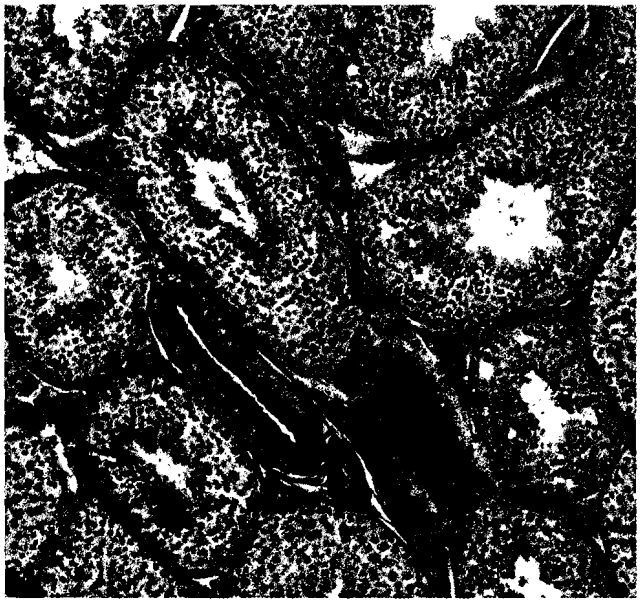
9 HUMAN REPRODUCTION

Spermatogenesis

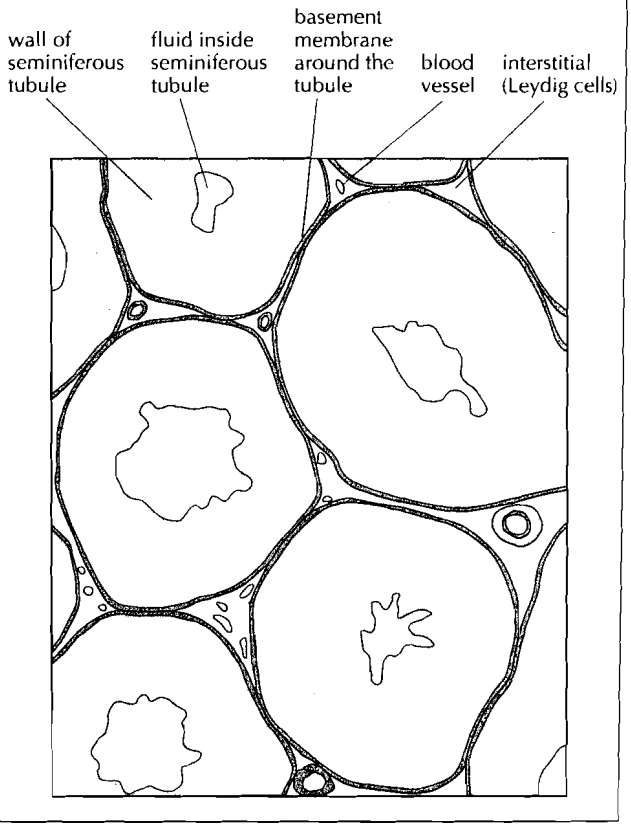
Electron micrograph of adenovirus

Spermatogenesis is the production of spermatozoa.
Spermatozoa are usually simply called sperm.
Spermatogenesis occurs in the testes, in narrow tubes called **seminiferous tubules**.
The figures (below and right) show the structure of testis tissue, including the seminiferous tubules. The figure (bottom) shows the processes involved in spermatogenesis

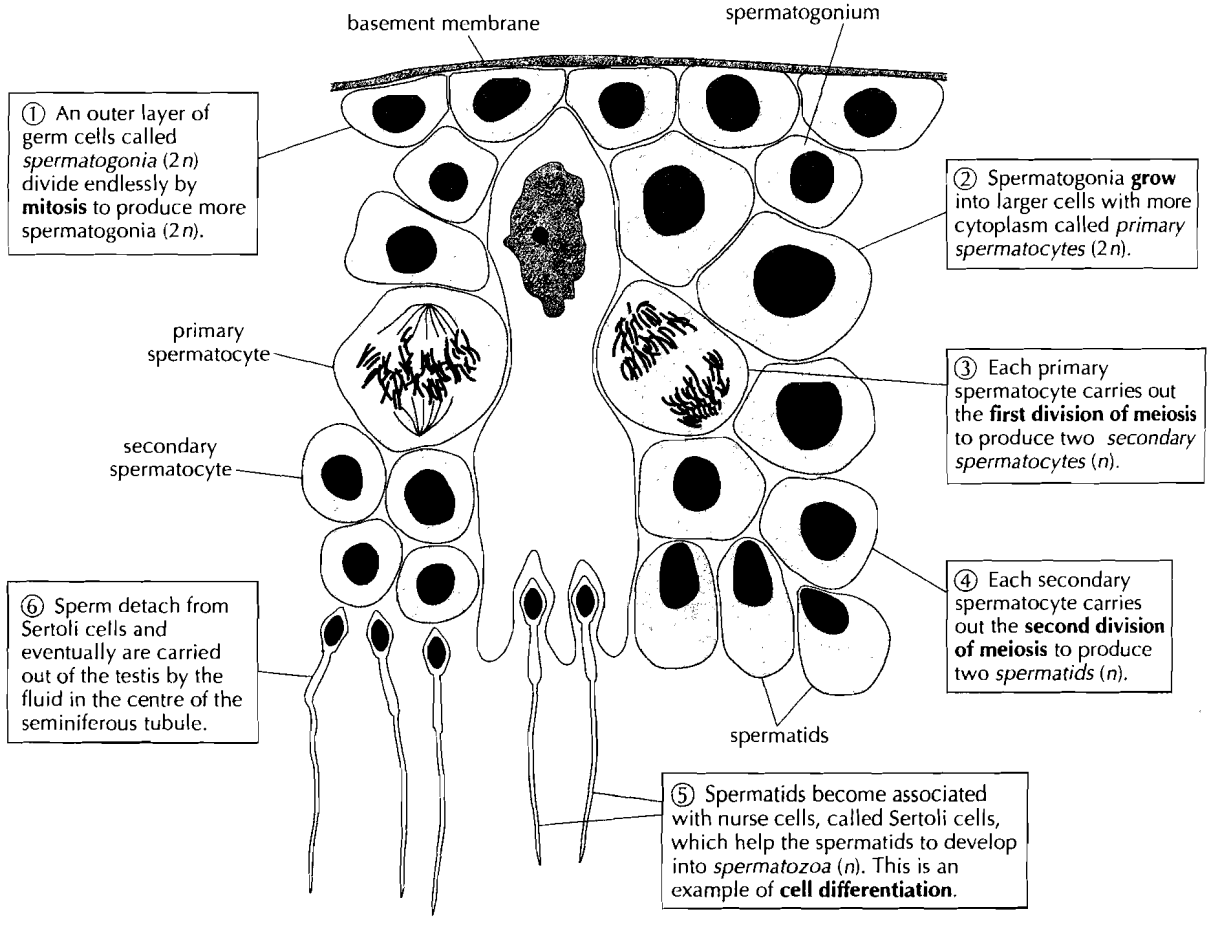
Micrograph of testis tissue (× 90)



Structure of testis tissue



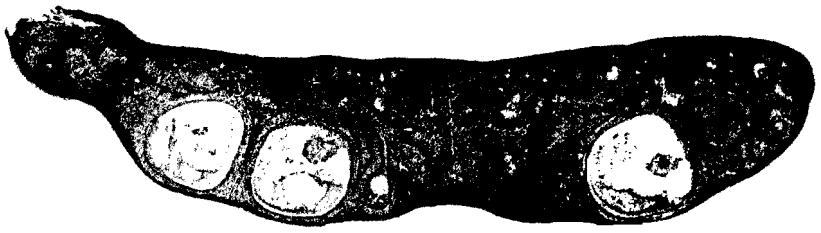
STAGES OF SPERMATOGENESIS



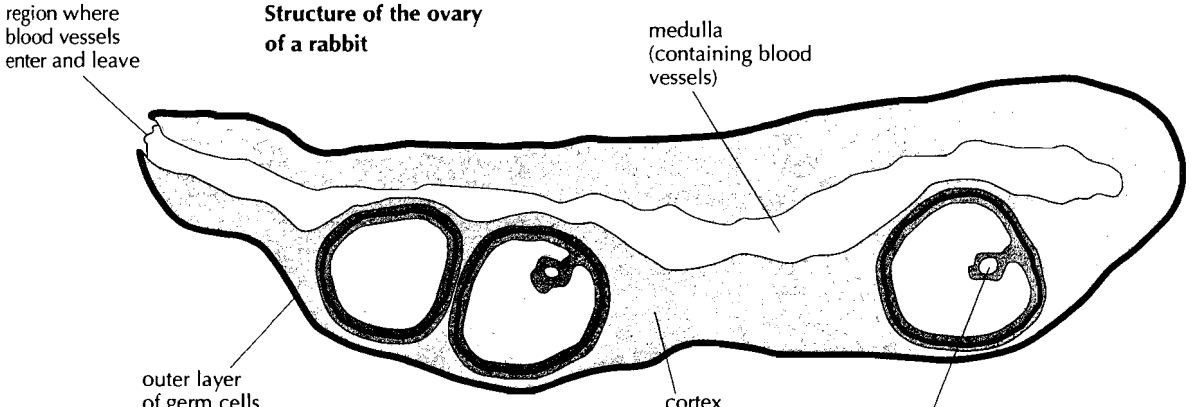
Oogenesis

Oogenesis is the production of an ovum. Ova are often simply called eggs. Oogenesis occurs in the ovaries. The figures below show the structure of ovary tissue. The figure (bottom) shows the processes involved in oogenesis.

Micrograph of the ovary of a rabbit



Structure of the ovary of a rabbit



STAGES OF OOGENESIS

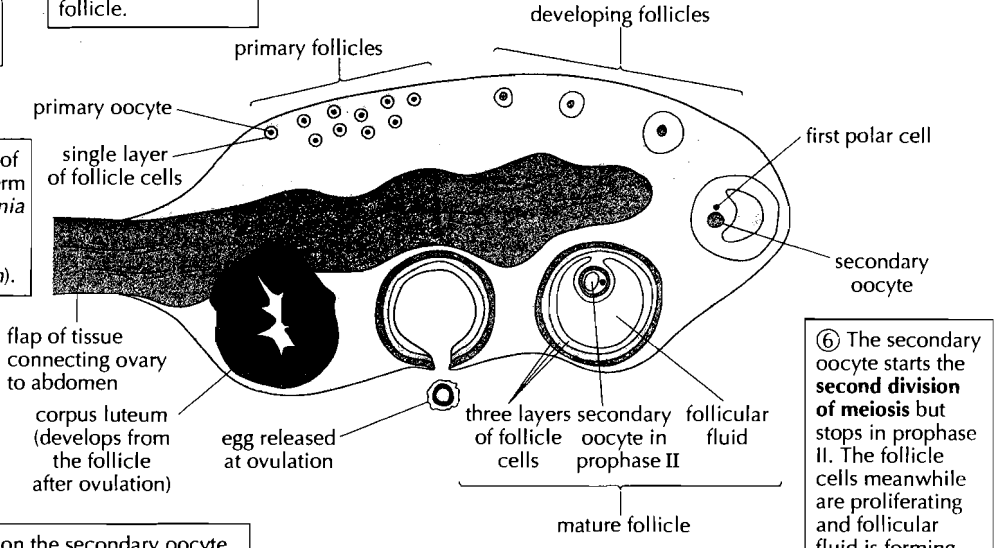
① In the ovaries of a female fetus, germ cells called *oogonia* (2*n*) divide by **mitosis** to form more oogonia (2*n*).

② Oogonia **grow** into larger cells called *primary oocytes* (2*n*).

③ Primary oocytes start the **first division of meiosis** but stop during prophase I. The primary oocyte and a single layer of follicle cells around form a primary follicle.

④ When a baby girl is born the ovaries contain about 400 000 primary follicles.

⑤ Every menstrual cycle a few primary follicles start to develop. The primary oocyte completes the first division of meiosis, forming two haploid nuclei. The cytoplasm of the primary oocyte is **divided unequally** forming a large secondary oocyte (*n*) and a small polar cell (*n*).



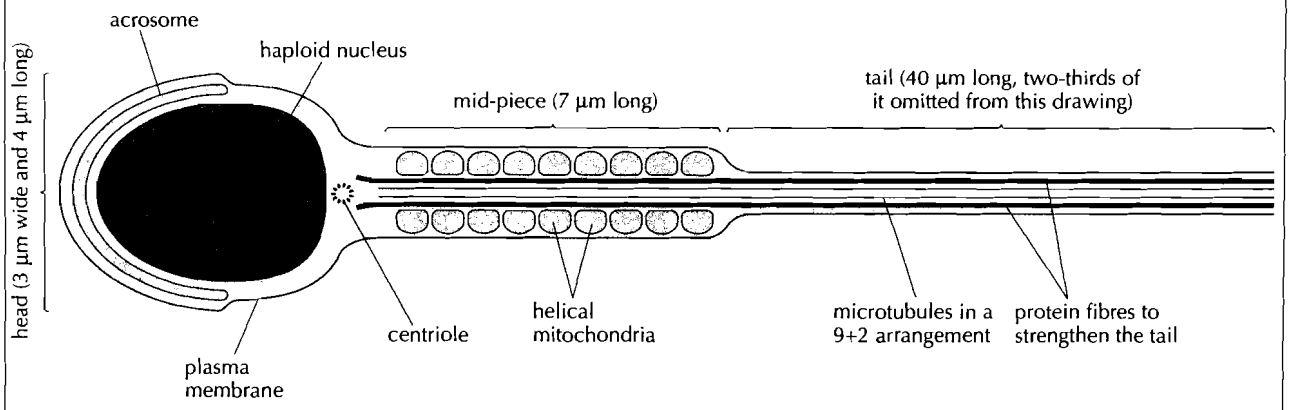
⑥ The secondary oocyte starts the **second division of meiosis** but stops in prophase II. The follicle cells meanwhile are proliferating and follicular fluid is forming.

⑦ When the mature follicle bursts, at the time of ovulation, the egg that is released is actually still a secondary oocyte.

⑧ After fertilization the secondary oocyte completes the second division of meiosis to form an ovum, (with a sperm nucleus already inside it) and a second polar cell or body. The first and second polar bodies do not develop and eventually **degenerate.**

Gametes

STRUCTURE OF HUMAN SPERM



HORMONAL CONTROL OF SPERMATOGENESIS

Three hormones are involved in the production of sperm.

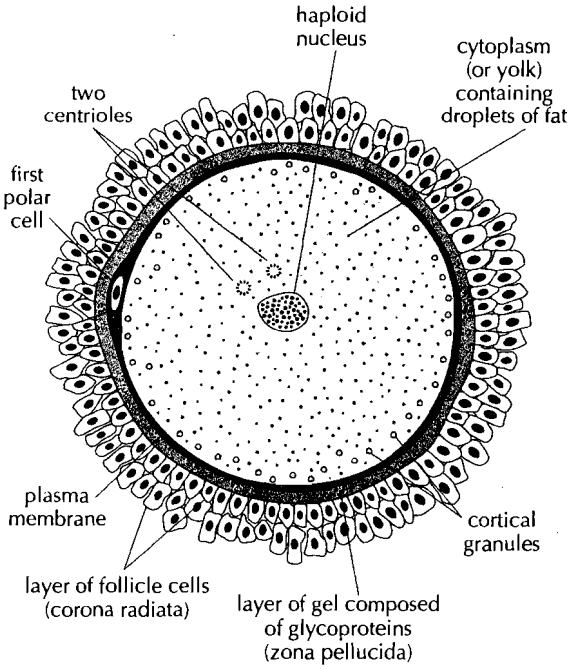
Hormone	Source	Role
FSH	Pituitary gland	Stimulates primary spermatocytes to undergo the first division of meiosis, to form secondary spermatocytes
Testosterone	Interstitial cells in the testis	Stimulates the development of secondary spermatocytes into mature sperm
LH	Pituitary gland	Stimulates the secretion of testosterone by the testis

PRODUCTION OF SEMEN

Three structures help to produce semen – the epididymis, seminal vesicles and prostate gland

When sperm from the testis arrive in the epididymis, they are unable to swim. The sperm undergo a maturing process while they are stored in the epididymis and become able to swim. The two seminal vesicles and prostate gland produce and store fluids and expel them during ejaculation. The fluid mixes with the sperm and increases the volume of the ejaculate. The fluid from the seminal vesicles contains nutrients for the sperm including fructose. It also contains mucus which protects the sperm in the vagina. The fluid from the prostate gland contains mineral ions and is alkaline so protects the sperm from the acid conditions in the vagina.

STRUCTURE OF A HUMAN EGG



Diameter of egg cell = 110 µm

COMPARING SPERMATOGENESIS WITH OOGENESIS

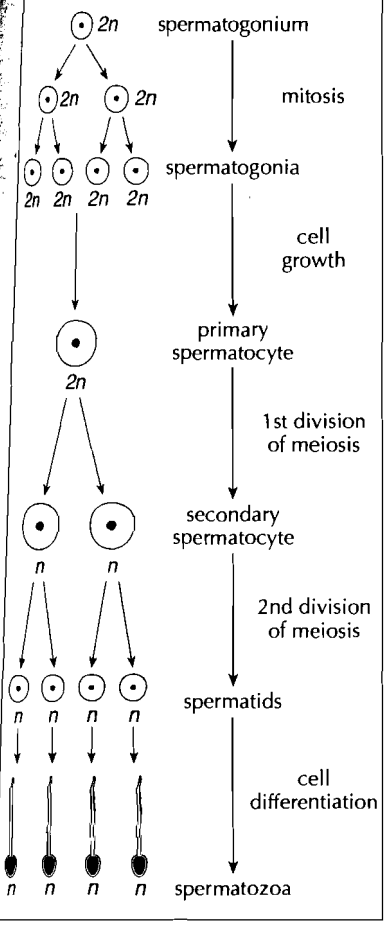
There are many similarities between the formation of sperm and eggs.

- Both start with proliferation of cells by mitosis.
- Both involve the cell growth before meiosis.
- Both involve the two divisions of meiosis.

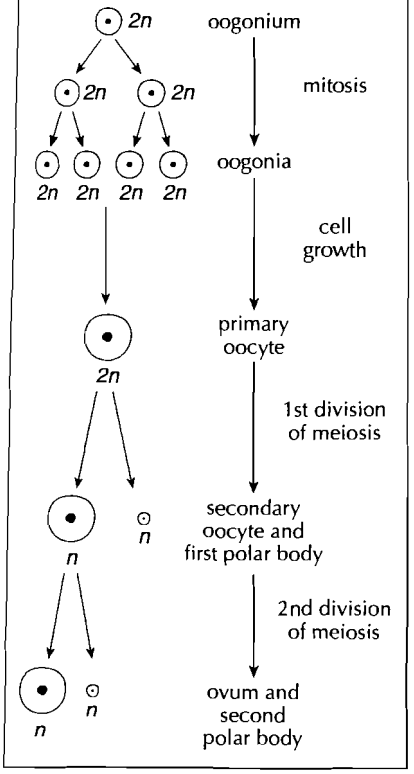
The table below shows some of the differences.

Spermatogenesis	Oogenesis
Millions produced daily	One produced every 28 days
Released during ejaculation	Released on about day 14 of menstrual cycle by ovulation
Sperm formation starts during puberty in boys	The early stages of egg production happen during fetal development in females
Sperm production continues throughout the adult life of men	Egg production becomes irregular and then stops at the menopause in women
Four sperm are produced per meiosis	Only one egg is produced per meiosis

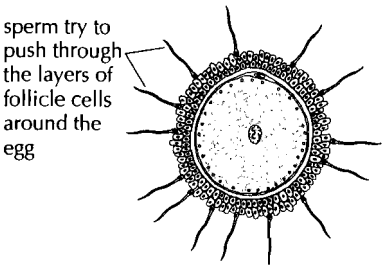
Summary of spermatogenesis



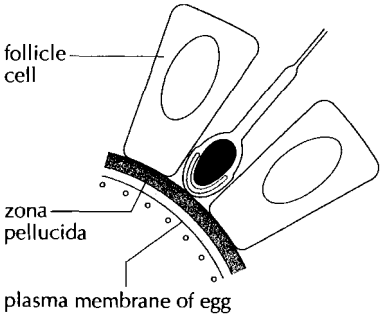
Summary of oogenesis



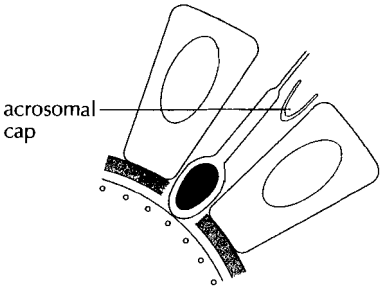
Stages in the fertilization of a human egg



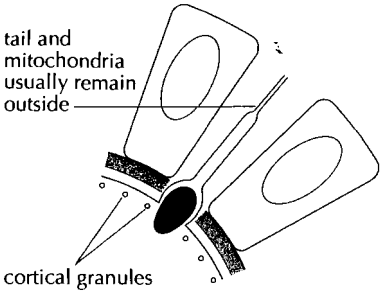
1. ***Arrival of sperm***
Sperm are attracted by a chemical signal and swim up the oviduct to reach the egg. Fertilization is only successful if many sperm reach the egg.



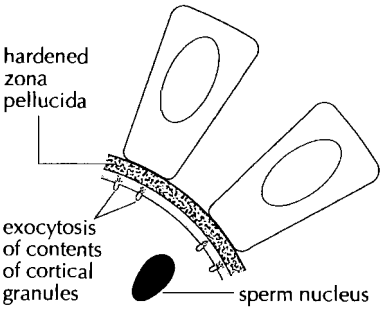
2. ***Binding***
The first sperm to break through the layers of follicle cells binds to the zona pellucida. This triggers the acrosome reaction.



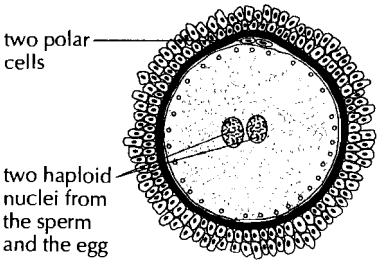
3. ***Acrosome reaction***
The contents of the acrosome are released, by the separation of the acrosomal cap from the sperm. Proteases from the acrosome digest a route for the sperm through the zona pellucida, allowing the sperm to reach the plasma membrane of the egg.



4. ***Fusion***
The plasma membranes of the sperm and egg fuse and the sperm nucleus enters the egg and joins the egg nucleus. Fusion causes the cortical reaction.



5. ***Cortical reaction***
Small vesicles called cortical granules move to the plasma membrane of the egg and fuse with it, releasing their contents by exocytosis. Enzymes from the cortical granules cause cross-linking of glycoproteins in the zona pellucida, making it hard and preventing the entry of any more sperm.



6. ***Mitosis***
The nuclei from the sperm and egg do not fuse together. Instead, both nuclei carry out mitosis, using the same centrioles and spindle of microtubules. A two-cell embryo is produced.

Pregnancy and the placenta

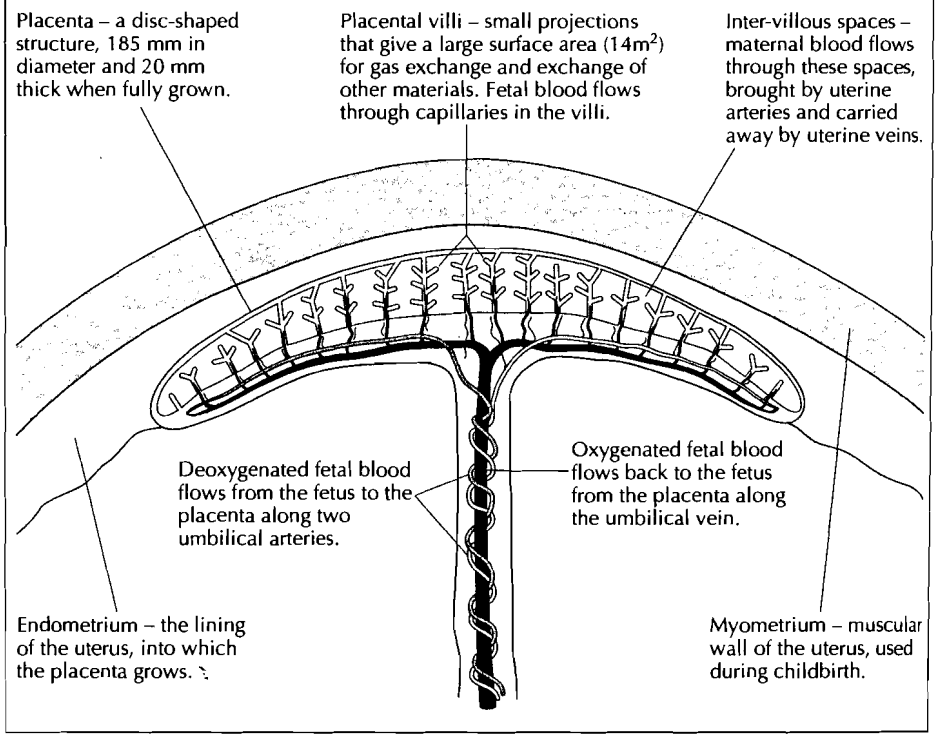
HORMONAL CONTROL OF PREGNANCY

Estrogen and progesterone are needed throughout pregnancy to stimulate the development of the uterus lining. During the first few days after ovulation the corpus luteum secretes these hormones whether or not there has been fertilization. After implanting in the uterus wall, the embryo starts to secrete a hormone called HCG (human chorionic gonadotrophin). HCG prevents degeneration of the corpus luteum, which would happen at the end of a menstrual cycle. HCG stimulates the corpus luteum to grow and to continue secretion of estrogen and progesterone. This is essential to allow the pregnancy to continue. By the middle of the pregnancy, the corpus luteum starts to degenerate, but by then cells in the placenta are secreting estrogen and progesterone and these cells secrete increasing amounts until the end of the pregnancy.

STRUCTURE AND FUNCTION OF THE PLACENTA

The figure (below) shows the structure and functions of the placenta.
The figure (bottom) shows how materials are exchanged between maternal and fetal blood at the surface of villi in the placenta.

Structure of the placenta



EXCHANGE OF MATERIALS ACROSS THE PLACENTA