CHAPTER THREE

ADAPTIVE FEATURES/ MECHANISMS

Adapt or perish, this looks like the motto of all living beings on Earth. Adaptations do not happen overnight nor developed in the course of an organism's life. Sometimes they happen over millions of years.

Physiological adaptations do not develop during an animal's life but over many generations. Camels depend on their physical features to help them obtain food, keep safe, withstand weather, and attract mates.

Adaptations are changes in an organism's structures or habits that allow it to adjust to its surroundings. Adaptations are special characteristics that an organism is born with and which enable it to survive in its natural habitat. All creatures require habitat. Habitats provide food, water, shelter etc. which are needed for survival. Camels have evolved to survive in deserts and harsh environments. They are the perfect example of how animals have evolved to suit their environments because of their abilities to survive in harsher desert environments for so long, where other animals, humans included, would perish.

3.1. Anatomical/Morphological Adaptation

Head: The **head** of the camel is small in comparison to that of other domestic animals. It bears no horns.

Ears: camel has small bluntly erected ears which can hear the minimal sound vibration for long distance in the desert. Hence, camel's hearing is acute.

Camel's ears are lined with fur/hair to filter out sand and dusts blowing into the ear canal. The small hairs also helps to warm the air entered the ears in sandy environment.

Eyes: a camel's eyes are large, with a soft, doe-like expression. The prominent eyes enable the camel to see in different directions and for long distances. Eyes are protected by a double row of long curly eye lashes that also help keep out sand and dust, while thick bushy eyebrows shield the eyes from the desert sun.

Nose: the nostrils of the camel are long slit-like appearance having wing (hairy slit). In this regard the camel is the only animal that can close its nostril as protection against sand and winds. A camel's nasal passages are protected by large muscular nostrils that can be opened and closed at will. When a camel twitches its nose, it is cooling the incoming air and condensing moisture from its outgoing breath. This helps them to control the body temperature.

Mouth: camel has a large, tough, very sturdy, very leathery and strong mouth able to chew thorny desert plants. The mouth contains 34 sharp teeth which enable the animal to eat rough thorny bushes without damaging the lining of its mouth. Teeth can be used as biting weapons against predators.

Lip: the mobile and prehensive split upper lip of camel enable to avoid the injuries of the desert plants. The upper lip is split and hairy, extensible and slightly prehensile, and very sensitive. This modification helps the camel to select its food (selective feeding) and avoid the thorny plants. The camel jaw and dental pad enable it to seize and tear branches off trees if required.

Tongue: The tongue is very leathery, strong, small but mobile with numerous hard papillae that assist in the mastication and ingestion of food. Therefore, camels can eat vegetation with thorns or cactuses, which most other mammals avoid. Even though camels can resist thorns to some extent, they are not completely immune to them, and feeding on very thorny species is a slow business.

Neck: The camel has a long arched neck helping him to manipulate the high tree plants and to explore the enemy from long distances.

Oesophagus: The oesophagus of camel has a large potential diameter with much mucus secreting glands. The oesophageal anatomy assists in the movement of hard materials without causing irritation to mucosa. A camel gulps down its food without chewing it first, later regurgitating the undigested food and chewing it in cud form.

Legs (limbs): long, thin legs of a camel have powerful muscles which allow the animal to carry heavy loads over long distances. The relatively long and slender legs are an adaptation, perhaps to a long easy gait in sandy environment, and to adaptive cooling.

More than 65% of the camel's total weight is supported by the front limbs. A camel can carry as much as 450kg, but a usual and more comfortable cargo weight is 150kgs. It is usual for a camel to work as a beast of burden for only 6 – 8 months of the year. The remainder of the time it needs to rest and recuperate.

Feet: The foot of the camel is well designed to cope with the loose sandy soils of the desert. Camels have broad, flat, leathery pads with two toes on each foot. The camel foot is excellent for movements on sand and less suitable for traversing stony desert although some hardening occurs in animals habituated to this kind of country.

The presence of the peculiar horny pads on the elbows, stifle and chest prevent more injuries to camel from the stony desert. When the camel places its foot on the ground the pads spread, preventing the foot from sinking into the sand. The foot stays out on taking the weight of the camel and thus acts as a firm base for levering the weight forward to the next stride.

When walking, the camel moves both feet on one side of its body, then both feet on the other. This gait suggests the rolling motion of a boat, explaining the camel's “ship of the desert” nickname.

A camel’s long legs are physical adaptation against the heat. The long legs keep camel above the most intense layer of heat rising from the ground.

Chest: the chest is deep and narrow which allows the balance to be shifted easily, so that it is directly over the weight bearing foreleg during locomotion.

Hard skin: thick callus-like bare spots of dry skin appear on a camel's chest and knee joints when the animal reaches five months of age. These leathery patches help support the animal's body weight when kneeling, resting and rising.

Hump: Hump is used to store fat, which is converted from excessive nutrients that camels do not need. When food is hard to find or when a camel needs additional food or water, they metabolize the fat in their hump(s). When this tissue is metabolized, it is not only a source of energy, but yields water. This allows them to survive without water for about two weeks, and without food for up to a month. When a camel uses its hump fat for sustenance, the mound becomes flabby and shrinks. If a camel draws too much fat, the small remaining lump will flop from its upright position and hang down the camel's side. Food and a few days' rest will return the hump to its normal firm condition.

Hair: The skin is covered with short fine hairs (waber). The layer of fur on the camel serves as layer of insulation and protects their skin from the harsh, scorching desert sun (prevents excessive heat gain by reflects sunlight, i.e. thermoregulation) and provide warmth during the cold desert nights. The fur may be longer in cooler climates or during the cool seasons in hot areas.

Colour: Camel's skin and fur has the same or similar colour to the desert, either dark-blonde, sandy or tan. Camels are also camouflaged.

3.2. Physiological adaptation

Physiological adaptation is a physiological processes involved in adjustments by the individual to climatic changes and changes in food quality, etc. Numerous adaptations have allowed the camel to survive the incredibly harsh environment of the desert.

Heat storage within the body of the camel, selective brain cooling, concentrated urine from unique kidneys, fur, respiration mechanisms (do not pant, perspire very little) and hormones all serve as important characteristics for the camel in terms of thermoregulation.

1. Heat storage (heat tolerance)

Camel has the ability to have a large fluctuation in its body temperature. During the day, when it is exposed to high temperatures, its body acts as a heat sink, and during the cool night of the desert, excess body heat is dissipated by radiation and conduction. In general dromedary camel's body temperature rises several degrees during the day and falls slowly during the night. The heat stored during the day (which causes drastic body temperature fluctuations) is dissipated at night. No other mammal can do this. The camel's body temperature is often lower than air temperature.

Two essential mechanisms are implicated in heat tolerance: adaptive heterothermy and selective brain cooling.

Adaptive heterothermy

Adaptive heterothermy is a process which reduces evaporation by storing body heat, ought to be enhanced by ambient heat load and water deficit.

The camel is able to fluctuate its body temperature between 34°C and 42 °C. The daily body temperature of hydrated camel fluctuates by only 2 ºC. The dehydrated camel's temperature will differ by as much as 7 ºC to prevent water loss through evaporation. In other words, camel can raise its body temperature tolerance level as much as 7ºC before perspiring, thereby conserving body fluids and avoiding unnecessary water loss. The perspiration in camel is limited and takes place only when body temperature reaches 42°C.

Selective brain cooling

Maintaining the brain temperature within certain limits is critical for animals; to assist this, camels have a complex of arteries and veins lying very close to each other which utilizes countercurrent blood flow to cool blood flowing to the brain.

Selective brain cooling is the reduction of brain temperature below arterial blood temperature. The camel has the ability to resist intensely high body temperatures without damaging its brain. The brain is one of the most heat sensitive parts of the body. Consequently the camel uses selective brain cooling so that it can keep the brain at a lower temperature during times of heat stress than the rest of the body. The brain cooling system provides protection for the brain in extreme temperatures and allows the camel to survive in temperatures that would normally be lethal to the sensitive brain.

How selective brain cooling is conducted?

When a dehydrated camel inhales, air flows over its large nasal surfaces, drying them out and consequently forming a layer of dried out mucous and cellular debris on the nasal surfaces. These dried out secretions are hygroscopic and therefore, take up water from the exhaled moist air coming from the lungs. Water is extracted from the exhaled air and therefore the camel's breath is dry. The large camel nasal surface absorbs the vapor and cools a network of small blood vessels, named the '**carotid rate'**. This carotid vessel network surrounds the **jugular vein** and cools its blood. On the way to the heart the cooled venous blood meets the warm arterial blood going to the brain and eyes, cooling it by more than 4 ºC ('counter current' effect). In this regard, the brain temperature of the camel is 4ºC lower than body temperature.

2. Dehydration adaptation

Camelus dromedarius can withstand considerable dehydration. In a hot environment it can tolerate a loss of 25 to 40 % of its body weight through dehydration. Such kind of dehydration brings other mammals into lethal explosive heat rise. The limit for dehydration of the camel is unknown. The dehydration adaptation in camel is both by plasma volume maintenance or water economy (lower water turnover).

Plasma volume is maintenance

When the camel becomes dehydrated the loss of water is not accompanied by a proportional loss in plasma volume. The camel possesses the ability to maintain a constant plasma volume throughout periods of fluctuation in drinking water availability. The maintenance of a high plasma volume facilitates circulation (which is one of the first functions to suffer during

dehydration of other animals in hot environments). No other mammal could live with blood as thick as that of a camel in a severely dehydrated state.

What makes this possible is the shape of a dromedary camel's red blood cells. A camel's red blood cells have an oval shape, unlike other mammals, which are circular. The advantage of having oval blood cells is that they continue to flow through the bloodstream after a camel becomes dehydrated. Circular blood cells clump together when plasma levels drop too low, and these clumps form clots that cause heart attacks, or strokes.

Water economy (lower water turnover) Water balance

The dromedary resistance to dehydration is not only related to its biological and behavioral characteristics but also to water economy. Camels have often to survive on limited quantities of water for long periods of time. Under very hot conditions, it may drink only every 8 to 10 days. A camel can go 5-7 days with little or no water and can survive up to 2 weeks without water.

Camel need very little water if their regular diet contains good pasture rich moisture. When water is available the camel will quickly drink to replace losses, showing few signs of stress. They can drink a very large amount of water at one session (as much as 100 litres in ten minutes) to make up for previous fluid loss. Such an amount would result in severe osmotic problems and kill another mammal. Camels can do this because water is absorbed very slowly from their stomach and intestines, allowing time for equilibration. The camel also possesses the ability to maintain a constant plasma volume throughout periods of fluctuation in drinking water availability.

The dromedary has a lower water turnover or water economy in comparison to others species and is able to reduce the water losses in different ways: cutaneous (sweating limited), respiratory (camels do not pant), digestive (reduction of salivary secretion, which can decrease from 80 to 16 liters/day

in a dehydrated camel) and urinary (reduced urine production and increased urine concentration).

Very important physiological aspect of the ability of camels to conserve water is their production of small, hard and very dry droppings. Camels lose only 1.3 liters liters of fluid daily through feces, whereas cattle lose 20 to 40 liters of fluid daily through feces. This is one of the primary methods for resisting water deprivation in the desert.

Reduced urine production and increased urine concentration

The structure and function of the kidneys are extreme importance in water conservation. The long loops of Henle in the medulla have the function of both concentrating urine and reducing its flow. The kidney controls water loss either by the absolute concentration achieved or by reduction in flow of urine (urine can become as thick as syrup and have twice the salt content of sea water). Concentration of urine not only serves to conserve water but allow camels to drink water even more concentrated than sea water and to eat very salty plant that would otherwise be poisonous. A reduction in urine flow is also achieved by reducing the glomelular filtration rate from a norm of 55-65 ml per 100kg body weight per minute to 15 ml per 100kg per minute.

A dehydrated camel urinates’ only drops of concentrated urine being shown by white stripes of salt crystals on the hind legs and tail. This concentrated urine not only serves to conserve water, but also allows camels to drink water which is more concentrated than sea water (above 3% NaCl), and to eat salty plants (halophytes) that would otherwise be toxic.

3. Rehydration capacity

Camel posses an enormous drinking capacity and is capable of drinking at any one time a volume of water equivalent to as much as 30 per cent of its body weight.

After periods of water restriction replenishing water losses is important. In some mammals rehydration is rapid while in others it is much slower. Man and rats belong to the group of animals that cannot rapidly replenish their water losses. The dog, sheep, donkey and camel belong to the group that replaces their water losses rapidly. When water is available, whether fresh or brackish (salty), camels drink well. The 600 kg camel replenished its entire deficit of 200 liters of water in 3 minutes which has occurred after 14 days without water.

Sheep after losing 25-31% of their body water replenished only after 2 days. The cessation of drinking in most animals is, therefore, not determined by the entry of water into the blood stream. In fact, except for the camel, no animal has a rapid entry of water into the blood. Camel replaces its water losses rapidly.

Rapid absorption of water into the blood stream is not safe physiologically to many animals. But camel’s erythrocytes are extremely resistant to hypotonicity and haemolysis. Camel’s red blood cells are very elastic (which can expand up to 200 times) and oval in shape contrary to disk (round) shaped of human and cattle red blood cells.

3.3. Behavioral Adaptations

The behavior of camel is unpredictable at best. Camels have the reputation of being bad tempered and obstinate creatures that spit and kick. In reality, they tend to be good tempered, patient and intelligent. The moaning and bawling sound they make when they're loaded up and have to rise to their feet is like the grunting and heavy breathing of a weight-lifter in action, not a sign of displeasure at having to do some work.

Ingestive behavior: camels are selective feeder not only with regard to plants but also in respect of the parts of the plants they eat i.e. they select only a few leaves from each plant and ingest the foliage parts. The natural selective feeding habits of the camel are considered the morpho physiological adaptation of the camel's digestive tract.

Camels' have an adaptive mechanism that compensate long period of poor quality food and water deprivation. It can take in a very large amount of water at one occasion for compensating previous fluid loss and is able to drink 200 liters in 3 minutes.

Thermal behavior: There are a number of behavioral factors which are thought to contribute to the conservation of water. Camels tend to remain lying down in the same spot from early morning, when the ground is still cold. They tuck in their legs while lying down, so that it absorbs little heat from the ground by conduction. Camels often align themselves with the sun's rays, only shifting position to maintain this orientation. They also tend to huddle (come close) together in one large group, as if in an effort to form a single organism with only its dorsal surface exposed (presenting the least possible body area for the absorption of radiant heat).

Sexual behavior: the camel's reproduction is characterized by a seasonal activity. During the sexual seasons, the male is very aggressive and presents some characteristic signs like the extrusion of the soft palate and becomes very vocal. Occipital glands (neck glands) become active and secrete a brownish liquid during sexual activity which attracts females.

Mating behavior: The male sniffs and bites the vulva and other parts of females' body prior to attempting to copulate with her. The male rotates his penis until the vulva is found and does not thrust into female in violent manner during intercourse. The whole sex act lasts as long as 35 minutes and usually consists of several entries. The male may exhaust himself on the female if he is not removed by handler. Both sexes are noisy during the act

and males particularly very noisy. The sexual act takes place with the female on the ground, which is unusual position for domestic animals.