DP IB Biology: HL

Your notes

6.6 Hormones, Homeostasis & Reproduction

Contents

Your notes

6.6.1 Hormones

Insulin & Glucagon

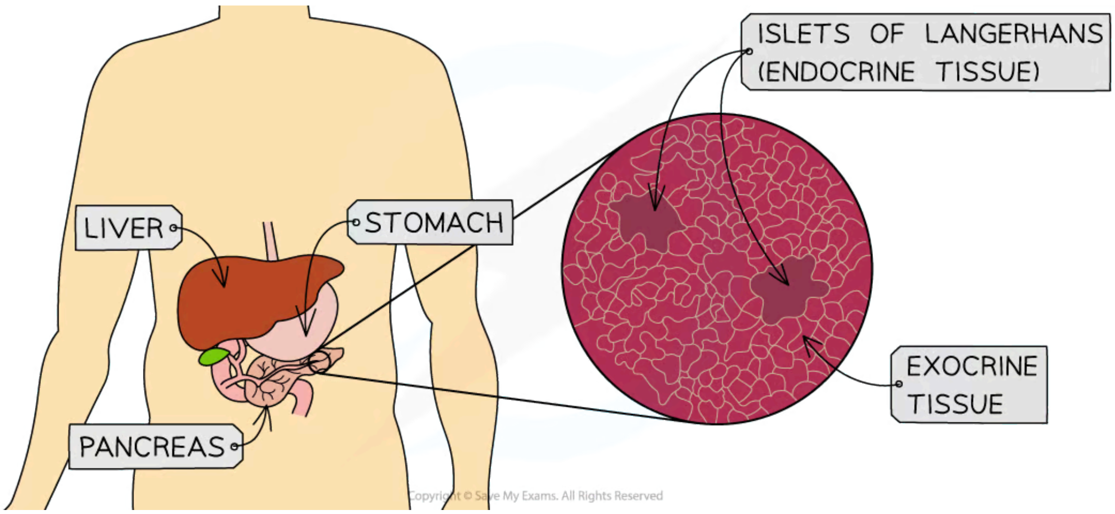
Introduction to Hormones

- A **hormone** is a chemical substance produced by an **endocrine gland** and **carried by the blood**
  - The endocrine glands that produce hormones in animals are known collectively as the **endocrine system**
  - A **gland** is a group of cells that produces and releases one or more substances (a process known as secretion)
- Hormones are **chemicals** which transmit information from one part of the organism to another and that bring about a **change**
- They alter the activity of one or more **specific target organs**
  - Hormones only affect cells with **receptors** that the hormone can bind to
  - These are either found on the cell surface membrane, or inside cells
  - Receptors have to be **complementary** to hormones for there to be an effect
- Hormones are used to control functions that **do not need instant responses**

Insulin and Glucagon

- The pancreas is an organ found in the abdomen of mammals
- It functions as both an **endocrine gland** and an **exocrine gland**
  - Endocrine glands secrete hormones **directly** into the blood, whereas exocrine glands secrete substance **via a duct**
  - The **exocrine** function of the pancreas is to **produce digestive enzymes** to be delivered to the small intestine
  - The **endocrine** function of the pancreas is to **produce the hormones glucagon and insulin**

- Within the pancreas, these two functions are performed by **different tissues**
  - Most of the cells of the pancreas secrete digestive enzymes, but throughout the organ, there are small sections of cells known as the **islets of Langerhans** that produce hormones
  - The islets of Langerhans contain **two** cell types: **alpha cells** (α cells), which secrete **glucagon**, and **beta cells** (β cells), which secrete **insulin**



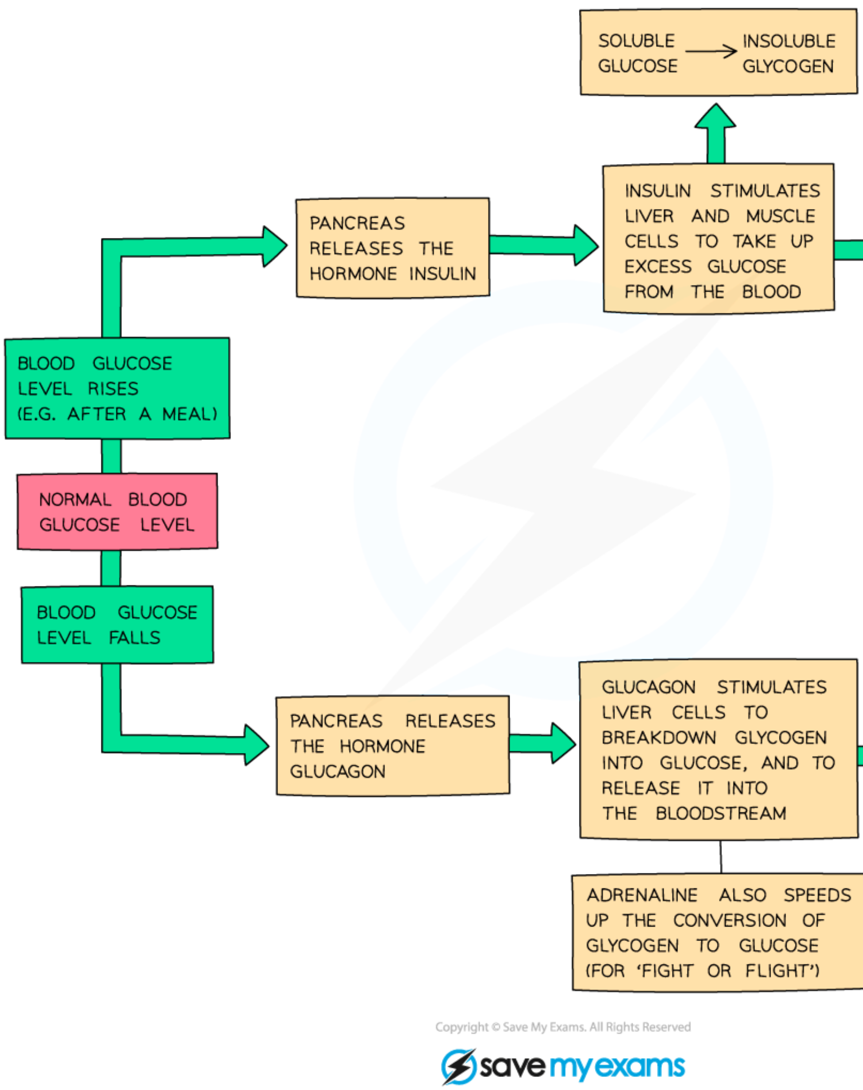
The location and structure of the pancreas

Your notes

The control of blood glucose by glucagon and insulin

- If the concentration of glucose in the blood **decreases** below a certain level, cells may not have enough glucose for **respiration** and so may not be able to function normally
- If the concentration of glucose in the blood **increases** above a certain level, this can also **disrupt the normal function of cells**, potentially causing major problems
- The control of blood glucose concentration is a key part of **homeostasis**
- Blood glucose concentration is controlled by **glucagon** and **insulin**:
  - **Glucagon** is synthesised and secreted by **α cells** when **blood glucose falls** and stimulates liver and muscle cells to **convert stored glycogen** into **glucose** to be released into the blood, **increasing blood glucose concentration**
  - **Insulin** is synthesised and secreted by **β cells** when **blood glucose rises** and stimulates liver and muscle cells to **convert excess glucose into glycogen** to be stored, **decreasing blood glucose concentration**

Your notes



Control of blood glucose levels

Examiner Tip

The terms glucagon and glycogen are very often mixed up by students as they sound similar. Remember:

- Glucagon is the **hormone**
- Glycogen is the **polysaccharide** that **glucose is stored as**

Learn the differences between the spellings and what each one does so you do not get confused in the exam!

Your notes

Diabetes

- There are over 3 million people suffering from diabetes in the UK
- Diabetes is a condition in which the homeostatic control of blood glucose has failed or deteriorated
- In individuals with diabetes their **insulin function is disrupted** which allows the **glucose concentration in the blood to rise**
- An elevated blood glucose level can lead to noticeable symptoms, some of which are harmful, e.g.
  - The kidneys are unable to filter out this excess glucose in the blood and so it is often present in the **urine**
  - The increased glucose concentration also causes the kidneys to produce large quantities of urine, making the individual feel thirsty due to **dehydration**
  - Continuously elevated blood glucose levels can also damage tissues, in particular their proteins
- There are two different types of diabetes: **type I** and **type II**

Type I diabetes

- **Type 1 diabetes** is a condition in which the pancreas fails to produce sufficient insulin to control blood glucose levels
- It normally begins in childhood due to an **autoimmune response** whereby the body's immune system **attacks the β cells** of the islets of Langerhans in the pancreas
  - The β cells **produce** and **release insulin**
- Insulin causes the cells to take up glucose from the blood for **respiration** and for storage as **glycogen**; without insulin the glucose remains in the blood, resulting in an individual feeling **fatigued**
- If the blood glucose concentration reaches a dangerously high level after a meal then **organ damage** can occur
- Type 1 diabetes is normally treated with regular blood tests to check glucose levels, **insulin injections** and a diabetes appropriate **diet**
  - Health authorities encourage type I diabetics to eat a similar diet to the general public. They suggest five portions of fruit and veg a day, minimally processed food and consuming more polysaccharides than monosaccharides or disaccharides
- The insulin used by diabetics can be **fast-acting** or **slow-acting**; each allowing for a different level of control

Type II diabetes

- Type II diabetes is more common than type I
- It usually develops in those **aged 40 and over,** however more and more young people are developing the condition
- In type II diabetes the pancreas still produces insulin but the receptors have reduced in number or no longer respond to it
- The lack of response to insulin means there is a **reduced glucose uptake** by the cells, which leads to a **high blood glucose concentration**
  - This can cause the **β cells** to produce more and more insulin in the attempt to lower blood glucose levels

Your notes

- Eventually the β cells can no longer produce enough insulin and blood sugar becomes uncontrollable
- For type II diabetes treatment involves a **sugar and fat controlled diet** and an **exercise regime**
    - Any food that is rapidly digested into sugar will cause a sudden, dangerous spike in blood sugar
- **Obesity** is a major risk factor for type II diabetes

Type I Diabetes and Type II Diabetes Table

	Type 1	Type 2
Cause	Inability of pancreas to produce insulin	Cells of the body become resistant to insulin or insufficient insulin produced by the pancreas
Treatment	Monitoring blood glucose levels and injecting human insulin throughout the day (particularly after meals consumed)	Maintain a low-carbohydrate diet and regular exercise to reduce need for insulin

Thyroxin

Your notes

- **Thyroxin** is a **hormone** that is released from the **thyroid gland,** located in the neck
- Thyroxin's main role is to **regulate** the **basal metabolic rate** (BMR); this is the speed at which **metabolic reactions occur** in the body when it is at rest
  - Thyroxin therefore **targets almost all cells in the body,** as all cells metabolise
  - However, the most metabolically active cells, such as those of the **liver**, **muscle** and **brain**, are most affected
- Thyroxin plays a role in regulating body temperature
  - If the body becomes **cooler**, this triggers **increased thyroxin secretion** by the thyroid gland
  - The increase in thyroxin **increases the metabolic rate**, which **increases the generation of body heat**
  - This causes **body temperature** to **rise**
- Thyroxin **deficiency,** caused by a condition known as **hypothyroidism,** has the following effects on the body:
  - Lack of energy
  - Low mood
  - Forgetfulness
  - Weight gain
    - Less glucose and fat is broken down by cellular respiration to release energy
  - Constantly feeling cold
    - Less heat is generated by respiration
  - Constipation
    - Muscular contractions in the gut wall slow down due to reduced energy from respiration
  - Impaired brain development in children

6.6.2 Hormones Continued

Your notes

Leptin

- **Leptin** is a **hormone** that is secreted by fat storage cells known as **adipose cells**
- The concentration of leptin in the blood is controlled by the **amount of adipose tissue** in the body
- As we eat food over a period of time, adipose cells store fats in the form of **lipids**
  - As adipose cells fill up, they secrete **more leptin**
  - This leptin circulates in the blood and targets groups of cells in the **hypothalamus** that are responsible for **controlling appetite**
  - It does this by **binding to receptors** in the membranes of these cells
  - This **inhibits appetite** and causes the **sensation of hunger to be suppressed,** or stopped
- If food intake is **low** over a period of time, the lipid reserves in adipose cells are **used up** and the adipose cells become empty again
  - As adipose cells empty and shrink, they secrete **less leptin**
  - The suppression of **appetite** stops, and the **sensation of hunger returns**

Testing Leptin

Your notes

- As leptin **inhibits appetite** and causes the sensation of hunger to be suppressed, it was once thought that **clinical obesity** could be **controlled** by **injecting patients with leptin**
- Early trials in mice showed promise
  - Mice with a genetic leptin deficiency were shown to be less active and to gain weight faster than mice without this deficiency
  - Individuals with leptin deficiency lost 30% of their body mass when injected with leptin
- However, clinical trials to test whether this could be an effective treatment for obesity in humans found it to be **ineffective**

Reasons for the failure to control obesity with leptin injections

- Unlike in mice, most obese humans have **very high concentrations of leptin in their blood**
  - There are some human individuals who have problems with leptin production, but these are the exception rather than the rule
- It seems as though their bodies have become **resistant to the effects of the hormone**
  - The **target cells** in the **hypothalamus** become **resistant to leptin** and therefore **fail to respond to it**
  - This leads to a **lack of appetite suppression**, causing a **continuous sensation of hunger** and **excessive food intake**
- This means that **injections of extra leptin fail to control obesity** in the majority of obese patients
- Other problems with the clinical trials included
  - The need to inject leptin **several times a day**
  - **Irritation** at the injection site
  - **Regain of any weight lost** after the end of the trial
- It is always important to remember that while other mammalian research models such as mice are important, they are **not always perfect**

Melatonin

- Many **physiological processes** and **behavioural patterns** occur in **regular, daily rhythms** in organisms throughout the plant and animal kingdoms
  - Many animal species are only active for a **specific part of the 24-hour cycle** e.g. nocturnal animals are only active at night
- Humans are **adapted** to live in a 24-hour cycle and many aspects of our physiology and behaviour, including **physical activity**, **sleep**, **body temperature,** and **secretion of hormones,** follow specific and regular cycles throughout the 24-hour period
  - These daily cycles are known as **circadian rhythms**
- In humans, many circadian rhythms are influenced by the hormone **melatonin**
  - Melatonin is **secreted** by the **pineal gland**, which is located in the **brain**
  - Melatonin secretion **increases in the evening** in response to **darkness** and **decreases at dawn** in response to **light**
- Although melatonin affects **many aspects of human physiology and behaviour**, one of the main circadian rhythms it controls is our **sleep-wake cycle**
  - **Increasing melatonin** levels lead to feelings of **tiredness** and **promote sleep**
  - **Decreasing melatonin** levels lead to the body's preparation for **waking up** and **staying awake during the day**
- Experiments have also suggested that
  - Increased melatonin at night contributes to the **night-time drop in core body temperature** in humans
  - Melatonin receptors in the kidney enable melatonin produced at night to cause the **night-time decrease in urine production** in humans
  - Melatonin is **still released in the absence of light and dark signals**, but on a slightly longer cycle than the usual 24 hours
    - Subjects living in the dark with no access to natural daylight still release melatonin on a roughly 24 hour cycle
    - This suggests that the role of light is to **reset the melatonin system** every day to keep the circadian rhythm in line with daylight hours

Your notes

Uses of Melatonin

Your notes

- **Jet lag** is the term used to describe the **various symptoms** a person can experience after **crossing multiple time zones** during a long **flight**
- The symptoms can include:
  - Difficulty in remaining awake during the day
  - Difficulty in sleeping during the night
  - General fatigue
  - Irritability
  - Headaches
  - Indigestion

- Jet lag occurs because the body's **circadian rhythms** are **still set to the timing of day and night** in the **time zone** from which the person has just **departed**, rather than the time zone they have just arrived in
- Jet lag usually only last for a **few days** as the body adjusts to the new day and night regime
- **Melatonin tablets** are sometimes taken to **prevent** or **reduce** jet-lag symptoms
  - The tablets are normally taken **just before going to sleep**
  - Some clinical trials have shown this use of melatonin to be **effective** in **promoting sleep** and reducing other jet lag symptoms
  - However, the **safe** and **appropriate** use of this medication **still needs more testing**

6.6.3 Reproduction: Background

Your notes

William Harvey & Sexual Reproduction in Deer

- William Harvey (1578 - 1657) was an English **physician** who contributed greatly to our understanding of anatomy and physiology
- He is mainly remembered for his work on the **circulation of the blood,** however, he also spent a lot of time studying **how life passes from one generation to the next** and conducted much research into **sexual reproduction**
- At the start of the 17th century there was **very little understanding** of how each sex; males and females, contributed to **producing offspring**
  - The main hypothesis at the time was that the **semen** produced by males **combined with the menstrual blood** of females to form an '**egg**', which would then develop into a **foetus** inside the mother

- William Harvey's work on understanding sexual reproduction involved **testing this old hypothesis** using animals, mainly **deer**
- His work included:
  - Dissecting the **uteruses,** or **wombs,** of female deer at all stages of pregnancy
    - Harvey found that the uterus was always empty at the time of conception i.e. just after successful mating, **disproving the hypothesis** that semen and menstrual blood combined in the uterus to form a foetus
    - Harvey expected to find 'eggs' developing in the uterus immediately after mating; instead, he only found something developing there **two or more months after mating**

  - Dissecting the **ovaries** of female deer throughout the mating season
    - He found **no sign** of an '**egg**'
    - Note that **he did not have access to a microscope** during his work

Your notes

William Harvey's Experimental Technique

NOS: Developments in scientific research follow improvements in apparatus; William Harvey was hampered in his observational research into reproduction by lack of equipment. The microscope was invented 17 years after his death

- In scientific research, **critical developments often follow improvements in scientific apparatus**
  - For example, distant objects in Space often remain undiscovered until a telescope, or some other piece of equipment, powerful enough to detect them is developed
- William Harvey was greatly held back in his observational research into reproduction by a **lack of suitable equipment**
  - The **microscope** was invented 17 years after his death
  - Harvey failed to solve the mystery of sexual reproduction because **effective microscopes were not available** when he was working
  - This meant he could not find and observe male and female gametes, so the fusion of gametes and subsequent embryo development remained undiscovered
    - In addition, Harvey's decision to use deer as a study species was unlucky, as deer embryos remain microscopically small i.e. small enough that they can only be viewed using a microscope, for an unusually long period of time
- Although the presence of sperm cells in semen was first reported in 1677, it wasn't until the 19th century that the fertilisation of an egg cell by a sperm cell was finally observed
  - This showed that something contained within the egg **and** the sperm was being **inherited by offspring**, which lead to a much **greater understanding of sexual reproduction**
- The fact that scientific research is often held back by a lack of **sufficiently powerful** or **precise apparatus** is a problem that will continue into the future
- In some ways this is very exciting, as it suggests that our scientific knowledge and understanding of the universe will **continue to expand** as new **scientific techniques** and **technologies** are developed

6.6.4 Reproduction: Sex Determination in Males

Your notes

SRY Gene

- In **sexual reproduction** in **humans**, a sperm from a male fuses with, or fertilises, an egg from a female to form a zygote, which then develops into an **embryo**
- To begin with the embryo develops **in the same way regardless of its sex,** and **embryonic** gonads develop that will either become **ovaries** in females or **testes** in males
- The factor that determines whether the embryonic gonads will develop into ovaries or testes is the **presence or absence** of a **single gene** known as the **SRY gene**
  - The SRY gene is located on the **Y chromosome**, meaning that is only present in roughly 50% of embryos
  - The SRY gene codes for a DNA-binding protein known as TDF, or testis determining factor, which stimulates the expression of further genes responsible for the **development of testes**
- If the SRY gene is present in the embryo's DNA, the **embryonic gonads** will develop into **testes**
- If the embryo has **two X chromosomes,** and therefore the SRY gene is **not present** in its DNA, the **embryonic gonads** will develop into **ovaries**

Your notes

Testosterone

- During embryonic development, at the time when the embryo is developing into a foetus, the testes develop **testosterone-secreting cells** which produce and secrete **testosterone**
- This testosterone causes **pre-natal development of male genitalia**
  - This testosterone secretion declines in the latter stages of pregnancy so that, at birth, the testes are **inactive**

- During **puberty** in males, **testosterone secretions increase** once again
- This leads to:
  - The stimulation of **sperm production in the testes;** a primary sexual characteristic of males
  - The development of male **secondary sexual characteristics** e.g.
    - The penis gets larger
    - Growth of facial hair
    - Deepening of the voice

Secondary sexual characteristics

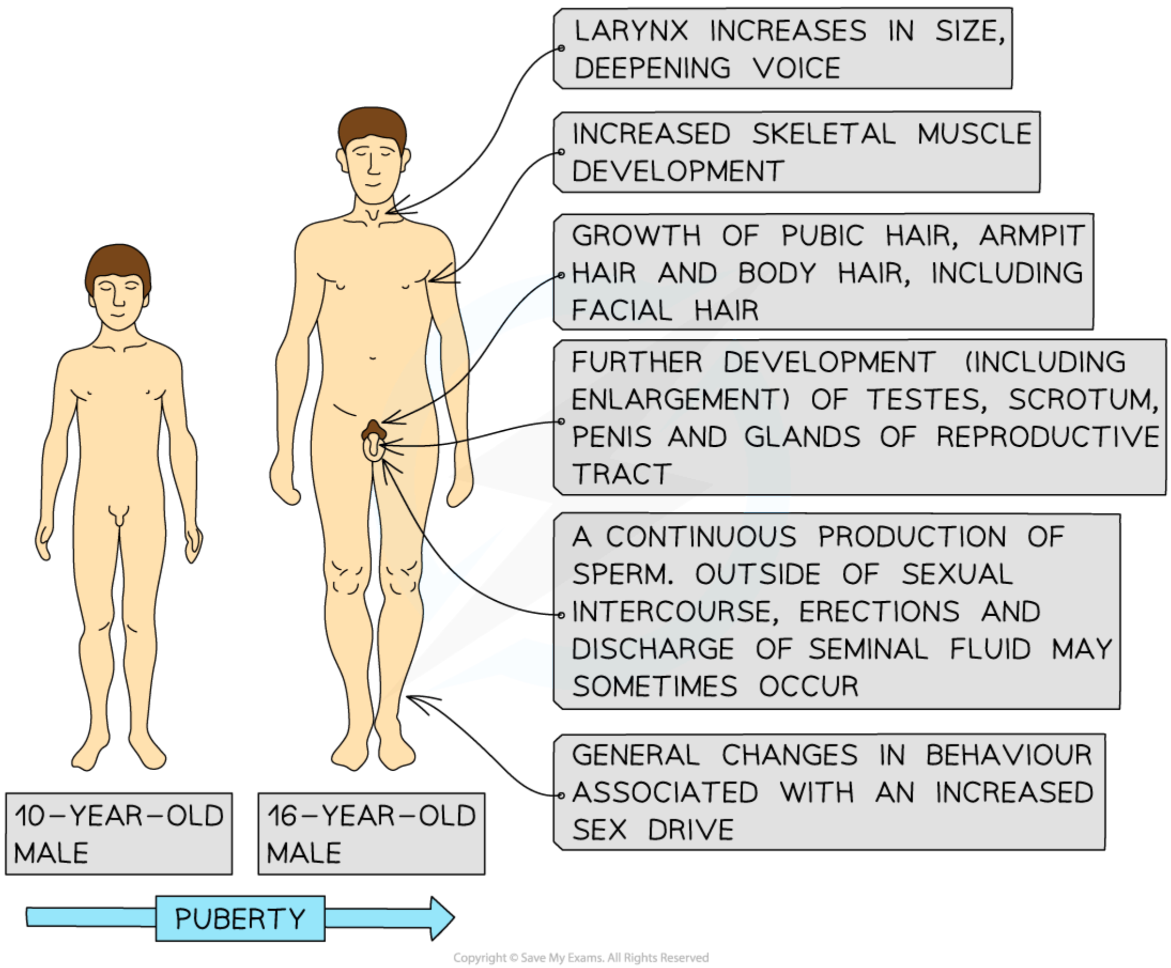
- **Primary sexual characteristics** are the features of reproductive organs that differ between males and females
  - They are **present during development** in the uterus

- **Secondary sexual characteristics** are the changes that occur **during puberty** as children grow into adults
- They are controlled by the release of **hormones**
  - **Oestrogen and progesterone** in females
  - **Testosterone** in males

- Some changes occur in both males and females, including:
  - The **further development of sexual organs**
  - The **growth of body hair**

- **Emotional changes** also occur at this time due to the increased levels of hormones in the body

Your notes



Secondary sexual characteristics of a human male

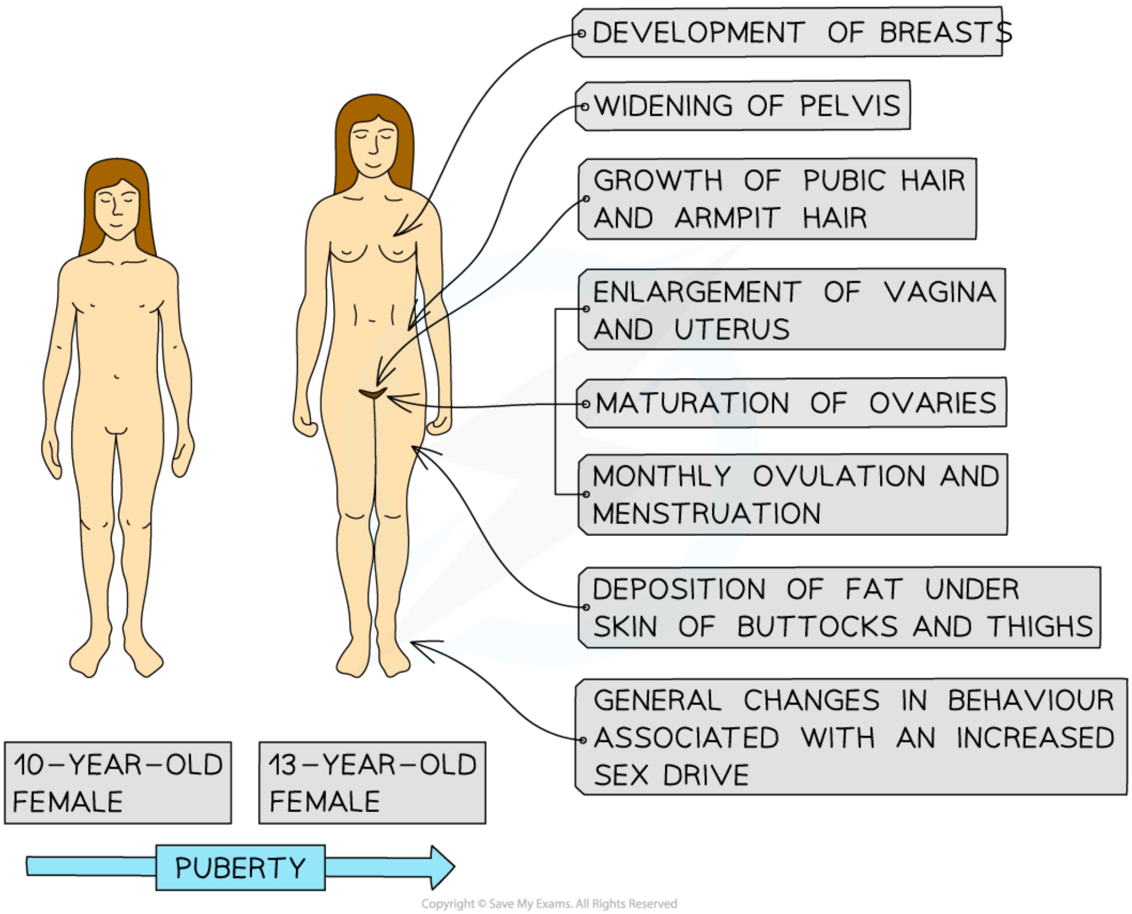
6.6.5 Reproduction: Sex Determination in Females

Your notes

Oestrogen & Progesterone

- During early development an embryo develops **embryonic** gonads that will either become **ovaries** in females or **testes** in males
- The factor that determines whether the embryonic gonads will develop into ovaries or testes is the **presence or absence** of a **single gene** known as the **SRY gene**
- The SRY gene is on the **Y chromosome,** so if the embryo has **two X chromosomes** the embryonic gonads will develop into **ovaries**
- This means **testosterone** will not be secreted by the developing embryo
- The two female hormones **oestrogen** and **progesterone** are **present throughout pregnancy**
  - These hormones are secreted by the **mother's ovaries** and the **placenta**
- The absence of foetal testosterone and presence of maternal oestrogen and progesterone causes female reproductive organs to develop
- During female **puberty, oestrogen and progesterone secretions increase**.
- This leads to:
  - The start of the **menstrual cycle**
  - The development of female **secondary sexual characteristics** e.g. breast development

Your notes



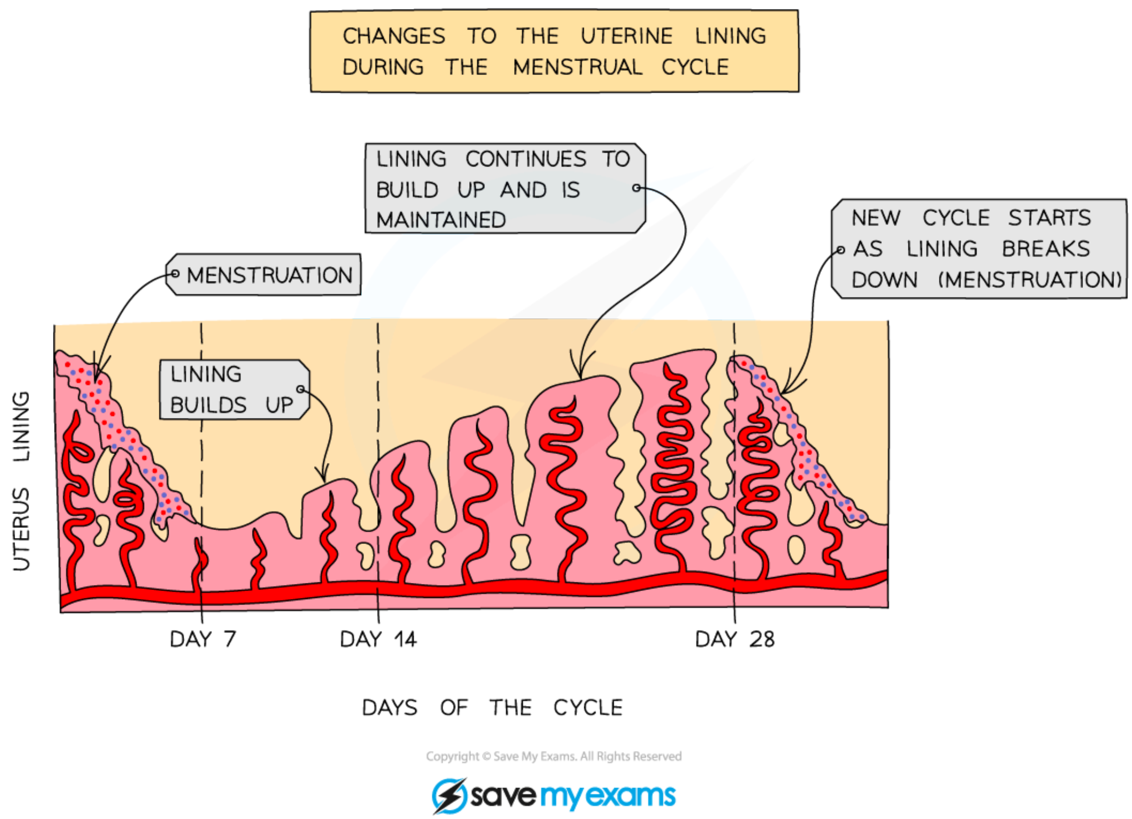
Secondary sexual characteristics of a human female

Menstrual Cycle

Your notes

- The **menstrual cycle** is the series of changes that take place in the female body leading up to and following the release of an egg from the ovaries
  - It starts in early adolescence in girls and is controlled by **hormones**
  - The average menstrual cycle is **28 days** long
- The **uterus lining**, or **endometrium**, thickens from **day 7** through to **day 28** of the cycle in preparation for receiving a fertilised egg
- The release of an egg, or **ovulation**, occurs about **halfway** through the cycle on **day 14,** and the egg then travels down the oviduct to the uterus
  - Eggs develop inside fluid-filled sacs known as **egg follicles** inside the ovary
  - The follicle releases the egg at ovulation and becomes an empty follicle known as a **corpus luteum**
- Failure to fertilise the egg leads to **menstruation,** commonly known as a period
  - Menstruation involves the loss of menstrual blood via the vagina
  - This is caused by the **breakdown of the endometrium**
- Menstruation takes place roughly between **days 1–7** of the cycle
  - The number of days during which menstruation occurs can vary
- After menstruation finishes, the endometrium starts to **thicken again** in preparation for the **possible implantation** of a fertilised egg in the next cycle

Your notes



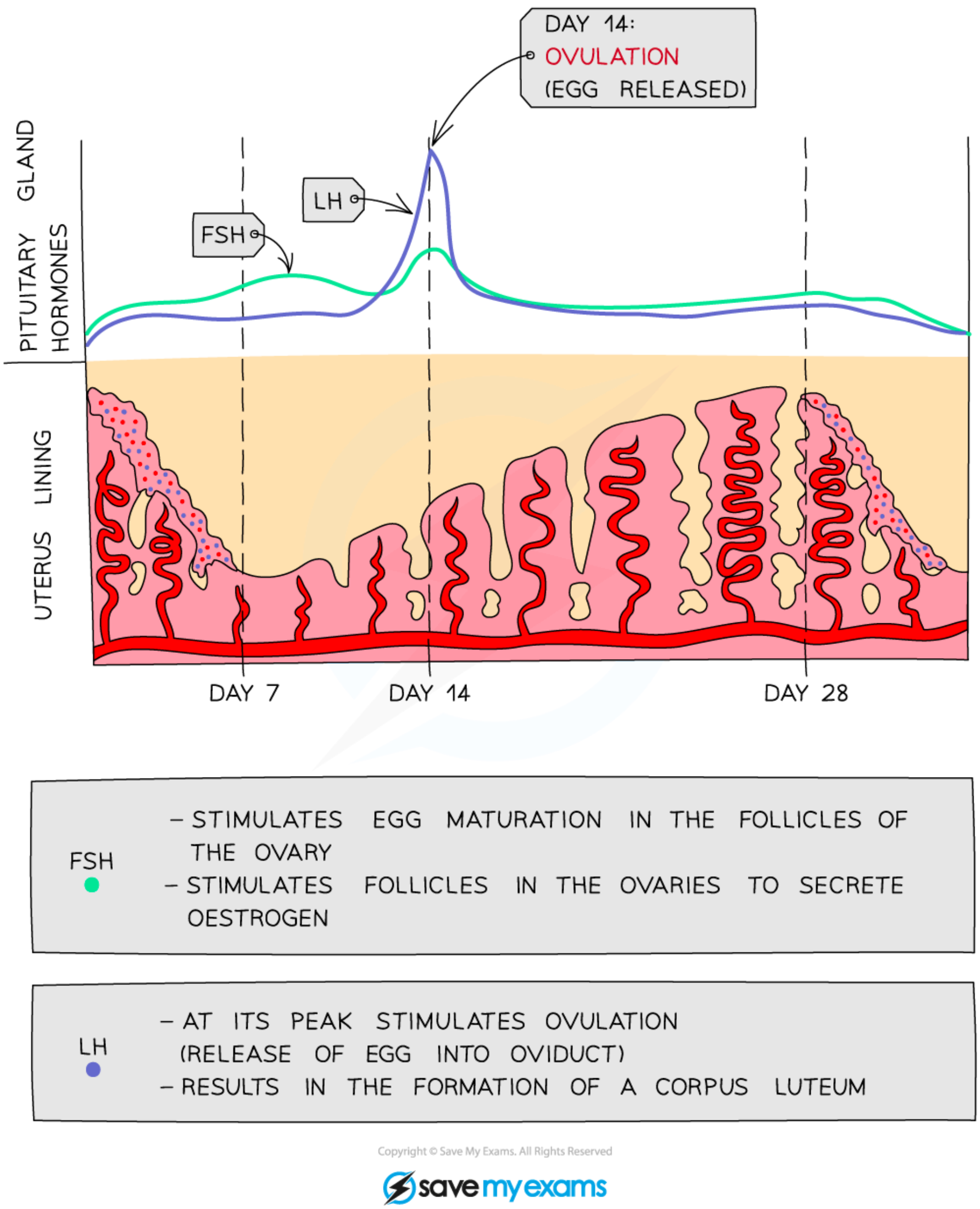
Changes in the endometrium during the menstrual cycle

How ovarian and pituitary hormones control the menstrual 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
    - **F**ollicle-**s**timulating **h**ormone (**FSH**)
    - **L**uteinising **h**ormone (**LH**)
  - The other two hormones are produced in the **ovaries**
    - **Oestrogen;** produced by the **egg follicle,** and by the **corpus luteum** after ovulation
    - **Progesterone;** produced by the corpus luteum
- The roles of FSH and LH:
  - FSH is secreted by the **pituitary gland** and stimulates the **development** of several immature **egg cells** in **follicles** in the **ovary**
  - FSH also stimulates the **secretion of oestrogen** by the **follicle wall**
  - The **pituitary gland** is stimulated to release LH when **oestrogen** levels have reached their **peak**
  - LH causes **ovulation to occur;** the shedding of the mature egg cell from the follicle and its release from the ovary

- The shedding of the mature egg cell leaves behind an empty egg follicle called the corpus luteum
- LH also **stimulates** the production of **progesterone** from the corpus luteum

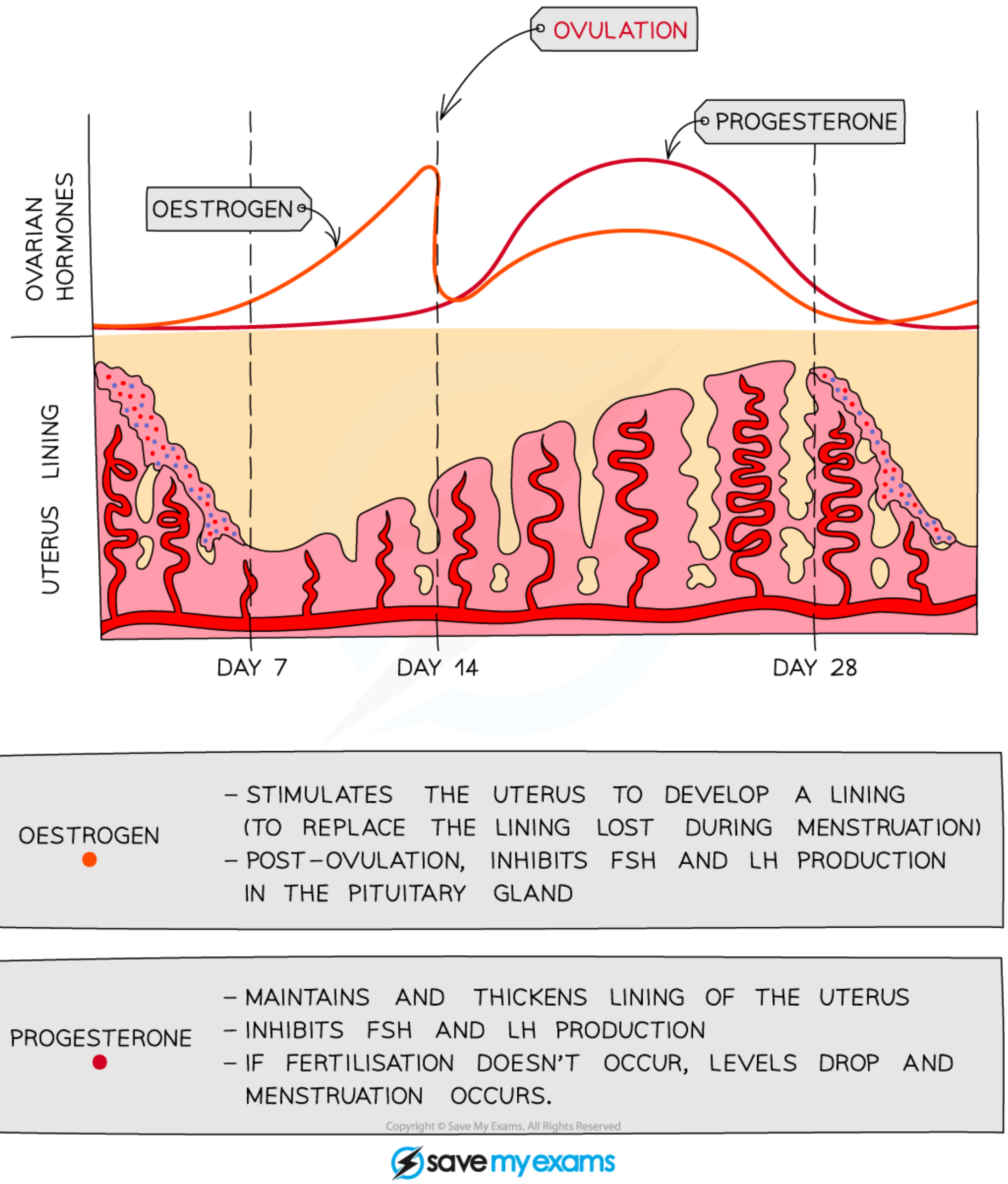
Your notes



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

Your notes

- The roles of oestrogen and progesterone:
  - **Oestrogen** levels rise from **day 1** to **peak** just before **day 14**
  - This causes the **endometrium** to start **thickening** and the egg cell to **mature**
  - The peak in oestrogen occurs just before the egg is released
  - **Progesterone** stays low from day 1–14 and starts to rise once ovulation has occurred
    - Progesterone is produced by the corpus luteum
  - The increasing levels of progesterone cause the endometrium to continue to thicken
  - A fall in progesterone levels as the corpus luteum deteriorates causes the endometrium to **break down**, resulting in **menstruation**



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

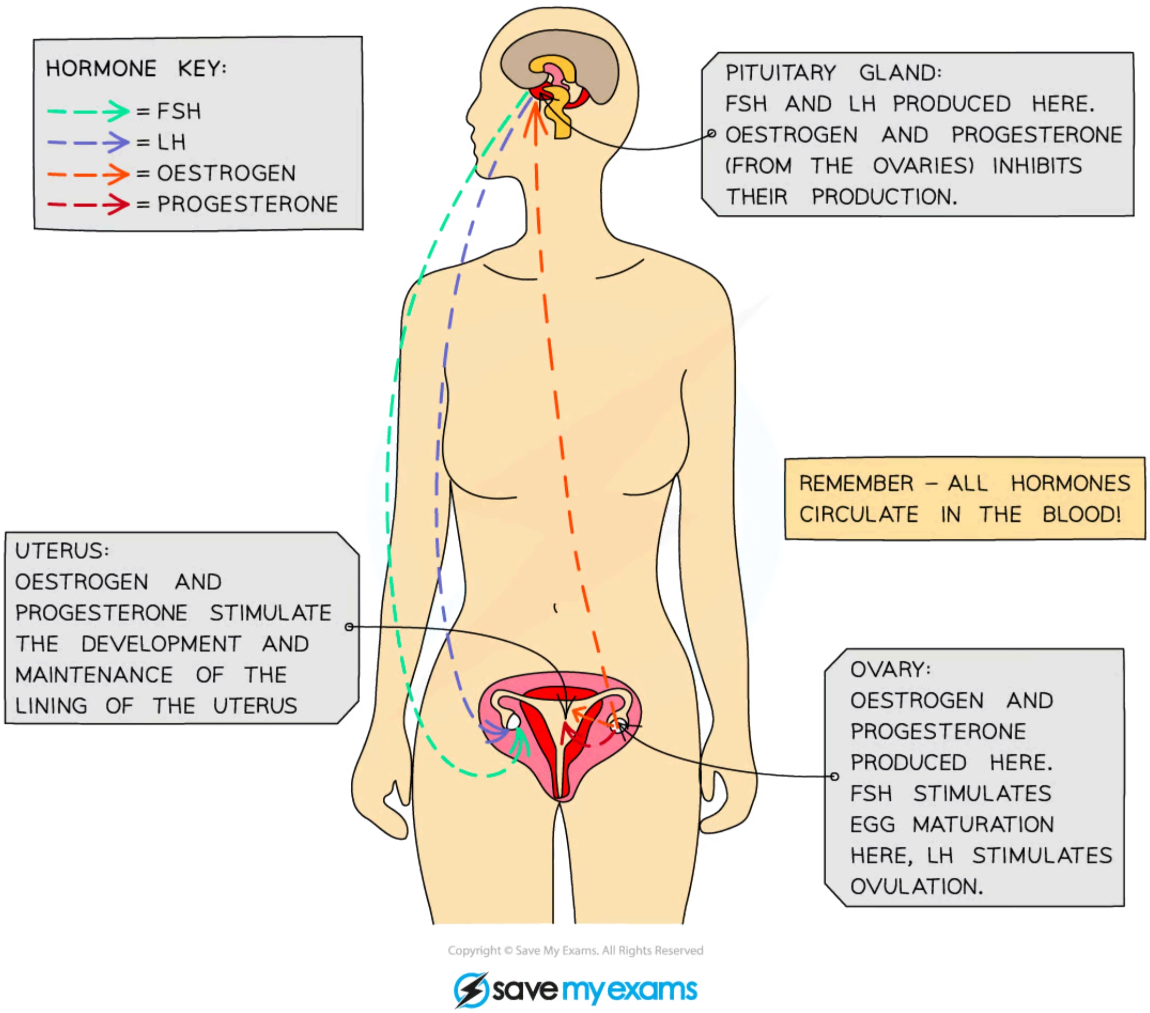
Negative and positive feedback mechanisms controlling the menstrual cycle

- The four hormones all **interact** to control the menstrual cycle via both negative and positive feedback
  - FSH and oestrogen

Your notes

    - FSH stimulates the development of a follicle, and the follicle wall produces the hormone oestrogen; it can be said that **FSH stimulates the production of oestrogen**
    - As well as causing growth and repair of the endometrium, oestrogen also causes an **increase in FSH receptors;** this makes the follicles **more receptive to FSH** which, in turn, **stimulates more oestrogen production**
        - This is **positive feedback**
    - When oestrogen levels are high enough, it **inhibits the secretion of FSH**
        - This is **negative feedback**
- LH and oestrogen
    - When oestrogen rises to a high enough level, it **stimulates the release of LH** from the pituitary gland, causing ovulation on around day 14 of the cycle
    - After ovulation, **LH causes the wall of the follicle to develop into the corpus luteum,** which **secretes more oestrogen**
        - This is **positive feedback**
- LH and progesterone
    - **LH** stimulates the wall of the follicle to develop into the **corpus luteum,** which **secretes progesterone**
    - Progesterone thickens and maintains the endometrium but also **inhibits the secretion of FSH and LH** from the pituitary gland
        - This is **negative feedback**

Your notes



Where hormones involved in the menstrual cycle are made and act – remember that hormones travel around the body in the bloodstream but only have an effect on a target organ

Hormones & IVF

Your notes

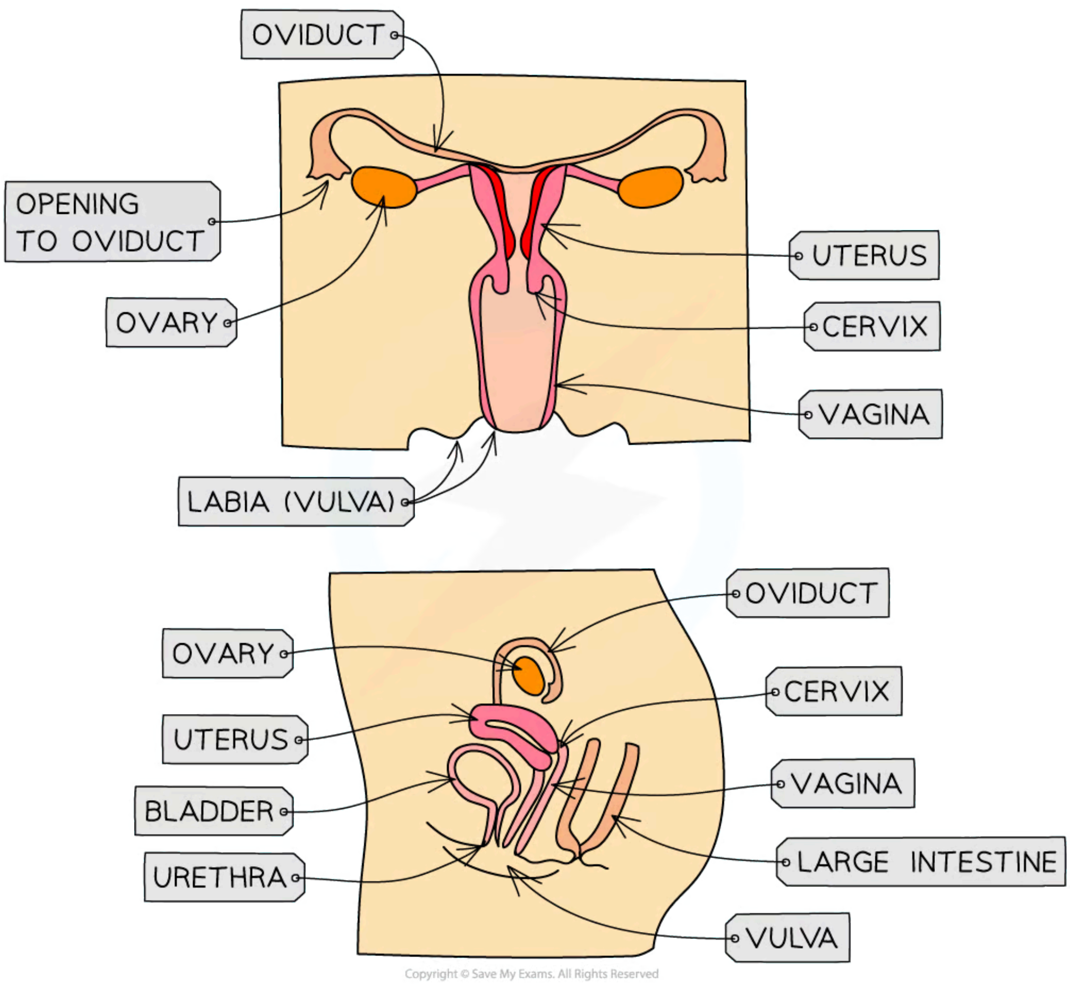
- A couple may find it difficult to conceive a baby **naturally**
- This can be due to **insufficient levels of reproductive hormones** affecting the development of egg and sperm cells, or as a result of **issues with the reproductive system of the male or female**
- One possible treatment is for eggs to be fertilised by sperm **outside the body** in carefully controlled laboratory conditions
  - This is known as ***i****n* ***v****itro* **f**ertilisation, or **IVF**
- Although the process can vary, it normally follows the same main steps:
  - The first step involves stopping the normal secretion of hormones; the woman takes a drug to **inhibit the secretion of FSH and LH** from the pituitary gland
    - This also causes oestrogen and progesterone secretions to stop
  - This **temporarily halts the menstrual cycle**, allowing doctors to control the **timing** and **quantity** of **egg production** in the woman's ovaries
  - The woman is then given **injections of FSH and LH to stimulate the development of follicles;** as the injection gives a much higher FSH concentration than is present during a normal menstrual cycle, '**superovulation**' occurs
    - Many more follicles than normal begin to mature
  - The eggs are then collected from the woman and fertilised by sperm from the man in **sterile conditions in the laboratory**
  - The fertilised eggs develop into **embryos**
  - At the stage when they are tiny balls of cells, about **48 hours after fertilisation**, one or more embryos are inserted into the mother's uterus
  - Finally, **extra progesterone** is normally given to the woman to ensure the **endometrium** is **maintained**
- 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

Your notes

6.6.6 Skills: Reproduction Diagrams

Male & Female Diagrams

- You should be able to **annotate diagrams** of the female and male **reproductive systems** to show the names of the different **structures**
- You should also be able to recall the **function** of each of these structures



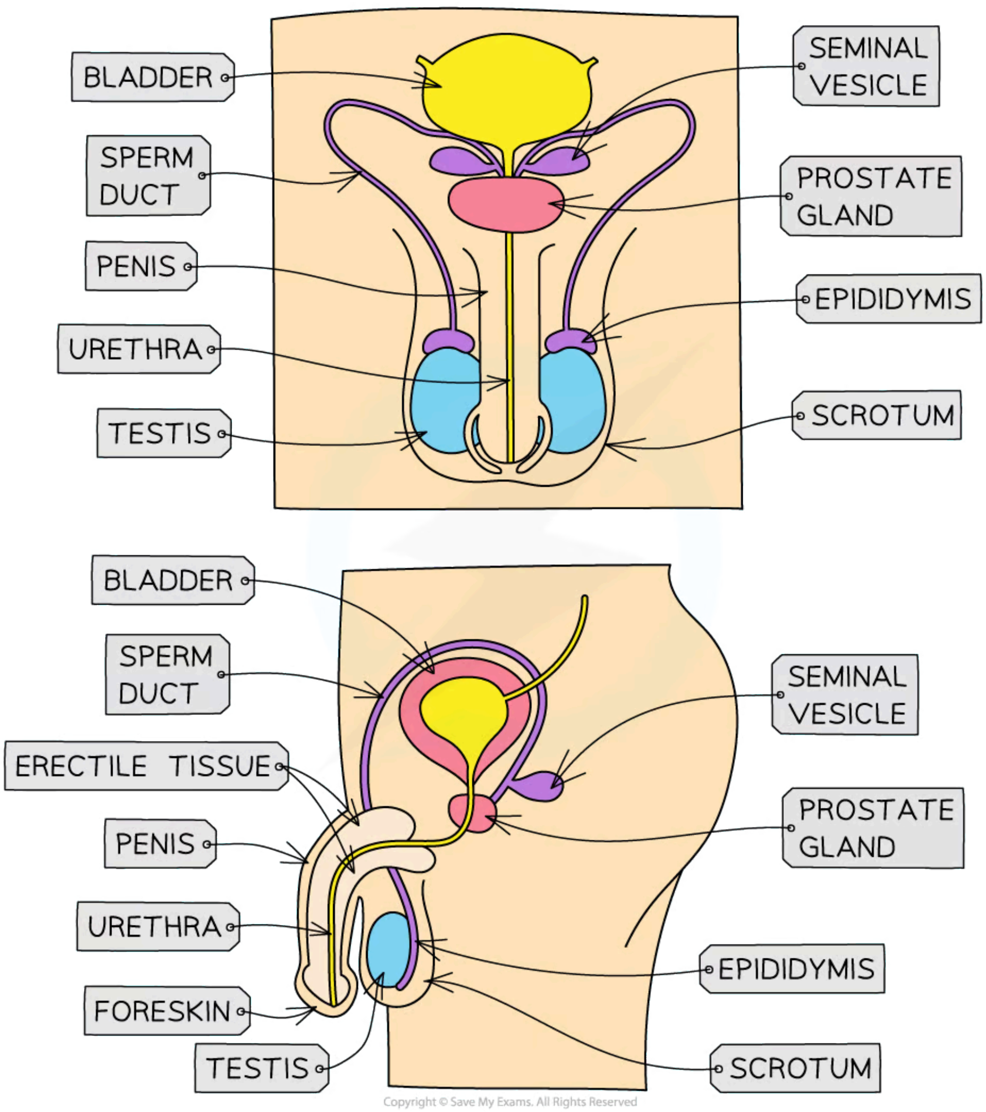
Front and side view of the female reproductive system

Female Reproductive System Table

Your notes

Structure	Function
Oviduct	Connects the ovary to the uterus and is lined with ciliated cells to push the released ovum down it. Fertilisation occurs here
Ovary	Contains ova (female gametes) which will mature and develop when hormones are released
Uterus	Muscular bag with a soft lining where the fertilised egg (zygote) willbe implanted to develop into a foetus
Cervix	Ring of muscle at the lower end of the uterus to keep the developing foetus in place during pregnancy
Vagina	Muscular tube that leads to the inside of the woman's body, where the male's penis will enter during sexual intercourse and sperm are deposited
Vulva	A collection of structures (including the pubic mound, labia, clitoris and hymen), one function of which is to protect the more internal parts of the female reproductive system

Your notes



Front and side view of the male reproductive system

Male Reproductive System Table

Structure	Function
Prostate gland and seminal vesicle	Produces fluid called semen that provide sperm cells with nutrients
Sperm duct	Sperm passes through the sperm duct to be mixed with fluids produced by the glands before being passed into the urethra for ejaculation
Urethra	Tube running down the centre of the penis that can carryout urine or semen, a ring of muscle in the urethra prevents the urine and semen from mixing
Testis	Contained in a bag of skin (scrotum) and produces sperm (male gamete) and testosterone (hormone)
Scrotum	Sac supporting the testes outside the body to ensure sperm are kept at temperature slightly lower than body temperature
Penis	Passes urine out of the body from the bladder and allows semen to pass into the vagina of a woman during sexual intercourse
Epididymis	Coiled tubes that store sperm until ejaculation

Your notes