middle corpus and the distal cauda. The caput
acted to the testis by efferent ductules, which ar
ed from the testis (see Brandes, 1974; see Hamilt
Epididymis is a highly convoluted duct which
ves spermatozoa from the testis and transports it
vas deferens, an extension of the epididymal du
gh which they are forcibly expelled at ejaculati
Bedford, 1975).

The epididymis is a dynamic structure made ofive cell types. They are principal, basal,
ulo, halo and clear cells (see Hamilton, 1972, 1976:
different type of cells are distinguished at the
microscopic level mainly by their shape, distri
position of nucleus and the presence or absence
toplasmic vacuoles (Heid and Cleland, 1957).
Pal cells are the major cell type of epididymis
are characterized by large golgi body, surround
umber of rough and smooth endoplasmic reticuli
Christensen and Gillim, 1969).

In contrast to most glandular epithelia, epid
er, 1979). The cyt架构ure of the epithelial cells vary at different regions of the epididymis. The apical cells carry out the dual function of secretion and absorption of particulate material (Hamilton, 1972; Bedford, 1975; Prakash et al., 1980; Turner, 1984).

Spermatogenesis and sperm maturation are orderly processes of cell proliferation and differentiation taking place in the testis and epididymis respectively, resulting in the production of highly specialized cell, the spermatozoon, which can fertilize the female gamete (see Orgebin-Crist et al., 1975). Testicular spermatozoa are both fertile and infertile (see Orgebin-Crist et al., 1975; Brooks, 1983). Sperm maturation takes place principally in the proximal caput and corpus regions of the epididuct, whereas the caudal region serves as a storage where mature spermatozoa are maintained in a quiescent condition prior to ejaculation (Orgebin-Crist, 1969; and Orgebin-Crist, 1973; see Brooks, 1983).

During epididymal sperm maturation, the spermatozoa spend time in the epididymis for varying periods of time in different mammals. The transit time of spermatozoa
er, 15.6 days; rabbit, 12.7 days and Wistar 8.1 days (see Amann et al., 1976). Numerous changes occur in the sperm during epididymal transit and include alterations in the fine structure, shape of the cytoplasmic droplet (Orgelin-Crist, 1969), changes in the size and shape of the acrosome, stabilization of structural components of the sperm tail by the formation of increased disulfide-links (see Bedford, 1975), increased susceptibility to shock (Quinn and White, 1967), and development of forward motility (Bedford and Calvin, 1974), change in lipid (Scott et al., 1967), and protein content (Mayr et al., 1980) and enzyme activity (Purvis et al., 1982).

The microenvironment inside the epididymis own to be important for the maturation of sperm (Orgelin-Crist, 1969). The epididymal epithelium secretes a variety of substances such as carnitine (On et al., 1980) glycercylphosphorylcholine (Sai, 1982), sialic acid (Rajalakshmi and Prasad, 1981, potassium (Wong and Lee, 1963), calcium (Mori, 1978), proteins and specific glycoproteins


The cellular concentration of carnitine in the sperm increases during their transit through the epididymis (Casillas, 1973). Carnitine serves as an energy source for spermatozoa in the epididymal lumen. Carnitine can also be readily oxidised by sperm mitochondria (Storey and Keyhani, 1974; Hutson, et al.). In addition to this, carnitine and acetyl carnitine have also been reported to stimulate sperm motility (Halichitar, 1977; Hinton et al., 1981).

Sialic acid is involved in facilitating support in the epididymis (Kim et al., 1973), maintaining osmotic balance in the cauda epididymis in the localization of acrosomal membranes (Rajalakshmi et al.). The epididymis is capable of synthesising phosphoethanolamine (PE) and epididymal phospholipid have been suggested as possible precursor of GPC (et al., 1963; Hinton and Catchell, 1980). Epididymal regions, caput is more active in GPC synthesis, maintains the osmotic pressure of the epididymis (Brooks et al., 1974; Casillas and Erickson,
presumably interact metabolically with spermatozoa during their epididymal transit (Cameo and Blaquier, 1978; Jones et al., 1981). The expression of specific epididymal glycoproteins are regulated to be under the control of androgens in oviparous species (Wom and Tsang, 1982; Brooks and Ti and they have shown that the epididymal glycoproteins regulate forward motility of immature sperm from caput epidymidis.

The amount of cyclic AMP (cAMP) in cauda epididymis is 40% higher than in caput spermatozoa (La et al., 1979). The increase may be due to increased degradation of cAMP, since cAMP phosphodiesterase inhibitors enhance overall motility of bovine caput spermatozoa with impact on the forward motility (Frenkel et al., 1981) cellular increase in pH was also found to be essential for sperm maturation, in addition to increase in (Iyamaghavan et al., 1985).

Acid phosphatase is uniformly present in the
various absorptive processes in the epididymis (et al., 1974; Bhardwaj and Lall, 1979). The phosphatase activity was also detected biochemically in the acrosomal region of the spermatozoa, which may have been involved in the process of fertilization (Allison and see, 1970; Abou-Hallil and Firl-Maurel, 1983). The biochemical findings also revealed the presence of a phosphatase in the spermatozoa of the monkey mouse (Arora-Dinakar et al., 1977; Abou-Hallil and Maurel, 1983). This enzyme activity gradually increased in spermatozoa migrating through the epididymis and Glover, 1972) and it may be involved in the transfer of organic molecules across the cell membrane (Pierre and Karnovsky, 1973). Adenosine triphosphatases are involved in the active transport of ion (Wacht et al., 1975). ATPases were also found to be present in the acrosomal tip, the middlepiece and the regions of the spermatozoa (Mathur, 1971). ATPs also alter the characteristics of the acrosome and decrease the motility (White and Voglmeier, 1986).

The steroid hormones reach the epididymis via of the rete testis fluid (RTF) and the blood
als produce an androgen binding protein (ABP) that is the carrier protein for the transport of androgens to the epididymis, through the rete testis efferent ducts (Ritzen et al., 1972; Hansson et al. Vernon et al., 1974). The rete testis fluid is a homogenous suspension of relatively immotile and a number of specific proteins, ABP, testosterone, hydrotestosterone (see Setchell and Waites, 1975; TF along with its constituents, transports spermatozoa to the epididymis, where selective absorption of a number of protein constituents occurs (see Setchell and Waites, 1975). From being secretory, epididymal epithelium has absorptive function. It absorbs testicular fluid during sperm maturation (Tuck et al., 1970; Levine and Levine, 1971). Microperfusion experiments have shown that concentration of Na+ decreases and that K+ increases in epididymal fluid flows down the epididymis. Tests that both Na+ and water are resorbed by the epididymal epithelium (Levine and Maish, 1971; "urine", 1977; Turner, 1984).

Androgens are well known to regulate the

...
The acquisition of fertilizing ability and
survival in the epididymis are androgen-depen-
dent events (see Orgebin-Crist et al., 1975). These
androgens are likely the result of interac-
tions with androgen receptors that are present in the
epididymis (Carrell et al., 1984; Darza and Elliot, '88;
and Danz, 1980).

Hypophysectomy decreased the fertilizing cap-
ability of epididymal sperm of rat, hamster and rabbit (see
Orgebin-Crist et al., 1975) and testosterone restored
ability in these animals. Administration of cypri-
tite, a potent inhibitor of testosterone action, pro-
duced restoration of fertility in these rats. The
se androgens that could maintain normal fertiliz-
ability in androgen-deprived hamsters in the decreas-
ing of efficiency are, 3β androstane-19, 5α-dih
androstane (DHT) and testosterone (Lubig-Mawroc'h et
al., 1973).

There are evidences that the epididymis can
synthesize androgens to some extent. The de novo sy-
thesis of testosterone from androstenedione was
observed.
nd rabbit epididymis (Hamilton et al., 1969; et al., 1977). The 5 -reductase, which is par
ly active in the proximal regions of the epididym
ate the conversion of testosterone to DHT (see
re et al., 1981). The principal metabolites of DHT are androstenediols (5 - androstane - 3 ,
diol and 5 - androstane - 3 p, 17p - diol). The
sions are brought about by the cytoplasmic and
3 p, hydroxysteroid dehydrogenases. In contra
5 - reductase, the hydroxysteroid dehydrogenases
ese reversible reactions and thus androgenic effe
drostenediols may probably be due to their conver
I (see Brooks, 1935).

In addition to androgens, estradiol has also b
to influence the secretory activity of the epidi
tors are present in the rabbit epididymis (Danzo
1975; Murphy et al., 1980; Toney and Danzo, 1988).
ol treatment has shown to bring about marked in
e in transit time of sperm through the epididymis
e (Meistrich et al., 1975), whereas in adult
The presence of specific prolactin mRNA sites also been reported in the epididymis of rat (Arar 
riessen, 1975), and monkeys (Jayakumar, 1988). More 
prolactin (Prl) was reported to have the ability to 
cause cytoplasmic and nuclear uptake of testosterone 
(HT) in accessory sex organs (Antliff et al., 1960; 
Barnesworth, 1972; Moer and Geswind, 1972; Johans 
see Baker et al., 1977; Keenan et al., 1961).

Altered serum levels of extra gonadal hormones as corticosterone and thyroid hormones are also 
ited to influence carbohydrate and lipid metabolism 
epididymis of pubertal and adult Wistar rats (P-
., 1983, 1983a, 1984; Balasubramanion et al., 1982 
1986, 1987, 1988). It has been reported that the 
aldosterone are essential for the maintenance 
and water resorption in rat cauda epididymis (A-
., 1973; see Ryan, 1980).

Diabetes mellitus is a metabolic disease involv 
ed ability to metabolise glucose. The most comm 
it associated with diabetes is an inability to secr 
in in response to increased blood glucose levels (
Traditionally, diabetes has been classified according to the patients age at onset of symptoms (child-onset versus adult-onset). In 1979, the National Institute of Health (NIH, USA) diabetes datad recommended that diabetes mellitus be classified into major types according to dependence on exogenous insulin. Most patients with diabetes come under one of two groups, namely insulin dependent (Type I) or insulin independent (Type II) diabetes mellitus (see Met al., 1983).

Earlier studies revealed the morphological changes in the islets of Langerhans of patients with diabetes (Lernmark et al., 1970). Careful morphological investigations by Kents (1965) showed major abnormalities in the number of B-cells and the presence of inflammation in the islets of Langerhans in Type-I insulin dependent diabetic patients. Recent studies with metrical techniques (Salier et al., 1963; Paulus et al., 1984) have shown that Type-I diabetes is associated with specific loss of the pancreatic islets.
chemicals like alloxan (Dunn et al., 1943; ex and Rossini, 1961) or Streptozotocin (Dulin et al., 1982) both of which induce diabetic state by causing severe pancreatic B-cell necrosis (Kakieten, see Dulin and Soret, 1973). Alloxan inhibits the induced insulin secretion (Lazarow, 1949; , 1970) by inhibiting glucokinase in pancreatic islets (Lenzen and Panten, 1980). This alloxan-induced diabetes in animals exists like diabetes mellitus in humans with typical symptoms like polydipsia, polyuria, loss of body weight, glycosuria, ketonuria and hyperglycemia (Lenzen and Panten, 1980).

The common secondary effect of diabetes is erectile dysfunction (Rodriguez-Rijaim, 1980). All disturbances such as impotence (Schoffling, 1963; Kolodny et al., 1974; Morley and Melm, 1960), decreased libido (Klebanow and MacLeod, 1960), decreased semen quality (Irisawa et al., 1966; Iik et al., 1975) are frequently observed in diabetics. Diabetes is shown to cause reduction in and accessory sex gland weights (Foglia et al., 196
creased serum androgen levels (Tesone et al., 1981; Gentol et al., 1958). It has
ted that diabetic patients is a group showed
red nocturnal penile tumescence is evident. 
ased total penile tumescent time, diminished frequecy of full erections and a reduction in t
um increase in penile circumference (Karaçan et 
1978; Fisher et al., 1979). Decreased release 
nd LH after the administration of gonadotropin 
ing hormone (GnRH) in diabetic patients has be 
ted (Distiller et al., 1975). However, Kastorj 
., (1974) reported no alteration in pituitary 
se to GnRH in diabetic patients.

It has been postulated that the reproductive 
bances in the diabetic rat could be due, atlea 
t, to alterations in the secretion or producti 
madotropin (Faglia et al., 1969; Salvo et al., 
evels of gonadotropins have been demonstrated 
alloxan administration. Streptozotocin-diabet 
also showed low levels of LH (Howland and Zeb 
and Prolactin (Smith et al., 1977) and it has 
sted that GnRH secretion by the hypothalamus of
otic animals is suggested to affect the activity of least one of the regulatory enzymes (3-B-Hydroxy-
and dehydrogenase) of the biosynthetic pathway from cholesterol to androgen (see Eik-Nes,
Ruiz de Galarreta et al., 1980; Blanco et al.).

- At the testicular level, the number of LH receptors reduced in diabetic rats (Charreau et al.).
- It has been suggested that reduced testicular steroidogenesis in diabetic rat may represent a di-
quence of insulin deficiency at the hypothalam-
or pituitary levels (Adashi et al., 1981; Benitez
Perez Diaz, 1985). In addition to this, the po-
rt role of insulin in the regulation of testicular
iogenesis has also been suggested (Adashi et al.

Human seminal plasma has been shown to con-
tain and that insulin increases the uptake and me-
form of glucose by human spermatozoa (Hicks et al.
- The effects of diabetes on sperm motility is-
ted (Paz et al., 1977). The concentrations
otein and sialic acid in the epididymis and the
The information that has so far been accumulated on sperm maturation, the related biochemical ever-increasing influence of hormones suggest that not much work carried out with particular reference to epididymal metabolism in experimental diabetes. Now insulin has been recognized as one of the important hormones involved in the regulation of male reproductive function. Studying epididymal metabolism in experimental diabetes designted importance in view of the specific role of epididymal metabolism in sperm maturation, an essential event to efficient fertilization. Since the sperm maturation is the result of an interaction between spermatozoa and testicular products of the epididymal epithelium, the epididymal tissue and spermatozoa were studied separately, better understanding on the specific effect of diabetes.