BIOLOGY

2008 National Qualifying Examination

Time Allowed:
Reading Time: 15 minutes
Examination Time: 120 minutes

INSTRUCTIONS

- **<u>Attempt all questions</u>**
- Permitted materials: Non-programmable, NON-GRAPHICAL calculator, pens, pencils, erasers and a ruler.
- Answer SECTIONS A and B on the ANSWER SHEET PROVIDED.
- Answer SECTION C in the answer booklet provided. Write in pen and use pencil only for graphs.

- **<u>Do not write on this question paper. It will not be marked.</u>**
- Particular attention should be paid to giving clear diagrams and explanations.
- 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	17 written answer questions	17 marks
SECTION C	5 written answer questions	36 marks
	Total marks for the paper	**100 marks**

SECTION A: MULTIPLE CHOICE
USE THE ANSWER SHEET PROVIDED

1. Which of the following is the BEST reason for including protein in the diet?

a. Energy for the body.
b. Fibre for digestion.
c. Raw materials for cell growth and repair.
d. Vitamins for fighting disease.

2. Which of the following organisms are used to convert milk into yoghurt?

a. Bacteria.
b. Protozoa.
c. Viruses.
d. Algae.
e. Fungi.

3. The growth of some plants can be improved by spreading bone meal (ground-up bones) around their roots. What does bone meal supply to plants that improves growth?

a. Energy.
b. Minerals.
c. Vitamins.
d. Carbon dioxide.

4. Tissues are found in living things. What is the definition of a tissue?

a. A group of cells with similar structure and function.
b. A group of cells with different structure and function working together.
c. A group of organelles contained inside a cell.
d. The substances that constitute the walls of a cell.

5. Which one of the following characteristics is most likely to be found in mammals that are subject to predation by other mammals?

a. Eyes on the sides of head.
b. Teeth that are long and pointed.
c. Claws on the feet.
d. Ears that cannot move.

6. Which of the following is NOT a function of the blood?

a. Digestion of food.
b. Protection against disease.
c. Transport of waste materials away from the tissues.
d. Transport of oxygen to different parts of the body.

7. Malaria is a disease in humans caused by the protozoan parasite *Plasmodium*, which is transmitted by mosquitoes. The drug chloroquine has been widely used to treat malaria for several decades. Recently, the number of malaria cases not responding to chloroquine has increased.

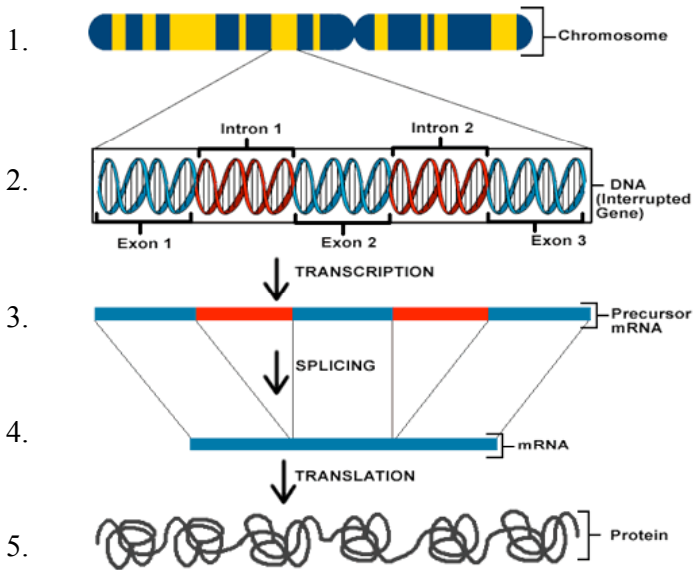
What of the following is the most likely explanation?

a. Malaria sufferers are now excreting chloroquine before it can kill the parasite.
b. Mutations conferring chloroquine resistance now arise more frequently in *Plasmodium*.
c. Chloroquine favours the survival and reproduction of resistant parasites.
d. A new species of *Plasmodium* has emerged.

8. Which of the following features of the platypus is characteristic of mammals?

a. Predation of other animals.
b. Production of milk.
c. Nesting and laying of eggs.
d. Webbed feet.

9. Eukaryotic genes tend to consist of coding regions (exons) and non-coding regions (introns). The figure shows how such a gene leads to the production of a protein.



Which of the following statements is true?

a. Thymine content of (1) and (2) is approximately equal.
b. The process occurring between (2) and (3) takes place in the cytosol.
c. (4) can hybridise with (2).
d. The number of amino acid residues in (5) must equal the number of nucleotide residues in (2).
e. All processes occurring between (3) and (5) take place in the nuclei.

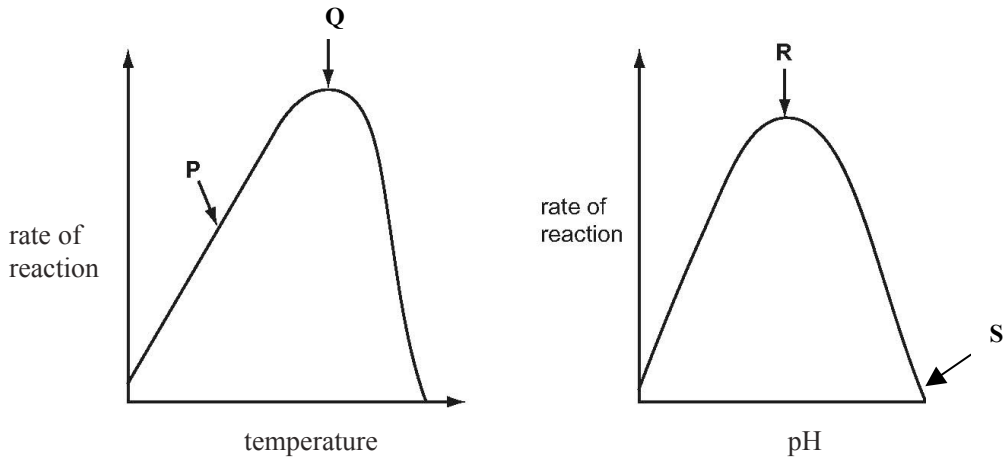
10. Seeds develop from which part of the plant?

a. Flower.
b. Leaf.
c. Root.
d. Stem.

11. When an active muscle cell experiences a shortage of oxygen the pH changes due to the build up of certain by-products of energy metabolism. Which of the following correctly lists the nature of the pH change and the major substance responsible?

	pH change	**substance**
a.	decrease	carbon dioxide
b.	decrease	lactic acid
c.	increase	carbon dioxide
d.	increase	lactic acid
e.	decrease	pyruvate

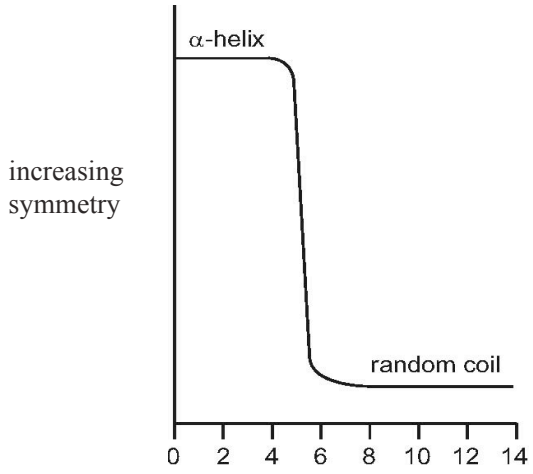
12. The graphs below show the effects of temperature and pH on enzyme activity.



Which statement explains the enzyme activity at the point shown?

a. At P, hydrogen bonds are formed between enzyme and substrate.
b. At Q, the kinetic energy of enzyme and substrate is highest.
c. At R, peptide bonds in the enzyme begin to break.
d. At S, the substrate is completely denatured.

13. The following graph shows the effect of pH on the structure of a protein that consists entirely of repeating residues of a single amino acid.



Which of the following statements is true?

a. At pH2 the protein has lost its secondary structure.
b. At pH2 the protein has lost its tertiary structure.
c. At pH10 the protein has lost its primary structure.
d. At pH10 the protein has lost its secondary structure.

14. The primary reason scientists repeat the measurements they take during experiments is so that they can:

a. check that the equipment is working.
b. list all the results in a table.
c. estimate experimental error.
d. change the experimental conditions.

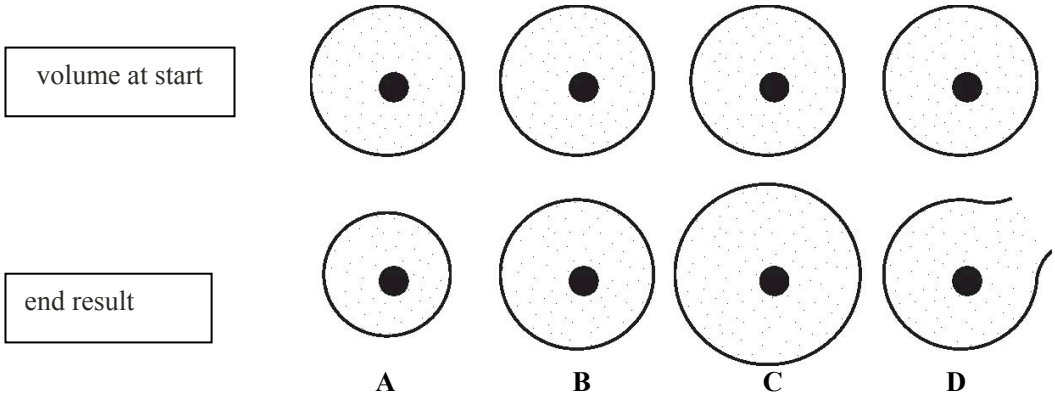
15. The body can reduce local blood flow by constricting blood vessels. This is particularly important in

a. thermal regulation.
b. preventing capillary rupture.
c. absorbing the correct amount of waste carbon dioxide.
d. lengthening the lifespan of red blood cells.
e. keeping the walls of thicker blood vessels elastic, in case of damage.

16. Which of the following characteristics of water makes life on Earth possible?

a. It has a low specific heat capacity.
b. It has a low heat of vaporisation.
c. It has a low relative surface tension.
d. It is found in all three states in the natural environment.
e. The liquid form is denser than the solid.

17. Identical animal cells were placed in solutions of differing water potentials. The diagram shows the volume of the cells at the start and the end of the experiment. Which cell was placed in the solution with the lowest (most negative) water potential?



18. Aldosterone is secreted by the adrenal cortex. It is regulated by ACTH, a hormone secreted by the anterior pituitary gland. Normally, negative feedback occurs where aldosterone inhibits the secretion of ACTH.

Addison's disease occurs when the aldosterone secreting cells of the adrenal cortex are impaired, resulting in lowered aldosterone secretion. Which of the following test results best confirms the presence of Addison's disease?

a. The injection of ACTH fails to increase the secretion of aldosterone.
b. The ACTH level in the blood is low.
c. The level of aldosterone in the blood is low.
d. The administration of aldosterone alleviates symptoms.
e. The removal of the adrenal cortex worsens symptoms.

19. Insulin is an important protein hormone in the regulation of blood glucose levels. Insulin-dependent diabetics are unable to synthesise their own insulin and must rely on the biotechnology industry to produce the insulin they cannot. Mature insulin consists of 2 polypeptide chains linked by several disulfide bonds. To synthesise correctly assembled insulin, the two amino acid chains are generated in separate strains of *E. coli* and purified. The purified chains are then combined under conditions favouring disulfide formation.

Which of the following aspects of insulin structure remain unchanged throughout this process?

a. Primary structure.
b. Tertiary structure.
c. Quaternary structure.
d. All aspects of structure are altered during this process.
e. All aspects of structure remain unchanged during this process but differ from the structure of insulin produced in healthy individuals.

20. The primary production of an ecosystem is the amount of biomass added through photosynthesis, measured in g/m^2/year.

	Average Primary Production (g/m^2/yr)	**Percentage of Total Primary Production of Earth**
Open ocean	125	24
Tropical rainforest	2200	22
Algal beds and reefs	2500	2

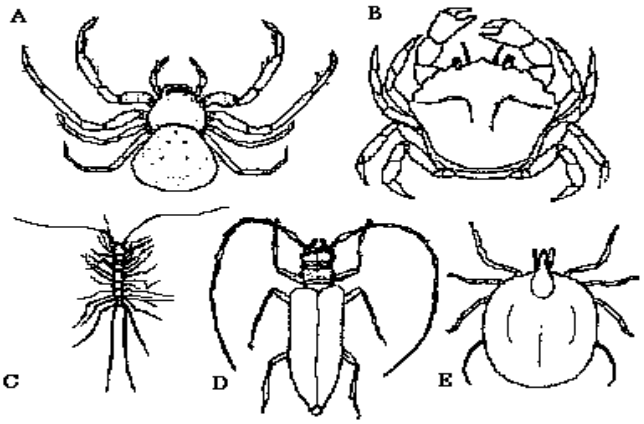
What is the most likely reason for the disparity between the average primary production and the percentage of the total primary production of the earth of the different ecosystems?

a. Cyanobacteria in the ocean can fix carbon into biomass at very high rates.
b. Algae fix carbon very slowly.
c. Algae fix carbon at the highest rates.
d. Algal beds make up a much lower proportion of the total surface area of the earth than the open ocean.
e. Phytoplankton in the ocean have a very high turnover rate.

21. The proportion of adenine bases in a sample of DNA was found to be 12%. Which of the following statements is true? The proportion of:

a. uracil bases in the sample is 12%.
b. uracil bases in the sample is 88%.
c. thyroxine bases in the sample is 12%.
d. cytosine bases in the sample is 38%.
e. cytosine bases in the sample is 12%.

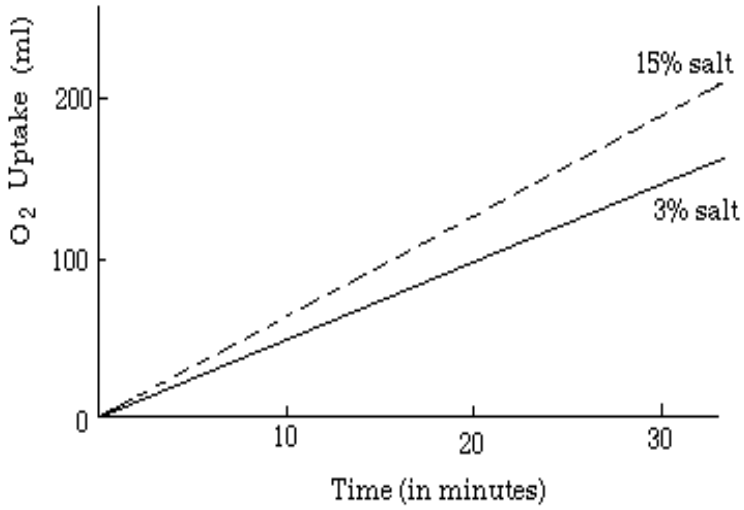
22. Consider the following diagrams:



Which of the specimens shown above is most closely related to specimen **E**?

a. Specimen **A**.
b. Specimen **B**.
c. Specimen **C**.
d. Specimen **D**.

23. An investigator measured the amount of oxygen used by brine shrimps living in 3% and 15% salt solutions. The results are presented in the graph below.



The investigator also made the following observations:

- Brine-shrimp living in 15% salt solution were less active than those in 3% salt solution.
- The animals grew less rapidly in the 15% salt solution.
- Females living in 3% salt solution produced more eggs.

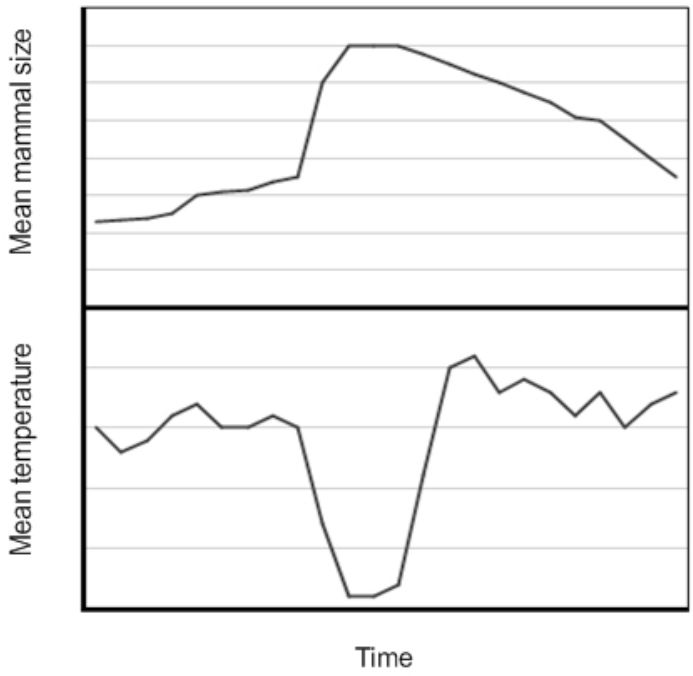
What hypothesis was being investigated?

a. Brine-shrimp have the ability to maintain a uniform internal concentration of salt.
b. The cells of the brine-shrimp performing the work of active transport require extra oxygen.
c. Brine-shrimp living in a 15% salt solution pump water instead of pumping salt.
d. A 15% salt solution contains less dissolved oxygen than 3% salt solution.

24. In the 1960s the drug *cholesterlower*, after the usual period of carefully monitored clinical trials, was declared by its manufacturers to be safe and very effective at lowering cholesterol levels in the blood. The World Health Organisation carried out exactly the same kind of trial on the drug but for a much longer period than the usual five years. The results in 1980 showed that the mortality rate from all causes was 25% higher for those on *cholesterlower* than for those who, though similar in other respects, had not taken the drug. Which of the following is a conclusion that can be drawn from the above passage?

a. The five-year trial period may not be sufficient to identify all drug side effects.
b. Taking *cholesterlower* reduces life expectancy by 25%.
c. *Cholesterlower* is less effective at reducing cholesterol levels than was at first thought.
d. After the original trials, the manufacturers concealed the side effects of *cholesterlower*.
e. The monitoring programme instigated by the World Health Organisation was carried out efficiently.

25. A study investigating the factors contributing to evolutionary changes in animal size was conducted. The mean size of all mammals in a region of North America was calculated (using data from the fossil record) for a period of 10 million years. The temperature in the region was also calculated and graphs representing the findings are shown below.



Which of the following is the most likely explanation of the trend evident in the graphs?

a. Larger animals can more easily avoid predation, thus having a selective advantage during cold periods when food is scarce.
b. Larger animals produce less CO_2 through respiration, which contributes to low atmospheric CO_2 levels and decreases global temperature.
c. The cold climate stimulates animals to grow larger, a characteristic they then pass on to their offspring.
d. Larger animals use energy to heat themselves more efficiently and have a selective advantage during cold periods.
e. The increased surface area to volume ratio of larger mammals gives them a selective advantage during cold periods.

26. What is the primary function of large leaves found on seedlings growing on the forest floor?

a. Provision of shade for their root systems.
b. Elimination of excess water that is entering via the roots.
c. To allow for leaf damage by insects.
d. Acquisition of as much light as possible for photosynthesis.

Use the following information to answer questions 27-29.

A microbiologist was testing the effect of antibiotics on one strain of pathogenic bacteria. She plated out the bacteria on a suitable agar medium and placed small discs soaked in antibiotic solutions of equal concentration on the agar. She then incubated the plates under matched conditions and measured the region of no growth surrounding the discs. The following results were obtained.

Antibiotic	**Diameter of zone with no bacterial growth (mm)**		
	Experiment	Positive control	Negative control
1	8	22	2
2	19	23	0
3	15	21	1
4	9	24	3
5	10	23	2

27. Which antibiotic appears to be the most effective?

a. 1
b. 2
c. 3
d. 4
e. 5

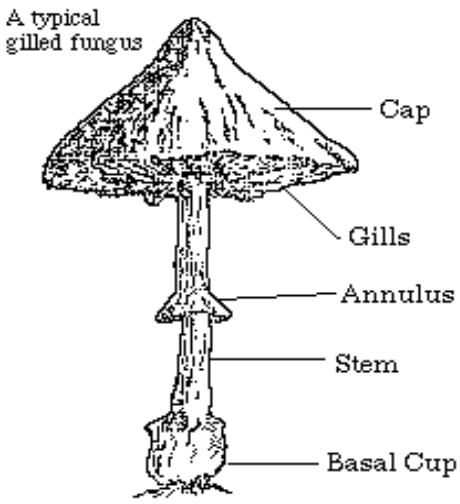
28. What would be a suitable negative control for this experiment?

a. Antibiotic discs but no bacteria.
b. Antibiotic discs and a different, antibiotic-resistant strain of bacteria.
c. Discs soaked in a harmless solution and the same strain of bacteria.
d. Discs soaked in a known toxic solution and the same strain of bacteria.
e. Antibiotic discs and yeast.

29. There is at least one variable that the microbiologist has not controlled in this experiment. What is it?

a. The amount of antibiotic applied to the agar.
b. The strain of bacteria used.
c. The temperature at which the plates were incubated.
d. The rate at which the antibiotic solutions diffuse through the agar.
e. The amount of moisture available to the bacteria.

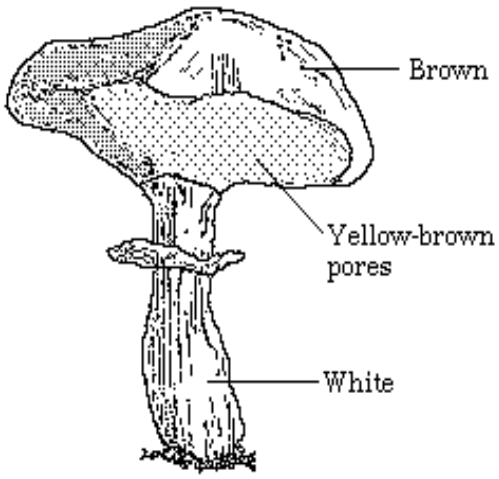
30. Consider the following diagram and key:



The following key has been devised for a group of toadstool fungi.

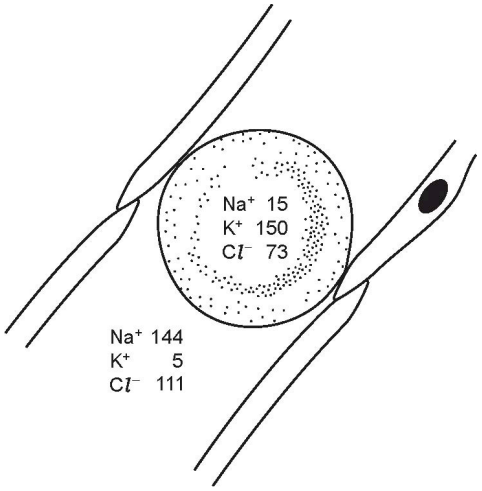
1a	Gills present under cap	2
1b	Gills not present under cap	5
2a	Basal cup absent	3
2b	Basal cup present	4
3a	Gills pink, turning brown	*Psalliota campestris*
3b	Gills not as above	*Lepiota gracilenta*
4a	Cap red with white flecks	*Amanita muscaria*
4b	Cap white	*Rozites australiensis*
5a	Annulus present	*Boletus elegans*
5b	Annulus absent	*Hydnum repandum*

Using the above key the following specimen may be identified as:



a. *Lepiota gracilenta.*
b. *Amanita muscaria.*
c. *Rozites australiensis.*
d. *Boletus elegans.*
e. *Hydnum repandum.*

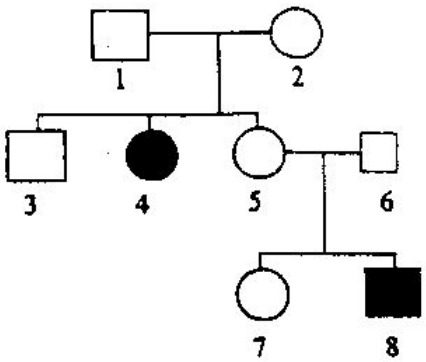
31. The diagram shows a red blood cell and the concentrations of ions, in mmol dm^{-3}, in the plasma and the cell.



Which ions are actively transported into and out of the cell?

	into cell	out of cell
a.	Cl^-	K^+
b.	K^+	Na^+
c.	Na^+	Cl^-
d.	Na^+	K^+

32. Use the pedigree below showing the inheritance of a recessive characteristic in a family.

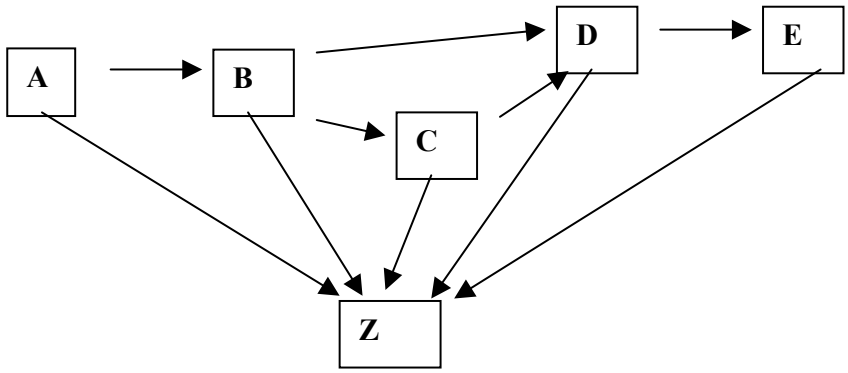


Which one of the lists given in the answer key below contains individuals in this pedigree who are definitely heterozygous for the recessive characteristic?

a. 1, 2 and 7.
b. 3, 6 and 7.
c. 1, 3 and 6.
d. 1, 5 and 6.

Use the following information to answer the questions 33-34.

The diagram below shows a food web. Arrows represent the direction of energy flow and a different letter represents each species.



Answer key	Type of organism
a.	Primary consumer
b.	Primary producer
c.	Tertiary consumer
d.	Herbivore
e.	Decomposer

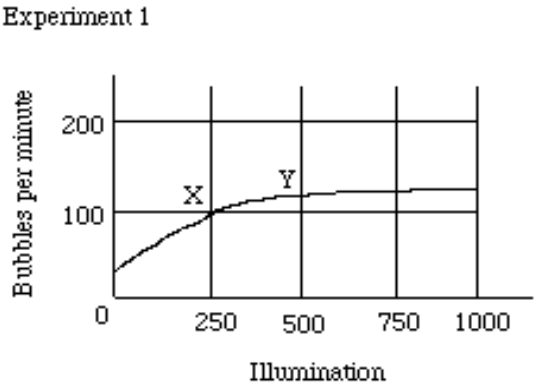
33. Which answer most correctly describes the role of organisms **D** ? Select your response from the above key.

34. Which answer most correctly describes the role of organisms **Z**? Select your response from the above key.

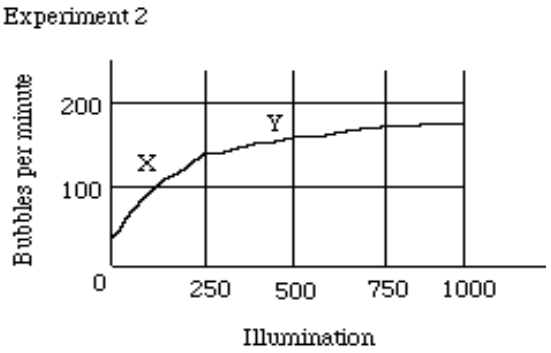
35. When pure breeding black Andalusian chickens are crossed with pure breeding white Andalusian chickens the first generation offspring are all grey in colour (known as 'blue' Andalusians). What is the expected phenotypic ratio when two of these 'blue' Andalusians are mated and produce offspring?

a. 25% grey, 50% black, 25% white.
b. 50% black, 50% white.
c. 25% black, 50% grey, 25% white.
d. 50% black, 50% grey.

36. A few shoots from the water plant, *Elodea,* were placed upside down in water and illuminated. Bubbles of constant size that were emitted from the leaves and stem were counted and the rate of bubble formation calculated at various light intensities. The results are summarised in the following figure.



The above experiment was repeated but a strong bicarbonate solution was added to provide an excess of CO_2. The results are shown in the following figure.



What does experiment **2** tell us about experiment **1**?

a. CO_2 is the limiting factor at **X** in experiment **1**.
b. Light can be made to be limiting by decreasing other factors.
c. Temperature is limiting at **Y** in experiment **2**.
d. CO_2 is limiting at **X** in experiment **2**.

37. A scientific study seeks to establish the optimum water temperature for growing trout under farming conditions. Which of the following factors is likely to be an unavoidable source of experimental error?

a. Length of study being curtailed by trout lifespan.
b. Death of trout at extremely high or low temperatures.
c. Cost of keeping trout tanks at different temperatures.
d. Variation of optimum temperature between individuals.
e. Obtaining accurate measurements of trout growth.

Use the following information to answer the questions 38-39

The gag reflex is a reflex contraction of the muscles of the throat, which stops material from entering the throat (except in swallowing) and helps to prevent choking. The sensory nerve in this reflex is the glossopharyngeal nerve, and the motor nerve to the throat muscles is the vagus nerve. For questions **38-39**, match the correct label to the components of the gag reflex. Each may be used once, more than once or not at all.

a. Afferent limb
b. Efferent limb
c. Integrator
d. Signal
e. Receptor

38. Glossopharyngeal nerve.

39. Pressure sensors in the throat.

40. Periodically, the sun develops relatively cool dark areas known as sunspots. Scientists have found that periods of high sunspot activity coincide with stormy periods on Earth. Hence sunspots cause storms on Earth. Which of the following is the best statement of the flaw in the argument above?

a. It disputes the fact that storms are the result of low-pressure systems in the Earth's atmosphere.
b. It ignores the influence of periods of low sunspot activity on Earth's weather systems.
c. It assumes that because sunspots and storms occur at the same time, sunspots cause storms.
d. It overlooks the fact that there is always a storm somewhere on Earth.
e. It ignores the fact that there are stormy periods in some areas but not in others while there is sunspot activity.

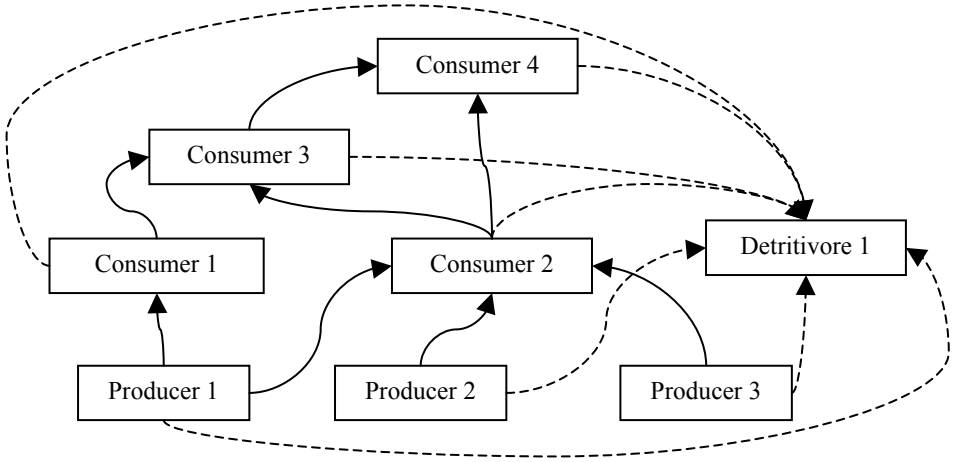
41. A DNA segment has this nucleotide sequence:

A A G C T C T T A C G A A T A T T C

Which mRNA sequence is complementary to this sequence?

a. A A G C T C T T A C G A A T A T T C
b. T T C G A G A A T G C T T A T A A G
c. A A G C U C U U A C G A A U A U U C
d. U U C G A G A A U G C U U A U A A G

42. The diagram below represents the relationships between organisms in a remote pond ecosystem.



From this information which of the following is the most likely to be correct?

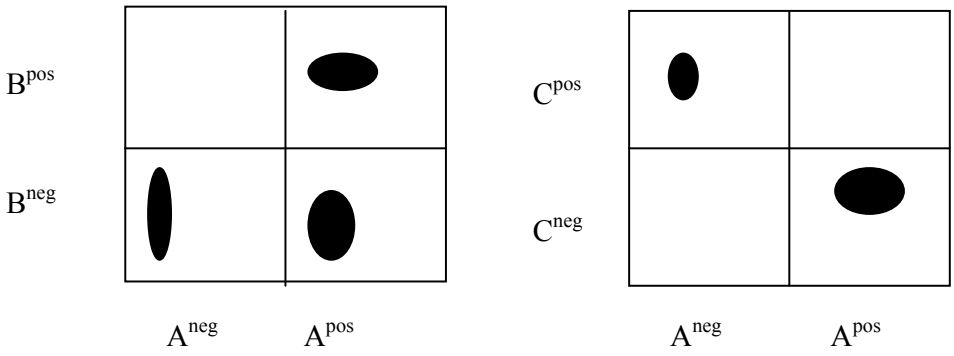
a. DDT introduced to the ecosystem would be in highest concentration in the tissues of Detritivore 1.
b. The introduction of consumer 4 individuals from an external population would lead to a temporary increase in numbers of producer 2.
c. Disease in the producer 1 population would lead to an increase in the producer 3 population.
d. Extermination of consumer 3 would cause a sustained increase in the population of consumer 2.
e. Consumer 1 is more adaptable with regards to its food source than consumer 3.

43. In humans, the hormone insulin is secreted by the pancreas in response to increased blood glucose levels. Insulin helps cells take up glucose from the bloodstream. Type II diabetes is a condition where body cells lose their sensitivity to insulin.

How will a person with type II diabetes respond to a rise in blood glucose?

	Blood insulin levels
a.	No change
b.	Increase
c.	Decrease

44. Different types of cells from the same organism can be distinguished by the different proteins they produce. Scientists often use these differences to identify subtly different cell types that look morphologically identical. The figure below shows two graphs representing the presence of particular proteins on the surface of a heterogenous cell population isolated from the blood. For example the graph on the left depicts three distinct cell subsets within the population; cells lacking both protein A and protein B ($A^{neg}B^{neg}$), cells with protein A but not protein B ($A^{pos}B^{neg}$) and cells with both protein A and protein B ($A^{pos}B^{pos}$). The plot on the right depicts the same cell population but is looking at the protein markers A and C.



From the information provided which of the following is true of this cell population?

a. There is a cell subset which is $A^{neg}B^{neg}C^{neg}$.
b. All B^{neg} cells are C^{pos}.
c. There is a cell subset positive for all three proteins.
d. All B^{pos} cells are C^{neg}.
e. There are more B^{neg} cells than B^{pos} cells.

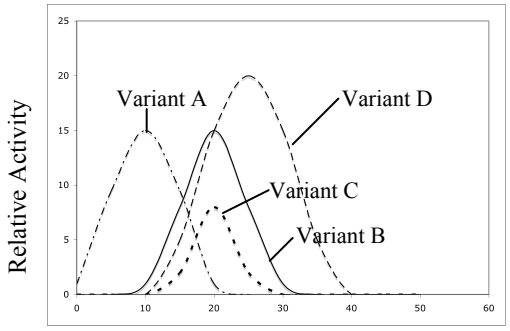
45. Consider the following key:

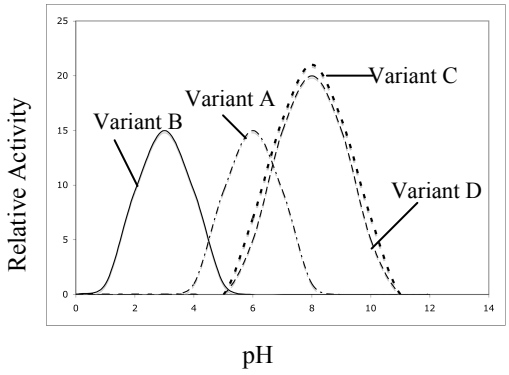
1a	Wings present	2
1b	Wings absent	Order Apterygota
2a	With one pair of wings	Order Diptera
2b	With two pairs of wings	3
3a	Front wings of coarser texture than hind wings	4
3b	All wings membranous. May be hair or scale covered	8
4a	Basal two-thirds of front wing thickened, remainder membranous	Order Hemiptera
4b	Whole of front wing of same texture	5
5a	Front wings hard and horny	Order Coleoptera
5b	Front wings slightly thickened with distinct veins	6
6a	Mouthparts of piercing type	Order Hemiptera
6b	Mouthparts of biting type	7
7a	Hind legs much longer than other legs	Order Orthoptera
7b	All legs more or less equal in length	Order Blattodea
8a	Wings and body completely covered by fine scales or hairs	Order Lepidoptera
8b	Wings without scales or hairs	9
9a	Hind and front wings linked by a row of hooks. Front of abdomen narrowed to form a 'waist'	Order Hymenoptera
9b	Wings not joined. No 'waist'	Order Odonata

Lepidoptera would have the following characteristics:

a. two pairs of membranous wings covered in fine scales.
b. one pair of membranous wings lacking scales or hairs.
c. two pairs of wings, the front pair being of coarse texture.
d. two pairs of membranous wings which are not hooked together and lack hairs or scales.

46. The enzyme subtilisin is a protease, originally found in the bacteria *Bacillus subtilis*, that is produced in vast quantities annually for use in laundry powders (Have you ever wondered about the mysterious "enzymes" mentioned in all those laundry powder ads?). In order to generate washing powders that work over a range of different conditions, subtilisin has been the focus of many protein engineers attempting (and succeeding) to create subtilisin variants that have optimal activity in conditions other than those naturally occurring in *B.subtilis*. The graphs below show the activities of engineered subtilisin variants over a range of temperatures and pH.





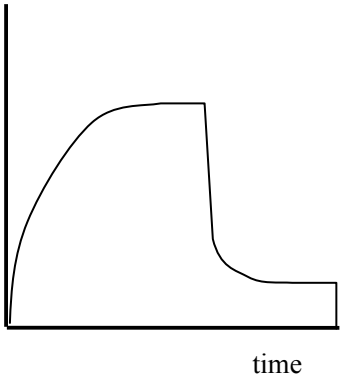
Which variant would be most appropriate for use in a cold water laundry detergent at 20°C?

a. A.
b. B.
c. C.
d. D.

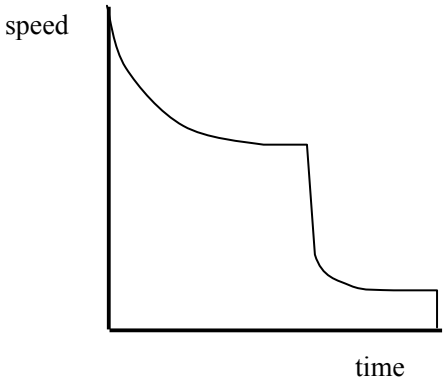
47. When an elephant jumps off a *very* tall platform, it initially gains speed rapidly. Its acceleration decreases due to air resistance until it reaches terminal velocity. The elephant then falls at this velocity until it opens its parachute. The parachute slows down the elephant until it reaches a new steady speed, which it maintains until it reaches the ground.

Which of these graphs shows this?

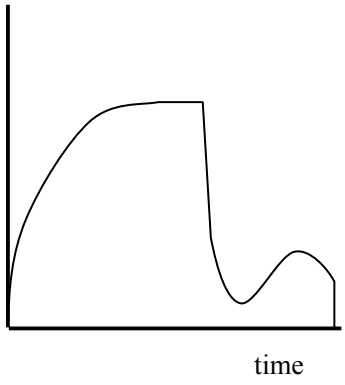
a.



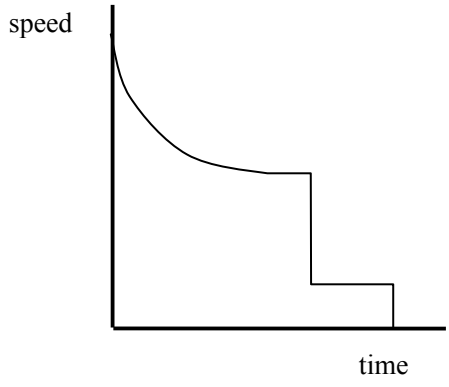
b.



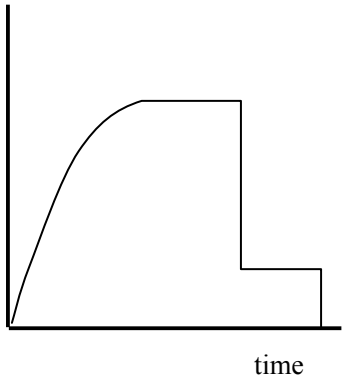
c.



d.



e.



END OF SECTION A

SECTION B: SHORT ANSWER QUESTIONS
USE THE ANSWER SHEET PROVIDED TO WRITE YOUR ANSWER
DO NOT USE THE ANSWER BOOKLET

48. (1 mark) What percentage of offspring from an AaBB x aaBb cross will be either AaBb OR aaBB? Write your answer as a percentage on the section B answer sheet.

49. (1 mark) Penetrance refers to the proportion of individuals of a given genotype who display the associated phenotype. For example in a particular plant seed coat colour can be either brown or red. The brown phenotype is seen in all individuals with genotypes RR or Rr and 40% of individuals with genotype rr. The remaining 60% of individuals with genotype rr have the red phenotype. Red seed coat is therefore said to be 60% penetrant.

What proportion of the seeds resulting from the crossing of genotype Rr with Rr would have brown seed coats? Write your answer as a percentage on the section B answer sheet.

50. (1 mark) Tinkerbell has 2 pigs. She estimates the weight of one as being 85 kg and the other as about 72 kg. She has ready access to a cheap source of potatoes but wishes to feed her pigs a 50/50 nutritional mix of potatoes and meal. Two tables from her feed book are reproduced below.

State of pig	*Amount of meal to feed each day(for feeding meal alone)*
80 kg bacon weight	2.5 kg
60 kg -80 kg	2.0 kg
50 kg -60 kg	1.8 kg
40 kg -50 kg	1.6 kg
30 kg -40 kg	1.4 kg
20 kg -30 kg	1.0 kg
Weaners 8 10 weeks	Up to 1.0 kg
Weaners 6 weeks to weaning	250 g -350 g

Nutritional equivalents to 1 kg of meal	
Carrots	8 kg
Comfrey	5 kg
Grass	5 kg
Kale	7 kg
Potatoes	5 kg
Skim milk	6 litres
Swedes	8 kg
Whey	9 -10 kg

How much meal should Tinkerbell feed her pigs each day? Calculate an amount in kg that would be sufficient to feed both pigs. Write your answer on the section B answer sheet.

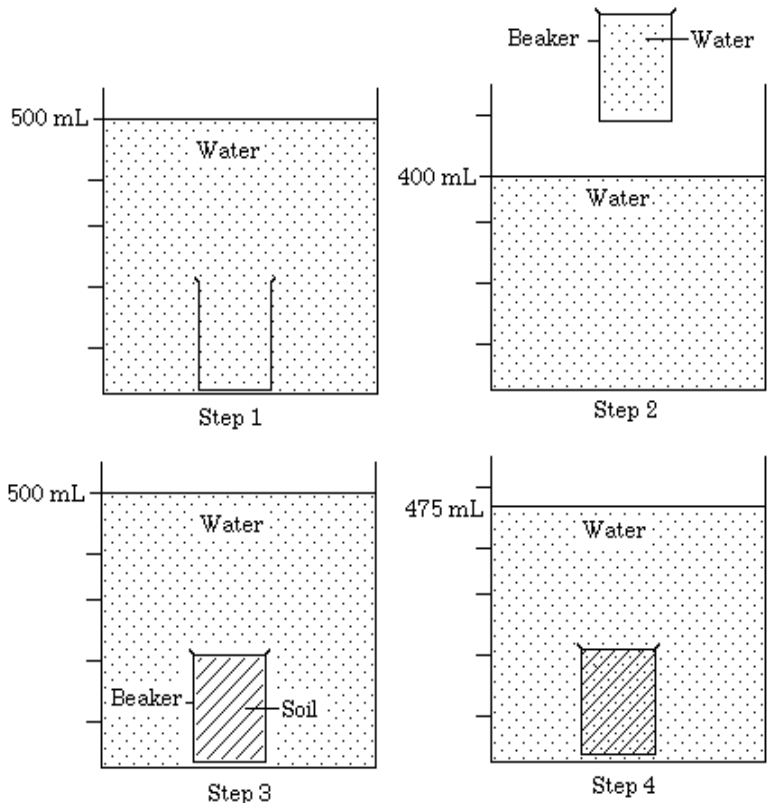
51. (1 mark) An organism that reproduces sexually has the genotype AaBbCcDd. How many unique haploid gametes can this organism generate? Write your answer as a whole number on the section B answer sheet.

52. (1 mark) Farmer Pan is planning to use a 10 acre field to supply winter silage for his cattle and hay for his sheep. He reckons to get 100 bales of hay from each acre. Before cutting the hay he will first cut an acre round the edge of the field as silage. This allows him to manoeuvre his hay making machinery. After making his hay in June he will cut the whole field as second cut silage in August and again as third cut silage in September. His farm manual provides the following information.

How many bales of silage will Farmer Pan have at the end of his harvest? Write your answer as a whole number on the section B answer sheet.

	As silage	**As hay**
First cut	7 bales per acre	100 small bales per acre
Second cut	5 bales per acre	Not applicable
Third cut	4 bales per acre	Not applicable

53. (1 mark) To measure the amount of air in soil, four steps were followed as illustrated in the diagram below, using identical beakers throughout.

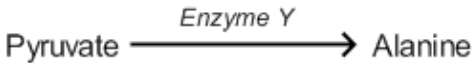


Calculate the % (by volume) of air in the soil sample. Write your answer as a percentage on the section B answer sheet.

Use the following information to answer the questions 54-59.

An experiment is set up to test if chemical X is mutagenic.

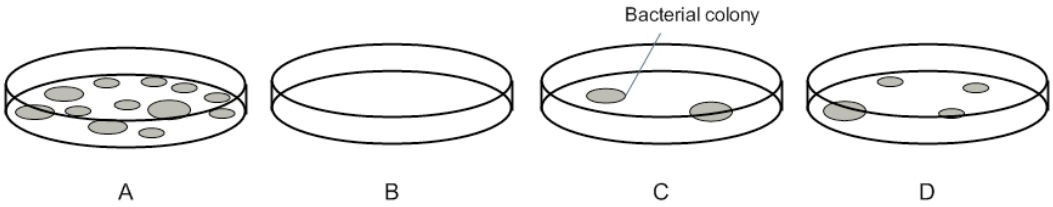
Alanine is an amino acid that is essential for bacterial growth. Many bacteria can synthesise alanine from pyruvate as shown by the reaction below:



A particular strain of *Escherichia coli* has a point mutation in the gene that codes for enzyme Y, which makes the enzyme non-functional. This strain of *E. coli* was inoculated onto agar plates and incubated for 24 hours. Additional chemicals were added as shown below.

Plate A – Alanine and pyruvate
Plate B – Pyruvate only
Plate C – Pyruvate and a known mutagen
Plate D – Pyruvate and chemical X

After incubation the plates were removed and inspected. The results are represented in the diagram below:



54. (1 mark) Which of the plates serve(s) as a positive control? Write your answer on the section B answer sheet.

Decide whether the following statements are true (T) or false (F). Mark the answer sheet either T or F.

55. (1 mark) The growth on plate A indicates that alanine is a potent mutagen.

56. (1 mark) On plates C and D, colonies grow only when a mutation has occurred in the faulty gene for enzyme Y.

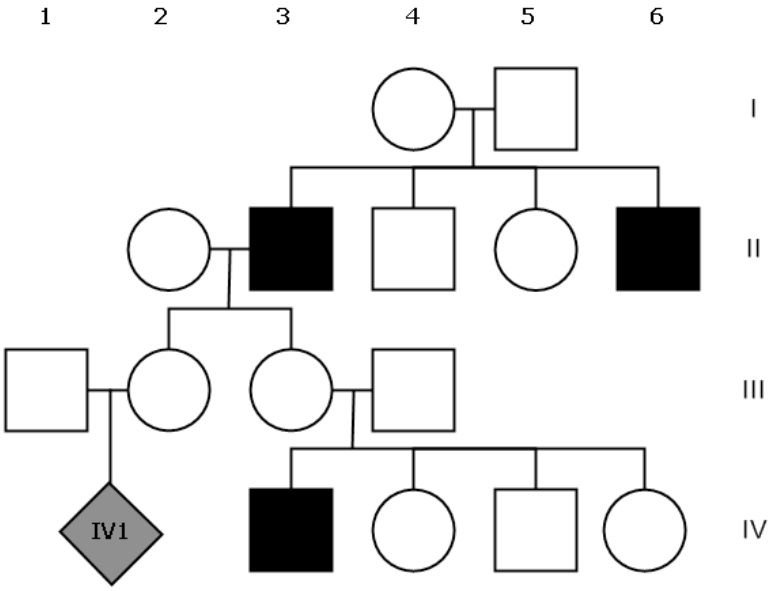
57. (1 mark) The difference in number of colonies on plates C and D must be due to differing concentrations of the mutagens.

58. (1 mark) Plate B is unnecessary for the purposes of this experiment.

59. (1 mark) Repetition would improve the accuracy of the results.

Use the following information to answer the questions 60-64.

Below is a pedigree showing members of a particular family affected by a disease that can lead to kidney failure.



By examining the pedigree, determine whether the following statements are true or false. For questions 60-62, mark the answer sheet either T or F.

60. (1 mark) The lack of affected individuals in generations I and III indicates the disorder arises from a spontaneous mutation.

61. (1 mark) There is sufficient information to conclude that the trait is X-linked.

62. (1 mark) Individual III3 is heterozygous for the trait

63. (1 mark) Assuming that the trait is X-linked, determine the probability that individual IV1 (sex unknown) is affected by the disorder. ***Write your answer as a decimal fraction on section B answer sheet.***

64. (1 mark) Assuming that the trait is X-linked, determine the probability that individual IV1 (sex unknown) is a carrier of the disorder. ***Write your answer as a decimal fraction on the section B answer sheet.***

SECTION C: SHORT ANSWER QUESTIONS
USE THE ANSWER BOOKLET PROVIDED TO WRITE YOUR ANSWER

65. (19 marks total) During photosynthesis, plants use light energy to incorporate carbon, sourced from CO_2, into glucose molecules. Photosynthesis can be studied by providing radioactive CO_2 (labelled with carbon-14) to plants and determining the amount of radioactive carbon present in plant tissue.

A healthy plant was kept for 24 hours in an enclosed environment at constant temperature and humidity, with a constant supply of oxygen and radioactive CO_2. The apparatus was set up near a window so the plant would be exposed to natural light.

Leaf samples were taken at 3 hour intervals and the amount of radioactivity present determined. The results are shown below.

Time point (hours)	Radioactivity in leaf tissue (counts per minute)
0	67
3	88
6	124
9	153
12	161
15	159
18	157
21	155
24	181

a. **(5 marks)** Plot the data in the table above on the axes provided.

b. **(1 mark)** Approximately what range of time points corresponds to night time?

c. **(3 marks)** Describe and explain the shape of your graph during the time period in part b.

d. **(2 marks)** The experiment is repeated using a similar plant, the leaves of which have been smeared with oil before the experiment starts. *On your graph,* draw and label a line to show the level of radioactivity in leaf tissue under these conditions for the same time period.

e. **(4 marks)** In another experiment, radioactive water (where the oxygen atoms were radioactively labelled) was added to plants. No radioactivity was detected in leaves. How might you account for this?

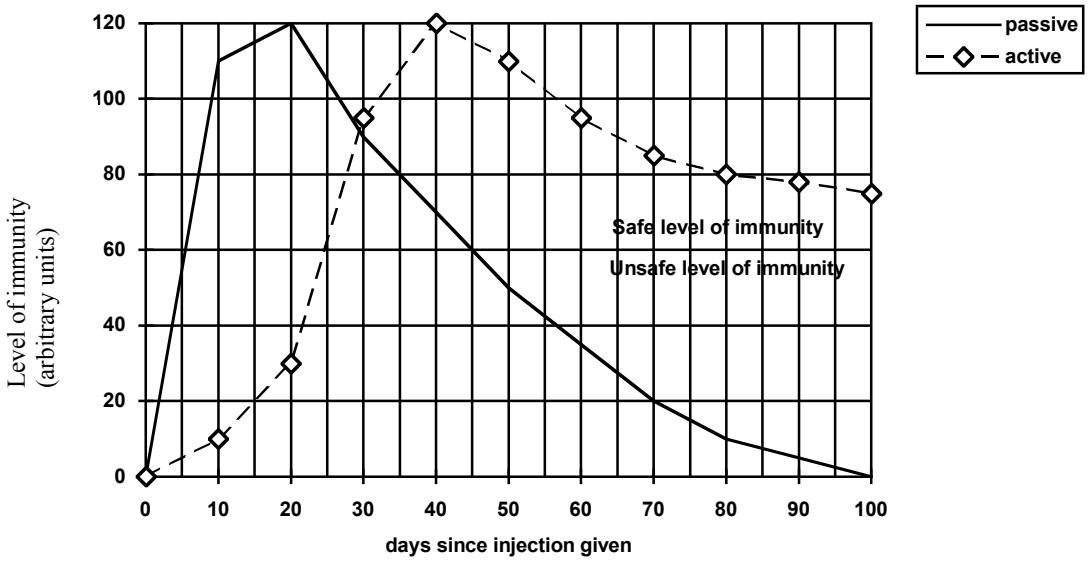
In another experiment, Farmer Loo investigated the effects of two different strains (707 and 313) of *Rhizobium* on the growth of a leguminous plant. The results are given in the table below.

Fertiliser added (kg/ha)	Fresh mass per plant (g)		
	No *Rhizobium*	Strain 707	Strain 313
0	7.0	12.4	9.7
20	8.4	7.7	7.7
40	9.4	6.6	8.0

f. **(2 marks)** Draw a bar chart to represent the data given.

g. **(2 marks)** Summarise the trend shown by the data.

66. (6 marks total) The graph shows two methods by which immunity can be brought about.



A safe level of immunity is given at 60 arbitrary units.

a. **(2 marks)** How long does it take for each method to give a safe level of immunity?

   I. Active

   II. Passive

b. **(2 marks)** Which method becomes ineffective first and after how long?

c. **(2 marks)** With reference to the data in the graph compare the active and passive immune responses.

67. (5 marks total) Flowering in flowering plants is regulated by photoperiodism, which is the relative lengths of daylight to darkness. Plants may be long day plants, short day plants or neutral to the effects of the daylength.

Consider the following information.

There is a plant pigment that exists in two forms, P_{660} and P_{730}.

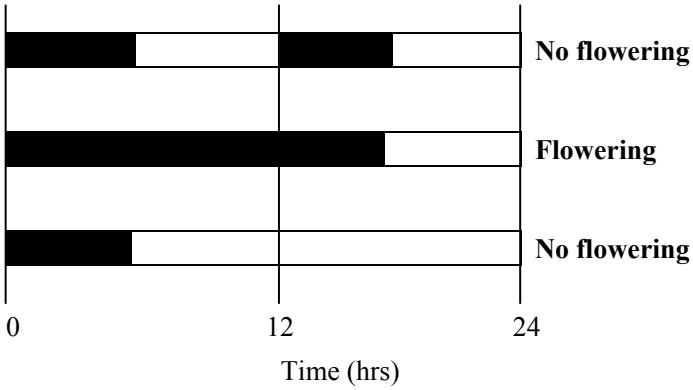
P_{660} has a maximum light absorption around 660 nm (red light) and P_{730} has a maximum light absorption around 730nm (far red light).

> Red light is absorbed by P_{660} which converts it to P_{730}.
> Far red light is absorbed by P_{730} which converts it to P_{660}.
> P_{730} in the dark slowly converts to P_{660} and it is this slow conversion that is the 'clock' by which the plant measures night length.

Flowering in long day plants is stimulated only if the level of P_{730} stays above a critical value. Flowering in short day plants is stimulated only if the level of P_{730} drops below a critical value.

a. **(2 marks)** Draw a simple flow chart to illustrate the interconversion between P_{660} and P_{730}.

A number of Poinsettia plants were subjected to three different patterns of illumination (blank spaces) and darkness (black spaces). The following results were obtained.



b. **(3 marks)** Using the information above, deduce whether Poinsettias are long day plants, short day plants or day neutral plants. Explain your answer.

68. (4 marks) Draw up a table comparing the causes and effects of global warming and the depletion of the ozone layer.

69. (2 marks) Sam the scholar was doing a thought experiment one day, idly weighing out 20mL of water for an osmosis experiment on a balance. He put his thumb into the beaker of water, thereby displacing the water. Never mind, he reasoned, it's not the volume that's important; it's the mass I'm after. Would the mass of the water increase, decrease or stay the same? Explain.

You have finished. Yay!

Integrity of the Competition

To ensure the integrity of the competition and to identify outstanding students the competition organisers reserve the right to re-examine or disqualify any student or group of students before determining a mark or award where there is evidence of collusion or other academic dishonesty.

Acknowledgements:

The examiners gratefully acknowledge contributions from a variety of sources including the following:

Chris Maslanka, writer of the Pyrgic Puzzles column, the *Guardian* newspaper for the germ of an idea in question 69.