6.6 Hormones and Homeostasis SL

1. What is the endocrine system?

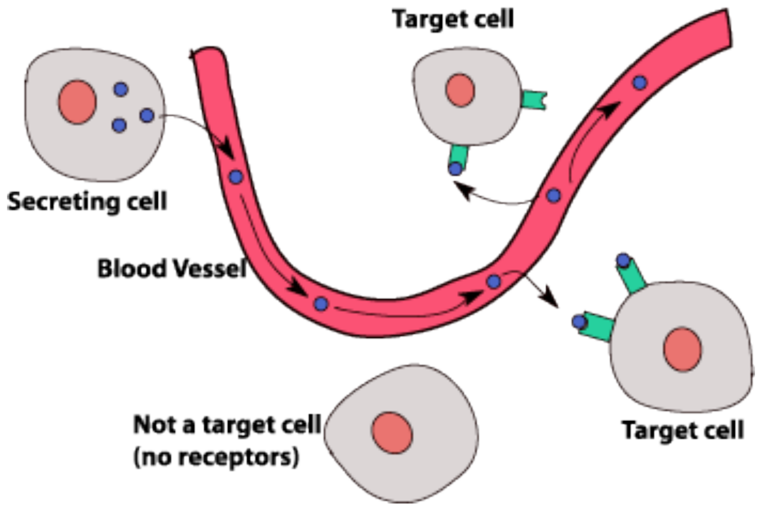
The endocrine system includes all of the glands that release hormones into the bloodstream.

2. What are endocrine glands?

Endocrine glands are ductless glands that produce hormones.

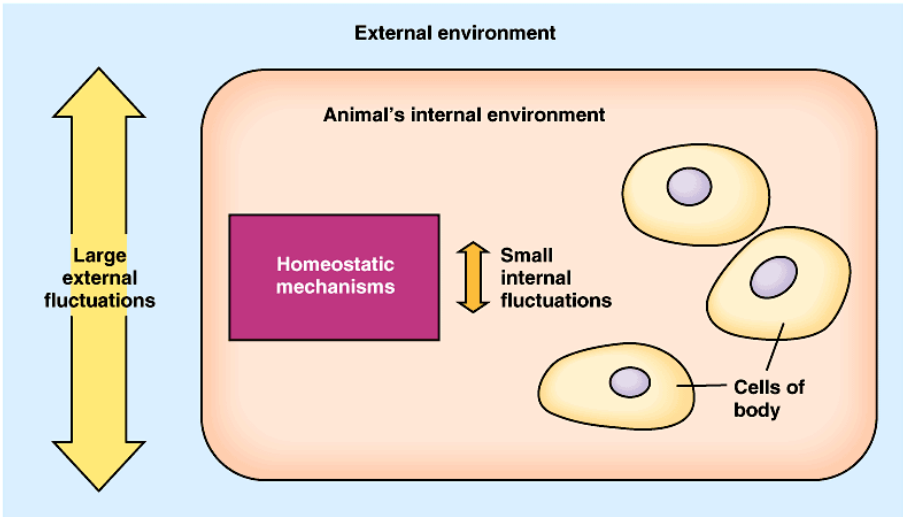
3. What are hormones?

Hormones are chemicals produced in endocrine glands, which are specific, and act in small quantities to control responses in the body. They travel through the blood system and are specific because only the target cell has receptors to recognise them.



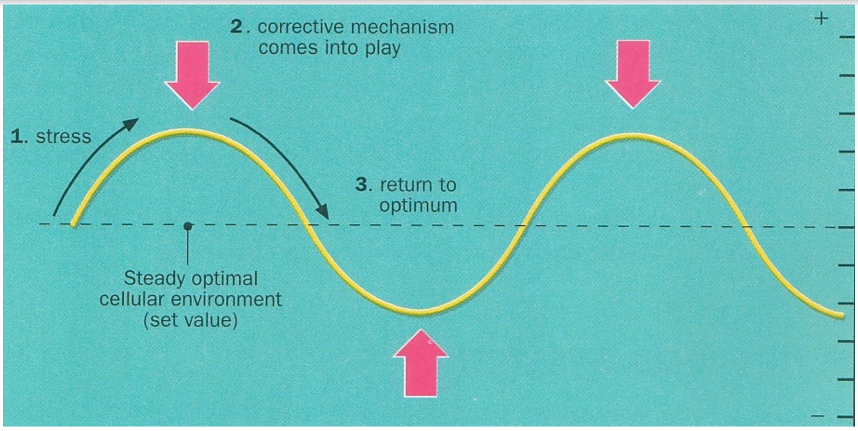
4. What is homeostasis?

Homeostasis is the maintenance of a relatively constant internal environment in the face of large external changes. The internal environment is blood and tissue fluid.



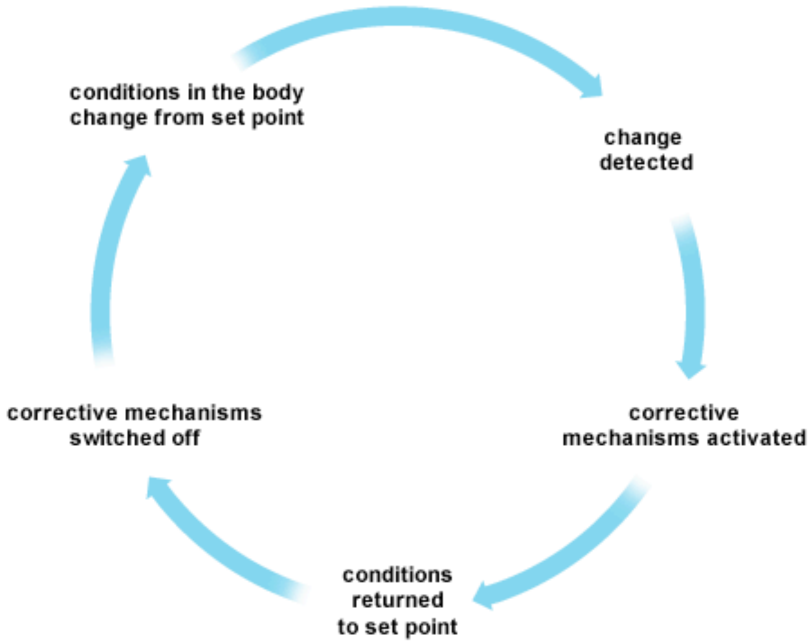
5. What sort of factors are controlled within narrow limits by homeostasis?

Blood pH, carbon dioxide concentration, blood glucose concentration, body temperature and water balance.

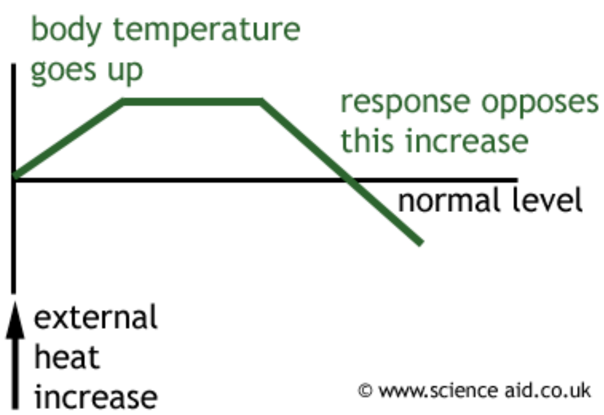


6. What is negative feedback?

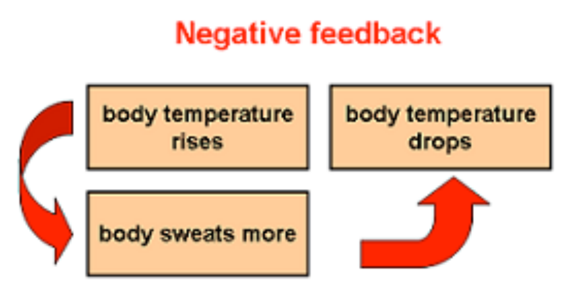
Negative feedback is the mechanism by which the body maintains conditions within particular limits. The body will do this by opposing a change that deviates from the normal.



Negative feedback occurs when a change leads to a response that opposes further change.



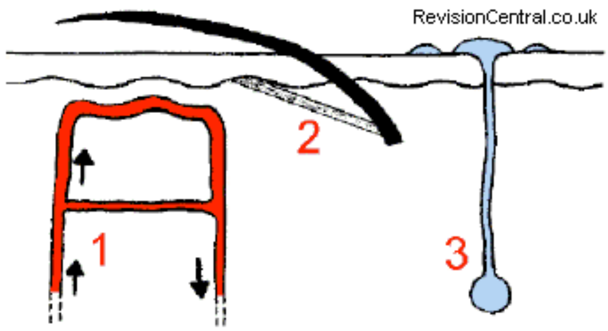
7. How is temperature controlled?



Body temperature is detected by the hypothalamus

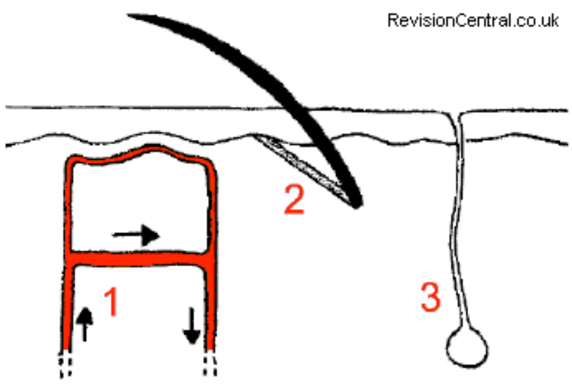
1. Body too hot

Vasodilation – skin arterioles dilate (enlarge) to allow more blood to reach the skin capillaries so that more heat can be lost by radiation. Sweating – increased so more evaporation of water to lose heat. Skin hairs – flatten so that a smaller layer of air is trapped therefore less insulation and more heat loss. Respiration - decreases as less thyroxine is produced by the thyroid.



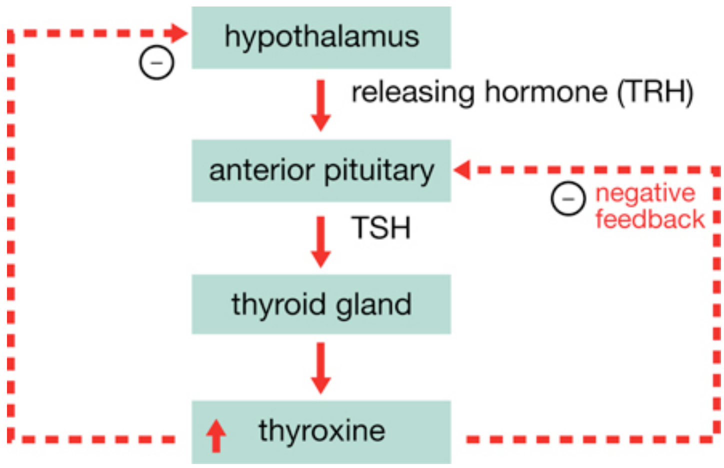
2. Body too cold

Vasoconstriction – skin arterioles constrict (get narrower) to allow less blood to reach the skin capillaries so that less heat can be lost by radiation. Sweating – reduced so less evaporation of water to lose heat. Skin hairs – stand erect so that a larger layer of air is trapped therefore more insulation and less heat loss. Shivering – rapid contraction and relaxing of skin muscles generates heat by respiration. Respiration – increases as more thyroxine is produced by the thyroid.



8. How does thyroxine control temperature?

The hypothalamus detects low blood temperature and sends a releasing hormone to the pituitary gland. It responds by sending a stimulating hormone to the thyroid gland in the neck. The thyroid responds by releasing thyroxine, which moves through the blood causing cells to increase the metabolic rate (protein synthesis, growth and respiration). This generates more heat, raising the temperature.



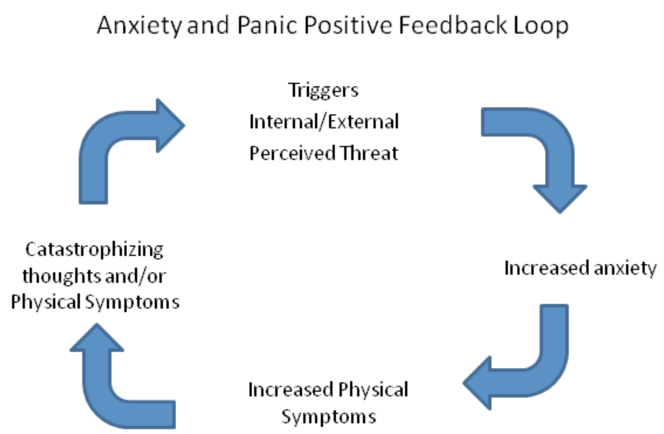
Thyroxine also switches off the pituitary so no more stimulating hormone will be released – negative feedback. The increase in temperature is also detected by the hypothalamus, which responds by switching off production of its releasing hormone – negative feedback.

9. What happens in thyroxin deficiency?

A lack of thyroxine causes forgetfulness, depression, tiredness, weight gain, feeling cold and impaired brain development in children. Iodine is needed for its production – a disease called goiter may develop.

10. What is positive feedback?

When a change leads to a response that leads to more change.



11. How is glucose sugar stored in the body?

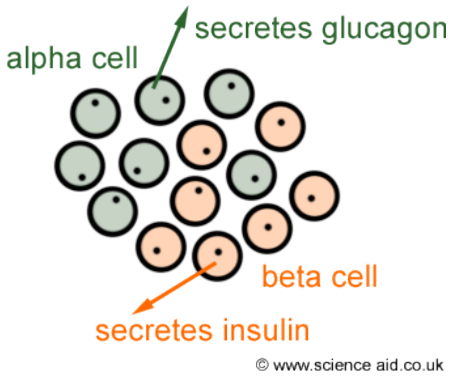
Glucose is stored as **glycogen** in the liver and muscle. The sugar can be released again from the liver by the breakdown of glycogen.

12. What does insulin do and where is it made?

Insulin causes glucose sugar to be stored as glycogen, reducing the blood sugar levels. Insulin is made in the ß cells of the islets of Langerhans of the pancreas.

13. What does glucagon do and where is it made?

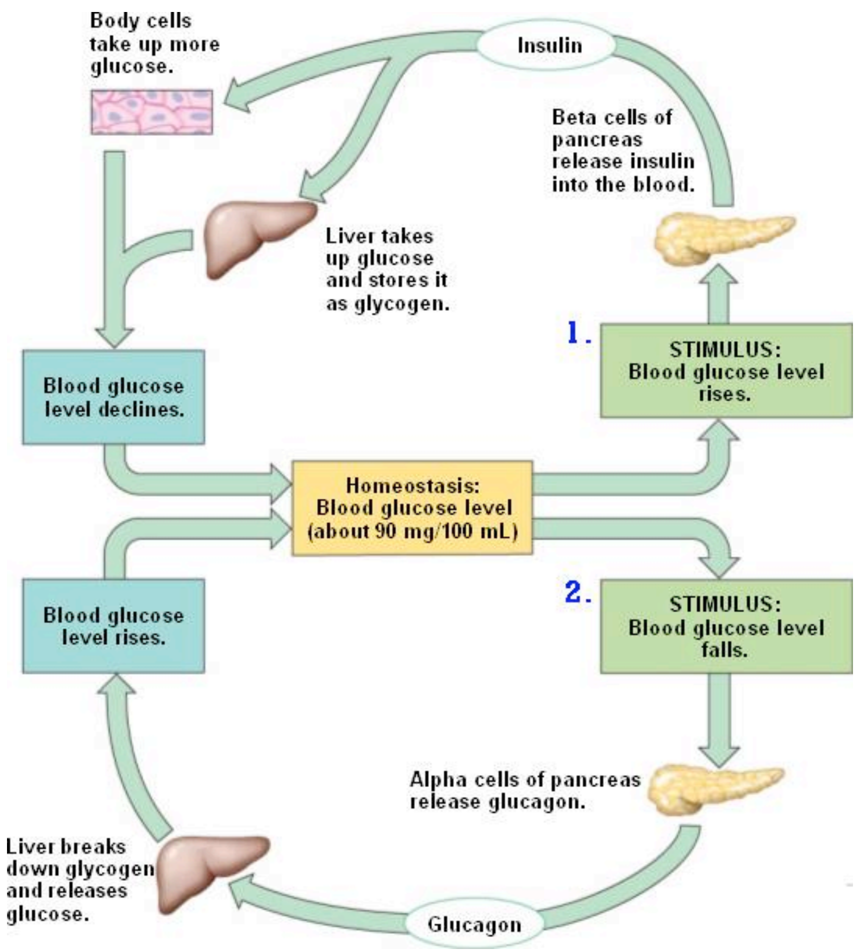
Glucagon causes the breakdown of glycogen stores, releasing glucose into the blood. Glucagon is made in the α cells of the islets of Langerhans of the pancreas.



14. How is blood sugar concentration controlled?

Glucagon and insulin work antagonistically to regulate blood glucose concentration. Each one uses negative feedback to prevent large swings in sugar.

Chemoreceptors in the pancreas detect the sugar levels in the blood and cause a response.



15. What is the difference between type I and II diabetes?

In people with diabetes, there is a problem with the production of insulin or with the body's ability to use the insulin.

Diabetes is a long-term condition characterised by high levels of glucose in the blood (hyperglycaemia). If not treated it can cause long-term complications such as heart disease, kidney damage, stroke, circulatory problems and damaged vision. While it is usually diagnosed between the ages of 7 - 12 years, it can occur at any age. Approximately 10% of all people with diabetes have Type 1.

In **type 1 diabetes** the pancreas produces little or no insulin. It is thought to occur as the result of an autoimmune reaction. During an autoimmune reaction the body's immune system attacks the body's own healthy cells and tissues. In Type 1 diabetes, it is thought that the body attacks and destroys the beta cells in the pancreas, making them incapable of producing insulin. It is not known what causes this autoimmune reaction to occur, but it is believed that certain viruses or environmental factors, as well as genetic, dietary or stress factors are involved.

In **type 2 diabetes** the pancreas still produces insulin, however it may not produce enough insulin to meet the body's needs. There is also a problem with the ability of the cells in the body to use the insulin (insulin resistance) - particularly the cells in the liver, fat and muscles.

Type 2 diabetes has also been referred to as "adult onset diabetes" as it usually begins later, but can occur at any age. It is the most common form of diabetes affecting approximately 90% of all people with diabetes.

There is a strong hereditary component to Type 2 diabetes. It is also related very strongly to obesity - the greater the degree of obesity, the greater the risk of developing the condition. Age is also an important factor, with the condition most commonly occurring after the age of 40 years. It is thought that as people age, beta cells become less efficient and the cells in the body become less able to use the insulin made by the pancreas.

Type I diabetes must have insulin treatments usually before meals to prevent glucose spikes. Implants are being developed to monitor and release insulin as required. Stem cells may be used in the future to reform beta cells. Only some type II patients respond to insulin. Diet can control type II but not type I.

16. What are circadian rhythms?

Humans are adapted to live in a 24 hour cycle. They have rhythms of behaviour based on this 24 hour rhythm, called **circadian rhythms**.

They continue even if a person is deprived of external environmental cues (like light). The rhythms are controlled internally.

17. What is the role of melatonin?

Melatonin causes drowsiness and sleep at night, so is responsible for the sleep-wake cycle. Melatonin levels increase in the evening and then drop to low levels by dawn.

18. Where is melatonin made?

Melatonin is made in the pineal gland in the brain.

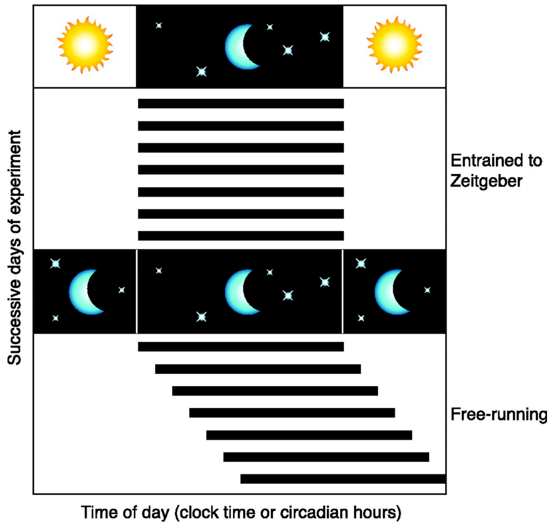
19. What controls the secretion of melatonin?

A group of cells called **suprachiasmatic nuclei** (**SCN**) in the hypothalamus of the brain control the circadian rhythm. The SCN controls the secretion of melatonin hormone by the pineal gland.

20. What is the period of our biological clock and why is this important?

The period of the internal rhythm is slightly more than 24 hours. So it is slightly out of phase with the external environment.

Cells in the retina absorb light and signal the SCN, which adjusts the rhythm to synchronise it the external environment.



21. What is jet lag and what causes it?

When crossing time zones the internal circadian rhythm gets out of synchrony with the external environment. This causes jet lag.

Symptoms are: difficulty in staying awake in the daytime, and/or sleeping at night, fatigue, irritability, headaches and indigestion.

After a few days the SCN adjusts as it receives light signals (cues). Melatonin tablets can be taken at night time.

22. What is leptin and what does it do?

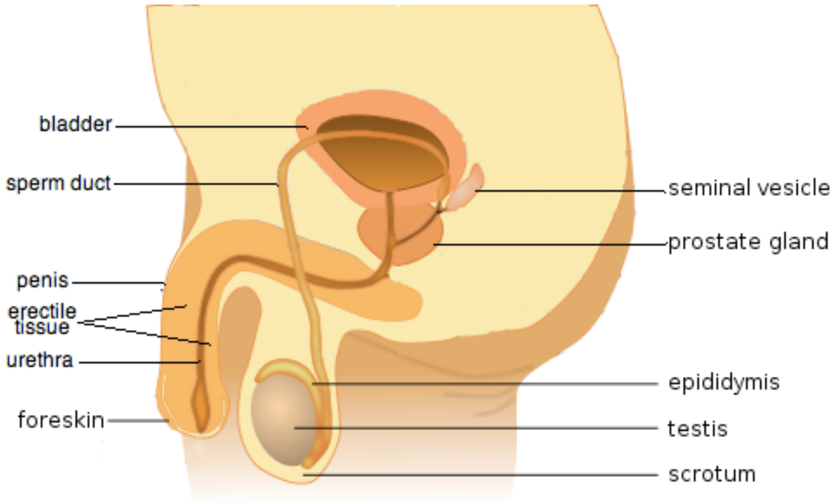
Leptin is a protein hormone secreted by adipose (fat storage cells) tissue. It acts on the hypothalamus to inhibit appetite.

23. How is leptin related to obesity?

Obese mice were found to lack leptin and responded to injections of leptin by losing weight. However, humans showed variable responses and gained weight again after the trial. Many people are probably resistant to leptin so injections are of no use. In the small numbers that it works for, several injections are needed per day and it affects development of gonads, so it has not been a success.

6.6 Reproduction SL

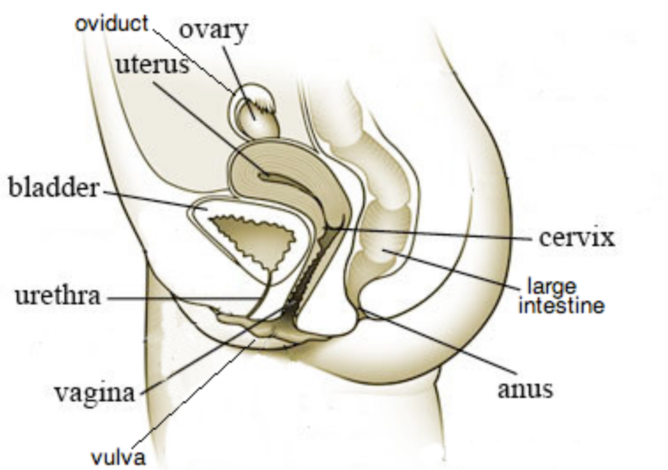
1. How do you draw the male reproductive system?



2. What are the functions of the parts of the male urogenital system?

- **Bladder** – stores urine.
- **Ureter** – carries urine from kidney to bladder.
- **Urethra** – a shared external opening for both urine and semen.
- **Testes** – site of spermatozoa (sperm) production.
- **Scrotum** – sac containing testes kept 3°C cooler than body.
- **Vas deferens** (sperm duct) – tube that carries sperm out of testes to urethra.
- **Epididymis** – coiled tube about 6m long where sperm are stored while they mature.
- **Prostate gland** and **seminal vesicles** – secrete fluid for the sperm to swim in. This alkaline fluid containing fructose sugar plus sperm is called seminal fluid (semen).
- **Penis** – contains the urethra, which carries sperm to the vagina during intercourse. Special spongy tissue can fill with blood to give an erection.

3. How do you draw the female reproductive system?



4. What are the functions of the parts of the male urogenital system?

- **Ovaries** – site of egg production and female hormones oestrogen and progesterone.
- **Oviducts** (fallopian tubes) – lined with cilia and muscular, they sweep the egg towards the uterus.
- **Uterus** – site of embryo implantation and development during pregnancy.
- **Endometrium** – lining of uterus that is well supplied with blood. It forms the placenta for exchange of materials.
- **Cervix** – narrow junction between uterus and vagina, closed off by a ring of muscle. It protects the foetus during pregnancy.
- **Vagina** – birth canal and site for sperm deposit during intercourse. Secretes acid to deter microorganisms.
- **Vulva** – protects internal parts of reproductive system.

5. What is a secondary sexual characteristic?

A characteristic, such as breast development, voice pitch, or facial hair, that distinguishes the sexes from each other but is not directly concerned with reproduction.

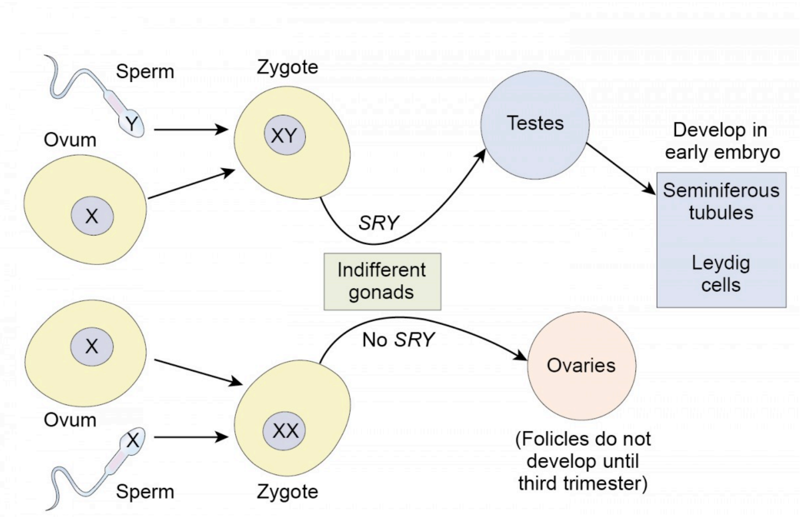
The appearance of these characteristics is influenced by the hormones testosterone and oestrogen and occurs at puberty. The secretion of these hormones increases at puberty.

6. What does testosterone do?

Testosterone causes the development of male genetalia in the foetus and at puberty it causes the devlopment of secondary sexual characteristics. It also causes sperm production and sex drive in the adut male.

7. How does 'maleness' develop?

All embryos initially develop gonads that could become either testes or ovaries. If the gene **SRY** is present (found on the Y chromosome) it codes for a DNA-binding protein called TDF (testes determining factor). **TDF** causes testes development.



8. How does 'femaleness' develop?

In the absence of gene SRY the gonads develop as ovaries.

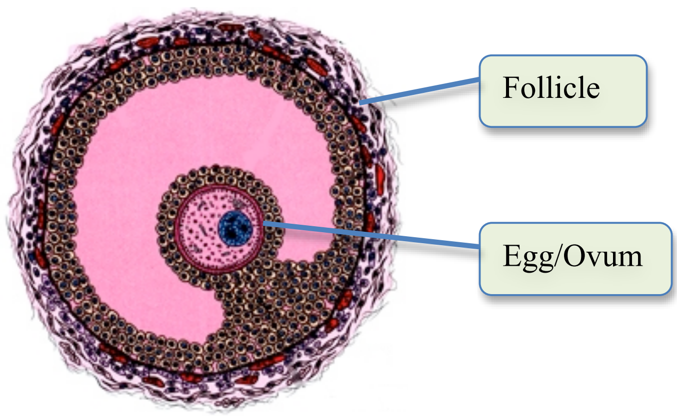
The mother secretes oestrogen and progesterone throughout pregnancy, which cause development of female reproductive organs.

9. What is the menstrual cycle?

It is an approximately monthly cycle of hormones leading to development and release of an egg. The menstrual cycle prepares a woman's body for pregnancy each month. A cycle is counted from the first day of 1 period to the first day of the next period. The average menstrual cycle is 28 days long. The rise and fall of levels of hormones and their negative feedback during the month control the menstrual cycle.

10. What is a follicle?

Each egg (also called an **ovum**) is kept inside a structure called a **follicle**. Once a month one follicle (or possibly a few) matures ripening the egg.



11. What are the phases of the menstrual cycle?

First half is the **Follicular phase** – a group of follicles develops in ovary. The lining of the uterus (endometrium) is repaired and starts to thicken. The most mature follicle breaks open releasing an egg into the oviduct. Other developing follicles degenerate.

Second half is the **Luteal phase** – the wall of the follicle that has released the egg becomes the **corpus luteum**. The endometrium continues to develop so it is ready for implantation of embryo. If there is no fertilisation, the corpus luteum breaks down. The endometrium also breaks down and is shed during **menstruation**.

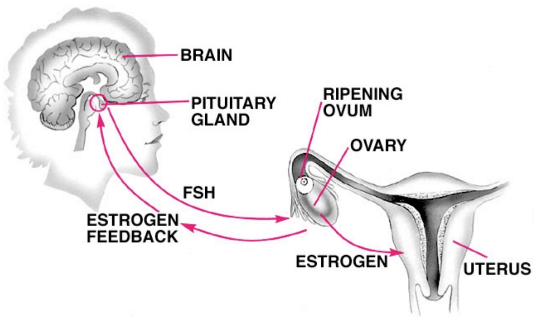
12. What does FHS do and where is it made?

Follicle stimulating hormone (FSH) is produced by the anterior **pituitary gland** and it causes the follicle to begin maturing in the ovary. It is released once a month to prepare an egg for release.

13. What does osetrogen do and where is it made?

Oestrogen is made by the follicle inside the ovary and it prepares the uterus wall for pregnancy. It causes the endometrium to thicken and develop blood vessels.

It switches off FSH production (by negative feedback) and causes the brain to release LH.

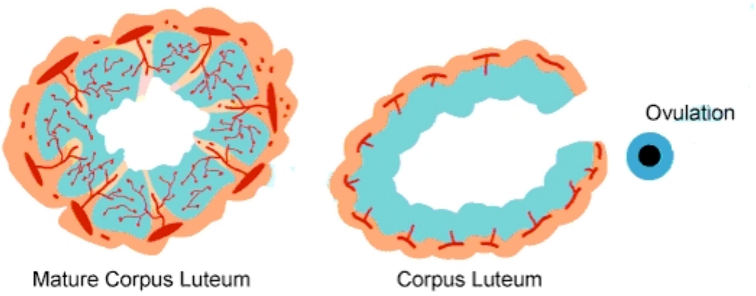


14. What does LH do and where is it made?

Luteinising hormone (LH) is released from the anterior pituitary and it causes **ovulation** – the release of an egg from the follicle and ovary.

15. What is the corpus luteum?

When the follicle releases the mature egg the follicle shell remains in the ovary. The remains of the follicle is called the **corpus luteum**.



16. What does progesterone do and where is it made?

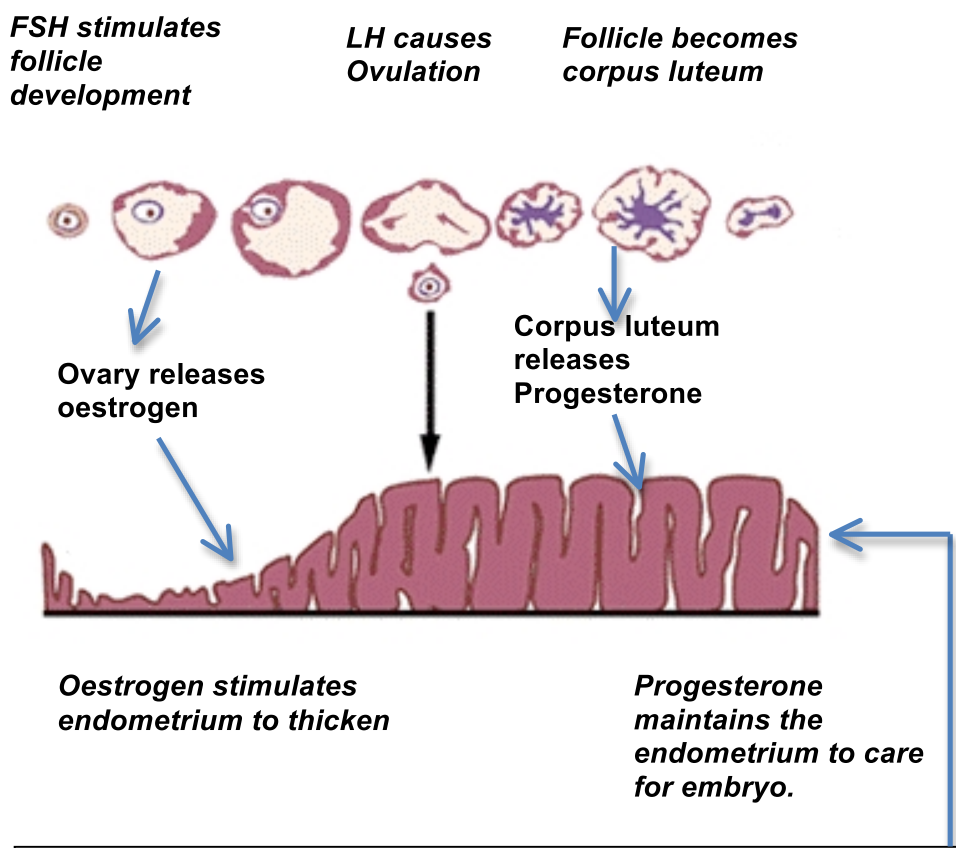
The corpus luteum makes **progesterone** which maintains the lining of the uterus. This is important if a successful pregnancy is to happen.

17. What is menstruation and why does it happen?

If no fertilisation happens the corpus luteum breaks down so progesterone decreases. The uterus lining breaks down and is shed as a period, or **menstruation**.

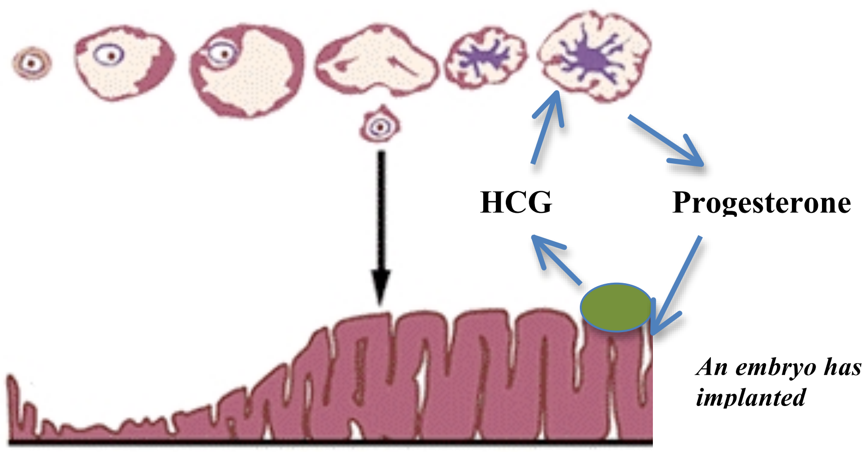
18. How do the hormones interact in the menstrual cycle?

1. FSH is secreted by the pituitary gland and its levels start to rise. This stimulates the follicle to develop and the follicle cells to secret oestrogen.
2. Oestrogen then causes the follicle cells to make more FSH receptors so that these can respond more strongly to the FSH.
3. This is positive feedback and causes the oestrogen levels to increase and stimulate the thickening of the endometrium (uterus lining).
4. Oestrogen levels increase to a peak and by doing so it stimulates LH secretion from the pituitary gland.
5. LH then increases to its peak and causes ovulation (release of egg from the follicle).
6. LH then stimulates the follicle cells to secrete less oestrogen and more progesterone. Once ovulation has occurred, LH stimulated the follicle to develop into the corpus luteum.
7. The corpus luteum then starts to secrete high amounts of progesterone. This prepares the uterine lining for an embryo.
8. The high levels of oestrogen and progesterone then start to inhibit FSH and LH.
9. If no embryo develops the levels of oestrogen and progesterone fall. This stimulates menstruation (break down of the uterine lining). When the levels of these two hormones are low enough FSH and LH start to be secreted again.
10. FSH levels rise once again and a new menstrual cycle begins.



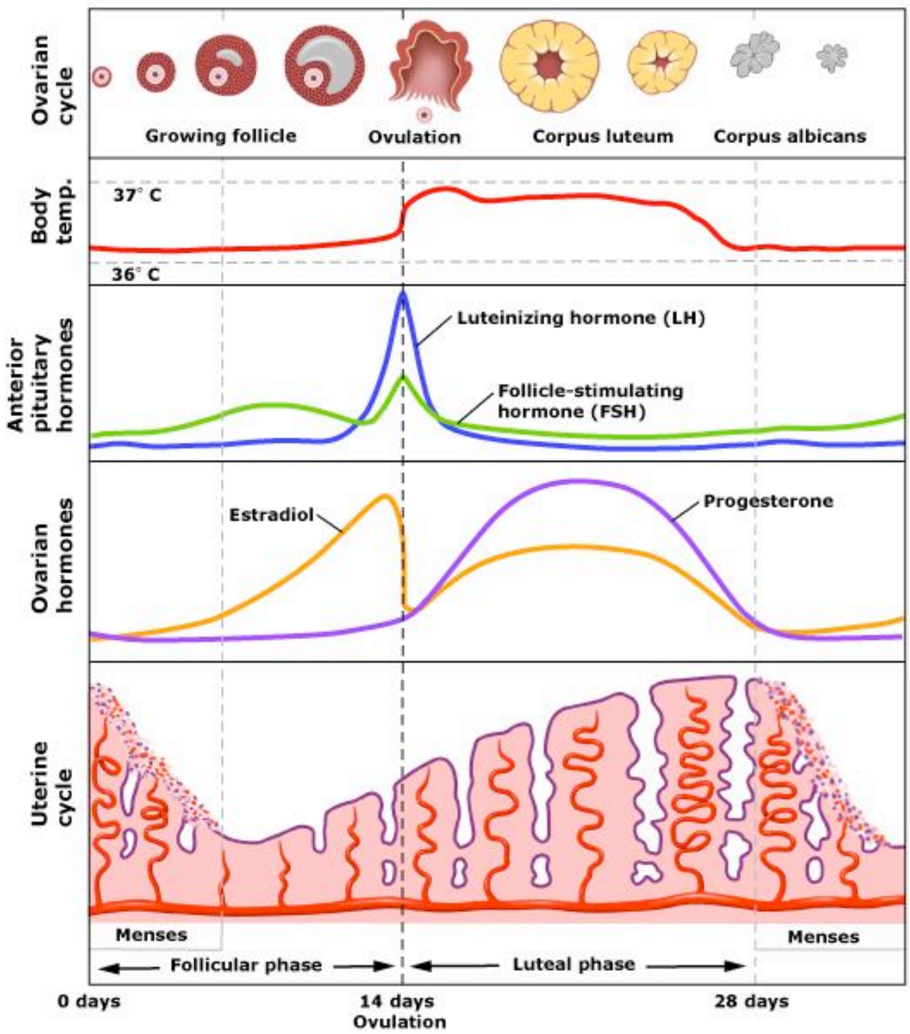
If no embryo implants the corpus luteum degenerates so progesterone levels fall and menstruation begins.

What about when an embryo implants in the uterus wall – i.e. pregnany?



If an embryo implants it signals its presence by sending HCG to the ovary which keeps the corpus luteum intact. This means the corpus luteum continues to send progesterone to the uterus.

19. How do the levels of hormones change during the cycle?



20. What is fertilisation and what is a zygote?

Fertilisation is the fusion of male and female gametes, usually in the oviducts. The **zygote**, or fertilised egg is formed.

21. What types of hormonal feedback occur in the menstrual cycle?

FSH peaks toward the end of the menstrual cycle and stimulates secretion of oestrogen. Oestrogen causes an increase in FSH receptors on follicles making them more receptive to FSH. This stimulates more oestrogen production in a positive feedback.

When oestrogen reaches high levels it inhibits FSH secretion by negative feedback, and stimulates LH secretion. LH stimulates the corpus luteum to develop and hence oestrogen (positive feedback) progesterone secretion. Progesterone inhibits FSH and LH secretions in negative feedback.

22. What is IVF and why is it used?

When a woman has blocked oviducts or a man has immotile sperm they cannot conceive naturally. This is when invitro fertilisation isused. The eggs are removed from the ovary and fertilised in a dish. The resulting embryo is implanted into her uterus where it will complete development.

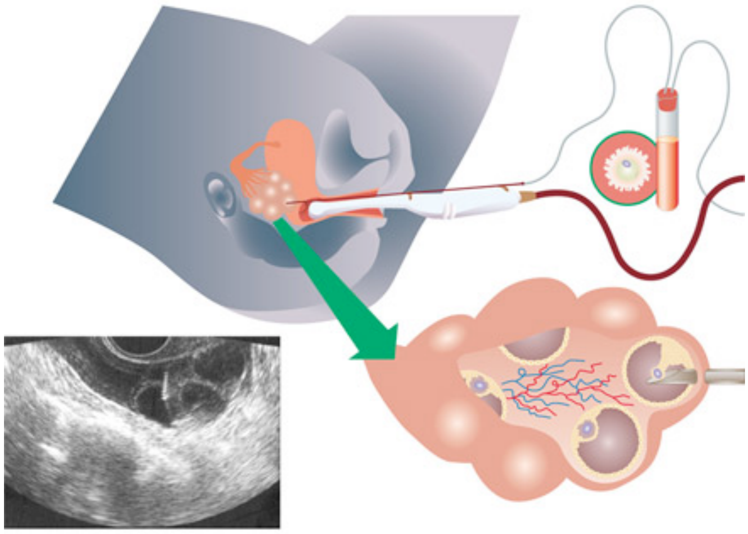
The woman is treated with a hormone to lower oestrogen and stimulate ovulation - several eggs are matured at the same time.

23. How are eggs collected from the woman?

The eggs are removed from the ovary and fertilised in a dish. The resulting embryo is implanted into her uterus where it will complete development.

Ultrasound is used to guide the needle to the ovary, to collect eggs. Many eggs are removed to increase the likelihood of success, but also of a multiple birth. Testing (e.g. gender determination) of embryos can occur.

24. What are the steps in IVF?



1. For a period of three weeks, the women has to have a drug injected (or nasal spray) to stop her normal menstrual cycle by inhibiting FSH/LH. This is called **Down-Regulation**.

2. After these three weeks, high doses of FSH and LH are injected so that many follicles develop in the ovaries (12-20). They are stimulated to mature with HCG hormone. This is called **Superovulation**.

3. The man needs to ejaculate into a jar so that sperm can be collected from the semen. The sperm are processed to concentrate the healthiest ones.

4. A device that is inserted through the wall of the vagina is used to extract the eggs from the follicles. The needle is guided with ultrasound.

5. Each egg is then mixed with sperm (50,000-100,000) in a sterile, shallow dish. The dishes are then put into an incubator (37°C) overnight.

6. The next day the dishes are looked at to see if fertilisation has happened.

7. If fertilisation has been successful, two or three of the embryos (about 48 hours old) are chosen to be placed in the uterus by the use of a long plastic tube. The uterus is prepared by adding a progesterone tablet ito the vagina.

8. A pregnancy test is done a few weeks later to find out if any of the embryos have implanted. Development proceeds as normal.

25. What are the ethics involved with the use of IVF?

There are many aruments that can be made for and against IVF, some are related to the fact that spare embryos are created and stored.

Arguments for IVF	Arguments against IVF
Many types of infertility are due to environmental factors rather than genetic which means that the offspring would not inherit the infertility.	The infertility of the parents may be inherited by their offspring passing on the suffering to the next generation.
The embryos that are killed during the IVF process cannot feel pain or suffering, as they do not have a developed nervous system.	More embryos are produced than needed and the ones that remain are usually killed which denies them the chance of a life.
Suffering caused by genetic diseases can be decreased by screening the embryos before placing them into the uterus.	Embryologists select which embryos will be placed into the uterus. Therefore they decide the fate of new individuals as they choose which ones will survive and which ones will die.
Since the IVF process is not an easy one emotionally and physically, is costly, takes time and there are no guarantees, parents who are willing to go through it must have a strong desire to have children and therefore are likely to be loving parents.	IVF is not a natural process which takes place in a laboratory compared to natural conception which occurs as a result of an act of love.
Infertility can cause emotional suffering to couples who want to have children. IVF can take away this suffering for some of those couples.	Infertility should be accepted as God's will and to go against it by using IVF procedures would be wrong.
Some scientists believe that sperm count/motility is declining so we may need IVF to reproduce.	IVF may be chosen by single women who want to raise a child on their own.
	Frozen spare embryos can be a problem in the future, say after a couple split, who owns them? No long term studies have been done on the effects of long term storage of embryos.

26. What was the 'Seed and Soil' theory of Aristotle?

Aristotle taught that the male produces a seed, which forms an egg when it mixes with the menstrual blood. The egg develops into a foetus inside the mother.

27. How did William Harvey test this theory?

Harvey dissected deer uteruses after mating epecting to see eggs developing immediately. He did not find them – no evidence of development was obvious for several months after mating. He concluded that the deer foetus did not develop from the seed of the male nor from the mixture of seed at mating. However, he realised that he had not solved the mystery.

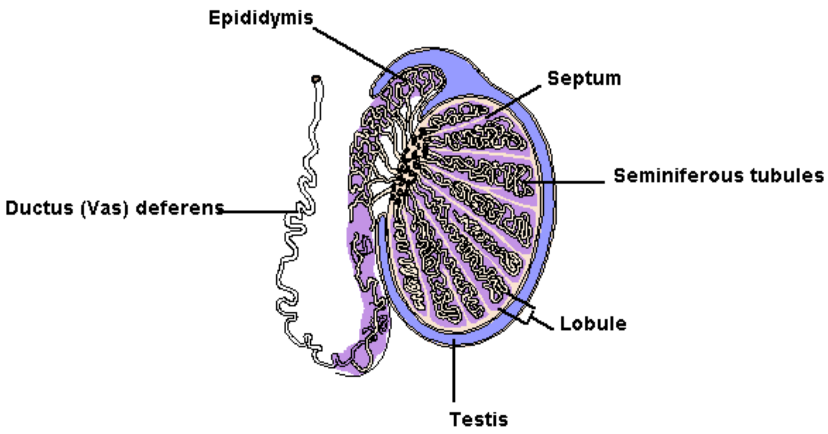
28. How was Harvey limited by a lack of appropriate equipment?

The microscope was not yet invented so he could not see fusion of gametes nor embryo development. Deer was an unfortunate choice as the developing embryo remains microscopically small for a long time.

11.4 Sexual Reproduction HL

1. What are seminiferous tubules?

The testes are packed with tightly coiled tubes (over 200 m), which produce sperm called **seminiferous tubules**. They interconnect and lead to the epididymis.



2. What are Leydig or interstitial cells?

Between the seminiferous tubules there are **interstitial cells (Leydig cells)** which produce testosterone. This stimulates Sertoli cells to mature sperm.

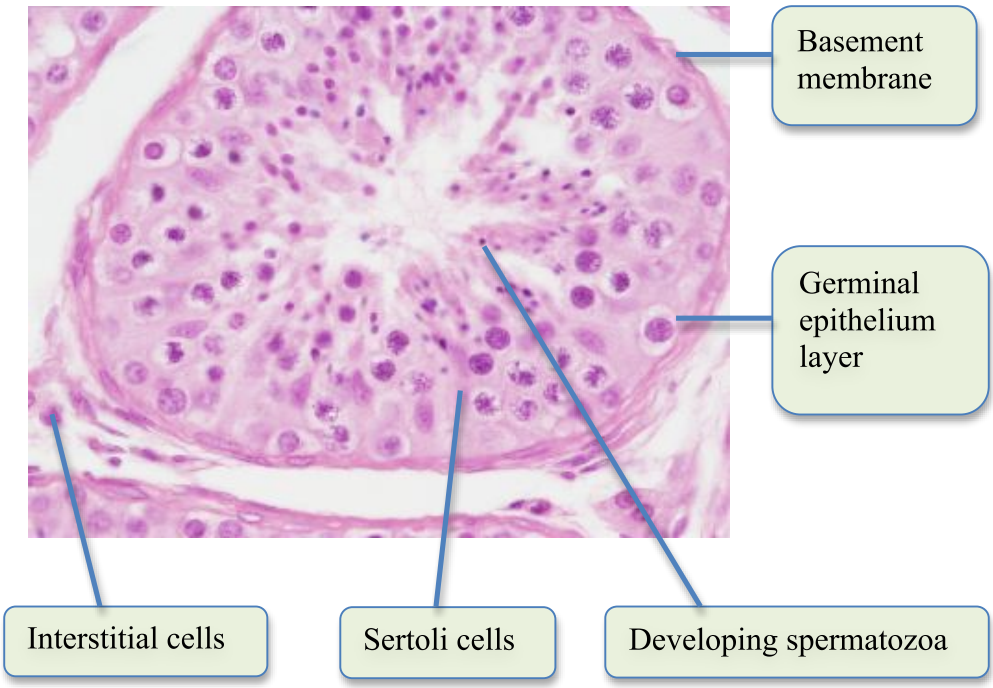
3. What are germinal epithelial cells?

The outer layer of the seminiferous tubule is called the **basement membrane** and inside that is the germ cell layer (**germinal epithelium layer**). These cells undergo mitosis then 2 divisions of meiosis to produce many **spermatozoa** (sperm) in males.

4. What are Sertoli cells?

Sertoli cells are in the seminiferous tubules and they are nurse cells which provide nourishment for the developing spermatozoa.

5. What does a cross section of a seminiferous tubule look like?



6. What is spermatogenesis?

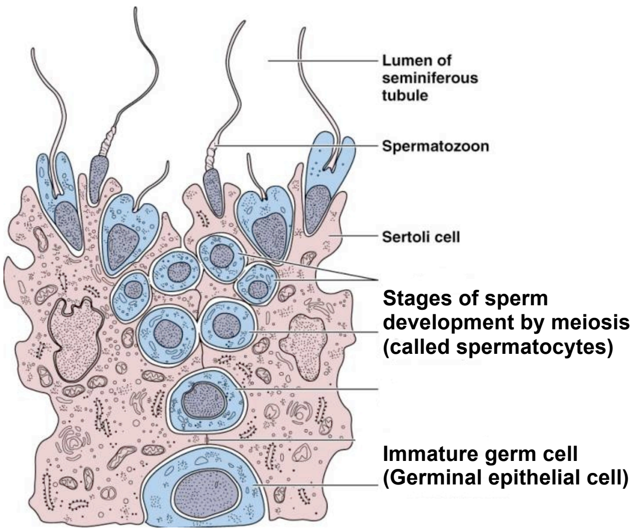
The production of male gametes (spermatozoa) is called spermatogenesis and it happens within the seminiferous tubules of the testes.

7. How does spermatogenesis occur?

Sperm development starts near the outside wall of the seminiferous tubule and progresses as they move towards the centre where mature sperm break away into the lumen. They float towards the epididymis for storage.

Sertoli cells in the wall of the tube secrete the fluid in the lumen and control the sperm development. They phagocytose some of the sperm cytoplasm.

The epididymis is so long that it may take 14 days for sperm to travel along it.



1. Interstitial cells secrete testosterone which stimulates Sertoli cells.

2. Germinal epithelial cells begin to divide, firstly by mitosis so they don't run out, then these new cells divide by meiosis and mature as they move toward the centre of the tubule. They are called spermatocytes during this process and spermatozoan (sperm) at the end of the process.

3. The Sertoli cells nourish the spermatocytes as they develop and then phagocytose some of the sperm cytoplasm. This is differentiation.

4. Mature sperm move into the lumen of the tubule and onto the epididymis for storage.

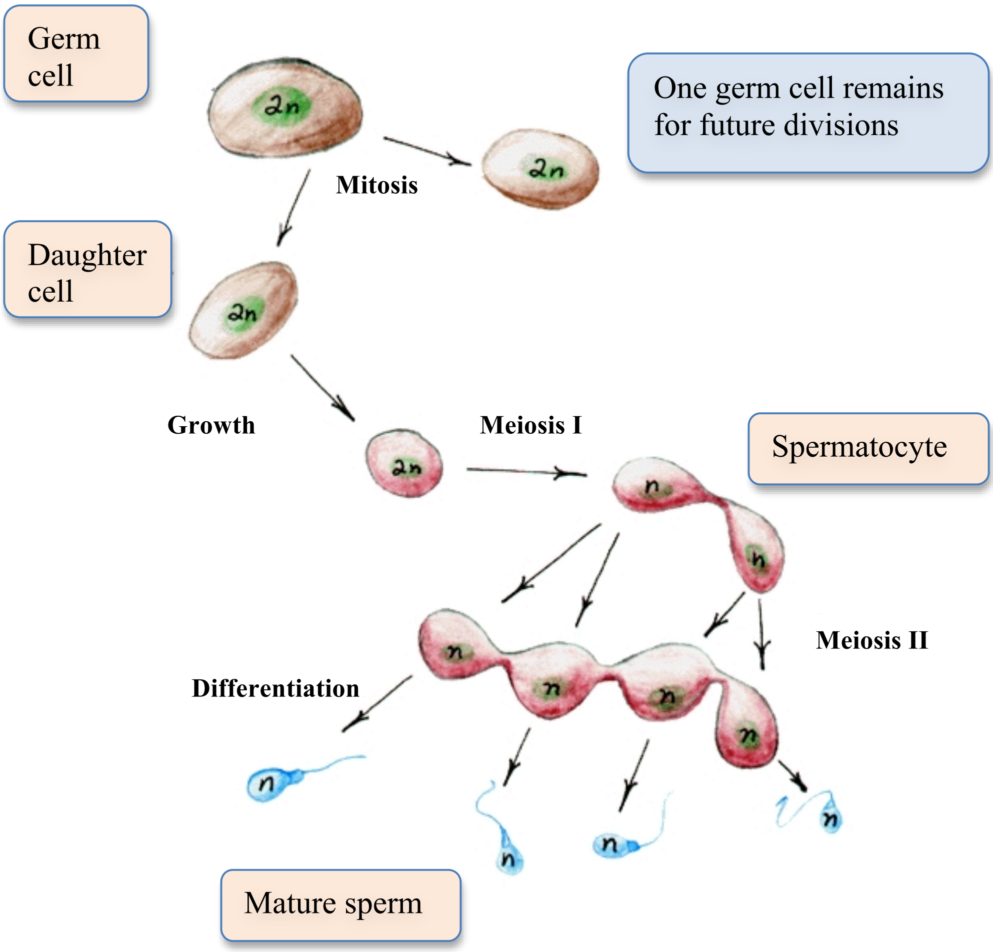
8. What roles do hormones have in spermatogenesis?

The pituitary gland releases **FSH** which causes sperm production in the seminiferous tubules.

The pituitary gland also releases **LH** which causes the interstitial cells (Leydig cells) to make **testosterone**.

Testosterone causes sperm to mature.

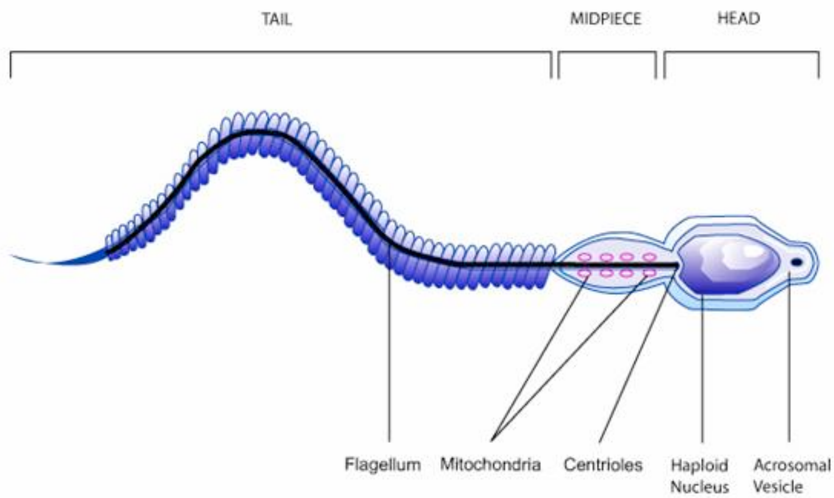
9. What are the stages in spermatogenesis and what happens to chromosome numbers?



10. What is the structure of sperm?

Sperm has 3 parts:

The head which carries enzymes (contained in an organelle called the **acrosome**) to penetrate the egg and the nucleus. The chromosomes are also in the head. The midpiece has mitochondria for energy needed by the tail. The tail propels the sperm.



11. How do the epididymis, prostate gland and seminal vesicles contribute to the production of semen?

Sperm are stored and complete their maturation in the epididymis until they are motile. Semen, or seminal fluid, provides the medium for transfer of sperm.

The prostate gland adds fluid which is alkaline to neutralise any acid from the urine or from the female reproductive tract.

The seminal vesicles secrete fluid containing fructose for energy to nourish the sperm and mucus which will also help protect the sperm from any acid. As the sperm pass through the vas deferens the seminal vesicles releases a large volume of fluid which increases the volume of the ejaculate. About 70% of fluid in semen is produced here.

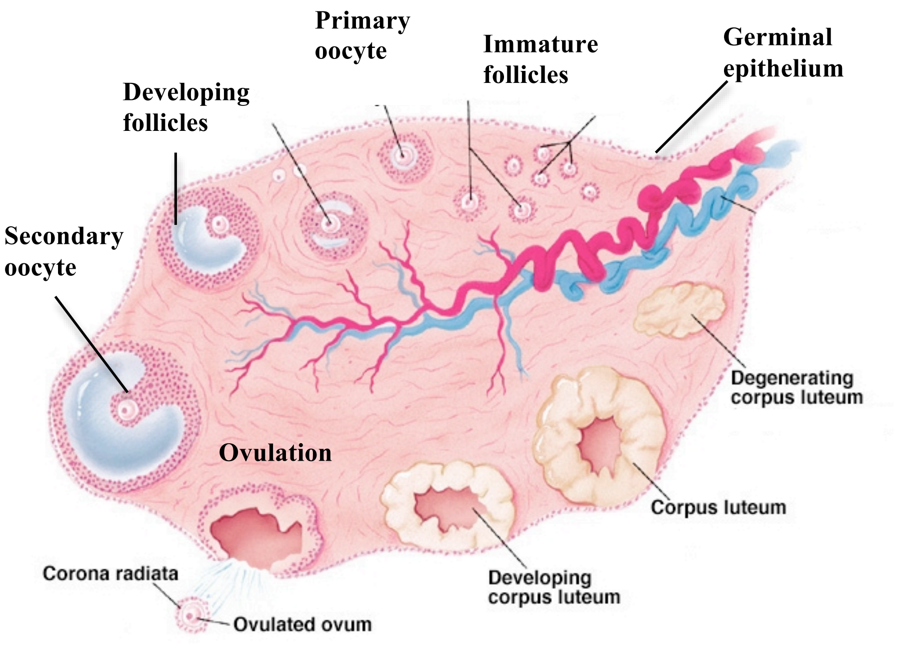
12. What is oogenesis?

The production of female gametes (ova) is called oogenesis and it happens within the follicles of the ovaries.

13. How does oogenesis occur?

In females the ovaries begin egg formation before birth. Inside follicles the germinal epithelium layer undergoes mitosis to make new cells which grow - these cells are called **primary oocytes**. They then continue to divide by meiosis but stop before completed. At birth these oocyte cells are stuck in prophase I of meiosis. They are surrounded by a layer of follicle cells and are called **primary follicles**.

When reproductive age is reached one oocyte per month matures by completing meiois I. One cell produced is much bigger and is called the **secondary oocyte**, while the other is a **polar body**.

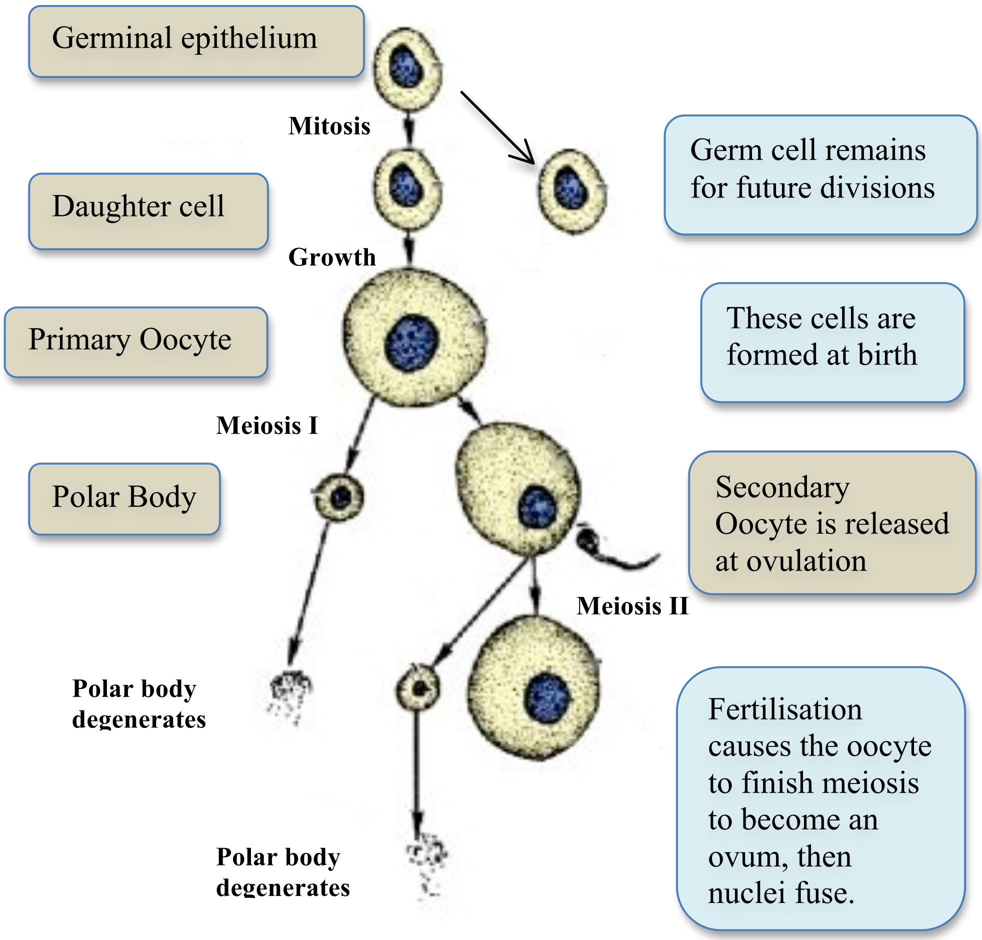


The follicle matures to form a **Graafian follicle**. Inside the oocyte begin meiois II once again getting stuck in prophase.

The outer layer of the Graafian follicle secretes the hormone, oestrogen. At ovulation the secondary oocyte is released from the follicle which becomes the **corpus luteum**. This slowly degenerates.

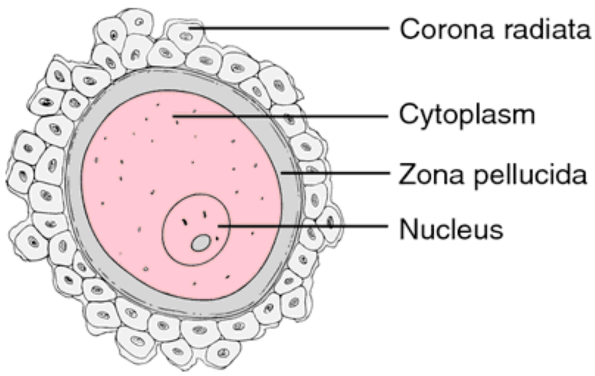
If the oocyte is fertilised on its way down the fallopian tube it will complete meiosis II to form an **ovum** and a second polar body, which degenerates. The ovum and sperm nuclei fuse to create a zygote.

14. What are the stages in oogenesis and what happens to chromosome numbers?

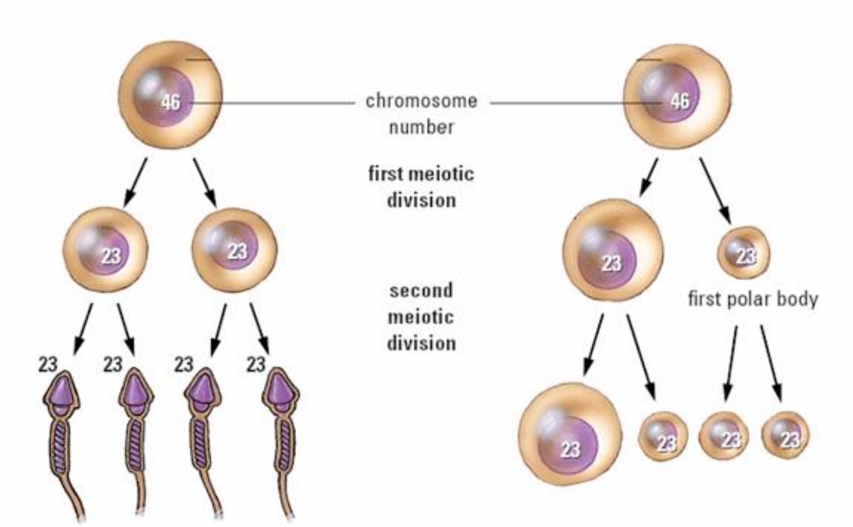


15. What is the structure of an egg?

The ovum is surrounded by a membrane called the **zona pellucida** and it in turn is surrounded by a layer of follicle cells called the **Corona radiata**.



16. How do oogenesis and spermatogenesis compare?



Oogenesis	Spermatogenesis
One secondary oocyte produced every 28 days or per cycle	Millions of sperm produced daily
Each germinal cell produces only one gamete during meiosis	Each germinal cell produces four gametes during meiosis
Gametes are very large	Gametes are very small
One gamete released during ovulation around day 14 of the menstrual cycle	Millions of gametes released during ejaculation
Occurs inside the ovaries	Occurs inside the testes
Ovulation releases a secondary oocyte	Spermatozoa are released during ejaculation
Egg production stops at menopause	Sperm production continues all through life
Formation of eggs begins very early in females; during the stages of foetal development	Formation of sperm begins during puberty in males
Meiosis II only completed after fertilisation occurs	Meiosis II completed before sperm ejaculated
Eggs increase their cytoplasm	Sperm have lost most of their cytoplasm

17. What are the main steps in fertilisation?

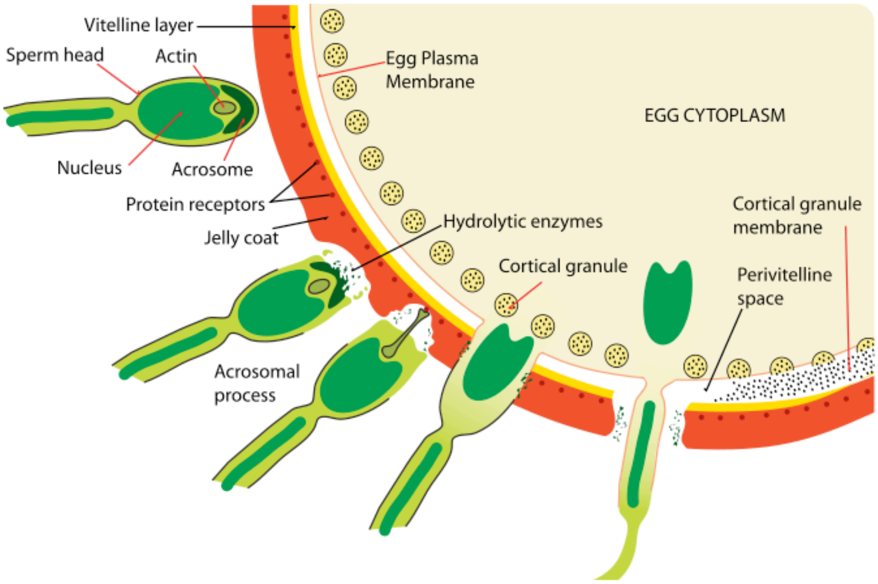
Sperm burrow through the Corona radiata layer of cells. The acrosome of the sperm head touches the cells of the zona pellucida and their membranes fuse, releasing proteolytic enzymes from the acrosome. They digest the cells allowing the sperm to penetrate this layer. This is the **acrosome reaction**.

Sperm are now able to pass through the Zona pellucida.

The sperm head fuses with the oocyte membrane causing the oocyte to complete meiosis and become the ovum. It also changes the electrical charge across the membrane, temporarily stopping further sperm from entering.

It also causes cortical granules to release enzymes to thicken the zona pellucida (called the **cortical reaction**).

This thickened membrane prevents entry of any other sperm. It is important that only one sperm fertilise the egg (ovum). This avoids **polyspermy**.The sperm loses its tail and the nuclei fuse with the ovum to form a zygote.



18. How does sperm find the egg?

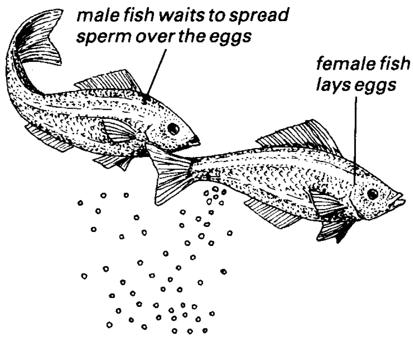
Sperm membranes have receptors to detect chemicals released by the egg. The sperm swim down a concentration gradient to the egg.

19. What are the differences between internal and external fertilisation?

Aquatic animals often release egg and sperm into the water where fertilisation happens externally. There is a greater risk of predation. Behaviour is often used to synchronise release to increase chance of fertilisation.

External fertilisation produces larger numbers of gametes due to greater predation, environmental risks like pollution, temperature and pH changes.

Terrestrial animals use internal fertilisation as gametes would dry out. There is a greater chance of fertilisation as gametes are placed close to each other for some time.



It also allows protection of the embryo inside the body.

20. What does HCG do in early pregnancy?

Early in pregnancy **human chorionic gonadotrophin** (HCG) is produced by the embryo and it causes the corpus luteum to remain intact for 4 months. Remember, the corpus luteum must produce progesterone (and oestrogen) to maintain the endometrium, and hence pregnancy.

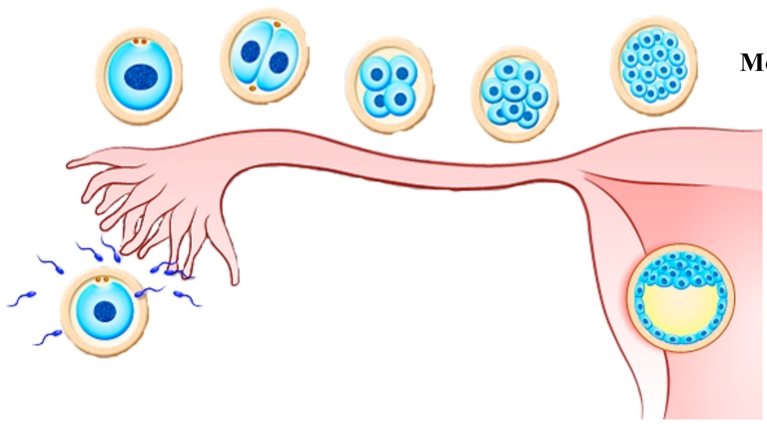
Without the HCG the corpus luteum would degenerate, inducing menstruation.

After about 4 months the role of making progesterone (and oestrogen) is taken over by the placenta – the corpus luteum disappears.

21. How does the embryo develop in the early stages? Include the morula and blastocyst.

The fertilised egg undergoes mitosis to produce a solid ball of cells (the blastomeres) called the **morula**.

As it moves down the oviduct further divisions produce a fluid space to form in the middle. It is now called a **blastocyst** – a hollow ball of cells. This takes about 4 days.

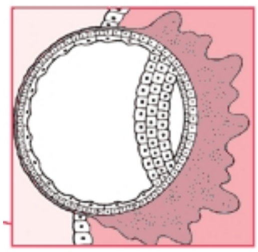


22. What is implantation?

The uterus wall (**endometrium**) prepares for the blastocyst by thickening and increasing its blood supply. The blastocyst attaches to and embeds in the endometrium – this is called **implantation**. It usually happens about 7 days after fertilisation.

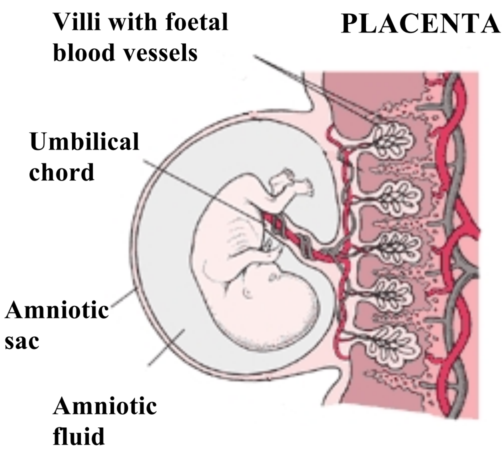
23. What is the placenta and what does it do?

Part of the reason the egg or ovum is so large is so that it has enough nutrients to support the fertilised egg until it can implant in the uterine lining. It is running out of stored nutrients once implantation occurs however implantation triggers the development of the placenta.

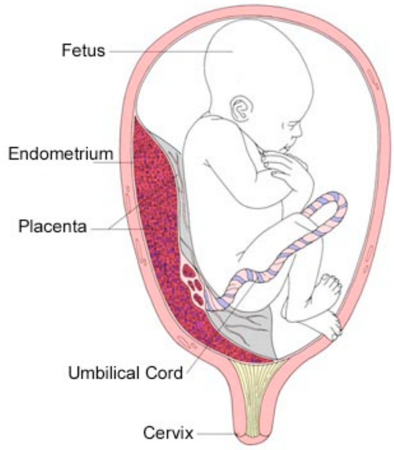


Villi containing blood vessels grow between the embryo and the endometrium for exchange of materials between mother and baby. This becomes a large disc shaped structure called the **placenta.** It connects to the baby by the **umbilical chord** which has foetal blood vessels.

The baby's blood vessels run very close to mums so exchange of nutrients and waste can occur. There is no direct link as the mum's blood pressure would blow baby's vessels apart. It also stops different blood types from mixing.



The foetus passes carbon dioxide, urea, water and hormones (e.g. HCG) to the mother and in return the mother passes oxygen, nutrients like glucose and amino acids, water, hormones, vitamins and minerals to the baby. Unfortunately, chemicals like alcohol and many drugs such as nicotine also pass from mother to baby, as do some viruses such as HIV.



Later in pregnancy, the placenta also begins to produce progesterone and oestrogen to maintain the endometrium as the corpus luteum eventually breaks down.

After 8-10 weeks of growth the embryo begins to develop bone tissue and all major organs have developed. From this point in development the embryo will now be known as a **foetus,** because it is recognisably human.

24. How is the foetus protected and supported?

The foetus is protected and supported by the **amniotic fluid** and **sac**. The fluid absorbs shocks and is filtered by mum – baby drinks fluid. The sac prevents infections.

During the 9 months or 40 weeks of pregnancy the hormone progesterone makes sure that the uterus develops properly and sustains the developing foetus.

25. What causes birth (parturition)?

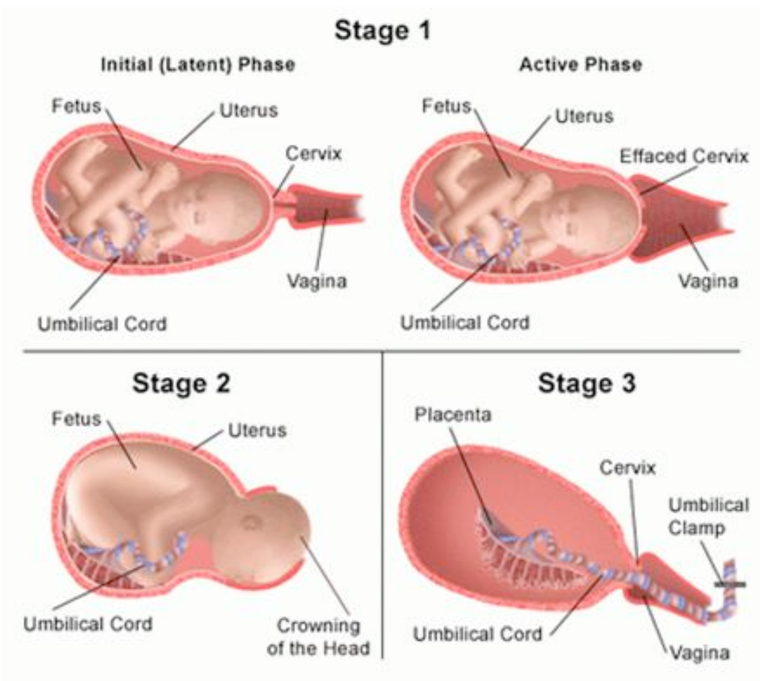
While progesterone levels are normally high in pregnant mothers, a drop in the progesterone levels (and a rise in oestrogen) indicates the end of the pregnancy and the onset of labour and childbirth – causes contractions to start.

26. What happens in childbirth and what does oxytocin do?

The decrease in progesterone is followed by an increase in **oxytocin**, a hormone that induces labour by causing the muscular walls of the uterus to contract. The contractions stimulate the release of more oxytocin, which in turn increases the frequency, and strength of the uterine contractions. This is an example of **positive feedback**.

The muscular contractions of the uterus cause the cervix to dilate and become thinner. The amniotic sac will burst releasing the amniotic fluid and this is usually referred to as the "**water breaking**". After many hours of contractions the cervix will dilate enough (10cm) to allow the baby to be pushed out and through the birth canal (vagina).

Even after the baby is born uterine contractions will continue until the mother delivers the placenta and amniotic sac, often referred to as the **afterbirth**.



27. What is the female contraceptive pill?

By consuming regular amounts of synthetic oestrogen, a woman can mimic pregnancy. This inhibits FSH production and hence the production of mature follicles and pregnancy.

28. Are there risks to male fertility by releasing synthetic oestrogen into the environment?

This was not considered when the pill was introduced. Since the 1980s elevated level have been found in water due to sewage. There has been a 50% decline in male sperm counts over the past 50 years. Studies have shown a 'feminisation' of male fish. The European Commission in 2012 proposed a maximum concentration in water supplies but industries argue the costs will be too high. Improved technologies for sewage treatment could remove most of the problem.

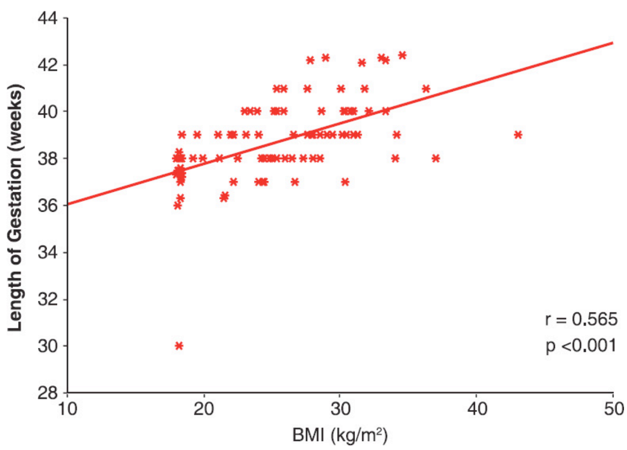
29. What is gestation?

Gestation is the period of development before birth of an animal.

30. What is the relationship between body size and length of gestation?

Some animals are born relatively helpless as they are incompletely developed at birth (**altricial species**) – eyes closed cannot move on their own. Others are born more able to fend for themselves – move and have their eyes open (**precocial species**).

Mammals with a large body size are more likely to be precocial and have a long gestation period.



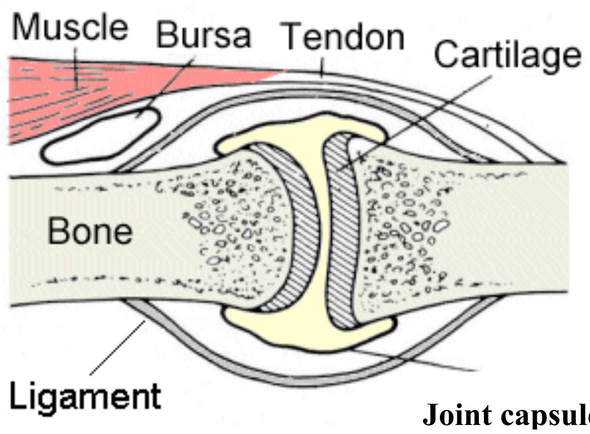
11.2 Movement HL

1. What are the functions of the skeleton?

The skeleton provides support and shape. It allows movement – forms a rigid framework of bone to which muscles are attached. They cause movement of bones. It protects vital organs, e.g. heart/lungs, produces blood cells, and stores minerals such as calcium salts.

2. What is a joint?

A **joint i**s where two or more bones come in contact with one another. Joints provide our skeleton with mobility and hold the skeletal system together. Joints include bones, ligaments, muscles, tendons and nerves.



Joint capsule with synovial fluid

3. What are ligaments?

Ligaments are tough, band-like structures that connect bone to bone and strengthen the joint. They restrict movement at the joints to prevent over extension and dislocation.

4. What are tendons?

Tendons are connective tissue that connects muscle to bone. Tendons are what allow muscles to pull on a bone.

5. What role do nerves have in movement?

The role of **nerves** is to stimulate the muscles. This will cause contraction of the muscle and the joint will move. The nerves also sense the contraction and the relative position of the limbs and this can help prevent overextension of the joint.

6. What are muscles? What are antagonistic pairs of muscles?

Muscles provide the force necessary or needed to move a joint by contracting. Muscles can move joints only when they contract so they must work in pairs. One muscle contracts and moves the joint in one direction while the other relaxes, and vice versa. This combination of muscles is known as **antagonistic pairs** and the biceps and triceps are an example of an antagonistic pair.

7. What is cartilage?

Cartilage provides the bones with a smooth surface to spread forces, which allows for easy movement, reduces friction and absorbs shock.

8. What is a joint capsule?

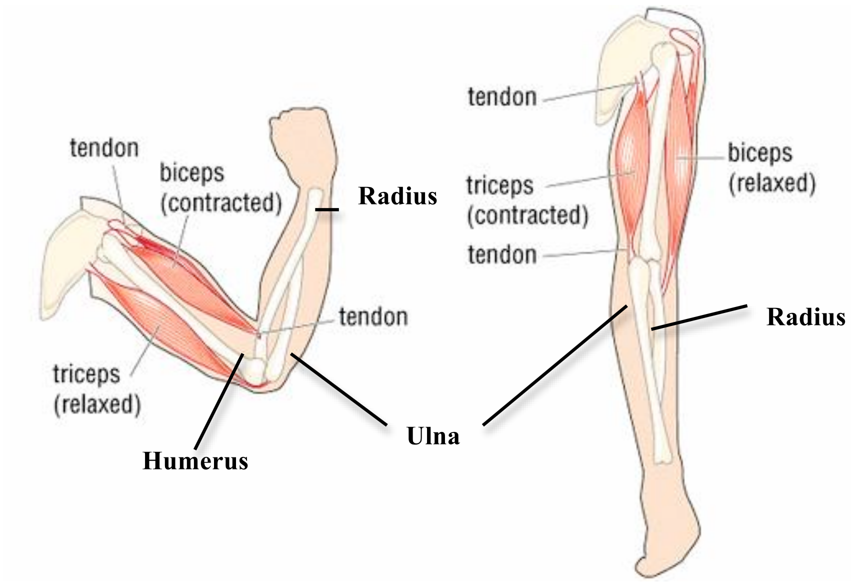
The joint capsule surrounds the joint, encloses the synovial cavity, and unites the connecting bones.

9. What is the synovial fluid?

Synovial fluid lubricates the joint to reduce friction and also provides nutrients and oxygen to the cells of the cartilage.

10. What is the structure of the human elbow joint?

The human elbow joint is a hinge joint, which means it can move similar to the action of a door; open and close. It involves three bones; the **humerus** is located in the upper arm and the lower arm consists of the **radius** and **ulna**.



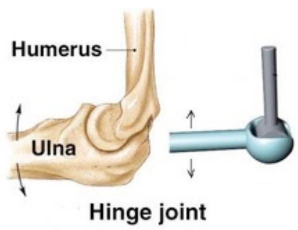
Contraction of the bicep muscle pulls on the lower arm causing flexion (bending) of the arm. Contraction of the triceps causes extension (straightening) of the arm. The humerus bone acts as a lever that allows for the anchoring of the muscles of the elbow. The radius acts as a lever for the biceps muscle, while the ulna acts as a lever for the triceps muscle.

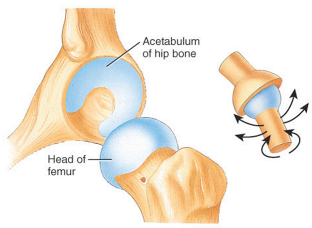
11. What is flexion and extension?

Flexion involves contraction of a muscle (e.g. biceps) to bend a joint.
Extension involves contraction of a muscle (e.g. triceps) to straighten a joint.

12. What are the types of joint?

A **hinge joint** like the elbow or knee movement is restricted to one plane. This is because of the shape of the surfaces and placement of ligaments. Movement is just flexion and extension.



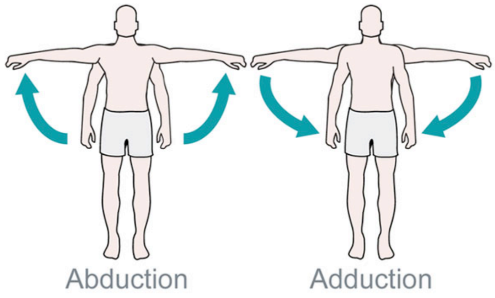


Ball and socket

In a **ball and socket** joint like the shoulder or hip movement is possible in 3 planes. This is called **circumduction**.

The hip joint can flex and extend like the knee but also rotate.

13. What are abduction and adduction?

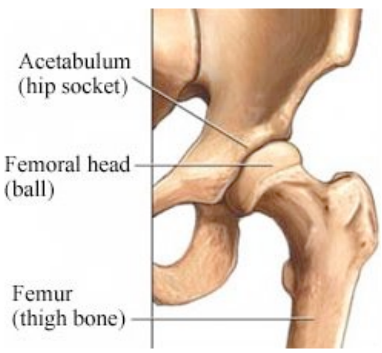


Adduction is movement toward the body's midline – e.g. arms pulled down to the sides. Abduction is movement away from the body's midline – e.g. arms raising towards the shoulder.

14. How does movement compare between the hip and knee joints?

Both the hip and knee joints are freely moveable. The knee joint, like the elbow joint, is a hinge joint. It allows for movement in one plane and this includes flexion and extension. A hinge joint does not allow for much movement in other planes.

The hip joint is a ball-and-socket joint. This type of joint permits movement in several planes including rotation. These types of movements can occur because the head of the femur is shaped like a ball and there is a cup-like depression in the hipbone that the head of the femur sits in.

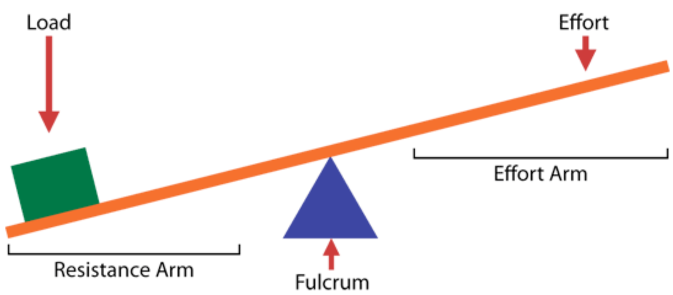


Hip Joint

Knee joint

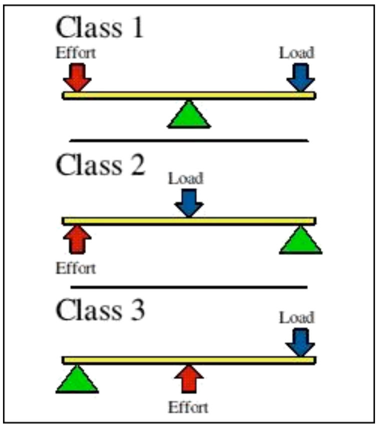
15. What are levers?

A **lever** is a simple machine that we can use to apply forces to objects. Each lever has a pivot point or **fulcrum**, a force applied called the **effort**; and a force to be overcome called the **load**.



16. What kinds of levers are there?

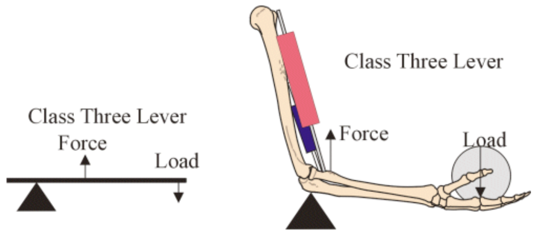
There are three types of lever depending on the arrangement of fulcrum, effort and load. Type 3 is the most common in the body.

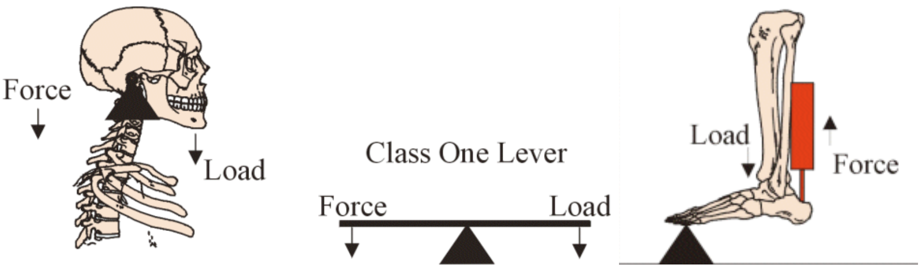


17. How are levers used in the body?

Our skeletal system is a system of levers.

The elbow is a class 3 lever. The effort is bigger than the load. It moves loads big distances with a small movement of muscle.



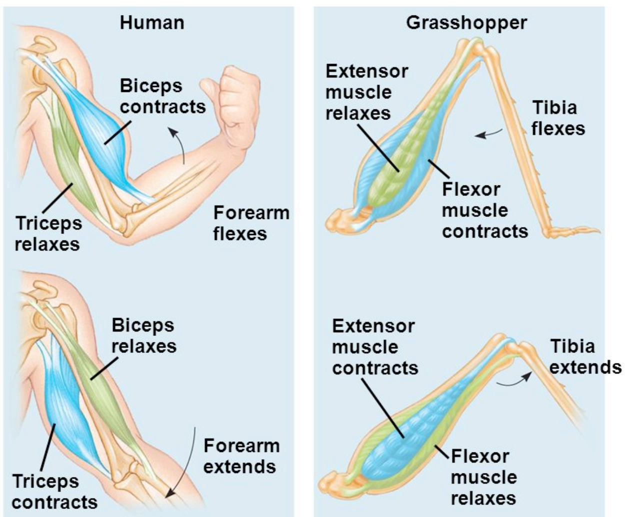


The neck is a class 1 lever. A small effort by the neck muscles move the larger load – stable and strong.

The ankle is a class 2 lever. It is stable and strong but slower acting and limited in range of flexibility.

18. How do insects move?

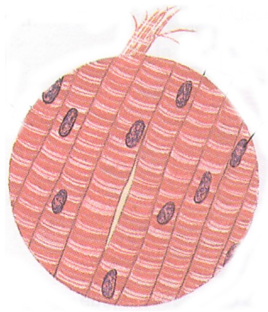
Insects have a strong external skeleton (**exoskeleton**) with muscle attached to the inside. Their legs are a series of hollow cylinders with antagonistic muscles attached across the joints.



Flexor muscles contract to produce a ‘z’ shape then extensor muscles propel the insect.

19. What is striated muscle?

Striated muscle can also be referred to as skeletal muscle because it is responsible for the movement of the skeleton.



20. What are muscle fibres?

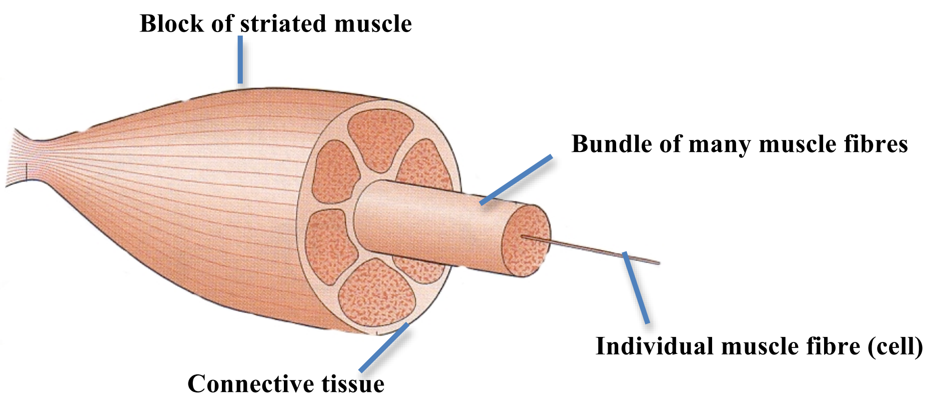
Striated muscle consists of thousands of cells referred to as **muscle fibres** because they are such long, **multinucleate cells**.

21. What is sarcolemma?

The muscle fibres are covered by a plasma membrane known as the **sarcolemma** which has many tunnel-like extensions known as **transverse tubules** that penetrate into the muscle cell.

22. What is sarcoplasm?

Muscle cells contain cytoplasm known as **sarcoplasm**. It contains a high number of organelles that store glycogen. It also contains large amounts of a red-colored protein known as myoglobin.

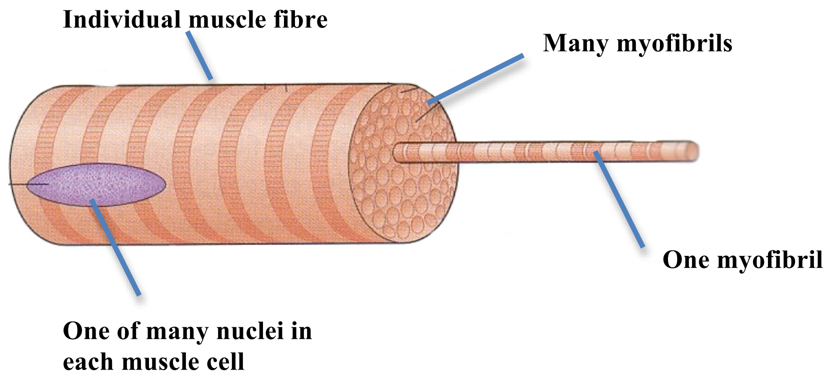


23. What is sarcoplasmic reticulum?

Striated muscle also contains **sarcoplasmic reticulum**, which is similar to endoplasmic reticulum. It is a fluid filled system of membranous sacs that surround the myofibrils.

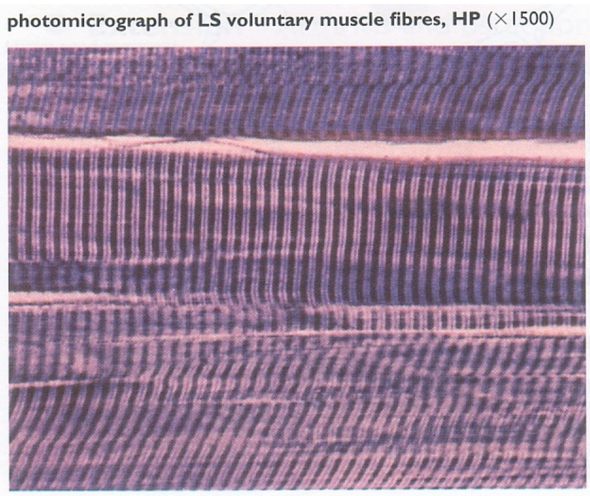
24. What is a myofibril?

Inside each muscle fibre are cylindrical structures known as **myofibrils**. They are rod-shaped and they run the length of the cell parallel to one another. In between the closely packed myofibrils are many **mitochondria**.



25. What is a sarcomere?

Electron micrographs of muscle tissue show alternating light and dark bands.

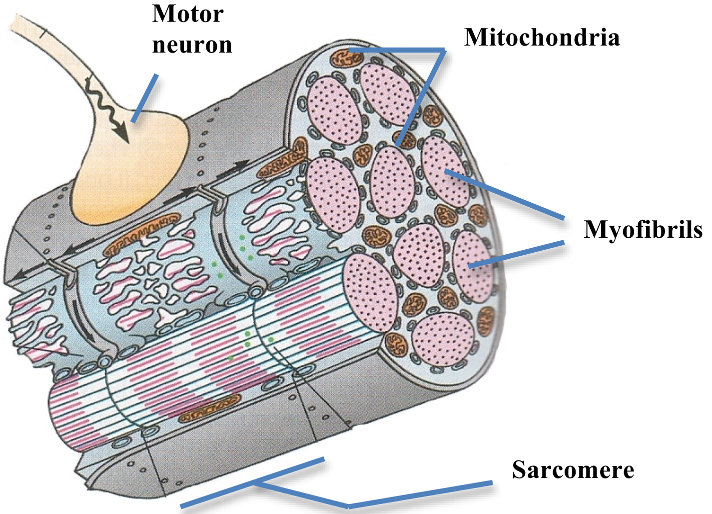


This is due to sarcomeres.

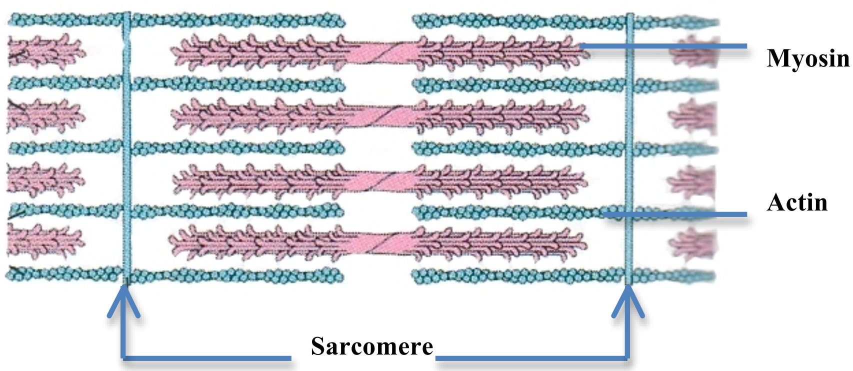
Each myofibril consists of smaller repeating units called **sarcomeres**, which are linked like elements of a chain to form the myofibril.

The sarcomeres are the units that allow for movement by shortening.

The sarcomeres' light and dark bands give skeletal muscle its characteristic striated or stripped appearance.

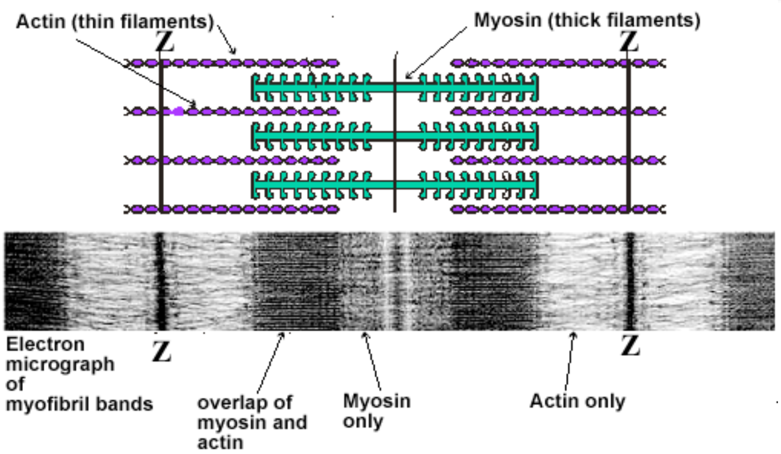


26. How are actin and myosin arranged in a sarcomere?



Inside the myofibrils there are two types of protein filament, a thinner filament called **actin** and a thicker filament called **myosin**.

27. What is the structure of a sarcomere and how does it relate to the Z-line and light and dark bands?



The thicker myosin filaments appear as darker bands and the thinner actin filaments appear as lighter bands. The myosin filaments have heads or cross bridges on them where they arttach to the actin filaments.

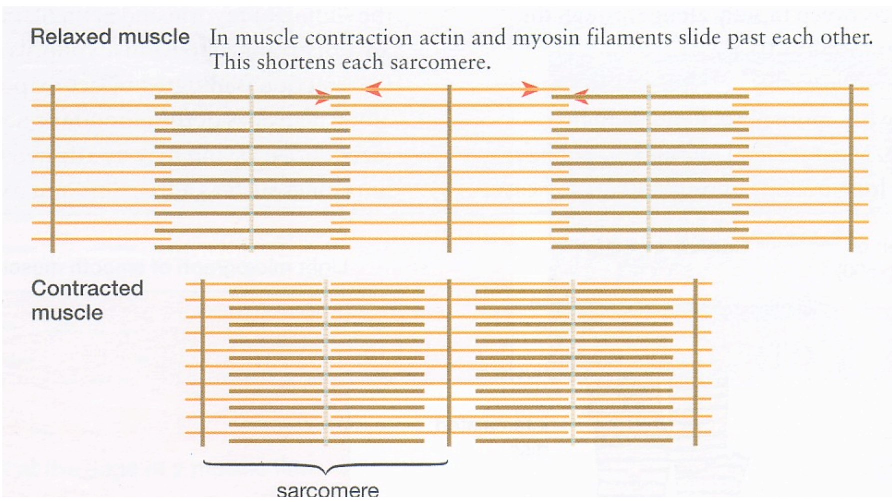
28. How does a muscle contract?

Each sarcomere gets shorter when the muscle contracts, so the whole muscle gets shorter. The sarcomere shortens but the actin and myosin filaments do not change length – they slide past each other. Actin slides along the thicker myosin filaments.

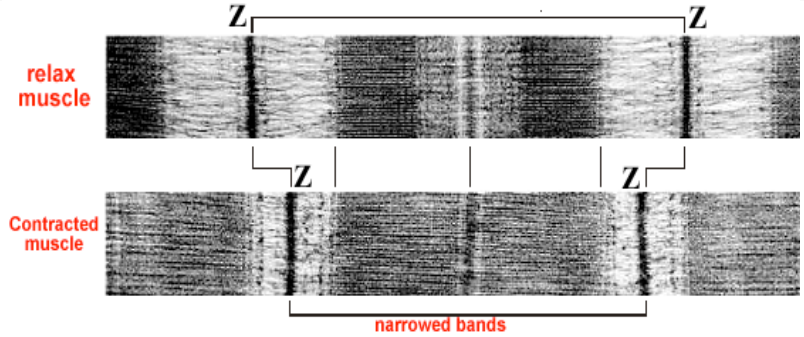
The myosin heads can attach (form cross-bridges) to the thinner actin filaments and pull them along – they do this up to 100 times per second during a contraction. This is a bit like a ratchet mechanism.

This is an active process requiring ATP.

This mechanism only shortens muscles. They lengthen again as a result of the antagonistic muscle contracting.



29. What do the light and dark bands look like in contracted and relaxed muscle?



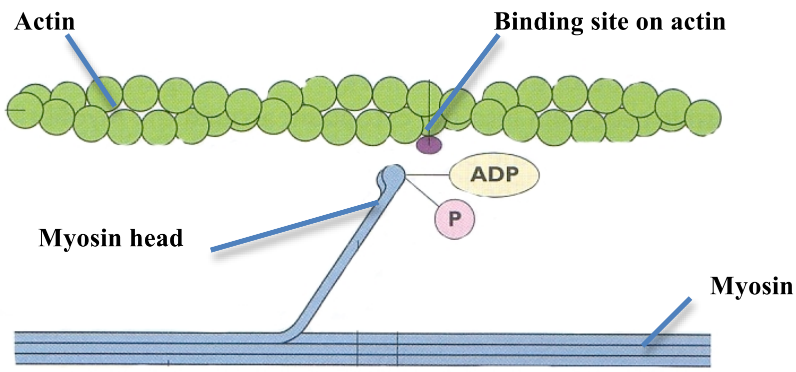
Each sarcomere gets shorter when the muscle contracts, so the whole muscle gets shorter. But the dark band (the thick filament) does not change in length.

This shows that the filaments don't contract themselves, but instead they slide past each other.

30. What is the sliding filament theory of muscle contraction – describe the steps?

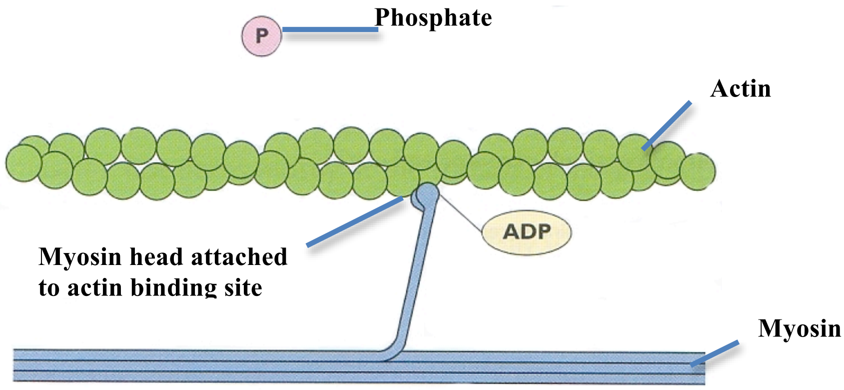
The sliding filament theory explains how muscles contract.

1. The action potential arrives at a myofibril causing release of Calcium ions. This clears the binding site on the actin.

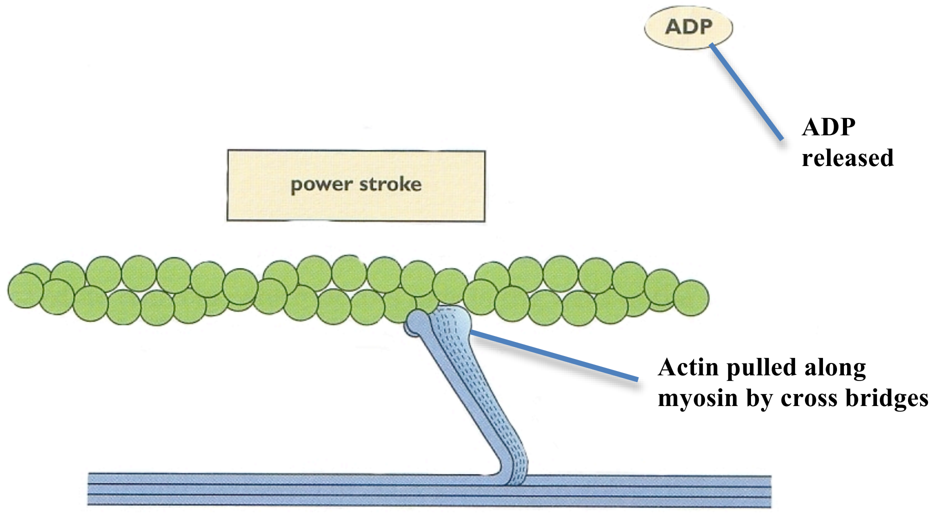


The head on the myosin binds ADP and P from the breakdown of ATP.

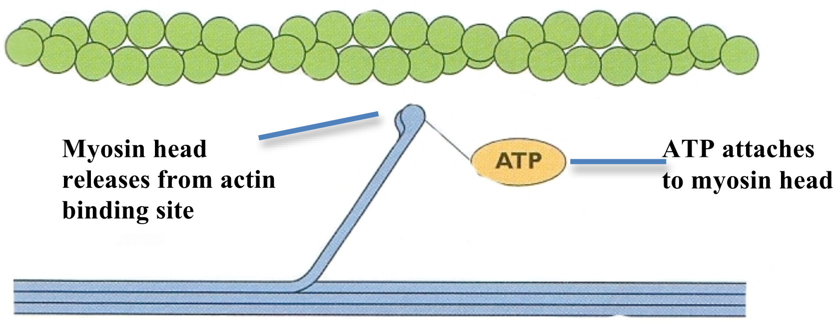
2. The myosin head binds to the exposed actin binding site and the phosphate is released.



3. The release of ADP triggers movement in a ‘rowing action’ – the **power stroke**. The actin is pulled past the myosin, shortening the muscle.

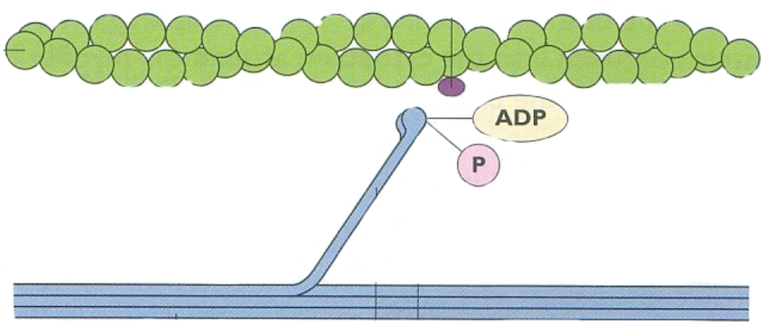


4. ATP combines with the myosin head, releasing it from the actin.



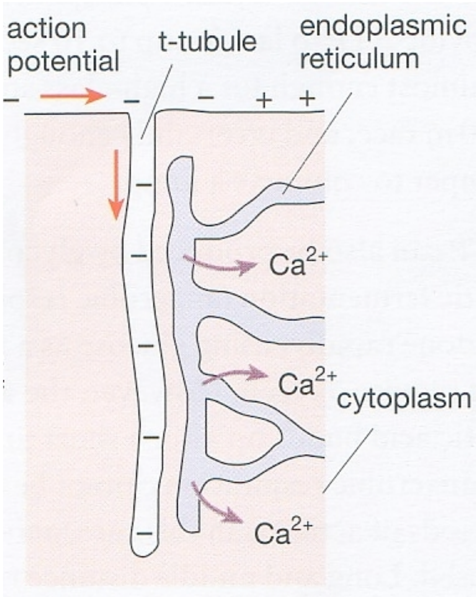
Notice energy (ATP) is needed to relax the muscle. This is why rigor mortis sets in – after death there is no ATP available so muscles remain contracted.

5. The cycle begins again further along the muscle. Break down of the ATP to give ADP + P allows myosin heads to attach to the actin.



31. What role does the sarcoplasmic reticulum have in muscle contraction?

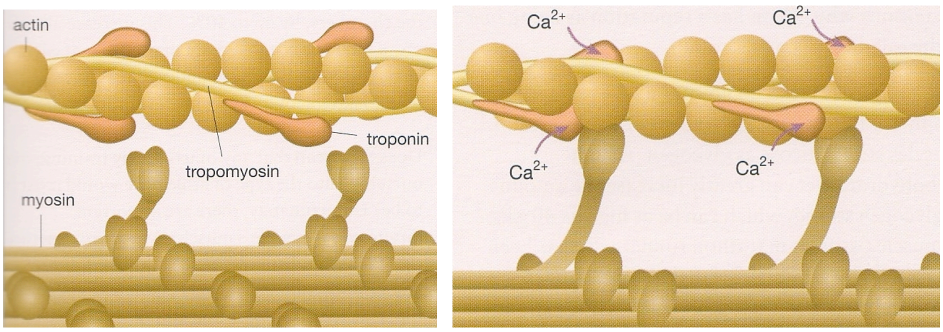
When an action potential arrives at the muscle it spreads through tubules. This causes Calcium ions to be released from the sarcoplasmic reticulum (the name for endoplasmic reticulum in muscle fibre). The calcium initiates the response by clearing the binding sites on the actin.



32. What are troponin and tropomyosin?

Troponin is a protein that blocks the binding sites on actin, so the myosin heads cannot cause contraction. It is attached to another protein called tropomyosin.

When calcium binds to troponin it changes shape causing these proteins to move away from the binding site. This allows the myosin heads to attach causing contraction.



33. How has improved technology helped our understanding of muscle action?

The attachment of fluorescent dyes to myosin allowed scientists to observe the heads during contraction. They were seen to 'walk along' the actin.

It also allowed them to show the ATP-dependence of the myosin-actin interactions.

11.3 The Kidney and osmoregulation HL

1. What is excretion?

Excretion is the removal from the body of the waste products of metabolic pathways.

2. What things are excreted?

Carbon dioxide, bile salts and pigments **Afferent arteriole** nitrogen waste (urea), heat, water, and mineral salts.

3. What forms of nitrogenous waste can be excreted?

Animals break down amino acids & nucleic acids to form nitrogenous waste. The product is ammonia which is highly toxic and basic. This can be converted into urea or uric acid which are less toxic.

4. How doe the environment and evolutionary pathway affect the form of nitrogenous waste used?

Animals in marine freshwater can excrete NH_3 directly as it is diluted (e.g. fish). Land animals convert it to either urea or uric acid, both require energy but are less toxic. Uric acid is not soluble in water so does not need water to remove the waste. So birds do not have to carry the extra weight of water for excretion. Insects also excrete uric acid. Animals laying eggs are better with uric acid as it crystallizes, rather than build up in concentration over time.

Urea requires water to dilute it for excretion but less energy than uric acid. Mammals excrete urea after deamination of amino acids. Aquatic mammals have retained urea due to their evolutionary origins on land. Amphibians release ammonia as a larva (tadpole) and switch to urea as an adult (frog).

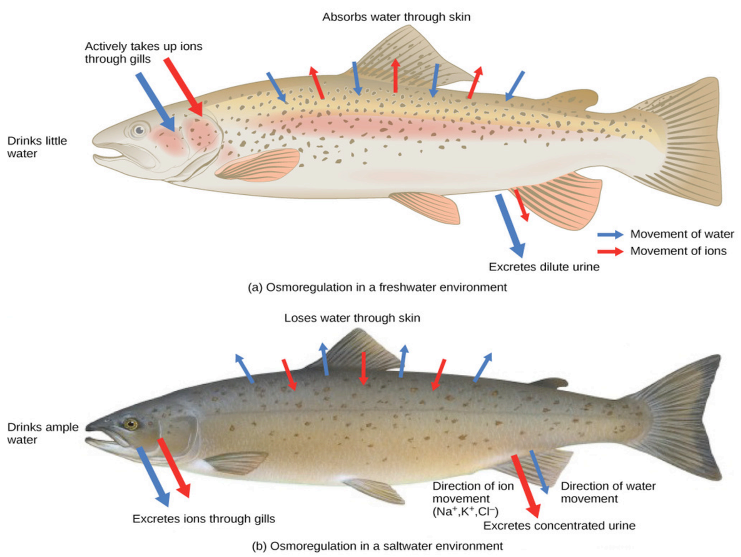
5. What is osmolarity?

Osmolarity is the solute concentration of a solution.

6. What are osmoregulators and osmoconformers?

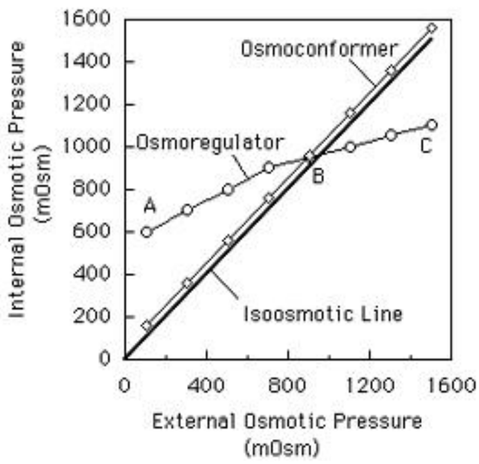
Osmoregulators maintain a constant internal solute concentration, even when their environment is very different.

They maintain at about 1/3 seawater or 10x freshwater solute concentrations. All land animals, freshwater animals, and some marine organisms like bony fish are osmoregulators.



(a) Osmoregulation in a freshwater environment
(b) Osmoregulation in a saltwater environment

Osmoconformers are animals whose internal solute concentration tends to be the same as the external environment. e.g. marine organisms.

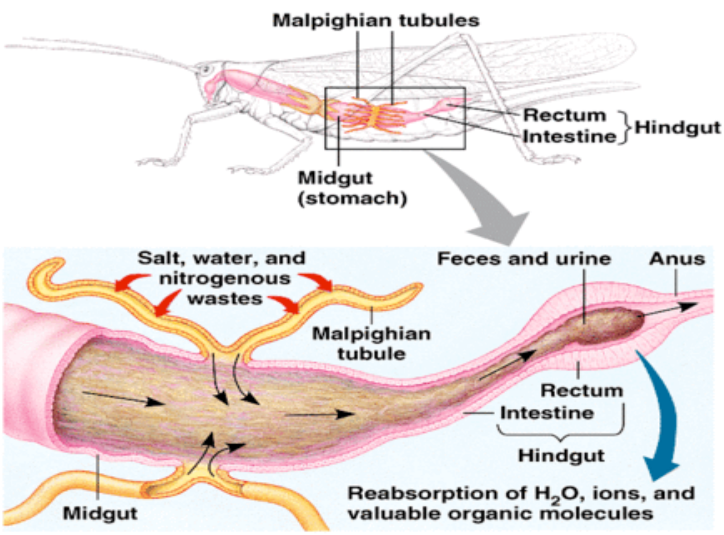


7. What is osmoregulation?

Osmoregulation is a kind of homeostasis where the concentration of blood or **hemolymph** (insects version of blood) is kept relatively constant.

8. How do insects carry out excretion and osmoregulation?

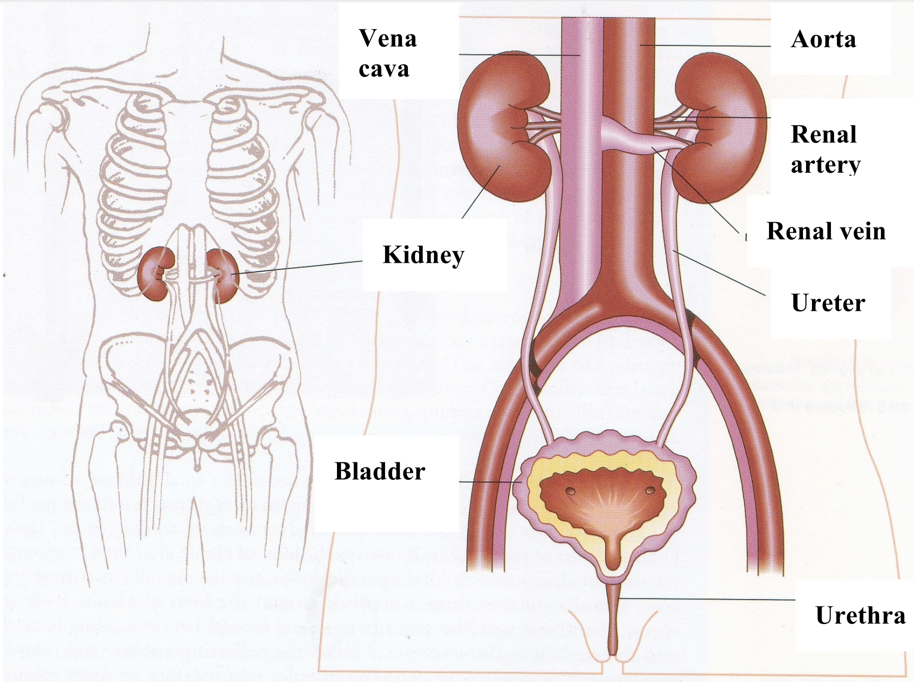
Insects have **Malipighian tubules** that branch off their digestive tract. Cells lining these tubules actively absorb uric acid from the hemolymph and release it into the lumen. The raised osmolarity in the tubules draws water inside from the hemolymph. The tubules empty their contents into the gut. Before it leaves most of the water and salts are reabsorbed in the hindgut. Finally the uric acid is excreted in the faeces.



9. What role do the kidneys have in excretion?

Your kidneys filter out urea to produce urine, removing nitrogen waste from your body. Kidneys also regulate water levels by excreting different amounts of urine.

10. What is the structure of the kidney and associated blood vessels?



11. What are functions of the parts of the kidney?

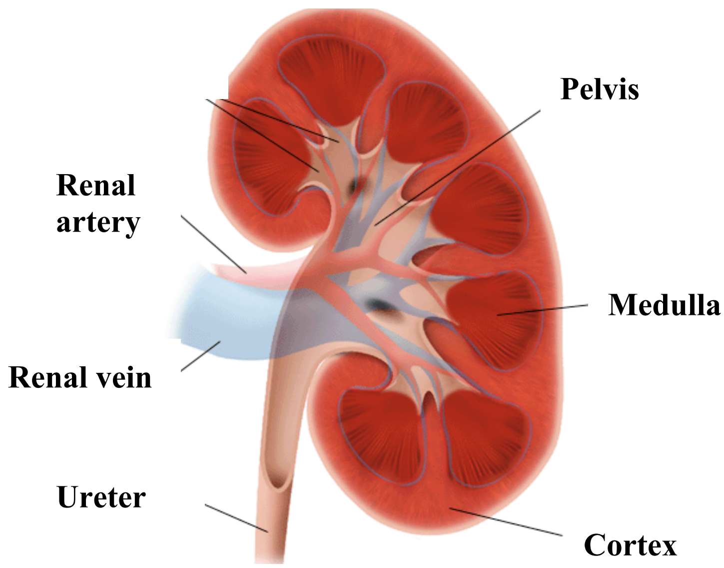
Kidneys act like filters, removing urea, and reabsorbing useful substances like glucose or salts. The waste product is called **urine** and it is sent to the bladder for storage. Each kidney has four parts:

Cortex – the outer layer of the kidney jammed pack full of filters called nephrons.

Medulla – the middle layer of the kidney which has the tubes carrying filtered wastes to the centre of the kidney.

Pelvis – area where all collecting ducts come together and connect with ureter.

Ureter – a tube that transports urine to the bladder.

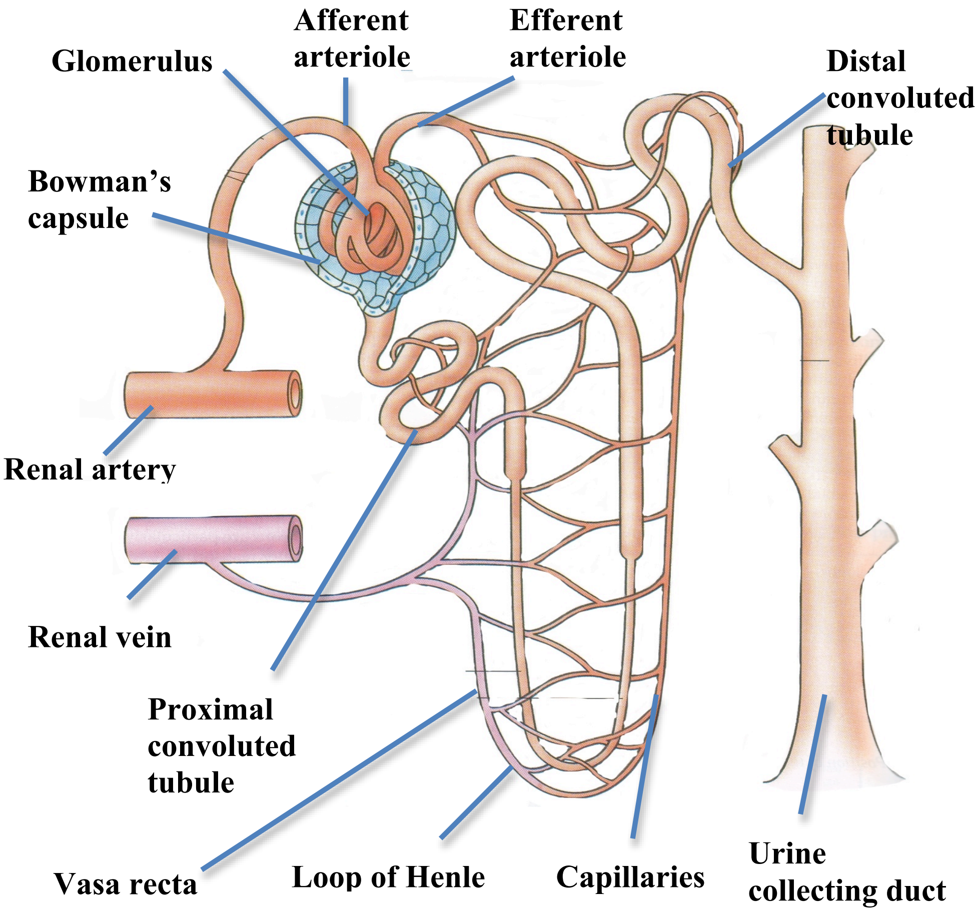


12. What is the function of the bladder and urethra?

The **bladder** stores urine until it is full, then the urine passes out the **urethra** to the exterior.

13. What is a nephron and what is its structure?

The unit of the kidney is called a **nephron** – it filters and reabsorbs. There are over one million nephrons per kidney.



14. What is the function of the glomerulus?

Ultrafiltration happens in a ball of capillaries called the **glomerulus**.

15. What is the function of the Bowman's capsule?

The glomerulus sits in a cup-shaped renal capsule that is called the **Bowman's capsule**. It receives filtrate from the glomerulus.

16. What is the function of the proximal convoluted tubule?

The **proximal convoluted tubule** is the first extension of the Bowman's capsule; it is a twisted tube where most reabsorption of glucose, salt and water occurs. It is lined with specialised cells for reabsorption.

17. What is the function of the loop of Henle?

The second part of the tube after the capsule is the **loop of Henle** where an ion gradient is set up to help absorption of water in the collecting duct. The loop descends deep into the medulla and ascends back to the cortex.

18. What is the function of the distal convoluted tubule?

The third part of the tube after the capsule is the **distal convoluted tubule** where further absorption occurs.

19. What is the function of the urine-collecting duct?

The **urine-collecting duct** extends into the medulla; it is where reabsorption of water happens. The absorption of water in this duct is regulated by ADH.

20. What is the function of the renal artery?

The renal artery brings blood to the nephron for filtration.

21. What is the function of the renal vein?

The renal vein takes blood away from the kidney.

22. What is the afferent arteriole?

This vessel brings blood to the glomerulus from the renal artery.

23. What is the efferent arteriole?

This vessel takes blood from the glomerulus and it is narrower to increase the blood pressure in the glomerulus.

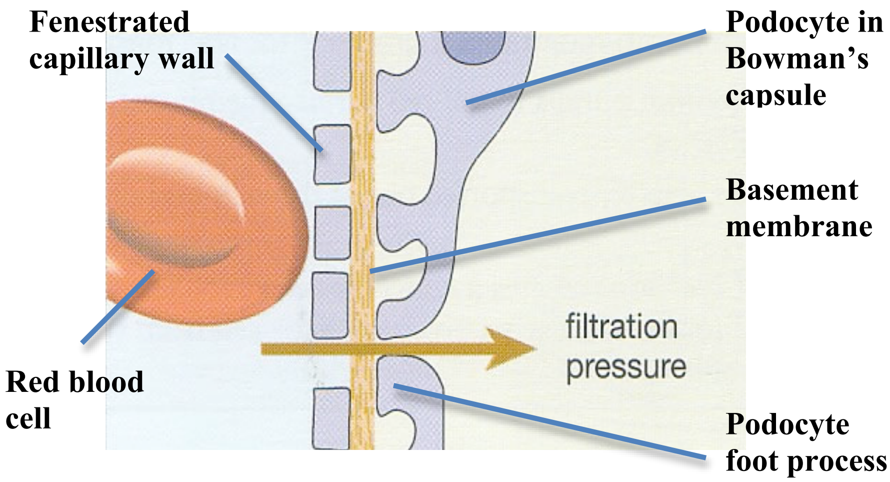
24. What are the vasa recta?

They are capillaries that carry blood deep into the medulla and back again to help set up the ion gradient.

25. What is ultrafiltration?

Ultrafiltration is the filtering of small molecules out of the blood in the glomerulus into the Bowman's capsule. Small molecules leave the capillary and enter the capsule – glucose, amino acids, salts, urea and water. It occurs because of the high blood pressure in the glomerulus, which pushes blood out of the capillary, and the liquid passing out is called **filtrate**.

26. How do the structures of the glomerulus and capsule allow ultrafiltration?



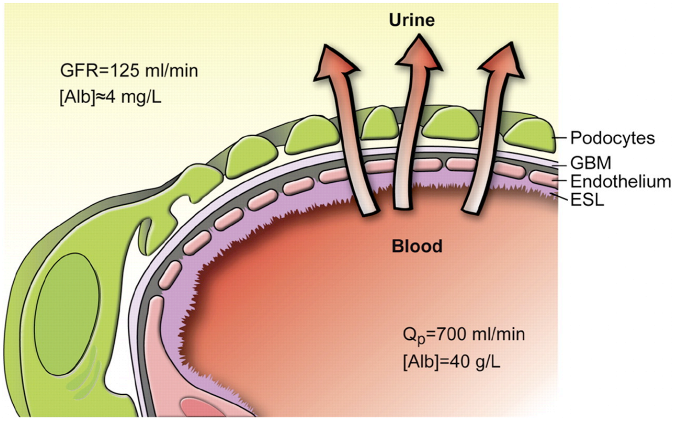
There are two cell layers to cross from the glomerulus to the Bowman's (or renal) capsule. Both are leaky as they have lots of pores.

We describe the glomerulus as **fenestrated** as it has pores or slits, which can let everything except red blood cells through.

The slits or pores open up with the blood pressure which is abnormally high due to the blood vessel leaving (**efferent arteriole**) the glomerulus being smaller than the one entering (**afferent arteriole**).

The **basement membrane** in the middle acts as a molecular sieve, stopping large objects such as blood proteins. It is a mesh of negatively charged glycoproteins.

Podocytes form the inner wall of the Bowman's capsule. They wrap around the capillaries of the glomerulus with extensions called foot processes. Their small gaps stop small molecules escaping the blood.



27. What does the filtrate contain?

The filtrate contains substances such as blood plasma, water, salt, ions and glucose and it enters the proximal convoluted tubule. Proteins and red blood cells are too big to enter the filtrate because of the basement membrane and podocytes.

28. How does the composition of the renal artery compare with the renal vein?

Comparison of blood between
RENAL ARTERY and **RENAL VEIN**

RENAL ARTERY	RENAL ARTERY
1. High concentration of O2	1. High concentration of CO2
2. Higher concentration of glucose and mineral salts	2. Lower concentration of glucose and mineral salts.
3. Higher concentration of nitrogenous wastes like (urea, uric acid and creatinine)	3. Lower concentration of nitrogenous wastes like (urea, uric acid and creatinine)

29. What is selective reabsorption and where does it happen?

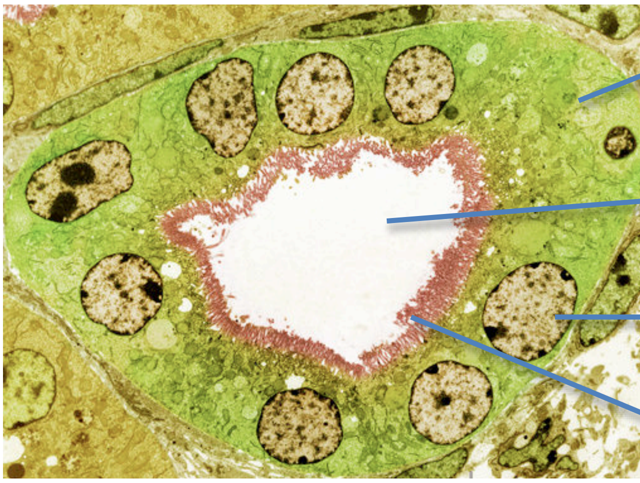
The liquid that passes from the glomerulus into the capsule is called **filtrate**. It contains many useful small molecules. Useful substances like glucose, water and salts are reabsorbed in the proximal convoluted tubules in a process called **selective reabsorption**. The cells lining the proximal convoluted tubule reabsorb about 80% of the filtrate.

30. How does the structure of epithelial cells help reabsorption?

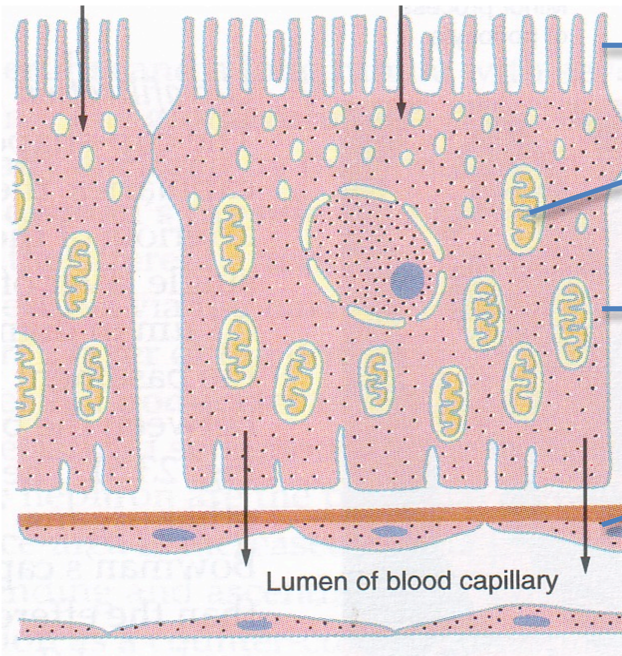
The walls of this tubule are lined with special **epithelial cells** – they have **microvilli** to increase surface area for absorption.

The bottom of these cells is never far from a capillary and is separated by a basement membrane.

Proximal and distal tubules are long and winding to increase surface area. Tubule walls are thin (one cell thick) to make absorption easier.



The brush border of microvilli greatly increases the surface area of the epithelial cells for absorption. These cells have lots of mitochondria to provide energy for active transport. Cells are in close contact with capillaries.



31. How are active transport and osmosis involved in reabsorption?

Proteins in the membrane act as pumps to carry out active transport. Glucose and amino acids are reabsorbed in this way, along with most of the salts.

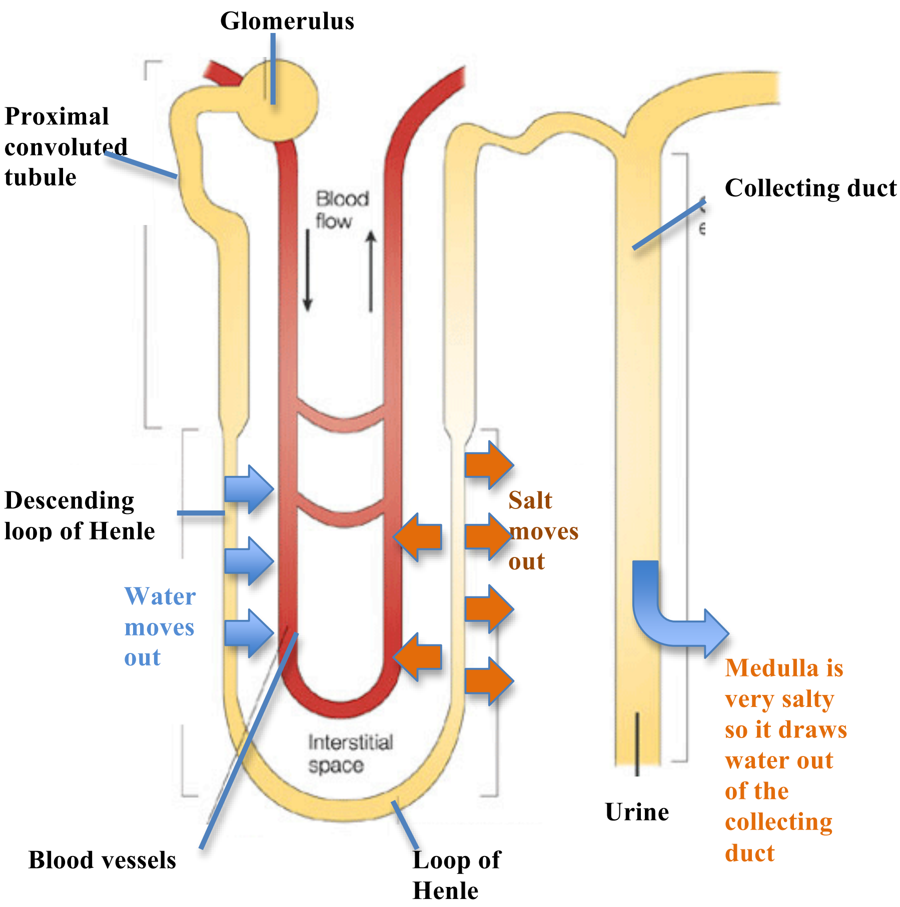
Because the salt concentration increases inside the cell, water is drawn in by osmosis. The nutrients then pass into the capillaries.

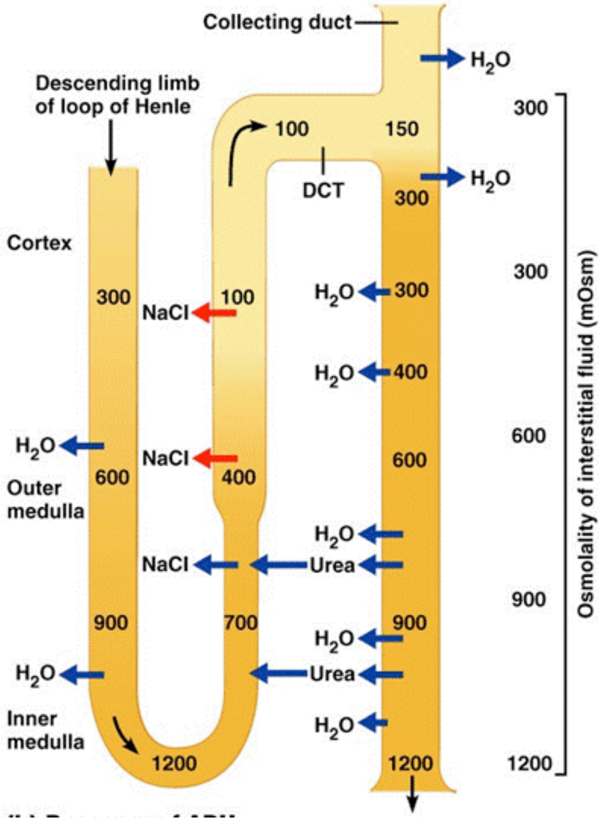
32. How do the loop of Henle, medulla and collecting duct maintain the water balance of the blood?

Filtrate that leaves the proximal convoluted tubule has most of the useful substances reabsorbed but still too much water to lose from the body. It passes into the descending arm of the loop of Henle. The walls of this tube are permeable to water but not to salt. Some water leaves the tube here.

Next, the filtrate moves up the ascending arm of the loop of Henle, which is permeable to salt, but not to water. Salt is actively pumped out of ascending limb into surrounding tissue fluid. This creates a salt gradient in the medulla tissue (high salt at the base).

This salt gradient pulls water out of the descending limb by osmosis and the water is removed by capillaries. By the time filtrate reaches the collecting duct it still has too much water in it so more water is removed by osmosis as it passes down this duct. The salt gradient draws water out of the urine collecting duct as it passes down through the medulla.





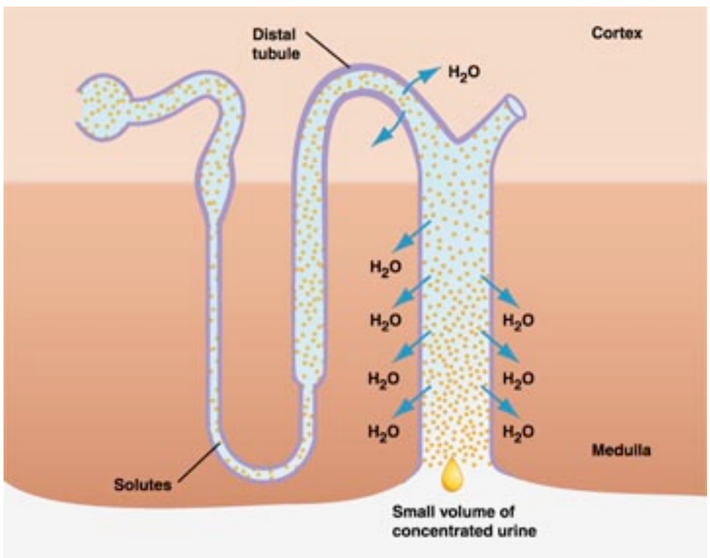
33. How does ADH maintain water balance?

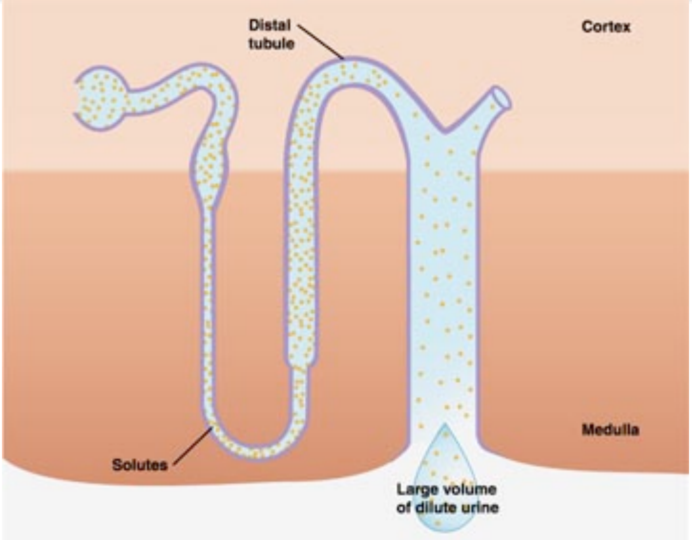
The diagram above shows lots of water being reabsorbed from the collecting duct, but this depends on how much water is in the body at the time. We can control the amount of water saved here by making the walls of this duct more or less permeable to water.

The permeability depends on the concentration of **ADH** (**antidiuretic hormone**). ADH is secreted by the posterior pituitary, travels in the bloodstream and targets the tissues of the collecting ducts.

When ADH is present the collecting ducts become permeable to water and water moves out of the collecting ducts and into the bloodstream and urine will be highly concentrated.

If ADH levels are low the collecting ducts remain impermeable to water and it stays in the collecting ducts and urine will be more dilute.





34. Why is there glucose in the urine of diabetics?

The reabsorption of glucose from the filtrate requires ATP, and there is a limit to the amount of energy available so there is a limit to the amount of glucose that can be reabsorbed (renal threshold) – usually it all is.

Diabetics have very high levels of blood and filtrate glucose so some passes into their urine.

35. How do the concentrations of substances differ between blood plasma, glomerular filtrate and urine?

When **blood plasma** enters the kidney via the renal artery it has a high concentration of oxygen and urea, salt and water content is more than required. When blood plasma leaves the kidney via the renal vein it contains carbon dioxide, a more optimal amount water and salt, the same amount of protein and glucose it entered with and very little urea.

The **glomerular filtrate** in the Bowman's capsule has a similar concentration of glucose and urea as that of the blood plasma however it does not contain the large proteins; these have been blocked by the basement membrane and prevented from entering the filtrate.

Urine contains less water, no proteins, no glucose and less salt then both the blood plasma and the glomerular filtrate. However it does contain a lot more urea then the glomerular filtrate.

Molecule	Amount in blood plasma in mg 100 ml^{-1}	Amount in glomerular filtrate in mg 100 ml^{-1}	Amount in urine in mg 100 ml^{-1}
Proteins	>700	0	0
Glucose	>90	>90	0
Urea	30	30	>1800

36. What is overhydration?

Relatively uncommon but can be due to excessive water intake without solutes after exercise.

Symptoms are cell swelling due to osmotic effect and headaches and reduced nerve function.

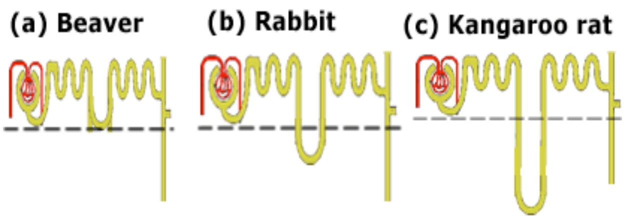
37. What is dehydration?

Dehydration is a lack of water and can be due to exercise, too little water intake, etc. Symptoms are darkened urine and tiredness/lethargy due to waste build up in tissues – too little water to remove.

Blood pressure can fall due to low blood volume, leading to increased heart rate. Body temperature can increase due to reduced sweating.

38. How does the loop of Henle match the environment in animals are found?

The longer the loop of Henle, the more water will be saved. Desert or dry-adapted animals will have very long loop of Henle.

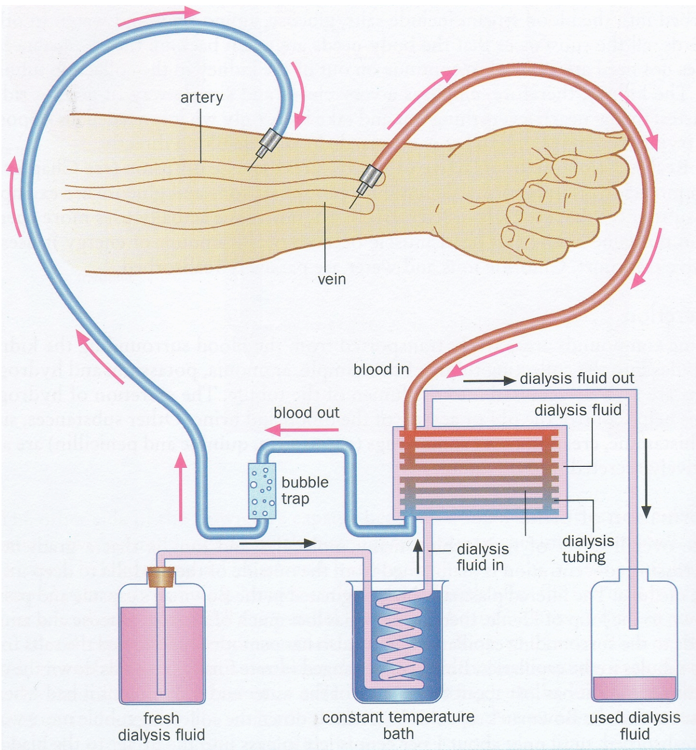


39. How do we treat kidney failure?

1. Kidney dialysis

This is the process of removing waste and excess fluid from the blood using an artificial kidney machine that filters or washes the blood. Blood is collected from a vein in the arm and passes along a tube that is semi-permeable.

The dialysis solution on the other side of the tube has no urea so urea passes out of the blood. Treatment is required three times a week, each lasting about five hours.



2. Kidney transplantation

A kidney transplant may be considered if your doctor feels that your general health is good enough to stand up to the operation. You also need drugs to suppress the immune system after surgery. This is needed to stop rejection of the foreign tissue.

A donor kidney can come from a living person (usually a blood relative such as a parent, brother, sister or child). Or, from someone who has died in hospital and permission has been given to use their kidneys. After a transplant the person no longer needs dialysis.

Advantages: You have a normal lifestyle as there is no dialysis. Dialysis takes several hours in hospital three times a week and makes a person very tired. Dialysis machines are expensive.

Disadvantages: A good tissue match is needed for the donor kidney to reduce rejection. It is a very expensive operation. There is a risk of rejection of the donor kidney so immunosuppressant drugs must be taken daily. Some religions do not allow transplants.

40. What is urinalysis?

This is the analysis of urine composition to compare it to normal. It can indicate several abnormal conditions. Glucose presence indicates diabetes.

High protein levels can indicate kidney damage. Using monoclonal antibodies we can test for banned or illegal drugs. The presence of white blood cells can indicate a urinary infection. Red blood cells can indicate a kidney stone or tumour.