A Level Biology B (Advancing Biology)
H422/02 Scientific literacy in biology
Sample Question Paper

Date – Morning/Afternoon
Time allowed: 2 hours 15 minutes

You must have:
- the Advance Notice (inserted)

You may use:
- a scientific calculator

First name	
Last name	
Centre number	
Candidate number	

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **24** pages.

Answer **all** the questions.

1 This question is based on the Advanced Notice article **MYOKINES**, which is an insert.

(a) IL-6 is produced by muscle cells in response to physical exercise.

(i) Using the data in **Table 1.1**, determine the mode and mean IL-6 increase after a 1.5 hour cycle ride.

Determine the mode to **one** significant figure and the mean to **three** significant figures.

mode …… mean …… **[3]**

(ii) Based on the data in **Table 1.1**, how valid are the following conclusions?

The duration of exercise affects IL-6 concentration in blood.

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Running has a greater influence than cycling on IL-6 concentrations.

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[4]

(b) **(i)** Suggest how IL-6 increases the uptake of glucose from the blood plasma to muscle cells **and** how it increases glucose production in the liver.

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(ii)* *"IL-6 increases the risk of type 2 diabetes."*

Evaluate the evidence that supports or contradicts the above statement.

Use information from the article **MYOKINES**.

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…… **[6]**

(c) Studies F and H in **Table 1.2** both used knockout mice.

(i) Outline **one** way in which a gene can be inactivated in the knockout procedure.

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…… **[1]**

(ii) Suggest **one** reason why mice are used as the model organism in the knockout procedure.

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…… **[1]**

(d) Cytokines produced in muscles are called myokines. IL-6 is an example of a myokine.

Cytokines can act as chemical signals between immune cells.

Describe **one** specific role of cytokines in the immune system.

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…… **[2]**

2 Haemoglobin is a molecule that is found in most vertebrate species.

(a) A student outlined the structure of haemoglobin using the description below.

A molecule of haemoglobin consists of two alpha and two beta chains. Each polypeptide chain has a coenzyme called haem associated with it. The four polypeptide chains form a 3D tertiary structure consisting of 574 amino acids.

State **two** errors the student has made in their description above and suggest how the student should correct his statement.

Error 1: ……

Correction 1: ……

Error 2: ……

Correction 2: ……

[2]

(b) People travelling to high altitudes can develop altitude sickness because they produce more haemoglobin than normal, which results in thick, viscous blood.

Many people in Tibet live more than 4 000 m above sea level, but they do not develop altitude sickness.

Tibetan people have a variant of the EPAS1 gene that causes them to maintain relatively low haemoglobin levels in their blood.

(i) Describe how the Tibetan variant of the EPAS1 gene has become common in Tibetan populations.

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…… **[4]**

(ii) What type of adaptation is represented by the maintenance of low haemoglobin levels in Tibetan people?

…… **[1]**

(iii) State and explain **one** problem that a Tibetan person with the EPAS1 gene variant might experience.

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…… **[2]**

(iv) Suggest a practical technique that could be used to compare the relative number of erythrocytes in a Tibetan population with that of another population **and** state what this technique would show.

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…… **[2]**

(c) **Fig. 2.1** shows oxygen dissociation curves for both haemoglobin and myoglobin.

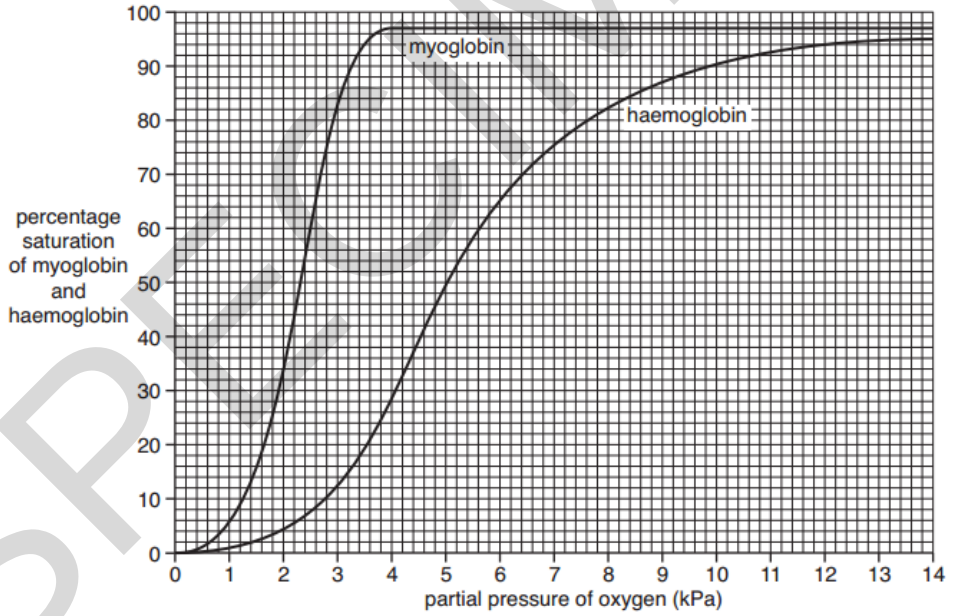

Fig. 2.1

The saturation of haemoglobin with oxygen increases as the partial pressure of oxygen is increased.

(i) Use **Fig. 2.1** to calculate the fastest rate of change in haemoglobin saturation as oxygen partial pressure increases. Determine the units for your answer.

answer …….. units ……**[3]**

(ii) Suggest where in the body a partial pressure of oxygen of 13 kPa would be found.

…….. **[1]**

(iii) **On Fig. 2.1**, sketch the oxygen dissociation curve for human fetal haemoglobin.

[1]

(iv) Explain the biological significance of the different oxygen dissociation curves of myoglobin and adult haemoglobin.

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…….. **[2]**

3 Thirty-three human blood group systems are known to exist. Two of these are the ABO blood group system and the Hh blood group system.

(a) Explain why a person whose blood group is AB expresses both A and B antigens on the surface of their red blood cells.

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…… **[2]**

(b) The Hh blood group system is controlled by one gene locus with two alleles.

The homozygous recessive genotype produces the Bombay phenotype, resulting in a very rare blood group, in which no antigen is expressed.

The Bombay phenotype is very rare. One person in 250 000 of the world's population is estimated to have the Bombay phenotype.

(i) Using the Hardy-Weinberg equations, calculate the **percentage** of the world's population who carry one copy of the recessive allele.

$$p + q = 1 \qquad p^2 + 2pq + q^2 = 1$$

Show each step in your working. Give your answer to **one significant figure**.

percentage …… **[4]**

(ii) The Bombay phenotype is more common in some regions of India, where it can occur in one in 10 000 people.

Researchers have suggested that the Bombay phenotype is more common in these regions because of the practice of endogamy, in which marriage occurs only between people within the same tribe or small social group.

Suggest why endogamy has increased the frequency of the Bombay phenotype.

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…… **[2]**

(c) A research team planned to compare the genetic diversity of the populations of three towns.

An overview of their methodology is provided below.

- Genetic analysis will be conducted on 20 people from town A, 50 people from town B and 155 people from town C.
- 100 gene loci will be analysed.

What additional information would need to be considered to improve this methodology?

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…… **[3]**

4 (a) Bacteria represent one of two prokaryotic domains.

The Gram staining method allows bacteria to be classified based on the thickness of the peptidoglycan layer in their cell wall.

Outline **one** risk involved in using the Gram staining method.

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…… **[1]**

(b) Like bacterial cells, palisade mesophyll cells have cell walls.

Complete **Table 4.1** to give **two** similarities and **two** differences between the structure of bacterial cells and palisade mesophyll cells **other than** the presence of a cell wall.

	Bacterial cells	**Palisade mesophyll cells**
Differences		
Similarities		

Table 4.1 **[4]**

(c) Some bacterial species aid digestion in ruminants.

Describe the role of bacteria in ruminant digestion.

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…… **[2]**

(d)* A student wrote the following statement:

> *Bacteria can be harmful and cause disease, but some bacteria can play important roles in the environment, for example, recycling nutrients. In recent years, scientists have developed techniques to genetically alter bacteria. These genetically modified bacteria have allowed us to produce useful substances.*

Using the ideas in the student's statement, outline the relationship between humans and bacteria.

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…… **[6]**

5 Plants experience two compensation points each day, one in the early morning and one in the evening. A compensation point is shown in **Fig. 5.1**, which illustrates the effect of light intensity on the carbon dioxide exchanged by the plant.

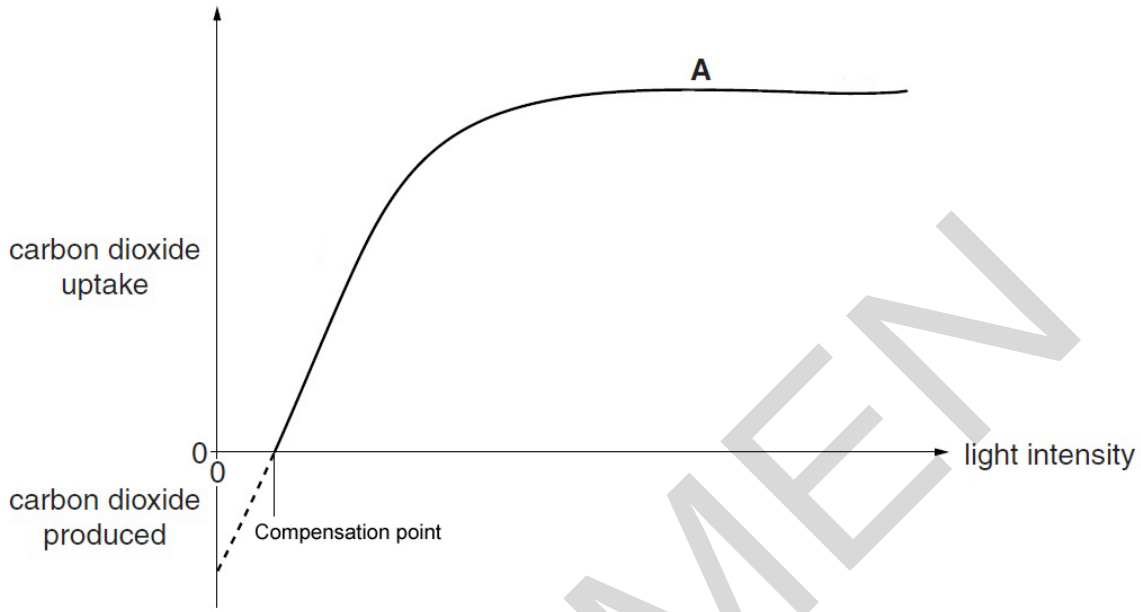

Fig. 5.1

(a) **(i)** Compare the rates of respiration and photosynthesis between 0 and the compensation point shown in **Fig. 5.1** above.

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…… **[1]**

(ii) Explain why the carbon dioxide uptake forms a plateau at **A** in **Fig. 5.1**.

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…… **[1]**

(b) (i) A student planned to compare the compensation points of two plant species.

Describe how the student could use hydrogencarbonate indicator solution to investigate the compensation points of the two species.

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…… **[3]**

(ii) The student conducted another experiment using a photosynthometer to investigate the effect of light intensity on the rate of photosynthesis.

When the light source was 0.50 m from the plant, an oxygen bubble 6.00 cm long was collected in the photosynthometer during a 2 minute period.

The diameter of the photosynthometer tube was 0.12 cm.

Calculate the rate of photosynthesis under these conditions.

rate of photosynthesis = …… $cm^3\ min^{-1}$ **[2]**

(c) The atmospheric carbon dioxide taken up by plants is used as a reactant in the Calvin cycle.

(i) Name **one** product of the light-dependent reactions of photosynthesis that is used as a reactant in the Calvin cycle **and** describe its role in the cycle.

Product **……**

Role **……**

[2]

Fig. 5.2 shows the molecular structure of the amino acid cysteine, which can be synthesised from products of the Calvin cycle.

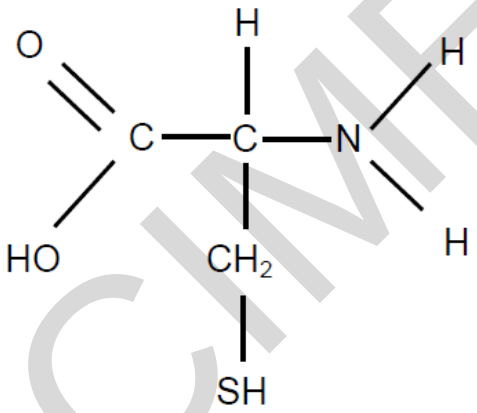

Fig. 5.2

(ii) In addition to the products of the Calvin cycle, suggest **two** mineral ions that plants would need to absorb through their roots in order to synthesise cysteine.

1 **……**

2 **……**

[2]

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6 Plants begin flowering in response to changes in day length. This is known as photoperiodism. Some plants, such as cocklebur, are "short-day" plants. They will only begin flowering when they have experienced a relatively long period in the dark.

Table 6.1 shows the results of experiments with cocklebur plants that were kept in darkness for different lengths of time. Some of the plants were exposed to particular wavelengths of light during the experiment.

	Period in darkness (hours)	**Light exposure during the dark period**	**Result**
A	8.5	None	Flowers
B	6.0	None	No flowers
C	12.0	Flash of red light (660 nm) after 6 hours	No flowers
D	12.0	Flash of red light followed by flash of far red light after 6 hours	Flowers
E	6.5	Intense exposure to far red light (730 nm) at the beginning of the 6.5 hours	Flowers

Table 6.1

(a) (i) A student examined the data in **Table 6.1** and made the following statement:

Plants will not flower without being kept in the dark for a minimum of 8.5 hours.

Using your knowledge of the control of flowering in plants and the information in **Table 6.1**, evaluate the validity of the student's conclusion.

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…… **[3]**

(ii) With reference to **C, D** and **E** in **Table 6.1**, what conclusions can you draw about the role of phytochrome in the control of flowering in plants?

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……**[4]**

(b) The ability of cocklebur plants to time their flowering to coincide with changes in day length maximises the chances of pollination.

Flowers also show features that are adapted for particular methods of pollination.

Describe **two** ways in which flowers are adapted for wind pollination.

1 ……

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2 ……

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[2]

7 Ocular melanoma is the most common form of cancer to affect the eye. More than 400 new cases are diagnosed each year in the UK.

Fig. 7.1 shows the structure of a human eye.

Ocular melanoma can develop in the choroid, ciliary body or at **A** in **Fig. 7.1**. Diagnosis is usually made earlier for melanomas that have developed at **A**.

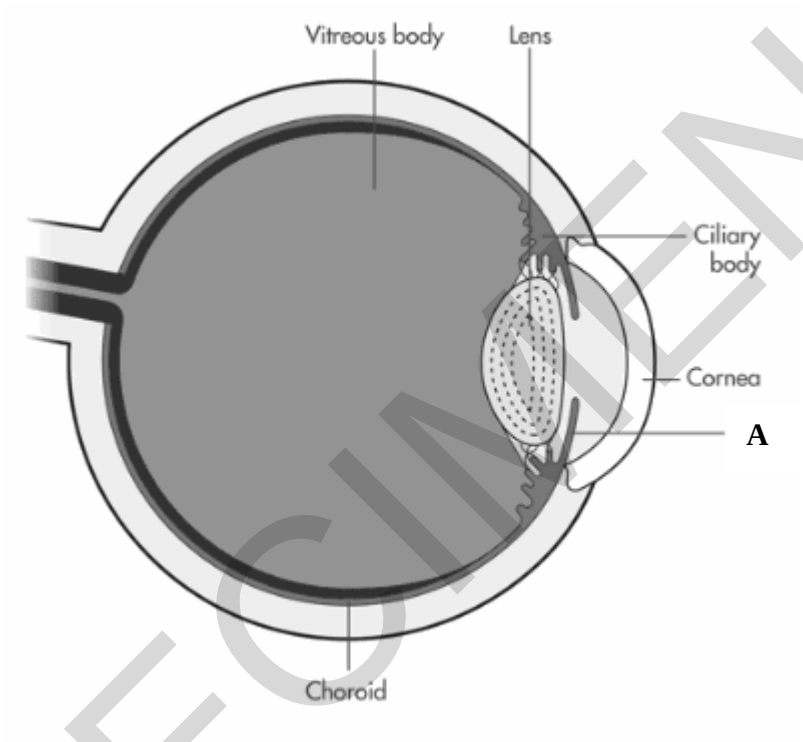

Fig. 7.1

(a) **(i)** Name the part of the eye labelled **A** in **Fig. 7.1**.

……... **[1]**

(ii) Suggest why melanomas at **A** are diagnosed earlier than other ocular melanomas.

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……..…… **[1]**

(iii) Cells in the choroid and **A** in **Fig. 7.1** produce a pigment called melanin.

Suggest and explain **two** functions of melanin.

1 ……

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2 ……

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[2]

(b) The GNA11 gene codes for a protein that is involved in cell signalling.

(i) Outline the changes in DNA which would lead to a faulty version of the GNA11 gene.

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…… **[1]**

(ii) Suggest how the faulty version of the GNA11 gene is formed and suggest how the faulty GNA11 causes the development of ocular melanoma.

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…… **[3]**

8 Parkinson's is a neurological disorder that affects one in 500 people in the UK. **Table 8.1** lists some of the drugs available to treat Parkinson's.

Drug	Short-term effectiveness	Long-term effectiveness	Short-term side effects	Long-term side effects
Levodopa	Controls symptoms, especially late-stage symptoms	Can become less effective	Nausea, joint stiffness	Can cause a serious movement disorder called dyskinesia
Procyclidine	Relatively effective at improving early, mild symptoms such as tremors	Ineffective for symptoms such as slowness and stiffness	Possible confusion and blurred vision	Possible memory loss in older patients; can reduce the effectiveness of levodopa
Dopamine agonists	Delays and manages symptoms but less effective than levodopa	Relatively ineffective at controlling late-stage symptoms	Drowsiness, nausea	Drowsiness, nausea
Entacapone	Improves the effectiveness of levodopa	Improves the effectiveness of levodopa	Can worsen the effects of dyskinesia	Worsens dyskinesia, but this effect reduces over time

Table 8.1

(a) (i) A doctor will often decide on a 10-year treatment plan for a person who has been diagnosed with early-stage Parkinson's.

Suggest the best drugs to include in a long-term, 10-year plan, based on the evidence in **Table 8.1**.

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…… **[3]**

(ii) People with Parkinson's produce lower levels of the neurotransmitter dopamine.

Dopamine can act as either an excitatory or an inhibitory neurotransmitter.

Describe how dopamine can produce an excitatory post-synaptic potential.

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…… **[2]**

(b) Alzheimer's is another neurological disorder. A potential new drug treatment for Alzheimer's has entered clinical trials. The drug has passed the phase 2 trial in which it was tested on 50 patients.

A brief summary of the plan for phase 3 of the trial is as follows:
- The new drug is compared to the best treatment currently available.
- 70 patients receive the new drug in total, 35 from hospital A and 35 from hospital B.
- A placebo is not used.
- Blind trials are used.

(i) Discuss aspects of the planned phase 3 clinical trial and explain how each aspect is likely to affect the validity of the results.

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…… **[3]**

(ii) State **two** possible causes of Alzheimer's.

1 ……

2 …… **[2]**

END OF QUESTION PAPER

A Level Biology B (Advancing Biology)
H422/02 Scientific literacy in biology
Sample Advance Notice Article

For issue on or after: Date/Year

NOTES FOR GUIDANCE (CANDIDATES)

1. This leaflet contains an article which is needed in preparation for a question in the externally assessed examination H422/02 Scientific literacy in biology.
2. You will need to read the article carefully and also have covered the learning outcomes for A Level in Biology B (Advancing Biology). The examination paper will contain questions on the article. You will be expected to apply your knowledge and understanding of the work covered in A Level in Biology B (Advancing Biology) to answer this question. There are 20–25 marks available on the question paper for this question.
3. You can seek advice from your teacher about the content of the article and you can discuss it with others in your class. You may also investigate the topic yourself using any resources available to you.
4. You will not be able to bring your copy of the article, or other materials, into the examination. The examination paper will contain a fresh copy of the article as an insert.
5. You will not have time to read this article for the first time in the examination if you are to complete the examination paper within the specified time. However, you should refer to the article when answering the questions.

This document consists of **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

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MYOKINES

Cytokines are proteins that send signals between cells. One of their principal functions is cell-signalling within the immune system. Scientists have discovered that some cytokines are produced by muscle fibres. These proteins have been named myokines. The myokine that has been studied the most is interleukin-6 (IL-6). Recent research has demonstrated that physical exercise stimulates the production of IL-6, which is a molecule that has been linked with changes in metabolism.

The effect of exercise on IL-6 production

Exercise can significantly increase IL-6 concentrations in blood plasma. Runners in a 246 km "Spartathlon" race showed an 8 000-fold increase in IL-6 levels. Few of us would attempt an extreme event like the Spartathlon, but milder exercise can also raise IL-6 levels. Many different studies have indicated that relatively short bouts of running or cycling will change the blood plasma concentrations of IL-6. Table 1.1 shows the results of some of these studies.

Cycling			Running		
Duration of exercise in each study (hr)	**IL-6 increase (fold change)**	**Number of participants in each study**	**Duration of exercise in each study (hr)**	**IL-6 increase (fold change)**	**Number of participants in each study**
0.3	2	7	0.2	1	12
0.3	1	9	0.9	9	12
0.3	2	7	1.0	4	7
0.4	1	9	1.0	9	7
0.4	2	8	1.5	4	8
0.5	2	9	1.5	8	8
0.7	1	16	1.5	20	10
0.8	3	6	1.6	10	10
1.0	2	7	2.5	8	30
1.0	2	17	2.5	25	10
1.0	5	8	2.5	29	7
1.0	5	7	2.5	30	9
1.0	5	9	2.5	52	10
1.0	9	8	2.5	109	16
1.5	2	9	3.0	10	16
1.5	2	8	3.0	50	6
1.5	3	11	3.3	63	16
1.5	6	7	3.5	88	18
2.0	2	6	3.5	92	10
2.0	3	6	3.5	128	10
2.0	4	8	3.7	43	18
2.0	8	6	4.5	42	50
2.0	11	8	6.0	4	19
2.0	20	6	9.1	6	6
2.0	38	8	9.8	28	13
2.5	16	15	9.9	29	7
2.5	24	10	26.3	126	60
3.0	8	18			
3.0	13	8			
3.0	26	6			

Table 1.1 Changes in IL-6 concentrations in the blood immediately after exercise

The use of PCR has revealed that exercise increases the transcription rate of the IL-6 gene. Within 30 minutes of exercise, IL-6 mRNA concentrations increase in skeletal muscle. Although it is clear that IL-6 levels increase during and immediately after exercise, the story is different in the long-term. Several studies have shown that regular physical activity decreases baseline concentrations of IL-6 in the blood plasma when the people being studied are at rest.

Short-term effects of IL-6 on carbohydrate metabolism

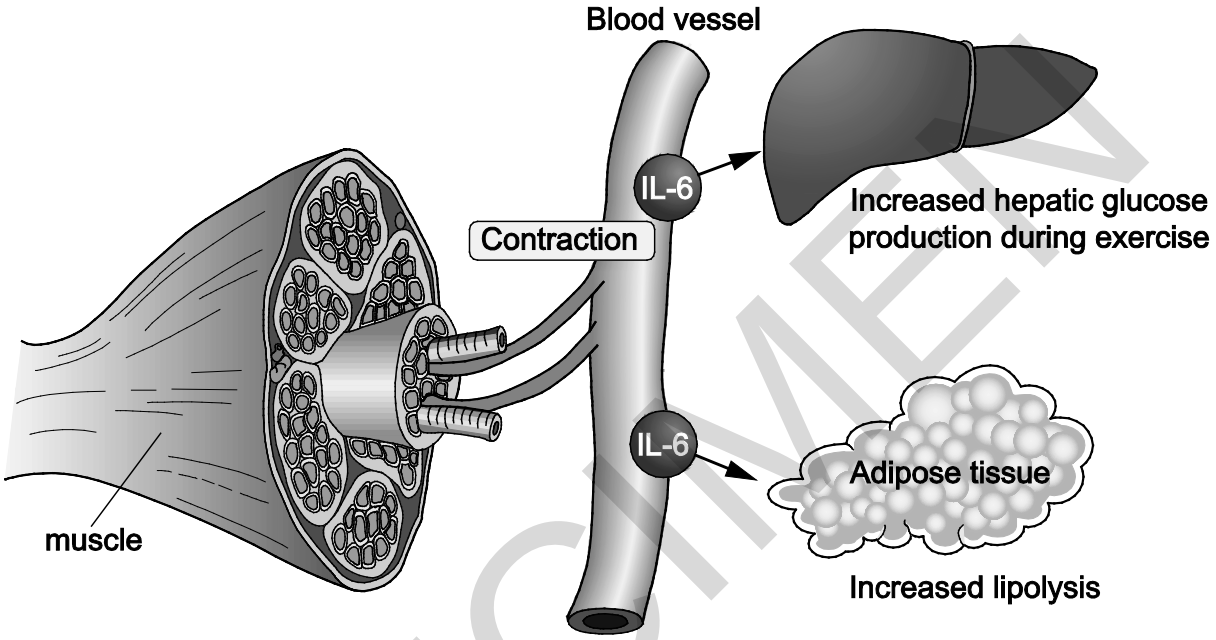

Fig. 1.1

Fig. 1.1 illustrates some of the effects of IL-6 when it is produced by muscles during exercise. IL-6 causes skeletal muscle cells to take up more glucose from the blood and to use more of their lipid reserves in respiration. IL-6 can also act like a hormone by travelling through the blood to produce effects in other tissues (e.g. adipose tissue and the liver).

Long-term effects of IL-6 on carbohydrate metabolism

The immediate effects on glucose metabolism of IL-6 produced during exercise are clear, but the long-term effects of this myokine are less certain. Whether IL-6 has a positive or negative effect on metabolism in the long-term is a controversial issue.

Table 1.2 lists various studies that have examined the effect of IL-6 on glucose metabolism and diseases such as diabetes.

Study	Type of study	Method	Results
A	In vitro experiment	Cultures of human muscle cells treated with insulin and IL-6.	The presence of IL-6 increased the uptake of glucose into muscle cells.
B	In vivo experiment	Mice were injected with high concentrations of IL-6.	Mice injected with IL-6 showed a reduced ability to take up glucose into muscle cells. The ability of insulin to stimulate glucose uptake from the blood was reduced.
C	Clinical observations	Blood analysis of patients with obesity and angina.	Concentrations of IL-6 in the blood of patients with obesity and angina were higher than concentrations in healthy people.
D	Clinical observations	Blood analysis.	As the blood concentration of IL-6 increases, the risk of developing type 2 diabetes increases.
E	In vivo experiment	A comparison of two groups: one that exercised regularly and one that did not, followed by an analysis of blood glucose concentration.	People who exercised regularly became more sensitive to insulin.
F	Gene knockout	Inactivation of the IL-6 gene in mice, and a comparison to a control group that was able to produce IL-6.	Mice that were unable to produce IL-6 were more likely to develop obesity and glucose intolerance.
G	In vitro experiment	Fat-storing cells from mice were exposed to another cytokine called TNF-alpha.	TNF-alpha decreased the ability of insulin to stimulate glucose uptake in the cells. TNF-alpha reduced the number of insulin receptors produced by the cells.
H	Gene knockout	Inactivation of the IL-6 gene in mice, and a comparison to a control group that was able to produce IL-6.	Mice that were unable to produce IL-6 exhibited increased concentrations of TNF-alpha in their blood.
I	Clinical trials	Patients with rheumatoid arthritis were given a monoclonal antibody that blocked the IL-6 receptor. This stopped IL-6 from producing any effects.	Cholesterol and glucose concentrations in the blood increased in patients with blocked IL-6 receptors.

Table 1.2

END OF ADVANCE NOTICE ARTICLE

A Level Biology B (Advancing Biology)

H422/02 Scientific literacy in biology

Sample Advance Notice – Teacher Instructions

To be read on receipt

To prepare candidates for the examination taken on Date/Year

This document consists of **2** pages.

NOTES FOR GUIDANCE

1. The Advance Notice material should be issued to candidates on or after the date shown on the front cover of the candidate instructions sheet at the discretion and convenience of the centre. Candidates can be given the material at any point, but it is suggested that this should be at least four weeks before the examination date.
2. Candidates will need to read the article carefully. Time can be built into the teaching programme to introduce the article content. Candidates should be able to discuss the article freely and be given support and advice in the interpretation of the content so that they are able to answer the questions based on the article in the externally assessed examination. Candidates should also be encouraged to investigate the topics covered in the article for themselves.
3. Candidates will be expected to apply their knowledge and understanding of the content in A Level in Biology B (Advancing Biology) to questions based on the article. There are 20–25 marks available on the paper for this question.
4. The Advance Notice material must not be taken into the examination. The examination paper H422/02 will contain a fresh copy of the article, as an insert. Candidates should be reminded that they do not have sufficient time during the examination to read the article for the first time. They should, however, refer to the article printed in the insert in the examination paper to help them to answer the questions.