MIDTERM #1

September 24, 2019

ROUGH OUTLINE

- 80 minutes
- 40 points
    - 19 multiple choice
    - 8 association
    - 5 short/long answer questions

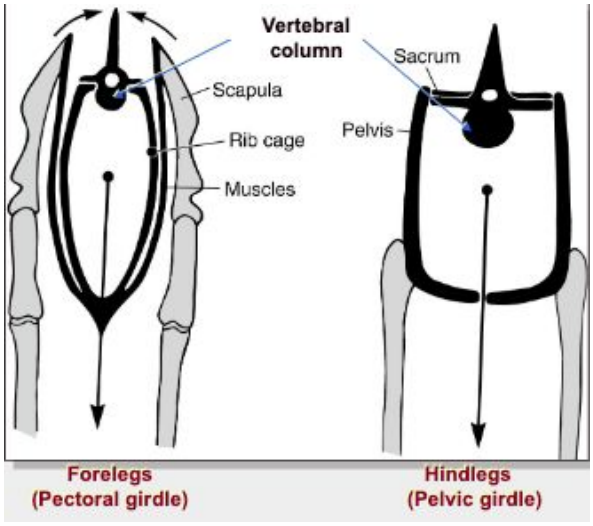
INTRO

September 4, 2019

EVOLUTION

- An example of evolution is the locomotion of cheetahs
- They are incredibly fast due to evolutionary reasons
- They have a high success rate in predator/prey relations
    - Use surprise more than speed to their advantage
    - Acceleration is fast
    - Success is dependent upon distance from prey

Physiology of a cheetah



- Hind legs play a vital role
- Head does not move
- Pelvic girdle
    - Pelvis fused to vertebral column
    - Acts as a motor to the motion

    - Pushes the vertical column
- Pectoral girdle
    - Limb slides on rib cage (scapula)
    - Moves with thoracic cavity
    - Scapula located behind rib cage for humans (required for tree dense environment)
        - In cheetahs, scapula is located on the side
    - Wish-bone like structure keeps head stable
    - Front legs used mostly for orientation
    - Scapula allows for longer strides because of their continuity with the limbs

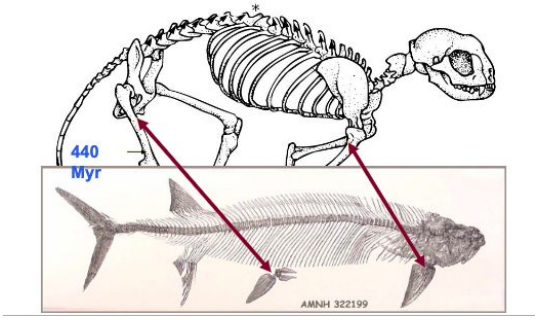
**The same system exists in the gazelle, however they have evolved for different purposes*

Evolutionary compromise

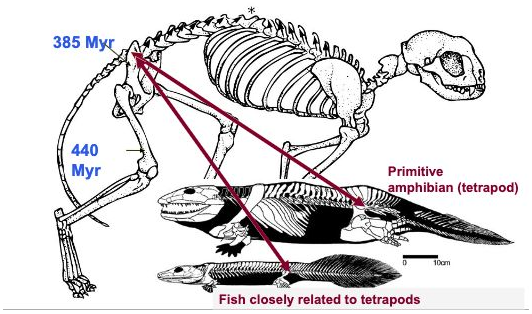
- The cheetah can never become the prey, if they do they will lose their speed and ability to capture prey
    - Therefore, if a stronger predator takes over their prey, they will not compete
- Humans are the only mammalian species that can choke on their own food (evolutionary purpose)

Morphology of a cheetah

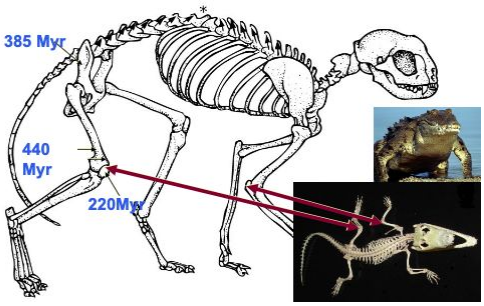
1. *Appearance of limbs*
    - Origin from fish
    - Fish had pectoral and pelvic fins for equilibrium
    - 440 Myr



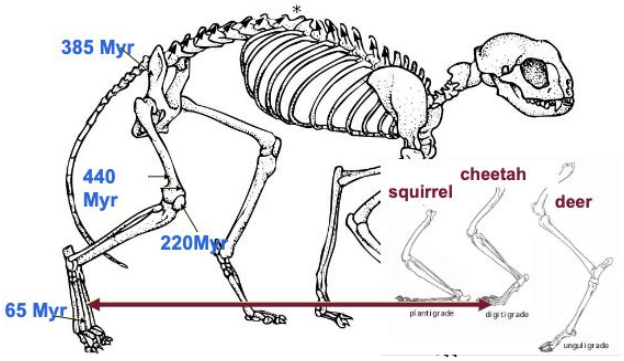
2. *Pelvic girdle attached to the vertebral column*
    - Terrestrial animals developed this because it was less dense on land than it was on water, therefore it is more efficient
    - 385 Myr



3. *Rotation of the knee and the elbow under the body*
    - Reptiles have failed to develop this
    - Torsion of the body was important for movement
    - It is more efficient
    - Sprawled posture, transformed body (passive evolution) allowed for body mass change
    - Pendulum motion is more efficient for mammals
    - 220 Myr

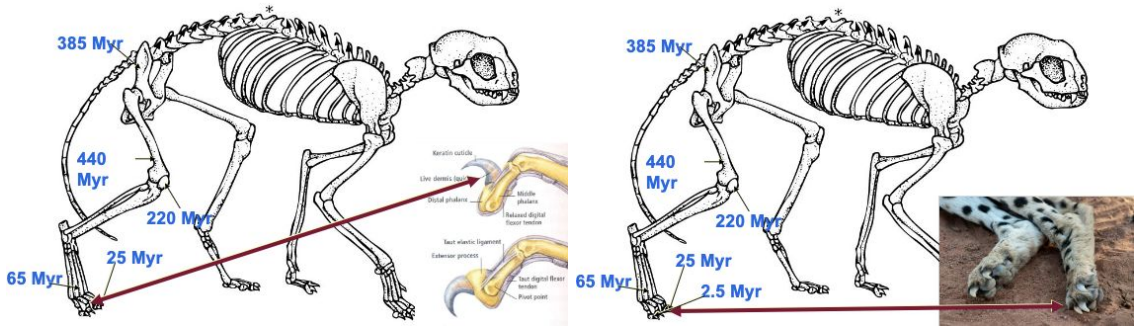


4. *Digitigrade*
    - Carnivores begin walking on fingers (digits)
        - Humans walk on soles
    - 65 Myr
    - **Advantages:** Speed, sole of foot goes with length of limb (long limbs allows for long strides)



5. *Retractable*
    - Feature is unique to cats
    - 25 Myr
    - Cheetahs have semi-retractable claws
    - **Advantages:** Reaction time, gives more traction, allows for cheetahs to change directions quickly

- 2.5 Myr



∴, *The hindlegs of a cheetah is the result of 440 Myr of evolution.*

ADAPTATIONS OF OTHER ANIMAL GROUPS IN RELATION TO THE CHEETAH

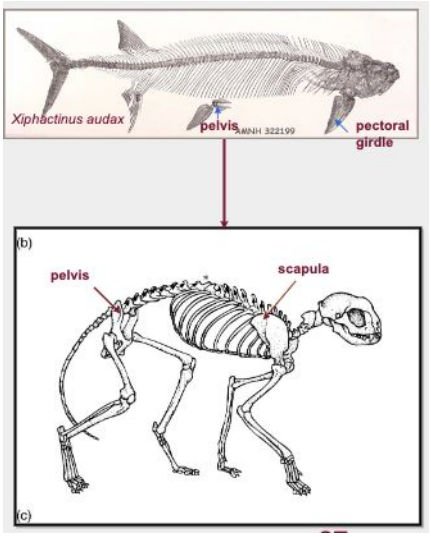
1. Adaptations of *vertebrates* in cheetahs
    - Locomotion organs (fins or limbs)

2. Adaptations of *terrestrial tetrapods* in cheetahs
    - Scapula detached from the skull
    - Pelvis fused to vertebral column

3. Adaptations of *mammals* in cheetahs
    - Rotation of knees and elbows under the body for support and/or speed

4. Adaptations of the order *carnivores* in cheetahs
    - Digitigrade

5. Adaptations of *felines* in comparison to cheetahs
    - Fur pigmentation
    - Stride length
        - Long and thin limbs especially in the distal end
        - No ligament in the tip of the limb
        - Higher fusion of bones doesn't require ligaments
    - Speed
        - Lightweight, slender and muscular body
    - Flexibility of spine (speed, stride length)
        - 1 jump is approx. 6-7m
        - Extension of spine allows for cheetah to generate speed



WHAT IS A CHEETAH?

- Mammal characterized by few derived traits that differentiates it from other feline species
- Result of 3500 Myr of evolution

- More than 99% of characteristics have evolved in species that are extinct
- Less than 1% of its features are unique
- More the result of the history of its ancestors than of its own history
- Applies to humans
    - Origin of humans: all current features are attributed to the first human
    - This being said, there are discrepancies in human evolution (Ex. abstract thought and speech, possible that neanderthals developed it)

IMPORTANCE OF GENETIC VARIABILITY

- Royal cheetah
    - Had irregular pigmentation
    - Unsure if it's a separate species or simply a mutation
- Cheetahs have little variability
    - As a result, a simple disease can kill all cheetahs (no genetic resilience)
- Darwin proposed the idea that genetic variability is advantageous

Population bottleneck Changes in environment causes population of cheetah to be drastically reduced to a small Population

'AMERICAN' CHEETAH

- Extinct for 20,000 years
- In general, 99% of species are extinct
    - Holes in views of life as a result of this
- Prey in North America (**pronghorn**) that are a typical prey of a predator such as a cheetah
    - Fast prey, no predator
- **Miracinonyx** (aka 'American' cheetah)
    - Fossil evidence similar to morphology of African cheetah

LECTURE 1

The Scientific Method

1.1 DEFINITION OF SCIENCE

Science The intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment.

Biology Science of how life works.

Scientific inquiry Diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work.

2 approaches

1. Description-based

    - Describing nature
    - We can protect different species through this approach

2. Hypothesis-based
    - Explaining nature
    - Framework used to explain nature

1.2 THE SCIENTIFIC METHOD

2 types of reasoning

1. Inductive reasoning
    - Link to descriptive-based approach
    - Generalization based on numerous specific observations
    - May provide for a false idea of what's going on
    - Common type of reasoning
    - Data → generalization or assumption only based on few observations

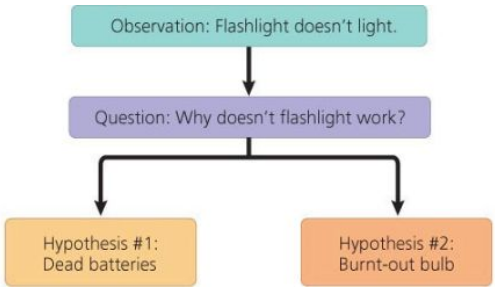
2. Deductive reasoning
    - Link to hypothesis-based approach
    - Evidence-based, provides evidence to get closer to the truth
    - Ensures that the hypothesis is closer to the truth
    - General → particular

Ex. Dead fish

- Starts with 1+ observations
- Scientific process must be implemented
- 4 episodes in 1 month
- Began as inductive
- *NOTE* All scientific inquiry relies on observation

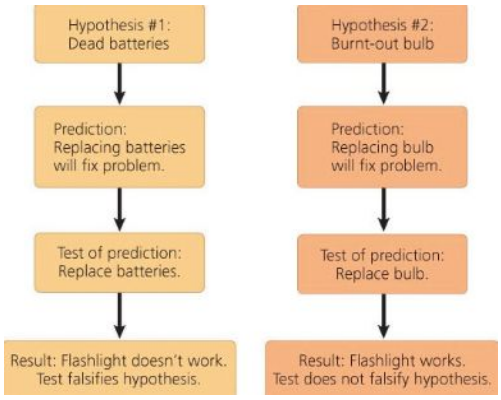
1.2.3 THE SCIENTIFIC PROCESS

- Scientific hypotheses must be verifiable, refutable and reproducible



- From a hypothesis, you can make a prediction
- Predictions must be testable and give a clear result
    - Essentially a way to test the original hypothesis
- The hypothesis can be falsified or not falsified

    - Proving a hypothesis to be a scientific truth is not possible
- If a hypothesis has survived multiple falsification attempts, it becomes a **theory**

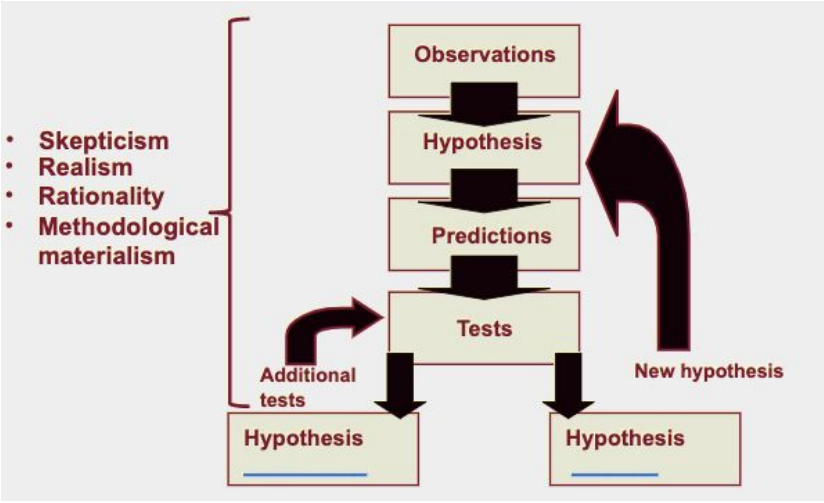


Ex. Dead fish in Gatineau

- After testing, the cause of death was gas bubble disease caused by the outflow of a hydro-electric dam on the Lievre River
    - Oversaturated in oxygen and nitrogen

Ex. Orange

- *Obs.* This orange is sweet.
- *Hyp.* All oranges are sweet.
- *Pred.* If I taste all kinds of oranges, then they will always be sweet
- *Tests* Tasting all kinds of oranges
    - Travel to Madagascar: tasted over sour orange
- Hypothesis falsified



*4 clauses on the left of Fig.1 allows for you to say that science can be advanced

Contract between science and knowledge

1. Initial skepticism on facts
    - Asking honest questions on facts and hypothesis
    - Re-test what has been formed
2. Realism
    - World is older and exists independently from my perception of it
    - Receive data by face value
    - No preconceived ideas that affect hypothesis
3. Rationality
    - *Logic* Steps of a scientist must have coherent steps
    - *Parsimony* Acceptable theories are hypothetically the most economical in terms of assumptions (simple hypothesis trumps others)
4. Methodological materialism
    - All accessible in the real world is material or has material origin
    - There are no supernatural forces in science

<u>Ex.</u> Crop circle enigma

- Spontaneous crop circles appearing in farming fields of an unknown origin
- Exterrestrials = main theory
- Was a result of two individuals doing it as an art form
- Therefore, the most parsimonious hypothesis was correct

<u>Ex. of skepticism</u>

- Two species of butterflies: viceroy and monarch
- Monarch are toxic, viceroy are non-toxic
    - Both butterflies possess patterns similar to each other
    - Was believed to be a result of *Batesian mimicry*
- *Batesian mimicry* is mimicry in which an edible animal takes on the appearance of a poisonous one to steer off predators
- After testing, scientists found that birds become sick after consuming viceroy bodies (they are toxic)
- What was believed to be Batesian mimicry was actually *Mullerian mimicry*
- *Mullerian mimicry* is mimicry where two poisonous animals develop similar appearances as a strong advertisement of their toxicity

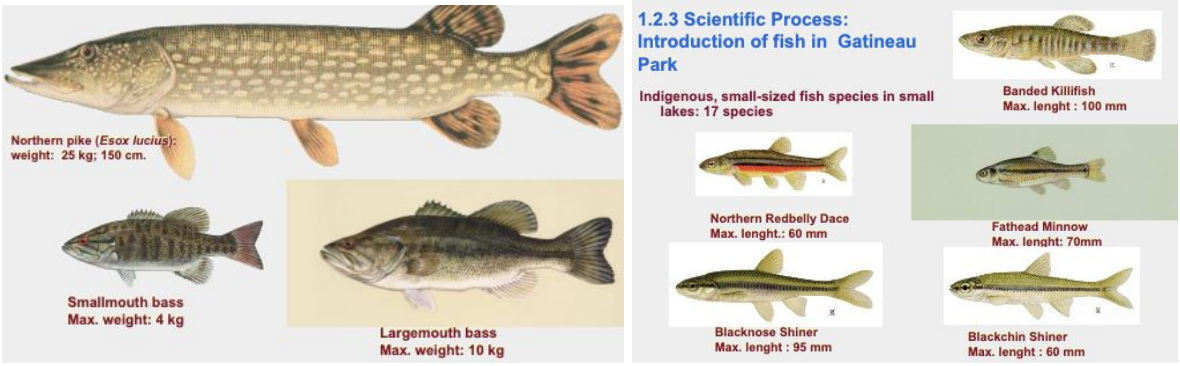
<u>Ex</u> Case study of the odd field mouse

- Fur colouration was studied
- Odd field mice living by the beach (white sands) had white fur, while the odd field mice living inland had brown fur
    - Prediction made by inductive reasoning
- *Hyp.* In this species, fur colouration patterns have evolved as camouflage in their native environments (protection against predation)

- *Pred.* If mice have a colouration that does not match their habitat then they will be preyed on more heavily than the native, well-matched mice
- *Test*
    - Plasticine mice spray painted in beach or inland colours
    - Spread both colour models (control + experimental) in equal numbers in both habitats
    - Count signs of attacks
- Test proved original hypothesis

Ex Case study of fish in Gatineau Park

- Fish species introduced for recreational fishing are often *piscivores* (fish that prey on other fish)
    - These types of fish were introduced to Gatineau Park (not native to the area)
- *Obs.* Small lakes in which piscivores have been introduced do not have schools of small fish near shore
- *Hyp.* Introduction of piscivore fish species in small lakes would result in a decline in the number of smaller species
- *Pred.* In small lakes from the same region, if lakes contain introduced piscivorous species then they will have fewer smaller fish species than lakes without the piscivores
- *Test* Determine the # of fish species in both types of lakes
    - A comparative analysis of fish species diversity in a region with small lakes with and without introduced piscivores



Piscivorous species vs. prey

- *Results:* Lakes without piscivorous fish species have significantly more (50%) small-sized fish species than lakes with introduced piscivorous

- Biodiversity is not conserved, no piscivorous species introduction in Gatineau Park to preserve it

CONCLUSION

- A valid scientific process must respect the clauses of the contract between science and knowledge
  - Breaking one of the clauses invalidates the contract because the acquisition of knowledge is not associated with an object search for the scientific truth (which can't be obtained)

LECTURE 2

Evolutionary thinking before Darwin

2.1 TRANSFORMISM IN ANTIQUITY

I. Anaximander

- First philosopher to write his thoughts
- Humans were first born as a fish, fish burst open on land and became human
- Main idea: All life came from water, the central element of the universe

II. Empedocles

- Student of Anaximander
- All structures of the world (matter) are made up of fire, water, air, earth
  - These elements are simple, eternal and unalterable
- Two major forces interact constantly on these elements *(love and strife)*
  - Love is construction, strife is destruction

III. Democritus

- Most scientific (beliefs based on deduction)
- Two realities
  1. Atoms
  2. Emptiness
- *Matter* is a group of atoms in constant movement. An atom cannot be created or destroyed and is the smallest possible element **(Atomic theory)**
- 2 particles are stuck together with an intrinsic force that keeps them together to form shapes
- *Spontaneous generation*: Belief that humans and animals are born directly from dirt

Conclusion

1. Acts of creation are not due to God, but rather due to the innovative power of matter
2. The origin of all things is not teleological (there is no goal, no ultimate purpose). Everything is random and a result of chance.

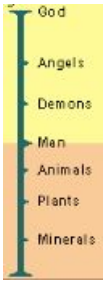
2.2 CLASSICAL THINKERS

- Materialistic approach of past philosophers converts to abstract questions
- Instead of nature, questions are posed towards the contemplation of the soul
  - Search for an understanding of concepts such as beauty, kindness, justice, sanity

    - Arguments about logical, ethical and political questions are more interesting than the search for truth
- Answers cannot be found in nature, but within the self

I. Plato
    - Theories of Ideal Forms (Essentialism)
        - The visible world is a poor imitation of the ideal world
        - We are born with a perfect understanding of the ideal world (ideas of justice, chair, etc.)
        - Things in nature are the imperfect version of its ideal form
        - Observing nature becomes more confusing, messes with our previous knowledge of ideal forms

II. Aristotle
    - Student of Plato
    - Does not believe in innate aspect, he believes that it is something we acquire
    - It is important to describe the essence of living beings
        - Essence can be observed in nature
        - Defining essence = defining species is similar
    - He is a vitalist, perceives multiple levels of soul (vegetal, animate, rational)
        - Rational = human
        - Animated = grow, reproduce, move
        - Vegetative = grow, reproduce
    - Created the *scala naturae* (great chain of beings) or a hierarchy of soul
        - Believes that species are fixed + unchangeable
    - Was the first to put order in nature

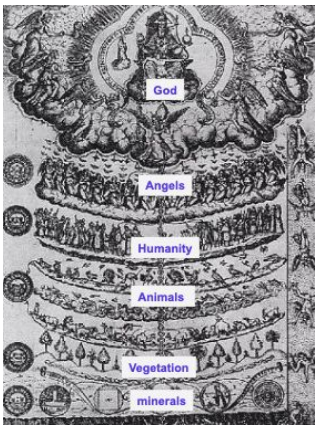


All classical thinkers believed that Gods made creation.

Summary of Plato and Aristotle (visions on essentialism)	
Plato	*Aristotle*
• World of Ideas or Forms that is completely separate from the material world • Things/beings we observe with our senses is a poor imitation of its perfect representation in the world of Forms • The World of Forms is innate	• No need to postulate the hypothetical existence of an innate world of Ideas or Forms • Essence of things can be determined by observing nature and carefully examining the world around us

2.3 IMPACT OF CHRISTIANISM

- Decline of Roman empire results in Christianity to be the main ideology in the western world
- Dark age for *transformism* (evolutionary thought)
    - They used the chain of being, species are fixed
    - Scala nature becomes metaphysical and true
- God is the measure of all things



2.4 FROM FIXITY OF SPECIES TO TRANSFORMISM

- Renaissance in Europe (14th-17th century)
    - Power of religion is challenged
    - Reverts back to nature (expeditions and discoveries)
- French revolution (end of 18th century)
    - Open mindedness towards science
    - Challenge of ordered systems (i.e. monarchy, aristocracy)
    - Quest for order to progress
    - Return towards experimentation and observation of nature
    - Attempts to classify living organisms done within the *Great Chain of Beings*

Linnaeus (1707-1778)

- Swedish scientist
- Father of modern taxonomy
    - Hierarchical classification
    - Binomial system of nomenclature (Genus species)
- Application of Aristotle's essentialism
- Not an evolutionist, believed that God created the world
    - Saw it as discovering how God created the world, putting together the puzzle

Buffon (1707-1788)

- Had the objective of describing nature as it is
- Example of the changing of thought during his time
- Believed that all animals derived from one common origin
- Brought forth the idea that the planet was much older than 10,000 years
    - Rejected the idea of the bible
- Thought that the Earth was a ball of fire and then cooled down
    - Explained fossils of tropical plants in cold climates
- Sorbonne censored his theories as they went against religious beliefs

- He forgot about his ideas and focused solely on observing nature

Lamarck (1774-1829)

- First evolutionist
  - Believed that species were not fixed
  - Species modify their morphology through time (proposed the theory of morphology with respect to time)
- *Environmental determinism*
  - Uses the environment as a factor of change
  - Species evolves with environment
- 2 principles that affect individuals
  1. Principle of usage and non usage
     - Without use of the trait, it would disappear/shrink
     - With use of the trait, it would grow
  2. Principle of inheritance of acquired traits
     - Actions within lifespan can affect future generations, cause future generations to have the same trait
- *Spontaneous generation*
  - Term that explains the presence of simple organisms
- Wasn't received well because it contradicted religious views

Ex. Tennis players

- Body of a tennis players is asymmetrical as a result of the use of one of their arms
- Depends on their side of service
- **Lamarck:** Traits acquired in the tennis player's lifetime is passed onto their offspring
  - This is not true, therefore his second principle is invalid

Ex. Bonsai

- Any tree can become a bonsai tree
- **Lamarck:** Therefore, a breeded bonsai tree will have bonsai sprout from its seeds
  - This is not the case, as the seed of the original tree species will sprout as the original tree species

Cuvier (1769-1832)

- Where Lamarck was an invertebrate specialist, Cuvier was a mammal fossil specialist
- Father of the science of paleontology
  - The older the stratum, the more dissimilar its fossils are to current species
  - Species appear and disappear from one layer to the next
- *Theory of correlation of parts (organs)*
- Believed in the fixity of species, extinction and that God created the world

    - Therefore God created fossils
- *Catastrophism*
    - Fixity of species
    - God made the event that caused the extinction of species
    - Essentially this was a form of progressive creationism
    - He believed that there was improvement with each extinction and creation

Hutton and Lyell (1728-1797, 1797-1875)

- Geologists
- Geological changes are the result of a slow, gradual and continuous process
    - Turning point of science/evolution from biology to geology
- *Principle of uniformity (uniformitarianism)*
    - Laws of nature are not affected by the passage of time
    - They are independent from time
- The present is the key to the past
- Our passage on the planet is relatively short

LECTURE 3

Charles Darwin (1809-1882) and evolution

3.1 CHARLES DARWIN: EDUCATION AND FAMILY

- Born 1809
- Came from a good/wealthy family
- Stops studies in medicine
- Married 1st cousin and had 10 children who had no genetic problems (that we know of)

3.2 THE VOYAGE ON THE BEAGLE

- Hired as a cartographist on the Beagle to the coast of South America
- Became the naturalist of the voyage
- Acquired a lot of samples of fauna and flora to study South-American geology
- Expeditions had little time at sea, most time spent on land
    - Goal was to kill as many animals and collect as many plants
- Lasted 5 years but was only planned for 2
- Popularity amongst common folk caused by his expedition stories

2 books/people that impacted Darwin

1. William Paley
    - Father of the Theology of Nature
    - Harmony and design in nature are indicators of the existence and acts of God
    - Everything that exists today is a part of intelligent design

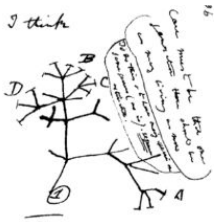
        - Darwin believed in this theory before the trip
        - Catastrophism

    2. Charles Lyell

        - Principle of uniformity
        - Believed in this theory after the expedition

- Along the coast of Chile, they experienced a major earthquake
    - This cause Darwin to redo the cartography of the island
    - 1 event changed the shape of the island
    - This idea could be applied to the real world
    - Maybe this was why marine organism fossils were found at 300m above sea level
- Darwin's thought process is known as the *accumulation of observations*
    - Slow but sure process
    - Changes of the world occurs this way
- The very distinct fauna of South America caused many questions
    - Why do the flora of different continents have few species in common?
    - Why do animals and plants living in a warm South American climate not resemble animals and plants existing in the warm European climate?
    - Why are mammal fossils of South America extinct? Why are they exclusive to South America?
- Galapagos Islands
    - Fauna on the island is unique
    - Ex. Marine iguana
        - Why does South America have a similar species, but this species is unique to the islands
    - Turtle shell variability on the islands
        - Following Lamarck's theory, they have the same environment but each island has a shell unique to it
    - Finches
        - Morphological variability
        - Every island has its own species
        - Same body with different beaks as a result of a different diet
        - Past belief was that they were created independently (not the same species)

3.3 EVOLUTION AND NATURAL SELECTION



- Darwin's notes mention that species show resemblance to each other, not because of a similar environment but because they share a common ancestor (first phylogenetic tree)
    - Rejects the fixity of species, accepts concept of descent with modification (evolution)
    - Materialistic view of life (contradicts religious dogma)
    - Rejects Lamarck's environmental determinism
- Darwin dislikes the term evolution for animals, as he believes that only humans evolve

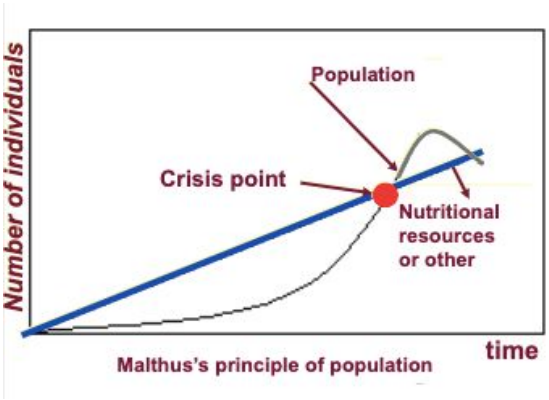
Ex. Finches

- They show morphological similarities because they share a common ancestor
- 99% of species that have lived on Earth are extinct

- Darwin was aware that his theory had holes
    - Fossils provided missing links
        - Speciation, intermediate morphology step, extinction (as a result of failure to survive in an organism's environment)
- Darwin read an essay by Malthus which inspired him to formulate his theory on natural selection

Points brought forth by Malthus

- Every human population has a tendency to increase exponentially
- As a result, resources also increase in a similar fashion
- When the human population increases faster than its capacity to feed itself, chaos happens
- Chaos causes a reduction in population size
- *Main idea:* There are winners and losers in the game of life



Darwin's observations

1. First observation
    - All species produce more offspring than their environment can sustain
    - Many of the offspring fail to survive and reproduce
    - There are winners and losers in reproduction

2. Second observation
    - Members of a population often vary in inherited traits
    - Desirable features are passed on from parents to offspring (as a result of the parent well adapted to environment able to survive for longer and reproduce)

Darwin's inferences

- Individuals whose inherited traits give them a higher probability of surviving and reproducing in a given environment tend to have more offspring
- *Differential reproductive success*
    - From generation to generation, the unequal capacity to survive and reproduce results in an accumulation of favourable traits in a population
- This is natural selection
    - Enables emergence of adaptations
- Genetic variability allows for resilience against the changing environment
- Wallace convinced Darwin to release ideas

    - He came to the same conclusions by observing fauna of Indonesia
- 23 years after his voyage, he released his views
- *"On the Origin of Species"*
    - First edition of his book
- In the 6th and last edition, he addresses criticism made against his views

Important points on natural selection

- Individuals do not evolve, populations do
- Only hereditary traits with variability can evolve
    - If a trait is well-adapted to its environment, it allows for higher relative fitness (reproductive success)
- Environmental factors vary in time and space
    - Trait that increases fitness in one environment might lose fitness in a changed environment
    - Advantage = based on context

Why does natural selection work?

- Respects *principle of uniformity* (Lyell and Hutton)
- Results are visible and can be verified on current populations (i.e. artificial selection)
- Concept is materialistic concept
    - Not a random mechanism, natural selection allows individuals who are better adapted to their environment to become more abundant
    - Not a quest for perfection, organisms only adapt to their environment

Artificial selection

- Finalized
- The goal is fixed in advance and precedes the causes
- End result can be obtained in a few generations

Natural selection

- Not finalized
- Takes a long time for changes to occur (on a geological time scale)

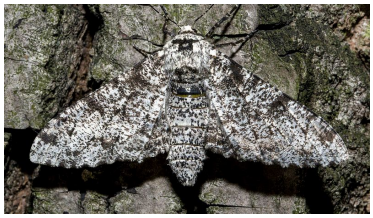
Ex. Peppered moth

- Two kinds of peppered moths
- Compared those in the city to those in the countryside

City

- Coal was used as the main source of energy
- Dark environment with dark trees
- As a result, moths in this environment were dark
- Ratio of 10% light to 90% dark

Countryside



- Bark on the trees was lighter, white
- Predators could easily see black moths
- More white moths survived
- Pigmentation was an inheritable trait, so more

white moths were there

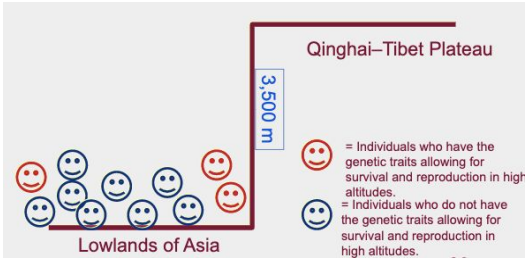
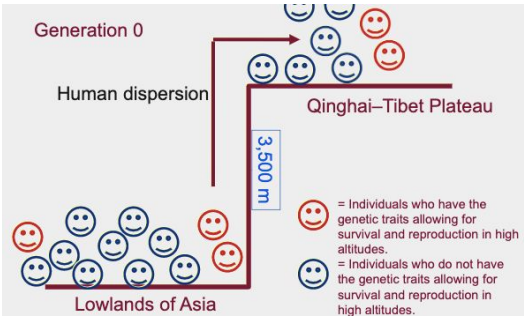
Ex. Climate and the Medium Ground finch

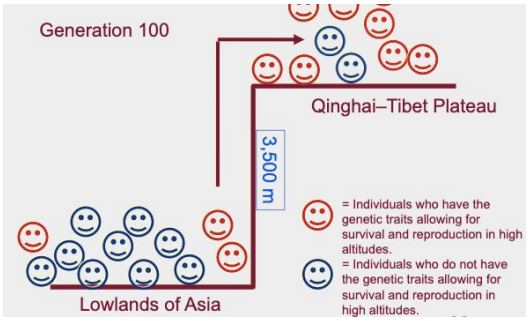
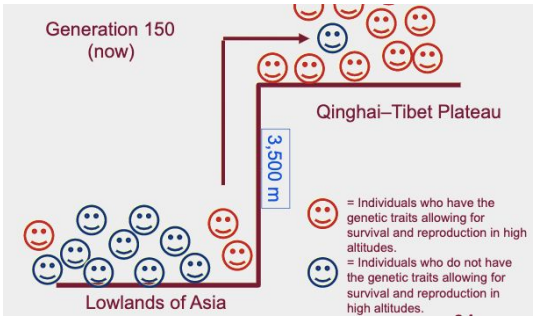
- Drought in 1977
- Population of 1200 adults to 80 adults
- Selection favoured individuals that have bigger and stronger beaks to break available seeds during the drought

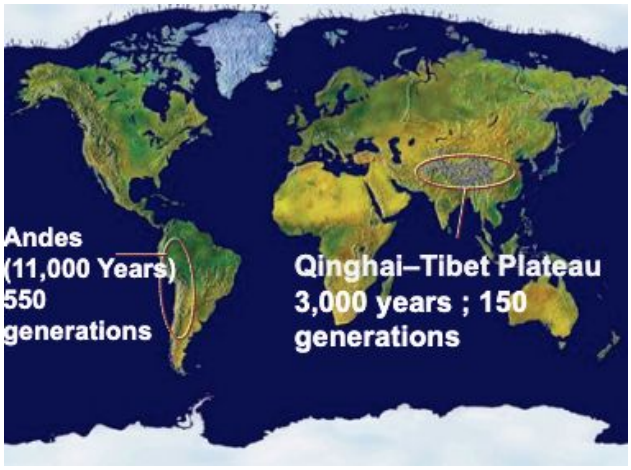
Ex. Humans and altitude

- People living in the mountains must adapt to the high altitude
- Above 2000m, partial pressure of O_2 is insufficient for normal saturation of hemoglobin
    - This causes altitude sickness
- The physiological response is *acclimatization*
    - Body increases the concentration of red blood cells to balance the low partial pressure of O_2
- Body may not be able to cope with the fast increase of red blood cells

Qinghai-Tibet plateau

Gen.	Event
0	 1. All individuals began in the lowlands. 2. Genetic mutation that allows for high survival at high altitudes cannot be commanded. Some individuals already have said mutation.  1. A group of individuals migrate to the Qinghai-Tibet Plateau. Some have the good mutation while others do not.

100		1. Because the individuals better adapted to the environment were able to survive and reproduce, the future generations have more individuals with that mutation.
150		1. Most individuals living at the top of the plateau have the genetic mutation.



- Human adaptation to high altitude on the Qinghai-Tibet plateau differs from the adaptations found in humans living in the Andes
- **Qinghai-Tibet**
    - Deeper breath, faster breathing cycle, larger pulmonary capacity, increased blood flow
    - Origin of adaptation can be found in the *Denisovan gene EPAS1*
- **Andes**
    - Higher alveolar surface in lungs
    - Same hemoglobin concentration in blood, but each molecule has a higher oxygen capacity

Conclusion

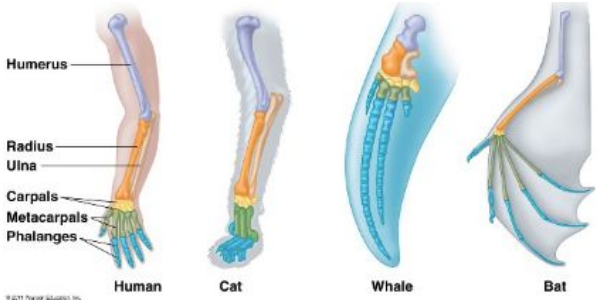
- In the three cases (moths, finches and humans) the hereditary traits that give a reproductive advantage to individuals in a population will be favoured
    - From generation to generation, there will be a higher % of individuals carrying the adaptation
    - This is natural selection (Darwin's descent with modification)
- Adaptations may redefine a species or define a new species

3.4 PROOF OF EVOLUTION

Evolution can be proven using different methods

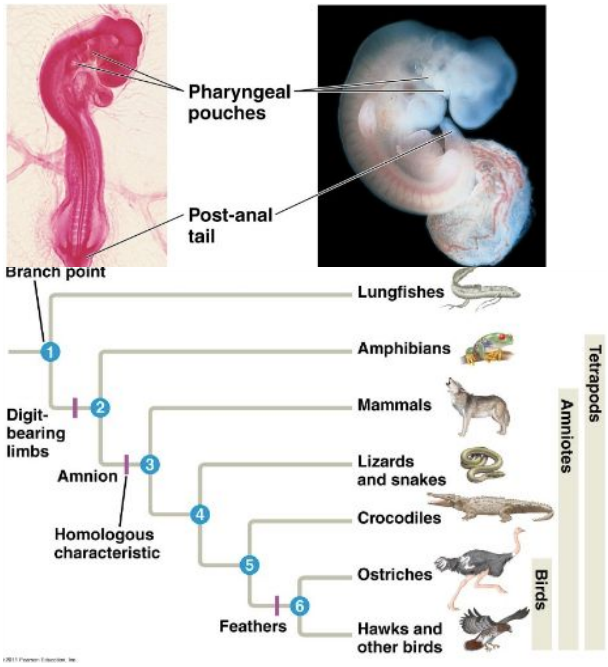
1. Homology
2. Fossils
3. Vestigial structures

Homology



- Theory of evolution explains resemblance between certain traits even if the functions are different
- *Homologous structures*
    - Structures are similar in appearance but different in function

Ex. Human embryo vs. chick embryo



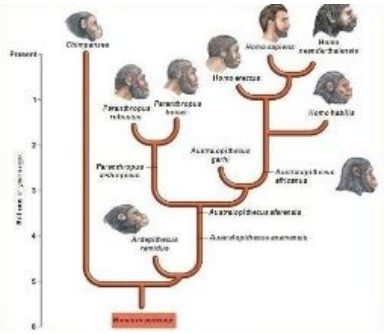
- Not obvious in an adult human but homologous structures are obvious in embryo
- Homologous structures generally appear early on

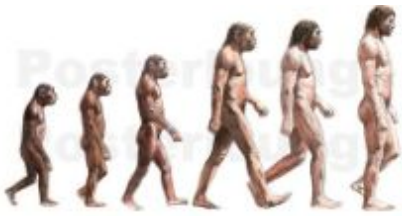
- When looking at evolution, we must use a tree-thinking process
- Evolution is not linear

Fossils

Ex. Humans

- Fossils show us that multiple species of the same group coexisted
- Different human species existed at the same time
    - Fossil record proves that there were other human species existing at the same time





Ex. Whales

- Fossil records show us that they evolved from a species called pakicetus
    - Common ancestor of all whales
    - Quadrupedal fossil
- Proved that whales come from a terrestrial animal
- Hippos are the closest relative to the whale that exist today
- Because the pakicetus became more aquatic, there was a shortening of limbs
- Pelvic bone in the whale fossil is a vestigial structure
    - No actual function in the modern whale
    - Indicator that this animal could once walk

Vestigial structures

- Anatomic structure that has lost almost all of its initial function

Ex. Vestigial structures in humans

- Nictitating membrane/third eyelid
    - Serves no function
    - Exists in reptiles and birds
    - Translucent membrane meant to protect the eyeball
- Appendix
    - Tendency to get inflamed
    - No digestive function
    - A large caecum is found in herbivores
        - This is an important digestive functions
        - Allows for them to digest vegetation
    - There are still remnants of a large caecum in humans
- Goosebumps
    - Hair stands up after stimuli
    - Common ancestor that had fur
        - Every strand has its own muscle
    - However, it provides no actual protection against a cold climate
    - We have the function but our hair density doesn't allow for it to be useful

- Hiccups
    - Comes from fish and amphibians
    - Occurs because of the phrenic nerve
    - Movement can cause the phrenic nerve to get pinched (this is when hiccups happen)
    - A long phrenic nerve is the result of a fish-like ancestor

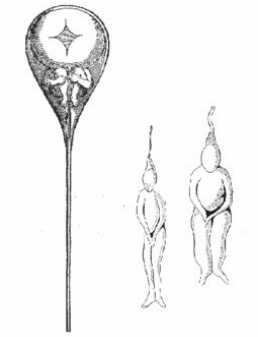
- Evolution could hypothetically be disproven if we discover a fossil in the wrong place in the geological archives
    - This has yet to happen

LECTURE 4

Genetics, Neo-Darwinism and modern synthesis

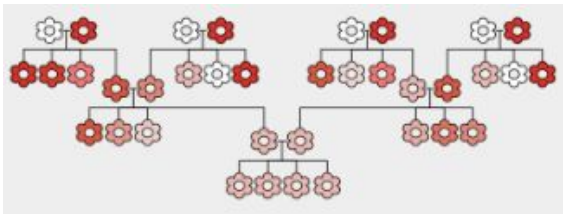
4.1 TRANSMISSION OF TRAITS (INHERITANCE): PRE-MENDEL PERSPECTIVES

Preformism and the theory of blending inheritance



- *Preformist theory* (until 19th century)
    - Main theory proposed by bible/religion
    - Believed that in the ova there was a miniature being
        - Sperm was key to trigger mini baby to be released from ova
    - Or the sperm held the mini baby
        - Ova provided environment for mini baby to grow
- *Epigenesis*
    - Accepted theory today
    - An embryo starts with cells and undergoes cell differentiation

- *Theory of blending inheritance* (until end of 19th century)
    - States that parents provide an equal genetic contribution to offspring
    - Could be disproven because following this logic, the offspring would become identical after a few generations



Darwin's pangenesis

- *Theory of gemmules*
    - Theory involving hereditary particles
    - When an organ is used, it grows and more gemmules are found in it
    - Gemmules are transported in the bloodstream from all parts of the body and assembled in the gametes when formed

- Gemmules = particles associated with the transmission of hereditary

Ex. Coloured rabbits

- Francis Galton conducted an experiment with coloured rabbits to test Darwin's theory
- Blood of white rabbit was injected into a brown rabbit and vice versa
- No result was found

August Weismann's theory

- Proposed that only the sex cells were responsible for heredity
- Rest of the organism disappeared with the death of the individual
  - Essentially the body of the organism contributed nothing to offspring
- Living beings are divided into 2 parts with different outcomes

1. *Germline*
   - Gametes
   - Sex cells
   - No impact on genes
2. *Soma*
   - The remainder of the body

- The germline is independent from environmental influences
- Heredity is just the continuation of the germline
- Germline and environment can influence the phenotype, the soma and the environment have no influence on the genotype
  - What we do in our lifetime doesn't affect our sex cells
- Natural selection is the only mechanism that can change the germline of a population
- *A chicken is the method by which an egg makes another egg*

Ex. Sexual life of the monkfish

- All monkfish caught are female
  - We know that sperm is involved but we don't know from where
- Example that shows that the soma is first and foremost the receptacle of the germline
  - Female monkfish get sperm from several sources to increase their reproductive ability
- Parasites found in females are associated with the genital area
  - Fused to female with most of their functions lost
  - All that was left was the sperm sac
- Therefore, the phenotype and genotype are independent **(Weismann)**
  - Soma can come from a different shape, so long as the genetic material is passed on