* The female reproductive system in general consists of a pair of **ovaries** which connect with a pair of **lateral oviducts.** These then join to form a **median oviduct** which opens posteriorly into a **genital chamber**. Sometimes the genital chamber is closed to form a tube called the **vagina**. The vagina is then often modified to form a **bursa copulatrix** for the reception of the penis. Opening from the genital chamber there is a **spermatheca** for the storage of sperm, and usually a pair of **accessory glands**.

OVARIES

* The ovaries lie in the abdomen either above the gut or to the side of the gut. Each ovary consists of a number of **egg-tubes**, or **ovarioles** which are comparable to the testicular follicles in the male. Development of the oocytes takes place in the ovarioles.

* The number of ovarioles is usually constant within a species, but in some insects the number of ovaries depends upon the adult development. For example, in the genus *Schistocerca*, individuals reared in crowded conditions have fewer ovarioles than individuals reared in isolation. The number of ovarioles can also be geographically dependent. The number of ovarioles in different species can be quite variable. Some Diptera may have only 1 or 2 ovarioles per ovary whereas queen termites may have over 2000 ovarioles per ovary.

* The ovaries of Collembola are not composed of ovarioles, but rather they are sac-like with a lateral germarium from which files of oocytes are produced. The ovaries are probably not homologous with those of other insects.

* There usually is no sheath around the ovaries as a whole (exception some Diptera), but frequently the ovarioles themselves have a wall that in many cases is composed of 2 cell layers [SEE OVERHEAD]. The outer layer forms an **external sheath** which is a cellular network of modified fatty tissue. These cells are rich in lipids and glycogen, but they are probably not directly concerned with oocyte development. The inner cell layer is called the **tunica propria** which is an elastic membrane containing fine fibrils. It surrounds the whole of the ovariole including the terminal filament. It is a fairly thick layer at first, but when the ovariole enlarges during vitellogenesis it becomes stretched and very thin. It is probably a product of the terminal filament and follicle cells. It functions as a supporting mechanism and may play a role in ovulation. There are often ameboid type cells between the 2 layers that probably serve in repairing damage to the tunica propria.

* Distally the ovariole is prolonged into a **terminal filament**. Usually the terminal filaments from each ovariole combine to form a **suspensory ligament** and sometimes the ligament from the 2 ovaries then combine to form a **median ligament**. The ligaments are inserted into the body wall or the dorsal diaphragm and so they suspend the ovaries in the haemocoel.

* Proximally the ovariole narrows into a fine duct called the **pedicel** (homologous with vas efferens) which connects with the **oviduct** (homologous with vas deferens). In many immature insects the lumen of the ovariole is cut off from the pedicel by an **epithelial plug**.

* In some insects the ovarioles open into the oviduct in a linear fashion, each separately, or in other insects the ovarioles open together into an expansion of the oviduct called the **calyx**.

OVIDUCTS

* The oviducts are tubes with walls of a single layer of either cuboid or columnar cells standing on a basement membrane and with a muscle layer on the outside. In some grasshoppers, part of the wall is glandular. Usually the 2 **lateral oviducts** join a **median oviduct**. Remember that the Ephemeroptera had 2 gonopores per individual. In these insects the lateral oviducts continue to the body wall and do not join to form a median oviduct.

* The median oviduct is ectodermal in origin so it does have a cuticular lining. The median oviduct is usually more muscular than the lateral oviducts possessing both circular and longitudinal muscles. As mentioned, the median oviduct then opens at the **gonopore** which in the Dermaptera it is ventral and located at the posterior end of abdominal segment 7. In most other insects, it opens into the **genital chamber** which is an invagination above the 8th sternum. In some insects the genital chamber is tubular and effectively is simply a continuation of the median oviduct through abdominal segment 9. This continuation is called the **vagina** and its opening the **vulva**. It is often not distinguishable from the oviduct, but at its anterior end, and the position of the true gonopore, is marked by the insertion of the **spermatheca**. Often the vagina is developed to form a pouch called the **bursa copulatrix**, which receives the penis. In viviparous Diptera, the anterior end of the vagina is enlarged to form the **uterus** in which larval development occurs.

* Most female Lepidoptera are unusual in that they have two reproductive openings. The 1st is on segment 9 and serves for the discharge of the eggs and is called the **oviporus**. The 2nd is on segment 8 and is the copulatory opening or **vulva**. This leads to the bursa copulatrix which is connected with the oviduct by a **sperm duct**.

SPERMATHECA

* The **spermatheca** serves as a storage area for the sperm from the time of copulation to the time the eggs are fertilized. Some insects possess 2 spermathecae (some Coleoptera and some Diptera), and most of the more advanced Diptera have 3. In the more primitive orders (Orthoptera), the spermatheca opens into the genital chamber independent of the oviduct. But in insects where the genital chamber forms a vagina the spermathecal opening becomes internal and is effectively within the oviduct.

* The spermatheca is ectodermal in origin and is lined with cuticle. The spermatheca typically consists of a storage pouch with a muscular duct leading to it. There is often an associated gland, or the spermathecal epithelium itself may be glandular, producing secretions which probably provide nutriments for the sperm.

ACCESSORY GLANDS

* Female **accessory glands** often arise from the genital chamber or the vagina, but in some Orthoptera they are simply anterior extensions of the lateral oviducts. These glands are absent in some insects, but often in this case the walls of the oviducts themselves may be glandular. Often these glands produce a substance for attaching the eggs to the substratum during oviposition, and in this case are called **colleterial glands**. They may also produce substances which may have a number of different functions. For example, the frothy eggpods around some Orthoptera eggs come from these glands. Some Coleoptera can spin silk from these glands which form a coccoon around the eggs.

* There may also be glands nearer the genitalia in some insects which may also have a variety of functions. For example, in some Hymenoptera they may form poisen glands associated with the sting. Some secretions may serve to lubricate the ovipositor. In some ants, these glands produce the trail marking pheromone.

OOGENESIS

* Each ovariole consists of a distal **germarium** in which oocytes are produced from **oogonia**, and a more proximal **vitellarium** in which the oocytes grow as the yolk is deposited in them. In mature insects, the vitellarium is quite large relative to the germarium.

* The **germarium** contains prefollicular tissue and the stem line oogonia. The stem line oogonia are derived directly from the original germ cells. When one of the stem line oogonia divides one of the daughter cells retains the stem line oogonia function, while the other daughter cell becomes a definitive oogonium and develops into an oocyte. Oocytes enlarge as they pass down the ovariole. As each ovariole leaves the germarium, it is clothed by the prefollicular tissue which forms the follicular epithelium. The follicular epithelium initially is 2 or 3 cell layers thick, but eventually becomes just 1 cell thick. The oocyte continues to grow and enlarge, and the follicular epithelial cells keep pace by cell division to form a cuboid or columnar layer

over the oocyte. Later, during yolk deposition, growth of the oocyte is very rapid, and at this time the follicular epithelium does not keep pace and becomes stretched.

* The nucleus of the oocyte also enlarges until yolk deposition when its growth slows. It is now often called the **germinal vesicle**.

* Typically each ovariole contains a linear gradient of oocytes with the most mature near the base. An oocyte with its surrounding follicular epithelium is called a **follicle**. The number of follicles per mature ovariole can be quite variable.

* In most insects the meiotic divisions are not completed in the ovary and the oocytes usually leave the ovarioles in the metaphase of the first maturation division. This is not true in ovoviviparous insects in which fertilization occurs in the ovary; in these insects maturation of the oocytes is completed in the ovary.

TYPES OF OVARIOLES

* There are 2 broad categories of ovarioles.
    1. **Panoistic** - these are ovarioles lacking specialized **nurse cells** (which furnish nutrients) or **trophocytes**. These are found in primitive orders (Thysanura, Odonata, Plecoptera, Orthoptera, and Isoptera). Among the holometabola only the Siphonaptera have this type of ovariole.
    2. **Meroistic** - these are ovarioles which have specialized nurse cells or trophocytes. These can be divided into 2 types:
        a. **Telotrophic** - in these, ovarioles have trophic tissue in the germarium. This is found in Heteroptera and many Coleoptera. The trophocytes are derived from the oogonia. In this type of ovariole the trophocytes remain in the germarium.
        b. **Polytrophic** - in these the trophocytes accompany each oocyte and are enclosed within the follicle. This type occurs in the Dermaptera and in lice and throughout the holometabola except Siphonaptera. In these the oogonium divides to produce an oocyte and a trophocyte.

VITELLOGENESIS

* **Vitellogenesis** is the deposition of yolk in the oocyte and occurs in the lower parts of the ovarioles. This results in a rapid increase in the size of the oocyte. The yolk consists of a number of different components some of which are the **protein yolk**, the **lipid yolk**, and **glycogen**.

* Also during vitellogenesis (near the end of it) the **vitelline membrane** is laid down to form the outer layer of the oocyte. Also during the latter stages of vitellogenesis the egg shell itself forms.

OTHER NOTES

* In some insects the oocytes can be reabsorbed in the ovarioles during times of starvation.

* The passage of the oocyte into the oviduct is called **ovulation** and involves escaping from the follicular epithelium and the breakdown of the epithelial plug at the entrance of the pedicel.