Age of the Earth & Fossil Record

- **James Ussher** - 6000yrs old estimate (not said in Bible)
- 4004BC - in Bible as an annotation
- Devil's toenail - **Gryphea**
- Snake stones - **Ammonites**
- Tongue stones - looked like tongues of dragon (shark teeth)
- Noah Ark story created fossil - animals drowned.
- **Leonardo Da Vinci** noticed that fossils appear in groups - remains of all habitat
- known as dug up thing

Fossils & Birth of Paleontology

Nicolas Steno

- Theorised that rock layers are formed by sediment accumulation - explaining why shark teeth found in rocks
- Found a way to date sediment rocks based on the layers - oldest at the bottom
- Law of original horizontality - layers of sediments were originally deposited horizontally
- Law of superposition - youngest layer at the top, oldest at the bottom if the layers were not disturbed.

Extinction & Species

John Ray (1627 - 1705)

- Study of the nature world - Wisdom of God manifested in the works of creation (wisdom of God seen through nature)
- Number of species fixed and limited - no new species have came about since creation
- Adaptation proves divine design - animals designed to fit in their environment

Robert Hooke

Micrographia(1665) - found that fossil wood matches the chamber of current wood, named the chamber **Cells**.

Carl Linnaeus (1707 - 1778)

- Cataloger of the living world
- More mammals known now compared to Ray
- Species are clear cut & only come from previous parents - no spontaneous generation
- Too many species to fit in Noah's Ark
- binomial nomenclature - two name system for naming plants and animals (genus and species)
- genus - family, species - specific name
- Plants and animals classification that satisfies the naming proves divine design
- Nothing has ever gone extinction
- Paradoxa in table - for the creatures that dint make sense (mermaids, unicorns)

Old Earth, Ancient Life

Georges Buffon (1707 - 1788)

- Speculated that Earth was a molten sphere then cooled to form the earth. Conducted experiments - 75,000 years old
- Species in different parts of the world are so different - must have created differently
- Species can change a little to fit their environments - but cannot change into a new species

Modern Mining

- Molten sphere idea came from mining - digging deeper gets hotter
- Intersection of different rocks below the surface - don't go straight down
- Started Geology

James Hutton (1726 - 1797) on Modern Geology

- Geological unconformity - rocks break the rules at that point in time.
- Layers are vertical under ocean, must have rose above sea and worn away by erosion, sunk back down again, then deposited horizontally. Entire formation rose up again.
- Gave a good estimate of the age of the Earth
- Believe Earth was infinite - imagine some sort of power that moved rock layers around. Eventually all dry land will be washed away because of erosion.
- Earth designed to work such that there's a force to counter erosion - maintain balance of land (earthquake, volcanoes), forms a cyclical system that goes on forever.
- Early geologists were all religious, many were priests. Ideas became universally accepted

Biostratigraphy by William Smith (1769 - 1839)

- Advised on the digging of canals that deliver goods.
- Fossils were always the same ones in the same layers(strata)
- Order of the beds of rocks are the same - age depends on the layers, fossils in the lower beds are older
- Made first geological map of England

Georges Cuvier(1769 - 1832) on Extinctions & Catastrophe

- comparative anatomy - comparison of the anatomy of living things
- 1800 - proposed age of reptiles, rocks of age dint have mammals
- 1796 - paper on living and fossil elephants
- 1808 to 1811 - Paris Basin publications: fossils characteristic of different strata. Rocks and material reveals there's no great flood but a complicated history.
- rocks showed environment changed from the past - different layer different types of fossils and environment
- Revolutions - changes of one era to another
- Proposed that fossil found is of extinct animal - viewed as not religious. Why God create it for it to die out?
- Prove from bones and teeth which family it belongs to (sloth vs fossil found that look like sloth)
- Knew it was reptile from teeth and bones

Jean-Baptiste de Lamarck (1744-1829) on Evolution by natural processes

- Inheritance of acquired characteristics - offspring acquire characteristics of parent (wrong theory)
- Zoological philosophy. No extinction, only change. More about progress
- Complexifying force - life gradually progress up to a greater complexity
- Adaptive force - adaptation of organisms to their environment via acquired characteristics
- How did giraffe get long neck? - stretch neck to reach tree
- Multiple lines that start at different points, life was still springing into existence. Starts own lineage and carry its on complexity differently, different level of progress.

Mary Anning (1799 - 1847) Fossil Collection

- Remarkable talent for searching sea cliffs for fossils.
- Found 2 remarkable creatures - crocodile like and a sea creature with a long neck. Bones were not mammals, were reptiles
- Mammal tails have horizontal fluke, fossil had vertical fluke
- Found other remains - fossil shit
- Fossil shit indicates what they ate
- 'a more ancient Dorset' - illustration of pre-human world
- Crystal Palace Dinosaurs (1854) - recreated of fossils live-size. Reconstructed them and put them in each geological era
- overseen by **Richard Owen**
- still there today and well maintained
- Careful when reconstructing geological age
- Progressive fossil records - oldest era, find the oldest kind of fossils, progressively gets more complex
- Picture looked like a evolution story but wasn't known to them then.

William Buckland (1784 - 1856)

- Menagerie of animals in his home and eat them
- Invite guests over to eat it with them - part of research
- Brought in a tortoise and let it walk across the dough, leaving tracks - explains marks found in rocks
- Last respectable holdout of the flood (believe that it happened)
- Bridgewater Treatise - series of books on science, demonstrate power, wisdom and goodness of God. Science no difference from Religion. Shows knowledge of geology knowledge known then. Classified rocks by age, but not actual age - which fossil found in which layer.
- Fossil history has no human beings, highest layer has human history

Louis Agassiz

- studied glaciers - weird phenomenons
- proposed ice age

Uniformitarianism by Charles Lyell(1797-1875)

- published Principle of geology - argued against sudden revolutions. Instead slow gradual change
- Natural causes
- Temple of Serapis, 3 columns from ancient Rome
- temple built on dry land, eruption buried them up to a point, ground subsided a bit, sea covered columns partly, dark bands created by sea creatures. Ground rose up again
- All these changes occurred gradually.
- No such thing as uniformitarian - meant to make fun of him
- insistent that the same power of causes happen through history
- extinction is a normal process because world is gradually is changing and the species cannot change
- origin of species - dodged question, dint know
- Living thing has a bit of plasticity so they can change abit. limit to how much they can change, if too much, go extinct.
- Hated evolution, Lamarck. Very disturbed that humans are closely related to animals.
- History of life was not progressive but circular - creation to suit new environments (migration), somehow created
- creation: formation of a new form we know not which, may not be supernatural
- can get same species to come again because of the definition of creation if the environment is right.
- **John Herschel** wrote to Lyell to praise the book. The appearance of new species on this earth - the mystery of mystery. "Origin of species" answers the origin of species.

Robert Chambers

- Vestiges of The Natural History of Creation - bring together the latest state of knowledge of science and history in another theory. Like Lamarck, it was progressive.
- Brought in nebula hypothesis(early stage of the formation of solar systems) - progress from the simple to complex
- Put humans as the highest point the laws of nature has obtained. Unacceptable that we evolved from primitive. Something more advanced than us because of progress
- Had bad reviews and scientific mistakes.
- Believed nature worked on its own.
- Fiercest review - Adam Sedgewick, compared bright red cover to a prostitute, people will be fooled by its exterior charm. Thought that this book would destroy moral fabric of society
- Darwin thought he was a clever writer
- Dint publish it himself, instead his wife copied the manuscript and sent to a friend and sent to a publisher.
- Hugely popular - converted more people to accept evolution of some sort. Reached many readers because of cheap. Familiarise people with living things changing overtime.
- Development, transformation, instead of evolution. Theory of Development.
- Darwin thought that this book prepared the public about accepting similar views on evolution.
- Mr Vestiges

Darwin's Background

- Born in Shrewsbury, England. The Mount, house of a wealthy family.
- Dr Robert Darwin (1766 - 1848), father. Dr Erasmus Darwin (1731 - 1802), grandfather.
- Susannah Wedgewoord Darwin - mother.
- New money families - make money during the industrial revolution.
- Father baptised him in church of england. Mother took him to unitarian chapel.
- Mother died in 1817. Conventional religous upbringing.

- Grammar School (1818 - 1825), dint like it.
- Sent him to university in edinburgh early, premium place to study medicine.
- Couldnt bear to see uncomfortable things. Operations had no aesthetics, unpleasant thing to see

Burke and Hare

- Make more bodies by murdering people and sell them to anatomy schools.
- Killed people by suffocating them.
- Burke executed, the other one rat him out. Disected in anatomy schools.

Robert Grant (1793 - 1874)

- Not a religous, Lamarckian - believe in some kind of evolution, based on what Lemarck thought.
- Jealous that Darwin discovered something about marine biology under the microscope first.

Cambridge

- Darwin's dad proposed that he come up with another job - a priest at the church of England.
- Christ College
- 4 ranks of students, top rank was for nobelman (sons of titled nobility). Fellow commoners - rich people that could purchase the ranking. Pensioners - normal students who paid their fees, Darwin was this. Sizars - students who had a scholarship, paid for by someone else, had to serve other students.
- Wearing trousers - novelty.
- Interested in fine art while he was a student at the university.
- Did science as a hobby. Collected beetles for fun and shared them with his cousins.

Rev. John Stevens Henslow (1796 - 1861)

- Darwin took his elective 3 times in a row. Was Darwin's mentor.
- Model for Darwin, wide range of scientific competence.
- Compatible - science and religon. Laid out botanic gardens.
- Collecting of many observations, on the basis of those, draw conclusion.
- Asked Darwin to join him.
- Dad dint allow - Darwin always changing his career. Uncle helped him and Darwin ended up going.

Alexander von Humboldt's Narrative of travels to South America

German explorer. Became Darwin's idol, most famous man of science. Studied nature and the people who stayed there. Good writer and observer.

John Herschel's Perliminary discourse (1831)

Famous astronomer. Science was building on top of one and another - progress. Law of continuity - connected to other parts in nature. Stress that the collection of facts, and done your homework, then you can theorise.

Rev Adam Sedgwick (1785 - 1873)

- Progressive change of living thing creation.
- Finding different fossil species at different layers proved design.
- New species that appear are not literally descended from previous.
- They are new creations at different steps, not connected by sexual reproduction.
- Believe that everything was created.
- Darwin went on a fieldtrip to investigate some rocks, whether one type of rock overlay another.

Voyage of Beagle

- Was naturalist on board ship. Invitation from Captain Robert FitzRoy. Map making expedition.
- Surveying depths of the water. Darwin just graduated and was free to go. Professor thought he would make an excellent candidate.
- Lived in the back of the ship. Library had 400 books, full of the latest scientific knowledge and travel accounts by earlier voyages.
- Spent most of the time in South America. Darwin spent most of the time on shore.

Cape de Verde

- Darwin was primarily a geologist. Able to reconstruct millions of years of geological activity based on observations.
- Impressed by the tropics because he was from the Northern Hemisphere.
- Intricate system of note taking - series of pocket notebooks. Delegated the info to different places after that, Correspondence, Diary, Zoological, Geological(twice as long in the end), Specimen, Collections(separate list for each collection to give it to an expert).
- Lived most the voyage speaking the Spanish. Took notes in Spanish, then translated it to English later.
- Travelled alot with Gauchos (like cowboy). Taught Darwin how to use a weapon to catch animals.
- Discovered on the East Coast of South America - series of level terraces like steps. Each one of the terrace was covered in rocks that was once part of the seashore. Repeatedly uplifted. Fossils are normally found in sentiments - usually sea creatures.

Princples of Geology

- Found fossils that the environment changed alot, dint understand why the species have vanished.
- Recognised that these were the same family of animals who live in south america today.
- Why should we have representative of an animal living in only one part of the earth? Why were there extinct members of the same family living in the same place where the family exclusively lives today?
- These questions prompted his thinking but dint get the answer whilst on the voyage. Habitat similar but seperated by some barrier and have multiple species.

Santa Cruz

- Attempt to find the river source. Did more geology instead.
- Fitzroy said that the stones could not be made by the big flood. Darwin criticised former geologists who tried to explain the erosion of the rocks of the valley.
- Commonly, Darwin and Fitzroy argue about religon, which is wrong. Laughed at by officers for quoting the Bible.

Tierra del Feugo (land of fire)

- Landscape full of many camp fires. Wanted to establish Christianity there.
- Shocked that the people (Fuegians) were so animal like in their way of lives. Bloodshot eyes from smoke in the hut.
- Extinct because constantly moved away and catching diseases. Perhaps made it easier for him to believe that humans came from animals.

West Coast of South America

- Geological sections - sideway cut to see the different kinds of rocks of a mountain.
- Walls parallel to motion of the earthquake dint fall - tried to reconstruct based on the earth.
- Volcanic activity and earthquake - what was the connection? Coast line was elevated 11 feet during the earthquake. Possible to imagine how the earth has been shaped by many instances of earthquakes.
- 'Tiny actions accumulated over time can bring about dramatic results'

Coquimbo

- Parallel terraces showed uplifting of the environment.
- Found fossilised trees in the Andes. Type of trees that lived in marshal lands found at high altitudes.

Galapagos Islands

- Volcanic rocks that rose out of the sea
- Possible that the species migrated. Kill species to preserve them in the museum thought they were doing it for science.
- Animals were fearless of people on Galapagos back then.
- Instinct that bare relationship to other species (snake that behaved like rattlesnakes without rattle).
- Why was animal created with an organ that is likely to be damaged? (burrowing rodent). Why do flightless birds have wings when they can't fly?
- Still thinks that species are created even after going to Galapagos Islands because why was were species on opposite ends of the world?

Visit to Galapagos

Spanish for tortoise. Established that iguanas were vegetarian because they ate seaweed. Darwin's Finches were an excellent example of evolution. Dint know they were finches.

John Gould

- Ornithologist - studied Darwin's collection.
- Told him birds he collected were finches. And that the birds collected was all closely related.
- How the beaks gradually got thicker. Seem to suggest that they could slowly change.

Galapagos Birds

- Galapagos mockingbirds - at the time, the mockingbirds looked different.
- Different islands had different mockingbirds.
- Upon preparing the lists for birds, discussed what he knew about their habits and theoretical reflections.
- Special notes in bird book - wrote down that maybe evolution is true.
- If the mockingbirds are 3 different species from 3 different islands, this would undermine the fact that species are fixed and wont change.
- Noticed the same in plants.
- Birds looked like the the same from south america, what about the botanists for the plants?
- "Of flowering plants are 225 species, 100 are new and are prolly confined to Galapagos" - why should that be?

Drawing Similarities

- Why are the plants and animals that live so similar to those that live on the closest continent (south america)?
- If not from south america, then it was created. But why are they so similar when the climates are different?
- Why different species for different islands? Creatures got washed out to islands, and occasionally found their way to some nearby islands.
- But were isolated from each other because of the different islands.
- Changed alittle bit independently from each other.

Coral Atolls

- Beagle ordered to look at coral atolls (ringed shape and very low islands) - dangerous.
- Corals can only live in shallow waters. Cannot have grown up from the bottom of the seas because of the lack of sunlight(that algae depends on).
- Volcano provide shallow water area for coral to grow.
- But how does coral atolls come about since there is an island in the middle.
- Darwin said there may be a crater of a volcano - provides the right depth.
- But why should there be so many volcanoes that stopped growing at the right depth? What if the island gradually go down, what will happen to reef? Reefs actually drowned.
- Darwin's theory - atoll formed if the volcano keep sinking, the coral can keep growing up to stay in the light.
- The islands can be completely underwater but the reefs would have grown high enough to form an atoll.
- Impressed onto him - a slow gradual process of change. Gradual accumulation of many change to give a dramatic change.
- Proposed theory that was against Lyell and Lyell accepted it. 1842, published the theory of coral reefs and atoll.
- Requires the ability to think cumulatively. Cumulative changes over a very long period of time.
- Final proof came from the atomic bomb. American tested atomic bomb on bikini atoll.
- In preparation, US needed to know how far down is the volcanic rock from the atoll. If they were able to drill through the coral and hit the volcanic rock, then it proved that Darwin was right.

- Volcanoes rest on seafloor and grown up.
- Darwin theory - Going down because seafloor was going down. Areas of atolls are areas of subsidence, seafloor going down.
- South America was going up and seafloor going down - maybe it was linked?

Tahiti

- Beagle targeted to anchor at Tahiti in Pacific.
- HMS Bounty went in 1787 because it was known that they had a special plant - breadfruit - believed to make excellent food for slaves on the sugar plantation in the Carribean.
- Dint happen because the captain was dictorial, cruel and unreasonable.
- Europeans came across this paradise - can just have sex with whoever.
- Led a mutiny and set the captain and those loyal to him adrift on a boat.
- The mutiny went back to see their girls. Can't stay there, if they were mutiny, will get executed.
- Mutiny sailed away and tried to find an island that they cannot be found.
- Pitcairm - burnt the ship, and stranded themselves there.
- 20 years later, an american ship found this island populated with women, kids and 1 guy (sole survivor).
- One of the girlfriend died, then mass killings. Sole survivor became religous. Descendents of mutiny survior still lived on Pitcairm.
- When Beagle went there, alot of have changed. Christianised.
- Missionaries were helpful, trying to bring religon to the Tahitians.
- When Beagle went to south africa, said that many westerners went there expecting to find paradise of topless girls but it has changed.
- Blamed missionaries for a lot of things. Criticised severely. Upon learning, prompted them to write a local article for local news.
- Darwin's first offical account of Christian missionaries - thought they were doing good.

Going Home & Collections

- Sailed to Sydney, Australia - nothing much since already populated by westerners. Dint respect Australia.
- Island of St Helena had alot of vertical cliffs. Drew a selfie of himself on the cliff.
- There were heavy winds beyond the cliff but not on the cliff.
- 1836 - Beagle returned home.
- Received government funding to help him prepare a series of books collected during the voyage. Alot of unpublished collections because of the size of the collection.

Aftermath of coming home

- Moved back to Cambridge after coming back. Forced to leave and head to London.
- Asked himself if he should get married or not. Made a list of pros and cons for marrying or not.
- Advantage - constant companion, object to be beloved and played with. Disadvantage - more time for his work, lost of time.
- Married cousin, Emma Wedgwood. Macau cottage because it was very bright. London was smoky back then because houses burnt coal. Dint suit him despite having alot of scientific friends there.
- Had enough money from their family. Wanted to stay outside the city. Chose Downe, south of London as their home. All his life work crammed into a corner in his room. Could be used to how he was working because of the way he lived on the Beagle. Stayed in Down House.
- Title of origin of species refers to John Herschel question about "that mystery of mysteries, the replacement of extinct species by others."

Agrument about Design

- William Paley (1743-1805).
- Wrote a popular book that remained in print for a century - socially and religously acceptable way of talking about science.
- Natual Theology, or evidences of the existence and attributes of the deity collceted from the appearances of nature (1802).
- By studying nature, we will find the existence and properties of god. Ideas came from John Ray and Carl Linnaeus before him. If he walk across a meadow and kick a rock. But what if he kicked against a watch instead? Cant say the same thing about the rock. The watch was designed and made to function.
- Analogy of living things for Paley. Retold argument that people were telling for a long time. Considered dusty and dangerous in Europe. What if evidence showed otherwise?

Coming Up with Theory

- Feb 1835 - still a creationist(thinks creation by a divine species).
- Grappling with problem of successive disappearance of species and unknown birth of new ones
- Goes through intermediate theory (life time theory of extinction)
- Species must have a lifetime programmed into them and they would only last so long.
- Heard the story of an apple in South America. This tree grew by cuttings and not seeds. Essentially all the same tree. This trees all died out. Why did all tree despite a difference in age?

Ornithological Notes (Jun - Jul 1836)

- Biology of remote islands would challenge the ideas that species cannot change if the mockingbirds were actually different species. Made him focus on bio-geography.
- Seemed curious and sceptical on whether new species appear, but not convinced of evolution.
-

Convinced of Evolution

- Early 1837, becames a transmutationist(someone who believe in evolution). Wrote down something that made him almost convince that species must change - character of S. American fossils(extinct animals were south american group of animals and they only live there today) and galapagos things.
- **Similarity between extinct and living creatures in the same place**. Extinct thing being replaced and the new species living in the same place as the old ones just millions of years apart - new ones descended somehow from the old ones.
- **Distribution of related living species**. Lived in the same area but separated physically. Difficult to decide whether something was a species was surprising. Indication that they were closely related?
- Varieties - races of animals. Different breeds of a species. Species with alot of variety. Where did the breeds come from? Descended from parents. Thought there were limits to how much animal can change
- **Relationship of Galapagos islands species to those of nearby continent**. Are they 3 species or not? Conventional thinking - independently created. But they were so similar that Darwin wasn't sure. Suggested that the species had a common ancestor. Only possible if theidea of evolution was accepted.
- Coral formations paper (May 1837). Study of remote coral islands that have not been in contact with other things. Are the things found remnants or are they new ones springing into existence? - thinking about evolution

Red Notebook (Jan - Jun 1837)

- Last notebook from voyage but continued to use. First jotting towards theory of evolution.
- Looks at the question of geographical distribution. 2 species come from common parent. Initial theory descended from common parent at one blow, saltational speciation. Perhaps new species of smaller size is formed.
- Distribution of species through time and space. Perhaps the relationship in space is similar to that in time as well. Law of succession of types in same locality. Everywhere in the world, a type of creature unique to a place, in the ancient past, youll find the fossil of a different species of that animal.
- Reproduction of individuals and species. Perhaps it dint die from change of environment. Individuals die when the time is up. If species have time limit on them, then everything should be dead. What if new species is borned before it dies out? And the cycle repeats. Halfway theory which was abandoned later.

Transmutation Notebooks (July 1837 - 1839)

Notebook B

- How do species become adapted to a changing world? Convinced that species change to fit environment
- One possibility was that sexual reproduction produced new offspring that is varied
- If things lived forever, bodies would become more and more problems. Old belief that parents passed body to offspring. Young will acquire the old body problems and keeps piling up. If short live times, then there wont be time to accumulate problems before they reproduce.
- **How do new species form?** Mostly from isolations like coral atols. Examples from isolated areas.
- **How does hierachy of taxonomy form?** Darwin thoght that they were categories in a tree structure of hierachy. Why is the arrangement like that? Actual representation of genelogical descent of their tree, fit perfectly with how they descended. Descend from common ancestors and split off.
- Tree of life. Why are there animals that belong somewhere else but found in weird places? Descended from the a common parent. Since they look almost identical.
- Tree of life sketch. Branch is considered another species. Deadends are extinct, lines at the end means still alive today. Letters represent something alive today.
- Able to explain why when theres a family of animals, some members are really similar but there are others who are really different. The reason is because of their family tree - how long they have been separated. Less separation means more similar.

Notebook C

- **Hereditary transmission of form** - how is it that living things pass on their characteristics? Widely accepted that it was just passed on.
- **Distribution of local and wide-ranging species** - why some species are only local but others can spread so far? Distinction between affinity and analogy. Similarity between 2 species doomed to descent from the same ancestor. Analogy is similarity due to apations because of similar environments.
- **Relation between habit and structure**. Which came first?

Notebook D

- What is the origin of adaptation? Got the idea that species are descended from earlier species. How did they come to be adapted? Why is the world not filled by 1 type? Natural selection (Sept 1838)
- Read book by Thomas Malthus - world is on collision cause for disaster. Came up theory of law of population.
- Population growth will be exponential but food production can only increase arithmatically, cannot keep up with exponential growth. What to do poor if they can't feed themselves?
- Some thought that the state should help but Malthus talks about feeding the poor offsprings of the poor? Find a way to prevent exponential population growth. Thought it was bad to help them.
- Population explosion doesn't really happen. If all offsprings lived, there will be a big problem. What are they held in check by?
- Those creatures that are born with the attributes that fit into the context of that field will survive.

Notebook E

- Evolution by natural selection. Random differences and variations may turn out to be useful in the environment.
- 3 principles will account for all (what his theory consist of) - **inheritance, variation, competition selection**.
- Seems to be a competition because not all will survive
- Small variations don't usually matter unless the environment was changing. Tiniest variation can give them a big advantage.
- Adaptation is relative - not formed with forsight that they will be needed. Adaptation is contingent on circumstances and variation is always there.
- Domesticated races are formed by human beings like how species are formed in nature

- Species can remain unchanged if it fits into the environment well.
- Combine attributes of geologist with biologist. Difficult to get people to understand his theory if they are not both a biologist and geologist. Sketched out theory of which to test.

Alfred Russel Wallace

- Represented as a working class scientist unlike rich Darwin.
- Parents were Mary Ann Wallace, Thomas Vere Wallace (a gentleman).
- Kensington Cottage, Usk - house which he was born.
- Went to Herford Free Gramma School 1828 - 1837.

Meeting Bates

- London 1837 - Saw working class people and how hard a time they were having.
- Saw them as people he felt sorry for. Did not see them as himself.
- Surveying 1837 - 1843 as his first job. Survey fields and hills and help railways help to plot their track.
- Went to Duke and built Mechanics Institute, Neath with his brother.
- Went to Collegiate School in Leicester 1844 - 1845 as a teacher.
- Met Henry Walter Bates (similar background). Was a collector of beetles.
- Introduction to formal science. Vestiges of creation - read this book.
- Book about evolution, first one that people heard of.
- Radical, trying to summarise the science of the day then.
- Evolution - organism give birth to something of higher form. Type of evolution theory that built into progress.
- Author was famous publisher, dint want radical ideas to damage business.

Phrenology & Mesmerism

- Phrenology - scientific psychology where they thought that feeling the bumps of someones head, you could understand their psychology.
- The bigger the brain part, the better the person should be at that aspect.
- Wallace very eager to accept this. Had someone read his head. Gullible and believed this things.
- Wallace as a young man was open to accepting radical ideas - like evolution.
- Mesmerism - magnetically influence the mind with animal magnetism.
- Put them into a stage of hypnosis(magnetic sleep). Thought can combine both together. Did this to students.

Letter to Bates (1845)

- Wallace is curious that evolution might be true and willing to investigate it but not convinced of it.
- Interested in topic of origin of species and want to collect.
- Not the same as saying that we should go and discover the origin of species(1863), after Darwin's book was published. Darwin came first.
- Bates claim he was first which was wrong. Friend wasn't interested in discovering origin of species. Just wanted to study some insects.

Collector Job

- Can be a collector because theres no degree in sciences. Pay good money for these collections.
- Collections could be alive or dead.
- Museums were full of remains of these animals. People who had money liked to collect plants and animals from museum.
- Wallace could make a living collecting things.
- Increasing knowledge of species that live in different parts of the world. Become experts and know what they are collecting even though its private. But its advancing science.

Amazon (Apr 1848 - Oct 1852)

- Collect birds and butterflies.
- Send them home and sold as specimens.
- Not as successful as he wanted it to be.
- Fish was hard to preserve - colour was lost. Draw and take note of the colours.
- On his way home, 1852 shipwrecked. Ship was on fire and had to abandon ship. Collection had to be abandoned, took some stuff and left.

Voyage to Singapore

- Had to go out and become a collector again because the trip failed.
- Got money from british government and took a trip to Singapore.
- First class passenger was listed in the newspaper. Arrived in Singapore 18 April 1854.
- Prolly stayed in London Hotel. Stayed at St Joseph's Church, Bukit Timah.
- Started collecting in south east asia here.
- 1854 Singapore Riots - dint know what was going on, riots was the greatest moment of civil unrest in Singapore.
- Chinese people were from China and identified with their ethnic group. Saw anyone else outside their group as foreign. Lots of killings and violence.
- Said that tigers killed someone everyday on average (wasn't true). Believed this story and put it in his book.
- Had a team of collectors to help him.
- Insects were mostly collected himself. Collected shells also.
- Animals collected has to be preserved. Shooting a bird makes it rot - they would skin the bird, put preservatives on skin and body, preserving the body as long as it doesn't get wet or mouldy.
- Wallace's mystery flycatcher - a bird called flycatcher, said it was collected in malacca in 1862.
- Wallace dint go there in 1862. Why is there this label in his handwriting when he wasnt there.
- Hired a friend to buy specimens from south east asia to sell them. And that bird was one of those.
- Asked his agent to sell books to George Rappa Junior. Partner with Philip Robinson to find Robinsons.

Charles Allen

- Frustrates Wallace because he wasn't careful.
- Leave employer and became a missionary in Sarawak.
- Came back to Singapore. Manager of Perserance Estate and became quite rich.
- Daughter married architect of Raffles Hotel.

Ali (1855 - 1862)

- Another assistant from Sarawak.
- Travelled with Wallace as he visited South East Asia.
- Trusted him, best assistant he had.
- Ali discovered species, Wallace took credits.
- Wallace gave equipements to Ali and used equipment to buy western clothing. Dint look as well compared to his native dress.

Sarawak's Law Paper 1855

- Misquoted as an article about evolution.
- Outlines theory without the specific things without natural selection (wrong)
- Dint ever suggest evolution.
- Lays out evidence suggesting evolution. Afraid to say that species evolve.
- New species are created (only used publicly because he want to suggest evolution).
- No reaction, everyone ignored it. Huge disappointment, thought that he was suggesting evolution and no one said anything.
- Darwin read paper and felt he knew all this already. Darwin already had notion of evolution for years. But because of language, thought he meant creation.

Wallace Line

- Greatest difference between animals in region of the world.
- Eastern side, australian animals. Western side, different animals with asian families.
- Surprising because the islands look the same, why are the species so different? History.
- Australia had their own species. But because of plate techtonics, island move closer together. Now really close to each other.

Wallace Fame

- 1871 - Wallace-Darwin episode form a bright point of rivalry
- 1908 - Speech for Wallace: nothing more delightful or nobel to be compared to Darwin
- 1980 - Wallace was victim of conspiracy and robbed of his priority in 1858
- 2010 - Wallace was not given the recognition of his theory of evolution

Ternate, Dutch East Indie

- Closest point to collect birds of paradise (incredible and exquisite birds). Very valuable specimens.
- February 1858 had a fever(prolly malaria). Had idea for natural selection while having a fever. No evidence of such thing happening.
- Letter to Bates 2 March 1858 (2 wks after eureka) - evidence related to time. 'but i have lately worked out a theory which accounts for them naturally' - only evidence of coming up with new theory.

Wallace Theory of Evolution

- Using coloured beetles on the soils they lived.
- Different islands always match the colour. Beetles of varying colours and the environment changed. Beetle used to fit in perfectly. But after changing, beetles that stoodout died.
- What if one of them happen to be the colour of the environment. Living variety replace species and cannot go back to the previous inferior one.

Ternate Essay

- Sent essay to Darwin. Surprised because its the same theory he was working on in private.
- Later, Wallace recalled he sent it by the next post. Sent on 9 March 1858.
- Conspiracy theory - Darwin lied and said he received it on 18 june? Conspiracy that Darwin stole the ideas from Wallace because the dates dont make sense.
- We knew the postal routes from Ternate to London. Theorists assume he sent it on the march steamer and prolly reached before june.
- Projecting a victim status for Wallace. And heroic because he was wronged and want to prove that Darwin was a cheat.
- Wallace had a surprising possibility, because Darwin and his hero was impressed with his work.
- Send to Darwin cos he believe in evolution. Dont need to fear being embarassed. If impressed, then can pass to his hero.
- On receiving the essay, Darwin was shocked. theory of evolution was more abrupt compared to Darwin's theory.
- Wallace theory had a bigger step than Darwin's gradual theory.
- Sent letter on 5 april, arrived in london on 17 june, then Darwin said he receive it on the 18.
- Darwin wrote to lyell and said it was that it had his theory of evolution and sent this for publication.
- Lyell dint reply and Darwin kept writing to him. Initially, Lyell just asked Darwin to publish his own theory. But not honourable because Wallace sent him and was to just get ahead in print which wasnt gentlemanly.
- Lyell's response was sent to Joseph Hooker (Darwin close friend). Instead of publishing something on its own, share what Wallace and Darwin have together.
- 1858 shared with the linnean society for the first time. No reaction, papers were too brief.
- When he heard of the news, wrote to his mom. He was delighted. His admirers felt that it was a grief.
- Darwin spent a year and condense his theory down into the origin of species. Huge reaction because he supported this controversial idea and he had good arguments and was powerfully convincing even though scientific community was against this idea.
- Changed the idea of evolution forever, widely accepted now. Darwin became famous because of the book.
- He had his own idea and published jointly with Darwin, but the notions were so brief until Darwin's book came out.
- When Wallace received the book, highly approved the book but had alot of elements that he had not thought of. Like sexual selection - change over time by virtue of females choosing. Males fight, get girl and then pass gene.
-

Wallace Comes Home

- Wallace stayed in southeast asia till 1862. After returning, he had a huge collection of animals and made his fortune. Got 300 pounds a year of interest from the bank.
- Darwin book is discussed everywhere and Wallace name was on the first page. Credited from the beginning who was clever enough to thought of the theory on his own.
- Wallace published Malay Archipelago. Well-known because of this book and being mentioned by Darwin.
- Blew the money - made some terrible loans. Darwin started a scheme to appeal to government for a state pension for Wallace to safe him financially.
- Wallace went to the 1870 meeting of the british association for advancment of science and said that there was no more fun debates because theory of evolution is solved.

Love Life

- Loved Ms L, and played chess with her dad. But was shy and couldnt work out the courage to tell her.She rejected him in a letter.
- Wallace showed letter to sister and mom. Suggested giving it abit more time. Spent an entire year playing chess before trying again.
- Asked the father first and he approved and she also said yes. Suddenly Ms L has gone away. Was super unhappy.
- Prolly cos of the difference in family income.
- Married Annie Mitten 1866, was about 20 years younger than him.

Natural Selection on Humans

- Had a strange change of evolution in 1869.
- Wrote review of lyell principles, said that natural selection can't explain human beings.
- Supernatural mind must have been involved in the evolution of humans. Darwin reacted and said that it applies to human beings and said Wallace has come up against him.

Flat Earth Wager 1870

- Someone placed a bet that the earth was flat and wanted scientific community to say otherwise.
- Wallace took up this bet because he was a surveyor.
- Went to a canal to test with flags because one flag will be lower than the other if earth is round. Flat earther refused to accept though it was true.
- Pursued and harrassed him for 20 years. Caused more legal fees to sue this guy.
- Asked for advice from lyell before. Dint take his problem seriously and asked him to just go ahead.

Spiritualism

- Became convinced that these mediums were talking to the dead.
- Wallace posed for photographs thinking that there was a ghost there. Medium got photo using double exposure.
- Wallace was told that he was taking a picture with his dead mom. looked at the photo and said that she dint look like her mother.
- Dint doubt it at all, tried to convince other people from scientific circle to come and listen.

Death

- Died in 1913
- Referred to as father of biogeography (distribution of plants across the earth)? Old topic before he wrote about it.
- Greatest field biologist of the 19th century? He wasnt really a biologist, was a naturalist.
- Most famous scientist when he died? Collected many interviews with him.

Darwin's Delay

- Delayed publishing his theory on evolution for 20 years because he was afraid of what the public would say. (False)
- In mid 2000s, prof suspected that something was not right.
- Never written by darwin himself that he kept his theory for 20 years. Fake photo of him shushing himself to show that he kept his theory quiet for over 20 years. Exhibitions in london and new york.
- From 1859 - 1940/1950s, no mention of Darwin delaying his publication. Early obituaries and biography accounts of him had no mention that he was keeping his theory a secret.
- In 1958, Julian Huxley suggested fear of upsetting scientific colleagues contributed to Darwin taking so long. Guessed that he was afraid to publish his theory.
- In 1974, Howard Gruber(psychologist) on Darwin on Man - obsessed that Darwin was afraid of publishing his theory. Can't apply modern theory on people in the pass.
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Dream of being hung

- In late 1830s, recorded a dream that someone was hung. Idea that - Tormented of the idea of being hung or beheaded for his radical views of evolution.
- Actually dreamt of another person. Wasn't a scary dream, interested in how the brain works thats why he wrote it down.
- What does delay he wrote about it in his autobiography mean? Conscious postponement or the time that had happened to elapse? Was read in the second sense back then but now read as the first sense. 2 instances of second sense of delay in his autobiography.

Publication Patterns

- A long gestation was typical for Darwin's books.
- He would notice something or have an idea and think about it for some time and when he finished a project and had free time, he would move on.
- Wrote about this concept to a fined.
- His inheritance theory was not published for 27 years in 1868. He began observing orchids in the 1830s but dint publish his book on the subject until 1862. Notes on psychological development of his son and was not published for 37 years in 1877. Worked on cross fertilisation in 1839 but only published in 1876. Realised the significance of worms in 1837 but dint publish his book until 1881.

Strong Language in Letters

- Darwin said its like confessing a murder to tell his friend that species change.
- 11 Jan 1844 to JD Hooker. Letter was published after his death. Wasnt read as an evidence of fear.
- Wrote that he was ready to commit suicide when publishing his book about Plants in a letter to Hooker 1875. It was just joking around with his friend.
- Language of murder, killing and suicide is actually his sense of humour.

Keeping Secrets

- He marked letters as Private.
- But please repeat nothing - tell his friend that this is a secret. Dint say ask his theory of evolution letter to be a secret.
- Darwin told alot of people (about more than 50 people because letters get lost) about his theory of evolution before publishing it. If he dint delay then what was he doing??
- Publishing the results of the Voyage of the Beagle. Sent the book for printing in 1844.

1844 Essay

- Rough draft of his theory of evolution.
- Had the thing copied by a professional copier. The fair copy - bounded in book form.
- The memoir to his wife. Dint said to publish the essay only after his death. Wrote letter to wife asking her to publish if something happen to him.
- 1844 Vestiges of Creation was published. No evidence that Darwin was afraid because of the poor reception of the Vestiges.
- Richard Owen wrote to the author of Vestiges. Said that discoveries of the law of nature that make species change is what top people (himself) is working on.
- Secondary causes refers to laws of nature. Primary would refer to God himself.
- Actually published it because of Wallace in 1859 instead of 1853. Finished Geology book in October 1846, and zoology took him another and +5 years then itll be 1853.

Barnacle Catalogue

- By 1846, only barnacles were unpublished. Wrote in may 1848 that the barnacles will put off his book for a long period of time.
- Only when he was done then he will move on to his evolution book.
- Cirriped mean hairy foot is another name for barnacles. Thought to be Molluscs (like clams). Barnacle is a Crustacean. Close relative of prawn. Life cycle of prawn and barnacle are quite similar. Offspring are quite similar, meaning they were related.
- Swim through like a tadpole. Glue itself to a rock or solid object. And form shell around its body.
- Shell similar to prawn. Stick foot out and feed on particles in the water. Grow the world's largest cock per body size. Can't move so they need a big cock to have sex. Barnacles have both genders.
- By 1850, Darwin took job to complete catalogue of barnacles. But started to hate it.
- Barnacles encrusted the bellies of ships and made them slow down. Started to lose interest in it. Cannot stop because he was almost done.
- 1847 - 1853, published his books on barnacles. Covered every species of barnacles dead or live.
- Had a lot of lessons for him on his theory of evolution. Segments of the shell showed that structures could adapt to suit new conditions.
- Owen wrote Nature of limbs (1849), theory of archetypes. Body plan for living things, evidence that living things have been designed by god and thats why they look similar. Different from theory of evolution. More religous theory, god had the same plan in them.
- Almost microscopic with no shell barnacle. Made a hole in a shell of a mollusc and made the shell as its home.
- Seems to break the rules but its clearly a relative of Crustacean.
- Found that some barnacles had some little things (were actually males living on the body of females) buried inside of them, complemented male.
- When the larger barnacle, the female can get sperm of another individual. Relevant to theory of evolution, creates mixing which is ideal.
- Why need distinct gender when they can be both? Noticed that animals with both genders were changing to be single gendered.
- Worked on barnacles for so long that his children couldnt remember anything else. Visited neighbor and one of his child asked where his dad worked at barnacles?

Unfinished Business

- Thought he solved using principle of divergence. Sexless females that dont reproduce - solved in november 1854, kin selection. Workers are part of her dna; she can only reproduce if workers protect her well.
- In final edition of origin of species (1872), concept of evolution no longer controversial.
- Says that in the old days, he talked to many people about evolution but no one agreed. Means it wasn't a secret.
- Wrote in a letter to Asa Gray from 1857 - said that while he was working on other things, he was collecting stuff on evolution.
- Wallace and the surprise of 1858 - Wallace surprised Darwin with the theory of evolution.

Contents of Origin of Species

- What is the book about? - Origin of humans? General process of how living things change over time. Evolution by natural selection explains a wide range of phenomena that are otherwise inexplicable. Lyell's gradualism underlies Origin, long slow action of small natural causes can accumulate to produce enormous changes.
- Book doesnt address religon or god. Just by reading the book, referred a few times to the creator. Coverup or just that author believe in god? Accepted that maybe species do change overtime, as long as god was behind it then its ok. He strongly implies, yes.

Domestication

- Variations continuously appear in living things and are everywhere. Differences could matter depending on context.
- We choose which living things we will breed from in order to enchance characteristics we like for domestication. Similar to how we do this to domesticated living things, its done in the natural world.
- For example pigeons. Breeders assumed that different looking birds came from a different ancestor. Darwin told them that it came from a common ancestor instead.
- Polish fowl. Cannot make a bird with big feathers, only can select an offspring that will look like that if you want to. Giovanni Stanchi painting of fruits showed ancestor of watermelon. Selective breeding. Ancon sheep - short stumpy legs (useful, cant jump over fences). Similarly with strawberries - original ancestors was tiny.
- Why is there no clear distinction between species and varieties? Members of one species, varieties is a race. Blend so gradually into one another and you can't tell the difference between one and the other.
- Tree of life makes sense of taxonomy. Represents the process and how it works in general. Different lineages. Creation cannot. Things descent from one another thats why they are so similar.

Struggle for Existence

- An effect of struggle of existence from over-reproduction. Only a few survive to pass on their characteristics. Results in what looks like a competition. Natural selection seems to imply that some agency is making the selection. Perhaps it should be natural perservation would be clearer.

Sexual Selection

- Very unique theory. Explains how they came to look and behave like how they did. Females have been selectors in those species, led to accentuation of some properties. Radical theory and dint like it because he attributed so much power to females.

Objections to his theories

- Had a good effect on his readers - impressed by his honesty, and he thought and had answered for most of them.
- How did huge changes ever begin? Every little tiny step had to be successful on its own. Overtime, big changes do happen.
- Traced everything to early fish. Had one opening for breathing and swim bladder to help them float. Some kinds can gulp air. Arrangement cannot be altered and too fundamental for land animals.
- Organs that seem too complicated and perfect, they must have been designed? Admits that these organ must have been designed.
- Why does bee die after stinging? Not a good design. String dint start off as a sting, ancestors may have used sting for something else. Characteristics may persist due to inheritance.
- Imperfection of geological record. Why is this not shown in fossils?
- Because of nature of fossil history. How they are buried matters as well. Small number of things get fossilised and hence fossil record is very incomplete. Hence the inperfect transition from fossil. Intermediatory patterns in fossil.
- Species once extinct never reappear. Succession of same families within same areas explained. Things are simply descended.
- Geographical distribution. Most compelling evidence for evolution - where things are where they are, are based on natural limitations that we can understand.
- Oceanic islands that wasn't part of a continent. How did the things that lived there get there?
- Swam, float, blown there. Pattern found was interesting. Some types of animals that don't live there like amphibeans. Even though the environment are perfect for them. Couldnt naturalistically get there, killed by salt water.
- Embryology. Embryos showed great similarity to other species in their early developments. Historical left overs that show ancestories of living things.
- Vestigial organs. Leftover things in the embryos of animals have features that disappeared during development. Homology - common structure in different species.
- Does the natural world reveal evidence of kind or benevolent design? He cannot believe it himself. Doesn't like the idea that a creator has thought up of a lifestyle.
- Ernst Haeckel's tree from The Evolution of Man. Man isnt on top of the tree. Everything that is alive today, had ancestors that went back an equal amount of time and adapted to live.
- Common misunderstanding that evolution is the process of progress that lead to betterment. Doesn't lead to perfection, leads to good enough. Misleading image of ape from men, appearing of humans was inevitable which is wrong.
- 6 editions of Origin of species - each changed over time. 3rd edition added historical sketch (1861). In 5th edition (1869), used survival of the fittest. Evolution is not survival of the fittest. Whatever survives in the context.

Reception of Origin of Species

- Most people believe it was a huge controvery as soon as the book appeared in 1859.
- Widely reviewed in educated periodicals, not newspaper for the masses.
- Wide range of reactions - many variables determined how people reacted. Major objections - thought God had to make species and cannot form themselves.
- 1869, 10 years after publishing, context has change, alot of new evidence and debates. Had to change wording in 3rd edition (1861). 5th edition (1869), changed the same statement.
- Scientific debate then was over. Accepted evolution - that living things change over time.
- Natural selection wasn't so successful. Historians wrote that natural selection was a reflection of victoria social values applied to nature. Puts social causes in driving seat. Why was it so unaccepted at that time? Doesn't make sense.
- When Darwin died in 1882, was the most famous person in science at that time.

Supporters of Theory

- Thomas Henry Huxley review 1860 - supported Darwin's theory.
- Darwin's great defender but was skeptical of the mechanism of Darwin's theory. Nicknamed Darwin's bulldog (not true).
- Wrote for a respected newspaper in London at that time. Dint argue that Darwin's theory was right but it should be discussed.
- H. C. Watson wrote a letter after reading. Highly praised Darwin's theory.
- Charles Kingsley, wrote to Darwin about what he thought of the book as a reverant. Combined theory of evolution with own religous belief. Darwin was impressed and asked to quote from his letter. Just as noble as the deity, that he has designed laws of nature to allow all this extinction gaps to be filled on their own.
- Oxford University Musuem 1860. Scientific meeting with Wilberforce and Huxley. Poked Huxley - asked whether he was descended from an ape. Huxley thought he had the perfect come back. Replied that he rather be descended from an ape.
- New evidence was found for Darwin. Bates put forward a discovery he made, Batian mimicry.
- Found thousands butterfly, knew that it tasted gross to birds. Those tend to be colourful. Found another species that looked like poisonous one but wasnt related.
- But how did it look so alike? Proved Darwin's theory - because poisonous ones and the mimic only occurred in the same location. Non-poisonous ones had advantage if offspring looked like the poisonous. Process continue and eventually they look alike.
- 1860 - oldest fossil feather. Too old for birds to appear. Archaeopteryx (1861 - 1863).
- Darwin predicted that the remains of creatures between 2 groups that we know, this fossil was the example of that. Was a mix of lizards and birds. Intermediate between 2 groups of animals.
- Revealed that dinosaurs dint go extinct when asteriod hit. Family of dinosaurs dint die out because birds are dinosaurs.
- Birds have scaly legs and walked on their hind legs, laid eggs. Where a bird wasnt covered with scales, they are covered with feathers. Ancient dinosaurs were fluffy to keep them warm.
- Asa Gray. American botanist and good friend of Darwin. Very religous, and combined Darwin's theory in his own way.
- Thought that Darwin's theory had tiny variation. Darwin convinced that this just happens.
- Thought that God induced the little variations to go a certain way. Saw Darwin's theory as steered by God in some directions. Darwin disagreed, had a lot of counterexamples.
- Huxley published Man's place in nature (1863). Put skeleton of apes and humans on his cover page, to show dramatic similarity. Humans are clearly animals.
- Made shocking point - man more similar to monkeys than they are to dogs. Scientifically speaking, humans are in same category of apes. Analysed all the different parts of anatomy of humans and compared with humans. Thought that Australian aboriginies were more primitive (not right).
- Discovery of fossiled horse bones in America. Went through geological records. Legs of horses were changing. Ancient ancestors of horse were little and gradually became bigger and optimised for running.

Opposes of Theory

- Geologist Louis Agassiz (1860), dint like Darwin's theory. Thought that it was a wrong and dangerous theory.
- Samuel Wilberforce review 1860.
- Flemming Jenkins review (1867) - had counter theory to disprove Darwin's theory.
- Very racist theory. If little tiny variations arised which are superior, they will be swamped away with another animal that dint have that variation. Known as blending inheritance(swamping argument).
- Racist story with European with an island full of black people. Europeans are superior, but will you get an island full of Europeans, no, because his characteristics would be blended away.
- Troubled Darwin, because they dint know about genes and dint know alot about inhertiance. Things may not get passed on. Seemed unlikely that Jenkins story will be a fatal flaw of Darwin's theory.
- Encountering the theory dint put your religon at stake. Gorilla became widely known (was a recent discovery). Paul Du Chailu published Explorations and Adventures in Africa (1861).
- Human-like animal appeared, and implications that humans descended from other speices. Already obvious that we belongs to primates. Gorilla seen as ferocios monster. Gorilla being opposite of human beings goes into modern stories like King Kong. Turned out to be wrong.
- Richard Owen 1857. Against Darwin's theory. Very jealous of Darwin's theory.
- Wrote anonymous reviews that attacked Darwin's theory and praised his own book. But was found out.
- Wanted to separate humans into another category. Convinced that he found a structure in the brain that was different in humans and apes. Put us in a completely different group of mammals.
- Felt very strongly that humans dint evolve. And his ideas are quite complicated and mysterious; confusing writing style and unclear. Only serious enemy of Darwin.
- Identified hippocampus (The Great Hippocampus Question). Challenged by Huxley. Claimed that Owen was wrong. Had major fights in newspapers.
- Difficult to dissect and see this part of the brain. Main debate was whether they belong in the same group as apes. The Great Hippo Test. Put Darwin's theory subtly into the book. Even though the moral book was different.
- Antiquity of man - how long has humans been on Earth? Don't know because haven't found fossils of humans.
- Lyell published book that borrowed ideas from everywhere. Found it difficult to accept Darwin's theory - against idea that human descended from apes. Made basic point that humans should not be separate in nature. Surveyed recent discoveries of early man, archaelogical evidence.

Preferences for natural laws

- Associated with the french because of french revolution; radical
- Turned churches into palace of reason (they worshipped reason).
- British said that thats the result of not being religous.
- Pierre-Simon Laplace (1749 - 1827). Presented Napolean his book and denied existence of God. Idea of evolution tinted by Lamarck.
- John Pringle Nicol book on nebulae. Creation of solar system is a natural process.

William Buckland Books

- Written to back up christianity. Not everyone agreed.
- Charles Babbage (1837) - wrote book to make fun of treatise.
- Computer referred to someone computing numbers.
- Demonstrated that something has happened in natural that breaks the rule, religous people called it a miracle. Trying to say that we hastily assumed its a miracle if its something that we dint understand.
-

Phrenology

- Franz Joseph Gall, created a system 1790s
- Travelled all over europe that the brain is divided up into little chunks.
- Believed that every organ does something specifically.
- Sounds like materialism, that the mind is an inmaterial substance. Wasnt a materialist.
- Thought that the mind could interact with the physical world by going through the brain.
- Size of the segment determine how active the mind was in that area. can determine character.

Scientific Psychology

- Nothing left that couldnt be examined by science. Spurzheim.
- Published book that made the system of Gall very different - wanted other people to adopt this idea.
- Reviewer(brain scientist) hated this book and damned the book.

George Combe

- Convert, became a phrenologist
- Combe doctrine of natural laws. Not a book on phrenology.
- How is man made up. Make up of man in relationship to natural.
- Laws of nature that they integrate one-to-one with the make up of humanity.
- Secular religon - taking us away from christian notion, we are not outside the laws of nature.
- Analogy of ship - people on board dint maintain their ship properly because they dint attend the law of nature (fixing the ship), the fact they are good and religous wont save them.
- Very controversial argument - stakes were high. Huge opposition to the book.
- Widely imitated, so convincing in that age, others started writing their own stuff that was very similar.
- Made victorian society more secular and made people accept more scientific theories that explains man kind. Vestiges of creation infused with ideas from combe. religous offspins existed as well.

Biblical Scholarship

- study of text of the bible
- Friedrich Schleiermacher (1768-1834), David Friedrich Strauss(1808-1874), Lugwig Feuerbach (1804-1872).
- Inspired by earlier studies of ancient writings. Analyse old books in greek, discovered that writing style was different.
- Work of alot of people over a long period of time.
- Many variations between the copies depending on age
- Story of woman caught in adultery - wasn't found in oldest manuscript of bible. writing style and vocabulary was different. Argued that story was added later.
- Made people doubt their religon, led people to lose their faith.
- George Ellot translations of books. Liberal Anglican theologies incorporating this historical scholarship into Christian doctrine in Essays and Reviews (1860). Very controversial.

Victorian Crisis of Faith

- Began to doubt their faith.
- Huxley the Agnostic (1869). Atheist - term of abuse. Huxley wasn't a believer. Coined the word agnostic (someone who feels that one way or another whether god exists or not). Doesn't deny existence of god but doesn't believe in god either.

Science Professionalisation

- Science back then wasn't a job or profession. now that its recognised as a job, has a different appearance.
- Huxley was leader in pushing this movement. Started to use the word scientist in the end of century.
- John Tyndall Belfast Address - very secular and controversial.
- Made case for sufficiency of natural laws - leaving no room for gods. Argued that religon had no authority over nature and science. pantheist (god and nature is the same thing), not a traditional view.

Victorian Evangelicalism

- Groups of christians with new way of thinking that was conservative.
- More popular whilst other things are getting popular too. Fiercely opposed, wrote alot of things to reject the secular doctrine.
- Darwin's book fall into this mix. most opposed darwin's book

Natural Selection in Plants

- Darwin critics claimed that natural selection couldn't explain details of living things (like flowers, specificially orchids).
- Orchids were a puzzle, why did they exist? Not to please people.

Fertilisation of Orchids (1862)

- Fertilisation of Orchids (1862), book after Evolution of Species.
- Early theory: plant self-fertilisation. Darwin doesn't believe this because there won't be any change.
- Contrivances - sounds something like what a contriver does, not what he meant.
- Details of evolution in this book. Plants have different sexes disovered 60years before.
- Experimented with Early Purple Orchid to find out how they were pollinated.
- Tried pollinating them artificially with their own pollen. Convinced that they cannot be self-fertilised.
- No one saw it happen, how to prove that it happened? Coevolution of plants - insects/animals help plants to have sex.
- Darwin calculated that orchids bear alot of seeds, potential population explosion. But doesn't happen, why does a few seeds make it and others don't?
- Made a prediction on madagascar's orchid having long nector strains implying that there must have a moth that exists (actually exist).
- 2 species become so coadapted to each other. In this case, only 1 type visit the same species.
- Increase the chances of fertilisation. Relationship is precarious, if one goes extinct, other goes extinct.
- Flowers have right structure to guide insects to right position to cause pollens to stick in this way and receive from visiting insects.
- Result of endless series of adjustments for a long time. Plants has as many intricate adaptations as animals.
- Orchid all share the same blueprint. Orchids too have vestigial structures.
- Useless structures that dont do anything is part of the design of nature so that the arrangement will flow gradually from one to another. Have it because it was descended, but it doesn't harm the plant so its just left there

Reactions

- Not everyone liked the book. Duke of Argyll's, Reign of law (1867) - sounded like one was talking about a creator doing the work.
- Asa Gray liked the book. If orchid book appeared first, people who believed in a creator would praise the book.
- Darwin said it was a flank movement. Put it in a way that it was so similar to the idea of a creator. 1874, Gray praised Darwin for finding this idea.

Insectivorous Plants

- Before Darwin, they said that creator created this plant to control insect population. Darwin drawn to common sun-dew.
- Published Insectivorous Plants (how do plants behave?). Modified leaves, but why do they move when insect lands on them?
- Why do some plants catch insects? Only substance with lots of nitrogen will react.
- Substance excreted thats similar to the digestive system; plants are eating the insects.
- Speculated history of sun dews : absorption, produce acidic juice for othe reasons, capture insects accidentally.
- Species of plants that were doing this were living in soils that were low in nitrogen. Since they capture insects to increase nitrogen levels, they can live there and colonise.
- Prolly evolved from hairs that trapped raindrop. Wanted to understand if they have equivalent of nerves and muscles. Bladderworts, live in water. People made fun of him when it was published.

Climbing Plants

- Twining plants make circling movements(nutations) as they grow.
- Some respond to stimuli: light, gravity and touch.
- They climb for sunlight (in dense forest). 2 ways of gaining height: grow a big body, climb up something else to get sunlight. Reconstructed how plants climbed.

Multitype of Flowers

- Different forms of flowers. Flowers that are differently shaped.
- Noticed that flowers on different plants with styles and stamens of 2 or 3 different length play a critical role in ensuring cross-pollination and preventing self polination. Known as heterostyly.
- Same species have different flower types. Pollens not fertilising itself.
- Stumbled on example where 2 sexes emerge from same. 3 flower types on the same flower. 6 types of possible crosses.

Power of Movement for Plants

- Power of movement for plants.
- Sensitivity to light and gravity. Not all grew by revolving, some bent side to side as they grew.

Variation of animals and plants under domestication

- Longest book, focuses on articial selection.
- Darwin worked more with pigeons. Similar to polish fowls from before.

Provisional hypothesis of pangenesis

- Little tiny particles are flowing through living things. These little particles are what allow hereditary information to be passed on.
- Wasn't a new idea.
- Every living thing can vary in every direction. Any variation that isn't favourable will be destroyed.
- Originally used descent with modification to mean evolution. What causes variations?
- Darwin doesn't depend on where they come from, just depend that they exist.
- Analogy of blocks of stone. Build house with rocks, unable to explain why the rock is a particular shape and could not be explained. All that matters is that the variation do exists and are everywhere.

The Descent of Man (1871)

- Humans weren't mentioned much in the books. Origin of species about the change of living things.
- Told readers that he collected notes on human evolution and that it would make people more reluctant to accept evolution. Its practically 2 books
- One part discuss human evolution, the other discuss sexual selection.
- Sexual selection by allowing the female to choose the male through some structure.
- Divide material into 3 main kinds of features.
- Homologies - structure thats the same in different species. Diseases spread between humans and other animals. Can catch disease from another mammal. Same ailments - show similarity in substance between us. Reproduce in the same way as well.
- Embryology - knew that as enbryo develop, they go through some stages. Why human embryo grow a tail for a while and reabsorb it? (lots of other features too). Gill slits, growth of blood vessels. In 6th, hairy covering of embryo but falls off. Left overs from ancestors. As long as it doesn't harm the animal, there is no need to change it.

- Rudimentary organs - organs similar to that of animals. Darwin point - slightly pointy bit in the ear. Leftover from pointy ears. Wisdom teeth - larger jaw from ancestor. Shortened caecum in intestines - change from herbivores to omnivores. Body hair - left over from hairy ancestors. Don't help us and not having it isnt costly. Not unique to humans.

Sexual Selection

- Human race not the result of adaption to environments but natural selection (wrong).
- Slavery - black african had separate origin from humans. Evidence showed otherwise
- Argus pheasant - female birds choosing their male partner.
- Darwin did not say that we come from monkeys. New world monkeys have tails that curl onto things - only south american monkeys can do this.

Expression of the emotions in man and animals (1872)

- Charles Bell had claimed that humans had special muscles in our face to express emotions.
- Darwin showed that human emotions and their expression were present to some degree in other animals.
- The main expressions are universal in all races - powerful evidence that all are descended from a single parent-stock, not culturally derived.
- Photographs in addition to the usual woodcuts.
- Differences in mental functions between humans and other animals is one of degree, not kind. Morality as a more refined development of instincts of other social animals
- Reciprocity and concern for the welfare of relatives.

Why did Darwin become non-religous later on?

- Daughter died when she was 10, made Darwin very stressed out.Death of Annie killed off his lingering belief in God.
- But after Darwin's death, this wasn't mentioned.
- First suggestion : 1982 remark by James Moore. Mentioned it in his book in 1989.
- Gave 2 reasons for this: proximity of Annie's death and religion in the Autobiograhy.
- Darwin was still reading religous books in 1840s and 1850s.
- 1991 biography by Desmond and Moore. A large burden of conjecture rests on this interpretation. No fresh evidence has emerged.
- Nowhere in the written words did Annie's death have to do with his lost of faith. In his autobiography, he mentioned that he dint think he was religous. It was in the years after the voyage 1836-9 that he started to think deeply about religon(written by Darwin himself). Moore dismissed these things.
- Autobiography published by granddaughter in 1958 omitted the date that Darwin wrote in the original manuscript within this comment.
- Darwin's views shifted from orthodox to doubts as early as 1838 is clear from a conversation with his father. Emma's letters show he dint.
- She referred to Darwin's doubts too. 'giving up revelation' - Darwin was considering giving up religon.
- Most of the reasons he gave were about comparative anthropology. He took a general view of religon in his country and people.
- Consistent with his thinking of species (human as a species and not elevated, one of many). Damnable doctrine (endless punishment in hell). 'The clearest evidence will be required' - important quote.

When did he stop attending church?

- Was an active member in church communities. Part of his social responsibility, isn't evidence that he believed. But shows that he wasn't anti-church.
- Randal Keynes (great-great grandson), Annie's box (2001) - quote about not entering church with family after Annie's death.
- Source comes from a former policeman interview after Darwin's death. Problem is he worked there decades after Annie's death; unreliable.
- Darwin saw his own loss of faith as part of a social context. His loss of faith was similar to friends and family in later Victorian Britain.
- According to Darwin, it was his gradual belieft that his former belief were not supported by evidence, and that available evidence of many kinds allowed for the belief in a creator as first cause but that as far as could be shown by science. "Everything in nature is the result of fixed laws."

Was Darwin an atheist?

- 1879 letter to John Fordyce an author of works on skepticism, Darwin wrote.
- He was being inconsistent, said he was an atheist (someone who belive in a god) and an agnostic (someone who doesn't know if theres a god). He is clearly atheist.

Edward Aveling Inteview

- This man was an atheist, extremely radical. Darwin asked him why he called himself an atheist? Abit of an educational elitist ("ordinary people").
- When he was telling Aveling that he gave up christianity at 40, could mean stop going to church. Reminds his readers not to overlook cruelty in nature.
- Not saying that God is cruel, but that its less discomforting that the laws of nature has its consequences and its not God doing his things.
- Darwin found it some consolation to regard staggering amount of pain and suffering in the world as the result of laws of nature rather than the direct will of God. But he also insisted that he was not an authority on religon.

Religon after Death

- Burial in Westminister Abbey, 1882. Westminister Abbey is the highest church in the land.
- Deathbed conversion wasn't true.
- Common viewpoints by end of 19th century. Alot of people thought that God created the laws of nature and it dint need interference.
- Darwin's theory showed that biology was under the control of natural laws. Humans were descended from earlier forms but perhaps God gave humans something special?
- No evidence he was an atheist. Alot of disagreement on what he represented and belief.

Darwin at his end

- Darwin's last book about worms in 1881.
- Shows little changes accumulate over a long period of time to make a huge change. Worms spit out dirt, elevated abit above the surface of the earth. This happens billions of times. Meant that any object that was too big will get buried.
- Conducted alot of experiments on the worms. They can't hear. Test for intelligence - cut paper into different shapes and watched what the worms did. Somehow managed to pull it down via the pointy end.
- Entire world landscapes shaped by tiny actions of the worms.
- The wormstone - measure how quickly it took for a stone to sink into the ground because of the action of the worms.

Francis Galton (1822-1911)

- Against pangensis (inheritance). Founding father of using stats to study heredity
- Use bunnies to test darwin's theory. Transfuse blood from one bunny to another. Check if offspring has characteristics from the blood owner. Darwin said this wasnt true.

Aguest Weissman

- Germ plasm theory (1896-1910)
- Inheritance only goes through germ cells and not the body cells. Meant that inheritance only came through sex cells and nothing else.

Gregor Mendel (1822-1884)

- Experiments on heredity using pea plants.
- When you cross them, get a certain ratio of offspring. Shows that some elements of information are inside even though it passed a generation.
- Mendel's 2 laws: law of segregation (individual posses a pair of alternative version of a gene, whichever allele is dominant will be expressed), law of independent assortment (different traits are inherited independently of each other).
- Not influential work at that time.
- Heredity was a particulate thing and such things could be explained through rules and ratio. Darwin dint know and dint have Mendal's work.

Hugo de Vries

- Theory of particulate
- 1900 Mendel is 're-discovered' by de Vries, Carl Correns and Erich von Tschermak
- Mutation theory by de Vries - thought he found a new type of flower which was a mutation.
- New species appear via mutations. Combine with statistics and combine with theory of origin. Proposed as an alternative theory to natural selection, disproof of darwin.

Sutton and Boveri

- Sutton and Boveri suggest chromosomes which segregate or split in a Mendelian way are hereditary units.

Thomas Hunt Morgan

- Wanted to prove mutation theory with fruit flies.
- 1910 showed that genes are on chromosomes. 1915 combine mendel theory with chromosomes theory.
- These 3 theories were thought to be alternative viewpoints but instead mendelian and darwin theory were seen to be compatible and part of the same thing.
- 1953 discover the structure of DNA, contributed to modern molecular genetics.

Radiology & Dynamic Earth

- Ernest Rutherford and radiometric dating led to the discovery that the Earth is about 4.5billion years old.
- Once radioactive decay was discovered, Earth's age wasn't a mystery anymore.
- Wallace line - surface of plant moved. Australia moved away from south america and drifted up to be close to asia. Because of marsupials.

Alfred Wegener (1880-1930)

- Theory of continental drift.
- Continental shapes seem to fit together. Rock types and fossil matches too. Was ridiculed by people even though he was right.
- Plate tectonics 1950s-1960s was accepted.
- Palaeomagnetism - studies of the ocean floor, show the direction of the magnetic field. Mapped the directions. Sea floor spreading, magnetic striping.
- Seabed moving in opposite directions. Because of magnetic poles flip, the particles are fixed into rock. Saw series of flips.
- Pattern of poles of flipping was symmetric about the atlantic ridge. Plays a fundamental role in why the living world is the way it is.
- Why different species are where they are. If Earth dint move, then life would be very different.
- When landmass gets isolated, difference will accumulate in species on that landmass. Made the world more diverse.

Modern Opponents to Evolution

- Wallace lecture tour of USA 1886-7. Wrote book Darwinism. No opponents of evolution.
- Modern opposition to evolution wasn't always around, more recent social movement.
- Scopes monkey trial 1925. Test a new law against the teaching of human evolution in public school. Challenged by American Liberty Group, seem to be imposing some religous doctrine into the school.
- John Scopes volunteered to enter trial to teach human evolution in high school. Technically committed a crime, lost trial.
- International recognition was huge. Thought that it was unfair that their kids were teaching something that contradicted parent's views. Law eventually overturned.

Religons Against Evolutions

- Evolution has been an accepted in science since 1870s, but new religions creationism(1970s) emerged.
- 1980s, creation-science. 1990s, intelligent design. Intelligent design and the design arugment.
- Intelligent design advocates claim that living things looked designed so they must be designed.

- Irreducible complexity - Michael Behe's Darwin's black box (1996).
- Biological structures so complicated that they couldn't have evolved. Complexity couldn't be reduced otherwise it won't work.

Eugenics

- Francis Galton coined the term in 1883. Consequences doesn't matter if its the truth. Thought they could improve human race by doing selective breeding.
- Sterilise people that were considered to be reproductively undesirable. They thought it was humane.Associated with the Nazis.
- Appeal to Consequences fallacy - if people are taught they are animals, they will behave like animals.

Darwinism & the World

- First World War was result of Darwinism. Holocaust was also a result of evolution theory.
- Creation Museum (Kentucky, USA, 2007), Young Earth creationism - reject modern science.
- Thought that dinosaurs lived with humans(false).
- Dendrochronology - tree ring dating. Space between ring showed climate, contradict creationism.
- Stalactites in caves, had something like rings. Coral reefs and atolls. Ice core drilling - reveals earth climate. Speed of light.

Common Objections

- Evolution is just a theory - problematic, means one thing in speech, one thing in science.
- Evolution is just a chance, randomness cannot make the living world. Its a subcomponent, not the entire thing.
- Evolution and thermadynamics - earth isn't a sealed system.

Evolution of Human

- There is no missing link. No fossil evidence of human beings. Nothing to link our species to others. No traces of anything connecting modern humans with ancestors.
- Fossil trail begins. 1856 a skull cap found in Neander valley of Germany. 1886 next Neanderthal remains found.
- Another species of humans - bigger, stronger than us. First time that we knew there was another species of humans.

Homo Erectus

- 1887 Eugene Dubois went to Indonesia. 1891, found a skull cap and femur. Large brained creature that walked on 2 legs like us, but smaller than us.

Other variations of humans

- Gravel pit at Piltdown, England. Someone faked the fragments of a skull and jawbone.
- Peking Man(1923-1937), 500,000 years old, a type of homo erectus.
- Taung Child (1924), was not a human. 2-3 million years old. More ape like.
- Homo habilis (1960), in Tanzania, Africa. 1.75 million years old.
- Lucy (1973), Ethiopia, 3.2 million years old.
- Laetoli, Tanzania, 1976-1978. 3.6 million years old footprints from same species as Lucy.
- Human floresiensis and denisovans.
- Latest hominin discovers: 2003 floresiensis (nickname the hobbits);they died out, 40,000 years ago. 2010 denisovans.
- Out of Africa - Darwin predicted this. Human 'races' don't exist, just an idea. Not really a biological thing, just regional differences.

Physical Changes in Human

- Why did hominids start walking on 2 legs?
- Hunting theory, see father over new savannahs, free hands, trees theory (some primates walk on 2 legs in trees).
- Evolution of big brains. Correlation of brain size to social group size. Large brains help us keep track of everyone else.

Modern Evolution

- Are we still evolving? This question is a misunderstanding.
- We are evolving through evolution
- Dark pigmentation to protect the skin when the hair dropped. Darker skin was disadvantage for northern climates, so evolved to lighter skin.
- Independent mutations in asian and european thats why its not the same form of light skin.
- Digestion of dairy products, some lose ability as they grow up.
- Chimpanzees exist because they adapt to their niche in the natural world.

Cooking Ape Hypothesis

- Richard Wrangham. Takes on traditional theory on how we became intelligent.
- Hunting theory. Is eating meat a mistake? Scientifically, we are omnivores. Because ancestors started eating meat, led to our evolution of our brains.
- Doesn't seem right since our close relatives do the same but their brains aren't as big as ours.

Cooking Hypothesis

- Cooking hypothesis - raw foods eaten only as an exception. No known cases of long-term survival on raw-food in the wild.
- Longterm raw-foodists - eating raw food is the only thing to do. Resulted in poor reproductive performance (symptom of starvation) and very little energy.
- Human guts are small, less equipment to break down raw food. Wrong equipment in our mouths, our teeth became smaller, adapted to soft diet.
- Cooked with fire. How to distinguish natural fire from man-made fire for cooking? Humans are biologically adapted to eat cooked food.
- Eating cooked food gives us more energy, more reproduction. Cooked food dint really make our jaws smaller and gut smaller.
- These changes couldn't have happen if not for the environment. Cooked food dint make us who we are.
- Protein denatured implies increased digestibility. Calories on labels are not reliable, if it needs to be cooked. Does not take into account how you cook it.
- Conducted experiments on animals, cooked food are more digestible for animals.
- When did this happen? Uncertain... happened around time of homo erectus.
- General shape of our ribcage smaller than monkeys, because we have less guts.
- Individual does not evolve, lineage evolve. Chased down prey to hunt.
- Cooking leads to early weaning, little chewing (less time spent chewing), bigger brains via small guts.
- Cooked food is an enabler, not a cause.
- Significance - anatomy, life-history, physiology, society. Hunting by man, gathering and cooking by woman.

Jared Diamond

- Professor Jared Diamond (Guns, Germs and Steel).
- European colonisation - one of the last great era of human migrations. Does not explain the world's wealth and technology is distributed the way it is.
- Races of people who live in different parts of the world. Ethnographic map - map where different types of people are.
- Homo sapiens - anatomically modern human. 200,000 years ago in Africa.
- Mitochondria DNA - passed through from woman. Revealed that we descended from 1 female. Not the first human female.
- Great leap forward about 60,000 years ago.
- Striking difference in the artifacts that people produced. Explosion of diversity in the things that we made. Tools are very specific to the time.

Cave Art

- Cave art, 44,000 years ago until recently.
- People did this for tens of thousands of years. Can date these art and these sights were used thousands of years.
- Art that predate arrival of modern humans in some areas.
- When we start writing things down (human history), vast majority of our existence is pre history. Entirety of our existence we lived as hunter gatherers. Dint do much work to live.

Domesticated Plants

- Very different from wild plants. Happened in the middle east, fertile crescent.
- Jared Diamond said that this part of the of the world had more plants that was easier to domesticate.
- Hunter-gatherers realised that the seeds they gathered had grown, grow more themselves. Ultimately depend on the sights where they cast the seeds
- Produced more calories to support more people
- Hard live - can't keep going to the grounds to cultivate. Had to feed the more mouths they have now.
- Hunter-gatherers that were not farming had a better life, were more healthy. Farmers were shorter than the hunter-gatherers. Diets weren't as good, source of nutrients had a smaller range. More sickly too
- Once crops were domesticated, did selective breeding of better food
- Agriculture began to spread, the people began to spread. People from different parts of the world discovered they could do farming.
- Fertile crescent was the first place to do it. Domesticated food come from all over the world. Spread of plants and agriculture in latitude (horizontal, east west direction).

Domesticated Animals

- First domesticated the wolf. Before we domesticated plants.
- Domesticated wolves by selecting well-behaved offsprings, killing hostile ones. Inadventently created new types of animals for us because of artificial selection.
- Tame vs domesticated? Tame - wild captured animals that were tamed to live with humans, born in the wild. Domesticated - changed by us.
- Different people in different part of the world developed based on where they are in the world. Domesticated animals provide all kinds of things like plowing. Had advantage over those who dint have the help of animals.

Domestication Results

- Populations grew.
- Not everyone had to go hunting, more food than ever before because of farming. Can specialise in things other than food.
- Once there was large stockpiles, this was wealth. Difference in wealth emerged.
- Rulers, kings and governments emerge and taxes as well.
- Combine people together to built monumental objects.
- Writing emerge from keeping tax records. Cuneiform script - wedge shape stylus, and poked it into wet clay.
- Recorded other forms of information. Script evolved from pictograms then became more and more abstract.
- The phoenician alphabet - ancestor of our alphabet. Not pictographic, but stood for a sound.
- Hunter-gatherers lived in clean places because they moved around, farmers lived in their own filth.

Expansions

- Indo-European expansion. Ukraine people spread out and mixed with people in asia and europe.
- Look at daughter languages to derive origin. Can be arranged to fit a family tree.
- Austroneasin expansion - spread from Taiwan. Ancestors of malays come from taiwan. Went out to pacific to discover the islands there.
- Bask people held out again the indo-european expansion - dint have environment for farming. Finnish people too.
- By 1500, there were very different societies in the world. Some had plants and animals that were domesticated.
- But they were equally intelligent. Parts of the world with domesticated plants and animals had a bigger population than those that dint.

Epidemic Diseases

- Hunter-gatherer don't develop must diseases, the disease would die out with them.
- In bigger populations, the disease will continue to be alive because there are new people to infect. Populations with this disease evolved and became more immune to them.
- There were so many diseases thats why they could be kept alive as well. Because we live so close to animals, one of their disease may hop over to us.
- Black death happened in the middle ages. Very deadly. Caused our population to go down. Dint go extinct.

- On exploration, they infected the people there with their crowd diseases.

Australia

- Original people lived there for 40,000 years.
- Dint have high population density because no plants and animals that could be domesticated. Only domesticated macademia nuts.
- Can't produce enough to built a civilisation. Less things in the new world, so europeans sailed.
- Additionally, things dint spread very rapidly because they were spreading north to south.

China

- Why Chinese dint explore the world?
- China geographically less divided, more united under one government. Consequence : once decisions are made, determines what happens there.

What is Evolution

- Evolution is not a thing, it cannot shape anything.
- Species don't compete, but individuals.
- Individuals don't evolve, only a population or lineage over generations.

Origin of Life

- 3.5 billions ago, simple organic molecules, single celled organisms with DNA, all species now share this DNA
- 2.5 billions years ago, some single cell creature clump together to form multicellular organisms.
- Began to produce oxygen by photosynthesising. Cyanobacteria, created oxygen as their waste product. Changed consistency of the atmosphere of the planet. Stromatolites - colony of bacteria.
- 500 millions ago, jellyfish appeared. Hydra, similar life cycle to jellyfish. Sponges - very primitive animal.
- Flatworms, move intentionally, sensory to help them detect where they are going. Organs are present.
- Worms became round, and dug into the seafloor. Developed shells with tentacles, some loss the worm part and became like clams.
- Nautilus and Ammonites. Octopus, squid, cuttlefish and argonauts - they are molluscs, relatives that lost their shells.
- Segmented worms - divided up into segments. Crustaceans (segments - body is insegments). Insects (segmented), first creature to walk on dry land, shell gave rigidity them to walk around on land (400 million years ago).
- Sea squirts - blob of jelly, pulls in seawater, filter food and spits out water. Larval form has a simple form of notochord (ancestor of spine).
- Vertebrates - better developed spine. Cartilaginous(fish that dint have hard bones, gives some structure) and bony fish.
- Fish acquired the first lungs to help with poorly oxygenated water with limb-like fins. 375 million years ago (Tiktaalik), fish whose fins are more stout for it to skittle across ponds. Backbone to walk out of water.
- How they walk around is similar to mudskippers. Fish slowly being able to walk out of water evolved more than once.
- 4 limb animals - tetrapods. Amphibians tied to water because they lay eggs in water to reproduce.
- Need to stay moist, semi-pearmeable skins. Reptiles had waterproof skins, retain scales, fish body shape and lay eggs.
- Real snakes went underground and dint grow legs. Scales grew over their ears and became blind, lost hearing too. Scales that covered their eyes got removed.
- 65million years ago, meteor hit, killing dinosaurs but smaller creatures survived.
- Mammal-like reptiles, ones that became mammals. Grew hair, began to walk with their spine with the limbs in front.
- Produce milk out of milk glands (platypus, echidna). Milk is evolved from fatty sweat.
- Mammals kept their eggs inside and gave birth. Placenta mammals - retain baby inside the body. Marsupials mammals - poaches like kangaroo.
- Recurrent laryngeal nerve, not ideal but good enough to work.
- Darwin say that if you can bring back bodies of all things that ever lived, the line will be damn long. If you get the arrangement correct, you will get the tree of life.

Evolution of Species

- How and why did birds of isolated islands become so tame? Birds that are afraid on the mainland, blown out to isolated islands.
- Nothing can hurt them on those islands. Instincts and alertness when there is sudden movement.
- Possible to be borned as less fearful, over time, becomes fearless since its a better adaptation.
- Flightless cormorant. No land predators to fly away from and no feeding grounds to fly to. Alot of energy to fly. Less flight muscle do a little bit better.
- Collared dove in Britain. No collared dove in britain. Slowly moved across europe, after world war 2, flew to britain.
- Land crabs that drown in water but must lay eggs near the sea.
- Aquatic mammals, sea snakes and turtles. Need air. Turtles must lay eggs on land.
- Tusks amongst African elephants.
- Caesarean births amongst humans decrease population of humans to have natural birth.
- Peppered moth, pollution from industrial revolution made the barks of the tree black. Rare form of moth was black to blend in.
- Polar bears never eaten penguins because they live at different areas, natural barrier.

Basic Principles of Evolution

- Every species come about gradually.
- Every step has to be advantageous in its own terms. No such thing as evolving for the good of the species - individuals live or die.
- Ancestry usually explains similarity.
- Isolation leads to difference.
- Progress isn't inevitable although complex things can only come after simpler ones. But sometimes more simple follows more complex
- New territory or niches opening up tend to draw in new species.
- Many things have happened again and again (big extinction events, explosions of diversity, evolution of carnivorous from herbivorous)
- Life on earth has always been mostly microogranisms.