Major Events in the History of Biology: Darwinian Thought:

Georges-Louis Leclerc, Comte de Buffon (1707-1788):

- Made inventory of things that he saw
- He recognized when you go around the world, there is morphology that depends on the environment → major in cats
- Found cats → but were different → adapted to where they are living
- Why would you make different species of cat if all the organisms arrive at the same place and time?
- Believes that everything is put in one place on the planet and as they move around the world, the essence modifies itself to fit different environments
- Can be modified to be successful in a certain environment
- The origin point of everything on the planet is the Garden of Eden
- That things have changed over time → depends on the environment

Erasmus Darwin (1731-1802):

- Translated Linnaeus into English
- Zoonomia (Laws of Organic life)
- The temple of nature poem describes:
    - Life evolving in the oceans → the first forms is the microorganisms
    - The life becomes more complex in the next generations → change over time
    - Acquires new trait
    - The vegetation first live on land and since the plants is on land, the animals move from the oceans to the land
- He is extremely wealthy and has a lot of time to do things

Georges Cuvier (1769-1832):

- When Paris is digging stuff up for buildings, he notices the bones in the ground → decides to connect the bones to each other
- Recognize that the skeletons of the animals were no longer living as a species in the Earth → means the animal died and was extinct → first to coin the term **extinction**
- Found out there is a large diversity in the planet
    - There was imperfect animals created in the creation of all animals
    - The animals change over time
- Comparative biology
- Catastrophic theory
    - There is an event that killed a lot of animals at once → killing the imperfect animals → they say that this event is that when the Ark transported all of the animals, a bunch of animals drowned in the process
- Extinction

    - Give this concept
    - Mostly mammal bones in the Paris
    - All the fossils found as well → so some species died and disappeared

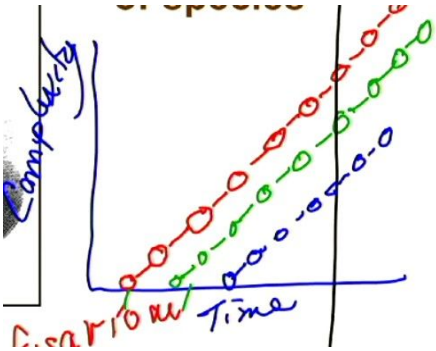
Charles Lyell (1797- 1875):

- He was a geologist
- **Uniformitarian** theory of geological change → slow, long, gradual changes (very uniform in how it happens in the Earth → the creation of these layers means the Earth is old
    - The creation date is wrong
- **Stratigraphy** and the geological time scale
    - If you look at the rocks, you will find layers → layers are called **strata**
    - If you travelled around the continents, you can see the same layer again, but maybe some extra ones on top
    - Can develop the idea of all the layers in the world → you can look at these layers and figure out the age of the Earth
    - You can take all of the layers found in the rocks → if you line them up, they are constant between continents → lines of time → sediment produced is producing these lines
    - The lying down of sediment in rock takes thousand years to produce → these lines show that the Earth cannot be 6000 years old if there is so many layers
- The rock cycle → most of the first rock in the Earth is magma → the oceans develop sediments in the bottom of the ocean
- The sedimentary rock in the oceans are mixed by plate tectonics → magma goes in the bottom of the ocean and create the sedimentary rock
- Carbon dioxide in the ocean and in the air is at equilibrium → $CO_2 + H_2O \rightarrow H_2CO_3$
    - The H_2CO_3 create a proton and a bicarbonate ion (HCO_3^-) and the Ca^+ mix together creates $CaCO_3$ which is insoluble
    - The HCO_3^- react with other ions to create insoluble molecules which sink to the bottom of the ocean and creates the sedimentary rock
- This reaction been happening for millions of years → the rocks change and the fossils of organisms also change
- The carbon cycle is a huge thing in the method → carbon dioxide in the air and its equilibrium of the carbon dioxide in the water → forming precipitate in the ocean
- Carbon cycle is also important on the land → the carbon dioxide is absorbed in plants → plants make glucose → animals eat plants and get glucose

Jean-Baptiste Lamarck (1744-1829):

- Finding evidence of things changing over time → Lyell's → Gradual
- Infamous for inheritance of acquired traits → believe if a trait causes a physical change in the organism, this trait will be passed on to the next generation
    - Ex. Giraffes long necks stretched as they eat leaves in higher branches → they have babies with the long necks
    - Flaw in theory → acquired traits cannot be passed down the generation because it is the change in the somatic cells of the organism → cells can mutate and change over time
    - He is assuming that the genetic information of the somatic cells is the same information that is being passed down to the generation
- In embryology, after the egg is fertilized and start to divide, the germ cells are set aside for the animal's lineage → rest become somatic cells
- Somatic cells don't undergo meiosis to create the genes to be passed to the generation
    - Germ cells become dormant and untouched until go do meiosis and make egg and sperm
    - Doesn't understand the meiosis and the genetic information (Germ cells are different than somatic cells)
- Trying to explain the biodiversity of the planet → admit that the species change
- Transmutation of species
    - As the changing of species → species change over time
    - In an early point, a simple organism called (infusoria (plural))
    - At this point, we believe in spontaneous generation → if you put water in the open, you can get organisms in it → this mechanism creates a infusoria
    - As the infusoria multiplies and create new generations, the infusoria increases in complexity
        - Infusoria is influenced by the environment and creates acquired traits → become more complexity
    - All organisms started as different infusoria and become more complex individually → species are transforming to new species
    - At one point in time, there are a lot of infusoria in different stages in complexity
    - Species are changing and why we have this diversity → things constantly disappearing and appearing because they are constantly being generated from the bottom
    - Depending on the slice of time, that is the diversity of the planet at that point in time → the essence of the organism is changing → essence is not static and the environment is making these changes
- 4 Major Theories:
    - He proposed that all species change through time.

- He recognized that changes are passed from one generation to the next.
- He suggested that organisms change in response to their environments.
- He hypothesized the existence of specific mechanisms that caused evolutionary change.



Story → simplest historical narrative
Physicalists → living things are made of machines
Essentialist explanation of change:

- Essentialist only explanation to one generation to the next and the difference between the living things and nonliving things
- Transmutation (not Lamarck)
  - Very rapid change of the essence
  - Transmutation of the essence
  - When essence changes, a new species is created
  - Extreme example is chicken egg → chicken and then fox comes out of the chicken egg (Not that dramatic)
  - (Transmutation basically mean change)
- Transformation
  - Mean the slow change of the essence
  - Finalism
    - Essence has a preloaded program → the essence modifies itself to improve
    - Natural progression of the complexity
  - Environmental (this is Lamarck)
    - The environment changes the essence slowly
- At this time, we don't really know what is being transferred and don't know about the genetic material

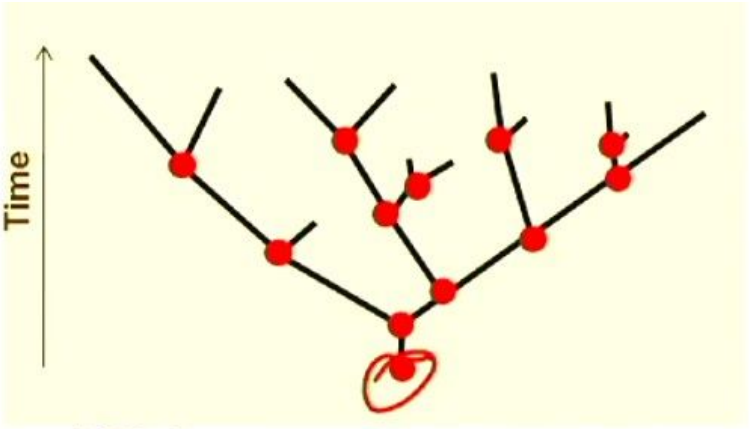
Wallace (1823-1913)

- He came up about the idea of natural selection
- He was in Indonesia gathering different organisms → animals that are superbly fit was selected for a population and their traits are augmented into the population

- Sent his work to the scientific society in London where Darwin was working on the same concept → Charles Lyell calls a special meeting with Darwin and Wallace to present their concepts of natural selection
    - Presented by Darwin and Wallace → Darwin has a lot more examples and evidence to explain the natural selection → Credit Darwin more

Darwin (1809-1882):

- Darwin likes beetle collecting and hunting more than studying
- Darwin drop out of medical school
- 5 years of exploring and collecting organisms while he travelled the world
    - Notice that the tortoises and birds in the Galapagos Islands differ from island to island
- 20 years of writing about concepts of natural selection
    - Notice people breed horses to make faster horses → artificial selection
    - Origins of Species by means of natural selection
    - Random genetic changes may improve the organism → the traits that are more fitted to the environment will be passed on to the next generations
- Grandfather is influential in the scientific community → father is a famous doctor in London → they were very wealthy, so you can choose your own path
    - Darwin turned down medicine and clergy
    - Find out about the HMS Beagle → stop around the world for commerce
    - Want to collect things → Lyell got him on the boat to go around the world
    - Lyell gives Darwin his geology book about straitrophy and uniformatism
    - Collect a lot of material → when boat go on port, he ships it back to his home in England
    - Collected a continent worth of stuff → high intellectual properties → good at analytics
    - His collection of stuff after 5 years rivals the collections in the museum's → biggest collection ever collected by an individual → know every sample because he collected them
    - So wealthy → don’t need to work a day in his life
    - Self employed, so he does not have any distractions
    - Emma Wedgwood → is also very wealthy → top pottery firms in London
    - Freedom to work on Origin of Species for his whole life
- There is a common ancestor with all of the organisms in world and creates a branching pattern
    - Change over time
    - Fittness → most fitted individuals pass their traits to the next generation → allow survive of the fittest → come from observing artificial selection



- Natural (Evolutionary) (taxonomy)
    - The classification of the living world should reflect the evolutionary history of the world
    - Origins of Species was sold out
- Over time and generations the traits providing reproductive advantage become more common within the population → **Descent with modification**

Darwin's five theories:

- Darwin never talked evolution and survival of the fittest

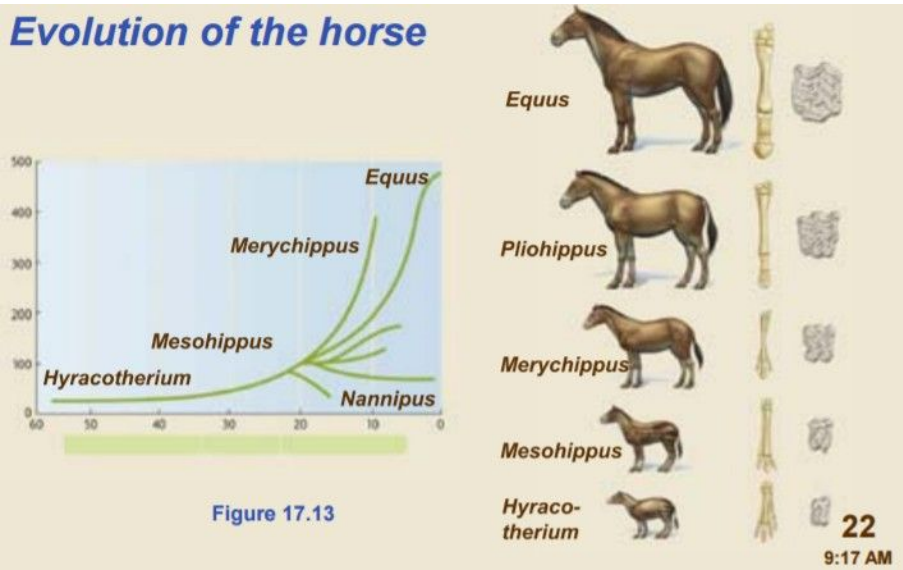
No constancy of species (Accepted right away)

- Definitely living things changed over time

Evidence of no constancy of species

- Fossils
    - Very rare thing to find → fossil record is incomplete
    - Often found in quarries → where areas of digging and industry
    - Darwin has a lot of large vertebrate fossil (bones and shells)→ scientists at that time cannot find soft bodied animal fossil → thought to not fossilize
    - In 1985, find invertebrate fossil → found in an ancient ocean → now it is the prairies → multicellular life first evolved
    - The bicarbonate layer lay onto the organisms → so long layering create shale (perfect layers of rock) when split in sheets → you can see the impressions of the invertebrate
    - So detailed that you can dissect stuff
    - Become predictable in finding the fossil through continental drift
- Extinction
- Transitional forms

- Missing links → fossil that show the intermediate steps of the evolution of the organisms
- Very rare in Darwin's time
- Most popular transitional forms is the evolution of the horse
- Climate change → when Africa became a grassland, a small animal went out and fed on the grass → the grassland made the animal vulnerable to predators and grass is a hard food to ingested and extracted nutrients from
- The horse organism become faster to run from predators → started with 5 digits in each of the legs and then ultimately, run with 1 digit + lengthening the leg
- Molars became more complex on the crown of the molar → thus enabling the horse to eat grass more efficiently



- Archaeopteryx lithographica → the transitional form of a reptile to a bird
  - Has a bony tail, has teeth → not found on birds
  - Beginning of the bird wing and the feathers
  - Trached history of feathers → many dinosaurs have feathers for colour, plumage and mating display
    - Then become used as insulation and ultimately, flight
  -

Common ancestry (Accepted right away)

- Proposes that since animals have similar characteristics → so, there must be a common initial form of the organism → modified over time
- Comparative anatomy
  - George Cuvier noticed similarities of the animals and predict that they are related
  - Homology - Divergent Evolution → see same structures of the arm
    - Ex. The structure is single large bone, set of pair bones, wrist bones and a bunch of fingers

        - Must have a common ancestor → the appendages are modified in different ways for doing different functions
- Comparative embryology
    - During the old times, the embryos of each of the animals look similar
    - But now, the organisms can be categorized by certain embryonic developments
    - One cell division create 2 cells → 2 cell divisions create 4 cells → cell division goes through the equator and create 4 cells atop of 4 cells
    - The rounded bottoms of the top cells fit perfectly atop of the rounded tops of the bottom cells OR the rounded bottoms of the top cells fit in the grooves of the cells on the bottom cells → these make up 2 category
- Vestigial structures
    - A structure that had a function in the past, but now it does not have any function
    - Making the hair stand on end helps make the body more warm and make you look bigger to other animals → humans have goosebump because of this past function
    - The nictitating membrane (corner of the eye) → ancestors use the membrane to roll over the eyes and keep the water out of the eye
    - The appendix → inoculation site for the bacterial flora of the GI tract → if young children, does not get the bacteria store site → it is bad for the immune system
- Biogeography
- Molecules
    - Proteins can change overtime → how they change → can find if the animal is related to one and another
    - Ribosomal and mitochondrial DNA
- With morphology, we are not looking at the source of variation
    - Categorizing the flight of the animals is important because flight is too big of a change to arise multiple times → must categorize by flight
    - If you look at the wings of the insect and the birds and the bats → realized the structure of the wings is completely different → end up saying that flight arose twice in the living world → NOT TRUE
    - Analogous → see they share a common function but not a common ancestor → when you look at the wings, they arise with flight in different events
        - The wrist bone and the digits are different
        - A bat has a wrist bone with the digits and the digits support the membranous wings of the bat
        - The bird have a different structure of the digits and they turn to one digit that supports the feathers of the bird
        - A pterosaur → walks on 4 legs and the modified pinky is used to lift back the wing of the organism → help lift the membranous wings off the ground

        - You now notice that the change of flight arose differently in each of the organisms
    - Called **homoplasy** - convergent evolution → the same traits arose in different organisms → the environment moulds the shape of an organism even though the organism is not related to each other

Pasteur (1822-1895)

- Notice that life emerges from life and there is no spontaneous generation
- The germ theory is established

Cell Theory:

- Schleiden and Schwann - 1860
- The basic unit of all organisms is the cell
- Organisms are made of compartments with nucleus in them → organism are made of cells
- All cells come from division of other cells
- Individual cells have all the characteristics of life

Mendel (1822-1884)

- Rediscover in the 1900s
- Law of segregation of characters
- Law of Independent assortment

Gradual Changes

- Adopts Lyell's uniformitarianism theory → endorses the fact that the Earth is much older than 4004 BCE
- It was not accepted right away → what is gradually change? Mechanism? How much gradual change do you need to make a new species? → Darwin doesn't know the mechanism → doesn't have heritability
- Darwin cannot explain the what is the essence?

Multiplication of species

- In these changes, new species arise → increase in the number of species → one microbe created all of the species → named LUCA (Lowest universal common ancestor of life)

Natural selection

- If the traits passed to generation increases the fitness of the organism (means the reproductive ability of an organism), the trait become more dominant in the population
    - The traits within the population changes over time (not a single organism like what Lamarck proposed)

Evaluating Systematic Characters:

- **Homologous Characters**

    - The limbs of tetrapod vertebrates are homologous characters that are similar in their evolutionary history but not necessarily their function
- **Analogous Characters**
    - Analogous characters are those in different animals that serve the same function.
    - **Homoplasious** → Characteristics shared by a set of species, often because they live in similar environments, but not present in their common ancestor; often the product of convergent evolution.