The Digestive System

Subject & topics: Biology | Physiology | Digestion & Excretion **Stage & difficulty:** A Level P2

The digestive system is composed of the gastrointestinal tract (GI) and the accessory organs of digestion.

The gastrointestinal tract (GI), also referred to as the "gut", is the passageway from the mouth to the anus. It is composed of all of the major organs that food moves through as it is digested.

The accessory organs are the organs that aid in digestion, but which food does not travel through.

Part A

The gastrointestinal tract

Drag the items (left) into the correct order (right) to show the passage of food through the gastrointestinal tract (top to bottom) in humans.

Note that not all of the items below are regions that food moves through, and so you should not use all of the items below.

Available items

- pharynx
- small intestine
- mouth
- oesophagus
- pancreas
- larynx
- anus
- stomach
- liver
- bladder
- large intestine
- kidneys

Part B

Parts & functions

Match the part of the digestive system to the function(s) in the table below.

Part	Function(s)
	main site of digestion and absorption of nutrients
	produces acidic solution that kills microorganisms, denatures proteins, and enables digestive enzymes with a low optimal pH (e.g. pepsin) to function
	produces alkaline solution that contains digestive enzymes
	absorbs water and ions, and ferments indigestible material
	produces bile which helps break down lipids
	moves food into the stomach

Items:

liver | large intestine | oesophagus | small intestine | stomach | pancreas

Part C

Digestive enzymes

Fill in the table below to show how large macromolecules are broken down into smaller molecules in the digestive system.

Enzyme	Site(s) of origin	Reactant(s)	Product(s)
amylase	salivary glands, pancreas		
pepsin	stomach		
lipase	stomach, pancreas		
maltase	small intestine	maltose	
lactase	small intestine	lactose	
sucrase	small intestine	sucrose	

Items:

triglycerides | small peptides/amino acids | trisaccharides & disaccharides | glycerol & fatty acids | proteins | glucose & fructose | glucose only | starch | glucose & galactose

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The Endocrine System

Subject & topics: Biology | Physiology | Hormones **Stage & difficulty:** A Level P1

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:

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

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

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:

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

Homeostasis

Subject & topics: Biology | Physiology | Hormones **Stage & difficulty:** A Level P1

Part A

Defining homeostasis

Which of the following is the definition of homeostasis?

- 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
- 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

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

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

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

Question deck:

STEM SMART Biology Week 36 - The Digestive & Endocrine Systems

Blood Glucose Regulation

Subject & topics: Biology | Physiology | Digestion & Excretion **Stage & difficulty:** A Level P3

Glucose is the main respiratory substrate used by cells for respiration. Because of this, organisms need to tightly regulate how much glucose is available. When glucose is abundant it needs to be stored so that, when glucose is scarce, stored glucose can be released to cells. There are two main hormones responsible for this regulation: insulin and glucagon.

Part A

Insulin secretion

Drag the items (left) into the correct order (right) to show the sequence of events that result in insulin secretion.

Note that not all of the items below are part of the correct sequence of events, and so you should not use all of the items below.

Available items

- ATP-sensitive potassium ion channels **close**, which means that potassium ions stop diffusing out of the cells, and so the cells begin to depolarise from $\approx -70\,\mathrm{mV}$ to $\approx -30\,\mathrm{mV}$
- Voltage-gated calcium ion channels open, which causes calcium ions to move **into** the cells
- Calcium ions cause insulin-containing secretory vesicles to release insulin by **endocytosis**
- the rate of respiration of glucose increases in the cells, which results in more ATP being produced
- ATP-sensitive potassium ion channels **open**, which means that potassium ions diffuse out of the cells, and so the cells begin to depolarise from $\approx -70\,\mathrm{mV}$ to $\approx -30\,\mathrm{mV}$
- a rise in glucose concentration results in more glucose diffusing (by facilitated diffusion) into the β cells of the islets of Langerhans
- Calcium ions cause insulin-containing secretory vesicles to release insulin by **exocytosis**
- Voltage-gated calcium ion channels open, which causes calcium ions to move **out of** the cells

Part B

Insulin action

Most cells in the body have insulin receptors in their cell membranes.

Which of the following events occur as a result of insulin binding to these insulin receptors? Select all that apply.

- [ ] insulin-dependent glucose membrane transport proteins open, causing an **increase** in uptake of glucose from the bloodstream by cells
- [ ] insulin-dependent glucose membrane transport proteins open, causing a **decrease** in uptake of glucose from the bloodstream by cells
- [ ] glucose is converted into glycogen (i.e. **glycogenesis**) in liver cells and skeletal muscle cells
- [ ] glycogen is broken down into glucose (i.e. **glycogenolysis**) in liver cells
- [ ] glucose is converted into triglycerides (i.e. **lipogenesis**) in liver cells and adipose cells
- [ ] triglycerides are broken down into glycerol and fatty acids (i.e. **lipolysis**) in adipose tissue, and glycerol and amino acids are converted into glucose (i.e. **gluconeogenesis**) in liver cells

Part C

Glucagon action

Unlike insulin, only a few cell types have glucagon receptors in their cell membranes.

Which of the following events occur as a result of glucagon binding to these glucagon receptors? Select all that apply.

- [ ] insulin-dependent glucose membrane transport proteins open, causing an **increase** in uptake of glucose from the bloodstream by cells
- [ ] insulin-dependent glucose membrane transport proteins open, causing a **decrease** in uptake of glucose from the bloodstream by cells
- [ ] glucose is converted into glycogen (i.e. **glycogenesis**) in liver cells and skeletal muscle cells
- [ ] glycogen is broken down into glucose (i.e. **glycogenolysis**) in liver cells
- [ ] glucose is converted into triglycerides (i.e. **lipogenesis**) in liver cells and adipose cells
- [ ] triglycerides are broken down into glycerol and fatty acids (i.e. **lipolysis**) in adipose tissue, and glycerol and amino acids are converted into glucose (i.e. **gluconeogenesis**) in liver cells

Part D

Name the hormone

Name **another** hormone that causes glycogenolysis in liver cells and muscle cells by binding to membrane receptors of those cells.

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Oral Glucose Tolerance Test

Subject & topics: Biology | Physiology | Digestion & Excretion **Stage & difficulty:** A Level C3

The oral glucose tolerance test (OGTT) is used to diagnose diabetes.

A result from an OGTT measuring blood glucose and insulin concentrations is shown below.

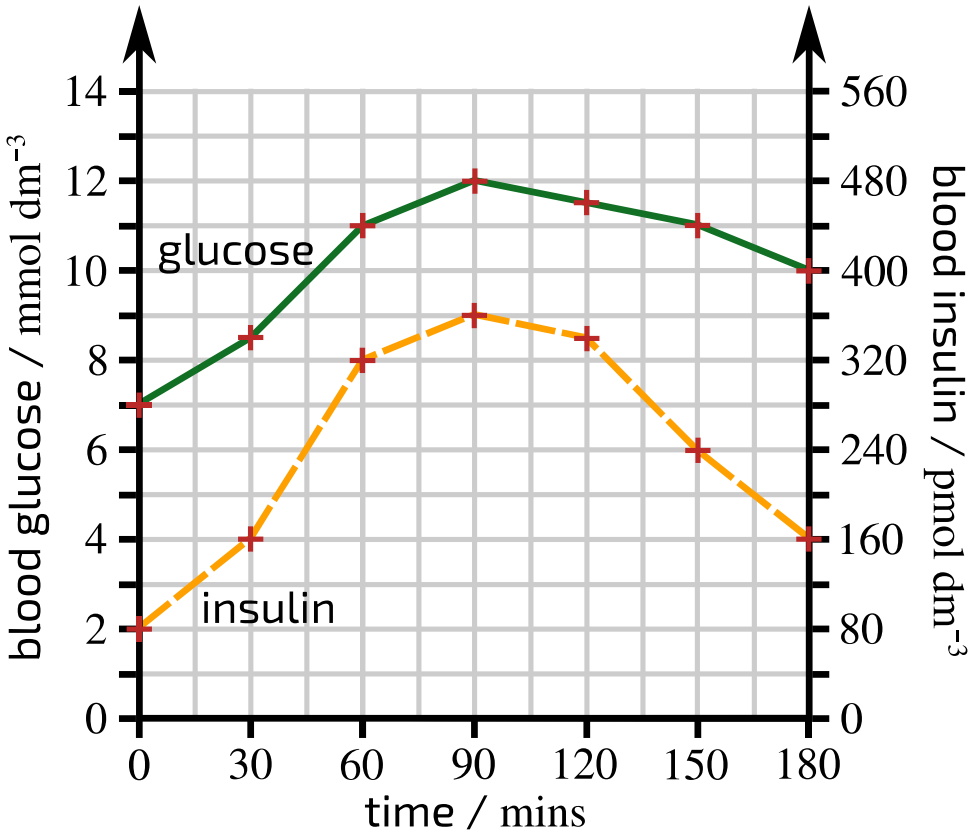

Figure 1: The results of an oral glucose tolerance test. The patient fasted for 12 hours prior to the test. At the beginning of the test (time $= 0$ mins), the patient was given a glucose solution to drink and a blood sample was taken. Blood samples were then taken every 30 mins over the next 3 hours. Glucose and insulin concentrations were measured from these blood samples and the results were plotted on a graph.

Part A

Glucose increase & decrease

Calculate the percentage increase in blood glucose concentration from 0 minutes to 90 minutes.

Give your answer to the nearest percent.

Calculate the percentage decrease in blood glucose concentration from 90 minutes to 180 minutes.

Give your answer to the nearest percent.

Part B

Glucose vs insulin concentrations

Calculate the value of $\frac{\text{blood glucose concentration}}{\text{blood insulin concentration}}$ at 90 minutes.

Give your answer to 1 significant figure.

Part C

Molecules of glucose

The individual has approximately $5\,\text{litres}$ of blood in their body.

Estimate the number of molecules of glucose in their circulatory system at 90 minutes.

Give your answer to 2 significant figures.

Part D

Diabetes diagnosis

The OGTT result in **Figure 1** shows evidence of diabetes.

Which type of diabetes does the patient have, and how can this be concluded? Select a type and **two** pieces of evidence below.

- [ ] type: 1
- [ ] type: 2
- [ ] evidence: the graph shows normal changes in blood glucose and insulin concentrations
- [ ] evidence: insulin is produced in response to a rise in blood glucose concentration
- [ ] evidence: not enough insulin is produced in response to a rise in blood glucose concentration
- [ ] evidence: blood insulation concentration is almost as high as blood glucose concentration
- [ ] evidence: blood glucose concentration decreases slowly in response to insulin
- [ ] evidence: blood glucose concentration continues to increase even when blood insulin concentration is increasing

Adapted with permission from OCR A Level Biology B, June 2017, Fundamentals of Biology, Question 32

Question deck:

STEM SMART Biology Week 36 - The Digestive & Endocrine Systems

The Second Messenger Model: Adrenaline

Subject & topics: Biology | Physiology | Hormones **Stage & difficulty:** A Level P2

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

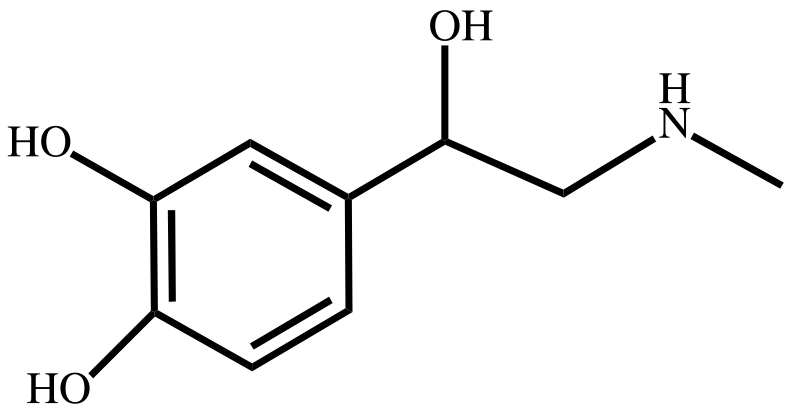

Figure 1: Skeletal formula of adrenaline.

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

- Glycogen is broken down into glucose molecules.
- Adenyl cyclase catalyses the formation of cyclic AMP (cAMP) from ATP.
- 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.
- Glucose molecules are converted into glycogen.
- Adrenaline passes through the liver cell membrane and binds to a receptor inside the cell.
- 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.

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:

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

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.