RECOGNISING ACHIEVEMENT

Oxford Cambridge and RSA Examinations

Advanced Subsidiary General Certificate of Education

HUMAN BIOLOGY

2858/01

Case Studies

Specimen Paper 2003

Additional materials: Ruler (cm/mm)
Electronic calculator

TIME 45 mins

Candidate Name	Centre Number	Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and candidate number in the spaces above.
- Write your answers, in blue or black ink, in the spaces provided on the question paper.
- Answer **all** the questions.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 45.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- *You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.*

FOR EXAMINER'S USE		
Question number	**Max.**	**Mark**
1	**14**	
2	**15**	
3	**16**	
TOTAL	**45**	

Case Study 1

A HEALTHY HEART

Cardiovascular disease is the main cause of death in Europe, accounting for more than 50% of all deaths in those over 65. Throughout the world, early death due to cardiovascular disease is 2.5 times higher in men than in women. Cardiovascular disease is *multifactorial.*

In 1992, the United Kingdom government published a report which set a number of targets for improving the health of the nation by the year 2000. This included reducing death and illness due to cardiovascular disease and reducing hypertension (excessively high blood pressure) in the population. Hypertension is one of the main causes of coronary heart disease (CHD).

A 57 year old female teacher visited her doctor complaining of tiredness and frequent headaches. She also experienced occasional dizziness, blurred vision and shortness of breath. Her doctor measured her blood pressure, which was 154/98. The doctor asked the patient a number of questions on diet, which revealed that the patient used salt frequently on her food. The doctor was fairly sure that diet was the cause of the patient's hypertension. The doctor compared the teacher's salt intake with the results of an investigation, which was conducted to assess the effect of salt in the diet on blood pressure. In this investigation 535 people over the age of 41 were studied. To assess long term salt intake each person was asked whether they put salt on each of six commonly eaten foods. Each positive answer was given one point so that they received scores of 0 to 6.
The results of this investigation are shown in **Fig. 1.1**.

Fig. 1.1

Case Study 2

ASTHMA AND THUNDERSTORMS

In recent years, there have been a number of 'epidemics' of acute asthma, resulting in increased numbers of patients being admitted to hospital. Many of these acute attacks have been associated with thunderstorms.

There were two thunderstorms in Melbourne, Australia, on the 8th November 1987 and 29th November 1989. During and after these thunderstorms there was an increase in admissions to hospital due to severe asthma attacks.

Before both thunderstorms, weather conditions were cloudless, with a northerly wind and temperatures of around 32°C. With the onset of the storms, temperatures fell to about 20°C, the wind shifted to the southwest and humidity increased from 25% to 85%. There were high levels of rye grass pollen on each day.

Table 2.1 shows the data collected from hospitals and emergency services in Melbourne during and after the two storms compared with days without storms.

Table 2.1

	Number of patients per day		
	1987 storm	**1989 storm**	**Days without storms**
emergency attendances at hospital for asthma	154	277	26
hospital admissions for asthma	26	47	6
requests for ambulance transport for asthma	22	44	2

The results of a similar investigation in Nottingham UK, are shown in **Fig. 2.1**. From June to August 1994 there were several severe thunderstorms over much of England, usually associated with high pollen counts, high humidity and poor air quality. The arrows indicate when severe thunderstorms occurred.

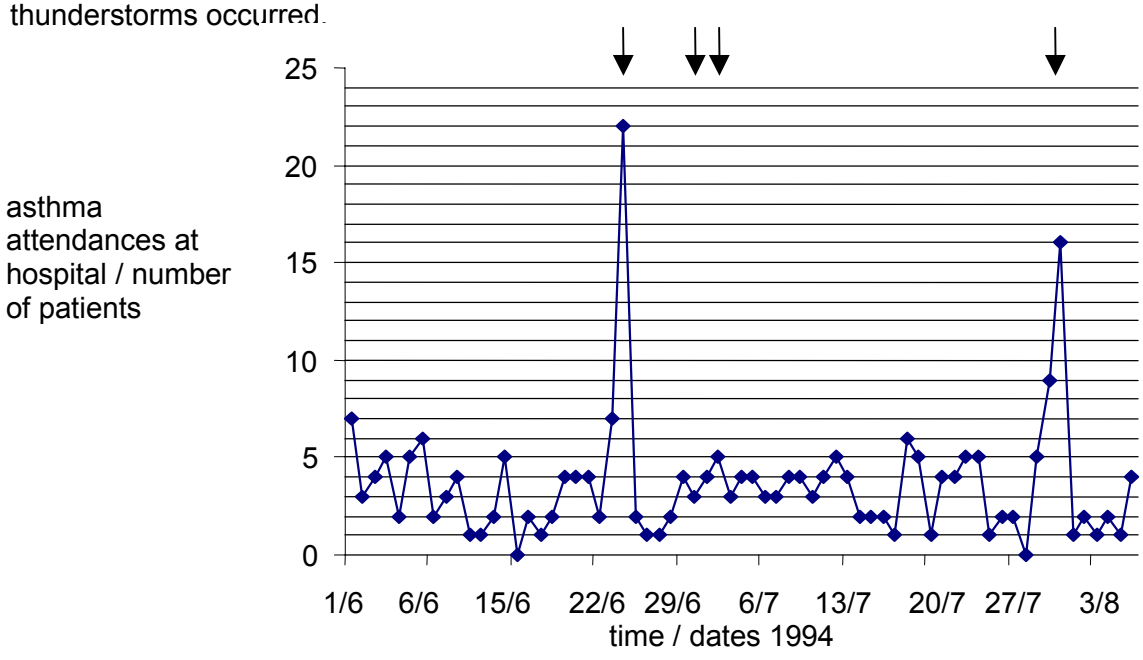

Fig. 2.1

A report on these thunderstorms found that the asthma epidemic was significantly associated with a fall in air temperature six hours before the storm and a high grass pollen count nine hours before.

Increases in severe asthma attacks in the London area during June and July 1994, that did not reach epidemic proportions were significantly associated with lightning strikes, increase in humidity or sulphur dioxide concentration, a fall in temperature or high rainfall the previous day, and a decrease in maximum air pressure or changes in grass pollen concentration over the previous two days.

An investigation into the effect of the storms of 24th to 26th June 1994 on attendances at hospitals in Cambridge and Peterborough produced the results shown in **Table 2.2**.

Table 2.2

	Cambridge	**Peterborough**
asthma attendances 25 June	39	37
average daily asthma attendances	1	1
lightning ground strikes 24 June	37	2
ozone levels 24-26 June / parts per billion	45	45
daily average ozone levels / parts per billion	28	29

References
Wilson JV and Pyatt FB Thunderstorms and asthma – a review of current research progress
UK Journal of Meteorology 1996; 21: 121-5
Bellomo R et al Two consecutive thunderstorm associated epidemics of asthma in the city of Melbourne
Medical Journal of Australia 1992; 156: 834-7
Sutherland A and Hall IP Thunderstorms and asthma admissions The Lancet 1994; 344: 1503-5
Campbell-Hewson G et al Epidemic of asthma possibly associated with electrical storms
British Medical Journal 1994; 309: 1086-7

Case Study 3

THE SICKLING DISEASE

Sickle cell anaemia is an inherited disease which can be extremely painful and debilitating. A student (EB) recently visited a medical scientist (MS) to discuss sickle cell anaemia. What follows is a transcript of their conversation.

EB *Why is sickle cell anaemia called that?*

MS The red blood cells contain haemoglobin, but in patients with sickle cell anaemia the haemoglobin (HbA) is replaced by an abnormal form of haemoglobin called haemoglobin S (HbS). Many of the red blood cells containing this abnormal form of haemoglobin are distorted into a sickle shape, hence the name.

EB *What causes sickle cell anaemia?*

MS Haemoglobin molecules are made up of four polypeptide chains known as globins. Each globin chain is attached to an iron-containing haem molecule which is the part that carries oxygen. Bonds between amino acids in adjacent globin chains hold the four chains together in the quaternary structure.

Under conditions of high oxygen concentration, such as in the lungs, normal haemoglobin picks up oxygen readily. In the body tissues, where oxygen concentrations are lower, the affinity of haemoglobin for oxygen is much less and oxygen is released.

Red blood cells containing HbS are less efficient than red blood cells containing normal haemoglobin at carrying oxygen.

HbS is also much less soluble than HbA and begins to crystallise when the oxygen concentration falls, such as in the capillaries of the tissues. The HbS molecules arrange themselves in long, parallel fibres within the red blood cells. These fibres are stabilised by interactions between the valine (substituted for glutamic acid) and hydrophobic regions on adjacent HbS molecules. This causes the 3D structure of the HbS molecule to be distorted. The red blood cells, therefore, distort and become sickle, or crescent, shaped.

EB *Tell me about the inheritance of sickle cell anaemia*

MS The inherited diseases of haemoglobin are the commonest single-gene disorders. Sickle-cell anaemia results from a mutation involving a substitution of a single nucleotide in the sixth codon of the gene for the β-globin chain. This mutation leads to a change in just one amino acid. Glutamic acid, a polar amino acid, is replaced by valine, a non-polar amino acid, in the β-globin chains. This alters the quaternary structure of the haemoglobin, and, consequently, sickle cell haemoglobin (HbS) replaces normal HbA in the red blood cells.

EB *What happens to people with sickle cell anaemia?*

MS During the lifetime of the red cells, they go through a series of cycles of sickling and desickling, and eventually go into irreversible sickling. This causes damage to the cell membrane, leading to lysis of the red blood cells after only a few days, unlike the lifespan of a normal red blood cell which is about 120 days.

Sickled cells are relatively rigid and inflexible. They also stack together and this leads to an increased viscosity of the blood. Small capillaries become blocked, which deprives tissues of their blood supply, leading eventually to death of the tissue. Any organ can be affected by this process, although bones are particularly susceptible. Blockage of tissues is extremely painful, and secondary infections often follow repeated blockage of blood vessels.

There are chronic complications which affect all organs, due to capillaries becoming blocked by the distorted red blood cells. There is kidney failure, recurrent leg ulcers, infections and painful deformities of the shoulder and hip joints. There is a very high mortality rate from sickle cell anaemia in the first two years of life, particularly in rural areas of East and West Africa, where health care facilities are minimal. In western countries, survival into adulthood is usual, but there is long term disability, frequent medical emergencies and overall very poor quality of life.

EB *Why do they have a poor quality of life?*

MS Severe infection is common, particularly from the *Pneumococcus* bacterium. Another problem is severe anaemia caused by grossly distorted red blood cells becoming trapped in the tiny capillaries of the spleen and their failure to carry enough oxygen.

EB *How do you treat a patient with a sickle cell crisis?*

MS There is a new treatment which is being used experimentally in the USA, using a drug called hydroxyurea. Daily doses of this drug were found to halve the number of acute crises. However, the drug is very powerful and can depress bone marrow, so that very regular white blood cell counts need to be performed.

References
Charatan FB US announces drug treatment for sickle cell anaemia BMJ 1995;310:352
Weatherall DJ ABC of clinical haematology: The hereditary anaemias BMJ 1997;314:492 (15 February)
MRC Research Update 7 The Sickling Disease.

This question is based on the article **'A HEALTHY HEART' (Case Study 1)**.

1 **(a)** Explain the meaning of the word *multifactorial.*

_____

_____ **[1]**

(b) Suggest **two** ways in which the **government** could reduce cardiovascular disease in the population.

1 _____

_____

2 _____

_____ **[2]**

(c) The 57 year old teacher in the Case Study had a blood pressure of 154/98.

State the normal blood pressure for a woman of this age.

_____ **[1]**

(d) **(i)** Describe how hypertension may cause coronary heart disease.

_____

_____

_____

_____

_____

_____

_____ **[3]**

(ii) Suggest a reason why cardiovascular disease in women is increasing to the level found in men.

_____

_____ **[1]**

1 **(e)** **Fig. 1.1** in the Case Study shows the mean systolic blood pressure at different salt intakes.

(i) Describe the results of the investigation shown in **Fig. 1.1**.

[1]

(ii) Suggest an explanation for these results.

[2]

(iii) State **one** variable which the investigators would need to control when conducting the investigation.

[1]

(f) Describe one cause of hypertension, **other than diet**.

[2]

This question is based on the article **'ASTHMA AND THUNDERSTORMS' (Case Study 2)**.

2 **(a)** Explain why the word *associated* is used in the article. (line 2)

_____

_____ **[1]**

(b) **(i)** Using the data in **Table 2.1**, calculate the average percentage increase in emergency attendances at hospital for asthma in Melbourne during the storm of 1989. Show your working.

Answer _____ % **[2]**

(ii) The thunderstorm of 1989 was associated with much more severe asthma attacks than that of 1987. Give **one** piece of evidence, other than emergency attendances at hospital, which supports this statement.

_____

_____

_____ **[1]**

(c) **(i)** Using the information in **Fig. 2.1**, describe the results of the Nottingham investigation.

_____

_____

_____

_____

_____ **[2]**

(ii) Explain whether the results of the Nottingham investigation support the hypothesis that acute asthma attacks are associated with thunderstorms.

_____

_____ **[1]**

2 **(d)** There is evidence that high pollen counts trigger acute asthma attacks. Explain how an increase in pollen count may trigger acute asthma attacks.

[3]

(e) Summarise the conclusions that you may draw about asthma from the investigations described in this article.

[3]

(f) Describe the likely **long term** effects if asthma is not successfully treated.

[2]

This question is based on the article **'THE SICKLING DISEASE' (Case Study 3)**.

3 **(a)** Suggest **one** reason why sickle shaped red blood cells are less efficient at taking up oxygen.

[1]

(b) *In this question, one mark is available for the quality of written communication*.

Explain **in detail**, how the substitution of a single nucleotide could eventually result in a different structure of the ¾ globin chains in haemoglobin.

[6]

Quality of Written Communication [1]

3 **(c)** The change in the structure of the haemoglobin molecules results in the sickle shape of the red blood cells. These cells increase the viscosity of the blood and block capillaries.

(i) Suggest the effects of increasing the viscosity on the circulation of the blood.

[2]

(ii) Explain why there is a 'very high mortality rate for sickle cell anaemia in the first two years of life … where health care facilities are minimal'.

[4]

(d) Explain why regular white cell counts are required when treating sickle cell disease with hydroxyurea.

[2]

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MARK SCHEME

ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1 Please ensure that you use the **final** version of the Mark Scheme.
You are advised to destroy all draft versions.

2 Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If **two** (or more) responses are required for one mark, use only **one** tick. Half marks (½) should never be used.

3 The following annotations may be used when marking. **No comments should be written on scripts unless they relate directly to the mark scheme. Remember that scripts may be returned to Centres.**

X	=	incorrect response (errors may also be underlined)
^	=	omission mark
bod	=	benefit of the doubt (where professional judgement has been used)
ecf	=	error carried forward (in consequential marking)
con	=	contradiction (in cases where candidates contradict themselves in the same response)
sf	=	error in the number of significant figures

4 The marks awarded for each part question should be indicated in the margin provided on the right hand side of the page. The mark total for each question should be ringed at the end of the question, on the right hand side. These totals should be added up to give the final total on the front of the paper.

5 In cases where candidates are required to give a specific number of answers, (e.g. 'give three reasons'), examiners should look at the responses given and make a judgement as to whether they are correct, incorrect or 'neutral'. They should then mark the first answer(s) given (unless they are judged to be 'neutral') up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the mark scheme.

6 Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated in the mark scheme. (An instruction on the paper to 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

7 Strike through all blank spaces and/or pages in order to give a clear indication that the whole of the script has been considered.

8 An element of professional judgement is required in the marking of any written paper, and candidates may not use the exact words that appear in the mark scheme. If the science is correct **and** answers the question, then the mark(s) should normally be credited. If you are in doubt about the validity of any answer, contact your Team Leader/Principal Examiner for guidance.

Abbreviations, annotations and conventions used in the Mark Scheme	/	=	alternative and acceptable answers for the same marking point
	;	=	separates marking points
	NOT	=	answers which are not worthy of credit
	( )	=	words which are not essential to gain credit
	____	=	(underlining) key words which **must** be used to gain credit
	ecf	=	error carried forward
	AW	=	alternative wording
	ora	=	or reverse argument

Question	Answer	Mark
1(a)	a disease which is caused, by many different things / factors / AW;	1
1(b)	increase advertising on dangers of smoking / lack of exercise / saturated fat /obesity; subsidise gyms / activity sports / weight loss classes / AW; provide more facilities for exercise / named; pass legislation on accurate food labelling; provide free / national health advice on diet / giving up smoking; AVP;; *Accept the first answer given on each answer line (unless the first is judged to be 'neutral'). If all the answer(s) given on one answer line are neutral, then look for a second correct answer on another line.*	2 max
1(c)	130/80 – 145/85; *accept any figures within this range*	1
1(d)(i)	damages wall of coronary artery; releases clotting factors; forms clot / thrombus; cholesterol deposited in damaged wall; intima grows round it; coronary artery occluded / blocked; AVP;	3 max
1(d)(ii)	a woman' s life style is now similar to a man's / more women have stressful jobs; more women smoke; AVP;	1 max
1(e)(i)	as salt intake increases systolic blood pressure increases; directly proportional / positive correlation;	1 max
1(e)(ii)	salt is absorbed, through gut epithelium / into blood; decreases water potential; water moves down water potential gradient; increases blood volume; increases pressure;	2 max
1(e)(iii)	(approximate) mass of patient; existing disease conditions; time of last meal; time of last drink; AVP;;	1 max

Question	Answer	Mark
1(f)	whether the patient smokes; nicotine constricts arteries; increases metabolic rate; increases blood pressure; **or** whether the patient has evidence of kidney disease; damaged kidney cells release hormone / angiotensin; which increases blood pressure; **or** whether the patient is diabetic; high blood glucose decreases water potential; increases blood volume;	**2 max**
	Total mark:	**14**
2(a)	there is not a causal relationship / AW; the evidence is insufficient; the evidence is circumstantial / not controlled / AW;	**1 max**
2(b)(i)	$\frac{277}{26}$ x 100; 1065(%); *OR correct answer only;*	**2**
2(b)(ii)	more patients were admitted to hospital / AW; more people needed an ambulance to get there;	**1 max**
2(c)(i)	the thunderstorm on 24th June / range / 4th August / range, caused a rise in asthma attendances; figs to illustrate; the thunderstorm on 30th June / range / 2nd July, did not cause a rise in asthma attendances; the average number of attendances is 3 / range, per day;	**2 max**
2(c)(ii)	the pollen count may not be so high; humidity may not be high; air quality may be good; must be another explanation;	**1 max**
2(d)	pollen is protein; acts as an allergen / antigen; causes immune response; ref' to histamine; inflammation; constriction bronchioles; difficulty in breathing; AVP;	**3 max**
2(e)	it is multifactorial / has many causes / named from article; the cause is not proved / AW; thunderstorms <u>may</u> increase asthma; asthma is always present in the population; may suddenly get worse / become acute; AVP;	**3 max**

Question	Answer	Mark
2(f)	emphysema; loss elasticity / no elastic recoil, in alveoli; walls break down / loss of surface area; fibrous / scar tissue; obstruction of capillaries; decreased gas exchange; stunted growth;	2 max
	Total mark:	**15**
3(a)	less surface area of red blood cell exposed / less surface area Hb molecule / binding site in HbS not exposed / AW	1
3(b)	base sequence DNA determines amino acid sequence; therefore if altered, so does amino acid sequence; two β chains affected; coded for by one gene; position 6; substitution; CTT → CAT / mRNA GAA → GUA; glutamic acid replaced by valine; transcribed by mRNA ; taken to ribosome; valine picked up by tRNA; translation into chain with valine substituted for glutamic acid; hydrophobic; change in bonding because glutamic acid is a polar amino acid; hydrophobic interaction / e.g. disulphide bridge; 3D shape changed;	6 max
	QWC: legible text with accurate spelling, punctuation and grammar;	1
3(c)(i)	increased blood pressure; increased peripheral resistance / AW; detail; poor delivery oxygen / nutrients to the tissues; AVP;	2 max
3(c)(ii)	rapid growth rate, in first two years; increased demand, for oxygen / nutrients / named; poor / slow exchange, between capillaries and tissues; poor bone development / joint deformity; kidney failure / poor kidney function; death of tissue; repeated infection;	4 max
3(d)	depresses bone marrow; stem cells in bone marrow; (stem cells) produce white blood cells;	2 max
	Total mark:	**16**
	PAPER TOTAL:	**45**