Midterm 1 Review Notes

Chapter 1

- Inductive reasoning could be true, could be false BUT we can never say we have the ultimate truth in science
  - Inductive reasoning goes from observing to making generalizations
  - A hypothesis is usually a statement or description of the nature of the 'subject'
  - If there is "truth" in science, it is at best conditional, based on the preponderance evidence
- **The CONTRACT**
  - The most important thing
  - Breaking it may result in fascinating results, but that's called science fiction
  - Healthy Skepticism
    - Asking questions about other people's hypotheses and results is a good way to progress in science
    - Sort of like constructive criticism
  - Realism
    - The world existed before we were born, and will continue to exist after we die
      - This applies to information gleaned during our lifetimes
    - We must examine nature for what it is
  - Rationality
    - Cannot be influenced by one's own emotions
    - Parsimony is the principle that often the simplest answer is the correct answer. If you want to explain something and use complicated theories that use lots of variables and unknowns, it is not recommended. Science likes simple things
      - Example: If you hear galloping behind you, it's more reasonable to assume that it's a horse, not a zebra.
      - Example: People thought that the crop circles were made by aliens, but it wasn't until 15 years later that 2 guys admitted it was them that were making the circles.
  - Methodological Materialism
    - We need to explain the real world with a materialistic approach

        - As in, all experiments must be done with materials easily accessible in the real world.

- Müllerian Mimicry means that not only do the 2 species look alike, but they also have the same characteristic. It's believed that this is so because it gives a stronger impression of that specific characteristic. Batesian Mimicry means that they only look alike, with usually one species evolving to look like a more venomous or dangerous prey to avoid being predated on.
    - 2 species of butterflies, the Viceroy and Monarch are perfect examples of this
        - The monarch feeds on milkweed, which makes it venomous to birds that may want to snack on it. It was originally believed that the Viceroy was a Batesian Mimicry of the monarch so as to protect itself, but an experiment proved that it was Müllerian Mimicry.
        - Scientists did an experiment on the 2 species, where they took their wings out (so as to avoid warning the birds of the butterflies' nature) and fed them to the birds. When the birds ate the monarch, they spit it out. What was interesting was that when the birds ate the Viceroy, they also spit it out. This led to the discovery of the Viceroy butterfly also being venomous.
- There was a case study done on the oddfield mouse, of which there are 2 different colourations (dependant on their location). The mice that lived on the beach had a lighter coloration, and the species that lived inland had darker coloration. It's believed this is to avoid predation (by blending into the surrounding landscape).
    - Mouse colour is the independent variable
    - Amount of predation is the dependent variable
- Piscivorous fish were introduced in the 20th century because trout was completely fished out
    - Piscivorous species include:
        - Northern pike
        - Smallmouth bass
        - Largemouth bass
    - This has led to the discovery that in lakes where there are no piscivorous fish, there is about 50% more small-fish species
        - This lead to the recommendation of banning piscivorous fish species in Gatineau Park's lakes to preserve the park's biodiversity
        - These small fish species include
            - Banded killifish
            - Northern Redbelly Dace

    - Blacknose Shiner
    - Fathead Minnow
    - Blackchin Shiner
  - However, the Three-spined stickleback fish is one of the only small fish species to have evaded the predation because of its unique nature (has spines coming outwards of its body)
    - It is a remnant from the Champlain sea that had dried up long ago
- They were introduced into 15 small lakes (experimental group) an there remained about 25 lakes without piscivorous species (control group)

Chapter 2

- 3 major philosophers that partook in transformism
  - Anaximander (610-546 BCE)
    - He was the first philosopher to write down his thoughts
    - His thoughts revolved around the idea that the central element of the universe is water and this is shown by his 'theory':
      - "Animals are born from the sea, by solar heat on water. They were first wrapped in spiny bark...as they aged, they migrated on the mainland. When the bark burst, they survived briefly in their new lifestyle."
      - Argued that humans evolved from fish that attempted to invade the mainland
  - Empedocles (482-423 BCE)
    - Argued that everything in the world was made up of 4 basic elements:
      - Water
      - Earth
      - Air
      - Fire
    - He also said that there were 2 major opposing forces that constantly acted on these 4 elements
      - Love
      - Hate
  - Democritus (460-360 BCE)
    - Was the most scientific of the Greek philosophers
    - Believed in 2 realities, atoms and emptiness
      - He argued that humans and animals are born from dirt via the result of chance interactions between atoms. If things weren't harmonious, they'd turn back to dirt. If we died, we'd turn back into atoms and could either be remade into another human or could be remade into a flower or an animal or whatever the atoms' arrangement was
  - In Summary:
    - Acts of creation are not due to Gods, but rather due to the innovative power of matter
    - The origin of all things is not theological, but rather a result of chance or of an irrational need

- Classical Thinkers
  - Generally had a total disinterest in nature as they saw it as an imperfect world, and thought it was more important to contemplate on our soul
  - Although they're more than 2000 years old, they still have an influence on us
  - Philosophers no longer sought to answer materialistic questions, but rather searched for beauty, kindness, justice and sanity
  - They thought that arguments about logical, ethical and political questions are more interesting than the search for truth
  - Argued that answers aren't found in nature, but rather, within one's self
    - Socrates (469-399 BCE) - Plato (427-347)
      - Formed the *Theories of Ideal Forms (essentialism):*
        - The visible, imperfect and changing realm which surrounds us is a poor imitation of an Ideal World
          - When we are born, we have an innate view on how things should be, but we spend most of our lives looking for a way to bring it back/materialize it
      - Argued that Gods are the creative forces
    - Aristotle (384-322 BCE)
      - DOESN'T BELIEVE in the Ideal World
      - Thought it was important to describe living things by their essence (which can be observed in nature)
      - Argued that species are static, and thus, morphological variability is an illusion and imperfection
        - Led to the creation of the *Scala Naturae*
- The Impact of Christianism
  - This is the dark age for evolutionary thought
    - God becomes the measure of all things, and the Christian Bible, the word of the day
  - The concept of *Scala Naturae* becomes purely metaphysical, proclaiming the perfection of the Creator
- When the Renaissance Movement happened (14th to 17th century), the oppression on evolutionary thought becomes 'lifted'
  - Back to nature (great expeditions and discoveries)

    - There was a return to experimentation and observation of nature
    - Tried to figure out how God created things and where living organisms belonged in the *Great Chain of Beings*
  - Power of religion is progressively challenged
  - The french revolution at the end of the 18th century challenged monarchy for an active pursuit of progress
    - Much more open-mindedness towards science
- Linnaeus (1707-1778)
  - Known as the father of modern taxonomy
    - Created the binomial system of nomeclature
      - The difference between Darwnin's and Linnaeus' system is that Darwin added some variability to the species
    - In his latest book, he says:
      - "I can't believe that there's no likeness between species, like why would they all look the same if they're not related"
- Buffon (1707-1788)
  - His objective was to describe nature (and he did through 44 volumes)
  - Around 1740, he wrote:
    - "every family, from animals to plants, has a common origin, all animals derive from one animal, which through time produced all animal species in existence today".
    - His theory established the age of the Earth to be around 75000 years old, and that the initial temperature of the Earth was very high
  - The Faculty of Theology of the Sorbonne censored many of his theories because of its conflicts with religious views
    - This caused him to abandon his evolutionary ideas and to focus on observing nature
- Lamarck (1774-1829)
  - First evolutionist to describe species modifying their morphology through time
  - Uses the environment as a factor of change (**environmental determinism)**
  - Had 2 main principles that affects usage part of his theory
    - Principle of usage and non-usage

        - The more you use the organ, the stronger and more efficient it gets
        - The less you use the organ, the smaller it gets until it disappears
    - Principle of inheritance of acquired characteristics
        - Couldn't be proven, so it was falsified
- Said that spontaneous generation explained the presence of simple organisms
- Wasn't well received because it contradicted religious views
- THE PROBLEM with his theory was that acquired traits [throughout a host's lifetime] could not be inherited

- Cuvier
    - Was a French scientist who was interested in mammal fossils
    - Established the fundament concepts of palaeontology
        - The older the stratum, the more dissimilar its fossils were to current species
        - Front one layer to the next, species appear and disappear
    - Came up with the Theory of Correlation of Parts
        - This theory disproved the idea that animals had stayed the same since the beginning of time
    - He believed in the fixity of species and catastrophism
        - Some catastrophe wiped out fauna, but then new fauna came up in their place
    - He stroke the final blow to the unifying concept of the great chain of beings, proclaiming God as the Creator of the 4 major types of animals
        - Radiata
        - Mollusca
        - Articulata
        - Vertebrata
- Hutton and Lyell
    - Both were geologists, who probably had the greatest influence on Darwin
    - Came to the conclusion that geological changes result from a slow, gradual and continuous processes
        - Principle of uniformity: the laws of nature are not affected by the passage of time

  - “The present is the key to the past”
- They had a vision of the world, “with respect to human observation, this world has neither a beginning nor an end”
- Lyell was the first to establish geology as a scientific discipline.

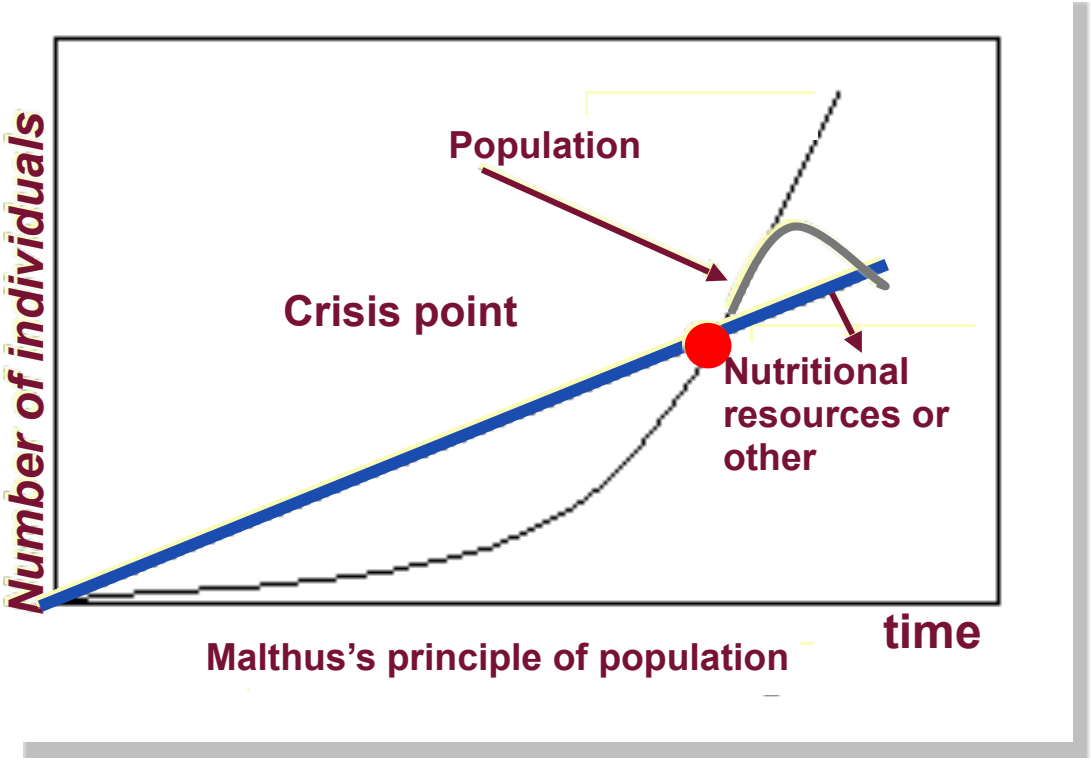
Chapter 3

- **Charles Darwin**
  - Education and Family
    - Born on February 12th, 1809
    - His father was a doctor, and his mother was from the Wedgwood family (dealt with porcelain)
    - He marries his cousin Emma Wedgwood (1808-1896) in 1838
    - Had 10 children
    - Was originally studying medicine, but took a more serious interest in religion at Cambridge University
      - The prerequisite to become a pastor was a Bachelor of Arts
    - He became interested in nature: taxidermy, collecting insects, botany, etc
  - The Voyage on the Beagle
    - In 1831, he leaves on the Beagle
      - The Beagle was a ship commissioned by the British government to cartography South America's coast
    - Darwin was invited on board as a companion to the captain Fitzroy, but quickly became the naturalist on the voyage
      - Naturalist: an expert in or student of natural history
    - He travels the world and spends most of his time on land to sample the fauna and flora and to study South-American geology
      - Although the voyage was planned for 2 YEARS, it lasted 5 YEARS.
    - During the voyage, 2 books greatly influenced Darwin
      - William Paley's "Theology, or evidences of the existence and attributes of the deity"
        - Paley is the father of the Theology of Nature. This theology advocated that harmony and design of nature as indicators of the existence and the act of God (known as **intelligent design** today)
          - Intelligent Design: Everything fits so well together so if someone was to take out a piece, it would stop functioning
      - Charles Lyell's "Principles of Geology"

        - This work had a great impact on Darwin. He started his expedition off as a good protestant that believed in the Great Flood and in Cuvier's catastrophism.
        - He returned 5 years later, agreeing with Lyell and Hutton's principle of uniformity
            - Principle of Uniformity: the assumption that the same natural laws and processes that operate in the universe now have always operated in the universe in the past and apply everywhere.
    - On his voyage he touched all the continents
        - When he was in Chile, there was a huge earthquake. After it was over, he realized that the current cartography of the island was wrong, because the earthquake changed the cartography of the island
    - The fauna on the Galapagos Islands surprises Darwin
        - He asked,
            - "Why is the fauna on the Islands so unique?"
            - "Why so much morphological variability in one group?"
            - "Why does each island, in most cases, have their own species?"
                - Examples of this are 'Darwin's Finches'
        - An example of this is the Galapagos Marine Iguana
            - Only iguanas known to live in a marine environment
            - Unique to the Islands
        - According to Lamarck's theory, similar environments should lead to similar morphs evolving, but there are 15 different subspecies of tortoise on the island

- **Evolution and Natural Selection**
    - In 1837, Darwin's notes first mention species resemble each other because they share a common ancestor (NOT a common environment)
        - Rejects the fixity of species and accepts the concept of descent with modifications (evolution)
        - Rejects Lamarck's theory
        - Because it was a materialistic vision, it contradicted the religious dogma at the time
    - 99% of species that have ever lived on earth are no extinct
    - Most of the evolutionary branches finish in a dead-end

- In 1838, he read “An Essay on the Principle of Population” written by economist Thomas R. Malthus
  - This reading was one of the main sources that brought him to formulate his famous theory on natural selection
  - In the book, Malthus writes that every human population has a tendency to increase geometrically, whereas the available resources to feed these populations increase arithmetically

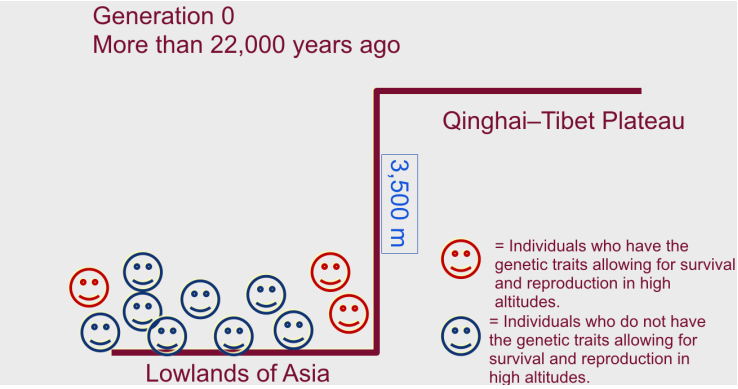


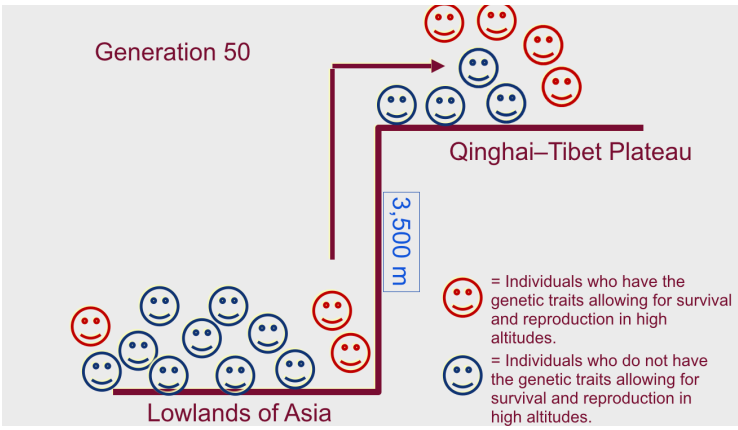
  - The human population increases faster than its capacity to feed itself. This leads to chaos (famine, sickness, war, etc) and eventually to a substantial reduction in population size
- Darwin’s first observation was that all species can produce more offspring than their environment can sustain, but many of these offspring fail to survive and reproduce
  - Examples of this are the Mola mola, maple tree and its samaras (helicopters) and the puffball and its spore cloud
- Darwin’s second observation was that members of a population often vary in their inherited traits
  - Examples of these Amphidromus adamsii and Asian ladybird beetles

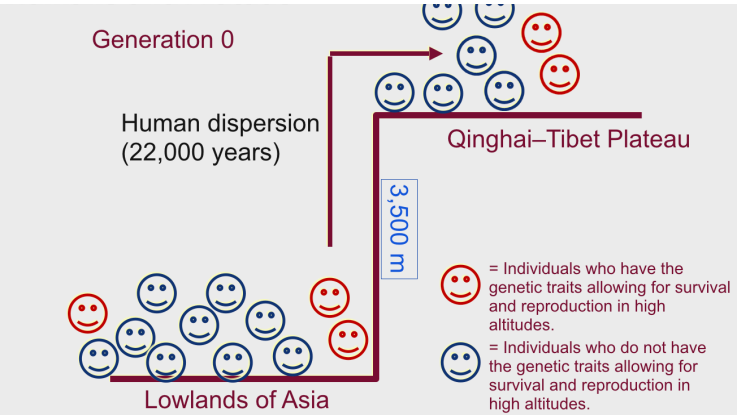
- Two interferences
  - Individuals whose inherited traits gives them a higher probability of surviving and reproducing in a given environment tend to leave more offspring than other individuals
  - From generation to generation, this unequal capacity of survival and reproduce (differential reproductive success) results in an accumulation of favourable traits in a population
    - This is called **natural selection**. It enables the emergence of adaptations
- It took a letter from Alfred Russel Wallace (1823-1913), received in 1853, that forced Darwin to publicly release his ideas
  - Wallace had come to the same conclusions as Darwin concerning the theory of natural selection by observing the fauna of Indonesia
  - Thus, it was 23 years later after Darwin's voyage on the Beagle that he finally released his views on the evolution of species
- In 1858, both Darwin and Wallace presented a resume of their ideas to the Linnean Society of London
  - In 1859, Darwin published the 1st edition of his book, "On the Origin of Species"
  - The 6th and final edition of the book published in 1872, contains some of the best arguments against his theory
- Important notions linked with natural selection
  - Individuals do not evolve, populations evolve
  - Only hereditary traits are subject to natural selection
  - Natural selection corresponds to differential reproductive success within a population from generation to generation*
  - With time, natural selection enables individuals to become better adapted to their environment
  - Environmental factors may vary in time and space. Thus, the selective forces are variable
  - Traits in populations will change and can modify the species
    - If a trait remains within a population, it could lead to a new species down the line
- Darwin thinks natural selection is valid because:
  - It respects the principle of uniformity of Lyell and Hutton
  - The results of natural selection are visible in nature

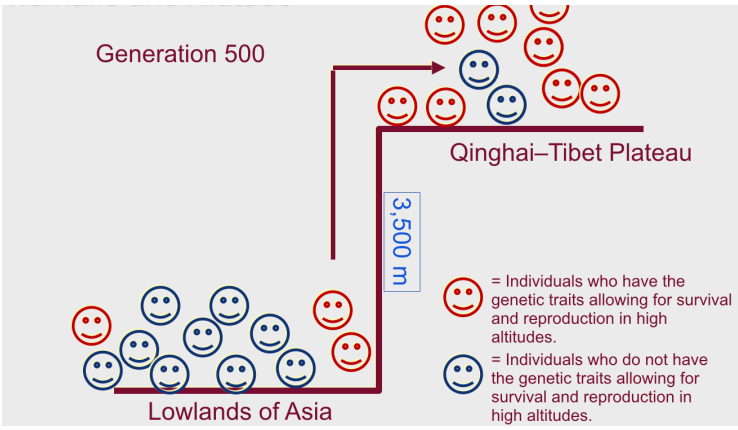
        - Examples of this are the peppered moths and their ‘evolution’
        - Another example of this is of the Medium Ground Finch (Geospiza fortis)
            - Massive drought in 1977, 1980 and 1982 that brought the adult population from 1200 to just 80
            - Natural selection favoured individuals that had bigger and stronger beaks to break seeds during the drought
                - A study was done where the correlation between the height of the beak in parents and off spring for the finches was measured. It shows that 74% of the traits are inherited from the parents
    - The mechanism can be verified on current populations (artificial selection)
        - Artificial selection is finalized because the goal (fixed well in advance) precedes the cause. The end result can be obtained in a few generations
            - Examples of this:
                - Wild mustard into cabbage (via selection for apical bud)
                - Wild mustard into broccoli (via selection for flowers and stems)
                - Wild mustard into brussels sprouts (via selection for axillary buds)
                - Wild mustard into kale (via selection for leaves)
    - It is a material concept (means there’s no need for divine intervention)
        - The mechanism is not random. Natural selection enables individuals that are better adapted to their environment become more abundant than those who aren’t (differential reproductive success)
        - Natural selection is not a quest for perfection, since evolution is not a directed process. It doesn't lead to the appearance of ‘perfect’ traits. Organisms only adapt to their environment

- **Adaptation to high altitudes**
    - Over 2000m, the partial pressure of O2 is insufficient for a normal saturation of hemoglobin for a traveller in high altitudes
        - This can cause shortness of breath, altitude sickness
        - After a couple days, the body undergoes a process called acclimatization
            - The body compensates the low partial pressure by increasing the concentration of red blood cells in our blood.
                - This can lead to serious health risks, such as thrombosis, pulmonary edema, etc.





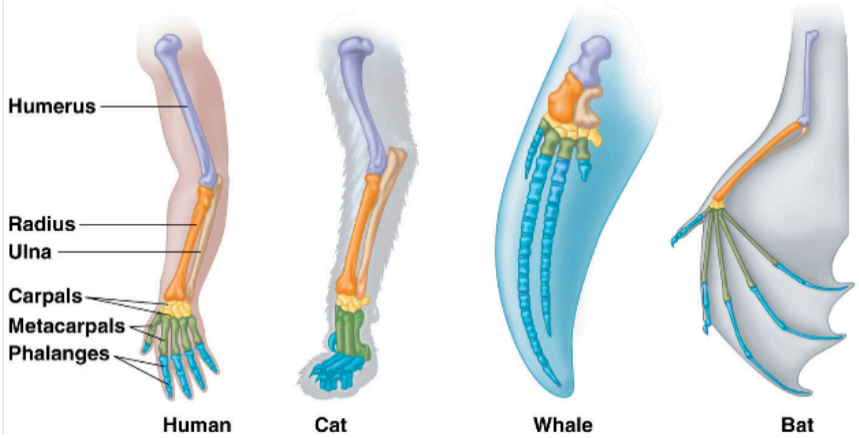




- Although many regions at high altitudes were independently colonized by humans, they differed in height and generations
  - Qinghai-Tibet had a colonization of 22 000 years and 1100 generations
    - Increased blood flow
  - The Andes had a colonization of 11 000 years and 550 years
    - Increase in hemoglobin concentration

- In all 3 cases (moths, finches, and humans) the hereditary traits that give a reproductive advantage (such as adaptation) to individuals in a population will be favoured over other individuals (thereby leading to a greater percentage of adapted individuals in each population). This is natural selection. **This is Darwin's descent with modification. (Evolution)**
  - These adaptations can sometimes define a new species

- **Proof of Evolution: Homology**
  - The descent with modification theory explains that the resemblance between certain traits even if their functions are different, such as homologous structures



  - Examples:
    - The post-anal tail and pharyngeal pouches found in the chick and human embryo
      - however, these 2 structures are only found in the embryo, not in adulthood
  - A cladiogram is essential in organizing evolutionary steps
    - It shows that some features can be used to describe large groups of species
- **Proof of Evolution: Fossils**
  - The image that shows humans evolving from monkeys is FALSE
  - The idea of linearity/linear sequence/linear evolution is FALSE
  - The proof of evolution through fossils can be proven by several different species, one of which is the horse
    - Their foot structure changed over time, from having 4 bones, to 3, to 1. This happened for several reasons
      - Less bones means that they have less ligaments, which means they're lighter, which means they can run faster
      - They went from browsers of vegetation (in forests) to grazers in plains
    - Their tooth structure changed because grazing in plains means they might also eat sand/soil/rocks

- At 15 million years, there were about 5/6 different horse species living (linear evolution doesn't make sense)

- Also applicable to humans, at around 2 million years ago, there were at least 5/6 different human species living

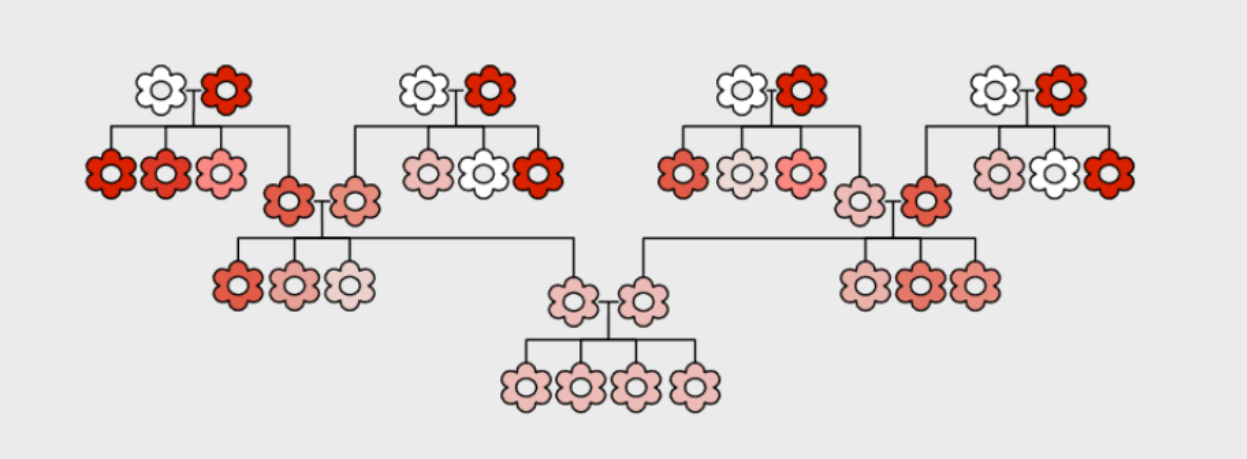
- **Proof of Evolution: Vestigial Structures**
  - Even though fish do not have legs, they still have the pelvic girdle
  - An example of this is in whales, where they have their pelvic girdle simply floating (disconnected from other bones) in their flesh
  - In museums they need to attach the pelvic girdle via wires
  - There are several vestigial structures in humans
    - The nictitating membrane (third eyelid)
      - Hawks have it to protect their eyes from dust/wind
      - Fish/crocodiles have to protect their eyeballs
      - Humans have a piece of skin remaining that has no use
    - The appendix
      - Remanent of a structure that was much larger
      - The caecum/appendix is used to 'marinate' vegetation so the cellulose can be broken down to gain access to nutrients
      - However, we don't eat much vegetation, so it's not needed
      - It has a tendency to inflame, so we need to get it removed or we'll die
    - Goosebumps
      - Humans have a fine coat of hair on the surface of the skin
      - The tip of the hair will form like a layer between the tip of the hair and the root of the air that can 'hold' a small layer of warm air
      - Only known role is that it creates goosebumps
      - Some animals communicate through their fur, but we do not need to
    - Hiccups
      - A remnant from fish and amphibians
        - When water enters the mouse, the phrenic nerve is used to close the glottis so water doesn't enter the lungs

- In humans, the nerve innervate the diaphragm and goes through the lungs, heart and into the epiglottis
  - If for any reason (such as a big meal, or a false movement) the phrenic nerve can get squished, and we will start hiccuping
    - This happens via causing the epiglottis to shut down and this causes contraction of the diaphragm
    - Only way to stop hiccuping is to unsquish the phrenic nerve through a large movement of the body
  - So why do we have a nerve that is so long?
    - If you look at a giraffe, it has the same structure, this is because we both have fish ancestors
    - the respiratory system is right behind the vertebrate, and the phrenic nerve is very short, but since we have a different respiratory system (down in the thoraxic cage/more posterior, the nerve has simply elongated)

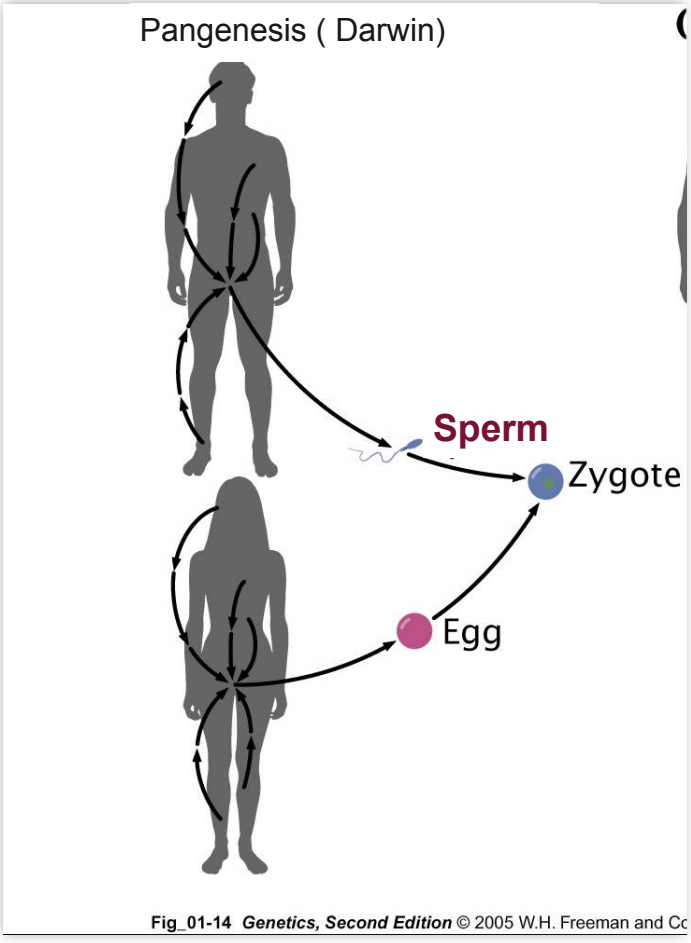
- **Proof of Evolution**
  - Finding a fossil in the wrong place would be sufficient to refute our concept of evolution
    - An example of this is finding human fossils in an era that had only fish (Devonian)

Chapter 4

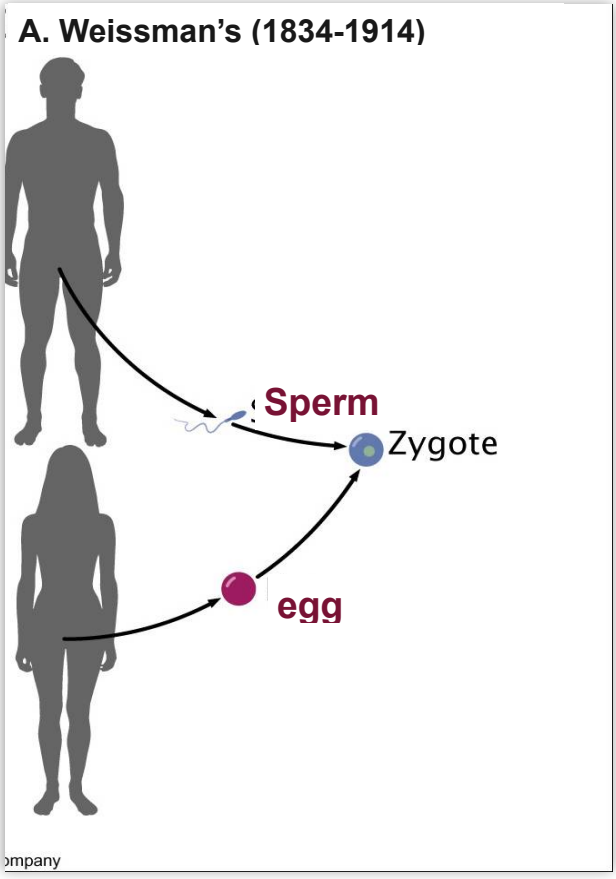
- **Preformism**
  - Was the popular theory up until the 19th century
  - Stated that all adults are present in their sex cell, but are in miniature size
  - Another theory stated that the mini adults are found in the egg, and that the sperm stimulates group and provides sustenance
    - It wasn't until the mid 19th century when microscopes were invented and scientists could see what the sperm contained
    - They also saw how so many "mini-humans" were being killed and it didn't make sense to them why so many would go to waste
  - The theory was refuted and the theory of epigenesis took its place
- **The theory of blending inheritence**
  - Was the popular theory up until the end of the 19th century
  - Stated that both parents partipated equally in the genetic makeup of offspring
  - "For each trait, the child would show an intermediate value between the traits of its parents"
    - example:
      - Mom has gene 1
      - Dad has gene 0
      - therefore, child has gene 0.5
    - This was quickly disproved, as the theory implied that all individuals would become identical (or very similar) and this is not consistent with current observations



- **Transmission of Traits (Inheritance): Pre-Mendel**
  - **Darwin's Pangenesis**
    - Created the theory of gemmules (heritary particles) produced by each part of the body
    - When an organ is used, it grows, and thus the more gemmules it contains. Also applicable vice versa
    - The gemmules would be transported in the bloodstream from all parts of the body and later assembled in the gametes when they formed
    - Gemmules would be the particles associated with the transmission of heredity
    - HOWEVER, this hypothesis was falsified by Francis Galton's experiment
      - extracted blood from each coloured rabbit and transfused them into the other rabbit, therefore the white rabbit should have some white spots, and vice vera, but since this didn't happen, the hypothesis was refused



- **August Weismann's Theory**
  - Proposed that only the sex cells were responsible for heredity, whereareas the rest of the organism was only a structure doomed to disappear with the death of the individual
    - Living beings are divided into 2 parts, the germline (gametes) and the soma (the remainder of the body)
    - The germline is impervious to environmental influences and heredity is simply the continuity of the germline
    - Thus, the germline and the environment can influence the phenotype, but the soma and the environemnt have no influence on the genotype.
    - Natural selection is the only mechanism that can eventually modify the germline of a population



  - A good example that shows the survival of the soma is first and foremost the receptacle of the germline is the angler fish and its light
    - They have light producing bacteria that attracts prey

- The females are big hoes and they want multiple sperm from mutliple guys to ensure success
    - When the males and females look MUCH different than each other, it’s called dimorphism