The Endocrine System

A Level

Part A Endocrine glands

The endocrine system is composed of endocrine glands (glands that release [ ] directly into the [ ]). These glands are found all over the body.

- Head/brain: the [ ], the pituitary gland, and the pineal gland
- Neck: the thyroid gland
- Chest: the thymus
- Abdomen: the [ ], the adrenal glands, and the gonads ([ ] in males, [ ] in females).

Items:

bloodstream **ovaries** **pancreas** **gastrointestinal tract** **enzymes** **testes** **hormones** **hypothalamus**

Part B Hormones

Which of the following statements about hormones are true? Select all that apply.

- [ ] hormones are proteins that catalyse biological reactions
- [ ] hormones are substances that are released by one part of the organism and act on another part of the organism
- [ ] hormones are substances that are released by one neuron into the space between it and another neuron
- [ ] all hormones are proteins
- [ ] all hormones are steroids
- [ ] some hormones are steroids and some hormones are proteins

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Part C Endocrine vs nervous system

Both the endocrine system and the nervous system help an organism respond to external changes. In many contexts, the two systems work together and are sometimes collectively referred to as the neuroendocrine system. However, there are some differences between the two systems. Fill in the table below to identify these differences.

	Endocrine system	Nervous system
signal type(s)		
signal carried by...		
speed of response		
duration of response		

Items:

electrical impulses and neurotransmitters | **long duration** | **short duration** | **neurons** | **blood** | **hormones** | **slower (seconds to days)** | **very fast (milliseconds)**

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Hormones

A Level

Part A Types of hormones

In animals, the two most common types of hormones are steroid hormones and peptide/protein hormones. The table below gives some examples of animal hormones.

Identify which type each hormone is.

Hormone	Type
insulin	
glucagon	
testosterone	
oestrogen	
follicle-stimulating hormone (FSH)	
luteinizing hormone (LH)	
cortisol	
antidiuretic hormone (ADH)	

Items:

steroid **peptide/protein**

Part B Steroid precursor

What is the precursor molecule that most steroid hormones are synthesised from?

Part C Hormone action

Which of the following statements are correct? Select all that apply.

- [ ] steroid hormones pass through the membrane of target cells and bind to receptor molecules inside the cell
- [ ] steroid hormones cannot pass through the membrane of target cells and so they bind to receptor molecules on the outside of the cell membrane
- [ ] peptide/protein hormones pass through the membrane of target cells and bind to receptor molecules inside the cell
- [ ] peptide/protein hormones cannot pass through the membrane of target cells and so they bind to receptor molecules on the outside of the cell membrane
- [ ] the binding of a hormone to a receptor inside the target cell forms a complex that can act as a transcription factor, causing specific genes to be expressed
- [ ] the binding of a hormone to a receptor on the outside of the target cell membrane can trigger a series of chemical reactions inside the cell

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Homeostasis

A Level

P P P

Part A Defining homeostasis

Which of the following is the definition of homeostasis?

- when a response produced by the control system leads to an **increase** in the stimulus detected by the receptor
- the maintenance of an internal environment within restricted limits
- the maintenance of body temperature within restricted limits
- when the response produced by the control system leads to a **decrease** in the stimulus detected by the receptor and turns the system off
- the maintenance of blood water potential within restricted limits

Part B Negative feedback

Negative feedback is an important mechanism in homeostasis.

Drag the steps below into the correct order on the right to show how negative feedback helps ensure homeostasis.

Available items

- the state returns to the normal state
- the change from the normal state is detected by sensory cells
- a change from the normal state occurs
- the response of the endocrine system/nervous system stops
- the endocrine system/nervous system produces a signal in response
- the sensory cells stop responding

Part C Examples of negative feedback

Which of the following things are regulated by negative feedback in mammals? Select all that apply.

- [ ] blood pH
- [ ] blood clotting
- [ ] blood water potential
- [ ] blood glucose levels
- [ ] blood pressure
- [ ] internal body temperature
- [ ] uterine contractions during childbirth

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The Hypothalamus and the Pituitary Gland

A Level
C C C

The hypothalamus is sometimes called the "control centre" of the brain. It receives signals from other parts of the nervous system and sends signals to other endocrine glands via the pituitary gland. The pituitary gland is sometimes called the "master gland" because it secretes hormones that regulate almost all of the other endocrine glands.

There are various subsystems within the endocrine system called "axes" that all involve the hypothalamus and the pituitary gland. These include:

- HPA axis (hypothalamic-pituitary-adrenal axis)
- HPG axis (hypothalamic-pituitary-gonadal axis)
- HPT axis (hypothalamic-pituitary-thyroid axis)

The hypothalamus connects to the pituitary gland in two different ways. It connects to the anterior pituitary gland via blood vessels, and it connects to the posterior pituitary gland via neurons.

Part A HPA axis

The HPA axis (hypothalamic-pituitary-adrenal axis) is responsible for releasing cortisol, one of the main "stress hormones" which is involved in increasing blood glucose levels and increasing blood pressure.

When a stressful stimulus is detected, corticotropin-releasing hormone (CRH) is released, which stimulates the release of adrenocorticotropic hormone (ACTH), which stimulates the release of cortisol.

Match the hormone to the endocrine gland in the table below.

Hormone	Endocrine gland
adrenocorticotropic hormone (ACTH)	
corticotropin-releasing hormone (CRH)	
cortisol	

Items:

adrenal glands **hypothalamus** **ovaries** **pancreas** **pituitary gland** **testes** **thymus** **thyroid gland**

Part B HPG axis

The HPG axis (hypothalamic-pituitary-gonadal axis) is responsible for releasing oestrogen and testosterone, two major "sex hormones" which are involved in the development of the reproductive systems during puberty, among other things.

In males, the release of gonadotropin-releasing hormone (GnRH) stimulates the release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH), which stimulate the release of testosterone and the production of sperm cells.

Match the hormone to the endocrine gland in the table below for males.

Hormone	Endocrine gland
follicle-stimulating hormone (FSH)	
gonadotropin-releasing hormone (GnRH)	
luteinizing hormone (LH)	
testosterone	

Items:

adrenal glands **hypothalamus** **ovaries** **pancreas** **pituitary gland** **testes** **thymus** **thyroid gland**

Part C HPT axis

The HPT axis (hypothalamic-pituitary-thyroid axis) is responsible for releasing thyroid hormones (T3 and T4) which are involved in regulating the body's metabolism.

The release of thyrotropin-releasing hormone (TRH) stimulates the release of thyroid-stimulating hormone (TSH), which stimulates the release of thyroid hormones (T3 and T4).

Match the hormone to the endocrine gland in the table below.

Hormone	Endocrine gland
thyroid hormones (T3 and T4)	
thyroid-stimulating hormone (TSH)	
thyrotropin-releasing hormone (TRH)	

Items:

adrenal glands **hypothalamus** **ovaries** **pancreas** **pituitary gland** **testes** **thymus** **thyroid gland**

Part D Regulation

In the examples given above, the hormones released by the adrenal glands/gonads/thyroid gland inhibit the release of the hormones released by the hypothalamus.

What is the name given to this mechanism which ensures that hormone levels will not keep increasing?

Part E Pituitary parts

In the examples given above, the hormones released by the hypothalamus travel to the pituitary gland via the bloodstream.

Which part of the pituitary gland will release hormones in response to this?

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Adrenaline

A Level

Adrenaline is one of the hormones involved in an animal's "fight or flight" response. When an animal detects a threat, the hypothalamus sends a signal through the sympathetic nervous system to trigger the release of adrenaline into the bloodstream.

Part A Source

Name the endocrine gland in humans that releases adrenaline into the bloodstream.

Part B Responses

Which of the following physiological responses are triggered by the binding of adrenaline to target cells? Select all that apply.

- [ ] increased heart rate
- [ ] decreased heart rate
- [ ] glycogenolysis in the liver
- [ ] glycogenesis in the liver
- [ ] smooth muscle relaxation in the lungs
- [ ] smooth muscle contraction in the lungs

Part C Functions

How do the physiological responses triggered by adrenaline help the organism respond to a threat? Select all that apply.

- [ ] oxygen uptake is increased
- [ ] aerobic respiration rates can increase
- [ ] the digestive system works faster
- [ ] more water is reabsorbed into the blood
- [ ] blood glucose levels are increased
- [ ] skeletal muscles can contract more frequently, allowing the organism to move quickly for a longer period of time

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Physics. You work it out.

The Second Messenger Model: Adrenaline

A Level

P P P

Hormones that cannot pass directly through the cell membrane rely on second messengers (small intracellular signalling molecules/ions) to induce a response in target cells. The model that describes this process is called the second messenger model.

In the second messenger model, the hormone (the first messenger) binds to a receptor on the outside of the cell membrane. This causes the activation of the primary effector inside the cell, which causes the production/activation of the second messenger. The second messenger then activates the secondary effector, which causes the target cell to carry out the correct response.

Adrenaline is an example of a hormone that relies on a second messenger.

Part A Adrenaline structure

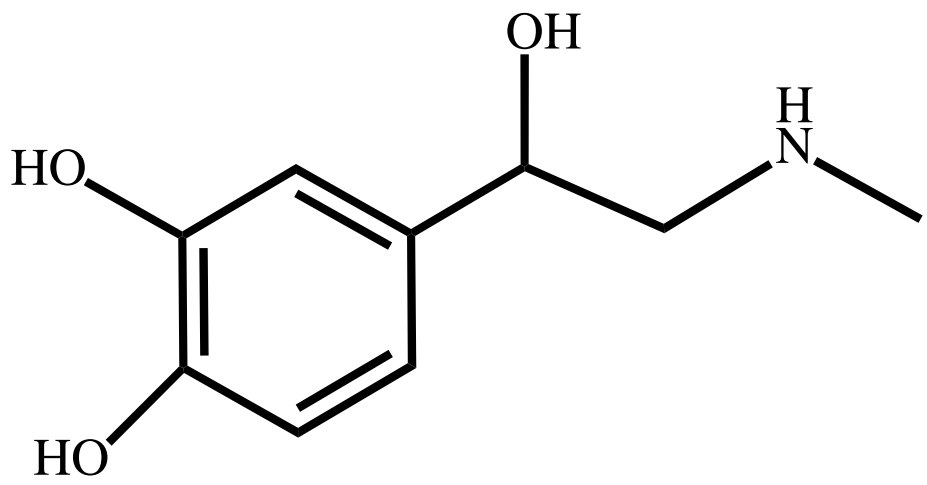

Figure 1: Skeletal formula of adrenaline.

Based on **Figure 1**, which of the following statements explain why adrenaline relies on a second messenger? Select all that apply.

- [ ] adrenaline is an ion
- [ ] adrenaline is a polar molecule
- [ ] adrenaline is a non-polar molecule
- [ ] adrenaline is too large to pass through the cell membrane
- [ ] only polar molecules and ions can pass through the cell membrane
- [ ] only non-polar molecules can pass through the cell membrane

Part B Adrenaline action

Drag the items below into the correct order on the right to show how adrenaline causes liver cells to break down glycogen.

Some of the items are not part of this process, and so you should not use all of them.

Available items

- Adrenaline binds to a receptor (a transmembrane protein) on the outside of the liver cell membrane.
- Cyclic AMP (cAMP) activates the enzyme protein kinase, which activates the enzymes required for glycogenolysis.
- Adenyl cyclase catalyses the formation of cyclic AMP (cAMP) from ATP.
- The transmembrane protein undergoes a conformational change, causing the activation of the enzyme adenyl cyclase, which is attached to the transmembrane protein inside the cell.
- Glucose molecules are converted into glycogen.
- Glycogen is broken down into glucose molecules.
- Adrenaline passes through the liver cell membrane and binds to a receptor inside the cell.

Part C Molecules & functions

Using the information above, and your answer to the previous section, match the molecule to the function in the table below.

Function	Molecule
First messenger	
Primary effector	
Second messenger	
Secondary effector	

Items:

glucose **adrenaline** **cyclic AMP (cAMP)** **protein kinase** **glycogen** **adenyl cyclase**

Part D True or false

Which of the following statements about second messengers are correct? Select all that apply.

- [ ] Second messengers are hormones that travel through the blood to the target cell.
- [ ] Second messengers are enzymes that carry out the response of the target cell.
- [ ] Second messengers are signalling molecules found inside the target cell.
- [ ] Second messengers pass through the target cell membrane.
- [ ] Second messengers relay signals from the target cell membrane to the cytosol or nucleus, where the response of the target cell occurs.

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