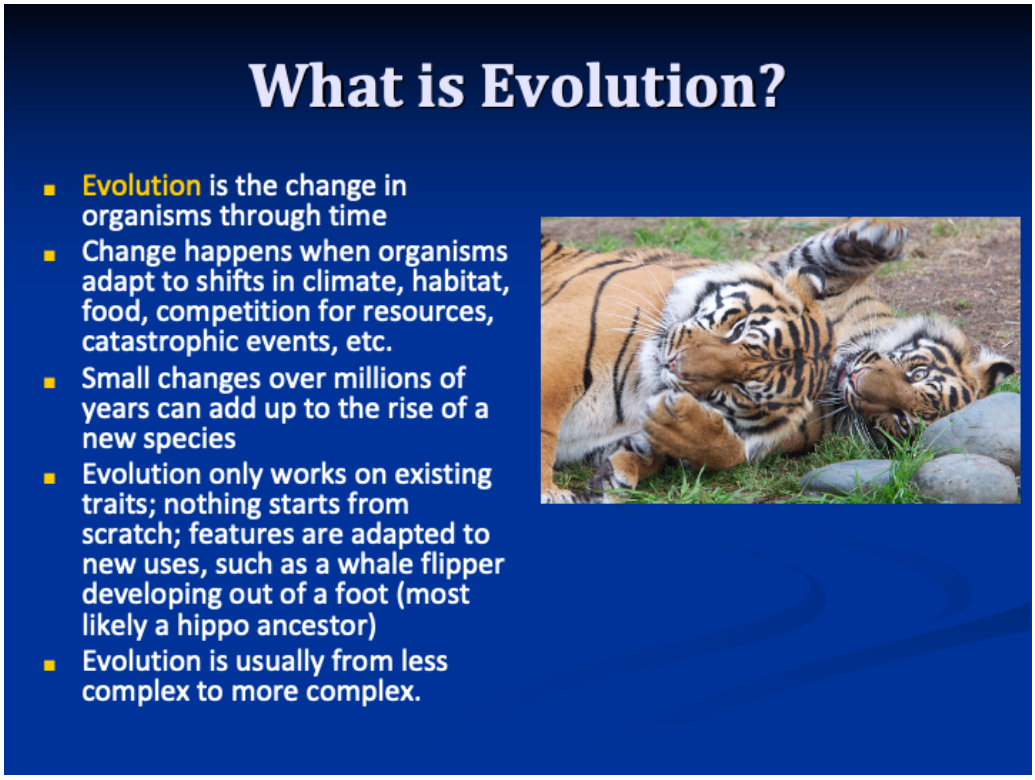
Evolution is a scientific theory that is the cornerstone of modern biology. The theory is based on scientific observation, fossil evidence and experimentation and has withstood the test of time. It explains that species change over time and addresses the mechanisms that create these changes. Our understanding of evolution allows us to understand how species have come to be the way they are; evolution explains the history, diversity, adaptation and complexity of life. The two fundamental processes within evolution are that the change within a lineage is caused by **natural selection** and **genetic drift,** and all species share a common ancestry from which new lineages formed by the splitting of existing lineages.

Through natural selection, the behavioral and physical characteristics of an animal have been modified to meet to meet the demands of an environment. **Adaptation** is the idea that organisms respond to changing environments by evolving a form, function, or behavior better suited to these new circumstances. An organism's ability to adapt is key to its survival and may give arise to new species. Through continual adaptations you may get the formation of new species. This process of species formation is called **speciation**. **Species** are defined as members of populations that actually or potentially interbreed in nature.



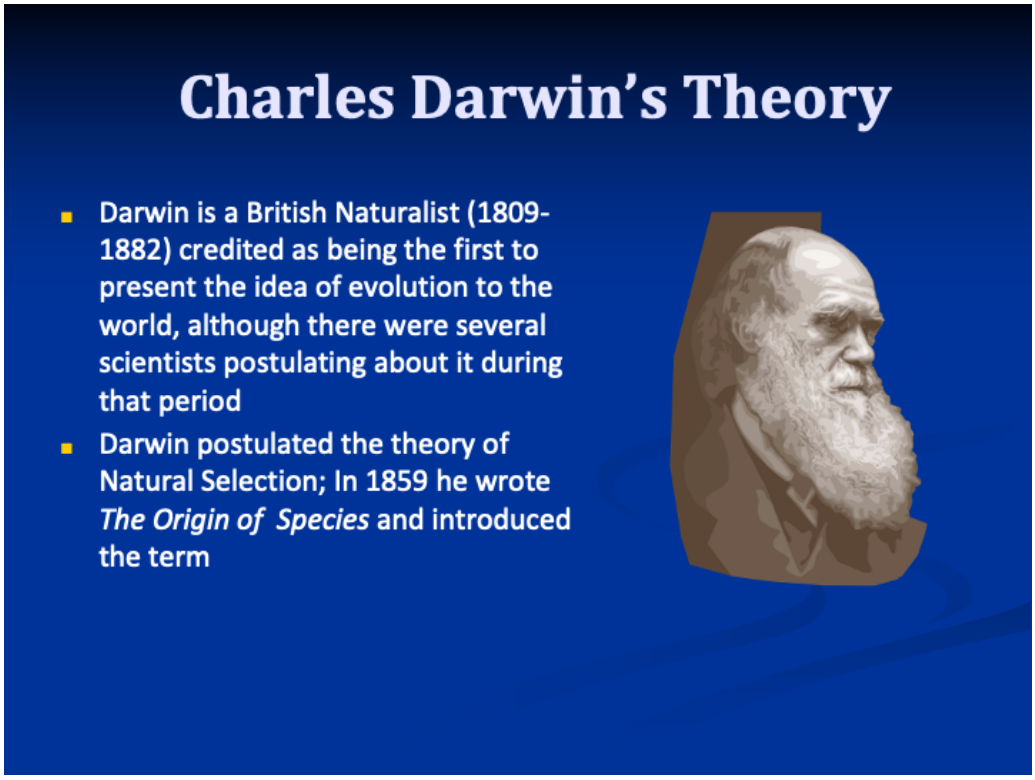
Theory of Evolution is the change in organisms through time; Evolution is an on-going process in response to shifts in an environment. Individuals do not evolve; the population as a whole does. Change happens when organisms adapt to shifts in climate, habitat, food, competition for resources, or catastrophic events. A gradual change allows time for the species to adjust to the new environment. Small changes over millions of years may result in the evolution of a new species.

Evolution only works on existing traits. It is thought that whales and hippos share a common semi-aquatic ancestry. One group of these mammals spent more and more time in the water, living on its abundant food supply. This group gradually evolved to live completely in the water, its feet gradually changed into flippers. Whales evolved.

A dominant idea in evolution is that animals develop from less complex to more complex allowing for increased specialization. Living organisms are fundamentally similar in the way that their basic anatomical structures develop and in their chemical compositions. Once complex cells and tissues like nervous systems evolved, they wouldn't disappear because having a more sophisticated tool gives an animal a survival advantage. Specialization often provides an advantage upon a species in its struggle for existence.

The fossil records reflects the development of species from simple to more complex such as vertebrate development from fish, to amphibians to reptiles and finally mammals and birds. If we look at just the heart, we see that fish have a two-chambered heart, most reptiles a three-chambered heart, and birds and mammals a more complex four-chambered heart.

Evolution is the change in the frequency of inherited traits in a population from generation to generation. The five processes that can cause gene frequency to change are: genetic drift, non-random mating, mutations, gene flow (migration in and out of a population) and natural selection.

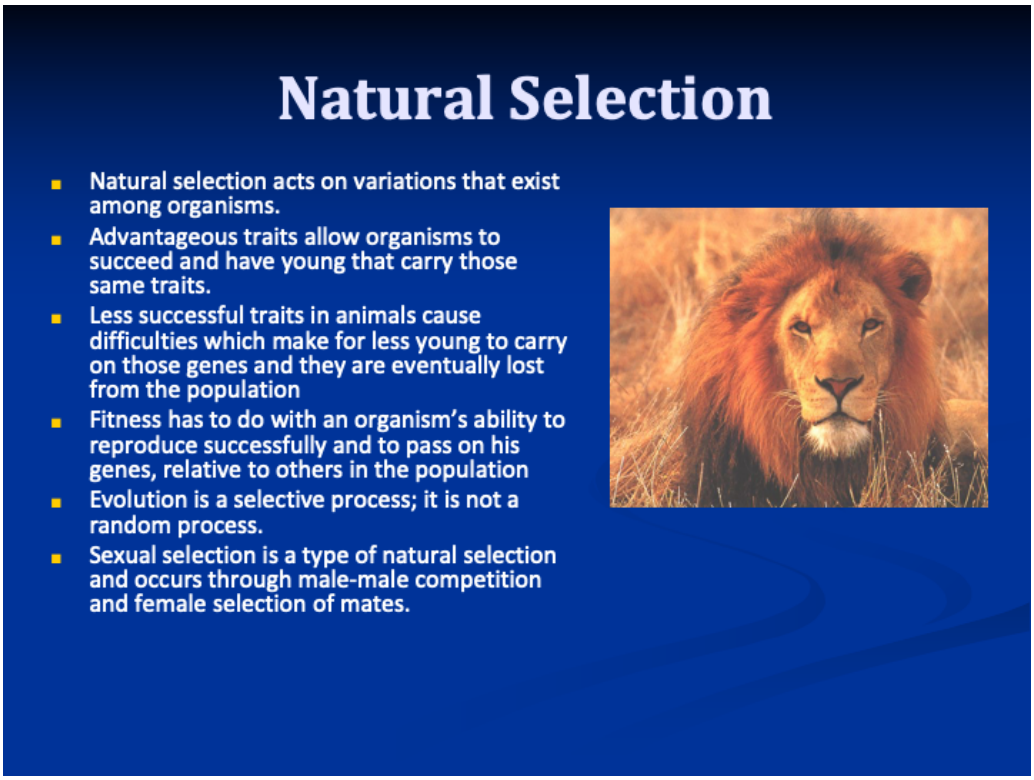


The **Theory of Evolution** is strongly identified with the British naturalist, Charles Darwin. It was during Darwin's five year excursion aboard the HMS Beagle that he began formulating his theory. His theory was based on careful observation of the similarities and differences in the anatomy of different species particularly the finches residing on the Galapagos Islands. Darwin quietly worked on his evolutionary theory for twenty years. He wanted to amass a wealth of evidence before publicly presenting his idea.

During those years he corresponded briefly with **Alfred Russel Wallace**, who had been inspired and influenced by Darwin when exploring the wildlife of South America and Asia. On his own travels, Wallace realized that there was a line that divided different groups of species, now called **Wallace's Line**, and it marks the Australian fauna and flora from the Asiatic flora and fauna. Wallace supplied Darwin with birds for his studies and decided to seek Darwin's help in publishing his own ideas on evolution. He sent Darwin his theory in 1858, which, to Darwin's shock, nearly replicated Darwin's own. Together they presented their ideas at the Linnaean Society, in 1858 but it was the publication of *"The Origin of Species"* a year later, that gave Darwin his notoriety.

Since Darwin's time, our understanding of the evolutionary processes has deepened considerably. However, the basics of the theory have remained unchanged. Although evolution is commonly misunderstood and misrepresented, the theory is actually quite simple. Darwin's big idea elegantly explained how new species arise, not from a mysterious or unobservable source, but from the inevitable interactions of three basic characteristics of life. Within a decade, Darwin's Theory of Evolution was accepted among the scientific community but the Theory of Natural Selection, the primary mechanism of evolution, did not get much notoriety until the 1940s.

Darwin's theory explained how new species arise from the inevitable interactions of three basic characteristics of life. **First**, If unchecked, organisms produce more offspring than the environment can support, leading to a struggle for survival. **Secondly**, organisms tend to resemble their parents. This is because parents pass on some or all of their genetic code to their offspring. **Lastly**, occasionally organisms are produced that have novel traits or novel trait variations. Although Darwin did not know it, one source of these novelties is genetic mutation (i.e. genetic drift).

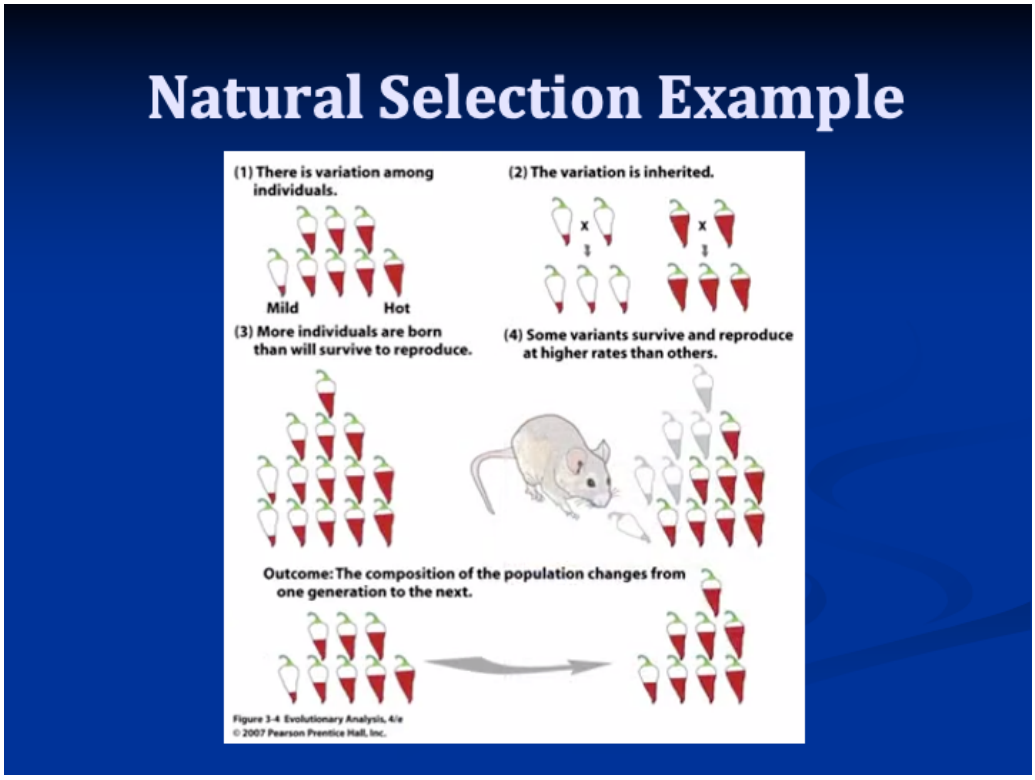


The process by which species evolve is **natural selection.** **Natural selection** acts on variations that exist among organisms; this variance comes from mutations in the genetic code. This variation within a given population is **genetic diversity**. Biological populations are altered over time as a result of propagation of inheritable traits that affect the capacity of an organism to survive and reproduce. Traits that are more advantageous for example in feeding, breeding, or defense, allow organisms to succeed and have young that may carry those same traits. Because more organisms are produced than can survive in an environment, some organisms do not survive. This means that organisms of different species must compete for resources. Similarly, organisms of the same species must compete for resources amongst themselves. Those that carry less successful traits will most likely not live as long and not be as successful in breeding. This is "**survival of the fittest**"; fitness having to do with an organism's ability to meet the challenges of life and the ability to pass his genes on to the next generation.

Mutations are the ultimate source of all genetic variations. Most of the time, genetic mutations are disadvantageous, for example albinism. But every so often, one of those novelties will be an advantage. That means the organism with the novelty will have a competitive edge at surviving and reproducing. Eventually, the offspring who inherit the advantageous novelty may come to dominate the entire population. This process will naturally repeat itself with more and more advantageous traits building up in the population. There is a **genetic drift** in the population, a change in the number of times you might see that trait in a population. Eventually, the genetic code of the population will be so different from its ancestors, that it will constitute a new species. This is evolution in a nutshell.

It is often incorrectly said that evolution is a random process. Just the opposite is true. Genetic mutations occur randomly, but the evolutionary process that weeds out disadvantageous mutations and favors advantageous mutations, is a selective process.

Modern research shows dark maned lions of Africa are becoming more prevalent in the lion population. Female lions tend to show a preference for the dark-haired males and are therefore choosing to mate with these males. The dark maned lions are producing more offspring and are passing on this gene more often and the dark maned lions are becoming more prevalent in the population. This is an example of a type of **natural selection**, **sexual selection,** where members of one sex chose their mate of the other sex. Sexual selection leads to the evolution of dramatic traits that often appear maladaptive for survival but persist for greater reproductive success. Males are fighting for the opportunity to reproduce and pass on their genes while females are looking to increase their reproductive success. These sexual differences within a species is known as **sexual dimorphism**. The sexual differences maybe dramatic as seen in the Indian peafowl and the Northern elephant seal.



Let us look at a natural selection example in a pepper plant:

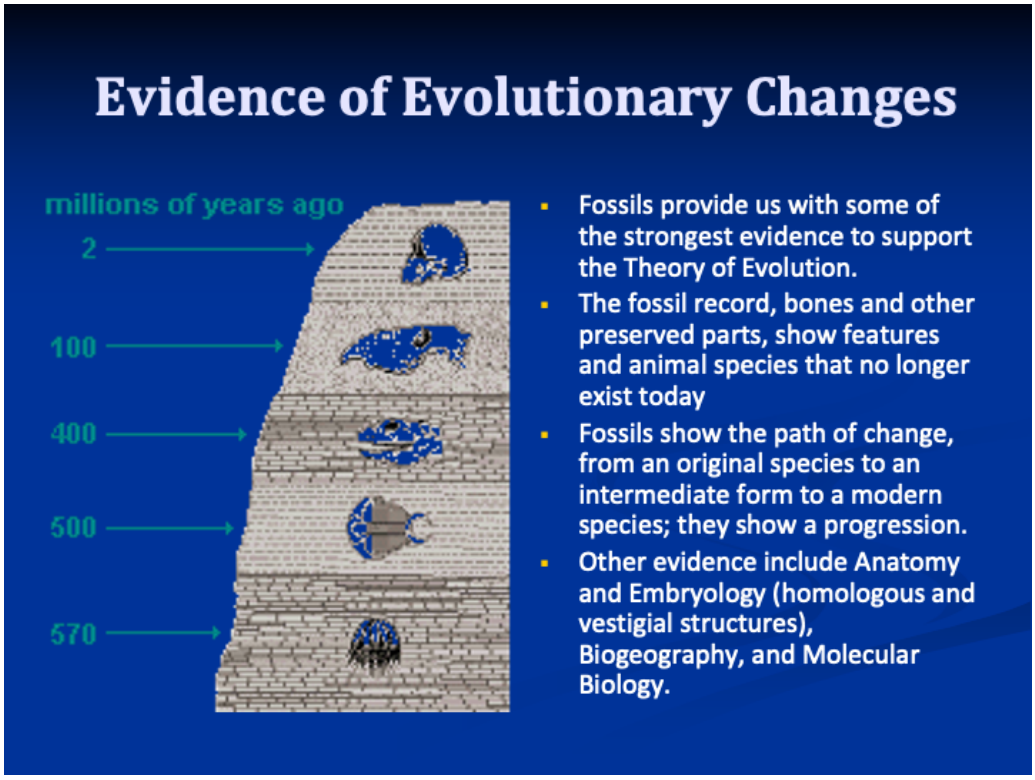
#1 - Here we have several peppers that vary in their mildness or hotness, some of them are mild, some of them are hot; there is variation in the individual peppers.

#2 - This variation is inherited, so the mild peppers give birth to other mild peppers, the hot ones breed other hot ones. Future generations are able to get the trait.

#3 – In the animal world, more individuals are born than will survive to reproduce. Their capacity for population growth tends to be very high. Since not everyone does survive, the higher birth rate ensures that the species will continue on.

Related to #3 is #4 - Some variants survive and reproduce at higher rates than others; they are "more fit". In this case, we can see that the milder peppers don't survive as well as the hot peppers because the milder ones get eaten up by things like mice or humans who like mild peppers.

The outcome of this is that the population changes over time. Over time, as this is iterated over and over again, more of the surviving peppers will be hot, because you've eliminated not only the mild peppers themselves, but even that genetic contribution within the population that made the peppers mild. The population has shifted toward hotter peppers.



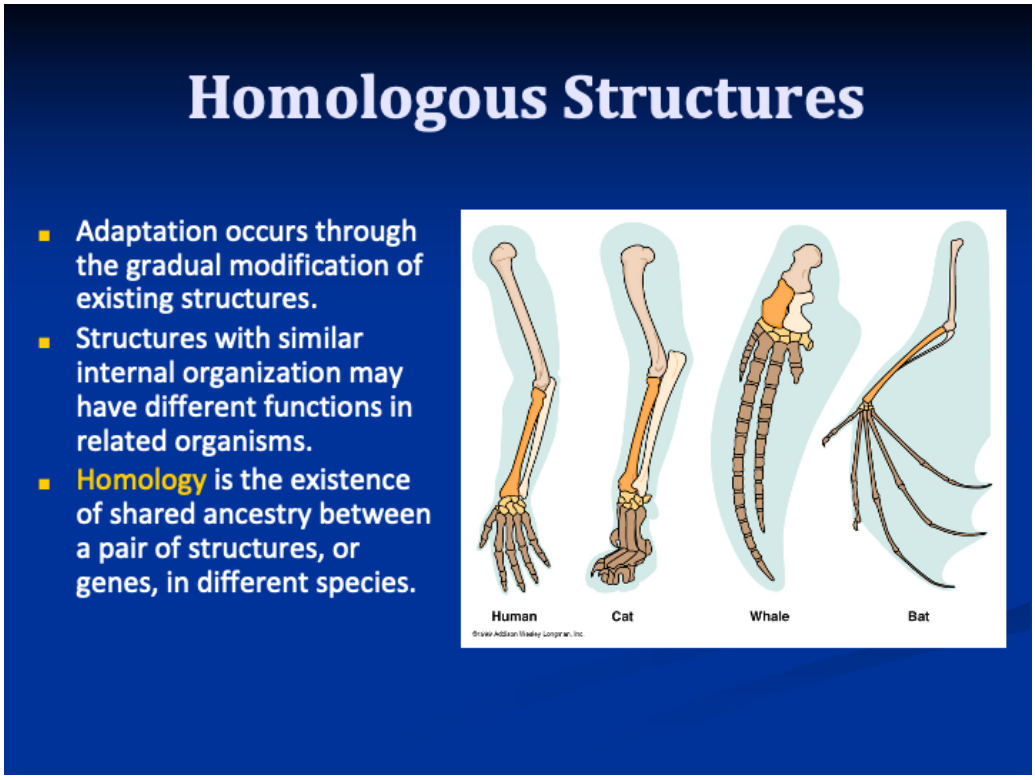
Paleontology, the study of fossil records, shows patterns of extinction and development of species over time; perpetual change is documented by the fossil record. The remains of animals and plants found in sedimentary rock deposits give us an indisputable record of past changes through vast periods of time. This evidence attests to the fact that there has been a tremendous variety of living things in earth's history. Some extinct species had traits that were transitional between major groups of organisms. Their existence confirms that species are not fixed but can evolve into other species over time.

Fossils help to explain the path of change from origin of a species to intermediate form to modern species. For example, the fossil of *Eohippus,* a small, five-toed horse, shows adaptations for a life spent walking on the soft, moist grounds of primeval forest. Through time, as grass species began to appear the horse's predecessors needed to be capable of greater speeds to outrun predators. This was attained through the lengthening of limbs and the lifting of some toes from the ground in such a way that the weight of the body was gradually placed on one of the longest toes, the third, giving rise to *Equus,* the large, modern single-toed horse.

In Embryology, the study of the development of the anatomy of an organism provides evidence of relatedness between now widely divergent groups of organisms. For example, all vertebrate embryos, including humans, exhibit gill slits at some point in early development. Also, great ape embryos, including humans, have a tail structure during their development that is lost by the time of birth.

Biogeography is best explained by the geographic distribution of organisms on the planet which follow patterns that are best explained by the movement of tectonic plates over geological time. (See section on Zoogeography for more details)

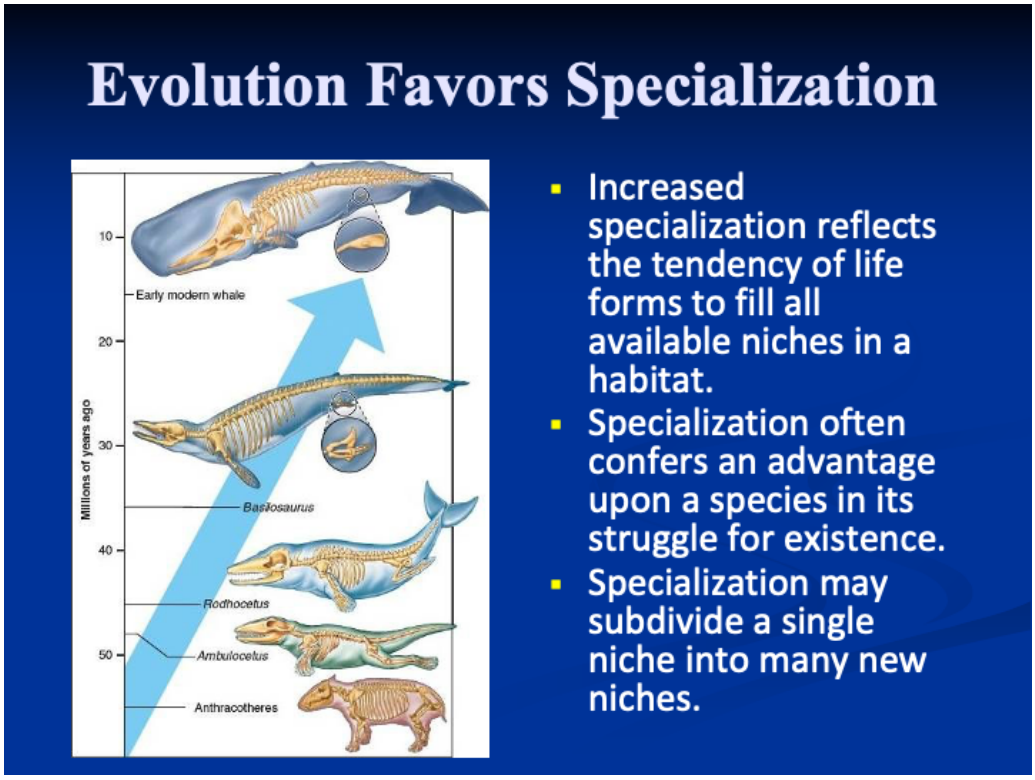
In more recent years, carbon dating and DNA analysis have further supported and reinforced the Theory of Evolution; all available evidence supports the central conclusions of evolutionary theory, that life on Earth has evolved and that species share common ancestors.



As mentioned on the previous slide, a type of evidence for evolution is the presence of structures in organisms that share the same basic form (seen in their anatomy or embryology). Evolution works on existing traits; there is a gradual modification of existing structures. Consequently, structures with similar internal organization may have different functions in related organisms. **Homology** is the existence of shared ancestry between a pair of structures, or genes, in different species. Here you can see the homologous bones in the forelimbs of four mammals, a human, cat, whale and bat. Colors denote homologous structures. The bones of these animals have the same basic structure but have been adapted for specific uses. Thus, they have evolved from a more general structure to a more specialized use which enhances the animal's survival. Through evolutionary process the common ancestor of these animals differentiated into these present-day forms.

The principle of homology was one of Charles Darwin's arguments in favor of evolution. Evolutionary change nearly always involves remodeling the old into the new. For example, the legs of land animals are variations on the stout limbs of ancestral fish; the tiny middle ear bones of mammals are remodeled jawbones of their reptilian ancestors; the wings of birds are fashioned from the legs of dinosaurs. Natural Selection works on existing traits; it doesn't produce new traits. In some cases the function is lost.

A **vestigial trait** is a feature of a species that was an adaptation in its ancestors, but that either lost its usefulness completely or, as in the penguin adapted for new uses; the penguin can no longer fly in the air, but in the water, its wing has become a flipper to "fly" them through the water. In humans, the coccyx and the appendix are both vestigial organs. The coccyx is what remains of the long tail or our ancestors and the appendix is a remnant of the enlarged caecum containing bacteria which our herbivorous ancestors used to help break down cellulose of plants. In the case of the penguin, a trait can be vestigial and functional at the same time; it is vestigial not because it's functionless, but because it no longer performs the function for which it evolved.



The better the species is adapted to its environment, the greater the survival rate for that species. Organisms may diversify when a change in the environment makes new resources available, creates new challenges, or opens new environmental niches.

During more arid times when traditional food sources became scarce, those animals that turned toward the sea for sustenance were better able to survive environmental change. The example above demonstrates the evolutionary change over the millennia which enabled a land mammal to take advantage of a more abundant food source by transitioning to a marine mammal. A foot with four to five toes became a fin specialized for swimming. Today whale fin x-rays reveal five jointed digits still encased in the fin. The rear legs have become internal and are reduced to nothing more than vestigial bones. Over 40 million years, the descendants of *Anthracotheres* ultimately evolved into an extremely successful marine mammal, the whale. The result of evolution has been the creation of multitudes of earth species each with specialties that have made them successful competitors and encouraged life to fill every ecological niche.

Will an animal that is more specialized in their niche be at greater risk of extinction under environmental changes than an animal that is more of a generalist? Specialists thrive when conditions are just right. They fulfill a niche and are very effective at competing with other organisms. Generalists respond much better to changes/uncertainty. These species usually survive for very long periods because they deal with unanticipated risks better. But unlike specialists, they don't maximize their current environment, because they don't fill a niche where they could be more successful. An environment with more competition breeds more specialists. Rainforests have huge diversity and competition and therefore many specialist species.

Natural Selection is the only evolutionary process that leads to adaptations. Species may have adapted to reduce competition for **food**. Koalas occupy a unique niche in that they consume eucalyptus leaves which are poisonous to most other animals. Giraffe's height provides a competitive advantage. They eat the leaves of the acacia tree that other animals cannot reach. In turn, the acacia avoids destruction by exuding a bitter chemical through its leaves as it it eaten. In response, the giraffe moves on minimizing damage to the tree and stimulating further tree growth. The giraffe and the tree have adapted to mutually support the other's survival.

Flamingos' beaks are adapted for filter feeding. The sharply downward bent bill is held upside down in the water and swept back and forth. The fleshy tongue pumps water through comb-like filtering structures lining the top half of their bill, filtering out the minute organisms. The form of the beak allows them to feed without getting the feathers wet.

An adaptation may improve **defense** to protect animals and their young from predators, pests and weather. Examples include protective coloration or different eye placement for prey and predatory animals. Horns on antelopes serve to fight for breeding rights but they are also used for protection against predators. If a lion goes for a neck bite, the horns are in perfect location to protect against the cat.

Locomotion is an important adaptation because animals must be able to move throughout their environment in order to find food, mates or to escape from predators. Examples include feet that have morphed into fins for swimming, arms that have evolved into wings for flying, or legs that have been made longer for jumping or running fast. Horses and zebras have developed hooves. Penguin wings are like paddles that allow the bird to fly through the water.

Adaptations may relate to **reproduction** or the perpetuation of species. Individuals must recognize their own species, attract a mate and raise young. Cats (excluding lions) are solitary animals that occupy different but overlapping territories. Cats had to develop a very strong sense of smell in order to track the scent of female cats in estrus if solitary species are to survive. Koalas are born in a minimally developed state. Newborns climb to the pouch and latch themselves onto a teat and remain while they continue to develop and are ready to come out of the pouch.

In many of the bird species, the male has brightly colored feathers to attract a mate. In primates, the female develops a distinct hind swelling so the male will know she is receptive to mating.

An adaptation may be an **external physical** feature such as coloration. Color or patterns can be used as camouflage or for identification. The lighter coloring of the kangaroo may keep it cooler in the heat of day in Australia.

An adaptation of size or shape enables it to reach food such as the long neck of the giraffe allows it to eat leaves on the taller trees. Otters and penguins have very streamlined bodies for swimming in their water environments. The male of a species might be larger than the female making him a better protector of his group or better able to compete with other males for the right to mate.

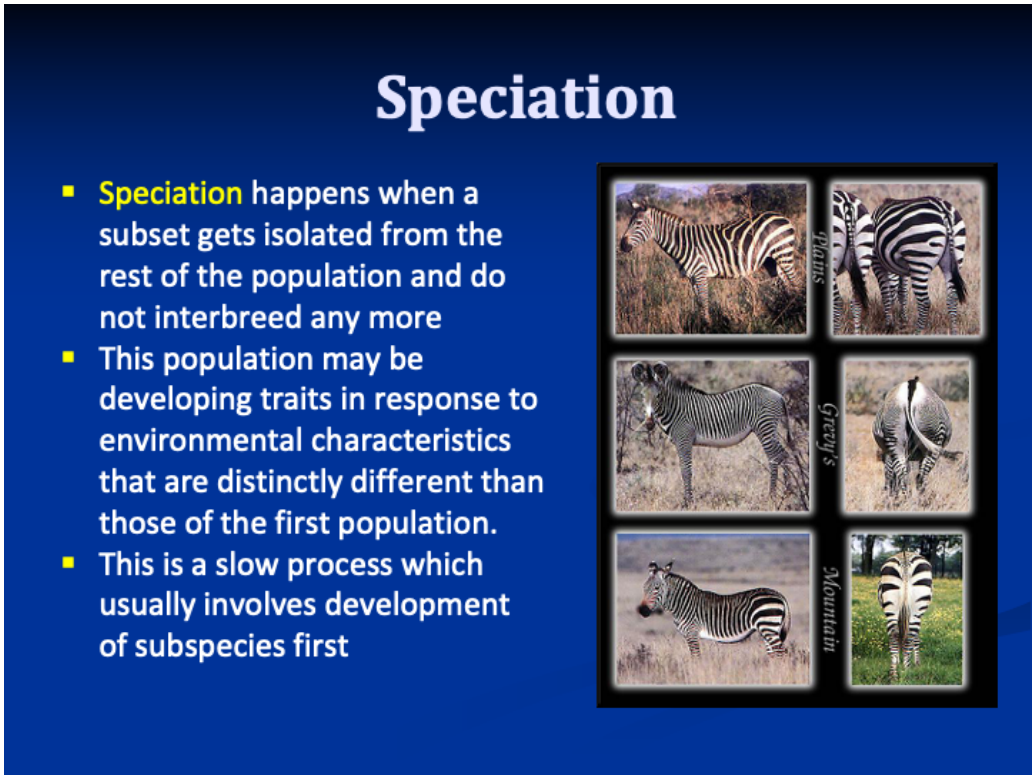
The peccary has adapted to eating cactus by developing a leathery snout. What is the purpose of the great horned owl's ear-tufts? The ear tufts on Great Horned Owls serve as visual cues in territorial and socio-sexual interactions and it helps break up the round face when trying to hide in a tree.

Animal pelts provide great clues as to where an animal lives. You tend to see lighter color and shorter fur on animals that live in warmer habitats as the sun is reflect off the lighter color and not absorbed as a dark fur would.

Some adaptations are not readily visible, but are internal. These are **internal physiological adaptations**. Ruminants have four chambered stomachs to allow for digestion of their fibrous, herbivorous diets. Giraffes, antelopes and cows all chew their cuds which is characteristic of ruminant digestion. Birds have the least dense bones which enable them to fly. Birds have a two chambered stomach, a gizzard and some a crop, all to aid in breaking down plant material.

Lastly adaptations can be **behavioral**. Behavioral adaptations are things animals do in order to survive. These behavioral changes are result of evolution occurring over long periods of time. You might see social behaviors of animals living in groups or alone. You might see animals defending their territory or in the gorilla community where the male is dominant in a social grouping of females and young . You might see animals resting during the day because they are nocturnal and do their feeding at night. The zebras and rhinos may roll in the mud to protect their skin from sun and insects.

These are only a few of the many adaptations that help animals to survive. The more you learn about an animal's adaptations the more amazing they will become to you and the more you will want to learn about an animal or plant.



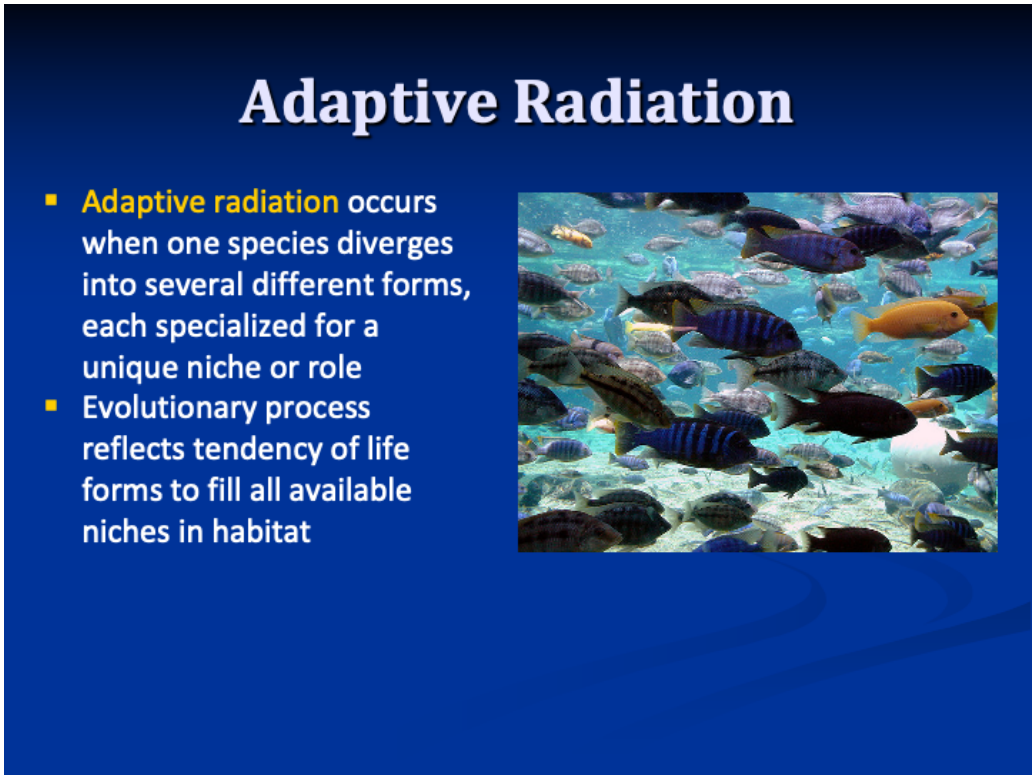
Speciation happens when a subset gets isolated from the rest of the population and the animals no longer interbreed. One population may be developing traits in response to environmental characteristics that are present only for its population, passing on features distinctly different from those of the first population. This reaches a point where the two populations are different enough that they can no longer reproduce with each other, and a new species evolves. This was the case of the three species of zebra who occupy different locations in Africa.

This is a slow process which usually involves development of subspecies first. Subspecies may never progress to full species in some cases.

In these pictures you can see the three species of Zebra: the plains zebra, the Grévy's zebra and the mountain zebra. What is the mechanism where different species arise? What conditions or events might have precipitated the evolution of these three zebra species?

If one looks at the geographic distribution of related species, one can see evidence of speciation. Islands and continents separated over time show distinct differences within and among species.

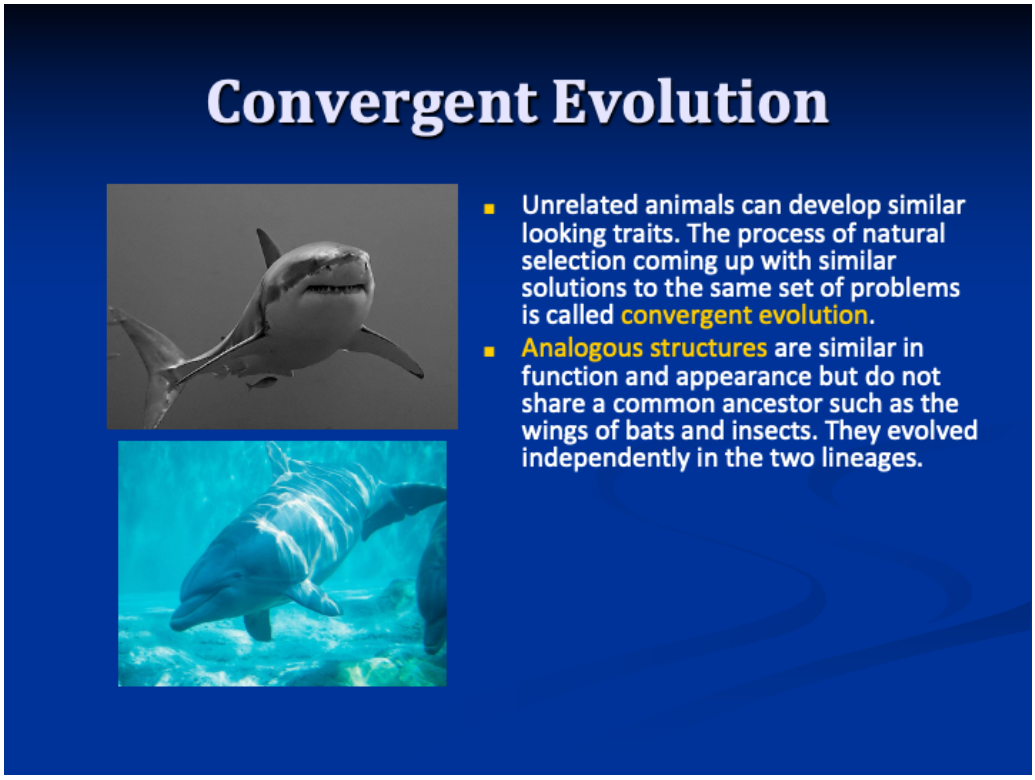
Madagascar is a prime example of an isolated island having a large number of endemic species that can be found nowhere else in the world. The most likely explanation for the existence of Madagascar's mostly unique biotic environment is that the life forms have been evolving in isolation from the rest of the world for millions of years. The lemurs can be used to bring this point across. Compare the picture of where the zoo's lemurs come from with the climate map of Madagascar. From the climate map explain the various climates from eastern rainforests, to the deciduous forests of the west, to the driest, desert-like conditions of the south. All our lemurs occupy different habitats. The red-roughed lemurs evolved in an isolated area of the island.



Adaptive radiation is one of the most important processes responsible for the origin of biological diversity. Adaptive radiation is the evolution from one kind of organism to several divergent forms, each specialized to fit a distinct and diverse way of life or niche. Examples can be seen in the development of diverse marsupial species in Australia, in Darwin's finches or in these African cichlids. Adaptive radiations often occur as a result of an organism arising in an environment with unoccupied niches, such as a newly formed lake or isolated island chain. The colonizing population may diversify rapidly to take advantage of all possible niches.

Another excellent example of adaptive radiation is the evolution of diversified lemur species in Madagascar. In the absence of competition from monkeys or apes, and few predators, many subspecies of lemurs developed to fill the various ecological niches on the island of Madagascar.

Adaptive radiations commonly follow mass extinctions. Today there is good evidence that a major meteorite impact occurred at the end of the Cretaceous period, leading to the extinction of non-avian dinosaurs opening a niche for the rise and diversification of mammals. There has been five mass extinction periods in earth history each opening opportunities for new species to rise and flourish through the process of adaptive radiation.



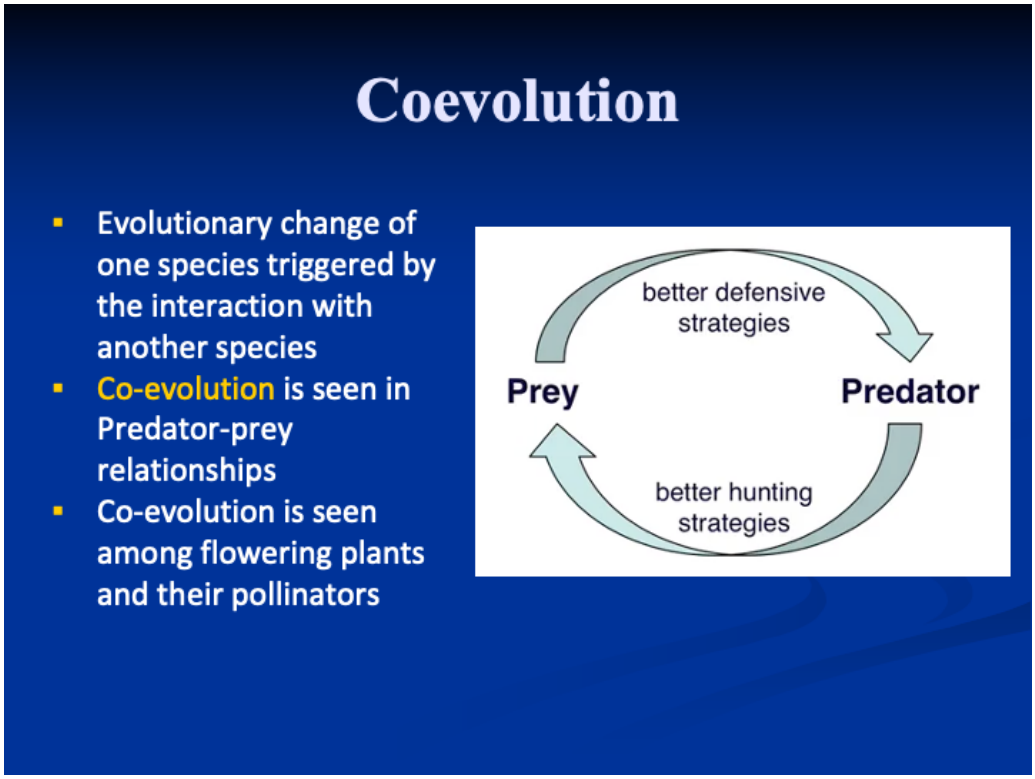
Convergent evolution is the independent evolution of similar features in species of different li**n**eage and often in widely separated areas. This happens as a result of the species having to adapt to similar environments or ecological niches.

For example sharks and dolphins have independently developed streamlined bodies allowing for rapid movement through their water environment. Also, bats and birds are very different animals, but they have both developed wings as an approach to flight.

Other animals which are not related, but have similar anatomy include snakes and legless lizards, echidnas and hedgehogs and the prehensile tails of Australian possums and some New World monkeys.

Within our own Children's Zoo the meerkats and prairie dogs both have communal underground lifestyles but meerkats are carnivorous, from Africa and are in the Family Carnivora, whereas the prairie dogs are herbivorous, from North America and are in the Family Rodentia. Compare the social behavior of the meerkat and prairie dogs. Show how their underground dwellings are very similar. How do prairie dogs and meerkat watch for and signal danger?

While animals may display some common anatomy due to convergent evolution, they also retain features and behaviors that illustrate that they are in fact different animals. Penguins and river otters both have streamline bodies and webbed feet that act like rudders in the water, but the penguin is covered in feathers while the otter is covered in fur. One lays eggs while the other has live birth.



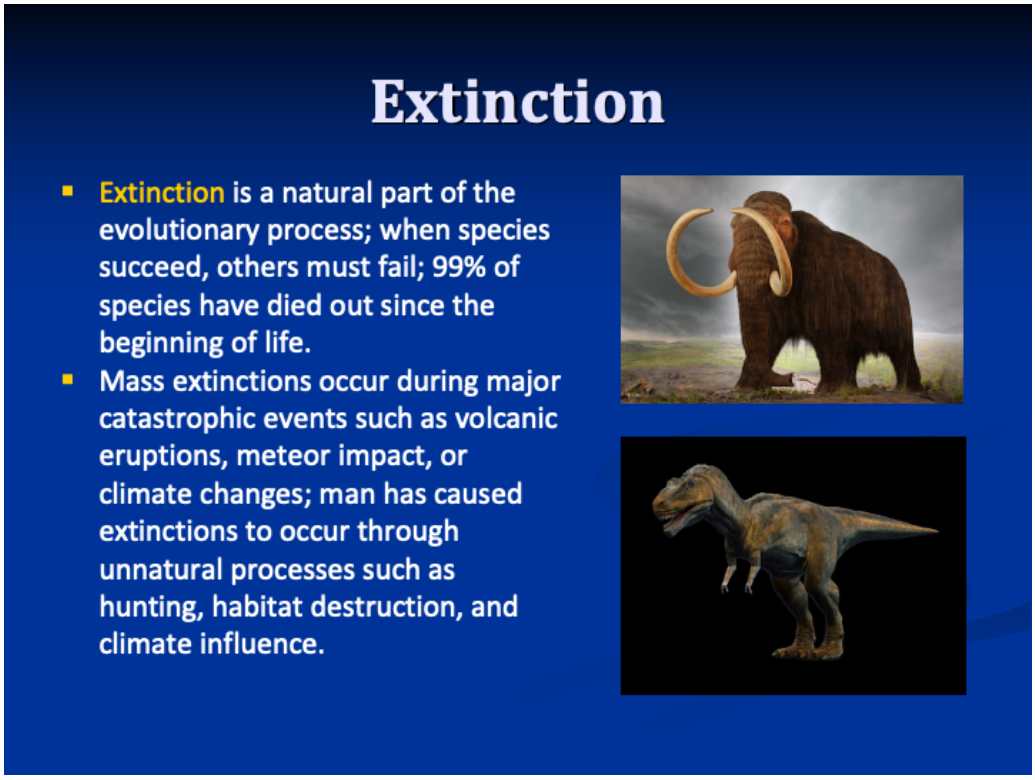
Coevolution is the evolutionary change of one species triggered by the interaction with another species. They reciprocally affect each other's evolution and the species usually have close ecological interaction with one another. Every form of life on Earth interacts over time with other organisms, as well as with its physical environment. Predator/prey relationships are a classic example of how two species influence each other.

Predators and prey are involved in an endless competitive tussle, a "cat-and-mouse" game, which has giving rise to physical and behavioral adaptations, resulting in **coevolution** of both the predator and the prey. Continual evolutionary adaptation produces the most efficient predators and the prey that is best able to evade capture. Predators and prey are constantly adapting, evolving, and proliferating not merely to gain reproductive advantage, but also simply to survive while pitted against ever-evolving opposing organisms in an ever-changing environment.

One such predator-prey relationship exists between between wolves and caribou. Wolves hunt caribou, chasing them down to capture them capture them. The slower caribou are more likely to be preyed upon, leaving the faster individuals to reproduce. The resulting faster offspring will be even more difficult for the wolves to catch, and only the fastest wolves or most clever wolves will get enough food to survive.

Another example of coevolution is the giraffe and the acacia tree. The animal and the plant evolved simultaneously. The acacia leaves are a staple in the giraffe's diet. If the giraffe harms the tree by eating too many leaves, the tree emits a bitter sap driving the giraffe away and the striped leaves stimulate the tree to produce more leaves. Both animal and plant share a mutually beneficial relationship.

Coevolution is especially seen among plants and their pollinators. A number of species of flowering plants have coevolved with specific pollinators, i.e. insects, bats, birds. The pollinator gets a reward such as nectar for pollinating the plant.



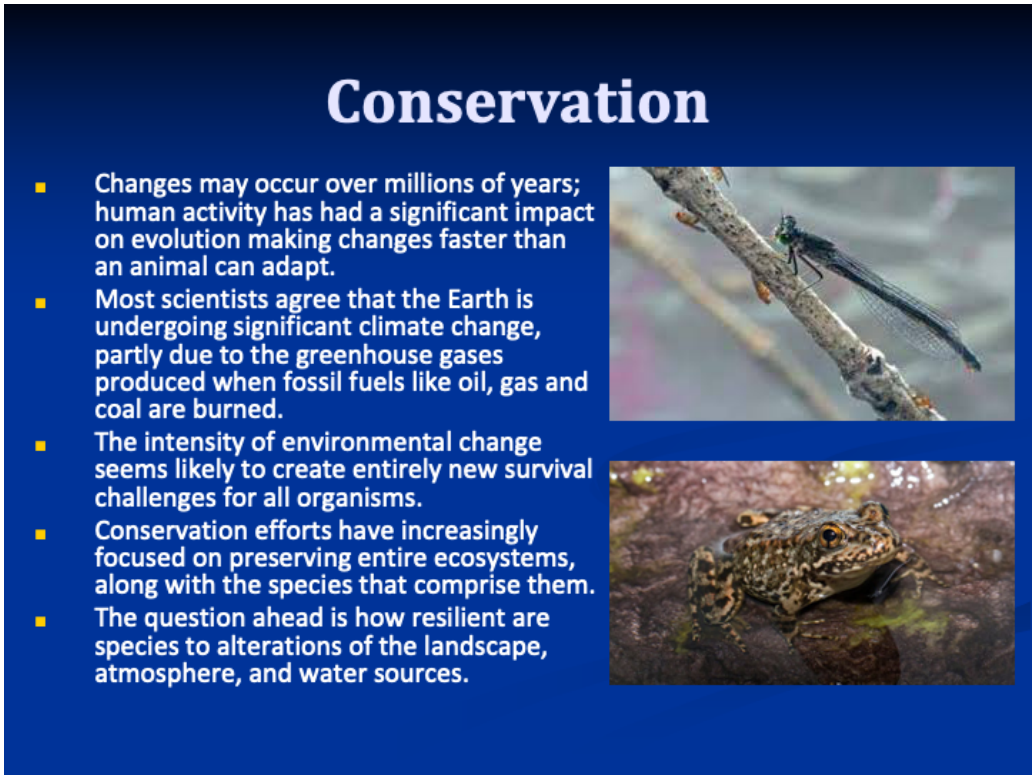
Extinction is a natural part of evolution as some species succeed and others do not. 99% of all species that have ever lived on earth have died out.

While most environmental changes are gradual, some such as volcanic eruptions or meteor strikes are not. Mass extinctions tend to follow these major catastrophic events. The earth has experienced five major extinctions that led to cataclysmic changes in the earth's flora and fauna alike.

Many species have recently become extinct as a result of human activities such as hunting, habitat destruction and climate change. Today scientists believe that we are experiencing a sixth major extinction due to these activities. It is the mission of the San Francisco Zoo and Gardens to conserve endangered species of today.

The Chacoan Peccaries at the zoo were once thought to be extinct. They were rediscovered in 1975 and are now part of a joint SF Zoo and Bolivian government conservation program which seeks to increase their numbers and reintroduce them into the wild.

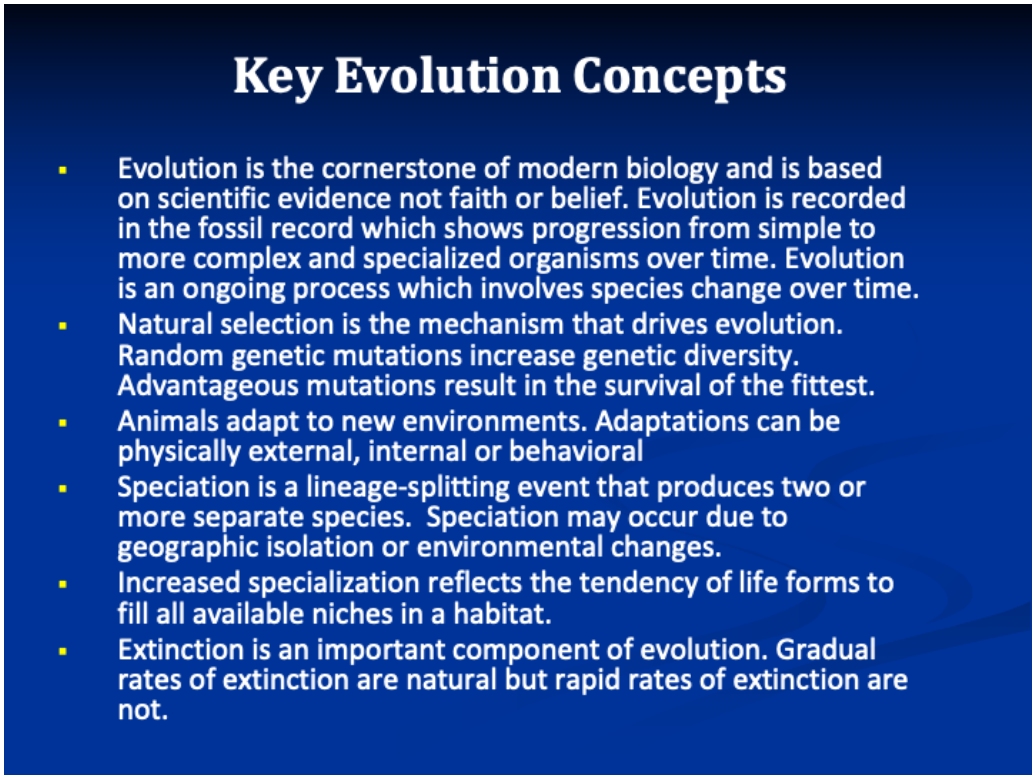
In 1975 The Mexican Grey Wolf's numbers had declined drastically due to human activity. For years government bounties which encouraged ranchers to shoot or poison wolves resulted in all but five surviving in the wild. The wild wolves were captured in order to start a captive breeding program. Our zoo is now part of an effort to increase the wolf population, reintroduce wolves into the wild and restore the natural ecological balance in the American southwest.



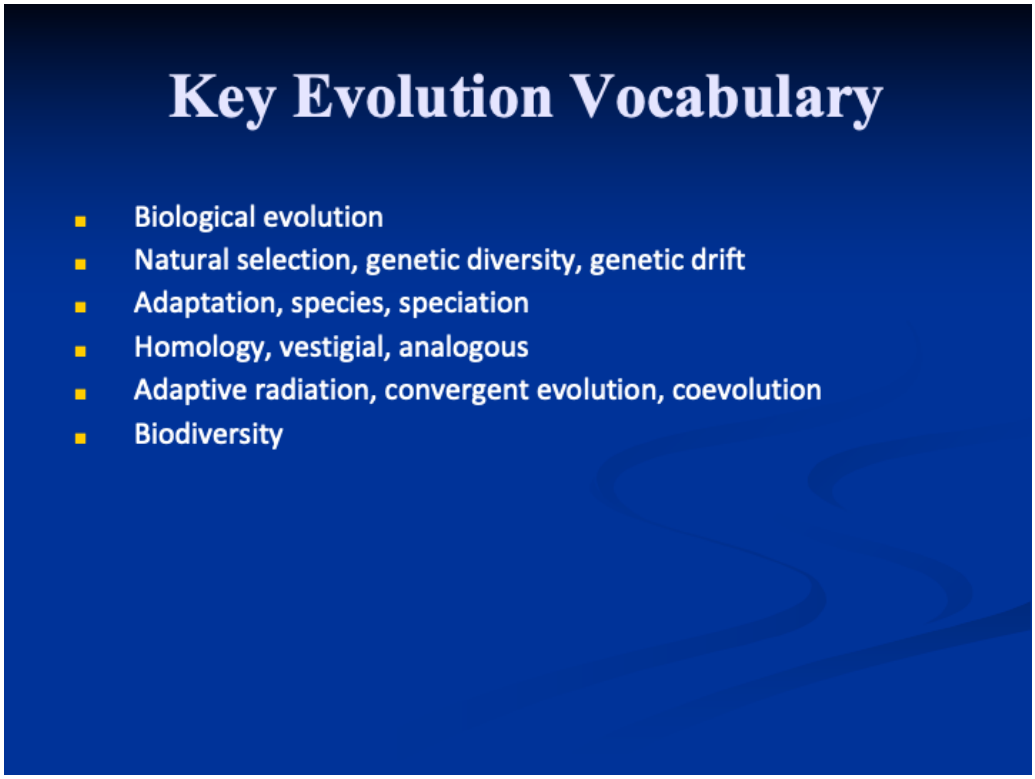
In the past, changes have occurred over millions of years, giving time for plants and animals to adjust. In more recent times, human activity has had a significant impact on evolution; most scientists agree that global warming is occurring due to the greenhouse gases emitted into the air. Environmental changes are occurring exponentially faster than they have in the past, creating entirely new survival challenges for all organisms.

Conservation efforts have increasingly focused on preserving entire ecosystems, along with the species that comprise them. But how do we decide which ecosystems to preserve? Many scientists argue that we should prioritize ecosystems with the highest **biodiversity**, or variety of all living things. Evolutionary relationships provide a useful measure of biodiversity. Studying the evolutionary history of the organisms that comprise those ecosystems can help us make decisions that maximize the biodiversity preserved.

The question ahead is “can species adapt fast enough to survive rapid environmental changes”?



Corresponds with pages 1-2 and 17-19 of the Zoology Study Guide and the Adaptations Touring Guide in the Docent Notebook.



Definitions:

Adaptive radiation: process in which organisms diversify rapidly into a multitude of new forms, particularly when a change in the environment makes new resources available, creates new challenges and opens environmental niches

Analogous structures: similar structures that evolved independently in two living organisms to serve the same purpose.

Biodiversity: Is the variety and variability of flora and fauna on earth.

Biological evolution: any genetic change in a population that is inherited over several generations. These changes may be small or large, noticeable or not so noticeable.

Coevolution: The process of reciprocal evolutionary change that occurs between pairs of species or among groups of species as they interact with one another; two (or more) species reciprocally affect each other's evolution; the evolutionary change of one species triggered by interaction with another species.

Convergent evolution: unrelated species can develop similar traits as the process of natural selection results in the same solution to a similar problem.

Genetic diversity: the total number of genetic characteristics in the genetic makeup of a species. It is distinguished from genetic variability, which describes the tendency of genetic characteristics to vary.

Genetic drift: a change in the number of times you might see a certain trait in a population due to chance or random events.

Homology: the existence of shared ancestry between a pair of structures, or genes, in different species.

Natural selection: Concept that individuals with mutations resulting in specific attributes may be better suited to conditions in a particular habitat. These better suited individuals survive and reproduce, passing along such favorable traits to their offspring. Such traits become more pronounced over time with succeeding generations, ultimately leading to new sub-species or entirely new species.

Speciation: the evolutionary process by which populations become distinct of species. Typically, but now always a result of geographic isolation over time.

Species: a group of living organisms consisting of similar individuals capable of interbreeding.

Vestigial: a feature of a species that is greatly reduced from the original ancestral form and is no longer functional or is of reduced or altered function.