DARWIN'S THEORY OF EVOLUTION

- **Evolution** - "______________________________" - the process by which modern organisms have descended from ancient organisms.

- **Theory** - ____________________________________________________________
  ____________________________________________________________
  ____________________________________________________________

- _______________ - joined the crew of the HMS Beagle and set sail for a voyage around the world. During his travels, Darwin collected evidence that led him to propose the theory of evolution.

- _______________ - Darwin observed that the characteristics of many animals and plants varied noticeably among the different islands of the Galapagos.

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**Domed**

**Intermediate**

**Saddle Back**

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EVOLUTIONARY THEORISTS

- _______________ - proposed that layers of rock form slowly and that rocks are shaped by natural forces that operate over ____________________________.

- _______________ - wrote *Principles of Geology*, which explained that processes that changed Earth in the past are still operating in the present.

- _______________ - proposed that by ____________________________
organisms acquired or lost certain traits during their lifetime. These traits could then be passed on to their offspring. Over time, this process led to change in a species.

- Lamarck’s hypothesis is now known to be ________________. While organisms to adapt to their environment, an organism’s ________________

- ________________- reasoned that if human population continued to grow unchecked, sooner or later there would be insufficient living space and food for everyone.

- Alfred Russel Wallace- a naturalist, like Darwin, who wrote an essay summarizing his thoughts on evolutionary change.

- ________________- Darwin’s book, published in 1859. Here he poses a mechanism for evolution that he called natural selection.

**INHERITED VARIATION AND ARTIFICIAL SELECTION**

- ________________- nature provides the variation and humans select the variations that they find useful.

**EVOLUTION BY NATURAL SELECTION**

- **Struggle for Existence**- members of each species compete to obtain food, living space, and other necessities of life.

- **Fitness**- ________________

- **Adaptation**- ________________

  - Successful adaptations enable organisms to become better suited to their environment and thus better able to survive and reproduce
• **Survival of the Fittest** - individuals that are better suited to their environment and have adaptations that enable fitness, __________________________________________________________________________. Individuals with characteristics that are not well suited to their environment have ________________________________________________________________________

  o Darwin referred to this idea as __________________________________________________________________________.
  o Over time, natural selection results in changes in the inherited characteristics of a population. These changes increase a species’ fitness in its environment.

**DESCENT WITH MODIFICATION**

  • __________________________________________________________________________ - over time, natural selection produces organisms that have different structures and establish different niches. As a result, species today look different from their ancestors.
  • __________________________________________________________________________ - all species-living and extinct- are derived from common ancestors, therefore a single “tree of life” links all living things.

**EVIDENCE FOR EVOLUTION**

  • The fossil record
  • Geographic distribution of living species
  • Homologous body structures
    o __________________________________________________________________________ - structures that have different mature forms but develop from the same embryonic tissues.
    o **Vestigial Organs** - __________________________________________________________________________

  • Similarities in embryology/early development.
SUMMARY OF DARWIN’S THEORIES

• Individual organisms differ and some of this variation is _________________.
• Organisms produce ___________________________________________________________________ and many that do survive do not reproduce.
• Because more organisms are produced than can survive, they _________________ for limited resources.
• Each unique species has different ___________________________________________________________________ in the struggle for existence.
• Species alive today are ___________________________________________________________________ from ancestral species. They evolved from common ancestors, which unite all organisms in a single tree of life.

GENES AND VARIATION

• Changes in genes produce heritable variation on which natural selection can operate.
• _________________- consists of all genes, including all the different alleles that are present in a population.
• _________________- the number of times an allele occurs in a gene pool, compared with the number of times other alleles for the same gene occur.
  o Typically expressed as a _________________.
  o Has nothing to do with dominant/recessive.
• In genetic terms, ____________________________________________________________________

SOURCES OF GENETIC VARIATION

• _________________
  o A mutation is any change in the DNA sequence, but mutations do not always affect an organism’s phenotype.
  o Mutations can be ________________, ________________, or ________________.
• ____________________________ (in sexual reproduction only)
  o The 23 pairs of chromosomes found in humans can form 8.4 million different combinations of genes- before crossing over.
  o Gene shuffling produces many different ____________________________, but does not alter the relative frequencies of each type of allele in the population.

SINGLE GENE AND POLYGENIC TRAITS
• The number of phenotypes produced for a given trait depends on how many genes control the trait.
• ____________________________ - a trait controlled by a single gene with two alleles.  (ex: widow's peak)
• ____________________________ - a trait controlled by two or more genes.  Each of these genes often has two or more alleles.  As a result, one polygenic trait can have many possible genotypes and phenotypes.  (ex: height in humans)

NATURAL SELECTION ON SINGLE GENE TRAIT
• ____________________________ evolve, not individual organisms.
• Natural selection on single-gene traits can lead to changes in allele frequencies and thus to evolution
  • ____________________________ Selection- when individuals at one end of the curve have higher fitness than individuals at another end of the curve, directional selection takes place.
  • ____________________________ Selection- when individuals near the center of the curve have higher fitness than individuals at either end of the curve, stabilizing selection takes place.
• **Disruptive Selection** - when individuals at the upper and lower ends of the curve have higher fitness than individuals near the middle, disruptive selection takes place.

**GENETIC DRIFT**

• **Genetic Drift** - allele frequencies change as a result of the migration of a small subgroup of a population.

**EVOLUTION VS. GENETIC EQUILIBRIUM**

• **Genetic Equilibrium** - the situation in which allele frequencies remain constant.
  
  o Five conditions are required to maintain genetic equilibrium:
    
    -  
    -  
    -  
    -  
    -  

  o If all of these conditions are **not** met, then equilibrium will be disrupted and the population will _________.

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SPECIATION

- Speciation - As new species evolve, populations become reproductively isolated from each other.

- Reproductive Isolation - when the members of two populations cannot interbreed and produce fertile offspring.

TYPES OF REPRODUCTIVE ISOLATION

- Isolation - occurs when two populations are capable of interbreeding but have differences in courtship rituals or other reproductive strategies that involve behavior. (ex: birds with different mating songs)

- Isolation - two populations are separated by geographic barriers such as rivers, mountains, or bodies of water. (ex: Colorado river separates two types of squirrels)

- Isolation - two or more species reproduce at different times. (ex: flowers releasing pollen at different times of year)

SPECIATION IN DARWIN’S FINCHES

- Founders Arrive - finches from South American mainland (species A) populated the Galapagos.

- Geographic Isolation - birds from species A crossed to another Galapagos island. The two populations became isolated from one another and had different gene pools.

- Changes in the Gene Pool - populations on the new island adapted to their environment, forming population B.

- Reproductive Isolation - because of their adaptations and different beaks, species A and B do not mate together if they come in contact.

- Ecological Competition - during dry season, individuals compete for food, and over time birds evolve better beaks (species C).

- Continued Evolution - this process continues over several generations and over times produces the 13 species seen today.
FOSSILS AND ANCIENT LIFE

- Paleontologists - provides evidence about the history of life on Earth. It also shows how different groups of organisms, including species, have changed over time.
  - For a fossil to form, either the remains of the organism or some trace of its presence must be preserved.

INTERPRETING FOSSIL EVIDENCE

- Paleontologists determine the age of fossils using two techniques: relative dating and radioactive dating:
  - Relative Dating - the age of a fossil is determined by comparing its placement with that of fossils in other layers of rock.
  - Radioactive Dating - scientists calculate the age of a sample based on the amount of remaining radioactive isotopes it contains.

GEOLOGIC TIME SCALE

- **Geologic Time Scale** - divisions used to represent evolutionary time.
  - Geologists divide time into four major eras: ________________, the ________________, the ________________, and the ________________ eras.
  - Each era is subdivided into ________________

- Precambrian
- 88% of Earth's history.
- Few multicellular fossils.

- **Paleozoic**
  - Many vertebrates and invertebrates lived during the Paleozoic.

- **Mesozoic**
  - "The Age of the _____________________________"
  - Mammals began to evolve during the mesozoic.

- **Cenozoic**
  - "The Age of the _____________________________"
  - The last 65 million years.

### FORMATION OF EARLY EARTH

- Geologic evidence shows that Earth is about ____________________________________ and was created over many years.
- Earth was formed from __________________________________ which compounded on one another over the course of millions of years.
- Early Earth was extremely __________, and unsuitable for life because of violent __________________________________________________________.

### FIRST ORGANIC MOLECULES

- 1950s- Stanley ____________ and Harold ____________ tried to simulate conditions of early Earth in the laboratory.
  - Filled flask with fluids and gases similar to those in Earth's early atmosphere.
  - Passed electric sparks through this mixture to simulate lightning. Their experiments produced amino acids, the building blocks of ____________.

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![Diagram of early life transition](image)
• Microfossils of unicellular organisms resembling bacteria have been found in rocks more than _______________, which means that they must have evolved in the absence of ________________, because there was little/no oxygen in Earth’s early atmosphere. (______________________________)

• ________________ organisms evolved later, which created a rise in oxygen levels in the atmosphere. This change likely caused some organisms to become extinct, while others evolved more efficient respiration mechanisms which utilized oxygen.

ENDOSYMBIONT THEORY

• One large prokaryotic cell, engulfed several other smaller prokaryotic cells with specialized functions. Together these cells lived symbiotically and were interdependent on one another. Collectively, they formed the first eukaryotic cell, which went on to divide and give rise to other eukaryotic cells.

MACROEVOLUTION AND EXTINCTION
• **Macroevolution** - the large scale evolutionary patterns and processes that occur over long periods of time.

• **Extinction**
  - More than _________ of all species that have ever lived are now extinct.
  - Several times in earth's history, mass extinctions wiped out entire ecosystems.
  - Each mass extinction provides opportunities for organisms that survive and often results in a burst of evolution that produces many new species.

**PATTERNS OF EVOLUTION**

• ___________________________ - when a single species or small group of species evolves into several different forms that live in different ways.

• ___________________________ - unrelated organisms independently evolve similarities when adapting to similar environments.
  - ___________________________ - structures which look and function similarly but are made up of parts that do not share a common evolutionary history.

• ___________________________ - when two species evolve in response to changes in each other.

• ___________________________ - when long stable periods are interrupted by brief periods of more rapid change.
  - **Gradualism** - the idea that biological change is ___________________________.
    (supported by Darwin)
  - Scientists suggest that most new species are produced by periods of rapid change, because organisms evolve rapidly to fill available niches.