GCE AS and A Level

Specimen Assessment Materials

Science in Society (v20)

AS exams 2009 onwards
A2 exams 2010 onwards

Note that this presentation includes the materials prepared to accompany the new specification for first teaching 2008: version 0.1, draft submitted to QCA (March 2007). It is prepared by the Nuffield Curriculum Centre for use in consultation and professional development.

The Nuffield Foundation

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Dr Michael Cresswell Director General.

Contents

GENERAL CERTIFICATE OF EDUCATION
SPECIMEN

SCIENCE IN SOCIETY UNIT 1: AS EXPLORING ISSUES

No additional materials are required
You may use a calculator

Time allowed 2 hours

Instructions

- Use blue or black ink.
- Answer **all** questions in the spaces provided.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want marked.
- Show your working in **all** calculations.

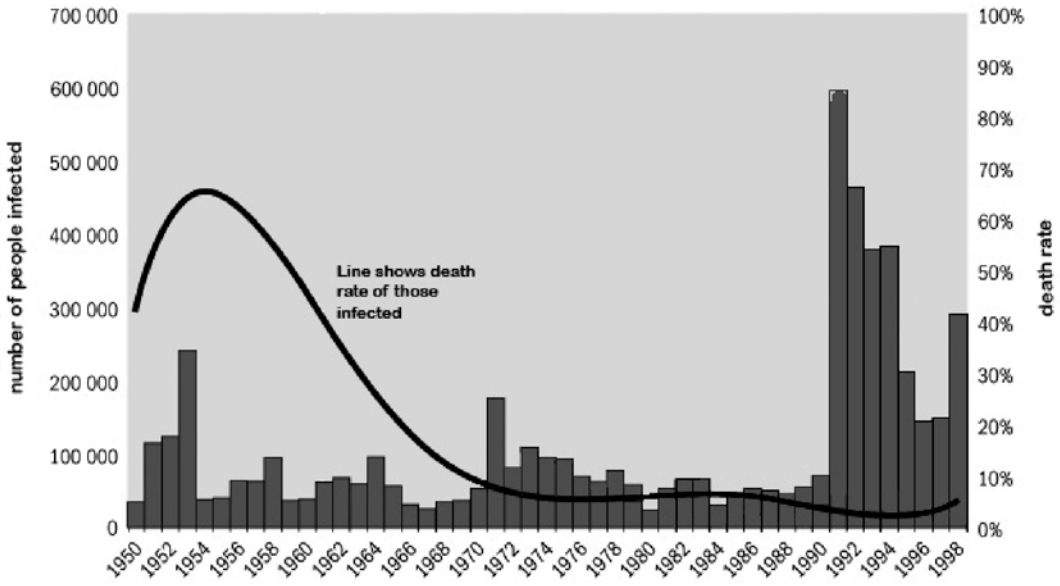
Information

- The maximum mark for this paper is 90.
- The marks for questions are shown in brackets.
- You are reminded of the need for good English and clear presentation in your answers. Questions 5(d) and 8(d) should be answered in continuous prose. Quality of Written Communication will be assessed in these answers.

1 Cholera is a serious infection of the digestive tract. Symptoms include diarrhoea. It is one of many infectious diseases that are transmitted in drinking water.

Figure 1 shows trends in the number of cholera cases in the world since 1950.

Figure 1



Cholera, reported number of people infected and death rates of those infected, 1950-1998

(a) Explain what is meant by an infectious disease.

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(2 marks)

(b) (i) Describe the main changes in the numbers of people infected, shown in **Figure 1**, over the period 1950 to 1998

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(2 marks)

(ii) Estimate the number of people who died of cholera in 1974.

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(2 marks)

(iii) In the1970s a new treatment was introduced for those infected with cholera. It is called Oral Rehydration Therapy, ORT. Do the data in **Figure 1** provide evidence that ORT treatment saved lives? Explain your answer.

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(2 marks)

(iv) Almost all the cases shown in **Figure 1** were in low income countries. Suggest **one** possible reason for this.

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(2 marks)

10

QUESTIONS CONTINUE ON THE NEXT PAGE

2 (a) During treatment for thyroid cancer the patient is given a drink containing a radioactive isotope of iodine. In the body, iodine concentrates in the thyroid. The radioactive iodine has a half-life of 8 days and emits beta and gamma radiation. Before the treatment patients are given the following information about what to expect.

- The doctors and staff on the ward will only stay in your room for short periods at a time.
- Visitors will be restricted and only allowed to stay in the room for a short time, if at all. Visitors will be able to talk to you from outside the room through an intercom.
- An instrument called a Geiger counter can be used to monitor the level of radiation in the room.
- Children and women who are pregnant will not be allowed to visit.

(i) Ionising radiation can harm living cells. Explain in what way the radiation damages cells.

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(2 marks)

(ii) Explain the reasons for the restrictions on visitors.

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(2 marks)

(iii) Explain why these restrictions only last for about 2 weeks.

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(2 marks)

(iv) Why is it acceptable to expose the patient to a dose hundreds of times higher than that permitted for the public?

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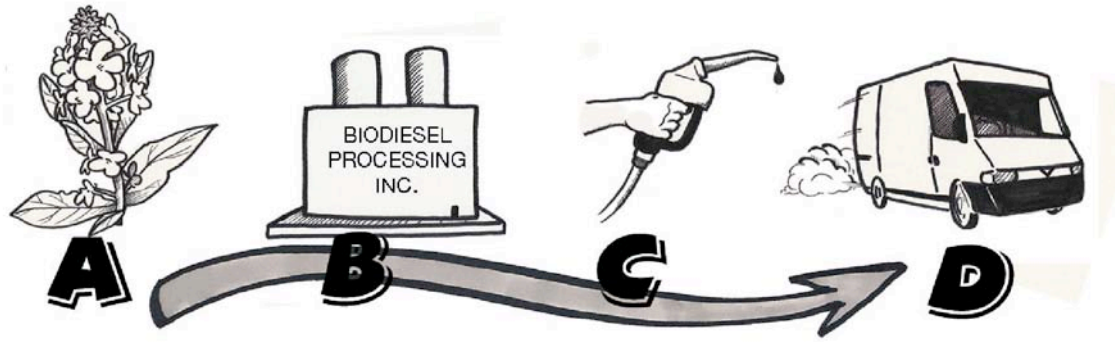
(2 marks)

8

QUESTIONS CONTINUE ON THE NEXT PAGE

3 Biodiesel, can be made from plant oils as an alternative to fossil fuel diesel. Biodiesel can be burned in normal diesel engines. **Figure 2** summarises the whole process.

Figure 2



(a) (i) Where does the energy for plant growth come from?

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(1 mark)

(ii) What has happened to all this energy after stage D?

.....

(1 mark)

(iii) Explain why biodiesel is a renewable fuel.

.....

.....

(2 marks)

(b) Biodiesel releases carbon dioxide when it burns but its use does not result in an overall increase in the amount of carbon dioxide in the atmosphere.

(i) At which of the stages shown in **Figure 2** is carbon dioxide removed from the atmosphere?

.....

(1 mark)

(ii) Where does the carbon in the carbon dioxide go when it is removed from the atmosphere?

.....

(1 mark)

(c) In Britain transport is predicted to release 27% of all greenhouse gas emissions by 2010. This is about thirty five million tonnes of carbon from transport. The EU has suggested that, by 2010, 6% of transport fuels should be biodiesel or other plant-derived fuels. However in meeting these targets factors other than emissions may also need to be considered.

(i) Land use is one issue. Britain would need either to:
plant biodiesel crops on about a third of all the farmland now used to grow food,
or import palm oil from plantations in tropical countries.

Give **one** advantage and **one** disadvantage of importing palm oil for biodiesel.

Advantage .....

.....

Disadvantage .....

.....

(2 marks)

Figure 3 shows estimates of how much it would cost to prevent the emission of one tonne of carbon in carbon dioxide using different transport technologies.

Figure 3

transport technology	**extra cost per tonne of carbon emission prevented**
biodiesel	£400
hydrogen powered vehicles (hydrogen from renewables)	£550
more efficient hybrid engines	£380

(d) (i) Of the three technologies given in Figure 3 which one is likely to be the least polluting overall? Explain your answer.

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(2marks)

(ii) All these technologies increase the immediate cost to the motorist. However, they might still prove cheaper in the long run. Suggest **one** reason why.

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(2 marks)

4 Chlorine is used to treat drinking water. It is a cheap and effective way of killing microbes that can cause disease. However chlorine reacts with impurities in the water to form compounds called trihalomethanes, (THMs).

There have been persistent fears that THMs in treated water may cause cancers. Evidence for this comes from two sources: animal studies and epidemiological studies.

Animal studies
Studies in rats, mice and dogs all gave similar results. They showed that THMs given over a long period cause cancer, but only when given in very high doses. The animals who developed cancer had received more than 10mg of THM per kg body weight every day. The normal human dose from water is about 10 000 times less than this.

(a) (i) Why do scientists repeat such tests on several different animal species?

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(2 marks)

(ii) Do the results of animal studies suggest that THMs in drinking water are likely to cause cancer in humans? Explain your answer.

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(2 marks)

Epidemiological studies
One very large study in the US compared the rate of cancer in different areas:

- areas where the water supply was treated with chlorine,
- areas where the water supply was not treated with chlorine.

It found that the risk of bladder cancer was 1.2 times higher in the areas with chlorine treated water, relative to areas with untreated water.
Similar epidemiological studies by other scientists have indicated risks ranging between 1.0 – 2.0 times higher.

(b) (i) Explain what is meant by an epidemiological study.

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(2 marks)

(ii) Bladder cancer is found to occur at a rate of 14 per 100 000 in those who drink untreated water. How many cases would be expected in a sample of 100 000 people drinking chlorine treated water if their risk is 1.2 times higher?

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(1 mark)

(iii) Suggest **two** reason why the epidemiological study described does not, on its own, confirm that THMs in drinking water cause cancer.

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(2 marks)

(c) Even though there may be a risk of harm from THMs in water most governments continue to treat drinking water with chlorine.
What factors might they have taken into account in making this decision?

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(3 marks)

12

QUESTIONS CONTINUE ON THE NEXT PAGE

5 Mice can be bred so that they lack light sensitive cells in the retina of their eyes. These mice are blind. Scientists have attempted to cure such blindness by transplanting cells into the defective eyes. They have used:

- stem cells
- cells from the retina of adult mice

Neither approach improved vision.

(a) What is a stem cell?

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(2 marks)

In another study scientists transplanted precursor cells for light sensitive cells, taken from normal three- to five-day-old mice. Precursor cells are cells that have already differentiated so that they can only go on to develop into a very limited range of cell types.

After the transplant the blind mice were able to react to bright lights.

(b) The publicity surrounding the success of the research claimed that it will lead to a cure for some forms of human blindness.

Suggest **two** further investigations that the scientists would need to undertake before this technique could be ready to trial in humans.

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(2 marks)

(c) When scientists announce the results of new biological research they often mention the promise of a cure for a human disease.

(i) Why might they do this?

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(2 marks)

(ii) Many patients, hearing about research of this kind, expect the cure to be available immediately. Do you think it is responsible for scientists and the media to raise hopes in this way? Explain your answer.

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(2 marks)

(d) Further research may show that transplanting suitable precursor cells is likely to restore human sight in some conditions. What issues would you expect members of an Ethics Committee to consider in deciding whether to approve research on humans?

Quality of written communication will be taken into account in awarding marks.

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(6 marks)

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE

6 In 1915 Einstein used his theory of General Relativity to try to understand what the cosmos was like. His calculations led to the conclusion that the universe could not be stable; it should be either expanding or collapsing. As Einstein believed the universe was stable, he modified his equations to produce that result. He thought he was improving his theory, to make it match better to reality – but he later described this as 'the biggest blunder of my life'.

In 1929, the American astronomer Edwin Hubble made measurements that allowed him to estimate the speed at which galaxies were moving away from the Earth. His calculations indicated that the further away a galaxy was, the faster it was moving away from us. This implied that the universe was expanding. Hubble and other astronomers proposed that the universe had originated in a 'Big Bang'.

Some other astronomers were not convinced. Their research led them to think that matter was distributed uniformly throughout the universe – and did not get more spread out with time. They proposed an alternative theory, the Steady State theory, which proposed that matter was constantly being produced to keep the average density of the universe constant as it expanded.

By the 1950s there were still two competing theories on the origin of the universe: the Big Bang theory and the Steady State theory. One of the predictions of the Big Bang theory was that radiation produced in the Big Bang should still be detectable. This radiation was found in 1964 by Penzias and Wilson. This is one of the reasons why most astronomers now accept the Big Bang theory.

(a) Explain briefly what is meant by the Big Bang theory.

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(2 marks)

(b) From the account above briefly identify an example of each of the following

(i) An observation

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(1 mark)

(ii) A correlation between two variables

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(1 mark)

(iii) An explanation that involved conjecture and creative imagination

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(1 mark)

(iv) A second explanation that also involved conjecture and creative imagination

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(1 mark)

(v) A testable prediction from a theory

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(1 mark)

(vi) The use of observation to increase confidence in an explanation or theory

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(1 mark)

(vii) The way a person's views can influence their interpretations.

.....

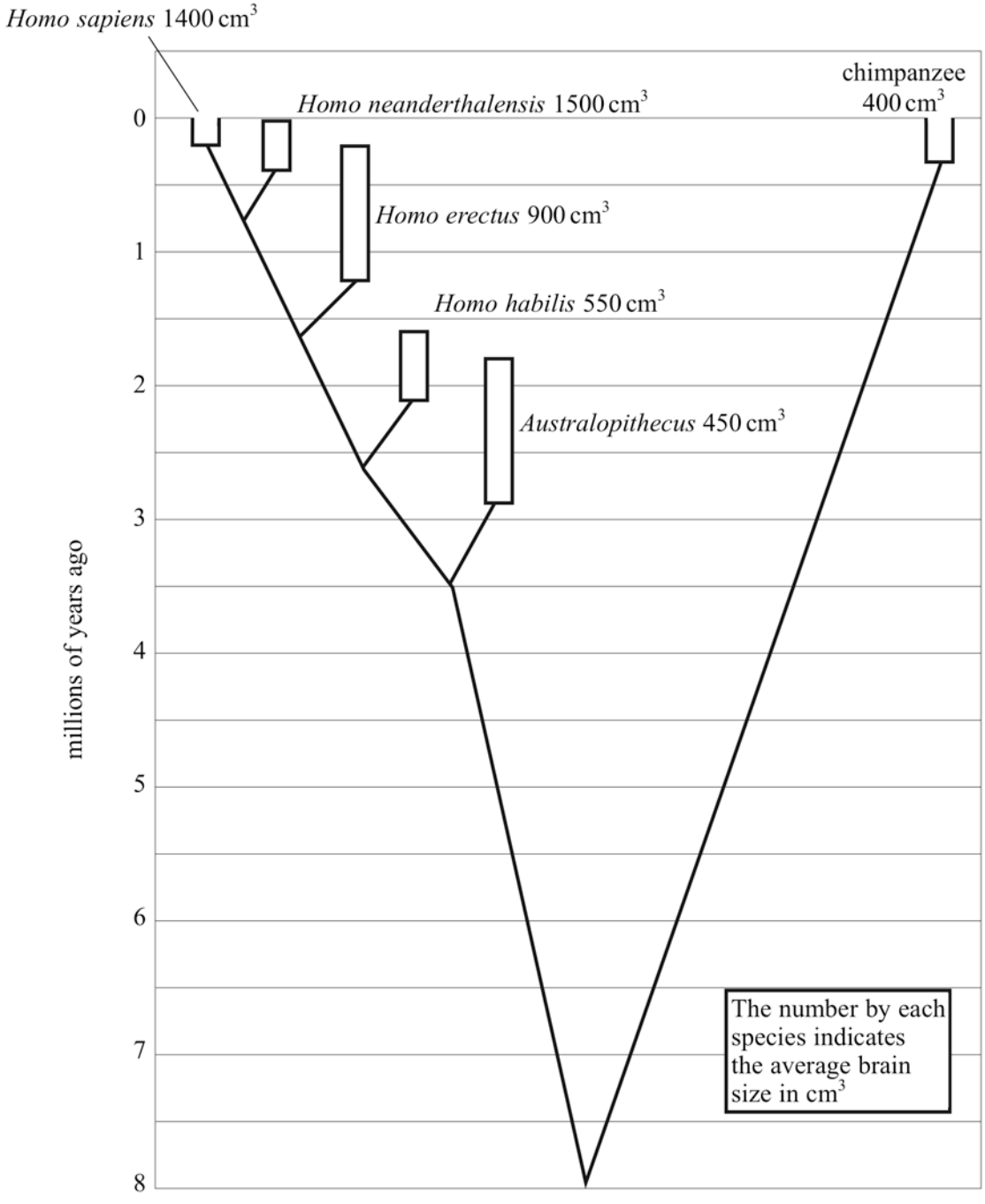
(1 mark)

9

QUESTIONS CONTINUE ON THE NEXT PAGE

7 Humans and chimpanzees are both primates. Many other primate species are now extinct. **Figure 4** shows one suggested relationship between modern humans, some of the other extinct human-like species and chimpanzees. The number by each species indicates the average brain size in cm^3.

Figure 4



(a) Name two homo species that became extinct less than 1 million years ago.

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(1 mark)

(b) Suggest how some of the information in Figure 6 can be explained by Darwin's theory of natural selection.

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(4 marks)

(c) (i) The information in **Figure 4** is derived from fossils. Scientists agree on most dates and the overall pattern. They disagree on some of the evolutionary relationships between one species and another. Explain why these disagreements do not lead most people to doubt the evolutionary origins of humans.

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(2 marks)

(ii) Suggest **two** reasons why some people find it hard to accept that humans have evolved from other species.

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(2 marks)

8 Read the article below and answer the questions that follow.

Should parents be free to decide what is acceptable?

A 66-year-old woman gives birth

Children are born selected as tissue donors for sick siblings

Women give birth to their own grandchildren, or to their nephew or niece

Children are conceived with the sperm of dead men.

All these things have happened, and might even become routine. Before long we may be able to screen embryos not just for disease-causing mutations, but also for desirable genetic characteristics. Egg freezing will allow women to delay having children until their forties or later.

These rapid advances in technology are making it hard for us to properly weigh up the ethical, social and biological consequences. The many reproductive choices available already raise difficult questions. Governments have responded to them in two ways: either by banning "undesirable" applications, as in the UK and Australia, or by leaving prospective parents to make up their own minds with the help of their doctors, as in the US.

Should governments intervene given the issues that reproductive science is raising? The answer is far from straightforward. One good reason for banning certain reproductive practices is to protect the health of the resulting children. There is, for instance, clear evidence of the dangers of implanting more than one in vitro fertilisation (IVF) embryo, as this results in more twins and triplets who generally face greater health risks than singletons. Limiting the number of embryos that can be transferred, as many European countries do, is undoubtedly improving the prospects of children conceived by IVF. On the other hand, is it right to deny twins to parents who want them?

In the UK, the government regulator goes further. Until recently, would-be parents in the UK could use pre-implantation genetic diagnosis (PGD) to screen only for fatal childhood diseases. The restrictions have now been relaxed, but parents are still denied the option of screening out many known disease-causing gene variants. It is also illegal in the UK to select an embryo on the basis of its sex, while in the US PGD can be used for whatever parents want and doctors will agree to, from sex selection to choosing deaf embryos.

Should governments intervene in these sensitive issues? Heavy handed legislation is never likely to be the best answer. For example, if parental choice is skewing the balance of the sexes, a suitable system of incentives could be used to restore it.

The majority of these advances are beneficial, and promise people a better quality of life than their grandparents could have dreamed of. We should not reject them simply because they are novel. Deciding what is acceptable will, however, take thoughtful policy-making at every step, and open, informed public debate.

Source: adapted from *New Scientist,* 21 October 2006, p5

(a) Give **two** restrictions placed on the use of IVF and PGD by the UK regulator.

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(2 marks)

(b) Explain how PGD can be used to *screen for fatal childhood diseases* (paragraph 5)

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(2 marks)

(c) (i) Describe the differences in the way that IVF and PGD are regulated in the US and the UK.

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(2 marks)

(ii) Give **one** reason in favour of government regulation that is mentioned in the article.

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(1 mark)

(iii) Give **two** reasons against government regulation mentioned in the article.

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(2 marks)

(iv) Give **one** procedure mentioned that is not yet possible.

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(1 mark)

(d) The article ends with hope for *open, informed public debate* on which of these technologies are acceptable and which should be controlled by regulation. People have a very wide range of opinions on the issue

Explain what you would want to say if you were asked to give and justify your opinion as part of this debate. You can discuss the issues in general or focus on just **one or two** of the applications mentioned in the article.

Quality of written communication will be taken into account in awarding marks.

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(6 marks)

16

Total 90

GENERAL CERTIFICATE OF EDUCATION
SPECIMEN MARK SCHEME

SCIENCE IN SOCIETY

UNIT 1: AS EXPLORING ISSUES

Examiners look to reward knowledge and understanding not to penalise.
Any correct response will be credited even if it does not appear in the mark scheme.

UNIT 1

Question 1				
(a)		• microbe/bacterium/virus/germ • reproduce in body • transmitted to new person	*any 2 for 1 mark each*	**2**
(b)	(i)	• mainly low/below 200 000 • variable/declining until 1988 • 1990s much higher	*any 2 for 1 mark each*	**2**
	(ii)	• 100 000 cases /6% death rate (5% - 10%) • 6000 deaths (5000 – 10 000)	*for 1 mark each*	**2**
	(iii)	• yes – death rate consistently low since 1970 • no – death rate falling before 1970	*any 1 for 2 marks*	**2**
	(iv)	• cholera transmitted in water - untreated water used/no water treatment plants/poor sewage treatment • very limited health care/ public health services – diagnosis/isolation of cases less likely	*any 1 for 1 or 2 marks*	**2**
			Total	**10**

Question 2				
(a)	(i)	• mutation/explanation of ionisation • damage to DNA/gene/chromosome/molecules in cell	*for 1 mark each*	**2**
	(ii)	• gamma rays emitted/ irradiation/ β • gamma travel/penetrate • risk of cancer proportional to dose/short exposure minimises **risk** • (must have some sense of risk ∝ time) • growing children particularly vulnerable to **risk** **no mark for repeat of (i)**	*any 2 for 1 mark each*	**2**
	(iii)	• half life of 8 days/short half-life • risk/radiation emitted reduced by factor of about 4/to safe level **not zero emission**	*for 1 mark each*	**2**

	(iv)	• patient's current benefit - outweighs future risk	*any one for*	**2**

	• visitor gains no personal benefit - therefore not worth taking the risk	*1 or 2 marks*	
		Total	**8**

Question 3				
(a)	(i)	• sun/photosynthesis	*for 1 mark*	**1**
	(ii)	• heat (in van and surroundings) • energy transferred to environment **not lost, wasted or used**	*for 1 mark*	**1**
	(iii)	• plants replaced /new plants grow • replacement on same time scale as rate of use • energy from Sun made available by plants	*any 2 for 1 mark each*	**2**
(b)	(i)	• A	*for 1 mark*	**1**
	(ii)	• plant material/A not biodiesel	*for 1 mark*	**1**
(c)		**advantage** • export crop for low income country • more efficient to grow plants in high sunlight • leaves land for UK **food** crops or other named use **disadvantage** • may compete with production of food • destruction of habitat to provide land • CO_2 from transport (not more expensive to import) • reliant on foreign supplier	*any 1 advantage and any 1 dis-advantage for 1 mark each*	**2**

(d)	(i)	• hydrogen • only product is water • other pollutants as well as CO_2 from burning hydrocarbon fuels • any named pollutant CO NO_x etc	*any 2 for 1 mark each*	**2**
	(ii)	• cost of climate change • flooding/ hurricanes • fossil fuels run out • price of fossil fuel will rise	*any 2 for 1 mark each*	**2**
			Total	**12**

Question 4				
(a)	(i)	• some species may have different responses to humans • some animals less/more prone to cancer • same response in several species increases confidence	*any 2 for 1 mark each*	**2**
	(ii)	• not at normal doses • animals received very high doses10 000 times more • very slight risk/not absolutely safe	*any 2 for 1 mark each*	**2**
(b)	(i)	• study of pattern of incidence of a disease • data from large population samples • looking for correlations between disease and lifestyle variables	*any 2 for 1 mark each*	**2**
	(ii)	• 14 × 1.2 • 17 cases in 100 000	*for 1 mark each*	**1**
	(iii)	• correlation does not prove cause • other variable may cause the effect • poor agreement with other studies	*any 2 for 1 mark each*	**2**
(c)		• much greater risk from water borne disease • cholera/other example • other treatments much more expensive • risk very low/3 extra cases in 100 000 • risk not proven	*any 3 for 1 mark each*	**3**
			Total	**12**

Question 5			

(a)	• cells that can divide indefinitely • cells are undifferentiated/not specialised • cells that can develop into any type of specialised cell • cells in early embryo	*any 2 for 1 mark each*	**2**
(b)	• repeat in other species • really restores sight? /does more than allow to react to bright light • safety/check for side effects • find source of suitable precursor cells	*any 2 for 1 mark each*	**2**
(c) (i)	• to get publicity for their work • publicity may influence funding decisions in their favour • scientists' personal motivation may raise their expectations of the benefits/influence their judgement	*any 2 for 1 mark each*	**2**
(ii)	• media has an important role in informing public about science • headlines need to capture interest • not responsible if they do not give timescale • not responsible if they do not give uncertainty of outcome	*any 2 for 1 mark each*	**2**

(d)	The marking scheme for this section includes an overall assessment for the quality of written communication. There are no discrete marks for the assessment of written communication but quality of written communication will be one of the criteria used to assign the answer to one of three levels. The mark should be awarded on the basis of the overall level of the candidate's response in relation to the following general descriptors for each level. An answer will meet most of the criteria given in the level descriptor	
level of response	**descriptors:** knowledge**,** understanding (AO1); explanation, argument and illustration, application of ideas, synthesis, evaluation (AO2); legibility, accuracy of grammar and syntax, clarity of meaning, style, organisation and vocabulary (QWC)	**mark range**
good - level 3	claims supported by an appropriate range of evidence; good use of information or ideas about science, going beyond those given in the question, demonstrating knowledge and understanding; use of specialist vocabulary for science and for how science works; argument well structured with minimal repetition or irrelevant points; accurate and clear expression of ideas with legible text and only minor errors of grammar, punctuation and spelling	**5-6**
modest - level 2	claims partially supported by evidence good use of information or ideas about science given in the question but showing limited knowledge beyond this; argument shows some attempt at structure; ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling	**3-4**
limited - level 1	valid points but not clearly linked to an argument structure; limited use of information or ideas about science; unstructured; errors in grammar, punctuation and spelling or lack of fluency	**1-2**
0	incorrect of no response	**0**
		Total **14**

Question 6				
(a)		• universe started from single point • release of energy/explosion (but not for explosion of pre-existing matter) • continuing expansion • matter formed later	*any 2 for 1 mark each*	**2**
(b)	(i)	• Hubble's measurements /speed of galaxies • background radiation	*any 1 for 1 mark*	**1**
	(ii)	• further away a galaxy the faster it is moving	*for 1 mark*	**1**
	(iii)	• Big Bang theory • general relativity • steady state theory	*for 1 mark*	**1**
	(iv)	• any other example from (iii)	*for 1 mark*	**1**
	(v)	• use of Big Bang theory to predict existence of background radiation	*for 1 mark*	**1**
	(vi)	• the background radiation predicted by Big Bang	*for 1 mark*	**1**
	(vii)	• Einstein believed the universe was stable and modified his equations • any scientist in 1950s who believed in steady state must imply a scientist not a theory	*any 1 for 1 mark*	**1**
			Total	**9**

Question 7				
(a)		• Neanderthal & erectus	*both for 1 mark*	**1**
(b)		• development of new **species** over time • more recent species show increasing brain size • **extinction of** smaller brain size/**less** adapted species • **better** adapted/ more intelligent more likely to survive • able to pass on advantageous characteristics • advantages may be language/tool making • example of exception (Neanderthal or chimpanzee) • species over reproduce	*any 4 for 1 mark each*	**4**
(c)	(i)	• fossil record consistent with evolution	*any 2 for 1*	**2**

(ii)	• detail of supporting evidence e.g. DNA, carbon dating • no contradictory evidence • good evidence for evolution of non-human species no marks for general similarity to chimps • we seem to be different from animals/ common ancestor with chimpanzees seems improbable/ only humans have language/self awareness/ moral sense/developed intelligence/technology not 'superior' or 'advanced' unless explained • religious books such as Bible describe creation/ evolution breaks special relationship with God/ some people consider humans superior • difficulty of imaging long timescale	*mark each* *any 2 for 1 mark each*	**2**
		Total	**9**

Question 8				
(a)		• sex selection • PGD to screen out many disease causing gene variants • limit to number of embryos implanted	*any 2 for 1 mark each*	**2**
(b)		• IVF embryo • one or two cells removed • genes tested for allele causing the disease	*any 2 for 1 mark each*	**2**
(c)	(i)	• US allows parent to make the decision/does not regulate • UK very strict regulation/prevents some applications	*for one mark each*	**2**
	(ii)	• limiting number of embryos implanted improves child's health	*for 1 mark*	**1**
	(iii)	• parents denied option of screening out known disease causing alleles • incentives rather than regulation can be used to influence sex selection	*any 1 for 1 mark*	**2**
	(iv)	• ability to screen embryos for desirable genetic characteristics	*any 1 for 1 mark*	**1**

(d)	The marking scheme for this section includes an overall assessment for the quality of written communication. There are no discrete marks for the assessment of written communication but quality of written communication will be one of the criteria used to assign the answer to one of three levels. The mark should be awarded on the basis of the overall level of the candidate's response in relation to the following general descriptors for each level. An answer will meet most of the criteria given in the level descriptor	
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good - level 3	claims supported by an appropriate range of evidence; good use of information or ideas about science, going beyond those given in the question, demonstrating knowledge and understanding; use of specialist vocabulary for science and for how science works; argument well structured with minimal repetition or irrelevant points; accurate and clear expression of ideas with legible text and only minor errors of grammar, punctuation and spelling	**5-6**
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limited - level 1	valid points but not clearly linked to an argument structure; limited use of information or ideas about science; unstructured; errors in grammar, punctuation and spelling or lack of fluency	**1-2**
0	incorrect of no response	**0**
		Total **16**

GENERAL CERTIFICATE OF EDUCATION
SPECIMEN

SCIENCE IN SOCIETY UNIT 3: A2 EXPLORING ISSUES

In addition to this paper you will require
A 4-page answer book
You may use a calculator

Time allowed 2 hours

Instructions

- Use blue or black ink
- Answer **all** questions
- This paper is divided into **two** sections. Answer section A questions in the spaces provided in this book. Answer the section B question in the separate answer book.
- Do all rough work in this book. Cross through any work you do not want marked.
- Show your working in all calculations.

Information

- The maximum mark for this paper is 90
- Mark allocations are shown in brackets
- You Are reminded of the need for good English and clear presentation in your answers. Questions 5(d), 6(d) and 7 should be answered in continuous prose. Quality of Written Communication will be assessed in these answers.

SECTION A

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

1 Premature babies have to undergo repeated medical procedures. Older children and adults would certainly find these painful. No one knows if very small babies can feel pain. For a long time it was assumed that the very immature brain did not feel pain. Now researchers are actively investigating the issue.

It seems certain that the pain receptors on the babies' skin do detect pain and babies show responses, such as withdrawal or change in heart rate, to pain stimuli,. However such responses can originate in the brain stem, even in fully conscious adults. The baby may not be conscious of the pain because the stimuli may not reach the cerebral cortex.

Researchers used near infrared spectroscopy, NIRS, to measure brain activity during 'painful' procedures. This involves wearing a special cap, much less stressful than most other scanning procedures. as shown in **Figure 1**. They found increased blood flow in the part of the cortex that processes bodily sensation in adults. This increase was not found when the baby was touched in a non-painful way.

Figure 1

A baby having an IR scan of its brain

(a) All organisms have reflex responses to pain that originate in the brain stem. What is the advantage of such responses, compared to conscious responses that originate in the cortex?

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(2 marks)

(b) What do we know about the development of the brain that makes it reasonable to suggest that premature babies may not be sufficiently conscious to experience and be emotionally distressed by pain?

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(2 marks)

(c) Doctors would prefer not to prescribe strong pain-killers to premature babies if it is not necessary. Give one reason why there might be particular risks in prescribing strong pain-killers for premature babies.

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(1 mark)

(d) Research on pain and premature babies is a relatively new and expanding field. Give two factors that are likely to have stimulated such research.

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(2 marks)

(e) What should medical researchers do, before starting research of this kind, to ensure that their experiments on small babies meet ethical guidelines?

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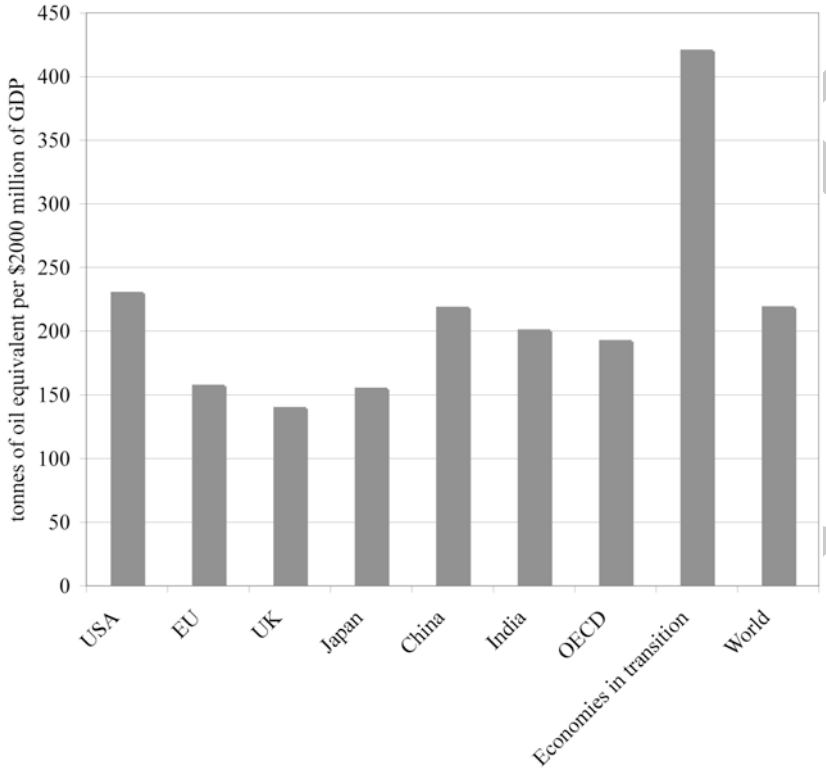
(3 marks)

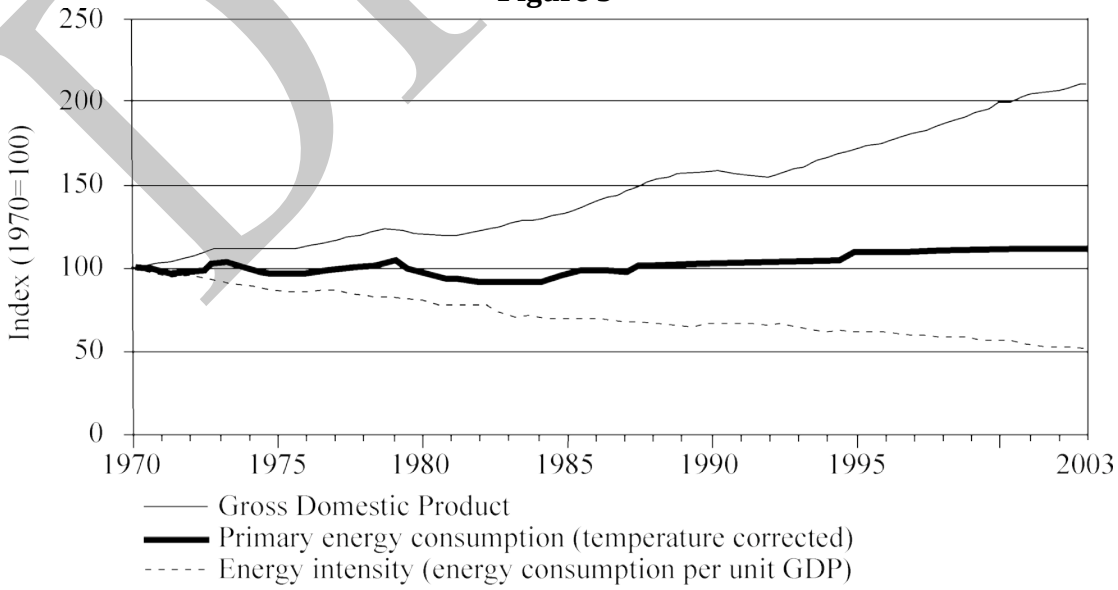
2 **Figure 2** shows the energy use, relative to every $1000 of GDP, for a range of countries. GDP, stands for Gross Domestic Product and is a measure of the value of all the goods and services produced in the country. **Figure 3** shows how GDP and energy consumption have changed over time in the UK.

Figure 2



Energy consumption in different countries in 2003

Figure 3



Energy consumption and GDP in the UK 1970–2003

(a) (i) In order to meet future demand for electricity, it is necessary to plan in advance. For many years planners assumed that the demand for energy would be proportional to GDP. Use the information in **Figure 2** and **Figure 3** to show that this assumption is no longer valid.

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(2 marks)

(ii) Give **two** reasons why it has become possible to create the same wealth in a country using less energy than would have been needed 30 years ago.

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(2 marks)

QUESTION 2 CONTINUES ON THE NEXT PAGE

(b) Planners have to ensure a secure supply of energy in the future. The UK government recently produced a report predicting the amount of different primary fuels required in the future, using three different scenarios. These scenarios were based on different assumptions about future energy supply and use. Among the assumptions built into the scenarios were:

A Hydrogen, produced using sunlight, becomes widely available as a fuel for transport.

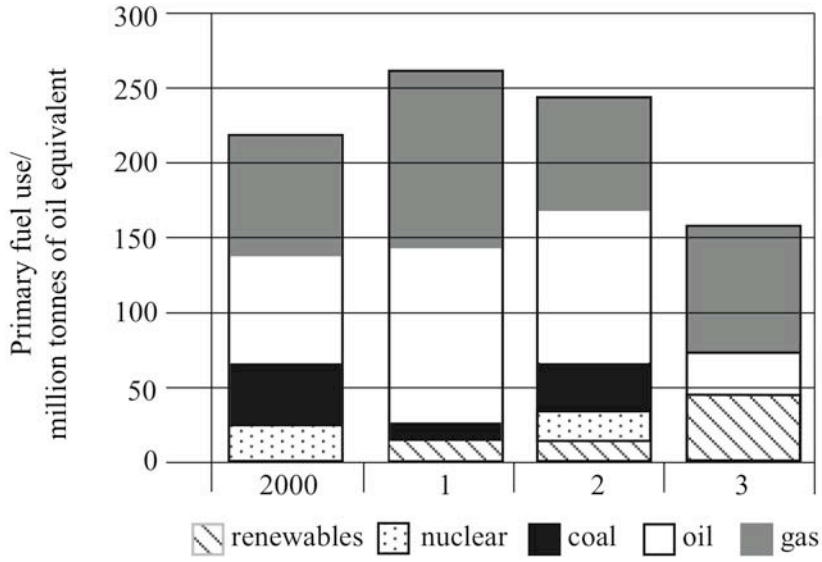
B A safe way of disposing of nuclear waste is developed.

C Large new oil and natural gas deposits are discovered.

D International agreement on reduction of carbon dioxide emissions by 60% by 2050 is reached and is strongly enforced.

Figure 4 shows the use of the primary energy sources; renewable, nuclear, coal, oil and gas in 2000 and three predictions for 2050 based on different scenarios.

Figure 4



(i) Identify one assumption (from **A** - **D** above) which is included in scenario 1. Explain your reasoning.

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(1 mark)

(ii) Identify two assumptions (from **A - D** above) which are included in scenario 2. Explain your reasoning.

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(2 marks)

(iii) Identify two assumptions (from A - D above) which are included in scenario 3. Explain your reasoning.

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(2 marks)

9

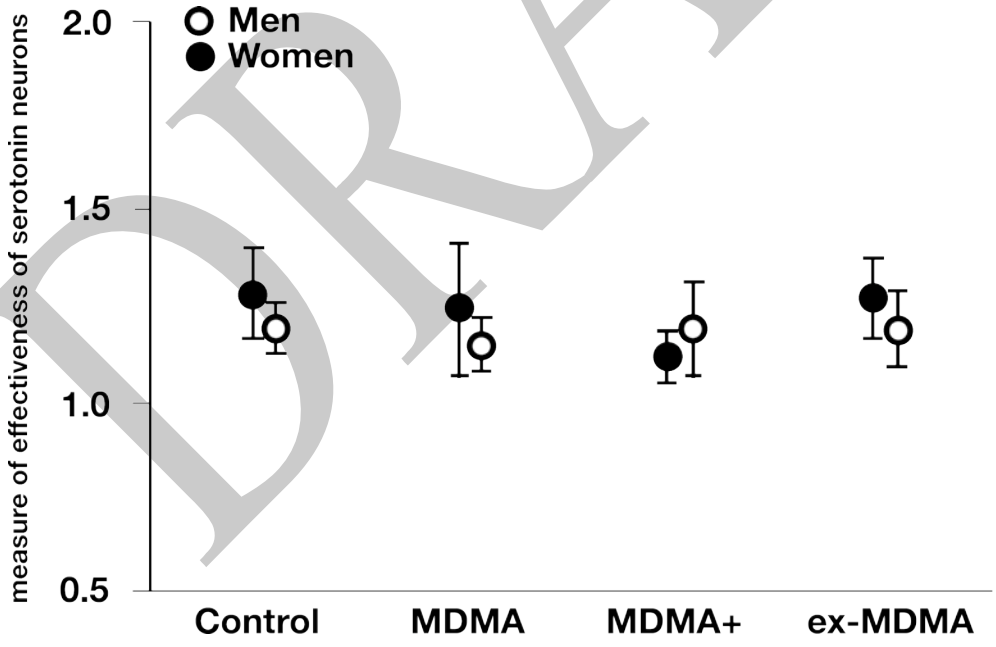
QUESTIONS CONTINUE ON THE NEXT PAGE

3 Ecstasy, MDMA, is a widely used recreational drug. It is known that it prevents reuptake of the neurotransmitter serotonin. This causes an increase in the concentration of serotonin in synapses, leading to pleasant feelings of well-being and empathy with others.
However there is debate about the long term risks created by regular use of the drug. One suspected long term effect is damage to serotonin neurons, leading to low levels of serotonin in the brain, but evidence is very contradictory. In 2001 one team carried out brain scans on ecstasy users to measure the effectiveness of the serotonin neurons. They compared four groups as shown in **Figure 5**. The results are shown in **Figure 6**.

Figure 5

	MDMA Moderate use over 4 – 5 years	**MDMA+** Heavy MDMA use over 4 – 5 years	**ex MDMA** Used over 4 – 5 years Stopped at least one year before trial	**Control group** No MDMA use
Number of men	9	12	8	7
Number of women	6	11	8	8
Total mean lifetime dose (number of tablets)	28.6	530.0	268.1	0

Figure 6



Mean measures of effectiveness of serotonin neurons for different subgroups of MDMA users and controls

Other groups, using similar scanning techniques, have shown stronger evidence of harm to serotonin neurons.

Some animal studies show clear signs of neuron damage when the brain is dissected some time after large doses of Ecstasy.

(a) Explain how a low level of serotonin might reduce the transmission of some signals within the brain.

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(2 marks)

(b) (i) The vertical bars on **Figure 6** indicate the standard deviation (SD) of the measure of effectiveness of serotonin neurons. What does the SD tell us about the range of values found in the heavy MDMA user groups?

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(2 marks)

(ii) Discuss the extent to which the data in **Figure 5** and **Figure 6** provide evidence of long term harm from MDMA use.

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(4 marks)

(c) Different teams of competent and professionally respected scientists have carried out detailed research and reached different conclusions about the long term risks of regular Ecstasy use. Outline reasons why such differences are possible.

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(6 marks)

14

4 There are two main factors which determine how human activities change climate:

- the rate of greenhouse gas emissions, and
- the response of climate to these emissions.

The second of these factors can only be explored through the use of climate models.

The UK Climate Impacts Programme (UKCIP) has published a report presenting possible climate scenarios for the United Kingdom. The scenarios are based on different assumptions about population, economic growth and energy futures. They do not make any allowance for targeted interventions to reduce greenhouse gas emissions. The assumptions are the basis for the data fed into the climate model experiments that lead to descriptions of future changes in climate

Figure 7

	2020s		2050s		2080s	
Assumption about greenhouse-gas emissions	Average temperature rise (°C)	Concentration of carbon dioxide (ppm)	Average temperature rise (°C)	Concentration of carbon dioxide (ppm)	Average temperature rise (°C)	Concentration of carbon dioxide (ppm)
Low emissions	0.79	422	1.41	489	2.00	525
Medium emissions	0.88	435	1.87	551	3.29	715
High emissions	0.94	437	2.24	593	3.88	810

Climate change estimates for three scenarios. All temperature changes are calculated with respect to the mean for 1961-1990. The pre-industrial level of carbon dioxide in the atmosphere was about 280 ppm (parts per million). Mean temperatures have risen by about 0.74 °C in the northern hemisphere since the start of the twentieth century.

(a) Use a diagram to explain in outline why an increase in the concentration of carbon dioxide in the atmosphere leads to a rise on the mean surface temperature of the Earth.

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(3 marks)

(b) Summarise **two** important conclusions you can draw from the data in **Figure 7**.

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(2 marks)

(c) The UKIP report states that 'the scenarios illustrate possible effects on UK climate over the coming century of choices being made around the World about technologies, about lifestyle and about values'.

(i) Explain the implications for the future of climate in the UK of a possible change in people's lifestyles.

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(2 marks)

(ii) Explain the implications for the future of climate in the UK of a possible choice about technology.

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(2 marks)

(d) Scientists are steadily improving the models they use to predict climate change. How are scientists able to test their climate models and show that they have improved?

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(2 marks)

(e) Results from the latest models show that in some regions, such as the northern parts of South America, a combination of rapid warming and a large drop in rainfall will cause forests to die back and their carbon be returned to the atmosphere.

Use this example, or another example, to explain the significance of 'positive feedback' to climate modelling.

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(2 marks)

(f) The results of modelling presented in the report are important to planners in the UK.

(i) Give an example of a decision that a planner might have to make that would be affected by the information in the report.

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(1 mark)

(ii) What type of data is needed to make an informed decision? Give **two** examples and justify your choices.

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(2 marks)

16

QUESTIONS CONTINUE ON THE NEXT PAGE

5 In 2003 a scientific paper was published in the journal Science with the title:

Influence of Life Stress on Depression

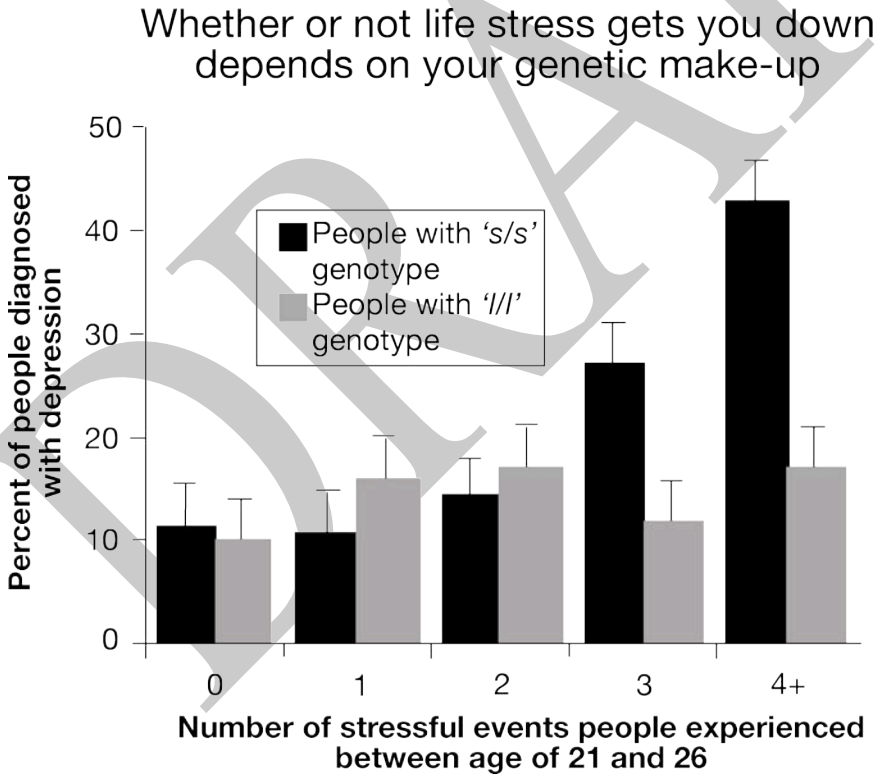
The abstract of the paper starts:

"In a prospective-longitudinal study of a representative birth cohort, we tested why stressful experiences lead to depression in some people but not in others."

There is evidence that both stressful life events and genetics influence the risk of depression. The researchers investigated the interaction between the two. They planned the research to test the hypothesis that alleles of the 5HTT gene have an influence on response to stressful experiences.

The 5HTT gene has two alleles known as short, *s*, and long, *l*. In the study 847 twenty six-year-olds in the cohort were tested for these alleles and assessed for depression using widely accepted criteria. Stressful events included financial, health, housing and relationship problems.

Figure 8



***s/s* people have only the *s* allele for the 5HTT gene, 147 people in the study**
***l/l* people have only the *l* allele for the 5HTT gene, 265 people in the study**

(a) What is the most probable genotype of the group of 435 people (of the original 847) not represented in **Figure 8**?

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(1 mark)

(b) This research used a cohort study, monitoring the participants from birth.

(i) Explain one reason why this type of study has an advantage over a retrospective case control study as a way of investigating factors that influence depression.

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(2 marks)

(ii) Suggest one reason why you might start your research with a case control study rather than a cohort study if you had a completely original hypothesis for a cause of depression.

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(1 mark)

(c) The researchers planned this study to test the hypothesis that alleles of the 5HTT gene have an influence on response to stressful experiences. Use the example of this research to explain how scientists test hypotheses or theories. Use the terms prediction, observation and falsification in your answer.

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(3 marks)

(d) Write a short article explaining the significance of this research. The article should be suitable for publication on an information web site for sufferers of depression and their families.

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(8 marks)

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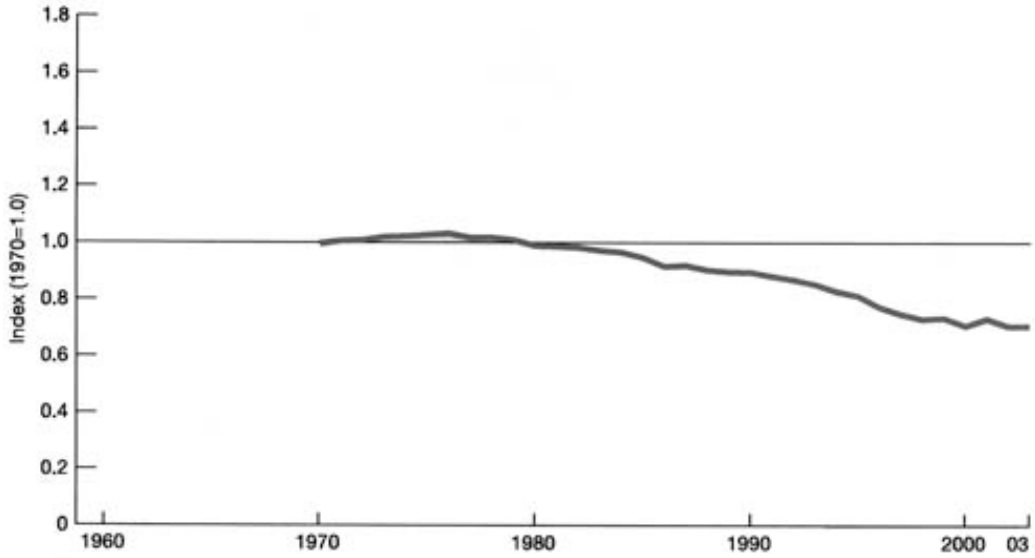
6 WWF (the Worldwide Fund for Nature) has been publishing Living Planet Reports since 1998. Each year the report describes the changing state of global biodiversity.

One of the two indicators in the report is the Living Planet Index which measures trends in the Earth's biological diversity. It tracks populations of 1313 vertebrate species – fish, amphibians, reptiles, birds, mammals – from all around the world.

The data used to calculate the Living Planet Index are measures of population size gathered from a variety of sources including scientific journals, reports from Non Governmental Organisations (NGOs) and from the Internet. Some data are estimates of the total population of a species; others are density measurements, such as the number of birds in a given area; others are proxies of population size such as the number of turtle nests on beaches.

The 2006 report includes a graph which shows the overall Living Planet Index (see **Figure 9**)

Figure 9



Living Planet Index (1970 – 2003)

(a) Scientists have a wide range of data available from which they might select to calculate the Living Planet Index. Suggest **two** criteria they should apply when deciding whether or not a particular set of data is reliable enough to be included the overall calculations.

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(2 marks)

(b) (i) Estimate from **Figure 9** the percentage fall in the overall Living Planet index between 1970 and 2003.

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(1 mark)

(ii) The authors of the 2006 report claim that the global trend in the index suggests that we are degrading natural ecosystems at a rate unprecedented in human history. Does the information in **Figure 9** support this claim? Give your reasons.

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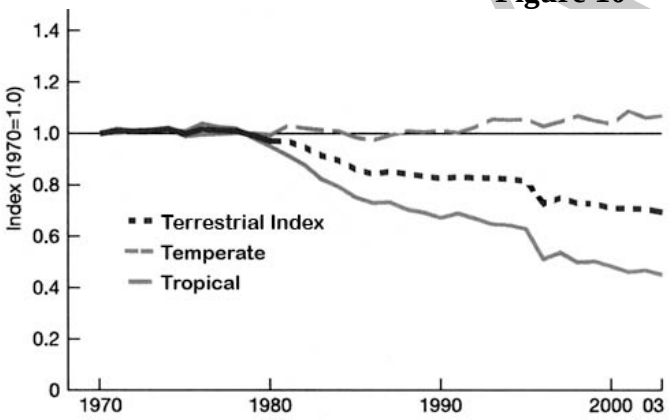
(1 mark)

WWF scientists calculate a value of the Living Planet Index just for organisms that live on land (terrestrial species). They also calculate separate values for land species that live in the tropics and species that live in temperate regions (that is regions with a mild climate between the tropics and the polar regions).

Figure 10



Living planet indices, 1970 – 2003:
overall terrestrial index (dotted line);
the separate indices from temperate (dashed line)
and tropical regions (solid line)

(c) Suggest an explanation for the difference in the trends in the index for temperate and tropical habitats in **Figure 10**.

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(2 marks)

(d) The 2006 WWF report states that the consequences of our accelerating pressure on the Earth's natural systems is predictable and creating a disastrous situation. Discuss whether or not you agree with this view giving your reasons.

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(8 marks)

SECTION B

- Answer **Question 7** in the separate answer book provided.
- Quality of written communication will be taken into account in awarding marks for this question.

7 "The UK Government is committed to 'evidence-based policy making'. However science policy can rarely be made using evidence alone. Evidence may be incomplete, other political, social and economic factors may also be relevant."

Discuss the above quote, choosing any illustrative examples you wish from one or more contexts.

(12 marks)

ASSESSMENT and QUALIFICATIONS ALLIANCE

GENERAL CERTIFICATE OF EDUCATION
SPECIMEN MARK SCHEME

SCIENCE IN SOCIETY

UNIT 3: A2 EXPLORING ISSUES

Examiners look to reward knowledge and understanding not to penalise.
Any correct response will be credited even if it does not appear in the mark scheme.

UNIT 3
SECTION A

Question 1			
(a)	• faster • brain stem nearer spinal cord • works even if unconscious/asleep	*any 2 for 1 mark each*	**2**
(b)	• cortex is main site of consciousness • very few connections to cortex • connections to cortex develop over first year	*any 2 for 1 mark each*	**2**
(c)	• drugs not tested for premature babies • may depress breathing • risk of side effects	*any 1 for 1 mark*	**1**
(d)	• more premature babies • new brain scanning technologies available	*any 2 for 1 mark each*	**2**
(e)	• consent from parents • full information to parents • minimise harm to baby • consider whether overall benefits of research outweigh discomfort to baby	*any 3 for 1 mark each*	**3**
		Total	**10**

Question 2				
(a)	(i)	• different countries have different energy use per $ GDP • e.g. Japan almost 1/3 of Canada • trend in energy consumption has diverged from trend in GDP in UK • GDP has doubled and energy use risen by 10% since 1970 in UK (this worth 2)	*any 2 for 1 mark each*	**2**
	(ii)	• second significantly different example of efficiency • less heavy industry • less manufacturing/more service sector	*any 2 for 1 mark each*	**2**

(b)	(i)	• C - increased use of fossil fuels implies new reserves	*1 mark for reason*	**1**
	(ii)	• B -waste disposal is a current constraint on nuclear/ • C - increased oil usage	*1 mark for reason in each case*	**2**
	(iii)	• A - less oil implies a new fuel for transport/ • D - less fossil fuels being burned	*1 mark for reason in each case*	**2**
			Total	**9**

Question 3				
(a)		• neurotransmitters carry signals across synapse • between one neuron and next • less serotonin/neurotransmitter reduces chance of transmission across synapse	*any 2 for 1 mark each*	**2**
(b)	(i)	• SD is a measure of the spread of results • wide range amongst men • smaller range amongst women	*any 2 for 1 mark each*	**2**
	(ii)	• sample sizes very small • differences between groups very small • no information on other variables • range of results /1SD overlap between all groups • women heavy users only group to show significant difference • ex-MDMA almost indistinguishable from control • binding ratio may not be only measure of damage • brain scan not very accurate discriminator • evidence of damage not strong	*any 4 for 1 mark each*	**4**

(c)	• many variables involved in the research • many different measures of harm • scientists have to make judgements about techniques to be used • bias in sampling always possible • negative results may not be published • scientists prior beliefs may influence their judgement • research may be funded by those with a vested interest in particular results • views on drugs are very strongly held	*any 6 for 1 mark each*	**6**
		Total	**14**

Question 4			
(a)	diagram to show: • incoming radiation from the Sun warming the surface of the Earth • longer wave-length (infrared) radiation from the cooler surface of the Earth • absorbed by CO_2 in the atmosphere	*for 3 marks*	**3**
(b)	any two defensible conclusions that follow from the data. For example: • the higher the level of emissions, the greater the level of atmospheric carbon dioxide and the higher the mean temperature rise • even with low emissions, by 2080, the concentration of carbon dioxide in the atmosphere will be close to double the pre-industrial era • even with low emissions the temperature rise by the 2020s will exceed that since the start of the 20th century • without targeted interventions to reduce emissions, there will be marked changes in the UK climate in the next 50 – 80 years	*for 2 marks*	**2**

(c)	(i)	• lifestyle change that leads to reduction of CO_2 emissions (e.g. a change that reduces use of fossil fuels for heating, or transport)	*for 1 mark*	**2**
		• explanation of why the life-style change cuts CO_2 emissions	*for 1 mark*	
	(ii)	• technology that either leads to a reduction of CO_2 emissions (e.g. changing from fossil fuels to renewables for generating electricity or transport)	*for 1 mark*	**2**
		• *or* *t*echnology change that reduces the radiation warming the surface of the Earth (e.g. reflective systems in upper atmosphere) explanation of why technology change cuts CO_2 emissions	*for 1 mark*	
(d)		• they can test models by inputting data related to past climates into the models	*for 1 mark*	**2**
		• then they compare what is known about climate change in the past and the predictions of the models	*for 1 mark*	
(e)		• positive feedback: a small change in the input (e.g. small temperature rise) …	*for 1 mark*	**2**
		• … tends to be magnified by the system and lead to large output (e.g. die back of forests leading to substantial release of CO_2). positive feedback has the potential to lead to runaway climate change	*for 1 mark*	
(f)	(i)	any one decision, e.g. • where to build houses • where to invest in forestry and various forms of agriculture • decisions about which habitats to conserve and what action to be taken to deal with changing distribution of species • whether or not to invest in new reservoirs, or to take steps to cut water use • whether to invest in more protection or to let land be inundated	*for 1 mark*	**1**
	(ii)	• appropriate data, with justification, related to the answer in (i), such as projected sea levels, rainfall, temperatures in different seasons	*1 mark each for 2 marks*	**2**
			Total	**16**

Question 5			
(a)	• *s/l*	*for 1 mark*	**1**
(b) (i)	• information on factors more reliable • does not rely on memory/reconstruction from other information	*for 1 mark each*	**3**
(ii)	• smaller groups required • results obtained more quickly	*any 1 for1 mark*	
(c)	• theory must led to a testable prediction • in this case prediction is 's/s alleles make people more susceptible to long-term harm from stressful events' • tested by comparing s/s and l/l people • observations of the incidence of depression in the two groups • no observed difference would falsify the hypothesis	*any 3 for 1 mark each*	**3**
(d)	use standard mark scheme points might include: • study compared two groups with different versions of the gene • s/s gene increases risk of depression • only has an effect if exposed to several stressful life events • both versions have some risk of depression/10% risk • even with s/s and 3 stressful life events only 30% risk • only one study/ needs to be repeated	*for 8 marks*	**8**
		Total	**15**

Question 6				
(a)		one mark for each of two criteria, such as: • whether or not the data has been peer reviewed • whether the data has been collected in a consistent way over a period of time • the experience and expertise of the people who collected the data • whether or not the people that collected the data had a vested interest in the findings	*for 2 marks*	**2**
(b)	(i)	• the index fell by 30%	*for 1 mark*	**2**
	(ii)	• no – there is no data for years before 1970 shown on the graph	*for 1 mark*	
(c)		explanation based on points such as: • decline due to change in land use – conversion of habitat to farmland or other types of development • in temperate regions the conversion of natural habitat to farmland took place before 1970 and populations have stabilised • in tropical regions the rapid population decline of many species is a result of the loss of natural habitat to cropland or pasture • tropical biodiversity is relatively high and destruction of tropical forests is having a disproportionate effect	*any 2 for 1 mark each*	**2**
(d)		use standard mark scheme answers might explore whether or not: • there is accelerating pressure on natural systems • whether the consequences are predictable • whether the consequences are disastrous for full marks candidates must give reasoned responses to some or all of these aspects of the statement and show whether or not they agree with the WWF statement	*for 8 marks*	**8**
			Total	**14**

Section B

	The marking scheme for this section includes an overall assessment for the quality of written communication. There are no discrete marks for the assessment of written communication but quality of written communication will be one of the criteria used to assign the answer to one of three levels. Marks are assigned according to level descriptors.	
level of response	**descriptors:** knowledge**,** understanding (AO1); explanation, argument and illustration, application of ideas, synthesis, evaluation (AO2); legibility, accuracy of grammar and syntax, clarity of meaning, style, organisation and vocabulary (QWC)	**mark range**
good – level 4	knowledge and understanding of key science explanations; knowledge and appreciation of related ideas about how science works; demonstrates overall grasp of the range and nature of issue(s); interprets and illustrates valid arguments, recognising counterclaims, coherently and convincingly to reach a reliable conclusion; fluency and accuracy of expression.	**10 - 12**
competent – level 3	knowledge and understanding, in context, of key science explanations and ideas about how science works; demonstrates general grasp of the range and nature of issue(s); interprets and illustrates fair arguments competently using a range of evidence with reasonable attempt at valid conclusion; accuracy of expression.	**7 - 9**
limited – level 2	some understanding and realisation of key science explanations and ideas about how science works; some competence and grasp of the issue(s); limited arguments and exemplification with weak conclusion; reasonable clarity of expression	**4 - 6**
inadequate – level 1	uncertain grasp, knowledge or understanding of issue(s) and/or science and ideas about how science works; lack of clarity of argument with little or no appropriate justification or exemplification; weak expression	**1 – 3**
0	**incorrect or no response**	**0**

	examples of the sort of points that might be included (relevance depends on examples chosen):		
	• incomplete scientific evidence a new risk - bird flu, mobile phones, GM crops long term effects - carcinogens, nuclear waste not enough research - harm from drugs, uncertain benefits from new technology – stem cells, carbon capture		
	• incomplete economic evidence predictions may require assumptions – future price of oil, decommissioning nuclear power, climate change costs of new technology uncertain – new energy technologies choice of factors to include in cost – environmental impact, possible NHS savings from reduced drug abuse, difficulty of weighing cost and benefit on same scale different groups usually receive benefit and cost – local impact of new power station, air travel, rising sea level		
	• pressures on decision makers media, pressure groups, vested interests, international organisations		
	• ethics utilitarian choices depend on evidence balancing rights of some individuals or groups against others – allowing research on humans, environmental impact absolute principles – stem cell research		
		Total	**12**

GENERAL CERTIFICATE OF EDUCATION
SPECIMEN

SCIENCE IN SOCIETY UNIT 4: CASE STUDY

In addition to this paper you will require
Insert 1: a copy of Pre-released source material (Sources A–F)
Insert 2: Additional source material (Source G)
An 8-page answer book
You may use a calculator

Time allowed: 1 hour 30 minutes

Instructions

- Answer all questions in Section A and Section B.
- Write your answers in continuous prose.
- Use your own words, rather than simply repeating those used in the sources, to show your understanding of the points being made.

Information

- **Section A**: Questions on your appreciation and understanding of the Case Study Source Material on the subject of *Nanotechnology and Cosmetics* (copy provided earlier) and additional material provided with this paper;
- **Section B**: Questions that ask you to demonstrate your ability to construct an appropriate scientific explanation for a given audience, and seek your argued opinion on an issue raised by the case study material.
- The maximum mark for this paper is 60 (32 for Section A and 28 for Section B).
- Part of the assessment will be based on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate.

SECTION A

- Answer **all** of Questions 1 to 3 in the answer book provided.
- Use Sources **A** to **F**.
- Where appropriate you may use your own knowledge and ideas to support and enhance your answers to the questions.
- Total for this Section is 32 marks.

1 Identify and explain **four** of the key issues raised in **Sources A and B**

(8 marks)

2 (a) Refer to **Source C**. Outline your understanding of the terms:

(i) 'leading scientific journals'
(ii) 'patents'
(iii) 'statistically significant number of people'
(iv) 'independent clinical study'

(8 marks)

(b) Suggest an explanation for the use of these terms in **Source C**

(4 marks)

3 Refer to **Sources E and F**.

(a) Explain why news of scientific research received by the on-line journal *Nano Letters* in early July 2004 could not appear in a news story for the general public until September 2004.

(3 marks)

(b) Use the information given in either **Figure 1** or **Figure 3** (**Source F**) to explain the importance of estimating accuracy when presenting scientific data.

(3 marks)

(c) Use the two pieces of research reported (**Source E**) as examples to outline briefly the way that scientific knowledge is built up over time.

(3 marks)

(d) Outline the purpose of the inclusion of the section titled **In vitro Cytotoxicity** in **Source F**.

(3 marks)

SECTION B

- Answer **both** of Questions 4 and 5 in the answer book provided.
- Use **Sources A – F** together with the additional insert **Source G** to provide examples and evidence for your argument.
- Write as if you were addressing the intelligent general reader.
- This section is worth 28 marks.

4 Refer to **Source G**. The box presents a summary by a group of scientists: *Why manufactured free nanoparticles and nanotubes are a cause for concern*.

Use information from **Source G** and appropriate information from **Source D** to explain the same issue for a magazine aimed at young students preparing for their GCSE examinations. You should consider the vocabulary and explanation of technical terms required. You may add sketch pictures or diagrams if you wish.

(12 marks)

5 Drawing upon all that you have read in **Sources A – G**:

Discuss the action that, in your opinion, the UK government should take as the use of nanoparticles in cosmetics develops.

(16 marks)

SOURCE A

Does Scarlett need regulatory oversight?

No, but her new makeup might. Johansson, star of films such as Lost in Translation and Match Point, has just signed a multimillion-dollar deal with cosmetics company L'Oréal in which her face will promote nanotechnology-based pigments.

At the same time, though, the US-based Project on Emerging Nanotechnologies released a report on government oversight of nanotechnology which suggested that new laws are needed to deal with the growing use of molecule-sized elements in more and more products, ranging from trousers to toothbrushes to suntan lotion and, of course, cosmetics.

The problem, according to the report's author, Clarence Davies — a former adviser to the Environmental Protection Agency for the first Bush administration — is that existing legislation is not well framed to deal with potential problems caused by nanotechnology.

The Food, Drugs and Cosmetics Act, for example, is 100 years old, and was originally introduced to protect people from patent medicine salesmen and unsanitary food-processing plants.

But now, cosmetics companies are reckoned to be the biggest commercial users of nanotechnology, because tinier particles offer more effective ways to get close to the skin. Nano-quality foundation looks smoother; nano-size bubbles of moisturiser can penetrate better into the pores. Of course, if it works better, you can charge a premium for it — above that charged for beauty products. Thus, when it comes to nanotech, L'Oréal has 192 patents, making it the US's sixth-largest holder in the field. Other cosmetics companies are hot on its heels.

But is it safe for Johansson to put this stuff on her skin? L'Oréal insists there is no evidence that the nanoparticles used in its cosmetics can penetrate to the living cells, rather than the dead dermis. But there's no definitive answer, mostly because commerce is moving a lot faster than regulatory bodies.

There has been no movement, for example, on the Royal Society's call last November, saying that further research into the health and safety aspects of nanotechnology was "urgently needed". With the jury out, Johansson is essentially a guinea pig — albeit a very well-paid one.

Source: Charles Arthur, *The Guardian*, January 21, 2006

SOURCE B

Safety fears over 'nano' anti-ageing cosmetics

THE cosmetics giant L'Oréal is marketing a range of skin treatments containing tiny "nano" particles, despite concerns about their possible long-term effects on the human body.

The products, which include anti-wrinkle creams such as Revitalift, are said to be absorbed deeper into the skin than more traditional treatments because of the far smaller size of their particles.

However, the cosmetic use of nanotechnology, originally employed in man-made fibres and pharmaceuticals, has led to calls from both the Royal Society and the Food and Drug Administration (FDA) in America for a comprehensive programme of research.

They aim to discover what effect the minute particles may have if they enter cells in the human body or leach into the bloodstream.

The FDA will also assess whether a trialling and licensing system should be introduced for cosmetics similar to that used for pharmaceuticals.

"Very little is known about the interaction of nano-scale particles and the skin," said the FDA. "We need urgent research to assess the safety and we are hoping to get some answers soon."

The Royal Society, Britain's most prestigious scientific body, said: "We don't know whether these particles are taken down through the skin and what the long-term effects might be in the bloodstream."

The cosmetics market is growing at about 10% a year and companies believe that nanotechnology will help to create a new generation of products. Within the next few years they hope that it may provide methods to prevent the greying of hair and even baldness.

L'Oréal, the world's largest cosmetics company, is devoting much of its £350m research budget to nanotechnology, which it believes offers great potential for slowing the effect of age on the skin.

Revitalift, described by L'Oréal as containing "nanosomes of Pro-Retinol A", claims to offer an "immediate lifting effect".

Conventional skincare products form a barrier to prevent moisture loss. The miniaturised particles, by contrast, are intended to work their way through the skin's outer layers and boost production of new cells so the skin remains soft, plump and free of wrinkles, even in middle age.

Nano particles also broaden the range of chemicals that can be used in cosmetics. They are used to coat the surfaces of microscopic packages of vitamins, growth promoters and other substances that, if used in their raw form, would cause irritation. When modified, they can be taken into the underlying layers of the skin.

Wendy Lewis, a skincare consultant and author of the book Beauty Secrets, said the use of nano particles was "hot technology that has lots of intriguing applications".

She added: "We are seeing a generation of baby boomers who don't want to grow old or look old and, if things work, they are prepared to spend the money to pay for them."

According to Lewis, Botox, the injectable anti-wrinkle agent, had increased the pressure on cosmetics companies to produce a skin cream with a similar effect. "Botox has proved women will pay a lot for something that works and the race is on to find a more convenient way of getting the same effect from a cream," she said.

L'Oréal declined to say how many of its 3,000 researchers worldwide are working on nano particles, nor would it discuss where the technology may lead. But the company has patented the use of dozens of different "nanosome" particles 800 times smaller than a human hair as delivery systems for nutrients.

"We think this is an important development and we want to stay at the leading edge of offering our customers better and better products," said a spokesman.

Other cosmetics houses are moving ahead with their own versions of the technology. Dior has invented the "liposome" to perform the same function as L'Oréal's nanosomes; an Australian company has just launched ZO1, which uses miniaturised zinc oxide particles as sunscreen. Estée Lauder and Johnson & Johnson are also developing products based on nanotechnology.

The Cosmetic Toiletry and Perfumery Association said this weekend that nano particles were not yet widely used in cosmetics, but all products were thoroughly tested before their launch: "With millions of consumers using cosmetic products as part of their daily routines, it is essential for our industry to ensure products are thoroughly assessed for safety."

Source: extracted from: Lois Rogers, *The Sunday Times*,

SOURCE C

The text is not reproduced here due to third-party copyright constraints.

The article can be viewed at http://www.lorealparis.co.uk/Technology/science.asp

SOURCE D

Source D consists of two extracts from Royal Society publications on nanotechnology.

Significance of the nanoscale

A nanometre (nm) is one thousand millionth of a metre. For comparison, a single human hair is about 80,000 nm wide, a red blood cell is approximately 7,000 nm wide and a water molecule is almost 0.3nm across. People are interested in the nanoscale (which we define to be from

100nm down to the size of atoms (approximately 0.2nm)) because it is at this scale that the properties of materials can be very different from those at a larger scale. We define nanoscience as the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale; and nanotechnologies as the design, characterisation, production and application of structures, devices and systems by controlling shape and size at the nanometre scale. In some senses, nanoscience and nanotechnologies are not new. Chemists have been making polymers, which are large molecules made up of nanoscale subunits, for many decades and nanotechnologies have been used to create the tiny features on computer chips for the past 20 years. However, advances in the tools that now allow atoms and molecules to be examined and probed with great precision have enabled the expansion and development of nanoscience and nanotechnologies.

Current and potential uses of nanoscience and nanotechnologies

Current applications of nanoscale materials include very thin coatings used, for example, in electronics and active surfaces (for example, self-cleaning windows). In most applications the nanoscale components will be fixed or embedded but in some, such as those used in cosmetics and in some pilot environmental remediation applications, free nanoparticles are used. The ability to machine materials to very high precision and accuracy (better than 100nm) is leading to considerable benefits in a wide range of industrial sectors, for example in the production of components for the information and communication technology (ICT), automotive and aerospace industries.

It is rarely possible to predict accurately the timescale of developments, but we expect that in the next few years nanomaterials will provide ways of improving performance in a range of products including silicon-based electronics, displays, paints, batteries, micro-machined silicon sensors and catalysts. Further into the future we may see composites that exploit the properties of carbon nanotubes – rolls of carbon with one or more walls, measuring a few nanometres in diameter and up to a few centimetres in length – which are extremely strong

and flexible and can conduct electricity. At the moment the applications of these tubes are limited by the difficulty of producing them in a uniform manner and separating them into individual nanotubes. We may also see lubricants based on inorganic nanospheres; magnetic materials using nanocrystalline grains; nanoceramics used for more durable and better medical prosthetics; automotive components or high-temperature furnaces; and nano-engineered membranes for more energy-efficient water purification.

Source: extracted from: Official Summary of *Nanoscience and nanotechnologies: opportunities and uncertainties*, The Royal Society & The Royal Academy of Engineering, 2004

Stakeholder and public dialogue

Quantitative survey findings

1 The first strand was a three-question survey with a representative sample of 1005 people aged 15 or over in Great Britain. This was designed to give a basic measure of awareness of nanotechnologies among members of the general public, establish whether those who had heard of it could provide any definition, and whether they thought it would have a positive or negative effect on quality of life. The questions used are shown in Box 1.

Box 1 The BMRB survey questions

The first question was asked of all 1005 respondents

Q1. Have you heard of nanotechnology? (n=1005)

If the respondent answered yes at question 1 they were then asked

Q2. What do you think nanotechnology is? (n=262)

Finally, if a person said yes at question 1 and had not said don't know at question 2 they were asked

Q3. Do you think nanotechnology will improve our way of life in the next 20 years, it will have no effect, or it will make things worse? (n=172)

2 As had been expected, there was limited awareness of nanotechnologies among the survey respondents.

3 In response to question 1, only 29%* of the survey respondents said they were aware of the term. Awareness was higher among men (40%) than women (19%), and was slightly lower for older respondents, falling from around one-third for those aged under 55, to one-fifth (20%) of those aged 65 or over. There was also a clear pattern by social grade, with awareness

peaking at 42% of socio-economic group AB and falling to 16% of socio-economic group DE.

4 At question 2, just 19% (172) of the survey sample could offer any form of definition. The most common centred on miniaturisation, or technology on a very small scale. Another frequent response relied on a particular application such as computing, electronics or medicine.

5 At question 3, the majority (68%) of those who were able to give a definition of the word felt that it would improve life in the future, compared with only 4% who thought it would make things worse. Thirteen per cent said unprompted that whether nanotechnology would make things better or worse depended on how it was used (despite the fact that this was not presented as an option on the questionnaire). This last finding is consistent with views presented in the qualitative workshops (discussed next), which also showed that participants' decisions about whether a technology is 'good' or 'bad' depends on what it is used for.

* 262 out of 1005 respondents gave this response at the time of the interview, which is approximately 26%. However, the final data are weighted to the profile of all adults in Great Britain. This means that those 262 respondents represent more respondents (293) in the weighted data. In terms of the estimated percentage of all GB adults, this is 29%.

Application	Material/device	Estimated production rates (tonnes/annum)		
		Present	2005–2010	2011–2020
Structural applications	Ceramics, catalysts, composites, coatings, thin films, powders, metals	10	10^3	10^4–10^5
Skincare products	Metal oxides (titanium dioxide, zinc oxide, iron oxide)	10^3	10^3	10^3 or less
ICT	Single wall nanotubes, nano electronics, opto-electro materials (titanium dioxide, zinc oxide, iron oxide), organic light-emitting diodes (OLEDs)	10	10^2	10^3 or more
Biotechnology	Nanoencapsulates, targeted drug delivery, bio-compatible, quantum dots, composites, biosensors	less than 1	1	10
Instruments, sensors, characterisation	MEMS, NEMS, SPM, dip-pen lithography, direct write tools	1	10^2	10^2–10^3
Environmental	Nanofiltration, membran	10	10^2	10^3–10^4

SOURCE E: Two related articles from the *New Scientist* magazine

Buckyballs cause brain damage in fish

Bob Holmes, 29 March 2004

Nanoparticles cause brain damage in fish, according to a study of the toxicity of synthetic carbon molecules called "buckyballs".

The soccer-ball-shaped molecules show great promise in nanotechnology. But the preliminary study raises the possibility that nanomaterials could cause significant environmental harm, although much further work is needed to establish the extent of this risk.

Eva Oberdorster of Southern Methodist University in Dallas, US, who led the study, found modest concentrations of buckyballs in water caused significant harm to two aquatic animals. Water fleas were killed by the addition of the tiny carbon balls, and fish showed up to a 17-fold increase in brain damage compared with unexposed animals.

Industry is just beginning to exploit the potential of buckyballs - more formally known as fullerenes - and their chemical kin, single-walled nanotubes. Though only a handful of factories worldwide are now producing such molecules, experts see them as having the potential for wide use ranging from drug delivery to cosmetics to environmental remediation.

"We believe that nanomaterials are eventually going to be made in large-scale quantities, so we need to understand their environmental and toxicological effects," says Kirsten Kulinowski, executive director of the Center for Biological and Environmental Nanotechnology at Rice University in Houston, Texas.

Lipid peroxidation

Oberdorster, an environmental toxicologist, used two standard toxicological tests to measure the effect of waterborne fullerenes on aquatic animals. A concentration of 800 parts per billion was enough to kill half the water fleas in a three-week test.

"That makes this moderately toxic. It's not extremely toxic, but it's not innocuous, either", says Oberdorster, who reported the results on Sunday at an American Chemical Society meeting in Anaheim, California.

In a second test using nine juvenile largemouth bass, Oberdorster found that a concentration of 500 ppb led to a 17-fold increase in a form of cellular damage in samples of brain tissue. This damage, known as lipid peroxidation, can impair the normal functioning of cell membranes and has been linked to illnesses such as Alzheimer's disease in humans.

Damaged lung tissue

Oberdorster's is not the first study to reveal toxic effects of fullerenes or nanotubes. In 2003, researchers found that nanotubes can damage lung tissue of mice if inhaled, and buckyballs can cause cell death in test-tube experiments. However, no previous study has looked at what might happen if such materials escaped into the environment, either through an accidental spill or through normal use.

Because nanomaterials are not widely used at present, no one knows yet what levels of environmental exposure are likely. "In order for there to be a problem there has to be both exposure and toxicity," says Kulinowski. "There are a lot of unknowns right now, and most are in the area of exposure."

But as fullerenes move into large-scale production, accidents are bound to occur. "It's not if it's going to happen, it's where and when," says Oberdorster. And applications such as environmental remediation could lead to the deliberate introduction of fullerenes into the environment.

"Fullerenes have some really positive potential," Oberdorster notes. "But alongside the development of these technologies, we do need to look at the toxicity."

Buckyballs made safer for humans

Katharine Davis , September 2004

Carbon molecules called “buckyballs” - which hold great promise for nanotechnology - but have been shown to harm fish have been made safer by scientists.

The soccer-ball-shaped carbon nanoparticles were shown to cause brain damage in fish and kill water fleas in a study in March 2004. But now a team at Rice University in Houston, Texas, US, has come close to understanding how buckyballs – more formally known as fullerenes - kill cells and how their toxicity can be lowered in human cells.

Although the toxic nature of the carbon-60 nanoparticles may be useful in medicine, for example in fighting cancer, there are concerns that their potentially widespread use in fuel cells, drug delivery and cosmetics could mean they find their way into the environment, and so into animals and humans.

“There are a couple of different manufacturers that will, and are, mass producing fullerenes,” says Christie Sayes, one of the team. “They could make it into consumer based products: fuel cells and batteries or make-up,” she says.

Ruptured cells

The team, led by Vicki Colvin, looked at the effects of buckyballs on human cells. They found that even at quite low concentrations in water the buckyballs killed human skin cells. However, when they attached chemical groups such as hydroxyl groups to the buckyballs, their toxicity was greatly reduced. The higher the number of groups that were attached, the less toxic the fullerenes became, so that a buckyball with 24 hydroxyl groups attached showed a toxicity seven orders of magnitude lower than the original buckyball.

The researchers believe the buckyball is toxic because in water it leads to the formation of an oxygen free radical which reacts with lipid molecules forming the cell membrane surrounding a cell. This causes the lipid molecules in turn to become free radicals – and when these try to interact with the water outside the cell, the membrane ruptures leading to cell death.

Health threat

The team were able to show the hole in the membrane using dyes that only fluoresce when in the cell. Dyes that are usually too big to enter a cell fluoresced after the buckyballs had been added, showing the permeability of the cell had increased to such an extent that even large molecules could move freely through the membrane.

More research is needed to determine whether the same result would be seen in the body, says Sayes. “Cells in culture act differently to those in the body,” she says.

The research could eventually be use to make buckyballs safer, so that they do not cause an environmental or health threat as they become more commonly used. Or even to make them more toxic for certain medical treatments.

Eva Oberdõrster at Southern Methodist University in Dallas, Texas, who led the buckyball study in fish, called the new work “an excellent first step” in reducing the toxicity of buckyballs.

Source: *NewScientist.com news service*, www.newscientist.com

SOURCE F

[Note that most references and some technical details have been removed for clarity.]

The Differential Cytotoxicity of Water-Soluble Fullerenes

NANO LETTERS
2004
Vol. 4, No. 10
1881−1887

Christie M. Sayes, John D. Fortner, Wenh Guo, Delina Lyon, Adina M. Boyd, Kevin D. Ausman, Yizhi J. Tao, Balaji Sitharaman, Lon J. Wilson, Joseph B. Hughes, Jennifer L. West, and Vicki L. Colvin*

Department of Chemistry, Department of Environmental and Civil Engineering, Center for Biological and Environmental Nanotechnology, Department of Bioengineering, Rice University, Houston, Texas, and School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, Georgia

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ABSTRACT

We show that the cytotoxicity of water-soluble fullerene species is a sensitive function of surface derivatization; in two different human cell lines, the lethal dose of fullerene changed over 7 orders of magnitude with relatively minor alterations in fullerene structure. In particular, an aggregated form of C_{60}, the least derivatized of the four materials, was substantially more toxic than highly soluble derivatives such as $C_{60}(OH)_{24}$. Oxidative damage to the cell membranes was observed in all cases where fullerene exposure led to cell death. We show that under ambient conditions in water fullerenes can generate superoxide anions and postulate that these oxygen radicals are responsible for membrane damage and subsequent cell death. This work demonstrates both a strategy for enhancing the toxicity of fullerenes for certain applications such as cancer therapeutics or bactericides, as well as a remediation for the possible unwarranted biological effects of pristine fullerenes.

Introduction

Water soluble fullerene derivatives are essential for many emerging biomedical technologies which exploit the unique chemical properties and physical structure of C_{60}.[1-3] Their toxicity, both in tissue culture and in vivo, is an important characteristic for defining and constraining these applications.[4-18] In some cases, the phototoxicity of fullerene molecules has been identified as a feature useful for therapeutics.[16,17,19] Other work has sought to minimize the toxicity of water-soluble fullerenes so as to permit their use in drug delivery applications. Water-soluble fullerene species are also important for understanding the eventual fate and environmental implications of fullerenes used in consumer products. In this case, underivatized fullerene materials upon contact with water form sparingly soluble fullerene colloids, termed in this work "nano-C_{60}". Because of both the environmental and biological significance of fullerenes in water, this paper examines the comparative cytotoxicity of several important types of water-soluble fullerenes using human liver carcinoma cells and dermal fibroblasts.

Our attention was drawn to this issue by the recent interest in the environmental effects of nanoscale aggregates of C_{60}, which we refer to here as "nano-C_{60}". This form results when pristine C_{60}, from either the solid state or organic solution, is placed into contact with neutral water. Rather than completely precipitating, some C_{60} will form suspended and water-stable aggregates up to 100 ppm concentrations.

The unintentional generation of these aggregates in aqueous environments is a possibility, particularly if C_{60} finds widespread use in consumer products such as coatings and fuel cells. Thus their toxicological and ecotoxicological effects are of great importance. Just recently these fullerene aggregates were found to elevate lipid oxidation levels in the brains of fish.[29]

Here, we report for the first time the effects these fullerene aggregates, or nano-C_{60}, have on human cells in culture, and find that even at very lowconcentrations this species is cytotoxic (Figure 1).

* Corresponding author. director of the Center for Biological and Environmental Nanotechnology, Rice University.

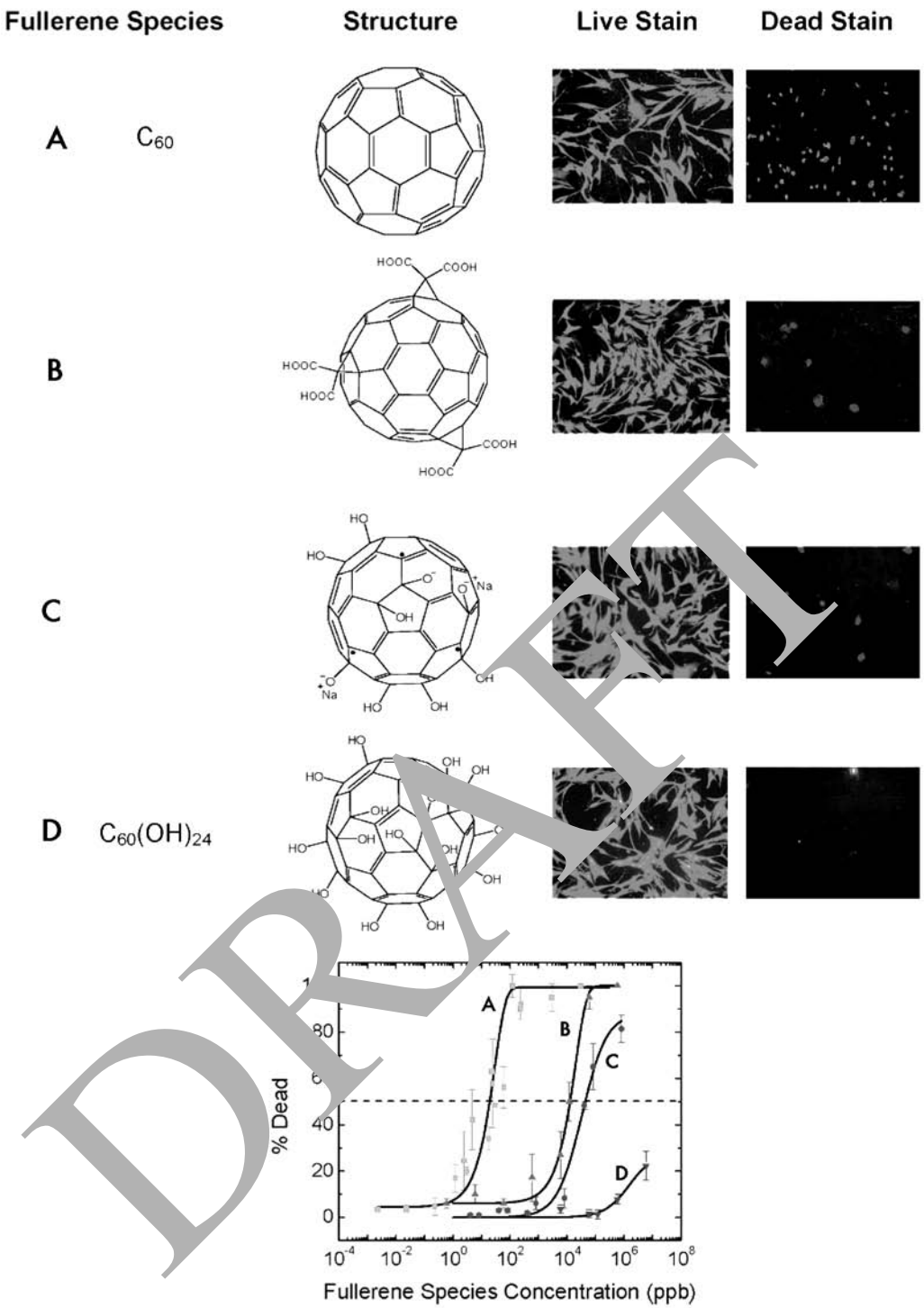

Figure 1
(Top) Differences in the structure and cellular activity of fullerene species. The structure of each fullerene species is shown in the table, as well as the live and dead stains. (Bottom) The differential cytotoxicity of nano-C_{60} (A) as compared to the other fullerene species in human dermal fibroblasts. Cells were exposed to toxicant for 48 h.

For the same cell lines, and under the same conditions, we find the high cytotoxicity of nano-C_{60} is not a universal property of C_{60} materials. Instead, the cytotoxicity of C_{60} derivatives systematically correlates with their chemical functionality in both human skin (HDF) and liver carcinoma (HepG2) cells. We show that for cells exposed to nano-C_{60} cell death occurs because of lipid oxidation caused by the generation of oxygen radicals; more highly derivatized C_{60} systems are not as facile at generating these species and thus have lower cellular toxicity. This mechanism suggests a basis for the first structure-function relationship for the toxicity of C_{60} based materials.
We hypothesize that sparingly soluble fullerenes will cause oxidative damage to cellular membranes even at relatively low concentrations, and that the resulting toxicity will diminish as the fullerene cage becomes more fully derivatized and water soluble.
...
Fullerene Derivatives. Sublimed C_{60} and $C_{60}(OH)_{24}$ were purchased from MER at 99.95% and 99.8% purity, respectively. [Other fullerene samples] were received from Dr. Lon Wilson, Rice University, and their characteristics have been previously reported. Preparation of the [sample C] began with C_{60} dissolved...

…
In Vitro Cytotoxicity
To consistently evaluate the cytotoxicity of water-soluble fullerenes species, two cell lines, human dermal fibroblasts (HDF) and human liver carcinoma cells (HepG2) (ATCC), were cultured in Dulbecco's modification of Eagles media (DMEM). Cells were grown to 70% confluency before exposure to each fullerene sample; each culture plate was incubated in the dark at 37 °C/5% CO_2 for 48 h…
…

Cytotoxicity Observed in the nano-C_{60} Water-Soluble Fullerene Species In Vitro
We measured the cytotoxicity of four different water-soluble fullerene species on human dermal fibroblasts (HDF) and human liver carcinoma cells (HepG2). The differential cytotoxicity was first examined using a standard cytotoxicity screen. After each species was administered separately to HDF and HepG2 for 48 h, viability was determined by staining...
...

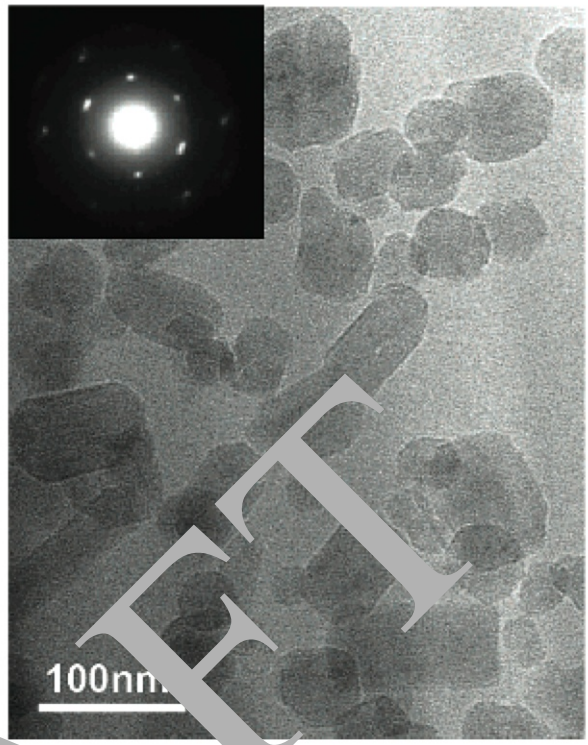

Figure 2
The cryo-TEM images and diffraction pattern of nano-C_{60}. Average size of nano-C_{60} crystalline nanoparticle is 100 nm.

Evidence of Leaky Cytoplasmic Membrane in the Presence of nano-C_{60}
We also evaluated the characteristics of cells exposed to fullerene species, in this case using the most toxic of the materials, nano-C_{60}. Based on several independent experiments, both HDF and HepG2 cells show evidence of a leaky plasma membrane after exposure to toxic concentrations of fullerenes...
...
A fluorescent indicator for the radical [formed in these circumstances] (MDTA) emits light only when associated with this species. Figure 3 shows the increasing emission as HDF cells are exposed to increasing levels of nano-C_{60}. This experiment was repeated for HepG2 cells, yielding the same results.

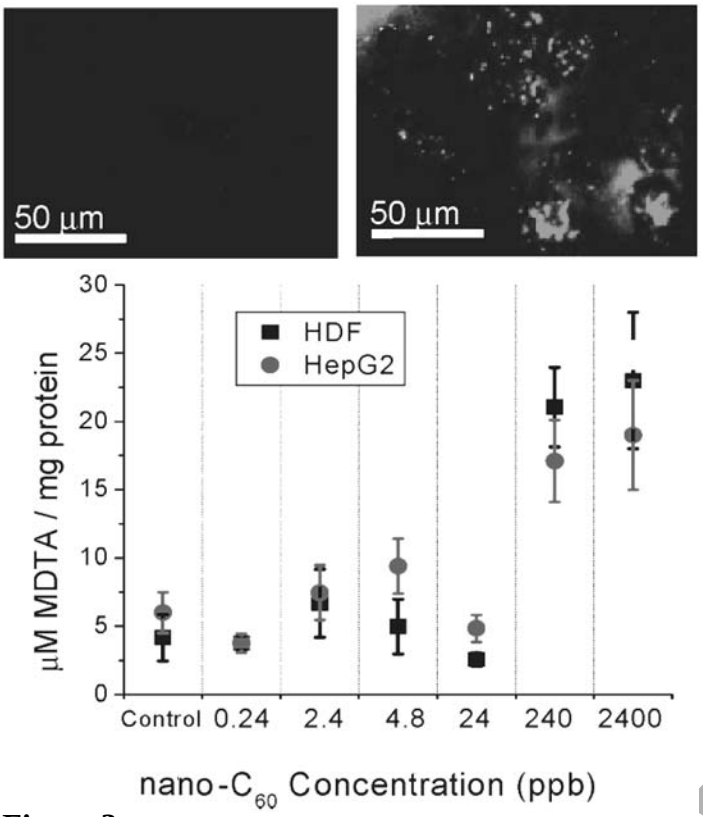

Figure 3
(Top) Fluorescence detection of disrupted plasma membranes. After normal HDF cells (left) had been dosed with 240 ppb nano-C60 and exposed for 24 h, flourescence detection of the dye was observed (right). (Bottom) Lipid peroxidation was observed in toxicated cells. As the nano-C_{60} concentration increases, the leakage (shown by MDTA) increases.

Nano-C_{60} Can Produce Oxygen Radical Species in Cell-Free Experiments
Experiments strongly suggest that the mechanism of cell death is oxygen radical induced peroxidation of the lipid bilayers of cells. We show that in cell-free aqueous solutions nano-C_{60} can produce the superoxide anion and, in comparison, fully hydroxylated fullerenes cannot. We measured the appearance of the superoxide anion in two ways to rule out any fullerene interference with the tests...
...
A detailed understanding of the mechanism by which nano-C_{60} generates superoxide anions is beyond the scope of this paper;... ongoing efforts will further establish a connection between the superoxide anion generation of fullerenes and their cytotoxicity.

Summary and Conclusions
In conclusion, we have shown that nano-C_{60} is cytotoxic to HDF and HepG2 cells at the 20 ppb level. More water-soluble fullerene species are less cytotoxic to HDF or HepG2 cells, while $C_{60}(OH)_{24}$ shows no cytotoxicity up to its limits of solubility. This provides striking evidence that water-soluble functional groups on the surface of a fullerene molecule dramatically decrease the toxicity of pristine C_{60}.
...
This work demonstrates that hydroxylation of the C_{60} cage could be used as a remediation for the possible unintentional biological effects of pristine fullerenes.

Acknowledgment
We thank Dr. Jane Grande-Allen for instrument use. This research was funded by the Center for Biological and Environmental Nanotechnology (EEC-0118007). L.J.W. and V.L.C. also acknowledge the Robert A. Welch Foundation for partial support.

References

(29) Oberdorster, E. *EnViron. Health Perspect.* **2004**, *112*, submitted.

[65 further precise references and citations are not included as candidates are not expected to follow up any further detail of this research.]

Source: extracted from: NANO LETTERS, **2004**, Vol. 4, No. 10, 1881-1887

GENERAL CERTIFICATE OF EDUCATION
SPECIMEN

SCIENCE IN SOCIETY UNIT 4: CASE STUDY

INSERT

ADDITIONAL SOURCE MATERIAL (SOURCE G)

SOURCE G

This source is an extract from the report of an international scientists' workshop on the effects of nanotechnology

Health and environmental impacts

Concerns over the potential negative impacts of nanomaterials on health and the environment arise from assumptions drawn from research on ultra-fine air pollution particles and asbestos, and the results of the limited research on nanoparticles. The reason that nanoparticles could be more harmful than the same chemical in larger form is briefly outlined in the following box.

Why are manufactured free nanoparticles and nanotubes a cause for concern?

Nanoparticles are typically defined as being between 0.2nm and 100nm, with a nanometre being equal to one-billionth of a metre (10^{-9}m). As a result of their size, nanoparticles have proportionally greater surface area and consequently proportionally more surface atoms than the same material in larger format, and this can influence the properties of the material such as its ability to absorb, catalytic and chemical activity and its reactivity. Because these properties can alter with both shape and size, nanomaterials are attractive for use in many new applications.

However, their size can also alter their toxicity when compared with the same substance in larger form. It is generally believed that the principal determinants of toxicity of nanoparticles are:

- chemical reactivity of the surface (including any surface components such as metals or coatings and particularly any ability to take part in reactions that release highly reactive particles such as free radicals);
- total surface area presented to the target organ;
- physical dimensions (which could influence penetration and removal in the body);
- solubility (soluble particles may disperse before initiating a toxic reaction).

Presentations at the workshop outlined some of the initiatives and programmes on the potential health, environmental and societal impacts of nanotechnologies in Japan, the UK, the EU and the US. Participants agreed that there is insufficient research being undertaken in these areas. Many felt that the British and Japanese Governments should be providing more funding to stimulate the necessary research.

Source:
Report of a joint Royal Society- Science Council of Japan workshop on the potential health, environmental and societal impacts of nanotechnologies, 11 and 12 July 2005

GENERAL CERTIFICATE OF EDUCATION
SPECIMEN MARK SCHEME

SCIENCE IN SOCIETY

UNIT 4: CASE STUDY

Examiners look to reward knowledge and understanding not to penalise.
Any correct response will be credited even if it does not appear in the mark scheme.

UNIT 4
SECTION A

Question 1			
	issues that might be raised include: question of need for new legislation to deal with regulation of developing nanotechnology; classification of cosmetics use of nanotechnology (drug?); commercial pressure/competition (patents); government reaction to advice from scientific bodies (national/international); appropriate testing regimes for new cosmetics (including long-term); budgets for commercial research relative to those for safety/regulation; social pressures for immediate use of new treatments any four appropriately identified (1 mark) with appropriate reference to the sources (1 mark)	*for 8 marks*	**8**
		Total	**8**

Question 2			
(a)	in each case, a correct 'definition' (1 mark); and an illustration/example/explanation based upon the source (1 mark) additional notes:	*for 8 marks*	**8**
(i)	journal as important means of communication, 'leading' interpreted as high circulation in field, peer reviewed;		
(ii)	patents as timed commercial protection in return for publication, competition;		
(iii)	include reference to variation in population and sample size		
(iv)	human study by scientists not employed by source company		
(b)	reference to technical language giving scientific/objective status to content (1 mark); appropriate illustration/example/explanation based upon the source (1 mark each point up to 3 marks)	*for 4 marks*	**4**
		Total	**12**

Question 3			
	in each case, a correct definition (1 mark); and an illustration/example/explanation based upon the source identified (1 mark), and explained (1 mark) additional notes:		
(a)	time for peer review — note revision of manuscript;	*for 3 marks*	**3**
(b)	reference to error bars and basis of estimations of accuracy;	*for 3 marks*	**3**
(c)	reference to earlier work in later research	*for 3 marks*	**3**
(d)	method section allows replication by other scientists	*for 3 marks*	**3**
			12

SECTION B

Question 4		
	The marking scheme for this section includes an overall assessment for the quality of written communication. There are no discrete marks for the assessment of written communication but quality of written communication will be one of the criteria used to assign the answer to one of three levels. Marks are assigned according to level descriptors.	
level of response	**descriptors:** knowledge**,** understanding (AO1); explanation, argument and illustration, application of ideas, synthesis, evaluation (AO2); legibility, accuracy of grammar and syntax, clarity of meaning, style, organisation and vocabulary (QWC)	**mark range**
good – level 4	knowledge and understanding of key science explanations; knowledge and appreciation of related ideas about how science works; demonstrates overall grasp of the range and nature of issue(s); interprets and illustrates valid arguments, recognising counterclaims, coherently and convincingly to reach a reliable conclusion; fluency and accuracy of expression.	**10 - 12**
competent – level 3	knowledge and understanding, in context, of key science explanations and ideas about how science works; demonstrates general grasp of the range and nature of issue(s); interprets and illustrates fair arguments competently using a range of evidence with reasonable attempt at valid conclusion; accuracy of expression.	**7 - 9**
limited – level 2	some understanding and realisation of key science explanations and ideas about how science works; some competence and grasp of the issue(s); limited arguments and exemplification with weak conclusion; reasonable clarity of expression	**4 - 6**
inadequate – level 1	uncertain grasp, knowledge or understanding of issue(s) and/or science and ideas about how science works; lack of clarity of argument with little or no appropriate justification or exemplification; weak expression	**1 – 3**
0	**incorrect or no response**	**0**
	Total	**12**

Question 5		
	The marking scheme for this section includes an overall assessment for the quality of written communication. There are no discrete marks for the assessment of written communication but quality of written communication will be one of the criteria used to assign the answer to one of three levels. Marks are assigned according to level descriptors.	
level of response	**descriptors:** knowledge**,** understanding (AO1); explanation, argument and illustration, application of ideas, synthesis, evaluation (AO2); legibility, accuracy of grammar and syntax, clarity of meaning, style, organisation and vocabulary (QWC)	**mark range**
good – level 4	clear exposition of science explanation relevant to the issue; appropriate use of ideas about how science works in a novel context; demonstrates overall grasp of the range and nature of issue(s); interprets and illustrates valid arguments, recognising counterclaims, coherently and convincingly to reach a reliable conclusion; fluency and accuracy of expression.	**13 - 16**
competent – level 3	identification of relevant science explanation in the context; appreciation of ideas about how science works in context; demonstrates general grasp of the range and nature of issue(s); interprets and illustrates fair arguments competently using a range of evidence with reasonable attempt at valid conclusion; accuracy of expression	**9 - 12**
limited – level 2	some understanding and realisation of key science explanations and ideas about how science works; some competence and grasp of the issue(s); limited arguments and exemplification with weak conclusion; reasonable clarity of expression	**5 - 8**
inadequate – level 1	little appreciation of science and ideas about how science works and/or the issue; lack of clarity of argument with little or no appropriate justification or exemplification; weak expression	**1 – 4**
0	**incorrect or no response**	**0**

	actions might include national regulation, pressure for international regulation, enforced safety testing regime, funding for (safety) research, acceptance of cosmetics as a voluntary market requiring no action, controls on social pressures (e.g. advertising, pricing). points might include cost (e.g. use of regulation to place cost with industry); international dimension; consideration of applicability of precautionary principle; different perceptions/demands in safety testing for cosmetics (c.f. medical drugs, for example); voluntary nature of cosmetics use; considerations beyond immediate use (e.g. cosmetics ending up in waste water). examples and illustration should draw on more than one of the given sources.	
	Total	**16**