SL Paper 3

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

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]

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

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

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]

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

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

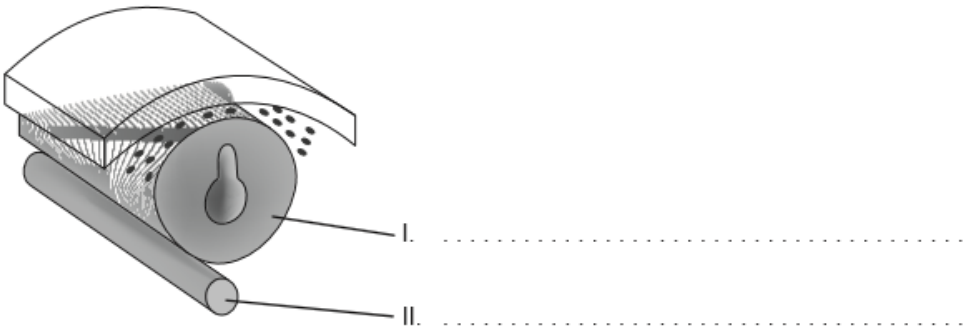
f. Hearing is a result of the stimulation of mechanoreceptors. List **three** other main types of receptors. [1]

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

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

---

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]

---

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]

---

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

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

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

---

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

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

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

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]

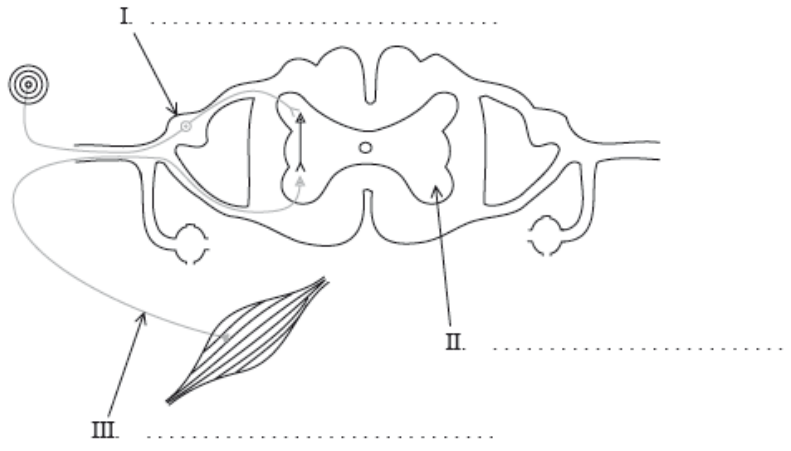
Explain the effects of tetrahydrocannabinol (THC) in terms of its action at synapses in the brain.

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]

Label the parts of the reflex arc shown below.



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.

---

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

Excitatory: .....

Inhibitory: .....

c. Discuss causes of addiction. [3]

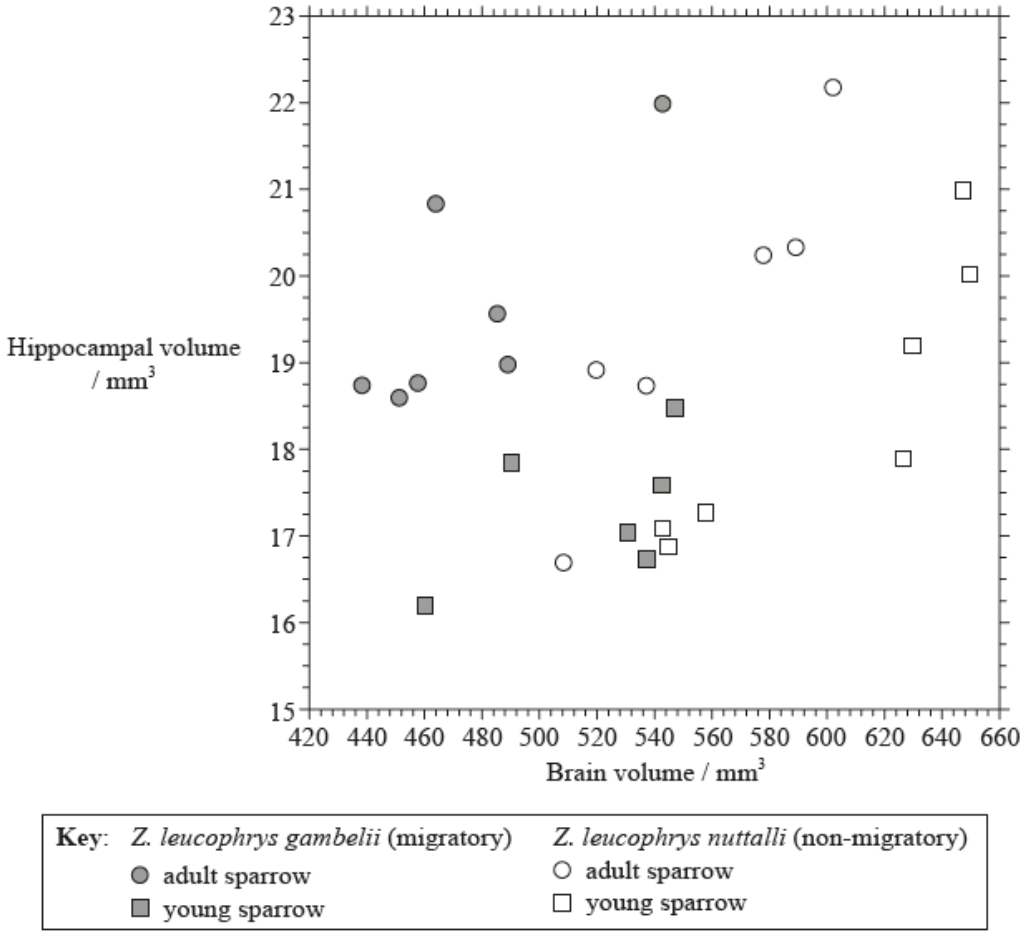
Explain the effects of psychoactive drugs on synaptic transmission.

---

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]

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]

Outline the development of birdsong in young birds.

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

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]

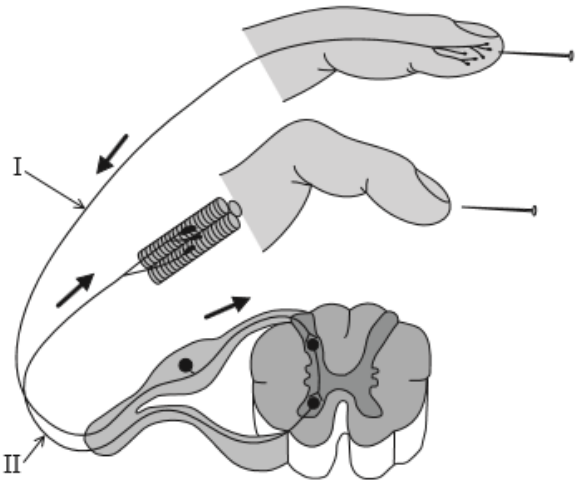
Discuss the correlation between diet and brain size.

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

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

Compare rod and cone cells.

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]

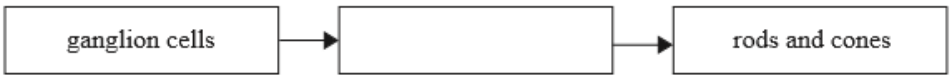
c. Explain how sound is perceived by the ear. [4]

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

1.

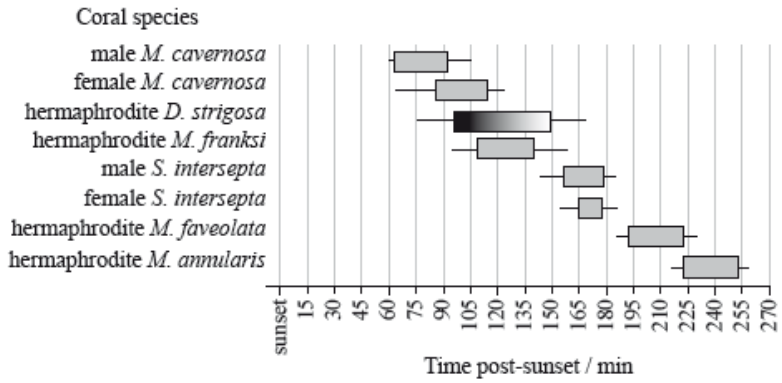
2.

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



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]

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]

---

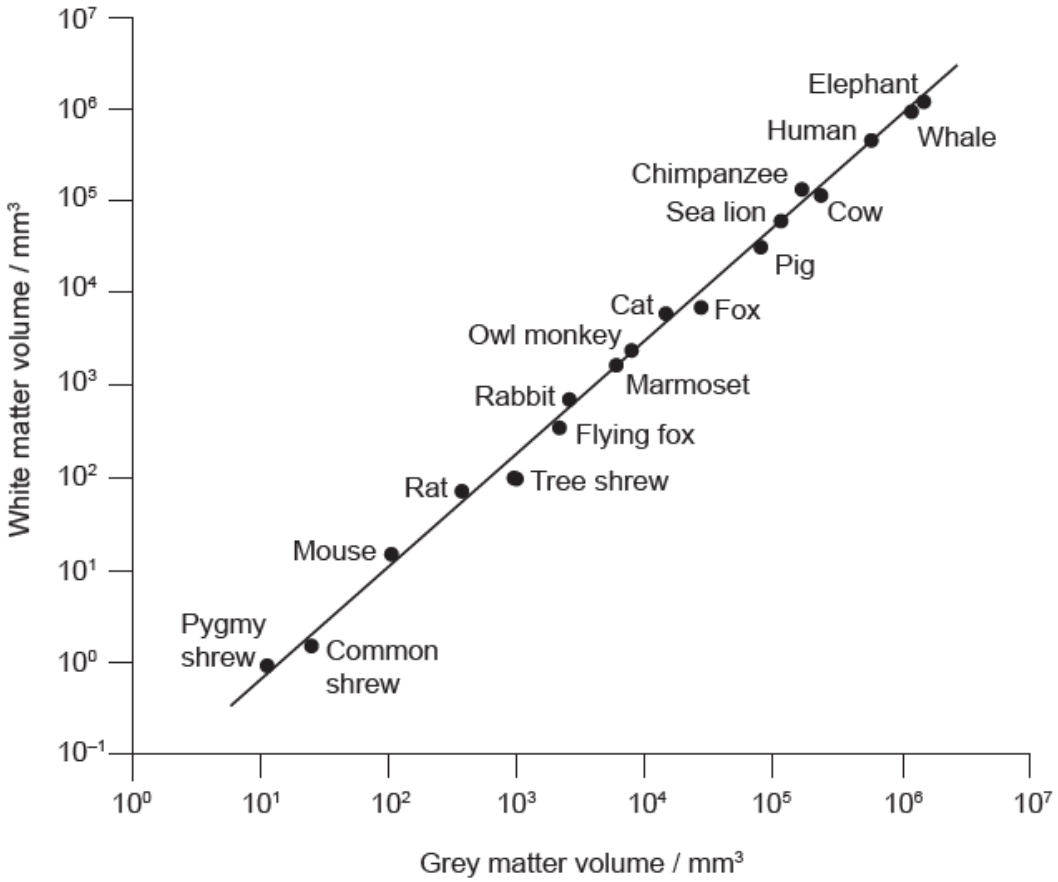
a. Define the term *reflex* in animal behaviour. [1]

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	

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

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]



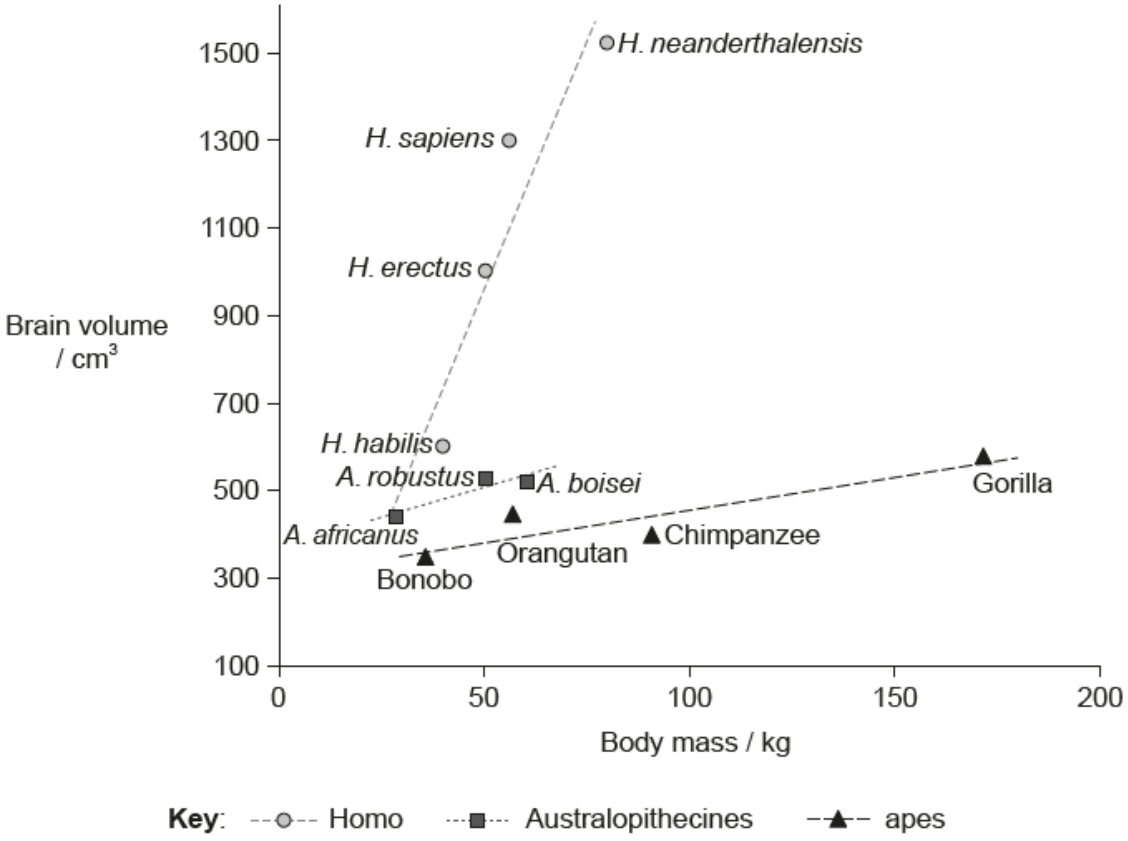
[Source: E. Bullmore and O. Sporns (2012) *Nature Reviews, Neuroscience* Vol. 3, pages 336–349. Reprinted by permission from Macmillan Publishers Ltd. http://www.nature.com/nrn/index.html]

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]

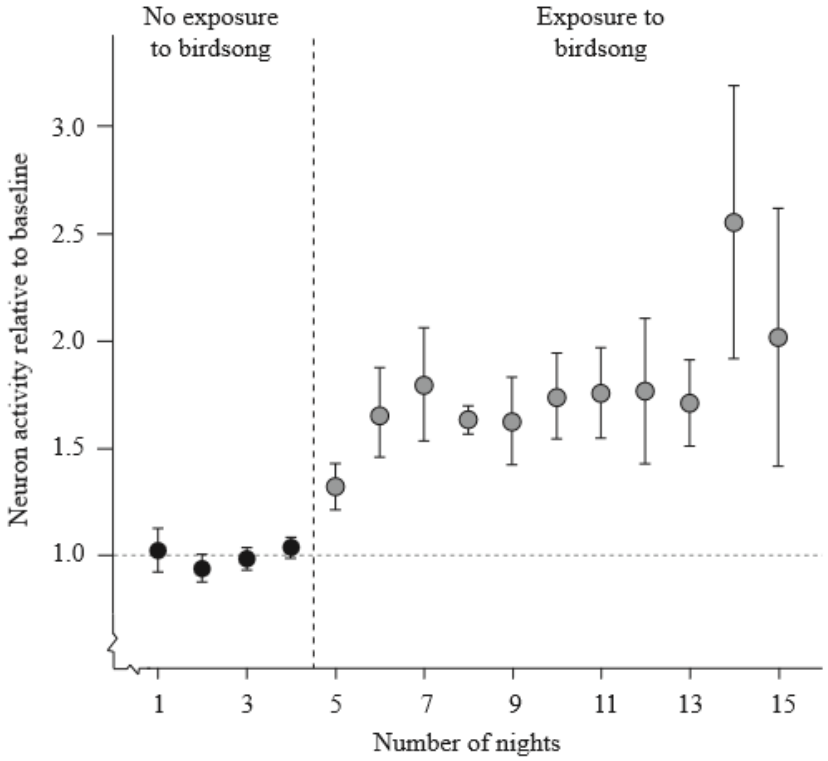
The graph shows the relationship between body mass and brain volume in three groups of primates.



[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.

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]

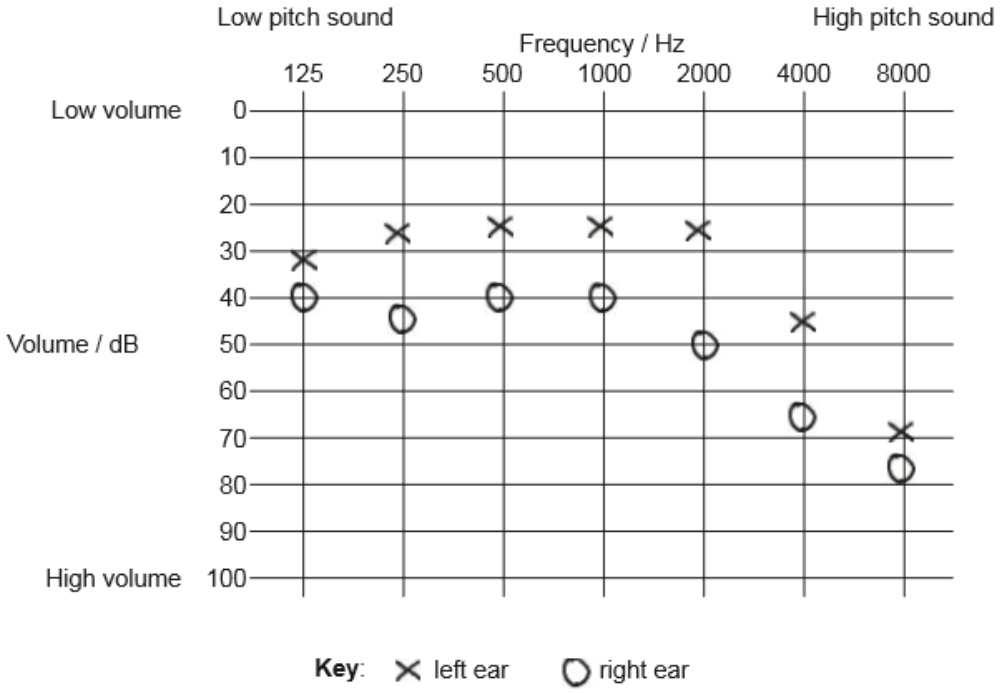
a. State the difference in neuron activity between nights 2 and 7. [1]

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]

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]

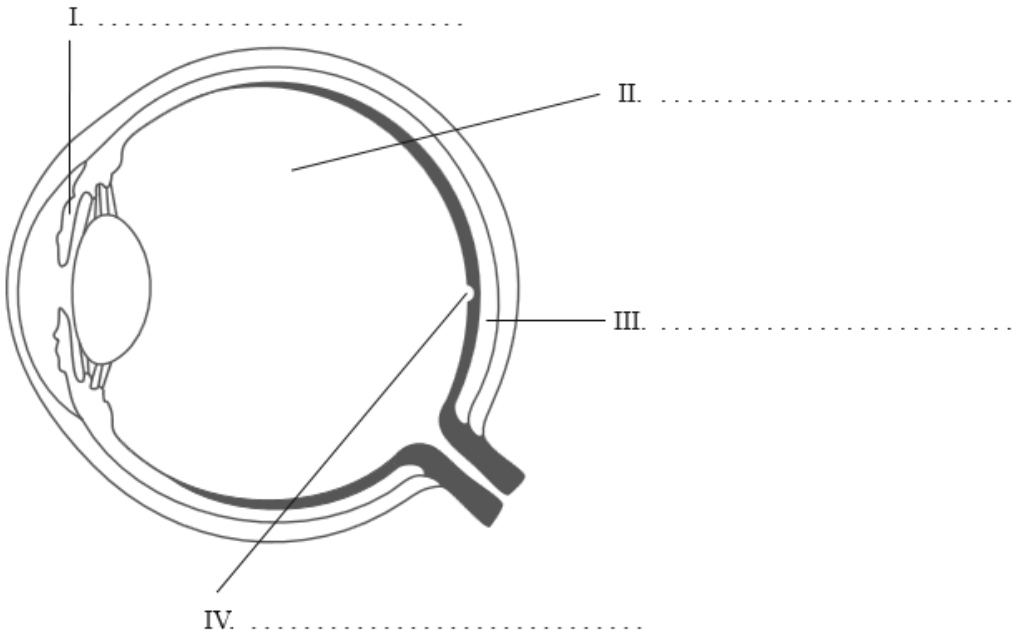
a. Human speech occurs at a volume of approximately 60 dB and at frequencies between 125 Hz and 4000 Hz. Outline whether the woman would hear all conversations with both ears. [1]

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]

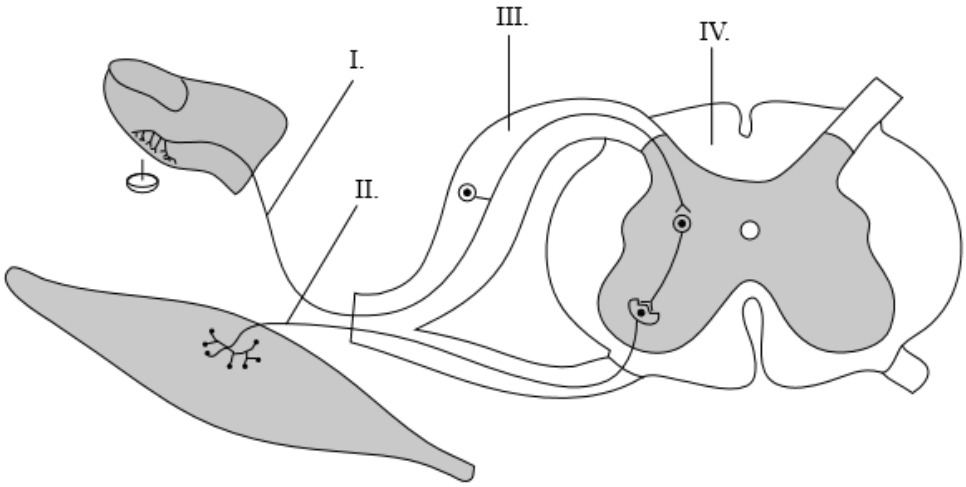
---

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



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

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. .....

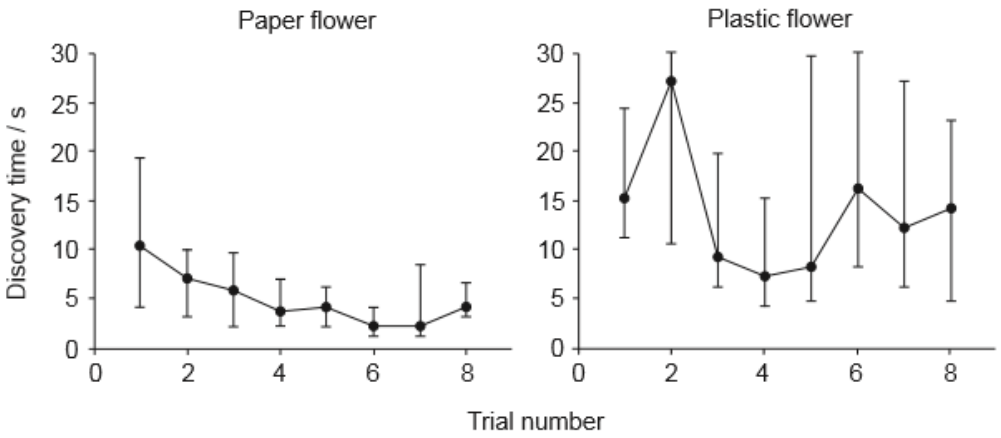
II. .....

III. .....

IV. .....

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

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]

---

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: .....

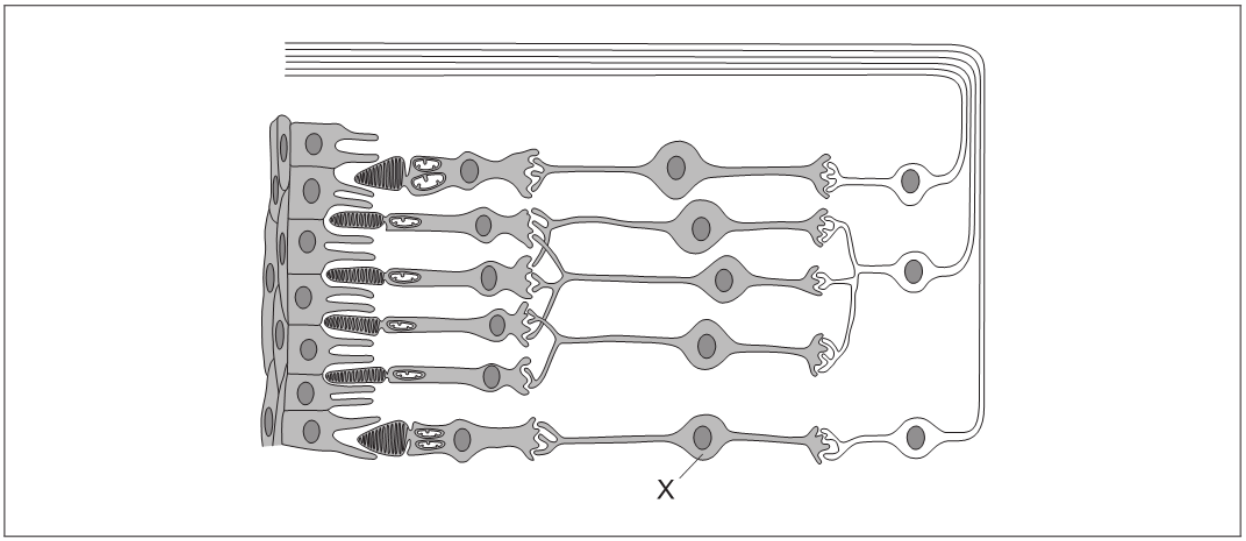
Inhibitory drug: .....

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]

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]

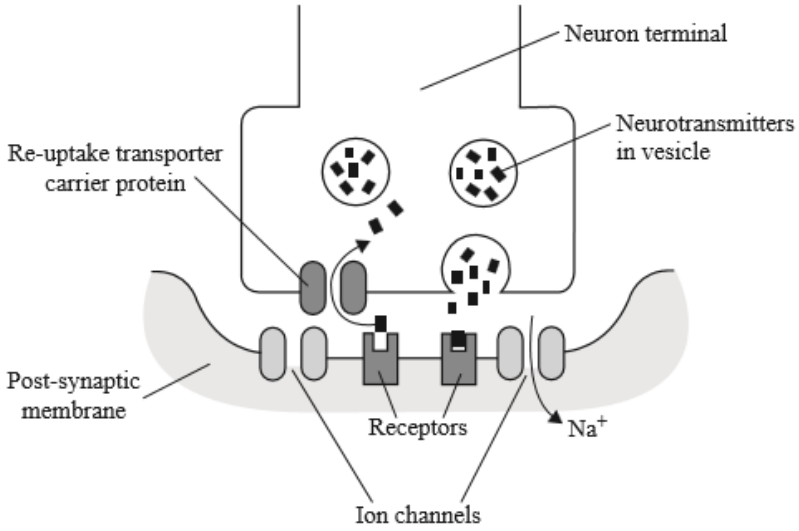
d.ii. Draw an arrow to show the direction of light through the retina. [1]

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

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

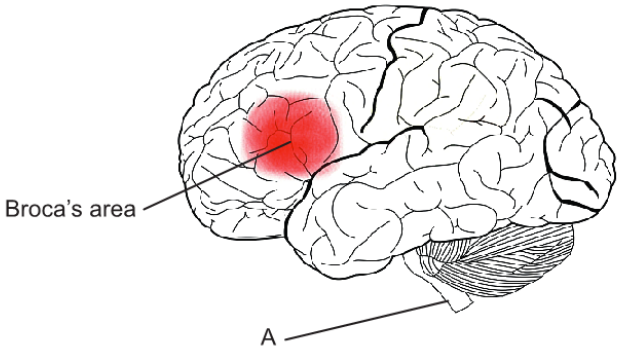
The diagram below shows a synapse where the neurotransmitter is dopamine and some of the processes that take place during nerve transmission.

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.]

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]

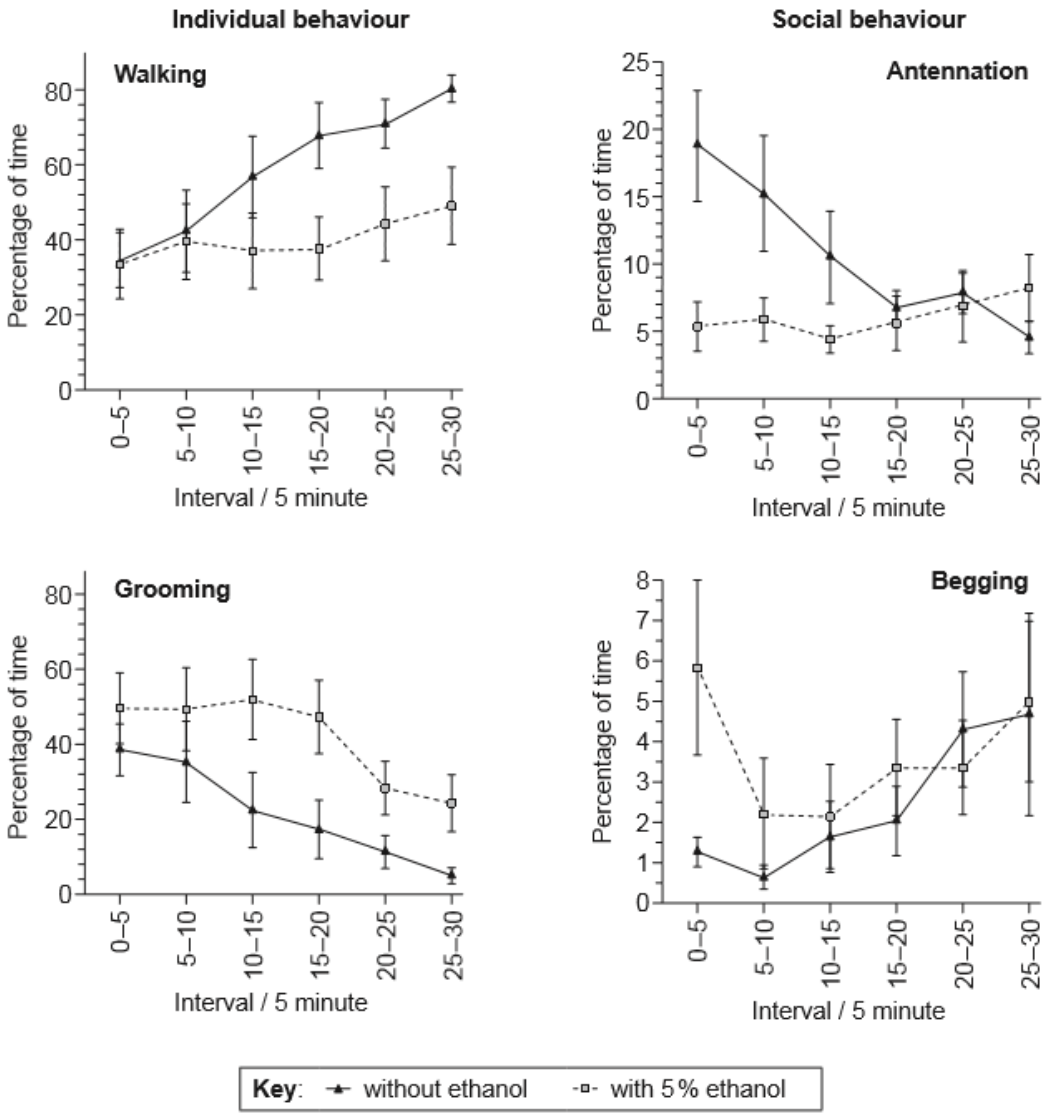
a.ii. List **two** functions of the structure labelled A. [2]

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]

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]

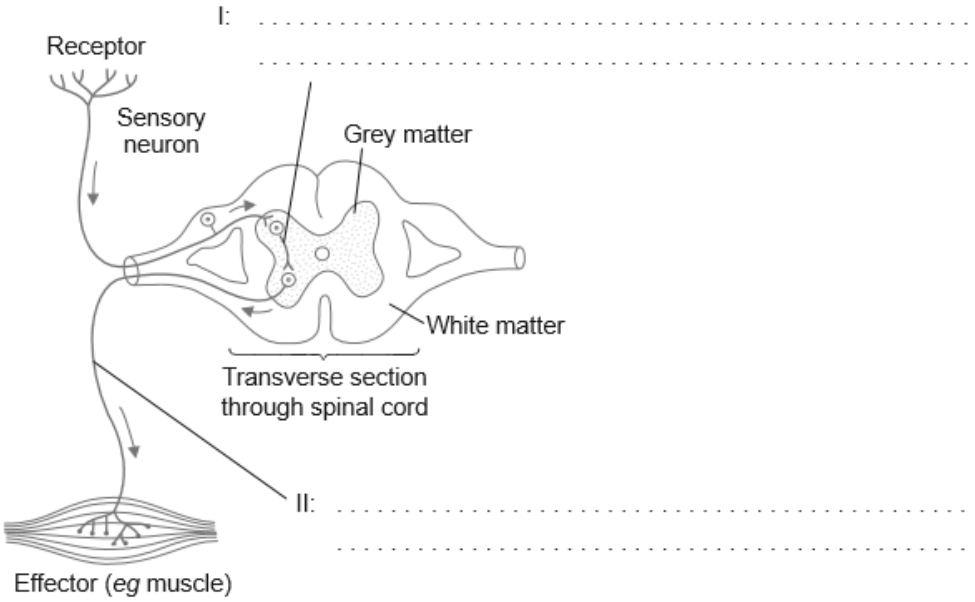
d. Evaluate the hypothesis that ethanol affects the social behaviour of honey bees. [3]

---

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

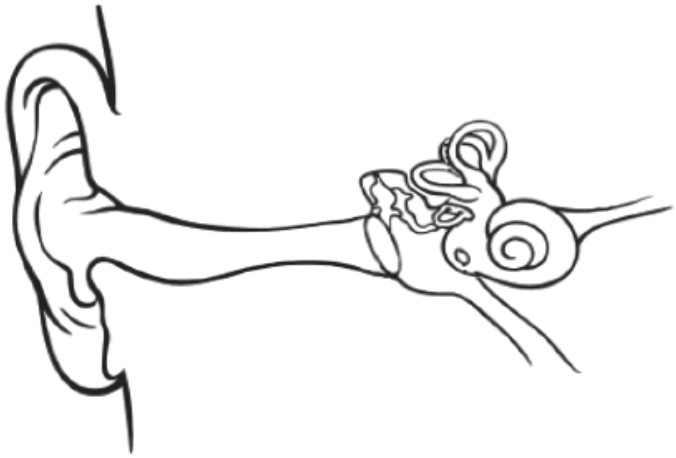
Smell: .....
Temperature: .....

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



---

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



Label the cochlea on the diagram.

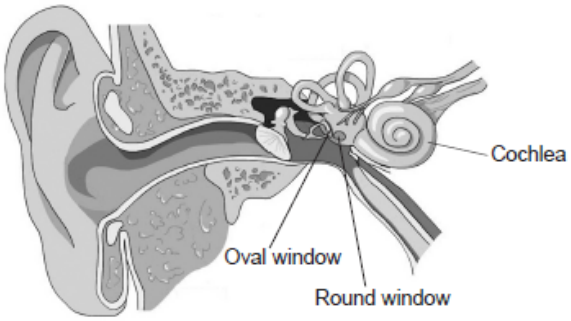
b. Explain the structure of the semicircular canals in relation to their functions. [4]

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

---

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

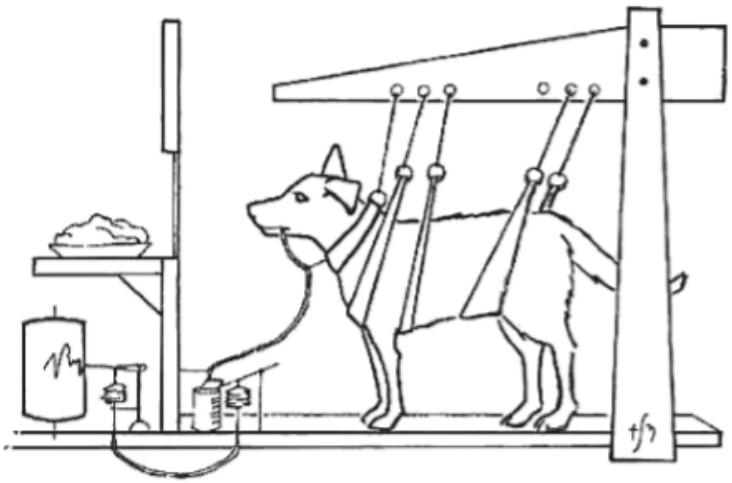
c. [1]



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

The image shows the human ear.

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

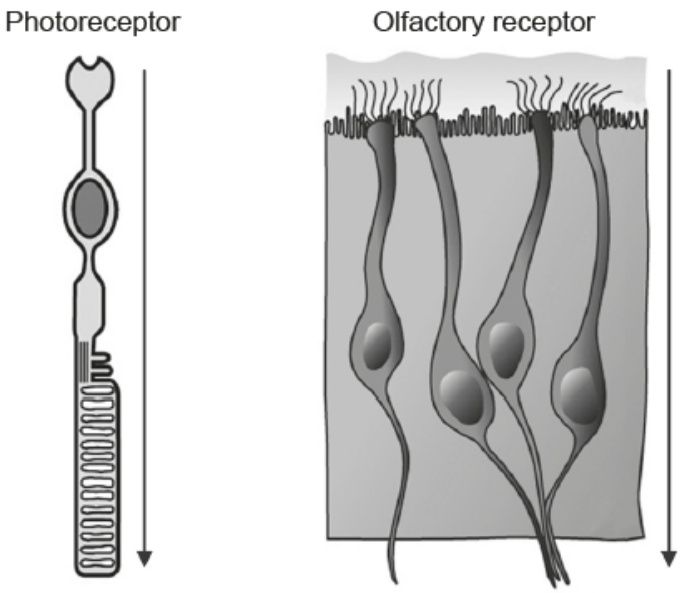


[Source: http://animalbehaviour.net/ClassicalConditioning.htm]

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]

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



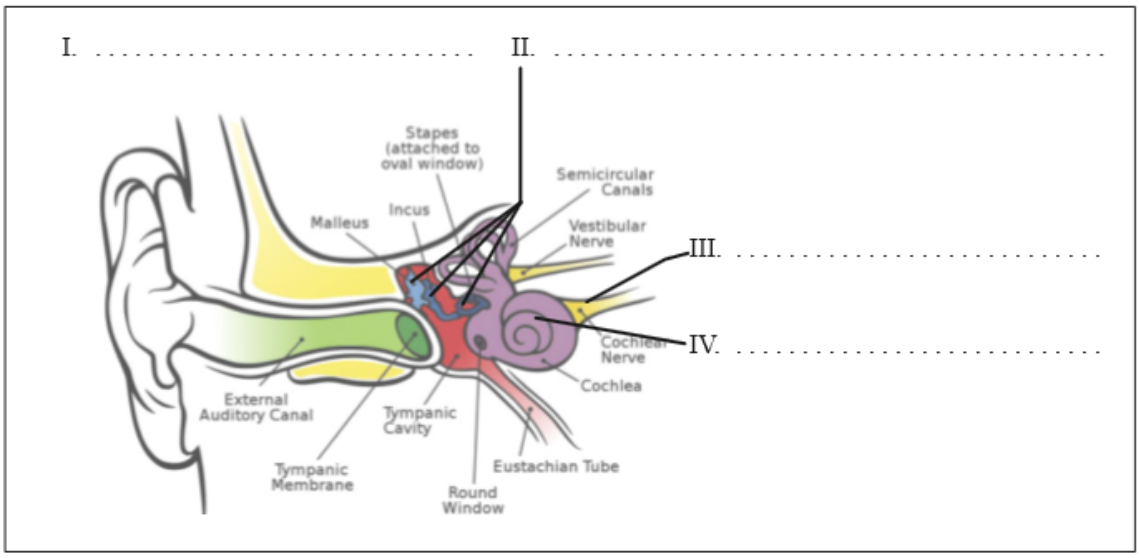
[Source: adapted from A Louvi and E A Grove (2011) *Neuron*, 69 (6), pages 1046–1060, with permission from Elsevier]

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		

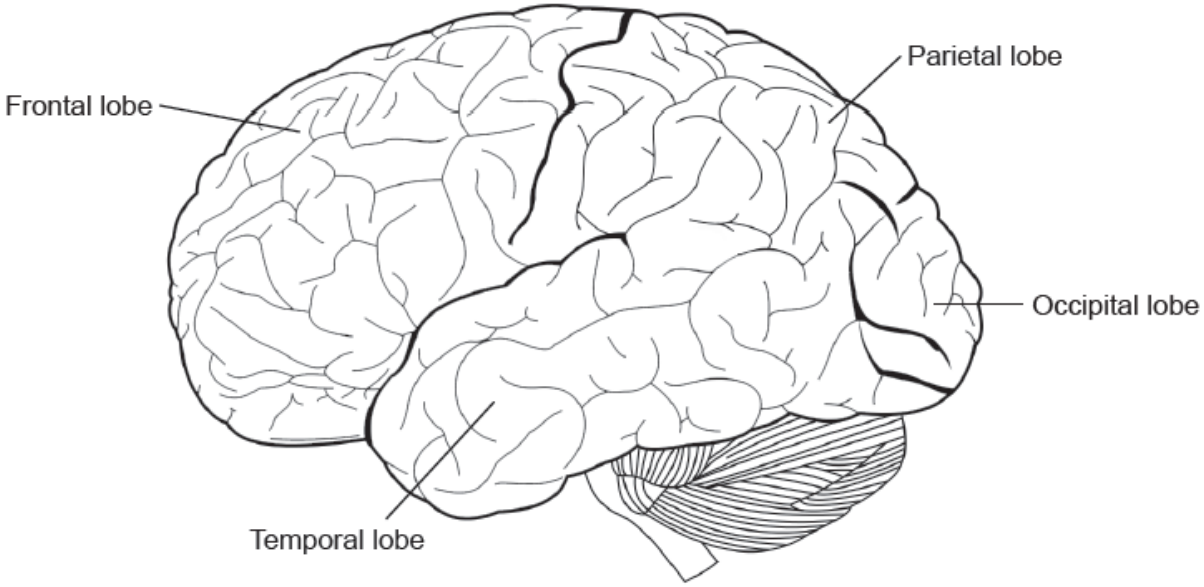
c. Label the diagram of the ear. [2]



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

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

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



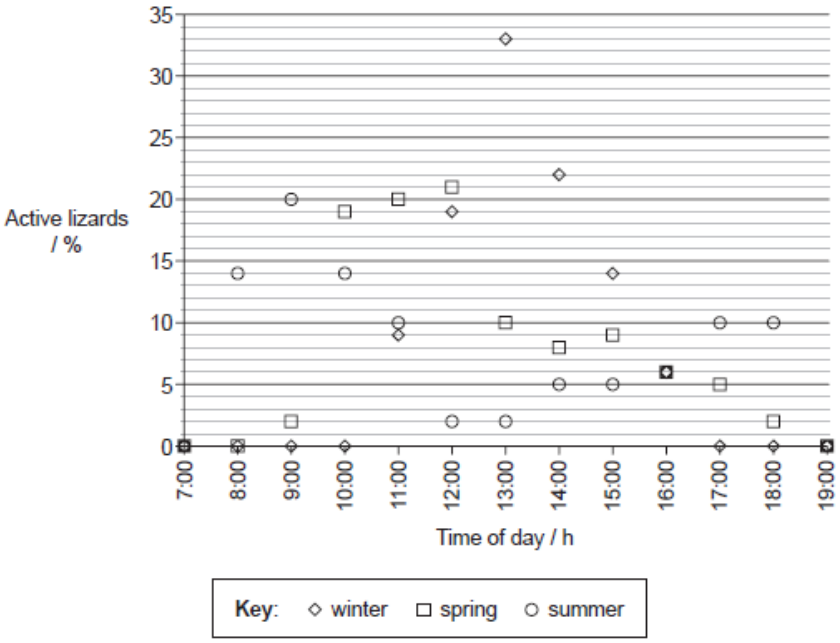
[Source: http://i0.wp.com/buquad.com/wp-content/uploads/2010/11/800px-Brain_Surface_Gyri.SVG_.png]

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

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

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]

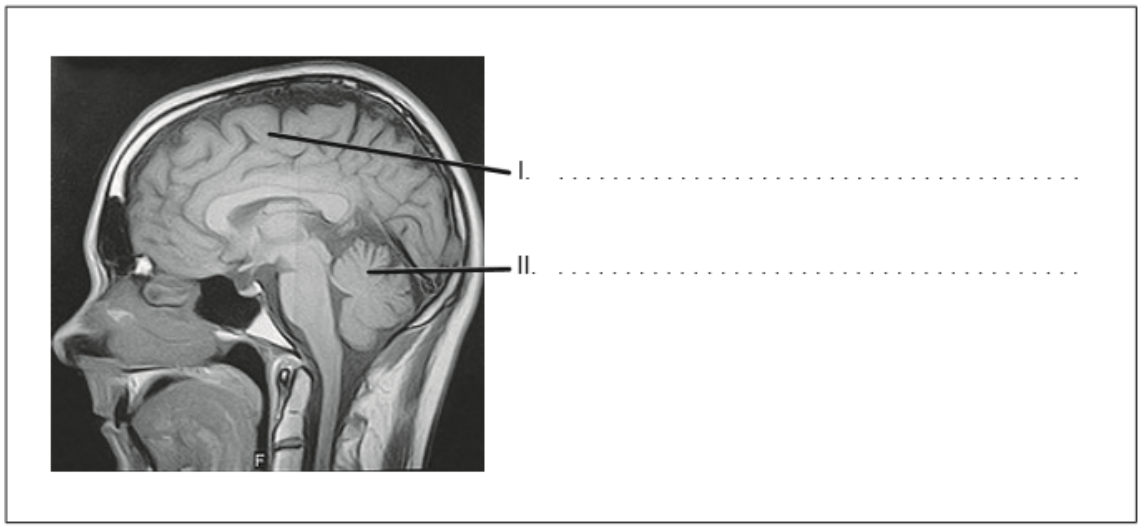
b(ii). The temperatures differ in summer and winter. Suggest **one** other possible reason why the lizard activity differs in summer and winter. [1]

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]

---

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

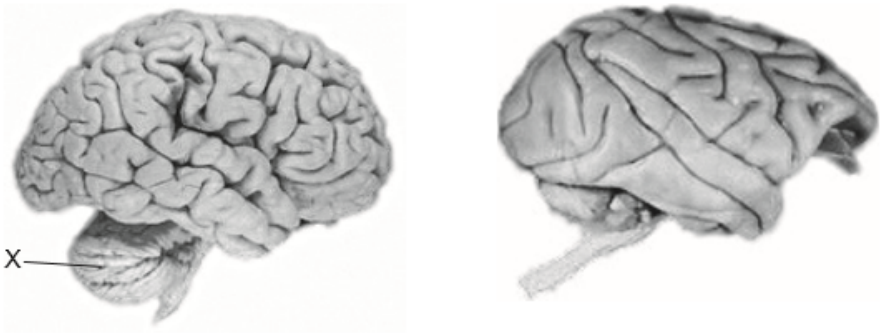
Identify the parts labelled I and II.



[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]

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



Human brain Baboon brain

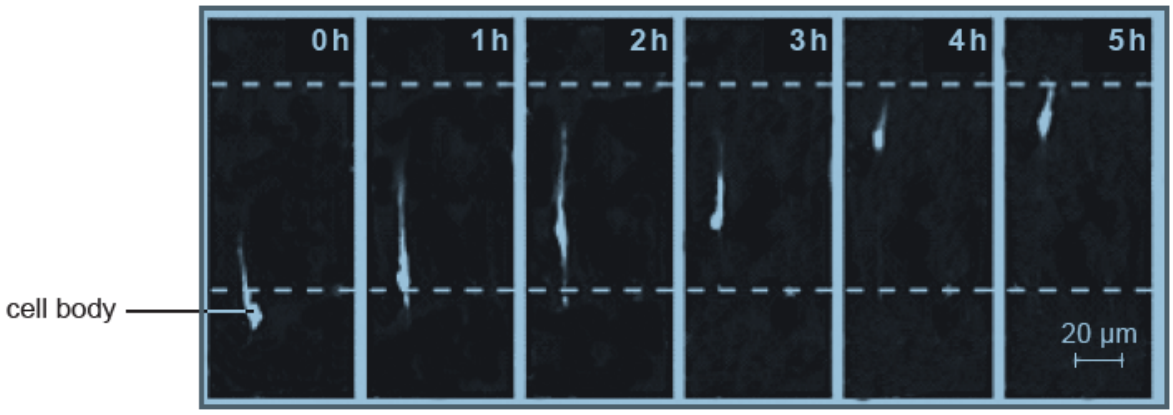
[Source: adapted from http://serendip.brynmawr.edu]

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]

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.



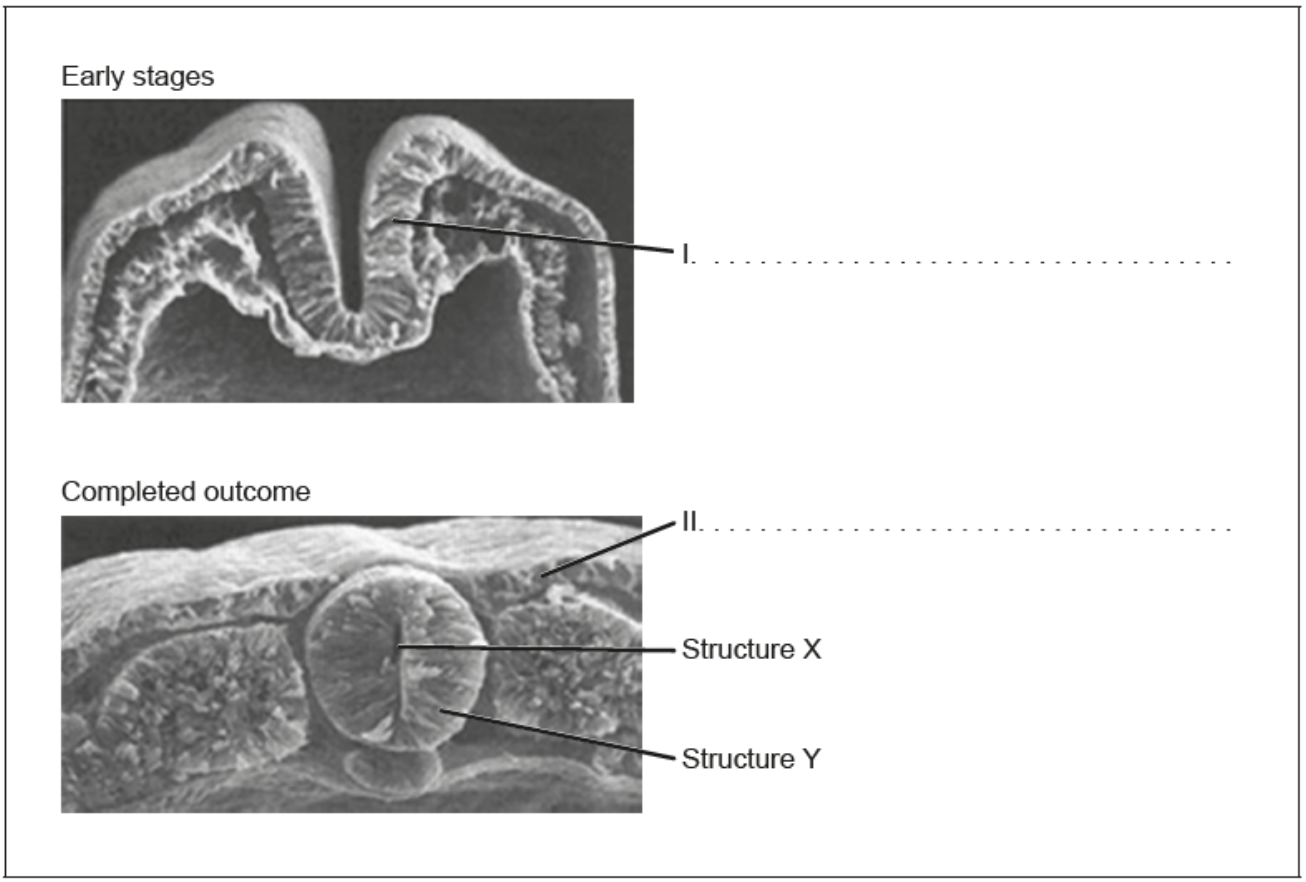
[Source: Reprinted from C. Gil-Sanz et al. (2013) *Neuron*, 79, pages 461–477, with permission from Elsevier.]

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]

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]

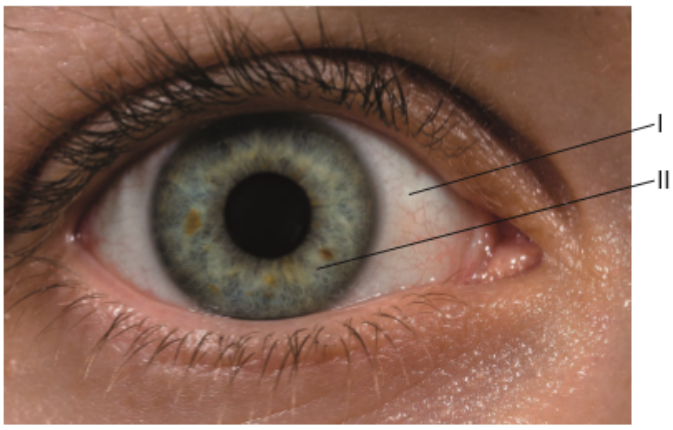
b. Structure Y will eventually elongate to form two structures. State the names of these **two** structures. [2]

1.

2.

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

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]

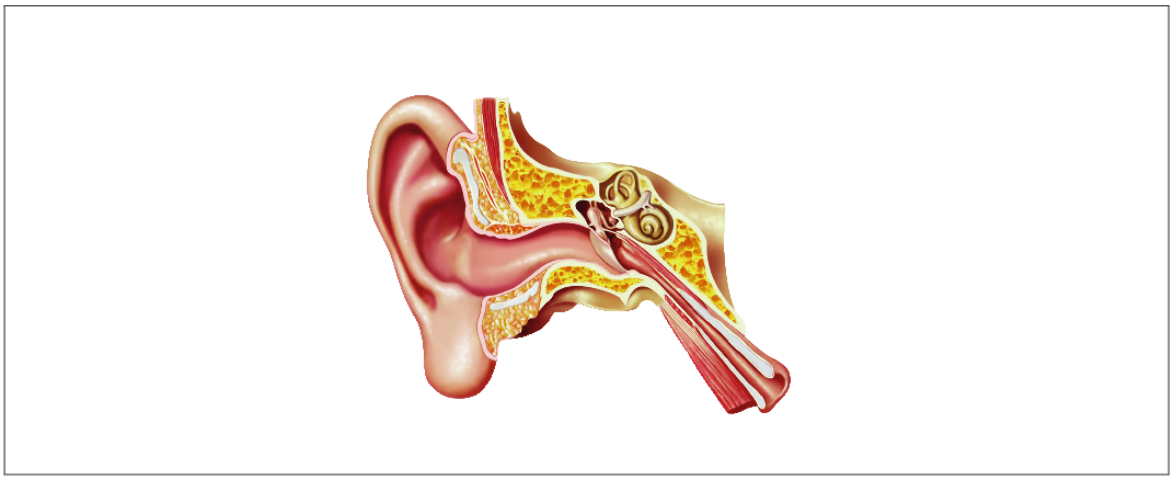
a. Identify the structures labelled I and II [1]

I. . . . . .

II. . . . . .

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

The image shows a human ear.



[Source: Leonello/iStock]

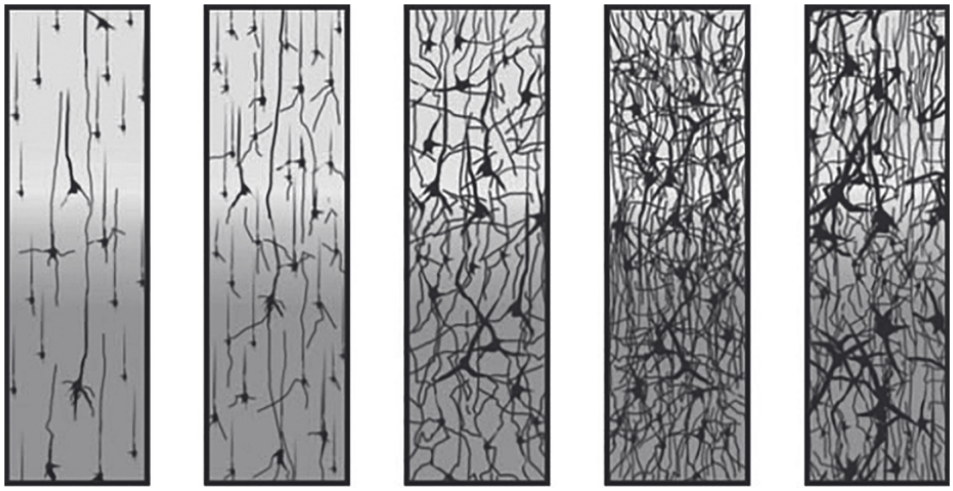
a.i. Using the letter M, label the structures which detect movement of the head. [1]

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]

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.
