OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

BIOLOGY 2806/01

Unifying Concepts in Biology

Tuesday **24 JANUARY 2006** Morning 1 hour 15 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator
Ruler (cm/mm)

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers, in blue or black ink, in the spaces provided on the question paper.
- Read each question carefully before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for quality of written communication where this is indicated in the question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	10	
2	14	
3	13	
4	10	
5	13	
TOTAL	60	

This question paper consists of 19 printed pages and 1 blank page and an insert.

Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

1 Cholesterol is a lipid which forms part of the structure of membranes of animal cells. It is absorbed from food and can also be synthesised by liver cells.

Cholesterol is transported by the blood with the help of specific transport proteins to which cholesterol molecules become reversibly attached. These complexes of lipid and protein are known as lipoproteins. There are three different types of lipoprotein transporting cholesterol in the blood. The concentration of cholesterol in blood can be measured, either as the total cholesterol, or as the amount carried by each of the different types of lipoprotein.

(a) Explain why cholesterol must be carried in the blood by proteins while glucose does **not** need any transport protein.

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..... [2]

Researchers and medical practitioners calculate the ratio of the total blood cholesterol concentration (**TC**) to the concentration of cholesterol carried by one type of lipoprotein, called high density lipoprotein (**HDL**). This ratio is called the **TC : HDL ratio**.

The TC : HDL ratio and the resting systolic blood pressure are both factors which are associated with the risk of having coronary heart disease (CHD).

Systolic pressure is the pressure in the major distributing arteries when the left ventricle contracts.

The way in which both the TC : HDL ratio and the resting systolic blood pressure are associated with the risk of CHD, is shown in Fig. 1.1.

key

less than 15% probability of developing coronary heart disease in the next ten years

15% to 30% probability of developing coronary heart disease in the next ten years

more than 30% probability of developing coronary heart disease in the next ten years

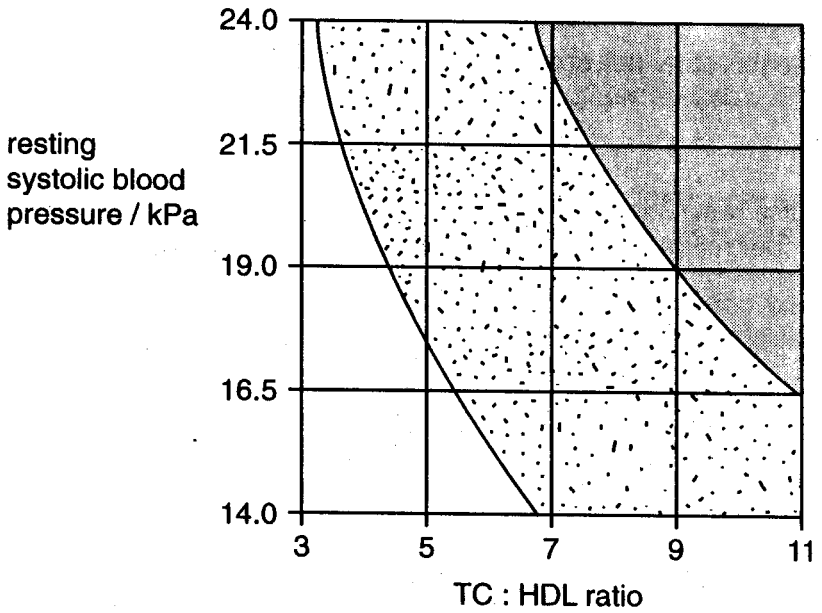

Fig. 1.1

(b) Using **only** the information in Fig. 1.1, describe the influence of the TC : HDL ratio and the resting systolic blood pressure on the risk of developing CHD.

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..... [3]

(c) The pulse rate, systolic blood pressure and diastolic blood pressure of a man were measured on three different days, at the same time of day, as shown in Table 1.1.

Diastolic pressure is the pressure in the major distributing arteries when the left ventricle is relaxed.

- On day 1, the measurements were taken after the man had rested in a chair for ten minutes.
- On day 2, the measurements were taken after he had walked quite fast for ten minutes.
- On day 3, the measurements were taken after he had run for ten minutes.

Table 1.1

day	pulse rate / beats per minute	systolic pressure / kPa	diastolic pressure / kPa
1	61	15.5	10.4
2	58	19.2	10.7
3	106	23.8	11.1

Using the data in Table 1.1, describe **and** explain the responses of the circulatory system to the demands of exercise.

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..... [5]

[Total: 10]

Examiner's Use

2 Grasslands which have been left undisturbed for several years often have ant mounds. Ants make burrows in the soil and bring fine crumbs of soil to the surface, where it accumulates as a mound. Each mound is about 50 cm across and about 20 cm high.

Plants grow on the mounds. Ants of the type that make mounds in grassland do not feed on plants.

A student noticed that a plant called wild thyme, *Thymus drucei*, seemed to be more common on ant mounds than it was on other parts of the same grassland, not occupied by ants.

In order to test the hypothesis that wild thyme was indeed more common on ant mounds, the student examined all the mounds in an area of grassland about 100 m by 100 m, noting whether or not wild thyme was present.

After surveying all 47 ant mounds in the grassland, the student threw a bunch of keys, 47 times, to obtain random points on the grassland, equal in number to the ant mounds.

Each time the keys were thrown, the point where they landed was used to place a 1 m^2 quadrat frame. The presence or absence of wild thyme in the quadrat was noted.

The data obtained are shown in Table 2.1.

Table 2.1

	number of ant mounds or quadrats with:	
	at least one wild thyme plant present	no wild thyme plants present
ant mound	36	11
1 m^2 quadrat	24	23

(a) **(i)** What evidence is there in Table 2.1 to support the hypothesis that wild thyme is more common on ant mounds?

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(ii) Describe **two** ways in which the survey methods could have been improved. Give a reason for each of the changes you have suggested.

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(b) Many investigations have shown that wild thyme is indeed more common on ant mounds. Suggest **two** reasons why this may be so.

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(c) In this question, one mark is available for the quality of spelling, punctuation and grammar.

A grassland, such as the one studied by the student, is an example of a community that may change, undergoing succession.

During succession, new ecological niches become available and some niches that were present in the pre-existing community cease to be available.

Explain, with the help of examples of succession, why the number of available niches increases as succession occurs.

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Quality of Written Communication [1]

[Total: 14]

3 A research team was investigating the properties of a newly-discovered enzyme, the product of which was a valuable drug.

This enzyme had been extracted from cells of a marine worm, found in the North Atlantic, where the temperature is always close to 5 °C. All the proteins of such animals are adapted to function at low temperatures.

Three water baths were set up at 15, 20 and 25 °C. Into each bath was placed a tube containing 1 cm^3 of the enzyme solution and a tube containing 10 cm^3 of concentrated substrate solution. On reaching the required temperature, the enzyme and substrate were quickly mixed and kept in the water bath.

There was a **large excess of the substrate**, so that substrate concentration was **not** a limiting factor.

Samples were taken from each tube at regular intervals and the concentration of the drug in these samples was determined. The results are shown in Fig. 3.1.

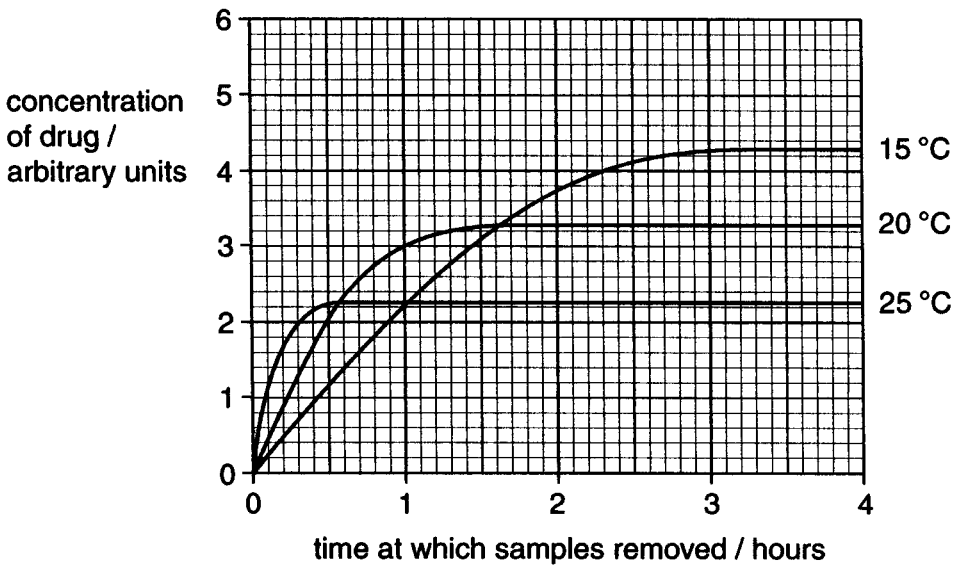

Fig. 3.1

(a) Using Fig. 3.1,

(i) describe what happened to the concentration of the drug in the tube at 15 °C;

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(ii) explain why the concentration of the drug changed in the way you have described.

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(b) State **one** factor, **not mentioned in the account of the investigation**, which would have been kept constant in all the tubes for the results to be valid.

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(c) Predict **and** explain the effect of carrying out the same procedure at 5 °C.

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Fig. 3.2 represents part of the primary and tertiary structure of the newly-discovered enzyme, including its active site. The amino acids are represented by circles, which are numbered to show their position in the primary structure.

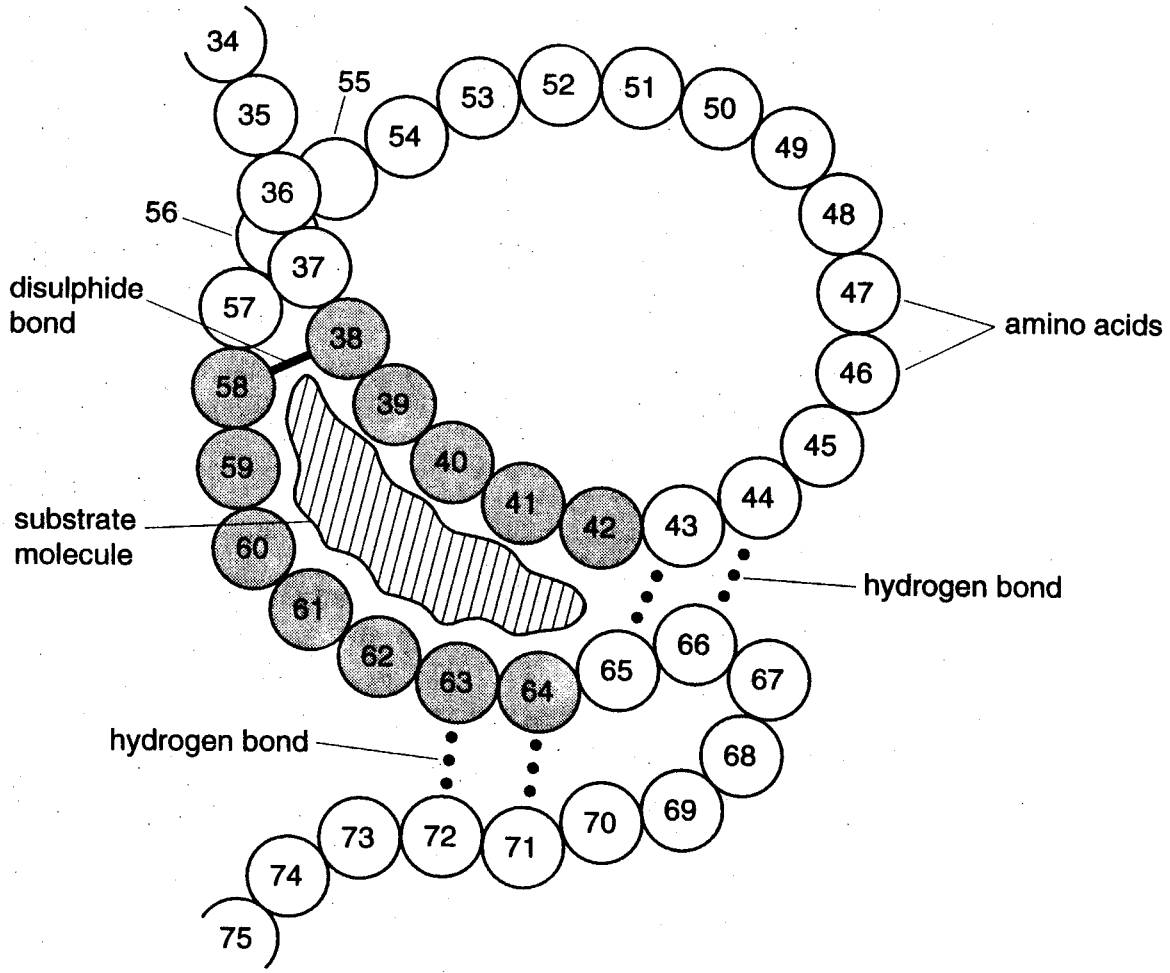

Fig. 3.2

(d) The research team wanted to change the structure of the enzyme so that it would function at higher temperatures to produce greater yields of the drug. They used a technique called **site directed mutagenesis**. In this technique:

- single changes to the amino acid sequence of the enzyme are planned
- the gene coding for the enzyme produced by the worm is isolated
- specific changes to the gene are made, in order to achieve the planned changes to the amino acid sequence
- the modified gene is introduced into a bacterium
- the offspring of the bacterium produce the changed enzyme molecules

(i) Suggest why it would be important that this procedure did **not** change any of the amino acids shaded grey in Fig. 3.2.

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..... [1]

(ii) The amino acids numbered 44 and 66 have side chains that link by hydrogen bonding.

Suggest why the research team might plan to replace these two amino acids with the amino acid cysteine, which forms disulphide bonds.

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(e) Explain why the technique of site directed mutagenesis involves changing nucleotide sequences.

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..... [2]

[Total: 13]

4 The outer surface of a plasma (cell surface) membrane incorporates glycoproteins of many different types.

In some types of cell, some of these glycoproteins have a carbohydrate component that is a polysaccharide. This consists of a long unbranched chain of repeating sugar units, as shown in Fig. 4.1.

The polysaccharide component extends into the tissue fluid surrounding the cells and in some tissues links the cells together, forming part of the mechanical support for the tissue.

Fig. 4.1 also shows the chemical structure of one of the component sugar units of the polysaccharide.

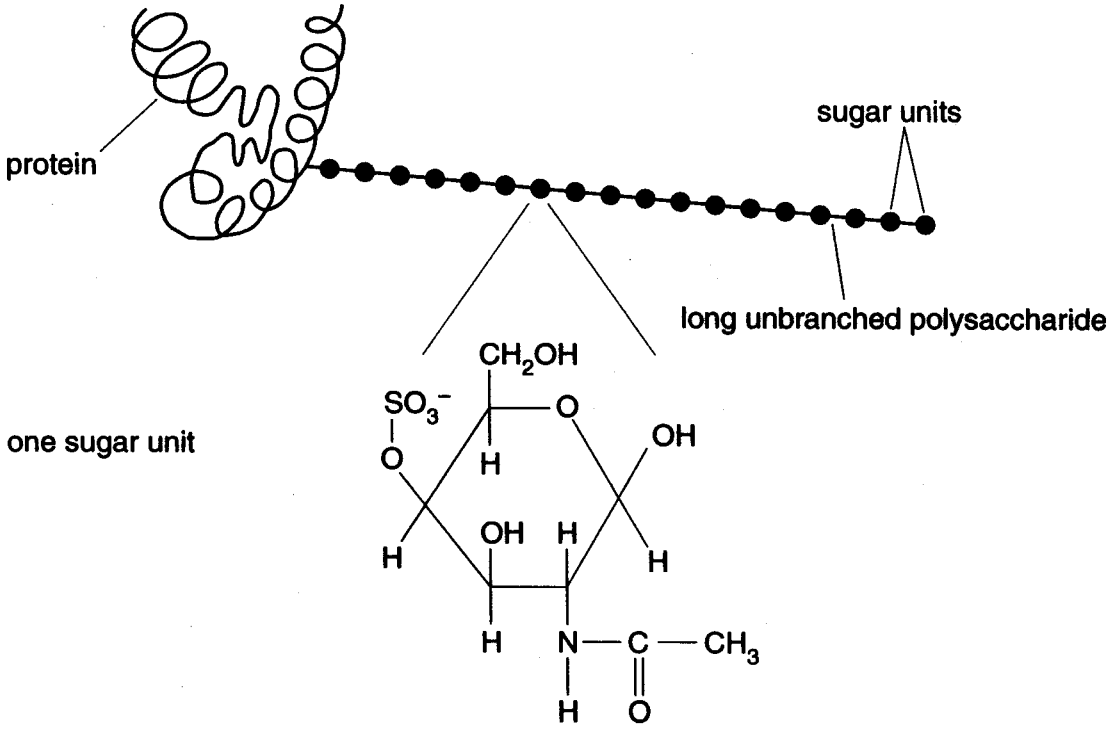

Fig. 4.1

(a) State **two** ways in which the structure of the polysaccharide shown in Fig. 4.1 differs from the structure of a molecule of cellulose.

1 .....

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2 .....

..... [2]

(b) During endocytosis, vesicles are formed from the plasma (cell surface) membrane and pass into the cytoplasm.

Any glycoprotein that enters the cell as part of the vesicle is broken down by enzymes in the lysosomes.

In an inherited disease called Hunter's syndrome, one of the enzymes needed to hydrolyse the polysaccharide chains shown in Fig. 4.1 is absent. Polysaccharides remain in the lysosomes until the cells eventually die.

Many body tissues are affected by Hunter's syndrome. The different tissues are not all affected to the same extent. Suggest an explanation for this observation.

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..... [1]

(c) Cells from an individual with Hunter's syndrome appear different to normal cells when viewed with an electron microscope.

Suggest **one** way in which they would appear different.

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..... [1]

Examiner's Use

Fig. 4.2 shows part of a family tree where some of the individuals have developed Hunter's syndrome.

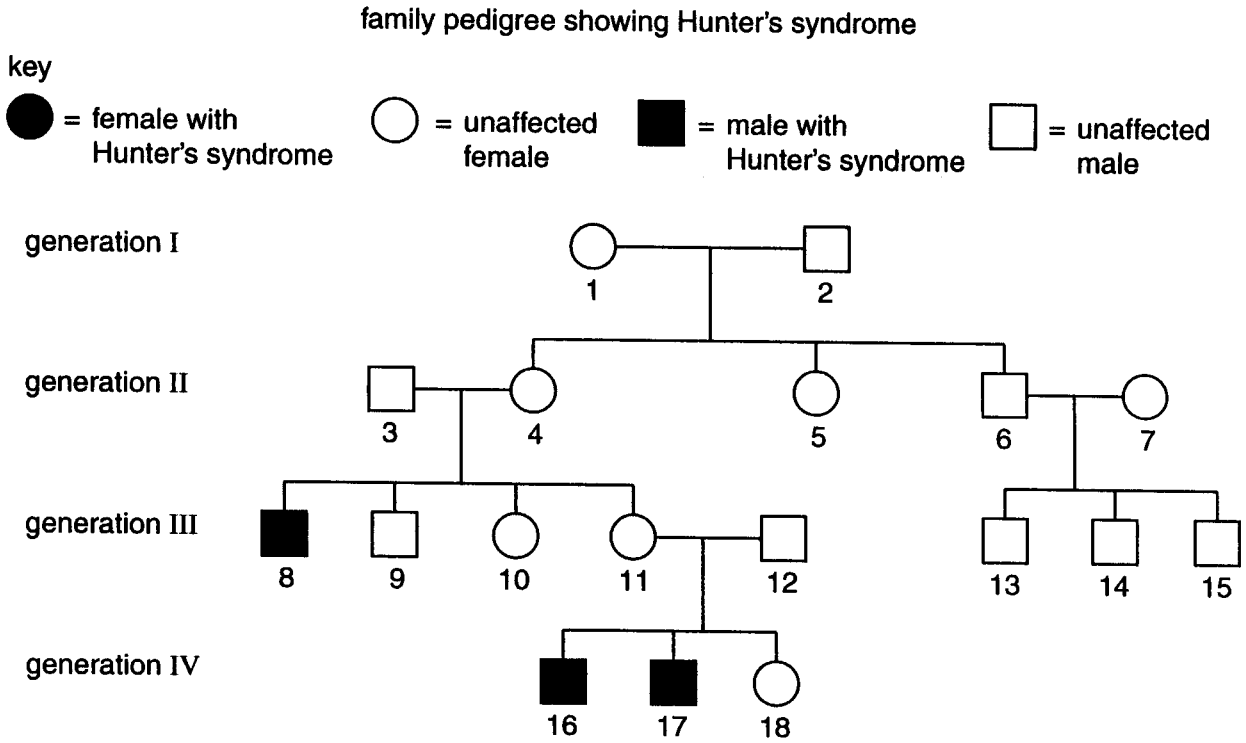

Fig. 4.2

(d) By referring to numbered individuals **and** the relationships shown in Fig. 4.2, explain why

(i) the allele that determines Hunter's syndrome must be recessive;

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..... [1]

(ii) the gene concerned may be sex linked.

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..... [2]

(e) Sex linkage is not conclusively shown by the family tree shown in Fig. 4.2.

Suggest why.

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..... [1]

(f) There are no drugs to treat Hunter's syndrome.

Suggest why a drug to treat people with Hunter's syndrome would be very difficult to develop.

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..... [2]

[Total: 10]

[Turn over

5 Read the passage below and answer the questions that follow, which relate to this passage.

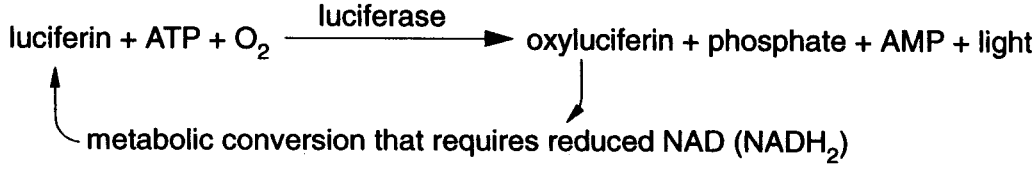
How fireflies light up

Fireflies are insects which have organs producing flashes of light. Fireflies are active at night and the light flashes are an important part of their sexual behaviour.

Within their light-producing organs are tubes, filled with air, called tracheae. These tracheae supply oxygen to light-producing cells. Fig. 5.1 on an insert shows the arrangement of light-producing cells around a trachea.

Light is produced by organelles situated well away from the surfaces of the cells nearest the trachea.

The reaction that produces light requires **both** oxygen **and** ATP.



When the organ is not producing any light, the numerous mitochondria use oxygen very fast. These mitochondria lie between the tracheae and the light-producing organelles, just under the cell membrane, so that no oxygen is available for the oxidation of luciferin.

A flash of light is produced when nerve impulses stimulate the walls of the tracheae and the cytoplasm of the light-producing cells, to produce nitrous oxide. Nitrous oxide diffuses rapidly through the cells. It enters mitochondria and inhibits oxidative phosphorylation, so the oxygen concentration increases in the cytoplasm of the light-producing cells.

Nitrous oxide is very unstable and breaks down quickly, so its effects are temporary.

An extract of crushed fireflies was found to be an extremely sensitive test for the presence of ATP in foods, such as milk and meat. The more bacteria there are in the food, the more light is produced, provided the mixture of food and firefly extract is well oxygenated.

Fortunately for fireflies, luciferin can be synthesised artificially and luciferase has been produced by gene technology, using methods similar to those for producing human insulin.

(a) Different species of firefly often live in the same habitat. The frequency with which a firefly flashes its light organ on and off, is a characteristic of a species.

Suggest an advantage, for fireflies, of flashing at a characteristic frequency.

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..... [1]

(b) **(i)** State the process by which oxygen reaches the light-producing organelles.

..... [1]

(ii) Explain why the light-producing organelles are located well away from the plasma (cell surface) membrane.

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(c) Suggest why it is important for the effects of nitrous oxide to be temporary.

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..... [2]

(d) Light-producing cells in fireflies do not divide. State **three** ways in which these cells might use ATP **other** than in the production of light.

1 .....

2 .....

3 ..... [3]

(e) If a firefly is suddenly crushed, for example by hitting a car windscreen, it produces a prolonged and unusually bright flash of light after which all light production ceases.

Suggest an explanation for these observations.

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..... [3]

Examiner's Use

(f) A solution containing luciferin, luciferase and oxygen glows when painted onto the surface of meat contaminated by live bacteria, but not if the meat is contaminated by dead bacteria.

Explain this observation.

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..... [1]

(g) What substance would be extracted and purified from light-producing cells of fireflies in order to produce luciferase by gene technology?

..... [1]

[Total: 13]

END OF QUESTION PAPER

OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

BIOLOGY 2806/01

Unifying Concepts in Biology
INSERT

Tuesday **24 JANUARY 2006** Morning 1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

- This insert contains Fig. 5.1.

This insert consists of 2 printed pages.

Registered Charity Number: 1066969
[Turn over

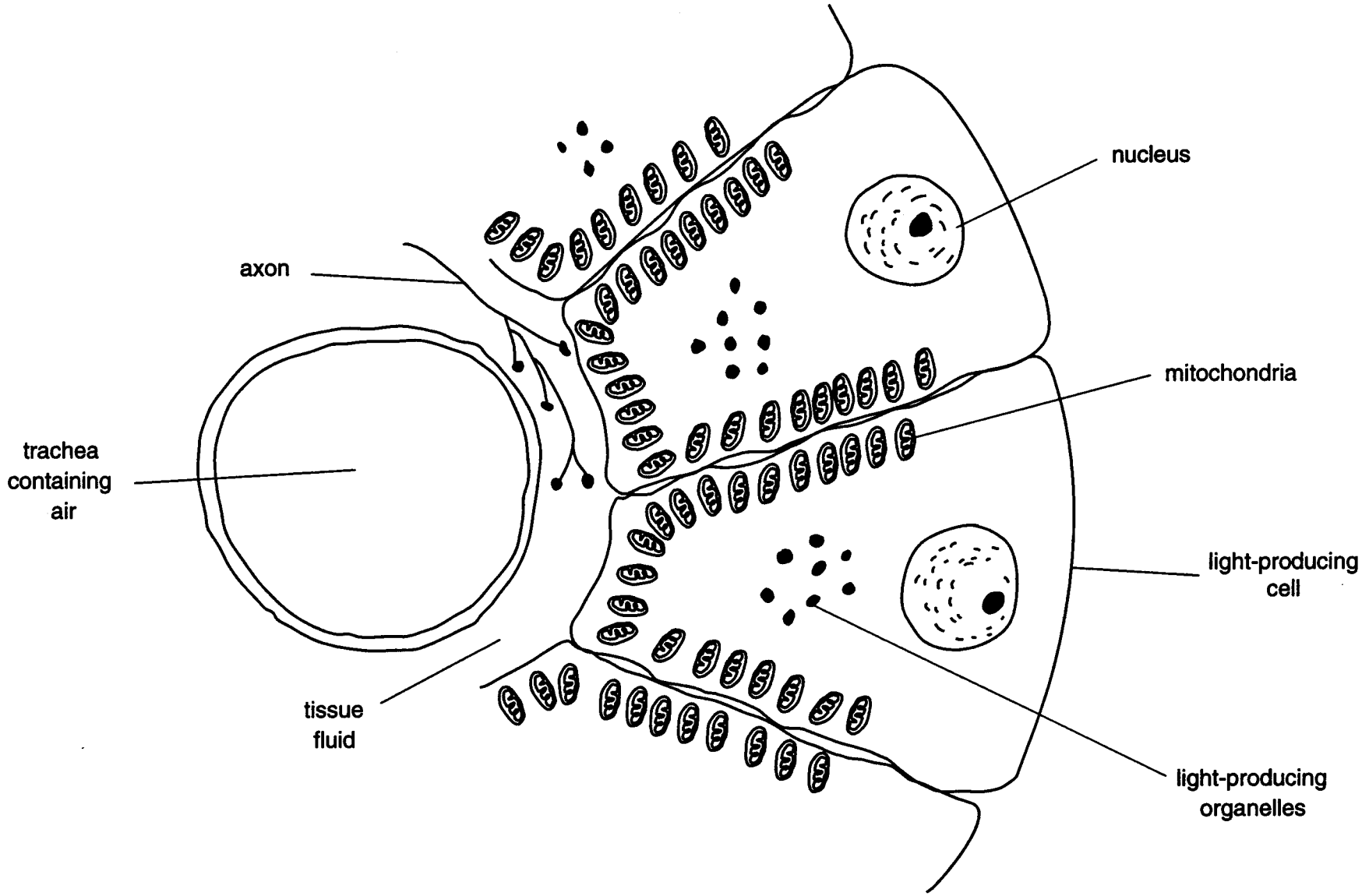
nucleus
axon
mitochondria
trachea
containing
air
light-producing
cell
tissue
fluid
light-producing
organelles

Fig. 5.1

RECOGNISING ACHIEVEMENT

2806/01 Unifying Concepts in Biology

January 2006

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'), mark the first answer(s) given up to the total number required. Examiners will be expected to use their professional judgment in marking answers that contain more than the number required. Advice about specific cases will be given at the standardisation meeting.

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
	R	=	reject
	( )	=	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
	A	=	accept
	ora	=	or reverse argument

Question		Expected Answers	Marks
1	(a)	cholesterol not soluble (in water) **;** lipids / cholesterol, hydrophobic / non-polar **;** glucose is (very) soluble (in water) **;** glucose is, hydrophilic / polar **;**	**2 max**
	(b)	low (TC:HDL) ratio = low risk **;** *ora* low (resting systolic) blood pressure = low risk **;** *ora* data quote **;** AVP **;** e.g. if ratio is 3 high systolic pressure does not increase risk	**3max**
	(c)	***A** day 1 → 2 for rest → walk, **A** day 2 → 3 for walk → run* *pulse* **1** rest to walk transition, has no (significant) effect / is anomaly **;** **2** rest / walk, to run transition increases pulse **;** **3** pulse data quote **;** **4** heart beats faster **;** **5** more O_2, supplied to / needed by, muscles **;** **6** for respiration **;** **7** to remove, more CO_2 / lactate / heat **;** *systolic pressure* **8** rises as, exercise / level of activity, increases **; A** ref days **9** systolic pressure data quote **; R** if no units **10** heart beats more forcefully / greater stroke volume **;** *diastolic pressure* **11** changes less than systolic **; A** relatively constant **12** because diastolic depends on elasticity of artery walls **;** **13** AVP **;** e.g. ref to aerobic (respiration), ref to cardiac output (qualified)	**5 max**
			[Total: 10]

Question			Expected Answers	Marks
2	(a)	(i)	higher, number / proportion / percentage / ratio / fraction, of mounds have thyme **;** (c.f. quadrats) *ora* **A** figs, e.g. $^{2}/_{3}$ vs ½ , 2:1 vs 1:1, 36 vs. 24	**1**
		(ii)	*look for a statement and a reason* use smaller quadrat **;** e.g. 50 cm x 50 cm for fair test **;** AW use grid and random numbers **;** throwing keys biased **;** AW estimate, percentage cover / abundance **;** **A** point (frame) quadrat may be single plants in some samples and many in others **;** bigger study area / more data **;** (keep equal numbers mounds and quadrats) improves reliability / AW **;** record other plants **;** could influence thyme **;** measure / note, abiotic variables **;** **A** example explanation of how named variable affects thyme **;** AVP **;** AVP **;**	**4 max**
	(b)		better drainage **;** finer soil **;** **A** looser more, nutrients / minerals / ions **;** **A** more fertile decay of, ants / prey / faeces **;** ants, eat / kill / drive away, animals that eat thyme **;** slopes of mound influence incident, light / sun (idea) **;** thyme, tolerates / grows well, when buried by growing mound **;** metabolism of ants warms soil **;** competing plants do not, thrive on / tolerate, the mounds **;** **A** less competition ants carry seeds of thyme **;** more wind on raised mounds **;** AVP **;** AVP **;**	**2 max**

(c) **1** named pioneer species **;**
2 ref to pioneer species change environment **;**
3 (as succession proceeds) stability increases **;**
4 example **;**
5 (as succession proceeds) nutrients increase **; A** more fertile
6 ref to leguminous plants increasing N **;**
7 ref to decay / nutrient cycle **;**
8 new species of plant can grow **; A** example
9 (pioneer) legumes outcompeted **; A** example
10 more food for herbivores / primary (1^{o}) consumers **; A** example
11 ref to specialised herbivores **; A** example
12 ref to specialised pollinators **; A** example
13 (more herbivores) more variety of food for next trophic level **; A** example
14 food webs more complex **;**

15 larger plants provide more, shelter / nest sites **;**
16 more microhabitats **; A** example
17 more spatial niches **; A** idea
18 AVP **;** e.g. pioneers outcompeted (qualified)
19 AVP **;** adaptation of pioneer **6 max**

QWC- legible text with accurate spelling, punctuation and grammar ; **1**

[Total: 14]

Question			Expected Answers	Marks
3	(a)	(i)	steep increase, for the first 1 - 2 hours / till 2.2 - 3.8 (a.u) **;** **A** linear, steady became constant at, 3 hours / 4.3 (a.u) **;** *if no figs in description, e.g. 'rose then constant' award 1 mark max*	**2**
		(ii)	(increased as) enzyme working / rate of reaction high / reaction proceeding **;** (increased as) substrate converted into, drug / product **;** (levelled off / became constant, after the) enzyme, became inactive / was denatured**;** (levelled off / became constant) because product inhibits, reaction / enzyme **;** **R** references to enzyme or substrate being used up **R** T ^{o}C limiting	**2**
	(b)		pH **;** degree of mixing **;** enzyme concentration **;** AVP **;** e.g. ref to concentration of inhibitors	**1 max**
	(c)		*max of 2 marks for predicting **or** explaining* **P1** concentration of drug higher / AW **;** **P2** rate of reaction slower / AW **;** **P3** may not level off (in time scale shown on graph) **;** **P4** time taken to reach the maximum yield (approximately) doubles **;** (c.f. 15 ^{o}C) **E1** not denatured **;** **E2** adapted to 5 ^{o}C / optimum / body / usual, temperature **;** **E3** ref to Q_{10} of about 2 **;** **E4** ref to lower kinetic energy / AW **;** **E5** ref to E-S, collisions / complexes **;** AVP **;** e.g. ref to active site	**3 max**
	(d)	(i)	(shaded amino acids) form the active site **;** substrate may not attach to the active site **;** enzyme-substrate complex may not be formed / AW **;**	**1 max**
		(ii)	44 and 66 not part of active site **;** hold, active site / 3^{o} structure / 3D structure, in shape **;** **A** stop denaturing hydrogen bonds weak **;** easily broken by, vibration / heat **;** **A** pH disulphide bridge strong **;** not broken by heat **;**	**2 max**
	(e)		nucleotide / base/ DNA, sequence codes for, protein / amino acid, sequence **;** changes DNA **;** **A** change triplet makes different mRNA **;** **A** change codon transcription **;** different tRNAs line up **;** **A** change anticodon translation **;** different (amino acid sequence in), enzyme / protein / polypeptide **;**	**2 max**

[Total: 13]

Question			Expected Answers	Marks
4	(a)		*any two of the following* (monomer) not glucose **;** contains nitrogen **;** contains, sulphur **;** AVP **;** **R** ref to branching	**2 max**
	(b)		amount of glycoprotein varies (in different cells) **;** (cells carry out) endocytosis to different extents **;** cells have different life spans / example **;** no time for polysaccharide to accumulate in short lived cells **;** number / role, of lysosomes not same in all cell types **;** AVP **;**	**1 max**
	(c)		*with Hunter's syndrome, lysosomes / vesicles, might be* larger **;** more numerous **;** have different shape **;** stain differently **;** AVP **;** e.g. granular cytoplasm	**1 max**
	(d)	(i)	unaffected parents can have an affected child **;** *ora* e.g. 3, 4, 8 / 11, 12, 16, 17 **;**	**1 max**
		(ii)	only males affected **;** *ora* mothers pass it on **;** *ora* on the X chromosome **;** carrier women asymptomatic / dominant normal allele masks trait **;** 4 / 11 / 1 , could be carriers **;**	**2 max**
	(e)		there are only 3 cases / too small a sample **;** mostly female line shown **;** AVP **;** e.g. pedigree of, 3 / 12, not known progeny of, 13 / 14 / 15, not known	**1 max**
	(f)		drug must act in all cells **;** lysosomes are within cells **;** hard for drug to reach **;** if drug acts as enzyme, polysaccharide on cell membranes may be broken down **;** tissue mechanical support would break down **;** AVP **;** AVP **;** e.g. no animal model protein drug digested in gut rare condition (qualified), economic argument	**2 max**
				[Total: 10]

Question			Expected Answers	Marks
5	(a)		avoid attracting a mate of a different species **;** *ora* ensure reproductive isolation **;**	**1 max**
	(b)	(i)	diffusion **;**	**1**
		(ii)	so that they do not receive oxygen constantly **;** there are mitochondria between them and the cell surface **;**	**1 max**
	(c)		mitochondria / aerobic respiration / oxidative phosphorylation, inhibited only briefly **;** oxygen concentration decreases again **;** preventing, action of luciferase / production of light **;** each flash short **;** *ora* e.g. so not continuously lit AVP **;**	**2 max**
	(d)		active transport **;** **A** e.g. Na^+/K^+ pump protein synthesis **;** synthesis of named substance **;** movement of organelles **;** phosphorylation of glucose **;** AVP **; ; ;** e.g. transcription, translation, anabolic reaction **R** respiration, DNA replication, chromosome movement, mitosis	**3 max**
	(e)		cells / membranes, damaged / disrupted **;** nitrous oxide released **;** mitochondria stop using oxygen **;** oxygen, allows light production / reaches light-producing organelles **;** in unlimited quantities / continuously, so light is brighter **;** respiration / oxidative phosphorylation, ceases **;** no more, ATP / $NADH_2$ **;** luciferin, synthesis / regeneration, stops **;** AVP **;**	**3 max**
	(f)		live bacteria, respire / produce ATP **;** *ora*	**1**
	(g)		<u>mRNA</u> (coding for luciferase) **;** **A** DNA	**1**

[Total: 13]