Chapter 1. Science: definition, methodology and perception

- 1.1 Intro and definition of science
    - Science= the intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment
    - Biology= the science of life
    - Scientific inquiry= diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work
    - Description based= describing nature eg
    - Hypothesis based= explaining nature eg
- 1.2 The scientific method
    - 1.2.1 Inductive reasoning
        - making a generalization often based on numerous specific observations
        - going from particular to general
        - linked to descriptive based approach
    - 1.2.2 Deductive reasoning
        - involves stating a hypothesis and drawing conclusions after experimentation or observation from this hypothesis
        - general to particular
        - linked to hypothesis based approach
    - 1.2.3. Scientific process
        - Inductive reasoning: observation —> generalization
        - scientific hypotheses must be verifiable, refutable, reproducible
            - from hypothesis you can make prediction
            - hypotheses can never prove a scientific truth
            - if then statements
        - scientific process is made up of four parts
            - skepticism —> ask questions on facts and hypothesis, re-test what has been found
            - realism —> the world is older and exists independently from my perception of it. the realm of ideas does not have the priority over the real world
            - rationality —> logic: demonstrations from scientists must be the result of coherent steps. parsimony: methodological principle which states that acceptable theories are hypothetically the most economical in assumptions
            - methodological materialism —> all that is experimentally accessible in the real world is material or has a material origin
        - mimicry
            - linked to first clause, skepticism: retest the hypothesis

            - batesian mimicry where the viceroy evolved to have the same colouration as monarch, which is toxic to birds. used for protection against predators
            - batesian mimicry turned into mullerian mimicry because turns out it is actually toxic- toxic species look alike, and this is advantage to mullerian mimicry because it sends an even stronger species
        - case study with mice coloration (causative hypothesis aimed at defining how the colouration pattern evolves)
        - case study with fish (descriptive hypothesis) with lakes introducing piscivorous fish species
- 1.3 Conclusion
    - clauses of the contract between the acquisition of knowledge and science

Chapter 2. Evolutionary thinking before Darwin

- 2.1 Transforminism in Antiquity

    - 2.1.1 Anaximander (610-546 BCE)
        - first philosopher to write his thoughts
        - water is the central element of the universe
        - honest attempt at trying to explain life by looking at nature of material and importance of water
        - first evidence of the notion of transformism
    - 2.1.2 Empedocles (483-423 BCE)
        - all structures of the world are made of earth, water, air, fire
        - two major forces interact constantly on these elemes, they are love and hate
        - monsters that survived are the things that appear on our earth – the outcome of the two forces on the four elements
        - materialistic view on the order of life
    - 2.1.3 Democritus (460-360 BCE)
        - two realities: atoms and emptiness
        - two realities were at the basis of the universe
        - by logic and deduction he figured out that the smallest piece of entity is atom
        - units that can't be destroyed or altered- atoms that detach and attach to create objects
        - thought atoms had an intrinsic force that could create shapes or possibly organs and organisms
        - materialistic view
    - Conclusion
        - acts of creation are not due to gods, but rather due to the innovative power of matter
        - the origin of all things is not teleological, but it is the result of chance

- 2.2 Classical thinkers
    - 2.2.1 Socrates (469-399 BCE) and Plato (427-347 BCE)
        - materialistic approach gave way to abstract way of handling things
        - the answers are not found in nature, but within the self
        - not visual but linked to search of sanity beauty things like that- nature wasn't useful
        - shifted away from transformism to different way of thinking
        - theories of ideal forms (essentialism): the visible, imperfect and changing realm which surrounds us is a poor imitation of an ideal world
        - plato put forth the idea that we are born with this world of ideal forms, everything is in our minds
            - during birth things become mixed up so we spend our whole lives trying to put back together the ideals we had
        - it is important to not be influenced by nature, we have to find the definition for things with ourselves
    - there is a world of ideas or forms that is totally separate from the material world. Every thing or living belongs that we observe with our senses is just a poor imitation of its perfect representation in the world of forms. This world of forms is innate.
    - 2.2.2 Aristotle (384-322 BCE)
        - does not believe in the innate aspect of the world of ideal forms
        - student of plato and disagreed on him on aspect- that we don't have an innate ideal form at birth
        - it's important to define the essence he said – by looking at nature we can define essence
        - species were static and unchangeable
        - variability in nature was kind of confusing the quest to find the essence of things - he changed the perspective from innateness within self to nature
        - first attempt to order nature – great chain of beings in a static hierarchy
        - aristotle thought that morphological variability was a mistake
    - there is no need to postulate the hypothetical existence of an innate world of ideas or forms. we determine the essence of things by carefully examining the world around us
- 2.3 The impact of Christianity
    - decline of roman empire means that christianity becomes the main ideology in the western world
    - the concept of scala naturae becomes purely metaphysical proclaiming the perfection of the creator

    - if you find a new species you fit it into the scala naturae, the great chain of being
    - any idea of transformism was squished
- 2.4 From fixity of a species to transforminism

    - Information
        - 14th-17th century in europe: power of religion is progressively challenged
        - meant that there was a bit more space for free thinking
        - industrial revolution occurred and now things are more accessible, rich becomes more widespread and people can acquire resources to get more comfort and pleasure out of life
        - open mindedness to science- new ideas became a little more accepted
        - attempts to classify living organisms were done within the framework of the great chains of being
        - the idea is to show a certain progression in the level of organisation of organisms
    - 2.4.1 Linnaeus (1707-1778)
        - binomial system of nomenclature
        - pedigree that goes from species as we see it to the domain of life in which it belongs
        - second contribution was binomial system with the genus and species name (latin)
        - species explains essence- characteristic that distinguishes it from other species
        - put order in nature – it was believed that by finding order then you were discovering how god created the world
    - 2.4.2 Buffon (1707-1788)
        - dedicated his life to describing nature
        - his classification system did not survive and they had to be described using the lineaus system
        - early in his professional career he thought that all animals and plants have a common origin
        - **transformansim is the first concept**
        - **the second idea predicts the creation of the earth**
        - he abandoned all his ideas and said that he believed the religious views because his ideas went against the religious dogma
        - became the director of the nature museum in paris that allowed him to continue publishing his books
        - society was not ready for the idea so instead buffon gets to live the high life
    - 2.4.3 Lamarck (1774-1829)
        - first evolutionist (species modify their morphology through time)
        - uses the environment as a factor of change (environmental determination)
        - 2 principles (affects individuals)
            - principle of usage and non usage

        - principle of inheritance of acquired characteristics
    - gradual mechanism, adaptive and involves an innate ability (internal force) of an organism to become more complex (i.e. the static ladder or chain becomes an escalator)
        - spontaneous generation explains the presence of simple organisms
        - thought that species morphology would modify over time
    - Idea that during the life of organism that organ that is used the most will become the strongest and the one that isn't used will become weakest (principle)
        - If animal acquired characteristic then it will pass on to progeny
        - far fetched because acquired traits don't affect genome
    - Second principle sucks and he didn't explain the internal force. He has some points though but he caused controversy
    - epigenetics: recent experiments show that the environment can affect the expression of genes, but not the genome itself- only lasts a few generations and may be reversible
        - in 1944 there was a lack of food, the progeny of pregnant woman have predisposition to diabetes and being obese, it was transmitted through three generations
        - rats being afraid of odour
- 2.4.4 Cuvier (1769-1832)
    - french scientists interested in mammals fossils, established the science of paleontology
        - the older the stratum, the more dissimilar its fossils are to current species
        - from one layer to the next, species appear and disappear
    - theory of correlation of parts
    - He realized while looking at fossils like old ones in deepest stratum were fairly simple and then higher upper stratum there were more complex fossils
    - His theory- thought organisms were harmonious, by finding one bone you can reconstruct whole anime- harmony of morphology in living beings
    - From one bone you can make many speculations and predictions of animal that ur dealing with
        - Palaeontology you only have parts of the skeleton and with knowledge of morphology you can guess what species you're dealing with
    - cuvier believed in the fixity of species, extinction and catastrophism. progressive creationism
        - catastrophism is the idea that once in awhile there are catastrophes that kill humans and then god creates other fauna and floras

        - from one creation to the other god makes better and more complex species – humans are the most recent and most complex creation
    - 2.4.5 Hutton (1728-1799) et Lyell (1797-1875)
        - hutton and lyell were geologists: geological changes are the result of a slow, gradual and continuous process
            - principle of uniformity (uniformitarianism): the laws of nature are not affected by the passage of time
        - Hutton and lyell were important in putting ideas of transformism in 18th century
        - Lyell took huttons ignored ideas and articulated them in a scientific discipline called geology
        - Hutton observes nature and didn't believe in catastrophisme because he couldn't test it's validity
        - Wanted to explain nature of nature- antiquity of Greek coming back
        - Huttons uniformity principle- present is key to the past. Laws of nature will be there for a long time and were there before, stable and unaffected
            - Different approach to understand world: since laws of nature don't change then the world doesn't have a beginning or end
            - it was impossible to think that the earth was 10000 years old
        - hoodoo example: Idea of lyell and Hutton- observing present is key to past. Looking at hoodoos and pattern of formation- structure that may take thousands of years to form

Chapter 3. Charles Darwin and the theory of evolution

- 3.1 Charles Darwin: education and family
    - born february 12, 1809
    - father: doctor, mother: from the wedgwood porcelain family
    - married (1838) his cousins emma (1808-1896)
    - had 10 children
    - stops his studies in medicine and takes a more serious interest in religion
        - if you weren't a doctor the next best job was a pastor
    - interests: taxidermy, insect collecting, botany
- 3.2 The Voyage on the Beagle
    - general
        - 1831: leaves on the Beagle to do the cartography of the coast of South America, last five year
        - invited on board as a companion of the captain fitzroy but then he became the naturalist of the voyage

        - spends most of his time on land sampling the flora/fauna and studying south-american geology
    - impactful books
        - william paley: "theology or evidences of the existence and attributes of the deity" —> harmony and design in nature are proofs of God
            - father of the theology of nature
            - harmony and design in nature are indicators of the existence and the acts of god (intelligent design)
            - described organisms and organs observed in nature in order to show that these things could not have existed without a higher designer
            - if you have a complex structure it is hard to envision that part of the structure has a complex function
            - nature is the same as a watch if you have a human eye, if you are missing a part of the organ, it doesn't work, someone had to make nature in the same way someone designed a watch
        - charles lyell: "principles of geology" —> law of uniformity
            - darwin began his expedition thinking like a good protestant, believing in the Great Flood and in Cuvier's catastrophism
            - returning five years later, he agreed with lyell and hutton's principle of uniformity, unsatisfied with lamarck's evolutionary process
        - essay by thomas malthus "an essay on the principle of population" —> populations increase geo, resources increase arth. chaos after intersection which results reduction in size
    - trip details
        - That idea of Galápagos Islands and eureka is BOGUS
        - Darwin started thinking about it after he came back and published his book about adventures
        - During the stops Darwin would spend weeks inland and collect things
        - Ended in galapagos and collected organisms then to new zealand australia
        - earthquake on the coast of chile changed the cartography
        - slowly thinking about lyell's principle of uniformity
        - Coast of Chile where he went to andes. 3000m he sees fossils of marine fauna, very interesting to see up there so it made him think- maybe Lyell was right. Cycle of formation of earth crust
        - He became convinced- opened the door for him after his travel where he could envision a process that lasted thousands of years
    - south america
        - distinct fauna in south america

        - very few species common to all four continents
        - differences between similar temperate zones of different continents – associated with lamarckism meaning that its the environment that dictates the adaptation
        - you would expect that the tropical animals look like each other because they live in the same climate even if its different countries but this was not the case
        - climate did not have such a big impact – this allowed him to understand the complexity of the biodiversity of each continent
        - disappointed with lamarck because it wasn't conclusive
        - he found answers for the question when he articulated his theory of common descent
    - galapagos islands
        - fauna on the galapagos islands surprises darwin
        - galapagos marine iguana (only iguanas to live in a marine environment, unique to the islands)
        - galapagos sea lions (closely related to the californian sea lion)
        - bunch of islands close to each other, often each islands fauna was distinct
    - ---
        - shell variability of tortoises in the galapagos
        - do not align to the idea of lamarck because they all have the same environment
    - ---
        - darwin collected finches and sent them to london to be identified
        - morphological variability in one group
        - varied between them: size of beaks
        - beak is adapted to food size
        - darwin says they look alike because they share a common ancestor

- 3.3 Evolution and natural selection
    - early developments
        - 1837: first mention of a common ancestor (why species show resemblance to each other)
        - rejects the fixity of species and accepts the concept of evolution
        - materialistic view of life in contradiction with the religious dogma of the time
        - rejects lamarck's evolutionary mechanism
        - begins to search for an evolutionary mechanism
        - thought that fossils were very important to understand gaps in morphology

- elephants
    - elephants are unique there is nothing that looks like them
    - the rock hyrax and dugong are closely related to elephants from a molecular perspective
- evolutionary branches
    - 99% of species that have lived on earth are extinct
    - Elephants seem to be fairly recent
    - Then the manatees and stuff at the top. There's a big morphological gap but it's filled when you add fossils, show gradation of shape of head for example between manatee and elephant
    - Fossils were important to him to fill the gaps
    - Lacking strong quantitative evidence that 99% of species are extinct. We have remnants of this fauna right now
    - Finish in dead end mostly but have common ancestors that are indicative of relationships
- thomas r. malthus
    - 1838: darwin read "an essay on the principle of population"
    - one of the main sources that inspired him to formulate his famous theory on natural selection
    - because he rejected lamarckism, he was able to explain the variability between fauna and flora between the continents
    - malthus wrote that: every human population has a tendency to increase geometrically, whereas the availability of resources to feed these populations increase arithmetically
        - Point where too many people for resource available
        - In malthus's opinion when this occurs there's a fight or crisis starvation sickness and in general population should go back down to be compatible with resources
        - the human population increases faster than its capacity to feed itself. this leads to chaos (famine, sickness, war, etc) and eventually a substantial reduction in population size
        - darwin looked back and tried to apply this idea to evolution
- darwin's observations
    - first

      all species can produce more offspring than their environment can sustain and many of these offspring fail and survive and reproduce

        - Doesn't apply to us bc we take care of our offspring

        - Most species produce massive offspring and only a few will survive
        - Puffball: billions of spores when squished and only a few are winners and become mushroom
        - only a few samaras germinate on maple trees
        - Fishes- this mola mola can produce the most number of eggs per spawn if eggs are fertilized the ocean would be filed. So only a few get to adult stage
    - second

      members of a population often vary in their inherited traits

        - traits are passed from parents
        - he genetic variability is the material upon what evolution works
        - ladybird number of spots and snail shells is inherited from parents
        - the idea of variability used to be an illusion but now they see it is very important and has the ability to evolve
        - if a species cannot evolve it has not future
        - the shift of looking at at variability in nature is one of the main contributions of darwin
- inferences

    - individuals whose inherited traits gives them a higher probability of surviving and reproducing in a given environment tend to leave more offspring than other individuals

    - from generation to generation, this unequal capacity to survive and reproduce (differential reproductive success) results in an accumulation of favorable traits in a population

        - this is natural selection
    - flatfish and other examples

        - Fish in a lake..... these individuals have a lot of genetic variability. Colours reflect variance. New predator comes in..... quack quack and since visual predator it starts feeding
        - Small population is now under pressure from ducks... individuals who can't camouflage get eaten. After a few generations the blue fish will survive more and produce more than the other individuals which are less in number
        - Population will remain variable bc there some areas in lake where duck isn't efficient
    - ---

        - colour of environment.....

        - If the trait for camouflage has genetic basis then it will be passed gen to gen, proportionally more abundant
        - New environmental pressure.... red background... result of climate change and now it's warm. Best fish can sustain heat ... some fish have better resistance yes red fish become proportionally abundant bc they can survive and reproduce
        - Population of other colour will diminish in turn
    - ---
        - temperature of the environment.....
        - Lakes aren't homogeneous systems where there's influx of water from underground which is colder so we have SOME genetic variability
        - Within this pop where all insidiously become well adapted to high temp and then fairly homogenous population. This trait is everywhere now and it seems that it's acquired and adapted to warm temp. Now genetic variability is gone
        - But now we have a cold spell and the trait isn't that efficient here... population has no variability and none that can adapt
        - Highly susceptible to diminish in number go extinct
        - Genetic variability is key component of resilience of species and without it evolution cannot occur
- peer pressure
    - 1853: alfred russel wallace forces darwin to release his ideas publicly by sending him a letter
    - wallace came to the same conclusion by observing the fauna of indonesia
    - wanted to confirm that he was right
    - darwin spends a few months putting together information and his book
    - 1858: darwin and wallace present a summary of their ideas on natural selection to the linnean society of london
    - 1859: darwin publishes the first edition: "on the origin of species"
        - caused lots of controversy but it was so well written that many people took his defense
    - 1872: 6th and last edition of his book, contains a chapter dedicated to the most important arguments against his theory
    - Theory hasn't been refuted for over 150 years and it's being built on bc it's almost considered a fact
- validity
    - respects the principle uniformity of lyell and hutton
    - results of natural selection are visible in nature
    - the mechanism can be verified on current populations
    - 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 vs natural
    - artificial selection is finalized because the goal, fixed well in advance, precedes the causes. the end result can be obtained in a few generations
        - bergamasco (mop) dog
        - to go through artificial selection, you need genetic variability in the population
        - wild mustard —> the origin of different species
    - natural selection is not finalized. it can take a long time for changes to occur (geological time scale)
        - change and adapt to the environment
- peppered moth
    - Nocturnal moth pepper moth , in the daytime it'll stay somewhere all day
    - Two forms- pale and dark
    - Idea of natural selection: this was one of the first tests associated
    - During the day they are susceptible to predation and these three visual predators, birds
    - 1850 where coal was main source of energy so lots of black smoke covered everything and even trees had dark bark
        - During the day the predator will spot the grey moth more than dark one so they get ATTACKED
        - In the countryside now we have greg camouflaging and dark ones who get KILLED bc they stand out
    - 1950s there was big clean up after ww2 and no more coal
        - new energy sources and cities became clean and now dark moths are rarer.
        - Now grey moth is more popular in city and country
- the ground finch
    - droughts in 1977, 1980, 1982
        - availability of seed is reduced by the drought
        - the only seed that remains were very large seeds
    - population decreases from 1200 to 80 finches
        - studied on daphne major

        - measured legs and beaks and different traits
    - medium ground finch feeds mainly on seeds

    - the height of the beak is important for a seed eater, the size of the beak indicates the size of the seed that they can eat

    - selection favours individuals who have bigger and stronger beaks to break available seeds during the drought

- humans and altitude

    - mountain life: adaptation to altitude
    - over 2000m, the partial pressure of O2 is insufficient for normal saturation of hemoglobin for a traveller in high altitudes
        - shortness of breath, altitude sickness
    - acclimatization: after a few days at high altitude, the body compensates the low partial pressure of O2 by increasing the concentration of red blood cells in our blood
- qinghai-tibet plateau

    - deeper breath, faster breathing cycle; larger pulmonary capacity and increase blood flow

    - Origin of adaptation (EPAS1)- humans have put permanent settlement on the plateau 3000 years ago. But also evidence for 30k years ago so we dk

    - More variable adaptation in andes because of several invasions of high altitude. Higher respiratory capacity, same Hgb concentration as us but each molecule had high O capacity. This compensates for low partial pressure of o

    - Among population of low asians had mutation that allowed them to survive in altitude THAT are high and reproduce

      among them there might have been few individuals that had this mutation

    - the mutation is random it did not appear because there was a need for it

    - individuals with this must have been favoured by natural selection

    - Proportion increased because had the trait to keep reproducing

        - no link between the adaptation and NEED for it, it was random

    - andes

        - 550 generations
        - the pool of potential mutations is different between areas, the one favoured in the andes is different than the one favoured in tibet, but the endpoint is the same, being able to breathe properly in an area where partial pressure of oxygen is fairly low
        - higher alveolar surface in lungs, same hemoglobin concentration in blood but each molecule has a higher oxygen capacity
    - summary of examples

        - In the three cases (moths, finches and humans) the hereditary traits that give a reproductive (i.e. adaptation) to individuals in a population will be favoured. this from generation to generation there will be a higher percentage of individuals carrying the adaptation. This is natural selection. it is darwin's descent with modification. it's evolution
        - these adaptations can sometimes redefine a species and, in certain circumstances, define a new species
- 3.4 Proofs of evolution: homologies, fossils, vestigial structures

    - homology

        - descent with modification theory (theory of evolution) explains the resemblance between certain traits even if the functions are different (homologous structure)
        - All the structures within these limbs are the same- implies same common ancestor
        - alternative is that they evolved independently or created independently and doesn't correspond to reality or parsimony
        - Humerus of human, cat, whale, bat is considered HS and indicative of common ancestry, modified through descent with modification- or through natural selection
    - Fish and humans

        - one of the amazing things is to visualize that fish chicken and human embryo have a common ancestor
        - commonality in structure between the fetus
        - **post anal tail** means that there is a tail coming after the anus
        - on week seven we have a beautiful tail that regresses as we grow —> commonality between all three species
        - **pharyngeal pouches** appear by the head of the human.

        - they disappear quickly in the human and chicken but in the fish they will continue their growth and become the gills
- phylogeny
    - relationship between species
    - All of those share a homology of taxon - digit bearing limbs- unique to tetrapods
    - snakes ancestors had legs
    - Honology that restricted within tetrapods- amnion is embryonic tissue found in amnions
    - feathers unique to those birds woo
    - Alternative is features developed convergently
- linear evolution of the horse
    - interpretation and representation of evolution
    - linear evolution shows the evolution within a group (WRONG)
    - horse: five species, and share a common ancestor (hyracotherium)
    - browsers: animals that feed on leaves, rely on camouflage not on speed. these animals had small teeth because there was no abrasion from their vegetable diet
    - when you compare the modern horse and its ancestor, they have a common adaptation for grazing and speed
    - number of bones in foot and foreleg means that the legs are thin and light (Adaptation for speeds)
    - follow the morphology path of speed
    - grazers: feed on vegetation from the ground
    - stronger and larger teeth in modern horse to resist wear and tear of their form of feeding
- more realistic evolution of the horse
    - No linear evolution of horses
    - Choice is subjective- as there is one species at 8 million years go, there was actually 5 other species living at that time too
    - Every horse is part of a branching tree- choice of horse is subjective to scientist
    - Tree, not lineage
    - Tendency to look at end point as perfect adaptation to environment but that's **misrepresentation**

- human evolution
    - there have been about 25 species of humans
    - linear evolution is totally wrong, it is fake news
    - we are not going from one species to humans
    - evolution simply indicates that we share a common ancestor with the chimpanzee maybe 6 myr ago
    - when we look at the linear version, we have to realize there would be more than one human species 2 myr ago
    - one of these lineages lead to humans
    - a selection of species among a tree of many other species
    - the closer we are to humans the taller the species is (thats FAKE)
    - you cannot associate body size with time, there is no trend
    - seems to suggest some kind of endpoint, something that is impossible with evolution, the species is never perfect
    - we shouldn't think of evolution as linear, always in a tree
- fossils
    - Tree thinking helped Darwin visualize evolution of certain groups
    - Whales are mammals but look like fish- ancestor must have quadrupedal
    - hippos are close to whales and have common ancestor, along with other even toed ungulates
    - At one point there were ancestral whales that had legs because there's a gap between them- fossils fill the gap
    - Pakicetus for sure its hind leg was typical of tetrapods- digitigrad too, fairly rapid predator
    - Rhodhectys used hind leg to swim pelvic girdle reduced in dorudon
    - Whales pelvic girdle that lies in flesh where legs could have been
- the walking whale
    - vestigial structures: anatomic structure that has lost almost all of its initial function
    - the whale has a reduced vestigial posterior limb, the pelvis reduced to a floating pelvic bone under the spine
        - whales must have had an ancestor with functioning legs
        - remnant of a pelvic girdle is an indication of the fact that its ancestor had legs
- humans and chickens
    - We live in symbiosis With microorganisms in order to digest vegetation
    - nictitating membrane or third eyelid
        - Third eyelid. Has no function and it's there- but important in birds and reptiles, it offers protection- transparent means it can move

and feed with no danger to eyeball. Present in birds crocodiles and mammals
        - Presence of this structure means that somewhere in phylogenetic tree there was a common ancestor with a fully functional third eyelid
    - Appendix
        - We have an appendix at the junction of two intestines- pocket and attached appendix. It is a vestigial structure. Caecum in herbivores is a large sac like in rabbits and it's important for nutrition, where microorganisms will actually secrete enzyme cellulaze that destroys cellulose found in cell wall of vegetal cell
            - Appendix is remnant of large saecum
            - Appendix is end of balloon gross. The cecum is smaller bc digestion of vegetation happens in colon so the appendix is useless
    - Goose Bumps and hair
        - Small muscle- arachor peelee that makes your hair stand up
        - Useless feature no function but it's vestigial structure
        - Furry animal like chat ou chien ou Arctic fox, hughes density of hair reacts in same way like standing up- to strong emotions and to cold
        - Tip of hair will fold a little form compact later on fur which will imprison layer between layer of skin and upper layer and keep warm
        - In birds like in winter they're on the wires and look like a ball of feathers
        - Air is flimsy and density low on humans so it doesn't preserve heat. Very temporary little heat
        - At one point in common ancestor they were furry and able to use this function
- hiccuping is for losers

    - the hiccup: a heritage from fishes and amphibians
    - things that suggest we don't have an optimal body: we hiccup
    - when we hiccup we have a contraction of the diaphragm and shut the epiglottis
        - epiglottis is a small cartilaginous flap that shuts down the trachea to protect from the intrusion of foreign material into the respiratory system
    - Why do we have hiccups? it emerges from the fourth cervical vertebra in our neck and goes through most of the thoracic cage and will attach to the diaphragm

        - it just happens that once in a while the phrenic nerve gets pinched which provokes the contraction of the diagram and the flapping of the epiglottis, every 4 or 5 seconds
        - in many people hiccups last for 1 or 2 minutes, you can have them once in awhile or everyday like me
        - the ultimate objective is to move your internal organs to reverse the pinching of the nerve
        - Why does the phrenic nerve emerge from the 4th cervical vertebra?
        - **because we share ancestor with fishes**
            - fishes have a respiratory organ in their throat so it is optimal, nerves coming out of the same region —> the length is perfect
            - but we do not have gills, the whole respiratory system has moved downwards and the nerve has moved down from the thoracic cavity to the abdominal cavity
            - it is not optimal but explain the fish as common ancestor
        - Why do we have a glottis?
            - appeared in the larvae of amphibians and it is highly functional during metamorphosis where tadpoles can breath through air and gills, so the glottis will have a flapping reaction
            - humans have this trait now too even though it is not optimal
        - all mammals have long phrenic nerves
        - it is unclear why we have hiccups

    - summary

        - A fossil in the wrong in the geological archives
        - If we find human with the dinosaurs then something IS WRONG
        - Many attempts at fraud but no such thing as fossil in the WRONG spot yet

Chapter 4. Genetics, Neo-Darwinism and Modern Synthesis

- 4.1 Transmission of Traits (inheritance): Pre-Mendelian Perspectives

    - 4.1.1 Preformism and the Theory of Blending Inheritance
        - Aristotle invented them and associated with different types of development
        - development of individuals: preformist theory until the 19th century
            - all individuals were found as miniature within the sex cells, the growth was the lengthening
            - basically after fertilization, the sperm or egg will develop and become a fetus and whatever is not being developed will be the nourishment
        - accepted theory today: epigenesis
            - in the 19th century they realized the epigenesis is closer to reality

        - epigenesis: individuals start in the womb as one or two cells and they will differentiate into more cells into tissues into organs
        - when they looked at early embryos they realized the epi was true not mini humans in the egg
    - theory of blending inheritance
        - universally accepted theory until the end of the 19th century
        - both parents participate equally in the genetic makeup of offspring
        - for each trait the child would show an intermediate value between the traits of its parents
        - all individuals would become identical, or at least very similar (non consistent with what we observe)
- 4.1.2 Darwin's Pangenesis
    - theory of gemmules= hereditary particles
    - when organ is used it creates more gemmules and grows, and is transported throughout the bloodstream and assembled in the gametes when they are formed
    - francais galton said that if you do blood transfusion the gemmules should transfer from original to new, but with white and brown rabbits didn't work
- 4.1.3 August Weismann's Theory (1834-1914)
    - weismann
        - proposed that only sex cells were responsible for heredity, whereas the rest of the organism was only a structure doomed to disappear with the death of the individual
        - living being are divided into two parts
            - soma = remainder of the body
            - germline = gametes
        - germline is impervious to the environmental influences, heredity is simply the continuity of the germline
        - the germline and the environment can influence the phenotype, soma and environment have no influence on the genotype
        - INDIVIDUAL OF EACH OTHER
        - natural selection is the only thing that can modify the germline
    - sexual life of the monkfish
        - live deep in ocean
        - all the fish seemed to be female
        - parasite attached to the genital WHAT of the fish.....but then they realized it was a male not a female
        - once the males are born they have a short independent life time
        - the only goal in life is to fuse themselves to the genital of the female, the abandon their own circulatory system and leech of the female, they leave everything except the testicle.....it's just a sperm sack attached to the genital papillae of the female
        - sometimes more than one male leech on which is ideal for genetic variability and diversity

            - they don't have much of a phenotype, but the germline remains there and active in the sense that genes are passed on from generation to generation
            - showing that the soma can be greatly reduced it doesn't matter as long as the germline is passed on
- 4.2 Mendelian Inheritance
    - mendel
        - founder of genetics
        - austrian monk
        - formulated his laws on the creation of hybrids (law of hereditary) in 1866, work recognized in 1900
        - made with exemplary scientific rigour
        - the choice of material was judicious
            - used peas (cheap, all kinds of variety, self-fertilization, lots of perigyny)
        - abundant data and mathematical analysis to verify his hypothesis
        - talks about "hereditary factors" (genes were still unknown at that time)
    - variation
        - variation of genetic traits is explained by the different shapes genes can have
        - each gene occupies a specific locus on a given chromosome
        - the dna sequence of the locus can show variants (alleles)
    - inheritance
        - all organisms inherit two copies of a gene (different or identical), one from the "father" and the other from the "mother". each copy is called an allele
    - Law of uniformity of hybrids
        - ear
            - free lobe is dominant
            - attached lobe is recessive
            - if these two mate, then the kid will be free
        - if both alleles of a locus are different, one of them, the dominant allele determines the appearance of the organism; whereas the the other, recessive allele has no notable effect on the appearance

        - purple and white, the f1 will all be purple because it is dominant
        - given true breeding parents, the f1 generation will be of one phenotype

- Law of segregation
    - two alleles for a heritable character segregate (separate from each other) during gamete formation and end up in different gametes
    - the point is that all cells of an individual are diploid (homologous pairs of chromosomes)
    - through meiosis PP, 1/2P gametes will be formed (they are haploid gametes)
    - if you cross the f1 at random, the f2 will be a combination of them, PP, Pp, Pp, pp
    - terms
        - phenotype: expression of genotypes
        - genotype: 3 types are homo dom homo rec and het
        - homozygous
        - heterozygous
    - test cross
        - one purple and one white but you don't know the genotype of the purple because it could be many
        - cross breeding to figure it out
        - if your purple flower is PP, then you would get this all purple result (**homozygous)
        - if your purple flower is Pp, then half will be white (**heterozygote)

- Law of independent assortment
    - hairlines
        - free earlobes (dominant) and straight hairlines (recessive)
        - attached earlobes (recessive) and v hairlines (dominant)
        - alleles of ear lobes and of the hairlines separates independently when the gametes are formed

        - every pair of allele separates independently from the other pairs when the gametes are formed
        - pair of alleles separate independently form other pairs
        - independent between traits
        - pure lineasges and cross the P, so you get hetero in F1 bc they dominant
        - f2: if you have a hypothesis of dependant- traits are linked, then you would get the left. two traits do not separate
        - but if they're independent, then you should get more phenotypes than the other proportion- all combos are possible

- 4.3 Initial Impacts of Mendel's Theory
    - negative impact on theory of NS because of confusion between evolution and this
    - emphasis on discontinuous aspects of traits associated with mendel's ratio and rejected continued variation observed in nature
- 4.4 Neo-Darwinism and Modern Synthesis
    - 1920's-1960's important
    - genetic bases of evolutionary changes, genetics and evolution reconciled and called NEO DARWINISM
        - impacts: starting to understand the effect of chance in the transmission of alleles from gen to gen (genetic drift)
        - the study of genetics shows the existence of an important and persistent variation (continued or discrete) which creates the hereditary material on which evolution can act
        - continuous variation has a mendelian basis
        - QUANTIFIABLE BASIS
    - the emergence of population genetics (MICROEVOLUTION) offered a new perspective about the significance of factors producing evolutionary changes in population
    - SPECIATION= (biological and genetic basis of the formation of species)
    - MACROEVOLUTION= study of species above the species level
    - PHYLOGENIES= elaboration of tree of life
- 4.5 Modern Additions to Mendel's Laws
    - INCOMPLETE DOMINANCE
    - CODOMINANCE
    - POLYGENISM= multiple genes (skin colour, several genes affecting one trait)

- EPISTASIS= effect of gene hides and blocks expression of another (labrador dog with recessive homozygous ee)
- PLEIOTROPY= one gene affects multiple traits (certain lethal with homozygous like the Manx cat)