VOCABULARY

Evolution = process by which modern organisms have descended from ancient organisms; change over time

Fossil = preserved remains or traces of ancient organisms

Artificial Selection = selective breeding of plants and animals to promote the occurence of desirable traits in offspring

Adaptation = heritable characteristic that increases an organism's ability to survive and reproduce in an environment

Fitness = how well an organism can survive and reproduce in its environment

Natural Selection: process by which organisms that are most suited to their environment survive and reproduce most successfully; also called survival of the fittest

Biogeography = study of past and present distribution of organisms

Homologous structures = structures that are similar in different species of common ancestry

Analogous structures = body parts that share a common function, but not structure

Vestigial structure = structure that is inherited from ancestors but has lost much or all of its original function

Gene Pool = all the genes, including all the different alleles for each gene, that are present in a population at one time

Allele frequency = the number of times that an allele occurs in a gene pool compared with the number of alleles in that pool for that same gene

Single-gene trait = trait controlled by one gene that has 2 alleles
polygenetic trait = trait controlled by 2 or more genes

Directional Selection = form of natural selection when individuals at one end of a distribution curve have higher fitness than individuals in the middle or at the other end of the curve

Stabilizing Selection: form of natural selection in which individuals near the center of a distribution curve has a higher fitness than individuals at either end of the curve

Disruptive Selection = natural selection in which individuals at the upper and lower ends of the curve have higher fitness than individuals near the middle of the curve

Genetic Drift: random change in allele frequency caused by a series of chance occurences that cause an allele to become more or less common in a population

Bottleneck effect = a change in allele frequency following a dramatic reduction in the size of a population

Founder effect = change in allele frequencies as a result of the migration of a small subgroup of a population

Genetic equilibrium = situation in which allele frequencies in a population remains the same

Sexual Selection = when individuals select mates based on heritable traits (non-random mating)

Species = a group of similar organisms that can breed and produce fertile offspring

speciation = formation of a new species

reproductive isolation = seperation of a species/population so that they no longer interbreed and evolve into 2 seperate species

Behavioral Isolation = form of reproductive isolating in which 2 populations develop differences in courtship rituals or other behaviors that prevent them from breeding

Geographic Isolation = form of reproductive isolation in which 2 populations are seperated by geographic barriers such as rivers, mountains, or bodies of water, leading to the formation of 2 seperate subspecies

Temporal Isolation = form of reproductive isolating in which 2 or more species reproduce at different times

Binomial nomenclature = classification system in which each species is assigned 2-part scientific name

Genus = group of closely related species, first part of binomial nomenclature

Systematics = study of the diversity of life and the evolutionary relationships between organisms

taxon = group or level of organization into which organisms are classified

phylogeny = study of evolutionary relationships among organisms

clade = evolutionary branch of a cladogram that includes a single ancestor and all its descendents

monophyletic group = group that consists of a single ancestral species and all its descendents and excludes any organisms that are not descended from the common ancestor

cladogram = diagram depicting patterns of shared characteristics among species

derived character = trait that appears in recent parts of a lineage, but not in its older members

relative dating = method of determining the age of a fossil by comparing its placement with that of fossils in other rock layers

index fossil = distinctive fossil that is used to compare the relative ages of fossils

geologic time scale = timeline to represent Earth's history

era = major division of geologic time, usually divided into 2 or more periods

macroevolutionary patterns = changes in anatomy, phylogeny, ecology, and behavior that take place in clades larger than a single species

Background extinction = extinction caused by slow and steady process of natural selection

Gradualism = the evolution of a species by gradual accumulation of small genetic changes over long periods of time

punctuated equilibrium = pattern of evolution in which long stable periods are interrupted by brief periods of more rapid change

Adaptive radiation = process by which a single species or a small group of species evolves into several different forms that live differently

Convergent evolution = process by which unrelated organisms independently evolve similarities when adapting to similar environments

Coevolution = process by which 2 species evolve in response to changes in each other over time

Endosymbiotic theory = theory that proposes that eukaryotic cells formed from a symbiotic relationship among several different prokaryotic cells

DARWIN - FATHER OF EVOLUTION :

Process of change over time = evolution

Darwin developed a scientific theory of biological evolution that explains how modern organisms evolved over long periods of time through descent of common ancestors

Darwin went on a 5-year long Beagle trip and travelled to the Galapagos Islands
Observed finches and tortoises on different islands
He observed that each different group had its own niche
They developed this niche based on what they ate and the area they lived.

Published his studies of evolution in novel called "The Origin of Species" in 1859

Darwin's work shows that the world is always changing
↳ helps understand modern phenomena such as drug-resistant bacteria and diseases

Darwin noticed 3 patterns of biological diversity: species vary globally, locally, and over time

Species vary globally: Darwin noticed that different, yet ecologically similar, animal species inhabited seperated, but ecologically similar, habitats around the globe.
Ex. rheas similar to ostrich but rheas = South America and Ostrich = Africa

Species vary locally: different, yet related animal species often occupied different habitats within a local area

Species vary over time: Darwin also collected fossils, which are preserved remains/traces of ancient organisms
Some fossils of extinct animals were similar to living species

The evidence suggested that species are not fixed and that they could change by some natural process

EVOLUTION BY NATURAL SELECTION

Artificial Selection: heritable variations in a species are manipulated by humans through controlled breeding
nature provides the variations and humans select those they find useful
breeder tries to isolate and choose the genotypes that are responsible for a desired characteristic

Struggle for Existence: If more individuals are produced than can survive, members of a population must compete to obtain food, living space, and other limited necessities of life

Variation/ Adaption: individuals have natural variations among their heritable traits
some of the variants are better suited to life in their environment than others
adaptation: heritable characteristics that increases an organism's ability to survive/reproduce
Adaptations can involve body parts or structres, or behaviors

Survival of the fittest: Fitness = ability to survive and reproduce viable offspring in its environments
differences in adaptations affect an individuals fitness
individuals with adaptations that are well suited to their environment have high fitness
the differences in rates of survival and reproduction is called survival of the fittest.
survival means reproducing and passing adaptations on to the next generation

Natural selection: process by which organisms with variations most suited to their environment survive/leave more offspring
only certain individuals in a population produce new individuals
the environment influences fitness
Occurs in any situation in which more individuals are born than can survive, there is natural heritable variation, and there is variable fitness among individuals
From generation to generation, populations continue to change as they become more adapted, or as the environment changes
Natural selection acts only on inherited traits because those are the only characteristics that parents can pass on

Common Descent: Natural selection depends on the ability of organisms to reproduce, which means to leave descents
Well-adapted species survive over time
over many generations, adaptation could cause successful species evolve into new species
descent with modification: living species, with modification, from common ancestors
implies that life has been on earth for a very long time
Deep time gave enough time for natural selection to act.
Darwin made a tree which implies that organisms are related
all species - living and extinct - are descended from ancient common ancestors.

EVIDENCE OF EVOLUTION

Biogeography: study of where organisms live now and where they and their ancestors lived in the past

Patterns in the distribution of living and fossil species tell us how modern organisms evolved from ancestors

closely related but different: the biogeography of Galapagos species suggested that populations on the island had evolved from mainland species
over time, natural selection on the islands produced variations among populations that resulted in different, but closely related, island species

Distantly Related but Similar: similar habitats around the world are often home to animals and plants that are only distantly related
Differences in the body structures among animals provide evidence that they evolved from different animals, but similarities among those animals provide evidence that similar selection pressures had caused distantly related species to develop similar adaptation

Age of Earth: evolution takes a long time. If life has evolved, then earth must be very old
Geologists use radioactive dating to establish the age of rocks/fossils. found that earth is 4.5 billion years old

Many recent discovered fossils form series that trace the evolution of modern species from extinct ancestors

Fossil Record: fossils or imprints of organisms had formed in different layers of rock
evidence of gradual change over time
one can view how a species had changed and produced different species over time

Homologous Structures: Proposed that animals with similar structures evolved from a common ancestor with basic version of structure
→ structures that are shared by related species and that have been inherited from common ancestor
evolutionary theory explains the existence of homologous structures adapted to different purposes as the result of descent with modification from a common ancestor
similarities and differences among homologous structures help determine how recently species shared a common ancestor
indicates shared genes (similar structures), but also shows genetic differences led to divergent evolution (modification of those structures

Analogous Structures: body parts that share a common function, but not structure.
similar solutions to same environmental challenges seen in unrelated species living in similar environments
represent convergent evolution; rather than shared genes, organisms are under similar pressures

Vestigial Structures: structures inherited from ancestors but lost their original function due to different selection pressures
presence of the structure does not affect an organisms fitness, therefore, natural selection doesn't eliminate it
show that different selection pressures shape organisms differently

Embryology: many embryos look especially similar during the early stages of development
the same group of embryonic cells develop in the same order and in similar patterns
Similar patterns of embryological development provide further evidence that organisms have descended from a common ancestor

Geographic Distribution of Living Species: similar species of animals live in the same area or similar environments
Theory of descent with modification: complex creatures evolve from a similar ancestor
random mutations occur; beneficial ones are passed on.

SUMMARY OF DARWIN'S THEORY

1) individual organisms in nature differ from one another. Some variation is inherited
2) organisms in nature produce more offspring than can survive and many of those that survive do not reproduce
3) more organisms are produced than can survive; members of each species must compete for limited resources
4) Each organism is unique, each has different advantages and disadvantages in the struggle for existence
5) individuals best suited to their environment survive and reproduce most successfully
   - best characteristics passed on; weaker individuals die off or leave fewer offspring
6) Species change over time. Over long periods, natural selection causes changes in characteristics of a species
   - new species arise and other species disappear
7) Species alive today have descended with modifications from species that live in the past
8) All organisms on Earth are united into a single tree of life by common descent

GENETICS AND EVOLUTION

Heritable traits are controlled by genes on chromosomes. Changes in genes/chromosomes generate variation
Variation is the raw material for natural selection

Natural Selection acts directly on phenotype, not genotype
↳ Natural selection acts on organisms characteristics not directly on its alleles

The individuals with phenotypes better suited to their environment survive and pass more copies of their genes to next generation.
Natural selection never acts directly on genes because it is an entire organism, not a single gene, that survives and reproduces

Population: group of individuals of the same species that mate and produce offspring

Members of a population interbreed, and share a common group of genes called a gene pool

Gene pool: consists of all the genes including all the different alleles for each gene, present in a population

Allele frequency: the number of times an allele occurs in a gene pool, compared to the total number of alleles in that pool for the same gene (Allele frequency has nothing to do with the allele being dominant or recessive)

Evolution, in genetic terms, involves a change in the frequency of alleles in a population over time. Populations not individuals evolve. Natural selection operates on individual organisms, but the changes it causes in allele frequency show in population.

There are 3 sources of genetic variation: mutations, genetic recombination during sexual reproduction, lateral gene transfer

Mutation: any change in the genetic material of a cell, accidental, may be beneficial
- some involve changes within individual genes, while some involve changes in larger pieces of chromosomes
- neutral mutations = do not change organism's phenotype
- mutations that produce changes in phenotype may or may not affect fitness
- mutations only matter in evolution only if they can be passed down
  - ↳ these mutations must occur in the germ line cells that produce eggs/sperm

Genetic Recombination: most heritable differences are not due to mutations but to genetic recombination during sexual reproduction
- each chromosome in a pair moves independently during meiosis, creating <u>many</u> gene combinations.
- crossing over is another way in which genes are recombined
- this is why Darwin noted that individual members of a species differ from each other.

Lateral Gene Transfer: some organisms pass genes from one individual to another, even from one species to another
- The gene passing from one organism to another organism = lateral gene transfer
- can increase genetic variation in any species that picks up the "new" genes

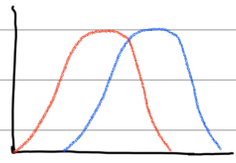
Gene Flow: introduction of genetic material by interbreeding from one population of a species to another, changing the composition of the gene pool of the recieving population

Natural selection on single-gene traits can lead to changes in allele frequency, and, thus, to changes in phenotype frequencies

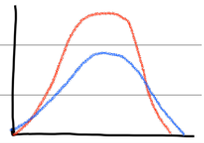
When traits are controlled by more than one gene, the effects of natural selection are more complex than one gene

Natural selection on polygenic traits can affect the relative fitness of phenotypes and thereby produce one of 3 types of selection: directional, stabilizing, or disruptive selection

Directional Selection: When individuals at one end of the curve have higher fitness than individuals in the middle or the other end
- The range of phenotypes shifts cause some individuals are more successful at surviving and reproducing than others.

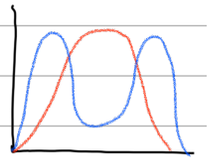


Stabilizing Selection: When individuals near the center of the curve have higher fitness than individuals at either end



This situation keeps the center of the curve at its current position, but narrows the curve overall

Disruptive Selection: When individuals at the outer ends of the curve have higher fitness than individuals near the middle of the curve



acts against individuals of an intermediate type.

If the pressure of natural selection is strong and lasts long enough, this situation can cause the single curve to split into 2 (can create 2 distinct phenotypes)

In small populations, individuals that carry a particular allele may leave more descendants than other individuals leave, just by chance. Over time, a series of chance occurences can cause an allele to become more or less common in a population traits may be lost or become more common

↳ random change in allele frequency = **genetic drift**

Usually in small, isolated populations in which the gene pool is small enough that chance events can can change its makeup in a significant way. Large populations → a specific allele is carried by so many individuals that it is almost sure to be transmitted by some of them even if many die

Genetic Bottlenecks: change in allele frequency following a dramatic reduction is size of a population can sharply reduce a populations genetic diversity Ex. disease

Founder Effect: when few individuals colonize a new habitat, the individuals may carry alleles that differ in relative frequencies from those of the main population

allele frequencies change as a result of the migration of a small subgroup of a population

genetic equilibrium: population is not evolving, allele frequencies it its gene pool do not change

5 conditions can disturb genetic equilibrium and cause evolution to occur: non random mating, small population size, immigration/emmigration, mutations, or natural selection

Non random mating: many individuals select mates based on heritable traits, a practice called Sexual Selection

when the probability that 2 individuals in a population will mate is not the same for all possible pairs of individuals

2 forms: inbreeding = production of offspring from the mating or breeding of individuals or organisms closely related genetically (family mating)

outbreeding = matings between individuals from different populations (cross breeding)

Small population: genetic drift does not usually have major effects in large populations, but can affect small populations Evolutionary change due to genetic drift this happens easily in small populations.

immigration/ emmigration: individuals who join a population may introduce new alleles into the gene pool, and individuals who leave may remove alleles.

any movement of individuals into or out of a population can change gene pool, called gene flow.

mutation: can introduce new alleles into a gene pool, changing allele frequencies

natural selection: if genotypes have different fitness, genetic equilibrium will be disrupted, and evolution will occur.

ISOLATING MECHANISMS

Natural selection and chance events can change the relative frequencies of alleles in a population and lead to speciation

species = population or group of populations whose members can interbreed and produce fertile offspring

speciation = the formation of a new species

The gene pool can split when some members of a population stop breeding with other members

Once a population has split into 2 groups, changes in one of those gene pools cannot spread to the other

Because these two populations no longer interbreed, reproductive isolation has occured.

When populations become reproductively isolated, they can evolve in 2 seperate species. Reproductive isolation can develop in a variety of ways, including behavioral isolation, geographic isolation, and temporal

reproductive isolation: the change in the frequency or occurence of a gene in a population as a result of chance

process that prevents gene flow between 2 populations of the same species

can be caused by geographic barriers, behavioral differences, structural differences, different mating seasons

Behavioral: when 2 populations have differences in courtship rituals, or other reproductive strategies including behavior.

Temporal: when 2 or more species reproduce at different times (AKA seasonal isolation)

Geographic: when 2 populations are seperated by geographic barriers Ex. rives or mountains

does not guarantee the formation of a new species

Geographic barrier may seperate certain organisms, but not others.

Adaptive Radiation: the process of evolution of different species in a given geographical area starting from a point and radiating to other areas of geography (habitats)

relatively fast evolution of many species from a single common ancestor.

CLASSIFICATION

Classification: the grouping of living organisms according to similar structures and functions

Carolus Linnaeus made a 2-word naming system called binomial nomenclature

In binomial nomenclature, each species is assigned a two-part scientific name

scientific names are written in italics, the 1st word begins with capital letter, 2nd word is lowercased

The first part of the name = genus = group of similar species 2nd part is unique to each species

The science of naming and grouping organisms is called systematics
The goal of systematics is to organize living things into groups that have biological meaning
These groups are called taxa (singular = taxon)
8 levels: domain → kingdom → phylum → class → order → family → genus → species (genus + species = scientific name)

The concept of descent with modification led to the study of phylogeny = evolutionary history of lineages
The goal of phylogenetic systematics, or evolutionary classification, is to group species into larger categories that reflect lines of evolutionary descent, rather than overall similarities and differences
phylogenetics = study of evolutionary relationships parsimony = simplest explanation is the best

evidence from living species, fossil record, and molecular data is shown with branching tree diagrams

Clade = group of species that includes a single common ancestor and all descendents of that ancestor- living/extinct
A clade must be a monophyletic group = includes a single common ancestor and all of its descendents.
Some groups of organisms can be paraphyletic = the group includes a common ancestor, but excludes one or more descendents. These groups are invalid under evolutionary classification

cladogram = links groups of organisms by showing how evolutionary lines or lineages branched off from common ancestors
Used to organize organisms based on evolutionary relationships and shared derived characteristics (AKA Synapomorphy)
nested, hierarchical assembly and representation of clades trait modified from the ancestral trait

The more derived genetic characters 2 species share, the more recently they share a common ancestor and the more closely they are related in evolutionary terms

CLASSIFICATION OF LIVING THINGS CHART

Domain	Bacteria	Archaea	Eukarya			
kingdom	Eubacteria	Archaebacteria	"Protista"	Fungi	Plantae	Animalia
cell type	Prokaryote	Prokaryote	Eukaryote	Eukaryote	Eukaryote	Eukaryote
cell structures	cell walls with peptidoglycan	cell walls without peptidoglycan	cell walls of cellulose in some; some have chloroplasts	cell walls of chitin	cell walls of cellulose in some; some have chloroplasts	no cell walls or chloroplasts
number of cells	unicellular	unicellular	most unicellular, some colonial, some multicellular	most multicellular, some unicellular	most multicellular, some green algae unicellular	multicellular
mode of nutrition	Autotroph/Heterotroph	Autotroph/Heterotroph	Autotroph/Heterotroph	Heterotroph	Autotroph	Heterotroph
Examples	Streptococcus, Escherichia coli	methanogens, halophiles	Amoeba, paramecium, slime molds giant kelp	mushrooms, yeasts	mosses, ferns, flowering plants	sponges, worms, insects, fishes, mammals
reproduction	asexual	asexual	sexual/asexual	sexual/asexual	sexual/asexual	sexual/asexual

Domain = larger, more inclusive category than a kingdom
Scientists recognize protista as paraphyletic group because there is no way to put all unicellular eukaryotes into a clade that contains a single common ancestor, all of its descendents, and only those.

Domain unicellular and prokaryotic

Bacteria: their cells have thick, rigid walls containing a substance called peptidoglycan surrounding cell membrane
ecologically diverse, some photosynthesize, some need oxygen, some don't. corresponds to kingdom Eubacteria

Domain unicellular and prokaryote cell walls lack peptidoglycan, and cell membranes contain unusual lipids

Archaea = live in extreme environments corresponds to kingdom Archaebacteria

Domain all organisms that have a nucleus (eukaryotes)

Eukarya = 4 kingdoms: "Protista", Fungi, Plantae, Anamalia

Protists = unicellular eukaryotes. each group is seperate, and each shares a common ancestor with other groups rather than with each other. some are multicellular and some are photosynthetic

fungi: heterotrops with cell walls containing chitin. most feed on dead/decaying organic matter (decomposes
unlike other heterotrophs, they secrete digestive enzymes into their food sources.
after the digestive enzymes have broken down the food into smaller molecules, the fungi absorb molecules
some are multicellular, some are unicellular

Plantae: autotrophs with cell walls containing cellulose. able to carry on photosynthesis using chlorophyll
nonmotile → cannot move from place to place

Animalia = multicellular heterotrophs. do not have cell walls. can move at least for some part of their life cycle

How do the Galapagos finches display adaptive radiation?

There were many varieties of finches in the same island. All the varieties evolved on the island itself, that is from the original seed eating features, many other forms with altered beaks arose enabling them to become insectivorous and vegetarian finches.

Why is the fossil record incomplete?

The fossil record is incomplete because many organisms never became fossils. And many fossils have yet to be discovered. For every organism perserved as a fossil, many died without leaving a trace.

Compare and contrast Plantae and Fungi

Fungi cell walls are made of chitin Plantae cell walls are made of cellulose
Plants have chloroplasts; fungi do not Fungi are heterotrophs Plantae are autotrophs
They both are Eukaryotes and belong to Domain Eukarya

(speciation) → one ancestor splitting into 2 or more species

Different types of evolution: adaptive radiation, convergent evolution, divergent evolution, coevolution,

Gradualism = the evolution of a species by gradual accumulation of small genetic changes over long periods of time

Punctuated equilibrium = pattern of evolution in which long stable periods are interrupted by brief periods of more rapid change

Adaptive radiation: process by which a single species or a small group of species evolves into several different forms that live differently

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THE FOSSIL RECORD

Although most fossils are preserved in sedimentary rocks, some can be presened in other ways such as amber

From the fossil record, paleontologists learn about the structure of ancient organisms, their enviornment, and living patterns

Relative dating allows paleontologists to determine whether a fossil is older or younger than other fossils to help establish the relative ages of rock layers and their fossils scientists use index fossils, which are distinctive fossils used to establish and compare the relative ages of rock layers and the fossils they contain
A useful index fossil must be easily recognized and will occur only in few rock layers (organism lived for short period) but found in many places (organism was widely distributed)

Radiometric dating relies on radioactive isotopes which decay, or break down, into stable isotopes at a steady rate
A ½ life is the time required for ½ of the radioactive atoms in a sample to decay
Radiometric dating uses the proportion of radioactive to stable isotopes to calculate the age of a sample

Timeline of earths history = geological time scale → based on relative and absolute dating
time line split into eons eons split into eras. eras split into periods ↳ radiometric/more accurate methods

Geological forces such as building mountains, opening coastlines and changing climates have altered habitats of living organisms repeatedly throughout Earth history
The actions of living organisms over time have changed conditions in the land, water, and atmosphere of Earth

MACROEVOLUTIONARY PATTERNS

macroevolutionary patterns = transformations which take plale in clades larger than a single species

Evidence shows that evolution has often proceeded at different rates for different organisms at different times over the long history of life on Earth

Gradualism = slow, steady, pace of evolution.
the evolution of a species by gradual accumulation of small genetic changes over long periods of time
Species that don't change over a period of time are in a state of equilibrium
Punctuated equilibrium = equilibrium that is interrupted by brief periods of rapid change

Two important patterns of macroevolution are adaptive radiation and convergent evolution
Adaptive radiation = process by which a single species or a small group of species evolves into several different forms that live differently
Convergent evolution = process by which unrelated organisms independently evolve similarities when adapting to similar enviornments

Coevolution = process by which 2 species evolve in response to changes in each other over time
The relationship between 2 coevolving organisms often becomes so specific that neither organism can survive without the other. Thus, an evolutionary change in one organism is usually followed by a change in the other organism