High Altitude Adaptations in Mammals. and in diving mammals

Introduction - The physiological, morphological and biochemical characteristics of several species of mammals residing at high altitude are similar to their sea level counterparts. The adaptive process is complex and made up of several components these components are interrelated the morphological physiological and biochemical adaptation are all help to counter hypoxia or to help in surviving at low oxygen level. Some of the most remarkable adaptations are discussed below —

① Circulatory adaptation - Data from calf and llama show that in these species there is a marked increase in heart rate but only moderate change in cardiac output. The hemodynamics of pulmonary circulation in various species age at altitude has received considerable attention with regard to smooth muscle response to hypoxia. The animals native to high altitude have a higher oxygen saturation than their sea level counterparts.

② Lung development - Studies on sheep and guinea pigs showed a slightly greater mean alveolar diameter, diffusible surface area to lung volume ratio, the total lung capacity in the altitude population showed that in hypoxic rats mean lung weight, alveolar surface area, and alveolar number were slightly greater than in normal animals.

Tissue capillary density – There is some sparse evidence that hypoxic environment may cause a slight decrease in oxygen requirements in mammals. This is called "respiratory dependence) This is brought about by decrease in the distance between capillaries, a condition that compensates for the reduction at altitude of the oxygen tension difference between the capillary blood and the mitochondria

myoglobin Concentration – A recent study in diving mammals has shown that they have a higher myoglobin concentration than terrestrial mammals

Physiological adaptations – Oxygen is transported from the environment to the cells by means of four linked mechanisms (Lenfant and Sullivan 1971) Ventilation Pulmonary diffusion Circulation and tissue diffusion. During life at altitude there are several physiological adjustments of these mechanisms that compensate for the decrease in availability of environmental oxygen

Respiratory adaptations – In all mammals minute ventilation is determined by oxygen demand and regulated by neural and chemical stimuli. One of the latter is partial pressure of oxygen, a decrease of which is characteristic of altitude

Hematological adaptation – The hematological adaptations considered are blood-oxygen carrying capacity and the haemoglobin affinity for oxygen. There is an increased

oxygen ~~ca~~ carrying capacity (increase in haemoglobin Concentration) was observed by Muntz (1911) in all of the mammalian species living at higher altitude.

Body morphology - The natives of high land have a significantly small build than the low landers. Differences in size and rate of growth between sea level and high altitude specimens have also been observed in rabbits, rats and in guinea pigs.

Biochemical adaptations - There is overwhelming evidence that some significant subcellular changes and alterations of the metabolic pathways takes place at species living in higher altitudes -

Oxygen requirement - There is an increased concentration of myoglobin in high altitude natives as compared to their sea level counterparts. Myoglobin concentration is an important component of the adaptation to chronic hypoxia.

Subcellular adaptations - Since oxygen is consumed at the subcellular level ie. by the mitochondria, It is important to determine whether the mitochondria and some of the metabolic substrates are modified. A recent study reveals in the slight in the mammalian heart acclimatized to high altitude. The number of mitochondria increased and enhances the intracellular diffusion process while the increase in enzyme

concentration suggest a higher rate of oxygen utilization. Similar observations have been made in diving mammals and been related to their diving capability.

Conclusions – The review of the high altitude adaptive mechanisms in mammals leads to several conclusions –

1) The adaptive process is complex being made up of ~~physiolog~~ physiologic, morphologic or biochemical in nature.

2) No single component can explain the completeness of the species adaptation whether new comer or native. This is exemplified by the position of the oxygen dissociation curve (Physiological adaptation) that is correlated to the capillary density (morphological adaptation) due to the critical P_{O_2} (bio chemical adaptation)

3) It appears that neither physiological nor morphological changes can fully explain the mechanisms of adaptation to altitude. The extreme tolerance of the the diving mammals to severe hypoxia, even though they do not have the benefit of the physiological adaptation found in residents at high altitude.