# Chapter 3 - Charles Darwin and Evolution

**Charles Darwin**

1. Born in 1809
2. Dropped his study in medicine to learn Religion
3. Interested in taxidermy, insect collecting, botany, etc.
4. Starts his 5 year voyage on the Beagle
    - Invited as companion of captain but quickly became the naturalist
5. 2 books
    - William Paley "Theology, or evidences of the existence and attributes of the deity"
        - Father of the Theology of Nature
        - Advocates that harmony and design in nature are indicators of the existence and the acts of God
    - Charles Lyell "Principles of Geology"
        - Convinced with Lyell's and Hutton's principle of uniformity
6. Travelled the world
7. Distinct fauna from different regions of the world, especially South America, had a profound effect on Darwin
8. Fauna of the Galapagos Islands surprises Darwin
9. Variability in shells of tortoises in the Galapagos
10. Even birds, even though they are from the same group
11. 1837, first mention that species show resemblance to each other because they share a common ancestor and not common environment
    - Rejects fixity of species and accepts the concept of descent with modifications
    - Rejects Lamarck's evolutionary mechanism (environmental determinism)
12. Begins search for evolutionary mechanism

**Evolution and Natural Selection**

- 99% of species that lived are now extinct
- Most of the evolutionary branches finish in a dead-end *Extinction*
- Thomas R. Malthus "An essay on the principle of population" - inspiration to formulate his *theory on natural selection*

Thomas R. Malthus:
"Every human population has a tendency to Increase geometrically whereas the available resources to feed these populations increase arithmetically. The human population increases faster than its capacity to feed itself. This leads to chaos and eventually to a substantial reduction in population size

- Darwin's observation
    1. All species can produce more offspring than their environment can sustain and many of these *offspring*fail to survive and reproduce.

        - Individuals whose *inherited* traits give them a higher probability of surviving and reproducing in a given environment tend to leave more offspring than other individuals
    2. Members of a population often vary in their *inherited traits*
        - From generation to generation, this unequal capacity to survive and to reproduce (*differential reproductive success)* results in an accumulation of favorable traits in a population.

This is natural selection. It enables the emergence of adaptations.

**Notions linked with natural selection**

- Individuals do not evolve, populations do.
- Only hereditary traits with variability can evolve
- Individuals that have set of traits that leads to greater survivorship and reproductive success are "fitter" compared with other individuals
- If a trait is well-adapted to its environment, it confers a higher relative fitness (reproductive success) to its bearer
- Environmental factors vary in time and space. Thus, selective forces are variable and a trait that increased fitness in a specific environment might lose this fitness in a changed environment
- Traits in populations may change and may modify the species

**For Darwin, this mechanism is valid because:**

- It respects the uniformity of Lyell and Hutton
- The results are visible in nature
- The mechanism can be verified on current populations (e.g. artificial selection)
- It is a materialistic concept (no need for divine intervention)
    - The mechanism is not random. Natural selection enables individuals that are better adapted to their environment to become more abundant than those who are not (differential reproductive success).
    - Not a quest for perfection(evolution is not a directed process.) It does not lead to the appearance of "perfect" traits. Organisms only adapt to their environment.

- Artificial selection is finalized because the goal, fixed well in advance, precedes the causes. The end result can be obtained in a few generations.
- Natural selection is not finalized. It can take a long time for changes to occur (geological time scale).
    - Peppered moths - industrial pollution
    - Finch - drought -> beaks suitable for seeds
    - Humans and altitude - concentration of red blood cell count
        - Andes
            - Higher alveolar surface in lungs, same hemoglobin concentration in blood for each molecule has a higher oxygen capacity
        - Qinghai - Tibet Plateau

        - Deeper breath, faster breathing cycle; larger pulmonary capacity and increased blood flow; lower hemoglobin concentration
            - Origin of adaptation: Denisovan gene
- In these three cases, the hereditary trait that gives a reproductive advantage (i.e. adaptation) to individuals in a population will be favored. Thus, from generation to generation, there will be a higher percentage of individuals carrying the adaptation. This is natural selection. It's Darwin's descent with modification. It's evolution.
- These adaptations can sometimes redefine a species and, in certain circumstances, define a new species.

**Proof of evolution: Homology**

- Descent with modification theory (theory of evolution) explains the resemblance between certain traits even if the functions are different. (Homologous structures)
- The post-anal tail in humans disappears after week 7 of growth.
- Vertebrates are characterized by pharyngeal pouches, in some cases they disappear very quickly but in some they become gill, e.g. fish
- Features of tetrapod -> digits and not arms
- Evolution is NOT LINEAR; use a phylogenetic tree instead

- Ancestors of horses were small animals lived in the forest; not running but hiding --> much smaller --> 2 toes therefore no speed
- Evolution of horses - increases in size - reduction in number of toes --> 4 to 1
- At one point, horses came out of the forest and out into the open space --> run and not hide to survive
- Also, teeth
- Leaves in a forest are tender and clean but in the open, grass is coarser --> teeth became bigger and more complex to sustain the wear and tear
- Decrease in weight so that the animal becomes light to optimize speed

**Proof of evolution: Vestigial Structures**

- Vestigial structure - anatomic structure that has lost almost all of its initial function
- E.g. in a species of blue whale, there is a reduced vestigial posterior limb, the pelvis reduced to a floating pelvic bone under the spine --> indicator that some ancestor of the whale could walk
- In humans:
    - Nictitating membrane aka third eyelid
        - Third eyelid usually extends over the eye - it is usually translucent and so animals can see through it - e.g. when flying or swimming -->extra protection
        - Indicates that in humans, one of our ancestors had this feature that was fully functional --> evidence for evolution
- Appendix
    - Remnants of what used to be a very big sacrum --> feature of mainly vegetarian diet -- meaning at some point, our ancestors ate mostly plants
- Goose bumps and hair

    - Important in animals that had a lot of fur or hair --> traps air in between the hair and the skin to keep warm
- Hiccups
    - Heritage from fishes and amphibians - glottis in fishes separate the gills and the lungs --became the epiglottis in humans

Discovery of a fossil in the wrong place for geological archives would be sufficient to refute our concept of evolution.