

Course Introduction: The Biology of Organisms

Science & Skepticism

Scientists can never say that have the truth--has margin of error associated w conclusions that are made

Eg. Species called *Homo naledi* labeled as possible first species of genus *Homo*--BUT they found bones of about 15 diff individuals in the same spot=either someone put them there or died there--no evidence that they acc died so maybe put them there so=funeral. Funeral rights were not that old and confirmed that not 300 million but 300 thousand

Eg. In 2018--found neanderthal and denisovan (2 human species) hybrid and they live in diff areas--means diff human species mated together so redefine species? Also 90 000 yrs ago, when found, we were there so at least 3 diff human species at the same time

Flatfish

Eg. sole, turbot, halibut, plaice

- Can vary in size
- Have two eyes on the same side of the body
 - Migration of the eye occurs during the development of larval flatfish
 - Hard to explain this process evolutionarily
- Have the capacity to change colour

**Duplain, Chapleau et Munroe (2012) described a new species of flatfish from Colombia

An Example of Evolution: Locomotion in Cheetahs

Cheetahs are extremely fast animals

- Acc from 0 to 70km/h, strides over 70m when running
- Strategy=close to prey and then burst of speed=surprise
- Fragile, efficient at catching prey
 - **Evolutionary compromise**
 - Will not fight hyenas who try and take prey away b/c main feature is speed=less prob of fighting bc might get injured
 - Eat very fast and nervously b/c see if any others will come to eat it and take it from them
 - Eg. **EC in humans**--we are the only species that can speak but cost: we have a very long pharynx and the only species that can acc choke on their food

Morphology of Cheetah

- Hind legs: Pelvic girdle (hips/pelvis)=attached to vertebral column--the back of the animal=speed/propulsion
- Forelegs: Pectoral girdle (scapula)--imp for propulsion but also orientation-- slides on the side of the rib cage (vertebral column) and this this ribcage is on a sling of muscle and this sling of muscle will act as a shock absorber

- When the animal moves its legs, the thorax does not move at the same speed imp b/c dont want organs to be tangled up bc going so fast
- Sling of muscle also good bc head stays straight

Sharing a Common Ancestor

- All species share a common ancestor (1st=bacteria) and look alike bc share CA

Cheetah as an Example of a Common Ancestor

- Limbs
 - Inherited limbs from ancestor
 - Limbs evolved in fishes (fins)--used to stabilize animal
 - Humerus, tibia and bones of wrist all evolved from fish
 - When tetrapods came on land, digits were added

Characteristics Specific to Cheetahs

- Posture of the limbs (erect posture)
 - Have knees under their bodies
 - Most amphibians and reptiles have spraw position- their humerus and femur are parallel to the ground--but requires a lot of energy so biggest creature that can=crocodile
 - Lifted constraint on the max size of mammal
- ***Dinosaurs also (evolved independently of mammals) have erect posture--some became bipedal or quadrupedal or evolved wings
- Walk on their fingers--not palm of feet but on digits
 - Gives them an advantage in terms of running b/c leg is longer and make longer strides
- ***Deer has very long legs bc very much on toes, walk on hooves/nails
 - Have a lot of fusion of bones--good for speed bc if have a lot of bones then=need a lot of ligaments and muscle to move fast and so will slow you down b/c heavier
- Retractable claws
 - Found in all cats--acquired from common ancestor
 - Cheetahs only species that have **semi** retractable claws--permanently sticking out a bit
 - b/c oriented towards running and making swift turns etc so good for traction on soil

Cheetah as an Example of Evolution: Overview

1. Adaptations of vertebrates in cheetahs
 - a. Locomotion organs (fins or limbs)
2. Ad of terrestrial tetrapods in cheetah
 - a. Pectoral girdle--detached from skull
 - b. Pelvic girdle (pelvis) fused to the vertebral column
3. Ad of mammals
 - a. Rotation of the knee
4. Ad of carnivores
 - a. Walk on fingertips
5. Ad of cheetah compared to other felines

- a. Fur pigmentation
- b. Long and thin limbs (lion=thick legs)= stride length
- c. Slender and lightweight=speed
- d. Flexibility of spine=speed and stride length
- e. Wide nostrils, heart and lungs with high functional capacity

Cheetah Overview

- A cheetah is a mammal char by few unique traits that distinguishes it from other feline species
 - Cheetah is a result of the history of its ancestors more than its own history
 - 99% of characteristics evolved in species that are now extinct

Importance of Genetic Variability

- Royal Cheetah
 - Found that it=mutation not a diff species
- Distribution of Cheetah
 - Mostly found in Africa
 - Endangered b/c genetic makeup
 - Cheetahs are same in diff location=no genetic variability
 - Evolution works if you have genetic variability
 - Cheetah is vulnerable b/c all same genes=no one is better suited for certain conditions/epidemics
 - Maybe b/c of climate change/glaciation/disease= a lot of individuals died=possess same genetic makeup of original population
 - Has not had time to mutate and inc genetic variability

** Humans=bottleneck=b/c volcano...SPECULATION

**Can understand a lot about nature by looking at nature now

- BUT to an extent...99% species gone extinct so keep an open mind
 - Eg. Pronghorn was v abundant in North America and hunted almost to extinction and then were protected--regained their numbers
 - It runs at 95 km/h..cheetah found in Africa..evolution of cheetah was an arms race..prey got faster-cheetah got faster etc.
 - Could explain how cheetah got fast
 - BUT HOW did pronghorn get so fast?
 - Faster than predator
 - Fossils show that maybe 20 000 yrs ago there was a species that had a bone structure similar to cheetah that was very fast--nothing rly to do with cheetah...independent evolution (convergent evolution) in diff continents
 - Looking at nature **we are missing pieces of the puzzle and fossils can help us find these pieces often**

Chapter 1: The Scientific Method

1.1 Definition of Science

Science: A coherent body of knowledge related to certain categories of facts, objects or phenomena obeying laws that **verifiable** through experimental methods

- a. Scientific inquiry aims to acquire new knowledge
 - i. Two Approaches
 1. Description-based science (describing nature)
 2. Hypothesis-based science (explaining nature)

1.2 The Scientific Method

Inductive Reasoning: linked to descriptive based approach... making a generalization often based on numerous specific observations

Eg. person looking at ppl entering classroom..concl=lecture going on BUT could be something else---PARTICULAR TO GENERAL

Deductive Reasoning: linked to hypothesis based approach...involves stating a hypothesis and drawing conclusions through experimentation or observation from this hypothesis

Eg. There's a lecture... how can i verify this? So if there's a lecture, there should be a prof and a course # on the screen...test/verify ---GENERAL TO PARTICULAR

1.2.3 The Scientific Process

1. Hypothesis
 - a. Must be verifiable, refutable and reproducible...needs to be able to falsified..the notion of proving a hypothesis is a bias..wanna make sure that the test would ensure that you eliminate all possibilities
 - b. Eg. Dead batteries or Burn out bulb
2. Prediction
 - a. Must be testable and give clear result..if/then statement....
 - b. Eg. replacing batteries will fix problem or rep bulb will
3. Test
 - a. Result: flashlight doesn't work...falsifies hyp or does not falsify hyp

**still need to keep testing it bc TRYING to falsify hypothesis

Contract Between Science and Knowledge

1. Initial Skepticism on Facts

We ask honest questions on facts and hypothesis (tangible/real things) and we always retest what has been found

2. Realism

The world is older and exists independently from my perception of it (the realm of ideas does not have the priority over the real world)--need to be put aside when doing science

3. Rationality

Logic: demonstrations from a scientist must be the result of coherent steps

Parsimony: methodological principle which states that acceptable theories are hypothetically the most economical in assumption---means that if you have the end result the simplest one should be closest to the truth

- i. Eg. hear galloping in a field is it (1) a zebra in ottawa or (2) horses in the field...obv (2) b/c whole bunch of assumption associated with (1) and the most complex one

Methodological Materialism: All that is experimentally accessible in the real world is material or has a material origin--cannot invoke supernatural causes to explain natural things

Crop Circle Enigma

In England there were these intricate geographic figures in agricultural fields and people tried to explain them...

- a. Possible aliens, supernatural causes, different DNA in the plants that were trampled
- b. BUT ended up being 2 guys--most parsimonious explanation

Mimicry

Monarch Butterfly

- a. When they feed on milkweed--the toxic substances transfer to the butterfly and make it distasteful for birds & stop touching monarchs
- b. Have very bright colour--can't miss them=don't eat me I'm toxic

Viceroy Butterfly

- a. Thought to be non toxic..said that it evolved colouration of monarch butterfly to stop from being eaten (**Batesian mimicry thought to be**)
- b. Tested this
 - i. Took away the wings
 - ii. Fed them to birds
 - iii. Viceroy was also tasted and rejected
 - iv. So Viceroy is actually toxic & non palatable either
- c. Actually an example of **Mullerian mimicry**: when toxic species tend to look alike to send a stronger message of toxicity...converge to the same colouration even if diff genus=diff ancestry
 - i. ALWAYS need to re test hypothesis to test if it is true

Case Study: Fur Colouration in *Peromyscus polionotus*, the Odd Field Mouse

Beach population= white fur Inland pop=brown

1. Hypothesis
 - a. In this species, fur colouration patterns has evolved as camouflage in their native environments

2. Prediction
 - a. **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
3. Test
 - a. Plasticine mice spray painted in beach or inland colours
 - b. Spread both colors models (control and experimental) in equal numbers in both habitats
 - c. Count signs of attacks

Case Study: Introduction of Fish in Gatineau Park

- The introduction of species has an impact on fish biodiversity
 - Lakes have value if clean and good for fishing
 - Adding species enhances the value of the lake
 - Gatineau park has dozens of small lakes where species were introduced for recreational fishing
1. **Observation**
 - a. Small lakes in which the recreational fishing species (piscivores--carnivorous fish) have been introduced do not have schools of small fish near shore
 2. **Hypothesis**
 - a. The introduction of piscivore fish species in small lakes would result in a decrease in the numbers of smaller species
 3. **Prediction**
 - a. 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
 4. **Testing the prediction**
 - a. Determine the number of fish species in both types of lakes
 - b. A comparative analysis of fish species diversity in a region with small lakes with and without introduced piscivores
 5. **Results**
 - a. Lakes without introduced pisc fish species have 50% more small sized fish species than lakes where there were piscivorous--no schools, hiding
 - i. Recommendation: no piscivorous species should be introduced to preserve the park's biodiversity

Chapter 2: Evolutionary Thinking Before Darwin

2.1 Transformism in Antiquity

1. Acts of creation are not due to God, but rather to the innovative power of matter
2. The origin of all things is not theological-- no objective or ultimate goal of an organism but is the result of chance or irrational need

2.1.1 Anaximander (610-546 BCE)

First philosopher to write his thoughts

1. Humans originated from fishes that attempted to invade the mainland
 - a. “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”
2. Water is the central element of this universe

2.1.2 Empedocles (483-423)

Student of Anaximander

1. All structures of the world (matter) are made of four elements
 - a. Earth
 - b. Water
 - c. Air
 - d. Fire
 - i. These elements are simple and eternal and unalterable
2. Two major forces interact constantly on these elements; love (attraction) and hate (repulsion or discord)
 - a. Would act on matter and create organisms that could be harmonious and functioning sometimes...mostly not
3. Envisioned the same matter for human and plants

2.1.2 Democritus (460-360)

The most scientific of the Greek philosophers

1. Two realities: atoms and emptiness
2. Matter: group of atoms in movement. An atom cannot be created or destroyed
 - a. Eg. split paper in 2, and get half and so on and so on
 - i. At the end you will end up with 2 smallest particles=atoms
 - ii. Emptiness allowed space for these particles to interact
3. There is an intrinsic property, a force of atoms that creates shapes
4. Humans and animals are born directly from dirt (spontaneous generation)

2.2 Classical Thinkers

2.2.1 Socrates (469-399 A.D)-- Plato (427-347 A.D)

Stopped worrying about nature--nature is a mess..only find truth within oneself

1. The important questions are not materialistic but rather linked to a search for beauty, kindness, justice and sanity
2. Arguments about logical, ethical and political questions are more interesting than the search for truth
3. Answers not found in nature but within the self

1. Plato

- a. Student of Socrates
- b. Theories of ideal forms (Essentialism)
 - i. The visible, imperfect and changing realm which surrounds us is a poor imitation of an IDEAL World (permanent and perfect that we possess at birth: the world of Ideal Forms)
 - ii. When born, had within us what the ideal shape of a chair, or beauty would be--innate
 1. Idea throughout your life was to search for them and seek them
 - a. Thus, nature=imperfect and not important
- c. The variation of forms is not important and detracts from the quest to define the ideal form and only that is important
- d. This philosophy will have a lasting impact on our perception of nature
- e. Gods are a creative forces

2.2.2 Aristotle (384-322)

- a. Does not believe in the Ideal Word of Ideal Forms
- b. Important to describe the essence of living beings; this essence can be observed in nature
 - i. Describe cats--
- c. Species are static/unchangeable
 - i. Thus, morphological variability is illusion and imperfection
 1. but all variants of cats were imperfect
- d. Created the scala naturae
 - i. Species are depicted in a static and unchangeable hierarchy
 - ii. Every being has a soul--multiple levels of souls with cumulative effects
 1. Organised in complexity order
 - a. Vegetal soul (plants)
 - b. Animate soul (animals)
 - c. Rational soul (humans)

2.3 The Impact of Christianity

With the decline of the Roman empire--Christianity becomes the main ideology in the western world

- a. This will be the dark age of transformism--evolutionary thought
- b. God becomes the measure of all things
 - i. The concept of scala naturae becomes purely metaphysical, proclaiming the perfection of the Creator

2.4 From Fixity of Species to Transformism

Renaissance in Europe (14-17th Century)

- a. Back to nature--great expeditions and discoveries
- b. Power of church is progressively challenged

French Revolution (end of 18th Century)

- a. Challenge of ordered systems--monarchy for an active pursuit of progress
- b. More open mindedness towards science
 - i. Industrial Revolution

Bonnet (1745)

During and immediately after the Renaissance, there was a return towards experimentation and the observation of nature

- a. Idée d'une échelle des être naturels
 - i. Attempts to classify living organisms were done within it
 - ii. Still no sign of evolution--static view of species

2.4.1 Linnaeus (1707-1778)

Influential Swedish scientist

Systema Naturae 1758

- a. Hierarchical classification (KPCOFGS)
- b. Binomial system of nomenclature
- c. Application of essentialism of Aristotle
- d. Discovering each piece of the Plan of Creation--Church liked it
- e. Mentioned in passing the occurrence of a common ancestor

2.4.2 Buffon (1707-88)

Objective: describe nature (44 volumes)

He wrote:

- a. "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"

- b. His theory established the age of Earth to be around 75 000 years. According to Buffon, the initial temperature of the Earth was very high. Since then the climate has mellowed out.

The faculty of Theology of Sorbonne censored many of Buffon's theories because of conflicts with religious views

- a. Then decided to abandon his evolutionary ideas and to focus on observing nature

2.4.3 Lamarck (1774-1829)

First evolutionist (species modify their morphology over time)

1. Uses the environment as a factor of change
 - a. Environmental determinism
2. 2 Principles (affects individuals)
 - a. Principle of usage/non usage--if you use organ a lot=good or if don't=shrivel/not function
 - b. Principle of inheritance of features by offspring
3. Gradual mechanisms, adaptive and involves an innate ability (internal force) of an organisms to become more complex
 - a. According to Lamarck--all of Federer's kids would be born with asymmetrical arm strength--**NO INHERITANCE OF ACQUIRED TRAITS**
4. According to Lamarck--if 2 env has same constraints should be the exact same species in there
 - a. Not the case

2.4.4 Cuvier (1769-1832)

French scientist interested in mammal fossils

1. Established the fundamental concepts of fossils
 - a. The older the stratum, the more dissimilar its fossils were to current species
 - b. From one layer to the next species appear and disappear
 - c. "God created all these species we see AND all the dead fossils"
 - i. Maybe God's rough draft?
2. Theory of correlation of parts--animals organs are all interdependent of each other
3. Cuvier believed in the fixity of species and catastrophism--many of the earth's crustal features formed as a result of past cataclysmic activity--the earth's surface has been scarred by catastrophic natural disasters
4. Cuvier modifies the unifying concept of the Great Chain of beings by suggesting that God created 4 major types of animals
 - a. Radiata
 - b. Mollusca
 - c. Articulata
 - d. Vertebrata

Feeding Habits vs Jaw of Organisms

1. Carnivores
 - a. The jaw joint is on the same level as row of teeth
 - b. Movement of jaw
 - i. Scissoring motion
 - c. Lower jaw attaches to the cranium @ roundish hinge--tight jaw joint so can be able to cut the meat efficiently--prevents disarticulation when grabbing prey's neck
2. Herbivores
 - a. High jaw joints relative to the row of teeth--helps molar and premolar to touch=grind food and break the cellulose
 - b. Shape of jaw
 - i. Jaw joint is not very tight, what's mobility of lower jaw..up and down..left and right so can grind food

2.4 From Fixity of Species to Transformism

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

Geologists

- a. Geological changes are the result of a slow, gradual and continuous process
 - i. Have a rock cliff, see portion of cliff fall, then big rocks will=break when cold=smaller and smaller=pebble then=sand
 1. Sand=go in ocean=go in crevices of volcanic activity=come back to land in solid format
- b. Principle of Uniformity
 - i. Uniformitarianism
 1. The laws of nature of nature are not affected by the passage of time
- c. The "present is the key to the past"
 - i. "With respect to human observation, this world has neither a beginning nor an end"
- d. Lyell is the first to establish geology as a scientific discipline

****Breaks view that planet is fixed..static**

Hoodoo (tent rock)

Big columns of sand with rock on top

- a. Formed because of a certain type of erosion--everything around the rock erodes
 - i. Takes thousands of years to form

Chapter 3: Charles Darwin & Evolution

3.1 Charles Darwin: Education

- Born February 12th 1809
- Father was a doctor
- Mother was from the Wedgwood family (porcelain)
- Married to his cousin Emma Wedgwood
- Had 10 children
- a. Stops his studies in medicine and takes a more serious interest in religion (Cambridge U)
 - i. Prereq to become a pastor: Bachelor of Arts
- b. Developed an interest in nature: taxidermy, insect collecting, botany etc

3.2 The Voyage on the Beagle

- a. 1831--he leaves on the Beagle, a ship commissioned by the British govt to do the cartography of the coast of South America
 - i. Invited on board a companion of the captain but quickly became the cartographer
- b. Trip lasts 5 years--supposed to be 2 years
 - i. Boat going from port to port--saw animals, persevered them in animals, leave at port, pick up barrels and bring back to london

During the voyage, two books had an impact on Darwin

- a. William Paley (1743-1805)
 - i. Theology or evidences of the existence and attributes of the deity
 - 1. So beautiful/harmonious...God must have made it
 - a. today=proof of evolution
- b. Charles Lyell
 - i. Principles of Geology
 - 1. B4= protestant beliefs--Great Flood and Catastrophism
 - 2. He was in total agreement with Lyell and Hutton's principle of uniformity

Darwin's Questions & Doubts

- a. Why do the fauna and flora of Africa, Europe, Australia and South America have relatively few species in common?
- b. Why are the animals and plants of the temperate zones of South America resemble the species living in the tropical zones of South America but not the species in temperate Europe?
- c. Why are the mammal fossils of South America absent from the current fauna (e.g Giant Sloth)? Why do these fossils show resemblance with current species found only in South America (eg. Three-toed Sloth)

Fauna on the Galapagos Islands surprises Darwin

- a. The fauna on the islands is unique. Why?
- b. Why does it show resemblance with species on the American continent?
- c. Only find marine iguana in Galapagos?
- d. Specific sea lions in Galapagos
- e. Sub species of Tortoise on each Island--if env only then why diff shell? Why is there giant turtles there and not anywhere else?

Types of beaks of Finches of the Galapagos Islands

- a. Why so much morphological variability in one group?
- b. Why does each island, in most cases, have their own species?
- c. SAME BODY but diff beaks?

1. Cactus eater
 - a. Intermediate beak
2. Insect eater
 - a. Thin beaks
3. Seed eater
 - a. Large beaks

****God not enough to explain this**

3.3 Evolution and Natural Selection

- a. 1837--find Darwin's notes the first mention that species show resemblance to each other b/c they share a **common ancestor** not common environment
 - i. Reject fixity of species and accepts the concept of descent with modifications (evolution)
 - ii. Materialistic view of life that opposes religious dogma of the time
 - iii. Rejects Lamarck's evolutionary mechanism of environmental determinism

...then begins search for evol mechanism--shied away from using the word 'evolution' b/c not inclusive of non humans

- b. The finches show morphological similarities because they **share a common ancestor**

i. flight of birds that got lost and found in GI and speciation--same w/ turtles, piece of island

****Even though species may seem not related at all--when analyzing fossils=see closely related**

****99% of species that have lived on Earth are extinct**

- a. Most of the evolutionary branches finish in a dead-end (extinction)

In 1838-- Darwin read "An essay on the principle of population" written by the economist Thomas R Malthus

- a. This reading became main source that inspired him to formulate the theory of **natural selection**
- b. Malthus wrote that

- i. Every human pop has a tendency to grow exponentially, whereas the available resources to feed these populations increase arithmetically
- ii. The human population increases faster than its capacity to feed itself
 - 1. This leads to the crisis point and eventually to substantial reduction in population size

Darwin's Observations

- 1. All species can produce more offspring than their environment can sustain and many of these offspring fail to survive and reproduce--b/c cannot control birth rate like humans
 - a. Puffball/Mushroom--spores coming out, Maple tree and its samaras
- 2. Members of a population often vary in their inherited traits
 - a. Only way to pass on inherited traits is thru genes

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 of survive and reproduce (differential reproductive success) results in an accumulation of favourable traits in population
 - a. Increase in allele frequency
 - b. This is natural selection. It enables the emergence of adaptations
 - i. Evolution is a change in heritable/hereditary characteristics

****For the first time we looked at variability as a good thing**

Wallace & Darwin

It is a letter from Alfred Russel Wallace (1823-1913), received in 1853, that forced Darwin to publicly release his ideas

- a. Wallace had come to the same concl as Darwin concerning the theory of natural selection by observing the fauna of Indonesia
 - i. Thus it was long after his voyage on the Beagle that Darwin publicly released his views on the evolution of species

On the same day, in 1858, Darwin and Wallace presented a resume of their ideas on natural selection to the Linnean Society of London

In 1859, Darwin published the first edition of his book "On the Origin of Species"

- a. Became instant bestseller and created controversy

Important Notions Linked w/ Natural Selection

- 1. Individuals do not evolve, populations evolve
 - a. Not like Lamarck

2. Only hereditary traits are subject to natural selection
3. For evolution to occur, we need genetic variability
4. Natural selection corresponds to differential reproductive success within a population from generation to generation
5. With time, natural selection enables individuals to become better adapted to their environment
6. Environmental factors vary in time and space.
 - a. Thus the selective forces are variable
 - i. Eg. diff seasons, diff migratory behaviour
7. Traits in populations will change and can modify the species
 - a. Change in morphology--eg. Human jaws getting progressively smaller b/c cut food w/ tools and back then used fire so started getting smaller then

For Darwin, This Mechanism is Valid Because:

1. It respects the principle of uniformity of Lyell and Hutton
2. The results of natural selection are visible in nature
3. The mechanism can be verified on current populations
 - a. Artificial selection
4. It is a materialistic concept (no need for divine intervention)
 - a. The mechanism is not random. Natural selection enables individuals that are better adapted to their environment to become more abundant than those who are not (differential reproductive ness)
 - b. Not a quest for perfection (evolution is not a directed process). It does not lead to the appearance of 'perfect' traits. Organisms only adapt to their environment.

Artificial Selection

Much of the food we eat come from one plant

- a. Portion of the plant have been made to become larger and bigger in order for us to be able to eat them
 - i. To obtain the vegetables
 1. Take a piece of the plant and select them
 - a. Look for largest individual and reproduce them
 - i. And get them to be larger

Dogs

- a. Artificially select a dog to make him look a certain way
 - i. Selects every generation dog that has the longest hair and keep going

Remember

1. Artificial selection is finalized b/c the goal is fixed well in advance, precedes the causes. The end result can be obtained in few generations
2. Natural selection is not finalized. It can take a long time for changes to occur (geological time scale)

Examples of Natural Selection

1. Peppered moth
 - a. Grey one & Dark one
 - i. During the day rest on tree
 - b. Cities in the 1800s were very polluted and dark and dirty
 - c. Countryside=clean
 - d. Birds eat the most readily available one
 - i. Population made mostly of dark morphs in cities b/c high favourable
 - ii. **vice versa for countryside
2. Finches
 - a. Seed eaters
 - b. Drought
 - i. Less small seeds
 - ii. More large seeds
 - iii. Largest beaked bird survived
 - iv. 30% Linked with env and 70% genetics
3. Humans and Altitude
 - a. Francois Chapleau
 - i. Comes from a population that has always lived under 500m above sea level
 - b. Guide
 - i. Born in Qinghai--Tibet in the Himalayas
 - ii. Lived over 3500m above sea level for 22 000 years
 - c. Over 2000m, the partial pressure of O₂ is insufficient for normal saturation of hemoglobin for a traveller in high alt
 - i. Shortness of breath, altitude sickness
 - d. Physiological response--creating more red blood cells--after a few days at high altitude, the body compensates the low partial pressure of O₂ by increasing the concentration of red blood cells in our blood
 - i. Serious health risks; thrombosis, pulmonary edema, etc.
 - e. **How did they adapt?**
 1. Lowlands of Asia had indiv w/o genetic traits for high alt (also those w/)
 - i. Variability and mutation
 2. Human dispersion of these individuals into Qinghai-Tibet plateau
 - ii. Both ppl w/ and w/o
 3. Natural selection
 - iii. Better suited=survive
 - b. Many regions in high altitude were independently colonized by humans
 - i. On the QT plateau, human adaptations to high altitude differs from the Andes (SA)

Adaptation Differences Between the Andes & the Qinghai-Tibet Plateau

1. Andes
 - a. Increase in hemoglobin conc (high red blood cells)
2. Qinghai Tibet Plateau
 - a. Deeper breath, larger pulmonary capacity and increased blood flow

3.4 Proof of Evolution (Descent with Modification Theory): Homology

1. Homologous structures
 - a. Diff function, same structure in diff species
 - b. Indicates a common ancestor
 - i. Sometimes homologous structures are in larval material
 1. Chick embryo and human embryo
 - a. Presence of pharyngeal pouches (all vertebrates and few chordates)
 - b. Post anal tail (all vertebrates)
 - i. Regresses in humans to become coccyx

Phylogenetic tree

1. Evolution of Horses
 - a. Two species that are forest dwellers=feed on leaves
 - i. Herbivory that does not require strong teeth=no selective pressure for strong teeth
 - b. Prairie dwellers
 - i. Vegetation has sand=selective pressure for stronger teeth for wear and tear support
 - c. Reality of horses is more complex so not a good idea to simplify
 - i. One species does not become the other..become the other etc
 1. More complexity than 'linear' type of evolution
 - a. Might have 6 or 7 or 8 species of horses living at the same time
 - i. Prefer tree thinking approach over a linear tree
2. Humans
 - a. This linear evolution provides a false picture of what evolution actually was
 - i. Think that monkey transformed into humans
 1. 'One species transformed into another into another etc'
 - a. Wrong
 - i. Need to have a tree thinking approach
 1. Chimps share a common ancestor with all human species

- a. Would mean that there would only ever have been one species of human around and it just 'transformed'
- b. Increase in height is also wrong
 - i. Humans did not progressively get taller

3.4.2 Proof of Evolution: Fossils

- 1. Whales (mammals)
 - a. Pakicetus had a fossil that resemble whales--morphological evidence are related to deer, hippos
 - i. Whales are related to hippos and deer
- **Fossils can help us fix the gap in morphology**
- a. Discovering more and more fossils that suggest a transition from a land animal to a totally aquatic animal
 - i. Pelvic Girdle
 - 1. Typical of land animals
 - a. Almost disappears in whale-like animal
 - i. In whales, sitting in flesh, no function
 - 1. Reduced vestigial posterior limb, the pelvis reduced to a floating pelvic bone under the spine

Vestigial Structures

Structures that have lost their function that are still present

- a. Proof of evolution
 - i. If ancestors of blue whales for eg didn't have back limbs then no reason for having it
 - 1. Remnants of what was once a function structure in an ancestor

Vestigial Structures in Humans

- 1. Nictitating membrane or third eyelid
 - a. Common in birds or crocodiles
 - b. Goes from inner corner and extend the eye
 - i. Provides protection for eye when in vulnerable position
 - 1. Eg bird flying, crocs in water
 - c. We have a remnant of this, no function
 - i. We have an ancestor with a functional NM
- 2. Appendix
 - a. Associated with the caecum (deflated caecum)
 - i. Part of the large intestine

- ii. Fingerlike projection on the caecum
- b. If removed, no impact on digestion function
- c. Rabbits and horses have large caecum (herbivores)
 - i. Have enzyme to break down cellulose
 - ii. They need increased surface area
 - iii. We don't need it to digest vegetation
 - 1. Do it through our colon
- 3. Goosebump/Fur/hair
 - a. Muscle associated with each strand of hair
 - i. Muscle contracts and hair will stick up
 - b. Won't help us from heat loss or anything b/c we only now have sparse hair on our arms
 - i. Ancestors had a lot of hair and when this happened=layer of warm hair

Heritage from Fishes and Amphibians

- 1. Hiccups
 - a. Light pinch of the phrenic nerve
 - i. Comes out of 4th cervical vertebra and innervates epiglottis (shuts down on trachea to prevent food from entering)
 - 1. Go thru thoracic cage and thru lungs into diaphragm
 - b. Scare=move area where phrenic nerve is pinched to unpinch=no hiccup
 - c. **Why do we have such a long phrenic nerve?**
 - i. Fish=first vertebrate
 - 1. Had their resp organs had it in their throat (equiv)
 - a. Had gills more resp
 - i. The movement of these gills is ass w/ the phrenic nerve
 - b. Land animals
 - i. Don't use gills
 - 1. Have resp that is much lower in thoracic cage
 - 2. Movement downwards or resp system into the cage
 - a. The nerve followed this movement down into the neck
 - i. Selection of longer and longer nerve until it reached into diaphragm
 - b. EVIDENCE that we have fish ancestors
 - d. Movement of diaphragm--epiglottis shuts down on trachea
 - i. In tadpoles
 - 1. Go from aquatic to land animal
 - a. Transition from gills to lungs
 - i. Prevent water from going into lungs thru the glottis

******Discovery of fossils that would be found in the wrong place/layer--eg. Finding a human in the cretaceous for eg (Flintstones) would be enough to refute our concept of evolution**

Chapter 4: Genetics, Neo-Darwinism and Modern Synthesis

4.1 Transmission of Traits (Inheritance)--Pre Mendel Perspectives

4.1.1 Preformism and the Theory of Blending Inheritance

Development of Individuals (Theories by Socrates)

1. Preformist Theory
 - a. Individuals that develop are found as miniature in the gametes
 - i. When fertilized, egg would nourish the embryo that is in the sperm
 1. Also believed that it was in the egg
 - a. Looked at sperm and saw no one was there
2. Epigenesis
 - a. Organs would form from a primordial mass (cell) and organs would form and differentiate to more complex shapes

Transmission of Traits

1. Theory of Blending Inheritance
 - a. Both parents participate equally in the genetic makeup of offspring
 - b. For each trait, the child would show an intermediate value between the traits of its parents
 - i. Thus, rapidly all individuals would become identical, or at least very similar, which is not consistent with what we observe

4.1.2 Darwin's Pangenesis

2. Theory of Gemmules
 - a. Gemmules=hereditary particles that are generated by each organ of the body and sent to the sex cells
 - b. The gemmules would be transported in the bloodstream from all parts of the body and assembled in the gametes when they are formed
 - c. Gemmules would be particles associated with the transmission of heredity
 - d. Galton's experiment refuted hypothesis
 - i. Took blood of black rabbit and injected in white rabbit
 1. White should equal black but didn't
 - a. No gemmule in bloodstream

4.1.3 August Weismann's Theory (1834-1914)

3. Weismann proposed that only the sex cells were responsible for heredity whereas the rest of the organism was only a structure doomed to disappear with the death of the individual

- a. Living beings are divided into two parts with distinct outcomes
 - i. Germline (gametes)
 - ii. Soma (the remainder of the body)
- b. The germline is impervious to environmental influences and heredity is simply the continuity of the germline
 - i. Genotype is carrier of phenotype
- c. Thus, the germline and the environment can influence the phenotype but the soma and the environment have no influence on the genotype
- d. Natural selection is the only mechanism that can eventually modify the germline of a population

Sexual Life of Monkfish as Evidence for the Importance of the Germline

- 1. Monkfish
 - a. Has structure sticking out--females
 - i. Males are parasite
 - 1. Attach to genital papilla of the female
 - a. The only objective of these males is to attach and fuse with the female
 - i. They lose all organs when doing so
 - 1. The only function is to produce sperm
 - a. Never detach and stay there all the time
 - i. The soma (rest of body) disappeared
 - ii. DIDN'T change anything about the quality of the sperm...shows the independence and that soma has no impact on the germline

