

Chapter 10

SOME GENERAL CONSIDERATIONS

With the increased realization of the importance of the fat body in the metabolism of insects, this tissue in insects is often regarded as equivalent to the liver of vertebrates. The studies presented in the preceding chapters though do not claim to provide complete answers to the many leading questions that are raised regarding exact functions of this tissue in insects, the investigator considers this an attempt to peep into the hitherto less known quarters of our knowledge of the physiology of this tissue.

In histological and histochemical studies undertaken, though with the aid of a light microscope and not with an electron microscope, ^{revealed} certain interesting organizational features of the cell structure and enzyme systems of the insect fat body. Free lipid droplets are known to occur in many different cells and tissues of the animal body and are generally restricted to the cell cytoplasm. The biological significance of cellular lipid droplets has been extensively studied in vertebrate tissues like the adipose tissue, the liver and the steroid producing glands. The orthopteran fat body is concerned principally with the storage ^{of} lipids as fuel reserves for the whole animal and there appears to be a continual chemical turnover of lipids though gross mobilization occurs only under certain circumstances. The fat body, thus seems to be in a

dynamic steady state. The mechanisms by which this state is maintained in animals are varied and less known.

The major constituent of the lipid store in the fat body seems to be neutral fats. Phospholipids and cholesterol are also present in appreciable concentration and there seems to be a definite pattern of the spatial distribution of glyceride fats and phospholipids in the cell. Phospholipids form the periphery of the fat globules as well as surround the nucleus. Some amount of fat may also be present in the cell nucleus under certain conditions.

Fat body may be concerned with protein synthesis as well. Ribonucleic acid is found in considerable quantity in the fat body of Poicelocera picta. However, this property may not be universal among the insects because ribonucleic acid was almost absent from the fat body of Periplaneta. The urate cells have rich RNA in their cytoplasm but the cytoplasm of oenocytes contain no RNA. The urate cells and the oenocytes, thus seem to be functionally quite different.

The intense phosphatase activity and its spatial distribution namely, acid phosphatase in the nuclei and alkaline phosphatase in the cytoplasm, is worth investigating further.

It is known from the studies of the vertebrate adipose tissue that certain mammals contain two types of adipose tissue (brown and yellow) which differ considerably

in their structural features as well as metabolic activity. The orthopteran fat body could be classified as white and yellow types. The white type (Periplaneta) differed greatly in its structural features as well as metabolic activity from the yellow type of fat body (Poicelocera, Schistocerca).

The white fat body cells have smaller nuclei, lack yellow pigmentation and oenocyte cells and usually are uninucleated. The cell cytoplasm is free of RNA basophilia. The enzymes like lipase and alkaline phosphatase and acid phosphatase are less in quantity. The fat globules in the cytoplasm are of varying sizes and usually a larger fat globule is surrounded by smaller ones. The yellow fat body cells have very large nuclei, contain yellow pigment and oenocytes and the cells may be binucleated. The cell cytoplasm is rich in RNA basophilia. Enzymes like lipase and phosphatases are in greater concentration. The fat globules in the cytoplasm are of uniform size. The nature of the fat in the two types of fat body, however, could not be ascertained. The urate cells which were found in the cockroach fat body were absent from the fat body of Poicelocera. In both the types the nuclei were centrally situated in the cell and not shifted to the cell boundary.

One of the fundamental characteristics of the organization of the animal system is the ability of adaptations to environmental alterations and the capacity of self regulation which results in the maintenance of a dynamic steady

state. To maintain this dynamic equilibrium or homeostasis the animal must have the capacity to alter the rate of metabolic reactions which underlie the different physiological processes. Since most of the metabolic processes are mediated through the activity of specific enzymes, it is necessary to investigate the role of enzymes in the maintenance of this homeostatic dynamic steady state. A study of the biochemical events during prolonged starvation can be utilized to explore the metabolic adaptations which the animal undergoes. Food reserves in the fat body are in a dynamic steady state. The animal can draw upon these only during certain circumstances and starvation is the one factor during which most of the lipid store gets depleted from the fat body. When Periplaneta was starved for a period of 30 days, drastic changes were observed in the fat content of its fat body. This fat depletion could only be possible if changes in the activity of the fat splitting enzyme, lipase, in the fat body could be brought about. Changes observed in the lipase activity during the period of 30 days starvation was interesting. The activity increased during the earlier period and gradually fell during the later period of starvation. Changes in lipase activity was also observed during ovarian development in Poicelocera when gross mobilization of fat takes place. Thus, increase or decrease in the enzyme activity is brought about by some means which acts to maintain the homeostatic state of the fat body.

The enzyme activity at any given time is the result

of the dynamic interactions of co-factors, co-enzymes and substrate level on one hand and the enzyme concentration on the other. Changes brought about in any one of the above will alter the reaction. This regulation may be hormonal or non-hormonal.

The depletion of the lipid material and the increased lipase activity in the fat body of starved cockroaches points to the fact that the enzyme concentration regulates the mobilization of the fat. This is true as long as the substrate is present in excess. The fall in lipase activity in the later period of starvation represents an enzyme system operating at a low substrate concentration. But the physiological significance of the changes observed in the lipase activity during starvation in Periplaneta and that during ovarian development in Poicilocera appears to be quite different.

The possible relationship between the endocrine factors and enzyme systems is important in the intermediary metabolism. Several studies have been made on this aspect in vertebrates but in insects not much is known. Hormones may act through biocatalysts and influence a sequence or a chain of chemical reactions by acting on some key reactions in the system. The starvation effect on lipase activity observed in the fat body of Periplaneta is of importance since it has been suggested (chapter 6) that one of the factors responsible for the fat depletion is lipase. It is possible, therefore, that a hormonal factor may control this process (fat depletion) by acting on lipase.

The neurosecretory cells of the brain, the corpora cardiaca, the corpora allata are all known to control many metabolic processes in insects. The medial neurosecretory cells and the corpora allata have been thought to be concerned in fat metabolism (Thomsen, 1942; Bodenstein, 1953). The corpora allata is also known to be involved in various phases of protein and carbohydrate metabolism (L'Helias, 1953a, b; 1956; Wang and Dixon, 1960). The changes observed in the medial neurosecretory cells in the brain of Poicelocera (chapter 9) may well be interpreted as influencing the corresponding changes that occur in lipase activity and fat and ribonucleic acid contents of the fat body of the animal during ovarian development. Though direct evidence has not been obtained in the present work, all the same, an assumption to this effect seems feasible.