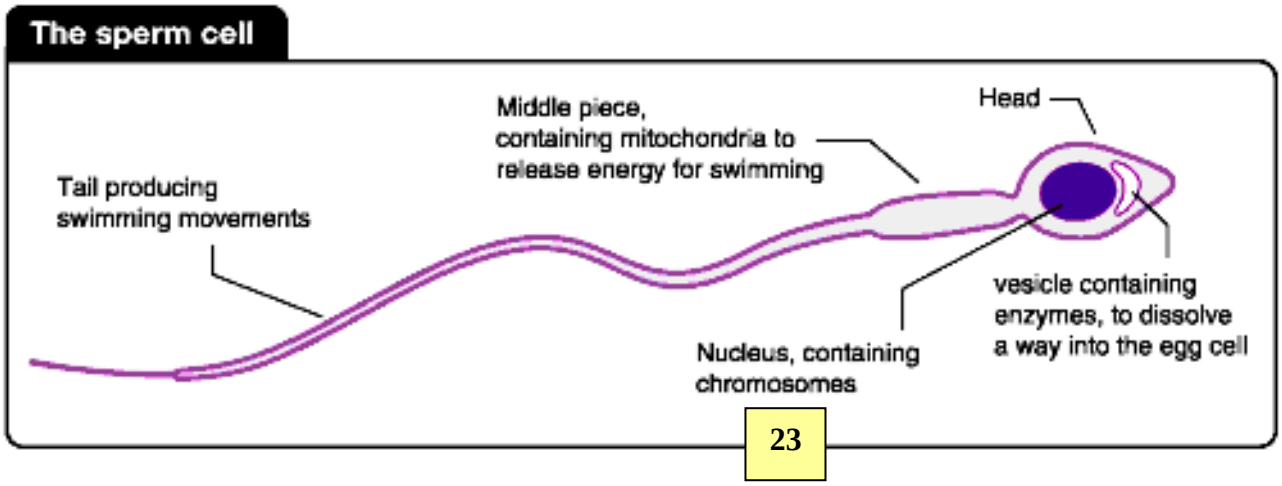
The Reproductive System

Sexual Reproduction in Animals

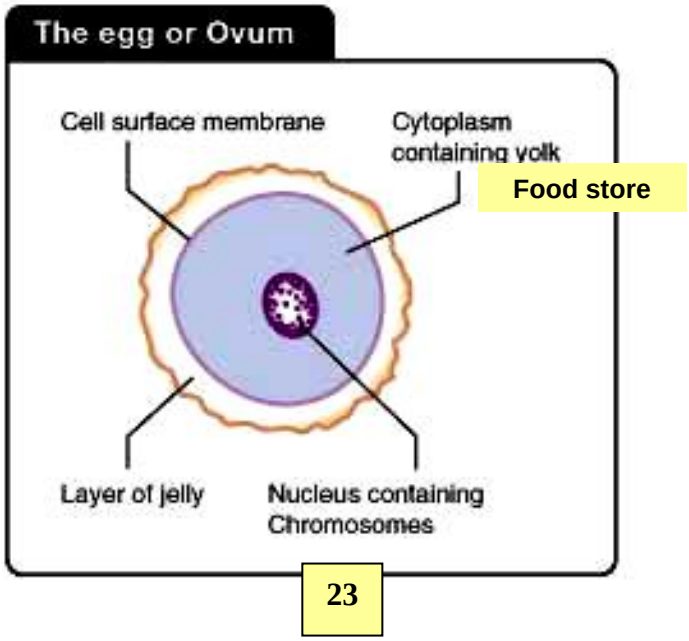
Reproduction - Ability to produce individuals (offspring) of the same species

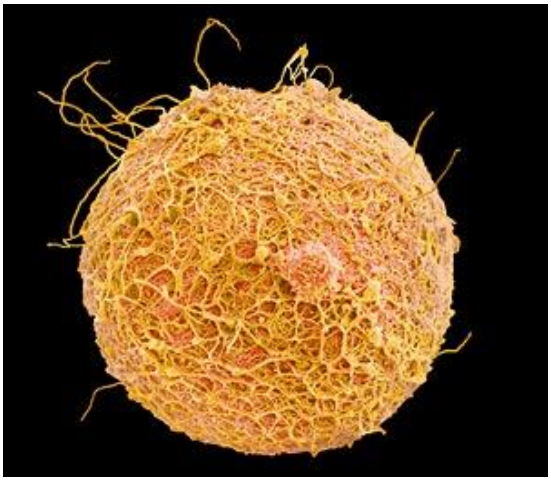
Most animals reproduce **sexually**. In **sexual reproduction** male and female parents produce sex cells or **gametes**, the nuclei of which contain the genetic material. Gametes are formed by **meiosis**

Male gamete = sperm – produced in testes and deposited though intercourse (mating) into female reproductive tract by male reproductive system



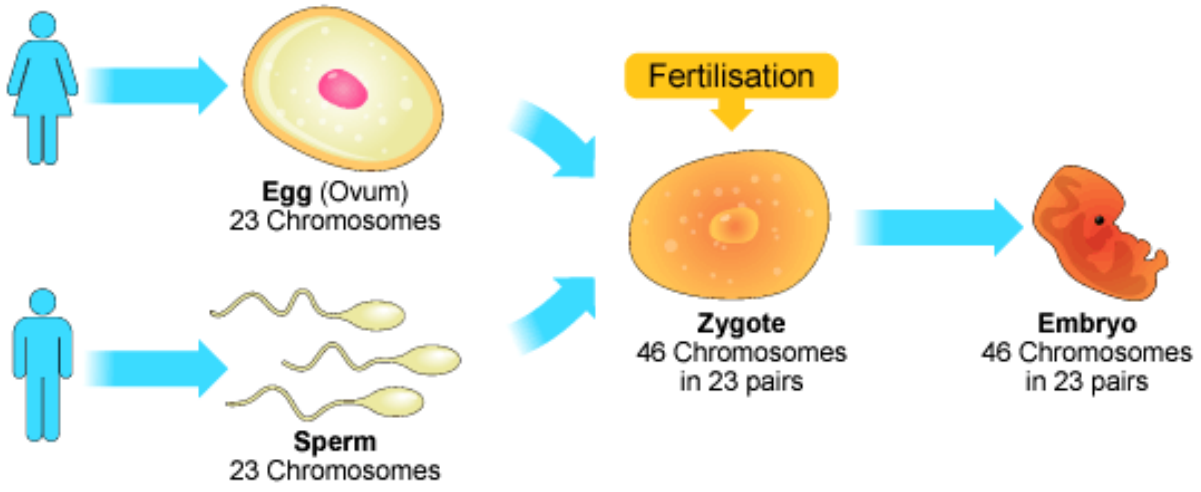
Female gamete – egg (ovum) – produced in ovaries – fuses with male sperm to form a zygote (which develops into a baby) in the female reproductive tract

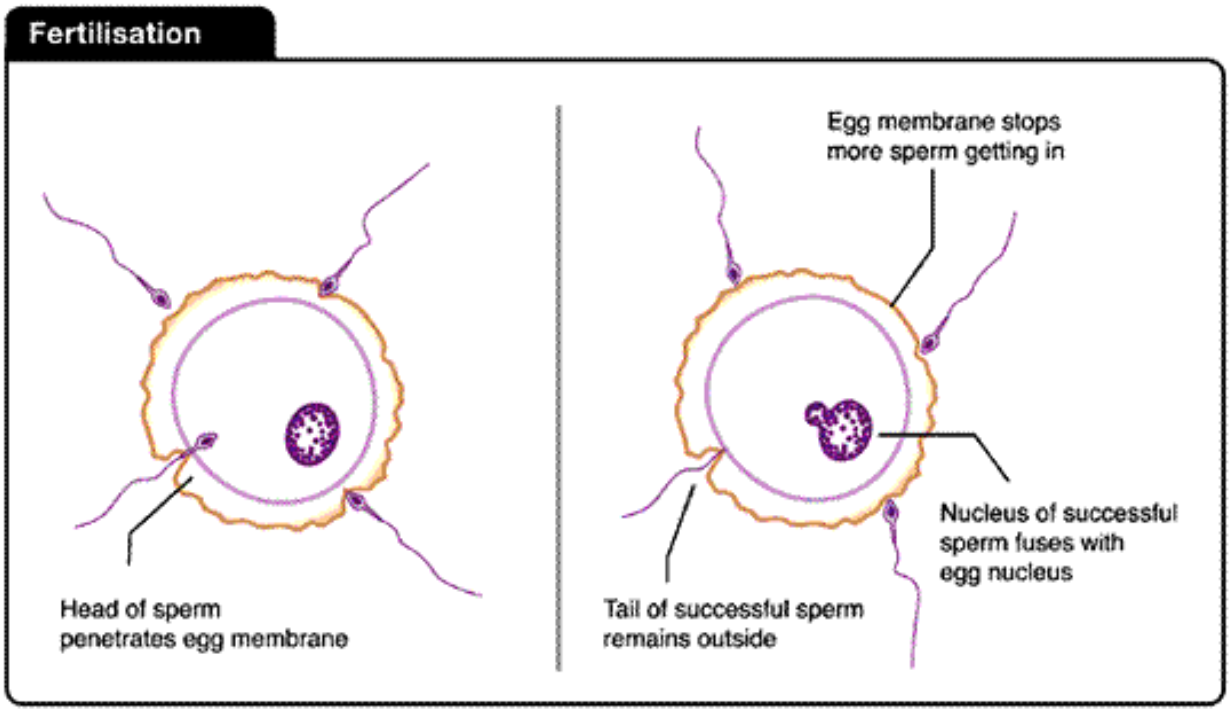




A human egg surrounded by sperm - one of which will fertilise it

Each gamete contains half the number of parental chromosomes. The two gametes fuse together during fertilisation to make a new individual with a full set of **chromosomes**.



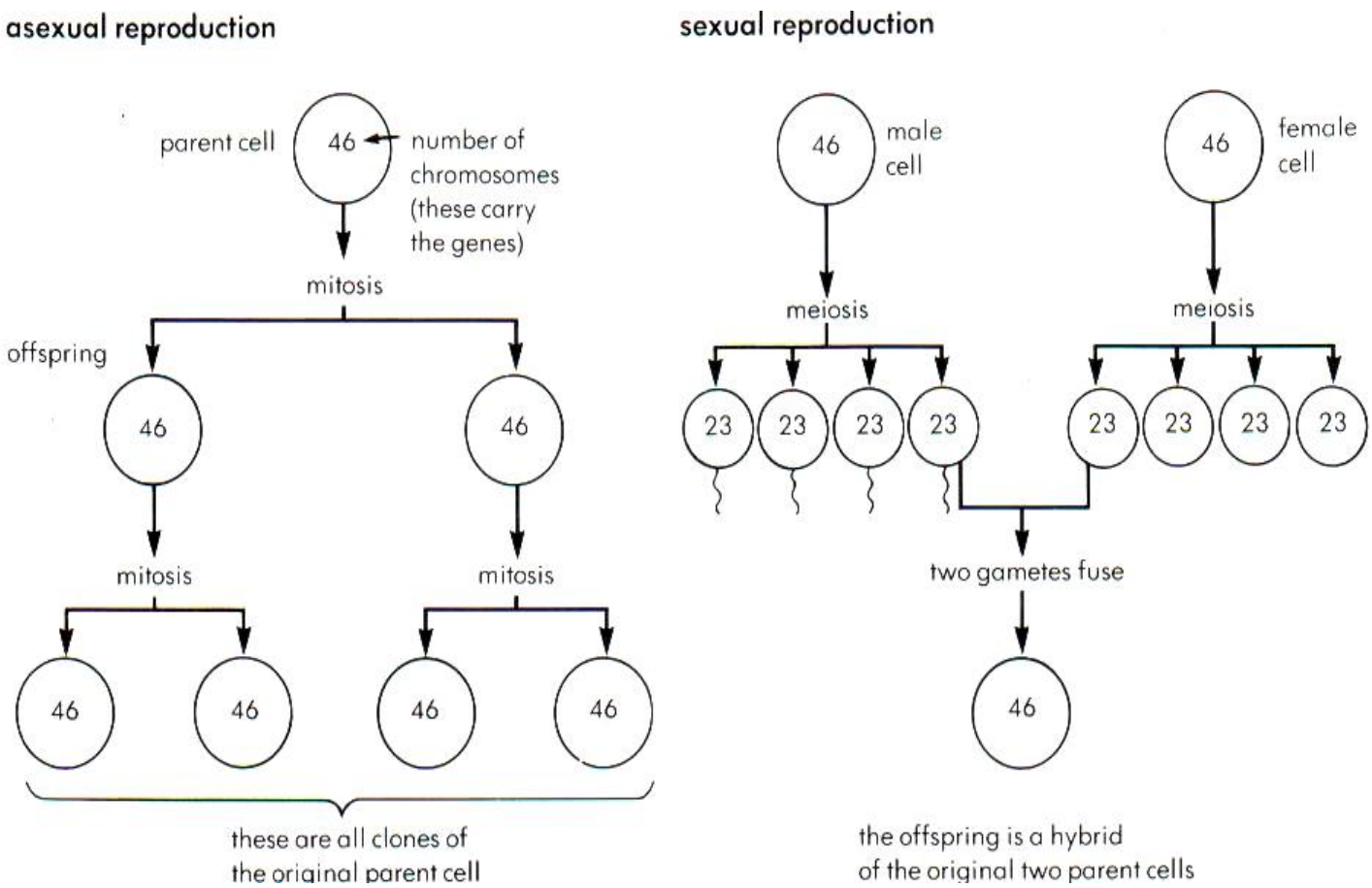


Sexual reproduction is the fertilization of a female gamete by a male gamete.

Asexual Reproduction

One parent only - no fusion of sex cells
New cells produced by mitosis only
Offspring genetically identical to parent (clones) - little variation – environment only
Produces offspring by

1 Binary fission – e.g, bacteria
2 Budding – e.g. yeast; hydra
3 Vegetative propagation – e.g. strawberry

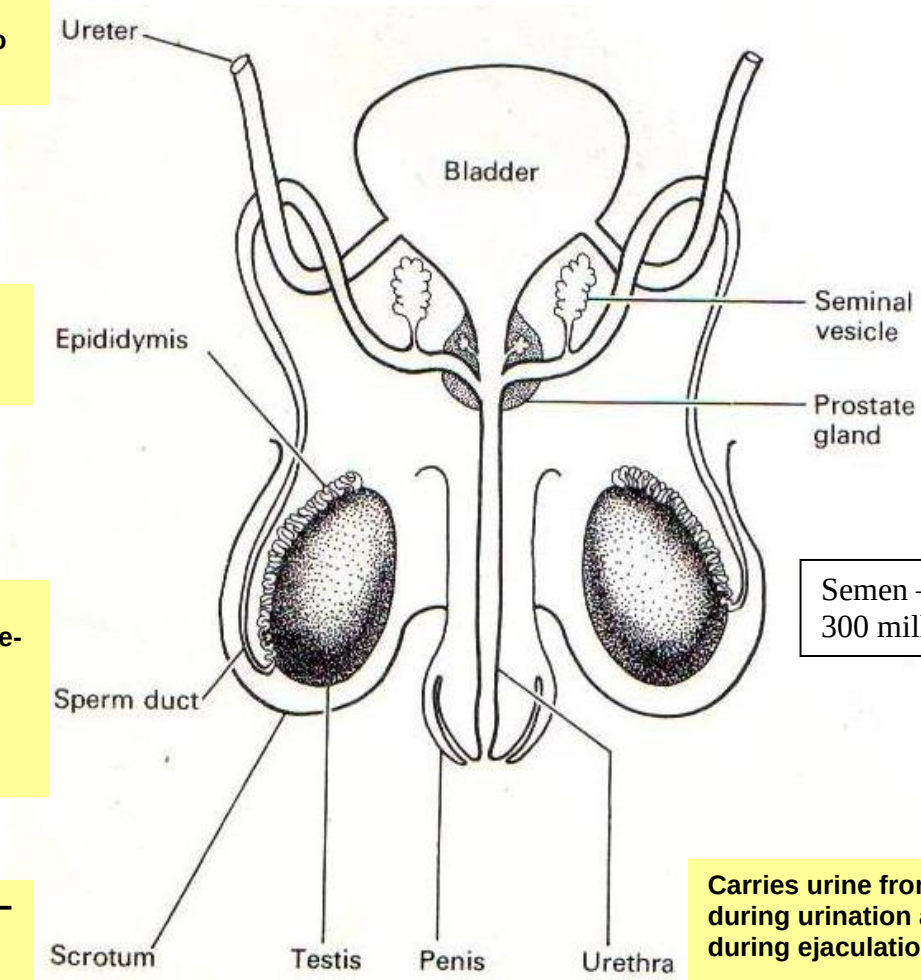


Stages in Sexual Reproduction in Humans

1. Once a month an egg cell is released from the ovary. This is called ovulation.
2. The egg cell moves into the oviduct.
3. Many sperm are deposited in the vagina during sexual intercourse. They pass through the cervix, into the uterus and along the oviduct.
4. A single sperm meets the egg cell in the oviduct and fertilisation (conception) takes place here.
5. The head of the sperm, which contains the nucleus (23 chromosomes) enters the ovum and fuses with the nucleus of the ovum, which also contains 23 chromosomes. Fusion of the sperm and egg nucleus results in a single cell termed the **zygote** (46 chromosomes)
6. The zygote divides by **mitosis** to form the embryo. The embryo embeds itself in the uterus wall and divides further. A placenta (exchange surface) is formed between the developing embryo and the maternal blood vessels in the uterus wall. The cells continue to divide and become specialised into tissues, which then form organs. At this stage the individual is termed the foetus. The foetus than develops into the baby.
7. The baby is delivered into the outside world at birth after 9 months (gestation period), by the process of parturition (or labour)

Male Reproductive System

Carries urine from bladder to urethra



Adds fluid containing fructose (for energy), enzymes and proteins to sperm

Storage of sperm
Site of sperm maturation

Adds alkaline fluid containing sugars to sperm

Semen – 3 to 5ml ejaculated
300 million sperm

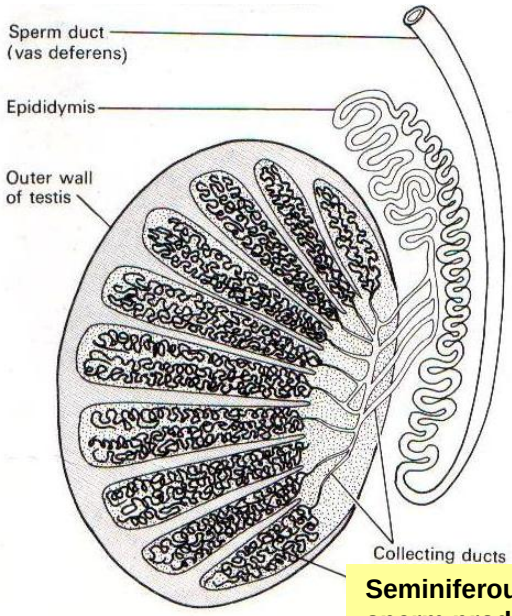
Carries sperm from testes to penis by wave-like muscular contractions (peristalsis) – also termed vas deferens

Carries urine from bladder during urination and sperm during ejaculation

Sac containing testes – outside the body
Maintains optimum temperature (below body temperature of 370C) for sperm formation by raising or lowering the testes
Sperm cannot survive for long at 370C

Produces sperm and the hormone testosterone (sex hormone)

Becomes erect when stimulated to enter female vagina, in order to deposit semen (sperm + fluid). An erection is caused by an increase in blood pressure, brought about by the dilation of arteries supplying blood to the penis, and the constriction of veins taking blood away from the penis.



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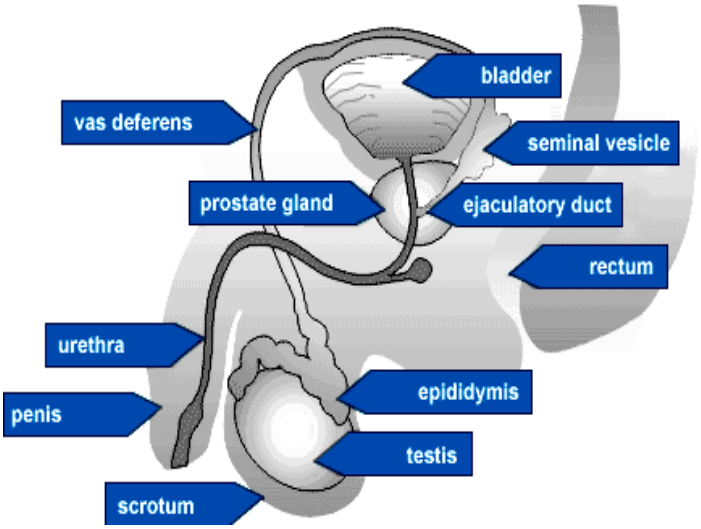
Seminiferous tubules – site of sperm production



Spermatogenesis (Sperm Production)

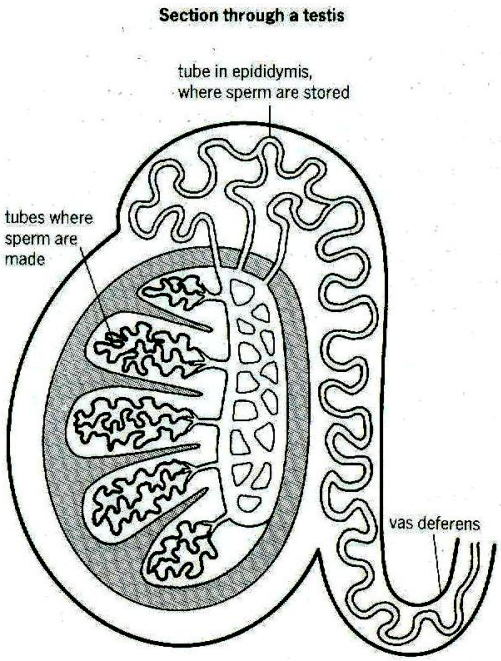
The control centres are the **pituitary gland** and the **hypothalamus** in the brain.

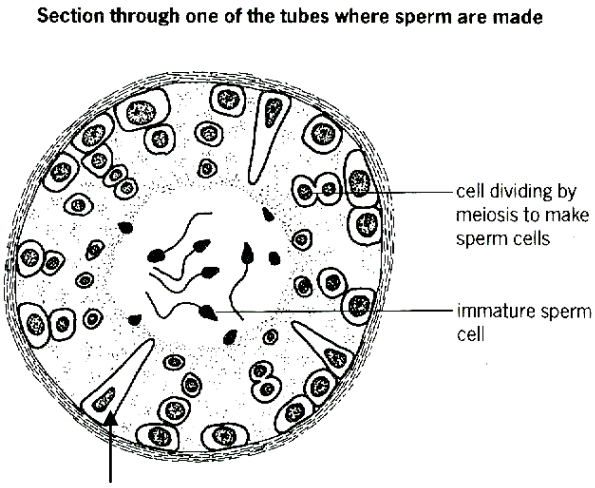
The hypothalamus secretes **GnRH** (**gonadotrophin releasing hormone**). This is released into the blood and stimulates the anterior lobe of the pituitary gland.

The anterior lobe of the pituitary gland secretes **ICSH** (**interstitial cell stimulating hormone**).

ICSH: this stimulates the **leydig cells** that produce testosterone. Testosterone also acts on the seminiferous tubules and stimulates sperm production.

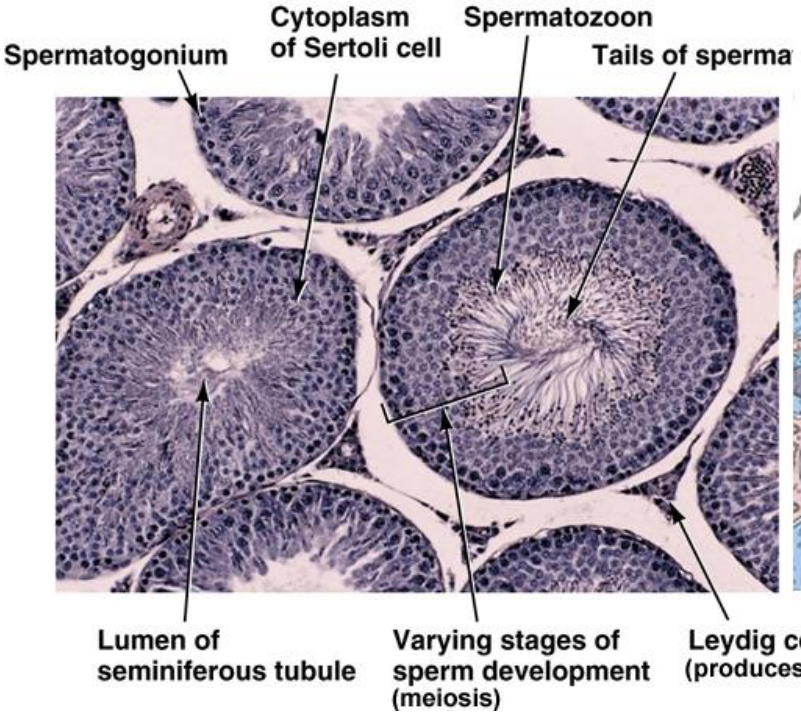
FSH: this stimulates the **seminiferous tubules**, including the Sertoli cells. They produce sperm in response.

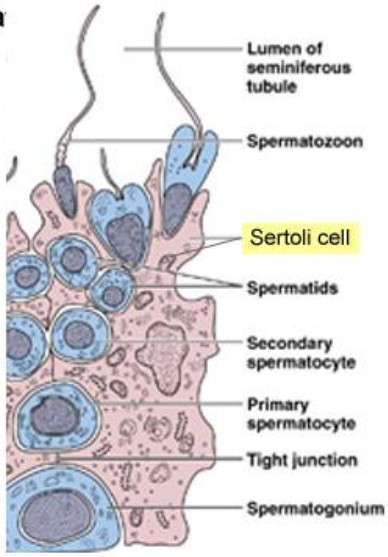




Sertoli cell – nourish sperm

Section through one of the tubes where sperm are made



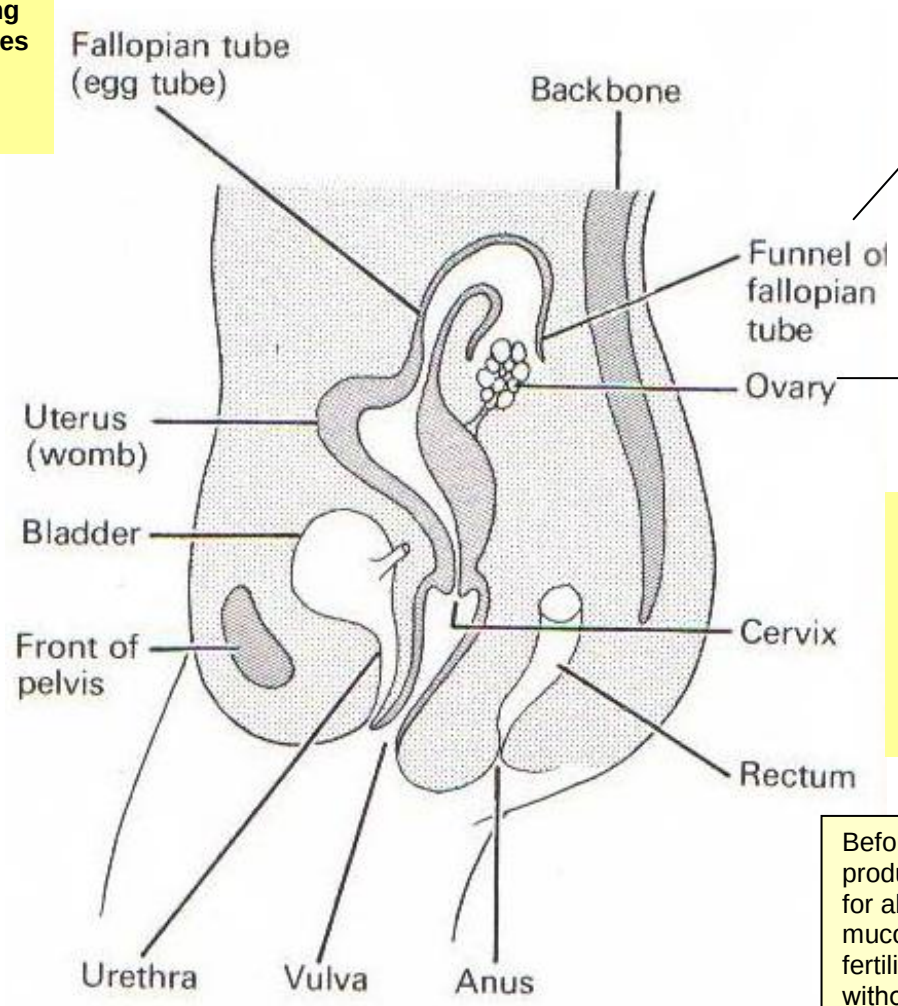


Female Reproductive System

Narrow tube carrying eggs from the ovaries to the uterus
Has ciliated cells
Site of fertilisarion

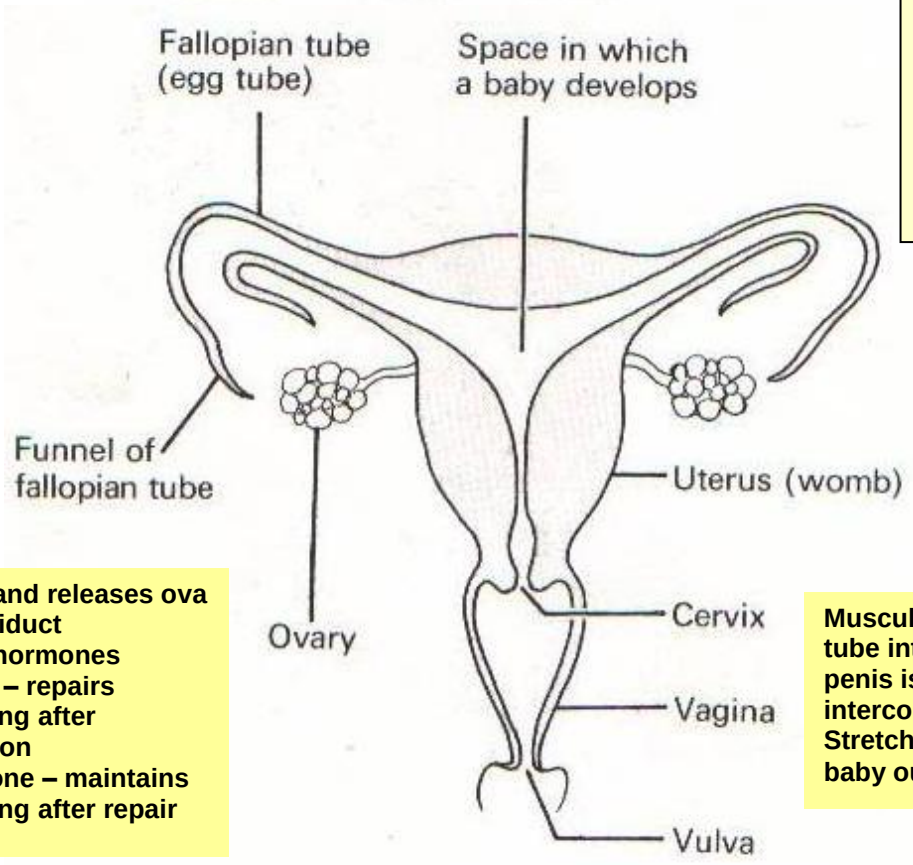
Collects eggs released from the ovary and directs them into the oviduct

Produces and releases eggs
Produces hormones – oestrogen and progesterone



Ring of muscle between vagina and uterus
Allows sperm to pass into uterus from vagina and blood to pass out during menstruation and the baby during birth

Before ovulation, the cervix produces a special mucous for about 3 to 9 days. This mucous is as crucial to fertility as ovulation because without it, the male's sperm cannot survive nor be transported inside the female to fertilize the eggs. When mucous is present, it nourishes and protects sperm allowing them to live for 3 to 5 days.



Muscular sac
Wall - site of implantation of fertilises egg and embryo; formation of placenta
Cavity in which foetus develops

Produces and releases ova into the oviduct
Produces hormones
Oestrogen – repairs uterine lining after menstruation
Progesterone – maintains uterine lining after repair

Muscular and elastic tube into which male penis is placedduring intercourse
Stretches to allow baby out at childbirth

Production of Eggs (Oogenesis)

Egg development - Cyclical process of 28 days. Takes place in the ovaries. It is controlled by hormones from the hypothalamus and the pituitary gland.

At birth, each ovary in a female has hundreds of thousands of eggs, but they are immature and remain dormant until her first menstrual cycle, which occurs during puberty (sexual maturity).

Every 28 days or so, from puberty until menopause (when ovulation and menstruation stops), between one and three eggs, the size of the head of a pin are released from the ovaries. This whole process takes about three minutes and is known as ovulation. The eggs are then move down the fallopian tubes towards the Uterus.

Effects of Oestrogen

Repair of uterine lining after menstruation
Stimulates release of LH
Inhibits production of \FSH
Secondary sexual characteristics at puberty

The outer layer of the ovary (the germinal epithelium) produces primary oocytes (immature eggs). It also produces follicle cells that congregate around the oocytes, forming a structure called the primary follicle.

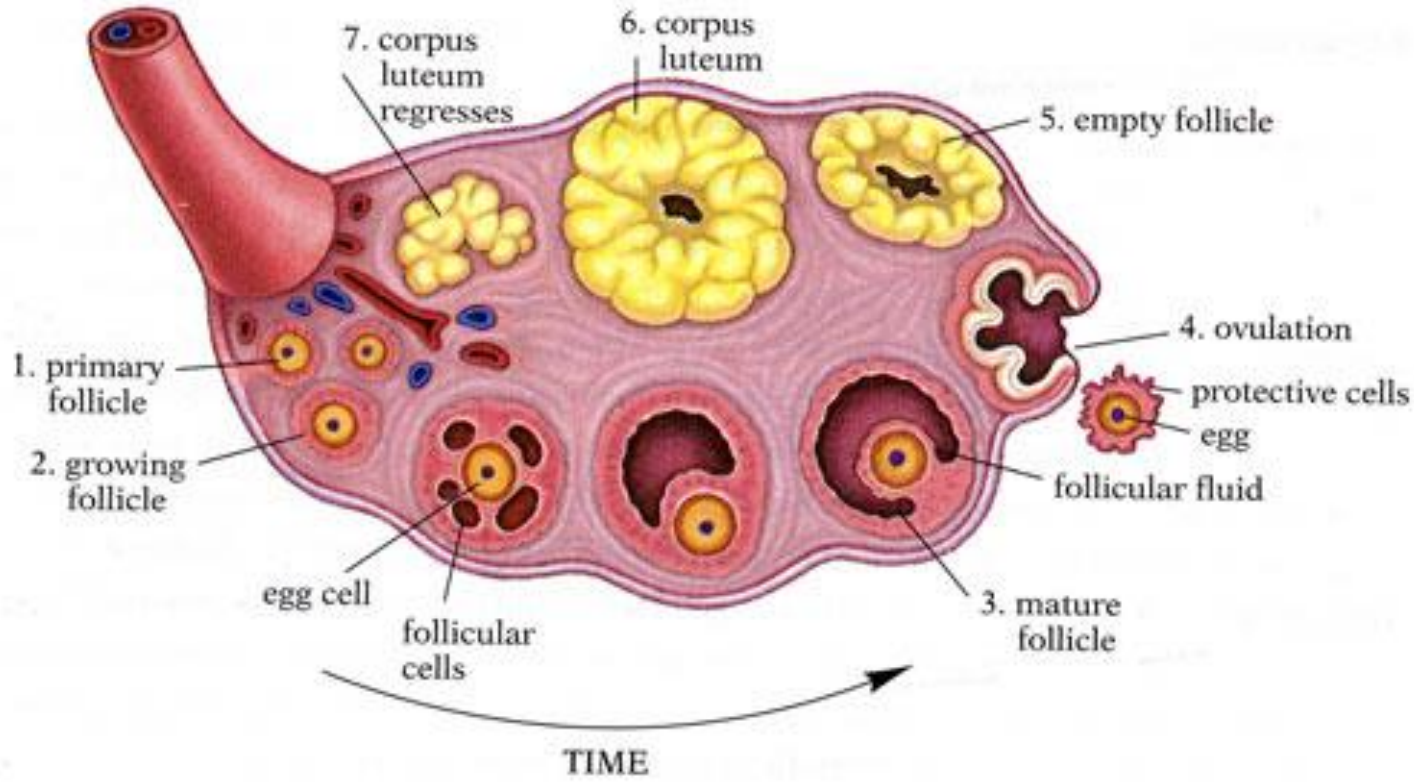
↓

After puberty one of these develops each month to form a secondary oocyte (mature egg). The follicle cells around it proliferate to form a wall many cells thick called the theca. Fluid collects inside the structure to form a fluid-filled cavity - the structure is called a Graafian follicle.

↓

The secondary oocyte is released from the Graafian follicle and leaves the ovary – termed ovulation. The secondary oocyte with some surrounding follicle cells enters one of the oviducts – to be propelled towards the uterus by cilia lining the oviducts

Ovary – Production and Release of Egg



The Menstrual Cycle

<u>If an egg is not fertilised</u>

The cycle begins with the start of the bleeding or menses (day 1), during which the lining of the uterus and he unfertilised egg is shed. it is this that gives the cycle its name, the menstrual cycle. The menstrual cycle has 4 stages to it.

1. The lining of the uterus breaks down and the bleeding starts (day 1-4)

2. From day 4 to day 14, this is when the lining is repaired.

3. On day 14 the egg is released from the ovary.

4. The maintenance stage - the repaired uterus lining is maintained, in case the egg is fertilised

If the egg is not fertilised, the cycle starts again.

- **The different stages of the cycle are controlled by a set of four hormones – FSH & LH from the pituitary; OES & PROG from the ovary**

- **Releasing hormone from hypothalamus - stimulates anterior lobe of the pituitary gland to release FSH. FSH stimulates development of follicles in ovary. The follicle cells secrete oestrogen**

- **Oestrogen stimulates the repair of the uterus wall and also inhibits the further release of FSH so no new follicles develop in case pregnancy results. The follicle matures into a Graafian follicle**

- **Oestrogen levels rise to a peak, with a surge shortly before ovulation (day 12-14). The surge in oestrogen stimulates the release of LH from the pituitary. LH also causes a slight surge in FSH**

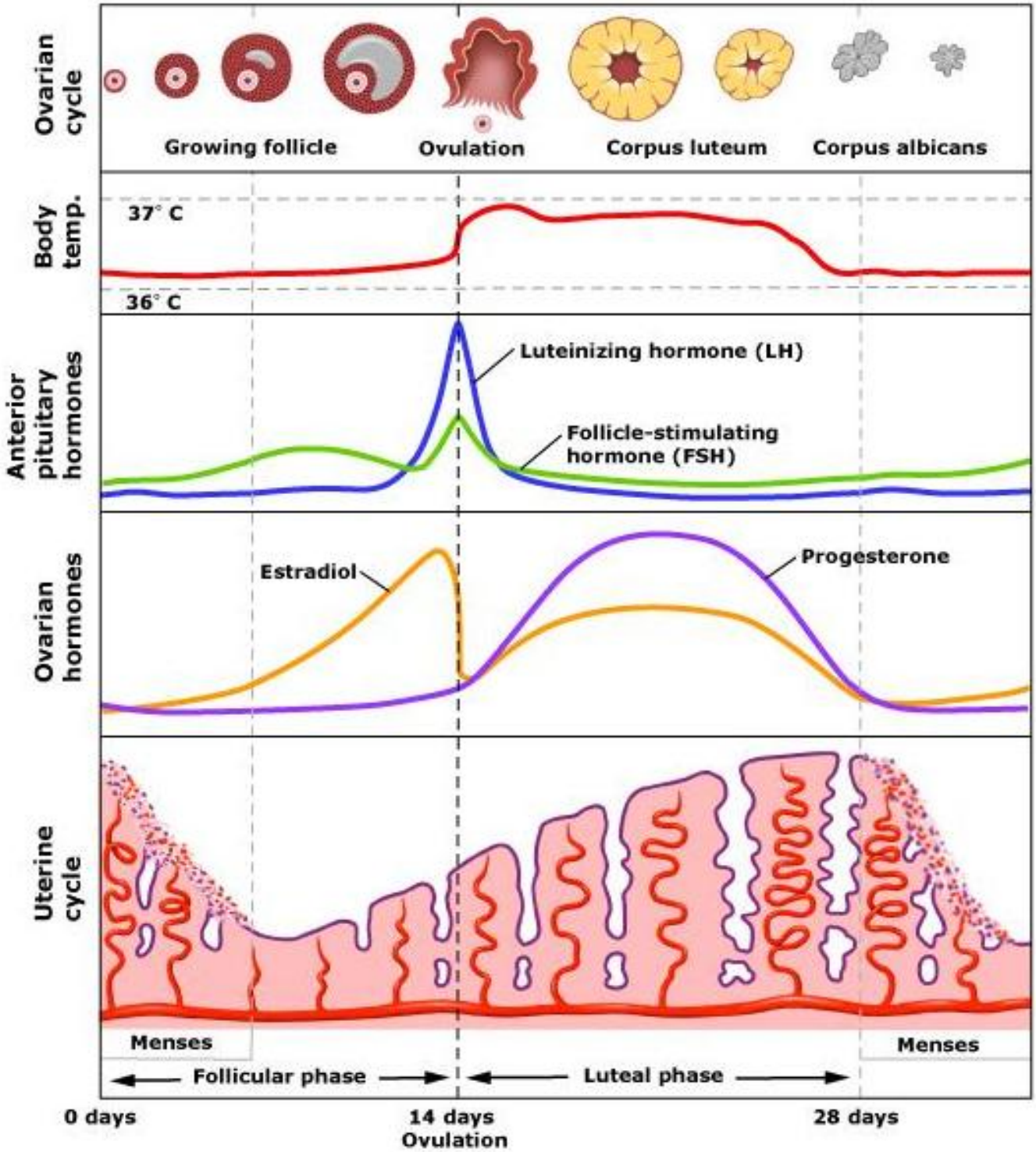
- **The surge of LH causes ovulation (release of the egg from the Graafian follicle into the oviduct) and the development of the corpus luteum "yellow body". Levels of LH and FSH decline after day 14**

- **The corpus luteum secretes progesterone. Progesterone inhibits the release of FSH and LH by the pituitary gland**

- **Progesterone also stimulates the thickening and the vascularisation of the uterus wall in preparation for pregnancy and implantation of the fertilised egg (embryo) – which takes about 7 days to reach the uterus. During this time the fertilised egg divides a number of times to form a ball of cells, termed the embryo. The embryo is then implanted in the wall of the uterus.**

- **The CL continues to secrete progesterone to maintain the lining. The placenta is formed, which also produces the hormone human chorionic gonadotrophin (hCG). hCG maintains the CL and the secretion of progesterone and oestrogen from the ovaries**

- **If the egg is not fertilised, the CL breaks down and stops making progesterone and menstruation occurs. FSH is no longer inhibited – a new follicle develops**



Oestrogen and progesterone are produced by the ovary. LH and FSH are produced in the pituitary gland in the brain.

FSH stimulates the ovary to get the egg ready for release. It also stimulates the ovary (follicle cells) to secrete oestrogen.

Oestrogen causes the lining of the uterus to grow and get ready for the egg. It also helps to trigger the release of the egg by stimulating the pituitary to release LH – LH causes ovulation. It stops FSH being produced (so no more eggs develop).

Progesterone maintains the uterus lining after the egg is released and Inhibits FSH production. .When the level of progesterone falls the lining breaks down

- The hypothalamus releases **GnRH:** this stimulates the anterior lobe of the pituitary gland.
- The pituitary gland releases **FSH:** this stimulates the development of follicles within the ovary.
- The follicle secretes **oestrogen:** this stimulates the repair of the uterus wall. It also inhibits the further release of FSH so no new follicles develop in case pregnancy results. It also inhibits the release of **LH** from the pituitary gland until shortly before ovulation. Then the level of oestrogen rises which actually stimulates the release of LH and FSH.
- A surge of **LH:** this causes ovulation and the development of the corpus luteum. LH feeds back to inhibit oestrogen release so, as a result, the levels of LH and FSH begin to fall.
- The corpus luteum secretes **progesterone:** this stimulates the thickening and the vascularisation of the uterus wall in preparation for pregnancy...

a) If **no pregnancy** occurs: the corpus luteum degenerates, progesterone is no longer released and the lining of the uterus breaks down. The discharge of the wall is called menstruation. FSH release is no longer inhibited so the cycle can begin again and a new follicle can develop.

b) If **pregnancy** occurs: the corpus luteum persists due to a hormone (**CG - chorionic gonadotrophin**) being released.

Using the hormones

By knowing about what the hormones do, doctors have been able to help women to control their egg release. This allows **fertility treatment** and **contraception.**

The **Pill** is a widely used means of contraception which contains both **progesterone** and **oestrogen.** This keeps the oestrogen levels high which stops further egg release.

If **FSH** is given to women who have problems ovulating (producing and releasing eggs) it triggers oestrogen release in the ovary and stimulates egg release. It works well although if you give too much you can get multiple births

Gender - Is it a girl or a boy?

Of the 23 pairs of chromosomes in the human cell's nucleus there is 1 pair that is called the "**sex chromosomes**". In women these chromosomes are the same size and are called **X chromosomes**. However men have one **X** chromosome and a smaller one, the **Y** chromosome. A woman has the genotype "**XX**" while a man has "**XY**". (The phenotypes are what the genes actually produce, the external features).

When the gametes are made through **meiosis** all the chromosome pairs are split up. But since both of the woman's sex chromosomes are **X**, each egg cell will contain an **X**. However men's sperm could either have an **X** or a **Y** chromosome.

The baby will be a girl if the fertilising sperm is an X sperm. The baby will be a boy if the fertilising sperm is a Y sperm. The Y chromosome carries instructions for the male reproductive organs in a region termed the sex determining region (SRY).

Pregnancy and Birth

The fertilised egg (the zygote) divides by mitosis into a ball of cells (the embryo), which settles into the prepared lining of the uterus – a process called implantation – resulting in pregnancy.

Some of the cells of the embryo produce outgrowth called **villi (chorionic villi)** – these extend into the uterus wall and eventually form the placenta

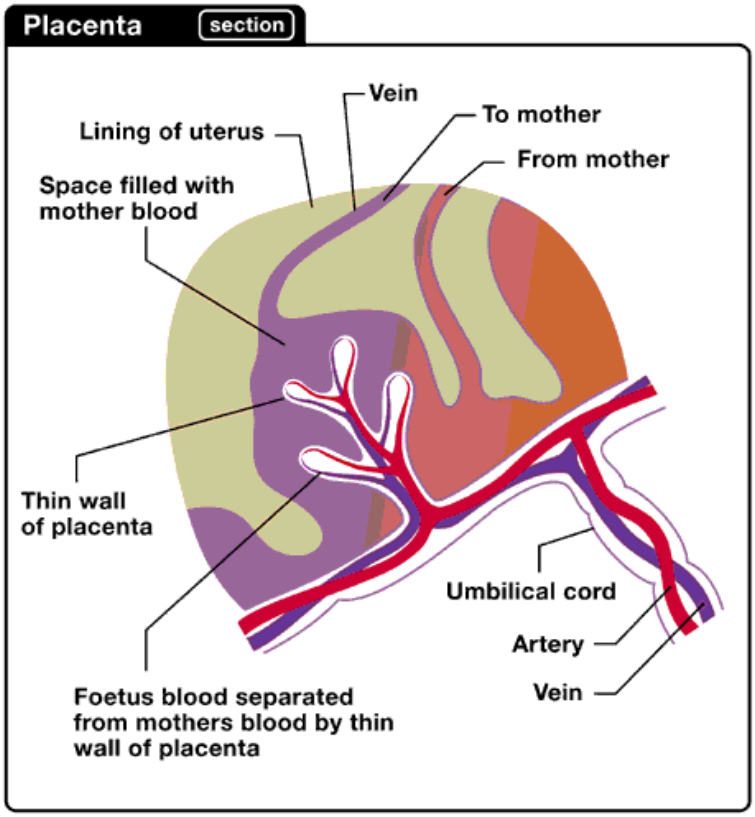
Enzymes are released by the embryo to break down arterial and venous blood vessels in the mother's endometrium. The mother's blood leaks into the space around the villi.

The placenta allows a very close meeting between the baby's blood and the mother's. The two blood streams don't mix but molecules diffuse across a thin barrier between them.

> **The mother and foetus are genetically different and may have different blood groups – this may cause incompatability (agglutination) and may cause the foetus to die or abort.**
>
> **Pathogens in the mother's blood are generally prevented from passing to the foetus. However, some viruses (e.g.. HIV, rubella) can cross the placenta**

As the embryo grows it becomes surrounded by a membrane (bag) called the **amnion**. Inside this bag is **amniotic fluid**, this cushions and protects the embryo

The embryo is supplied with food, water and oxygen, from the mother, via the **umbilical cord** that attaches it to the **placenta**. Waste materials such as carbon dioxide are also removed.



The umbilical cord contains

Umbilical artery – carries **deoxygenated** blood, CO_2, urea & heat from foetus to placenta

Umbilical vein – carries **oxygenated** blood from placenta to foetus (carrying O_2 and nutrients)

Villi - provide a massive surface area over which transport of molecules can take place.

Nutrients are carried by the **mother's artery to the placenta**. They diffuse into the capillaries of the foetus. They are taken **to the foetus by the umbilical vein** – e.g:

- Oxygen **diffuses** from mother's blood to foetal blood;
- Carbon dioxide and urea diffuse from foetal blood to mother's blood;
- Glucose, amino acids and vitamins move by **facilitated diffusion** into the foetal blood;
- Sodium, potassium and calcium are **actively transported** into the foetal blood.

Antibodies - pass from mother to foetus to give the foetus passive immunity during the pregnancy and for a few months after birth.

Waste substances from the foetus are carried by the umbilical artery. They diffuse into the blood-filled space and into the mother's vein to be carried away.

Throughout pregnancy, the placenta releases oestrogen, progesterone, HPL (Human Placental Lactogen), and HCG (Human Chorionic Gonadotrophin).

Oestrogen: ✓	Stimulates growth of uterus.
✓	Inhibits release of FSH.
✓	Stimulates the duct system of the breasts to develop.
✓	Inhibits lactation by inhibiting the release of **prolactin.**
✓	Increases the sensitivity of the uterus to the hormone **oxytocin** (this causes the uterus wall to contract).
Progesterone: ✓	Maintains the endometrium.
✓	Inhibits myometrium contractions (therefore decreasing the possibility of miscarriage).
✓	Stimulates the development of milk glands in the breasts.
✓	Inhibits the release of prolactin.
✓	Inhibits the release of FSH.
HPL: ✓	Stimulates the growth and development of breasts. **Note:** Without HPL oestrogen and progesterone would not affect the breasts.
HCG: ✓	Maintains the corpus luteum for about 3 months. This means that oestrogen and progesterone are produced before the placenta assumes this role.

Needs of the Mother and Foetus

Practical and emotional support - from partner, family, friends and society. Mother may exhibit one or more of the following:

Nausea – "morning sickness" due to hormonal changes (early months of pregnancy)

Tender breasts

Tiredness

Backache – additional 12 kg to support during pregnancy – strain on muscles and backbone

Frequent urination – due to pressure on bladder from enlarged womb

Loss of sexual drive

Stress – over finances, housing, etc

Antenatal clinic – mother to visit during pregnancy - to check the health of the mother and foetus

Weight

Blood pressure – if too high may cause the build up of proteins and waste in her blood – causing toxaemia – dangerous and may be fatal for both mother and foetus if not treated

Cervical smear – to detect cervical cancer

Haemoglobin and RBC's – to prevent anaemia

Blood group

Urine tests - sugar indicates diabetes; proteins indicate toxaemia

Ultrasound scans – later in pregnancy – allows visualisation of the developing foetus – beating of heart, physical abnormalities, identify sex (sometimes)

Recommendations Eat well; folic acid supplements + other vitamins + minerals (Ca, Fe); avoid smoking, drugs, alcohol, unnecessary medications; exercise; rest and sleep; antenatal classes;

Birth

At the end of pregnancy (approx 38 weeks), the baby lies with its head towards the cervix.

High levels of **progesterone** during pregnancy **inhibit** the release of the hormone **oxytocin** from the pituitary. Late in pregnancy, progesterone levels decrease and **prostaglandins** are produced. This causes the release of oxytocin from the pituitary. They stimulate contractions of uterine muscle, which are strong, as oxytocin is no longer inhibited by high progesterone levels

Birth (labour) can be divided into:

Stage 1

Pituitary gland of the mother secretes oxytocin

Oxytocin causes smooth muscle of the uterus to contract – approximately at 20 minute intervals initially and then more frequently – eventually pushing the baby out of the vagina.

The cervix gradually dilates. The baby's head passes through the cervix within 4-12 hours after the first contractions

At some point the amnion breaks – releasing the amniotic fluid ("breaking of the waters")

Stage 2 (Delivery)

Baby's head is pushed out of the cervix into the vagina – the uterus, cervix and vagina form a continuous birth canal.

Strong contractions of the uterus continue to push baby – within 10-60 minutes the head emerges from the birth canal – the rest of the body following within minutes – helped by a midwife or an obstetrician

Once the baby starts to breathe and cries, the umbilical cord is clamped in two places and cut between the clamps

Stage 3 (Afterbirth)

Muscular contractions of the uterus continue after delivery to expel the placenta and the remaining umbilical cord.

Lactation.

Due to the loss of the placenta, oestrogen and progesterone levels fall, prolactin is no longer inhibited so the breasts can produce milk. Oxytocin is released from the posterior pituitary gland, which forces milk out of the nipples.

Complications

Breech birth – feet or bottom appear first. Baby may be turned around if detected early. Can endanger the baby – forceps delivery (use of forceps to turn the baby around – may damage head) or Caesarian section (baby removed through a cut in the abdominal wall and uterus) performed.

Induction – labour started artificially – either by cutting the amnion, or by an injection of the hormone oxytocin to induce (start) the contractions. Performed in cases of health risks or overdue birth

Mutations

Most of the time, everything from fertilisation to birth goes well. However sometimes things go wrong. There seem to be mistakes made in the development of cells. The changes that are seen in the genetic code are called **mutations.**

Mutations are the **changes in the DNA** sequence. Or in other words, changes in parts of genes in chromosomes. **The base sequences are messed up!**

Sometimes as little as one base might be missing or it could be a few. On other occasions a couple of bases might be swapped around. It is also possible that during meiosis parts of chromosomes get damaged.

If the genetic instructions are wrong what it does will also be wrong. It might end up making an enzyme the wrong shape so that it doesn't work. Anything could go wrong!

Mutations can occur naturally.

Mutations are more likely with exposure to nuclear radiation including X rays and UV rays, ' Others include chemicals known to cause mutations (termed **"mutagens") -** cigarette and tobacco smoke contains many carcinogens, cancer-causing chemicals.

All of these things can damage your DNA.

Women must be careful what they consume or take while they are pregnant. Many substances such as **alcohol**, **bacteria**, **viruses** and **drugs** can cross through the **placenta** to the baby. This could cause serious damage to the developing embryo.

Most mutations are harmful.

In developing **embryos** they cause **abnormal development** and may cause **early death.** In older tissue they can cause cells to keep on **dividing uncontrollably**. These cells develop into tumours, spread into other parts of the body and so become **cancers.**

However, rarely some mutations can be beneficial. For example a **bacterial** cell might mutate into a form that shows **antibiotic resistance**. Or a plant might mutate so that it grows in poorer soil in which nothing else grows. **Natural selection** is thought to be brought about by these rare, beneficial mutations.

Birth Defects

Genetic Causes

Downs Syndrome

Extra copy of chromosome 21 (trisomy 21)

47 chromosomes instead of 46

Almond shaped eyes; round face; learning difficulties; reduced life expectancy; older couples more at risk of having offspring with trisomy 21 – mothers age more significant than fathers.

Cystic Fibrosis

Mutation in chromosome 7

Sticky mucus produced in airways, digestive and reproductive tract. Breathing difficulties and respiratory infections; digestive problems (pancreatic duct blocked); reduced life expectancy

Treatment – physiotherapy to remove mucus; mucolytic agents (thins mucus); antibiotics to prevent infection; capsules containing pancreatic enzymes; gene therapy

Environmental Causes

Spina Bifida

Part of spinal cord protrudes through vertebral column; incomplete closure of embryonic neural tube (spinal cord)

Normal or paralysed; can be surgically closed but nerve damage is permanent; prevented if folic acid supplements taken before conception

Smoking

Cigarette smoke contains CO – crosses placenta and combined irreversinly with Hb to form carboxyhaemoglobin; prevents carriage of O2 leading to anaemia; cells starved of oxygen – reduced energy production

Low birth weight; respiratory tract infections; mental impairment; cot death

Alcohol

Alcohol crosses the placenta; highly lipid soluble – affects nervous system and liver

Foetal alcohol syndrome – less intelligent

Growth and Development

Growth – irreversible increase in the dry mass of an organism

Development – regular change in the structure and functioning of an organism; four aspects – physical, mental, emotional, social

Rapid growth – 0 to 2 years

Slow growth – 3 to 13

Rapid growth – 14 to 15

Rate of glow gets progressively slower – 15 to 18

Boys have a bigger growth spurt at puberty – hence, men are usually taller and heavier than women by the time growth ends (18-20)

Girls are often taller than boys at 12-13

Growth under the control of GH (anterior pituitary) – underproduction leads to dwarfism – overproduction leads to gigantinism (very tall with large hands and feet)

Puberty

Maturation of sex organs and appearance of secondary sexual characteristics, accompanied by emotional changes (self image; reaction to authority; independence; identity crisis; responsibility; family relationships (good or bad), etc

Male	**Female**
Hormone – Testosterone	**Hormone - Oestrogen**
Sperm production - testes	Egg production + ovulation - ovaries
Ejaculation	Menstruation
Growth of hair (pubis + axilla)	Growth of hair (pubic + axilla)
Growth of facial hair	Growth of breasts (milk + sexual attraction)
Deepening of voice	Widening of the hips
Oily skin (sebum)	Oily skin (sebum)
Testis, penis, and scrotum enlarge	Vagina + uterus enlarge
Increase muscular strength	

Adulthood (General)

Physical growth and development are complete

Capable of living independently of family

End of formal education and starting of full-time work

Form sexual relationships

Have children

Women (45 – 55) - undergo menopause – menstrual cycle stops permanently. Up to menopause, menstruation may stop temporarily due to:

Pregnancy

Breast feeding

Drop in body mass (e.g. in anorexia nervosa)

Towards reaching adulthood, a person gets taller, heavier, and changes in shape

Head becomes larger but relatively smaller – smaller proportion of body compared to earlier years

Lymphoid system (thymus, lymph nodes and tonsils) – increases to 12 – body needs to develop immunity to a large number of infectious diseases

Reproductive system – increase in growth after 12

General body growth – increases to adulthood

Brain, head, and nervous system – rapid growth from birth to 1 year

Old Age (Senescence) and Death

Senescence – decrease in the ability of a person to function maximally due to getting older.

Loss of muscle strength; decrease in vital capacity of lungs; decline in nervous function (longer reaction time, poor vision and hearing, poorer sense of taste and smell; loss of libido (sexual desire); stiffening of joints and loss of flexibility; arthritis; weakening of bones (osteoporosis) due to loss of bone mineral (Ca); wrinkling of skin; loss of thermoregulation; loss of mental ability; digestive problems; changes in external appearance (curved spine; white hair; increased dependence on others; diseases (e.g. cancer, heart disease, stroke)

Cancer

Abnormal, uncontrolled growth of cells – characterised by repeated division of cells resulting in a tumour – a mass of abnormally arranged cells which continue to multiply even though the body does not need extra cells for repair or growth.

Malignant tumours – cells from malignant tumours invade surrounding healthy tissues or enter the blood system and are carried to other parts of the body where they form secondary tumours which are themselves cancerous.

Benign tumours – cells from benign tumours do not invade surrounding tissues.

Causes Chemical carcinogens (cancer causing substances) – tar in cigarette smoke (lung cancer), asbestos (lung cancer), distillation products of fossil fuels (tumours in the bladder), ionising radiation (X rays, gamma rays) – cause cancer of the bone marrow (leukaemia) and other organs, UV light (skin tumours)

Treated by surgery, radiotherapy or chemotherapy

Richard Doll – investigated correlation between cancer and its cause – accumulated data and demonstrated the link (correlation - not a proof) between cigarette smoking and cancer.

Large number of observations of cases of lung cancer – large sample size

Showed correlation between lung cancer and smoking – not a proof, since the cancers in some people may have been caused by other factors

Used data for the incidence of lung cancer in non-smokers as a type of “control” to establish a baseline for comparison with the incidence in smokers

Female reproductive system and egg production

The production of eggs is called **oogenesis.** It takes place in the ovaries and begins before birth.

The outer layer of the ovary (the germinal epithelium) produces **primary oocytes.** It also produces follicle cells that congregate around the oocytes, forming a structure called the **primary follicle.**

By the time a baby girl is born, the primary oocytes in the primary follicles have started the first meiotic division but the process halts at the first stage (prophase I).

After puberty one of these develops each month. It completes meiosis I to form a **secondary oocyte** and **first polar body** (the latter of which will eventually disintegrate). The follicle cells around it proliferate to form a wall many cells thick called the **theca.** Fluid collects inside the structure to form a fluid-filled cavity.

The whole structure is called a **Graafian follicle.**

At a time controlled by hormones the secondary oocyte is released from the Graafian follicle and it leaves the ovary - a process called **ovulation.** The secondary oocyte with some surrounding follicle cells leaves the ovary and enters one of the oviducts. What is left behind on the surface of the ovary turns into a structure called the **corpus luteum.**

Sexual Reproduction in Humans - The Final Stages

Sexual intercourse and fertilisation

For pregnancy to occur a sperm must fertilise the egg.

The sperm travel from the **epididymis** into the **vas deferens** by waves of contractions along the walls of the tubes.

For sex to take place, the penis needs to be inserted into the woman's vagina and thus it needs to be erect.

Sexual stimulation triggers contractions in the wall of the vas deferens. Sperm are swept along, past the prostate gland and the seminal vesicles, which secrete fluid to maintain the sperm in a viable state. The resulting mixture, called semen, is expelled from the end of the penis during ejaculation. The alkaline semen is deposited at the top of the acidic vagina.

A layer of mucus blocks the cervix. It is thinnest, and therefore easiest for the sperm to penetrate at the beginning of the menstrual cycle. For the sperm it is an incredibly long journey from the cervix to the egg in the oviducts, so it probably manages it by a combination of swimming using their tails, muscular contractions of the uterus and/or oviducts, and the action of cilia lining the uterus and the oviducts.

It takes several hours to reach the oviducts, but this is beneficial because, before sperm can fertilise an egg they must undergo a process called **capacitation.** This is where enzymes from the female genital tract remove molecules from the outer surface of the sperm.

It is possible for a sperm to fuse with a secondary oocyte if there is one near the top of an oviduct. Sperm surround it and, if one manages to penetrate the outer layer so that the two cell membranes fuse, **meiosis II** is completed in the secondary oocyte to form the haploid nucleus that is now ready to be fertilised.

The process of fertilisation is shown below:

When the two plasma membranes fuse the **cortical reaction** takes place. Cortical granules from the secondary oocyte release their contents into the space around the oocyte. They cause the zona pellucida to thicken and harden. It becomes impenetrable and so prevents the entry of more than one sperm. After fertilisation the diploid zygote divides by mitosis to form a solid ball of cells.

At this stage the embryo is called the **morula.** The morula moves towards the uterus, developing into a hollow ball of cells, called the **blastocyst**. After about 6-8 days it implants into the uterus wall.

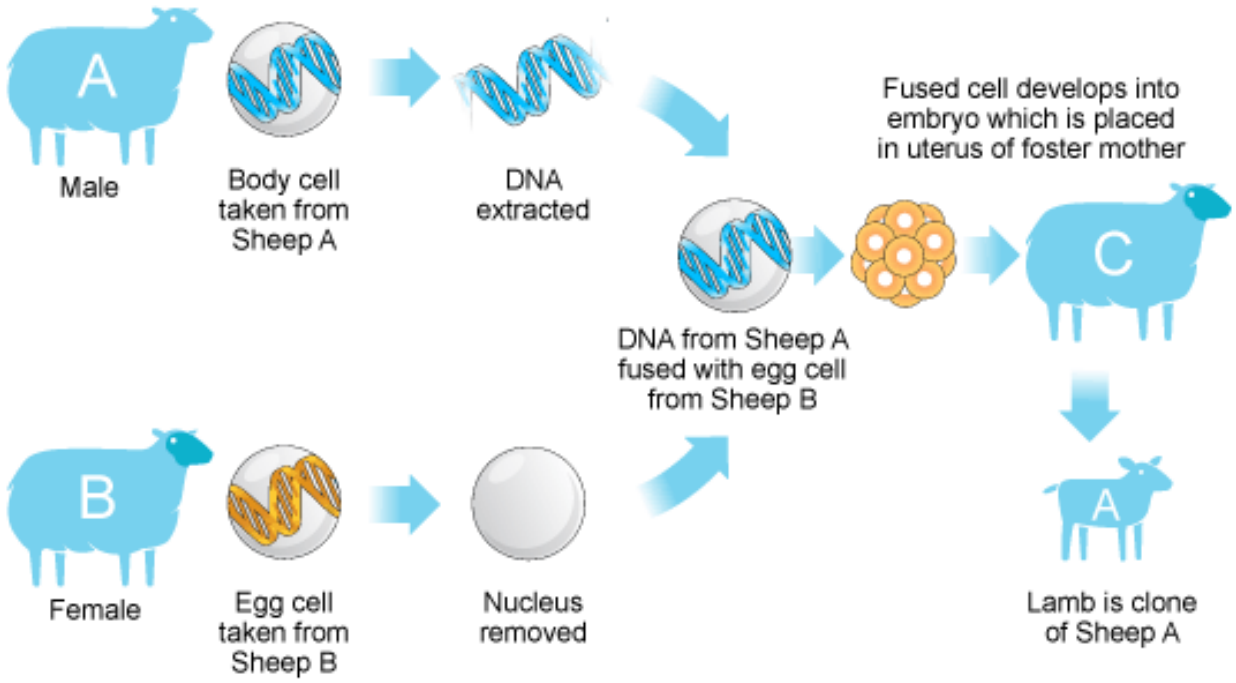
The development of a baby

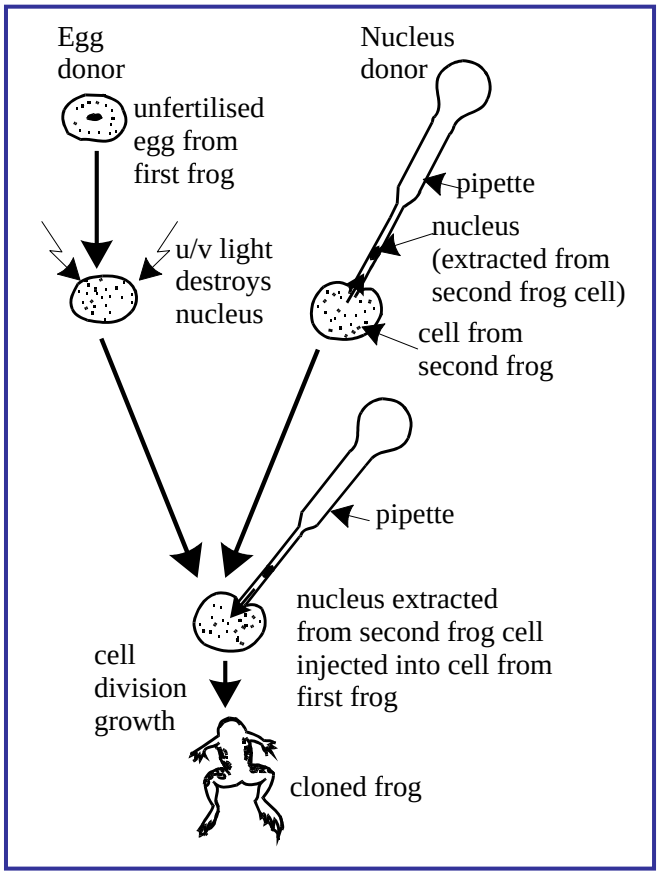
About a week after the sperm has fertilized the egg, the egg has become a multicelled blastocyst, a pinhead-sized hollow ball with fluid inside, now present in the uterus. The blastocyst burrows into the thickened endometrium, which is the lining of the uterus. It is the Oestrogen that causes the endometrium to thicken and become rich with blood, and progesterone, another hormone released by the ovaries, keeps the thickness of the endometrium constant so that the blastocyst can attach itself securely to the uterus and continue to absorb nutrients from it. This process is called implantation.

The egg grows and develops inside the uterus (womb) over the next 40 weeks under the protection of the newly developed placenta. The egg develops into an embryo and then at eight weeks, it is a foetus with recognisable features such as hands, feet and eyes.

The cloning process of 'Dolly the sheep'

Produces exact copies
Genes copied within same species





(a) Cloned frog is identical to second frog
Nucleus comes from this frog;
DNA/genes/information in nucleus; this controls development

(b) Advantages of cloning
large number of identical offspring;
guaranteed desired features; quick; economic

(c) Disadvantages of clonoing
may all succumb to unexpected disease/change in conditions
cut adaptation/reduce gene pool/limits variation

Plants can be cloned artificially using cuttings