Edexcel GCSE Biology

Your notes

Animal Hormones

Contents

- The Endocrine System
- Adrenaline
- Thyroxine
- Hormones & the Menstrual Cycle
- Contraception
- Hormones & Assisted Reproductive Technology

Your notes

The Endocrine System

- The endocrine system is made up of **endocrine glands** that release **chemical substances,** known as **hormones,** into the **blood** stream
  - A gland is a group of cells that produces and releases one or more substances (a process known as secretion)
- Compared to the **nervous system** the effects of hormones are **slower** but they act for **longer, so** the endocrine system is used to control functions that **do not need instant responses**

Structures that make up the endocrine system

- Important structures in the endocrine system are:
  - **Pituitary gland**: a 'master gland' that makes hormones such as **FSH** and **LH**
  - **Thyroid**: produces thyroxine, which controls metabolic rates and affects growth
  - **Pancreas**: produces **insulin**, which regulates blood glucose levels
  - **Adrenal glands**: produces **adrenaline**
  - **Testes** (males): produce **testosterone**
  - **Ovaries** (females): produce **oestrogen**

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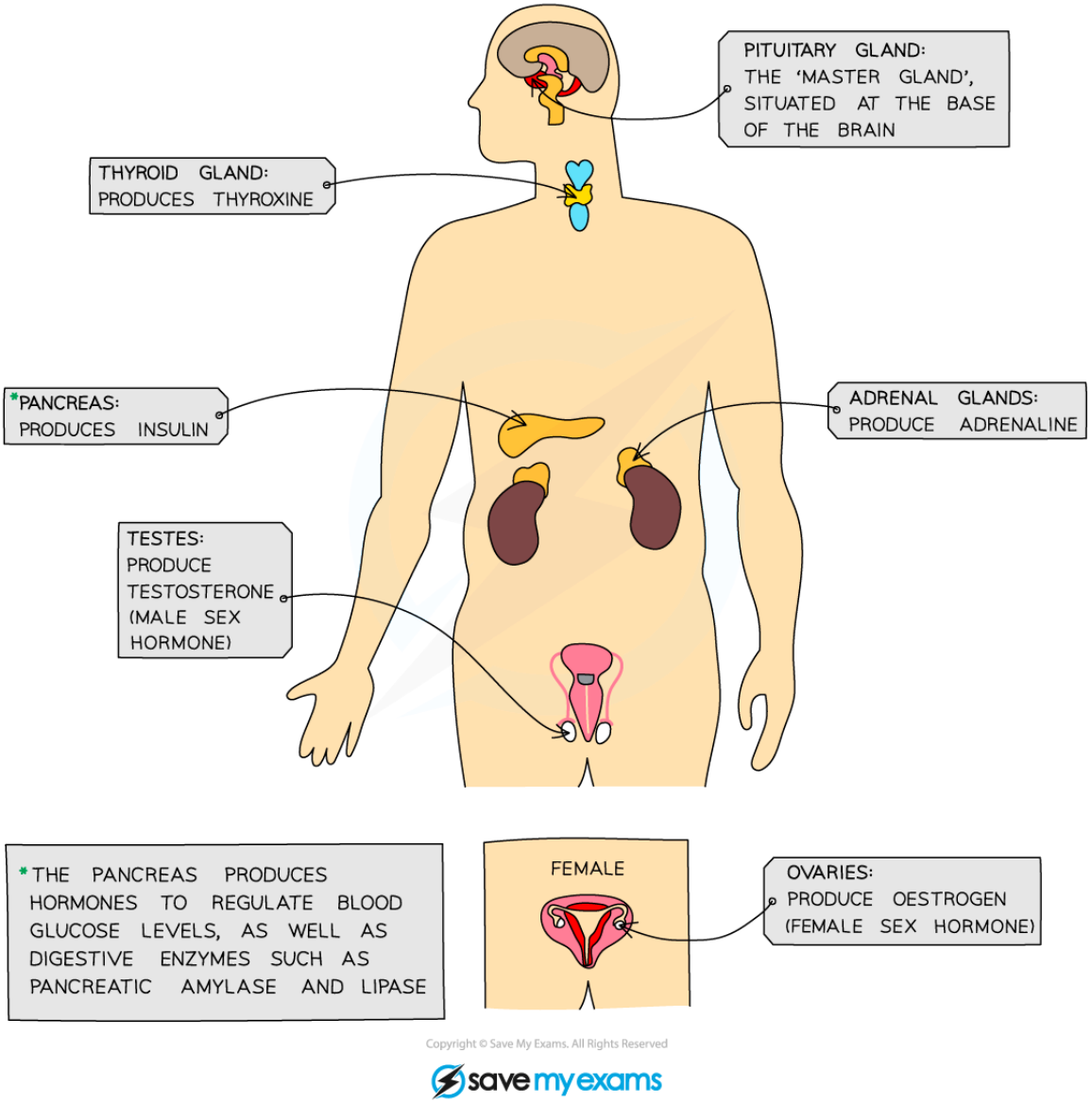

The major endocrine glands of the body. These glands secrete hormones that circulate around the body in the bloodstream.

Examiner Tips and Tricks

Make sure you can recognise and recall all the structures shown in the diagram above. Although you will not be expected to recall the thyroid gland and the role of thyroxine in the body, this endocrine gland may be referred to in an exam question that asks more generally about the endocrine system or hormones, so it is worth being aware of!

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Hormones

- A **hormone** is a chemical substance produced by a **gland**
- Hormones are carried by the **blood** and can therefore circulate around the whole body
  - They are chemicals that transmit information from one part of the organism to another and bring about a **change (they provide a signal that triggers a response)**
- They alter the activity of specific **target cells, tissues or organs**
- The following hormones are of great importance in humans:
  - **Adrenaline**
  - **Insulin**
  - **Testosterone**
  - **Progesterone**
  - **Oestrogen**

Adrenaline and how it prepares the body for action

- Adrenaline is known as the **'fight or flight'** hormone as it is produced in situations where the body may be in **danger**
- It causes a **range of different things** to happen in the body, all designed to **prepare it for movement** (i.e. fight or flight).
- These include:
  - An **increase in heart rate and breathing rate** - ensures **glucose** and **oxygen** can be delivered to **muscle cells** (and carbon dioxide can be taken away from muscles cells) at a **faster rate**
  - **Diverting blood flow towards muscles** and away from non-essential parts of the body such as the alimentary canal - ensures an **increased supply of the reactants of respiration** (glucose and oxygen)
  - **Dilation of the blood vessels inside muscles** - ensures **more blood** can circulate through them (again, supplying **more glucose and oxygen**)
  - **Breaking down of stored glycogen to glucose** in the liver and muscle cells, with glucose released by the liver being transported to active muscle cells - ensures a **higher blood glucose**

concentration for **increased respiration** in muscle cells (providing **greater energy for movement**)


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Insulin and how it controls blood sugar

- Blood glucose concentration must be kept within a **narrow range**, so it's another example of **homeostasis** (like the control of core body temperature)
  - **Too high** a level of glucose in the blood can lead to cells of the body losing water by osmosis, which can be dangerous
  - **Too low** a level of glucose in the blood can lead to the brain receiving insufficient glucose for **respiration**, potentially leading to a coma or even death
- The **pancreas** and **liver** work together to **control blood glucose levels**
- To carry out this role, the pancreas acts as an **endocrine gland** (making and secreting **hormones** into the **bloodstream**), although it does also plays a vital (but separate) role in digestion (making and secreting enzymes into the digestive system)
- **If the blood glucose concentration gets too high:**
  - Cells in the pancreas detect the increased blood glucose levels
  - The pancreas produces the hormone **insulin**, secreting it into the blood
  - Insulin stimulates **muscles** and the **liver** to **take up glucose** from the bloodstream and **store it as glycogen** (a polymer of glucose)
  - This **reduces** the concentration of glucose in the blood back to normal levels, at which point the pancreas stops secreting insulin
- **If the blood glucose concentration gets too low:**
  - Cells in the pancreas detect the decreased blood glucose levels
  - The pancreas produces the hormone **glucagon**
  - Glucagon causes the **glycogen** stored in the **liver** to be **converted into glucose** and released into the blood
  - This **increases** the concentration of glucose in the blood back to normal levels, at which point the pancreas stops secreting glucagon

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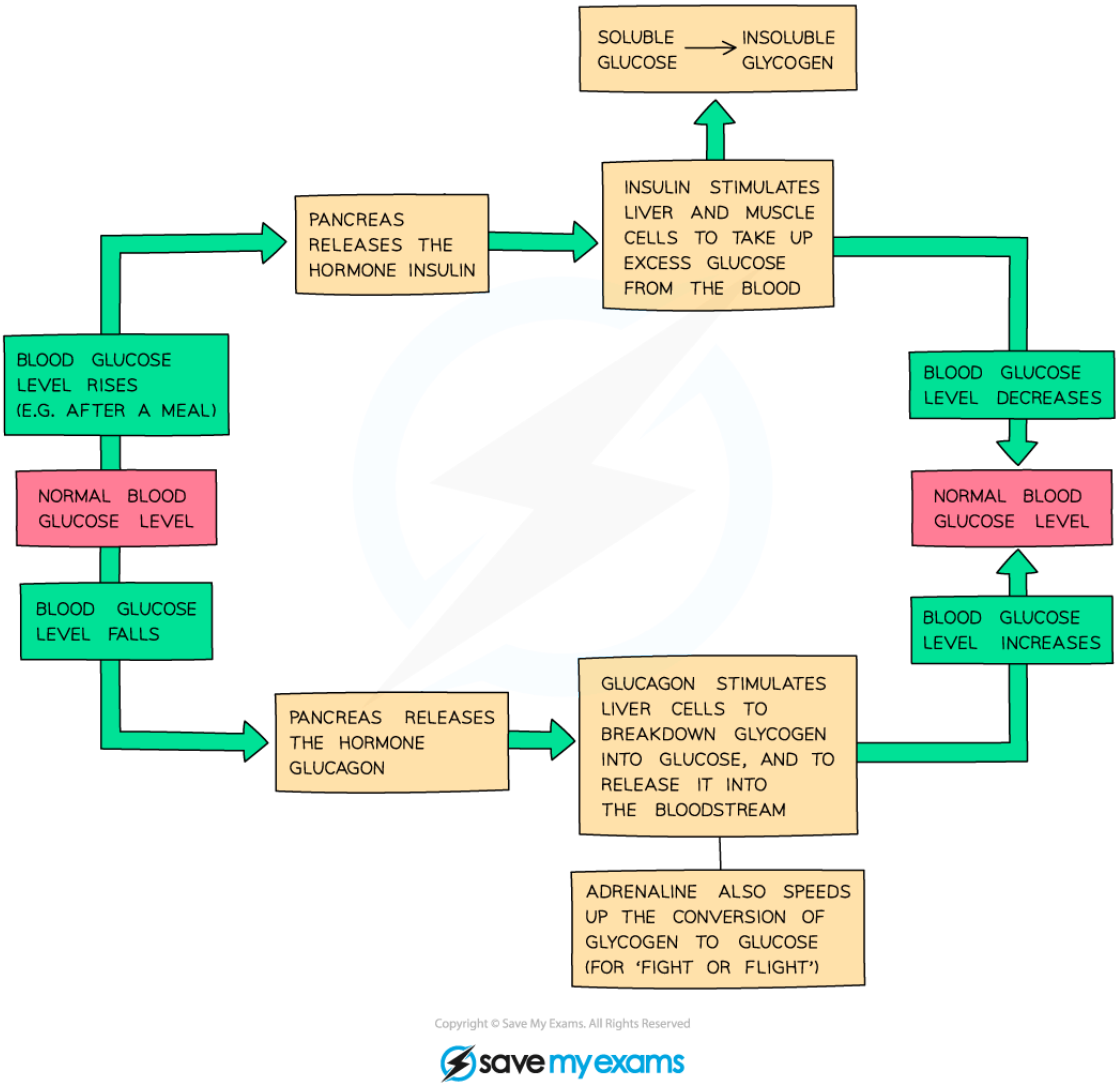

The regulation of blood glucose levels

Testosterone

- Testosterone is produced in the male testes
- It is responsible for the development of secondary sexual characteristics in males

Progesterone

- Progesterone is produced in the female ovaries

- It is responsible for maintaining the uterine lining during pregnancy

Oestrogen

- Oestrogen is produced by the female ovaries
- It is responsible for the development of secondary sexual characteristics in females and regulating the menstrual cycle

Important Hormones in the Body Table

Hormone	Source	Role	Effect
Adrenaline	Adrenal gland	Readies the body for a 'flight or flight' response	Increases heart and breathing rate
Insulin	Pancreas	Lowers blood glucose levels	Causes excess glucose in the blood to be taken up by the muscles and liver and converted into glycogen for storage
Testosterone	Testes	Main sex hormone in males	Development of secondary sexual characteristics in males
Progesterone	Ovaries	Maintains pregnancy	Maintains the uterus lining to cushion fertilized egg and allow it to develop
Oestrogen	Ovaries	Main sex hormone in females	Development of secondary sexual characteristics in females and controls menstrual cycle

Examiner Tips and Tricks

It is worth learning this list of effects of adrenaline on the body as it is a fairly common exam question and can be worth several easy marks.Also, be careful when answering questions on the control of blood glucose levels - the terms glucagon and glycogen are very often mixed up by students as they sound similar.

- Glucagon is a **hormone**

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- Glycogen is a **polysaccharide** (i.e. the polymer of glucose that acts as a glucose storage molecule)

Learn the differences between the spellings and what each one does so you don't get confused in the exam!


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Adrenaline

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Adrenaline

Higher tier only

- Adrenaline is known as the fight or flight hormone as it is **produced in situations where the body may be in danger**
- It causes a range of different things to happen in the body, all designed to prepare it for movement (ie fight or flight).
- These include:
  - **Increasing blood glucose concentration** for **increased respiration in muscle cells**
  - **Increasing heart rate** and **breathing rate** so glucose and oxygen can be **delivered to muscle cells**, and carbon dioxide taken away, from muscles cells **more quickly**
  - **Increased blood pressure**
  - **Diverting blood flow towards muscles** and away from non-essential parts of the body such as the alimentary canal; again to ensure the reactants of respiration are as available as possible
  - **Dilating pupils** to allow as much light as possible to reach the retina so **more information can be sent to the brain**

Examiner Tips and Tricks

It is worth learning this list of effects of adrenaline on the body as it is a fairly common exam question and can be worth several easy marks.

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Thyroxine

Higher tier only

Negative feedback mechanisms

- **Negative feedback** mechanisms in homeostasis help to **maintain conditions** in the body within an optimal narrow range; any movement away from ideal conditions results in changes occurring which bring them back
- This involves detecting that the level of a substance or a condition has gone above or below normal levels, which **triggers** a **response** to bring the level back to normal again
- Thyroxine and control of the basal metabolic rate is an example of negative feedback

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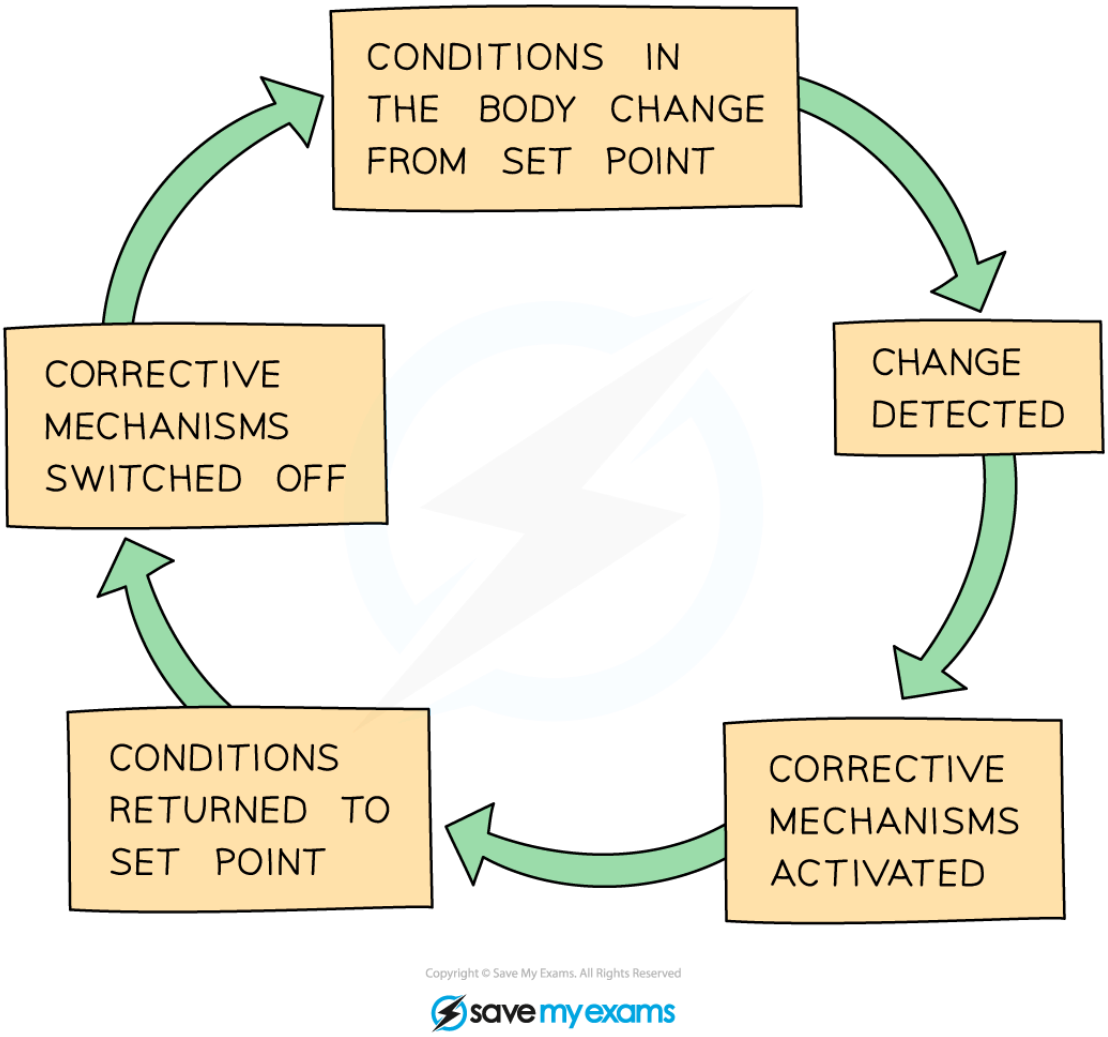

A negative feedback cycle

- Thyroxine is a hormone that is released from the thyroid gland (which is located in the neck)
- **Thyroxine** has a number of important roles in the body
  - It stimulates the **basal metabolic rate (BMR)**; this is the speed at which chemical reactions occur in the body when it is at rest
- Thyroxine levels are also controlled by **negative feedback**; with levels of **TSH** (thyroid-stimulating hormone) released from the pituitary gland responsible for maintaining normal levels in the bloodstream

- If the level of thyroxine is **normal** or **too high**
  - **TRH** production is inhibited in the hypothalamus
  - The release of TSH from the pituitary is therefore also **inhibited**
  - So **less thyroxine is released** from the thyroid gland
- If the level of thyroxine **falls below** a normal level
  - **TRH** is released in the hypothalamus
  - This **increases** the release of TSH from the pituitary gland
  - TSH stimulates the thyroid to **release more thyroxine**

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Conditions of the thyroid

- Two conditions related to the thyroid gland are:
  - **Hyperthyroidism**, caused by an overactive thyroid gland secreting too much thyroxine into the bloodstream which causes an increase in BMR and protein synthesis
  - **Hypothyroidism** caused by an underactive thyroid gland secreting too little thyroxine into the bloodstream which can lead to heart and nerve problems, and death

Examiner Tips and Tricks

You should be able to interpret and explain simple diagrams of negative feedback control in the exam, recognising what happens when a change away from the normal level is detected.

Hormones & the Menstrual Cycle

Your notes

The Menstrual Cycle

- During puberty, reproductive hormones cause **secondary sex characteristics** to develop
- The main male reproductive hormone is **testosterone** which is produced by the testes; testosterone stimulates sperm production
- The main female reproductive hormone is **oestrogen** which is produced by the ovaries
- Oestrogen plays an important role in the menstrual cycle which begins at puberty, as well as causing physical changes to occur in the body (such as breast development)
- During the menstrual cycle, eggs in the ovaries begin to mature and one is released approximately every **28 days** in a process called **ovulation**

Stages of the menstrual cycle

- During the menstrual cycle, the lining of the uterus builds up and ovulation occurs
- The average menstrual cycle is 28 days long and there are four overall stages:

1. **Menstruation** – loss of lining from the uterus, occurs at the start of the cycle if no fertilisation has occurred
2. The **lining** starts to thicken
3. **Ovulation** occurs around the middle of the cycle (about day 14), the egg travels down the oviduct towards the uterus
4. The lining is **maintained** ready to accept a fertilized egg

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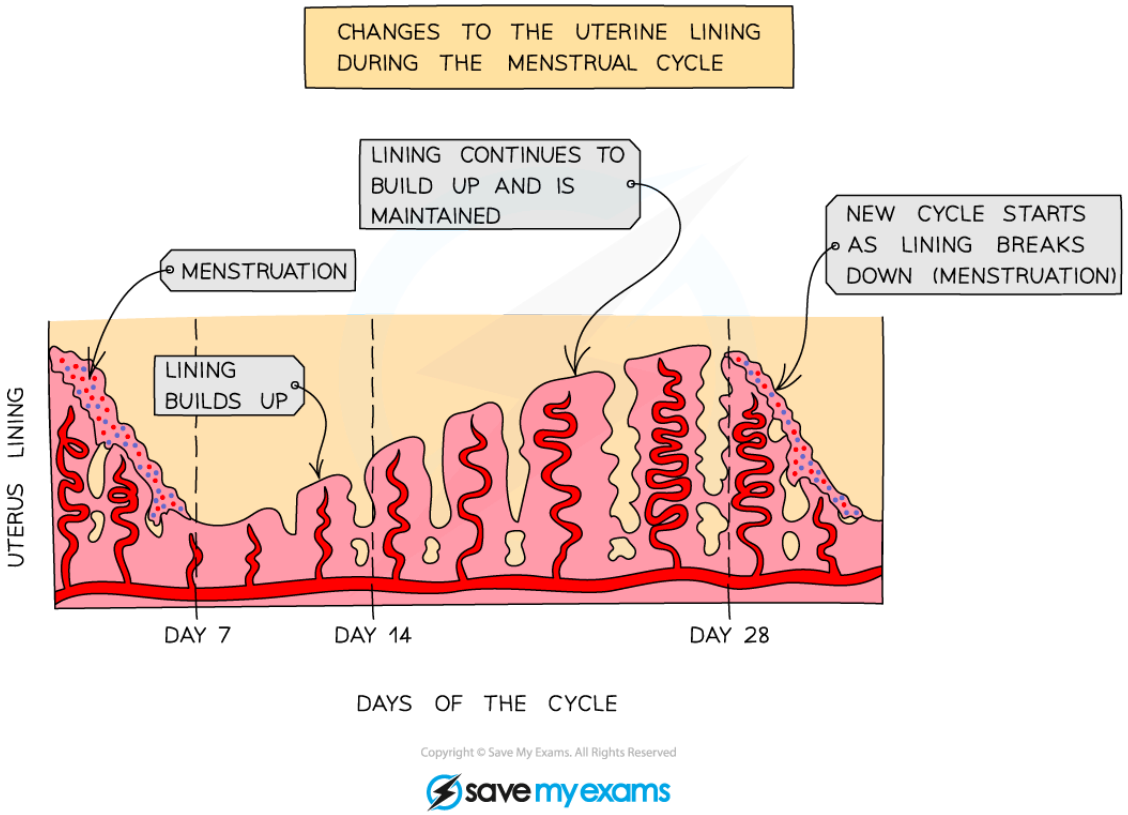

Menstruation occurs at the start of the menstrual cycle, with an egg released around the middle

Hormonal control of the cycle

- **Four** hormones control the events that occur during the menstrual cycle
- Two of these hormones are produced by the pituitary gland in the brain:
  - Follicle-stimulating hormone **(FSH)** causes maturation of an egg in the ovary
  - Luteinising hormone **(LH)** stimulates the release of the egg
- The other two hormones, **oestrogen** and **progesterone** are involved in maintaining the uterus lining with oestrogen being made by the ovaries and progesterone specifically by an empty egg follicle called the corpus luteum

Interacting Hormones in the Menstrual Cycle

Higher tier only

- The pituitary gland produces **FSH** which stimulates the development of a **follicle** in the ovary
- An egg matures inside the follicle and the follicle produces the hormone **oestrogen** – so FSH stimulates the production of oestrogen
- Oestrogen causes **growth and repair of the lining of the uterus wall** and inhibits the production of **FSH**
- When **oestrogen** rises to a high enough level it stimulates the release of **LH** from the pituitary gland which causes **ovulation** (usually around day 14 of the cycle)
- The follicle becomes a **corpus luteum** and starts producing **progesterone**
- Progesterone **maintains the uterus lining** (the thickness of the uterus wall)
- If the egg is not fertilised, the corpus luteum breaks down and progesterone levels drop
- This causes **menstruation** – commonly known as having a period
- If fertilisation does occur the corpus luteum **continues to produce progesterone**, preventing the uterus lining from breaking down (breakdown of the lining would **prevent** a pregnancy)
- Once the **placenta** has developed, it starts secreting progesterone and **continues to do so throughout the pregnancy** to maintain the lining


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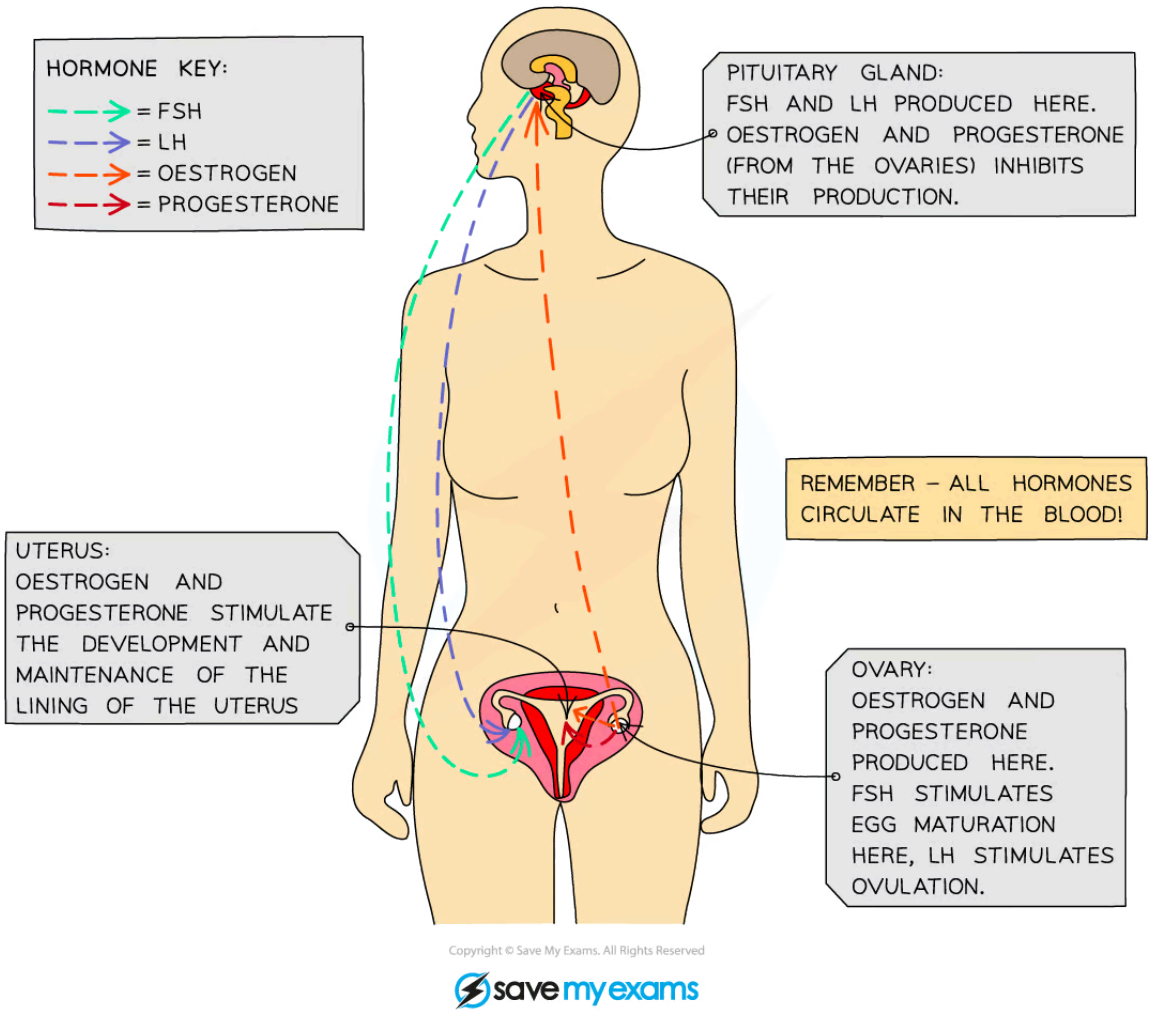

Remember that hormones travel around the body in the bloodstream but only have an effect on a target organ

Hormone level graphs

- You need to be able to extract and interpret data from graphs showing hormone levels during the menstrual cycle:

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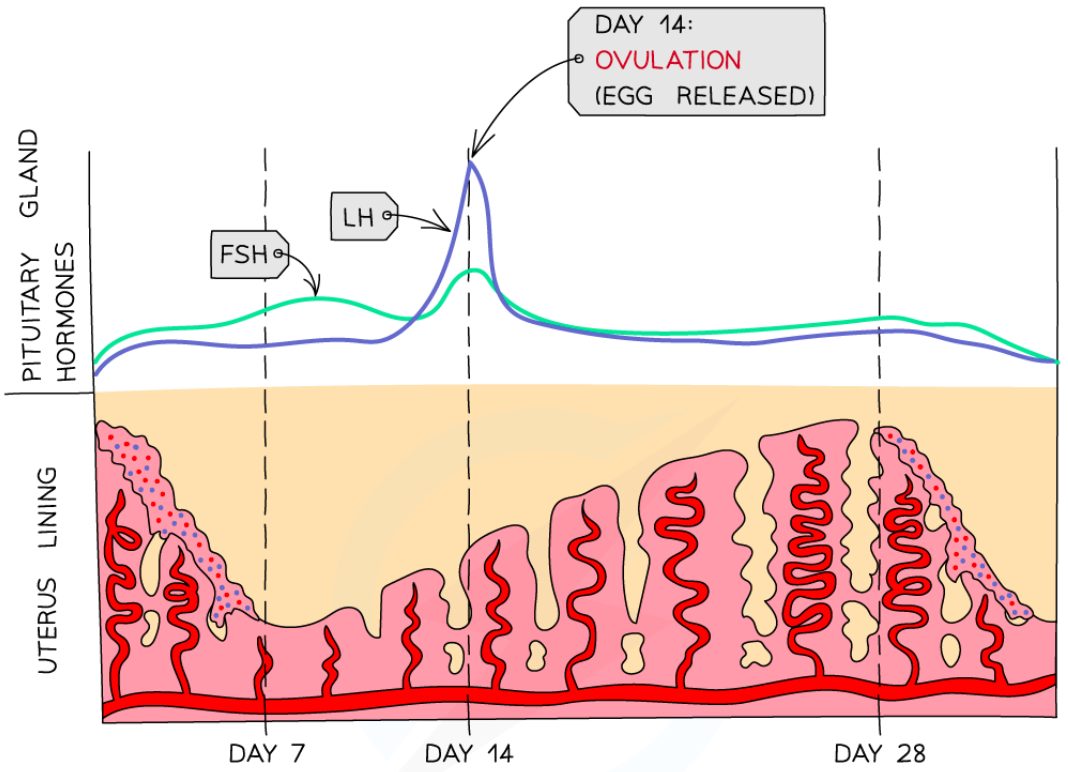

FSH	– STIMULATES EGG MATURATION IN THE FOLLICLES OF THE OVARY – STIMULATES FOLLICLES IN THE OVARIES TO SECRETE OESTROGEN
LH	– AT ITS PEAK STIMULATES OVULATION (RELEASE OF EGG INTO OVIDUCT) – RESULTS IN THE FORMATION OF A CORPUS LUTEUM

Changes in the levels of the pituitary hormones FSH and LH in the blood during the menstrual cycle

- **FSH** (**f**ollicle-**s**timulating **h**ormone) is released by the **pituitary gland** and causes an **egg to start maturing** in the ovary

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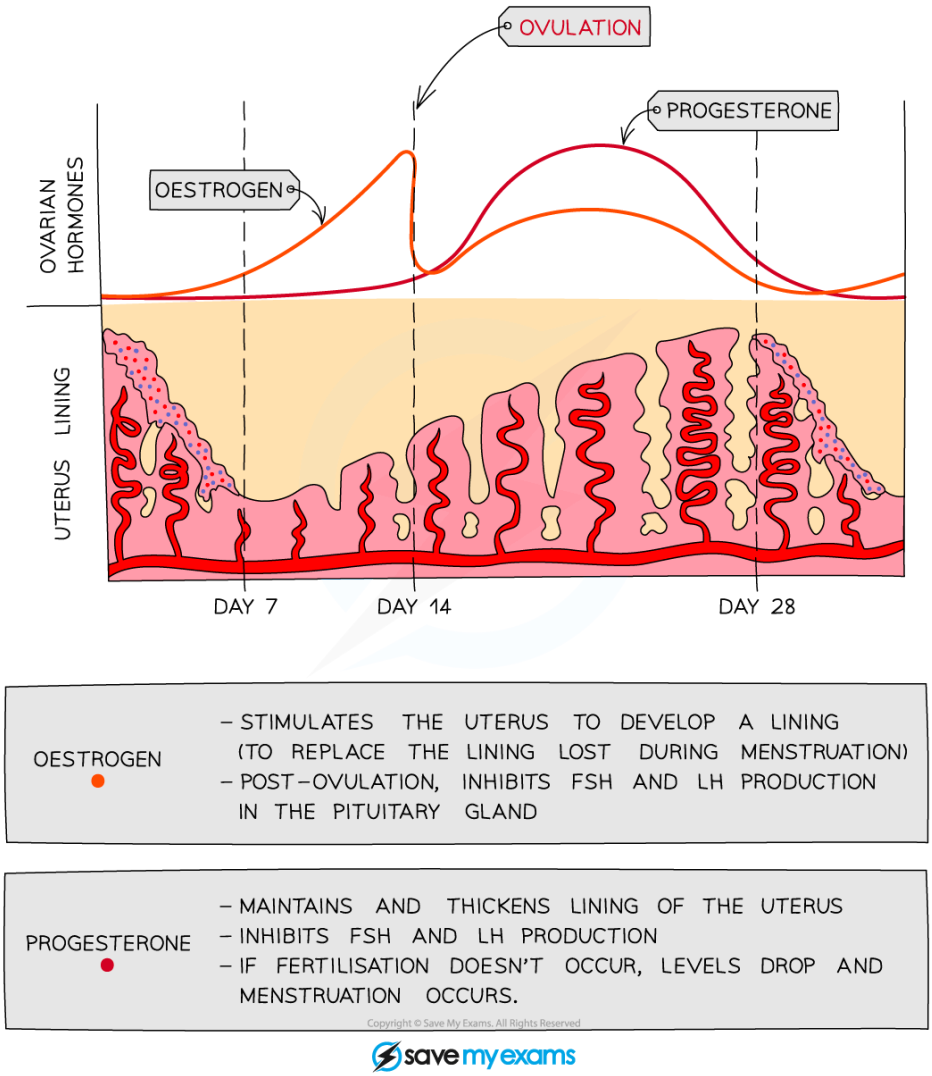
- It also **stimulates the ovaries** to start releasing **oestrogen**
- **LH** (**l**uteinising **h**ormone) is released from the **pituitary gland**
  - This is stimulated when **oestrogen** levels have reached their peak
  - LH causes **ovulation to occur** and also **stimulates the ovary** to produce **progesterone**



Changes in the levels of oestrogen and progesterone in the blood during the menstrual cycle

- **Oestrogen** levels rise from day 1 to **peak** just before day **14**
  - This causes the **uterine** wall to start **thickening** and the egg to mature

- The peak in oestrogen occurs just before the egg is released

- **Progesterone** stays low from day 1 - 14 and starts to **rise after ovulation**
  - The increasing levels cause the uterine lining to thicken further; a **fall** in **progesterone** levels causes the uterine lining to break down (**menstruation**)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Contraception

- Birth control methods are important in **keeping family sizes small** and in **limiting the increase in human population**
- Humans can use mechanical, chemical, surgical and natural contraceptive methods to prevent a pregnancy
- Some birth control methods also give protection from **sexually transmitted infections**

Natural

- **Abstinence**
  - Avoiding sexual intercourse completely
- **Rhythm method**
  - Avoiding sexual intercourse during the fertile period of the menstrual cycle when ovulation occurs
  - The exact time ovulation happens can be worked out by monitoring body temperature and quality of cervical mucus
  - **This is the least reliable method of birth control and is, instead, a better method used to determine the best time to conceive rather than a method of contraception**

Chemical

- **IUD / IUS**
  - An intrauterine device or intrauterine system is a small device fitted inside the uterus by a doctor or nurse
  - It releases sex hormones which thicken the mucus produced in the cervix, making it difficult for sperm to swim into the uterus
  - It also thins the lining of the uterus, making it more difficult for a fertilised egg to implant
  - An IUD also interferes with passage of sperm through the uterus, in which way it is acting as a barrier method of birth control
- **Contraceptive pill, implant, injection**
  - May contain just progesterone or a mixture of progesterone and oestrogen
  - Very effective when taken regularly

- The hormones can also be delivered from a small skin implant or an injection, both of which last several months and increase the effectiveness as they remove the risk of forgetting to take a pill regularly
- They work by mimicking some of the hormone levels during pregnancy
- By raising the levels of progesterone and oestrogen, the uterus lining is maintained and development of another egg cell is prevented
- This means that sex at any time of the month cannot cause pregnancy as no egg is released to be fertilised


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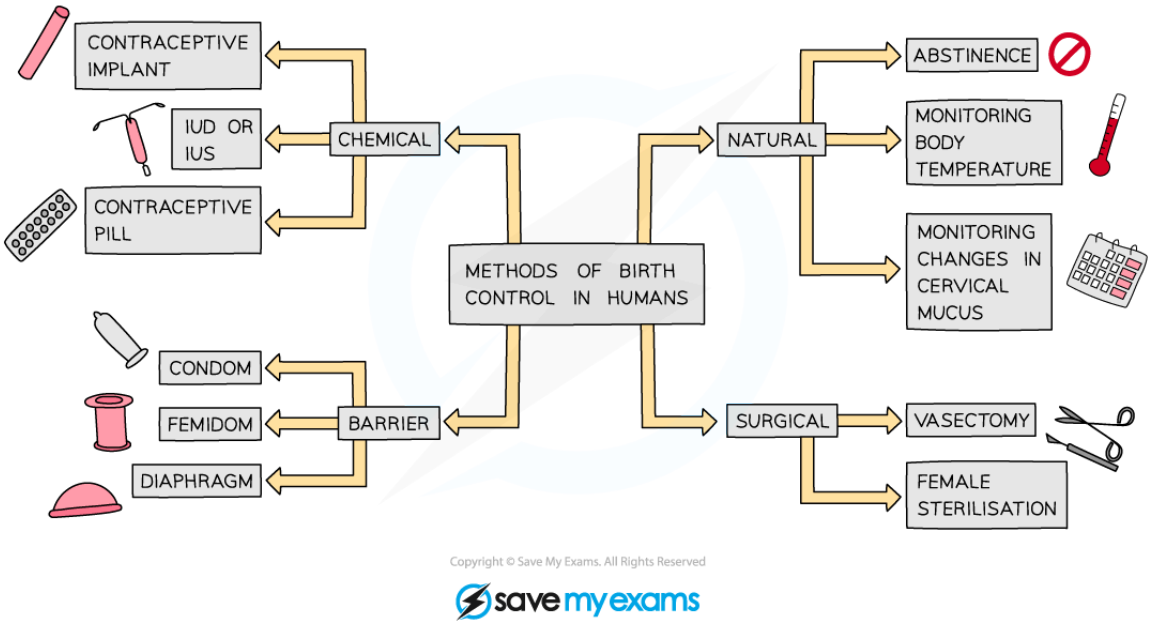
Barrier

These all work by preventing sperm from reaching the egg

- **Condom**
  - Latex sheath worn over the penis
  - Prevents sperm entering the vagina as ejaculate remains in condom
  - Also protects against STIs
- **Femidom**
  - Latex sheath inserted into the vagina
  - Prevents entry of sperm into the vagina
- **Diaphragm**
  - A rubber cap that fits over the entrance to the cervix
  - Prevents entry of sperm into uterus
  - Often used with a spermicide (cream which kills sperm)

Surgical

- **Vasectomy**
  - The sperm ducts are cut, meaning that no sperm is present in the semen when ejaculation occurs
  - Very effective but difficult to reverse
- **Female sterilisation (tubal ligation)**
  - The oviducts are cut or tied off, preventing eggs from reaching the uterus or sperm from reaching the eggs
  - Very effective but difficult to reverse



Types of birth control

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Hormones & Assisted Reproductive Technology

Higher tier only

- Infertility occurs when a couple find it difficult or are unable to conceive naturally
- This can be a result of insufficient or too low levels of reproductive hormones affecting the development of egg and sperm cells, or as a result of issues with the reproductive system of the female

Clomifene therapy

- Artificial hormones are used as part of modern reproductive technologies to treat infertility, particularly when the female is not producing enough eggs, or they are not producing them on regular basis
  - This is usually as a result of the pituitary gland not producing sufficient FSH to cause egg maturation
- The drug **clomifene** can be given to women to stimulate egg maturation and ovulaton
- It does this by **causing more of the hormones FSH and LH to be released**
- An important social issue to consider with this is that several eggs can be released at once so this increases the chance of multiple births (twins or triplets etc)
- It also doesn't have a particularly high success rate and can be expensive

IVF treatment

- An alternative treatment is for eggs to be fertilised by sperm outside of the body ('***in vitro***' means 'in glass') – this is used particularly when there are issues with both male and female fertility
- The process involves:
  - Giving a mother FSH and LH to stimulate the maturation of several eggs
  - The eggs are collected from the mother and fertilised by sperm from the father in the laboratory
  - The fertilised eggs develop into embryos
  - At the stage when they are tiny balls of cells, one or two embryos are inserted into the mother's uterus (womb)
- The success rate of IVF is low (~30%) but there have been many improvements and advancements in medical technologies which are helping to increase the success rate

- These advancements include improvements in microscope techniques and micro-tools that enable single cells to be removed from an embryo for genetic testing to identify if the embryo is healthy or has genetic defaults the couple might want to consider
- IVF is an example of **ART** (Assisted reproductive technology) as it is a fertility treatment that occurs (initially) **outside of the body**


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Issues with fertility treatments

- Fertility treatments can give a couple the chance to have a baby of their own, which is a big positive
- Potential issues to consider include:
  - As several embryos are implanted, the risk of **multiple births** is quite high (which increases the risk of miscarriage or stillbirths)
  - The **success rate** is not very high (although it is increasing); IVF treatment failures can be very emotionally upsetting and physically stressful for couples
  - Some women use IVF to get pregnant at a **later age** than they would be able to conceive naturally
  - Some people are against IVF as more embryos can be produced than are used; the issue of who owns these embryos and whether they are used in **research** before eventually being destroyed is contentious (as embryos are a potential life)
  - The use of **genetic testing** is controversial as there is potential it could be misused in choosing characteristics of offspring (this is not allowed)

Examiner Tips and Tricks

You may have to evaluate methods used to treat infertility from the perspective of patients and doctors – they may have different views.