

- The evolution of resistance to insecticides in hundreds of insect species is a classic example of natural selection in action.
- Initial applications of new insecticides are usually 99% effective.
- But the effectiveness of the insecticide drops in repeated applications.
- In general, natural selection operates not to create variation, but to edit existing variation → ***resistant is favored, non-resistant is not!***
- Natural selection favors those characteristics in a variable population that fit the current, local environment
- We see evidence of evolution by natural selection in the changes in biological diversity documented by the ***fossil record***.
 - Fossils are remains of ancient organisms
 - Fossils document the history of life on earth from prokaryotes to humans
- In descent with modification, new species descend from ancestral species by the ***accumulation of modifications as populations adapt to new environments***.
 - The novel features that characterize a new species are not entirely new, but are altered versions of ancestral features.
 - Similarities in characteristics resulting from common ancestry is known as ***homology***.
- Descent with modification is evident in anatomical similarities between species grouped in the same taxonomic category.
- For example, the forelimbs of human, cats, whales, and bats share the same skeletal elements, but different functions because they diverged from the ancestral tetrapod forelimb.
- They are ***homologous structures***.
- Comparative anatomy confirms that evolution is a ***remodeling process*** by alteration of existing structures.
- Some of the most interesting homologous structures are ***vestigial organs***, structures of little or no importance to a current organism, but which had important functions in ancestors.
 - For example: human appendix, human external ear muscles, human tailbones, wisdom teeth, and snake hips.
- Sometimes, homologies that are not obvious in adult organisms become evident when we look at ***embryonic development*** (comparative embryology).
 - For example, all vertebrate embryos have structures called pharyngeal pouches in their throat at some stage in their development.
 - These embryonic structures develop into very different, but still homologous, adult structures, such as the gills of fish or the Eustacean tubes that connect the middle ear with the throat in mammals.
- The concept of homology also applies at the ***molecular level*** (molecular homology) and allows links between organisms that have no macroscopic anatomy in common (e.g., plants and animals).
 - All species of life have the same basic genetic machinery of RNA and DNA and the ***genetic code is essentially universal***.

- If two species have libraries of genes and proteins with sequences that match closely, the sequences have probably been copied from a common ancestor.
 - For example, the number of amino acid differences in human hemoglobin when compared to other vertebrates show the same patterns of evolutionary relationships that researchers find based on other proteins or other types of data.
- The geographical distribution of species - **biogeography** - first suggested evolution to Darwin.
 - Species tend to be more closely related to other species from the *same area* than to other species with the same way of life, but living in different areas.
 - For example, Australia – isolated continent – no native placental mammals
 - Even though some marsupial mammals (those that complete their development in an external pouch) of Australia have look-alikes among the placental mammals (those that complete their development in the uterus) that live on other continents, all the marsupial mammals are still more closely related to each other than they are to any placental mammal.
- For example, while the sugar glider and flying squirrel have adapted to the same mode of life, they are not closely related.
- Instead, the sugar glider from Australia is more closely related to other marsupial mammals from Australia than to the flying squirrel, a placental mammal from North America.
- The resemblance between them is an example of **convergent evolution**.
- Island and island archipelagos have provided strong evidence of evolution.
 - Often islands have many species of plants and animals that are found nowhere else in the world, called **endemics**.
 - As Darwin observed when he reassessed his collections from the *Beagle's* voyage, these endemic species are typically related more closely to species living on the nearest mainland (despite different environments) than those from other island groups.
- In island chains, or archipelagos, individual islands may have different, but related species as the first mainland invaders reached one island and then evolved into several new species as they colonized other islands in the archipelago.
 - Several well-investigated examples of this phenomenon include the diversification of finches on the Galapagos Islands and fruit flies (*Drosophila*) on the Hawaiian Archipelago.
 - All of the 500 or so endemic species of *Drosophila* in the Hawaiian archipelago descended from a common ancestor that reached Kauai over 5 million years ago
- The succession of fossil forms is compatible with what is known from other types of evidence about the major branches of descent in the tree of life.
 - For example, fossil fishes pre date all other vertebrates, with amphibians next, followed by reptiles, then mammals and birds.
 - This is consistent with the history of vertebrate descent as revealed by many other types of evidence.

- In contrast, the idea that all species were individually created at about the same time predicts that all vertebrate classes would make their first appearance in the fossil record in rocks of the same age.
 - This is not what paleontologists actually observe.
- Descent with modification also predicts that evolutionary transitions should leave signs in the fossil record.
 - Recent discoveries include fossilized whales that link these aquatic mammals to their terrestrial ancestors.
 - The hypothesis that whales evolved from terrestrial ancestors predicts a four-limbed beginning for whales.
 - Paleontologists digging in Egypt and Pakistan have identified extinct whales that had hind limbs – vestigial structures.