The present thesis embodies a comparative account of the morphological and cytochemical studies on the gonads and associated structures of the trematodes, Paradistomoides orientalis and Paramphistomum epiclitum, the cestodes, Oochoristica symmetrica and Senga lucknowensis and the nematodes, Diplotraena bhamaensis and Ascaridia galli.

The male reproductive system in each of these helminths comprises the testes, vas deferens and an ejaculatory duct (absent in Diplotraena). In the trematodes and cestodes studied, the prostatic gland cells open into the ejaculatory duct.

There are two testes in each of the trematodes, numerous in the cestodes and one testis in each of the nematodes. The testes are round in Paradistomoides, Oochoristica and Senga, lobulated in Paramphistomum and tubular in Diplotraena and Ascaridia.

The testis, in all the helminths studied, is covered over by a thin sheath comprising the muscle fibres (rich in proteins and 1:2 glycol groups) and a layer of epithelial cells, which are comparatively flat and small in the
trematodes and the cestodes, but are quite large in the nematodes. Located at the tip of each nematode testis is an apical cell having 2-5 nuclei. The cytoplasm of the sheath cells of the trematodes and cestodes is rich in proteins and polysaccharides (1:2, glycol groups) but is hardly basophilic; whereas in nematodes, it reveals proteins, glycogen and some RNA too. In addition, the sheath cells of Diplotriaena reveal very prominent bodies rich in phospholipids. The sheath cells of all the helminths, in addition, reveal in their cytoplasm alkaline phosphatase activity which strengthens the view that these sheath cells are engaged in the diffusion of nutritive material either from the surrounding parenchymatous tissue (platyhelminths) or from the perienteric fluid (nematodes) to the developing germ cells within.

Large nutritive cells, sometimes with irregular peripheries, have been sighted in the peripheral regions of the testis of Paradistomoides, Paramphistomum, Senga and Oochoristica. These cells reveal in their cytoplasm darkly stained bodies, which are particularly prominent in Paradistomoides. It is conjectured that these cells, in addition to their functioning as trophic intermediaries, phagocytose the sloughed-off remnants of the developing spermatozoa or the degenerating germ cells.

The testis in all the helminths shows germ cells in
various stages of spermatogonic differentiation. In the
trematodes and cestodes, the spermatogonia are located
peripherally, whereas in the telogonic testes of Diplostomum
and Ascaridia, the spermatogonia are lodged in the anterior
region of the testis, whereas the middle and posterior regions
reveal spermatocytes, spermatids and maturing spermatozoa.
The differentiating male germ cells in the trematodes and
cestodes are peculiar inasmuch as these do not separate out
but remain connected to one another with protoplasmic strands
after division and are thus arranged in rosettes, each
comprising 2, 4, 8, 16, 32 cells with a central blastophore.
In the nematodes, however, the rosette-like arrangement of
the germ cells is lacking, though the spermatogonia and the
spermatocytes are attached to, and are in cytoplasmic
continuity with, the branching central rachis. The cytoplasm
of the central rachis in Diplostomum and Ascaridia and the
blastophores of the trematodes and cestodes are histochemically
somewhat identical and appear rich in proteins and RNA. In
Ascaridia, the central rachis reveals, in addition, some
phospholipid bodies. The blastophores have been considered
to be the reservoirs for the residual cytoplasm. It is
conjectured that these blastophores as well as the rachis of
the nematodes are also concerned with the synchronization of
the germ cell maturation.

The cytoplasm of the spermatogonia and spermatocytes
of all the helminths is sufficiently basophilic—RNA-rich. The degree of basophilia is gradually reduced during spermatogenesis till there is hardly any basophilia left in the developing spermatids and spermatozoa.

The filamentous, rod-like or granular mitochondria of the male germ cells of all the helminths studied are as usual lipoproteinous. In Diplocotylena and Ascaridia, intact mitochondria could be distinctly seen even in the mature spermatozoa. However, in Paradistomoides, Paramphistomum, Oochoristica and Senga, the bulk of the mitochondria migrate to the blastophore during spermateleosis. The fate of the remaining mitochondria, which are left in the developing germ cells, could not be ascertained under the optical microscope.

The Golgi bodies in the spermatogonia of Paramphistomum, Paradistomoides, Oochoristica and Senga occur in the form of 2-3 darkly staining granules which, during subsequent stages, are seen lodged in the narrow ends of the pear-shaped spermatocytes and spermatids, from where they shift to the blastophore and are sloughed off along with the latter. In Diplocotylena and Ascaridia, however, the Golgi bodies up to spermatocytes appear granular or spheroidal (homogeneous or duplex), after which refringent granules start differentiating in their interna. After the formation of the refringent granules, the Golgi remnants get dissociated
from them and seem to be resorbed in the cytoplasm, since they have never been sighted during the late stages of 
spermiogenesis.

The Golgi granules and the externa of the Golgi spheroids in all the helminths studied are lipoproteinous. The interna of these Golgi spheroids, however, appear PAS-positive and are also stained, though feebly in the various tests employed for the identification of lipids and proteins.

Refringent granules or bodies, a characteristic feature of the male germ cells of the nematodes, have been considered homologous with the 'yolk granules', 'ascaridine granules', 'proacrosomal bodies', 'membranous specializations', 'fibrous bodies' or 'membranous organelles' of the previous workers. In Ascaridia and Diplostomina, the refringent granules or bodies, which originate in the chromophobic medullae of the duplex Golgi spheroids, are homogeneous and spherical in the spermatocytes, but become ellipsoidal in the later stages. Cytochemically, they are composed of proteins rich in $\text{NH}_2$ groups and tyrosine and RNA. The mature spermatozoa, at the time of fertilization, carry the refringent bodies into the ovum and thus seem to contribute some ribonucleoprotein material (possibly polyribosomes) to the fertilized ovum.

In the trematodes, Paradistomoides and Paramphistomum and the cestodes, Oochoristica and Senga, two axial filaments
originate in the maturing spermatids which later on twine around each other to give the appearance of a single flagellum.

The mature spermatozoa in the trematodes and cestodes are long and filiform, whereas those of the nematodes studied are non-flagellate. Even in the mature nematode spermatozoa, there can be seen the refringent bodies, mitochondria and some other dense spherical structures.

Characteristically, the mature spermatozoa of all the helminths studied lack acrosomes. In the nematodes, Diplotriaena and Ascaridia, however, some dense bodies are observed in the maturing spermatozoa which are sufficiently PAS-positive and also reveal acid phosphatase activity. On the basis of their histochemical characteristics they have been considered homologous with the acrosome of other spermatozoa.

The vas deferens in the trematodes, Paradistomoides and Paramphistomum and the cestodes, Oochoristica and Senga is lined by a layer of cuboidal or flat epithelial cells. The seminal vesicle in these animals is a simple enlargement of the vas deferens and is lined by similar flat cells which are of the non-secretory type and do not establish any intimate association with spermatozoa in the lumen.
The vas deferens in each of the nematodes, *Ascaridia* and *Diplotriaena*, is a long tube showing regional differentiation into an anterior glandular and a posterior non-glandular portion. The glandular portion is lined by columnar cells which gradually lose height from the anterior to the posterior region. These cells throw out pseudopodia-like projections into the lumen, and also indicate their phagocytic role. The secretion product in these cells is in the form of granules and globules which are rich in proteins (-$\text{NH}_2$ and -$\text{SH}$ groups) and polysaccharides (1:2 glycol groups). In addition, the cells lining the vas deferens in *Diplotriaena* reveal large irregular phospholipid-rich dark bodies—perhaps representing phagocytosed degenerating remnants of residual cytoplasm.

Except in *Diplotriaena*, where the ejaculatory duct could not be demarcated, this duct in all other helminths studied is represented by the terminal tubular portion of the male duct. In *Ascaridia*, the ejaculatory duct is represented by a straight tube having two pouches at its anterior end. The pouches as well as the duct itself are lined by cuboidal to columnar epithelial cells filled with 2 types of secretory products: (i) granular which is rich in proteins and polysaccharides (1:2, glycol groups) and (ii) globular which contain proteins only. In addition,
these cells reveal irregular dark phospholipid-rich bodies which seem to represent the phagocytosed sperm remnants or the degenerating spermatozoa.

In the trematodes, Paradistomoides and Paramphistomum and the cestodes, Oochoristica and Senga, a number of pear-shaped prostatic gland cells surround the ejaculatory duct. The prostatic gland cells reveal two types of secretion products: (i) the granules which are cytochemically complex containing lipids, proteins and polysaccharides (1:2, glycol groups) and (ii) globules containing phospholipids alone. It is conjectured that this material does not only increase the volume of the seminal plasma but also seems to help the spermatozoa to mature.

The female reproductive complex in each of the helminths studied comprises the ovary, the oviduct, the seminal receptacle (absent in Ascaridia) and the uterus. In the trematodes and the cestodes, additionally, there are present the vitellaria, Mehlis' gland and their associated ducts. The ovary in both the trematodes, Paradistomoides and Paramphistomum, is simple, more or less round, whereas in the cestodes, Oochoristica and Senga, it is bilobed. The nematodes, Ascaridia and
Diplotriaena, have paired long, tubular and telogonic ovaries.

The ovary in all the helminths studied is bounded by a sheath comprising an outer muscular layer, inner to which is present a layer of epithelial cells. The sheath cells of the ovaries of the trematodes and cestodes are small and of the non-secretory type. The ovarian epithelium of Diplotriaena and Ascaridia, however, comprises elongated or cuboidal cells which reveal in their cytoplasm granules or spheres rich in polysaccharides (1:2, glycol groups). In addition, the cytoplasm of these cells also contains some phospholipid bodies. The ground cytoplasm of these cells reveals the presence of proteins with $-\text{NH}_2$ groups, a small amount of glycogen and also an alkaline phosphatase activity. The ovarian epithelium of all the helminths studied appears to have the same function as its counterparts in the tests.

In both the nematodes, Ascaridia and Diplotriaena, the female germ cells are grouped around an enucleate rachis which is branched anteriorly and reveals the presence of sizeable lipid bodies. In Ascaridia, in addition to these lipid bodies, are seen a few PAS-positive inclusions, either evenly scattered in the cytoplasm or sometimes even forming small aggregations. There is also observed a gradual increase of cytoplasmic inclusions in
the rachis from the anterior to the posterior end. It is conjectured that the rachis is concerned with the synchronization of the development of the oocytes.

In addition to these non-germinal components, the ovary of Paramphistomum reveals a few nurse cells lying towards the inner side of the ovarian sheath, and they throw cytoplasmic processes into the lumen of the ovary. The cytoplasm of these cells reveals certain globules rich in the carbohydrates (1:2, glycol groups) and the phospholipids. The close association of these nurse cells with the germ cells and the cytochemistry of their globules testify to their nutritive role. No such cells were encountered in the ovaries of other helminths investigated.

The ovary of all the helminths studied during the course of the present investigations contains only the oogonia and the primary oocytes; maturation divisions (meiosis) occur only when these cells reach the proximal part of the uterus.

The mitochondria in the oogonia and the early oocytes of Paramphistomum and Paradistomoides are aggregated on one side of the nucleus, whereas in the later stages, they get evenly dispersed in the cytoplasm. However, in the cestodes, Senga and Oochoristica, the mitochondria are uniformly scattered in the cytoplasm right from the
oogonial stages onwards. In Ooehorista, the vitelline bodies seem to emerge in close relationship or approximation with the mitochondria which are temporarily somewhat aggregated at these sites. The close approximation of the mitochondria with the developing vitelline bodies is considered physiologically vital. In both the nematodes, Ascaridia and Diplotrichosa, the mitochondria in the oogonia and the early oocytes form a juxta-nuclear clump, but with the growth of the oocyte, they get uniformly dispersed. Their fate in the fully mature oocytes could not be ascertained, as the egg cytoplasm becomes occluded with the nutritive as well as with the egg shell forming material; both these substances completely eclipse the mitochondria.

The mitochondria in the female germ cells of all the helminths studied reveal, as usual, their lipoproteinaceous nature, the lipids in them being phospholipids. No polysaccharides and RNA have ever been detected.

A large number of distinct pyroninophilic granules are observed in the ooplasm of Paramphistomum, whereas in the oocytes of Paradistomoides, there is present a distinct, sizable basophilic cytoplasmic body. These pyroninophilic granules or bodies seem to represent the extruded nucleolar material. In addition, the oocytes of Paramphistomum and Paradistomoides reveal some PAS-positive material, either scattered in the cytoplasm or concentrated in the
circum-nuclear area. Each oocyte of the cestode, *Oochoristica*, reveals 5-8 bodies (=vitelline bodies) rich in RNA and proteins.

In the cytoplasm of the nematode oocytes are discernible a variety of structures, in addition to mitochondria, which on the basis of cytochemical nature can be differentiated into: (i) lipoprotein granules, (ii) phospholipid bodies, (iii) lipid yolk, (iv) PAS-positive bodies or hyaline spheres.

The nutritive material in the oocytes of the nematodes, *Dipteriaena* and *Ascaridia*, comprises the lipid yolk and the PAS-positive bodies or hyaline spheres. In addition, the ooplasm also reveals glycogen. The lipid yolk globules histochemically comprise pure triglycerides. The hyaline spheres of *Ascaridia*, however, are composed of proteins, RNA and acid mucopolysaccharides and are thus comparable with the compound yolk of other animals. The PAS positive bodies encountered in the oocytes of *Dipteriaena*, however, are comparable with the carbohydrate yolk.

The Golgi elements could not be distinctly identified in the female germ cells of the trematodes, *Paramphistomum* and *Paradistomoides* and the cestodes, *Oochoristica* and *Senga*. In the nematodes, however, the lipoprotein granules
represent the Golgi bodies.

The vitelline glands in both the trematodes, Paradistomoides and Paramphistomum, and in the cestode, Senga, comprise numerous follicles occupying the lateral regions of the body, whereas in the cyclophyllid, Oochoristica, the vitelline gland is represented by a small, somewhat lobulated mass lying close to, but behind, the ovary. The young vitelline cells in each vitelline follicle or gland undergo a process of maturation during which they grow and gradually become filled with the shell forming as well as with the nutritive materials. Small vitelline granules first emerge in ergastoplasmic areas, and they later accumulate in clusters or even coalesce to form large globules. In addition to the vitelline material, the vitelline cells in Paramphistomum and Senga contain some lipid spheroids.

The vitelline material in all the helminths mainly contains proteins rich in -NH₂ groups. In Paradistomoides and Senga, it also reveals the presence of tyrosine. The vitelline material in both the cestodes is, in addition, pyroninophilic in contrast with that of the trematodes where it does not show any RNA-dependent basophilia. The vitelline material in Oochoristica also contains carbohydrates (1:2, glycol groups). The vitelline globules of Paramphistomum reveal the presence of keratin. A tyrosinase
activity is also present in the vitelline material of Paradistomoides and Senga. The vitelline glands of all the platyhelminths studied also reveal alkaline phosphatase activity.

The Mehlis' gland in all the platyhelminths studied is composed of a large number of club-shaped cells arranged radially around the oocyte. These cells in Paradistomoides can be differentiated into two types, viz. $S_1$ cells secreting large secretion bodies and $S_2$ cells with small secretion globules. No $S_1$ and $S_2$ type cells could be categorized in the Mehlis' glands of other platyhelminths.

The secretion product of the Mehlis' gland in Paramphistomum, Oochoristica, Senga and from the $S_2$ cells of Paradistomoides is rich in proteins, carbohydrates (1:2, glycol groups) and phospholipids, whereas that from and $S_1$ cells of Paradistomoides contains proteins and carbohydrates only. In addition, a high acid phosphatase activity was observed in the Mehlis' gland cells of all the animals studied. The Mehlis' gland secretion has been ascribed a role of forming a thin membrane around the aggregation of vitelline cells, ovum and spermatozoon, on the inner side of which the eggshell is laid.

The primary oocytes from the ovary pass through the small oviduct to reach the next region of the female tract,
the uterus. The wall of the oviduct in all the helminths studied appears to be a continuation of the ovarian sheath and comprises the same layers, i.e. the outer muscular layer and the inner layer of epithelial cells, which may be flat or cuboidal or even columnar. The cells do not reveal any secretory activity. In the trematodes, Paradistomoides and Paramphistomum, however, the proximal region of the oviduct is lined by ciliated epithelium which facilitate the passage of the ova.

The oviduct in the case of the trematodes, Paradistomoides and Paramphistomum and the cestodes, Oochoristica and Seneg, before joining the uterus enlarges to form a chamber, the ootype, which is lined with cuboidal epithelial cells and is surrounded by Mehls' gland cells. The formation of the egg shell specifically starts in this region of the female duct.

In Paradistomoides, Paramphistomum, Seneg, Oochoristica and Diplotriaena, the spermatozoa before fertilization are temporarily stored in the female in the seminal receptacle. In Ascaridia, however, they are stored in the proximal part of the uterus.

The seminal receptacle in all the platyhelminths studied is lined with flat cells which do not reveal any secretory activity. The spermatozoa also do not show any
special association with the cells lining the wall of seminal receptacle.

In the nematodes, Diploptriaena and Ascaridia, the seminal receptacle or the anterior region of the uterus is lined with cuboidal epithelial cells having pseudopodia-like cytoplasmic processes projecting into the lumen. These cells are secretory, the secretion product being rich in the polysaccharides (1:2, glycol groups) and the phospholipids. The close association of the spermatozoa with these wall cells suggests some nutritive role of the latter. Also, this region serves to phagocytose the degenerating germ cells. The significance of this intracellular digestion by the cells lining the seminal receptacle or the anterior region of uterus has also been discussed.

The uterus in the trematodes and cestodes is a continuation of the ootype. In Paradistomoides, Senga and Oochoristica, it is lined with a layer of flat epithelial cells. However, in Paramphistomum, the epithelial lining comprises cuboidal cells covered over (on the luminal side) by a cytoplasmic layer. These cells do not seem to participate in the formation of the egg shell.

The uterine lining of the nematodes studied, viz. Ascaridia and Diploptriaena, comprise large cuboidal cells, which, at places, project into the lumen to establish an
approximation with the eggs. These cells are normally filled with lipid material which in *Diplotriaena* is in the form of large spheres, whereas in *Ascaridia*, this material is granular. The secretion of these cells has a nutritive role. These cells do not seem to participate in the formation of the egg shell.

During the formation of the egg shell in *Paramphistomum*, *Paradistomoides* and *Senga*, a number of vitelline cells surround the ovum in the ootype and release the vitelline material, which then seems to form the shell. In the cyclophyllidean cestode, *Oochoristica*, a single vitelline cell becomes associated with each ovum, around which is formed a thin shell. As all the precursors of the sclerotization of proteins, viz. proteins rich in -NH$_2$ groups and tyrosine and the enzyme tyrosinase, have been identified in the vitelline material of *Paradistomoides* and *Senga*, the egg shells seem to be formed by quinone-tanning. In *Paramphistomum*, however, the egg shells are of keratin-type. The vitelline cells after the discharge of the vitelline material get reorganized. During this process, some basophilic granules (rich in proteins and RNA) and some lipid granules develop in the circum-nuclear regions of these cells.

The egg shells of the nematodes, *Ascaridia* and
Diplotriaena, however, comprise 3 layers, out of which the middle chitinous one is the most prominent. The coelemma, which separates from the oocyte surface just after fertilization forms the outer lipoproteinous layer. For the middle layer, the glycogen material of the egg serves as a precursor of the chitinous material. Inner to this chitinous layer is present another lipoproteinous layer which is formed as a result of the extrusion and the fusion of lipoprotein granules from the oocytes. This layer has been compared with the ascoroside layer of other workers.