SL Paper 3

Explain the effects of cocaine in terms of action at synapses in the brain.

Markscheme

cocaine affects synapses using dopamine as neurotransmitter;

cocaine attaches to dopamine receptors on presynaptic membrane;

blocks dopamine transporters/prevents re-uptake / causes dopamine to persist in the synaptic cleft;

amplifies synaptic transmission / is an excitatory psychoactive drug / causes constant stimulation of postsynaptic neuron;

dopamine builds up in the synapse contributing to euphoria/pleasurable effects;

Examiners report

Most candidates have some understanding of the effects of cocaine, but answers were often lacking in sufficient detail for two marks. The majority did not understand the way that cocaine affects the synapse.

a. Distinguish between innate and learned behaviour. [1]

b. Outline the role of inheritance and learning in the development of birdsong in young birds. [2]

c. Explain the effects of cocaine on mood and behaviour. [2]

Markscheme

a. innate behaviour develops independently of the environmental context/genetically

   inherited <u>and</u> learned behaviour develops as a result of experience / *OWTTE*

b. young birds learn birdsong from parents/other adults;

   young birds removed from parents capable of own song;

   basic song template may be inherited;

   learned birdsong is louder/richer;

c. (cocaine causes) dopamine build up in synapses / continuous neurotransmitter presence;

increased energy/alertness/feeling of euphoria/pleasure;

user becomes isolated/suspicious/less productive / alienates family and friends;

cocaine addiction/use may lead to crime/robbery to buy cocaine;

Examiners report

a. Many were not able to explain the difference between innate and learned behaviour clearly.

b. The outlines given by candidates on the role of inheritance and learning on development of birdsong were often not clear.

c. Many candidates were able to obtain one mark for indicating an example of the effect cocaine had on mood or behaviour. Few were able to state the build up of dopamine in synapses or continuous neurotransmitter presence due to cocaine.

---

a. List **two** groups of sensory receptors, giving the stimulus each perceives. [2]

b. Explain the processing of visual stimuli. [4]

Markscheme

a. mechanoreceptors – pressure;

chemoreceptors – chemical substances/pH;

thermoreceptors – temperature;

photoreceptors – light;

mechanoreceptors/proprioceptors – stretching/pressure;

hydroreceptors – humidity;

Accept other appropriate receptors with a stimulus.

b. retina/rod/cone cells convert light into impulses;

impulses pass to bipolar cells;

bipolar cells pass impulses to (sensory neurons of) the optic nerve;

at the optic chiasma, impulses cross over to the opposite optic nerve;

impulses continue to the thalamus where optical information is processed;

images form in the visual cortex;

Examiners report

a. N/A

b. The candidates found difficulty again with explanation of process. Many candidates were just regurgitating from some text about peripheral vision and not answering the question. Few scored rods/cones converting light to nerve impulses. Many candidates were wrongly stating that light passes through the nerves.

---

a. Outline the function of the autonomic nervous system in the human body. [2]

b. Evaluate the use of the pupil reflex to test for brain damage. [3]

Markscheme

a. a. controls involuntary processes in the body

b. «uses centres located» in the brain stem/medulla

c. example of action of autonomic nervous system *eg: the regulation of heart rate*

b. a. a light is shone in the eye

b. «when light shone in eyes» if pupil does not constrict then there is some brain damage

c. if the pupil constricts it rules out certain types of brain damage

d. different response from each eye could indicate brain damage

e. more testing is needed to determine area/extent of brain damage *OWTTE*

Examiners report

a. [N/A]
b. [N/A]

Explain the functioning of hair cells in the semicircular canals of the inner ear.

Markscheme

«Sensory hair cells found in semicircular canals» detect movement of the head

Fluid in the canals lags behind movement of head
OR
inertia of fluid makes it move more slowly than head

Fluid movement causes “hairs” of hair cells to bend

Bending of hairs causes nearby sensory neuron to conduct signal

Hairs in all three semicircular canals «which are at right angles so» detect head movement in any direction

Signals passed on to the nerve/brain

Examiners report

Many candidates confused the semicircular canals with the cochlea and described the role of the hair cells in in hearing.

---

e. Explain how sound is perceived by the ear. [3]

f. Hearing is a result of the stimulation of mechanoreceptors. List **three** other main types of receptors. [1]

1. .....
2. .....
3. .....

Markscheme

e. sound (waves) vibrate eardrum/tympanic membrane;

movement is magnified by ossicles/middle ear bones;

oval window vibrates / fluid in cochlea moves and moves hairs in cochlea;

different frequencies detected by different parts of cochlea membrane and hair cells;

these are connected to the auditory nerve;

f. chemoreceptors / photoreceptors / thermoreceptors / baroreceptors

*Award **[1]** for three correct receptors*.

Examiners report

e. Most candidates were able to gain at least 2 marks and many 3 marks in (e) for explaining sound perception by the ear.

f. Many candidates were able to list three other types of receptors for the mark in (f).

Explain how information from the left and right sides of the visual field is processed.

Markscheme

a. information from the left-half of the visual field is detected by the right-half of the retina

OR

information from the right-half of the visual field is detected by the left-half of the retina

b. information from left-half of visual field is processed by the right hemisphere

OR

information from right-half of visual field is processed by the left hemisphere

c. impulses travel through optic nerve

d. optic nerves from each eye meet at the «optic» chiasma

e. information from inner fields «closer to the nose» cross at the «optic» chiasma *OWTTE*

f. impulses continue to the brain

g. an image forms in the visual cortex

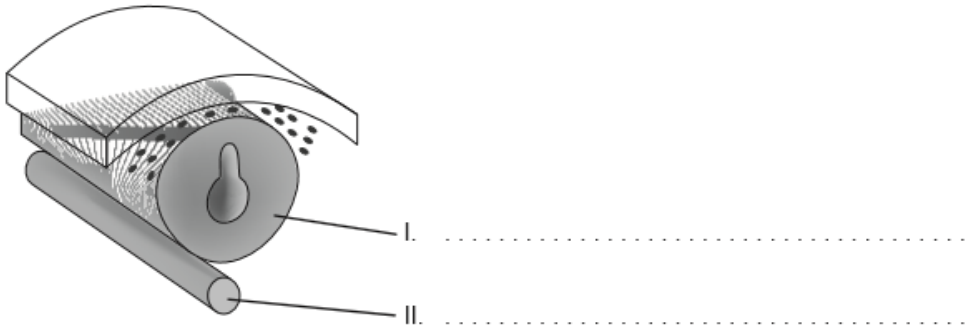
Accept answer in a clearly annotated diagram.

Examiners report

[N/A]

---

a. The diagram shows an advanced stage during neurulation in humans or chicks. [2]



Label structures I and II

b. State the process by which neurons are initially produced in the embryo. [1]

c. Outline the plasticity of the nervous system. [2]

Markscheme

a. *I*: neural tube

II: notochord

b. Differentiation/neurogenesis «in the neural tube»

c. Plasticity allows the nervous system to adapt «structurally»

OR

plasticity allows cortical remapping/new connections

Neurons «axons» grow in response to stimulation/experience

Unused neurons die/are lost through pruning

Accept synapses in place of neurons

Examiners report

a. Question 4 was generally well answered. A few candidates had difficulty labelling the diagram of neurulation.

b. Question 4 was generally well answered.

c. Question 4 was generally well answered. Most could outline plasticity.

---

a. List two examples of excitatory psychoactive drugs. [1]

b. Outline the possible effects of excitatory drugs on mood and behaviour. [2]

c. Discuss the causes of addiction to cocaine. [3]

Markscheme

a. nicotine;

cocaine;

amphetamines;

ecstasy;

*Award **[1]** for any **two**. Consider the first two only, if there are more.*

b. a. increases arousal/alertness;

b. feelings of excitement/euphoria;

c. aggressive behaviour;

d. loss of judgement/self-control;

e. social withdrawal/depression/dysfunction;

f. loss of appetite;

c. a. peer pressure / cultural traditions;

b. inherited / genetic predisposition;

c. social problems / trauma;

d. passed from mother to newborn/when breast feeding;

e. many stimulate synapses with dopamine as a transmitter / blocks re-uptake of dopamine;

f. pleasurable effects of dopamine/euphoria/regular use may lead to addiction;

g. increasingly large/more regular doses needed for effect;

Examiners report

a. The majority of candidates knew two excitatory drugs and could list effects on behaviour.

b. The majority of candidates knew two excitatory drugs and could list effects on behaviour.

c. There were good answers addressing reasons for drug addiction, with many explaining the dopamine effect.

---

a (ii) State **two** effects that presynaptic neurons can have on postsynaptic transmission. [1]

1. .....
2. .....

c. Suggest causes of addiction to drugs. [3]

Markscheme

a (ii) excite and inhibit (*both needed*)

c. a. dopamine stimulates brain's reward system/pathways / addiction requires dopamine excess in brain;

b. inhibitory drugs/benzodiazepines/alcohol/drugs decrease neuron activity that inhibits dopamine release so brain becomes addicted;

c. excitatory drugs/cocaine/amphetamines/nicotine block removal of dopamine stimulating brain (reward system);

d. genetic component involved;

e. genetic tendency for addiction influenced by social factor/example of social factor (eg peer pressure, poverty, social deprivation, trauma, mental health problem/culture);

Examiners report

a (ii) Few were able to give excite and inhibit as the two effects in a(ii).

c. In c the genetic components and the effects of social pressure were well known. Many knew that the cause was linked to dopamine, but did not explain in sufficient detail.

---

a. Distinguish between innate behaviour and learned behaviour. [1]

b. Outline Pavlov's experiments into conditioning of dogs. [2]

Markscheme

a. innate behaviour develops independently of the environmental context, whereas

learned behaviour develops as a result of experience

*To award **[1]**, answers need to address both innate and learned behaviour.*

Do not accept "instinct" as a description of innate behaviour.

b. conditioned stimulus of sound/ringing bell / other stimulus used by Pavlov;

replaces unconditioned stimulus of sight/smell of food;

both result in conditioned response/production of saliva;

Examiners report

a. The question in part (a) has occurred frequently and it seems that many were able to distinguish between innate and learned behavior.

b. There were some very good outlines of Pavlov's experiments in (b) into conditioning in dogs. Many candidates were able to gain 2 marks, showing a good understanding of Pavlov's experiment.

Explain the effect of tetrahydrocannabinol (THC) on brain function.

Markscheme

binds to cannaboid/pre-synaptic receptors;

inhibits neurotransmitter release;

therefore no excitation of post-synaptic membranes;

Examiners report

Many candidates explained the effect of THC correctly.

---

a (i) State the type of receptor cells that detect sound. [1]

b. Outline the role of inheritance and learning in the development of birdsong in young birds. [2]

Markscheme

a (i) mechanoreceptor

b. inheritance plays role as basic song is the same for all members of a species;

birds raised in isolation still sing but song lacks complexity/sounds different from song heard in the wild / more complex songs develop when there is social interaction;

young birds learn details of songs/dialects from fathers/other birds;

(development of birdsong) is a form of motor learning/ability to learn is genetic/inherited;

Examiners report

a (i) Most candidates were able to give the correct answer to this.

b. This was generally not answered well apart from a few candidates who had obviously been well prepared. Most answers were vague and did not address the points in the mark scheme.

Explain the effects of tetrahydrocannabinol (THC) in terms of its action at synapses in the brain.

Markscheme

THC binds to cannabinoid receptor;

blocks release of (excitatory) neurotransmitter;

therefore it is inhibitory;

euphoria/anxiety/short-term memory loss/impaired coordination/pain relief;

extended use leading to social dysfunction/addiction;

Examiners report

Many candidates were able to gain 2 marks and the better ones 3 marks for the effects of THC in (b). Some responses, however, seemed to rely on common street knowledge rather than any biological knowledge.

---

a. List **two** dietary sources of vitamin D. [1]

a (ii) State an example of these receptors in humans. [1]

b. Discuss exposure to sunlight as a source of vitamin D. [3]

Markscheme

a. *e.g.* cod liver oil / fish liver oil / oily fish (accept correctly named example) / egg yolk / fortified cereal / ONE named dairy product (*i.e.* milk/cheese/ yoghurt)

*Allow any **two** sources for the mark. Reject fish alone.*

a (ii) hair cells of cochlea

b. UV light/sunlight on skin causes chemical production of vitamin D;

UV too low in winter in high latitudes;

vitamin D stored in liver so can make enough to last several months/through winter;

UV light can damage skin and cause skin cancer so exposure needs to be limited;

use of sun-block will inhibit vitamin D production;

covering skin with clothing prevents UV reaching skin; *Accept reference to cultural/religious customs*

Examiners report

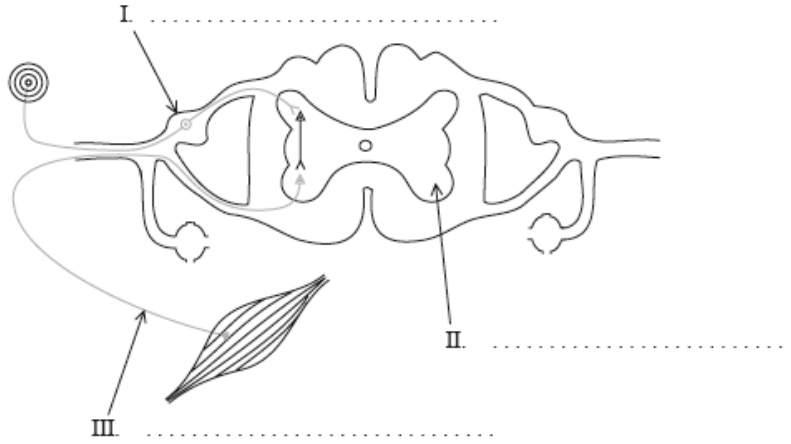
a. Many gained the mark here, but a large proportion could not list two valid dietary sources of vitamin D, often giving fruit and vegetables as a possibility. The emphasis should also have been on oily fish.

a (ii) Few correct answers to this part, many suggesting “eardrum”, or simply “hairs in ears”.

b. This question was badly answered on the whole. The main misconception is that sunlight contains vitamin D, and many did not explain the role of the skin in the production of the vitamin. There is, however, an overall general awareness of the connection between UV light and skin cancer

---

Label the parts of the reflex arc shown below.



Markscheme

I. dorsal root ganglion;

II. grey matter;

III. motor neuron;

Examiners report

The labelling of the spinal reflex was fairly well done. The structure that caused problems was the dorsal root ganglion with some indicating this was a sensory cell body.

---

a. Compare rods and cones. [3]

b. Explain the role of receptors, sensory neurons and motor neurons in the response of animals to stimuli. [3]

c. List **four** general kinds of sensory receptor. [2]

1.

2.

3.

4.

Markscheme

a.

Rods	*Cones*
work better in dim conditions	only stimulated by bright light;
absorb all the visible wavelengths of light / but do not distinguish wavelengths/colours	different kinds of cones absorb different wavelengths / different types for different wavelengths/colours of light;
spread through retina	concentrated in centre of retina;
multiple rod cells per neuron	one cone cell per neuron;

b. receptors detect stimuli;

transmit information regarding stimuli to the central nervous system;

via sensory neurons;

central nervous system sends impulse to effector;

via motor neuron;

c. *Award **[1]** for every two correct answers.*

thermoreceptor / chemoreceptor / photoreceptor / mechanoreceptor / baroreceptor / propioceptor

Examiners report

a. This was answered well by a few candidates who adequately compared rod cells with cone cells. A frequent misconception among some candidates was that each cone cell is sensitive to all three colours (red, green and blue).

b. Most candidates answered this question correctly.

c. Most candidates knew four examples of sensory receptors.

---

a. State **one** example of an excitatory and **one** example of an inhibitory psychoactive drug. [2]

Excitatory: .....

Inhibitory: .....

c. Discuss causes of addiction. [3]

Markscheme

a. *excitatory*: cocaine / nicotine / amphetamines;

inhibitory: benzodiazepines / alcohol / THC;

Accept other suitable examples.

c. addictive drugs trigger secretion of dopamine which causes feelings of pleasure/ well-being/reward / users become dependent on feelings;

genetic predisposition is most common with addiction to alcohol;

social factors affect the incidence of addiction;

it is not certain that a person who is genetically predisposed will develop addiction when exposed to the drug / *OWTTE*;

although many drugs are (potentially) addictive, not every user becomes an addict;

named social factors which must be explained:
e.g. cultural traditions / peer pressure;
social deprivation / traumatic life experiences / mental problems;

Examiners report

a. E3 was well answered on the whole, though a few candidates confused inhibitory with excitatory drugs.

c. E3 was well answered on the whole.

Explain the effects of psychoactive drugs on synaptic transmission.

Markscheme

psychoactive drugs may increase or decrease transmission (to the post-synaptic membrane);

may increase the release/delay the breakdown/interfere with storage/uptake/reabsorption of neurotransmitters;

may mimic the action of neurotransmitters;

inhibitory drugs may reduce the effect of excitatory neurotransmitters / increase the effect/release of inhibitory neurotransmitters;

inhibitory drugs can hyperpolarize the post-synaptic neuron;

Examiners report

This question was generally not well answered, with many candidates describing specific drugs rather than giving general effects on the synapse.

---

a. Distinguish, using examples, between innate behaviour and learned behaviour. [3]

b. Using **two** examples, discuss how the process of learning can improve survival. [2]

Markscheme

a. learned behaviour occurs as a result of experience (while innate is independent of environment);

   innate behaviour is controlled by genes/inherited (while learned is not inherited);

   correct example of both;

b. name of animal, how they learn and advantages for survival;

   name of another animal, how they learn and advantages for survival;

   e.g. grizzly bears by operant conditioning/practise how to catch salmon providing needed food supply;

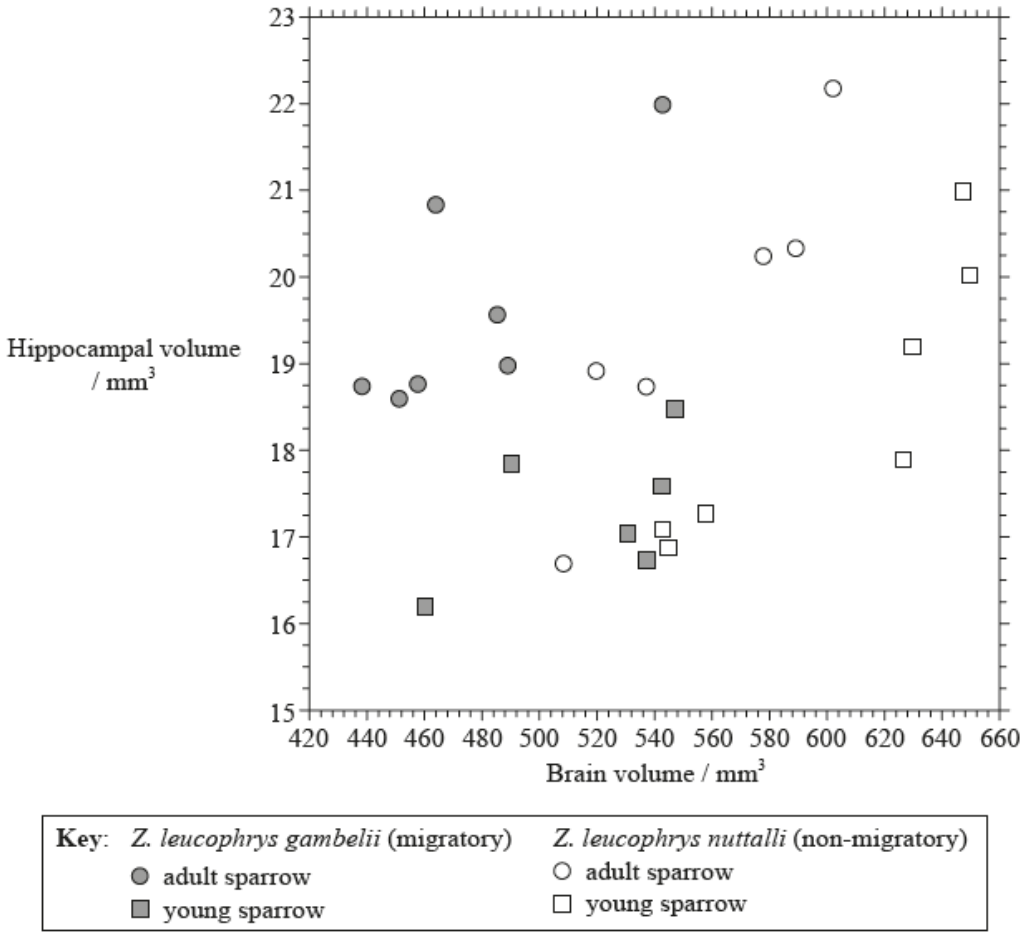
   goslings learn who their mother is/imprinting, avoid predators by staying near mother;

Examiners report

a. N/A

b. Connecting the learning to survival seemed difficult for some. It seemed that everyone knew about the hedgehogs crossing the roads.

The hippocampus plays an important role in memory and spatial navigation. A larger hippocampus relative to brain volume has been associated with better spatial memory in birds. Two subspecies of the white-crowned sparrow, *Zonotrichia leucophrys gambelii* (migratory) and *Zonotrichia leucophrys nuttalli* (non-migratory) were compared. The graph shows the relationship between the volumes of the hippocampus and the brain in adult and young sparrows.



[Source: Adapted from V. V. Pravosudov et al. (2006) 'The relationship between migratory behaviour, memory and the hippocampus: an intraspecific comparison.' *Proceedings of the Royal Society B*, **273** (1601), pp. 2641–2649. Fig. 3. By permission of the Royal Society.]

Relative hippocampal volume is the ratio between the volume of the hippocampus and the volume of the whole brain (hippocampus/brain).

a. State the relationship between brain volume and hippocampal volume in the non-migratory sparrows. [1]

b. Compare the hippocampal volume in migratory and non-migratory young and adult sparrows. [2]

c.i. Analyse the data in the scattergraph to find which of the four groups of birds has the highest relative hippocampal volume. [1]

c.ii. Suggest a reason why this group needs the largest relative hippocampal volume. [1]

d. It is possible that non-migratory species possess more advanced cognitive skills other than spatial memory. Use the data to evaluate this hypothesis. [2]

Markscheme

a. as brain volume increases so does hippocampus volume / positive correlation

b. hippocampus volumes are larger in adults than in young birds;

larger range for migratory;

young non-migratory show wider range of hippocampus volumes than young migratory;

some overlap for non-migratory / none for migratory;

c.i. adult migratory (as for any brain volume this group has the largest hippocampal volume) } *(allow mathematical explanation)*

c.ii. needed for migration / only adults migrate/remember flight paths

(Do not accept spatial navigation on its own without reference to migration)

d. *Hypothesis supported*:

non-migratory have larger brain volume;

larger brain implies more thinking skills;

hippocampus in non-migratory is approx same size as in migratory;

Hypothesis not supported:

only two species/small sample studied so over generalization;

similar hippocampus volume in both migratory and non-migratory birds;

Examiners report

a. Most candidates received this mark for noting the positive correlation shown in the graph.

b. This was poorly answered overall, with more than 1 mark seldom being awarded for noting that hippocampus volumes are larger in adults than in young birds. Many looked at hippocampus to brain volume ratios while the question asks only about hippocampus volume.

c.i. Most candidates correctly answered both parts (i) and (ii).

c.ii. Most candidates correctly answered both parts (i) and (ii).

d. The evaluations done were mainly quite superficial yet many were able to get two marks for this question.

Outline the development of birdsong in young birds.

Markscheme

bird born with innate knowledge of (basic) song;

song birds have sensitive period during which they can learn a song;

must listen to tutor song;

birds are selective in what song they learn / not any song can be learned;

song must match some innate knowledge of song that bird is born with/inherited;

practice singing (subsong) precedes full song;

song, once learned, is rarely modified;

Examiners report

Most candidates were able to outline the development of birdsong.

Outline the nervous system processes involved in reading and responding to this question.

Markscheme

Photoreceptors in the retina detect reflected light/stimulus «from the page» (*Accept rods and cones in place of photoreceptors*).

Transmitted via the optic nerve to the visual cortex/brain/occipital lobe

Interpreting occurs in the cerebral cortex

Cerebral cortex involved in thinking

Cerebral cortex involved in memory

Motor/cerebral cortex involved in motor control
OR
motor neurons send impulses to muscle to move

Broca's area is a region in the cortex linked to speech production

Examiners report

Some confused ideas but most understood the nervous system processes and structures involved.

---

a. Using the table below, distinguish between *rod cells* and *cone cells*. [3]

Characteristic	Rod cells	Cone cells
Location		
Light intensity detected		
Connection to optic nerve		

b. Outline how sound is perceived in the ear. [3]

Markscheme

a.

characteristic	*rod cells*	*cone cells*
location	(all along the) retina	in fovea;
light intensity detected	dim/low	bright/high;
connection to optic nerve	group of rod cells to single nerve fibre	single cone to single nerve fibre;

*Award **[1]** for each correct row.*

b. sound waves make eardrum/tympanic membrane vibrate;

vibration passes along the bones of middle ear/ossicles/malleus, incus and stapes making oval window vibrate;

vibration passed to fluid in cochlea;

vibration in cochlea stimulate hair cells/mechanoreceptors;

nerve impulse passed to auditory nerve;

Examiners report

a. Although this seemed like an easy question, comments on the G2 forms indicated that the wording of the question was such that it was not clear what was required under 'characteristics'. In retrospect, candidates did do poorly on this as many earned only one mark for correctly identifying the different light intensities detected by rods and cones. A surprising number could not identify the fovea as the location of the cones. The connection to the optic nerve was answered correctly only by the better candidates. Perhaps the use of the optic nerve was confusing and bipolar neuron would have been clearer.

b. This is a question that occurred frequently. Outlining how sound is perceived by the ear was well done by the majority of candidates, with full marks often awarded.

Discuss the correlation between diet and brain size.

Markscheme

improved diet quality correlated (positively) with hominid skull development/size;

improved diet quality provides energy to support a greater brain function;

change of habitat (in Africa) 2.5 mya may have prompted emergence of *Homo* sp;

change in diet to include meat increased brain size (of hominids);

cooking food enabled hominids to eat a wider variety of food;

Examiners report

N/A

---

a. Outline Pavlov’s experiments into the conditioning of dogs. [3]

b. Outline how sound stimuli are detected in the ear. [2]

Markscheme

a. a. classical conditioning;

b. Pavlov sounded a bell before food / conditioned stimulus;

c. dogs salivated when they heard the bell / conditioned response;

d. the amount of salivation after the bell was as great as when the food alone was presented;

e. dogs had learnt to associate the two external stimuli;

b. a. sound waves reaching eardrum cause it to vibrate;

b. vibrations passed to bones of middle ear/oval window/fluid in cochlea;

c. detected by mechanoreceptors/hair cells (in cochlea of ear);

Examiners report

a. Almost everyone received at least two marks for the outline of Pavlov’s experiment and many received the full three marks.

b. Most received the full 2 marks for this section on hearing as well.

Compare rod and cone cells.

Markscheme

rods and cones are both light-sensitive cells;

rods are far more numerous than cones;

rods are distributed evenly throughout the retina while cones are particularly concentrated at and around the fovea;

rod cells are all the same/black and white vision but there are three types of cone cells (absorb red, blue and green colour)/colour vision;

rod cells absorb all the visible wavelengths but each type of cone cell absorbs a different range;

rods are longer and thinner, cones have cone shape;

rod cells are principally used for dim light and night vision while cone cells require bright light / rods give poor visual acuity while cones give good visual acuity;

the pigment in rod cells is rhodopsin while in cone cells is iodopsin;

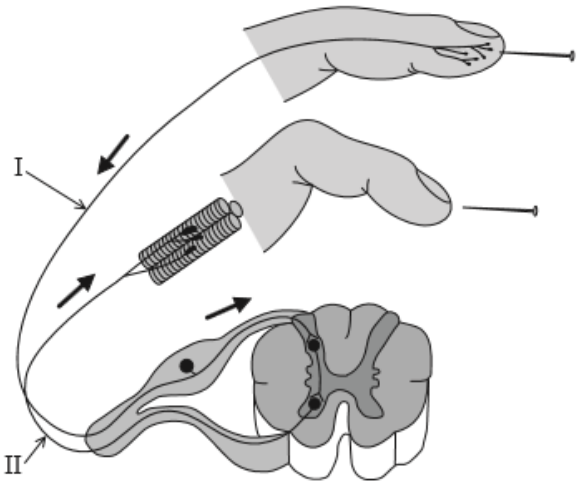
each individual cone cell is fed to a single (bipolar) neuron, whereas many rod cells synapse with a single (bipolar) neuron;

Examiners report

There were some very good answers to this question, the majority did give comparative statements, and gained three marks. A few weaker candidates got the connections between the cells and the bipolar neurons the wrong way round.

---

a. The diagram below shows a reflex arc. [1]



[Source: adapted from www.sciencegeek.net/Biology/review/graphics/Unit8/ReflexArc.jpg]

Label I and II.

I. .....

II. .....

b. Outline how stimuli can be detected by human sensory receptors. [2]

c. Explain how sound is perceived by the ear. [4]

Markscheme

a. I: sensory neuron

II: motor neuron

(*both needed*)

b. sensory receptors transfer stimulus energy into electrochemical energy;

mechanoreceptors respond to touch/pressure/movement/sound waves;

thermoreceptors respond to temperature changes;

chemoreceptors detect chemicals/molecules;

photoreceptors respond to electromagnetic stimulation/light;

c. sound waves are (funneled through the ear canal) causing ear drum to vibrate;

vibrations of ear drum cause the bones of the middle ear/ossicles/malleus, incus and stapes/hammer, anvil and stirrup to move;

lever system of middle ear bones increases pressure on the oval window;

vibrations are transmitted from oval window through (fluid-filled) cochlea;

stimulation of hair cells/mechanoreceptors in cochlea;

vibrations are transformed into nerve impulses/action potentials;

impulse sent to brain along auditory nerve;

Examiners report

a. Most candidates were able to identify the sensory and motor neurones indicated.

b. This question proved difficult for many candidates. Many incorrectly described a reflex arc rather than outlining how sensory receptors detect stimuli.

c. This section on sound perception was very well done by the majority of candidates with many receiving full marks.

List **two** examples of inhibitory psychoactive drugs.

1.

2.

Markscheme

benzodiazepines;

alcohol;

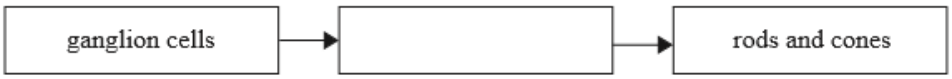
tetrahydrocannabinol / THC / marijuana;

Do not accept brand names.

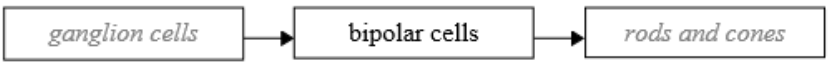
Examiners report

Most were awarded 2 marks for correctly identifying two inhibitory psychoactive drugs.

State the missing cell type in the sequence encountered as light enters the retina.



Markscheme

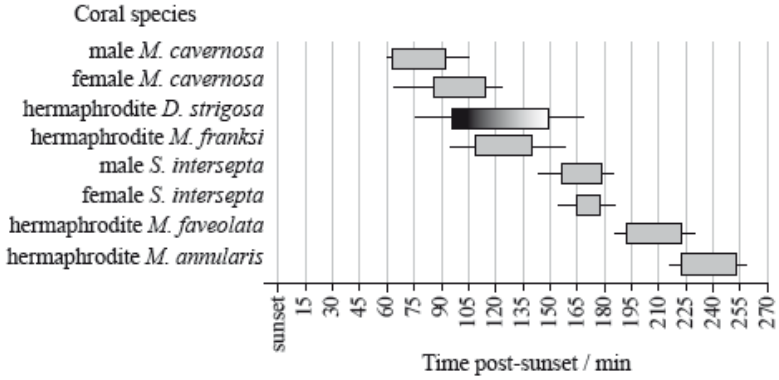


Examiners report

Better students gained the mark for bipolar cells in a.

Corals can be male, female or hermaphrodite (both male and female) and the release of their gametes is called spawning. Data was collected to study the spawning behaviour in the Gulf of Mexico of three genera of coral: *Montastraea*, *Stephanocoenia* and *Diploria*.

The spawning behaviour is expressed in minutes post-sunset. Peak spawning windows are shown as grey bars and the range as black bars. *D. strigosa* is shown as a shaded gradient indicating a strong bias towards spawning in the early portion of this window.



[Adapted from P. D. Vize, J. A. Embesi, M. Nickell, D. P. Brown and D. K. Hagman (2005) "Tight temporal consistency of coral mass spawning at the Flower Garden Banks, Gulf of Mexico, from 1997–2003." _Gulf of Mexico Science_, 1, pp. 107–114.
]

a. State the range of the time of spawning for the male *M. cavernosa*. [1]

b. Suggest why it may be advantageous for each species of coral to spawn within a tight time frame. [1]

c. Discuss the significance of different spawning windows for different species. [2]

e. Scientists hypothesized that the release of the male gamete triggers a chemical signal for females to release their eggs. Discuss this hypothesis. [2]

Markscheme

a. from 60 to 105 minutes (post-sunset) / 45 minutes

b. to increase the possibilities of fertilization

c. a. to avoid interspecific/cross-fertilization;

b. cross-fertilization usually not successful/non-productive;

c. some overlap of species spawning occurs so temporal separation is not completely successful;

d. example of overlap (*e.g. D. strigosa* overlaps with *M. cavernosa*/*M. franksi*);

e. a. females always spawned after males suggesting hypothesis correct;

b. for example in *M. cavernosa* or *S. intercepta*;

c. difficult to tell for hermaphrodites;

d. chemical analysis of water should be undertaken after males spawned / other chemical signals / further evidence required to support cause and effect;

Examiners report

a. Almost everyone correctly identified the range of spawning requested.

b. Few candidates were able to clearly express that the tight time frame of spawning of males and females of a species increased the possibility of fertilization. Many mentioned predators and carried this on into part (c) rather than looking at fertilization.

c. Many candidates gained 1 mark for suggesting that different spawning windows for different species avoided interspecific fertilization but few were able to get a second mark. Some were able to state that such cross-fertilization was usually non-productive.

e. Many received full marks.

The diagram shows the early development of the nervous system in embryonic chordates.

[Source: adapted from www.geol.umd.edu]

a. Outline the process taking place in the diagram. [2]

b. State what occurs to structure X immediately following its formation. [1]

c. Outline how spina bifida could occur during embryonic development. [1]

Markscheme

a. a. infolding of the ectoderm /neural plate

"Ectoderm" is essential for the mark.

b. formation of the neural tube
OR
neurulation

"Neural tube" or "neurulation" is essential for the mark.

b. elongation / forms a tube

c. a. neural tube/structure X does not close properly

b. folic acid/folacin/folate/vitamin B9 deficiency

c. may be due to mutation / genetic condition

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

---

a. Define the term *reflex* in animal behaviour. [1]

b. Outline the main roles of motor, sensory and relay neurons in a spinal reflex arc. [3]

	Main role
Motor neuron	
Sensory neuron	
Relay neuron	

Markscheme

a. a rapid and unconscious/automatic response (to a stimulus)

b.

	Main role
Motor neuron	carry impulses from central nervous system/CNS to muscles/glands/effectors;
Sensory neuron	receive/carry impulses from receptors/sense organs to central nervous system/CNS;
Relay neuron	connects sensory neuron and motor neuron;

Examiners report

a. This question was generally well answered; the majority of students could accurately define a reflex. Some answers however, did not refer to the rapid nature of the response.

b. There were few good responses to this question, and it may be because the order of the neurons was different to the usual format. Most managed to give the role of the relay neuron, but in the other two, there were no references to the CNS or to receptors/effectors, with answers being generally very imprecise.

Draw a labelled diagram of a reflex arc for a pain withdrawal reflex.

Markscheme

Diagrams are to include the following structures appropriately drawn and in appropriate relationship to each other.

(pain) receptor indicated at the dendrite end of the sensory neuron;

sensory neuron shown in appropriate abbreviated shape from a (pain) receptor to the central nervous system (CNS) with dendrites and axon;

dorsal root ganglion shown next to the CNS;

relay neuron/interneuron/associative neuron shown in the CNS/spinal cord with dendrites and axon;

motor neuron shown with dendrites and axon from the CNS to an effector;

effector/muscle labelled as a muscle;

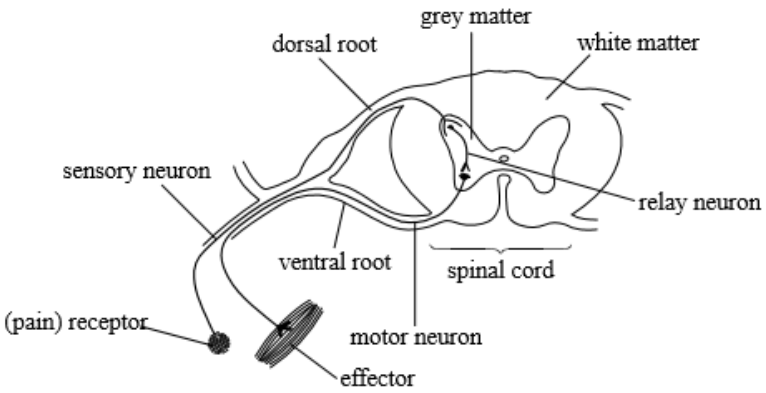
white matter shown correctly in the spinal cord;

grey matter shown correctly in the spinal cord;

spinal cord shown connected to the brain and with appropriate position relative to the structures given above;

*Award **[3 max]** for inaccurate diagrams.*

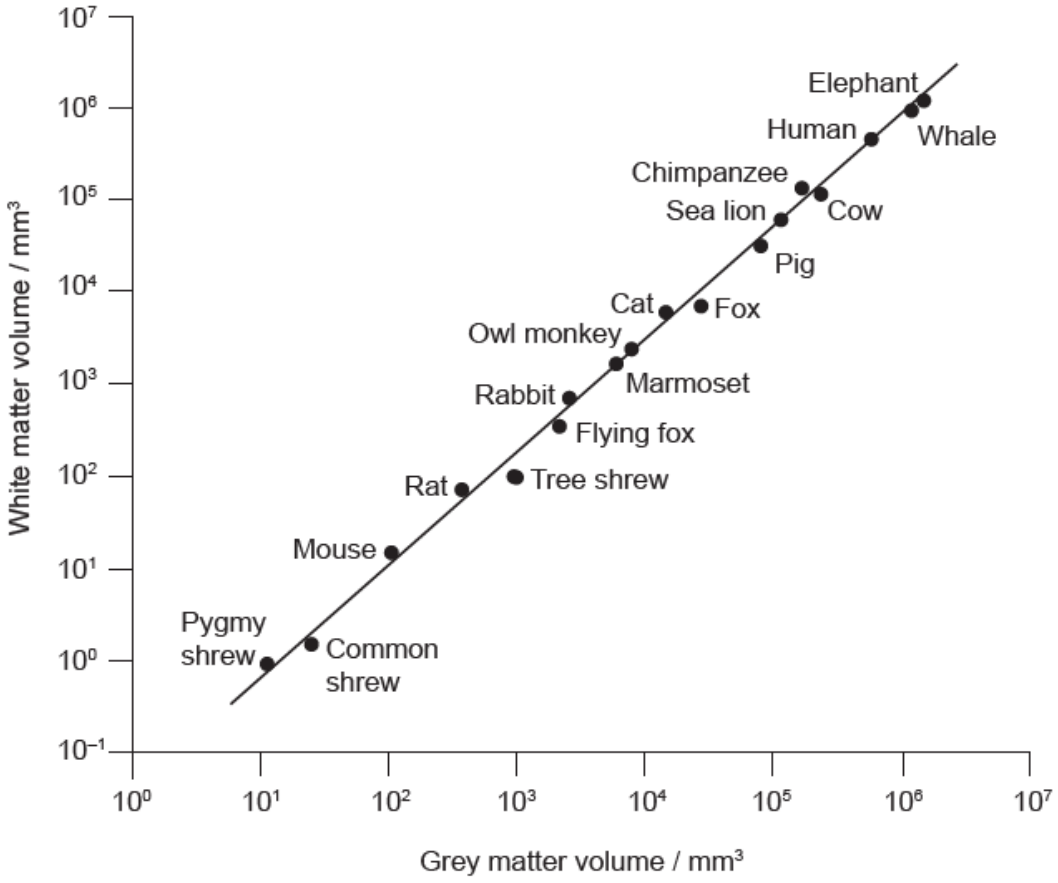
***N.B.** Accept stylized diagrams of neurons.*



Examiners report

E2 was either done very well (the majority of candidates) or very poorly. It is important to emphasis clear drawing and annotation.

a. In a study of brain organization, several factors were investigated. The relationship between the volumes of grey and white matter across mammalian species was compared. [1]



[Source: E. Bullmore and O. Sporns (2012) *Nature Reviews, Neuroscience* Vol. 3, pages 336–349. Reprinted by permission from Macmillan Publishers Ltd. http://www.nature.com/nrn/index.html]

Describe the relationship between the volume of white matter and grey matter.

b. Outline the organization of the human cerebral cortex with regard to structure and function. [3]

c. Outline **one** reason for the large energy requirement of the brain. [1]

Markscheme

a. a. positive correlation «between grey matter volume and white matter volume»

OR

as white matter «volume» increases so does grey matter «volume»

b. As animal/brain size increase the volume of grey and white matter are «approaching» equal
OR
as volume of grey matter increases, the ratio grey : white becomes closer to 1

b. *Structure*:

a. divided into left and right hemisphere

b. has extensive folding

c. has a large surface area : volume ratio

Function:

d. responsible for higher order functions/thinking/learning/memory/language

e. functions are located in specific areas of the cortex/lobes

f. sensory/motor functions of the left hemisphere correspond to the right side of the body

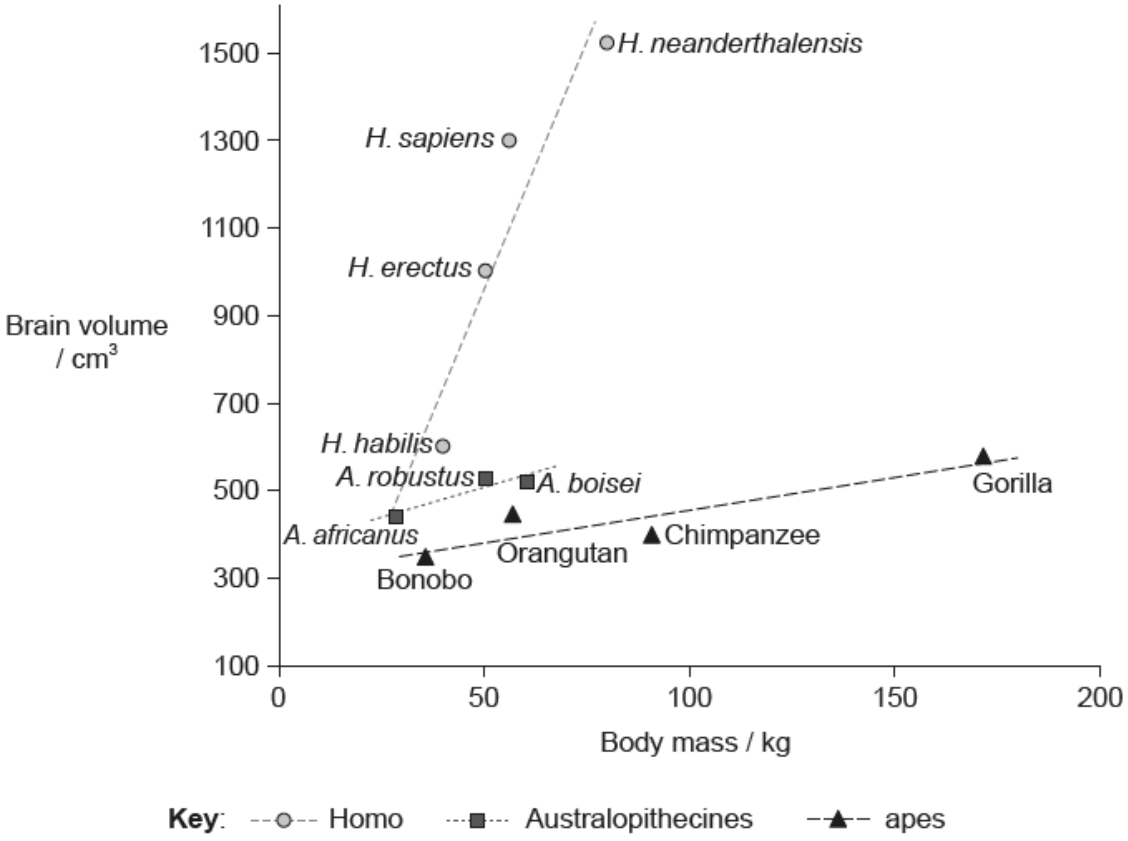
c. a. «brain» cells/neurons carry out large amount of respiration/metabolic activity

b. maintenance of resting potential requires energy/ATP
OR
functioning of Na-K pumps requires energy/ATP
OR
nerve impulse requires energy/ATP

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

The graph shows the relationship between body mass and brain volume in three groups of primates.



[Source: adapted from G Roth and U Dicke (2005) *TRENDS in Cognitive Sciences*, 9 (5), with permission from Elsevier]

Analyse the relationship between body mass and brain volume in these primates.

Markscheme

a. in all groups an increase in body mass means an increase in brain volume

b. in the apes, brain volume has increased only slightly with body mass

c. in the Homo group brain volume increases steeply with body mass

d. in Australopithecines brain volume has increased only slightly with body mass
OR
in Australopithecines fewer species were studied

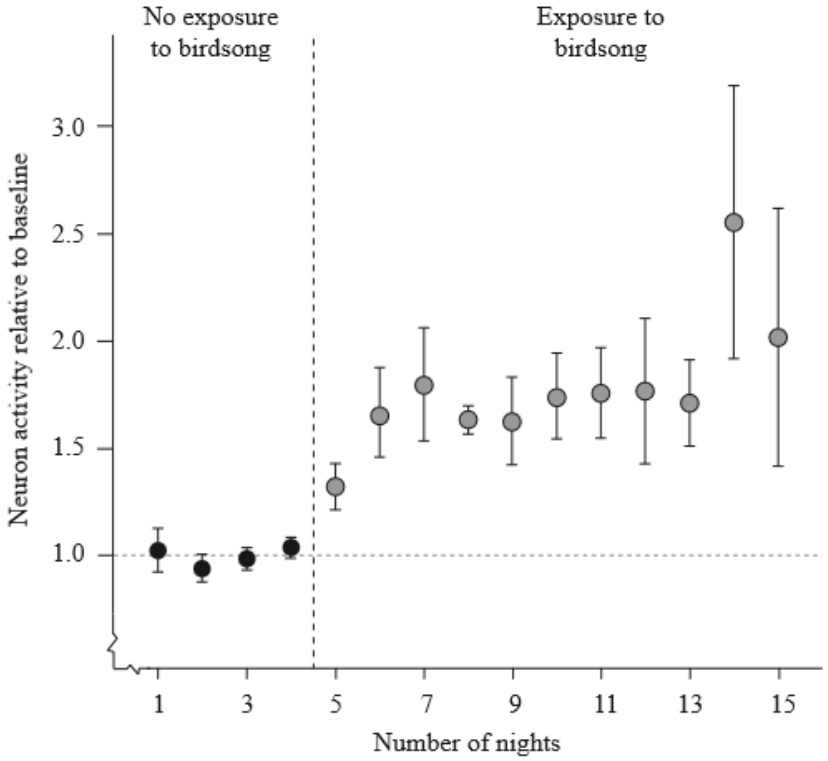
e. at a small mass the brain volumes are more similar

Examiners report

[N/A]

Scientists investigated if training has an influence on the learning of birdsong. They studied juvenile zebra finches (*Taeniopygia guttata*) that had never been exposed to adult bird songs. They measured neuron activity in an area of the brain involved with song learning. This was done during their sleep, first for four nights when the birds had not heard any birdsong during the previous day, and then for a series of nights after days when they were

exposed to recordings of adult zebra finches' songs. In the graph below, the mean neuron activity in the period of no exposure to birdsong was used as a baseline and assigned a value of 1. All other measurements of neuron activity are shown relative to this.



[Source: Reprinted by permission from Macmillan Publishers Ltd, *Nature*, Sylvan S. Shank & Daniel Margoliash, 'Sleep and sensorimotor integration during early vocal learning in a songbird', Vol. 458, pages 73–77, copyright 2009]

a. State the difference in neuron activity between nights 2 and 7. [1]

b. Outline the effect of exposure to birdsong on neuron activity. [2]

c. Suggest **one** reason for the large error bars on days 14 and 15. [1]

d. Evaluate the hypothesis that listening to other zebra finches is important to develop singing ability amongst juveniles. [2]

Markscheme

a. 0.8 (*Accept answers from 0.75 to 0.85.*)

b. a. increases neuron activity;

b. increase over three days/increase of about 75 %/of 50–100 %;

c. then plateaus/levels off;

d. large variation on days 14 and 15;

c. a. small sample so one measure can skew the average / higher average value due to only one measurement;

b. different birds respond differently/nothing being learned;

c. change in behaviour due to biotic/abiotic changes;

d. a. hypothesis seems to be verified since all points after exposure to birdsong are higher;

b. learning phase (supported by changes on days 5–7);

c. experiment shows only one brain area activity / other factors may also be involved;

Examiners report

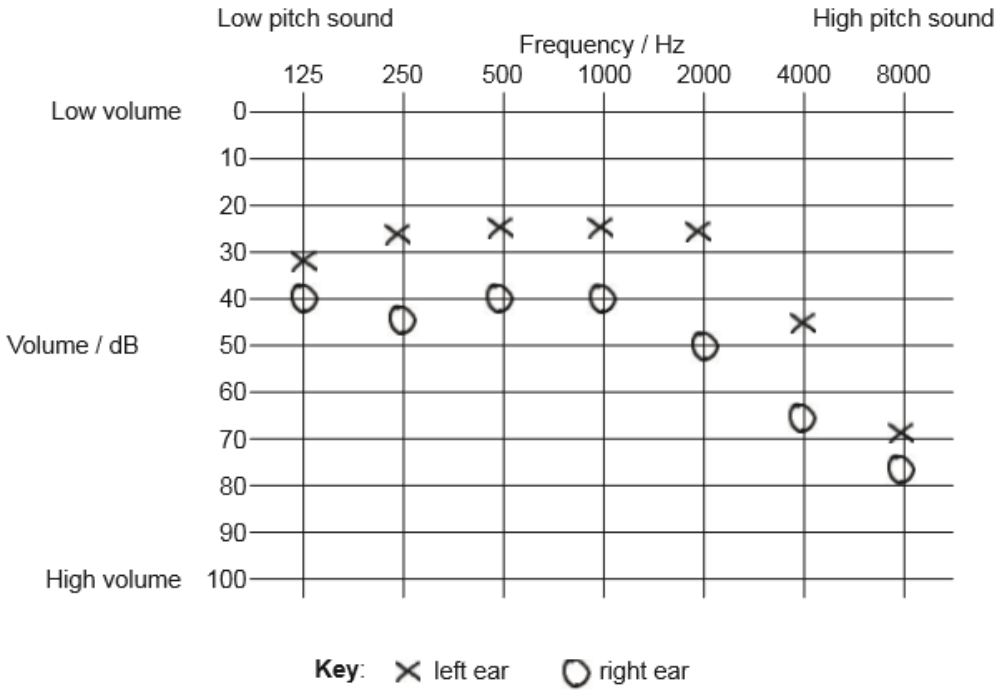
a. In E1 (a) and (b) almost all candidates had correct answers.

b. In E1, (a) and (b) almost all candidates had correct answers.

c. (c) appeared to confuse most candidates.

d. (d) in general answers were on topic, but few students evaluated the hypothesis.

To test hearing, sounds are played at very low volume levels and gradually increased until the patient can hear the sound. This is repeated with different frequencies which correspond to low or high pitch sounds. The results are marked on an audiogram. This audiogram is from a 60-year-old woman.



[Source: © International Baccalaureate Organization 2016]

a. Human speech occurs at a volume of approximately 60 dB and at frequencies between 125 Hz and 4000 Hz. Outline whether the woman would hear all conversations with both ears. [1]

b. The woman suffers from otosclerosis in the right ear, a condition where the bones of the middle ear do not function properly. Describe how this is consistent with the hearing test result shown in the audiogram. [2]

c. Explain the role of the hair cells in the cochlea. [3]

Markscheme

a. left ear would hear everything but the right ear would not «at higher frequencies»

OR

cannot hear all high frequencies of speech (with both ears)

Allow numerical responses in support of the answer.

b. a. the bones in the middle ear amplify/make sounds louder

b. the audiogram shows the woman needs louder sounds to hear with her right ear

Allow vice versa.
Could use data to support answer.

c. a. sounds/vibrations make the fluid/liquid in the cochlea move/vibrate

b. amount of movement is proportional to the amplitude /loudness/ of the sound *OWTTE.*

c. amount of movement is proportional to the frequency/wavelength/pitch

d. hair cells located within organ of Corti

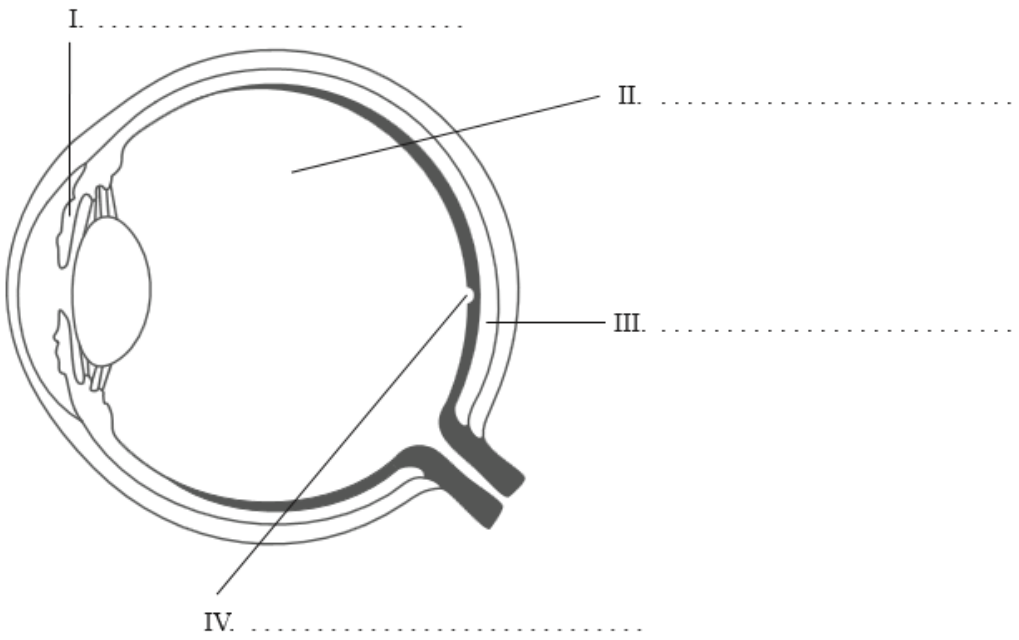
e. (hair cells have) nerve cells connected to auditory nerve
OR
nerve cells transmit impulses to brain

Examiners report

a. [N/A]
b. [N/A]
[N/A]

c.

a. Label the following diagram of the eye. [2]



c. Outline the diversity of stimuli that can be detected by human chemoreceptors. [2]

Markscheme

a. I iris

II vitreous humour

III choroid

IV fovea (*do not accept yellow spot*)

*Award **[1]** for every two correct answers.*

c. a. (dissolved) chemicals detected by taste buds (in the tongue and mouth);

b. (airborne) chemicals detected by (olfactory) receptors;

c. chemicals/ions/pH in blood (for example CO_2/glucose) detected by chemoreceptors (in carotid artery/medulla oblongata);

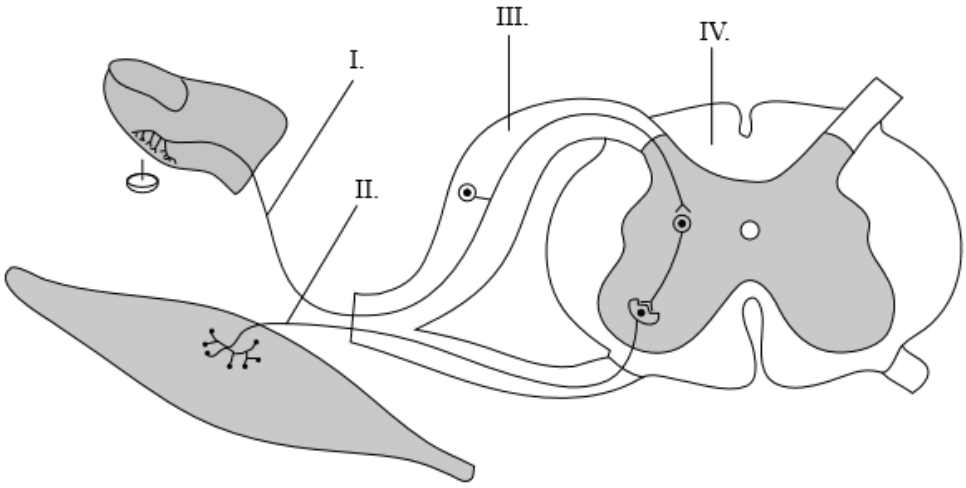
d. neuroreceptors detect neurotransmitters;

Examiners report

a. (a) was well done with most candidates being able to identify the structures of the eye appropriately.

c. (c) was also well answered.

Below is a diagram of a reflex arc for a pain withdrawal reflex.



a . Define *reflex*. [1]

b (i) Label the parts indicated by the letters I–IV. [2]

I. .....

II. .....

III. .....

IV. .....

b (ii) Explain the role of parts I and II in a pain withdrawal reflex. [2]

Markscheme

a . rapid response that occurs automatically/involuntarily in response to a stimulus

b (i) *Two correct labels for* ***[1]***

I: sensory neuron

II: motor neuron

III: dorsal root (of spinal nerve) *NOT dorsal root ganglion*

IV: white matter (of spinal cord

b (ii) eceptor cell detects stimulus and converts it to a nerve impulse;

impulse travels along sensory neuron to (dorsal root of) spinal cord;

impulse travels along motor neuron to effector organ;

causes muscle to contract removing contact with painful stimulus;

Need to mention BOTH structures I AND II for 2 marks.

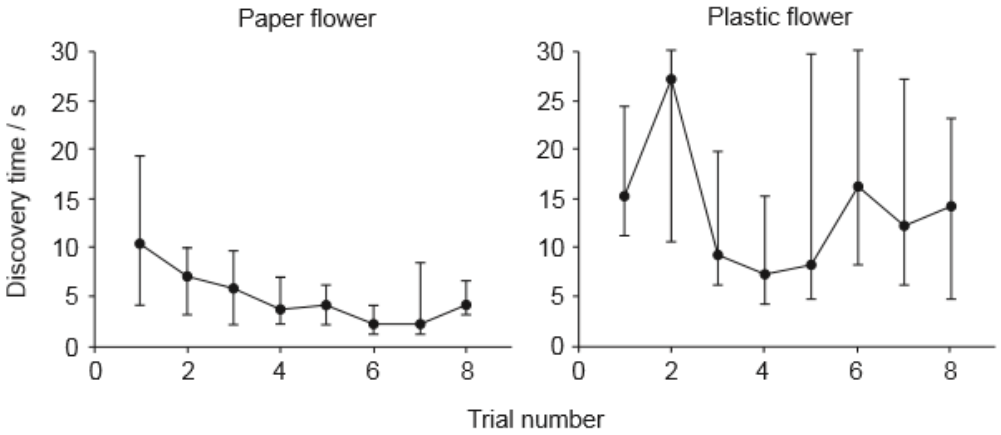
Examiners report

a . Many candidates could not give a correct definition of a reflex.

b (i) The labelling was also not well done.

b (ii) There were many references to “signals” rather than “impulses” in the explanation, with often little connection to the parts shown in the diagram.

Moths use a variety of sensory processes (including vision, smell and mechanoreception) to locate nectar on flowers. The ability of the nocturnal tobacco hornworm moth, *Manduca sexta*, to find nectar using mechanoreceptors was investigated using artifical flowers. Three-day-old moths that had no experience of natural flowers were used in the investigation. The artificial flowers had nectar placed at the centre and were made of either paper (with a rough surface to stimulate mechanoreception) or plastic (to reduce mechanoreception). The time taken for moths to discover the nectar (discovery time) over a series of eight trials is shown for the artificial flower types. Vertical bars show the variation in the data.



[Source: Joaquín Goyret and Robert A. Raguso, “The role of mechanosensory input in flower handling efficiency and learning by Manduca sexta”. *J Exp Biol* 2006 **209**:1585–1593. doi:10.1242/jeb.02169
Reproduced with permission from *The Journal of Experimental Biology*: jeb.biologists.org]

a. Identify the trial for each flower type that shows the greatest variation. [1]

Paper:
Plastic:

b. Compare the data for plastic and paper flowers. [2]

c. Outline the evidence from the data that the ability to find nectar using mechanoreceptors is a learned behaviour. [2]

d. Discuss how learning to find nectar using mechanoreceptors could lead to improved chances of survival and reproduction for the tobacco hornworm moth. [2]

Markscheme

a. *Paper:* (trial) 1

Plastic: (trial) 5

*Both required for **[1]**.*

b. a. discovery time in paper flowers always shorter than plastic flowers;

b. larger variation in data for plastic flowers;

c. decreasing discovery time (over the eight trials) for the paper flowers only;

d. no trend in discovery time for plastic flowers;

e. from trial four discovery time for paper flowers remains fairly constant/slight variation whereas for plastic flowers discovery time increases;

c. a. mechanoreceptors are touch receptors;

b. discovery time decreases over the eight trials for paper flowers;

c. showing evidence of learning;

d. plastic flowers discovery times show no evidence of learning;

e. paper flowers have a rough surface so mechanoreceptors are more effective / plastic flowers smooth so do not stimulate mechanoreceptors;

d. a. improved chances of finding food;

b. advantage in dark/conditions when coloured/scented flowers not available;

c. not completely dependent on light/chemoreceptors to find food;

d. more likely to reproduce and pass gene (for mechanoreceptors) to offspring; advantage over other members of the species through learning;

Examiners report

a. Questions 13 a-c were generally well answered.

b. Questions 13 a-c were generally well answered.

c. Questions 13 a-c were generally well answered.

d. In 13(d) most candidates commented on improved chances of finding food but other suitable answers were rare except for the top grades, which generally made reference to moths flying at night and therefore being unable to use light receptors. Answers involving inheritance were very rare.

---

a. Compare the effects of cocaine and THC. [4]

b. State one other example of an excitatory and an inhibitory psychoactive drug. [2]

Excitatory drug: .....

Inhibitory drug: .....

Markscheme

a.

	cocaine	THC
a.	excitatory (psychoactive) drug	inhibitory (psychoactive) drug;
b.	affects dopamine transmitters	affects cannabinoid receptors
c.	prevents the return of dopamine to the presynaptic membrane	blocks release of excitatory neurotransmitter;
d.	depressive mood disorders	loss of memory / slurred speech / loss of balance / impairs reaction time/muscle coordination;
e.	pleasurable feeling	increases intensity of sensual perception / feeling of emotional well-being / allows clear thinking of complex ideas;
f.	addictive;	

Answers do not need to be in a table format.

b. a. *excitatory drug*: nicotine / amphetamines/ other drug;

b. *inhibitory drug*: benzodiazepines / alcohol / other drug;

Examiners report

a. Comparison of the effects of cocaine and THC were generally poor. Candidates wrote all they knew about cocaine then all they knew about THC without providing contrasting statements. Many failed to score more that the fact that one was excitatory and one was inhibitory.

b. Many repeated THC and cocaine despite being asked for one other example.

---

a. Define the term *reflex*. [1]

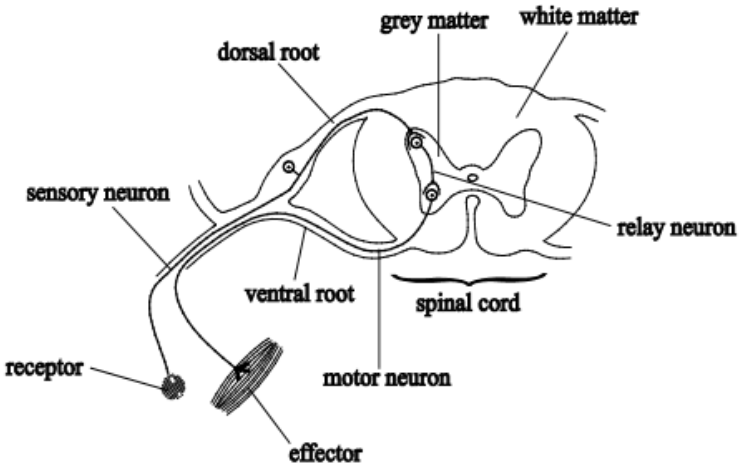
b. Draw a labelled diagram of a reflex arc for a pain withdrawal reflex. [3]

c. Outline Pavlov's experiments into conditioning in dogs. [2]

Markscheme

a. rapid <u>and</u> unconscious/automatic response (to a stimulus)

b. *Example of diagram.*



sensory neuron shown connecting site of stimulus/receptor to relay neuron;
relay neuron shown in grey matter, connecting sensory neuron to motor neuron;
motor neuron shown connecting relay neuron to effector/muscle / cell body of motor neuron shown in grey matter;
cell body of sensory neuron shown outside spinal cord/in dorsal root;
spinal cord shown with grey and white matter;

c. unconditioned stimulus is smell/sight of food and unconditioned response is salivation;

conditioned stimulus is sound of a bell and conditioned response is salivation at sound of bell;

bell/other stimulus is repeatedly applied just before food;

after several repeats the response can be seen without the food/when only the bell is rung/other stimulus;

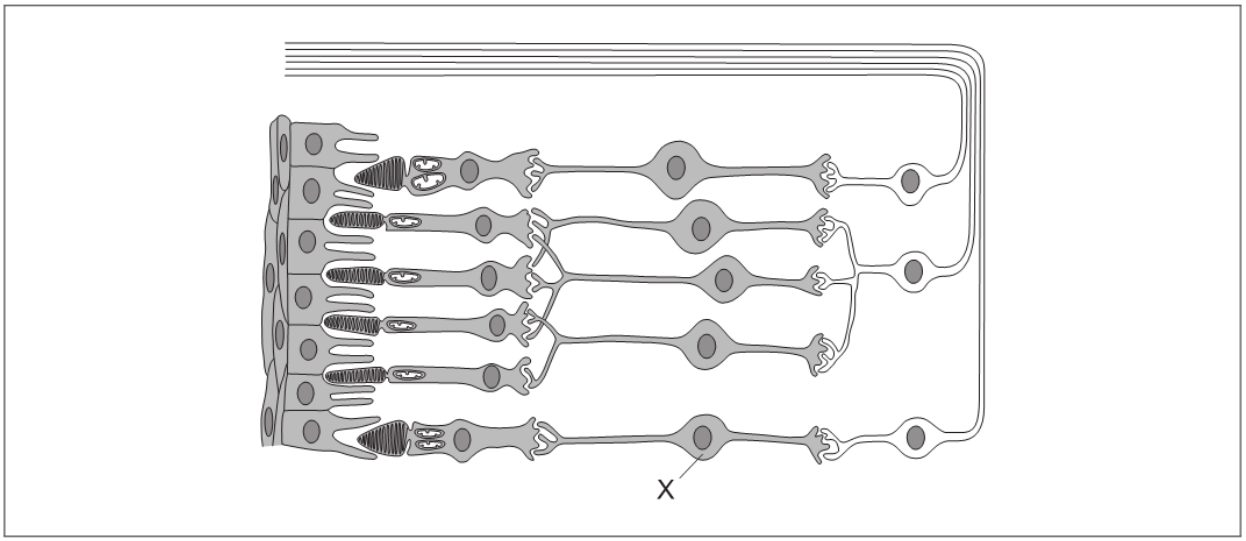
Examiners report

a. Many could not give a full correct definition of a reflex, often omitting the fact that it is a *rapid* response.

b. Many candidates did not attempt to draw a diagram, and those that were drawn were of very poor quality, gaining no marks. There were often no distinct neurons shown, and the division of the spinal cord into white and grey matter was generally inaccurate. Some diagrams were unrecognisable as a reflex arc.

c. There were some good, clearly explained descriptions of Pavlov"s experiments, and most candidates gained the two marks.

The diagram shows part of a retina.



[Source: C. J. Clegg, Introduction to Advanced Biology, 2000, p. 285. Reproduced by permission of Hodder Education.]

d.i. Identify the cell labelled X. [1]

d.ii. Draw an arrow to show the direction of light through the retina. [1]

Markscheme

d.i. bipolar «cell»

d.ii. arrow pointing from right to left

Examiners report

d.i. [N/A]
d.ii. [N/A]

---

a. Draw a labelled diagram of a reflex arc for a pain withdrawal reflex. [4]

b. Distinguish between innate behaviour and learned behaviour. [3]

Markscheme

a. *Award **[1]** for any one of the following clearly drawn and correctly labelled.*

a. spinal cord – showing white and grey matter;

b. spinal nerves – showing dorsal and ventral roots;

c. sensory neuron / receptor;

d. motor neuron / effector;

e. relay neuron;

f. arrows showing path from stimulus/receptor to response/effector;

b.

	innate behaviour	*learned behaviour*
a.	develops independently of the environmental context	from experience / environmental stimulus;
b.	controlled by genes / inherited from parents;	not controlled by genes / not inherited from parents / from experience / environmental stimulus;
c.	developed by natural selection	from experience / environmental stimulus;
d.	increases chance of survival/ reproduction	may or may not increase chance of survival/reproduction;
e.	valid example	valid example;

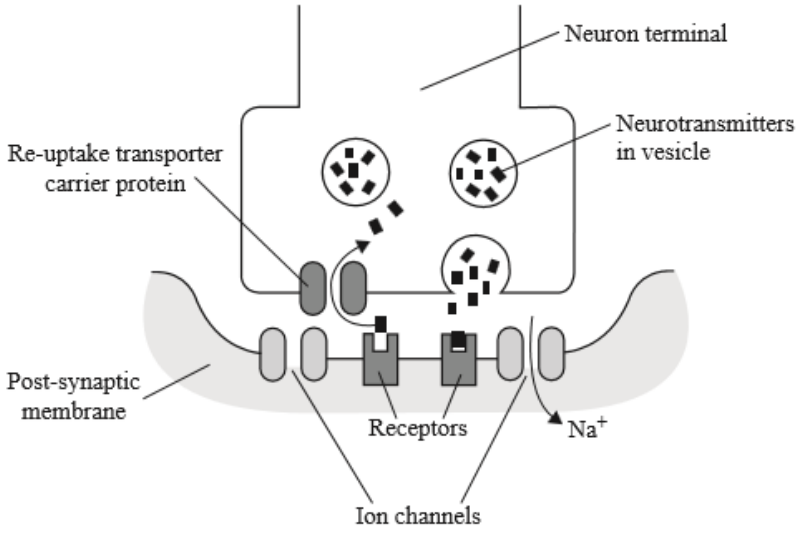
Examiners report

a. There was a range of diagrams of the reflex arc but the majority got all 4 marks.

b. Most candidates had difficulty scoring 3 marks in their distinctions between learned and innate behaviour.

The diagram below shows a synapse where the neurotransmitter is dopamine and some of the processes that take place during nerve transmission.

Explain the effect of cocaine on neurotransmission at a synapse.



[Source: Birmingham City University, Faculty of Health http://www.hce.uce.ac.uk/physiology/pharmacology01.htm
Reprinted with permission from the Faculty of Health, Birmingham City University, UK.]

Markscheme

a. dopamine initiates depolarization of post-synaptic membrane;

b. cocaine binds to (transporter) carrier proteins/proteins in pre-synaptic membrane;

c. cocaine blocks reabsorption (of dopamine);

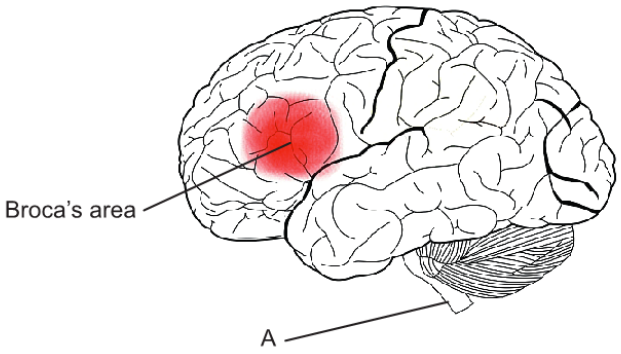
d. cocaine causes dopamine build up in synaptic cleft/space;

e. so stimulus continues/cocaine is excitatory;

Examiners report

Most candidates were able to explain the effect of cocaine at synapses.

The diagram shows the human brain.



[Source: By charlyzon (Own work) [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons.]

a.i. Identify the structure labelled A. [1]

a.ii. List **two** functions of the structure labelled A. [2]

b. Outline the reason that Broca's area is more developed in humans than other primates. [1]

c. Suggest how an injury to the brain can help in understanding brain function. [1]

Markscheme

a.i. medulla «oblongata»

OR

brain stem

a.ii. a. breathing «rate»

b. heart function

c. digestion/saliva production

d. swallowing reflex

e. coughing

f. vomiting

g. blood pressure

h. state of consciousness/sleep

Allow any two functions.

No ECF

[Max 2 Marks]

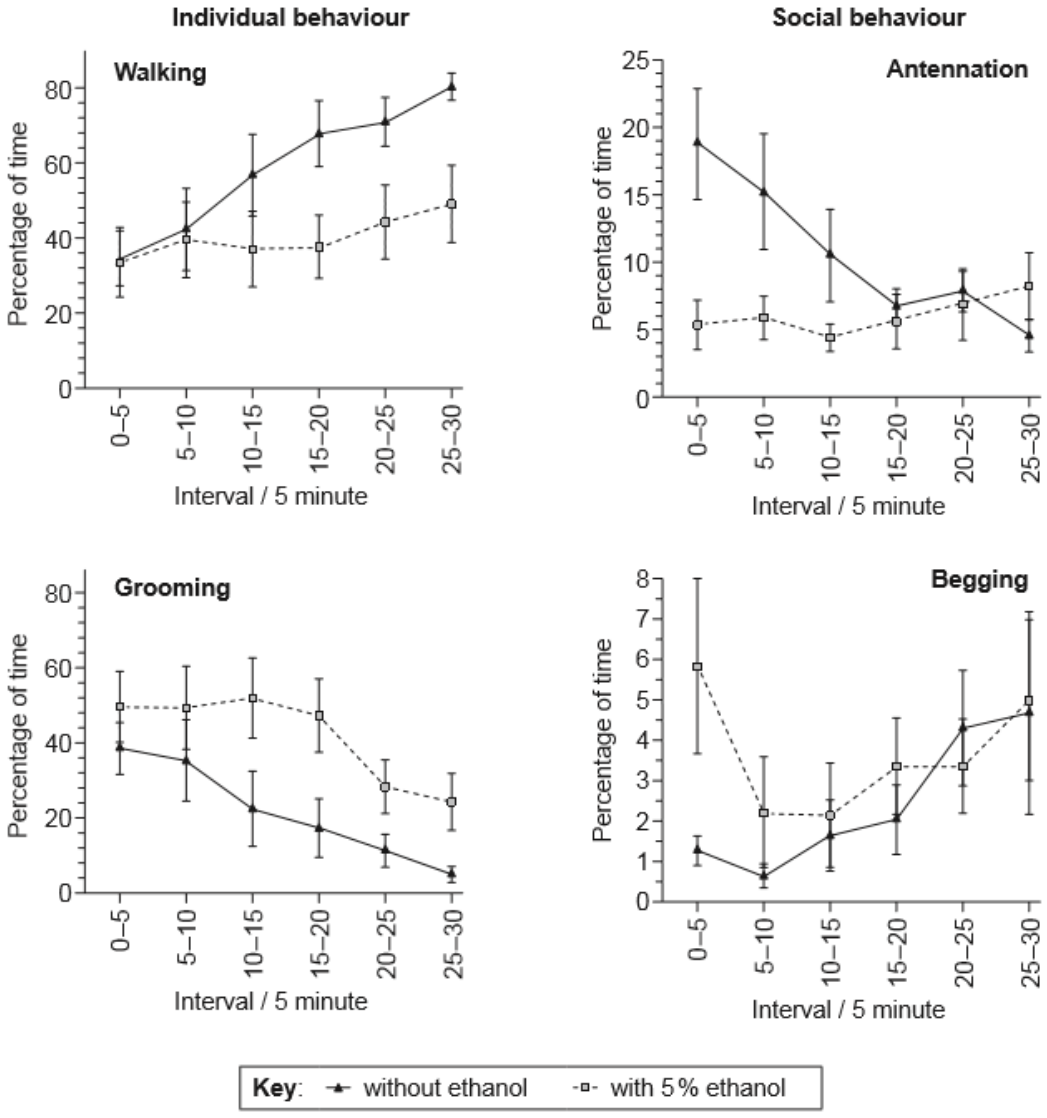
b. «controls motor functions involved with speech and» speech is more developed in humans

c. observe any changes in the person

Examiners report

a.i. [N/A]
a.ii. [N/A]
b. [N/A]
c. [N/A]

Honey bees (*Apis mellifera*) were fed with sucrose solution only or with low doses of ethanol in sucrose solution to examine how a slightly intoxicated state could affect their behaviour. Individual behaviour involves walking and grooming while social behaviour includes contact of antennae between bees to show recognition (antennation) and asking other bees for food when hungry (begging). The graphs show individual and social behaviour changes observed in successive five minute intervals two hours after honey bees were fed sucrose solution either with or without ethanol.



[Source: Wright, G. A., Lillvis, J. L., Bray, H. J. and Mustard, J. A. (2012) Physiological State Influences the Social Interactions of Two Honeybee Nest Mates. *PLoS ONE* **7**(3): e32677.mdoi:10.1371/journal.pone.0032677. Figs 5 (A), (D), (E), (F)]

a. State the percentage of time the honey bees engaged in begging during the first five minute interval. [1]

Bees fed with ethanol: .....%
Bees fed without ethanol: .....%

b. Describe the trends in antennation for honey bees fed with ethanol and without ethanol. [2]

c. Distinguish between the times spent walking and grooming for honey bees fed with ethanol and without ethanol. [2]

d. Evaluate the hypothesis that ethanol affects the social behaviour of honey bees. [3]

Markscheme

a. *bees fed with ethanol*:
5.9 (%); *(allow answers in the range of 5.8 (%) to 6.0 (%))*
bees fed without ethanol:
1.3 (%); *(allow answers in the range of 1.2 (%) to 1.4 (%))*
} *(both needed)*

b. a. without alcohol (antennation starts at a high level and) decreases with time;

b. with alcohol, the value (starts low and) very slowly increases;

c. the values of both group become very similar with time;

c. a. (time spent) walking is greater in bees without alcohol (than alcohol);

b. (time spent) grooming is greater with alcohol (than without alcohol);

c. the end point difference is greater in walking;

d. (time spent) walking increases whereas grooming decreases for both groups of bees;

d. a. (hypothesis supported as) alcohol decreases antennation at the start of the experiment;

b. (hypothesis supported as) alcohol increases begging at the start;

c. begging time is more variable/has less significant differences with alcohol so less clear than in antennation;

d. (hypothesis is supported as) the effect of alcohol on social behaviours becomes less distinguishable over time (with the effect of sucrose);

Examiners report

a. Option E data consisted of four graphs describing how the behaviour of honey bees changed when fed with alcohol. The candidates had a lot of information provided in the data and this did cause considerable confusion particularly among weaker candidates.

b. Option E data consisted of four graphs describing how the behaviour of honey bees changed when fed with alcohol. The candidates had a lot of information provided in the data and this did cause considerable confusion particularly among weaker candidates.

c. Option E data consisted of four graphs describing how the behaviour of honey bees changed when fed with alcohol. The candidates had a lot of information provided in the data and this did cause considerable confusion particularly among weaker candidates.

The question confused weaker candidates as they were unsure what distinctions had to be made.

d. Option E data consisted of four graphs describing how the behaviour of honey bees changed when fed with alcohol. The candidates had a lot of information provided in the data and this did cause considerable confusion particularly among weaker candidates.

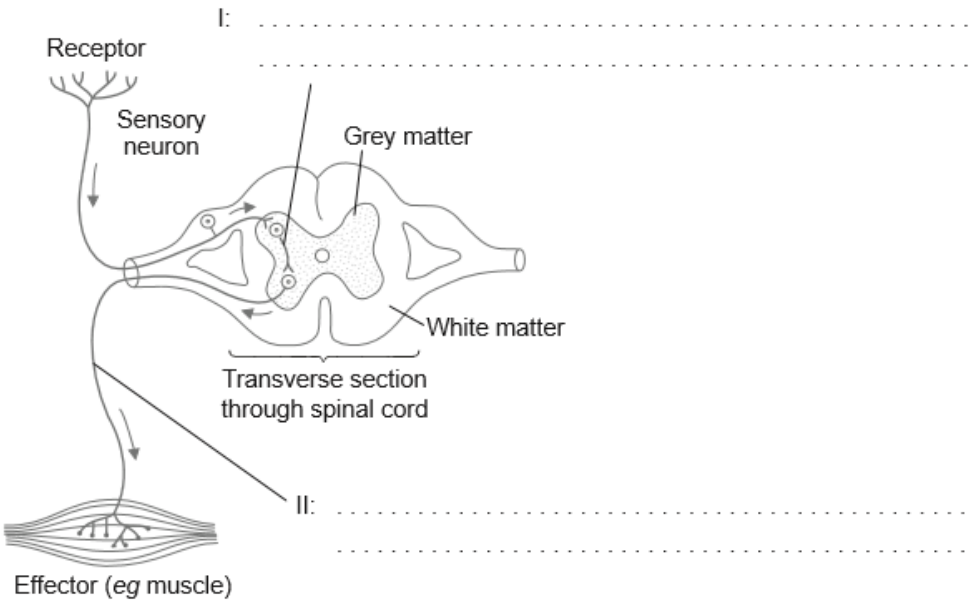
The candidates tended to look at trends in the data and did not realise that they simply had to look at the first points in the graph to show that ethanol had affected the behaviour of the bees.

---

a. State the type of receptors that detect smell and temperature. [2]

Smell: .....
Temperature: .....

b. Annotate the diagram of the reflex arc to show the name and function of the neurons labelled I and II. [2]



Markscheme

a. a. *smell*: chemoreceptor; (do not accept olfactory)

b. *temperature*: thermoreceptors;

b. *I*: *name*: intermediate/relay neuron
function: send impulse/message from sensory to motor neuron;
II: *name*: motor neuron
function: send impulse/message from spinal cord to effector/muscle;
(name and function needed for the mark)

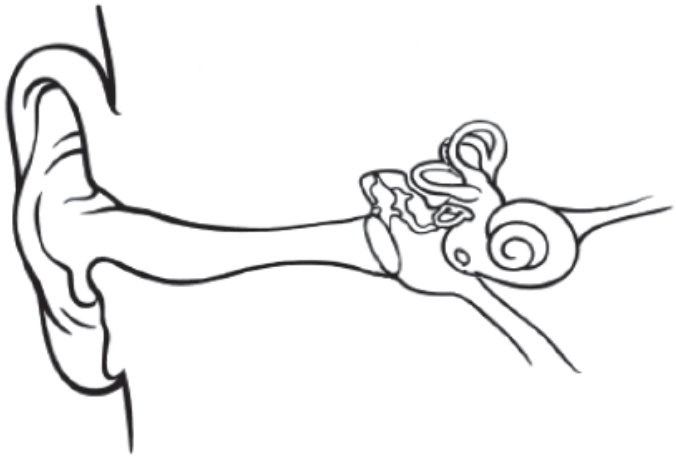
Examiners report

a. Most candidates knew thermoreceptors detected temperature but were uncertain about chemoreceptors in smell.

b. Many candidates failed to realise that the action verb “annotate” requires more than a simple label.

---

a. The diagram shows the anatomy of the human ear. [1]



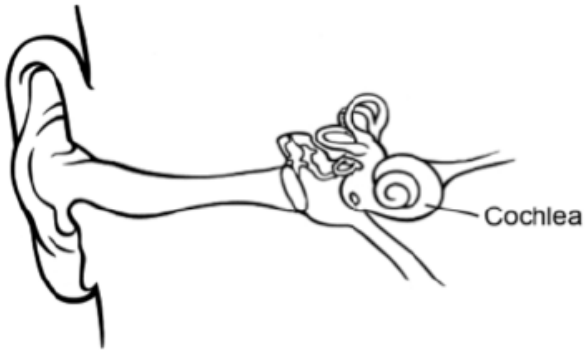
Label the cochlea on the diagram.

b. Explain the structure of the semicircular canals in relation to their functions. [4]

c. Explain the role of ganglion cells in the eye. [2]

Markscheme

a.



b. a. there are three semi-circular canals set perpendicular to one another /orientated in three planes of space / the direction of movement of the head in any direction is sensed

b. each canal is filled with liquid/perilymph

c. each canal contains «sensory» hairs

d. when the head moves the liquid in the canal moves more slowly/lags behind

e. this causes the sensory hairs to bend

f. send impulses to the brain «via the vestibular nerve»

c. a. ganglion cells transfer information to the brain

b. they receive visual information from photoreceptors/rod and cone cells/bipolar cells

c. their long axon extends to the brain «in the optic nerve»

d. they detect/process movement/colour

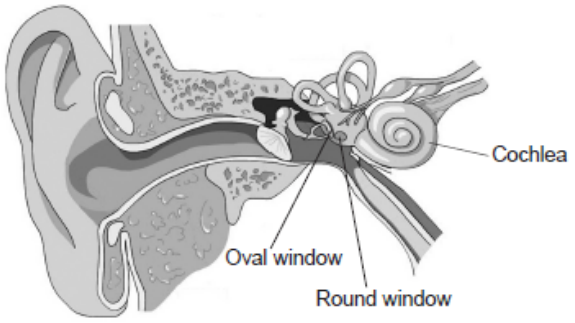
Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

---

a. Identify the type of retinal cells that function best in dim light. [1]

c. [1]



[Source: adapted from http://truesoundhac.com]

The image shows the human ear.

Outline the role of the round window in the perception of sound.

Markscheme

a. rods

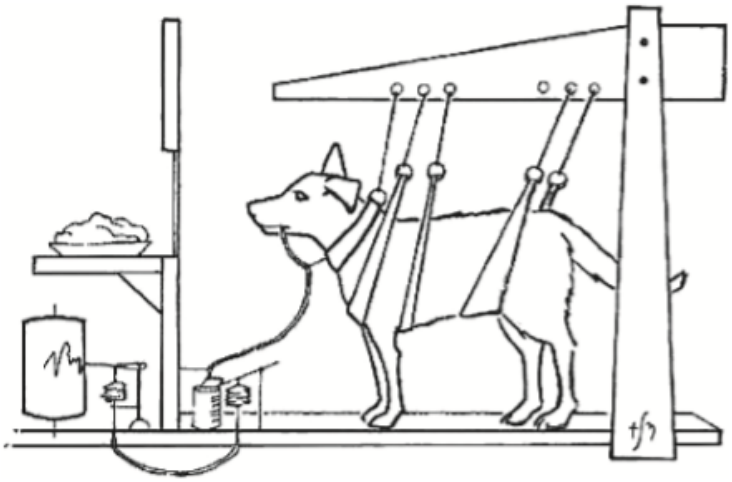
c. a. allows fluid in the cochlea to move;

b. as oval window moves in, round window moves out / *vice versa*;

Examiners report

a. [N/A]

c. Many candidates described the oval window.



[Source: http://animalbehaviour.net/ClassicalConditioning.htm]

a. The diagram above shows the set up similar to that used in Pavlov's experiments on conditioning in dogs. Describe Pavlov's experiments on conditioning in dogs. [3]

b. Salivation is normally a simple reflex. Explain the role of sensory, relay and motor neurons in a simple reflex. [2]

Markscheme

a. a. smell or sight of food provides the (unconditioned) stimulus at the start of the experiment;

b. salivation at the sight or smell of the food is the (unconditioned) response;

c. bell/other stimulus repeatedly applied just before food;

d. bell/other stimulus provides a (conditioned) stimulus;

e. (conditioned) response is salivation at the bell/other stimulus only;

f. experiment was an example of classical conditioning;

*Award **[2 max]** if the terms stimulus and response are not used.*

b. a. sensory neuron carries signal from sense organ/receptors/nose/eye to CNS;

b. motor neuron carries signal from CNS to effector/muscle/salivary gland;

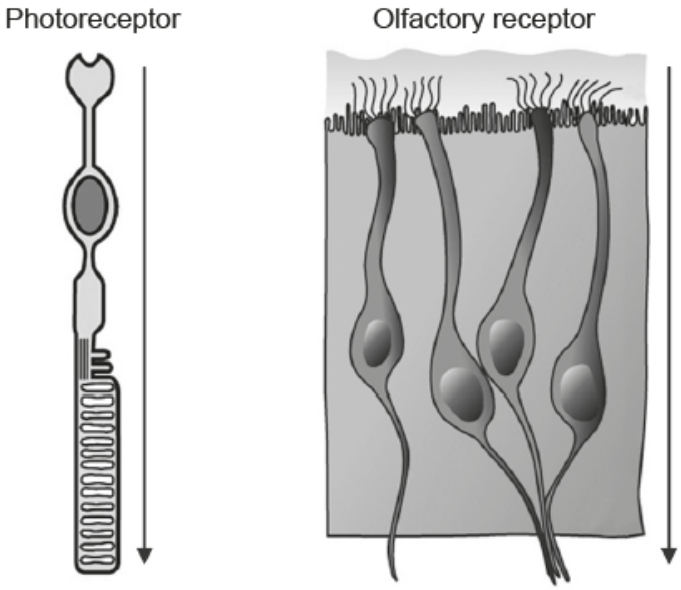
c. relay neuron carries signal from sensory neuron to motor neuron;

Examiners report

a. Nearly all candidates had sound knowledge of Pavlov's experiment, although many did not use the required terms.

b. There was poor knowledge of the exact functions of neurons.

The diagram shows a photoreceptor and an olfactory receptor. The arrows show the direction of the stimulus.



[Source: adapted from A Louvi and E A Grove (2011) *Neuron*, 69 (6), pages 1046–1060, with permission from Elsevier]

a. State the name of the photoreceptor shown. [1]

b. Distinguish between a photoreceptor and an olfactory receptor. [2]

	Photoreceptor	**Olfactory receptor**
Stimulus perceived		
Tissue where it is found		

Markscheme

a. rod

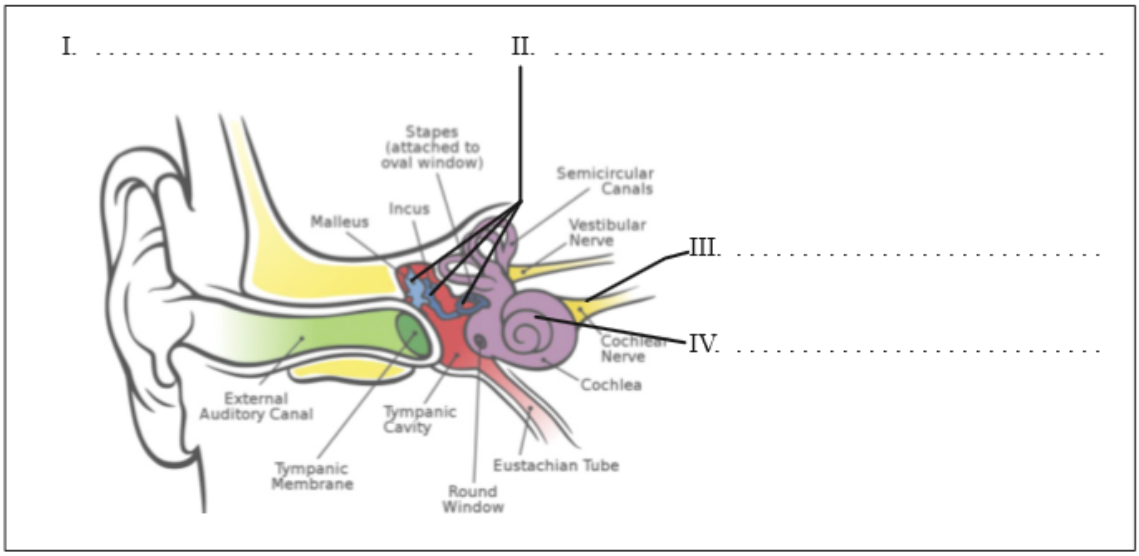
b.

	photoreceptor	***olfactory receptor***
stimulus perceived	light	dissolved molecules ***OR*** chemicals
tissue where it is found	retina	«olfactory» epithelium

Examiners report

a. [N/A]
b. [N/A]

c. Label the diagram of the ear. [2]



[Acknowledgment: http://upload.wikimedia.org/wikipedia/commons/d/d2/Anatomy_of_the_Human_Ear.svg]

d. Explain how the cochlea functions during hearing. [3]

Markscheme

c. *Award **[1]** for any two of the following correctly identified.*

I. pinna;

II. bones of the middle ear/ossicles/malleus, incus and stapes;

III. auditory nerve;

IV. cochlea;

d. bone/ossicle/stapes contacts oval window of cochlea;

ossicle vibrations are transmitted to cochlear fluid via the oval window;

cochlear fluid vibrations cause movement of (basilar) membrane (in precise areas);

movement depends on membrane width and thickness in specific area;

movement causes shearing motion of hair bundles projecting from hair cells attached to membrane;

stimulated hair cells generate action potential that arrive in the brain via auditory nerve;

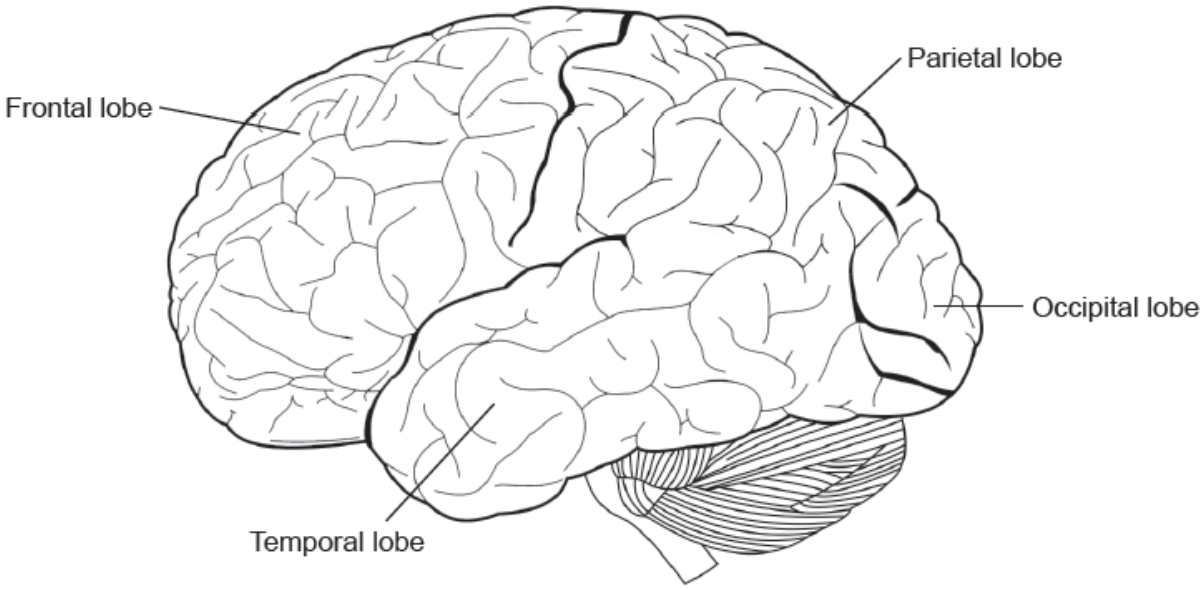
Examiners report

c. E2 (c) was well answered.

d. E2 (d) was answered in very vague terms; there was a lack of biological language.

---

a. The cortex of the brain consists of several regions. [1]



[Source: http://i0.wp.com/buquad.com/wp-content/uploads/2010/11/800px-Brain_Surface_Gyri.SVG_.png]

State whether this view of the brain shows the left side or the right side.

b. Outline the function of Broca's area. [2]

Markscheme

a. left «side»

b. a. speech production

b. language comprehension/processing

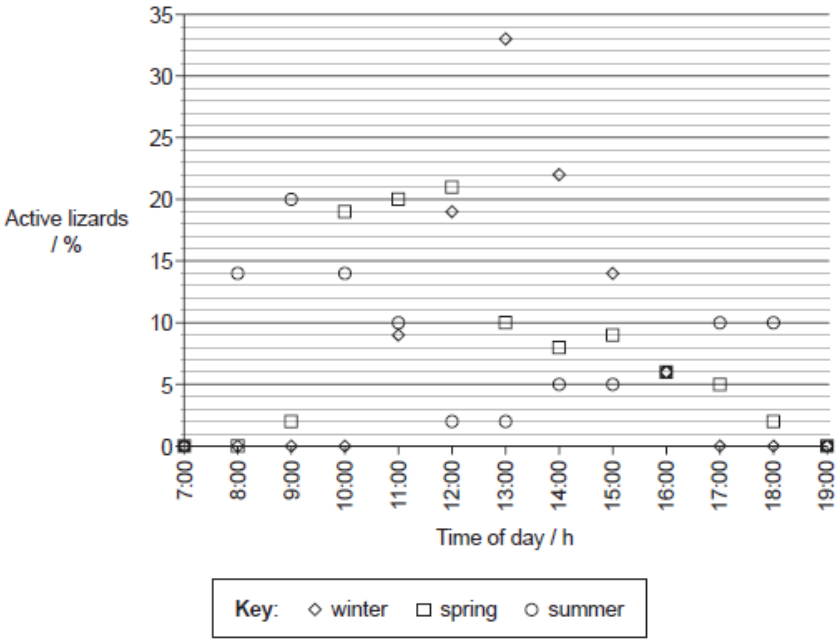
c. damage leads to difficulty in verbalising thoughts

Examiners report

a. [N/A]
b. [N/A]

Lizards living in the Kalahari Desert of southern Africa are diurnal (active in daylight). Scientists studied this rhythmical behaviour during different seasons of the year. Observations were made of the number of lizards active each hour and this was recorded as a percentage of the total number of lizards that were active. The graph shows the results for the Southern Spiny Agama (*Agama hispida*) lizard. Between the hours of 19:00 and 7:00 the lizards were inactive.

[Source: www.biodiversityexplorer.org]



[Source: adapted from RB Huey and EP Pianka, (1977), *Ecology*, **58** (5), pages 1066–1075]

a. State **one** time in spring when 5 % of the lizards were active. [1]

b(i). Winter and summer weather conditions differ in the Kalahari Desert. Compare the results for summer and winter. [3]

b(ii). The temperatures differ in summer and winter. Suggest **one** other possible reason why the lizard activity differs in summer and winter. [1]

c. The body temperature of the lizard is similar to environmental temperature. State the type of receptors that could detect changes in external temperature. [1]

Markscheme

a. 17:00

b(i).

	summer	winter
a.	active for more hours	active for fewer hours;
b.	peak activity at 9:00 / more active in the morning	peak activity at 13:00 / more active mid-day / *OWTTE*;
c.	peak activity lower	peak activity (much) higher;
d.	two peaks of activity	(only) one (high) peak;
e.	both have more inactive hours than active;	
f.	same level of activity at 16:00;	

A table format is not required.

b(ii) a. change in behaviour/availability of their prey/food sources;

b. changes in presence of predators;

c. protection from sun (in the middle of the day in summer);

d. amount of daylight hours (is reduced in winter);

Do not accept answers related to temperature eg: cold blooded or poikilothermic.

c. thermoreceptors/thermo

Examiners report

a. [N/A]

b(i) Most scored 2 marks. A significant number did not compare as required.

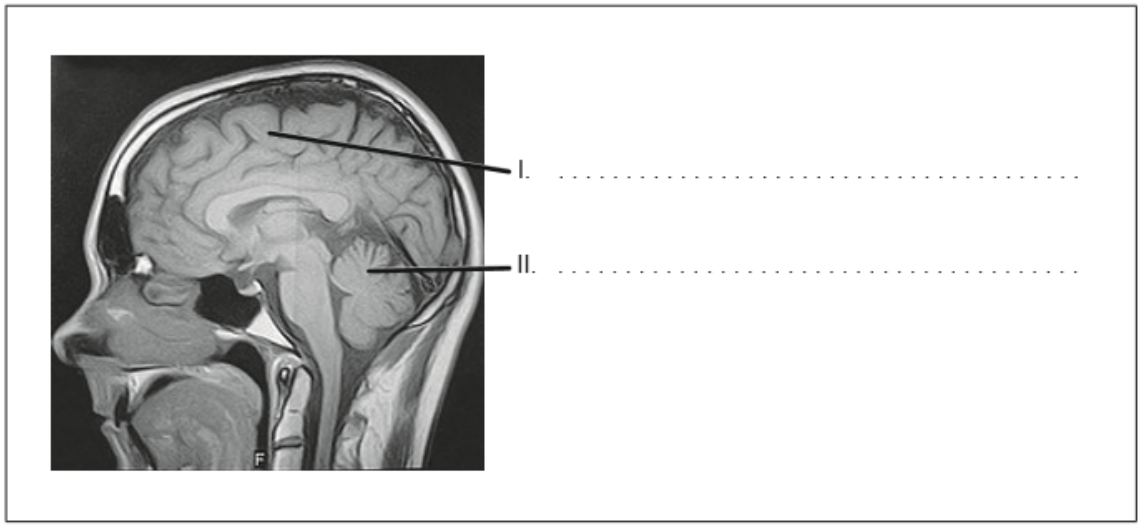
b(ii) Weaker candidates referred to temperature.

c. [N/A]

---

a. This image shows an MRI (magnetic resonance image) human brain scan. [2]

Identify the parts labelled I and II.



[Source: "Humans may have a brain-deep aversion to income inequality", Paul Raven, 03-03-2010. http://futurismic.com/?s=mri+brain.]

b. Outline the source of visual sensory input to the right cerebral hemisphere. [1]

Markscheme

a. *I*: cerebral cortex/hemisphere

OR

cerebrum

II: cerebellum

b. The left side of visual field in both eyes

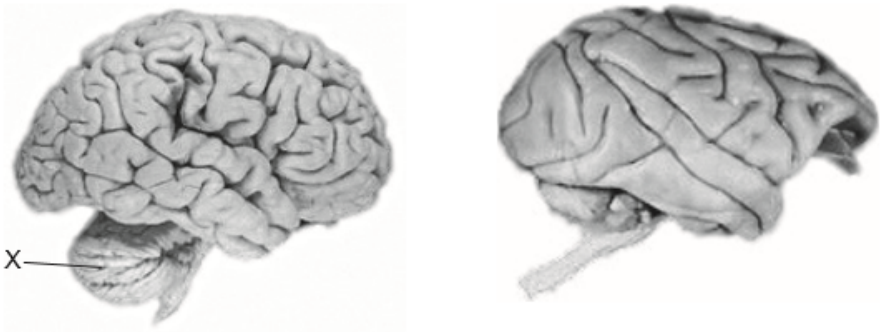
Reference to both left and right eyes is required

Examiners report

a. N/A

b. Candidates confused left visual field with the left eye.

The images show the brains of human (*Homo sapiens*) and baboon (*Papio hamadryas*). The images are not drawn to scale.



Human brain Baboon brain

[Source: adapted from http://serendip.brynmawr.edu]

a. (i) Identify the structure labelled X. [3]

(ii) Outline the function of X in the human brain

b. With reference to structures visible in the diagrams, explain how the human brain is more evolved for higher order functions than the baboon brain. [2]

Markscheme

a. (i) cerebellum

(ii)

a. coordinates the actions of muscles
OR
motor control

b. important in balance/movement/muscle tone/posture

Do not allow ECF.

b. a. «higher order functions are» controlled by the cerebral hemispheres

b. the human brain has more folding of the (cerebral) cortex than the baboon brain

c. «folding» allows for more surface area / more synapses

d. «more cerebral cortex» without increasing cranium size

e. frontal lobe is larger proportion in the human brain than in the baboon brain

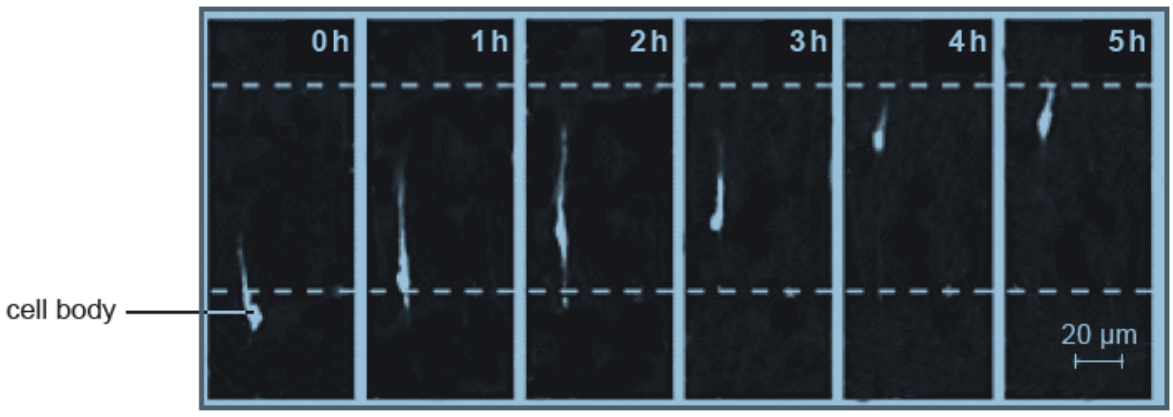
Do not allow answers relating to size as diagrams are not to scale and size is not "visible".

Do not accept cerebellum unless a higher order function is given.

Examiners report

a. [N/A]
b. [N/A]

The photomicrographs below show time lapse images of a migrating neuron in the grey matter of the cerebrum of an embryo. The time lapse images were taken at one hour intervals. The cell body is the rounded bright area towards the rear of the migrating neuron.



[Source: Reprinted from C. Gil-Sanz et al. (2013) *Neuron*, 79, pages 461–477, with permission from Elsevier.]

a. Calculate the rate of movement of the neuron cell body between 0 and 5 h. Working should be shown, giving the units. [2]

b. Suggest a reason for the migration of neurons in the embryonic nervous system. [1]

c. Outline neural pruning. [2]

Markscheme

a. a. cell moves 25–28mm

OR

71–93μm

b. speed range is 71–93 μm in 5 hours

c. answer in the range 14–19 μm/h or μm h^{-1}

b. a. «neural migration» positions cell types from different origins into specific locations

b. «neural migration» allows formation of connections/synapses

c. allows for differentiation of cell types/types of neuron

c. a. neural pruning is the removal of synapses/dendrites/ neural connections

b. caused by lack of use

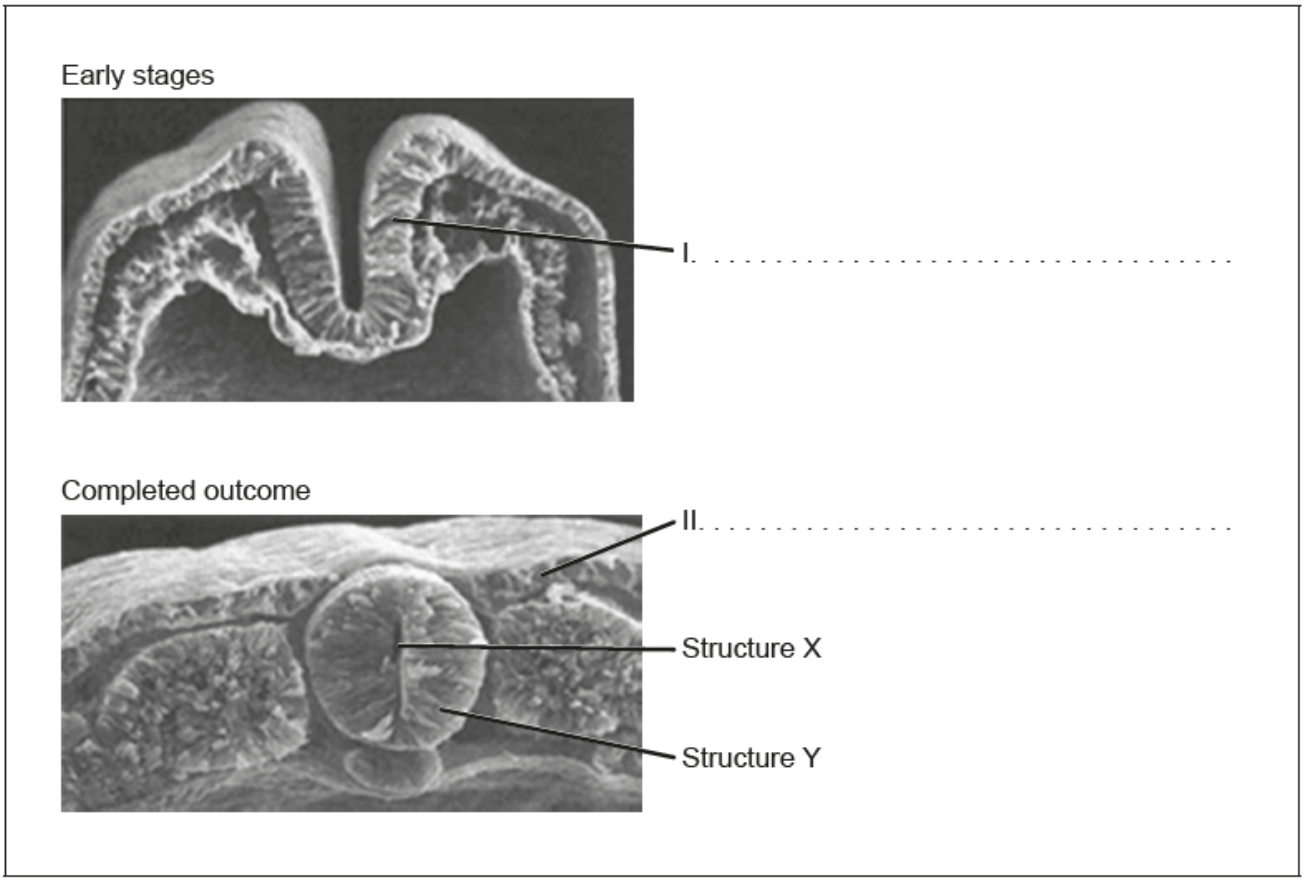
c. it occurs during brain development/between birth and end of puberty

d. allows new neural connections/makes nervous system more efficient /plasticity

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

The images show the early stages and completed outcome of the process of neurulation.



[Source: adapted from www.slideshare.net]

a. Label the parts I and II on the images. [2]

b. Structure Y will eventually elongate to form two structures. State the names of these **two** structures. [2]

1.

2.

c. State the condition that arises if the closure of structure X is incomplete during embryonic development. [1]

Markscheme

a. *I*: neural groove/plate/fold

II: ectoderm

b. brain

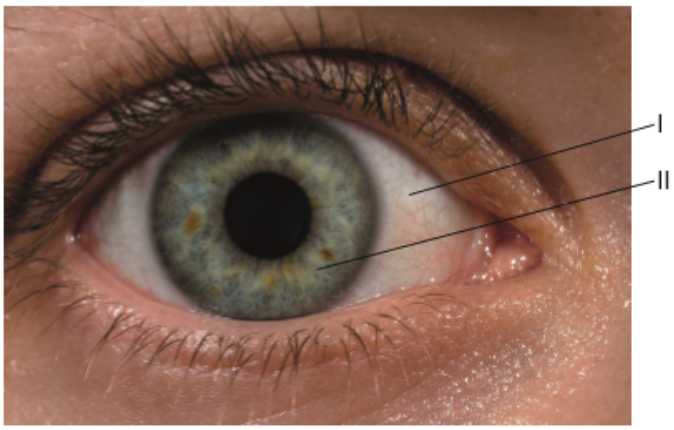
spinal cord

c. spina bifida

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

The image shows a human eye.



[Source: adapted from https://en.wikipedia.org/wiki/Human_eye#/media/File:Human_eye_with_blood_vessels.jpg, by ROTFLOLEB]

a. Identify the structures labelled I and II [1]

I. . . . . .

II. . . . . .

b. Explain how the pupil of the eye can be used to assess brain damage. [4]

Markscheme

a. *I:* conjunctiva/sclera

AND

II: iris/cornea

*To award **[1]** both answers are needed.*

b. a. bright lights causes the pupil to constrict/iris to increase in size

b. low light causes the pupil to dilate/iris decrease in size

c. these are reflex actions

d. the test for brain damage is to (briefly) shine a bright light in the eyes

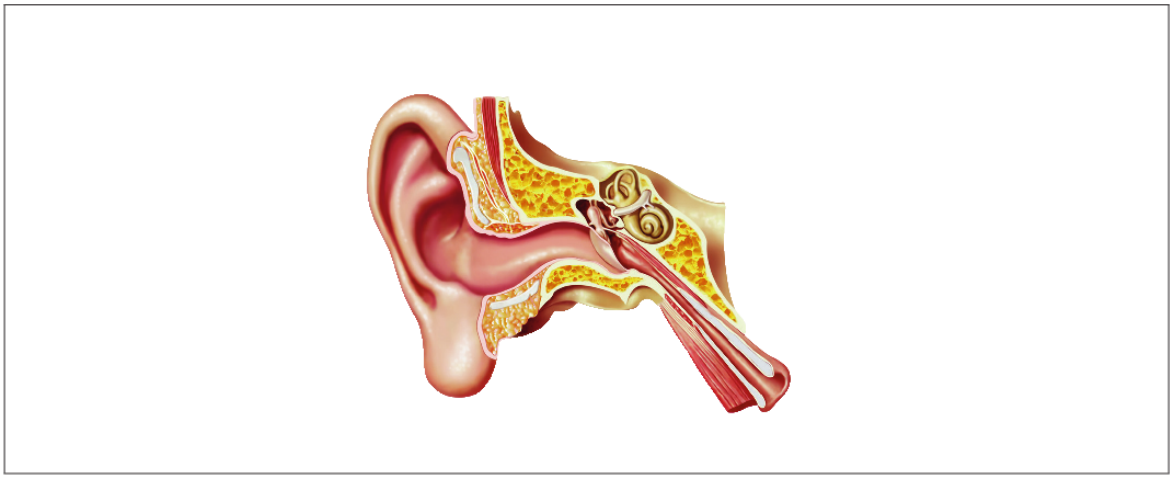
e. slow or unresponsive change in pupil size indicates brain damage/concussion

f. different response of each eye indicates brain damage/concussion

Examiners report

a. [N/A]
b. [N/A]

The image shows a human ear.



[Source: Leonello/iStock]

a.i. Using the letter M, label the structures which detect movement of the head. [1]

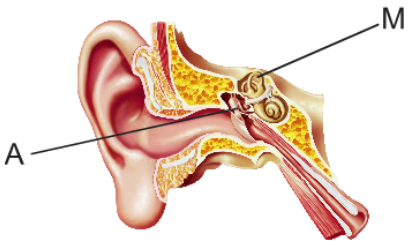
a.ii. Using the letter A, label where sound is amplified. [1]

b. Explain the function of the cochlea in hearing. [2]

c. Outline how the hearing of a deaf or partially deaf person could be improved. [1]

Markscheme

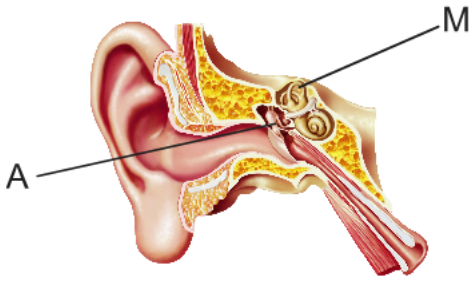
a.i. Example of answer for part (a)(i)



The candidate should label the semicircular canals

Line with the letter M is expected but accept the letter M on diagram if clearly indicating the correct structure

a.ii. Example of answer for part (a)(ii)



The candidate should label the bones/ossicles in middle ear

Line with the letter A is expected but accept the letter A on diagram if clearly indicating the correct location

b. a. sound «waves» enters the ear causing fluid in the cochlea to move/vibrate

b. «movement of fluid in cochlea» causes the hair cells to move

c. «details of hair cell movement» is transmitted to brain via the auditory nerve

[Max 2 Marks]

c. hearing aid/cochlear implant

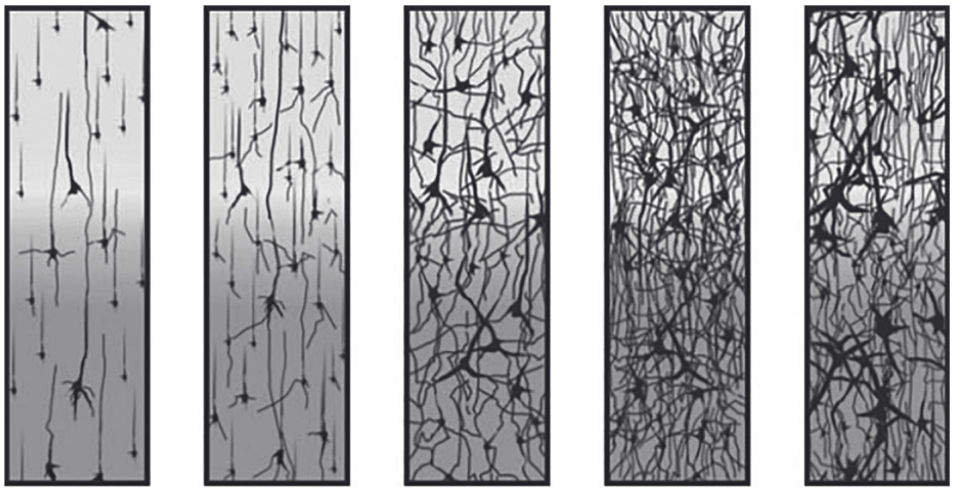
Answer must refer to ear, not for example just "operation"

Accept other valid answers

Examiners report

a.i. [N/A]
a.ii. [N/A]
b. [N/A]
c. [N/A]

The diagrams illustrate changes in synapse density of the cerebral cortex from newborn to adult.



[Source: THE POSTNATAL DEVELOPMENT OF THE HUMAN CEREBRAL CORTEX, VOLUMES IVIII, by Jesse LeRoy Conel, Cambridge, Mass.: Harvard University Press, Copyright © 1939, 1941, 1947, 1951, 1955, 1959, 1963, 1967
by the President and Fellows of Harvard College. Copyright © renewed 1967, 1969, 1975, 1979, 1983, 1987, 1991.]

Explain the processes illustrated by the diagrams.

Markscheme

a. at birth neurons are mainly unconnected

b. after birth «up to 2 years» neurons start to make synapses/connections with other neurons

OR

up to 2 years the number of synapses/connections increases

c. «increase in synapses» occurs rapidly due to learning/new experiences

d. each neuron can make multiple synapses

e. brain makes many more connections than are required

f. «after 2 years/in adults» neural pruning causes the loss of unused neurons/synapses/connections

Do not accept more neurons are made

[Max 4 Marks]

Examiners report

[N/A]