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Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

Wednesday 20 November 2019 (afternoon)

Candidate session number

2 hours 15 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[72 marks]**.

20 pages

8819 – 6002

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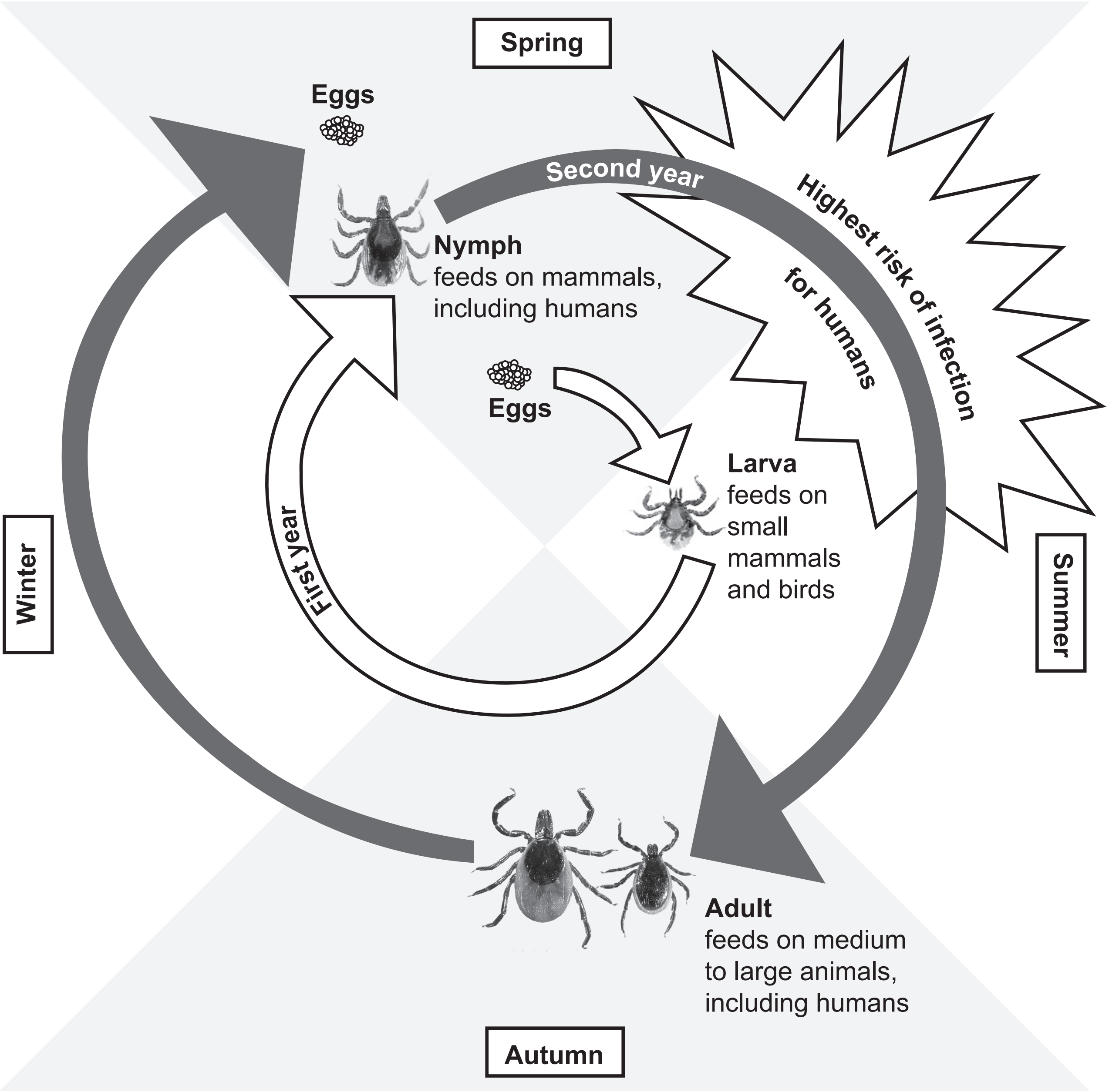
Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

1. The black-legged tick (*Ixodes scapularis*) is an arthropod which sucks blood from humans and other mammals. It is encountered mainly in wooded and semi-wooded areas.
Some ticks can be infected by the bacterium *Borrelia burgdorferi*. When a tick bites a human, the bacterium is often introduced, causing Lyme disease. Lyme disease is a public health problem in North America and, if left untreated, can cause important neurological impairment.
The diagram represents the two-year life cycle of a tick.



[Source: Cary Institute of Ecosystem Studies / Leslie Tumblety]

(This question continues on the following page)

(Question 1 continued)

(a) State the domain into which ticks are classified. [1]

. . . .

(b) Using information from the text, identify **one** possible simple treatment for Lyme disease. [1]

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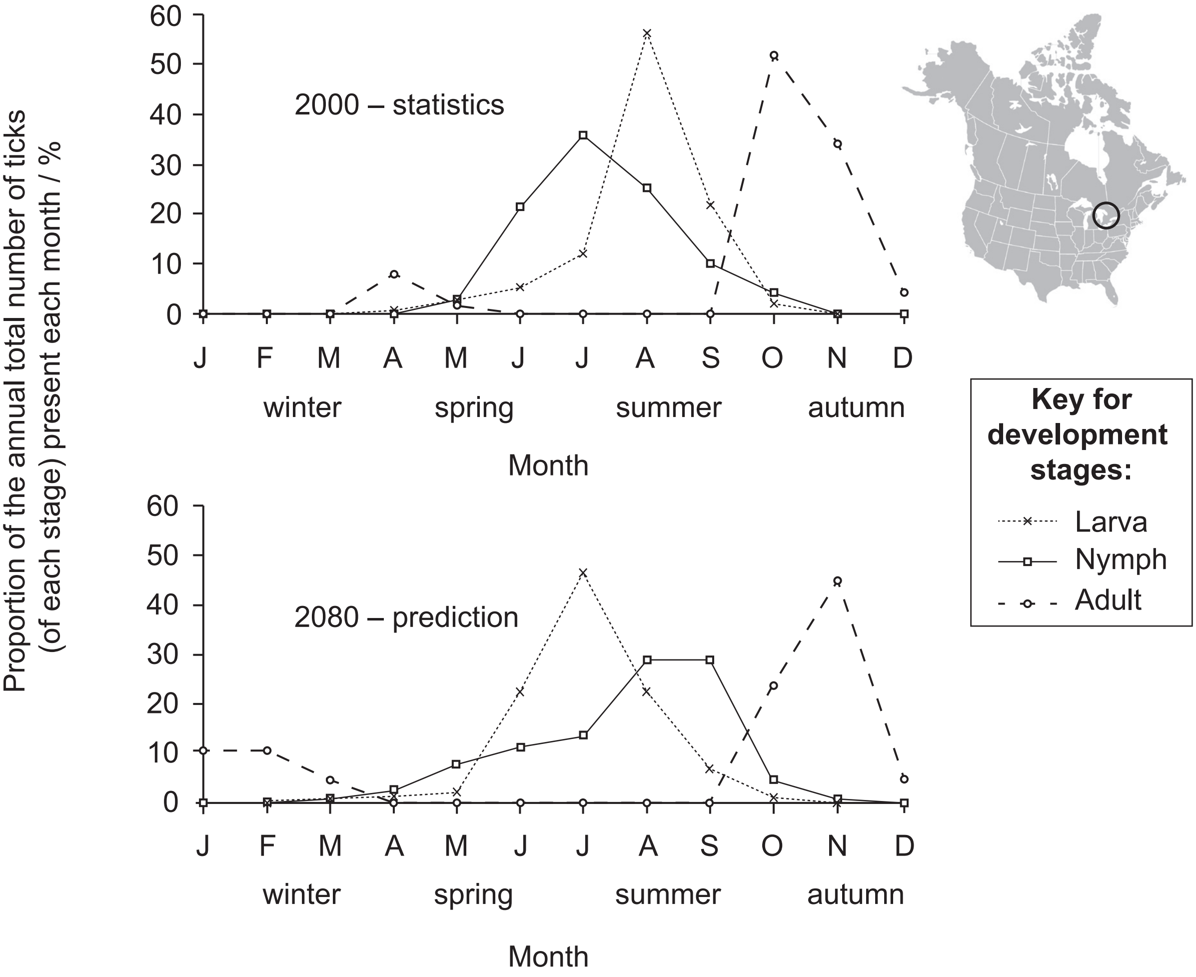
(This question continues on the following page)

Turn over

(Question 1 continued)

Scientists fear that global warming will change the distribution range of ticks.

The graphs show the developmental stages of ticks throughout seasons in a densely human-populated area of south-eastern Canada, surrounded by woods (circled on the map). Values are already established for 2000 and are predicted for 2080.



[Source: reprinted from *International Journal for Parasitology*, **36**(1), N.H. Ogden, A. Maarouf, I.K. Barker, M. Bigras-Poulin, L.R. Lindsay, M.G. Morshed, C.J. O'Callaghan, F. Ramay, D. Waltner-Toews, D.F. Charron, Climate change and the potential for range expansion of the Lyme disease vector Ixodes scapularis in Canada, 63–70, Copyright (2006), with permission from Elsevier]

(c) Identify the month when small birds had the greatest chance of being infected by *B. burgdorferi* bacteria in the year 2000 **and** the month when they would be most likely to become infected according to the 2080 predictions. [1]

2000: . . . .

2080: . . . .

(This question continues on the following page)

(Question 1 continued)

(d) Using the life cycle diagram and the graph for the year 2000, analyse the distribution of adult ticks throughout the different seasons. [2]

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(e) Evaluate the effect of the change in distribution of the different life stages of ticks on the spread of Lyme disease in south-eastern Canada. [3]

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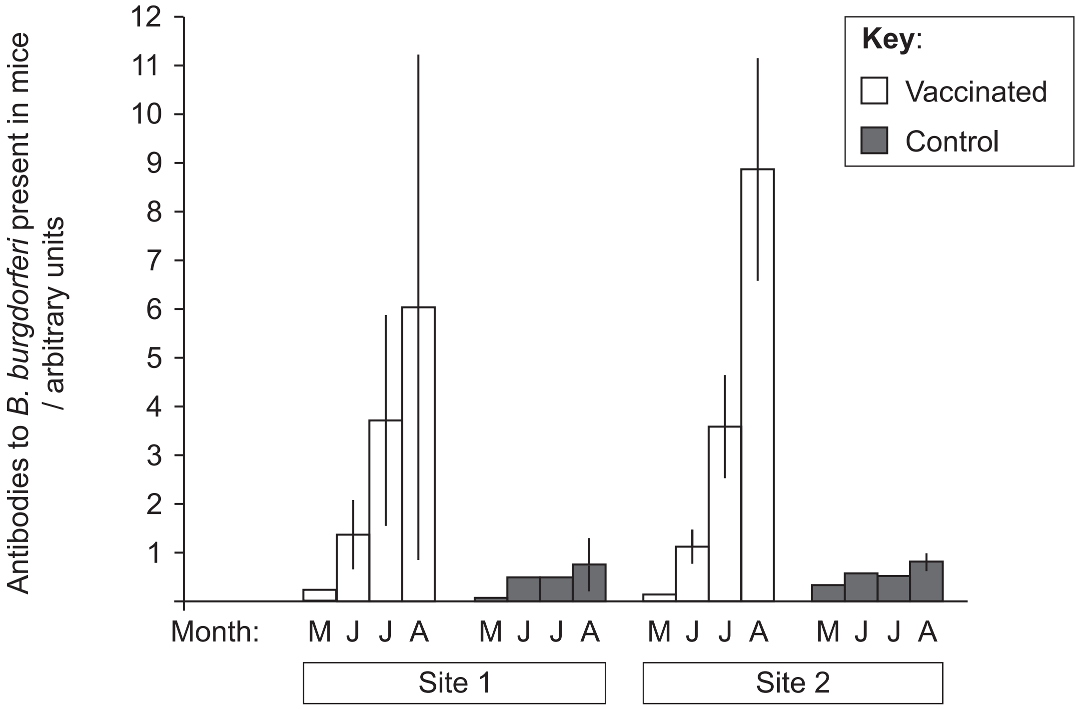
(This question continues on the following page)

(Question 1 continued)

White-footed mice (*Peromyscus leucopus*) in eastern North America's wooded areas often host *B. burgdorferi* bacteria. To determine whether bacterial transmission from mice to tick nymphs could be prevented, mice were vaccinated with antigens from Lyme disease-causing *B. burgdorferi*. Scientists captured wild mice at two different sites in the woods once a month, over 4 months. Each time, they measured the levels of antibodies to *B. burgdorferi* present in the captured and re-captured mice, inoculated all of them, and released them into the woods. The control group was not vaccinated with *B. burgdorferi* antigen.



[Source: Copyright (2004) National Academy of Sciences, U.S.A. An ecological approach to preventing human infection: Vaccinating wild mouse reservoirs intervenes in the Lyme disease cycle, Jean I. Tsao, J. Timothy Wootton, Jonas Bunikis, Maria Gabriela Luna, Durland Fish, Alan G. Barbour, *Proceedings of the National Academy of Sciences* Dec 2004, **101** (52) 18159–18164; DOI: 10.1073/pnas.0405763102]

(f) (i) State the reason for performing the experiment in the months of May to August. [1]

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(This question continues on the following page)

(Question 1 continued)

(ii) Suggest possible reasons for the observed pattern of presence of antibodies in vaccinated mice. [3]

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The summer after vaccination, the prevalence of *B. burgdorferi* infection in tick nymphs collected on mice from the two sites was measured.

	State of infection of tick nymphs with *B. burgdorferi*			
	Site 1		**Site 2**	
Host mice	Infected	Not infected	Infected	Not infected
Control mice	90	315	57	89
Vaccinated mice	87	288	49	121

[Source: Copyright (2004) National Academy of Sciences, U.S.A. An ecological approach to preventing human infection: Vaccinating wild mouse reservoirs intervenes in the Lyme disease cycle, Jean I. Tsao, J. Timothy Wootton, Jonas Bunikis, Maria Gabriela Luna, Durland Fish, Alan G. Barbour, *Proceedings of the National Academy of Sciences* Dec 2004, **101** (52) 18159–18164; DOI: 10.1073/pnas.0405763102]

(g) Analyse the data on the state of infection of tick nymphs with *B. burgdorferi* in control and vaccinated mice. [2]

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(This question continues on the following page)

(Question 1 continued)

(h) Using **all** the data, discuss whether inoculating mice with the antigen to *B. burgdorferi* could be an effective method of controlling the spread of Lyme disease. [3]

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2. The diagram shows one of Thomas Hunt Morgan's crosses of *Drosophila* in the early 20th century.

Parents: Grey body – normal wings heterozygous for both genes × Black body – vestigial wings homozygous for both genes

Offspring:
- Grey body – normal wings n=965
- Black body – vestigial wings n=944
- Grey body – vestigial wings n=206
- Black body – normal wings n=185

Total offspring=2300

(a) State the type of inheritance shown. [1]

. . . .

(b) Identify the recombinants. [1]

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(This question continues on the following page)

(Question 2 continued)

(c) The chi-squared value was calculated as shown. Deduce, with reasons, whether the observed ratio differed significantly from the expected Mendelian ratio. [2]

$$c^{2} = \Sigma \frac{(\text{Observed} - \text{Expected})^{2}}{\text{Expected}} = 1002.6$$

	Probability										
Degrees of freedom	**0.995**	**0.975**	**0.20**	**0.10**	**0.05**	**0.025**	**0.02**	**0.01**	**0.005**	**0.002**	**0.001**
1	0.00004	0.001	1.642	2.706	3.841	5.024	5.412	6.635	7.879	9.550	10.828
2	0.010	0.051	3.219	4.605	5.991	7.378	7.824	9.210	10.597	12.429	13.816
3	0.072	0.216	4.642	6.251	7.815	9.348	9.837	11.345	12.838	14.796	16.266
4	0.207	0.484	5.989	7.779	9.488	11.143	11.668	13.277	14.860	16.924	18.467
5	0.412	0.831	7.289	9.236	11.070	12.833	13.388	15.086	16.750	18.907	20.515
6	0.676	1.237	8.558	10.645	12.592	14.449	15.033	16.812	18.548	20.791	22.458
7	0.989	1.690	9.803	12.017	14.067	16.013	16.622	18.475	20.278	22.601	24.322

3. (a) Describe what is shown in a cladogram. [2]

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(b) Outline how variation in organisms of the same species could lead to natural selection. [3]

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4. (a) (i) State the property of amphipathic phospholipids that enables them to form a bilayer. [1]

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(ii) State the reason cis and trans fatty acids are said to be unsaturated. [1]

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(b) During photosynthesis plants use water in the conversion of light energy to chemical energy.

(i) State the name of this process. [1]

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(ii) Explain how water is used in photosynthesis. [3]

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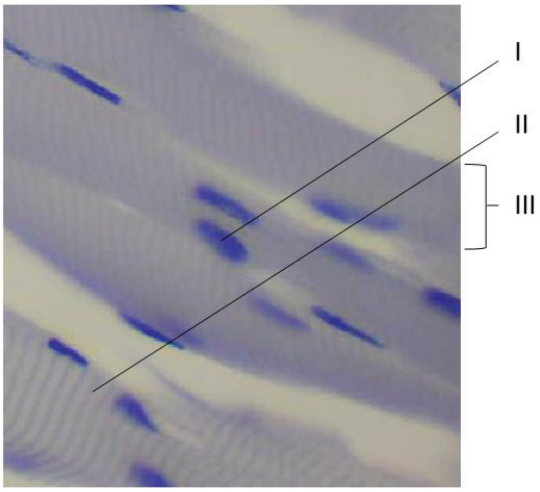
5. This light micrograph shows skeletal muscle.



[Source: adapted from https://en.wikipedia.org/wiki/Skeletal_muscle#/media/File:Skeletal_muscle_%E6%A8%AA%E7%BA%B9%E8%82%8C1.JPG, Urana/ 乌拉跨氪]

(a) Identify

(i) the dark structure indicated by I. [1]

. . . .

(ii) the protein producing the thick filament in the dark band indicated by II. [1]

. . . .

(iii) the structure indicated by III. [1]

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(This question continues on the following page)

(Question 5 continued)

(b) Discuss whether the tissue shown in the micrograph consists of cells or not. [2]

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(c) Explain how calcium is involved in muscle contraction. [3]

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Section B

Answer **two** questions. Up to one additional mark is available for the construction of your answers for each question. Answers must be written within the answer boxes provided.

6. (a) Draw the structure of a section of DNA showing all possible bases. [4]

(b) Outline the structural and genetic characteristics of eukaryotic chromosomes. [4]

(c) Explain how a polypeptide chain is synthesized in a eukaryotic cell. [7]

7. (a) Outline the reasons for the differences in blood concentrations between the renal artery and the renal vein. [4]

(b) Outline how two parents could have a child with any of the four ABO blood groups. [4]

(c) Explain the control mechanism of the heart rate. [7]

8. (a) Draw a half-view of an animal-pollinated flower. [4]

(b) Outline the growth of plant shoot apex. [4]

(c) Explain the movement of energy and inorganic nutrients in an ecosystem. [7]