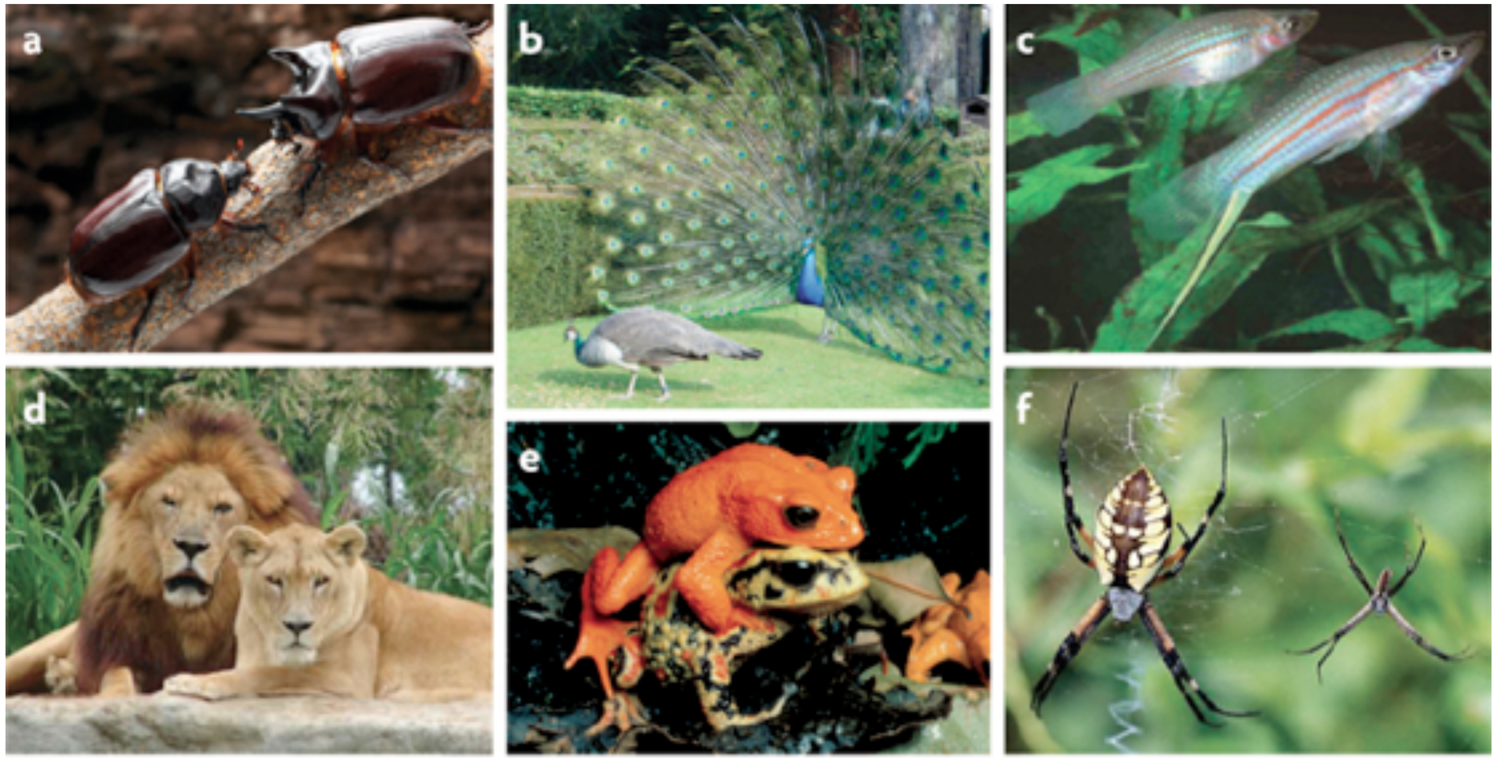
This is a “substitution” mutation notice the thymine was switched with alanine.

The normal beta subunit consists of 438 nucleotides and 146 amino acids.

A change in 1 nucleotide, changes 1 amino acid resulting in sickle cell disease

Sexual Selection

- ***Sexual Selection***- **special type of natural selection where certain traits lead to certain individuals being more likely to mate.**
  - **Not only can sexual selection lead to adaptation but it can also result in sexual dimorphisms.**
  - ***Sexual Dimorphisms***- **differences between secondary sex characters of males and females.**



Sexual Selection

- **Sexual selection works in two ways.**
  - ***Intrasexual Selection-*** **selection occurs within the same sex**
    - **ex. male fighting another male over right to reproduce**
  - ***Intersexual Selection-*** **mate choice, usually females select males**
    - **ex. females choose male mates based upon some trait(s) or behavior(s)**
    - **it is thought that these traits and behaviors represent good overall genetic quality**

Sexual Selection

- **Males and Females share the same biological imperative...reproduction or passing their genes into future generations.**
- **Their strategies for reproductive success can however be very different.**
  - **In general males have a "quantity" strategy and females employ a "quality" strategy.**
  - **This can be partly explained by their respective fecundity.**

Not so choosey Males...Quantity

- **In general males have greater fecundity than females.**
  - **their gametes are small and energetically inexpensive to make**
  - **they have numerous gametes in each copulation**
  - **theoretically males could produce thousands of offspring**
- **In general males do not bear or rear offspring**
- **In general males have more reproductive years**

Choosey Females...Quality

- **In general females have lower fecundity than males.**
  - **their gametes are large and energetically expensive to make**
  - **they have one or few gametes per copulation**
  - **practically females could produce fewer offspring**
- **In general females must bear and rear offspring**
- **In general females have less reproductive years**
  - **ex. menopause**

Evolutionary Fitness

- ***Fitness***- contribution an individual makes to the gene pool of the next generation relative to others.
    - ***Relative Fitness***- contribution that a genotype makes to the gene pool of the next generation for same locus relative to others.
    - **Be careful natural selection acts on phenotypes/traits not genotypes.**
        - **The organism as a "whole" is selected.**
    - **Thus the fitness of any one allele is dependent on the entire genetic make up of the organism and the environment at that point in time.**
        - **This can sometimes result in strange consequences...**

Evolutionary Fitness

- **This type fitness is not all about "physical fitness".**

6 Kids

Greater Evolution Fitness

0 Kids

This fitness is all about reproductive success and the traits that make one fit can be very subtle.

Evolutionary Fitness

- **This type fitness is not all about pure survival.**

3 Kids, dies at age 35

0 Kids, dies at age 98

Greater Evolution Fitness

A long life span does not always equate to evolutionary fitness.

Evolutionary Fitness

- **Lastly sometimes alleles that do have no value or even slightly maladaptive can be perpetuated if the organism's overall fitness is high.**
  - **This explains have old useless DNA persists in a genome over time.**
- **It can go the other way as well... sometimes alleles that do have value are not perpetuated if the organism's overall fitness is low or by some accident dies suddenly.**

“The Perfect Organism”

- No, Never, Not going to happen!
- Natural selection has never and will never fashion the perfect organism.
    - Selection can act on only existing variation.
    - Bad luck and changing environments
    - Can only work with what your given
    - Life is all about Trade-offs

"The Perfect Organism"

- Natural selection has never and will never fashion the perfect organism.
- **Selection can act on only existing variation.**
  - **Organisms can not call upon mutations at will, they are random.**
  - **Organisms can not order a trait that they need.**

Adaptation doesn't involve trying.

Natural selection does not grant organisms what they "need".

"The Perfect Organism"

- **Natural selection has never and will never fashion the perfect organism.**
- **Bad luck and changing environments.**
  - **The natural events that move organisms from one place to another or result in "bottlenecks" is random.**
    - **Tsunami's kill indiscriminately whether an organism is well adapted or not.**
  - **Climate and environments are constantly changing as organisms become well suited for one another different one could emerge.**

“The Perfect Organism”

- Natural selection has never and will never fashion the perfect organism.
- **Can only work with what your given.**
    - **Organisms can throw away the traits given to them by their ancestors, instead they have modify what they have been given.**

Wings would certainly work better

"The Perfect Organism"

- Natural selection has never and will never fashion the perfect organism.
- **Life is all about Trade-offs.**
  - **Unit after unit we have seen examples of trade-offs or compromises**
  - **Consider ectothermy which is energetically cheap but a sudden or severe cold front could cost the organism its life.**

A few years ago we saw this first hand as iguana's died in great numbers from a severe cold front