INTRODUCTION

In the life span of birds, there are periods when metabolic activities in tissues are altered in response to various types of stimuli. The metabolic activities are generally controlled and regulated through neuro-endocrine mechanisms to cope up with variety of stress and conditions arising from both internal and external environments. A bird such as pigeon passes during development, through periods of several dramatic changes that have direct bearing on the metabolic activities taking place in the body. An embryo develops in an environment of steady supply of stored food carefully packed in that wonderful creation of the nature, the egg. From such a phase of total dependency on the supply of stored food, upon hatching, the young one enters a phase when food is specifically prepared (crop milk of pigeon) or selected and given by the parents. This food meets the initial requirements of protein and other high energy yielding substances, that are essential for the proper growth and maturation of tissues and organs. Slowly, the parents switch the food over to one that is akin to that of adults. The termination of parental food supply, that takes place at a later stage during post-hatching development, renders the availability of metabolites, subject to external environmental factors. As mentioned by Hanson *et al*. (1975), the adulthood characterizes a stage when the bird has to develop a metabolic machinery that must have a considerable flexibility to withstand periods of abundance and starvation, dietary imbalances and harmony, competition and resulting strife, and many other environmental changes, that curb and alter the food chain cycle, while still providing for basic energetic and biosynthetic needs of the bird whether it is leading a quiescent life or undergoing those physiological alterations necessary for survival (thermo-regulation etc.) or procreation.

Hence, whether a bird is in a state of undergoing growth and maturation or in a state of adulthood, there are constant qualitative and quantitative changes in dietary intake. Although, the general feature of metabolic activities during development is that each organ tends to develop physiological adaptation compatible in adult stage, the machinery has to show tremendous viability equally complex and important as that occurs in adult stage. The only difference is that during early development (post-hatching), the dietary changes are predetermined and occur precisely in a time scale as they are brought about by parents, governed by the indestructive instinct, while in adulthood the dietary changes are inconsistent and subjected to environmental factors. In other words, during development, the metabolic changes and adaptations could be in a sequential order and could be anticipatory while in the adults such changes and adaptations have to be on a cause-effect basis.

Biochemical expressions of adaptive metabolic changes are based on modifications in the rates of synthesis of enzymes, their degradation as well as on the quantum and nature of factors that activate the whole enzyme machinery. It is the neuroendocrine systems that bring about short term or long term metabolic adjustments. Like any other physiological adjustments, metabolic adaptations could also be preemptive and anticipatory disregarding the cause and effect relationships, as long as they are also regulated by hormones.

As far as metabolic activities and adaptations are concerned, the liver has a central or key role to play. The metabolic adaptations of the liver are those concerned with gluconeogenesis, lipogenesis, protein synthesis, glycogen synthesis, HMP shunt pathway, glycolysis and lipolysis. Although the liver has the machinery for all these metabolic reactions, at any given time all these pathways need not be operating at a full swing. The maximum activation of any one or several particular metabolic pathways is a function (1) oriented towards maximum utilization of an increasingly available metabolite(s) (2) directed towards maximum synthesis of highly essential metabolites and (3) regulated by hormones and neurohormones. The participating neuroendocrine systems bring about short term metabolic adjustments by activating already existing enzyme complements and the long term adaptations by activating the machinery that synthesize more enzyme molecules.

Depending upon the amount of intake of carbohydrates, protein and fat, metabolic machinery in the liver is adjusted and modulated with the help of neuroendocrine mediators so as to bring about interconversions, storage and utilization of available metabolites. However, such metabolic adjustments in the liver also depend upon the physiological stage and need of the bird. A developing bird needs such metabolic reactions that support growth in the initial stages. In the adult conditions many physiological processes demand specialized metabolic adaptations, especially during moulting, thermogenesis, reproduction and migration. Apart from this, the diet itself could bring about semipermanent metabolic adaptations in the liver; for example a carbohydrate rich diet like the one the pigeon is having, seems to be responsible for a high acid phosphatase activity in the liver (Shah *et al.*, 1972a), neutral fat content (Pilo *et al.*, 1973a), cholinesterase activity (Shah *et al.*, 1972b) and low alkaline phosphatase activity (Shah *et al.*, 1972a). These adaptations are long term adaptations lasting a stretch of time. However, there also has to be ~~a~~ day to day adjustments of the metabolic reactions in the liver in response to increasing or decreasing influence of metabolites, especially glucose. Several endocrine secretions and neural participation are involved in the control of such daily metabolic reactions. Thus, neuroendocrine mechanisms are responsible for the regulation of levels of nutrients by influencing their absorption from the gut, their levels in the circulating fluid, the nature and degree of their deposition in storage tissues and cells, their release from tissues and their incorporation in the structural elements of the body (see Bentley, 1976). In other words during development as well as in adult condition the whole intermediary metabolism could be under neuroendocrine control.

With these backdrop of information and generalizations, it was deemed worthwhile to investigate the metabolic activities of the liver of pigeon during development as well as in the adult condition and the mechanisms that regulate these activities.

RESUME

CHAPTER 1:

Post-hatching development of the liver of young ones of pigeon was studied with respect to its growth rate, liver-body weight ratio, weight of non fat dry tissue and water, fat, glycogen and nucleic acid components of the liver. The maximum rate of growth of the liver occurred during the first 10 days of post-hatching development. Correspondingly, DNA and RNA contents were also found to be very high. A steady increase in glycogen and fat was noticed in the liver during the development period, while water content registered an equally linear decrease. The maximum fat deposition that occurred at 20th day along with a high quantity of glycogen at the same period coincided with the independent feeding attempts of the young ones. It is suggested that following a faster rate of physical growth of pigeon liver in the first 10 days after hatching, the organ achieves its functional maturity, although it takes about 30 days for the pigeon young ones to fly.

CHAPTER 2:

Acetylcholinesterase (AChE) activity in the liver and serum was quantitatively determined in pigeon young ones in the post-hatching development period. The activity of this esterase in the liver is taken as an index for the acetylcholine (ACh) released. The maximum AChE activity was noticed in the liver and serum of 20 day old pigeon. The concentrations of electrolytes (sodium, potassium and calcium) in the liver were also noticed to increase in the 20 day old pigeon. Since there was no increase in the water content of the liver, this ionic increase is considered to be due to the increased permeability of hepatic cell membrane brought about by the ACh released by the cholinergic nerve plexus. Since, the 20 days old pigeon was fed maximally with whole grains by the parents the carbohydrate intake by the bird and glucose uptake by the liver is also maximum at this period. In the histochemical preparations, the AChE reactivity was noticed in the linings of the sinusoids of the liver lobules. The increased ACh release and the concomitant increase in the AChE activity in the liver is suggestive of the participation of ACh-AChE system in the assimilation of glucose. The function of serum AChE, the activity of which was found to be maximum at à time when ACh release was also maximum in the lining of the liver sinusoids, is suggested to be for the hydrolysis of ACh that escape into the blood stream.

CHAPTER 3:

The changes in the ascorbic acid contents of the liver and kidney of growing pigeon young ones were studied in order to understand the correlation of liver growth and time of functional maturity with duration of nestling period. The pigeon young one ceases to be a nestling by about 20th day. The ascorbic acid, necessary for the formation of intra-cellular materials as well as for several metabolic and enzymatic reactions, was found to be maximum in the liver by about 20th day. It is concluded that the liver becomes functionally and structurally mature by the time the birds are about to leave the nest.

CHAPTER 4:

In an attempt to understand the relationship of duration of nestling period and functional maturity of the liver, the activities of lipogenic enzymes such as 'malic' enzyme and G-6-PDH were determined in the liver of post-hatching developing pigeon. The thyroid gland was also studied to reveal its possible function in the development of mature metabolic pattern in the liver.

The cytometric study on the thyroid follicles revealed that the gland becomes more active by 20th day~~s~~ after hatching. At the same time, in the liver, two lipogenic enzymes viz., G-6-PDH and 'malic' enzyme which are known to be influenced by thyroxine also become more active. The peak levels of activities of both gland and enzymes are attained by 20th day when maximum amount of lipid is also deposited in the liver. Since these enzymes are highly essential for the supply of $NADPH_2$ required for lipid synthesis as well as are influenced by thyroxine, correlation could be established between the thyroid function and the liver metabolic or functional maturity. Thyroxine thus could synchronize the functional development of liver so that at a time when the young ones are forced to fend for themselves, the liver is not only metabolically ready but also has managed to deposit~~s~~ a large amount of fat in anticipation of forthcoming cessation of ready supply of food by parents, as well as the bird's active life away from nest.

CHAPTER 5:

Non-specific acid and alkaline phosphatases were measured in the liver and serum of growing pigeon to understand the relationship of enzyme activity pattern to the functional maturity of the organ.

A gradual increase of non-specific acid phosphatase activity in liver of pigeon during development, with a peak at 20th day, could be correlated with its active role in absorption of digested carbohydrate i.e., glucose, by plasma membrane of hepatocytes and resultant active glycogenesis as well as lipogenesis. Meanwhile, alkaline phosphatase activity showed a different pattern. It was at the highest level on the first day after hatching (0.215 unit), and declined during development and remained at a low level in the adult age also. A high level of alkaline phosphatase activity in the liver in the early phase of development could be suggestive of its active role in the hepatic absorption of amino acids and lipids. The presence of some L-Phenylalanine sensitive (I-type) alkaline phosphatase in addition to native (L-type) alkaline phosphatase and stimulatory influence of corticosteroid hormone from cortical cells of adrenal gland which occupies 80-90% of the gland in one day old pigeon, are also suggested to be responsible for keeping high alkaline phosphatase activity in the early age of post-hatching development.

The acid phosphatase activity in serum of one day old pigeon was low but it increased during post-hatching development. On the other hand alkaline phosphatase activity was higher in the serum of one day old pigeon than that found in serum of adult pigeon and was at the highest level on

20th day after hatching, which could be due to hyperthyroidic condition during development at this period.

CHAPTER 6:

A study of SDH, ATPase and LDH activities in the pigeon liver was undertaken with a view to understand how and when the liver preferentially utilizes the available energy for the growth and maturation as well as the hepatic metabolic activities during post-hatching development.

From the result obtained in this investigation it could be concluded that oxidative metabolism increases from one day to 20th day of post-hatching development, while anerobic glycolysis is maximum on the first day and decreases as the pigeon grows in age. Moreover, the increase in the activities of both SDH and ATPase in the liver, indicates that mitochondrial function develops and attains maturity by 20th day of post-hatching life. Further, the data also indicate that the synthesis of ATP molecules (through TCA cycle) and hydrolysis of ATP for energy production (ATPase) run parallel and become hyperactive when liver is showing maximum lipogenesis and glycogenesis, so that ATP produced during endergonic reactions (TCA cycle) could be used in the same cell for the purpose of building the essential macromolecules and other exergonic reactions (which require ATP) such as active transport.

CHAPTER 7:

To establish a relationship of activity of endocrine glands with the post-hatching development of liver, thyroid, pancreas and adrenal were studied in the developing pigeon. It was found that adrenocortical tissue was more in the early stage of post-hatching development. Through the secretion of corticosteroids, gluconeogenesis is maintained during this period. The thyroid gland was more active towards the later stages which coincided with the increased lipogenic capacity of the liver. From the observation on the number of B-islets in the splenic lobe of pancreas it was concluded that insulin release could be high during the period (20th day) when a ~~high intake of~~ carbohydrate rich diet is provided to the nestlings by the parents. It could be reasonably assumed that some of the metabolic changes seen in the developing liver could have been initiated by the hormonal actions.

CHAPTER 8a:

The activity of acetylcholinesterase (AChE) in the liver, pancreas~~s~~, skin and serum of adult pigeons was measured after administration of glucose to understand the degree of release of acetylcholine (ACh) in these tissues in response to a glucose load. The AChE activity showed an increase in the liver, pancreas, skin and serum at 30 minutes after glucose injection when blood sugar, skin glucose and hepatic glycogen content were also maximum. Histochemical studies revealed that AChE was localized in the sinusoidal linings of the liver. The AChE activity was also observed in the sinusoidal spaces of the islets of Langerhans.

It is suggested that in the pigeon liver, the glucose uptake is mainly through the flow coupled transport mediated by ACh, while insulin only plays a secondary role in the regulation of blood sugar level. In the pancreas, ACh must be aiding the release of insulin from B-cells. In the skin, ACh might be having only a vasodialatory influence.

CHAPTER 8b:

The sugar transport to the cells of a particular tissue can be by one or several methods. One of the methods is through flow coupled transport, *i.e.*, the sugar transport is coupled with flow of ions. Acetylcholine (ACh) by initiating the transport of ions can also facilitate glucose uptake. Since the degree of acetylcholinesterase (AChE) activity can be an index of ACh released, AChE was measured in the liver, pancreas, skin and serum of rats following intraperitonial injection of glucose.

At 60 minutes after injection; blood glucose, AChE in liver, pancreas and skin; and glycogen content of the liver were found to be elevated considerably. Serum AChE was found to be high at 30 minutes while skin glycogen was maximum at 90 minutes.

It is concluded that in the pancreas ACh could stimulate insulin secretion, while in the liver it also facilitates glucose uptake, utilizing the energy of Na^+ and K^+ transport stimulated by ACh. Insulin, however, by activating glucokinase brings about faster movement of glucose across the membrane. In the skin, ACh might not be having much influence over glucose transport but may cause vasodialation. The serum AChE is probably meant for the effective removal of ACh released from the sinusoidal linings of the liver lobules into the blood stream and as such becomes more active before the maximum ACh release at 60 minutes in the liver of rats.

CHAPTER 9:

A study of glucose uptake by liver slices of both pigeon and rat under the influence of insulin, acetylcholine and both together revealed that the pigeon liver slices deposited more glycogen when incubated with acetylcholine, while rat liver slices deposited more glycogen when incubated with insulin. From the data it is surmised that the pigeon liver must be having less insulin receptors or having less insulin sensitive hexokinase than rat liver. Due to either or both of these reasons,pigeon liver depends mainly on flow coupled transport for the uptake of glucose and thus has resulted in a lower rate of glucose uptake in pigeon liver than that seen in rat liver. This disparity may be due to the fact that (1) the transport through chemiosmotic mechanism (phosphorylation) mediated by insulin is more efficient than the flow coupled transport that might be predominent in the pigeon liver or (2) the major part of glucose that enters the pigeon liver is converted into other metabolites rather than into glycogen only.

CHAPTER 10:

A study on the response of enzymes such as glycogen synthetase, G-6-PDH, 'malic' enzyme and lactate dehydrogenase was carried out in pigeon liver following glucose injection. It was observed that glycogen synthetase became active at 30 minutes after injection, coinciding with the peak in glycogen deposition in the liver. However, both G-6-PDH and 'malic' enzyme showed an increase in the activities for a prolonged duration indicating that lipid synthesis is a predominent response to glucose load in pigeon. Of the two dehydrogenases, 'malic' enzyme was more sensitive to glucose loading. ~~than that of latter~~. Lactate dehydrogenase activity ~~was~~ peaked at 90 minutes probably due to elevated lactate concentration in the blood at this time following glucose injection.

CHAPTER 1

STUDIES ON DEVELOPING AVIAN LIVER 1.
THE RATE OF GROWTH AND METABOLIC FUNCTIONS OF LIVER OF PIGEON DURING POST-HATCHING PERIOD

The post-hatching development in birds varies from species to species, and these variations are usually with respect to the duration of nestling and fledgling periods, active or inactive life they lead after hatching, the mode of feeding, and the type of food consumed during the period. Some birds develop much faster after hatching and they take only 14-16 days to take to wings and to lead an independent life. Others develop very slowly and take longer time to become independent. In most of the cases the young ones are fed by the parents while they remain immobile in the arboreal nests. In some cases (e.g., fowl and duck) the young ones feed themselves under the supervision and guidance of parent(s). Most of the young ones are fed with insect food by parents, some are provided with fish while few are nourished with crop milk initially.

These variations, especially the type of food given to the young ones and the time taken for their post-hatching development, might also be reflected on the rate, degree and time of attainment of adult functional status by the metabolic machineries of the organs like liver. In the present study, the weight of the body and liver, weight of non-fat dry tissue of the liver, and contents of water, glycogen, fat and nucleic acids in the liver, were taken as parameters that may indicate the rate of morphological and functional growth of the pigeon liver during post-hatching development.

MATERIAL AND METHODS

The pigeon nestlings and fledglings used in the study were from a colony of domestic pigeons (Columba livia) maintained in an open aviary of the department. Young ones ~~of~~ 1, 5, 10, 15, 20, 25, and 30 days old and adults were selected and sacrificed. For each stage 5-10 birds were utilized. Body and liver weights were recorded. Some pieces of liver were digested in KOH, some pieces were fixed in picroformol, a part of the liver was homogenized in chilled glass distilled water for nucleic acid estimation, and rest of the liver was dried for lipid estimation. Glycogen was demonstrated histochemically by PAS technique as described by Pearse (1968) and estimation of glycogen was carried out by the method of Seifter et al. (1950). Nucleic acids were estimated by pentose analysis (Schneider, 1956) using C.Z. Spectrophotometer VSU 2P. DNA was estimated at 600 mµ while RNA was at 660 mµ and expressed as µg/mg tissue.

Lipid was determined gravimetrically after extracting the fat from known quantity of dried tissue with 2:1 chloroform-methanol mixture (Folch et al., 1957). Lipid and glycogen were expressed as gm/100 gm wet tissue.

OBSERVATIONS AND DISCUSSION

The pigeon nestlings are fed with only crop milk by the parents till 5th day of hatching. Thereafter the crop milk is given along with small, pulverized grains. The size of the grains fed becomes larger and larger gradually as the age advances. By about 15 days, the crop milk is discontinued totally and the young ones are fed with whole grains. The young ones remain in the nest till 20th day and then onwards the parents virtually disown them and peck them out of the nest. The outcasts from the nests then feed by themselves and when 30 to 35 days old they are able to fly.

The rate of growth of young ones in the early stages is amazing. In 30 days time they gain about 15 times their

TABLE 1

The changes in the body and liver weights and composition of liver of pigeon during post-hatching development. Mean ± S.D.

Age in days	Body wt. g	Liver wt. g	Liver wt/100g body wt.	Total non fat dry liver g	Water g/100 g liver	Glycogen g/100 g liver	Fat g/100 g liver	DNA µg/mg liver	RNA µg/mg liver
1	17.5 ±00.5	0.4405 ±0.0900	2.518 ±0.455	0.3670 ±0.0210	76.22 ±00.78	0.2616 ±0.0848	9.970 ±0.223	0.0952 ±0.0091	0.0356 ±0.0023
5	56.0 ± 5.7	3.6552 ±0.3400	6.527 ±0.395	0.6145 ±0.0300	75.38 ± 1.04	0.5072 ±0.1300	8.427 ±0.722	0.0593 ±0.0062	0.0423 ±0.0031
10	144.0 ±19.3	7.8052 ±0.7350	5.405 ±0.401	1.1233 ±0.0920	74.15 ± 1.77	1.3455 ±0.0910	8.035 ±1.063	0.0510 ±0.0030	0.0373 ±0.0020
15	168.0 ± 7.4	7.3974 ±0.3280	3.946 ±0.374	1.1887 ±0.0830	74.15 ± 1.38	2.5304 ±0.3123	8.235 ±1.293	0.0354 ±0.0038	0.0237 ±0.0019
20	202.0 ± 6.1	10.3760 ±0.2090	5.008 ±0.305	1.2016 ±0.0700	73.78 ± 2.08	3.0436 ±0.1415	13.530 ±1.810	0.0319 ±0.0030	0.0192 ±0.0013
25	217.0 ±19.0	8.6800 ±0.2390	3.954 ±0.407	1.3307 ±0.1010	73.12 ± 2.345	3.2100 ±0.1484	10.770 ±2.210	0.0294 ±0.0022	0.0332 ±0.0030
30	235.0 ±12.2	8.6290 ±0.2430	3.630 ±0.363	1.5810 ±0.1130	71.31 ± 2.07	5.4242 ±0.3294	12.590 ±2.820	0.0306 ±0.0024	0.0261 ±0.0021
ADULT	278.0 ±17.0	8.8306 ±0.2700	3.271 ±0.312	1.5920 ±0.0980	70.635 ± 1.909	4.8550 ±0.3285	12.130 ±1.030	0.0672 ±0.0064	0.0334 ±0.0027
*Significant at the level	$p < .001$	$p < .001$	$p < .01$	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .01$

*p value refers to differences between 1 day and 20 day stages. The Student's 't' test was used to analyse differences in means.

weight at hatching. The overall growth is rapid between 1st and 10th day and between 15th and 20th day if the body weight is taken as the criterion of growth (Table 1). The liver, in its turn, surpasses the general growth rate of the body during initial stages and by 25th day synchronizes its growth with that of the body to maintain, thereafter, 3 to 4% of body weight (Table 1). Maximum weight increase of the liver between 1st and 10th day coincides with the feeding of crop milk and particulated grains by the parents, and that of 20th day with the initiation of independent feeding by the young ones. The rapid weight increase of the liver during these two periods is either due to increase in the liver mass or due to deposition of large amount of metabolites. The increase in the liver mass could be judged from the non fat dry tissue (NFDT) component of the liver. The maximum increase of NFDT is between 1st and 10th day of hatching. Hence, the weight increase of the liver during these days can be considered to be due to the growth of the organ itself. This fact is further corroborated by the parallel changes in the values of nucleic acids noted in liver during the first ten days. Both DNA and RNA values are maximum during this period. Thereafter, weight of NFDT has increased only gradually. The tremendous increase in the weight of the liver by 20th day is not correspondingly reflected in the increase of NFDT, denoting that the liver weight increase at this stage is due to deposition of metabolites, specially fat (Table 1). The adult liver also showed high DNA content which is perhaps due to the dinucleate condition of adult hepatocytes.

The initial glycogen value of 1.1 g/100 gm liver weight on the day of hatching, falls considerably on the next day, reaching 0.2616 ± 0.0848 g/100 gm weight, but thereafter it rises steadily. The result of glycogen histochemical study also goes along with quantitative observations. On 5th day the hepatic lobule is almost negative to PAS reaction (Fig. 1) whereas, on 10th day some of the cells show glycogen deposition (Fig. 2). Glycogen deposition increases with age and the distribution becomes uniform throughout the lobule (Figs. 3 & 4). Decline in the level of glycogen concentration on one day after hatching could be due to the mobilization of energy providing metabolite, glucose, to the other tissues. Till 5th day the liver glycogen is formed by gluconeogenesis, as the diet of the young viz., crop milk contains no sugar. Even during embryonic development the glycogen formation occurs by gluconeogenesis since the yolk too contains no sugar. The chick embryo, likewise, employs gluconeogenesis

CHAPTER 1

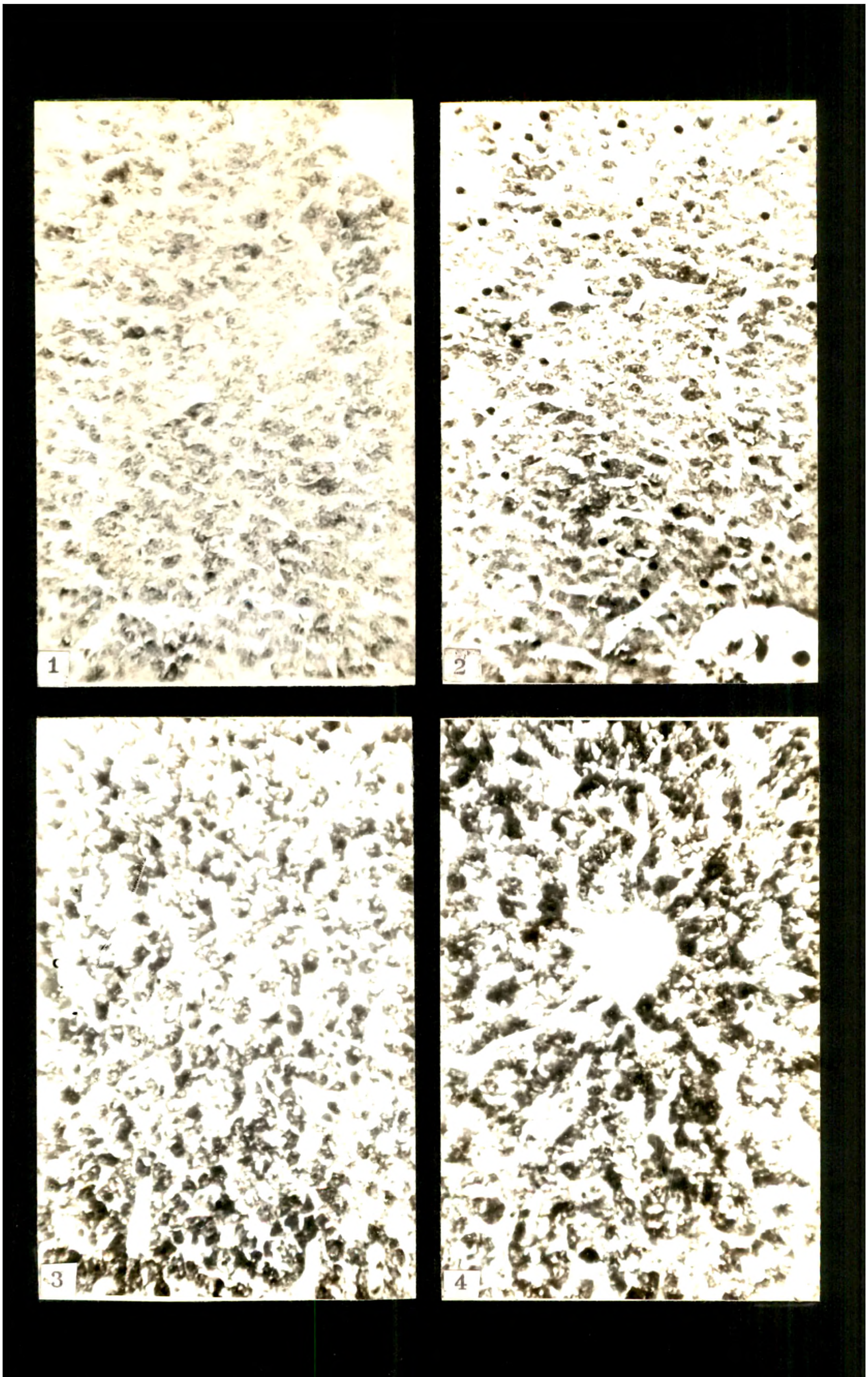
EXPLANATIONS FOR FIGURES

Photomicrographs of sections of the liver of the developing pigeons processed for glycogen with PAS technique.

Fig. 1. 5 day old pigeon liver. Lobule is almost negative to PAS reaction, 200X.

Fig. 2. 10 day old pigeon liver. Some cells (stained dark) showing glycogen deposition. 200X.

Figs. 3 and 4. 30 day old and adult pigeon liver. Sections are showing uniform glycogen deposition throughout the lobule. 200X.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for the supply of glucose (Ballard and Oliver, 1963). In contrast, the mammalian embryo derives glucose from meternal blood and hence the enzymes concerned with glycogen synthesis increase in the liver only towards the end of gestation (Ballard and Oliver, 1963; Dawkins, 1963; Burch _et al_., 1963; Kornfeld and Brown, 1963), while active gluconeogenesis appears at birth (Ballard and Oliver, 1963). However, the enzymes, concerned with gluconeogenesis in chick embryo, that become active and reach maximum level around the time of hatching (Okuno _et al_., 1964; Felicioli _et al_., 1967; Sheid and Hirschberg, 1967), show a decrease soon after hatching (Thind _et al_., 1966). In chick, the hepatic glycogen is mobilized within 24 hrs of hatching (Muglia and Massuelli, 1934; Gill, 1938; Freeman, 1965, 1969) and the glycogen value in the liver, remains low thereafter throughout the first month (Shulyak, 1967). Unlike in chick, in the pigeon liver, the glycogen deposition gains momentum from 5th day after hatching because of heavy intake of carbohydrates through the food.

The deposition of metabolites in the liver of developing young one depends mainly on the food intake, the enzyme machinery and the energy expenditure during development. During the first 5 days the nestlings subsist exclusively on crop milk and thereafter they are fed with the particulate grains mixed and moistened with crop milk. This crop milk is produced by desquamation of proliferating squamous epithelial cells lining the crop (Beams and Meyer, 1931; Litwer, 1926; Niethammer, 1931, 1933; Weber, 1962). Thus the crop milk is rich in protein and fat but contains no sugar (Bernard, 1959; Carr and James, 1931; Davies, 1939; Dulzetto and diVolsi, 1934; Vandepulle-Pomer, 1968). In this respect (metabolite contents) the crop milk resembles yolk. In other words, till first five days after hatching, the developing pigeons mainly depend on fat and proteins and its glucose requirement then may be met by gluconeogenesis. Consequently the main supply of energy could be from fat till 5th day. From 5th day onwards the fat loaded crop milk is supplemented with particulated grains till 15th day. But 20 day young ones (squabs) get only grains and no crop milk. The increased influx of carbohydrate rich diet, could be having both lipid synthesizing and fat sparing action and hence increased amount of fat gets deposited from 20th day onwards. Thereafter, the young ones start feeding grains all by themselves, the net energy gain may be much more than the energy requirement, which may be probably due to a lull in the growth rate, and hence both glycogen and fat get deposited increasingly in the liver. The deposition of fat might be having a corollary effect on the water content. The moisture content of the liver is found to decrease from 76.22 ± 0.7747 to 70.635 ± 1.909 during growth. Either the fat is displacing the water or the fat is filling the space vacated by water. From the studies on the premigratory fat deposition in the liver of the migratory starling, <u>Sturnus roseus</u>, Pilo (1967) has suggested that by regulating the ionic concentration the liver eliminates water which in turn perhaps facilitates lipid synthesis and/or deposition.

It is pertinent to mention here that the post-hatching development of pigeon is altricial in nature. However, the rate of growth of liver after hatching is faster and the development of full metabolic complements is more or less completed during the first 20 days after hatching. Many workers have studied relative liver size with increasing body weight in different hybrids of Leghorn chickens and have shown that the liver weight increased considerably in the first 10 days of hatching followed by a parabolic fall until maturity (Al-Dabagh and Abdulla, 1963; Boldizsar and Kozma, 1968). In contrast, in Fayoumi chicks, it has been reported that, there is little variation in liver and body weight ratio during first two years of life (Hafez, 1955). In pigeon young ones, the liver grows at a faster rate till

20th day, by which time the organ also acquires the ability to cope up with adult type diet (grains). It is at this point that the parents disown them. Perhaps the metabolic maturity of the liver in almost all birds occurs within the first 10 to 20 days of hatching depending upon the time available to the nestlings. The time taken for the young one to lead an independent life or to fly out of the nest, then, depends upon the functional development of other organs and structures such as neural and sensory systems, muscles and feathers.