

BIOLOGY

2009 National Qualifying Examination

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

INSTRUCTIONS

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

- **Do not write on this question paper. It will not be marked.**
- 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	35 multiple choice questions	35 marks
SECTION B	10 written answer questions	26 marks
SECTION C	11 written answer questions	62 marks
	Total marks for the paper	123 marks

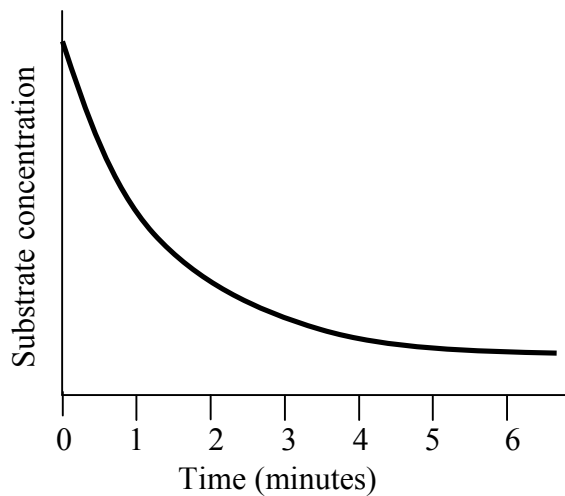
SECTION A: MULTIPLE CHOICE
USE THE ANSWER SHEET PROVIDED

1. What percentage of adenine bases would there be in double stranded DNA that is comprised of 34% guanine bases?
 - a. 16%
 - b. 32%
 - c. 34%
 - d. 66%

2. Proteins are components of all of the following except:
 - a. ATP
 - b. Cell walls
 - c. Enzymes
 - d. Ribosomes
 - e. Xylem

3. Which of the following does **NOT** increase genetic variation of cells?
 - a. Insertion of foreign DNA into the genome
 - b. Integration of DNA from a virus into the host genome
 - c. Sexual reproduction
 - d. Point mutations
 - e. Chromosomal translocations

4. The graph below shows the decrease in concentration of the substrate for an enzymatic reaction over time. The half-life of any reaction is the time taken for the concentration of a limiting reactant to halve.



What is the best estimate of the half-life for this reaction?

- 0.5 minutes
- 1 minute
- 1.5 minutes
- 3 minutes
- 6 minutes

Use the following information to answer questions 5 and 6:

Cane toads were introduced from Hawaii to Australia in 1935 to combat the native cane beetles that were devouring sugarcane crops. After their release into parts of Queensland they have been advancing at about 50 kilometres a year across Australia. Recently it has been observed that new generations of toads at the frontline of the spread have longer legs.

5. Which of the following does **NOT** explain this observation?
- Individuals with shorter legs are less likely to survive
 - In the original population of toads, natural variation meant that leg lengths varied between individuals
 - Longer legs enable individuals to travel faster and further than others
 - The spread is occurring at an increasing rate as their legs become longer

6. This is an example of which type of selection?
- Balancing
 - Directional
 - Diversifying
 - Negative
 - Stabilising
7. What are the possible blood types of a child of a man with blood type B and a woman (whose parents were both AB) of blood type A?
- A only
 - A or B only
 - B or O only
 - A or AB only
 - B or AB only
8. The effects of a gaseous pollutant are assessed by exposing a cage of 100 mice to the pollutant. The survival rate is then compared to another cage of similar mice with clean air. The cages were chosen in a randomised manner. What is the greatest flaw in this experimental design? A lack of:
- appropriate control groups
 - replication
 - clear outcome measure
 - randomisation
9. Which of the following contains blood with the highest oxygen content?
- Aorta
 - Left ventricle
 - Pulmonary artery
 - Pulmonary vein
 - Right atrium

- 10.** Skin pigmentation in a South American species of frog is autosomally inherited and controlled by three alleles, R, r^y and r^r . r^y (yellow) and r^r (red) are codominantly expressed such that the $r^y r^r$ genotype results in an orange phenotype. The R allele is dominant over both of the others and results in a dark blue phenotype.

Two frogs are crossed and offspring produced in the following ratio -
2 blue : 1 red : 1 orange

What are the genotypes of the parent frogs?

- Rr^y and Rr^r
 - $r^y r^r$ and $r^y r^r$
 - Rr^r and Rr^r
 - $r^y r^r$ and Rr^r
 - Rr^r and $r^y r^y$
- 11.** The energy of a photon is inversely proportional to its wavelength. The wavelengths of visible light, from lowest to highest, are: violet, indigo, blue, green, yellow, orange, red. An unusual species of plant has leaves that appear blue. Otherwise its photosynthetic system is identical to that of typical green plants. Which colour plant, blue or a green, would be able to regenerate more ATP from the same amount of white light?
- A blue plant would be more efficient
 - Both plants will be equally efficient, as they are being exposed to white light
 - A green plant would be more efficient
 - Neither plant will be able to generate any ATP
 - It is impossible to tell from the information provided
- 12.** The rate of photosynthesis in a plant can be indirectly measured via determining the:
- carbon dioxide output
 - change in biomass
 - change in humidity of the space around a plant
 - pH of the leaves of a plant

Use the following information to answer questions 13 and 14.

An experiment is set up to test the effectiveness of a newly developed antibiotic, 'Nobact'. Bacteria are plated out onto agar and the plates are incubated at 37°. The composition of the 5 plates are shown below:

Plate 1	<i>E. coli</i>
Plate 2	<i>E. coli</i> + doxycycline (a known antibiotic at a concentration known to be bactericidal)
Plate 3	<i>E. coli</i> + Nobact (0.25 relative concentration)
Plate 4	<i>E. coli</i> + Nobact (0.50 relative concentration)
Plate 5	<i>E. coli</i> + Nobact (1.00 relative concentration)

13. Which of the plates can be described as a **positive** control?

- Plate 1
- Plate 2
- Plate 3
- Plate 4
- Plate 5

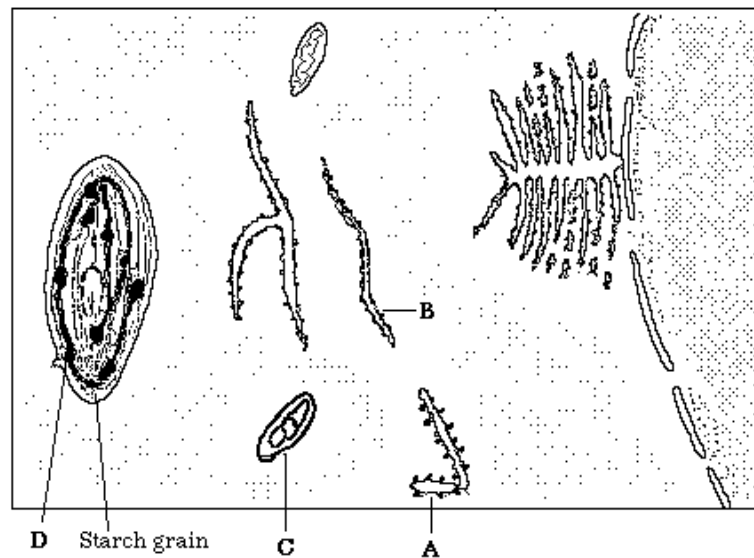
It was found that a relative concentration of 0.25 Nobact was insufficient to prevent bacterial growth, but at a relative concentration of 0.50 no bacterial growth was seen. However this information is insufficient to determine if Nobact is bactericidal or simply bacteriostatic (arrests bacterial growth, but is not lethal) at this concentration. Nobact is a heat-labile compound that is susceptible to breakdown by the enzyme β -lactamase.

14. Which of the following would be the most effective means of determining if Nobact is bactericidal or bacteriostatic at a relative concentration of 0.50?

Treat the plate grown incubated with 0.50 Nobact with:

- doxycycline and reincubate observing any changes
- 100°C moist heat and reincubate
- doxycycline and 100°C moist heat prior to reincubation
- β -lactamase and reincubate
- β -lactamase and 100°C moist heat prior to reincubation

15. Consider the following diagram, which represents part of a cell.



If the cell comes from an organism that has been growing in an environment in which its sole source of nitrogen is labelled radioactively, we would expect to find radioactivity in structure/s:

- A only
 - A and B only
 - A, B and C only
 - A, B, C and D
16. Which statement best explains why red blood cells are incapable of carrying out mitosis?
- They don't contain DNA
 - They have reached full maturity
 - They do not need to replicate
 - They are biconcave
 - They contain haemoglobin

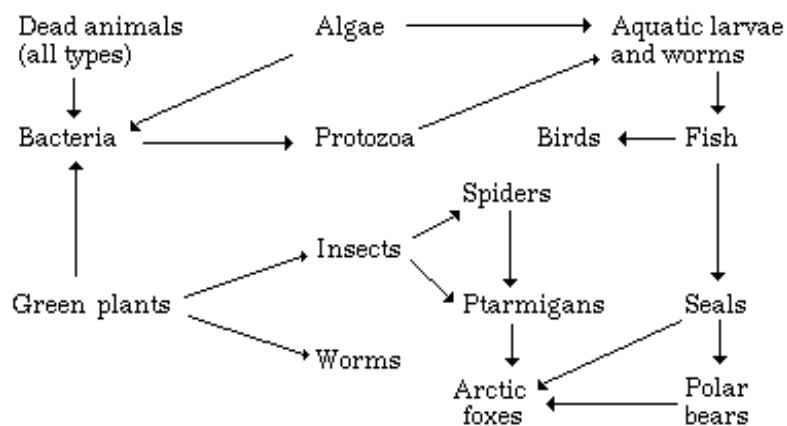
17. Consider the following five types of organisms

- I** decay causing bacteria.
- II** photosynthesising bacteria.
- III** mould fungi.
- IV** flowering plants.
- V** animals.

Which of the following arrangements best classifies these organisms into two groups based on their nutrition?

- | Group I | Group II |
|-------------------------------------|-----------------------------|
| a. I and II | III, IV and V |
| b. I, III and V | II and IV |
| c. I, II and III | IV and V |
| d. I, II, III, and IV | V |

18. The relationships of certain organisms of the Arctic regions are shown in the figure below.



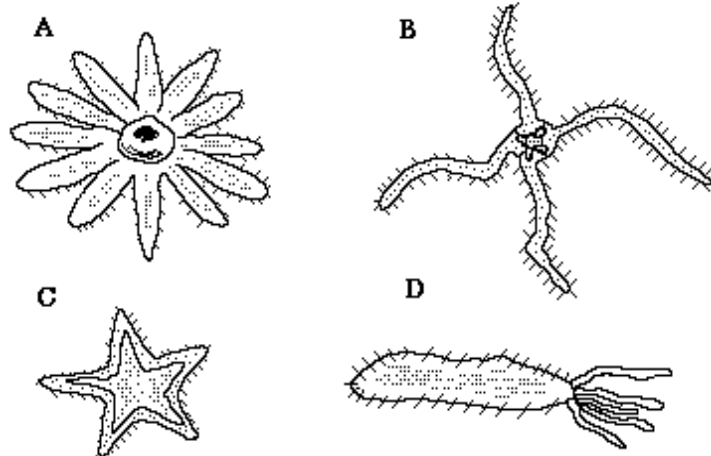
A reduction in the intensity of light would first affect:

- a. Bacteria
- b. Protozoans
- c. Spiders
- d. Algae
- e. Aquatic larvae and worms

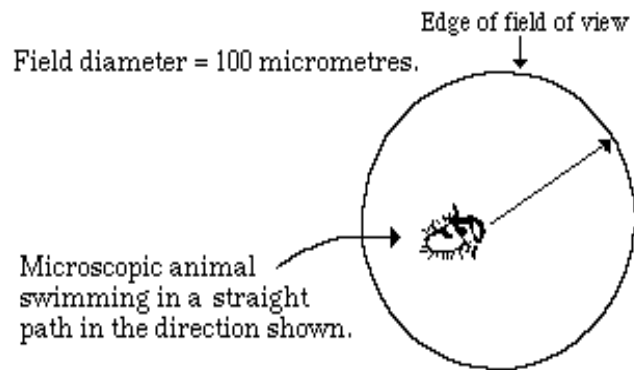
19. A Year 11 Biology student was given a number of identified and labelled echinoderms which he used to construct the following key:

1A	Animal star-shaped	2
1B	Not star-shaped	6
2A	Arms touching near body	3
2B	Arms completely separated at body	5
3A	Five arms	4
3B	More than five arms	<i>Solaster pappous</i>
4A	Arm length about half total radius of the animal	<i>Asterina gibbosa</i>
4B	Arm length much more than half of the total radius of the animal	<i>Aserias rubens</i>
5A	Five arms	<i>Ophiothrix fragilis</i>
5B	More than five arms	<i>Ophiothrix multans</i>
6A	Spherical or heart-shaped, covered in spines	7
6B	Gherkin-shaped with spines	<i>Cucumoria normani</i>
7A	Body heart-shaped, with weak spines	<i>Spatangus purpureus</i>
7B	Body spherical, with long spines	<i>Echinus esculentus</i>

Which of the following animals was NOT used by the student to construct his key?



20. A student looking through a microscope made the observations shown in the diagram below:



What is the approximate length of the animal?

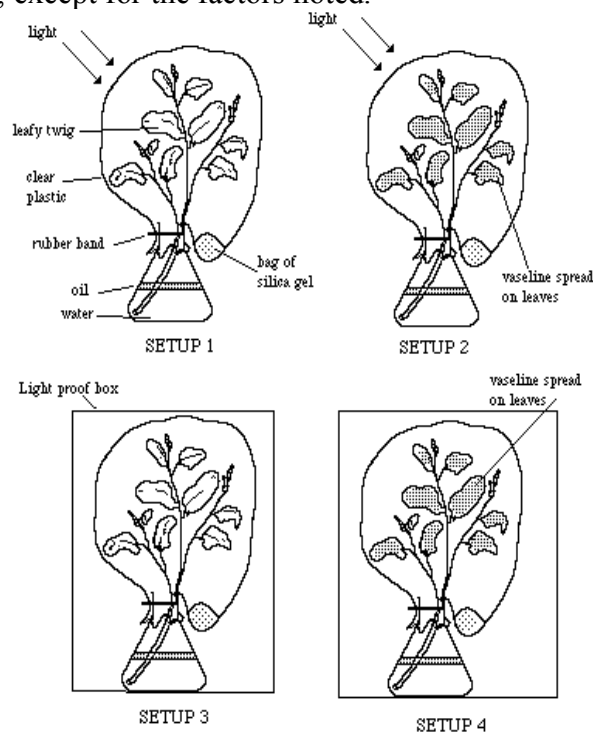
- 0.02mm
 - 10 millimetres
 - 40 micrometres
 - 200 micrometres
21. Two experiments are outlined below
- Experiment I.** When leaf blades were removed from young *Coleus* plants, leaving the leaf stalks intact, the leaf stalks fell off many weeks before those of control plants. However, if small portions of the leaf blade were left on, the leaf stalks remained on the stem for much longer periods.
- Experiment II.** Leaf blades from *Coleus* plants were removed leaving the leaf stalk intact. The cut ends of the leaf stalks of half of the plants were covered with lanolin containing auxin. Leaf stalks of the other half of the plants were covered with plain lanolin. The leaf stalks with plain lanolin fell off in a few days; those treated with auxin remained on the plant for as long, or longer, than plants with intact leaves.

What hypothesis was being tested by experiment II?

- Auxin is a growth hormone and therefore stimulates growth of the leaf blade
- Leaf blades produce auxin
- Auxin produced in the leaf blade causes leaf fall
- Auxin in the leaf blade prevents leaf fall
- Auxin has no effect on leaf fall

Use the following information to answer questions 22 and 23.

In an investigation of factors affecting water loss by plants, the following four experimental setups were prepared, and were left for two hours. Conditions in the setups were similar, except for the factors noted.



Silica gel absorbs water. The silica gel was weighed before and after the two-hour period and the increase in weight taken as a measure of water lost by the leafy twig.

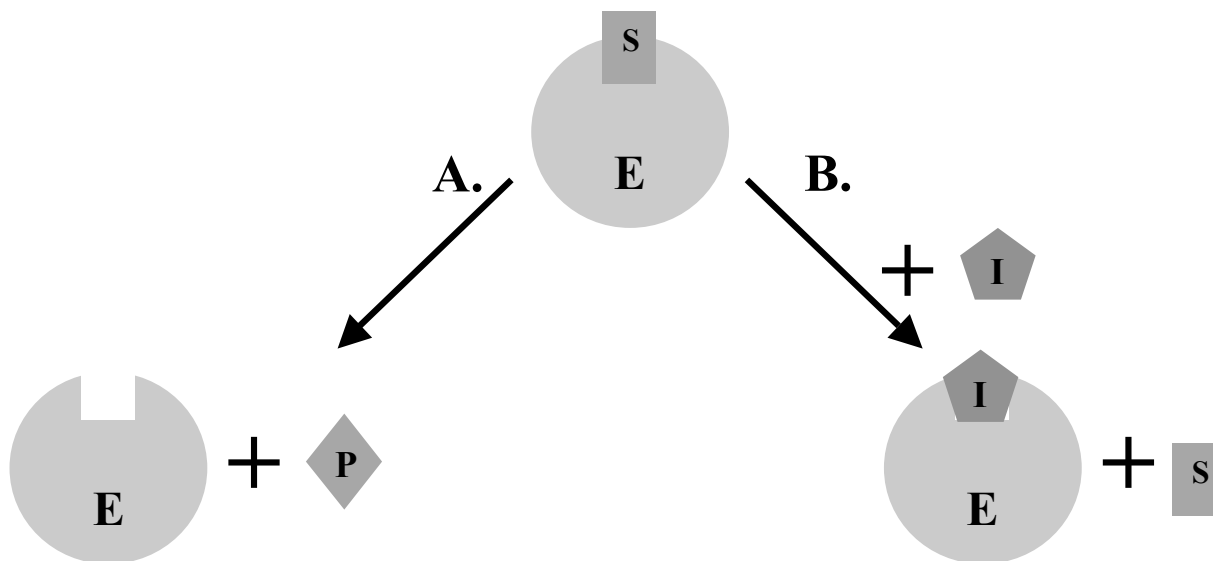
22. A biologist stated that twig 1 would be expected to lose more water than twig 3 if the stomata of the species of plant were sensitive to light. To make this prediction he must have assumed that:

- more stomata are found in leaves than in stems
- much of the water is lost through the stomata
- plants lose more water while photosynthesising
- stomata of this species of plant open in the dark

23. Comparison of the mass of the silica gel from setups 1 and 2 would help determine if:

- gas exchange is necessary for photosynthesis
- light is necessary for photosynthesis
- water is lost via the leaves
- stomatal opening is dependent on the CO_2 concentration within the leaf
- stomata are present on the stem

24. The following scheme shows the relationship between an enzyme (**E**) and its substrate (**S**), product (**P**) and an inhibitor (**I**):



In the above scheme, assume (i) that increasing the concentration of **S** increases the activity of the enzyme (ii) that at low substrate concentrations the presence of **I** reduces reaction velocity, and (iii) that the same maximum velocity of reaction can be reached in the presence or absence of **I**. Which of the following terms best describes what is occurring in pathway B?

- Positive Feedback
- Non-competitive inhibition
- Competitive inhibition
- Negative feedback
- Homeostatic regulation

25. As people get older, the walls of their arteries become less elastic. What effect would this have on their blood flow?

- Blood flow will increase due to the heart having to pump harder
- Blood flow will become uneven due to fluctuations in blood pressure
- Blood flow will slow dramatically, due to a sudden drop in blood pressure
- Blood flow will remain unchanged as it is unaffected by changes to the arteries
- Blood flow becomes greater, because the blood becomes thinner as people get older

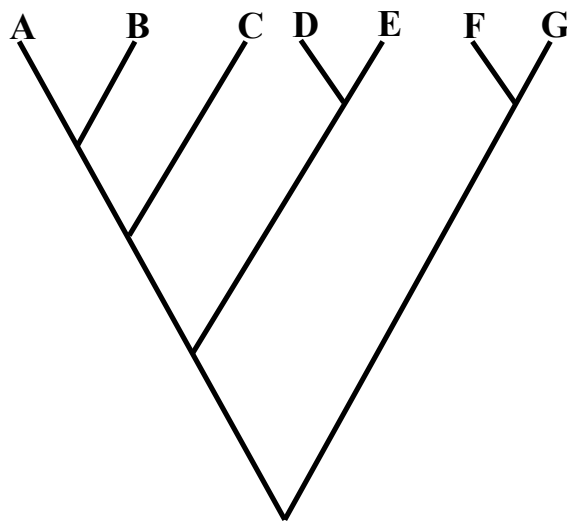
26. Look carefully at the following table:

Type of cell	Amount of DNA (arbitrary units)
Epithelial cell	400
Ovum	200
Cheek cell	400
Ciliated cell	400

How many arbitrary units of DNA would a sperm cell have from an individual of the same species?

- a. 800
- b. 100
- c. 200
- d. 400
- e. 300

27. The phylogenetic tree of species A-G can be split into genera in many different ways. However, one of the options below is clearly invalid. Which one?



- a. Genus 1: ABC Genus 2: DE Genus 3: FG
- b. Genus 1: AB Genus 2: CDE Genus 3: FG
- c. Genus 1: A Genus 2: BCDE Genus 3: FG
- d. Genus 1: AB Genus 2: CD Genus 3: EFG
- e. Genus 1: ABCDE Genus 2: FG

28. 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?

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

29. A scientist was investigating the factors needed to produce the green pigment chlorophyll in seedlings. Four groups of broad bean seedlings were grown from seeds under identical conditions with the exception of the presence of magnesium ions (Mg^{2+}), chloride ions (Cl^-) and light, which were varied as shown in the table below.

A stock nutrient solution was used to administer all mineral ions necessary for healthy plant growth, except for Mg^{2+} and Cl^- .

+ = presence

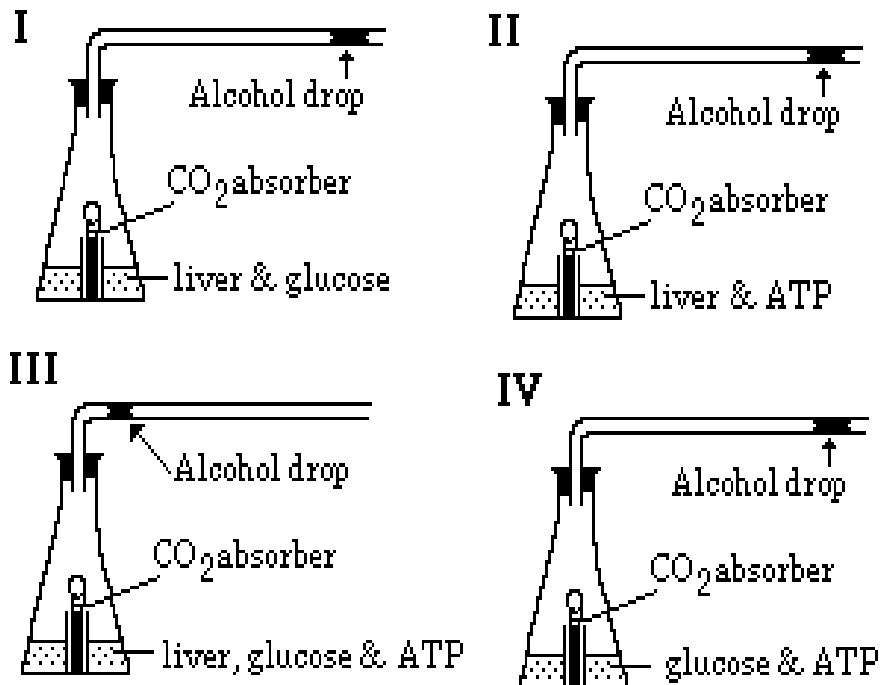
- = absence

	Nutrients used			Growth conditions	Observations of shoots after 20 days
	Stock solution (no Mg^{2+} and Cl^-)	Mg^{2+}	Cl^-		
1	+	+	-	Light	Green
2	+	+	+	Light	Green
4	+	+	+	Dark	White
5	+	-	+	Light	White

From these results, it would be reasonable to conclude that for chlorophyll production:

- chloride ions are not needed
- magnesium ions are required when light is absent
- either magnesium or chloride are sufficient
- magnesium ions counter the effect of chloride ions
- light is not required

30. Consider the following experiment in which equal amounts of ground up liver cells, with the ATP removed, are placed in respirometers I, II and III. Flask I contains glucose. ATP is added to flask II. Flask III contains a glucose solution and ATP. Flask IV contains no liver - only glucose and ATP. All flasks are placed in a water bath at 20°C. The following figures represent the respirometers after one hour.



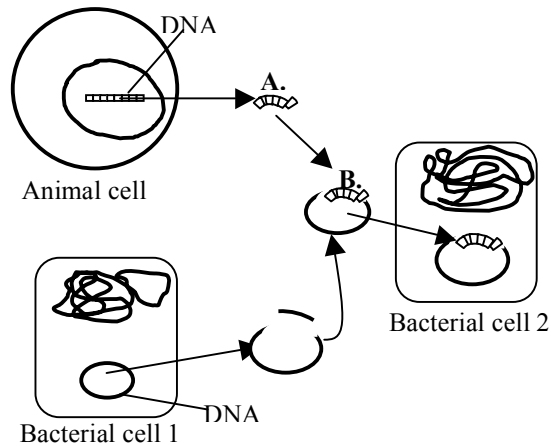
The main function of flask number IV is to:

- measure gas changes due to temperature changes
- measure gas changes due to temperature and air pressure changes
- control changes in gas pressures
- determine how glucose and ATP function

Use the information below to answer questions 31-33.

Using special enzymes, scientists have been able to isolate the gene for the anti-viral animal protein interferon, and splice it into the DNA of certain bacteria. These bacteria can now produce interferon.

The steps involved in this process are shown in the diagram below.



31. Structure A is probably a/an:

- single nucleotide
- DNA polynucleotide
- RNA polynucleotide
- interferon polypeptide
- oligosaccharide

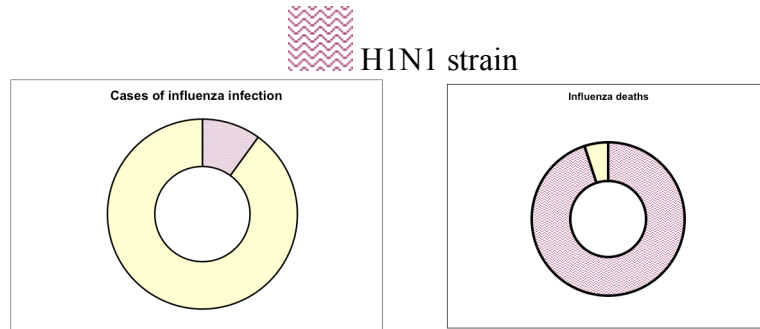
32. Structure B is probably:

- a ribosome
- a folded interferon protein
- recombinant DNA
- messenger RNA
- transfer RNA

33. Prokaryotic DNA does not typically contain introns. With this in mind, what would be the most appropriate type of DNA to use when inserting a eukaryotic gene into bacterial DNA?

- The antisense DNA strand of the eukaryotic gene
- The reverse transcriptase product of the antisense DNA strand of the eukaryotic gene
- The pre-mRNA of the eukaryotic gene
- The mRNA of the eukaryotic gene
- The reverse transcriptase product of the mRNA of the eukaryotic gene

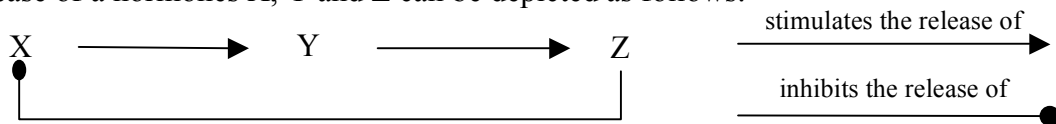
34. The graphs below show the proportion of the total cases and deaths caused by the influenza virus due to the strain H1N1



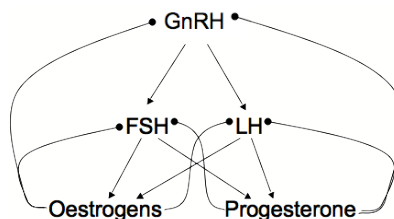
The two diagrams together indicate that:

- a. H1N1 infections make up about 10% of all influenza infections yet cause about 95% of all influenza deaths
- b. H1N1 infections contribute little to the number of influenza deaths as it only accounts for about 10% of all cases
- c. Influenza deaths as a result of infection by other strains are more likely than those caused by the H1N1 strain
- d. Most other strains of influenza are relatively harmless

35. Hormones are often involved in negative feedback loops. For example, the release of a hormones X, Y and Z can be depicted as follows:



The hormones involved in the female reproductive cycle are GnRH, LH, FSH, progesterone and oestrogens. A flowchart outlining the relationships between these is shown as follows:



Progesterone and oestrogens are required to maintain the uterine wall during pregnancy and LH and FSH are required for ovulation.

Based on the above information, which of the following would be the **MOST** effective contraceptive?

- a. High daily doses of LH and FSH
- b. High daily doses of progesterone and oestrogens
- c. High daily doses of GnRH
- d. High daily doses of oestrogens only

END OF SECTION A

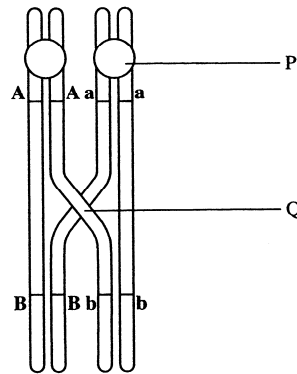
SECTION B
USE THE ANSWER SHEET PROVIDED TO WRITE YOUR
ANSWERS
DO NOT USE THE ANSWER BOOKLET

36. (1 mark) A sexual organism has the genotype AaBbCcDd. How many unique haploid gametes can this organism generate?
37. (2 marks) 91% of the mass of an average cabbage is made up of water.
- If 90% of the remaining mass is made up of carbohydrates and 10% of protein, estimate, in MJ, the energy contained in 2 cabbages weighing 700g each. Note that the average heat of combustion of carbohydrates and proteins are 17 and 24kJ/g respectively.
 - If a human consumed these two cabbages, would you expect them to obtain the calculated amount of energy?
Yes (Y) or No (N)
38. (1 mark) The active ingredient of chillies is capsaicin. The piquancy of a chilli can be measured by the Scoville scale using the Scoville Organoleptic Test. Extracts from a chilli are diluted until a panel of tasters (typically 5) can no longer taste the capsaicin. So a chilli yielding an extract that can still be tasted at a 1 in 10 000 dilution scores 10 000 SHU (Scoville heat units).

A chemist is assessing the strength of the *Capsicum chinense*, or Habanero chilli. During the extraction process, 1 part chilli pulp is combined with 1 part pure ethanol. A series of tubes (labelled 1-6) is prepared, each with 9 mL of water. 1 mL of the chilli/ethanol extract is placed in tube 1, and then mixed. 1 mL is then taken from tube 1 and placed in tube 2, and then mixed. The process is repeated for tubes 3-6.

The chemist determines that capsaicin can be detected in tube 1-5, but not in tube 6. What is the minimum strength of the Habanero chilli in SHU?

39. (3 marks) The diagram below depicts the loci of two genes during a stage of meiosis.



Use the following key to answer parts a and b.

1.	Telomere	6.	Plasmodesmata
2.	Centrosome	7.	Plasma
3.	Centromere	8.	Intron
4.	Centriole	9.	Exon
5.	Chiasma		

- Name the structures labelled P on the diagram.
- Name the structures labelled Q on the diagram

Use the following key to answer part c.

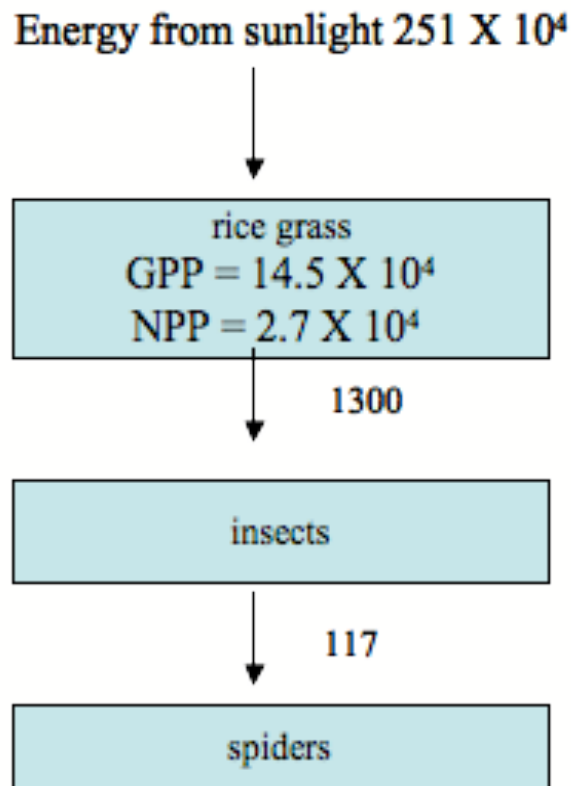
1.	Interphase	6.	Anaphase I
2.	Prophase II	7.	Anaphase II
3.	Metaphase I	8.	Telophase I
4.	Metaphase II	9.	Telophase II

- Name a stage in meiosis when Q would be visible.

With reference to the chromosome diagram above determine whether the following statements are **true (T)** or **false (F)** of a cross between individuals of genotype AaBb and aabb.

- If the loci of genes A/a and B/b were located on different chromosomes the genotypic ratio of the offspring would be approximately 1:3
- The closer the genes are on the chromosome the greater the difference between the genotypic ratios of the offspring found than if the genes were located on separate chromosomes
- It is likely that there will be more offspring of genotype AaBb than Aabb

40. (3 marks) The diagram shows the energy flow for part of a salt marsh ecosystem. All values are given in $\text{kJ/m}^2/\text{yr}$. (GPP = Gross Primary Production, NPP = Net Primary Production)



- a. Calculate the percentage of the energy from sunlight which is fixed as GPP by the rice grass.

Determine whether the following statements are **true (T)** or **false(F)**.

- b. Primary Production refers to the conversion of photons into chemical energy
- c. The energy lost between the rice grass and the insects is solely due to metabolism by the rice grass

41. (5 marks) Peeled potatoes were cut into two sizes of cubes – 1 cm^3 ($1\text{ cm} \times 1\text{ cm} \times 1\text{ cm}$) and 27 cm^3 ($3\text{ cm} \times 3\text{ cm} \times 3\text{ cm}$) and weighed. Then, 27 of the 1 cm^3 cubes were placed in one beaker of distilled water, and one 27 cm^3 cube was placed in another beaker. One hour later the cubes were removed and their surfaces carefully dried. They were then reweighed. The results are shown in the table

	Small cubes	Large cube
Volume of cube (cm^3)	1	27
Surface area of cube (cm^2)	6	54
Number of cubes in beaker	27	1
Total mass of cubes at start (g)	52.75	52.97
Total mass after 1 hour in water (g)	55.31	53.55

For each cube size calculate the total increase in mass over the hour

- Small
- Large

For each cube size calculate the surface area: volume ratio

- Small
- Large

For each cube size calculate the percentage increase in mass after 1 hour in water

- Small
- Large

Determine whether the following statements are **true (T)** or **false (F)**

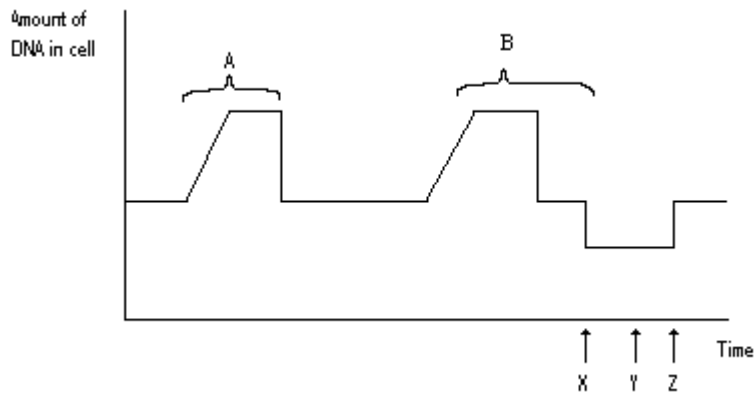
- The 27 small cubes were used as they have the same total volume and surface area as the large cube
- The lower water potential of the potato compared to the surrounding solution results in the mass increase of the potato
- The difference in percentage increase in mass of the large and small cubes is due to the larger volume of the large cube compared one of the individual small cubes
- If the potatoes were left in the water long enough for the system to reach equilibrium the large cube would display percentage increase in mass equal to that of the small cubes

42. (2.5 marks) The table below describes the structure and function of some organelles in eukaryotic cells. Complete the table by choosing from the list (1 - 13) to identify the empty boxes a-e.

organelle	structure / feature	function of feature
nucleus	nucleoli present	c.
a.	inner membrane folded into cristae	d.
b.	vesicles containing hydrolytic enzyme	breakdown of old organelles
smooth endoplasmic reticulum	flattened membrane-bound sacs	e.

1. DNA replication
 2. Mitochondria
 3. Chloroplast
 4. Increased surface area for enzymes
 5. RNA synthesis
 6. Rough endoplasmic reticulum
 7. Lipid storage and synthesis
 8. Cell membrane
 9. Lysosomes
 10. Ribosomal RNA synthesis
 11. Processing proteins in a cell
 12. Golgi apparatus
 13. Storage of enzymes
43. (1 mark) The half-life of carbon-14 is approximately 5700 years. During a study of human evolution, a human skull is found to have approximately $1/8^{\text{th}}$ of the carbon-14 levels found in the atmosphere. What is the age of the skull? (give your answer to the nearest 1000 years)
44. (2.5 marks) Determine whether the following statements are **true (T)** or **false (F)**.
- a. If humans and pandas belong to the same class, then they must also belong to the same genus
 - b. The fins of the mackerel and the seal are shared, primitive characteristics
 - c. For approximately half of the history of life, there has been nothing but single celled organisms
 - d. Natural selection acts only on the species level
 - e. Natural selection acts directly on the genotype of an organism

45. (5 marks) The graph below shows the changes in quantity of DNA within a cell as it goes through a series of cell divisions.



Use the following answer key to answer questions a to e.

1	Mitosis	8	Prometaphase
2	Meiosis	9	Crossing over
3	Plasmolysis	10	Fertilization
4	DNA replication	11	Prophase
5	Anaphase	12	Somatocytes
6	Metaphase	13	Gametes
7	Cytokinesis	14	Oogonia

- What type of cell division is occurring at A?
- What type of cell division is occurring during B?
- What event is occurring at the point marked X?
- What is the name given to the cells produced at point marked Y?
- What event is occurring at the point marked Z?

END OF SECTION B

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

46. (9 marks) A university student was studying the animals in the Grant Memorial National Park. Following are the numbers of kangaroos and dingoes that were recorded visiting a watering site in the middle of the park over two years.
- a. Convert the figures into a line graph by plotting the animal numbers on the vertical axis against time on the horizontal axis. Plot the kangaroo numbers and the dingo numbers on the same graph but use different colours for each line.

Month	Kangaroo population estimate	Dingo population estimate
January	111	16
February	109	18
March	93	21
April	91	17
May	90	16
June	86	14
July	89	12
August	94	9
September	98	11
October	105	13
November	121	15
December	125	16
January	130	16
February	124	19
March	113	23
April	108	24
May	99	20
June	95	19
July	97	15
August	100	14
September	106	11
October	109	13
November	113	14
December	111	18

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- b. Is there any relationship between the kangaroo and the dingo numbers? If so, account for this.
- c. The park management have decided to stop a rabbit prevention program because it is too expensive. What effect could this have on the dingo population and why?

47. (5 marks) The movement of water by osmosis plays a crucial role in the maintenance of biological systems. The osmotic pressure (π) generated by a solute is proportional to the concentration of that solute and can be approximated by the following formula:

$$\pi = CRT$$

where

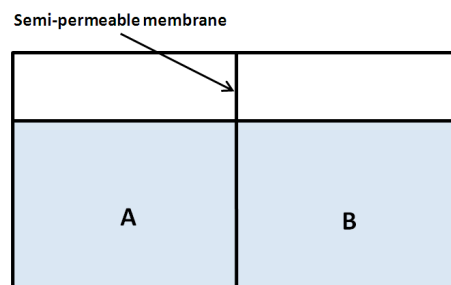
π is in mmHg

C is the concentration of the solution in osmoles L^{-1}

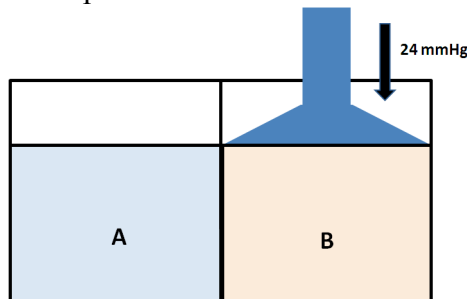
R = 62.36367 L mmHg $K^{-1} mol^{-1}$

T = absolute temperature (273 + degrees celcius)

The following experiment is set up. Compartments A and B both contain 1 litre of pure water separated by a semi-permeable membrane (through which glucose cannot travel).



2 mmol of glucose is dissolved in compartment B and a pressure of 24 mmHg (additional to atmospheric pressure) is applied to the top of the compartment (as shown). Assume that the temperature is 24°C.



Which direction (if at all) would water move? Explain your answer showing all working.

48. (8 marks) The diagram below shows one possible pattern for human evolution. This is a simplified diagram, which only shows four of the many hominid species which scientists think have existed over the last 1.7 million years.

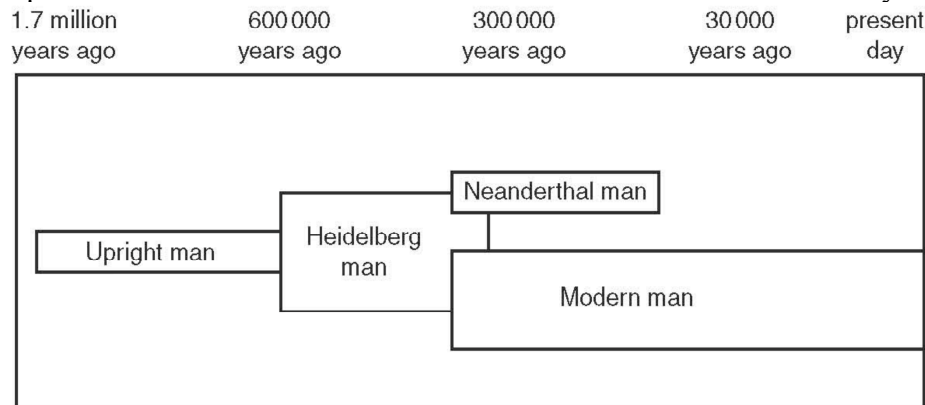


Figure 1: A simple diagram of the development of hominid species over the last 1.7 million years.

Michael Morwood from the University of Wollongong, was one of the anthropologists in 2004 to unearth LB1, the first specimen, an adult female, of a suspected new species to be named *Homo floresiensis*. LB1 was found on Flores, an island in Indonesia, which still undergoes periods of volcanic activity.

LB1 was estimated to be about 18,000 years old. Since 2004, discussion has centred on whether this is a new species of human, the remains from a dwarf or an individual with microcephaly. Individuals with microcephaly have very small brains, reduced life expectancy and delayed development. Due to genetic factors microcephaly can become fixed in small populations.

Last year, Australian researchers Peter Obendorf, Charles Oxnard and Ben Kefford suggested an environmental cause, iodine deficiency, as an explanation for the small size of the Flores specimens. They postulated that these specimens are cretins of iodine deficient mothers, UWA Professor Oxnard stating that many of the “features are actually due to the complexly delayed growth patterns” found in cretins. Iodine is an essential component of thyroxine, an important hormone produced by the thyroid gland. Lack of thyroxine leading to cretinism is found in children born to iodine-depleted mothers. This is becoming more common in the US and Australia.

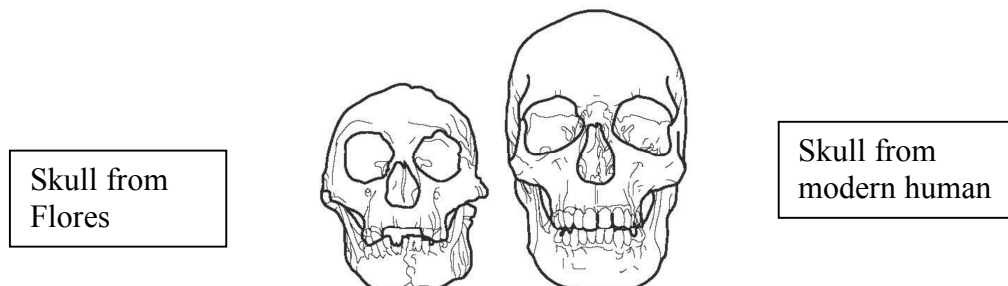


Figure 2: A diagram of skulls from the hominid skull in Flores and a modern human.

Alongside the skeletal remains of LB1 were animal remains, evidence of tools and cooking equipment. It is not clear if these artefacts were associated directly with LB1 or modern humans. The wrist, shoulder and arm bones seemed to resemble those of a chimpanzee or an early hominid such as the australopithecines, rather than modern humans. But as Oxnard points out, this is the pattern in some cretins as well.

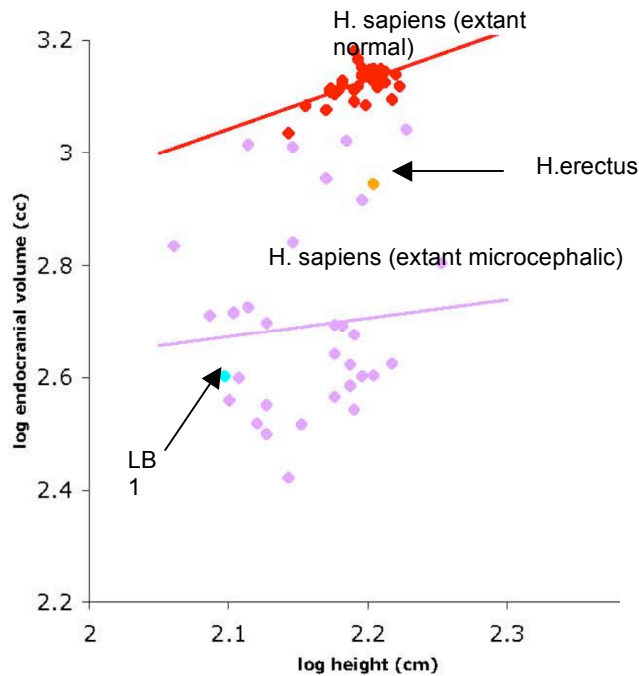


Figure 3: Relationship between the cranial capacity and height in different hominids. (from Schoenemann and Allen, 2006)

- Discuss the evidence for and against the classification of LB1 as a specimen of a new species
- How could small size be considered to be an adaptation to isolated island conditions?
- Suggest two possible reasons for the loss of species from Flores.
- What remedy would you suggest to prevent iodine deficiency in modern humans?

49. (5 marks) Flower colour in a species of plant is determined by two gene pairs, R/B and C/c. The R allele is codominant to the B allele, and the C allele is dominant to the c allele. If at least one C allele is present, the flowers will be coloured; otherwise, they will be white. The R/B allele pair determine whether the flower is red (RR), purple (RB) or blue (BB).

Two of these plants are crossed to give 100 offspring which all have either white or purple flowers.

Use the answer key below to answer questions a and b.

	Genotype		Genotype/Phenotype
1.	CCRR	8.	ccRB
2.	CCRB	9.	ccBB
3.	CCBB	10.	white
4.	CcRR	11.	red
5.	CcRB	12.	purple
6.	CcBB	13.	blue
7.	ccRR		

What is/are the possible genotype(s) of the:

- White offspring?
- Purple offspring?

What are the possible genotypes of the parents if, of the 100 offspring, 50 have white flowers and 50 have purple flowers and one parent has:

- red flowers?
- blue flowers?
- What are the possible genotypes of the parents if, of the 100 offspring, 25 have white flowers and 75 have purple flowers?

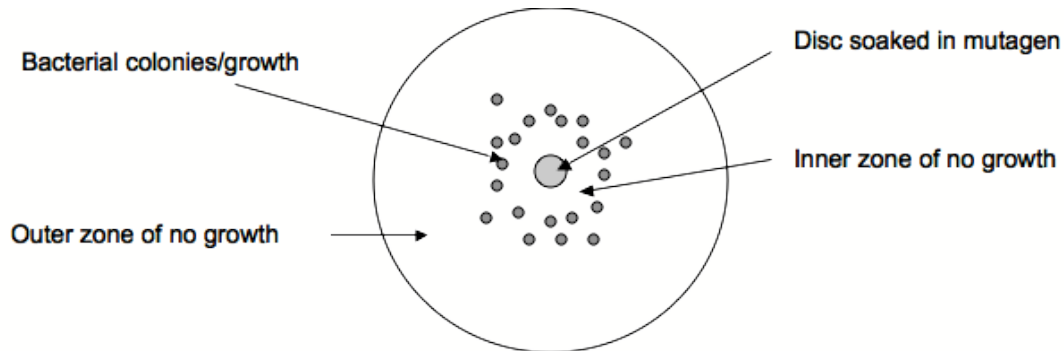
- 50. (2 marks)** Explain the relationship between the following two observations.
- Cancers generally develop from a single cell containing multiple mutations within its genome.
 - Cancer is often described as a disease of old age, its incidence rising greatly in older generations.

- 51. (4 marks)** There are two main types of rabies vaccines. The first consists of inactivated virus, whilst the second contains anti-rabies immunoglobulin.

Which of these vaccines would be most appropriate to administer to a traveller intending to spend an extended period of time in a country where rabies is present in the canine population? Explain your choice.

- 52. (2 marks)** In the Galapagos Islands there have been many efforts to eradicate the introduced rat population that is negatively affecting the endemic fauna. One suggestion for the eradication of the rat population is to introduce a snake from mainland Ecuador that commonly feeds on rats. What are two foreseeable problems with this method of control?
- 53. (4 marks)** In the sub-Antarctic forests near Ushuaia, Argentina, a single leaf can take 2 years to decompose completely, significantly longer than an equivalent leaf in rainforests in northern parts of South America. With reference to the organisms responsible for decomposition of organic matter discuss possible reasons for this discrepancy.
- 54. (4 marks)** The Ames test is a simple test for the mutagenic capacity of chemical compounds. To conduct the test, bacteria unable to synthesise histidine due to a mutation in a single gene of the synthesis pathway are plated on an agar plate lacking histidine. (Histidine is an amino acid essential for growth).

A small paper disc soaked in a known concentration of the suspected mutagen is then placed at the centre of the plate allowing the mutagen to diffuse out into the plate. The bacterial growth is then monitored. Growth occurs when the mutagen reverses the mutation within the mutated gene of the histidine synthesis pathway. The diagram below depicts the outcome of an Ames test conducted with a known mutagen.

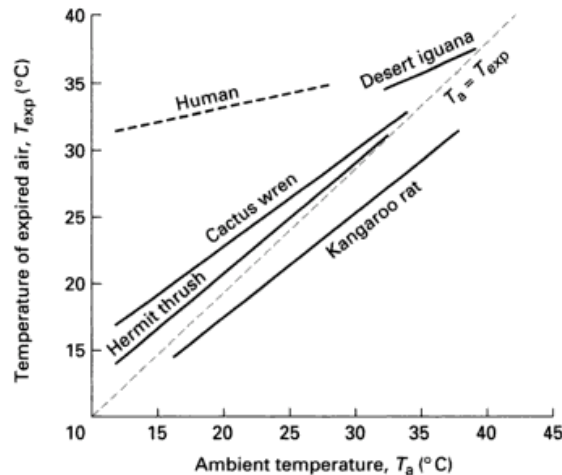


- a. Explain the absence of bacterial growth in the:
 - i. Inner zone of no growth.
 - ii. Outer zone of no growth.

- b. Draw rings on the diagram on the **ANSWER SHEET** (labelled i and ii) to indicate the location of the bacterial growth zone if the disc was soaked in:
 - i. a higher concentration of the same mutagen.
 - ii. an equal concentration of a less effective mutagen.

55. (7 marks) The kangaroo rat (genus *Dipodomys*) is a rodent that lives in arid and semi-arid desert regions in North America. Able to survive without any drinking water, the Kangaroo rat has many behavioural, physiological and anatomical adaptations to help conserve water.

The following graph shows the relationship between air temperature (ambient temperature) and the temperature of expired air in various desert dwelling animals and humans.



Graph is from “Environmental physiology of animals”
By Pat Willmer, G. Stone, Ian A. Johnston, published by Wiley-Blackwell, 2000

- Describe the trend seen in the graph, by comparing the data for humans and kangaroo rats.
- Explain how this helps the kangaroo rat to conserve water.

The kangaroo rat consumes no water, yet it is still lost through evaporation and waste excretion (albeit in small quantities).

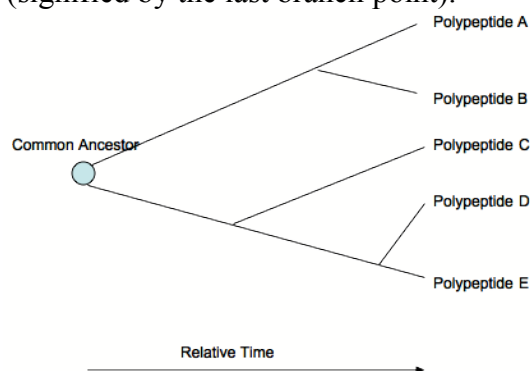
- Explain how it is able to replace this water given that it only ingests seeds, which are protein and carbohydrate rich.
- Describe a behavioural adaptation likely to help conserve water in the kangaroo rat.

56. (12 marks) The amino acid sequences of polypeptides are often represented using a single letter code to designate the amino acids. The table in the Appendix, shows the alignment of 5 related polypeptides represented in this fashion. The amino acid code is also included on this page.

The aligned polypeptides have descended from a common ancestor, the greater the time since their divergence, the greater the difference between their sequences. By comparing their sequences it is therefore possible judge which polypeptides diverged earlier, and which share a more recent common ancestor. The simplest way to compare the sequences is to count the amino acid differences (an example of such a difference has been circled on the alignment).

- Count the amino acid differences between each of the polypeptides and complete the table on the **ANSWER SHEET**. The number of amino acid changes between polypeptide a10 and the other polypeptides has already been completed to help you along.
- Which polypeptides probably share the most recent common ancestor?
- Which polypeptide probably diverged from the others first?

The evolutionary relationship between polypeptides such as these can be represented in the form a tree, an example of which is shown below, where Polypeptides D and E are the most closely related, sharing the most recent common ancestor (signified by the last branch point).



- In the space provided on the **ANSWER SHEET** draw a similar tree to show the relationship between the polypeptides as inferred by the alignment.
- Would you expect the gene sequences for these polypeptides to appear more or less similar in sequence to each other than the polypeptide sequences? Explain your answer.
- This sequence alignment shows that only certain regions of the polypeptide sequences are prone to change, whilst others show relatively little change over time. Why might this be the case?

END OF EXAM

Appendix

Sequence Alignment

a10	E	N	A	A	N	W	L	T	A	K	S	G	R	K	K	R	C	P	Y	T	K	H	Q	T	L	E	L	E	K	E	F	L	F	N	M	Y	L	T	R	E	R	R	L	E	I	S	R	S	V	H	L	T	D	R	Q	V	K	I	W	F	Q	N	R	R	M	K	L	K	K	M	N	R	E	N	R	I
c9	N	P	V	A	N	W	I	H	A	R	S	T	R	K	K	R	C	P	Y	T	K	Y	Q	T	L	E	L	E	K	E	F	L	F	N	M	Y	L	T	R	D	R	R	Y	E	V	A	R	V	L	N	L	T	E	R	Q	V	K	I	W	F	Q	N	R	R	M	K	M	K	M	N	K	E	K	T	D	
d9	N	P	A	A	N	W	I	H	A	R	S	T	R	K	K	R	C	P	Y	T	K	Y	Q	T	L	E	L	E	K	E	F	L	F	N	M	Y	L	T	R	D	R	R	Y	E	V	A	R	I	L	N	L	T	E	R	Q	V	K	I	W	F	Q	N	R	R	M	K	M	K	M	S	K	E	K	C	P	
d10	T	P	T	S	N	W	L	T	A	K	S	G	R	K	K	R	C	P	Y	T	K	H	Q	T	L	E	L	E	K	E	F	L	F	N	M	Y	L	T	R	E	R	R	L	E	I	S	K	S	V	N	L	T	D	R	Q	V	K	I	W	F	Q	N	R	R	M	K	L	K	K	M	S	R	E	N	R	I
AbdB	P	G	L	H	E	W	T	G	Q	V	S	V	R	K	K	R	K	P	Y	S	K	F	Q	T	L	E	L	E	K	E	F	L	F	N	A	Y	V	S	K	Q	K	R	W	E	L	A	R	N	L	Q	L	T	E	R	Q	V	K	I	W	F	Q	N	R	R	M	K	N	K	N	S	Q	R	Q	A	N	

Amino Acid Code

A = alanine	G = glycine	M = methionine	S = serine
C = cysteine	H = histidine	N = asparagine	T = threonine
D = aspartic acid	I = isoleucine	P = proline	V = valine
E = glutamic acid	K = lysine	Q = glutamine	W = tryptophan
F = phenylalanine	L = leucine	R = arginine	Y = tyrosine

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.

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OCR for use of figures 1 and 2 in question 48. <http://www.ocr.org.uk/index.html>

Figure 3 comes from the conference proceedings of the 2005 Annual Meeting of the American Association of Physical Anthropologists: *Scaling of brain and body weight within modern and fossil hominids: implications for the Flores specimen*

P. Thomas Schoenemann and John S. Allen

Professor Charles Oxnard, UWA, for permission to use a quote, and for his comments and suggestions on the question. The quote comes from the UWA news and is available at <http://www.news.uwa.edu.au/20090219896/anatomy-and-human-biology/is-iodine-deficiency-key-flores-hobbit-mystery>

The graph in question 55 comes 'Environmental physiology of animals' by Pat Willmer, G. Stone, Ian A. Johnston, published by Wiley-Blackwell, 2000