Centre Number						Candidate Number				
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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6	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2014

Science in Society SCIS3

Unit 3 Exploring Key Scientific Issues

Wednesday 18 June 2014 9.00 am to 11.00 am

For this paper you must have:
- a calculator
- a ruler.

Time allowed
- 2 hours

Instructions
A
- 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.

There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED

Section A

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

1 Psychedelic drugs affect consciousness. They change perceptions and emotions, often leading to hallucinations. The use of psychedelic drugs is illegal. One such drug, psilocybin, is derived from 'magic mushrooms'.

Psilocybin acts in the same way as the neurotransmitter serotonin at some synapses. Scientists used this information to form the following hypothesis.

Hypothesis A: psilocybin makes the brain more active and this explains how the drug causes hallucinations.

1 (a) Why was it reasonable for scientists to suggest that, if psilocybin acts like a neurotransmitter, it would make the brain more active?

[2 marks]

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1 (b) Researchers tested the predictions from Hypothesis A by studying the action of psilocybin on the brain. They used fMRI scanning to measure cerebral blood flow (CBF) in different parts of the brain.

Why do increases in CBF indicate increases in brain activity?

[1 mark]

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Question 1 continues on the next page

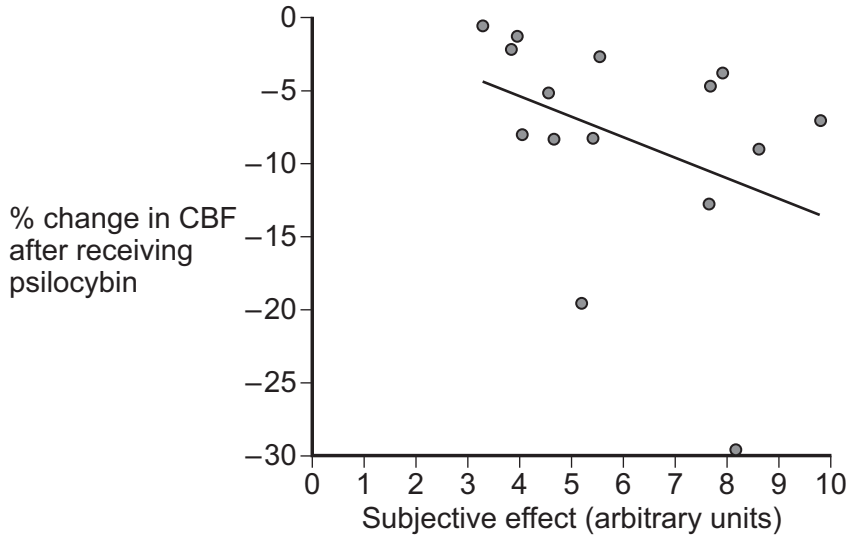
1 (c) During the investigation 15 healthy volunteers were given psilocybin on one day and a placebo on another day, whilst in an MRI scanner. On both days the following data were recorded:

- the volunteers rated the intensity of the effect on their perceptions. This rating is described as the subjective effect
- at the same time the scanner monitored CBF in different parts of the brain.

The CBF value after taking psilocybin was compared with the CBF value after taking the placebo. The difference was expressed as % change in CBF after receiving psilocybin.

The fMRI scans found that after psilocybin there was a reduction of CBF in several brain regions. The percentage change was plotted against the volunteers' rating of the subjective effect. Results for one of these regions, the anterior cingulate cortex, are shown in **Figure 1**.

Figure 1 Percentage change in CBF in the anterior cingulate cortex plotted against reported subjective effect



1 (c) (i) Describe the relationship shown in **Figure 1**.

[2 marks]

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1 (c) (ii) The researchers described the results, including those in **Figure 1**, as 'unexpected'.

How do these results differ from those that would be predicted by Hypothesis A?

[2 marks]

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1 (d) The unexpected results led the researchers to come up with a new hypothesis, B, to explain the action of psychedelic substances. Hypothesis B explained their results but included claims for which there was no direct evidence in their research.

Explain how new hypotheses of this kind can help to advance scientific understanding.

[2 marks]

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1 (e) Suggest **two** questions a research ethics committee might ask before deciding whether to approve the research described in parts **(b)** and **(c)**.

[2 marks]

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1 (f) Since the 1950s there have been several reports showing that psilocybin has helped with treatment of some mental illnesses and addictions. However, there has been almost no further research into such use. It has been suggested that this is because of political influence.

Examples of the way political pressure may have influenced research choices are:

- many governments are waging a 'War on Drugs' and consider them as wholly bad
- researchers have found it hard to get public funds for research into benefits from psychedelic drugs
- some researchers believe that such research would harm their reputations.

Do you think that decisions about the choice of research topic should be influenced by politics? Justify your opinion.

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Turn over for the next question

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2 Some children are affected by dyslexia. This means they find it very hard to learn to read when young. Dyslexia affects about 7% of the population. Dyslexia is known to run in families.

2 (a) One study measured a skill required for reading. It tested several hundred pairs of twins. The study found that the correlation coefficient between the skill score in one twin and the other was 0.7 for identical twins and 0.5 for non-identical twins.

2 (a) (i) Explain why these correlation coefficients show that the skill is partly inherited.

[2 marks]

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2 (a) (ii) Based on these values, suggest an approximate correlation coefficient between the reading skills of pairs of non-twin children in a family. Explain your answer.

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2 (b) Many researchers have been trying to identify the genes responsible for dyslexia. One technique used is to compare the whole genome of children with dyslexia with that of children without dyslexia. Regions of the genome that are different in the two groups may be those that contribute to dyslexia.

Different research groups have reported at least 10 regions of the genome which correlate with reading ability. All show only a very small effect, less than 0.5% of the total variance in reading ability. Some have not been confirmed by later independent research.

2 (b) (i) Suggest **two** reasons why it is so difficult to identify the genes that correlate with conditions such as dyslexia.

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2 (b) (ii) Suggest **two** reasons why this research cannot claim to have identified 'a dyslexia gene'.

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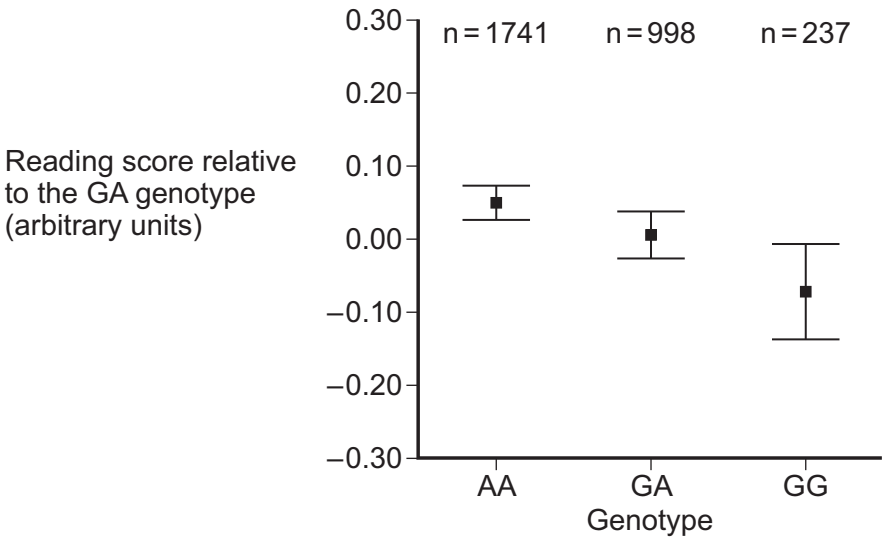
Question 2 continues on the next page

2 (c) Some of the genes identified as described in part **(b)** were studied in more detail. The results for one such gene are shown in **Figure 2**.
The gene can have either an A or a G allele.

Figure 2 Reading scores for 3 genotypes



2 (c) (i) Why do two alleles give rise to three genotypes as shown in **Figure 2**?

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2 (c) (ii) What conclusion can you draw from **Figure 2** about the impact of allele G on reading ability? Justify your answer.

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2 (d) Reading requires several regions of the brain with different functions to act together. These regions are connected by bundles of axons.

One group of researchers found that one allele of a gene called KIAA was associated with significantly thinner bundles of axons than normal.

Several research groups have shown that the same allele of KIAA shows a small correlation with poor reading ability.

Discuss the extent to which these research findings suggest a causative mechanism to explain how genes affect reading skills.

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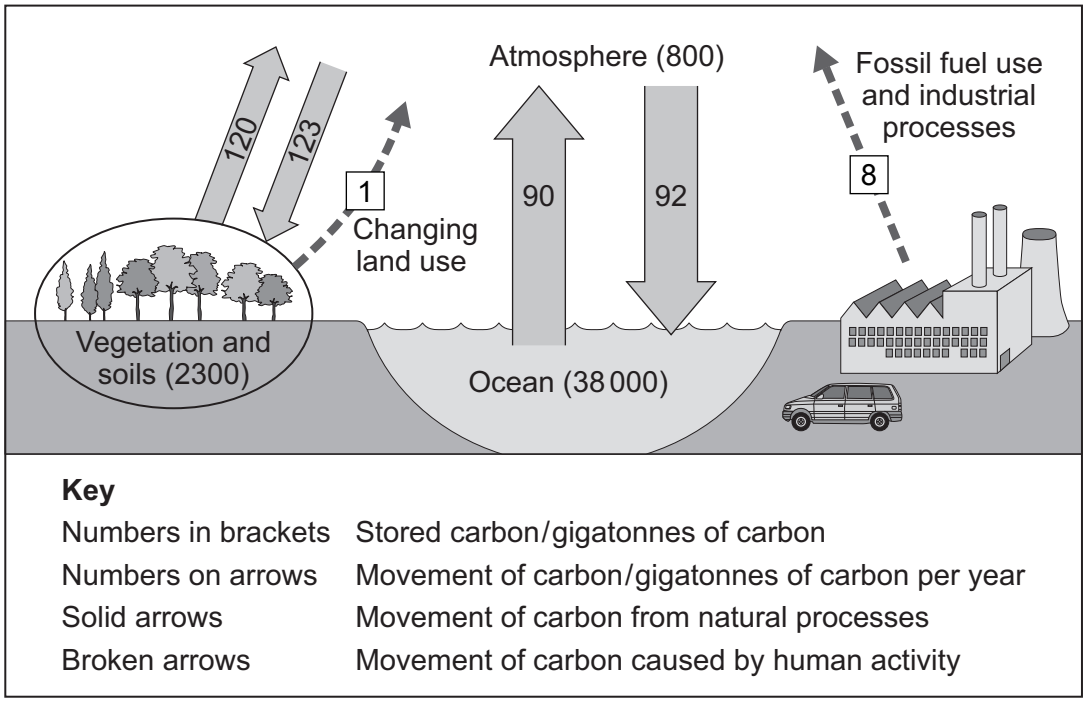
3 **Figure 3** shows a simplified version of the carbon cycle. It gives data on stored carbon and on carbon movements in one year. Carbon in the diagram refers to carbon combined in compounds.

Figure 3 The carbon cycle



Key

Numbers in brackets	Stored carbon/gigatonnes of carbon
Numbers on arrows	Movement of carbon/gigatonnes of carbon per year
Solid arrows	Movement of carbon from natural processes
Broken arrows	Movement of carbon caused by human activity

3 (a) (i) What is the chemical reaction that transfers carbon from fossil fuel to the atmosphere?

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3 (a) (ii) What is the annual increase in atmospheric carbon according to **Figure 3**?

[1 mark]

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3 (b) **Figure 3** shows that vegetation and soils remove and store carbon from the atmosphere.

3 (b) (i) How do trees remove carbon from the atmosphere?

[1 mark]

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3 (b) (ii) How do trees store carbon?

[1 mark]

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3 (c) The Amazon rainforest is one of the world's single most important carbon stores. It is estimated to store between 60 and 100 gigatonnes of carbon.

3 (c) (i) Over the last 20 years about 9% of the Amazon rainforest has been cut down. Suggest **two** social or economic factors that may have caused people to cut down trees in the Amazon region.

[2 marks]

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3 (c) (ii) What effect would loss of trees have on the movements of carbon in the carbon cycle as shown in **Figure 3**?

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Question 3 continues on the next page

3 (d) New research is studying the effects of climate change on the Amazon ecosystem. Three techniques have been used to study the effects on the trees:

- regular visits to about 200 small plots throughout the forest
- aerial surveys to detect vegetation density
- modelling the effects of climate change on future tree growth and survival. The models all include the effects on trees of rainfall, humidity, temperature, and carbon dioxide concentrations in the air.

Suggest **two** advantages of modelling as a research tool in this situation compared to the other two techniques.

[2 marks]

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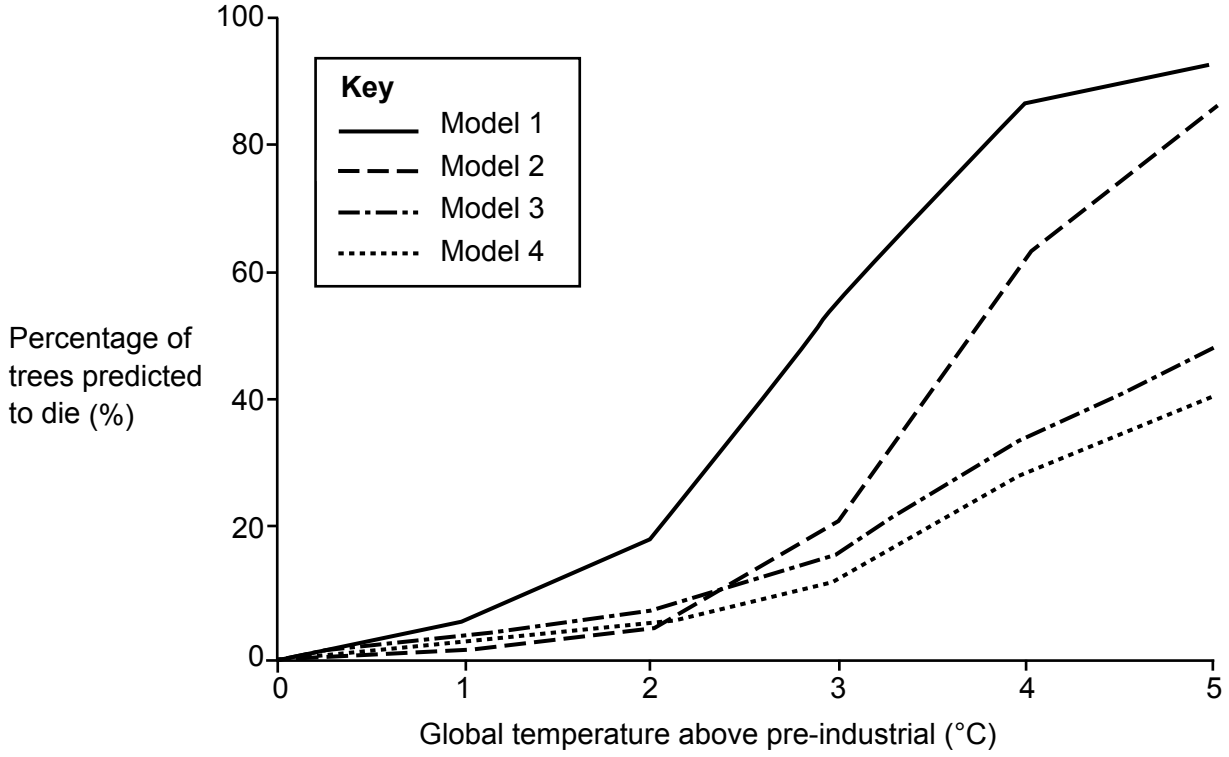
3 (e) Some of the predictions made by modelling research are shown in **Figure 4**. This shows the percentage of trees that are predicted to die due to climate change at different values of the temperature rise.

Figure 4 Predicted percentage of trees in the Amazon that will die for different temperature rises using 4 different models



3 (e) (i) Suggest **two** reasons why different models make different predictions.

[2 marks]

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3 (e) (ii) Summarise the conclusions that can be drawn from **Figure 4** about the interactions between climate change and the death of trees.

[2 marks]

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3 (f) Explain why the interaction between climate change and the death of trees in the Amazon is an example of positive feedback.

[2 marks]

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Question 3 continues on the next page

3 (g) Current international agreements on climate change aim to keep global warming down to a maximum increase of 2 °C. At present it seems that this target is unlikely to be met.

Discuss reasons why it is proving so difficult to get countries to reduce their carbon emissions.

[4 marks]

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4 Solar photovoltaic (PV) technology generates electricity directly from sunlight. Photovoltaic panels are a relatively new technology in the UK. In 2012 they supplied about 0.1% of all UK electricity.

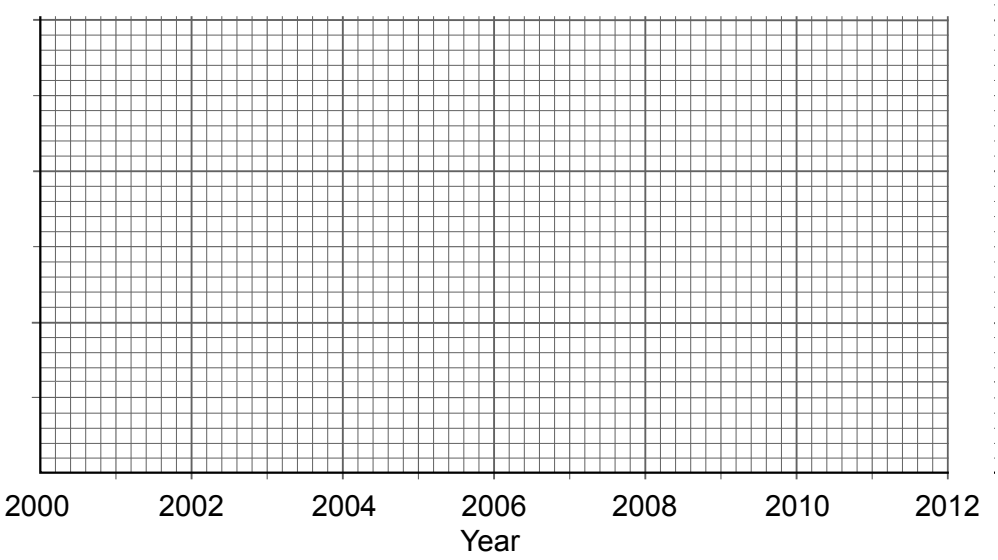
Table 1 shows the growth in PV capacity in the UK since 2000.

Table 1 PV capacity in the UK 2000–2012

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total installed capacity (MW)	1.9	2.7	4.1	5.9	8.2	10.9	14.3	18.1	22.5	26.0	69.8	976	1371

4 (a) (i) Sketch a graph showing these data. You do not need to plot individual points.

[2 marks]



4 (a) (ii) Discuss the relative advantages of using a table or a graph as a way of showing the data.

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Question 4 continues on the next page

4 (b) In the UK, solar radiation provides about 1000 W/m^2 in full sun.

4 (b) (i) A typical 1 m^2 PV solar panel has an output of about 150 W in full sun.
What is the efficiency of this solar panel?

[1 mark]

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Efficiency = ...%

4 (b) (ii) What happens to the rest of the energy of the solar radiation falling on the panel?

[1 mark]

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4 (c) PV technology is becoming increasingly important in some parts of the world. However, there are disagreements about whether it is suitable for the UK. At present PV generation is subsidised in the UK. In 2011 this subsidy was £14 million.

Government energy policy has to consider:

- security of supply
- environmental impact
- cost.

Do you support government policies that actively encourage the growth of PV technology in the UK? Give your reasons.

[6 marks]

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Turn over for the next question

5 Bees are insects that live in colonies. The queen bee lays the eggs. Most of the other bees in a colony are worker bees. Worker bees gather nectar and pollen from flowers to feed the colony.

Bee populations have been declining in recent years in many parts of the world. Alternative explanations for this are:

- spread of disease
- pesticides used in farming.

Bees have important economic and environmental roles. They pollinate many food crops and wild plants. Without pollination the fruits and seeds do not form. It has been estimated that pollination by bees contributes £200 million annually to the UK economy.

5 (a) In Britain bees pollinate flowers that form fruits, such as apples, and wild berries, such as hawthorn, blackberry and rowan; all are important foods for small birds and mammals.

Describe the likely effect on the populations of some other plant and animal species in the British countryside if bees died out. Give reasons for the effect.

[3 marks]

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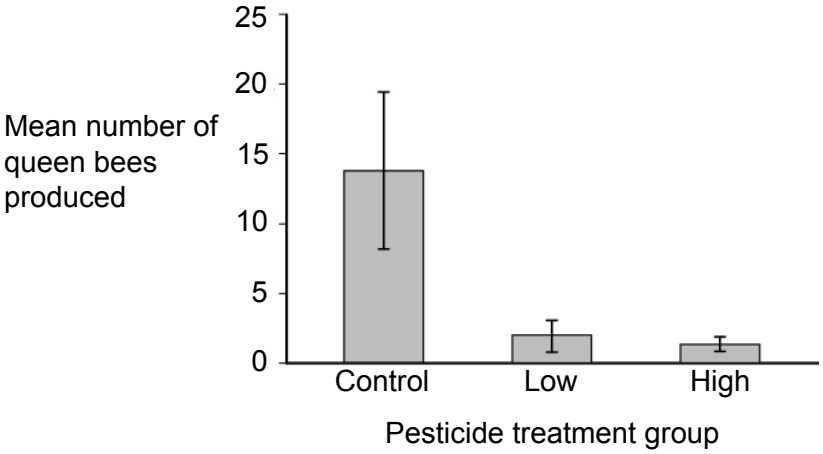
5 (b) Recent research has studied the way in which even low doses of pesticides affect bee populations.
In one experiment researchers fed bumblebee colonies in the laboratory for 2 weeks on sugar and pollen containing different concentrations of a widely used pesticide, pesticide **A**. They then took the hives, in which the colonies live, outside and allowed the bees to live naturally.
At the end of 8 weeks the researchers counted the number of queen bees in each colony. These queen bees are important because they start the new colonies the following year. The results are shown in **Figure 5**.

Figure 5 Mean number of queen bees produced per colony in control, low pesticide and high pesticide treatment groups. There were 25 colonies in each group



5 (b) (i) The researchers reported that there were significant differences between the control group and both the high and the low treatment groups.

What does the term **significant difference** mean as used here?

[1 mark]

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5 (b) (ii) Some other scientists claim that low doses of pesticide have no effect on the long term survival of bees.

Discuss whether the data in **Figure 5** support this claim.

[2 marks]

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5 (c) Another research team studied the effects on bees of pesticide **A** and another pesticide, **B**. They used the pesticides separately and together over a 4 week period. These conditions were chosen to mimic bees' exposure to pesticides when they collect nectar from flowering crops.

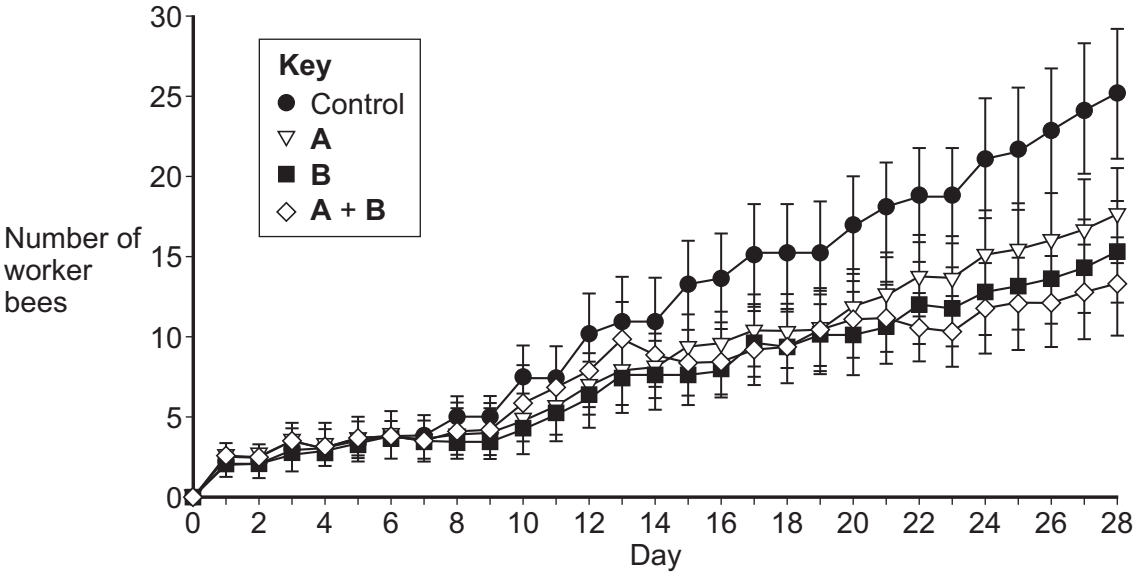
The 40 bumblebee colonies were divided into four groups as shown in **Table 2**.

Table 2 Treatment of the four groups of colonies

Treatment	Control	Pesticide **A** only	Pesticide **B** only	Both pesticides **A** and **B**
Number of colonies	10	10	10	10

Some of the results are shown in **Figure 6**.

Figure 6 Colony growth shown as mean number of live worker bees



Describe **two** conclusions you can draw from **Figure 6** about the differences between control and pesticide-treated colonies during the experiment.

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5 (d) The use of pesticide by farmers is subject to strict control. However, tests which set a 'safe' level for bees:

- study single pesticides
- study exposure for a maximum of 96 hours
- measure the dose at which 50% of the bees die but do not look at the colony as a whole.

Use the data in **Figure 5** and **Figure 6** to suggest how and why these tests should be changed.

[4 marks]

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Question 5 continues on the next page

5 (e) In April 2012 two papers describing the harm done to bee colonies by pesticide **A** were published in an influential journal called 'Science'. One of these papers is the source of the data in **Figure 5**. In response to these papers the French Government banned the use of this pesticide. The UK Government allowed its use to continue.

Suggest some of the factors that the two governments would have taken into account in making their different decisions.

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6 The popular media play a part in:

- providing information
- setting the agenda
- influencing opinion

on issues involving science and technology.

Discuss these three roles of the media. Describe both the benefits and disadvantages for society of the roles. Give examples.

[12 marks]

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END OF QUESTIONS

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Figure 1 Carhart-Harris et al, 'Neural correlates of the psychedelic state as determined by fMRI studies with psilocybin', PNAS volume 109 page 2140, 2012, published by National Academy of Sciences.
Figure 2 Reprinted by permission from Macmillan Publishers Ltd: Molecular Psychiatry (2008) volume 13, pp. 729-740. EL Meaburn et al, 'Quantitative trait locus association scan of early reading disability and ability using pooled DNA and 100K SNP microarrays in a sample of 5760 children'.
Figure 3 Source: U.S. Energy Information Administration (2001).
Figure 4 Contains public sector information licensed under the Open Government Licence v1.0.
Figure 5 From Science volume 336 page 352. 'Neonicotinoid Pesticide Reduces Bumble Bee Colony Growth and Queen Production'. Whitehorn et al, 2012. Reprinted with permission from AAAS.
Figure 6 Adapted by permission from Macmillan Publishers Ltd: Nature, volume 491, page 2. Gill et al, 'Combined pesticide exposure severely affects individual- and colony-level traits in bees' (2012).