OCR (A) Biology GCSE

Topic 3: Organism Level Systems

Notes

(Content in bold is for higher tier only)

Coordination and control: the nervous system

How the nervous system coordinates responses (3.1a and b)

The central nervous system (CNS) consists of the brain and the spinal cord. It allows us to make sense of our surroundings and respond to it in order to survive.

1) Receptor cells convert a stimulus (such as a bright light) into an electrical impulse.
2) This electrical impulse travels along cells called sensory neurons to the central nervous system (CNS).
3) Here, the information is processed and the appropriate response is coordinated, resulting in an electrical impulse being sent along motor neurones to effectors.
4) The effectors carry out the response (this may be muscles contracting or glands secreting hormones).

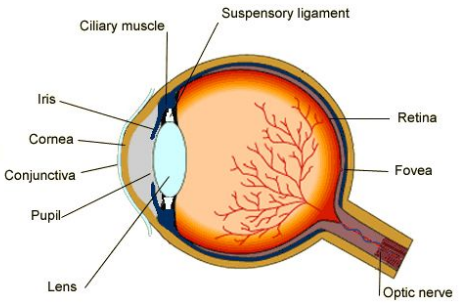
Reflex arc (3.1c)

The reflex arc is a subconscious response to a dangerous stimuli, such as a hot surface. Sometimes an extremely quick response is needed and there is not enough time for it to go through the conscious portion of brain so the CNS is involved instead.

1) A stimulus is detected by receptors, such as thermoreceptors in fingertips detecting heat
2) Impulses are sent along a sensory neuron.
3) In the CNS the impulse passes to a relay neuron.
4) Impulses are sent along a motor neuron
5) The impulse reaches an effector resulting in the appropriate response, such as a contraction of the biceps to move the arm away from the heat source

The eye (3.1d and e)
Biology only

Structure of the eye



- Cornea: the transparent outer part of the eye
  - It refracts light to reach the retina
- Iris: the coloured part of the eye that does not allow light to go through
  - Controls how much light enters eye
  - In bright light, the circular muscles contract and radial muscles relax to make the pupil smaller, avoiding damage to the retina.
  - In dim light, the circular muscles relax and the radial muscles contract to make the pupil larger, so more light can enter to create a better image.
- Lens: transparent, biconvex disc that attaches to ciliary muscles by the suspensory ligaments
  - Focuses light onto the retina
- Retina: contains light receptors
  - Contains rods (respond to dim light) and cones (respond to colour)
- Optic nerve: carries impulses between the eye and the brain

Common defects

Colour blindness: the inability to tell the difference between different colours due to the lack of or defects in the receptors in the retina. It is an inherited condition and the most common form is red-green colour blindness.

Short-sightedness (myopia): ability to see near objects but not distant objects, due to the lens focusing the image in front the retina. They are treated by concave lenses in glasses.

Long-sightedness (hyperopia): ability to see distant objects but not near objects, due to the lens focusing the image behind the retina. They are treated by convex lenses in glasses.

The brain (3.1f-h)
Biology only

Structure of the brain

Cerebrum:

- Functions: intelligence, vocabulary, personality and conscious thought
- Features:
    - The largest part of the brain and divides into 2 cerebral hemispheres
    - Each half processes the information it receives from the opposite side of the body
    - The outside is made from grey matter (containing myelinated nerves) and the inside is made of white matter

Cerebellum: coordinate voluntary body movements and help with balance

Medulla: control centre for heart rate, blood pressure and breathing rate

Hypothalamus: controls temperature and water balance in the body through the hormonal system

Pituitary gland: an important gland releasing hormones, such as growth hormone, into the blood

Limitations in investigating and treating brain damage

There are ethical issues with investigating brain damage, as it is unethical to ask patients who may not be in the state to make an informed decision about whether they want to take part in a study. The investigative study would require surgery, which has many risks in itself. There is also a considerable amount that we have yet to learn about the brain and its functions so it may be hard to interpret findings of case studies.

There are limitations in treating brain damage because the central nervous system cells do not have the ability to regenerate and repair and there may be areas that are very difficult or dangerous to access during surgery. Drugs may also have difficulty penetrating the different membranes surrounding the brain.

Coordination and control: the endocrine system

Endocrine system (3.2a and b)

Hormones are chemical messengers that are secreted by endocrine glands into the bloodstream, where they are transported around the body to receptors on the target organ. The pituitary gland, mentioned before, it one of the most important glands.

	Endocrine system	Nervous system
Type of signal	Chemical	Electrical
Transmitter	Hormones in bloodstream	Nerve cells
Speed of response	Slower	Very fast
Duration of response	Long	Short

Examples of hormones:

- **Adrenaline**
  - **Produced by the adrenal glands that sit on top of kidneys**
  - **Targets many different organs, such as the heart and lungs**
  - **Responsible for the 'fight or flight' response for survival - increases heart rate, dilates pupils, makes hairs stand erect, increasing breathing rate**
- **Thyroxine**
  - **Produced by thyroid gland in the neck**
  - **Responsible for controlling metabolic rate, meaning it controls how quickly oxygen and food react to release energy. It is therefore responsible for growth.**
  - **Example of negative feedback - if thyroxine levels are too low it stimulates the hypothalamus to produce a hormone called TRH and the pituitary then releases TSH (thyroid stimulating hormone) which causes the thyroid to produce more thyroxine. When the levels are returned to normal these hormones are inhibited to stop further increases.**

Human reproduction (3.2c-f)

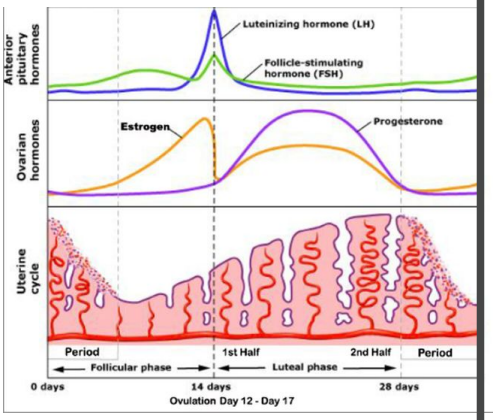
Hormones are responsible for controlling puberty and also the menstrual cycle

Puberty

Hormones are responsible for the changes to the body that occur during puberty.
Testerone, produced by the testes, are responsible for the development of sperm and also secondary sexual characteristics in males, such as deepening voices and increased hair.
Oestrogen, produced by the ovaries, are responsible for secondary sexual characteristics in females, such as breast development and widening hips.

Menstrual cycle

The menstrual cycle last 28 days and the egg is usually released on day 14 (ovulation).



Oestrogen

- Oestrogen causes thickening of the uterus in preparation for implantation of an egg
- Levels peak on day 10 and then begin to fall

FSH and LH

- FSH (follicle stimulating hormone) causes maturation of the egg within the ovary
- LH (luteinising hormone) stimulates the release of the egg during ovulation
- **A decrease in oestrogen causes LH and FSH to start increasing**
- Ovulation (the release of an egg cell from one of the ovaries) occurs when LH and FSH levels peak

Progesterone

- Progesterone maintains the thick lining of uterus
- **Inhibits the release of LH and FSH**
- The egg matures on day 14 and progesterone starts increasing after this until it reaches its peak 3 days later
- If the egg is not fertilised progesterone levels fall and the uterus lining breaks down in a period that lasts for around 5 days

Menopause occurs when a woman no longer has a menstrual cycle, usually around 50-55 years of age.

Contraception

Hormonal methods:

- Oral contraceptives (the pill)
  - Contains progesterone and oestrogen, which inhibit the production of FSH so that eggs do not mature
  - More than 99% effective if taken properly
  - Side effects such as mood swings, weight gain
- Contraceptive implants
  - More than 99% effective
  - Cause slow release of progesterone to prevent ovaries from releasing the egg, thickens mucus in cervix so sperm cannot swim through
  - Will not need to remember to take everyday

Non-hormonal methods:

- Physical barrier methods, such as condoms
  - Easy to use and obtain and also protects from STIs
  - However, condoms can rip
  - Over 99% effective
  - Can be made more effective with spermicidal agents, but some people can be allergic to it
- Vasectomy/female sterilisation
  - Sperm tubes/oviducts are cut to prevent gametes becoming fertilised
  - Almost 100% reliable
  - However, can be irreversible
- Copper intrauterine device (IUD/the coil)
  - T-shaped device implanted into uterus
  - Stops fertilised embryos implanting, copper kills sperm
  - Can last for up to 10 years, over 99% effective
  - Must be fitted by a doctor, small chance of ectopic pregnancy
- Abstinence

Fertility treatments

Fertility treatments allow infertile couples the opportunity to have children. Infertility can be caused by many issues, such as sperm quality or quantity problems or a lack of FSH to mature eggs. However, fertility treatments are not guaranteed to work and if they do they can increase the likelihood of twins, triplets etc.

Fertility drugs:

- **FSH and LH mainly used because they stimulate the maturation and release of the egg.**
- **The woman can then become pregnant normally.**

IVF:

- **Mother is given FSH and LH to stimulate eggs to mature**
- **Eggs are collected and fertilised by the father's sperm in a laboratory**
- **The fertilised eggs develop into embryos**
- **These embryos are then implanted into the mother's uterus**
- **However, can be extremely expensive if it needs to be repeated**

Plant hormones (3.2g-i)
Biology only

Plants need hormones to coordinate and control growth. They are needed for tropisms. Examples of these include phototropism, the response to light, and gravitropism or geotropism, the response to gravity. Hormones move from the place they are made to where they are needed in order to produce the appropriate response.

Auxins

Most plants show positive phototropism because they grow towards the light source.

- The plant is exposed to light on one side.
- Auxin, a growth hormone, moves to the shaded side of the shoot.
- Auxin stimulates cells to grow more here.
- This means the shoot bends towards the light.
- The plant receives more light, meaning photosynthesis can occur at a faster rate.

Most shoots show negative gravitropism as they grow away from gravity. If a shoot is horizontal:

- Auxin moves to the lower side.
- The cells of the shoot grow more on the side with most auxin, so it stimulates cells to grow more here.
- This makes the shoot bend and grow away from the ground.
- This is beneficial as light levels are likely to be higher further away from the ground.

Most roots show positive gravitropism as they grow towards gravity. If a root is horizontal:

- Auxin moves to the lower side.
- The cells of the root grow more on the side with less auxin, so it stimulates cells to grow on the upper side.
- This makes the root bend and grow downwards.
- This is beneficial as there are more likely to be increased levels of water and nutrients lower down, and it provides stability for the plant.

When the auxin distribution becomes equal on both sides it grows straight in that directions.

You can investigate the effect of light or gravity on newly germinated seedlings by varying conditions.

- Placing in cardboard box and shining light from one side
- Attaching a petri dish containing the seedlings to a wall (effects of gravity)

Use of auxins:

1. **As weed killers**
    - **Many weeds are broad-leaved**
    - **Weedkillers, containing auxin, have been synthesised so they only affect broad-leaved plants**
    - **The increased amount of auxin causes the cells to grow too rapidly**

- This results in the weed dying

2. As rooting powders
    - Plants with desirable features are cloned to make more plants with the same feature
    - One way to clone a plant is to take a cutting from the original plant
    - Rooting powder containing auxin is applied to it and it is placed in the ground
    - Roots grow and the new plant begins to grow very quickly
3. To promote growth in tissue culture
    - Another way to clone a plant is to use tissue culture
    - Cells from the plant are taken are placed in a growth medium containing lots of nutrients
    - Hormones such as auxins are added
    - The cells begin to form roots and shoots

Gibberellins

Gibberellins are another plant hormone important to stimulate seed germination, flowering and shedding of leaves

Uses:

1. Ending seed dormancy
    - In the brewing industry, the germination rate of barley seeds is increased to make malt.
2. Promoting flowering
    - Instead of requiring certain conditions such as longer days and low temperatures to flower, applying this hormone allows it to flower in any conditions and with bigger flowers.
3. Increasing fruit size
    - The seeds in fruit produce gibberellins to increase fruit size.
    - This means that seedless fruit is generally smaller.
    - Seedless fruit can be sprayed with gibberellins to increase their size.

Ethene

Ethene is involved in cell division and the ripening of fruits.

Uses:

- Used in the food industry.
- Fruit is picked when it is not ripe
- It is firm which means that during transport it gets less bruised and damaged
- When it is needed to be sold, it is exposed to ethene and warmer temperatures
- Ethene is involved in controlling cell division and stimulates enzymes that result in fruit ripening.
- This reduces wastage as more fruit is suitable to be sold and it does not ripen too early

Maintaining internal environments

Controlling temperature (3.3a and b)

Biology only

Homeostasis is the maintenance of a constant internal environment. Mechanisms are in place to keep optimum conditions despite internal and external changes. This is needed for enzyme action and all cell functions.

The thermoregulatory centre which monitors and controls body temperature is found in the brain.

- Has receptors that monitor the temperature of the blood
- Has receptors in the skin that send impulses to the thermoregulatory centre

Human body temperature is 37.5 degrees celsius.
If it becomes too high:

- Sweat (evaporates from skin surface resulting in increased energy transfer away from body) is produced from sweat glands
- Vasodilation means more blood flows closer to the surface of the skin, resulting in increased energy transfer from the body

If it decreases too much:

- Sweating stops
- Skeletal muscles contract rapidly (shivering) to generate heat from respiration
- Hairs stand on end to create an insulating layer, trapping warm air
- Vasoconstriction means blood does not flow so close to the surface, resulting in less heat lost

Controlling blood sugar levels (3.3c and d)

The concentration of glucose in your blood needs to be kept within a certain limit because glucose is needed by cells for respiration. It is controlled by the pancreas.

Insulin

Eating foods that contain carbohydrates increases the glucose levels in the blood.

- If the glucose levels are too high, the pancreas produces the hormone insulin
- Insulin binds to cell in target organs (muscles and liver) causing:
    - 1) Glucose to move from the blood into muscle cells for respiration
    - 2) Excess glucose to be converted into glycogen which is stored in the liver
- The blood glucose concentration is reduced

Glucagon

Rigorous activity, e.g. exercise, uses glucose for respiration and therefore there is less in the blood.

- **If glucose levels decrease, the pancreas produces the hormone glucagon**
- **Glucagon binds to to the liver cells causing glycogen to be broken down into glucose**
- **Glucose is released into the blood, increasing the blood glucose concentration**

Your blood glucose concentration is kept constant through using these two hormones. They work in a negative feedback loop.

- **When blood glucose levels increase/decrease, a hormone is secreted to oppose the change.**
- **The action of this hormone cannot occur continually because when the blood arrives at a certain glucose concentration the other hormone is produced, resulting in the opposite effect.**

Diabetes

Diabetes is a disease where the body cannot control blood sugar levels properly.

Type 1 diabetes: the pancreas cannot produce enough insulin

- Blood glucose level can rise to a fatal amount
- Glucose is excreted with urine and lots of urine is produced leaving the individual very thirsty
- It is treated with insulin injections at meal times, which results in glucose being taken up from the bloodstream
- It is also advised to limit the intake of simple carbohydrates which contain lots of glucose
- Doctors are attempting to cure diabetes with pancreas and pancreatic cell transplants, and genetically engineering pancreatic cells from mice to make insulin

Type 2 diabetes: the body cells no longer respond to insulin

- Blood glucose levels can rise to a fatal amount
- Obesity is a risk factor for this disease
- Treatments include reducing the number of simple carbohydrates in diet, losing weight and increasing exercise
- There are also drugs to make insulin more effective on body cells, help the pancreas make more insulin or reduce the amount of glucose absorbed from the gut

Kidneys (3.3f-j)

Biology only

Effects of osmotic changes to body fluids

If water concentration of the blood increases, i.e. has higher water potential than the cells, water will move into the cells causing them to expand. Eventually this can lead to bursting (lysis)

If the water concentration of the blood decreases, i.e. has lower water potential than the cells, excess water will leave the cell causing shrinking.

Function of the kidneys

The kidneys are very important in maintaining the balance of water and other substances in the body. As blood moves through the body, it makes urine by:

- Filtering out the waste products, such as water, ions and urea (from amino acids), at high pressures
- Selectively reabsorbing useful substances such as glucose, ions and water

Structure of the kidney

- The inner part of the kidney is called the medulla and the outer part is called the cortex.
- The ureter carries from kidneys to the bladder to be excreted out the body.
- The kidney is supplied by the renal artery and a renal vein takes blood away.
- Each kidney contains millions of kidney tubules or nephrons and these are made up of a glomerulus (ball of capillaries), a region for selective reabsorption of substances to occur and a kidney tubule where water and salt is regulated.

ADH

Anti-diuretic hormone (ADH) is a hormone involved in the control of the loss of water as urine. It is released when a receptor in the brain detects that the blood is too concentrated.

ADH is released by the pituitary gland into the blood and travels to receptors in (distal convoluted tubule/collecting duct of) the kidney.

- **It travels in the bloodstream to the kidney tubules**
- **An increased amount of ADH reaching the tubules increases their permeability to water, so more moves out of the tubule and back into the bloodstream**
- **This results in a smaller volume of more concentrated (yellow) urine and the blood becoming less concentrated as more water moves into it.**

This is an example of a negative feedback loop, because if the concentration of the blood increases/decreases, more/less ADH is secreted to reverse this change.

In high temperatures, increased sweating can lead to dehydration. This can lead to salt loss in sweat, meaning that the kidneys may try to compensate for the change by increasing salt retention. The brain detects this and makes us feel that we are thirsty so that we drink more water to dilute the salts in our blood.