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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
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TOTAL	



General Certificate of Education
Advanced Level Examination
June 2011

Science in Society

SCIS3

Unit 3 Exploring Key Scientific Issues

Wednesday 15 June 2011 9.00 am to 11.00 am

<p>For this paper you must have:</p> <ul style="list-style-type: none"> • a calculator • a ruler.
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Time allowed

- 2 hours

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 90.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



JUN11SCIS301

Section A

Answer **all** questions in the spaces provided.

- 1** Teenagers show some mental characteristics that are different from those of younger children and of adults. Recent research has tried to relate these characteristics to changes in the brain as it develops.
- 1 (a)** The number of neurons in the brain does not change significantly from birth to adulthood although we become more capable in many ways. What changes do happen to the neurons in the brain during its development?

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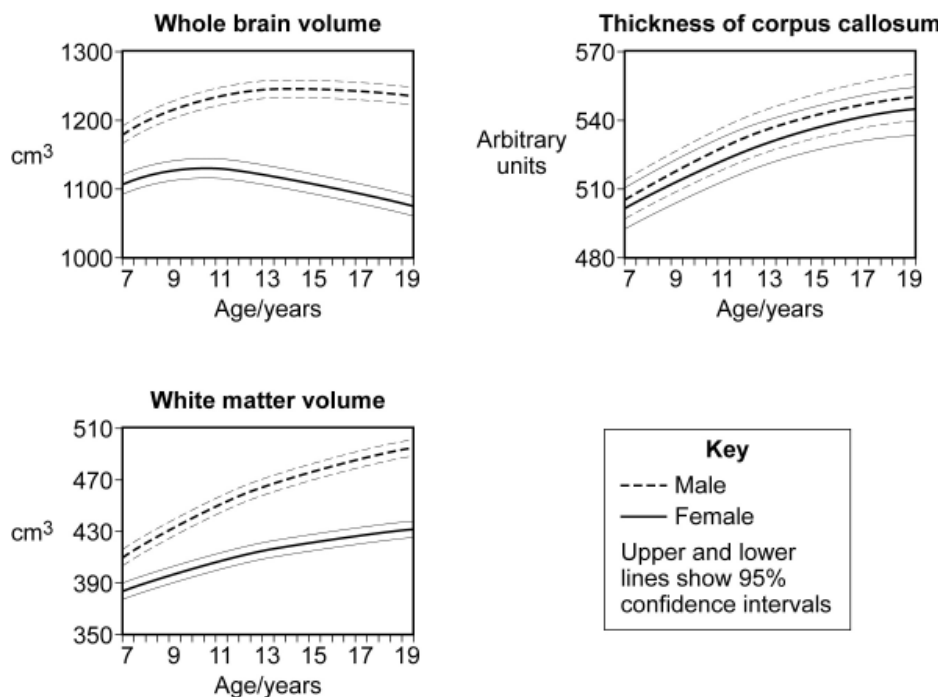
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(2 marks)

- 1 (b)** One study, reported in the *Journal of Adolescent Health* in 2008, used MRI to monitor changes in the brains of 387 young people between ages 7 and 19 years at two-yearly intervals. The researchers made 475 scans of males and 354 of females. They looked at the volume of the whole brain and the volume of the white matter, the axons. They also looked at the thickness of the corpus callosum, the bundle of axons that carry impulses between the right and left halves of the brain. **Figure 1** shows some of the results.

Figure 1

Mean volume of male and female brains and brain features at different ages



1 (b) (i) What do the data in **Figure 1** suggest about the age at which the physical structure of the brain appears to be mature? Explain your answer.

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(2 marks)

1 (b) (ii) There is no overall difference between average male and female IQ values despite the difference in average brain size. However, women are, on average, better than men at some mental skills that require integration of ideas. This difference has sometimes been explained in terms of the different thickness of the corpus callosum. Do these data support such an explanation? Explain your answer.

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(2 marks)

1 (c) (i) This research report has been cited in 67 further articles in the two years after publication. Another paper on the same topic has only been cited by 3 further articles in the same period. Suggest **two** possible reasons for the difference.

Reason 1

Reason 2

(2 marks)

1 (c) (ii) The journal reports that it received the paper in October 2007 and approved it for publication in January 2008. What happened between these two dates to allow the editors to decide that the paper could be published in the journal?

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(1 mark)

9

Turn over ▶



- 2 Some drug addicts die suddenly after showing one or more of the following symptoms: extreme agitation, aggression, paranoia, great strength, numbness to pain, and high body temperature. Their agitated behaviour may require police intervention and death often occurs during restraint by the police. Scientists as well as lawyers have become involved in these cases. Two different explanations have been used to account for the deaths:

Explanation A

It is a distinct mental illness called 'excited delirium' triggered by drug use but probably with an underlying genetic factor. Those with the condition are at extreme risk of sudden death with or without police intervention.

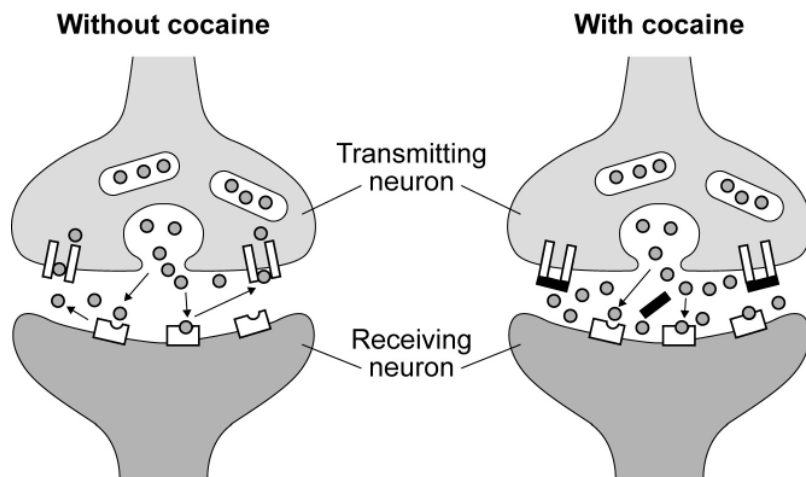
Explanation B

The deaths are caused by the police using forms or methods of restraint which are too extreme. This harsh restraint triggers heart failure or breathing difficulties.

Most of the victims are long-term cocaine addicts but the symptoms are quite different from those of death from acute cocaine poisoning. 'Excited delirium' is not recognised by the American Psychiatric Association as a distinct mental disorder.

- 2 (a) The drug cocaine increases dopamine levels in the brain. It does this by preventing re-uptake of dopamine by dopamine transporters at the synapses. **Figure 2** shows the action of cocaine at a synapse.

Figure 2



- 2 (a) (i) Complete the key for **Figure 2** by drawing the correct symbols against the four names.

The symbols are:



Key

..... Dopamine transporter sites

..... Cocaine

..... Dopamine receptor molecule

..... Dopamine

(2 marks)



- 2 (a) (ii) Referring to the diagram in **Figure 2**, explain why an increase in dopamine levels means that signals are transmitted through the synapse more frequently.

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(2 marks)

- 2 (b) Long-term cocaine addicts often have different numbers of dopamine transporter sites from non-addicts. (Note that the apparent relationship between long-term cocaine use and the number of transporter sites is distinct from the short-term effects of cocaine on nerve function shown in **Figure 2**.) Researchers have compared the number of dopamine transporter sites in brain samples from three groups, X, Y and Z. Some of their results are shown in **Figure 3**.

Figure 3
Post-mortem measures of dopamine transporter sites

	Cause of death	Number of subjects	Average number of dopamine transporter sites /unit mass of brain tissue \pm standard deviation
X	'excited delirium'	90	115.4 \pm 2.7
Y	acute cocaine poisoning	38	256.7 \pm 7.9
Z	unrelated to cocaine	35	165.0 \pm 5.0

- 2 (b) (i) Why does a decrease in the number of dopamine transporter sites lead to an increase in the concentration of dopamine in the synapses? You may refer to **Figure 2** in your answer.

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(1 mark)

- 2 (b) (ii) In **Figure 3** the standard deviation is given for the average number of dopamine transporter sites found in the 'excited delirium' victims. What does this information tell us?

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(2 marks)

Turn over ►



2 (c) The scientists who did this research favour Explanation A and suggest that measuring the number of dopamine transporter sites in brain samples could be a way of identifying cases of ‘excited delirium’ after death.

2 (c) (i) What evidence do the data in **Figure 3** provide that might help you decide between Explanation A and Explanation B for the cause of death?

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(2 marks)

2 (c) (ii) Do you think this evidence is sufficient? Explain your answer.

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(2 marks)

2 (d) A study of 111 deaths recorded as caused by ‘excited delirium’ found that 97% of these deaths happened whilst the people were being forcibly restrained, or very soon afterwards.

Explain why scientists who think that Explanation B accounts for the deaths could use this data as evidence to support this explanation.

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(1 mark)

2 (e) Discuss possible factors in the personal background of the scientists involved that might have some influence on which of the two explanations they come to accept.

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(2 marks)



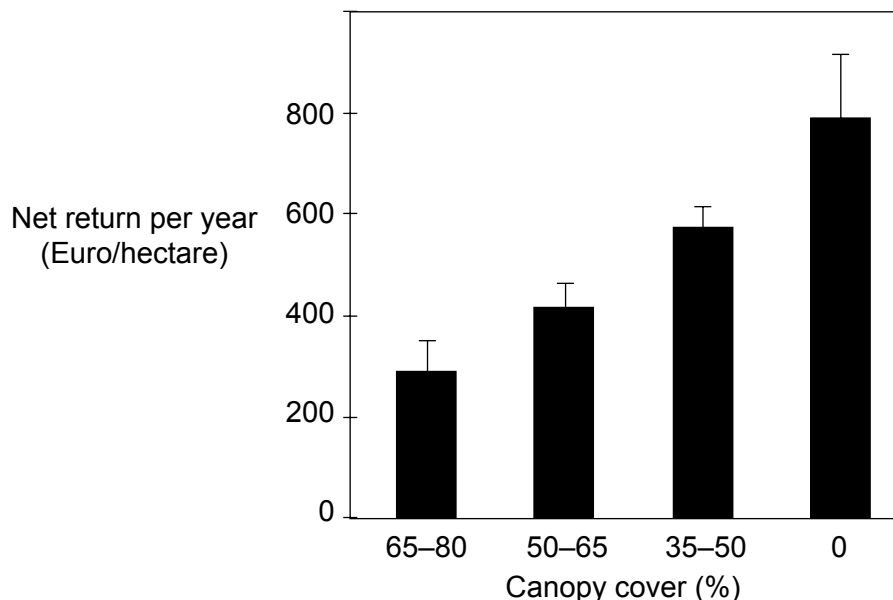
- 3 Tropical forests occupy land that could also be used to grow food or cash crops. Cacao, which provides the raw material for chocolate manufacture, is an example of a cash crop. Cacao trees can be grown either on cleared land in open plantations or in 'cacao forestry'.

Cacao forestry is a managed tropical forest system under the shade of the taller forest trees. This shade is known as canopy cover. Uncleared tropical forest has 100% canopy cover, an open plantation has 0% canopy cover. In a managed forest some trees may be cut down to reduce the canopy cover.

One research group studied how different levels of canopy cover influence the economic and environmental effects of cacao forestry. The research was done in Indonesia, a large developing country in Asia.

Figure 4 provides economic data on the relationship between the percentage of canopy cover and farmers' income per hectare from cacao forestry.

Figure 4
Returns from cacao forestry systems in relation to canopy cover



- 3 (a) Suggest **two** reasons why the percentage of canopy cover influences the growth and yield of cacao trees, as suggested by the data in **Figure 4**.

Reason 1

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Reason 2

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(2 marks)

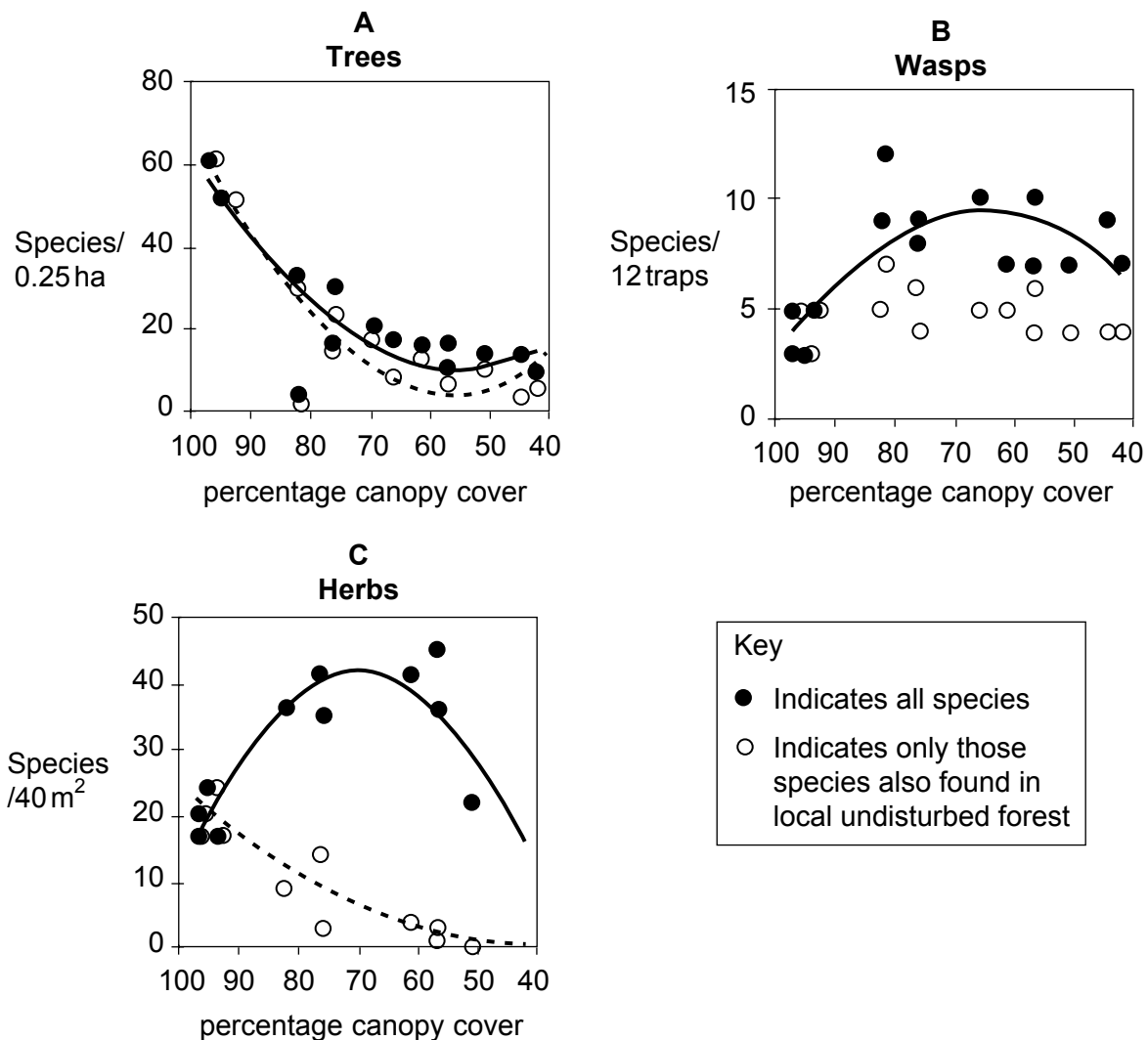
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- 3 (b)** There is worldwide concern that loss of tropical rain forest causes loss of biodiversity. The researchers studied the relationship between the level of canopy cover and biodiversity for different groups of plants and insects. They looked at total species richness, in each of these groups. Species richness means the number of different species found in a given unit. Some of the results are shown in **Figure 5**.

Figure 5 also shows separately how canopy cover affects the species richness of the subset of species that are also found in the local undisturbed tropical forest.

Figure 5
Species richness of one insect and two plant groups along a gradient of canopy cover in cacao forestry systems



3 (b) (i) What conclusions can you draw from **Figure 5A** about the relationship between canopy cover and the overall species richness of trees (black dots)?

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(2 marks)

3 (b) (ii) We might have less confidence in any conclusions drawn from **Figure 5B** about the effect of canopy cover on all wasp species (black dots) than in conclusions drawn from **Figure 5A** about the effect of canopy cover on tree species. Explain why.

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(1 mark)

3 (b) (iii) In addition to the conservation of a wide range of species it is important to conserve those specialised species that exist in the undisturbed forests (indicated by white dots in **Figure 5**).

What evidence do the three graphs in **Figure 5** provide about the impact of cacao plantations on the conservation of species richness for specialised forest-based species (white dots)?

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(2 marks)

3 (c) Why is it important to prevent the specialised forest-based species becoming extinct? Give **two** reasons.

Reason 1

Reason 2

(2 marks)

Turn over ▶



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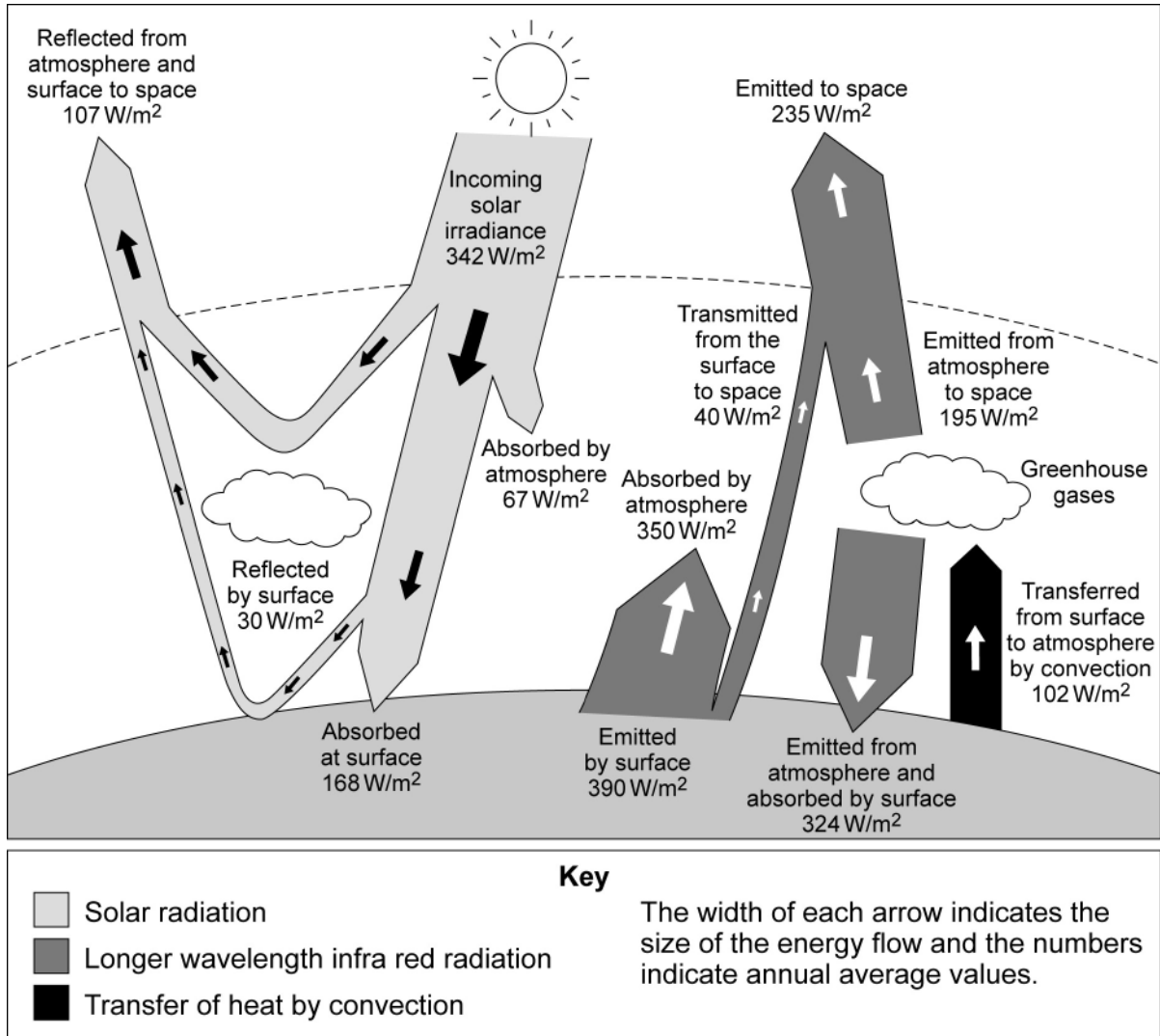
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- 4 Scientists have developed models to help them understand the complex, inter-linked processes involved in climate change. Climate models are based on science that describes and explains how energy is transferred throughout the climate system.

Figure 6
Average energy flows into and out of the Earth's atmosphere



- 4 (a) **Figure 6** shows a steady state where the average temperature of the Earth remains constant.
- 4 (a) (i) Show that in the diagram the energy flows are in balance at the top of the atmosphere.

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(1 mark)



4 (a) (ii) Show that in the diagram the total energy absorbed by the atmosphere is equal to the total energy emitted by the atmosphere.

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(1 mark)

4 (a) (iii) As the concentration of greenhouse gases in the atmosphere rises the balance of energy flows changes. Explain, in terms of the energy flows in **Figure 6**, why one effect of this is a rise in the temperature of the atmosphere.

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(1 mark)

4 (a) (iv) Name **one** energy flow that increases if the temperature of the Earth's surface increases.

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(1 mark)

4 (b) (i) Suggest **two** reasons why climate models are developed by interdisciplinary teams rather than by scientists working as individuals.

Reason 1

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Reason 2

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(2 marks)

4 (b) (ii) Explain why data derived from a model on a computer can never represent exactly what is really happening to the Earth's climate.

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(2 marks)

Turn over ▶



4 (b) (iii) The dynamic models used to study climate change have to take into account feedback effects. Explain why greater melting of sea ice due to global warming leads to positive feedback in the climate system.

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(2 marks)

4 (b) (iv) Outline **one** way that scientists test their models of climate change.

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(2 marks)

4 (c) There is a strong consensus among most scientists that human activities have increased the emissions of greenhouse gases and that this has caused global warming. However the popular media do not always reflect this consensus. Their stories give the impression that the issue is much more controversial than is suggested by official reports, such as those from the Intergovernmental Panel on Climate Change (IPCC). Suggest reasons why the popular media report the issue in this way.

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(2 marks)

Turn to page 16 for the next question



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5 A scientist and an engineer in California came up with a plan in 2009 to show that all the energy needs in the world, *for all purposes*, could be supplied by wind, water and solar resources by 2030.

The plan is based on technologies that work, or are close to working, today on a large scale. The selected technologies have very low, or zero, emissions of greenhouse gases and other air pollutants over their entire life-cycle (including construction, operation and decommissioning).

All the technologies generate electricity. The plan assumes that energy for heating and transport can in future be supplied by electricity.

Figure 7
Summary of the plan to supply worldwide energy needs for all purposes by 2030.
All the methods are used to generate electricity.

	Tidal turbine	Geothermal power station	Hydro-electric power station	Wind turbine	Wave power machines	Concentrated solar power	Rooftop photo-voltaic panels	Photo-voltaic power plant
Typical power output	1 MW	100 MW	1 300 MW	5 MW	0.75 MW	300 MW	0.003 MW	300 MW
Number required	490 000	5 350	900	3 800 000	720 000	49 000	1 700 million	40 000
Percentage of this capacity in place in 2009	< 1%	2%	70%	1%	< 1%	< 1%	< 1%	< 1%

(1 MW = 1 million watts)

5 (a) The authors claim that they have produced a plan for a sustainable future. What do you understand by the term 'sustainable future'?

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(2 marks)

5 (b) Suggest **two** reasons why the authors of the plan did not include nuclear power stations as one of the methods for generating electricity.

Reason 1

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Reason 2

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(2 marks)



5 (c) The plan is based on the assumption that 11.5 TW (11 500 000 MW) of power generation will be needed to meet all the world's needs in 2030.

5 (c) (i) Work out the maximum power available from all the wind turbines in the plan.

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(1 mark)

5 (c) (ii) The number of wind turbines in the plan appears to give a power output that exceeds the world's need for power. Suggest a reason why so many wind turbines are included.

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(1 mark)

5 (d) (i) Do you think that it is **technically** possible to implement this plan worldwide, by 2030? Give your reasons.

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(3 marks)

5 (d) (ii) Do you think that it is **politically** possible to implement this plan worldwide, by 2030? Give your reasons.

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(3 marks)

12

Turn over ▶



- 6** Humans differ in their mental abilities. However, it has proved hard to explain the causes of these differences. One area of research is the role of genes in memory formation.
- Forming new memories requires strengthening of synaptic connections or formation of new synapses between neurons.
 - One of the proteins in the brain that is essential for this process is brain-derived neurotrophic factor, BDNF.
 - *Expression of a gene* that codes for BDNF is stimulated by memory tasks and new experiences.
 - The gene that codes for BDNF has two common alleles, which code for either valine, val, or methionine, met, at position 66 in the protein. There are therefore three possible genotypes, val/val, val/met or met/met.

Researchers have studied the relationship between the different BDNF alleles and human memory skills, using three very different techniques:

- memory testing
- fMRI
- experiments with neurons in cell cultures.

6 (a) (i) Explain what is meant by expression of a gene

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 (1 mark)

6 (a) (ii) How is gene expression controlled?

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 (1 mark)

6 (b) Memory testing research compared individuals with different genotypes. Subjects were told a story and asked to recall details half an hour later. Some results are shown in **Figure 8**. **Figure 9** shows some of the characteristics of the subjects involved in the research.

Figure 8
BDNF effect on memory

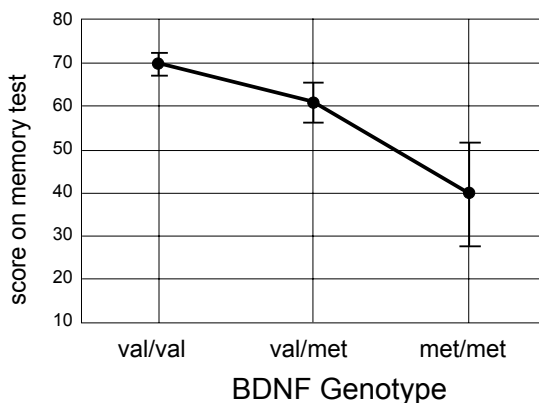


Figure 9
Some characteristics of the subjects

	Genotype		
	val/val	val/met	met/met
Number of subjects	91	36	6
Mean age	35.0	34.1	39.3
Mean IQ	107.6	109.1	105.7



6 (b) (i) The researchers report that the difference in score on the memory test between met/met and val/met genotypes shown in **Figure 8** is *statistically significant*, ($p = 0.05$).

What does 'statistically significant, ($p = 0.05$)' mean?

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(2 marks)

6 (b) (ii) The data in **Figure 9** describe the sample of people tested. Explain why this information is relevant to the conclusions that can be drawn from **Figure 8**.

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(2 marks)

6 (b) (iii) Give **one** advantage and **one** limitation of this research technique as a way of increasing understanding of the role of BDNF alleles in memory.

Advantage

Limitation

(2 marks)

6 (c) fMRI was used to compare activity in a region of the brain called the hippocampus. The hippocampus is important in the processing of new memories. The researchers looked at two groups of subjects with genotypes val/val and val/met whilst the subjects carried out a memory task involving recall of pictures.

They found that

- subjects with val/val genotype showed greater activity in the hippocampus during learning than the val/met subjects
- the level of activity in the hippocampus during the learning process correlated with accuracy of later recall.

Turn over ▶



6 (c) (i) What changes in the brain does an fMRI scanner detect?

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(1 mark)

6 (c) (ii) Give **one** advantage and **one** limitation of using fMRI to investigate memory in a study of this kind.

Advantage

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Limitation

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(2 marks)

6 (d) Neurons in cell cultures were used for further research. BDNF in these neurons was monitored under a microscope. The researchers found that the BDNF made by the val allele, valBDNF, spreads readily into the dendrites whereas the metBDNF does not spread and remains in the cell body when released.

What contribution does research using neurons in cell culture make to the development of an understanding of the role of BDNF alleles in memory?

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(2 marks)

6 (e) There are reports that some children are already being tested for their BDNF alleles as a guide to future educational performance.

Suggest some reasons why this focus on the role of an individual gene is inappropriate.

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(3 marks)



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Figure 1 Journal of Adolescent Health, April 2008

Figure 3 Forensic Science International, September 2009 © Elsevier Publications

Figures 4 & 5 The National Academy of Science in the USA, March 2007

Figure 7 Scientific American Magazine, November 2009 © Elsevier Publications

Figures 8 & 9 www.cell.com, January 2003

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