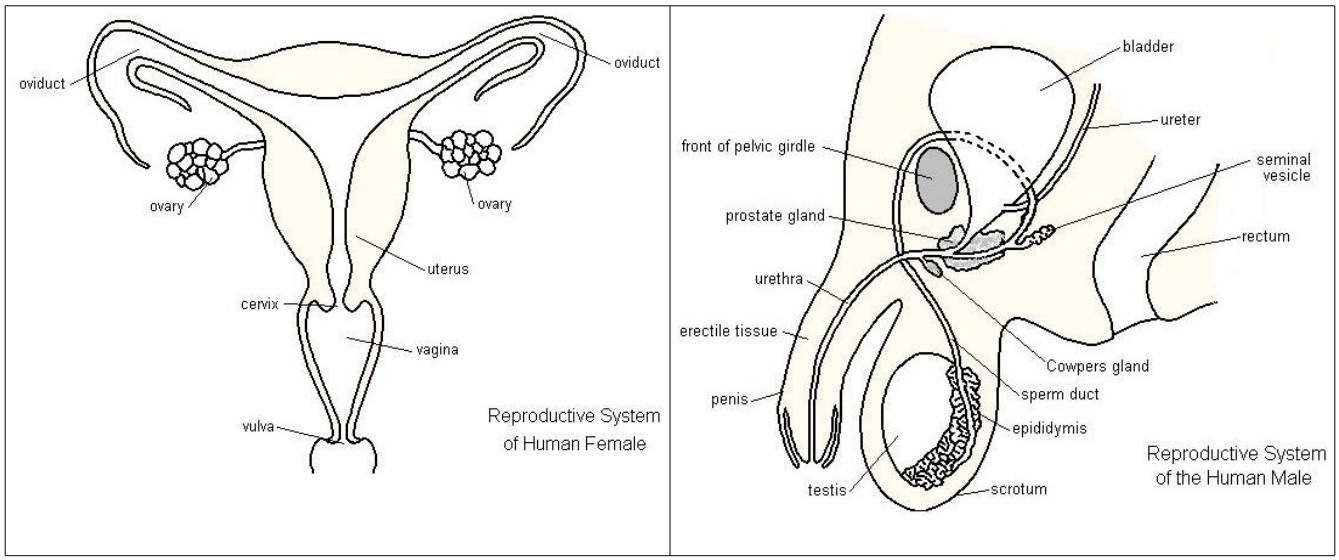
The information in this document is meant to cover the IB syllabus for topics 6.6 and 11.4 (HL ONLY).

The Male and Female Reproductive Systems



Images from http://www.dannynicholson.co.uk/learningzone/body/organs/organs1.htm

Reproductive Hormones

Reproductive hormones are involved in the changes of puberty, and in regulation of the menstrual cycle.

In females,

- Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH) are produced by the anterior pituitary gland.
- Estrogen and progesterone are produced by the ovary.
- FSH, LH, estrogen & progesterone work together to control the menstrual cycle.
  - FSH stimulates maturation of an ovum within its follicle.
  - As the follicle grows, it begins producing estrogen, which inhibits FSH, but stimulates LH production. Estrogen also increases the thickness of the endometrium.
  - LH stimulates ovulation and formation of the corpus luteum, which produces progesterone.
  - Progesterone ("the pregnancy hormone") maintains the endometrium and inhibits production of FSH & LH, thereby inhibiting ovulation. If fertilization does not occur, the corpus luteum breaks down, and the pituitary gland will start producing FSH again to stimulate another follicle.
- At this point, the endometrium is expelled from the uterus (menstruation).
- Estrogen also plays a role in puberty: it promotes the development of the female secondary sexual characteristics.

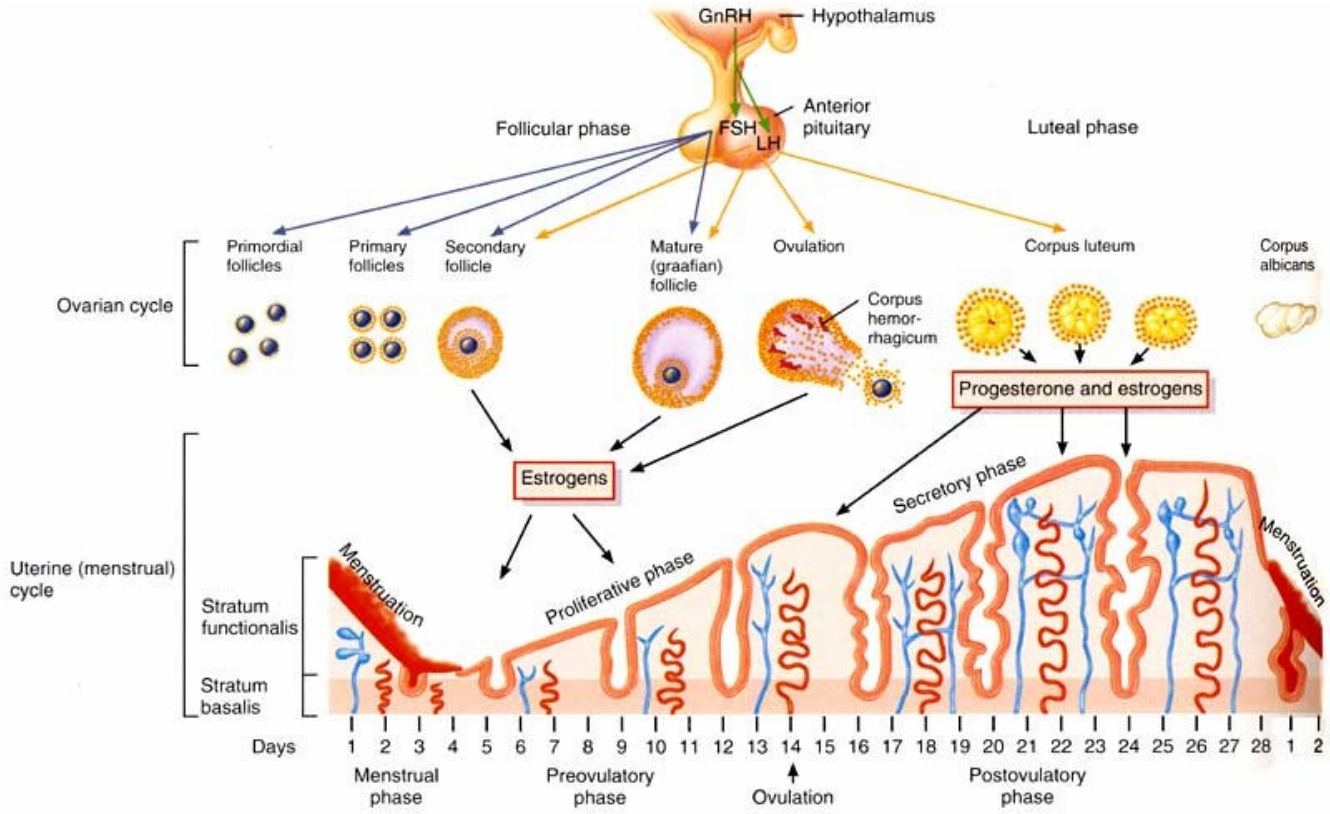


Image from http://scienceblogs.com/pharyngula/upload/2006/04/cycle_lg.jpg

In males,

- FSH promotes spermatogenesis (production of male gametes).
- LH (in males, called interstitial cell stimulating hormone or ICSH) stimulates secretion of testosterone.
- Testosterone and other hormones collectively known as androgens are produced by the Leydig cells (near blood vessels of the interstitial tissue of the testes). It stimulates pre-natal development of the male genitalia, development of secondary sex characteristics (during puberty) and maintenance of the sex drive. Testosterone also stimulates maturation of sperm from secondary spermatocytes.

Gonads & Gametogenesis

The sex organs, or gonads, are responsible for production of gametes, or gametogenesis.

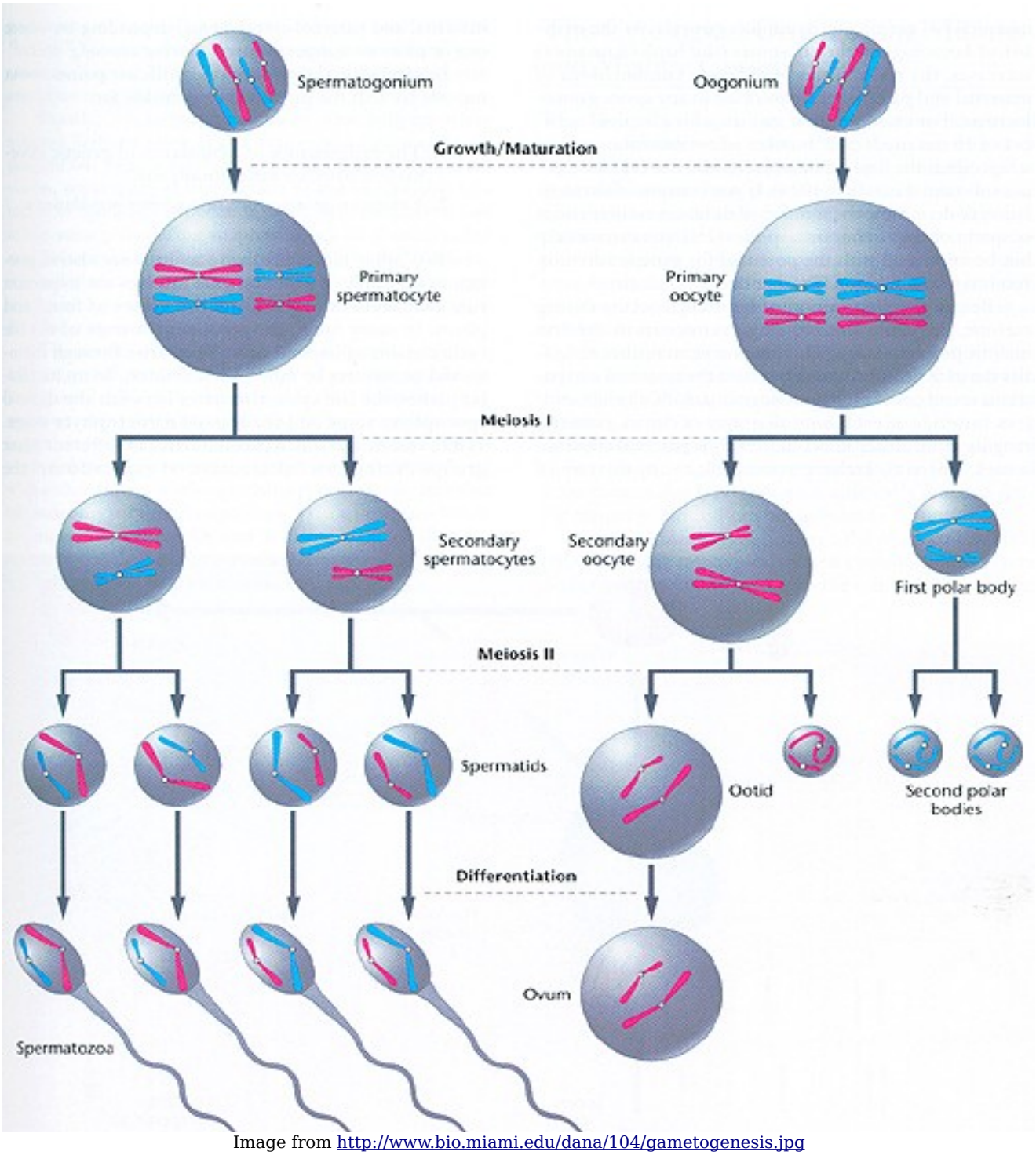


Image from http://www.bio.miami.edu/dana/104/gametogenesis.jpg

In females, the ovaries produce ova , or eggs, by the process of oogenesis, a specialized form of meiosis which only results in formation of one haploid cell:

- oogenesis begins *in utero*, before a female baby is even born
- a large number of oogonia are formed by mitosis
- oogonia undergo cell growth, enlarging and forming primary oocytes
- primary oocytes begin meiosis but stop in prophase I, remaining dormant until puberty begins
- at onset of puberty, some follicles will begin to develop, in response to FSH, and the primary oocyte inside will complete the first meiotic division
- two cells of unequal sizes are formed – cytoplasm and organelles are given to one cell (now called a secondary oocyte); the second is essentially a nucleus in a cell membrane → this structure is called a polar body
- the polar body eventually disintegrates and is reabsorbed by the body
- the secondary oocyte proceeds to meiosis II, stopping in prophase II
- meiosis II completes if the cell is fertilized: this forms an ovum and a second polar body

In males, the testes produce sperm, by the process of spermatogenesis, also a form of meiosis; however each round of spermatogenesis produces four spermatids, or immature sperm.

Ovary Structure

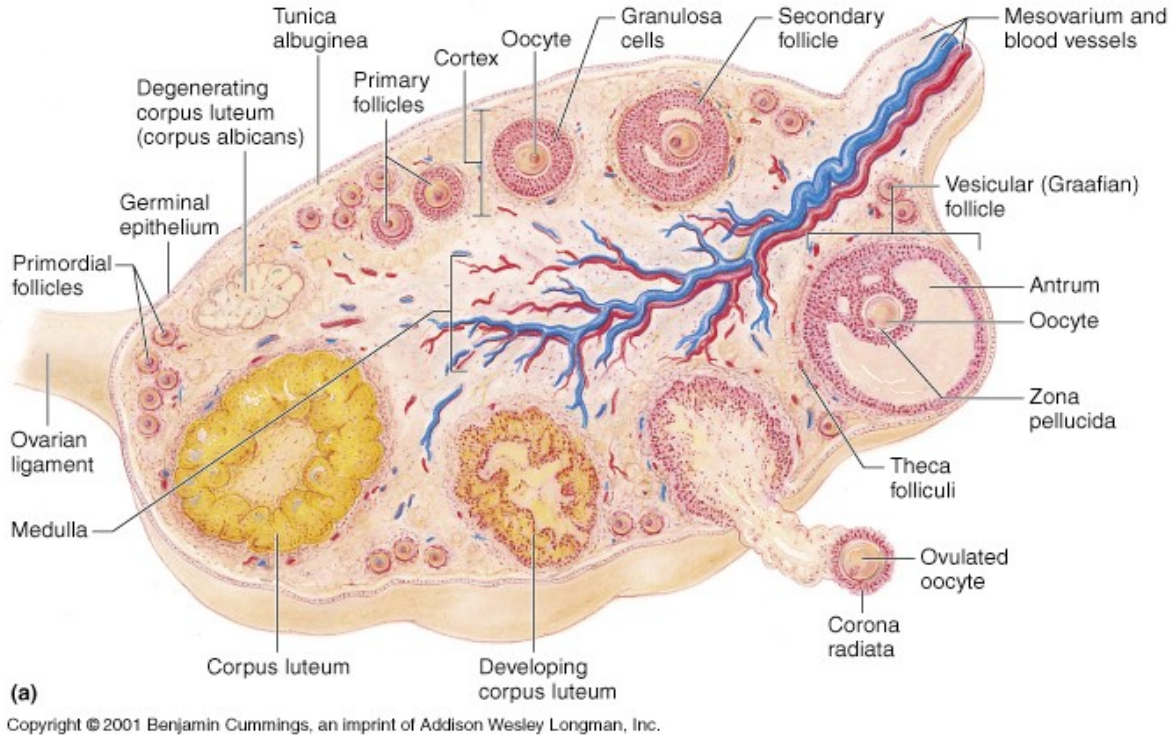


Image from http://www.tarleton.edu/~anatomy/ovary.jpg

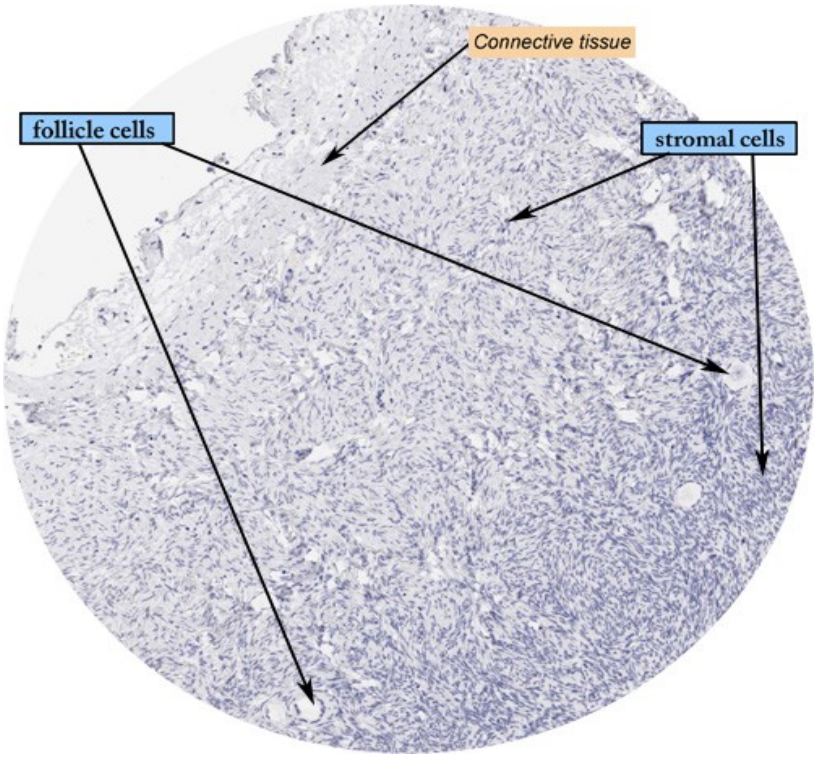


Image from http://www.proteinatlas.org/histology.php?content_id=20

Testis Structure

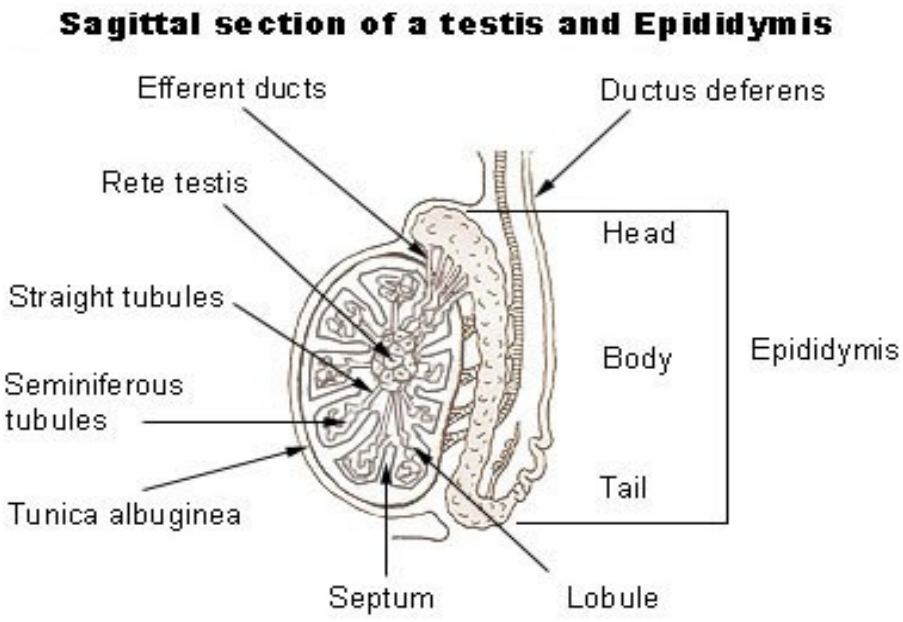


Image from http://www.web-books.com/eLibrary/Medicine/Physiology/Reproductive/testis.jpg

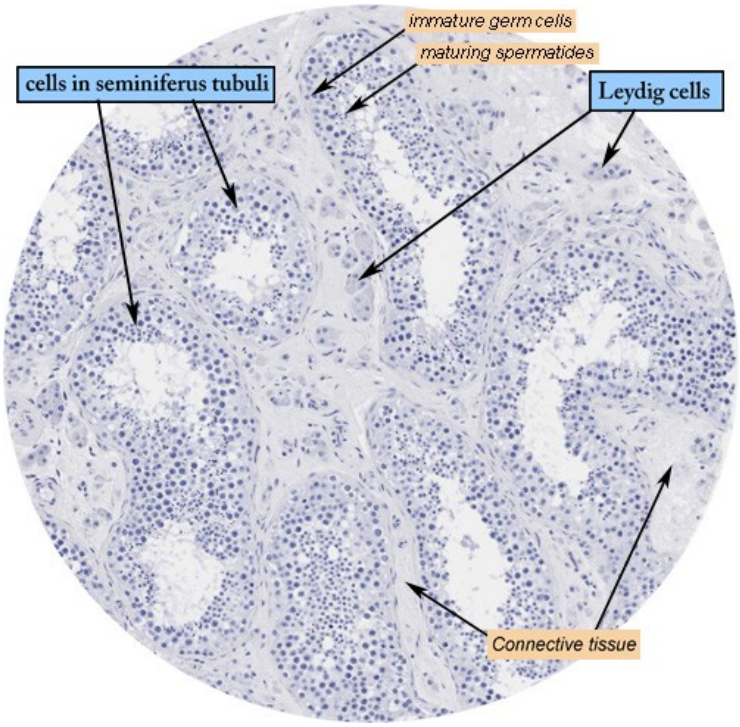


Image from http://www.proteinatlas.org/tissue_dictionary/testish1.jpg

Sperm are released from the body within semen, or seminal fluid. It is produced by several glands:

Seminal Vesicles

- two pouches located in the pelvic region behind the bladder
- supply a viscous, nutrient-rich (citric acid, amino acids, fructose) alkaline secretion that forms a part of the seminal fluid
- supply about 30% of the volume of seminal fluid

Prostate Gland

- largest of all male reproductive glands (about the size of a chestnut); located just beneath the bladder
- contributes about 60% of the seminal fluid
- it secretes a thin, milky-white alkaline fluid similar to that of the seminal vesicles; neutralizes acidic fluids both in the male urethra and the female vagina so that the sperm are not damaged

Bulbourethral Gland (Cowper's Gland)

- pea-sized gland located beneath the prostate gland
- contributes about 10% of the seminal fluid

Epididymis

- tightly-coiled tube located on top of the testis (6 m long if stretched out)
- sperm are stored in the epididymis for about 2 weeks while they mature, develop motility and become capable of fertilization

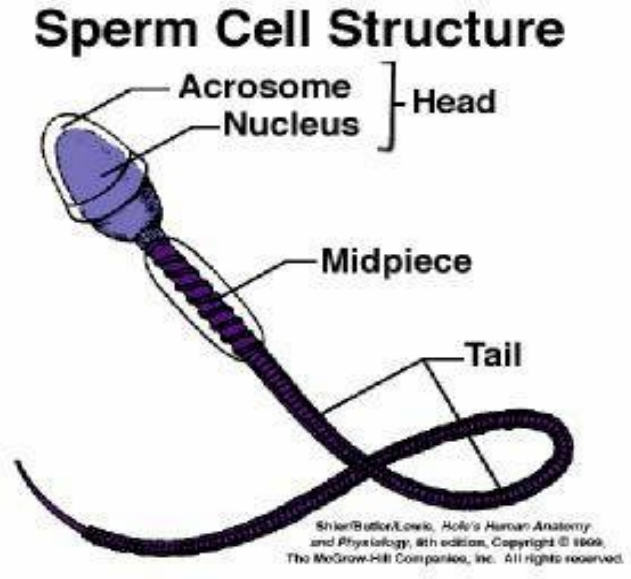


Image from
http://distance.stcc.edu/AandP/AP/AP2pages/reprod/spermato.htm

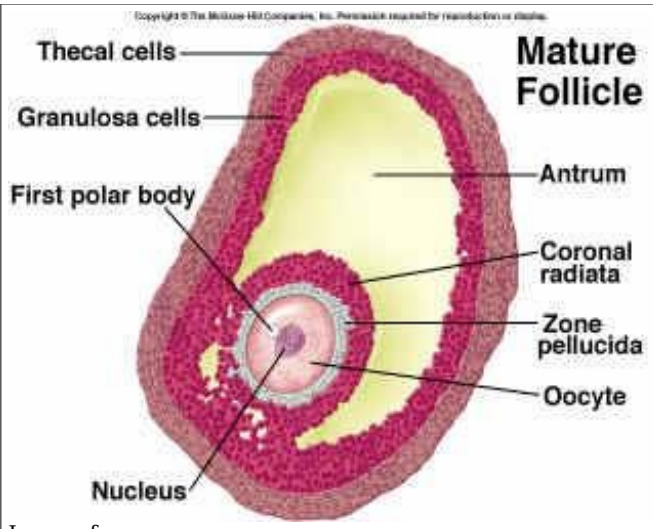


Image from
http://faculty.southwest.tn.edu/rburkett/repro_15.jpg

Comparing Spermatogenesis and Oogenesis

Similarities:

- Both spermatogenesis & oogenesis involve mitosis and cell growth before undergoing meiosis.
- The hormones LH and FSH are involved in regulation of both processes.

Differences:

- Spermatogenesis occurs in the testes, while oogenesis occurs in the ovaries.
- Spermatogenesis starts at puberty, while oogenesis starts during gestation (fetal development).
- Spermatogenesis occurs until death, while oogenesis ceases at menopause.
- Spermatogenesis occurs continuously, whole oogenesis is cyclic (menstrual cycle).
- Millions of sperm are created daily, while only one ovum (or two) is produced every 28 days.
- Ejaculation of sperm can occur at any time, while ovulation only occurs once per menstrual cycle.
- Sperm are produced by equal divisions, producing four spermatids, while unequal divisions in oogenesis result in the production of only one ovum.
- Spermatogenesis doesn't produce polar bodies, while oogenesis produces 2 or 3 polar bodies.
- Spermatogenesis requires testosterone, while oogenesis does not.

Pregnancy

Copulation is the physical contact between the male and female reproductive structures that is needed for sperm to move from the male to the female but does not necessarily result in fertilization due to the use of a contraceptive, infertility, or timing.

Fertilization is the fusion of male and female gametes, forming a zygote.

- The acrosome reaction is when the sperm comes into contact with the coats surrounding the egg, and as the contact takes place the acrosome (an enzyme-filled vacuole at the tip of the sperm) bursts open and releases enzymes that digest the jelly coat of the egg.
- The sperm membrane then comes in contact with the egg cell membrane and the two membranes fuse, followed by the entry of the sperm nucleus into the cytoplasm of the egg.
- The cortical reaction results as the sperm comes in contact with the egg cell membrane, triggering changes to the egg cell membrane making it impossible for other sperm cells to enter.
- After fertilization, the chromosomes of the male and female gametes line up at the cell's equator in preparation for mitosis. Since this division is not followed by cell growth, and simply cleaves the cell into two smaller ones, it is called a cleavage division.
- Several cleavage divisions occur, resulting in the formation of a solid ball of cells, the morula, which in humans reaches the uterus about 4 days after fertilization.
- Unequal divisions in the morula occur, resulting in the formation of a fluid-filled space in the middle – it is now a hollow ball of cells called a blastocyst.
- The blastocyst implants in the endometrium about 7 days after conception.
- During first 2 to 4 weeks of development the embryo obtains nutrients directly from the endometrium. However, tissues grow out from the developing embryo and mingle with the endometrium and form the placenta.
- Materials are exchanged between the maternal and fetal blood in the placenta.
    - The placenta is a fetal tissue which invades the maternal tissue (the uterus). It is disk-shaped and grows to about the size of a dinner plate weighing less than 1 kg.
    - Diffusion of material between the maternal and embryonic circulatory systems provides nutrients, exchanges respiratory gases, and disposes of metabolic wastes for the embryo.
    - Blood from the embryo travels to the placenta through arteries of the umbilical cord and returns via the umbilical vein, passing through the liver of the embryo.
- In addition, the placenta plays an endocrine role in maintaining pregnancy. In early pregnancy, it secretes human chorionic gonadotopin. After the breakdown of the corpus luteum, the placenta secretes both estrogen and progesterone. If the levels of these hormones are not maintained, the pregnancy will abort spontaneously because the uterus has not maintained favourable conditions for fetal growth.
- HCG acts like pituitary LH to maintain secretion of progesterone and estrogens by the corpus luteum through the first trimester. In the absence of this hormonal override, the decline in maternal LH due to inhibition of the pituitary by progesterone would result in menstruation and spontaneous abortion of the

embryo. Levels of HCG in the maternal blood are so high that some is excreted in the urine, where it can be detected in pregnancy tests.

- For the next two months, the growing baby is called an embryo, and is barely discernible as human.
- In the third month of pregnancy, the growing baby starts to look more human, and is known as a fetus until its birth.
- The fetus is supported and protected by the amniotic sac and amniotic fluid.
    - The fetus floats in the amniotic fluid. The fluid is constantly circulated by the fetus swallowing and "inhaling" it, and "exhaling" and urinating into it.
    - Amniotic fluid provides cushioning protection to the fetus.
    - It allows for freedom of fetal movement, which permits symmetrical musculoskeletal development.
    - It maintains a relatively constant temperature surrounding the fetus, which protects it from heat loss.
    - It permits proper lung development, because it is inhaled into & exhaled from the lungs.

Birth

Approximately 38 weeks after conception, the fetus is ready to leave the uterus.

- Before birth, progesterone levels will drop.
- It will send a signal to the extra-embryonic membranes – which leads to the secretion of prostaglandins.
- Prostaglandins initiate uterine contractions.
- Contraction of the uterus pushes the baby's head against the cervix, causing it to dilate.
- Nerve endings in the cervix and uterus tell the brain that contractions are occurring, and the posterior pituitary gland will secrete oxytocin.
- Oxytocin, prostaglandins and a positive feedback system cause the uterine contractions to become stronger and longer in duration.
- When the cervix is fully dilated (10 cm), stage one of birth, (labour) is complete. Labour can take many hours.
- Stage two (expulsion) occurs as powerful contractions force the baby out of the uterus. Stage two usually lasts no more than one hour.
- Once the baby has been born, the uterus has nothing to push against – this ends the positive feedback loop, and contractions diminish.
- The final stage of birth is expulsion of the placenta, caused by a few more uterine contractions.

in vitro Fertilization (IVF)

Some couples are unable to conceive due to infertility issues such as blocked Fallopian tubes or a low sperm count. IVF is one common way that couples with fertility issues are able to become pregnant.

- A drug is injected once a day for three weeks, to stop the woman's normal menstrual cycle.
- Large doses of FSH are injected once a day for 10-12 days to stimulate the ovaries to develop many follicles.
- HCG is injected 36 hours before egg collection, to loosen the eggs in their follicles and to make them mature.
- The man provides semen by ejaculating into a container. The sperm are processed to concentrate the healthiest ones.
- The eggs are extracted from the follicles using a device inserted through the wall of the vagina.
- Each egg is mixed with sperm in a Petri dish, which is kept in an incubator overnight.
- The Petri dishes are checked the next day to see if fertilization has occurred.
- Two or three embryos are selected and placed, via a long plastic tube into the uterus.
- About two weeks after placing the embryos, a pregnancy test is done to see if any embryos have implanted.
- A scan is done about a month after placing the embryos, to see if the pregnancy is continuing normally. The heartbeat should be visible.

Ethical Concerns Regarding IVF

Pros	Cons
• promotes fertility in childless couples • suffering due to genetic disease could be reduced if embryos were screened before transferring to the uterus.	• against religious principles • multiple births are more likely, and carry a greater risk to the mother • doctors decide which embryos are transferred to the uterus – so humans are deciding who lives & dies • more embryos are produced than are normally implanted in one procedure – spares may be destroyed if they are not stored for later procedures