GET1020 Midterm Notes

Lecture 1: The age of the Earth & the fossil record 1500-1830. Part 1

- Many myths and legends on how the world began – ancient Egyptians, Norse, Sumatra, Australian aborigines, Mayans, ancient Hebrews, etc
- No common consensus on the age on the earth
- European scholarship began to mature

James Usher, 1950s

- Counted the generations in the bible to try and compute how old the world was
- Came up with 4004 BC – the date the world was created
- Eventually became so widely believed that it was added into the editorial notes in the bible
- John Lightfoot of Cambridge – pinpointed earth's creation was exactly 23 October 4004 BC, 9am
- But he was mostly discredited and made fun of

- But how about the things not mentioned in creation stories? – Fossils

Fossils

- Ancient Greeks explained them as monsters from their mythologies
- Elephant skull – the origins of the cyclops?
- Snake stone – local legend: lady found a place infested with snakes, used her magical powers to turn them to stone. Craftsmen carved them to have heads (since the fossils didn't have one)
- Devil's toenail, tongue stone, etc

Nicholas Stenos, 1667

- Fishermen had caught an unusually large shark
- Stenos compared the shark's teeth to the tongue stone fossils – they were extremely similar
- But the tongue stone were found inside rock – how did a tooth turn to stone?
- Pioneered study of stratigraphy
    - Silt and mud falling from water stacks over time to form rocks
    - Law of original horizontality: strata of rock are layered horizontally
    - Law of superposition: newer layers on top, older layers at the bottom
    - If layers are not in alignment, it must have been changed (broken)
- Hence shark tooth had shaped the rock – formed via sedimentation of rock

Ammonites

- Relatives of octopuses and squid
- Fossils were thought to have been created during Noah's flood
- But fossils are **not found in a random jumble** – similar fossils are found near one another
- ie, found clustered in their habitat, rather than having been just washed away

Robert Hooke: Micrographia, 1685

- Microscope had just been invented
- Victorian times – very filthy and dirty, everyone had fleas
- Famous blown up drawing of a flea – looked nothing like the tiny fleck that it was in reality
- People could for the first time see what was crawling over them
- Microscope opened up possibilities of seeing things previously unknown or taken for granted
- Before this, did not even know microorganisms even existed
- There is far more to the world than previously known
- Coined the term "cells" – the smallest unit of which living things are made of
- People were still skeptical fossils used to be living things
- Maybe they were like crystals? Just grew from nature
- Used microscope to examine fossils
- Found that fossils had structures and patterns in their cells similar to living thing, which is unlikely to be random, proving that fossils used to be living organisms

John Ray (1627 – 1705)

- There are thousands of species
- Adaptation proves design – the fact that living things can adapt to fit the world proves that there is design
- God created a set number of species – number will not change

Carl Linnaeus (1707 – 1778)

- Knew twice the number of mammals known in Ray's time
- Thought species were clear cut and can only come from previous parents – each species is distinct
- There are no new species
- Extinction is not possible
    - How about ammonites? Reasoned that they are still living, just in another part of the world
- Wanted to catalogue and categorise all living things in the world
- Names of species were too long
- Introduced binomial nomenclature – genus and species
- The fact that living things could be classified and ordered so neatly was proof of God's divine design
- Realised there are far too many species for Noah's ark
    - He was still religious – not challenging religion!
    - The bible was read different back then – understood the bible was metaphorical, not to be taken literally

Nesting Taxonomy Classification System

- Classified living things according to the degree of similarities
- Main group of species branches out into multiple subgroups
- Organisms are nested in ascending specificity
- Genus – species
- Paradoxa
    - Things that did not fit into the scheme of nature (eg: mermaids, unicorns)
    - Mythical creatures that were then still believed to be real, sincere there were so many reports of sightings by travellers
    - A space was left for them in the classification system

Species

- Meaning: a specific kind of thing
- Eg: Javan myna vs common myna
- Members of a species look very similar
- Species can be part of a larger group – eg: birds -> mynas

Georges Buffon (1707 – 1788)

- Estimated the earth was 75000 years old
- Wrote a book: *les époques de la nature*
- Wanted to find out the age of the earth – did an experiment
- Like people of his time, he believed that when the earth began it was a ball of molten hot rock. So how long does it take a ball to cool down?
- Took a metal sphere and heated it up, placed it in a cave and timed how long it took to cool down. Used this measurement and scaled it up to calculate the earth's age
- Believed animals could adapt a little to fit the environment, but not completely change species
- Common knowledge as farm animals had changed over 100 years when domesticated

Mining

- Allowed people to create imaginary cross sections through the earth
- History of the earth is found to be complicated and dynamic

James Hutton (1726 – 1797)

- The earth is shaped by methods and causes that are still happening now
- Geological unconformity, *Theory of the Earth*
    - Initial layers are horizontal, deeper layers are vertical
    - Each layer of sediment would take thousands of years to form

    - A large subterranean force must have twisted the rock vertical
    - Erosion of the vertical section proves there was a change in orientation
- New land created by volcanic eruptions
- Land is destroyed by erosion
- Cliffs: land which are uplifted from the sea
- How the land is “twisted” – emergence of volcano pushes previously horizontal land up
- Possible to reconstruct how the land previously looked like using the angles of layers

William Smith (1769 - 1839)

- The same fossils are found in the same rock layer
- Layers of strata are always in the same sequence in an area, no matter the alleviation
- Reconstructed the whole country – a geographical map showing all the rocks and where to find them
- Very useful – now know where to dig for resources like coal

The history of life on earth can be reconstructed from the clues and pieces that remains today

Lecture 2: The age of the Earth & the fossil record 1500-1830. Part 2

Georges Cuvier (1769 - 1823)

- French naturalist
- Comparative anatomy – specialised in comparing the anatomy of various living things
- Proposed that there was an era before now: the age of reptiles - when reptiles ruled the earth
- Layers of rock show a sequence of eras in which different layers contained different ecosystems
    - Eg: one layer can contain plants and animals, another with seashells, another from an arid environment
- Succession of the series of life on earth
    - Cuvier lived through the French Revolution
    - Believed the earth had gone through many dramatic revolutions
    - Progressive eras: creation -> destruction -> creation -> destruction…
- 1796 paper on living and fossil elephants

Skeleton of Mastodon

- Skeleton looked like a mammal, but unlike any that currently existed
- The animal is huge – no way it is still alive and not been seen around
- Mammoth: similar to elephants, but bigger
- Cuvier compared it with the 2 species of elephants that existed – Asian and African elephants
- Bold conclusion: they are no longer found anymore; they are extinct
- Popular thought back then: nothing ever went extinct, as God's design was perfect
- Conclusion is controversial, but eventually scientific opinion changed as evidence of extinction emerged
    - Eg: sloths vs giant sloths – have not been roaming the earth for hundreds of years
    - Eg: dodo birds
    - Eg: pterodactyl – flying reptile with elongated fingers

Jean Baptiste Lamarck (1744 – 1829)

- Zoological philosophy: no extinction, instead, change
- Hated Cuvier's idea of extinction – did not believe God would allow anything to go extinct
- Instead, living things change over time
- Eg: mammoth evolved into elephant
- The complexifying theory: the inherent law in nature that drove living things to evolve towards complexity
    - Each line has a family lineage, life originates at the base of each lineage
    - Living things constantly change into one of a higher level
- The adaptive force: the adaptation of living things to fit their living environment
    - Eg: giraffe stretched to reach the leaves, and after generations of stretching, finally achieved its long neck
    - Today: most known for his theory of inheritance of acquired characteristics
    - But this was NOT his main theory!
- Lamarckism = change over time towards complexity
- First person to publish a *somewhat* evolutionary theory – but it is different from Darwin's theory!

Lamarck VS Darwin – transformist vs evolutionist

- Lamarck: parallel linearism – life appears, and then starts the 'evolving escalator' individually in each species
    - Explains why everything isn't equally complex: different points of creation
- Darwin: all species branched from a single point (common ancestor)
- Lamarck was not very successful in convincing the scientific community (was put down by the more influential and powerful Cuvier)
- The idea that living things could evolve was discredited together with Lamarck

Mary Anning (1799 - 1847)

- Amateur fossil hunter – sold fossils for a living
- Found 2 fossils – a porpoise and ichthyosaurs (reptile, literally: fish-lizard)
- Bones gave many clues
- Tails of mammals beat up and down
- Tails of reptiles beat side to side

- Also found fossil poop (coprolites) – could discover what they ate

Kirkdale Cave and Hyenas, 1821

- Cave found with their bones in them, in addition to other crunched up bones
- Previously, it was thought that the Great Flood had washed up all the bones into the cave
- William Buckland analysed the cave
- Brought an ox bone to a hyena and observed how they crunched up the bones
- Conclusion: hyenas had lived in the caves, other bone were from animals they ate

Dinosaurs

- Not every giant reptile, just a few species
- Named by Richard Owen (dinosaur literally means terrible lizard)
- Managed to do reconstructions – paintings
- Displayed to the public chronologically by geological era
- Different species characterised to different eras

Progressive Fossil Record Before Darwin

- Cuvier's progression theory was prevalent then
- Illustrations published – showed progressive history of life on earth
- Ammonites -> dinosaurs -> mammlas
- This was NOT an illustration of evolution
    - Contextualise: the people then did not see change, but a series of ages and times the earth had been through (as per Cuvier's theory)
- People then were still homogeneously religious – no such thing as science versus religion
    - Eg: the global flood in the bible was known to have not happened due to the overwhelming evidence against such an event – story to be taken metaphorically and not literally

William Buckland (1784 – 1856)

- One of the last geologist who believed in the Great Flood
- Despite also being interested in fossils and nature
- Was very fascinated by animals – displayed them in his home, and would try and eat every living thing at least once
- *Bridgewater Treatise* – coloured map + the different eras of species in different layers of the earth
- Humans were a relatively new species
    - So many geological eras but none with human fossils or tools
    - Humans illustrated on the top most layer
- Showed a progressive but static of the history of life on earth

Charles Lyell (1797 – 1875)

- Thought the earth went through slow and gradual change
- Natural causes like erosion, silting, volcanic eruptions, etc shaped the earth
    - The present is a key to the past
    - Geological processes have always been slow
    - There is no progress or direction
- Argued against Cuvier's sudden revolutions
- He thought the progressive idea looked a lot like evolution – a dangerous and wrong theory
- His book: *Principles of Geology*
- Uniformitarianism: the world changes gradually according to the geological forces we see today
    - World does not change drastically, but rather, slowly
    - History of life on earth is not progressive – tried desperately to steer away from this
    - Animals gradually went extinct from time to time
    - Extinct things would eventually reappear again given the right conditions
- Evidence: Temple of Serapis
    - Holes in pillars drilled by marine creatures
    - Proves that sea levels are changing
- How do new species appear? He dodged the question and was vague about this
- Theory met with mixed reception

- John Herschel wrote to Lyell to praise his book

Vestiges

- *Vestiges of The Natural History of Creation*
- Published anonymously
- Popular science book of the day due to its controversy and public appeal
- Took all the latest science and made a readable overview
- Told an exciting story of how the laws of nature control everything, without needing divine intervention
- Was actually written by Robert Chamber
    - Scottish publisher
    - Published anonymously as he was afraid the controversial book may damage his business
    - Admitted that he was an amateur naturalist
    - Was not very religious unlike his fellow naturalists
- Used the word "development", not "evolution – living things were preprogramed to develop by nature
- Scientific community unanimously condemned this book
    - Lyell is horrified – this looks just like evolution
    - Sedgewick - the book is so foul, it is as if a woman had written it
- Vestiges theory: everything happening in the natural world is controlled by the laws of nature. Everything in nature is developing in accordance with these laws
    - Similar to Lamarck's theory
- Suggested that humans developed from apes – and humans will continue to develop beyond what we are now
- Was controversial as it put God out of the picture

	Cuvier	**Lamarck**	**Lyell**	**Vestiges**	**Darwin**
Theory	Sudden revolutions	Complexifying theory Adaptive theory	Uniformitarianism	Development	Natural selection
How does change occur?	Progressive, dramatic change. Era after era	Change over time Parallel linearism towards complexity	Slow and gradual change via geological forces	Laws of nature induces development	Living things evolve from a common ancestor
Reception	Prevailing theory (in his time)	Negative, put down by Cuvier	Mixed reception	Controversial and condemned	Prevailing theory till today
Does extinction occur?	Yes	No	Yes, but will eventually come back	Yes	Yes
Quirks	Famous and dangerous	Hated idea of extinction	Hates evolution with a passion	Radical and controversial	-

Lecture 3: Darwin's childhood & education

Darwin's Childhood (1809 – 1882)

- Born in Shrewsbury, England
- The Darwins lived in a large house, The Mount – were the wealthiest in the neighbourhood
- Erasmus Darwin: (1731-1802) Grandfather – physicist, author, poet, free thinker
- Robert Darwin: (1766-1848) Father – made money by lending money to the rich, was also really fat
- Mother's side of the family – was also wealthy
- Tendency in Darwin's family: fathers would always be free-thinkers, while mothers were religious
- Darwin was taken to The Unitarian Chapel by his mother until her death in 1817
- Darwin was baptised as a child
    - Baptised at Church of St. Chad's
    - This would have implications later in his life
    - If you were not a member of the established church, you can't go to university or run for parliament
- Darwin's mother died early
    - Myth: Darwin was traumatised by his mother's death
    - Reality: he didn't have much memory of his mother, and the death didn't really affect him
    - Large family with many sisters and maids filled the emotional gap?

Shrewsbury Grammar School (1818 – 1825)

- There was no science, only classics and geography
- School subjects were dull

Edinburgh University (1825 – 1827)

- Prestigious medical university in Scotland
- Intentions: follow the family legacy and become a doctor
- Alexander Monro III
    - Anatomy professor – was boring and old fashioned
    - Actually read out his grandfather's lecture notes rather than create new relevant notes
    - His boringness put Darwin off anatomy
- Burke and Hare
    - Fresh bodies need to study anatomy (preservation not a thing yet)
    - Murderer duo who took homeless people and prostitutes, and killed them to supply dead bodies needed by the university
    - Would suffocate victims to ensure no wounds
    - Eventually caught, one was publicly executed
- Darwin took further classes in physics, midwifery, chemistry, geology and zoology

Dr Robert Grant (1793-1874)

- A gentleman, expert on marine invertebrates
- Free thinker and fierce Lamarckian
- Quite a radical person for a young Darwin to meet
- Darwin did science as a hobby
- While Darwin was along the beach one day, Grant suddenly bursts out praising the evolution theories of Lamarck
- Took Darwin under his wing
    - Note: Darwin's grandfather also had some evolution theories in his poetry as well
- Flustra – lower orders of marine life (corals, sponges)
    - To Grant: these gave clues of early animal/plant life
- Grant also introduced Darwin to scientific jealously – when Darwin showed him a new discovery, he would not be happy for him, and instead took credit for his work

Medicine is not for Darwin

- Darwin was not suited to be a physician – he was very squeamish
- Anaesthetic had not yet been discovered – operations occurred with the patient still awake
- Operation on a child made Darwin run out of the room to escape the gore and screams
- Darwin's father accepts that being a doctor isn't for him

- Need to find a new profession that at the same time matches his social status
- Proposes Darwin becomes a clergyman

Christ's College, Cambridge (1828 – 1831)

- Myth: he went there to study divinity and theology
- Truth: there was no theology course in Cambridge!
    - Myth comes from the fact that Darwin intended on becoming clergyman
    - However, clergymen needed to get a bachelors (BA) first before taking divinity
- University was very hierarchical – students were ranked according to their status
    - Noblemen – sons of noblemen and aristocrats
    - Follow commoners – rich people
    - Pensioners – average people who could pay their own school fees -> Darwin was here
    - Sizars – students who were not rich enough to pay school fees, on scholarship or beneficiaries
- Each rank had their own cap and gown – compulsory to always have it on
- Gowns descended from church gowns
    - Students had to be male and baptised
    - Shows ties between university and church

Darwin's Hobbies

- Darwin was into the outdoors and shooting
    - Would even practice in his own room
    - Had a friend move around a candle and he would try to extinguish the flame by shooting it
- Possible hanky-panky???
    - Females were not allowed in the university
    - Exception: bedmakers – but they were recruited to be as ugly as possible to prevent temptation
    - Darwin's cousin's diary: found pages in Greek (so the servants could not read it) which showed that he might have been seeing women + receipts that suggested he was fathering a child
    - But Darwin's cousin was a respectable man! Such behaviour not expected of him
    - Moral of the story: there is no real way to tell if Darwin himself had engaged in such shenanigans in his school days
- Darwin loved collecting beetles
    - Note: any drawing of beetles in Darwin's books – Darwin could not draw at all, probably his sister helped him draw them
    - Caught beetle at any cost: Darwin had one beetle in his hand, but then he found another nice beetle and was reluctant to let either go. So, he put one in his mouth, and it sprayed a putrid acid
    - Beetle collecting not exactly a scientific thing – he just liked collecting pretty beetles
    - Informal competition between Darwin and other students to find more species of beetles
    - Was very passionate about collecting beetles – when he discovered his friend was sabotaging his collecting, he shouted at him (the only recorded instance of violence in Darwin's life)
    - Beetle collecting although not scientific, would lead him into his scientific career
    - Learned how to prepare and preserve specimens

Rev. John Stevens Henslow (1796 – 1861)

- Professor of botany
- Famous for setting up the botanic gardens in Cambridge
- Darwin's favourite lecturer and mentor
- Darwin became a teacher's pet and wanted to spend as much time with Henslow as possible
- Invited to tea party at Henslow's house with other professors – first step to recognition in the science community
- Darwin always tried to impress and get attention
    - Eg: Henslow wanted a rare plant that was in the middle of a swamp, Darwin got muddy and retrieved it for him
- Darwin attended his lectures for 3 years
- Henslow was interested in the variety of plants – how they were so many variations and species
- Pollen pockets of orchids – could be used to cross pollinate and create hybrids
- Was also deeply religious and conservative
    - Told Darwin that he would be deeply pained if the points in the bible were changed

- Studying plants was both a religious and scientific pursuit to him (studying God's work

Alexander von Humboldt

- Famous scientist, documented his travels in a 6-volume book
- *Narrative of Travels to the Equinoctial Regions of the New Continent* (South America)
- Darwin's favourite read
- Humboldt tried to scale what they thought was the tallest mountain in the world
  - Recorded his journey in his journal
  - Discovered that different species lived on different altitudes
  - Split the species into different stratum to categorise
- Darwin is influenced by Humboldt's natural romanticism
- Inspired and wanted to do his own journey

John Herschel's *Preliminary Discourse,* 1831

- Another of Darwin's favourite read
- Essentially a book on "how to do science properly"
- A very whiggish history of science – science is all about progress, and will keep on improving
  - Note: when reading a history if science written by a scientist, treat it with scepticism. They are scientists, not historians
- Law of continuity: all parts of nature and science will be interconsistent
- Stressed collecting masses of facts, and then coming to inductive conclusions based on them
- In other words
  - Laws of nature are fixed, and everything is consistent with it
  - There is an order to everything
  - How to do science: gather masses of facts, lay it out, and then try to draw a general conclusion
- This would shape the way Darwin did science for the rest of his life

Rev. Adam Sedgwick (1785 - 1873)

- Professor of Geology
- Studied the most ancient rocks and fossils
- Wrote a very negative and critical review on *Vestiges*
- Static era progression school of thought
  - Species could change and adapt locally to a limited degree
  - When the world changes and living things can't adapt – extinction happens
  - When the world is empty – creation happens and a new era is born
- If living things change, means God did not create them
- Was zealously religious
- However, was also a geologist, and accepted that the great flood did not happen
  - The only person who still believed in the flood was Lyell

Sedgewick and Darwin

- Henslow arranged for Darwin to go on a field trip with Sedgewick
- Darwin learned a lot from Sedgewick
  - Eg: Darwin found a fossil out of place and thought it was an anomaly, but Sedgewick dismissed it, as that one specimen cannot disprove thousands of others

Darwin's Future Plans

- To graduate with a BA degree: take 2 exams – one in year 2 and another in final year
- As a clergyman, would have loads of free time
- Can do hobbies and science in his free time
- Was also considered very respectable to study God's creation
- That was Darwin's trajectory after graduating
- Suddenly received a letter – an offer to travel on a navy ship as the ship's naturalist
  - Darwin was recommended by Henslow, as he could not make it

Lecture 4: The voyage of the *Beagle*. Part 1

- Darwin receives invitation to travel with the HMS Beagle as its naturalist
- Why Darwin? – Recommended by Henslow, was rich (trip had to be self-funded), and he was single

Captain Robert FitzRoy

- Aristocratic family background
- Nobel and outstanding sailor navigator
- Conservative background
- Approved Darwin for the voyage

About The HMS Beagle

- HMS Beagle offer came from Fitzroy
- He wanted to take along a dedicated naturalist
- Myth: Darwin was not the official naturalist
- Truth: He was! His presence was officially sanction by the navy and his position as the ship's naturalist was official
- Since Darwin was not in the navy, he had a 'special status' on board – he was a gentleman, a qualified naturalist as requested by the captain
- Beagle travelled mostly the southern half of the South American continent
- Objective of the trip: surveying
    - South America had just been broken free from Spanish and Portuguese rule, opening it up to foreign trade
    - Britain needed to chart the seas around it to enable profitable shipping
    - The Beagle was a coastline map making expedition
- Point of the Beagle was NOT to carry Darwin round. He was just part of the crew
- The Beagle Library
    - 400 volumes of books in the ship's library in Darwin's quarters
    - Fitzroy also gave him Lyell's book, which he read on the voyage

Santiago, Carpe de Verde Islands

- Darwin's first chance to be a geologist
- Examined the rocks – was able to reconstruct the geological history of the earth in the area just by looking at the rocks
- Found that the rocks also was in alignment with Lyell's treatment of geology
- First stop and he already had made some discoveries! Was very excited, had idea to publish a book about the voyage
- Excited about the sheer diversity of plants in the tropical rainforest (many more species compared to Europe)

Darwin's Notebooks

- Field notebooks: pocket sized, brought around with him while he walked
    - Correspondence, diary, zoological diary, geological diary, specimen notebooks
    - Geological notes way thicker than the ones on biology
- Collection notes: a copy of his notes to be given to other scientists
- Darwin probably wrote over a million words by the end of the 5 years
- Red notebook: written after the voyage, first hint of evolutionary ideas

Darwin and Gauchos

- Most of the voyage took place in Spanish areas
- Most of the info in Spanish, people he spoke to were also Spanish (called Don Carlos by them)
- Darwin rode with the Gauchos as his guides – rough, rugged, South American cowboys
- Darwin could ride and shoot (hobby from his school days) – was respected by them
- Bolas – Darwin tried to catch animals while riding, and ended up getting the bola entangled with his own horse, to the amusement of the gauchos

Section of the Cliffs of Patagonia

- A cross section of the coast of Patagonia
- As Darwin went inland, there were beaches that were high and dry
- Many levels of upraised beach
- Different levels shows evidence of previous beaches – oldest beach is the highest
- Shows that the land has been uplifted again and again

Charles Lyell's Principles of Geology

- Lyell addressed not just geology but also biology
- Theory: species are like a rubber band
  - Species can change to a limited extent to fit the environment. However, if the environment changed more than the species could, they go extinct
  - Analogy: can stretch a rubber band to a degree, but beyond that and it snaps
- Appearances of new species as a result of 'special creation', created to fit the new environment

Fossils

- Darwin unearthed fossils, and from the rocks around them could contextualise these fossils
- Found extinct mammals
- Macrauchenia: an extinct llama?
- Toxodon: an extinct ground sloth
- Glyptodon: has an armour body, similar to armadillos
- Curious pattern: similarity between the ancient world and today's living things in the same place

Horses in America

- Darwin found a fossilised tooth of an ancient horse
- Unusual as there were no horses when the first Europeans visited
- Shows that horses used to live in South America – where did they go? What happened?
- According to Lyell: the environment will change until animals cannot adapt and die out
- But the environment in South America is perfect for horses! No reason for them to have died out
- Rocks show no flood, no geological disaster, etc
- Proved that Lyell was wrong in this aspect – if animals were also created to fit the environment, why were the horses created and then destroyed without any reason?
- Same type of animals appear and disappear in the same areas – why? Why does it have to be locally, why not globally?
- These questions puzzled Darwin
- Glyptodon and Armadillo: 1) Similarity between extinct and living creatures in the same place.

2 Species of Rheas

- Heard that there was a second species of rhea around and wanted to find it
- While at a campfire dinner, noticed that the feathers of the bird he was eating looked suspiciously different
- Realised he was eating the new species
- Gathered the bones and feathers of what was left – that became his specimen
- The 2 species of rhea were divided by a wide river, each species on a respective side
  - Similar climate on both sides – why would there be 2 species? 2) Distribution of related living species
  - Again, if different species were created to fit different environments, why would a river cause the creation of 2 species since the environment was the same anyway?
  - The river was created by erosion over time
  - No massive geological event occurred to explain split of the rheas

Santa Cruz Expedition

- Land once under the sea – proof of continental uplift
- Darwin criticized former geologist who believed that such formations were formed in dramatic catastrophes
- Slow and gradual erosion of the rock

Creationist FitzRoy VS Sceptical Darwin?

- Myth: Fitzroy and Darwin were at odds – a battle of religion versus science, and were always arguing
- Truth: Darwin was as religious as anyone on the voyage

- Was actually teased by officers on the Beagle for being overly religious!
- ❖ FitzRoy recognised the flood to have not happened
- ❖ It was only *after* the voyage did his extremely religious views emerge
  - Married his secret fiancé, who was deeply religious
  - Appendix attached to the end of his book after the voyage where he concluded that the earth was indeed very young, and the great flood had occurred
  - This led to today's sensationalist portrayal

Tierra del Fuego and Fuegians, 1832 & 1834

- ❖ Almost animal like savages – primitive, dirty, used gruff language
- ❖ Darwin could not believe that there were people in the world who were so primitive
- ❖ Shock and disgusted
- ❖ Fuegians ate seafood like mussels and clams, dead whales if they were lucky
- ❖ Fitzroy brought 3 Fuegians who were previously "taken along"
  - Kidnapped when they were children, brought to England to be "civilised" and to be used as translators
- ❖ Darwin able to ask the Fuegians questions via these interpreters
- ❖ Found out they would eat the old women when food was scarce in the winter
  - Darwin is shocked. Why not eat the dogs?
  - Reply: dogs catch otters. Old women don't
- ❖ Note: modern historians today think Darwin may have been mistaken about them being cannibals
- ❖ Fuegians are extinct today
  - Europeans kept sending missionaries, Fuegians kept being kidnapped to be civilised, caught European diseases, and as a result eventually died out
- ❖ Jemmy: one of the 3 Fuegians. Only after a few months after returning home, he shed his European clothing and habits and went back to being a savage
- ❖ Darwin's realisation: his ancestors had been like this too – this was his past
- ❖ Maybe it made it easier to accept that humans had come from animals later in developing his theory

West coast of South America - from June 1834

The Fox of Chiloe Island

- ❖ Rumour – unique species of mammal on the island
- ❖ But foxes are shy and difficult to find
- ❖ Fox appeared one day while they were setting up equipment
- ❖ Darwin crept up on fox and killed it with a hammer

Traverse through the Andes

- ❖ Thought to be the tallest mountain in the world then

Darwin's *Geological Observations on South America* (1846)

1835 Concepción earthquake

- ❖ Beagle was a little off the area, Darwin was sleeping on the ground when it happened
- ❖ Darwin timed the duration, and saw the devastation that ran through the city
- ❖ Studies the collapse of infrastructure – could infer the direction movement
- ❖ Volcanoes in the area became active at the same time – a connection
- ❖ Current understanding: parts of the earth go up and down
  - Darwin: earth feels like a "crust over a fluid" – was almost close to deducing that the earth really moves from side to side!

Coquimbo, Chile

- ❖ Terraces of repeated crustal uplift
- ❖ Noticed barnacles – can see where previous sea levels were
- ❖ Proof that the land got uplifted from the sea
- ❖ In general, Darwin studied everything he could find, even the dust that landed on the ship at sea

Darwin found animals that lived in habitats different from which their group is adapted

- Snake that behaved like a rattlesnake, but had no rattle
- A kind of subterranean lizard which possessed only front legs
- A burrowing rodent, which seemed to be losing its eyes
- Flatworms living under decaying trees on dry land (they are normally sea creatures)
- Falkland Island's goose that had wings but could not fly
- Galapagos lizard that feeds in the sea
    - Darwin experimented with this iguana: threw it out to the sea, and then watched it swim back to shore, and did this repeatedly. Despite knowing it was going to be flung, the iguana kept coming back. Darwin concluded that whatever was at sea was a bigger threat than Darwin
    - This was actually false – real reason: it is cold blooded, was seeking warmth on land or it would die

- The geological change in South America had been slow and gradual
- But comparatively, the animals had changed drastically
- Why? No reason for so many animals to have gone extinct

Lecture 5: The voyage of the *Beagle*. Part 2

Galapagos Island

- Series of small volcanic islands
- Bizarre animals living on the island
- Named after the abundance of giant tortoises
- Animals were tame – had no land predators and no fear of men
- Island had not seen people for 200 years – Darwin was probably the first qualified naturalist to reach these islands – an unexplored territory for science
- Galapagos iguanas - land animals, but went to the water to look for food

Galapagos Finches

- Myth: Darwin noticed the beaks of the Galapagos finches and the idea of evolution struck him
- Truth: Darwin did not even know the birds were all finches
- Did not discover any new species there
- Did not know the birds were unique to the Galapagos
- Did not know the beaks were ecologically specialised e.g. Nihoa finch heavy beak is suited to a diet of seeds
- John Gould (Ornithologist): Was the one who analysed Darwin's specimens and who told Darwin they were all part of the finch family
- David Lack: ecological specification to specific diets
    - *Darwin's Finches, 1947* – quoted Darwin many times, leading to the misattribution

Galapagos Mockingbirds

- 3 species of mocking birds on 3 isolated islands
- 3 species were also similar to those found on South America
- If the islands were all the same, the species should be the same. But they are different

Darwin's Galapagos Plant Specimens

- Many unique species confined to the island
- But at the same time closely related to those on South America
- Same pattern as with the mockingbirds

Endemic Species and Puzzling Questions

- Endemic species = confined to a particular place
- Why so many endemic species?
- Why so many from American families?
- Mockingbirds: 3 species on 3 isolated islands
    - No reason to be different – same environment, same climate
    - Prevailing theory: species are created to fit the environment
    - But if the environment is the same on the 3 islands, why 3 different species?
- Mockingbirds on Galapagos island similar to those in South America
    - Galapagos environment is very different from South America
    - If things were created to fit the environment, why not a unique Galapagos species?
    - Why are the mockingbirds related? Flown there?
- The species must have somehow come from South America
- Why different species on different islands?
    - Very improbable that each species landed independently on a specific island
    - Darwin's reasoning: must have migrated within the islands once they all got there
- Mockingbirds don't fly over oceans
    - How were they populated? Through natural dispersal?
- Many puzzles and questions plagued Darwin
- In later years, this would be what inspired Darwin's evolution theory: Isolations result in divergence.

Darwin's Ornithological Collection Notes, 1836

- Ornithological = study of birds
- Reflecting on the mockingbirds
- If the birds were really a different species, it would undermine the common belief that life does not evolve

- The beginning of Darwin's evolution theorising
- Note: it was NOT a private diary. Was a set of notes to be given to other naturalists
- Darwin had intention on keeping it secret

Coral Atolls

- One of the purposes of the voyage: to study coral atolls
- Wanted to understand them – where are they from?
- Usually in a ring shaped island
- Usually low lying waters – dangerous for ships (ships were powered by wind)
- Corals grow in shallow water where sunlight can reach
- So how do corals reefs appear in the middle of a deep, dark ocean?
- Prevailing theory (Lyell's): corals grow on the rim of round volcanic craters under the sea
- Darwin had issue with this theory – how is it so many volcanic craters were at just right the depth to allow corals to grow?

Tahiti

- Beagle leaves South America and Galapagos, and sails across the pacific to Tahiti
- Known as paradise to Europeans
- Popular due to previous voyages and folk lore – they had promiscuous women, and sailors were deprived
- Pitcairn Islands – descendants of the mutiny and the Tahiti girls
- Christian missionaries in Tahiti
    - Clothed, Christianised and 'civilised' them
    - Darwin was fully in favour of this – thought the missionaries were doing a great job
    - Together with FitzRoy, wrote a letter praising their noble efforts
    - Evidence that counters the popular narrative that Darwin was against religion!

Darwin's Theory of Coral Atoll Formation

- Darwin climbed the mountain of Tahiti (Eureka moment)
- Island and reef of Moorea (Eimeo), seen from the mountain of Tahiti
- Overlooking Moorea from the aerial view, Darwin had a sudden epiphany
- Moorea: coral atoll with a volcano in the centre
- Theory- the land sinks gradually, leaving a ring of coral
    - Corals take very long to grow
    - If the land sinks too fast, the corals get submerged and die
    - But if the rate of coral growth can keep up with the rate of sinking, eventually the island would vanish, leaving only an encircling coral reef
- Theory was well accepted by fellow naturalists
- Darwin was using Lyell's thinking – slow and gradual
    - Tiny actions, added up over time, produce massive change

Bikini Atoll

- US testing of the atomic bomb
- Need to drill down to see how deep the bed rock is
- Drilled and discovered coral was one mile deep
- Land was sinking, and the coral was growing to keep up with the sinking to keep in the light
- The only way the coral could have been so thick at the bottom was that the land must have been previously elevated
- Darwin's theory was right!

South America rising?

- If one part is being pushed down, then another part must be pushed up – connected global system
- Darwin was right that they were connected, just not in the way he imagined

Sydney, Australia

- Marsupials – eg: platypus & echidna
- Different from mammals – produce milk, but do not have nipples; it just oozes out from their skin

- ❖ The most primitive animal alive today – similar to early mammals
- ❖ Mammals are able to give their young nourishment
- ❖ What is milk?
    - Milk is modified fatty sweat
    - Glands that produce milk are just modified sweat glands
    - Over generations, sweat evolved to have more and more fats as it was beneficial - until it became milk
- ❖ Australia used to be connected to South America – broke away and drifted over the years
- ❖ The only marsupials in the world are found in Oceania and South America
- ❖ Related things are usually near each other
- ❖ Not as many marsupials in South America as mammals killed them off

Marsupial mammals vs Placental mammals

- ❖ Placental mammals: babies born mature and 'ready'
- ❖ Marsupials: babies born a 'half-baked worm', crawls out and attaches itself to the mother's nipples and drinks milk until mature
- ❖ An ancient form of reproduction that has died out everywhere on earth, except in Australia

Antlion

- ❖ Darwin: "surely two distinct creators must have been at work"
- ❖ All the animals were so different, except this one insect which was the same between Australia and South America

More puzzling questions

- ❖ Darwin encountered a huge range of natural phenomena which provoked his curiosity, as well as puzzles and problems he could not answer in his day
- ❖ Why is one insect the same, but all other animals different?
- ❖ Why have similar things and different things?
- ❖ Why are they distributed as such across the world?
- ❖ Where do new species come from?
- ❖ If they are somehow created to fit where they live, why do the mockingbirds in Galapagos look like they came from South America?
- ❖ If they did come from South America, why are the species different?
- ❖ Traditional theories starting to crumble as they did not explain things
- ❖ Today we know
    - Because they changed across a very long period of time
    - Things in Australia and the Galapagos are isolated

Island of St Helena, 11 July 1836

- ❖ Steep cliffs with windy updrafts
- ❖ Seagulls are flying against the wind – look stationery
- ❖ Darwin did not just look at animals, he looked at the earth
- ❖ How the earth changes, and living things are just "hitching a ride" on the earth
- ❖ As the earth changes, living things must keep up, or they die
- ❖ Aware of how unbelievably old the earth is – it had been through ages and changes, but life still prevailed

- Voyage ends, the Beagle returns
- Darwin is the talk of the country – he has found so much, brought back so many samples, and discovered many things
- Work was published
- Collection was enormous – Darwin had basically collected anything he could get this hands on

- Back in England, Darwin questions his beliefs
- Is there enough evidence to accept the bible – that species are created the way they are?
- Ponders questions on life – how does life work, why two sexes?
- Where do species come from? How do living things change?

Lecture 6: The beginnings of a theory

- October 1836: The Beagle returns home
- 1836 – 1837: After returning from the Beagle voyage, Darwin lived briefly in his Cambridge home

London

- Scientific community were located in London
- Darwin shifts from Cambridge to London to join them
- Has trouble persuading people to take on and examine his specimens + publicize his collection
- Thought about other plans in life
- Family plan of Darwin becoming a Clergyman was dropped – by then Darwin was recognised as a small scientific figure (Darwin's father was very proud)
- Darwin thinks about getting married
- Conversation with father showed that he was beginning to have doubts about his religion
- Father advices Darwin that if he were to get married, he should hide his doubts, lest the woman worry

Marriage

- To marry or not to marry?
- Darwin weighs the pros and cons in his journal
    - (+) constant companion
    - (+) can have children
    - (-) forced to visit relatives
    - (-) no more freedom to go where one likes
    - (-) less free time
- Darwin leans towards getting married – and eventually does
- January 1839: Darwin marries his cousin Emma Wedgewood
- Did not conceal his religious doubts – this caused some trouble initially, but as their relationship matured, they didn't talk about religion that much

1842: The Darwins moved to Down, in rural Kent, south of London

- Eventually decided to leave London despite all the scientific action being there
- London was dirty, noisy, and smelly – noisy transportation, constant burning of coal
- Darwin was a country person, didn't like the busy city life – hence moved to the countryside
- Darwin was well to do, need not work a day in his life
- Worked in a small, crammed space despite the large house
    - Probably because he was used to working in a small confined space in the Beagle

John Herschel: "the mysteries of mysteries, the replacement of extinct species by others"

- Ie, Species come and go – everyone knows how they go -> extinction
- But where do they come from?

Argument from Design

- Ie, Team God created species
- John Ray (1627 – 1705)
- Carl Linneaus (1707 – 1778)
- Rev. William Paley (1743 – 1805)
    - *Natural theology, or evidences of the existence and attributes of the deity collected from nature (1802)*

Paley's *Natural Theology*, 1802

- Book about proving the existence of God through studying nature
- Was a very old fashioned book, no one really read it anymore
- Argument by analogy - clock
- Living things must have been designed by a designer
- Myth: Paley vs Darwin

- Reality: Paley and Darwin were from different generations – by Darwin's time it was already very old fashioned
    - Darwin read the book in Cambridge and loved it
    - Thought the logic was so powerful it had to be true
- Darwin used to like this kind of thinking, but after what he had seen during the Beagle voyage, was slowly turning away from it

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Tracing the theoretical pathway which Darwin took to arrive at his final theory

The Position of the bones of Mastodon, Feb 1835

- Darwin was still a creationist
- Grappling with the problem of successive disappearance of species and the unknown birth of new ones
- Why do species die out?
- Darwin heard about apple trees grown from grafts on Chiloe, could this explain the extinction of the Mastodon?
    - Apple tree: the only way the tree could be propagated was through planting cuttings
    - Hence they aren't actually reproducing – all the trees in the island would have come from the same few trees
    - Was told that all the trees had died at the same time
- Lifetime theory of extinction
    - Darwin's theory: species just had an inherent biological 'clock' which determined how long their species could live for. When time runs out, the species dies out
- Maybe both the apple trees and Mastodons died out because its timer expired
- Would explain why the Mastodons went extinct without any evidence of why in the rocks
- Note: the then orthodox view: species don't change – they somehow appear, stay, and then die out

Ornithological Notes, June – July 1836

- Darwin is starting to turn a corner
- Began to suspect that perhaps living things evolved
- Biogeography and isolation seems to have resulted in different species
- Galapagos mockingbirds undermine the current understanding of species
- Curious and sceptical, but not yet convinced

Early 1837: Becomes a transmutationist

- Transmutation = 19 century term for evolution
- Transmutation notebooks – Darwin recorded his thoughts
- 3 Reasons that convinced Darwin to change his mind
    - **Similarity between extinct and living creatures in the same place**
      Why would things in the same family replace each other, when things are supposed to be created independently?
      Eg: Macrauchenia → llama, Glyptodon → armadillos
    - **Distribution of related, living species**
      Difficult to determine if something is a new species, or just a variety
      Eg: rheas were really 2 species, not 1
    - **Relationship of Galapagos Islands species to those of nearby continents**
      Different species living on different island, each isolate from one another
      -mocking bird
      -finches

Coral Formations Paper, May 1837

- Myth: Darwin was worried about his evolution theory being unorthodox, and hid it
- Reality: Darwin did not hide anything
- Paper shows the direction his ideas were headed towards
- *"whether certain groups of living beings peculiar to small spots are the remnants of a former large population, or a new one springing into existence."*

Red Notebook, January – June 1837

- Darwin speculates on temporary theories to explain his observations
- Geographical distribution
  - The two rheas descended from a common parent, but at one blow (saltational speciation)
  - Perhaps the ancestral species laid some eggs, and the eggs for some reason were very different – so different it was now considered a new species
- Distribution of species through time and space
  - Darwin's law of succession of types in same locality
  - Greater and lesser rhea related across space
  - Macrauchenia and llama related across time
- Reproduction of individuals and species
  - Living things which were sickly were thought pass them down their bad traits, leading to the accumulating of bad traits inherited by offspring – a short species "lifespan" would prevent this snowballing accumulation, and create a constantly refreshing 'new start'

Transmutation Notebooks B, C, D, E, M, N, July 1837 – 1839

Notebook B

- How do species become adapted to a changing world? (adaptation)
  - Lyell: the environment keeps changing, when species can't keep up they die
  - Darwin disagrees: species don't die, they keep changing
  - The ultimate source of continuous variation comes from sexual reproduction
  - Life is short because mutilations would spoil a species
- How do new species form? (speciation)
  - Isolation seems necessary for new species to form
  - Differences can accumulate over time when isolated
  - Explains the weird anomalies
    Eg: Woodpecker that does not peck wood: descended from other woodpeckers, but there were no trees around
    Eg: Desert kingfisher: descended from other kingfishers, but got isolated in another evnvironment
- How does the hierarchy of taxonomy form? (phylogeny)
  - Why can all living things be organised into a neat hierarchy?
  - Must be because living things descend from a common ancestor
  - Occasional extinction causes the appearance of gaps

Notebook B's Famous Tree of Life Sketch, 1837

- Called the first tree of life diagram
- Shows how Darwin's genealogical descent can explain things
- Starts at the base of the tree – common ancestor
- Over time, many lineages develop from this ancestor, and branching starts
- Dead end = extinct
- Cap at the end of the branch = currently living species
- Why some species are more similar than others – more recent common ancestor
- Note: this fits into Darwin's kind of thinking: slow and gradual, as opposed to his previous temporary theory, which had sudden change

Notebook C

- Heredity transmission of form
  - How are traits passed on? Genetics not discovered yet
- Distribution of local and wide-ranging species
- Distinction between affinity and analogy
  - Affinity: similarities inherited from ancestors
  - Analogy: similarities gotten from adaptation to a common environment
- The relation between habit (behaviour) and structure
  - Does behaviour come first or structure come first?
  - Lamarck's theory: giraffe stretched until it got its long neck

- Maybe it got its long neck first?

Notebook D

- Main theme is reproduction
- Why is the world not filled by one type?
- The influence of economics?
- **Malthusian law of population**
  - Thomas Malthus
  - Wrote a book about population theory
  - Populations would grow exponentially and eventually outstrip food and resources
  - Everyone is going die from lack of resources
  - Solutions
    1) Don't help the poor – they they'll just reproduce, let them die off
  - 2) Passion between the sexes needs to be reined in – moral restraint
  - Darwin read the book
  - If every living thing survives and manages to reproduce, the population on earth would be unimaginable
  - But this is not the case in real life! Something caps off the population
  - Some are killed by predators, some cannot find food, etc
  - What is so special about the ones who make it? What controls what lives and what dies?

Notebook E

- His full theory – principle of differential survival by natural selection
- Three principles that account for all inheritance, variation, and competition-selection
- **Small hereditary variations**
  - Tiny differences matter – determines who gets to live and die
  - In an isolated island with lack of predators – tame animals have an advantage over flighty, active ones – they waste less energy
  - The reason why the animals in the Galapagos were so tame
- **Adaptation is relative**
  - Variation is not directed at any goal
  - Eg: stupid birds can be born among healthy birds, and the stupid ones will eventually die off
- **Adaptation is contingent on circumstances, and variation is always there**
  - Farmers and planters choose which plants and animals they want to breed through artificial selection
  - By selecting what one chooses to reproduce, the off spring can be determined
  - Humans could almost 'design a breed'
  - Chicken story: wanted to increase number of eggs, so they chose the chickens that made the most eggs and bred them together. Turns out they actually selected the most aggressive of chicken, creating a hyper aggressive breed of chickens. Eggs production went down because chickens were always fighting
  - Sheep – bred by farmer to have short legs so they couldn't jump fenses
  - But in the natural world, there is no one doing the selecting – nature is the one "selecting"
- Darwin's theory was shocking as it involves a lot of death – what we see today in the living world are the survivors
- The notebook is finished but open ended, ready for elaboration…

Lecture 7: Another naturalist: Alfred Russel Wallace

Alfred Russel Wallace

- 2 common themes in history: emphasizing his genius, and his enormous struggles
- Wallace was NOT working class – father was a gentleman (but had lost all his money)
- Social class in Britain was not determined by wealth – so he was still considered a gentleman
- Lived in Kensington Cottage, Usk

Hertford Free Grammar School, 1828-1837

- Grammar schools – schools for the sons of gentlemen
- Studied the same subjects as Darwin
- Myth: Wallace was forced to leave school at 13 when his family ran out of money
- Reality: 13 was the normal age to leave grammar school!

London, 1837

- Was sent to London to live with his brother
- First encounter with working class people
- Saw the people there as separate from himself – Wallace was NOT working class

Surveying (1837 – 1843)

- Went with his brother William to work as a surveyor
- Railway boom – people were building railways everywhere, even in remove places (it was an investment bubble)
- Surveyor – checked whether the land was appropriate to build
- Was Wallace's introduction to working life and nature – interests started here
- After the railway bubble collapsed, he hopped from job to job

The Collegiate School in Leicester (1844 – 1845)

- Became a teacher at Leicester
- Job left him with a lot of free time, so he read a lot
- Read Vestiges
- Was somewhat convinced by the book – that the natural world does change
- Met Henry Walter Bates – who collected beetles, was amazed at their diversity
- Bates introduced Wallace to insect collecting, which led him into the scientific community

Phrenology and Mesmerism

- Phrenology – based on the belief that the brain is divided into compartments ('organs'), and each organ was responsible for doing something, and that these organs could be felt through the skull
  - So essentially, by reading the bumps on someone's head, could scientifically derive their personality
  - Wallace was very convinced
- Mesmerism – invisible circulatory system flowing throw organisms
  - Ie, hypnotism today
  - People figured out that it was possible to put people into a trace – and that people in this trance could not feel pain
  - Used this phenomenon to operate on people
  - This legitimised the practice
- Phreno-mesmerism – use mesmerism to control the bumps in the brain
- Wallace's belief in phrenology and mesmerism shows that he was the kind of person who was eager to believe radical things
- Vestiges – a radical fringe science theory as well

1845 Letter From Wallace to Bates

- Showed that he accepted some sort of evolutionary theory but was not satisfied yet

1847 Letter From Wallace to Bates

- A very often quoted letter by his fans
- Wallace was dissatisfied with a mere insect collection
- Wallace used the phrase "origin of species"
  - Used by fans to argue that Wallace was seeking to solve the origin of species
  - Reality: he was probably paraphrasing from a chapter in *Vestiges*, and Wallace's "origin of species" did not have the same meaning as Darwin's 1860s "origin of species"

Victorian Natural History Collecting

- Victorians were obsessed with collecting – there was a market for specimens
- Collecting specimens from the tropic was lucrative
- Specimens came from collectors who travelled far and then sent them back home

Amazon, April 1848 – October 1852

- Wallace and Bates saved money and went to the Amazon on a cheap ship
- Made a living by collecting specimens
- Shot animals and shipped them back, which were sold to a museum
- Journal: Wallace can draw very well (unlike Darwin)
- After 5 years, decided to go home
- On the way back across the Atlantic – ship caught fire. Wallace's personal collection, notes, specimens, were all destroyed
- Even though many things were destroyed along the ship, he had made more money collecting than any other job he previously did
- Was a naturalist – beyond collecting bugs, he also observed and wrote papers

Wallace in 1853, aged 30, after his return from the Amazon

- Had the middle-class dream – quiet house where he can do his science
- Made a lot of money from the Amazon trip
- Decides not to go back to Brazil where Bates was still collecting

Singapore, 1854

- British had a lack of collections from Southeast Asia
- Got funding to be sent first class to Singapore
- Arrived on 18 April 1854 (it was published in the newspaper under arrivals)
- Got connected with a French Catholic missionary
- Stayed with her at St. Joseph's Church in Bukit Timah
- Bukit Timah was the only place which had forests left (lowlands had been cleared for plantations and houses)

The 1854 Singapore Riots

- Hokkiens vs Teochews
- Existing racial tensions + raises in rice prices
- Many people died, shops and houses burnt down
- Wallace was in the middle of arguably one of the greatest conflicts in Singapore before WWII
- Wallace had no clue what was going on since he was stuck in a forest, and did not speak any dialect
  - Commented on how he saw men going to buy rice while heavily armed, and found it peculiar

Tigers in Singapore

- Wallace was told that tigers kill a person a day, typically farmers
- This was a false legend – only 22 people were killed by tigers in the entire year
- Painting of caged tiger
  - People laid traps for tigers, hoping to capture them and sell at a high price
  - One was caught and then put on public display outside the police station
  - Possible origin of the painting

Wallace's Collecting Habit

- Wallace shot and captured as many animals as possible – he was a commercial collector
- Collected over 126,000 samples
- Contrary to Darwin – he tried to get a representative sample of what lived in the area

Wallace's Mystery Flycatcher

- Asian brown flycatcher (specimen currently in LCKNHM in NUS)
- Wallace did not go to Malacca in 1862. How did it end up in the museum and labelled this way?
- What really happened: Wallace was in England -> friend in Malacca shot the bird, and sent the specimen back -> Wallace helped label them, and split the money with his friend -> Berlin museum bought the specimen -> Singapore and Berlin museum did a collection swap -> specimen ends up in Singapore

Wallace's Insect Specimens

- How to preserve butterflies: use paper and pin to dry out butterfly with wings spread out
- Pin through the beetle – minimised damage of specimen as it could be picked up through the pin
- Short form of where the beetle was found written on head of pin
- Wallace's giant bee – biggest bee in the world. Was not seen again until a 100 years later

Wallace and his Assistants

- Wallace had loads of assistants
- Charles Allen – was slow and dim witted
  - Was a son of a carpenter when Wallace hired him at 14
  - Eventually stayed behind in Asia and settled in Singapore
- Ali: Wallace's assistant from Sarawak, 1855-1862
  - After Charles left, Wallace hired Ali
  - Ali became his most skilled, trusted assistant
  - After Wallace left, he gave Ali a large sum of money and his equipment – Ali used the money to buy a European suit and took a photograph, which he sent to Wallace

- Wallace was never alone. He always had a team which were everywhere, collecting on his behalf
- Note: when reading sources on Wallace, treat it with caution. Most are written by die-hard Wallace fanatics, who tend to exaggerate and sensationalise.

Lecture 8: Wallace in the Malay Archipelago

Singapore to Sarawak (1854-1856)

- Wallace leaves Singapore for Sarawak
- Sarawak – ruled by James Brooke. Known as the white raja
- Wallace spent most of his time doing his job – collecting
- As scary as an ogre – locals had never seen a white man before
    - Wallace looked very intimidating, especially covered with equipment
    - They often ran away when they first encountered him

Sarawak Law Paper 1855

- Living things have been "created" in a progressive order - after the disappearance of similar ones, and in the same place
- Principles of Divergence - new structures that appear that are not needed by an animal
    - Eg: orangutan have sharp pointy teeth, but have no need for it
    - Animals with random unnecessary characteristics that may have use for it in the future
- Myth: this was the first time Wallace announced his belief of evolution
- Conspiracy theory: Darwin read the article and stole Wallace's idea
- Reality: the paper does not even mention evolution at all!
    - The paper is misread by modern people - taken out of context
    - The paper only subtly suggests that there is evidence that leads to evolution
    - Still states that creation happened
    - Wallace was testing the waters of the scientific community, while being very cautious because of all the bigotry towards evolutionary views
    - Wallace hid his meaning so carefully that no one really saw its hidden meaning

"Branching" – Wallace vs Darwin

- Conspiracy theory: Wallace proposed evolutionary branching in his essay, and Darwin stole the idea
- Reality: False for 2 reasons: Wallace used 'branching' in a different context + Darwin understood evolutionary branching way before the essay was published
- Have to contextualise – what did branching mean to them?
- Wallace (1855) – used branching to illustrate how groups of molluscs were similar – branching as a organisational word
- Darwin's Notebook B (1837) – ancestral branching of lepadidae, ie he already understood branching theory

Strickland's 1840 "Map" of the affinities of kingfishers

- Was trying to find the best diagram to illustrate the similarities between groups of birds
- Again, did NOT imply evolution – simply wanted to compare similarities and branching was the best way to organise them

December 1855

- Darwin wrote to 30 men around the world asking for domestic chicken skins
- One of these men was Wallace
- In his letter mentioned that he was working on evolution
- Must have been exciting for Wallace who thought he was alone in his evolution ideas!
- Note: letter to Wallace did not survive, however 3 of the letters did, and they are identical, so we can safely assume the letter to Wallace looked the same

Wallace on the Habits of the Orangutan, 1856

- Orangutans have extra features that serve no purpose
- Proves that features aren't adapted to the environment
- Shows Wallace's aversion to the idea of adaptation

Note on the Theory of Permanent and Geographical Varieties, 1875

- Varieties: from the same parent species, but differ a little
  - Eg: humans are all the same species, but there are different races (varieties)
- Wallace points out the inconsistencies in treatment of species and varieties
- If varieties are understood to have descended from a common species, then why are species, which are also differ very slightly from each other, treated as having been created?
- Double standards!
- Again, a concealed way of saying he believed in evolution

Wallace's Notebook 4

- A new variety is born at once suddenly, and look different from the parent
  - Eg: albino animals are suddenly born = a new species
- Similar to Darwin's temporary theory that he discarded
- Wallace is still thinking like Vestiges – sudden change
- Opposite of Darwin's thought process – slow change over long time

Island of Ternate, February 1858 and the Eureka Moment

- Went there to collect Birds of Paradise
- Wallace falls sick with a fever (malaria) – and had a eureka moment
- Popular theory: Wallace was inspired by Malthus' Book on population theory
  - Unlikely, as Wallace had never mentioned Malthus or his work until he met Darwin and read the book 12 years later
- Popular theory: Wallace was on the wrong island (Gilolo island) and saw the different races
  - False, he was really on Ternate
- Popular theory: Fever inspired thoughts of death
  - Unlikely, he often had fevers in his travels

The Gist of Wallace's Ternate Essay

- Countered Lyell that animals could not change to a large degree
- Lyell: There is a struggle for existence in nature, and only some survive
- Lyell: As environments change, some species become unsuited and go extinct – "rubber band" theory
- Wallace: But a variety may be better suited, and so survive and replace the parent species
- Why did Wallace switch to adaptation?

Wallace to F. Bates, 2 March 1858

- A clue to his epiphany?
- Wallace wrote that he noticed beetles were coloured to fit the environment. Beetles that live on mud, sand, etc. are all the same colour as the ground
- How do the insects come to fit their background so perfectly? What naturalistic process if not by design?
- Wallace thought he had formulated a theory to explain

Tiger Beetles

- Theory again counters Lyell: species CAN change to a large extent
- When the environment changes, the parent beetle dies as it now no longer fits the environment
- Daughter species that fit continue to propagate
- The species will now no longer go back to its original form as it is an "inferior version"
- Species drastically change, and will not revert back
- Seems like Tiger beetles were what inspired the Ternate essay

The Ternate Essay

- Wallace had written his first essay saying that species evolve
- Wallace wants to send his essay to Lyell
- Sends to Darwin as the middle man, who then sends to Lyell
- Why send to Darwin of all people?
- Wallace had concealed his belief in evolution until now, and was worried about the response
- Darwin was a safe person to send to because he believed in evolution too
- Darwin sends back a letter praising Wallace

- The most flattering letter Wallace had ever received

Essay is signed Ternate, February 1858

- But Wallace said he sent it by the next post – which was 9 March
- The letter to Bates also sent 9 March – arrived on 3 June
- Darwin claimed to have received it on 18 June
- Discrepancy in the dates have led to conspiracy theories on Darwin lying

Charles Lyell and Joseph Hooker

- Lyell and Hooker were given the essay as requested
- Darwin's situation: Wallace's theory was very similar to his – one that he has been working on for 20 years
- Lyell's advice – just go ahead and publish. Lyell wasn't very interested in the situation
- Hooker's idea – announce both their theories to the scientific community at the same time

Darwin's and Wallace's theories are published at the same time

- Conspiracy theory: this was wrong and unethical! They published Wallace's work without his permission!
- Reality: When Wallace found out what happened, he wrote to Hooker saying he felt flattered that he shared priority with Darwin
    - "Printed without my knowledge" – the work was so good that they immediately published it!
    - Context of the time: anything sent that was not marked 'private' was free to be published
    - Wallace's letter to his mother – proves that he was delighted, not unhappy
- The joint paper by Wallace and Darwin did nothing to convince the scientific community however
- The paper was so brief that Darwin's peers encouraged him to produce a more detailed book
- Darwin puts his current work on hold to produce a condensed version of his full theory – the *Origin of Species*

Why is Wallace less famous than Darwin?

- It was Darwin's *Origin of Species* that single-handedly changed the opinion of the scientific community
- Not Wallace's work!
- Wallace was not well known to begin with, he had not done 20 years of work, did not write or contribute to the Origin of Species, did not change any opinion of the scientific community
- Wallace himself is also aware of this, that his work paled in comparison to Darwin's
- Wallace after reading the Origin of Species – became a great admirer of Darwin
- Wallace is not the forgotten and extorted underdog his fans make him out to be

The Wallace Line

- After visiting many islands in Asia and Oceania, he noticed a pattern in the division of species
- Drastically different living things near each other, as if divided by an imaginary line
- Odd as this usually occurs across oceans
- Wallace guessed that there were 2 super continents that have sunk, and what remains is the highland

Wallace back in England, 1862 & His Personal Life

- Wallace is now a respected member of the scientific community, and was rich from collecting money and investments
- Starting courting a lady (that was out of his league) by going to her father's house to play chess
- Wrote a love letter to her, but got friendzoned
- After advice from his mother and sister, was encouraged to try harder
- Eventually got engaged, but she dumped him and ran away
- Got depressed, met Annie Mitten, and gets the rebound
- People, knowing that he was rich, kept asking him for favours
- He doesn't know how to say "no" – became broke again (like his Father)

1869 in a Review of Lyell's Principles

- Publishes new paper that takes a back step on evolution
- Thought natural selection could not explain man
- An "overruling intelligence" must be behind the creation of man
- Darwin is disappointed "I hope you have not murdered too completely your own and my child"

In a few years, things had changed…

- Wallace complained to Darwin that there was no intelligent people left who opposed evolution. Darwin's theory had been universally accepted across the scientific community

Spiritualism

- Why Wallace's sudden change in opinion?
- He got into spiritualism
- Spirit photographs – photos with ghosts in them
- Photo manipulation was an unknown trade secret
- Wallace said that it was strange that the figure in his photo looked nothing like his mother – but was still convinced that it was her anyway
- This hurt Wallace's reputation very much – unlike before, he did not hide his opinions

Wallace's Study in Old Orchard in 1909

- Darwin got his friends to write to the prime minister to get state pension for Wallace as his heard Wallace wasn't doing very well
- 1913 Wallace dies in his sleep

Lecture 9: Did Darwin Delay?

Darwin's Delay

- For decades, hundreds of books and articles have been saying that Darwin delayed publishing his theory for 20 years
- Even Darwin's own son mentioned nothing about a delay!
- Where did this idea of a hold back come from?
- The Darwin's 'delay' did not appear in any literature until the 1950s

Julian Huxley 1958 article

- Suggested that Darwin was afraid of sharing his ideas with the scientific community
- The first time anyone suggested a delay
- Over time, this version of events became more solidified and believed to be real

"Evidence" 1: The Dream

- Howard Gruber's *Darwin on Man,* 1974
- Psychologist, not a historian – concluded Darwin delayed out of fear
- Interpreted Darwin's dream as being afraid, that he would be killed if he shared his ideas
- Darwin was so terrified of sharing his ideas, he dreamt of it

Notebook M

- Check what the original says before coming to weird conclusions!
- The dream was in third person and not scary
- Gruber's interpretation of the dream is bizarre and against the text

"Evidence" 2: What Darwin Said

- "I gained much by my delay in publishing…"
- 2 meanings of the word delay: postponement, or time elapsed?
- Darwin's meaning: time elapsed
    - He always meant time elapsed when using the word 'delay' – can check with the other instances he uses the word
- What Darwin actually means: delay due to illness, and he wanted to publish more interesting things
- A long gestation was also typical of Darwin's books
    - Eg: *pangenesis* was not published for 27 years, orchid 30 years, psychological development of his son 37 years, cross fertilisation in plant 37 years
    - Eg: significance of worms was not published for 42 years
    - Origin of species is actually the shortest delay among Darwin's works!

"Evidence" 3: Like confessing a murder

- Darwin's letter to Hooker: theory of evolution was "like confessing a murder"
- One of the most quoted evidence by the conspiracy theorists
- The phrase, like the word 'delay', is also misinterpreted by people today
- Darwin was just joking when he said this – just hyperbolic humour. It's a joke!
    - Darwin has a tendency to use such humor
    - Eg: "I am ready to commit sucide"
    - Eg: "this is something like murder"
    - These phrases are not to be taken literally! It's an exaggeration; he's joking

How Darwin Treated Secrets

- He was very explicit with what he wanted to be kept secret
- Would mark such letters as "private" – meant that it was confidential, and cannot be printed or published
- None of his letters on evolution are marked as private
- Did Darwin really keep his theory secret?
    - He told at least 50 people – and that is just based on historical evidence that survived

1844 Essay

- A rough draft on the theory of evolution
- Sent the essay to have it commercially copied
- Back then, people had to hand write and copy everything
- If Darwin was so afraid, why would he send his essay to the copier?

"Evidence" 4: Memoir to his Wife

- Myth: Darwin told the wife to only publish his rough draft only after he's dead
- Truth: He said only IF something were to happen to him – the essay is still a crude draft that needs a lot of work and editing. Pay a man 400£ to refine the work
- Darwin wanted to finish his Beagle work before publishing his species work

Did Vestiges' Reaction Dissuade Darwin?

- The letter to his wife was written BEFORE vestiges was published
- Hence, vestiges had nothing to do with Darwin putting his species work aside
- In addition, Vestiges was not considered a proper scientific book – why would Darwin consider himself with a book of that standing?

Vestige's Reactions wasn't completely negative

- Adam Sedgewick – only a woman could have written such a foul book
- Richard Owen – wrote to the author privately, praising the book on the discovery of secondary causes
    - primary causes = direct actions of God
    - secondary causes = laws of nature (ie, indirect actions of God)

Darwin works on Barnacles

- Darwin thought he was going to start on his species work right after finishing Beagle work
- But was urged by colleagues to work on barnacles
- They were still very unknown, had no species classifications
- Darwin is happy to be working on the field again
- Worked on making a complete list of all the barnacles – a complete catalogue

Fun Facts about the Barnacle

- Was just figured out to not be a mollusc, but a kind of crustacean
- Have a very unique life cycle
    - Swim around when young and then glue themselves to a surface
    - Develops hard plates as adults
    - Use their legs to catch and eat plankton
- Barnacle sex
    - Are hermaphrodites – both male and female
    - Grow the world's largest penis

By 1850

- Worked on barnacles for 8 years
- Darwin got sick and bored with barnacles after writing and dissecting them for years
- Now a barnacle expert that hates barnacles with a passion
- Published 2 books on all the barnacles he found, including the fossils
- These homologies showed how structures could adapt function to suit new condition
- Same body plan presented in the barnacle and prawn
- Wing of a bat and our own arm

Owen, *Nature of limbs* (1849)

- Why do living things have the shape they do? Different creatures but with similar bone structure and organs
- Owen: creatures are based on an archetype – an ideal model that God has created
- Later on, an opponent to Darwin's theory – similar body shape is not due to common descent, but due to a common body plan

Chilean abalone

- Mollusc with tiny holes in its shell
- In the shell were tiny creatures – turned out to be parasitic barnacles
- Had the same life cycle, but looked nothing like normal barnacles

Why 2 sexes?

- Darwin wonders: why do things have individual sexes? Why not just mate asexually?
- Most species have 2 sexes – there must be some kind of advantage
- Advantage: variation in the offspring
- Mixing of genes allow for unique offspring – higher chance of survival in different and changing environments

Unfinished business

- Darwin was not done with his species theory
- Principle of divergence: The tendency in organic beings descended from the same stock to diverge in character as they become modified.
- Puzzle in his theory: sterile female insects (eg, bees, ants) can't pass on their genes. Kin Selection.
- How could a species have such complex behaviour, but most of the species could not reproduce?
- Darwin himself described the theory as a work in progress that was not finished yet, with many big issues that were yet to be solved

***Origin of Species*, 6th edition**

- Conclusion of the book: Darwin said that he spoke to many naturalists on the theory
- Direct proof! If Darwin told so many people, how could it be a secret

Darwin in a letter to Asa Gray, 1857

- Again, no secrecy
- Occurred to Darwin that he could have continued working on species and evolution, while working on other things at the same time

Alfred Russel Wallace and the surprise of 1858

- Interrupted Darwin's massive book with his essay
- Led to him working on the Origins of species
- Note: "publish or perish" mentality not present in Victorian times

Lecture 10: On *The Origin of Species*

About the book

- 8 Years later, Darwin finally finishes working on barnacles
- The same day he finished, he started working full time on species
- Doesn't necessarily mean he's working on the book yet – also working on unfinished thoughts
- What is the book about? Evolution by natural selection explains a wide range of phenomena that are otherwise inexplicable
- Lyell's gradualism underlies the book - long, slow action of small natural causes can accumulate to produce massive change
- Questions the book does not address – what is the origin of life? Does god exist? Is god behind nature?

Epigraphs

- There to give inspiration or "cover your back"
- Implies that the book is not at all irreligious, just studying how nature works

Chapter 1: Variations under Domestication

- Variations are ubiquitous
- Artificial selection changes species – humans, by selecting certain breeds, change a species over time
    - Polish fowl bred to have huge plumes
    - Chicken bred to be fatter and fatter
    - Watermelon bred to have more flesh and less seeds
    - Ancon sheep bred to have short stumpy legs so they couldn't jump fenses
    - Strawberries bred to be large
- Breeds of domesticated animals and plants are analogous to new species

Chapter 2: Variation under Nature

- Plants and animals in nature vary just like the domesticated ones
- There is no clear distinction between species and varieties
    - It is an artificial, arbitrary line drawn by scientists, not an actual natural distinction or catagorisation
- Tree of life diagram is able to make sense of taxonomy – gradual evolution over time
    - Tree of life is the only diagram in the book
    - Similar to the tree diagram in Notebook B
    - Does not represent any specific family, just a generic diagram to illustrate the process
    - Each space in between the lines connecting species may represent thousands of generations
    - Split earlier = species will be more different, Dead end = extinct

Chapter 3: Struggle for Existence

- Given population growth, competition for survival is inevitable
- Only a few live – who survives?
- Any variation that has properties beneficial to the system in nature is more likely to live and give birth to offspring
- Offspring with similar traits will likewise continue to pass the down
- Farmers and breeders: artificial selection
- In the natural world: natural selection

Chapter 4: Natural Selection

- Sexual Selection
- Eg: peacocks have heavy, showy, large tails – doesn't seem very practical in survival
- But they are the result of sexual selection – beautiful feathers are needed to attract a mate, and the showy traits are passed down
- Birds of paradise – picky females
    - Have caused males to evolve colourful plumes and elaborate mating dances
- Pheasants – males have good singing voices due to female sexual selection

Chapter 5: Laws of Variation

- Ie, genetics today

Chapter 6: Difficulties on Theory

- How could huge changes ever begin?
  - Eg: a land animal becomes an aquatic one; bats and birds start to fly; what good is only half an eye or wing?
  - By many gradual steps and selection. Many transitional forms are all around us
- Some organs seem too complicated and perfect, they must have been designed by God?
  - Eg: the eye
  - Eye evolved gradually over time – we still have species today with eyes at different stages of complexity
- Why does the bee die after stinging?
  - Because of their ancestry. Their stingers were originally meant for drilling into wood to deposit their eggs into trees - a sharp organ became useful for defence as well, despite it not being its initial purpose
- Why aren't all features adaptive or useful?
  - Eg: why do mammals have an oesophagus and windpipe that share a common opening? Seems like poor design that makes choking risky
  - Land animals are descended from fish – had a hole that led to stomach and swim bladder
  - Descendants that evolved from the fish who came out of water have a breathing system that is similar to the predecessor
  - Features that are useless may just be left over from ancestors, and are just inherited

Chapter 7: Instinct

Chapter 8: Hybridism

Chapter 9: Imperfections in the Geological Record

- Why do fossils show sudden appearances of animals, without any gradual change?
- The fossil record is even more fragmentary than we realised – shows only little snippets of history
- Fossilisation happens very rarely and only in certain places
- Immeasurable amount of time has passed since the creatures were buried - as evidenced by the extremely slow rate of deposition and erosion of the earth
- May look like groups of species just suddenly appeared – but it is really due to the nature of fossilisation which fails to show the gradual progress -fossils show an incomplete picture with gaps

Chapter 10: On the Geological Succession of Organic Beings

- Species once extinct, never reappear
- Species that look very similar just come from a common ancestor

Chapter 11 & 12: Geographic Distribution

- Biogeography – the study of geographic distribution of living organism. Most compelling evidence for evolution
- Environments cannot explain distribution – some animals that are suited to the environment don't live there
- Explanation: biological distribution is dependent on the common ancestor - animals and plants have moved about and diversified from their ancestors, limited to natural barriers
- The facts of distribution only make sense in terms of evolution

Chapter 13: Mutual Affinities of Organic Beings: Morphology: Embryology: Rudimentary Organs

- Embryology
  - Embryos of different species look surprisingly similar in the early stages of development
  - At some time during embryonic development all vertebrates have postanal tails and pharyngeal pouches
  - The more closely related the creatures are, the more similar the embryo into later stages of development
  - Eg: why do humans have a tail as an embryo? Leftover from ancestors

    - Only evolution from a common ancestor explain these similarities
    - Embryo development stages map perfectly onto the family tree of evolution
- Vestigial organs
    - Useless organs that serve no purpose – why develop them in the embryotic stage?
    - Eg: toothless whale embryos that have teeth, which are later reabsorbed – because it had evolved from whale which had teeth
    - An example of a vestigial structure: Whale pelvic bone
- Homology
    - The same structure in different species
    - Why are there the same structures in so many different animals?
    - Eg: arm bones – same number of finger and bones in humans, bats, frogs, birds, etc.
    - Common ancestor – shared features carry on in descendant species

Does the natural world reveal kind design?

- Cruelty in nature seems contrary to what a benevolent and omnipotent god would do
- Eg: parasitic spiders, cats like to play with their prey, humans are cruel
- Some other process of species creation must be happening

Ernst Haeckel's tree of life from The Evolution of Man (1879)

- Misleading and misrepresentative of Darwin's theory
- Mistakenly implies that there is a direction or perfection in evolution
- There is no inherent tendency for things to be more complex – rather, things change in response to the environment
- There is no direction or "higher and better" of the evolutionary progress – change, not progress!

Six editions of *Origin of species* - it changed over time

- Book went through several editions
- The historical sketch added to the third edition (1861)
- The fifth edition (1869) first used Herbert Spencer's expression "the survival of the fittest"
    - Today: a misrepresented shorthand, as it leaves out the core idea of descent from ancestors
- Darwin thought a better term would have been "natural preservation"
    - "Natural selection" created confusion among his readers as it gave the impression that there was an agent doing the selecting, when there isn't

Self-test Questions

1. **Prior to 1800s people believed species were specially created and fixed in time.**
    - **John Ray (1627 – 1705)**

❖ There are thousands of species
❖ Adaptation proves design – the fact that living things can adapt to fit the world proves that there is design
❖ God created a set number of species – number will not change

- **Carl Linnaeus (1707 – 1778)**

❖ Knew twice the number of mammals known in Ray's time
❖ Thought species were clear cut and can only come from previous parents – each species is distinct
❖ There are no new species
❖ Extinction is not possible
    - How about ammonites? Reasoned that they are still living, just in another part of the world
❖ Wanted to catalogue and categorise all living things in the world
❖ Names of species were too long
❖ Introduced binomial nomenclature – genus and species
❖ The fact that living things could be classified and ordered so neatly was proof of God's divine design
❖ Realised there are far too many species for Noah's ark
    - He was still religious – not challenging religion!
    - The bible was read different back then – understood the bible was metaphorical, not to be taken literally

2. **Darwin's major mission on the voyage of the HMS Beagle was to find evidence for the theory of natural selection. FALSE.**
    - **About The HMS Beagle**

❖ HMS Beagle offer came from Fitzroy
❖ He wanted to take along a dedicated naturalist
➢ Myth: Darwin was not the official naturalist
➢ Truth: He was! His presence was officially sanction by the navy and his position as the ship's naturalist was official
❖ Since Darwin was not in the navy, he had a 'special status' on board – he was a gentleman, a qualified naturalist as requested by the captain
❖ Beagle travelled mostly the southern half of the South American continent
❖ Objective of the trip: surveying
    - South America had just been broken free from Spanish and Portuguese rule, opening it up to foreign trade
    - Britain needed to chart the seas around it to enable profitable shipping
    - The Beagle was a coastline map making expedition
❖ Point of the Beagle was NOT to carry Darwin round. He was just part of the crew
❖ The Beagle Library
    - 400 volumes of books in the ship's library in Darwin's quarters
    - Fitzroy also gave him Lyell's book, which he read on the voyage

3. **Darwin single-handedly changed the world view of evolution. False.**
4. **The father of taxonomy who gave us the binomial system of nomenclature is _____.**
5. **Carl Linnaeus also believed in an "ideal structure and function" and fixity of species.**
    - **Carl Linnaeus (1707 – 1778)**

❖ Knew twice the number of mammals known in Ray's time
❖ Thought species were clear cut and can only come from previous parents – each species is distinct
❖ There are no new species
❖ Extinction is not possible
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- Names of species were too long
- Introduced binomial nomenclature – genus and species
- The fact that living things could be classified and ordered so neatly was proof of God's divine design
- Realised there are far too many species for Noah's ark
    - He was still religious – not challenging religion!
    - The bible was read different back then – understood the bible was metaphorical, not to be taken literally

6. **Lamarck supported the idea of inheritance of acquired characteristics. True.**
    a. **Is no longer a valid and accepted theory, presumes that changes to your somatic cells are inheritable (e.g. you can inherit a sunburn), is not supported by modern day knowledge of generic inheritance.**
        - **Jean Baptiste Lamarck (1744 – 1829)**

- Zoological philosophy: no extinction, instead, change
- Hated Cuvier's idea of extinction – did not believe God would allow anything to go extinct
- Instead, living things change over time
- Eg: mammoth evolved into elephant
- **The complexifying theory**: the inherent law in nature that drove living things to evolve towards complexity
    - Each line has a family lineage, life originates at the base of each lineage
    - Living things constantly change into one of a higher level
- The adaptive force: the adaptation of living things to fit their living environment
    - Eg: giraffe stretched to reach the leaves, and after generations of stretching, finally achieved its long neck
    - Today: most known for his theory of inheritance of acquired characteristics
    - But this was NOT his main theory!
- Lamarckism = change over time towards complexity
- First person to publish a *somewhat* evolutionary theory – but it is different from Darwin's theory!

7. **Erasmus Darwin based his conclusions regarding common descent on _____.**

A) changes undergone by animals during development
B) artificial selection by humans
C) the presence of vestigial organs
D) all of the above

8. **Which of the following is true of the post-Darwinian view of the world?**

A) the Earth is relatively old - age is measured in billions of years
B) species are related by descent
C) observations and experimentation are used to test hypotheses
D) all of the above

9. **The first to use comparative anatomy to develop a system of classifying animals and the founder of the science of paleontology was _____.**

A) Lamarck
B) Aristotle
C) Cuvier
D) Linnaeus

Cuvier proposed the explanation of the history of life known as catastrophism to explain the succession of life-forms observed in the earth's strata in a particular region.

Georges Cuvier (1769 - 1823)

- French naturalist
- Comparative anatomy – specialised in comparing the anatomy of various living things
- Proposed that there was an era before now: the age of reptiles - when reptiles ruled the earth
- Layers of rock show a sequence of eras in which different layers contained different ecosystems
    - Eg: one layer can contain plants and animals, another with seashells, another from an arid environment
    - Fossils found in the lowest or deepest geological stratum are generally **most primitive**

- Scala naturae, the lowest rung of the ladder is occupied by the **simplest and most materials of beings.**
- **Sedimentary rocks often contains fossils and can be uplifted from below sea level to form land.**

❖ Succession of the series of life on earth
- Cuvier lived through the French Revolution
- Believed the earth had gone through many dramatic revolutions
- Progressive eras: creation -> destruction -> creation -> destruction…

❖ 1796 paper on living and fossil elephants

10. Which of the following is true of scientific thought/work prior to Lamarck, Charles Darwin, and Alfred Wallace?

A) a mechanism by which evolutionary descent occurred was clearly stated
B) Linneaus proposed taxonomic categories for organisms based on their genetic similarities
C) species were thought to be very diverse and constantly changing
D) none of the above

11. James Hutton believed that the earth was subject to slow but continuous cycles of erosion and uplift.

A) True
B) False

James Hutton (1726 – 1797)

❖ The earth is shaped by methods and causes that are still happening now
❖ Geological unconformity, *Theory of the Earth*
- Initial layers are horizontal, deeper layers are vertical
- Each layer of sediment would take thousands of years to form
- A large subterranean force must have twisted the rock vertical
- Erosion of the vertical section proves there was a change in orientation

❖ New land created by volcanic eruptions
❖ Land is destroyed by erosion
❖ Cliffs: land which are uplifted from the sea
❖ How the land is "twisted" – emergence of volcano pushes previously horizontal land up
❖ Possible to reconstruct how the land previously looked like using the angles of layers

12. Darwin encountered forms of life very different from those in his native England on his voyage aboard the HMS Beagle.

A) True
B) False

13. Darwin made some of his most famous observations of species' adaptations on the _____ Islands.

A) Virgin
B) Galapagos
C) Falkland
D) Philippines

14. Darwin collected fossil remains of a _____ on the east coast of South America.

A) long necked tortoises
B) a woodpecker type finch
C) an armadillo-like animal
D) all of the above

Fossils

❖ Darwin unearthed fossils, and from the rocks around them could contextualise these fossils
❖ Found extinct mammals
❖ Macrauchenia: an extinct llama?
❖ Toxodon: an extinct ground sloth
❖ Glyptodon: has an armour body, similar to armadillos

- ❖ Curious pattern: similarity between the ancient world and today's living things in the same place

15. Which of the following observations contributed to Darwin's conclusion that the earth was very old?
    A) inland marine shells well above sea level in Chile
    B) Patagonian hares that resembled rabbits and guinea pigs
    C) varying beak sizes of the finches on the Galapagos Islands
    D) tortoises with varying neck lengths on the Galapagos Islands

Section of the Cliffs of Patagonia (Part of Chile)

- ❖ A cross section of the coast of Patagonia
- ❖ As Darwin went inland, there were beaches that were high and dry
- ❖ Many levels of upraised beach
- ❖ Different levels shows evidence of previous beaches – oldest beach is the highest
- ❖ Shows that the land has been uplifted again and again

16. The species Darwin encountered on the Galapagos Islands _____.

A) varied from island to island
B) were slightly different from the species Darwin observed on the mainland
C) both A and B

17. Which of the following did not contribute to Darwin's development of the theory of natural selection?

A) new ideas about the age of Earth, that it was much older than previously thought
B) a correlation between finch beak shape and the type of food eaten by the finch
C) Mendel's theories about genetic inheritance
D) all of the above facilitated Darwin's development of natural selection

18. Preconditions of natural selection include _____.

A) the members of a population have heritable variations
B) in a population many more individuals are produced each generation than can survive and reproduce
C) some individuals can survive and reproduce better than other individuals
D) all of the above

19. An adaptation is a trait that helps an organism to be more suited to its environment.

A) True
B) False

20. Only certain members of a population survive and reproduce each generation.

A) True
B) False

21. The result of natural selection is _____.

A) extinction of a species
B) a group of organisms that can survive anywhere
C) a population that is adapted to its local environment
D) none of the above

22. Extinction can occur when previous adaptations are no longer suitable to a changed environment.

A) True
B) False

23. Variations in a population _____.

A) are caused by mutations
B) arise from the recombination of alleles during sexual reproduction

C) are essential to the natural selection process
D) all of the above

24. Darwin applied the concept of human reproductive potential stressed by Malthus to all organisms and concluded that_____.
A) the earth is much older than previously thought
B) the available resources were not sufficient for all members of a population to survive
C) variations are the result of allele recombinations during sexual reproduction
D) all of the above

25. Darwin was heavily influenced by _____ which made him think adaptation to the environment accounts for diversification.
A) biogeography
B) Malthus's essay on human reproductive potential
C) the geological observations of Lyell and Hutton
D) Lamarck's conclusions about the giraffes' necks

26. Before Darwin variations were considered to be imperfections that should be ignored since they were not important to the description of a species.
A) True
B) False

27. The most fit individuals _____.
A) capture a disproportionate amount of resources
B) have characteristics that help them capture prey and avoid being captured
C) have a larger number of viable offspring
D) all of the above

28. Which of these traits is likely to increase fitness?
A) a variation that increases speed of a hoofed animal
B) a variation that reduces water loss in a desert plant
C) a variation that increases the sense of smell in a wild dog
D) all of the above

29. Natural selection is the only process by which evolution can occur.
A) True
B) False

30. Islands often have many unique species of animals and plants found no place else because of geographic isolation.
A) True
B) False

31. After separation of the continents marsupials diversified into many different forms in _____ because there were few, if any, placental mammals present.
A) Antarctica
B) Europe
C) Australia
D) North America

32. It appears that gradual evolutionary processes are the norm, but environmental disturbances promote rapid evolutionary change and replacement of old species by new species.
A) True
B) False

33. Which of the following statements is true?

A) marsupials are widely distributed throughout the world
B) cacti grow in North American and African deserts
C) each different Galapagos finch had a different ancestral finch from the mainland
D) none of the above

34. Which of the following is not homologous to the others?

A) alligator's forelimb
B) whale's flipper
C) insect's wing
D) cow's forelimb

- Homology
  - The same structure in different species
  - Why are there the same structures in so many different animals?
  - Eg: arm bones – same number of finger and bones in humans, bats, frogs, birds, etc.
  - Inherited from Common ancestor – shared features carry on in descendant species
  - Exemplified by vertebrate forelimbs

35. Anatomical structures that are fully developed in one group of organisms but are reduced and have no function in similar groups are called vestigial structures.

36. Evolutionary principles help us understand _____.

A) why organisms are different and alike
B) why some species flourish
C) why some species become extinct
D) all of the above

37. The hypothesis of common descent is supported by _____.

A) similarity in DNA base sequences
B) homologous structures
C) embryological development
D) all of the above

38. In postulating the theory of evolution by natural selection Dawwin was greatly influenced by

1. Mutation theory of Hugo de Vries
2. Lamarck's theory of accquired characters
3. Malthus idea of population control (Population multiply faster than food supply)
4. Environmental factors

Important dates:
Beagle voyage: 1831-1836
Origin of species published: November 1859

Past mid-term questions:
Important and reliable source of evidence?
Ans: Contemporary evidence: evidence of that time

Darwin do with 1850 sketch?
Ans: Publish only something happen to him

What have we learnt recently about when Wallace send essay to Darwin
Ans: He send month later after he previously assume

Lyell belief that went againt other geologist
Ans: History of life is circular not progressive

What were varieties?
Ans: Races are sub species, that's what varieties are

Details of Wallace line

Who came out with the first book on human evolution? Should be Thomas Huxley.

Sample Test Questions -- Midterm 2

Darwin, Natural Selection, Microevolution

1. Evolution is:
a. A rare event
b. Currently occurring only in scientific laboratories
c. Constantly occurring at the same rate in ALL organisms
d. An inevitable consequence of the nature of organisms

2. Which describes natural selection?
a. Some live and some die in each generation
b. Only the largest and strongest survive
c. Random assortment of genes results in better characteristics in the following generations
d. The best adapted individuals survive and reproduce, contributing the most to the next generation

3. Which of the following is NOT one of the premises on which evolution by natural selection is based?
a. Organisms usually produce many more offspring than the environment can support.
b. Most natural populations remain approximately the same size through time.
c. Organisms can alter their genes to help them survive in a particular environment.
d. Hereditary differences between organisms can be passed on to their offspring.

4. Which of the following statements is FALSE?
a. Convergent evolution demonstrates evolutionary relationships.
b. Homologous structures are the same body parts that are modified in different ways in different lines of descent from a common ancestor.
c. Fossils can show evolutionary changes in bones and teeth.
d. The more similarity in the structure of two proteins from different organisms, the more closely related the organisms are.

5. Darwin and Wallace first suggested
a. The idea that evolution might occur.
b. A testable and believable mechanism to explain how evolution might occur.
c. The idea that changes to an organism's body caused by the environment might be passed on to its offspring.
d. None of the above.

6. Darwin explained the differences in beak shape among Galapagos finches as being the result of
a. chance events
b. adaptations to eating different foods
c. differences that existed in the colonizing species
d. inheritance of acquired characteristics

7. Industrial melanism describes the change in moth color from pale to dark after pollution from factories resulted in coating tree trunks with a layer of dark soot. Which statement is true concerning industrial melanism?
a. After the pollution occurred, moths became dark because soot got on their wings.
b. The dark moths survived better after the pollution because they were not poisoned by the pollutants.
c. Individual moths changed their color in response to the pollution.
d. Some dark moths must have been born in the population even before pollution occurred.

8. Which of the following is true of evolution?
a. evolutionary changes increase the ability of a species to survive and reproduce in a specific environment.
b. evolutionary changes increase the ability of a species to survive and reproduce under any circumstances.
c. evolutionary changes result in a species becoming more and more abundant over time.
d. evolutionary changes result in animals becoming larger over time and having larger numbers of offspring.

9. Which of the following is a basic requirement for natural selection to be an effective evolutionary force?
a. Individuals must reproduce at a rapid rate.
b. Each population must be limited to a small size.
c. A population must exhibit some genetic variability.
d. All of the above.

10. Darwin and Wallace were more knowledgeable about ___ than were most European biologists of their day, which gave them an advantage in understanding how evolution might occur.
a. heredity
b. sexual reproduction
c. the diversity of life
d. population growth and dynamics

11. According to natural selection, birds such as cardinals, eagles, and ducks have differently shaped feet due to
a. random changes in foot structure
b. adaptations to different environments and feeding habits
c. differences inherited from their ancestors
d. inheritance of acquired characteristics

12. The theory of common descent states that all modern organisms
a. can change in response to environmental change.
b. are descended from a single ancestral species.
c. can be arranged in a linear order from "least evolved" to "most evolved".
d. have not changed over time.

13. Which of the following is NOT required in order for mimicry to evolve? (Note that models are the toxic or inedible organisms that mimics resemble.)
a. models and mimics must inhabit the same area
b. models and mimics must eat the same food
c. mimics must be rarer than models
d. all of these requirements must be met for mimicry to evolve

14. Which of the following is an example of a microevolution?
a. The evolution of antibiotic resistance in bacteria.
b. The speciation of finches on the Galapagos islands.
c. The increase in size, over time, of fossil horses.
d. The evolution of humans from an ancestral primate.

15. The process of biological evolution
a. is not supported by scientific evidence
b. requires biological diversity in a population
c. results in changes in allele frequencies over generations
d. both b and c

each of two or more alternative forms of a gene

16. Whose letter to Darwin in 1858 describing a similar mechanism of evolution prompted Darwin to finally publish his theory?
a. Mendel
b. Erasmus Darwin
c. Alfred Russel Wallace
d. Lamarck

17. Which of the following is indirect evidence in support of the theory of evolution by natural selection?
a. Improvement of domesticated animals and plants by breeding individuals with desirable traits
b. The fossil record that shows a clear relationship between living and extinct animals
c. homologous structures in different organisms that are dissimilar in form and function but that have underlying structural similarities.
d. all of the above

d. all of the above

18. Which of the following statements is true?
a. Antibiotics kill all bacterial that they encounter.
b. Antibiotics don't kill bacteria which have a pre-existing allele allowing them to break down the antibiotic.
c. Antibiotics don't kill bacteria which can evolve an allele allowing them to break down the antibiotic after they encounter the antibiotic
d. None of these

19. Artificial selection has given us
a. the many species of wild cats
b. breeds of domesticated dogs
c. various human societies
d. the many rainforest species

20. In many cases, one type of organism puts selection pressure on another, so they evolve together. For example, flowers and their pollinators. This is called
a. artificial selection b. coevolution c. random mutation d. mimicry

21. Viceroy and monarch butterflies are a good example of
a. analogy b. mimicry c. speciation d. melanism

22. The idea of evolution_____Darwin
a. was originated by
b. was never really considered by
c. destroyed the reputation of
d. was thought of before

23. Artificial selection has been a big factor in the evolution of:
a. moths b. panda bears c. dogs d. whales

24. Which of the following has provided an abundance of evidence that the diversity of life on Earth has changed over time?
a. population genetics b. the fossil record c. natural selection d. creationism

25. During a study session about evolution, one of your fellow students remarks, "The giraffe stretched its neck while reaching for higher leaves; its offspring inherited longer necks as a result." To correct your friend's misconception, what would you say?
a. Spontaneous mutations can result in the appearance of new traits.
b. Only favorable adaptations have survival value.
c. Overproduction of offspring leads to a struggle for survival.
d. Characteristics acquired during an organism's life are not passed on through genes

26. All of the following statements are related to the ideas of natural selection except which one?
a. There is heritable variation among individuals.
b. Production of offspring is unrelated to the availability of essential resources.
c. Only a fraction of offspring survive because of competition for limited resources.
d. Unequal reproductive success leads to adaptations.

27. Natural selection tends to reduce variation in gene pools. What process serves to balance natural selection by creating new alleles?
a. meiosis b. sex c. mutation d. migration

28. Of the following anatomical structures, which is homologous to the wing of a bat?
a. the dorsal fin of a shark b. the tail of a kangaroo c. the wing of a butterfly d. the arm of a human

29. It is possible for evolution to be influenced by choices that individuals make concerning which individual to mate with or even which offspring to pay more attention to.
a. true b. false

30. Mutations of genetic material
a. are usually harmful
b. are often beneficial
c. usually help an organism adapt more effectively to its environment
d. occur frequently

31. The core idea of evolutionary "success" is oriented around
a. intelligence b. reproduction c. achievement of a long life d. better senses

32. Lamarck's early 1800's theory of evolution is characterized primarily by the idea that
a. characteristics acquired during life are passed on to offspring
b. evolution is a completely random process
c. most organisms don't produce enough offspring
d. none of these

33. In the evolution of organisms through time,
a. species always become bigger, stronger, or faster
b. intelligence continually increases in animal species
c. there is no particular direction to evolutionary change
d. species slowly degenerate

34. When the allele frequencies within a species change over time, that species is
a. mutating b. on its way to extinction c. evolving d. none of the above.

35. Which process enlarges a species' gene pool?
a. reproduction b. mutation c. evolution d. meiosis

36. Eyes have evolved separately several times during animal evolution.
a. true b. false

37. Modern whales lack hindlimbs, but have tiny bones in their skeletons which are the remnants of pelvic and leg bones. Which of the following is NOT TRUE concerning this information?
a. The remnants of pelvic and leg bones in whales are vestigial structures.
b. Modern whales most likely had an ancestor that possessed hindlimbs.
c. This is anatomical evidence in support of the theory of evolution.
d. This is biochemical evidence in support of the theory of evolution.

38. Which shows the effects of artificial selection?
a. moths b. pandas c. dairy cows d. cheetahs

39. Which has the least complicated type of eye?
a. fish b. human c. planarian d. nautilus

40. What might you conclude from the observation that the bones in your arm and hand are similar to the bones in a bat's wing?
a. The bones in the bat's wing are vestigial structures, no longer useful as "arm" bones.
b. The bones in the bat's wing are homologous to your arm and hand bones.
c. Bats lost their thumbs during the course of evolution.
d. The ancestors of humans could fly.

41. Which of the following is an example of a microevolution?
a. The evolution of pesticide resistance in grasshoppers.
b. The speciation of finches on the Galapagos islands.
c. The increase in size, over time, of fossil horses.
d. The evolution of humans from an ancestral primate.

42. When populations with separate ancestors adapt in similar ways to similar environmental constraints (e.g., "flippers" in whales and penguins), it is referred to as
a. homology
b. natural selection
c. convergent evolution
d. coevolution

43. Which observation most clearly contradicts Lamarck's hypothesis that acquired characteristics are inherited?
a. The cactus plant spread very rapidly when introduced into Australia.
b. Most zebras can fun faster than lions, and their offspring also run faster than lions.
c. Bacteria which are resistant to penicillin have been discovered.
d. The seeds from a pine tree that was bent by the wind grew into tall, straight trees in a sheltered valley.

44. Which of the following observations or assumptions was NOT part of Darwin's theory of natural selection?
a. Traits are inherited as discrete units called genes.
b. Evolution occurs over long periods of time.
c. Populations produce more offspring than the environment can support.
d. Organisms compete for limited resources.

45. Which owl was most fit?
a. Owl 1 laid 8 eggs, of which 6 hatched and 5 young successfully left the nest.
b. Owl 2 laid 9 eggs, of which 8 hatched and 3 young successfully left the nest.
c. Owl 3 laid 12 eggs, of which 10 hatched and were all eaten by a squirrel.
d. Owl 4 laid 4 eggs, of which all 4 hatched and all 4 young successfully left the nest.

46. Which ONE of the following statements is true of evolution:
a. Evolution by natural selection leads to changes which increase the ability of a population to succeed in the environment in which they find themselves.
b. Evolutionary changes must lead to increased genetic diversity in a population.
c. When a population is evolving, offspring will not resemble their parents.
d. Natural selection can cause inheritable (genetic) changes in an organism.

47. Which of the following is an acceptable definition of evolution?
a. a change in the phenotypic makeup of a population
b. a change in the genetic makeup of a population
c. a change in the environmental conditions of a population
d. a change in the species composition of a region

48. Which of the following environments would select for flight in insects?
a. a cage with slippery walls that insects can't climb, and an electrified screen at the top
b. a swamp full of frogs that can see and catch flying insects better than crawling insects
c. a forest full of bats the catch insects in flight
d. a cage with no predators, in which food is provided in high dishes

49. Organisms can cause themselves to mutate in particular ways to meet environmental challenges.
a. true
b. false

50. Evolution is the theme that ties together all of biology. This is because the process of evolution
a. explains how organisms become adapted to their environment.
b. explains the diversity of organisms
c. explains why distantly related organisms sometimes resemble one another.
d. all of the above are appropriate answers.

51. Before Darwin's work, Lamarck proposed a hypothesis of evolution by inheritance of acquired characteristics. He used the example of how giraffes got long necks, saying that during their lifetimes giraffes stretched their necks as they tried to reach higher and higher leaves. Their necks became longer due to this effort, and the children of these longer-necked giraffes also had longer necks. Those giraffes who did not try to reach the higher leaves starved and died. From our current understanding of evolution, what was the **biggest** problem with Lamarck's idea?
a. The giraffes with short necks died because they couldn't reach the food as well as those with longer necks
b. the giraffes with longer necks had longer necked children
c. the giraffes that acquired longer necks by stretching had longer necked children
d. nothing

52. An example of one of Darwin's pieces of evidence for natural selection is
a. in a litter of tiger cubs, some are born larger than others
b. mutations occur when organisms are exposed to UV light
c. the deeper in the ground a fossil is, the older it is
d. DNA sequences can help scientists determine the relationships between species

53. Darwin was interested in domesticated pigeons because
a. he was sent one by the captain of the Beagle
b. they were an excellent example of natural selection
c. he liked them
d. they were an excellent example of artificial selection

54. Specific environmental factors that favor certain characteristics in organisms are called
a. selecting agents
b. hurricanes
c. mutations
d. disruptive factors

55. Each of the following phrases describes the process of evolution EXCEPT
a. changes in allele frequency over time
b. traits acquired by an individual during its lifetime are passed on to its offspring
c. descent with modification
d. progressively more complex forms of life are derived from simpler ancestors

56. Which evolves?
a. individuals
b. populations
c. genes
d. all of these

57. People have thought and wondered about evolution
a. since the 18th century
b. since the 19th century
c. since the 20th century
d. since the times of the ancient Greeks

58. While reading for biology 105 you developed a callus on your index finger from turning so many pages. Someone tells

58. While reading for biology 103 you developed a callus on your index finger from turning so many pages. Someone tells you that your children will now have a greater tendency towards developing callused fingers. This reflects the ideas of
a. Darwin b. Mendel c. Lamarck d. Watson

59. The sickle cell trait
a. is common in people whose ancestors came from areas where malaria was a significant health problem because of a serious bottleneck effect
b. is an example of hybrid vigor
c. can result in an increase in the fitness of people who are heterozygous for the trait
d. results in resistance to malaria among people homozygous for the trait

60. The gene pool of a species
a. remains constant over time b. continually loses alleles
c. is changed by evolution d. is identical to that of many other species

61. Death of some individuals due to dehydration in a desert would be an example of _____ selection.
a. natural b. artificial c. sexual d. parental

62. Average beak size in one generation of Galapagos finches is associated with
a. amount of rain the previous year b. average temperatures the previous year
c. size of predators the previous year d. the prevalence of ticks and mites the previous year

63. Which of the following might exert selection pressure on a population of mice?
a. their predators b. their diseases c. their food d. any of these

64. .When populations descended from the same ancestral group show different adaptations with the same basic underlying structure to them (for example whale flippers and human arms), it is referred to as
a. homology b. natural selection c. analogy d. coevolution

65. If rates of geological processes such as erosion, mountain building, cave formation, etc. occurred in the past similarly to the way they do now, the Earth must be
a. hundreds of years old b. thousands of years old c. millions of years old d. billions of years old

66. Organisms _____ come up with a mutation needed to cope with an environmental stress after selection pressure of that stress has been applied.
a. can easily b. cannot c. can sometimes

67. The impressive tail of the peacock
a. may not be favored by natural selection
b. may provide peahens with an index of the health status prospective mates
c. is most likely a result of the founder effect instead of natural selection
d. both a and b are true

68. Selection is any process that changes the genetic composition of a population by ensuring that some individuals leave _____ offspring than others.
a. more b. fewer c. better d. larger

69. It is possible to do actual experiments on evolution in a laboratory setting.
a. true b. false

Speciation; Origin and Types of Life

70. Boa constrictors have tiny pelvic girdles and leg bones within their bodies. Since these structures are nonfunctional, they are called:
a. vestigial b. analogous c. maladaptive d. homologous

71. The process by which unrelated organisms with similar environmental demands evolve superficially similar structures is:
a. natural selection b. homologous c. convergent evolution d. comparative anatomy

72. Most new species arise from a common ancestor when
a. many mutations occur. b. the ancestral species decides to evolve
c. there is no natural selection d. populations of the ancestral species become isolated from one another.

73. What does speciation, the formation of one species from another, usually require?
a. human intervention b. billions of years c. reproductive isolation d. all of the above

74. During a speciation event, which normally comes first, geographical isolation or reproductive isolation?
a. reproductive isolation b. geographical isolation c. they both occur at the same time

75. Which of the following is NOT cited as a source of evidence in favor of the occurrence of macroevolution?
a. fossils b. comparative embryology
c. similarity of genes and proteins d. all of the above are used as evidence

76. Which is an example of temporal isolation?
a. a type of fly is ready to mate by the middle of February every year, while a closely related species does not mate until the middle of March.
b. two animals of different species can mate but the fertilized egg never survives to develop.
c. female fruit flies can distinguish males of their species by a special antenna-waving dance
d. pollen from one plant cannot grow correctly on the flower of a different species

77. What characteristic of has been created in the laboratory under conditions resembling those of the primitive Earth ?
a. organic molecules b. cells c. metabolism d. none of the above

78. Which is the correct order of appearance on Earth?
a. photosynthetic procaryotes, eucaryotes, primordial soup, non-photosynthetic procaryotes
b. primordial soup, non-photosynthetic procaryotes, photosynthetic procaryotes, eucaryotes
c. primordial soup, eucaryotes, photosynthetic prokaryotes, non-photosynthetic procaryotes
d. non-photosynthetic procaryotes, photosynthetic procaryotes, primordial soup, eukaryotes

79. Which evolutionary innovation allowed animals to grow bigger without needing new body parts or new genetic information, and also opened the door for the later evolution of many specialized body structures?
a. the flow-though digestive system b. stinging tentacles c. the head d. segmentation

80. According to the biological species concept, a species is
a. a group of individuals which can interbreed and produce fertile offspring.
b. a group of individuals which can interbreed and which live close enough together to actually do so
c. a group of individuals who look very similar
d. a group of individuals who have a common ancestor

81. Which is an example of behavioral isolation?
a. a type of fly is ready to mate by the middle of February every year, while a closely related species does not mate until the middle of March.
b. two animals of different species can mate but the fertilized egg never survives to develop.
c. female fruit flies can distinguish males of their species by a special antenna-waving dance.
d. pollen from one plant cannot grow correctly on the flower of a different species.

82. Endosymbiosis is thought to have been necessary for the evolution of which group?
a. non-photosynthetic procaryotes b. photosynthetic prokaryotes c. eucaryotes d. all of the above

83. Which group consists of ancient organisms living in unusual environments such as hot springs, very salty water, or anaerobic conditions?
a. plantae. b. bacteria c. fungi d. archaea

84. Bilateral symmetry, and the tendency to move forward in one direction, led to evolution of
a. the flow-though digestive system b. stinging tentacles c. segmentation d. the head

85. The first known (oldest) fossils are of
a. plants b. prokaryotic cells c. eukaryotic cells d. small animals

86. Which of the following is NOT believed to have been a component of the early Earth's atmosphere?
a. nitrogen gas (N_2) b. hydrogen gas (H_2) c. carbon monoxide (CO) d. oxygen gas (O_2)

87. Endosymbionts are
a. structures residing within our cells which once were free-living bacteria b. organisms which engulf their food
c. two organisms which help each other survive d. a type of fungus

88. Some species of *Anopheles* mosquito live in brackish water, some in running freshwater, and others in stagnant water. What type of reproductive barrier is separating these different species?
a. ecological isolation b. chemical incompatibility c. behavioral isolation d. postzygotic isolation

89. If two groups are reproductively isolated from one another, their members will never meet one another.
a. true b. false

90. Which came first in the history of the Earth?
a. an atmosphere with hydrogen, nitrogen oxides and carbon dioxide, among other compounds
b. an atmosphere based on free oxygen

Answers to even-numbered questions
2d, 4a, 6b, 8a, 10c, 12b, 14a, 16c, 18b, 20b, 22d, 24b, 26b, 28d, 30a, 32a, 34c, 36a, 38c, 40b, 42c, 44a, 46a, 48d, 50d, 52a, 54a, 56b, 58c, 60c, 62a, 64a, 66b, 68a, 70a, 72d, 74b, 76a, 78b, 80a, 82c, 84d, 86d, 88a, 90a, 92b, 94d, 96a, 98d, 100b, 102b, 104d, 106c, 108a, 110b, 112a, 114b, 116d, 118c, 120b, 122b, 124b, 126a, 128c, 130a, 132a, 134a, 136d, 138a, 140c, 142d, 144c, 146c, 148c, 150b, 152b, 154a, 156c, 158b, 160a, 162b, 164a, 166d, 168c, 170b, 172c, 174a, 176a, 178d, 180a, 182d, 184c, 186a, 188a, 190a, 192c, 194c

91. During the early history of life, which evolved first?
a. photosynthetic prokaryotes b. heterotrophic (non-photosynthetic) prokaryotes
c. eukaryotes d. all evolved at the same time

92. According to the biological species concept, horses and donkeys could be considered part of the same species because they can mate and produce healthy, although infertile, offspring.
a. true b. false

93. In which group did we first see bilateral symmetry?
a. fish b. roundworms c. sponges d. flatworms

94. Which of the following is (are) true of species, according to the biological species concept?
a. Species consist of a group of plants or animals which all look very similar to one another.
b. A species is a group of plants or animals that has the potential to evolve as a unit.
c. A species is a group of plants or animals which can interbreed under natural conditions and produce fertile offspring.
d. Both b and c are true.

95. Which of the following might be able to lead to reproductive isolation within a species of insect?
a. If one subpopulation of the insects had larger wings than the other subpopulation.
b. If one subpopulation had larger wings than the other subpopulation, and the subpopulation with larger wings was more successful at escaping from enemies.
c. If one subpopulation had larger wings than the other subpopulation, and the subpopulation with larger wings flew up higher in the trees to mate.
d. All of these would be likely to lead to isolation of the gene pools of the two subpopulations.

96. If you found a fish fossil, you would determine which species the fossil belonged to based on
a. the morphological species concept b. the biological species concept
c. you could use either d. you could not use either one

97. About how long ago was the Earth formed?
a. 10 billion years ago b. 4.5 billion years ago c. 4 million years ago d. 100,000 years ago

98. Chemicals in the ancient Earth's atmosphere may have been given the energy they needed to react by
a. volcanic eruption b. UV light c. lightning d. all of the above

99. Which evolutionary innovation allowed animals to get and process more food faster?
a. the head b. segmentation c. the flow-through digestive system d. bilateral symmetry

100. Which evolutionary innovation allowed animals to grow bigger bodies without needing much new information?
a. the head b. segmentation c. the flow-through digestive system d. bilateral symmetry

101. In the primordial soup, you might find all EXCEPT which?
a. organic (cellular) molecules b. primitive cells c. toxic substances d. plants and animals

102. Photosynthesis, when it first evolved, saved the future of life because
a. it produced oxygen b. it produced food molecules
c. it allowed organisms to grow large d. it used up harmful substances in the environment

103. Which was the first animal group to evolve flow-through digestion?
a. jellyfish b. flatworms c. roundworms d. vertebrates

Answers to even-numbered questions
2d, 4a, 6b, 8a, 10c, 12b, 14a, 16c, 18b, 20b, 22d, 24b, 26b, 28d, 30a, 32a, 34c, 36a, 38c, 40b, 42c, 44a, 46a, 48d, 50d, 52a, 54a, 56b, 58c, 60c, 62a, 64a, 66b, 68a, 70a, 72d, 74b, 76a, 78b, 80a, 82c, 84d, 86d, 88a, 90a, 92b, 94d, 96a, 98d, 100b, 102b, 104d, 106c, 108a, 110b, 112a, 114b, 116d, 118c, 120b, 122b, 124b, 126a, 128c, 130a, 132a, 134a, 136d, 138a, 140c, 142d, 144c, 146c, 148c, 150b, 152b, 154a, 156c, 158b, 160a, 162b, 164a, 166d, 168c, 170b, 172c, 174a, 176a, 178d, 180a, 182d, 184c, 186a, 188a, 190a, 192c, 194c

104. Vertebrate embryos resemble each other during early development. For example, fish, turtles, chickens, mice and humans all go through a stage where they have tails and gill slits. This suggests that____.
a. Early embryonic development doesn't change much.
b. Ancestral vertebrates had genes causing the development of tails and gill slits, and their descendants still retain those genes.
c. Genes which change the developmental pathways in vertebrates arose later in evolution.
d. All of the above.

105. Bird and insect wings are similar because they carry out the same type of function. However, structurally they are very different. They are examples of
a. homologous structures b. convergent evolution c. mutation d .acquired characteristics

106. Oxygen in the atmosphere
a. has always been present at the same concentration
b. was produced by physical processes soon after the Earth was formed
c. was produced by biological processes after the evolution of life
d. None of the above are true

107. Homologous structures in two species
a. have no apparent function b. are usually very reduced in size
c. indicate that those species share a common ancestor d. all of the above

108. What is the most likely effect of killing 80% of a colony of bacteria with a certain antibiotic?
a. The remaining bacteria will re-grow into a new colony more resistant to the antibiotic
b. The remaining bacteria will die because of the drastic decimation
c. The bacteria will not cause any further infections because their numbers have been drastically reduced
d. The bacteria will try to start a new colony where the antibiotic will not be found

109. If an organism can make its own food, has cell walls, and can't move, it is most likely a
a. bacteria b. animal c. plant d. fungus

110. What is the defining feature of eukaryotic cells?
a. ability to photosynthesize b. possession of a nucleus and other membranous organelles
c. ability to carry out aerobic respiration d. all of these

111. It is thought that chloroplasts evolved before mitochondria.
a. true b. false

112. Which of the following is least likely to become fossilized?
a. a jellyfish b. a dinosaur bone c. a clam shell d. pollen

113. Which of the following pairs shows convergent evolution?
a a bird wing and an insect wing b. a bird wing and a human arm
c. both pairs d. neither pair

114. Which is the broadest (most inclusive) category?
a. class b. kingdom c. species d. family

115. Evidence for the endosymbiotic theory includes the observation that mitochondria
a. have their own DNA b. can reproduce independently outside of a cell
c both of these d. neither of these

116. Which eukaryotic group evolved first?
a. animals b. plants c. fungi d. protests

117. Which group of animals was first to colonize the land (become terrestrial)?
a. sponges b. birds c. reptiles d. amphibians

118. Which of the following statements about prokaryotes is NOT true?
a. they lack mitochondria b. they appear in the fossil record before eukaryotes do
c. the theory of endosymbiosis explains their origin d. they can be seen only under a microscope

119. The structural similarities between the flippers of whales and the arms of humans are used to show that:
a. the human species began life in the ocean b. humans and whales have a common ancestor
c. whales are older than the human species d. whales evolved from humans

120. Galapagos finches
a. resulted from convergent evolution operating on a variety of dissimilar species to adapt them to similar niches
b. resulted from the effects that population growth and natural selection have on geographically isolated populations
c. resulted from the effects of continuous gene flow between the islands and the mainland over many thousands of years
d. provide a good example of the artificial selection that is common in equatorial areas.

121. Which evolved first in the history of animal evolution?
a. segmentation b. flow-through digestive system c. bilateral symmetry

122. In some plants, pollen from one flower is transferred to the flower of another type, and fertilization occurs. The seeds start to grow but the embryo does not develop right and dies, producing a fruit with unusually small, nonfunctional seeds. This is a
a. prefertilization barrier to reproduction b. postfertilization barrier to reproduction
c. neither a nor b d. it could be either a or b

123. Which of the following is a homology shared by all living creatures?
a. 46 chromosomes b. a common genetic code c. hair d. nuclei in cells

124. A vestigial organ
a. becomes vestigial because it is not needed, organisms stop using it, and they pass down that disuse to their offspring
b. has no function in an existing species, but is functional in related species, suggesting that its function was lost in the species in which it is vestigial
c. is as functional as the non-vestigial organs in related species, its just smaller

Answers to even-numbered questions
2d, 4a, 6b, 8a, 10c, 12b, 14a, 16c, 18b, 20b, 22d, 24b, 26b, 28d, 30a, 32a, 34c, 36a, 38c, 40b, 42c, 44a, 46a, 48d, 50d, 52a, 54a, 56b, 58c, 60c, 62a, 64a, 66b, 68a, 70a, 72d, 74b, 76a, 78b, 80a, 82c, 84d, 86d, 88a, 90a, 92b, 94d, 96a, 98d, 100b, 102b, 104d, 106c, 108a, 110b, 112a, 114b, 116d, 118c, 120b, 122b, 124b, 126a, 128c, 130a, 132a, 134a, 136d, 138a, 140c, 142d, 144c, 146c, 148c, 150b, 152b, 154a, 156c, 158b, 160a, 162b, 164a, 166d, 168c, 170b, 172c, 174a, 176a, 178d, 180a, 182d, 184c, 186a, 188a, 190a, 192c, 194c

d. never had a function

125. Which of the following is a vestigial trait in humans?
a. opposable thumbs b. forearms c. goosebumps d. body hair

126. Which of the following is true about a vestigial structure or trait?
a. It does not have a necessary function in more highly evolved organisms, but it did in more ancestral organisms.
b. It did not have a necessary function in more ancestral organisms, but it does in more highly evolved organisms.
c. It has an important function in both more highly evolved and more ancestral organisms.

127. If two species have each descended from the same common ancestor, then
a. those species will be identical
b. those species will have no anatomical features in common
c. those species will have DNA sequences in common
d. those species will still exist on Earth today

128. Similarity between species that is the result of common descent it termed
a. analogy b. convergence c. homology d. homoplasy

128. Which pair is most likely to be associated with speciation?
a. a changing environment and animals struggling for survival b. a high mutation rate and reproductive isolation
c. mountains and icebergs d. human impact and global warming

129. Which gas was NOT used in Miller's primitive Earth apparatus?
a. Hydrogen gas (H_2) b. water vapor (H_2O) c. Oxygen gas (O_2) d. all of these were used

130. Which is easy to see occurring around us?
a. microevolution b. macroevolution c. both d. neither

131. Fossils are used as evidence to show that ____ has occurred.
a. microevolution b. macroevolution c. both d. neither

132. Which is most likely to become fossilized?
a. teeth b. flowers c. worms d. eggs

133. Horses evolution occurred as their habitat was becoming
a. wetter b. drier c. colder d. hotter

134. At one stage in their development, human embryos resemble fish embryos in having gill slits in their necks, and tails.
a. true b. false

135. North American cacti resemble South African euphorbs because they
a. both live in hot, dry deserts b. are closely related c. are eaten by similar animals d. both a and b

136. Artificial selection was responsible for
a. extinction of the dinosaurs b. the evolution of sharks
c. differences between human societies d. types of fancy pigeons

137. Primordial soup was found on Earth
a. soon after it was formed b. for the first 4 billion years of Earth's history
c. from the beginning of the Earth until now d. never

138. What do mitochondria and chloroplasts have that suggest they came from endosymbiotic cells?
a. DNA b. enzymes c. membranes d. cell walls

139. Which group specializes in complex biochemical abilities?
a. plants b. bacteria c. animals d. fungi

140. Which group consists of eukaryotic single celled organisms that often form the basis of aquatic ecosystems?
a. fungi b. plants c. protists d. animals

141. Which group consists of multi-cellular organisms with rigid cell walls that absorb food from their environment?
a. plants b. bacteria c. animals d. fungi

142. Which group consists of organisms whose body is formed of thread-like structures called hyphae, and which contribute greatly to forest ecosystem productivity?
a. plants b. bacteria c. animals d. fungi

143. Animals appeared in a burst of evolution called
a. the Cambrian Explosion b. the Big Bang c. the Animal Explosion d. the Evolutionary Imperative

144. The theory of uniformitarianism (or gradualism), which stated that geological processes in the past operated the same way that they do today, was important in helping scientists understand and interpret which?
a. evolution b. that some species previously found on Earth were no longer here
c. the age of the Earth d. the origin of species

145. Monarch butterflies make birds sick; viceroys don't, but they look a lot like monarchs. Viceroys are
a. mimics b. models c. toxic d. parasites

146. Which scientist wondered why God would create a separate species of tortoise for each of 15 different nearby islands?
a. Alfred Russel Wallace b. Gregor Mendel c. Charles Darwin d. Frances Crick

147. When populations with different ancestors adapt in the same way to similar environments (for example wings in birds and beetles), it is referred to as
a. homology b. natural selection c. analogy d. coevolution

148. Which of the following is NOT believed to be true of the conditions on Earth before life evolved?
a. The atmosphere contained many gasses toxic to most life.
b. There were high levels of ultraviolet radiation.
c. Oxygen was present in the atmosphere.
d. Water was absent.

Human Evolution and Races; Populations

149. The statement that "Human populations classified in the same race appear to be more genetically similar than human populations placed in different races." is
a. true b. false

150. Which was the first to use fire?
a. *Homo sapiens* b. *Homo erectus* c. *Homo habilis* d. *Australipithicus afarensis*

151. M and N are codominant genes coding for blood proteins. If population A has the genotype frequencies: 55% NN, 10% MN, and 35% MM, does its allele frequency differ from population B which has genotype frequency of 20% NN, 80% MN and 0% MM?
a. yes b. no c. you can't tell from this data

152. Which is the most primitive direct human ancestor?
a. *Homo erectus* b. *Australopithicus afarensis* c. *Homo habilis* d. *Australopithicus boysei*

153. Which is true?
a. A person from a hot, humid environment is likely to have a flat, wide nose.
b. A person whose ancestors adapted to a hot, humid environment is likely to have a flat, wide nose.
c. A person from a hot, humid environment is likely to have a long, narrow nose.
d. A person whose ancestors adapted to a hot, humid environment is likely to have a long, narrow nose.

154. M and N are codominant genes coding for blood proteins. If population A has the genotype frequencies: 35% NN, 50% MN, and 15% MM, does its allele frequency differ from population B which has genotype frequency of 35% NN, 40% MN and 25% MM?
a. yes b. no c. you can't tell from this data

155. Humans evolved on which continent?
a. Africa b. North America c. Asia d. Europe

156. Which lived on Earth before *Homo habilis*?
a. *Homo erectus* b. *Homo sapiens* c. *Australopithicus* d. all of the above

157. The following shows actual data comparing a mitochondrial DNA sequence from humans and several other species

Human	ACACCATA
Chimp	ACACCATA
Bonobo	ACACCATA
Gorilla	CCACCACA
Orangutan	CCACCACA
Gibbon	CCACCATA

From this data, what can we conclude?
a. humans are more closely related to chimps than to bonobos
b. there seems to be no relationship between these species
c. the least closely related to humans seem to be gorillas and orangutans
d. bonobos, gorillas, and gibbons form the most closely related grouping

158. The first humans to expand their range well outside Africa were
a. *Homo habilis* b. *Homo erectus* c. *Australopithecus afarensis* d. Neanderthals

159. A group of organisms of the same species which interbreed under natural conditions are called a
a. population b. species c. kingdom d. family

160. Humans _____ primates.
a. are b. are related to (but are not themselves) c. are not related to

161. Forward-facing eyes are adaptive for primates because
a. it helps them see farther b. their sense of smell is not very good
c. it allows depth perception d. it helps develop social skills

162. In the human line, which evolved first?
a. a large brain b. bipedalism (walking on two legs)

163. Gene frequencies in a gene pool may shift randomly and by chance. This is called
a. artificial selection b. adaptive radiation c. genetic drift d. natural selection

164. People with pale skin tend to suffer from
a. not enough folate in sunny tropical areas b. not enough vitamin D in sunny tropical areas

sunlight produces vitamin D
destroys folate

165. People with dark skin tend to suffer from
a. not enough folate in regions with little sunlight b. not enough vitamin D in region with little sunlight

166. Which of the following would indicate that one subpopulation of a species is evolving independently of another?
a. Mutations arising in one subpopulation are not transferred to the other subpopulation.
b. There are no similar genes in the gene pools of the two groups.
c. The frequency of an allele in one subpopulation is different than the frequency of the same allele in the other subpopulation.
d. Both a and c are correct.

167. In a certain plant population, red flowers (R) are dominant to yellow flowers (r). If there are 50 plants, 10 homozygous dominant, 35 heterozygous, and 5 homozygous recessive, what are the allele frequencies in that population?
a. 10% R, 90 % r b. 55% R, 45% r c. 45% R, 55% r d. you can't tell from this data

168. A new group of islands forms far from any land mass. A pregnant toad manages to get to the island to lay her eggs. A new population forms, which initially has very low genetic diversity since the first generation were all siblings. Over millions of years, 15 species of toad evolve from the original population. Then a freak snow storm kills off all but the seven hairiest, fattest toads, who were able to survive the cold. These seven toads start a new population, and again genetic diversity is greatly reduced. This story demonstrates

Answers to even-numbered questions
2d, 4a, 6b, 8a, 10c, 12b, 14a, 16c, 18b, 20b, 22d, 24b, 26b, 28d, 30a, 32a, 34c, 36a, 38c, 40b, 42c, 44a, 46a, 48d, 50d, 52a, 54a, 56b, 58c, 60c, 62a, 64a, 66b, 68a, 70a, 72d, 74b, 76a, 78b, 80a, 82c, 84d, 86d, 88a, 90a, 92b, 94d, 96a, 98d, 100b, 102b, 104d, 106c, 108a, 110b, 112a, 114b, 116d, 118c, 120b, 122b, 124b, 126a, 128c, 130a, 132a, 134a, 136d, 138a, 140c, 142d, 144c, 146c, 148c, 150b, 152b, 154a, 156c, 158b, 160a, 162b, 164a, 166d, 168c, 170b, 172c, 174a, 176a, 178d, 180a, 182d, 184c, 186a, 188a, 190a, 192c, 194c

a. the founder effect b. the
c. the founder effect, followed by the bottleneck effect d. the bottleneck effect, followed by the founder effect

169. Mitochondrial genes are
a. located within the nucleus b. maternally inherited c. paternally inherited d. not inherited at all

170. Which of the following statements about Neanderthals is NOT TRUE?
a. Neanderthals coexisted with our own species, Homo sapiens
b. Neanderthals are genetically indistinguishable from modern human populations.
c. Neanderthals had heavier eyebrow ridges than our species does.
d. Neanderthals were bipedal.

171 The structure of a fossil hominid's knee joint can indicate whether that hominid
a. had front-facing eyes b. walked upright
c. could capture prey d. could produce and understand speech

172. The high degree of similarity between chimp and human DNA suggests that
a. chimps and humans are in the same genus
b. chimps are descended from humans
c. chimps and humans probably both descended from a more primitive apelike ancestor
d. humans are descended from chimps

173. Sickle-cell trait was selected for by nature in west and central Africa because
a it provides some immunity to anemia b. it provides some immunity to malaria
c. it helps people have larger families d. none of the above

174. In order for an animal to be able to judge distance,
a. its eyes must be forward-facing b. it must be able to see color
c. it must be able to walk d. all of these

175. The first primates to appear were
a. australopithicines b. prosimians c. gorillas d. New World monkeys

176. A biologist analyzes the DNA sequences of 3 different primates. She finds that primates A and B have almost exactly the same DNA sequences, whose those of primate C are different in several places. She would most likely infer
a. primates A and B are more closely related to one another than either is to primate C
b. all 3 primates appeared on Earth at the same time
c. either primate A or primate B must be a direct ancestor of primate C
d. primate C must have been the ancestor of both A and B.

177. Lucy's skeleton revealed that she was bipedal. This means that she
a. walked using all 4 limbs b. lived in trees c. walked on 2 legs d. crawled on the jungle floor

178. The hypothesis that *Homo sapiens* evolved in Africa is supported by the finding that
a. all *Homo sapiens* have the same number of chromosomes.
b. mitochondrial DNA is inherited only from one's mother
c. the fewest number of mitochondrial mutations are found among modern Africans
d. the greatest variety of mitochondrial sequences are found among modern Africans

179. Which is the closest human relative?
a. New World monkeys b. chimps c. gorillas d. none of these are related to humans

180. Which of these split first from the human line of evolution?
a. New World monkeys b. chimps c. gorillas d. none of these are related to humans

181. Tall, thin people evolve in what type of area?
a. arctic b. high mountains c. tropics d. any of these

182. A living fossil is
a. a computer-animated extinct creature, such as the dinosaurs in Jurassic Park
b. a fossil that still contains recoverable DNA and traces of metabolic activity
c. a missing link
d. a modern organism that has changed little from its ancient fossil ancestors

183. Which is the earliest member of the genus Homo?
a. *Homo erectus* b. *Homo habilis* c. *Homo neanderthalensis* d. *Homo sapiens*

184. During human evolution, people who lived in _____ parts of the Earth found light colored skin to be most adaptive.
a. hot, sunny b. wet c. cool, cloudy

185. During human evolution, people who lived in _____ parts of the Earth found dark colored skin to be most adaptive.
a. hot, sunny b. wet c. cool, cloudy

186. Which vitamin is destroyed by UV light?
a. folate b. vitamin D

187. Which vitamin is made by UV light?
a. folate b. vitamin D

188. During the time when hominins were evolving, the climate they inhabited was becoming
a. cooler and drier b. warmer and drier c. hotter and more humid d. much colder

189. The ape line is derived from the
a. Old World monkeys b. New World monkeys

190. Which is an example of the founder effect?
a. all of the deer on an island were killed off, but the population was restored by immigration of a small number of deer from the mainland
b. when the climate of a desert changed, the main species of mouse evolved into two different species specializing for slightly different environments.
c. most of the native birds were lost when cats were introduced to a tropical island, but the populations have recently grown again.
d. an introduced fungus killed off all of the American elm trees in the Midwest.

191. Humans have genes in common with all of these, but with which do they have the most genes in common?

a. bacteria b. mice c. fish d. jellyfish

192. Apes evolved a unique _____ which helps them climb and swing through trees.
a. head b. tail c. shoulder d. pelvis

193. To which group do humans belong?
a. hominids b. hominins c. both d. neither

194. Which is the most recent direct ancestor of *Homo sapiens*?
a. *Homo neanderthalensis* b. *Homo erectus* c. *Homo heidelbergensis* d. *Homo habilis*

Answers to even-numbered questions
2d, 4a, 6b, 8a, 10c, 12b, 14a, 16c, 18b, 20b, 22d, 24b, 26b, 28d, 30a, 32a, 34c, 36a, 38c, 40b, 42c, 44a, 46a, 48d, 50d, 52a, 54a, 56b, 58c, 60c, 62a, 64a, 66b, 68a, 70a, 72d, 74b, 76a, 78b, 80a, 82c, 84d, 86d, 88a, 90a, 92b, 94d, 96a, 98d, 100b, 102b, 104d, 106c, 108a, 110b, 112a, 114b, 116d, 118c, 120b, 122b, 124b, 126a, 128c, 130a, 132a, 134a, 136d, 138a, 140c, 142d, 144c, 146c, 148c, 150b, 152b, 154a, 156c, 158b, 160a, 162b, 164a, 166d, 168c, 170b, 172c, 174a, 176a, 178d, 180a, 182d, 184c, 186a, 188a, 190a, 192c, 194c

Mid-Terms Questions, AY18/19 Semester 1

Lecture 1 – The age of the Earth & fossil record 1500-1830 Part I

1. Who proposed that the world is 6000 years old?
   A. Georges Buffon
   B. James Ussher
   C. James Hutton
   D. Jean-Baptiste de Lamarck

   Ans: B

   (I can't remember the exact qn, whether it's this or "Who came up with the creation date of 4004 BC?")

2. What were the principles attributed to Nicholas Stenos about rock layers?
   A. *Law of superposition* and *Law of original horizontality*

   Ans: A

3. Who invented the microscope?
   A. John Ray
   B. Carl Linnaeus
   C. Robert Hooke

   Ans: C

4. What classification did Carl Linnaeus introduce?
   A. Binomial nomenclature
   B. Taxonomy

   Ans: A

5. How old did James Hutton propose the earth to be?
   A. 6000 years old
   B. Eternal, built and destroyed

   Ans: B

Lecture 2 – The age of the Earth & fossil record 1500-1830 Part II

6. Which of the following did Cuvier proposed?
   A. The earth was eternal
   B. Slow and gradual changes of the earth
   C. Extinction happened

   Ans: C

7. What was the meaning of Lamarckism wrongly interpreted by the public?
   A. Inheritance of acquired characteristics

   Ans: A

8. What is the original meaning of Lamarckism?
   A. The complexifying force and the adaptive force

   Ans: A

9. Which of the following are fossils found by Mary Anning?
   A. *Ichthyosaurus* and *Plesiosaur*
   B. *Ichthyosaur* and *Plesiosaurus*

   Ans: B

   (note the spelling! The other options were just random variations of these 2 spellings!)

10. Who was the most important influencer for Darwin's work?
    A. Charles Lyell
    B. Alfred Wallace

    Ans: A

11. What was Charles Lyell's *Principles of geology* about?
    I. Slow and gradual changes
    II. The present is the key to the past
    III. No progress or direction

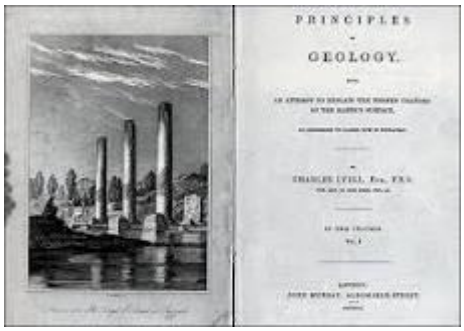
    Ans: I, II, III

    (option II was slightly paraphrased, to something like "events occur at the same rate in the past as they did now")

12. What did Charles Lyell's Principle of geology book cover page feature?

    A. Temple of Serapis

    Ans: A



Lecture 3 – Darwin's childhood & education

13. What did Darwin wanted to become initially after losing interest in becoming a physician?

    A. Surveyor

    B. Clergyman

    Ans: B

Lecture 4 – The voyage of the Beagle Part I

14. Which of the following is/are true?

    I. Darwin uncovered many fossils on South America.

    II. Beagles voyage mostly on land.

    Ans: I, II

15. What is the name of the native human beings that Captain FitzRoy brought to England?

    A. Fuegians

    B. Gauchos

    C. Hunter-gatherers

    Ans: A

Lecture 5 – The voyage of the Beagle Part II

16. What animal was first evoked Darwin's thought on evolution?

    A. Finches

    B. Mockingbird

    Ans: B

17. What were the evidences that inspired Darwin's theory?
    I. Uncovering fossil mammals in South America.
    II. Gradual change of species towards the South. One species will end, and another begin.
    III. Remarkable relationships of species living in Galapagos and those in South America, but not the same species from South America.

    Ans: I, II, III

18. Why did the species on Galapagos looked similar to those from South America?
    A. The species came from South America to Galapagos, then change/ evolve there

    Ans: A

    (answer was phrased something like that)

19. How did Coral Atolls form?
    A. Fringing coral reef surrounding a volcanic island will grow upwards as the islands sinks
    B. Corals grew from volcanic reefs underwater

    Ans: A

Lecture 6 – The beginnings of a theory

20. Who believed in the argument from design?
    A. William Paley

    Ans: A

    (John Ray and Carl Linnaeus weren't an option anyway)

21. Which of the following were evidences to Darwin's theory of evolution?
    I. Similarities between extinct and living creatures in the same place
    II. Distribution of related, living species
    III. Relationship of Galapagos islands species to those of nearby continent

    Ans: I, II, III

22. Who introduced the Law of population?
    A. Charles Darwin
    B. Charles Lyell
    C. Thomas Malthus

    Ans: C

Lecture 7 – Another naturalist: Alfred Russel Wallace

23. Which of the following is/are true?

    I. Wallace was working class middle class

    II. Wallace dropped out of school at age 14

    Ans: None of the above

    (see finals Q8 for a similar question)

Lecture 8 – Wallace in the Malay Archipelago

24. Which two regions does the Wallace Line separate?

    A. North America and South America

    B. Europe and Asia

    C. Asia and Australia

    Ans: C

25. What book did Wallace publish after travelling in the South East Asia?

    A. The Ternate essay

    B. The Sarawak Law paper

    C. The Malay Archipelago

    Ans: C

    (also his greatest book)

26. When was Darwin's theory of evolution accepted by the scientific community?

    A. 1859 published → took 15 - 20 years to be widely accepted.

    B. 1870

    C. 1880

    Ans: B

Lecture 9 – Did Darwin delay?

27. Why did Darwin delay publishing the *Origin of Species*?

    A. He was afraid of the reactions of the public

    B. He kept reviewing and improving on his work

    Ans: B

(basically, the idea that he unintentionally delayed publishing, not because he was afraid of the reactions)

28. What is the scientific name for barnacles?
    A. Cirripede
    B. Hermaphrodite

    Ans: A

29. Barnacles belong to which family?
    A. Molluscs
    B. Crustaceans
    C. Ammonites

    Ans: B

Lecture 10 – The *Origin of Species*

30. What animal did Darwin kept as pets for his research?
    A. Pigeons
    B. Fowls

    Ans: A

31. What analogy did Darwin use to explain his theory of natural selection?
    A. Artificial selection through domestication

    Ans: A

32. What did sexual selection describe?
    A. The selection of male partner by females and the competition between male counterparts
    B. The selection of female partners by males and the competition between female counterparts

    Ans: A

    (answer was phrased something like that)

33. What is the term for disuse of an organ but still left behind due to inheritance from ancestors?
    A. Vestigial
    B. Homology

    Ans: A

34. Which of the following were evidence of common ancestry?
    A. Variation, natural selection and evolution
    B. Homology, embryology and rudimentary

    Ans: B

    (option A sounds legit, but not answering qn)

35. Who coined the phrase "*survival of the fittest"*?
    A. Charles Darwin
    B. Alfred Wallace
    C. Herbert Spencer

    Ans: C

Lecture 11 – Reception of the *Origin of Species.* Was it a conflict of science and religion?

36. What did Wilberforce ask Huxley during the 1860 Oxford evolution debate?
    A. Whether his grandfather or grandmother looked like a monkey
    B. Whether it was through his grandfather or grandmother that descended from a monkey

    Ans: B

37. What did Fleeming Jenkin proposed?
    A. Blending inheritance
    B. Eugenics

    Ans: A

38. What did the Batesian mimicry describe?
    A. Resemblance of poisonous animals to unrelated non-poisonous animals
    B. Resemblance of non-poisonous animals to unrelated poisonous animals

    Ans: B

39. What was the name of the most famous transitional fossil?
    A. *Archaeopteryx*

    Ans: A

40. Which of the following were features of the famous transitional fossil?
    I. Feathers
    II. Bony tail
    III. Teeth
    IV. Wings with claws

    Ans: I, II, III, IV

41. Which was the first book written about human evolution?
    A. Huxley's *Man's place in nature*
    B. Darwin's *Descent of Man*

    Ans: A

Additional questions (I have a vague memory of these appearing)

1. Who was the first to describe the pterodactyl? George Cuvier
2. Who coined the word '*dinosauria*'? Richard Owen
3. Who introduced Darwin to scientific jealousy and competition? Robert Grant
4. Who gave Darwin the opportunity to go on the *Voyage of Beagles*? John Stevens Henslow
5. What species did Wallace use in his Ternate essay as an example for species changing? Tiger beetles