# CHAPTER 7

## THE RELATIONSHIP OF DIETARY PREFERENCES OF VARIOUS REPRESENTATIVE BIRDS ~~WITH~~ TO THE DISTRIBUTION OF ADENOSINE TRIPHOSPHATASE IN THEIR LIVERS

Dietary preferences of various species of birds have corollary effects on their morphological and physiological adaptations. The morphological adaptations are concerned with feeding habits of the birds, and are seen in the size, shape and structure of beak and claws as well as in the alimentary canal where crop and muscular gizzard are either present or absent according to the type and consistancy of the food ingested. The physiological adaptations are those concerned with gastric, hepatic, pancreatic and intestinal secretions, amount of enzymes present in the secretions, and the rate of absorption and assimilation of various types of digested food materials. Since the liver plays an important role in the assimilation and treatment of the absorbed food, it shows metabolic and enzymic adaptations. The enzymic adaptations are not only reflected in the intensity of their reaction but also in their localization and distribution pattern in the liver lobules.

Though considerable studies have been carried out on the histochemical distribution of various enzymes in the mammalian liver (see Wachstein, 1963) similar studies on the avian liver are relatively few. There are also lacunae in the knowledge of the enzyme distribution pattern in the liver and its correlation with the type of food ingested by birds. ATPase is responsible for splitting of ATP to ADP releasing utilizable free energy. It is now realized that ATPase is a group of enzymes localized in various cellular organelles functioning at different pH optima. ATPase is demonstrated in liver mitochondria (Wachstein et al., 1960, 1962a), in bile canaliculi (Novikoff et al., 1958; Wachstein and Meisel, 1957) and there are several reports on the ATPase of cell membranes. One difficulty in the determinations of specific ATPase in different zones of acinar units of liver lobules, is the apparent participation of nonspecific phosphatases in the splitting of ATP, as well as the presence of different strains of similar enzymes with different optima of substrate concentration and pH. However, the histochemical techniques are useful in locating the sites of enzyme activity rather than the nature of the enzymes (Wachstein, 1963). The present investigation is an attempt to determine whether dietary preferences of birds have any influence

on the spatial distribution of ATPase in the lobules and acinar units of their livers.

## MATERIAL AND METHODS

The birds belonging to different orders were classified accordingly to their diets and could be grouped under four groups viz., carnivores (carrion feeders), insectivores, omnivores and graminivores (vegetable matters, fruits and grains) and from each group a few representative birds were selected (Table I, Chapter 1) for the present study. The birds were shot with an air rifle during morning hours at a time when they started feeding. Since these birds were collected from the University Campus itself, they were immediately brought to the laboratory and the liver from each one was quickly removed. Fresh frozen sections of 12 µ thickness were cut on a microtome mounted in a cryostat maintained at -20°C. These sections were fixed for 10 minutes in 6% cold neutral formalin and were thoroughly washed with distilled water and finally incubated in a medium containing:

20 ml ... of 125 mg ATP/100 ml solution

20 ml ... of 0.2 M tris buffer pH 7.2

3 ml ... of 2% lead nitrate

5 ml ... of M/10 (0.1M) $MgSO_4$

2 ml ... of distilled water

The incubation medium and the method followed were as described by Wachstein and Meisel (1957). After incubating for 60 minutes, the sections were washed in tap water, treated with dilute yellow ammonium sulphide, and mounted in glycerine jelly. ~~For~~ As control sections were incubated in the medium devoid of substrate.

## OBSERVATIONS

### GROUP I (Carnivores)

ATPase was seen more or less uniformly distributed all over the liver lobules with its localization around the bile canaliculi in the livers of Vulture and Kite (Figs. 1 & 2).

### GROUP II (Insectivores)

In the livers of insectivores the enzyme localization and distribution pattern was similar to that seen in carnivores. However, amongst the insectivores, Tailor Bird (Fig. 6), Bee Eater (Fig. 5) and Drongo (Fig. 8) showed relatively higher enzyme reactivity whereas that in the Cattle Egret (Fig.3) was relatively ~~little~~ less.

GROUP III (Omnivores)

The localization of ATPase in the livers of omnivores was peribiliary as was observed in carnivores and insectivores. However, in omnivores the bile canaliculi of the periportal areas showed a higher intensity of the enzyme reaction than those in the centrolobular regions (Figs. 9-18).

GROUP IV (Graminivores)

As in the carnivores, insectivores and omnivores the birds of this group also showed a uniform distribution and peribiliary localization of ATPase in their liver lobules (Figs. 20-22).

Thus in general, ATPase activity in the livers of all the birds presently investigated, irrespective of their dietary habits, was seen localized around bile canaliculi but the intensity of its reactivity was varied in insectivores and omnivores.

## DISCUSSION

Though ATPases are present in most of the cellular organelles our interest was to study the ATPase associated with bile canaliculi in the livers of birds with different diets.

From the observations it is clear that as far as the localization of the enzyme is concerned it is peribiliary and the dietary variations and specializations of birds have no influence on it. The presence of higher intensity of reaction around periportal areas in the livers of omnivores, may be due to dilation of bile canaliculi as they approach the portal spaces. Wachstein (1963) reports similar observations in mammalian livers.

The presence of ATPase around bile canaliculi definitely denotes its participation in the bile secretion. The bile salts are formed by the hepatic parenchymal cells and are transported across the wall of bile canaliculi which are then retained there against a concentration gradient. Such active transport of bile salts against a concentration gradient also takes place in the intestine. Active transport against a concentration gradient wherever it takes place, requires energy. Lack and Weiner (1961) and Holt (1964) reported that the transport of bile salts across the intestinal mucosa requires metabolic energy. Faust and Wu (1965a,b,c) concluded from their experiments that with an increase in the bile salts concentration within the mucosa and serosa of rat and hamster ileum, the ATP level registered a fall. Further experiments by the same workers (1966a, ~~1966b~~) proved that bile salts are capable

of increasing ATPase activity which explains the reduction in ATPase levels in the mucosa of ileum of rat during the uptake of bile salts.

Recently Gemmel and Heath (1973) through electron microscopic studies on the biliary and pancreatic tract of the sheep, observed that secretin, which elicites increased secretion of bile and pancreatic juice into biliary and pancreatic tracts respectively, also stimulates ATPase activity on the ductular microvilli. The function of ATPase around bile canaliculi in the livers of birds investigated, in the light of above reports, can be said to provide energy for the transport of bile components into the bile canaliculi.

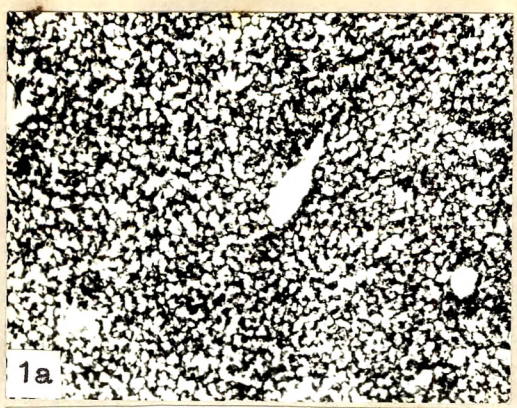
The presence of ATPase around bile canaliculi is observed to be a common feature in the livers of all birds studied, irrespective of their dietary preferences. However, the occurence of a high intensity of the enzyme reactivity noted in some of the insectivores and omnivores suggest enhanced bile secretion which in turn is due to a higher proportion of fat in their diet which requires a larger quantity of bile for its digestion and absorption. Thus the higher enzyme reactivity in the livers of the few insectivores indicated above and almost all omnivores could be explained as a metabolic adaptation of their livers with respect to the diet.

## EXPLANATIONS TO FIGURES (CHAPTER 7)

Figs. 1 to 22 (a & b). Photomicrographs of the liver of birds showing ATPase activity.

Figs. 1a to 22a are magnified 50X.
Figs. 1b to 22b are magnified 125X.

| | | | |
|---|---|---|---|
| GROUP I. | Figs. 1a & 1b. | Vulture (*G. bengalensis*) |
| | Figs. 2a & 2b. | Kite (*M. migrans*) |
| GROUP II. | Figs. 3a & 3b. | Cattle Egret (*B. ibis*) |
| | Figs. 4a & 4b. | House Swift (*A. affinis*) |
| | Figs. 5a & 5b. | Bee-eater (*M. orientalis*) |
| | Figs. 6a & 6b. | Tailor Bird (*O. sutorius*) |
| | Figs. 7a & 7b. | Martin (*H. concolor*) |
| | Figs. 8a & 8b. | Drongo (*D. adsimilis*) |
| GROUP III. | Figs. 9a & 9b. | Brahminy Myna (*S. pagodarum*) |
| | Figs.10a & 10b. | Common Myna (*A. tristis*) |
| | Figs.11a & 11b. | Jungle Babbler (*T. striatus*) |
| | Figs.12a & 12b. | Indian Robin (*S. fulicata*) |
| | Figs.13a & 13b. | Bulbul (*P. cafer*) |
| | Figs.14a & 14b. | Koel (*E. scolopacea*) |
| | Figs.15a & 15b. | House Crow (*C. splendens*) |
| | Figs.16a & 16b. | House Sparrow (*P. domesticus*) |
| | Figs.17a & 17b. | Barbet (*M. haemacephala*) |
| | Figs.18a & 18b. | Fowl (*G. domesticus*) |
| | Figs.19a & 19b. | Duck (*A. domesticus*) |
| GROUP IV. | Figs.20a & 20b. | Parakeet (*P. krameri*) |
| | Figs.21a & 21b. | Dove (*S. senegalensis*) |
| | Figs.22a & 22b. | Blue Rock Pigeon (*C. livia*) |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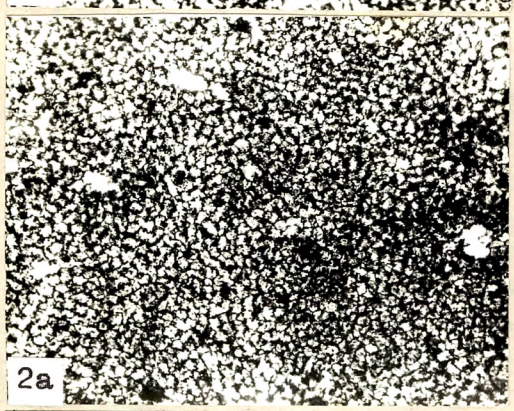
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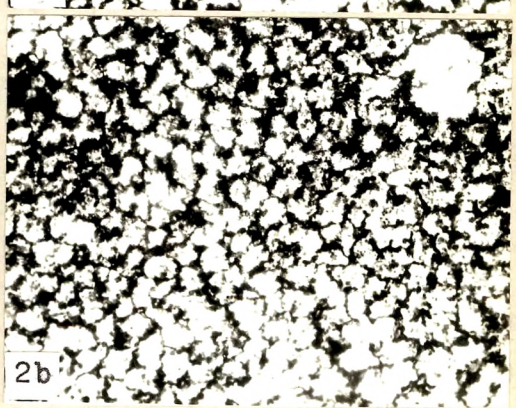
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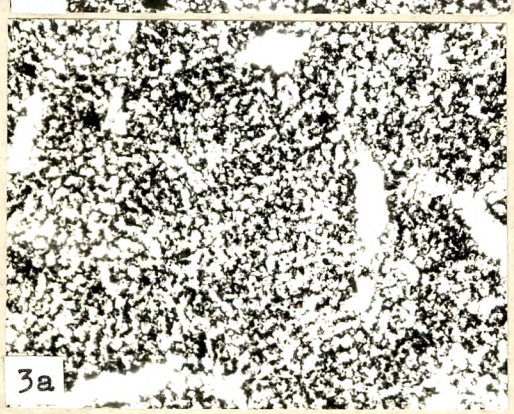
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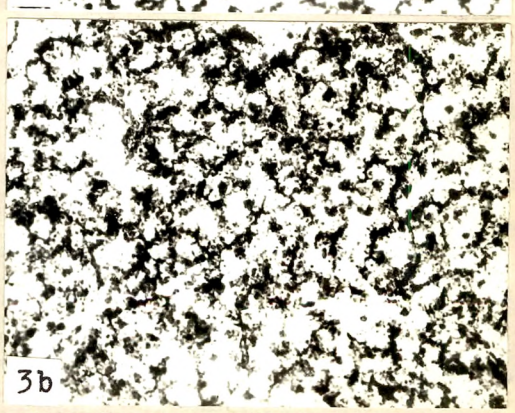
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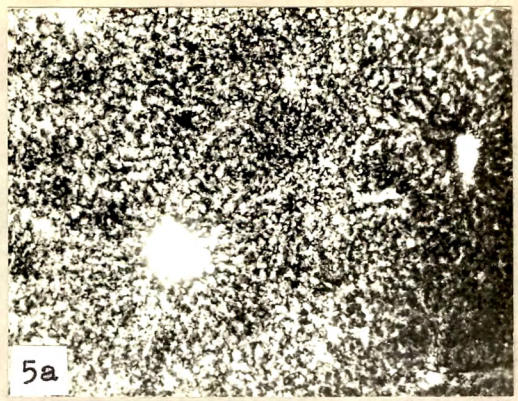
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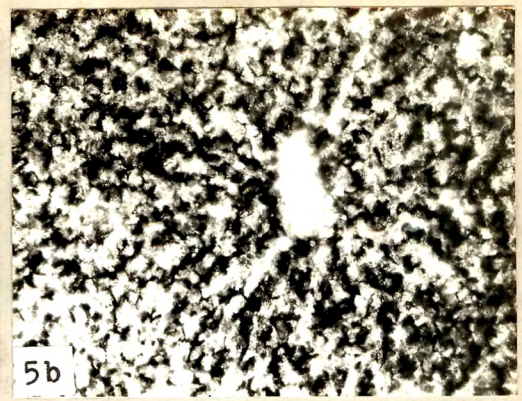
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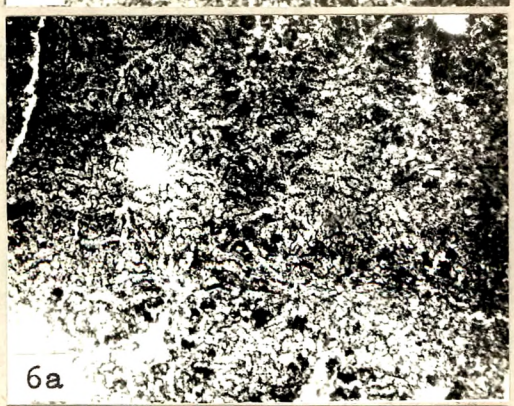
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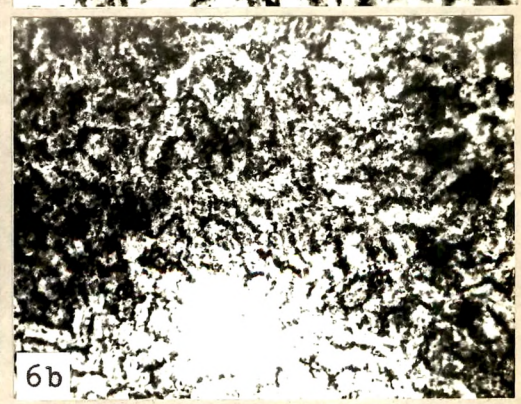
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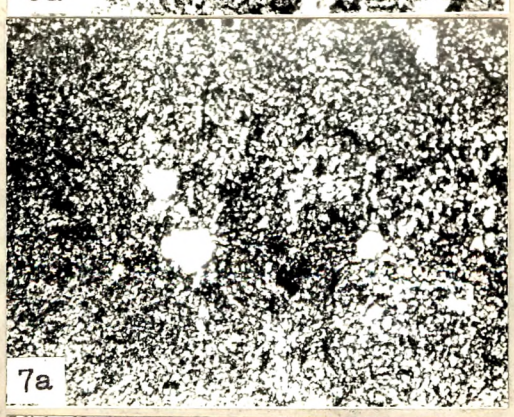
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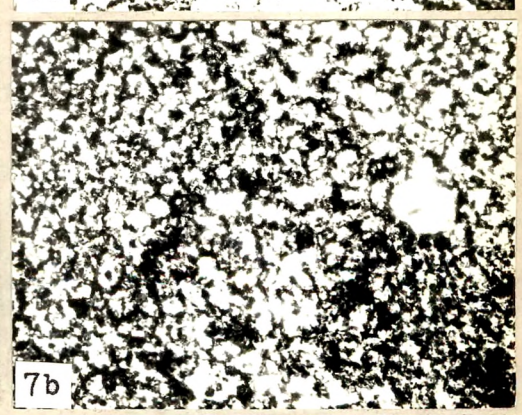
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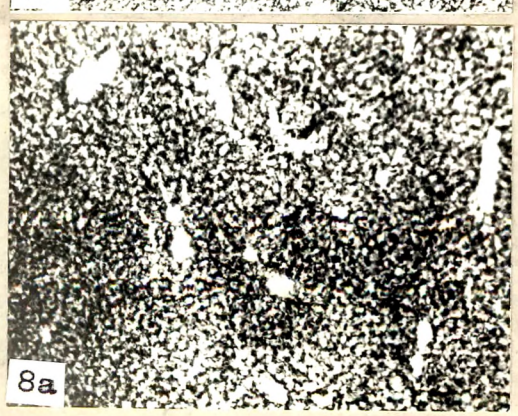
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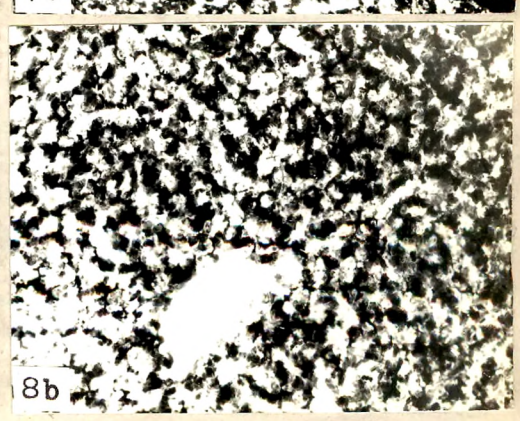
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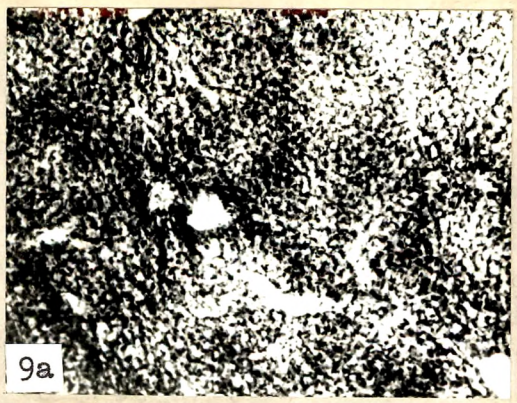
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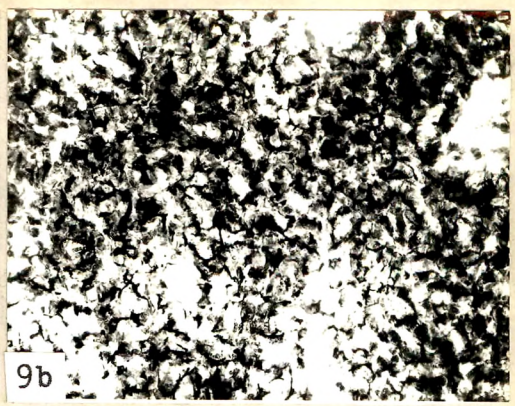
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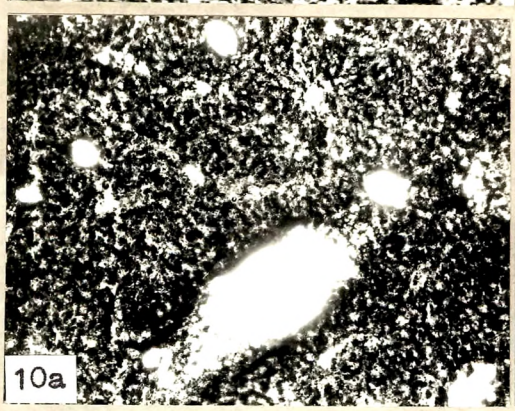
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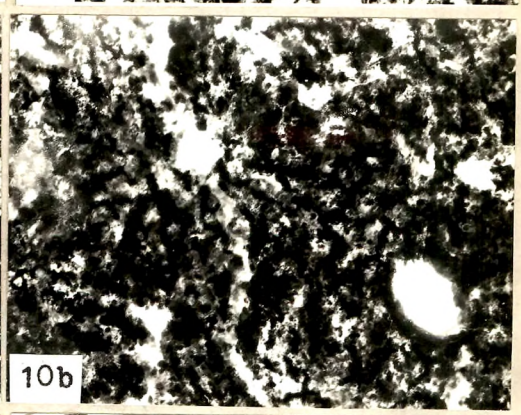
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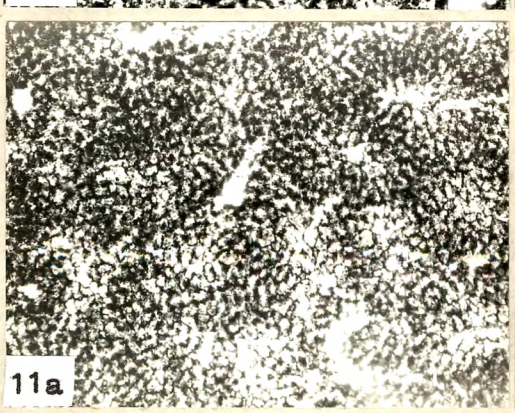
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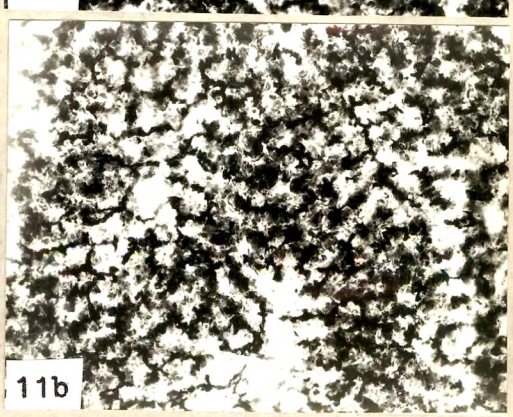
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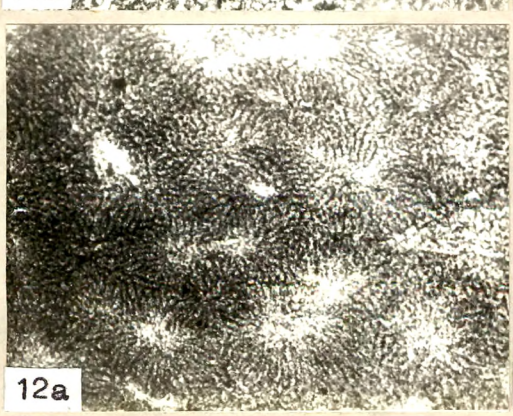
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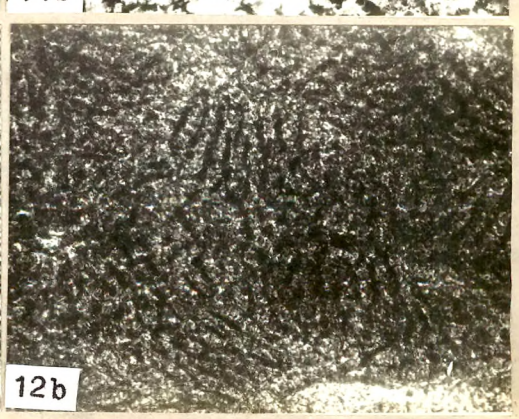
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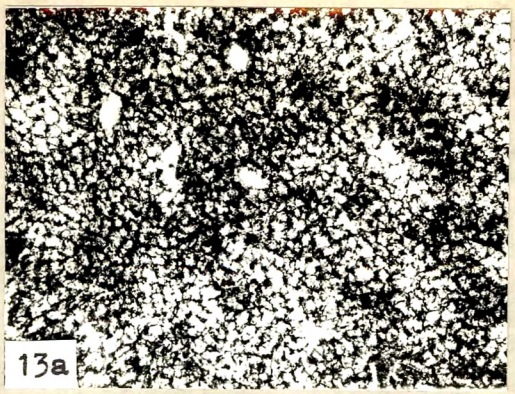
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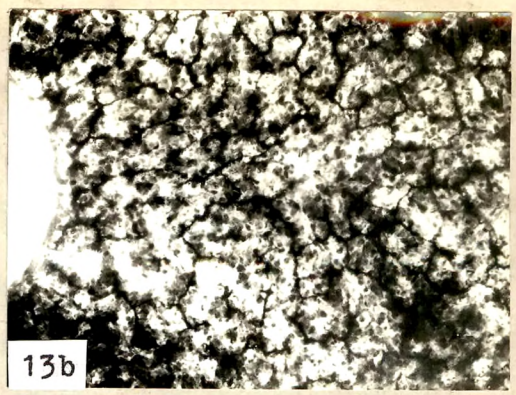
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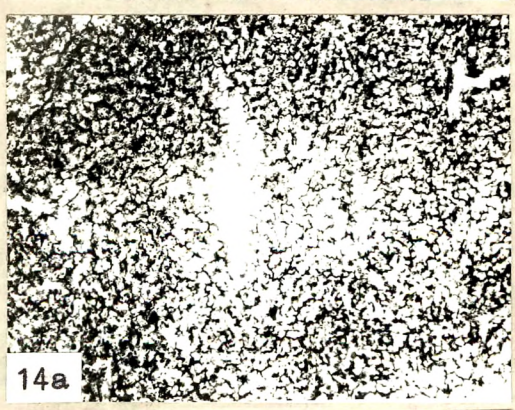
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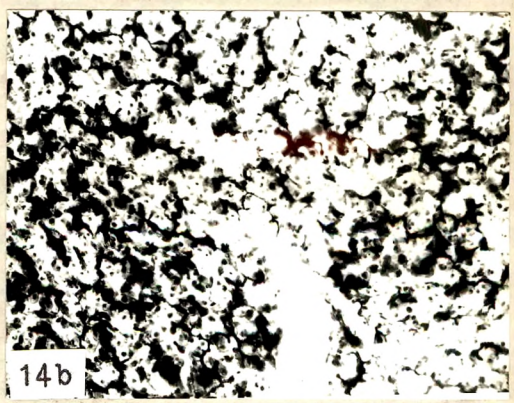
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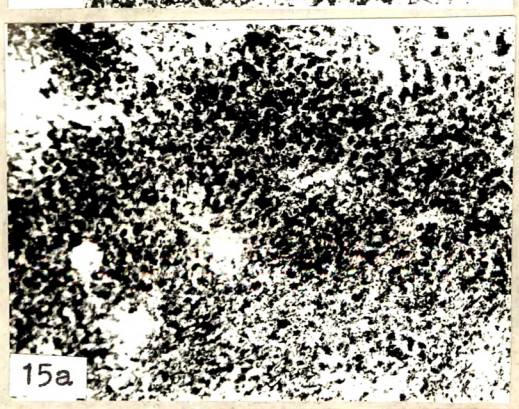
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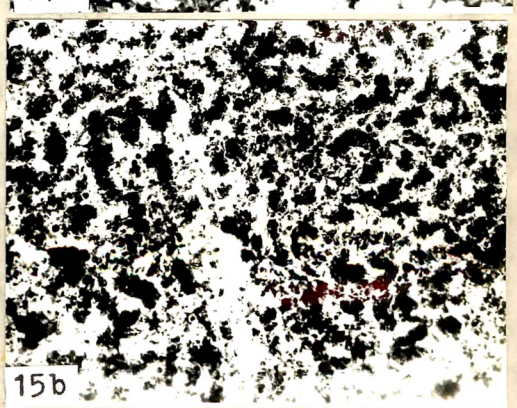
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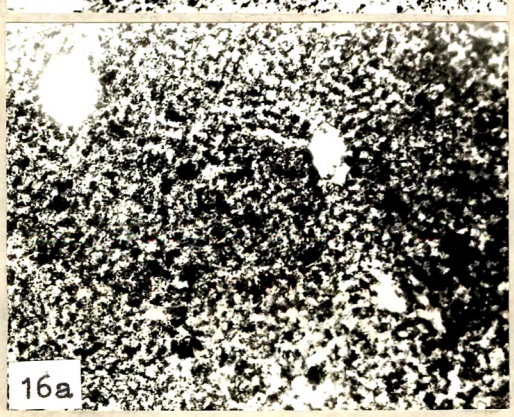
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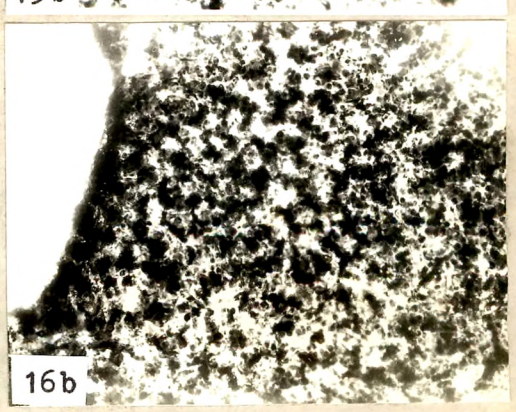
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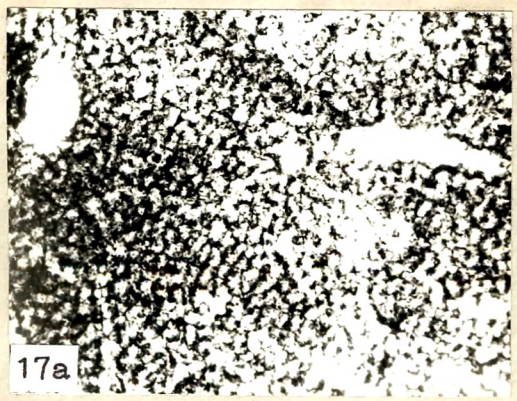

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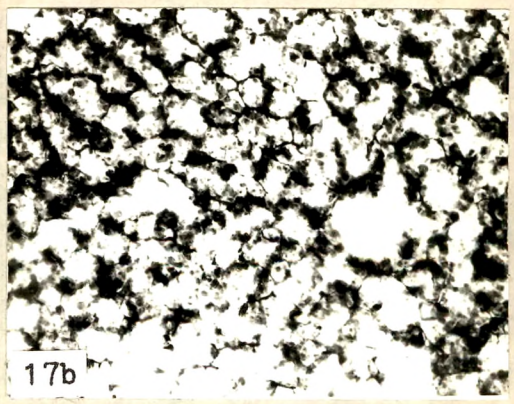

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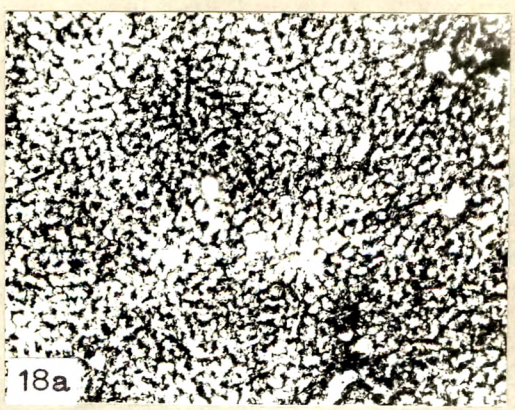

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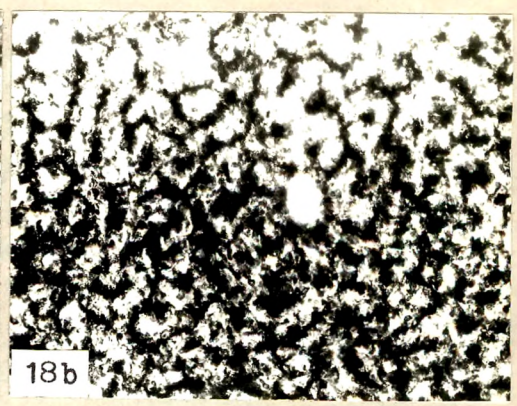

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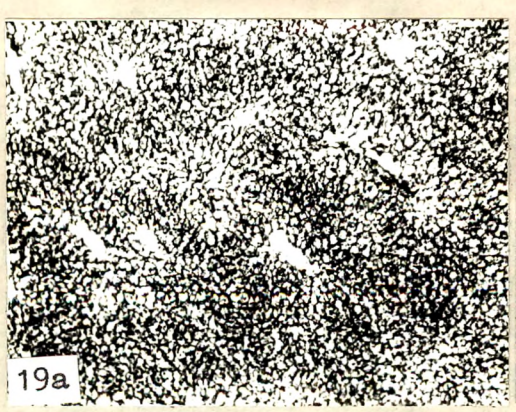

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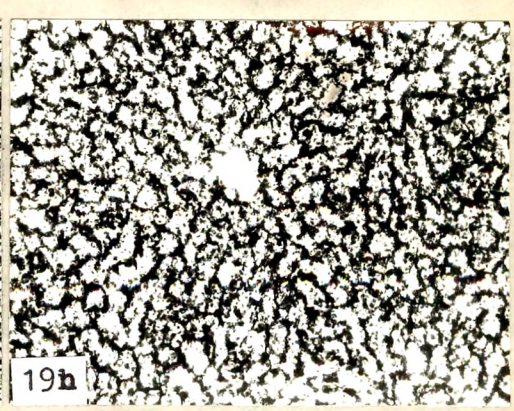

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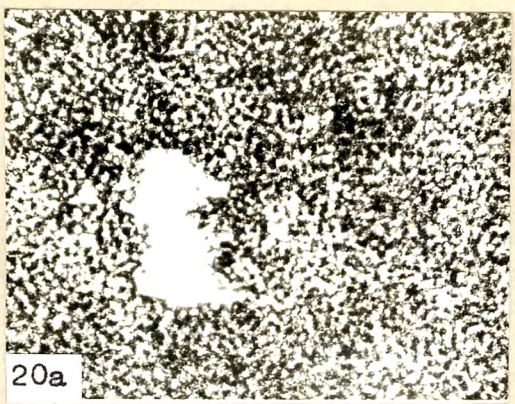
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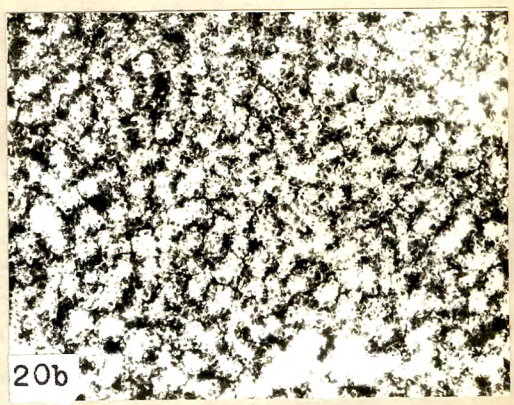
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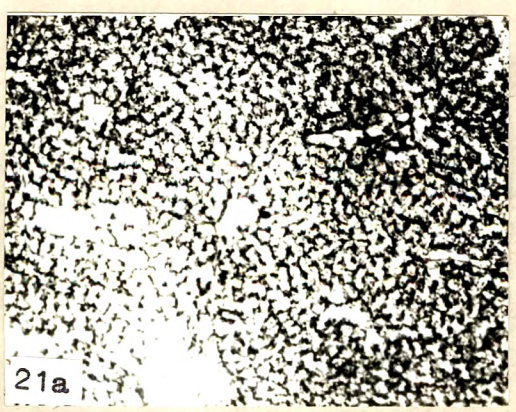
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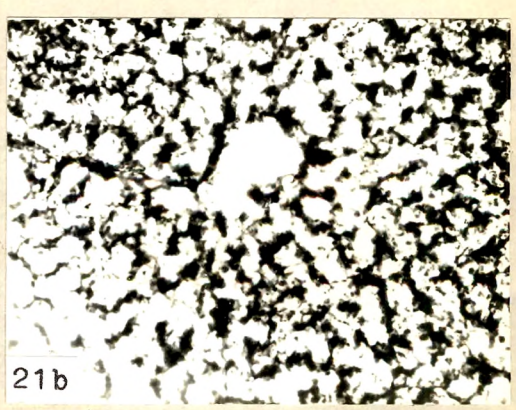
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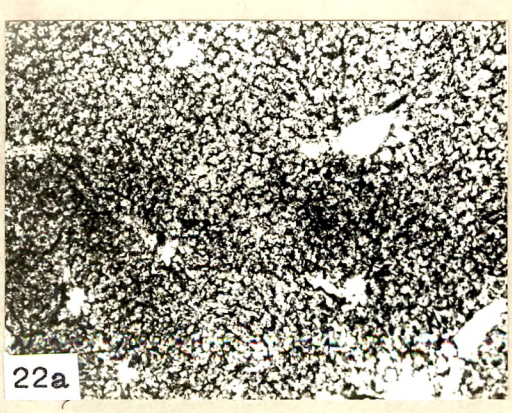
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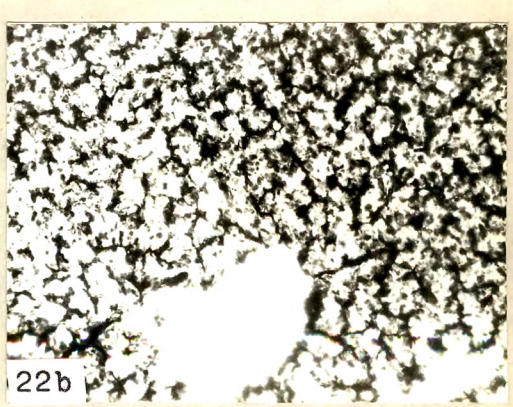
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