ASI School ID:

2013 AUSTRALIAN SCIENCE OLYMPIAD EXAMINATION

BIOLOGY – SECTION C

TO BE COMPLETED BY THE STUDENT USE CAPITAL LETTERS

Student Name: ……..…..……

Home Address: ..……..……..

……..... **Post Code:** ……...

Telephone: (…….) …… **Mobile:** …….

E-Mail: …..……... **Date of Birth:** ……/……/...….

□ **Male** □ **Female** **Year 10** □ **Year 11** □ **Other:** …….

Name of School: ……..**State:** ……...

To be eligible for selection for the Australian Science Olympiad Summer School, students must be able to hold an Australian passport by the time of team selection (March 2014).

The Australian Olympiad teams in Biology, Chemistry and Physics will be selected from students participating in the Science Summer School.

Please note - students in Year 12 in 2013 are not eligible to attend the 2014 Australian Science Olympiad Summer School.

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Examiners Use Only:

BIOLOGY

2013 Australian Science Olympiad Examination

Time Allowed:

Reading Time: 10 minutes

Examination Time: 120 minutes

INSTRUCTIONS

- *Attempt all questions in ALL sections of this paper.*
- Permitted materials: Non-programmable, non-graphical calculator, pens, pencils, erasers and a ruler.
- Answer SECTIONS A and B on the MULTIPLE CHOICE and TRUE/FALSE ANSWER SHEETS PROVIDED. Use a pencil.
- Answer SECTION C in the answer booklet provided. Write in pen and use pencil only for graphs.
- Ensure that your diagrams are clear and labelled.
- All numerical answers must have correct units.
- Marks will not be deducted for incorrect answers.

MARKS

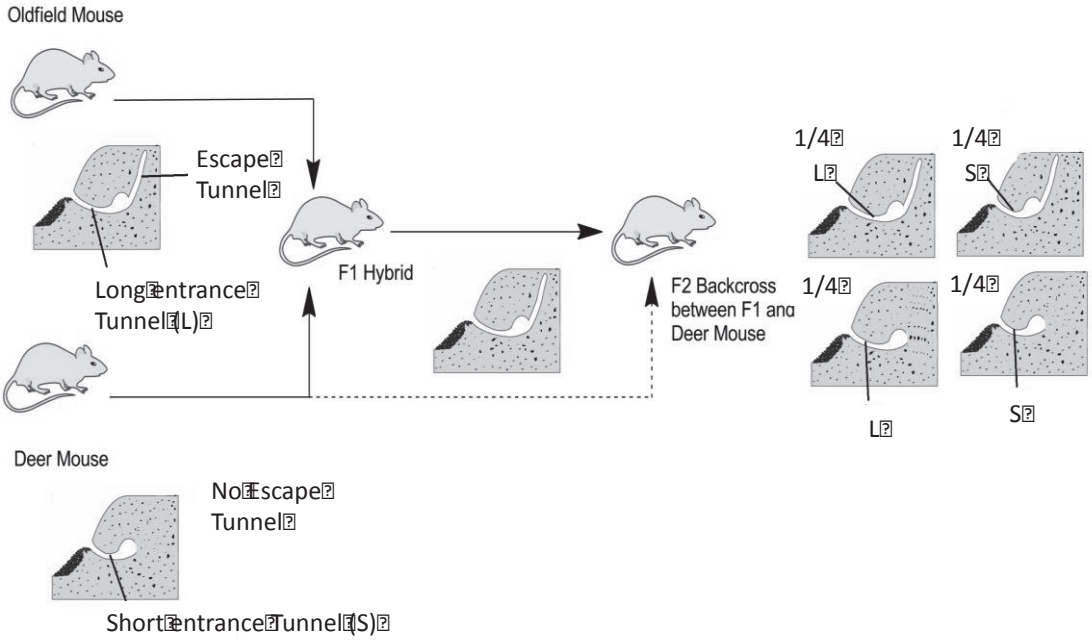
SECTION A	47 multiple choice questions	47 marks
SECTION B	6 sets of true/false questions	9 marks
SECTION C	24 written answer questions	47 marks
	Total marks for the paper	103 marks

SECTION C: WRITE YOUR ANSWERS IN THIS BOOKLET

Use the following information and diagram to answer question 1.

A recent study of the burrowing behaviours of the North American Oldfield and Deer mice (capable of interbreeding) showed that traits such as tunnel length (long/short) and presence of an escape tunnel (present/absent) where determined by discrete genetic factors.

When the F1 offspring of a cross between pure breeding Oldfield (burrows always long with an escape tunnel) and Deer (burrows always short without an escape tunnel) mice parentals, all of which made burrows with long entrances and escape tunnels, were backcrossed with the pure breeding Deer mice parentals, a ratio of 1:1:1:1 (long + escape : long, no escape : short + escape : short, no escape) was observed, as seen in the figure below.



1. What would the phenotype ratio be if the F1 offspring were self-crossed (F1 hybrid crossed with F1 hybrid)? Enter your answer in the box provided below. **(2 marks)**

(long + escape : long, no escape : short + escape : short, no escape)

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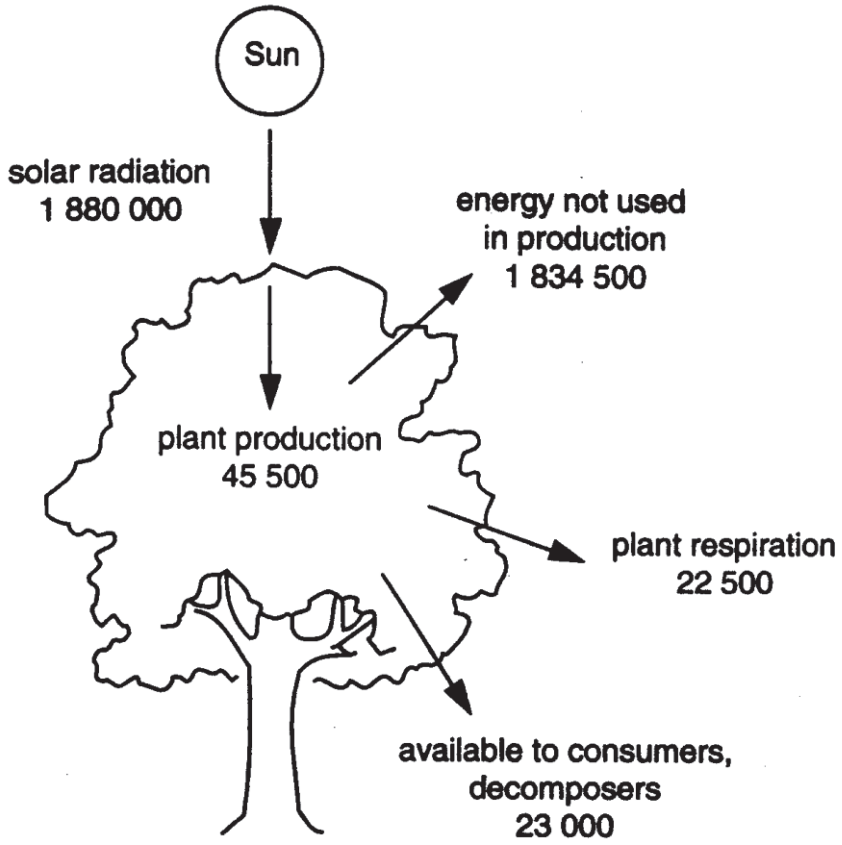
Use the following diagram of energy flow in an ecosystem to answer questions 2 – 5. All figures given are in units of kilojoules per m^2 per year.



2. How much energy enters the system via photosynthesis? **(1 mark)**

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3. What is the efficiency of photosynthesis compared to the input? **(1 mark)**

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4. Plant respiration accounts for 22500 kJm^2y^{-1}. What proportion of primary production is diverted to plant respiration? **(1 mark)**

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5. How is this energy released from the ecosystem? **(1 mark)**

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6. In the space below, draw a diagram of the carbon cycle, which explains the movements of carbon into and out of the atmosphere from major natural carbon pools. **(4 marks)**

7. Explain the interaction (positive feedback) between climate change and sea ice. **(3 marks)**

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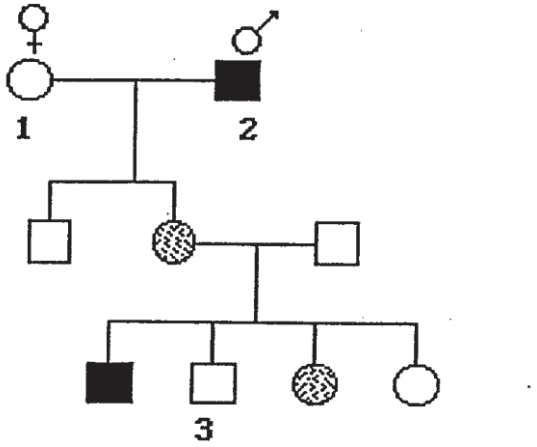
8. A cross was made between two individuals (AAbb and aaBB) and a phenotypically identical F_1 generation was produced. These were 'self crossed' to produce the F_2 generation. Use the space below to work out the possible genotype combinations in the F_2 generation and the expected proportions of each genotype. **(3 marks)**

Possible genotypes of the F_2 generation: _____

Proportions of each genotype:_____

Use the following information to answer questions 9 – 11.

The pedigree below shows the pattern of inheritance for an unusual form of toe curling. Unaffected, affected and slightly affected individuals are represented by white, black and shaded circles/squares respectively.



Using the symbols **T** and **t** for the alleles for normal and curling toe formation respectively. Determine the **genotypes** of the individuals 1 – 3. **(3 marks)**

9. Individual 1 _____

10. Individual 2 _____

11. Individual 3 _____

12. Breeding cattle involves considerable knowledge and understanding of genetics. Hornless cattle are known as 'polled' and this condition is dominant over the development of horns. Coat colour can be red, white or roan (a mixture of red and white patches), and is controlled by a single gene with two allelic variants. The gene for coat colour and the gene controlling the 'polled'/horned phenotype are located on different autosomal chromosomes.

Two roan individuals were mated, both of which were heterozygous for the polled condition. Calculate the probability of producing roan, polled offspring compared with white polled offspring. **(3 marks)**

_____

_____

_____

13. In rabbits, there are four alleles controlling coat colour, which segregate at a single gene locus. These are, in order of dominance, C (black), c^{ch} (chinchilla), c^{h} (himalayan), and c (albino). What Mendelian phenotypic ratio would result from the cross Cc^{h} x $c^{ch}c$? **(2 marks)**

_____

_____

Use the following information to answer questions 14 - 16.

Red blood cell (erythrocyte) production is regulated by an enzyme, renal erythropoietic factor, which is secreted by the kidneys especially when they are deficient in oxygen. The enzyme acts on a plasma protein to convert it to the hormone erythropoietin. This hormone increases the rate of mitosis of the erythrocyte stem cells in the red bone marrow.

Use this information and your own knowledge to explain why:

14. Athletes often spend time at high altitudes before racing or competing. **(3 marks)**

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_____

15. Individuals undergoing renal dialysis are often anaemic. **(2 marks)**

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16. Individuals with liver disease are often anaemic. **(2 marks)**

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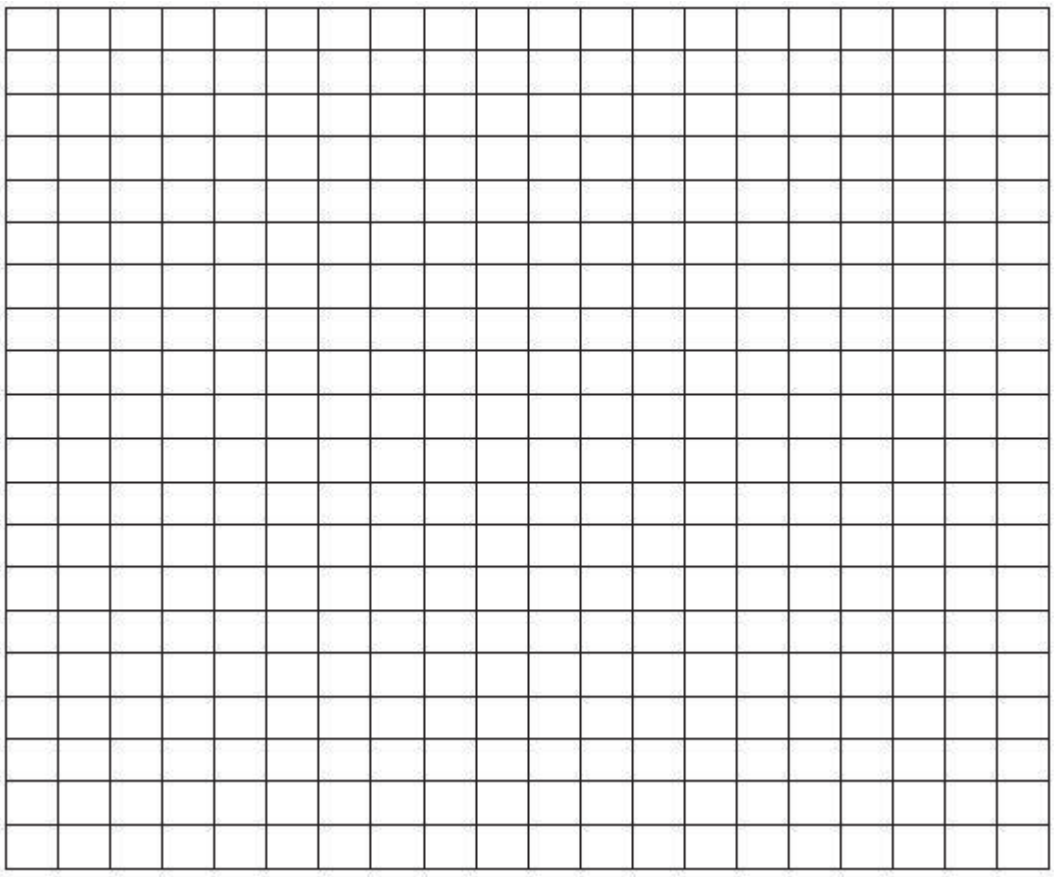
Use the following information to answer questions 17 – 21.

Some air-breathing animals have developed physiological and biochemical mechanisms that allow them to survive while submerged underwater for long periods of time. Breath-holding diving animals use a mechanism that relies on a protein called myoglobin. This protein is located inside muscle cells. In humans it constitutes only a very small percentage of the muscle mass, however this percentage changes dramatically in the animals with the need to hold their breath.

The table below shows the dive time and myoglobin concentration of various mammals.

Mammal	**Average Dive Time (min)**	**Muscle Myoglobin** ($g\ kg^{-1}$)
Northern elephant seal	120	57
Sperm whale	108	54
Weddell seal	65	50
Greenland whale	52	46
Walrus	16	30
California sea lion	10	28

17. Plot the data on the graph provided. Label your axes appropriately. **(5 marks)**



18. What is the relationship between average dive time and muscle myoglobin concentration? (**2 marks)**

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19. A new species of sea otter has been discovered and a muscle biopsy has determined that this otter has a muscle myoglobin concentration of 35 g kg^{-1}. Using your graph determine the expected average dive time for this otter. (**1 mark)**

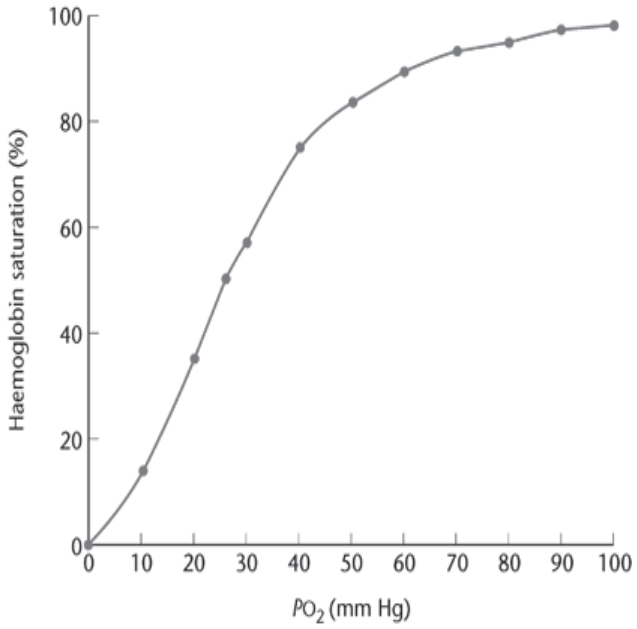
_____

20. Even though different species have different diving capacities, their solutions to the problems associated with diving are similar. How do you propose these animals conserve oxygen whilst diving? (**2 marks)**

_____

_____

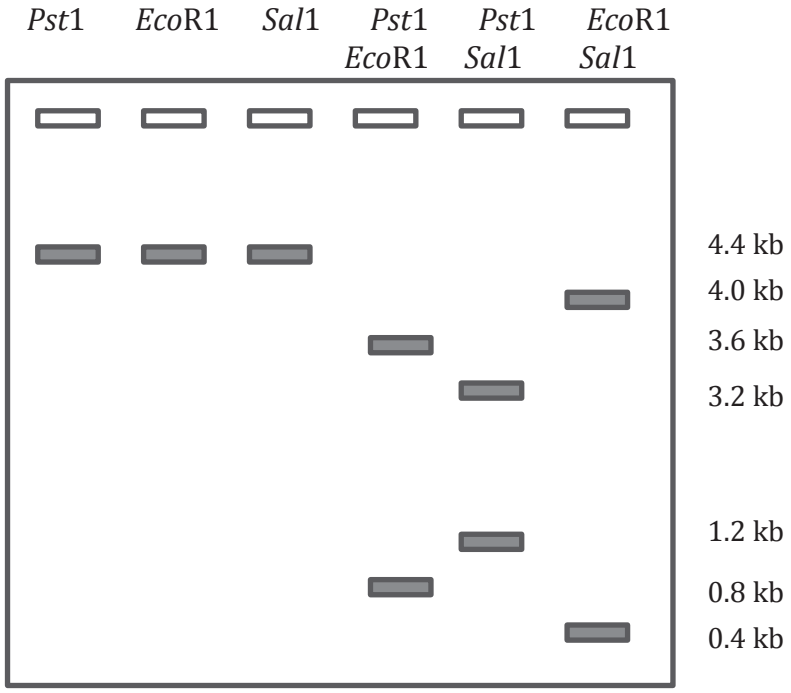
21. Below is a diagram of the oxygen dissociation curve for haemoglobin of a particular mammal. On this graph, plot the oxygen dissociation curve that you would expect myoglobin of the same mammal to exhibit. **(1 mark)**



Use the following information to answer questions 22 – 24.

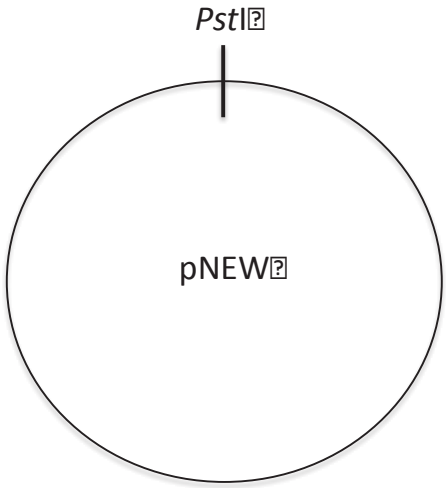
Restriction Endonucleases are enzymes that cut DNA at defined sequences of bases (restriction sites). The following electrophoresis gel resulted from a study of the effects of three restriction endonucleases (*Pst*I, *Eco*RI, and *Sal*I), both alone and in combination, on the plasmid *p*NEW. Labels above the gel indicate which enzymes the plasmid was treated with prior to introduction to the gel; numbers to the right are the estimated sizes, in kilobases (kb), of the DNA fragments comprising each of the bands. Your objective is to use these data to construct a restriction map (a map showing where the restriction sites are located and the distance in kb between them) for *p*NEW.

Note: Plasmids are small, circular DNA molecules.



22. Examine the gel and estimate the total size of the plasmid in kilobases (kb). **(1 mark)**_____

23. In the following map we have arbitarily placed the cut site for *Pst*I at 12 o'clock. Consider the bands resulting from digesting *p*NEW with both *Pst*I and *Eco*RI (well 4). Based on the sizes of these fragments, mark on the map at the expected location of *Eco*RI's restriction site noting the distance in kb between the two sites. Two locations are possible. **(2 marks)**



24. Now, on the same diagram above, mark the location of the *Sal*I restriction site, considering both its distance from the *Pst*I site and the *Eco*RI site. Note the distances in kb between the restriction sites. **(2 marks)**

Integrity of Competition

If there is evidence of collusion or other academic dishonesty, students will be disqualified. Markers' decisions are final