BIO 1130
Introduction to Organismal Biology
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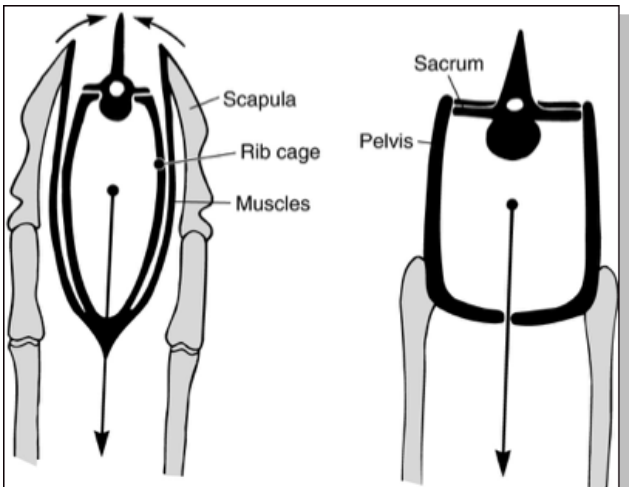
Monday: 10am-12pm
Wednesday: 10am-11:15am

Example of Evolution: Locomotion in Cheetahs

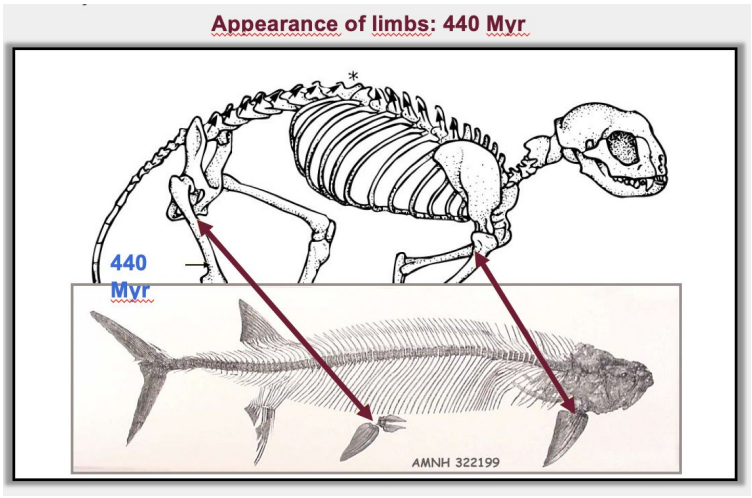


-pelvis fused to the vertebral column (spine)
-muscle between the ribcage and the leg bones acts as a shock absorber, keeps the head stable, prevents the movement of important internal organs
-forelegs have pendulum-like movement due to attachment to the ribcage
→ flexibility of forelegs allows cheetahs to react to their prey's movement
→ long limbs with this type of movement allows for long stride = faster speeds
→ preference for speed compromises stamina

→ flexibility of spine = longer strides and jumps (accounts for 30% of the stride)

-cheetahs are lightweight in comparison to other large felines = faster

-favour of speed compromises their ability to defend their prey = must prevent injuries to legs
→ speed may act as a preference in terms of reproductive advantages
→ hunt in groups to defend prey = one member watch over for other predators
→ eat prey very fast = prevents attracting other predators



-limbs first originated from fish fins
→ fish have structures in their fins that can be comparable to bones in the upper arm
→ pelvic fin in fish is independent of their skeleton, allows fish to keep stability
→ mammals have their pelvic bones attached to their vertical columns

→ the attachment of the pelvic bone to the spin first developed in primitive amphibians

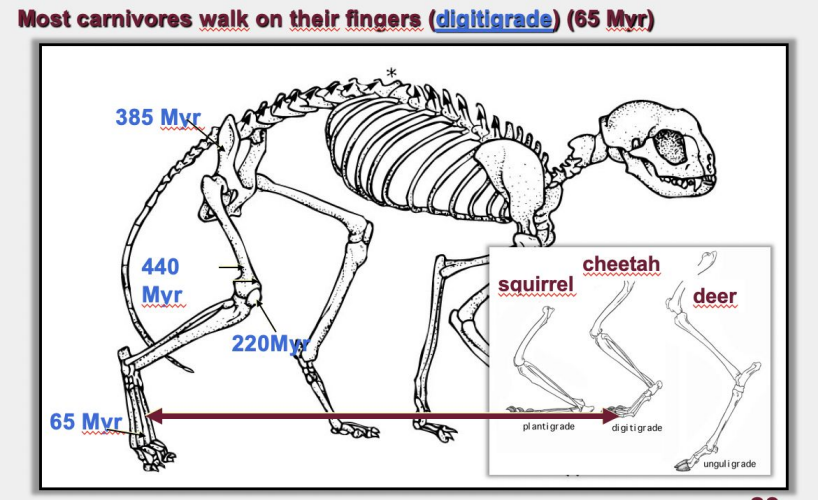
-cheetahs have an upright body posture vs early land vertebrates have limbs in a sprawled position

→ example: crocodiles move by pushing up from the ground

→ crocodiles have maximum size of living with sprawl posture

-mammals like the cheetah can evolve and grow to larger size due to their posture (rotation of the knee and elbows)

→ dinosaurs have rotation of the knee but not the elbow = bipedal and relied on hind legs



-cheetahs run on their toes, not pads of their feet (digitigrade)

→ took a different evolutionary path in comparison to humans

→ this type of walk is found in all carnivores

→ bear are an exception (omnivores)

-sole of foot is off the ground and included in the length of the leg

→ longer leg = longer stride = faster = adaptation for speed

→ has function in claws while allowing for longer legs

-deers have even more extreme evolution of this adaptation (walk on finger tips)

→ less bones in leg = lighter = faster

-felines can retract their claws, cheetahs have semi retractable claws to protect from wear and tear, and better for traction + swift hunting

-pigmentation of the fur has been adapted = camouflage for their environment = get close to prey without detection

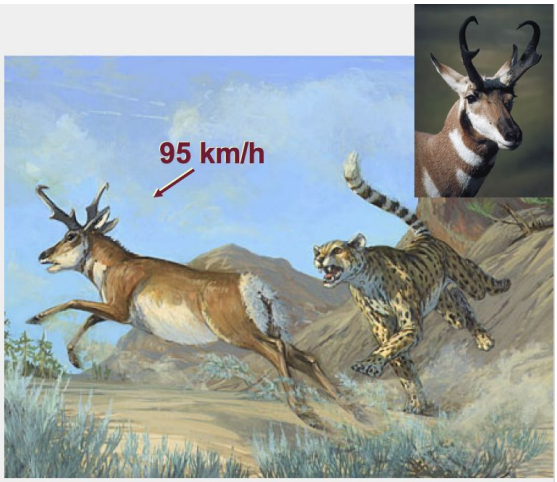
Question: What is a species? What is a mutation?

-Darwin's first theory = genetic variability is key to evolution

→ before Darwin, variability = imperfection and unimportant

-cheetahs have little/no genetic variation due to bottleneck effect

→ traumatic event wiped out nearly the entire population (disease, climate change, hunting...etc)
→ lack of genetic variation leaves species vulnerable to plague and disease
→ scientists don't understand how a species with so little genetic variation can survive and populate two continents



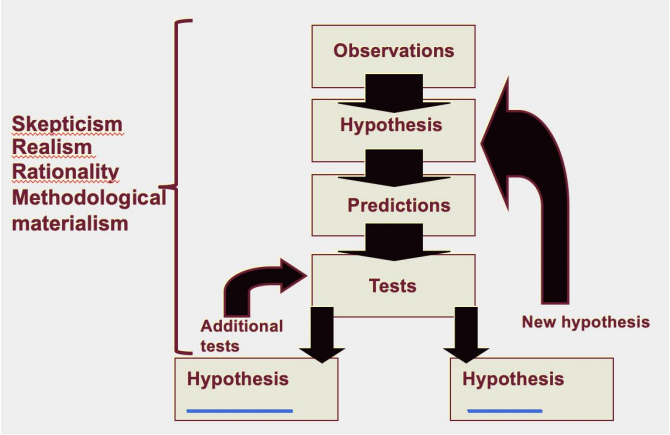
***Miracinonyx*: 'American cheetah' chasing a pronghorn**

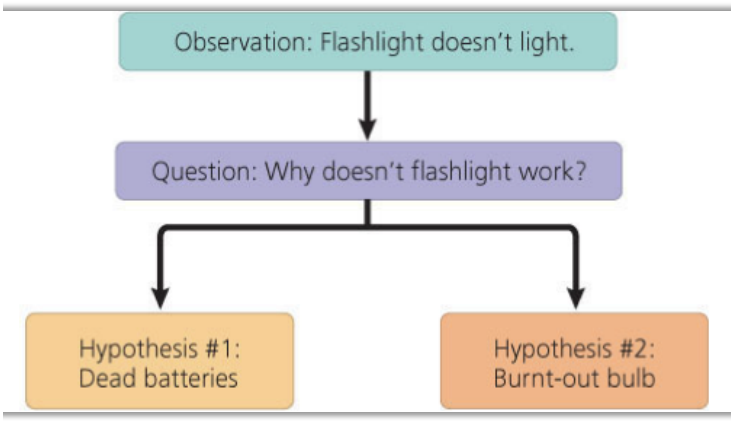
-North America has no top predator that mimics a cheetah's speed but there are prey present
→ potentially there was a predator that could reach top speeds but went extinct years ago
→ looking towards fossils to find bones of a large cat with features that can reach top speeds
→ potentially Miracinonyx was the predator but it went extinct due to unknown reasons
→ there no more selective pressure for Pronghorns but it is difficult to speculate if its speed will decrease (or how a feature will disappear)

Chapter 1. Science: Definition, Methodology and Perception

Sept 9th
-inductive reasoning (linked to a descriptive based approach)
→ making a generalization often based on numerous specific observations
→ hypothesis to general
→ problem with inductive reasoning:
-stopping at the generalization level, leaves room for error through the likelihood of probability
-ex: looking outside, seeing blue sky and determining it's a nice day
-deductive reasoning (linked to a hypothesis based approach)
→ involves stating a hypothesis and drawing conclusions
→ general to hypothesis
→ minimizes the probability of error
→ ex: looking outside, seeing blue sky, determining it's a nice day, checking weather network to ensure hypothesis is correct

Scientific hypothesis must be verifiable, refutable, reproducible





Scientific Process: Mimicry → [Viceroy Butterfly was deemed non-toxic in early study]
-monarch butterflies consume plants (milkweed) with toxins that tis body can absorbs, however this causes the butterfly to be toxic (prevents consumption from predators)

→ other non-toxic species have evolved to mimic the monarch's wing pattern to also avoid predators from consuming them

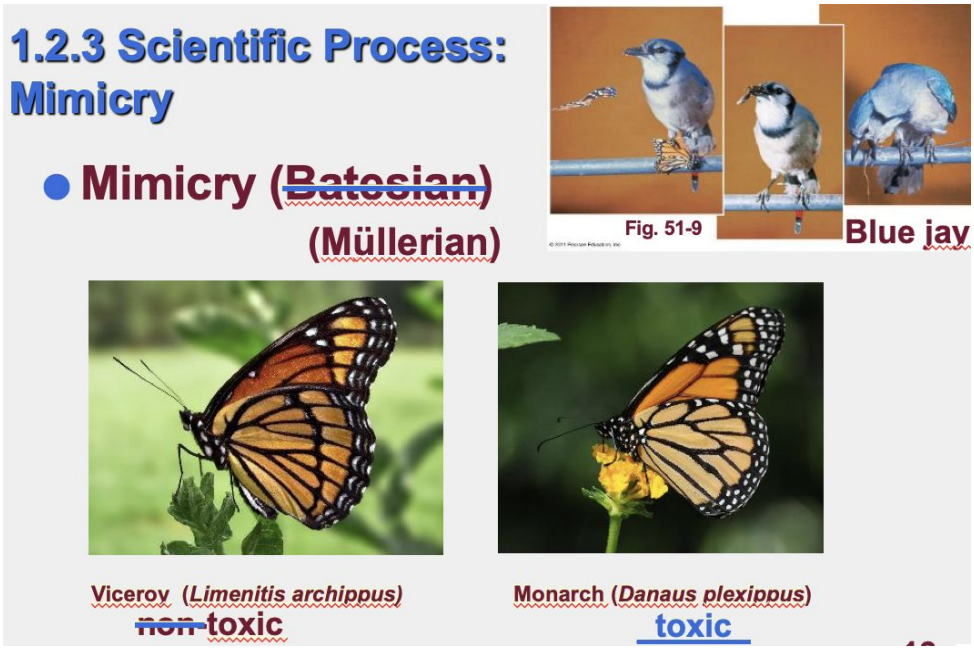
→ known as Batesian mimicry = non-toxic species adopts the physical features of a toxic species, prevents provocation from predators

-the viceroy became toxic over time

→ previously on-toxic 100 years ago, recent tests revealed that both species are toxic

→ became Mullerian mimicry = toxic species evolve shared physical features to further enforce certain physical features with toxicity (stronger enforcement against predators)

-the test stating that the viceroy species was non-toxic was never retested until recently = scientists must be skeptical and meticulous



Chapter 2. Evolutionary thinking before Darwin

-Anaximander was the first philosopher to write out his thoughts = preserved his writing to present day = glimpse of philosophy from that time period

→ people rarely recorded their thoughts before him

→ he claimed that water was the central element of life = the creation of all matter was derived/ explained by water

→ explained that the first baby was born by fish giving birth on land

-Empedocies believed there were four main elements that created life

→ fire, earth, air and water

→ forces within these elements drew them together or repulsed them from each other (forming new objects)

→ some combination of love (attraction) and hate (repulsion) formed the first living beings like humans

-Democritus came to the conclusion there were two universes, the universe of man and the universe of atoms (macroscopic and microscopic)

→ deduced the idea of atom by the theory of separating paper into smaller and smaller pieces until he could only separate the last two particles of paper

→ theorized the idea that there is a force that draws and keeps atoms attracted and bound to each other

→ the properties and combination of these atoms would create human beings and other living creatures

→ he claims the first human beings were born from dirt through spontaneous generation

Conclusion:

1) Acts of creation are not due to gods but rather die to the innovative power of matter
2) The origin of all things is not teleological (with an ultimate goal/destiny) by is the result of chance

-Socrates began the approach to more abstract questions like the concepts of beauty, kindness, justice, and sanity

→ argued from multiple different perspectives to see how far he could defend his position

→ arguments about logical ethical, and political questions are = interesting not for search of truth

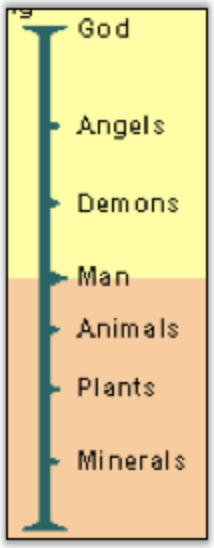
→ answers were not found in nature but within one's self

→ believed in essentialism

Essentialism: we are born with the perfect understanding of pure concepts (i.e. justice)

→ destined to spend our lives trying to convey and explain the purity of the concept
→ those who were born blind would maintain the image of a perfect chair despite never having seen a chair

-Aristotle was Socrates' student but beliefs countered Socrates' beliefs
→ to define and understand the nature of concept, we must be exposed to that concept
→ empty slate when born
→ still uses this form of understanding today
→ when describing new species, we are trying to understand its nature and its essence
→ by studying nature, we could understand the essence of the universe
-Aristotle believed that souls existed in a hierarchy
→ bottom tier is the soul in a vegetal state (minerals and plants)
→ middle tier is the animates soul (animals)
→ top tier the the rational soul (humans)
→ Aristotle was the first to create a hierarchy of beings, still follow this system today with the classification of species
→ believed in creationism = all beings were born the way they exist
→ thought variability was unimportant and imperfect = thought species were unchangeable = born the way they exist



-decline of Roman Empire = Christianity becomes main ideology in the West
→ dark age for science, lack of advancement due to tight religious grasp
→ God becomes measure of all things

-loss of religious power over the people due to new discoveries such as new land and technologies
→ created small opening of curiosity and doubt = people challenged religion
→ French revolution was a rejection of order, hierarchy, government and religion
→ Industrial Revolution followed along with the development of many new scientific ideas

Chapter 3. Charles Darwin and the theory of evolution

Sept 16th
-Darwin first left in 1831 to do the cartography of the coast of South America (commissioned by the britsih government)
→ companion of the captain, quickly became the naturalist

-Darwin was influenced by William Paley's "Theology, or evidences of the existence and attributes of the deity" and Charles Lyell's "Principles of Geology"
→ Paley is the father of the theology of nature, harmony and design in nature are indicators of God's presence

→ Darwin started the expedition believing in the Great Flood and in Cuvier's catastrophism but by the end of the trip, Darwin was aligned with Lyell and Hutton's principle of uniformity

→ there was a belief at the time that the human eye was far too complex to be developed by the laws of nature, must have been made from God or a higher being

-After a significant earthquake to one the island during his expedition, Darwin noticed significant change to the coastline of the island

→ later during his expedition, he made observations of sea animals fossils at 3000m altitudes

→ his observation of these changes strengthened his faith in the principle of uniformity

-Darwin noticed very distinct fauna in South America

→ why did Africa, Europe, Australia and South America have relatively few species of flora and fauna in common?

→ Why are mammal fossils of South America absent from the current fauna? Why do these fossils show resemblance with current species found only in South America?

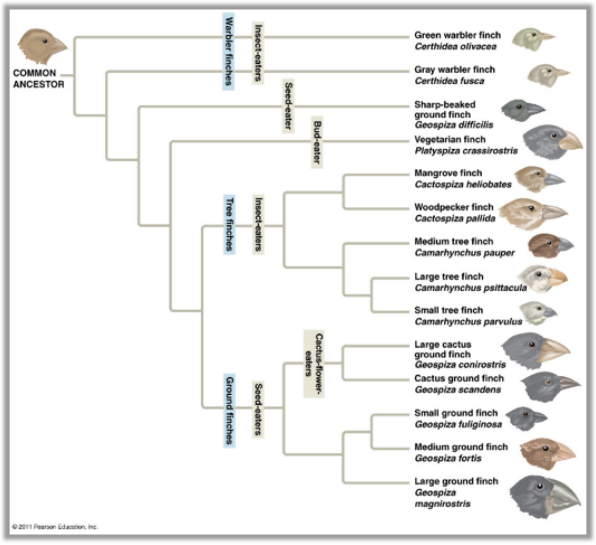
-Darwin first mentions that species share a resemblance due to a common ancestor (1837)

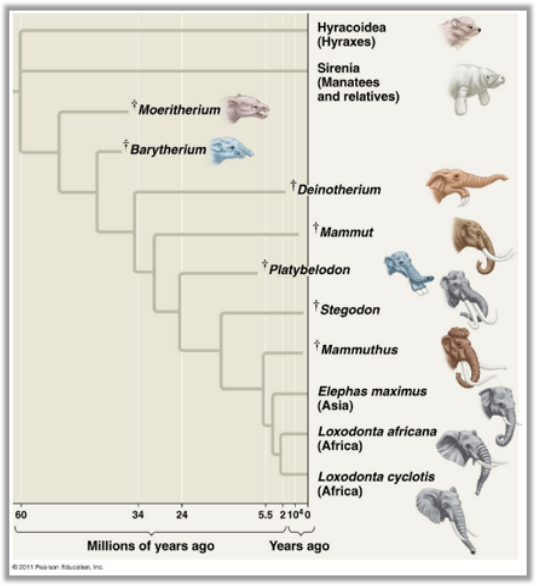
→ rejects fixity, contradicts the religious dogma of the time

-Rejects Lamarck's evolutionary mechanism (environmental determinism)

→ due to the vastly different species he saw within a common environment, he went against Lamarck's belief and claimed that a common ancestor causes the similarities in species

→ rejected Lamarck's theory because Darwin couldn't see it in action in nature



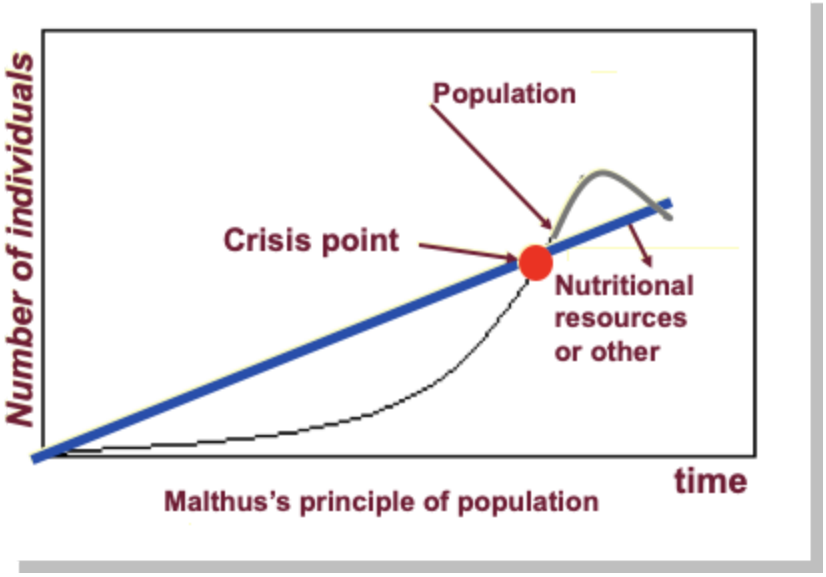


-Darwin heavily relied on fossiles to fill in the gaps between species with vastly different morphologies

→ Darwin wanted to find intermediate forms of animals in the form of a fossil to connect any gaps in the difference in morphology

→ Based this theory one the knowledge that 99% of the species that have existed on Earth are extinct, most evolutionary branches finish with extinction

-Darwin was inspired by his reading of “An essay on the principle of population” by Thomas Malthus, main source when formulating his theory on natural selection



-In Malthus’ book, he stated that:

→ human populations grow geometrically while resources grow arithmetically

→ when these numbers coincide, there will be chaos

→ there are winners (those who can go on to reproduce and pass on their genetic information), and there are losers (those who could not support themselves/get enough resources to survive and reproduce)

The human population increases faster than its capacity to feed itself, leading to war, famine, and significant reduction in population size. Government has to step in and put in place orders to prevent this from occurring.

-Darwin’s first observation was that a species produces more offspring than the resources of an environment can sustain, and only some offspring live to reproduce

→ this pattern exists in plants and animals

→ allows for a better chance of some offspring surviving to reproduce

-Darwin’s second observation was that members of a population often vary in their inherited traits

→ i.e. the number of spots on the ladybird beetles have genetic variability depending on their parents genetics

→ the variability of traits in the progeny

→ allows for offspring to survive any chances to the environment

TWO INFERENCES:

1) 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
2) From generation to generation, this unequal capacity to survive and to reproduce (differential reproductive success) results in an accumulation of favourable traits in a population

EXAMPLE: FISH IN CHANGING ENVIRONMENT

-fishes with variation in their colour due to inherited traits will be impacted by predation if their colour contrast their environment, making them stand out to predators

-fish who can blend in and camouflage with the water will survive and proceed to produce offspring with the traits that gave them the advantage

-if the temperature/environment of the habitat changed and fish who can blend with the environment suffer, the fishes who can adapt to the change will go on to produce offspring with the traits that gave them the advantage

<u>THEREFORE</u> offspring will often have variability to survive to produce offspring and continue the lineage

→ If selective/environment pressure are immense, the species may be pushed to one species morphology

→ if there is a bottleneck effect where genetic variability is diminished, the species will be unable to adapt to change and suffer from predation

-when Darwin noted this in his book, scientists began to understand the importance of the variability

→ selective pressure is needed in order for the species to undergo evolution, the species may not necessarily diminish but it will not undergo any change

→ if there is contrasting selective pressure, the net total of the pressure will determine how the species evolves

-Darwin was forced to publish his findings in 1858 due to another scientist, Alfred Russel Wallace drawing the same conclusions as Darwin and stating that he would soon publish his research

IMPORTANT NOTATIONS WITH NATURAL SELECTION:

-individuals do not evolve, populations evolve

→ we can measure at the population level, which characteristics allow for the species to survive and give advantages

→ individually, we cannot evolve as we are only the carriers of the genes passed on from our parents

-those who have the right traits to survive and have offspring, are better suited for the

environment and therefore “more fit”
→ if a trait is well-adapted to its environment, it confers a higher relative fitness aka reproductive success
→ a trait that increases fitness in a specific environment might lose this fitness in a changed environment

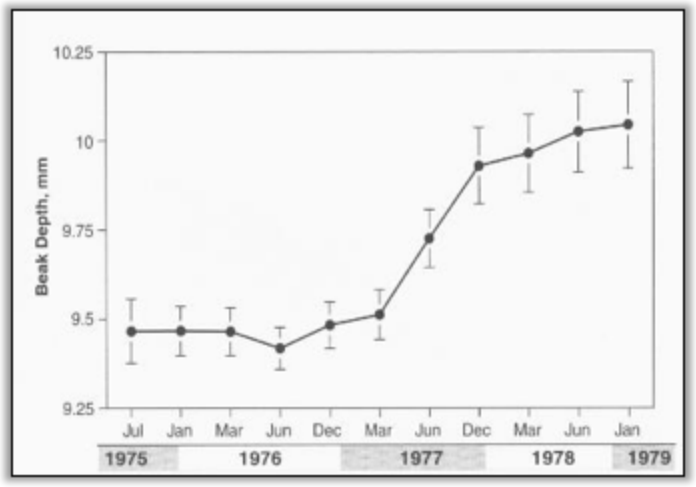
-Artificial selection is finalized, the end goal is predetermined/precedes the cause = can be obtained in a few generations
-Natural selection is not finalized = cna take long periods of time to observe changes

EXAMPLE: PEPPERED MOTH

-the genetic variability of peppered moth was due to intense usage of coal spreading into the natural habitat
→ Individuals who had more contrast against the environment suffered from predation
→ over a couple generations, the moths that had a darker wing pattern survived and proceeded to have offspring
→ as technology advanced and the environment was cleaned up, the darker moths have diminished because they now have more contrast against their environment
→ lighter coloured moths are seen in abundance in the cities and in the forests

EXAMPLE: GALAPAGOS FINCHES

-the beak of the bird provides the diet-type of the bird (seeds)
→ there was a slight variability in the height of the beak
→ after the drought in 1977, there was a lack of prey for the birds and the only type of nourishment available were larger-type seeds
→ the population that managed to survive were those who had larger beaks



EXAMPLE: ADAPTATION FOR ALTITUDE SICKNESS

-altitude sickness can be avoided by slowly adjusting and adapting your body to the lack of oxygen
→ the guide who was already adapted to the high altitude and low levels of oxygen allowed him to move with normal function whereas those who are not adjusted will have more difficulty

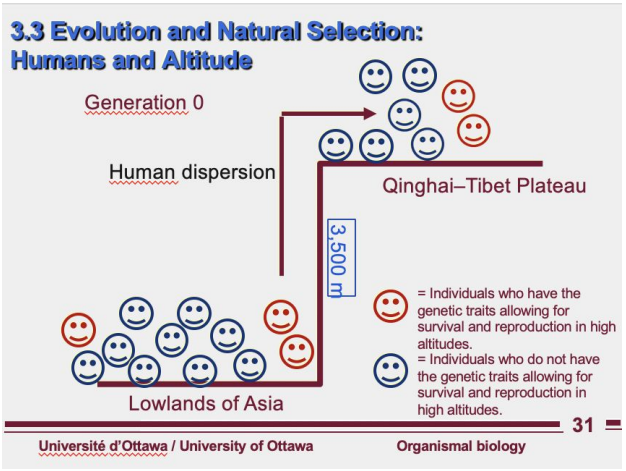
→ is an acquired trait but some are born with genetics that give them an advantage to adjusting to lower levels of oxygen

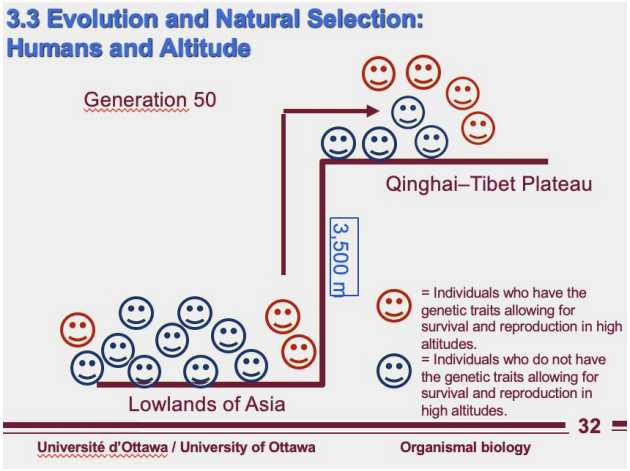
-over the course of 3000 years, natural selection causes the population that live on the Tibetian Plateau to show an abundance of individuals who have genetic traits allowing for survival and reproduction in higher altitudes

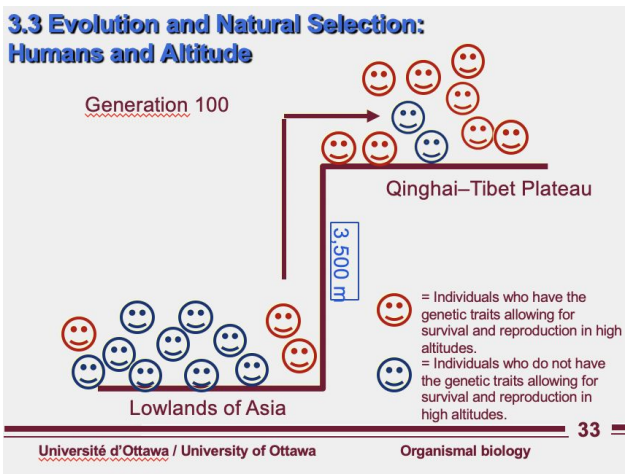
→ this was due to a mutation
→ acclimatization needs some form of genetic capability in order for those who travel to higher altitudes to survive, despite being an acquired trait
→ those who have adapted to higher altitudes, have blood cells that are more receptive to oxygen in a lowly oxygenated area
→ they also have deeper breaths and a quicker breathe cycle
→ slightly larger capillaries compared to others who live in lower altitudes, more transportation of oxygen to other parts of the body

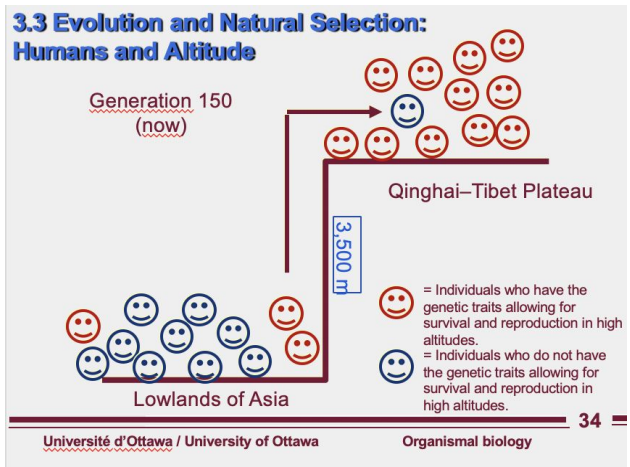
-mutations do not need a reason to occur, they are random and do to genetic errors

→ mutations are the source of genetic variability, they are needed for evolution









Chapter 4. Genetics, Neo-Darwinism and Modern Synthesis

Sept 23rd

-the preformist hypothesis from the 19th describes that there was a miniature version of a human in the sperm, and that the egg provided the environment for the human to grow

→ there were doubts to this theory when microscopes invented and realized there were no humans in the sperm

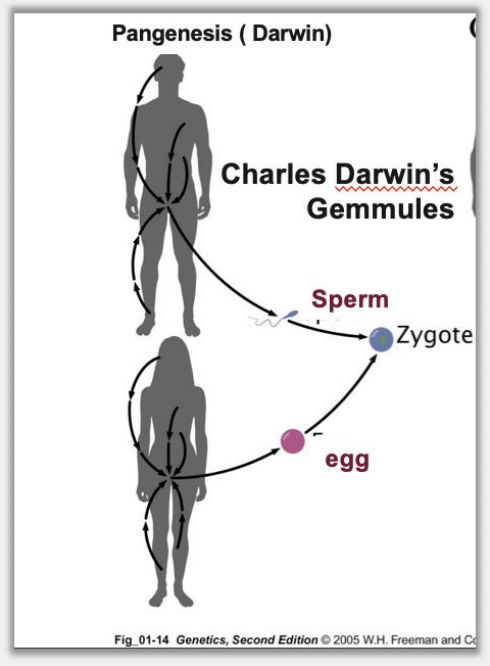
-the epigenesis theory describes that organisms start off as individual cells and eventually differentiate into different features/organs/limbs

-theory of blending inheritance was universally accepted until the end of 19th century

→ both parents participate equally in the genetic makeup of offspring

→ each trait the progeny would express acts as an intermediate value of its parent's traits

→ thus all individuals would rapidly become very similar (not consistent with what is observed in nature)



-theory of gemmules (hereditary perticles) presented by Darwin

→ gemmules were associated with the transmission of heredity

→ all organs produced gemmules, when an organ i used, it grows and produces more gemmules

→ all gemmules were convened in the sex cell (transported by bloodstream to the gametes) and were passed on to the progeny

→ Galton tried transferring blood from a white rabbit to a grey rabbit, he expected that the grey rabbit would eventually have a progeny with white fur but the theory was proved to be untrue

-Weismann's theory proposed that only sex cells were responsible for heredity = rest of organism doomed to disappear along with death of individual

→living beings are divided into two parts, germline (gametes) and soma (remainder of body)

→ germline not affected by environmental changes, heredity is continuity of germline

→ germline and environment can influence phenotype, soma and environment cannot influence genotype

→ natural selection only mechanism to modify a population

→ a new study is finding evidence that there are influences from the environment that can change the progeny but not necessarily have a strong impact on the evolution of the species

EXAMPLE: MONKFISH

-the male serve no purpose but to fertilize the eggs in the females

→ the male will fuse with the female and lose all its features to the female

-this goes against Weismann's theory

-the male's phenotype is unnecessary, and nearly vanishes as the only usage is the testicles