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BIOLOGY
HIGHER LEVEL
PAPER 3

Wednesday 3 November 2010 (morning)

1 hour 15 minutes

Candidate session number

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INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

0119

Option D — Evolution

D1. Superoxide dismutase is an enzyme used by cells to protect themselves against oxidative damage. These enzymes can have different metals as part of their structure.

A study to compare two dismutases from *Escherichia coli* bacteria and two dismutases from eukaryotic cells was undertaken. The following enzymes were used:

- *E. coli* dismutase with iron (Fe)
- *E. coli* dismutase with manganese (Mn)
- eukaryotic mitochondrial dismutase with manganese (Mn)
- eukaryotic cytoplasmic dismutase with copper-zinc (Cu-Zn).

The following shows part of the amino acid sequences of these enzymes. Boxes enclose identical amino acids in the sequence of the two *E. coli* and mitochondrial dismutases.

	①				⑤									⑩								⑮
E. coli (Fe)	Ser	–	Phe	–	Glu	–	Leu	–	Pro	–	Ala	–	Leu	–	Pro	–	Tyr	–	Ala	–	Lys	–	Asp	–	Ala	–	Leu	–	Ala
E. coli (Mn)	Ser	–	Tyr	–	Thr	–	Leu	–	Pro	–	Ser	–	Leu	–	Pro	–	Tyr	–	Ala	–	Tyr	–	Asp	–	Ala	–	Leu	–	Glu
Mitochondrial (Mn)	Lys	–	His	–	Thr	–	Leu	–	Pro	–	Asp	–	Leu	–	Pro	–	Tyr	–	Asp	–	Tyr	–	Gly	–	Ala	–	Leu	–	Glu
Cytoplasmic (Cu-Zn)	AcAla	–	Thr	–	Lys	–	Ala	–	Val	–	Cys	–	Val	–	Leu	–	Lys	–	Gly	–	Asp	–	Gly	–	Pro	–	Val	–	Gln

	⑯					⑳											㉕									
E. coli (Fe)	Pro	–	His	–	Ile	–	Ser	–	Ala	–	Glu	–	Thr	–	Ile	–	Glu	–	Tyr	–	His	–	Tyr	–	Gly	–	Lys
E. coli (Mn)	Pro	–	His	–	Phe	–	Asp	–	Lys	–	Gln	–	Thr	–	Met	–	Glu	–	Leu	–	His	–	His	–	Thr	–	Lys
Mitochondrial (Mn)	Pro	–	His	–	Ile	–	Ser	–	Ala	–	Glu	–	Ile	–	Met	–	Gln	–	Leu	–	His	–	His	–	Ser	–	Lys
Cytoplasmic (Cu-Zn)	Gly	–	Thr	–	Ile	–	His	–	Phe	–	Glu	–	Ala	–	Lys	–	Gly	–	Asp	–	Thr	–	Val	–	Val	–	Val

[H. M. Steinman and R. L. Hill (1973) "Sequence homologies among bacterial and mitochondrial superoxide dismutases". PNAS journal (USA), 70 (12), pp. 3725-–3729. Used with the permission of the authors.]

(a) State how many amino acids are in the same position in the *E. coli* (Fe), *E. coli* (Mn) and the mitochondrial dismutase sequences shown. *[1]*

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(b) State the amino acids which are present in the same position in at **least one** bacterial dismutase and in **both** eukaryotic dismutases. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(c) Compare the *E. coli* (Mn) and the mitochondrial dismutases. *[2]*

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(d) Using the diagram, suggest whether the evolution of bacterial dismutase and cytoplasmic dismutase is convergent **or** divergent. *[1]*

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(e) The sequences of the two bacterial dismutases and the mitochondrial dismutase show a high degree of homology. Discuss how this supports the endosymbiotic theory for the origin of mitochondria. *[2]*

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D2. (a) Define the terms *allele frequency* and *gene pool*. *[1]*

Allele frequency: . . . . . .

Gene pool: . . . . . .

(b) State **one** assumption made when the Hardy–Weinberg equation is used. *[1]*

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(c) Outline how variations in specific molecules can lead to phylogeny. *[3]*

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(d) Outline the value of classifying organisms. *[2]*

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D3. Discuss the incompleteness of the fossil record and the resulting uncertainties concerning human evolution. *[6]*

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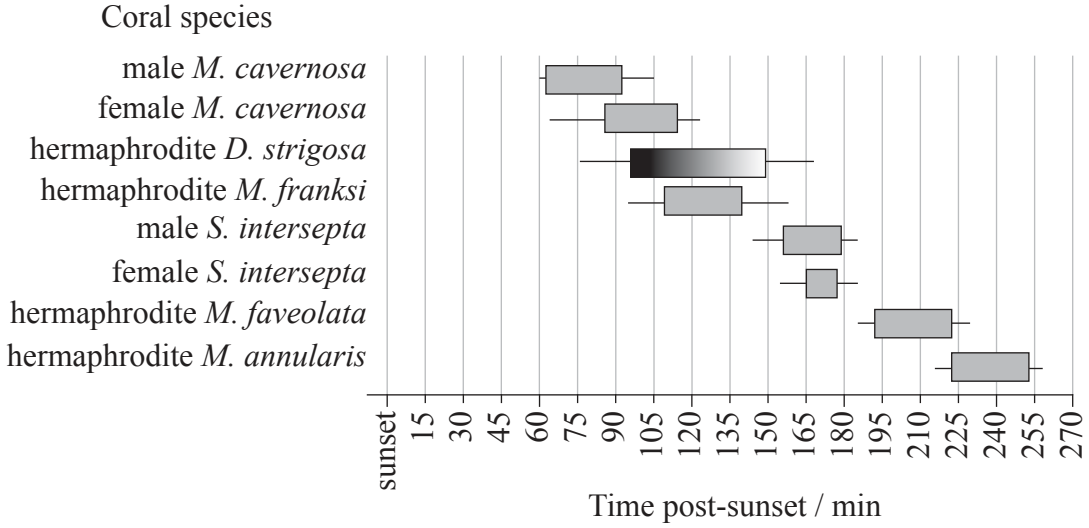
Option E — Neurobiology and behaviour

E1. Corals can be male, female or hermaphrodite (both male and female) and the release of their gametes is called spawning. Data was collected to study the spawning behaviour in the Gulf of Mexico of three genera of coral: *Montastraea*, *Stephanocoenia* and *Diploria*.

The spawning behaviour is expressed in minutes post-sunset. Peak spawning windows are shown as grey bars (▭) and the range as black bars (———).



[Adapted from P. D. Vize, J. A. Embesi, M. Nickell, D. P. Brown and D. K. Hagman (2005) "Tight temporal consistency of coral mass spawning at the Flower Garden Banks, Gulf of Mexico, from 1997–2003." _Gulf of Mexico Science_, 1, pp. 107–114.
]

(a) State the range of the time of spawning for the male *M. cavernosa*. *[1]*

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(b) Suggest why it may be advantageous for each species of coral to spawn within a tight time frame. *[1]*

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(c) Discuss the significance of different spawning windows for different species. *[2]*

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(Question E1 continued)

(d) Scientists hypothesized that the release of the male gamete triggers a chemical signal for females to release their eggs. Discuss this hypothesis. *[2]*

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(e) The spawning window of *D. strigosa* is shown as a shaded gradient indicating a strong bias towards spawning in the early portion of the window. Suggest a reason for the spawning behaviour of *D. strigosa.* *[1]*

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(f) Define the term *innate behaviour*. *[1]*

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E2. (a) Define the term *stimulus*. *[1]*

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(b) List **two** stimuli and the receptors that detect them. *[2]*

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(c) Outline how pain is perceived and the role of endorphins in this process. *[3]*

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E3. Discuss the causes of addiction, including genetic predisposition, social factors and dopamine secretion. *[6]*

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Option F — Microbes and biotechnology

F1. Antibiotics are sometimes given orally to poultry to prevent disease that may lead to reduced growth. Antibiotic resistance of bacteria from turkeys and chickens bred for meat and from egg laying hens was measured.

Excrement was collected and *Escherichia coli* bacteria were isolated. These bacteria were tested for resistance to a range of antibiotics and the results are shown below.

Number of antibiotics to which *E. coli* are resistant	**Turkeys *n* = 43**	**Chickens *n* = 45**	**Egg laying hens *n* = 20**
0	7	9	13
1	8	5	3
2	7	7	0
3	2	7	3
4	5	7	1
≥5	14	10	0

[Antibiotic resistance of faecal _Escherichia coli_ in poultry, poultry farmers and poultry slaughterers. A. E. van den Bogaard, N. London, C. Driessen, E. E. Stobberingh. _Journal of Antimicrobial Chemotherapy_, 47, June 1, 763--771. 2001, Oxford University Press.]

(a) Calculate the percentage risk of bacteria becoming resistant to more than five kinds of antibiotics in turkeys and egg laying hens. *[1]*

Turkeys: . . . . . .

Egg laying hens: . . . . . .

(b) Compare the incidence of drug resistance in bacteria from chickens and egg laying hens. *[2]*

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(c) Discuss the hypothesis that giving antibiotics increases antibiotic resistance in poultry bacteria. *[2]*

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(This question continues on the following page)

(Question F1 continued)

(d) Suggest how antibiotic-resistant bacteria are passed from animals to humans. *[1]*

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(e) Outline the mechanism of the action of antibiotics. *[2]*

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F2. (a) (i) State **two** nitrogen-fixing bacteria. *[1]*

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2. . . . . .

(ii) Outline the conditions that favour denitrification. *[2]*

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(b) Microorganisms can be used in many different ways. Outline the production of soy sauce using microorganisms. *[3]*

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F3. Explain the use of bacteria in the bioremediation of water. *[6]*

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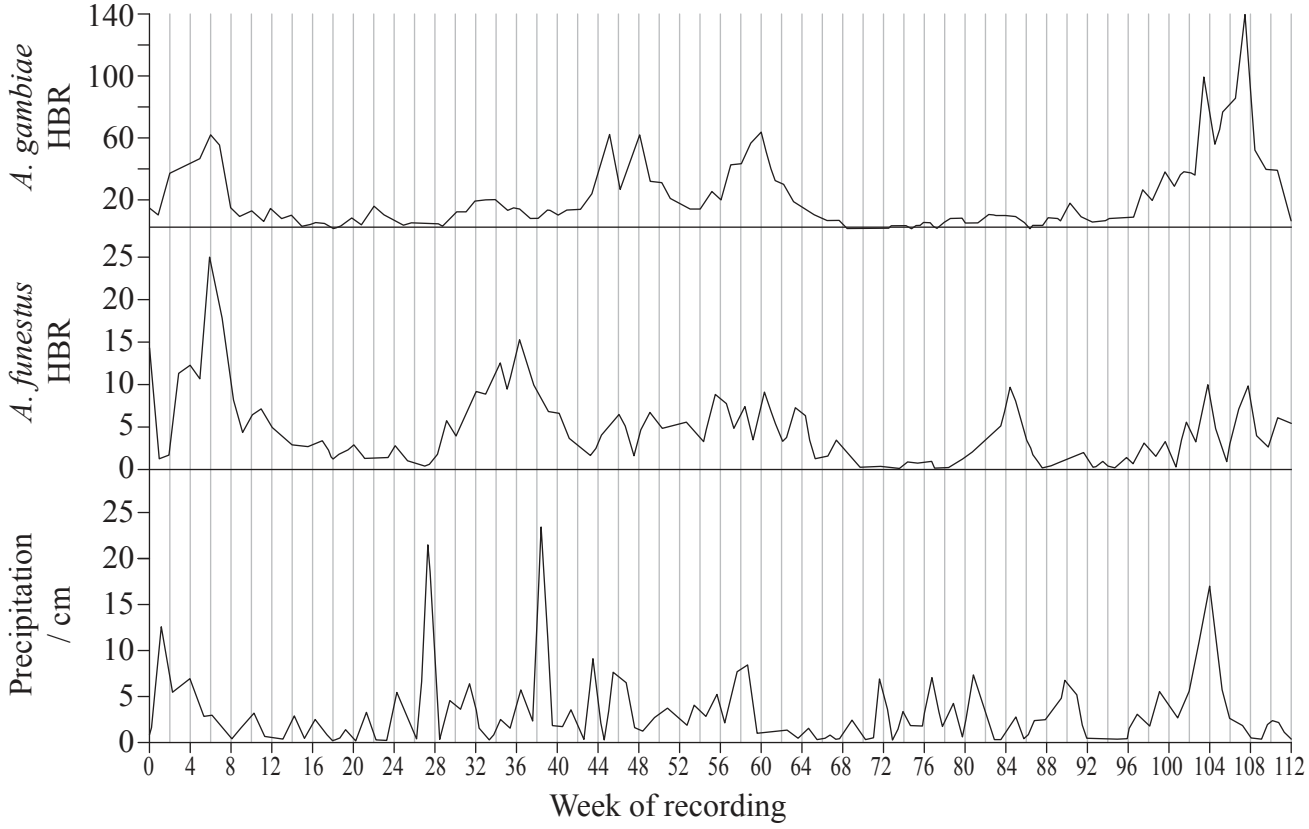
Option G — Ecology and conservation

G1. Many factors affect the distribution of animal species including weather patterns. The mosquito *Anopheles* is a carrier of malaria, a disease that kills one to two million people annually. The eggs of the mosquito are laid in water and they hatch out as larvae before turning into adult mosquitoes. A study was undertaken to look at the influence of weather patterns on the incidence of bites on children. Being bitten increases the risk of catching malaria.

The graphs show human biting rates (HBR) by *Anopheles gambiae* and *Anopheles funestus* and precipitation over the study period.



[J.A. Patz _et al._, 1998, "Predicting key malaria transmission factors, biting and entymological inoculation rates, using modelled soil moisture in Kenya", _Tropical Medicine & International Health_, 3, pp. 818-827, Figure 1 (adapted). Used with permission of John Wiley & Sons Inc.]

(a) State the week number when the highest human biting rate (HBR) is found for *A. gambiae*. *[1]*

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(This question continues on the following page)

(Question G1 continued)

(b) Calculate the difference in peak HBR for *A. gambiae* and *A. funestus* for week 6. *[1]*

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(c) Evaluate the effect of increased precipitation on HBR for both species. *[3]*

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(d) Suggest how predictions of global climate changes, such as predictions of precipitation patterns, could be used to help control malaria. *[1]*

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(e) Suggest another factor which might affect the ecological distribution of mosquitoes. *[1]*

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(f) Suggest a biological control that might be introduced to reduce HBR. *[1]*

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G2. (a) Earthworms are primary consumers that can be grown on household food waste such as fruit and salad leftovers. Outline their potential as an energy-containing food source for humans. *[3]*

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(b) State the units used in a pyramid of energy. *[1]*

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(c) Describe the effects of ultraviolet radiation on living tissues. *[2]*

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G3. Discuss the role of *ex situ* conservation of endangered species. *[6]*

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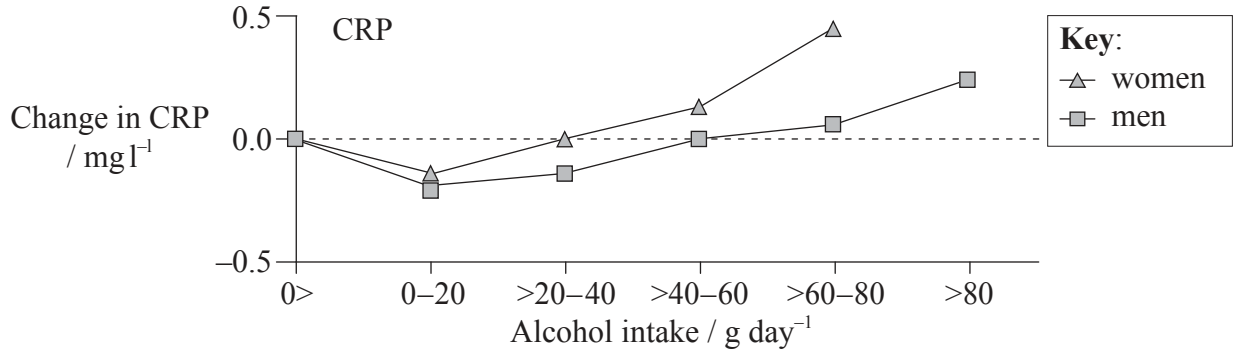
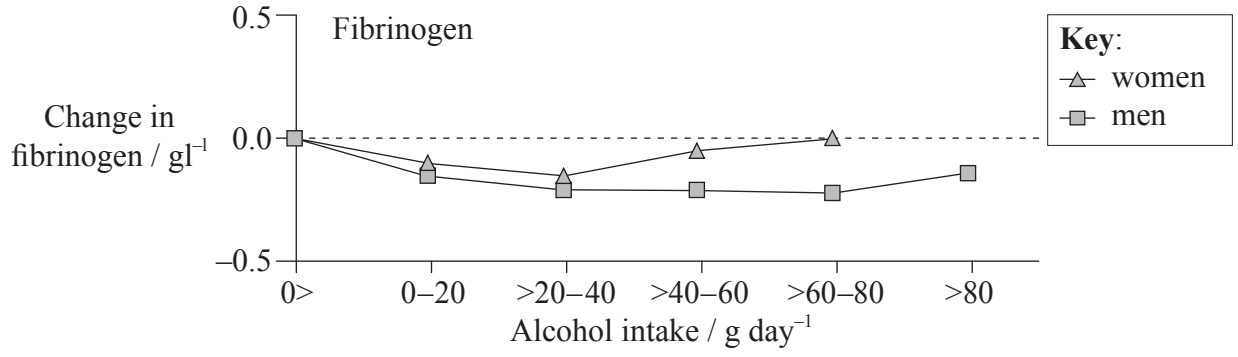
Option H — Further human physiology

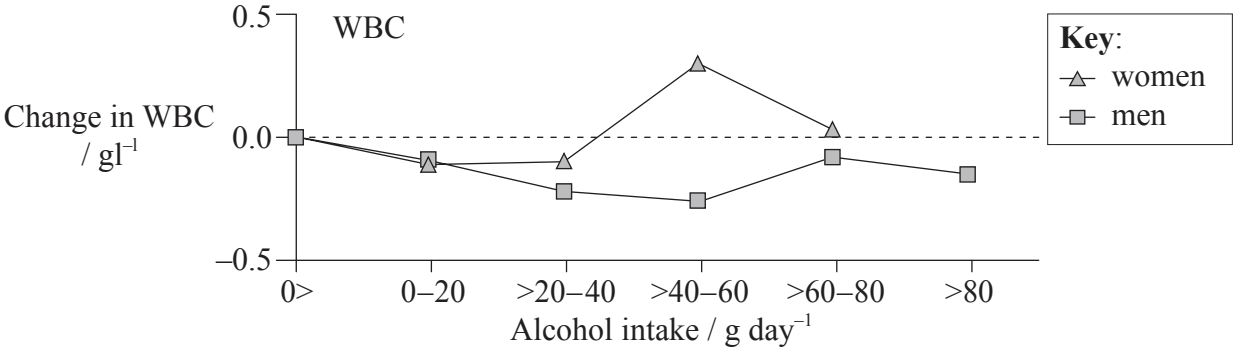
H1. Alcohol is known to increase the risk of cardiovascular disease (CVD). An investigation was undertaken to look at the effects of drinking different amounts of alcohol in men and women.

C-reactive protein (CRP), fibrinogen and total white blood cell count (WBC) were measured. These are markers that can be used to measure the risk of cardiovascular disease (CVD).

Samples were taken from populations in three different countries and their drinking habits were determined and their blood was analysed.







[Overall alcohol intake, beer, wine, and systemic markers of inflammation in western Europe: results from three MONICA samples (Augsburg, Glasgow, Lille), A. Imhof, M. Woodward, A. Doering, N. Helbecque, H. Loewel, P. Amouyel, G.D.O. Lowe, W. Koenig. European Heart Journal, December 1, 2004, Oxford University Press]

(This question continues on the following page)

(Question H1 continued)

(a) State the overall trend for CRP for men and women over the range of alcohol consumption. *[1]*

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(b) Evaluate, using all the data, whether drinking small amounts of alcohol reduces the risk of CVD. *[3]*

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(c) Deduce which is the best marker to measure the risk of CVD. *[1]*

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(d) Outline atherosclerosis and the causes of CVD. *[2]*

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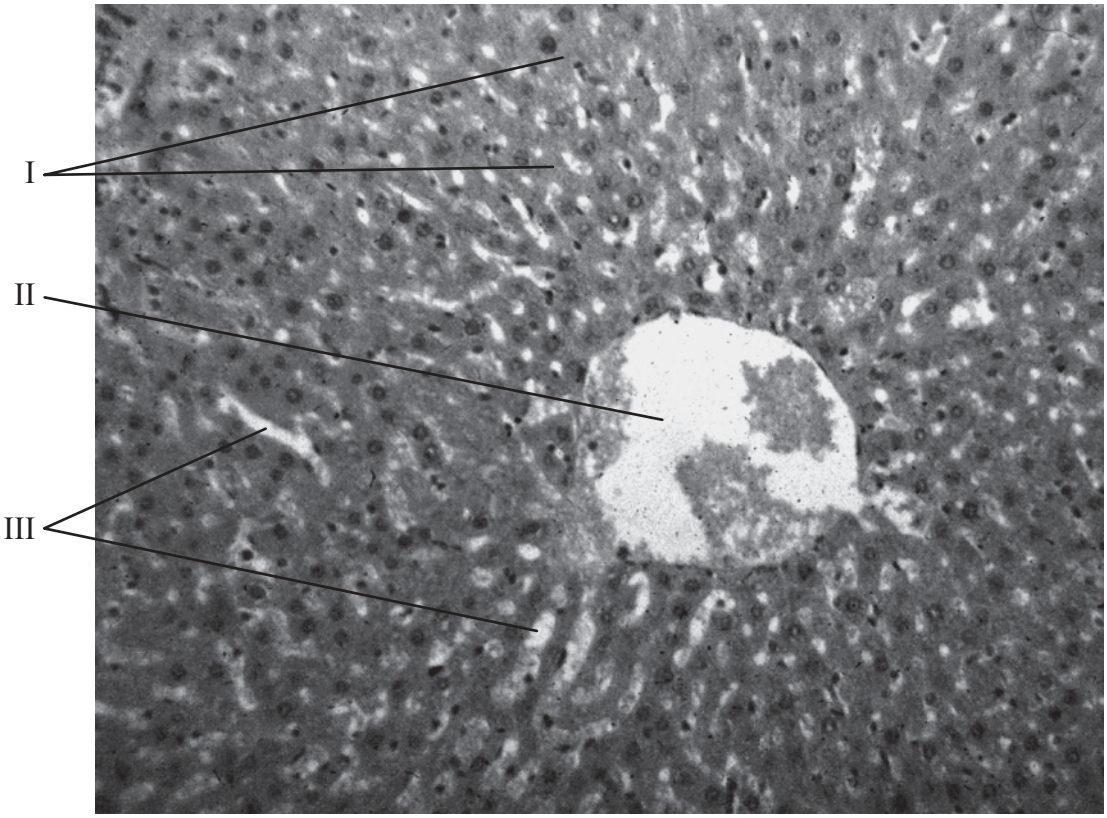
H2. (a) Label the section of healthy liver tissue below. *[3]*



[P. Billiet et al. (2000) Further Investigations in Biology, 4, p. 64, IBID Press. Reproduced with permission.]

I. . . . . .

II. . . . . .

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(b) Outline **two** roles of the liver. *[2]*

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(c) List **two** materials that are not absorbed but are egested by the body. *[1]*

1. . . . . .

2. . . . . .

(d) State an example of a protein hormone. *[1]*

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H3. Explain the oxygen dissociation curves of adult hemoglobin, fetal hemoglobin and myoglobin. *[6]*

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