

## Mammals

- 1) Origin of mammals
  - a) Mammals have the most complete fossil record tracing their evolutionary lineages back to our earliest ectothermic hairless small ancestor about 150million years ago (Jurassic period).
  - b) The earliest ancestor, like all amniotes, had fenestrae. Mammals only have one making them **synapsids**.
  - c) The earliest synapsid is a group of organisms called **pelycosaurs**
    - i) These organisms resemble lizards outwardly but are in fact not closely related to reptiles at all.
    - ii) They are synapsids, they have their legs under their body (unlike reptiles whose legs are off to the side), expanded brain, specialized jaw musculature and teeth, loss of lower ribs and structures to help maintain an internal body temperature.
  - d) The earliest true mammal were small mouse sized organisms with enlarged heads (presumably to support larger brains).
  - e) Early mammals also formed new dentition patterns
    - i) Reptiles, amphibians and fish (who have teeth) all display **polyodont** teeth, meaning they loose and replace them as needed (though a few evolved later one set of teeth fused to the jaw like alligators or some snakes).
    - ii) Mammals have **diphyodont** teeth, meaning they have 2 set of teeth, a temporary and permanent set.
      - (1) This would allow for different types of teeth to increase food processing, and when the first set wears out they have a second set that comes in about half way through their life.
  - f) Early mammals were endothermic
    - i) Their body temperature would have been lower than modern placental mammals but still maintained my metabolic functions.
    - ii) Hair aided in the regulation of temperature and is seen in the earliest mammals
      - (1) With the evolution of hair came the evolution of many new glands that aid in thermoregulation and new forms of chemical communication
  - g) Even though early mammals share all the characteristics of modern mammals they were prevented from diversifying because of the large overpowering presence of dinosaurs
    - i) During the Cenozoic extinction event all large dinosaurs disappeared which suddenly opened up many previously occupied niches.
    - ii) About 58million years ago during the Eocene epoch we see the diversification of these furry, agile, endothermic, highly intelligent, adaptable, and most importantly developing their offspring internally and feeding them with secreted milk, thus eliminating vulnerable eggs laid in nests.
- 2) Characteristics of mammals
  - a) All mammals share characteristics that unite the group
    - i) Hair
      - (1) As described earlier hair is a good insulator for maintaining internal heat

- (2) Hair comes in two types, a thin soft under hair for insulation and a thick longer guard hair for protection.
    - (a) In mammals that live in the water like beavers, fur seals, otters, etc... the guard hair sticks together forming a water proof layer allowing the under hair to remain dry and keep the animal warm.
  - (3) Hair grows continuously out of a follicle. It is made up of living cells on the inside that create keratin (hard substance that make up finger nails). The keratin forms the outer layer of the hair. By the time the hair is pushed out of the skin it no longer receives nutrients and is just made of keratin.
  - (4) Some hairs have become specialized for other purposes
    - (a) Porcupine
    - (b) Whiskers
    - (c) Hackles
- ii) Horns/ antlers
- (1) True horns and antlers are only seen on mammals
  - (2) True horns are only in the bovine family (antelopes, sheep, cattle)
    - (a) These horns are hollow keratin with bone in the middle coming out of the skull
    - (b) True horns don't fall out but will continue to grow the animals entire life
    - (c) True horns are also not branched although some can be greatly curved
  - (3) Antlers in the deer family are branched and made of solid bone
    - (a) During the spring antlers begin to grown under the soft skin on the head (called velvet)
    - (b) Just before mating season (usually early fall) blood vessels constrict and the deer removes the velvet by rubbing it off against trees or any hard object
    - (c) The antlers are used in competing for rites to mate after mating they fall off
  - (4) Other horns
    - (a) Giraffes have horns similar to deer but they never remove the velvet and they never fall off
    - (b) Rhinos horns are formed of millions of keratinized hairs cemented together and is not attached to the skull
      - (i) In an effort to protect endangered rhinos (which all of them are) from poachers wildlife officials are removing the horns
- iii) Glands
- (1) Mammals have specialized glands that form from their specialized outer skin
  - (2) Sweat glands
    - (a) These glands are all over the body. They come in 2 forms:
      - (i) **Eccrine**- secrete a watery substance that cooled the body when evaporated on the skin
      - (ii) **Apocrine** – are in the hair follicles and produce a thicker substance that dry on the skin but are not involved in heat regulation
        - 1. In humans these are located only in the armpits, genitalia, breasts, and ear canals

(3) Scent glands

- (a) These are used in producing chemical communication in species, they can attract mates, mark territories, use as a warning or defense
  - (i) Skunks use their scent glands to produce a noxious odor and spray it 2-3 meters when threatened
- (b) Humans also have scent glands but we tend not to like our own smell (hints all the beauty products out there)

(4) Sebaceous glands

- (a) These produce an oil called sebum
- (b) Sebum is what makes your hair shine and keeps your skin from drying out
- (c) Most mammals have them all over their body, humans tend to have them more concentrated on the head and face

(5) Mammary glands

- (a) These occur in females (and males) of mammals.
- (b) The glands produce a milk that nourishes the young
- (c) Young will nurse on the nipple of most mammals until they develop enough to forage for themselves
  - (i) Monotremes (platypuses) lack nipples and just secrete milk from hair follicles so the offspring suck on the mothers hair

iv) Teeth

- (1) Mammals feed on a variety of food items, because of this their teeth have become adapted for the specific food that animal eats
  - (a) In fact the most commonly used tool for identifying species of mammals from skulls is to use its dentition
- (2) 4 types of teeth
  - (a) **Incisors**- the forward most teeth with flat sharp edges for slicing or cutting
  - (b) **Canines**- long conical teeth used for piercing and holding
  - (c) **Premolars**- have a prominent point and a flat surface, used for shredding or crushing
  - (d) **Molars**- rear most teeth relatively flat used for crushing and grinding
- (3) All mammals have 2 sets of teeth as previously discussed, all teeth except molars will be replaced in the mouth only one time

3) Digestive systems

- a) Mammals feed on many different things so there is no one size fits all classification for the digestive system
- b) Types of feeding specialization
  - i) **insectivore**- feed on insects, they use canines to pierce insect exoskeletons, however some like the anteater has no teeth.
    - (1) Digestive tracts are usually shorter with very small or no cecum
  - ii) **herbivore**- feeds on vegetation, some graze like cows, deer, horses, bison, etc... while other gnaw like beavers, rodents, rabbits, etc...

- (1) vegetation is very hard to digest so two types of digestive tracts have evolved to accommodate this.
  - (a) **Non-ruminant**- these are many rabbits, rodents, horses. They have very long small intestine and very large cecum's.
    - (i) Because most nutrient absorption takes place in the small intestine and fermentation takes place in the colon/cecum many nutrients are lost in feces.
    - (ii) This has led to some organisms practicing **coprophagy**- eating your feces to get the nutrients missed the first time through.
    - (iii) Many rabbits have to preform this or they die, while other animals (like your dog) does this only if its normal diet is missing a critical nutrient.
  - (b) **Ruminant**- these are cattle, deer, goats, antelopes, giraffes, etc... These are our "4 stomached animals" they don't actually have 4 stomachs but one stomach with 4 chambers.
    - (i) Food is brought into the first chamber (the **rumen**) where it is digested by bacteria and forms into balls called **cud**.
    - (ii) the cud is returned to the mouth to be further chewed
    - (iii) it is re-swallowed to go through fermentation again
    - (iv) it is then passed through 2 chambers where byproducts of the bacteria and water soluble nutrients are absorbed
    - (v) the last chamber is similar to non-ruminant stomachs in that it has acid and helps break down non-water soluble nutrients (proteins and fats)
    - (vi) finally it passes through the small intestine a cecum and the large intestine
    - (vii) this is very affective at collecting nutrients from plants, however it requires large amounts of food to sustain the organism
      1. a 6 ton elephant must eat 400lbs of vegetation to stay healthy
- iii) **carnivores**- includes cats, cetaceans (dolphins and whales), weasels, wolverines, Tasmanian devils
  - (1) eat only meat, with large canines used to kill prey and hold them while they die and incisors and premolars to shred the meat to manageable sizes
  - (2) digestive systems are very small because proteins are easy to digest
  - (3) they tend to have distinct meals rather than continuous feeding, so they have more leisure time
    - (a) a pride of lions will kill an animal and gorge themselves on that animal, then they will rest for as long as a week before eating again
- iv) **omnivores**- includes most primates, dogs, foxes, pigs, raccoons, bears and many rodents
  - (1) they tend to have a variety of teeth to accommodate any food source
  - (2) tend to be opportunistic feeders
  - (3) digestive systems are about the same as a carnivore but cecum's are present just reduced
- v) there are some other specialized feeding out there as well
  - (1) **frugivores**- fruit eaters (fruit bats)
  - (2) **piscivores**- fish eaters (dolphins, some bats and whales)

(3) **plankton feeders**- filter feed plankton (baleen whales)

- 4) Cardiovascular system
  - a) Almost exactly the same as birds
    - i) 4 chambered hearts,
    - ii) High blood pressure
    - iii) Double circulation
  - b) Blood is non-nucleated
- 5) Respiratory system
  - a) Has a mixed pool lung
    - i) Air is drawn in and oxygen is absorbed through **alveoli**
    - ii) This method mixes oxygenated and deoxygenated air and is less efficient than a birds one way system
- 6) Reproduction
  - a) All mammals reproduce sexually, however development between mammals divides mammals into 3 groups
    - i) **Monotremes**- the only living examples are the Platypus and the spiny anteaters in New Guinea.
      - (1) The main characteristic difference between them and other mammals is they have a cloaca, and lay eggs.
      - (2) If I told you I had a mammal that lays eggs, had a bill like a duck , tail like a beaver, feet like an otter, and venomous claws like something out of a Norse myth, you would probably think im crazy but that is exactly what a platypus is.
        - (a) This species does not give live birth, embryos develop about 10 days in the womb surviving on a yolk sac
        - (b) A thin leathery membrane then surrounds the embryo and the egg is laid in a burrow
        - (c) The eggs hatch in about 12 day to very underdeveloped offspring
        - (d) The offspring latch to the belly of the mother and drink milk that is formed on the hairs for 3-4 months until old enough to survive on their own.
    - ii) **Marsupials**- these are animals primarily living in Australia (~70%) but there are about 70 species in South America, another 13 in Central America and one in North America (the opossum).
      - (1) marsupials main characteristic is their pouch
      - (2) Female marsupials give birth to embryos. The opossum give birth to embryos smaller than bumblebees.
        - (a) Young then reside in a pouch attached to a nipple for at least the next month
        - (b) After the initial development they still remain in the pouch for protection and nourishment
    - iii) **Placental mammals** – these are the most common existing mammal on earth. They include dogs, cats, primates, elephants, mice, etc...
      - (1) these mammals carry their young internally all the way to term (full development)

- (2) they form a placenta which allows for maternal blood to oxygenate it and take away waste, while the embryo delivers waste to get rid of, and pick up nutrients and oxygen the mothers blood left behind.
- (3) Gestation is very costly on the mother but increases the chances of survival tremendously.
- (4) Gestation time is related to body size
  - (a) Mice have gestation of only 21 days
  - (b) Dogs and cats about 60days
  - (c) Cattle about 280 days
  - (d) And elephants about 2 years!

## 7) Interesting examples

### a) Bats

- i) These are the only flying mammals, they have very small bodies and skin stretched between the limbs.
- ii) Most eat insects and play a major role in keeping pest populations down
  - (1) If your out at night by a body of water you will see all the bats diving after the emerging mosquitos, take a small rock and throw it in the air as high as you can all the bats will detect it with their echo location and dive after it.
- iii) Echo location- by producing sharp sound waves and listening for them to bounce off an object and return, a bat can tell location, movement/direction/speed, size, and even texture of an object.
  - (1) This is really effective, if you somehow got in one of those holly wood scenes where your in a cave and all the bats start swirling around you, the best thing to do is stay as still as possible they will detect you and fly around you.
- iv) "Blind as a bat" bats actually have better vision than you!

### b) Cetaceans

- i) These are whales and dolphins
- ii) All of these shared a common ancestor with a house cat sized terrestrial herbivore that lived about 48million years ago
  - (1) From here there is a series of fossils (and now genetic evidence) that shows a progression from land, to becoming amphibious, to being aquatic, loosing terrestrial limbs and finally evolving the blow hole.
  - (2) This all took place over a 13 million year period, that led to the first fully recognizable whale form
  - (3) Although modern whales and dolphins didn't appear until about 15million years ago.
- iii) There are two types of cetaceans
  - (1) whales
    - (a) Baleen- these are whales that filter feed plankton
      - (i) They include the largest animal ever to live on earth about 33.5meters (110 feet) and 190 tons (419,000lbs).
    - (b) Toothed whales- including the sperm whales, beluga whales, narwhals, etc...
      - (i) They all are active predators

- (2) Dolphins
  - (a) Dolphins and porpoises are basically the same thing with a few morphological differences in teeth shape (dolphins are spade shaped, porpoises are cones) and general shape (dolphins are skinny, porpoises are plump).
  - (b) The largest member of the dolphin family is actually the orca (killer whale).
- (3) Cetaceans are highly intelligent with good problem solving abilities
- (4) Dolphins are also the only known animals (besides humans) to have sex for fun
  - (a) All that cute behavior like jumping and slapping its tail, etc... is actually dolphin foreplay.
- iv) Armadillos
  - (1) Big shell, sharp claws, and leprosy
- v) Humans...
  - (1) Humans are primates, primates are divided very early into a group consisting of lemurs lorises, tarsiers and a group containing everyone else (**simians**).
    - (a) Both groups are predominantly tree dwelling which suggest (along with fossils) that the ancestral form was arboreal as well.
  - (2) Simians are split three ways
    - (a) New world monkeys- these are predominantly American species with long grasping tails
    - (b) Old world monkeys- these are primarily of Africa and Asia. They have no grasping tail for climbing
    - (c) Apes- these include gibbons, orangutans, gorillas, chimps, bonobos, and humans
      - (i) All but gibbons are in the family hominidae
      - (ii) All fossils more closely related to humans than chimps are called hominines or humans
      - (iii) The earliest ape fossils are found to be 23 million years old from east Africa.
      - (iv) DNA suggest humans and chimps split from each other about 6 million years ago
        - 1. A fossil found in Chad showed a beautiful transitional skull with chimp like teeth but hominine brain case and structures.
  - (3) As hominines evolved differences tend to be related to changes in diet and posture.
  - (4) The earliest hominine found is about 4.4 million years old from Ethiopia
    - (a) *Ardipithecus ramidus* (Ardi for short) would have lived in a wooded forest where it retained many characteristics of still living at least part of its life in a tree but is also was the first to begin **bipedal** locomotion
      - (i) Bipedal locomotion probably was a byproduct of standing up to see of tall grasses in savannahs. This time frame in Africa was when the formation of the great savannahs began. So as tree disappeared these arboreal species had to adapt.
    - (b) *Australopithecus afarensis* (lucy) was about 1 meter tall stood on 2 feet and ate a diet of mostly fruit but probably scavenged meat as well. From Kenya and Ethiopia (about 3.7-3 million year old rock) many species of Australopithecus have been

unearthed showing specialization in the newly forming savannah. Evidence suggest this genus is our direct descendants.

- (c) Other species have been unearth from that same time period such as *P. robustus* but their evolutionary relationship is still unknown but likely they formed an extinct branch of hominid evolution and are not our direct descendants.
- (d) the first species of the genus Homo is still debated but most agree from what we have found it was *Homo habilis* (handy man), this species was similar to *Australopithecus* but had a larger brain and made stone tools.
  - (i) The ability to make and use tools defined the beginning of *Homo* as a genus.
  - (ii) Chimpanzees cannot make stone tools nor can they be taught to (and many have tried)
- (e) With the expanding savannah in Africa many species of *Homo* have been discovered living in the same general area including *H. rudolfensis* (slightly more robust than *habilis* but evolutionary relationship is still unknown), *paranthropus sp.*, and *Homo erectus*.
- (f) About 1.9 millions years ago *Homo erectus* appeared measuring in at 5-6 feet tall, a strong brow, and have been found in Africa as well as Eurasia suggesting this species started proliferating out beyond African savannahs. Their brain size would have been just smaller than modern humans.
  - (i) They were the first to control and use fire
  - (ii) This species survived until about 150,000 years ago in china and java
- (g) *Homo floresiensis* (hobbit man) was discovered on an island in Indonesia and is a descendent of *erectus* that went extinct only about 13,000 years ago
- (h) from *erectus* about 200,000 years ago the two most modern hominines evolved *Homo neanderthalensis* and *Homo sapiens*.
  - (i) Neanderthals flourished along the receding glaciers in Europe while humans flourished in Africa
  - (ii) Neanderthals had very muscular bodies and advanced tools that helped them survive in cold climates and hunting large animals
  - (iii) Humans however were more intelligent and had better cultural structure. When they began to spread out of Africa about 40,000 years ago, Neanderthals quickly disappeared.
    1. Direct evidence for why they disappeared is lacking but is most likely the two species competed for resources and the superior intelligence beat out the brute strength
    2. Other evidence also shows there was interbreeding between the two once humans spread out (Neanderthal genes are found in European and Asian lineages but not African)
- (i) Humans are the only remaining species of the genus Homo but it is important to note that humans went through the same evolutionary pressure of speciation and competition as any other species
- (j) We know of 5 species of Homo that have existed in the last 4 million years.