MESOZOIC ERA: TRIASSIC, JURASSIC & CRETACEOUS

- Early Triassic (237 Ma)
  - Pangea is going to start breaking apart
- Mass extinctions
  - There is a mass extinction in the Triassic which causes the reptiles to be the dominant form on the planet
  - Mesozoic = Age of reptiles
- Late Jurassic (152 Ma)
  - Gondwana is pulled away from the northern part
  - Pangea is broken apart into 2 components: Laurasia & Gondwana
- Late Cretaceous (92 Ma)
  - Continents start to separate from each other until we get to the late Cretaceous where we get the next giant mass extinction

- Amniota (Autapomorphies)
  - Amniote egg
    - Waterproof egg that contains an embryo, bathed in amniotic fluid which is provisioned with nutrients
  - Keratinized skin
    - Waterproof skin with keratin
    - Keratin protein is embedded in dead skin cells that are linked together to create a waterproof surface
  - Temporal fenestra in skull
    - Major changes in the jaw in terms of being able to feed
    - Special arrangement for the musculature of the jaw = temporal fenestra
  - Perfect getting up on land (what the amphibians didn't do)
- Amniote egg
  - Embryo sits inside an amniotic sac which is fluid-filled
  - External to it is nutrient reserves to provide it with nourishment
  - <u>The yolk sac is another membrane system that is plugged in the digestive system of the developing embryo = gets the nutrients from the yolk, turn them into tissue for growth</u>
  - Albumin (white part of the egg) is a water reserve for the developing egg
  - Allantois = Storage for metabolic waste
  - Embryo starts off very small but as it gets bigger, it moves to the space where the food was that is has consumed & converted into tissues
  - Embryo is surrounded by a Chorion which lays down the shell that protects it & through which it can breathe
  - Has a distinct advantage because it's away from predators in the oceans & the only thing up on land was the insects which couldn't consume the egg
  - 2 groups use the amniotic egg:
    - The mammals = aka **Synapsids**
    - The reptiles = aka **Diapsids**
    - Terms are a reference to the musculatures of the jaw

- Reptilla (Diapsida)
    - Diapsid skull
    - Beta-Keratin in scales and feathers
        - In the Diapsids, the keratin is folded in beta sheets
        - Complex structures are used to be able to produce scales & feathers
- Opivarous reproduction
    - Reptiles all lay eggs & don't engage in maternal care for eggs
    - **WHEN THE EGGS ARE LAID BY THE FEMALE & THE EMBRYO DEVELOPS OUTSIDE THE BODY OF THE FEMALE**
- Keratinized skin
    - Keratin covers the body & the scales for defense and allow toughness of the skin often with stretchy elements in between
    - Keratinized layer is non-living = has to be discarded
    - I.e. humans, snakes
- Extant diapsids: Crocodiles crushing jaws
    - The teeth are still conical, not modified
    - It does have a powerful jaw
    - Grab its nose & it won't be able to open its jaw
- Major reptile groups
    - Originally the jaw muscles were inserted inside the cranium = end up with muscles moving out & inserting on the surface of the cranium
    - Basically have a tendon that goes up through a hole on the cranium to the muscle that's going to pull the jaw
    - There are 2 different forms:
    - Anapsids
    - Diapsids (Anapsids) = 2 holes
        - Dinosaurs, pterosaurs, birds, snakes, and lizards
        - Turtles
    - Synapsids = 1 hole
        - Modern mammals
        - humans
- Anapsids
    - Turtle = genetically matched to the diapsids
    - Always thought that the turtles are some kind of sister group to the reptiles
    - Now we understand that the turtle's strategy is to fuse bones together to make the shell they live in (ribs & vertebrae & sternum)
    - In fusing all the bone, the 2 diapsid holes got filled in = means that the powerful muscles associated with the reptiles also decreased in size
    - They don't have jaws and teeth= they have a keratinized beak instead (not much muscle required to be able to move that beak)
    - Turtles represent diapsids that fused the skull together & the 2 openings are gone
- Major diapsid groups
    - Extinct
        - Dinosaurs, and pterosaurs

    - Extant (living)
        - Snakes, crocodiles, and lizards
    - The age of the reptiles (from the Permian to the Cenozoic) are only the vertebrates on land
    - Other groups are going to be there but they are minimal
- Extinct diapsids
    - Saurishchian dinosaurs
        - Group of dinosaurs that include big long neck dinosaurs (herbivores)
        - Solved the issue of getting the limbs underneath the body so that propulsion is carrying the body through all times
        - The bones of the hip (attach the leg to the vertebral column) are what put them up on land
    - Ornithischian dinosaurs
        - Have a different type of hip
        - There were 2 groups that got the body on top of the organisms
    - Pterosaurs
        - Flyers
        - Qaudrupeds that ran around with their knuckles down & a finger that was elongated with a membranous wing on it which was used for them to fly
- Synapsid reptiles
    - Have only 1 temporal fenestra
    - The Therapsids
- Reptiles - Therapsids (all warm-blooded)
    - Warm-blooded
        - They regulated their body temperature to keep it warm
    - Noturnal
        - Come out at night to feed while the small reptiles which are subject to cooling are affected by it
        - They feed on the same food sources the small reptiles fed on during the day
    - Glandular skin
        - Parts are associated with chemical communication in the group
    - Specialized teeth and chewed their food
        - One of the conical teeth becomes the canine
        - Used to trap their prey
    - Beginnings of the mammal lineage
    - At the end of the Cenozoic, this group is able to survive & diversify
- Angiosperms (Flowering plants)
    - The whole plant composition of the planet changes
    - In the gymnosperms = Within the female cone, the megasporangium differentiated & got ready to receive a pollen grain even if none shows up
    - Producing huge amounts of pollen of which there was very little likelihood for them to fertilize the egg
    - Huge waste of reproductive effort to produce megasporangia with eggs that are never going to be fertilized & pollen that is never going to fertilize it

    - Flowering plants are going to solve that issue
- Flower anatomy
    - Part of the plant that are male & female are modified leaves that have curled around the gametophyte structure of the plant
    - **Carpel** = female part
        - has a stigma = a disc at the top
        - Style = a shaft down where the sperm moves
        - a large part at the bottom with the ovary & egg in it
        - Carpel consists of the stigma, style & ovary
    - **Stamen** = male part
        - Male has anthers where pollen is made which sit on shafts (filament) that are also connected down to the bottom of the plant
        - Stamen consists of the anther & filament
    - All are modified leaves containing the gametophyte stage
- Angiosperm life cycle
    - The megaspore at the base of the carpel inside the ovary undergoes meiosis, makes 4 products, the 3 disappear, the one remaining divides 3 times to make 8 cells
    - The 8 cells are going to distribute themselves inside the macrogametophyte in a very specific pattern
    - In the anthers, the males are producing microspores. Meiosis to get 4 then thousands of rounds of mitosis to get lots of them. They are then pollen grains that contain a limited number of cells.
    - There are only 4 cells in a pollen grain
- Pollen (male gametophyte)
    - When it germinates, it has 1 nucleus which makes a tube (like in the gymnosperm & a generative cell that contained the genetic info of the gymnosperm)
    - 2 sperm cells in the pollen grain of flowering plants that are involved in fertilization
- Ovary (Ovule)
    - Megaspores sitting at the bottom of the carpel
    - Undergoes meiosis (haploid state)
    - 3 disappear (occurs in all female systems)
    - 1 remaining divides 3 times to make 8 cells
        - **Pole cells** (n) = 3 cells that sit at the pole
        - **Center cells** (2n) = 2 cells that sit at the center
        - **Egg cell** (n) = 1 cell
        - **Synergids** (n) = 2 cells
    - Of the remaining three, one becomes the egg & the other 2 becomes the synergids
    - 8 cells sitting on the gametophyte which are surrounded by tissue produced by the sporophyte
    - On top is the stigma where the sperm lands which has to swim down to fertilize the egg
- Double fertilization
    - Pollen grain lands on top, the tube cell starts to build the pollen tube in which the 2 nuclei swim

        - i.e. corn = silks on the corn (pollen tube)
    - 2 nuclei
        - one fertilizes the egg to create the zygote
        - The other joins with the 2 central cells to mate & fuse with the cell that is triploid (3n)
        - Endosperm = the triploid cell
    - Double fertilization = created an endosperm & a zygote
    - The endosperms with their nuclear material, produces all the nutrients (aka the gametophyte tissue the embryo/the baby sprophyte needs)
    - The plant can recognize its own pollen
        - If it's its own pollen, the tissues of the carpel assist the tube nucleus to make the pollen tube
        - The pollen tube can grow in a matter of days
    - The egg cell remains dormant
        - No provision for the embryo unless fertilization occurs
    - Once we get the double fertilization, there is a reproductive effort into making the nutrients to provision the embryo that's going to be within the seed
    - Don't make a precursor of the seed unless fertilization occurs = efficient system
- Pollination strategies
    - Vast majority of the flowering plants use animals to carry their pollen to increase the likelihood of pollination
    - i.e. bats, hummingbirds, bees & butterflies are the major pollinators
- Insect plant coevolution
    - Bees
    - Butterflies
    - The butterflies evolved as a major insect taxon with the appearance of the flowering plants
    - The tissue that surrounded the ovary in the carpel that comes from the original plant can be modified to become pulp
    - i.e. pulp of an apple, pulp of a lemon/orange, coconut husks
- Seed dispersal
    - Seeds can also be distributed by modifying the outer coat
    - Instead of having the seeds drop or be carried by the wind like a conifer
    - If you create a food source that the animal wants to eat, what happens is the animal eats the food source, puts it in its digestive system & as it moves around it drops the seed out the other end far away from the original parent plant = seed dispersal
    - Seed is in poop of the animal that it spreads the seed on different locations
    - Flowering plants dominate the planet. Conifers are found in cold damp forests.
    - The plant sources of the planet are changing
- K/T Boundary (66 Ma)
    - Supposed meterorite lands in the Yukotan peninsula (called KT Boundary = materials found there)
- Mass extinctions
    - End Cretaceous = Dinosaurs are wiped off the face of the planet

- Cretaceous extinction
  - Probably a localized extinction event
  - The dinosaurs had become huge, massive organisms. Herbivores were migrating pole to pole, stripping that land of vegetation that fed them. They caused massive changes in the herbivores (the primary productivity of the planet)
  - Trophic pyramid at the age of reptiles = find around 5 top predators. Towards the end of the cretaceous, they start to diminish.
  - When the top predators are wiped out, the whole system collapses
  - There was a sufficient change that the great dinosaurs were wiped out
  - In their overabundance, they went over the carrying capacity of the planet & from there caused the collapse of the trophic structure of the planet
  - Since 1970, the WWF found that 66% of all the animal forms have disappeared off the planet
  - They project that within the next 5 years, that will reach 75-80% of all the biodiversity on the planet
  - Anthropomorphic extinction = reference to humans modifying the planet on a global scale that alters the geology & the rock strata that occurs from the fossils that are there

CENOZOIC ERA

- K/T Boundary (66 Ma)
- Middle Eocene: Paleogene (50.2 Ma)
- Middle Miocene: Neogene (14 Ma)
- Modern World
  - Everything is drifting until it reaches their final locations where we are now
- Birds
  - Reptile feathered birds
  - Feathers were originally for thermoregulation (thought to be unique to the group but it was recently found to be common in dinosaurs)
  - We may think that it was modified for flight (not the original function of the feathers)
  - Ground-up theory of flight in birds
    - When the first feathered organisms were feeding, they originally ran across the ground, sweeping the insects to feed on them
    - Somewhere along the line, they discovered that they could use their wings for flight
  - Tree-down theory
    - Bird climbs up the tree -> gets out on the end of the branch -> jumps of the branch, uses the feathers to glide with its mouth open to eat the insects as it falls back down to the ground
- Feather structure
  - Feathers are a keratinized structure (beta-keratin because it's a reptile)
  - It consists of small elements that are all locked together to create a very light-weight structure

    - Holes are so small that it can still push against air
    - Generates lift for the bird
    - There's an advantage to being a lighter organism
- Flight adaptations skeleton
    - Change in their bones to make them lighter
    - Reduction of bones
        - Tail is completely gone
        - Jaw is replaced by a beak made out of keratin
        - Many of the vertebrae is also gone
        - Reduction of bones within the wings
    - Feathers do all the work
    - The power to lift the feathers is centralized
    - All of the organ systems in the bird are centralized in 1 region - a center of gravity
    - The lifting force is placed above the center of gravity
    - One muscle that runs on top that lifts the wing, another muscle (the bigger one) pulls the wing down.
    - All the bones are filled with air (not solid bones) to lighten them up
- Parental care
    - Birds engage in parental care
    - Parental care does make its appearance in reptiles
    - They take care of their eggs & sometimes even the offspring
    - Produce few offspring BUT guaranteed the success of their offspring = effective reproductive strategy
- Mammalia (Synapsida) - humans
    - Synapsid skull
        - 1 opening for the jaw muscles
    - Glandular skin with alpha-Keratin (always alpha-keratin that will make hair/nails)
        - Skin is loaded with glands = producing materials to the surface (hairs)
    - Lactation
        - The glandular skin is modified to produce a nourishment for feeding = mammary glands & lactation
    - Heterodont deciduous dentition
- Mammalian integument
    - Skin is glandular, sebaceous glands secrete oils to keep the hair supple & smooth
    - <u>Hair creates the insulating layer that keeps the mammal warm & maintain a constant body temperature</u>
    - Eccrine sweat glands = cooling
    - Apocrine glands = scent gland (produces pheromones)
- Mammal jaws
    - Have different types of dentitions
    - Omnioves = mix of both herbivores & carnivores
    - Herbivores
        - have big grinding molars & incisors to chop grass
    - Carnivores

        - have molars, & canines (canines puncture a lung/vital blood vessel in the neck to kill the prey)
    - Jaw processes food before it swallows
        - The only other group that pre-processed their food was the arthropods which used their limbs to manipulate it before they swallowed it
    - Cheeks = to prevent food to fall out as the jaw is chewing the food
    - 2 sets of teeth = baby teeth, and when the jaw gets bigger, another set of molars come from behind (wisdom teeth)
    - changing the baby teeth to adult teeth as the jaw grows bigger
    - **Deciduous** = baby teeth
    - **Diphyodont** = animal with 2 sets of teeth
- Mammalian reproduction
    - Oviparous
        - Monotremes
            - 1 group of mammals that produce eggs
            - i.e. <u>Platypus</u> = takes its babies, holds it against its skin where the apocrine glands are producing a nutritious fat rich milk to nourish the young
            - Ultimately become the mammary gland
            - Perfected by the teat
    - Viviparous = produce young internally
        - Marsupials
            - no blood brain barrier between the developing young & the mother
            - The mother's immune system sees the developing multicellular form in its uterus as a foreign object & it will reject it
            - But before it does that, the embryo crawls out of the uterus, crawls up the fur of the pouch, stays inside the pouch where there is the mammary & the teat to be able to nourish itself & maintain its development
            - Sits there until it becomes large enough
            - i.e. Kangaroos
        - Eutherians
            - Includes humans
            - perfect the blood brain barrier between the mother & the child = the **Placenta**
            - The mother & child can have different blood types, etc.
- Placental mammals
    - Placenta ensures that the blood-brain barrier keeps the blood independent from each other
    - Have an amnion, placenta, nutrients & supplies for the developing embryo
- Parental Care
    - Young are born in a susceptible state = they are born that are not fully developed
    - <u>Parental care & nourishment from the mammary glands allow the young to continue its growth</u>
    - Even after lactation, the young continue to get parental care
- Macroevolution

- **Macroevolution** = evolution of species and their interactions with everything else
- Microevolution = evolution that generates species
- How did biodiversity change overtime? Why did things appear? How did new species arise? What are the origins of groups that made them function the way they do?
- Evolution above the level of species
- Includes
    - Adaptive radiations of taxa
        - How different taxa branched to create the diversity in the planet
        - Cladograms = mapped biodiversity & showed adaptive radiation
    - Biodiversity changes over time (paleontology)
    - Extinctions
    - Speciation
    - Origins of novel structures
        - From a spindle body in the fungus to the phragmata in the plant to the radula in a mollusk
        - Autapomorphies for each group on the cladogram (the novel structures that define them)
        - Novel strucutres = autapomorphies