Mammals
Module # 7 – Component # 1

Introduction to Mammals

Origin of Mammals

This topic was one of the most debated and controversial subjects in the whole of biological science for centuries. The main reasons for this are the ramifications and implications for our own origin. Those of you who have completed our component on the introduction to evolution will know that we don’t advocate any specific point of view for the origin and evolution of man. This discussion on the origin of mammals will deal with the group carefully avoiding any specific species accounts.

Amongst the reptiles of the late Carboniferous period (some 300 million years ago), one line heralded the mammal-like reptiles - the subclass Synapsida. It is important to clarify that these animals are reptiles (older than the dinosaurs) and were only showing the first faint signs of evolving. During the Permian and the early Triassic periods, the synapsids flourished and were dominant. Over millions of years, their skeletons changed from the cumbersome reptilian mould into a more lively form that was indicative of the early mammals. According to the fossil record, the divergence of mammals from reptiles is indicated by changes in the hinge mechanism of the lower jaw and the skull.

However, during the late Triassic period, the dinosaurs came into being and very nearly annihilated the synapsids. Those that survived evolved into true mammals of which the first were 5cm [2 in] long, nocturnal and probably partly arboreal.

In the late Cretaceous period (135 -65 million years ago,) the dinosaurs lumbered mysteriously into oblivion. No one is certain as to why mammals finally prospered and the dinosaurs declined. It may have been triggered by the cooling climate of the Mesozoic era (the Triassic, Jurassic and Cretaceous periods) with its daily and seasonal fluctuations in temperature.
Early mammals probably avoided competition with dinosaurs by becoming nocturnal. The evolution of endothermy (internal self-regulation of the body temperature) made it possible for them to become nocturnal. In addition, endothermy allowed them to grow faster and therefore breed more prolifically than reptiles.

Another reason why mammals usurped the dinosaurs’ supremacy, could have stemmed from the development of lactation and parental care in mammals.

Young dinosaurs hatched, as do modern crocodiles, as miniature replicas of their parents. They grew slowly at a rate which depended on their foraging success. In contrast, the infant mammal grew rapidly towards adulthood under parental care with the great benefits of lactation (explained below). At independence, the young mammal is almost fully grown and unlike the still infantile reptile of the same age, enters roughly the same niche as adults of its species. If this reconstruction is correct, then we can assume that the supremacy of mammals was assured by parental care and particularly lactation.
What is a mammal?

Defining a mammal is not an entirely simple process. Some characteristics are unique to the group, some are shared by others. Some characteristics are found in all species, some are missing from others. You can divide the mammalian characteristics into the must have and the may have.

### Must Have Characteristics:

- **Endothermic** – warm blooded
- **Lactation** – feeding with milk
- **Unique jaw articulation**
- **Backbone**
- **High degree of cephalization** – well developed brain
- **Air breathing**
- **Four footed**
- **Viviparous** – bear live young
- **Parental care**

### Several of these are shared by other groups of animals:

- Birds are endothermic
- All vertebrates have backbones from frogs to fish
- Reptiles, birds and amphibians are air breathing
- Reptiles are four footed.
- Parental care is seen in all vertebrate classes as well as among many invertebrates.

However, all mammals share all these characteristics apart from the aquatic mammals which are not four footed and the monotremes (Duck-billed platypus and the Echidna) which are not viviparous.

### May Have Characteristics:

- **Body hair**
- **Sweat glands**
- **Mammary glands**
- **External pinnae (external ear structures – lobes)**

These specific features are only found in mammals, although not all mammals have them. Whales and dolphins don’t have body hair, ear-lobes or sweat glands and the monotremes have no mammary glands. The marine mammals do however have subcutaneous hair follicles with microscopic hairs, an indication of their previous evolution from land mammals.
**Endothermy**

It was the function of endothermy that allowed the early mammals to become nocturnal and thereby avoid competing with dinosaurs thus ensuring their future. This makes endothermy a prime mammalian characteristic.

Endothermy is made possible by the oxidation (burning) of food within the body. The internal temperature is regulated by a “thermostat” situated within the hypothalamus in the brain. Endothermy confers on mammals an internal constancy which is greatly advantageous:

- It allows them to function in environments that exclude ectothermic animals such as reptiles. (The internal temperatures of ectothermic animals rise and fall with the outside temperatures).
- It also assures biochemical stability for their bodies - chemical reactions, which are dependent upon the correct temperature.

However, endothermy is costly. Mammals must work hard at either warming or cooling themselves depending on their surroundings. They have many adaptations involved in minimising these running costs.

Image: Andrew Russell
Hair

The coats of most mammals usually consist of an outer layer of larger, more bristle-like, water-repellent guard hairs which provide a tough covering for the dense, soft underfur.

Hair provides insulation for the animal, allowing it to retain the internally generated heat. Hair protects the skin from the rays of the sun or from freezing wind. It reduces sweat and keeps aquatic mammals dry. Hairs are waterproofed by sebum, an oily secretion of the sebaceous glands of the hair roots.
**Torpor and Hibernation**

Some mammals minimise the costs of endothermy by **not constantly maintaining the internal temperature**.

For example, the body temperature drops in **hibernating mammals** during hibernation, and many bats allow their temperature to fall when at rest.

When body temperature is dropped daily as in the case of bats it is called **torpor**.

When temperature is dropped for a **prolonged period**, the process is called **hibernation**. In both instances, internal body temperature is dropped and **metabolism is slowed**.
Sweat Glands

A disadvantage of endothermy is the fact that animals can overheat. Endothermy is not only about generating heat internally, but also regulating this heat. One of the many mechanisms that assist in cooling is the sweat glands.

The skin of mammals contains coiled sweat glands which secrete a watery fluid onto the skin’s surface. This evaporates and in doing so draws heat from the skin and cools it. The distribution and number of sweat glands varies:

- Primates have sweat glands all over the body.
- Members of the cat and dog families have sweat glands on the pads of their feet only and resort to panting, losing heat by evaporation of saliva.
- Whales, manatees and golden moles have no sweat gland at all.

Now we introduce a new term: Homeothermy. Homeothermy describes the process of regulating internal body temperature. Therefore, most mammals may be correctly said to be homeothermic instead of endothermic.
Scent Glands

Certain sweat and sebaceous glands in mammals have become adapted to produce complicated odours with which mammals communicate. The sites of scent glands vary, for example: elephants have them behind the eyes whereas hyraxes have them in the middle of their back. The scent glands of civets lie in a pocket between the anus and the genitals. For centuries, the greasy secretions of these glands have been exploited for the base of expensive perfumes. Glands around the genitals of the musk deer are similarly prized by some people.

The topic of scent glands is well developed and is well described in Module # 8, Ethology – component # 4 – Communication.
Mammary Glands

Mammals can be divided into three groups under this heading:

- Monotremes or egg-laying mammals
- Marsupials, primitive mammals or pouch-bearing mammals
- Placental or true mammals.

Common to all is the presence of mammary glands or at least mammary tissue. Mammary glands are unique to mammals. Only the glands of females produce milk which protects their infants from the demands of foraging for themselves while they are still small and vulnerable.

Thus, true mammals, in comparison to other viviparous (giving birth to live young) vertebrates, are born small (the average litter is about 10 percent of the mother’s weight), minimising the burden upon their mothers. They grow very fast and become independent of their mothers at a much larger size - a development sustained by lactation and hastened by endothermy.

The monotremes are the most primitive of mammals and closely related to reptiles. They possess teatless mammary tissue from which milk is discharged onto tufts of hair. The two members of this group are the Duckbilled platypus and Echidna, both resident to Australia only.

The marsupials are more advanced than the monotremes in several ways but most importantly their mammary glands are grouped into true mammae ending in mammae or teats. Marsupials retain the eggs in the uterus until they hatch, unlike the monotremes which lay their eggs. There is no placenta connecting the embryo to the mother. The marsupial infant is poorly developed at birth and needs a period of further development in the pouch where the mammae are situated. Examples of this group are the Koala Bear, Kangaroo, wombat and wallaby.

Placental mammals are characterised by the possession of a placenta ensuring nutritive, respiratory and excretory exchange between the mother and the foetus. An additional function of the placenta is the transfer of antibodies from the mother to her offspring thus providing immunity to disease. Because of the placenta, the young are born in a more advanced condition compared with the young of the monotremes and marsupials.
Lactation has many advantages:

- It **protects** the infant mammal from the harsh environment and food shortage.
- It allows the young to **devote more energy to growth** than it could if hunting and foraging for itself.
- It **prolongs** the young mammal’s **apprenticeship in** complex adult skills.
- It allows for the administration of **colostrum** (explained below).
- Lastly it **postpones the need for teeth** until much of the jaw’s growth is complete. (The cusps of mammalian teeth need to fit together for chewing. In a growing jaw teeth, would be thrown out of alignment).

**Lactation milk** contains water, proteins, fats and carbohydrates. The proportions of which vary widely between species depending on their needs. For example, milk of the California sea lions has a **53 percent fat** content because of the need for rapid weight gain prior to immersion in the cold seas.

The colostrum is a **complex mixture of anti-bodies, nutrients** and, in herbivores, **bacteria** (to aid in the **digestion of cellulose**).

These compounds are delivered to the **infant via their mother’s breast milk in the first 3 – 4 days after birth**.

In the dairy industry and to a lesser extent the wildlife industry, **artificial colostrums** have been developed to cope with orphaned animals. Infant animals that do not receive their colostrum have a **lower survival rate**.
Reproduction

Reproduction is visited in great detail in many of the accompanying Modules and components. These vary from individual species accounts to generalised group accounts. What follows is a very brief description of the common mechanics and characteristics of mammalian reproduction.

Pairings may be short-lived or lifelong. Mating is monogamous (individuals have only one mate per breeding season), polygynous (male mates with several females during one breeding season) or polyandrous (one female mates with several males).

The timing of breeding is of utmost importance to the survival of the species. It is generally triggered by the effect of day length on the pineal body situated in the brain.

Once the young are weaned, there will be an extra burden on the food resources within the parent’s home range and consequently, in seasonal environments, most species will give birth when food is abundant.
Foot Posture and Feet

This is quite an important topic. It is through different foot postures that many mammals are divided up. This is not only a useful taxonomic tool for modern mammals, but is extremely useful for identifying and classifying extinct mammals and mammal skeletons.

The most primitive foot posture is the plantigrade type. This term is used to describe standing and/or walking on the whole length of the foot. This method is used by man, apes, monkeys and bears.

A more advanced mode is that of the digitigrade position. In this position the heel and instep are raised so that only the digits touch the ground. This is adopted by predatory animals (members of the dog and cat families) and it enables them to move silently.

In ungulates, this process has been advanced further and is an adaptation to running. It is termed the unguligrade mode and allows these mammals to stand right on the tips of their toes which have greatly enlarged nails or hooves.

Plantigrade and digitigrade mammals normally possess four or five digits. The ungulate digits have become reduced to three, two and even one as in the zebra.

A pentadactyl foot is one which bears five digits as in the elephant. It is from this primitive form that two groups of ungulates have evolved: odd-toed ungulates such as the Rhino, having a large middle toe and the even-toed ungulates, such as the giraffe, with two digits of equal size. These and many other related subjects can be found in the other mammal courses.

In the following components of this module many different species and group accounts are given. Hopefully this component will have provided you with some of the basic understanding and scientific terminology that you will encounter in your upcoming exploration of these courses.