Science

Name:______________________________

Pre-Y12 Biology A-Level summer home learning

In September 2020, you will begin your studies of the A-level biology course. In order to help you prepare, you must spend a total of 3 hours on this home learning project over the summer.

This will be due to your Y12 form tutor on your first day.

Part 1: 1.5 hours done? ☐

Read the extract from **"Life on the Edge: The Coming of Age of Quantum Biology"**

Answer the **essay** question "**What is the next big revolution in Biology?**" Your essay question should take at least one side of A4. You may type and print your response.

Part 2: 1.5 hours done? ☐

Answer all the exam questions. These are from the GCSE course and all supporting knowledge should be secure before arriving in September. You should thoroughly complete any revision necessary to answer the questions. You will be given the answers during your first week.

Part 1

Read the extract from the book **"Life on the Edge: The Coming of Age of Quantum Biology"**. This should take about 20 minutes. You should annotate the extract and highlight words/phrases you want to look up.

THE WINTER FROST has arrived early this year in Europe and there is a penetrating chill in the evening air. Buried deep within a young robin's mind, a once vague sense of purpose and resolve grows stronger.

The bird has spent the past few weeks devouring far more than her normal intake of insects, spiders, worms and berries and is now almost double the weight that she was when her brood flew the nest back in August. This extra bulk is mostly fat reserves, which she will require as fuel for the arduous journey upon which she is about to embark.

This will be her first migration away from the spruce forest in central Sweden where she has lived for the duration of her short life and where she reared her young chicks just a few months ago. Luckily for her, the previous winter was not too harsh, for a year ago she was not yet fully grown and therefore not strong enough to undertake such a long journey. But now, with her parental responsibilities discharged until next spring, she has only herself to think about, and she is ready to escape the coming winter by heading south to seek a warmer climate.

It is a couple of hours after sunset. Rather than settle for the night, she hops in the gathering gloom to the tip of a branch near the base of the huge tree that she has made her home since the spring. She gives herself a quick shake, much like a marathon runner loosening up her muscles before a race. Her orange breast glistens in the moonlight. The painstaking effort and care she invested in building her nest – just a few feet away, partially hidden against the moss-covered bark of the tree trunk – is now a dim memory.

She is not the only bird preparing to depart, for other robins – both male and female – have also decided that this is the right night to begin their long migration south. In the trees all around her she hears loud, shrill singing that drowns out the usual sounds of other nocturnal woodland creatures. It is as though the birds feel compelled to announce their departure, sending out a message to the other forest inhabitants that they should think twice before contemplating invading the birds' territory and empty nests while they are gone. For these robins most certainly plan to be back in the spring.

With a quick tilt of her head this way and that to make sure the coast is clear, she takes off into the evening sky. The nights have been lengthening with winter's advance and she will have a good ten hours or so of flying ahead of her before she can rest again.

She sets off on a course bearing of 195° (15° to the west of due south). Over the coming days she will carry on flying in, more or less, this same direction, covering two hundred miles on a good day. She has no idea what to expect along the journey, nor any sense of how long it will take. The terrain around her spruce wood is a familiar one, but after a few miles she is flying over an alien moonlit landscape of lakes, valleys and towns.

Somewhere near the Mediterranean she will arrive at her destination; although she is not heading for any specific location, when she does arrive at a favourable spot she will stop, memorizing the local landmarks so that she can return there in the coming years. If she has the strength, she may even fly all the way across to the North African coast. But this is her first migration, and her only priority now is to escape the biting cold of the approaching Nordic winter.

She seems oblivious to the surrounding robins that are all flying in roughly the same direction, some of which will have made the journey many times before. Her night vision is superb, but she is not looking for any landmarks – as we might were we making such a journey – nor is she tracking the pattern of the stars in the clear night sky by consulting her internal celestial map, as many other nocturnal migrating birds do. Instead, she has a rather remarkable skill and several million years of evolution to thank for her capacity to make what will become an annual autumn migration, a trip of some two thousand miles.

Migration is, of course, commonplace in the animal kingdom. Every winter, for instance, salmon spawn in the rivers and lakes of northern Europe, leaving young fry that, after hatching, follow the course of their river out to sea and into the North Atlantic, where they grow and mature; three years later, these young salmon return to breed in the same rivers and lakes where they spawned. New World monarch butterflies migrate thousands of miles southward across the entire United States in the autumn. They, or their descendants (as they will breed en route), then return north to the same trees in which they pupated in the spring. Green turtles that hatch on the shores of Ascension Island in the South Atlantic swim across thousands of miles of ocean before returning, every three years, to breed on the exact same eggshell-littered beach from which they emerged. The list goes on: many species of birds, whales, caribou, spiny lobsters, frogs, salamanders and even bees are all capable of undertaking journeys that would challenge the greatest human explorers.

How animals manage to find their way around the globe has been a mystery for centuries. We now know that they employ a variety of methods: some use solar navigation during the day and celestial navigation at night; some memorize landmarks; others can even *smell* their way around the planet. But the most mysterious navigational sense of all is the one possessed by the European robin: the ability to detect the direction and strength of the earth's magnetic field, known as magnetoreception. And while we now know of a number of other creatures that possess this ability, it is the way the European robin (*Erithacus rubecula*) finds her way across the globe that is of greatest interest to our story.

The mechanism that enables our robin to know how far to fly, and in which direction, is encoded in the DNA she inherited from her parents. This ability is a sophisticated and unusual one – a *sixth sense* that she uses to plot her course. For, like many other birds, and indeed insects and marine creatures, she has the ability to sense the earth's weak magnetic field and to draw directional information from it by way of an inbuilt navigational sense, which in her case requires a novel type of chemical compass.

Magnetoreception is an enigma. The problem is that the earth's magnetic field is very weak – between 30 and 70 microtesla at the surface: sufficient to deflect a finely balanced and almost frictionless compass needle, but only about a hundredth the force of a typical fridge magnet. This presents a puzzle: for the earth's magnetic field to be detected by an animal it must somehow influence a chemical reaction somewhere in the animal's body – this is, after all, how all living creatures, ourselves included, sense any external signal. But the amount of energy supplied by the interaction of the earth's magnetic field with the molecules within living cells is less than a billionth of the energy needed to break or make a chemical bond. How, then, can that magnetic field be perceptible to the robin?

Mysteries, however small, are fascinating because there's always the possibility that their solution may lead to a fundamental shift in our understanding of the world. Copernicus's ponderings in the sixteenth century on a relatively minor problem concerning the geometry of the Ptolemaic geocentric model of the solar system, for instance, led him to shift the centre of gravity of the entire universe away from humankind. Darwin's obsession with the geographical distribution of animal species and the mystery of why isolated island species of finches and mockingbirds tend to be so specialized led him to propose his theory of evolution. And German physicist Max Planck's solution to the mystery of blackbody radiation, concerning the way warm objects emit heat, led him to suggest that energy came in discrete lumps called 'quanta', leading to the birth of quantum theory in the year 1900. So, could the solution to the mystery of how birds find their way around the globe lead to a revolution in biology? The answer, bizarre as it may seem, is: yes.

A digital copy of the text can be seen at https://www.amazon.co.uk/Life-Edge-Coming-Quantum-Biology/dp/0593069323

It is not necessary, nor expected, that you purchase this book. It will not be needed for your course.

Essay question: What is the next big revolution in Biology?

Your extended response essay should take about 30 minutes to research and 30 minutes to write. You should spend about 10 minutes checking your work.

Your answer ***could*** follow this structure:

Paragraph 1: What are the big unanswered questions in Biology?

Paragraph 2: What discovery or revolution would be most impactful? Why?

Paragraph 3: Who, if anyone, is currently funding or working on research in this area? If it is not being studied, why not? What are the current priorities in biological research?

Your response does not necessarily need to refer to the extract you have just read. Your essay could focus on, but is not limited to:

- Personalisation of human medicine. Can we find a way to cure anyone of any disease, instantly?
- Creating organisms that are immune to mutation. Is this the key to eliminating cancer? If this is possible, what are the implications for evolution?
- Stopping the antibacterial resistance crisis. What could the solution to the biggest healthcare crisis of our generation be?
- Understanding and slowing human ageing. If humans could live forever, how could this discovery be used responsibly?
- Communication with other species. Will humans ever be able to talk to animals?

You could start your research with the following links to additional resources.

- https://www.cell.com/molecular-cell/pdf/S1097-2765(11)00331-5.pdf
- https://en.wikipedia.org/wiki/List_of_unsolved_problems_in_biology
- https://www.theguardian.com/science/2013/sep/01/20-big-questions-in-science
- https://www.newscientist.com/round-up/revolutionary-ideas/
- https://www.forbes.com/sites/quora/2017/02/14/what-are-the-most-important-unanswered-questions-in-science-that-are-likely-to-be-answered-by-2025/#365057d751e2

Your essay question should take at least one side of A4 or you may type and print your response (around 500 words). You should write using accurate English.

Part 2

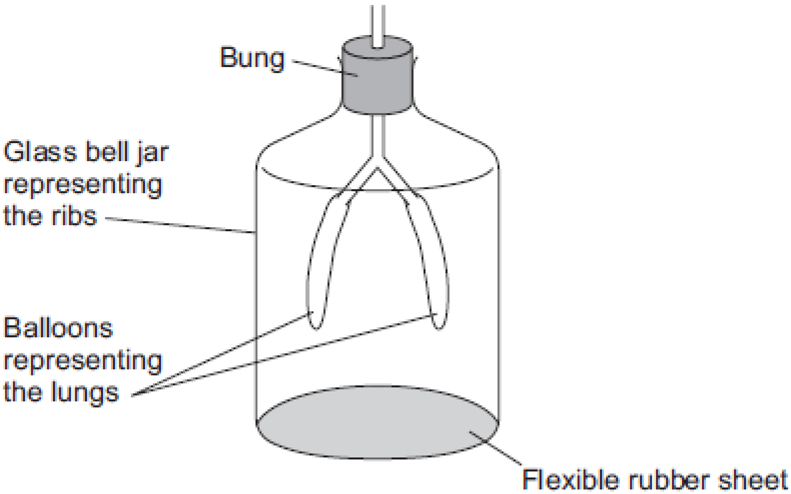
Answer all the exam questions. These are from the GCSE course and all supporting knowledge should be secure before arriving in September. You should thoroughly complete any revision necessary to answer the questions. You will be given the answers during your first week.

Q1.

Figure 1 shows a model representing the human breathing system.

The different parts of the model represent different parts of the human breathing system.

Figure 1



(a) (i) Which part of the human breathing system does the flexible rubber sheet represent?

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(1)

(ii) Explain why the balloons inflate when the flexible rubber sheet is pulled down.

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(3)

(b) (i) During breathing, oxygen moves into the blood.

Explain how oxygen moves into the blood.

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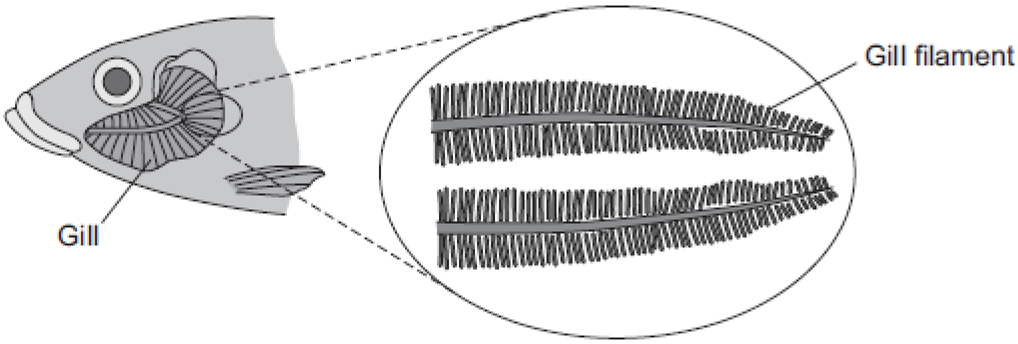
(2)

(ii) **Figure 2** shows a fish head and gill.

Figure 2



Fish absorb oxygen from the water. Oxygen is absorbed through the gills of the fish.

Explain **one** way in which the gills are adapted for rapid absorption of oxygen.

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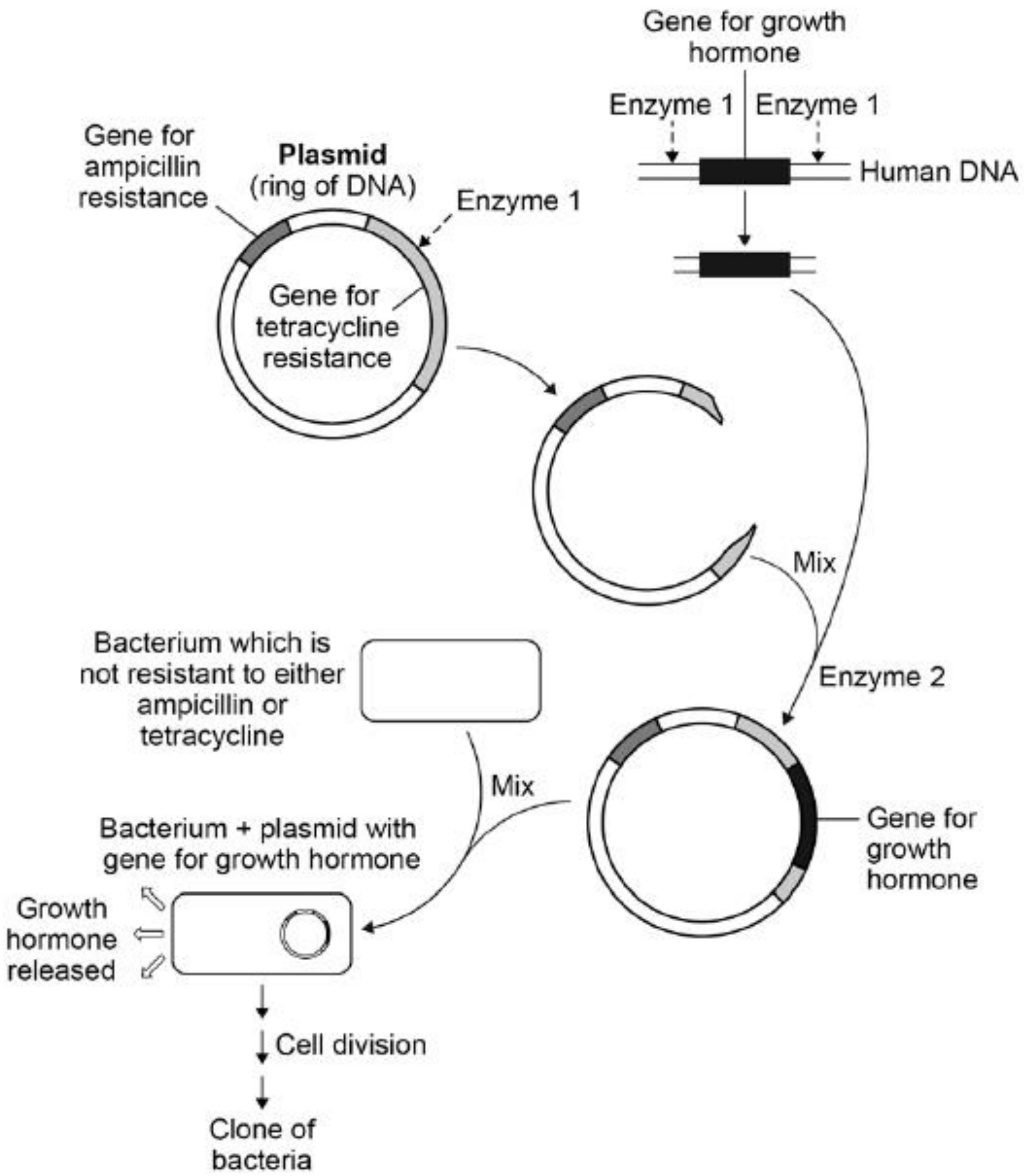
(2)
(Total 8 marks)

Q2. The diagram shows how scientists can use genetic engineering to produce human growth hormone.



(a) Human growth hormone is made by the pituitary gland.

The human DNA containing the gene for growth hormone can be taken from a white blood cell.

Give the reason why the gene does **not** have to be taken from cells in the pituitary gland.

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1)

The figure above shows that the plasmid contains two genes for antibiotic resistance:

- a gene for resistance to the antibiotic ampicillin
- a gene for resistance to the antibiotic tetracycline.

(b) Explain how the structure of **Enzyme 1** allows it to cut the gene for tetracycline resistance, but **not** the gene for ampicillin resistance.

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(3)

(c) In the final step of the diagram above, very few bacteria take up a plasmid containing the gene for growth hormone.

Some bacteria take up an unmodified plasmid.

Most bacteria do **not** take up a plasmid.

Complete the table below.

- Put a tick in the box if the bacterium **can** multiply in the presence of the given antibiotic.
- Put a cross in the box if the bacterium **cannot** multiply in the presence of the given antibiotic.

	Bacterium can multiply in the presence of	
	Ampicillin	**Tetracycline**
Bacterium + plasmid with growth hormone gene		
Bacterium without a plasmid		
Bacterium with an unmodified plasmid		

(d) The figure above shows that the bacterium containing the gene for human growth hormone multiplies by cell division.

This produces a clone of bacteria.

Explain why **all** the bacteria in this clone are able to produce growth hormone.

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(3)

(Total 10 marks)

Q3.

The circulatory system contains arteries and veins.

(a) (i) Describe how the structure of an artery is different from the structure of a vein.

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(2)

(ii) A comparison is made between blood taken from an artery in the leg and blood taken from a vein in the leg.

Give **two** differences in the composition of the blood.

1. ____

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2. ____

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(2)

(b) During operations patients can lose a lot of blood. Patients often need blood transfusions to keep them alive.

The text shows information about a new artificial blood product.

Sea worms give hope for people in need of blood transfusions

Scientists have carried out a five-year trial using a new artificial blood product. The scientists have used a protein from sea worms to create the new artificial blood and the results from the trial are very positive. Thousands of sea worms can be grown and collected.

During the trial, mice were given blood transfusions of the artificial blood. The bodies of the mice tolerated the artificial blood and the artificial blood did not cause any side effects.

Suggest **two** possible advantages of using the new artificial blood, instead of using human blood for a transfusion in humans.

1. ____

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2. ____

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(2)

(Total 6 marks)

Q4.

A gardener is looking at the plants in his greenhouse.

(a) Some of the plants have a disease.

Give **two** ways the gardener could identify the pathogen infecting the plants.

1. ____

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2. ____

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(2)

(b) Plants can become unhealthy if they do not have essential mineral ions.

Describe the appearance of plants with:

- **nitrate** deficiency
- **magnesium** deficiency.

Nitrate deficiency ____

____

Magnesium deficiency ____

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(2)

(c) Plants need other mineral ions.

- Potassium ions are needed for healthy root growth.
- Phosphate ions are needed for healthy flowers and fruits.

The gardener makes his own garden compost.

The percentage (%) of minerals in his compost was compared with two fertilisers he could buy.

The data are shown in the table below.

	Percentage (%) mineral content			
	Nitrate ions	**Phosphate ions**	**Potassium ions**	**Cost in £ / kg**
Garden compost	0.5	0.3	0.8	0.00
Fertiliser S	5.0	1.3	6.6	4.99
Fertiliser T	3.0	12.0	6.0	9.99

The gardener buys Fertiliser **S**. Explain why he chose Fertiliser **S**.

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(4)
(Total 8 marks)

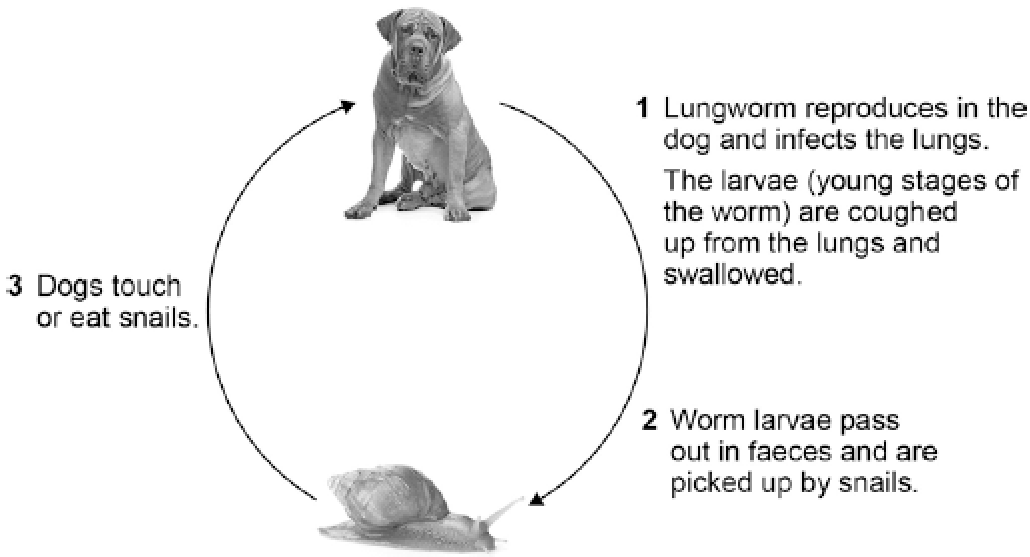
Q5.

Lungworm is an infection.

Lungworm can kill dogs.

It is caused by a small worm.

The diagram below shows the lifecycle of the lungworm.



Dog © Eriklam/iStock/Thinkstock, snail © Karandaev/iStock/Thinkstock

(a) What type of organism is represented by the snail in the lifecycle of the lungworm?

Tick **one** box.

Fungus ☐

Parasite ☐

Protist ☐

Vector ☐

(1)

(b) Suggest how the spread of the lungworm disease can be prevented.

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(3)

(c) Malaria is a disease spread by mosquitoes.

Describe **two** ways to control the spread of malaria.

1. ____

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2. ____

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(2)
(Total 6 marks)

Q6.

All living cells respire.

(a) Respiration transfers energy from glucose for muscle contraction.

Describe how glucose from the small intestine is moved to a muscle cell.

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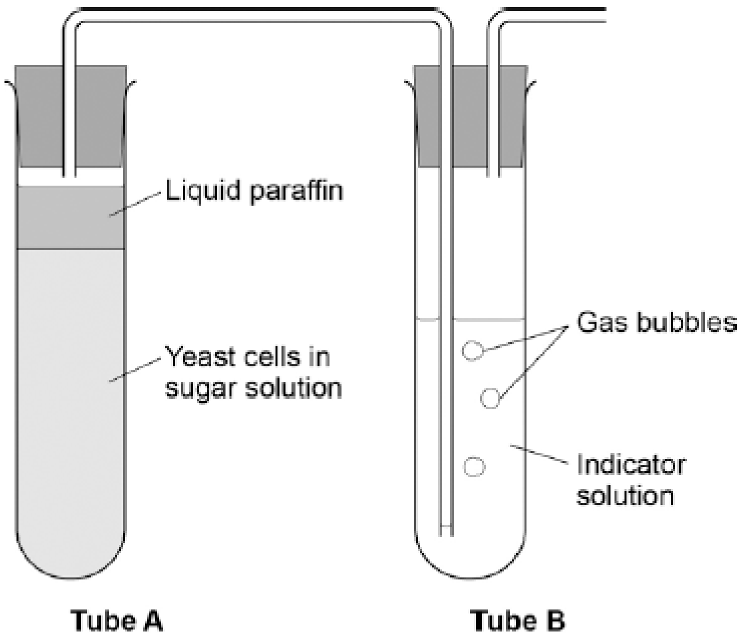
(2)

(b) The diagram below shows an experiment to investigate **anaerobic** respiration in yeast cells.



What is the purpose of the liquid paraffin in Tube **A**?

Tick **one** box.

To prevent evaporation	☐
To stop air getting in	☐
To stop the temperature going up	☐
To stop water getting in	☐

(1)

(c) The indicator solution in Tube **B** shows changes in the concentration of carbon dioxide (CO_2).

The indicator is:

- **blue** when the concentration of CO_2 is very low
- **green** when the concentration of CO_2 is low
- **yellow** when the concentration of CO_2 is high.

What colour would you expect the indicator to be in Tube **B** during maximum rate of anaerobic respiration?

Tick **one** box.

Blue ☐

Green ☐

Yellow ☐

(1)

(d) Suggest how the experiment could be changed to give a reproducible way to measure the rate of the reaction.

Include any apparatus you would use.

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(2)

(e) Compare anaerobic respiration in a yeast cell with anaerobic respiration in a muscle cell.

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(3)

(Total 9 marks)

Q7. Green plants can make glucose.

(a) Plants need energy to make glucose.

How do plants get this energy?

(2)

(b) Plants can use the glucose they have made to supply them with energy.

Give **four** other ways in which plants use the glucose they have made.

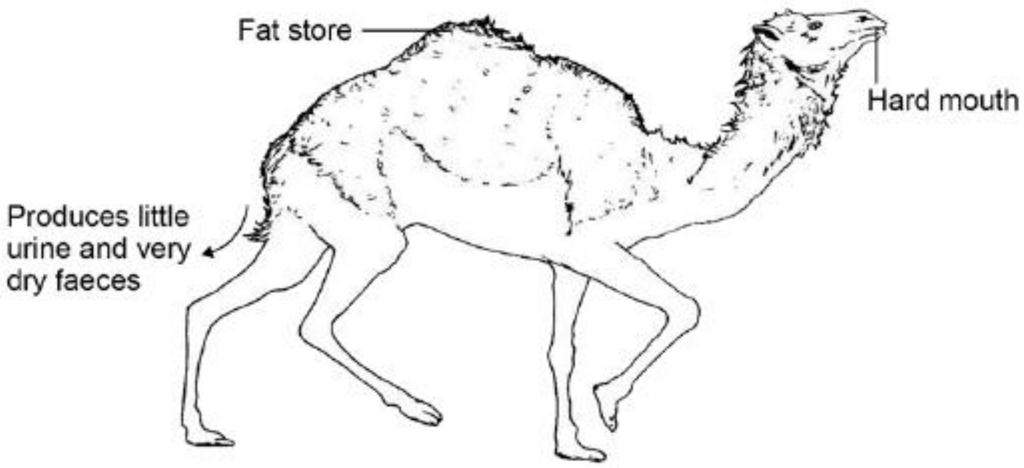
(4)

(Total 6 marks)

Q8. **Figure 1** shows a type of camel called a dromedary (*Camelus dromedarius*).

The dromedary lives in hot, dry deserts.

Figure 1



(a) One adaptation of the dromedary is 'temperature tolerance'.

This means that the animal's body temperature can rise by up to 6 °C before it starts to sweat.

Explain how temperature tolerance can help the dromedary to survive in the desert.

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(2)

(b) Three more adaptations of the dromedary are given in **Figure 1**. Give a reason why each adaptation helps the animal survive in the desert.

Fat store ____

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Produces little urine and very dry faeces ___________________________________

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Hard mouth ____

____**(3)**

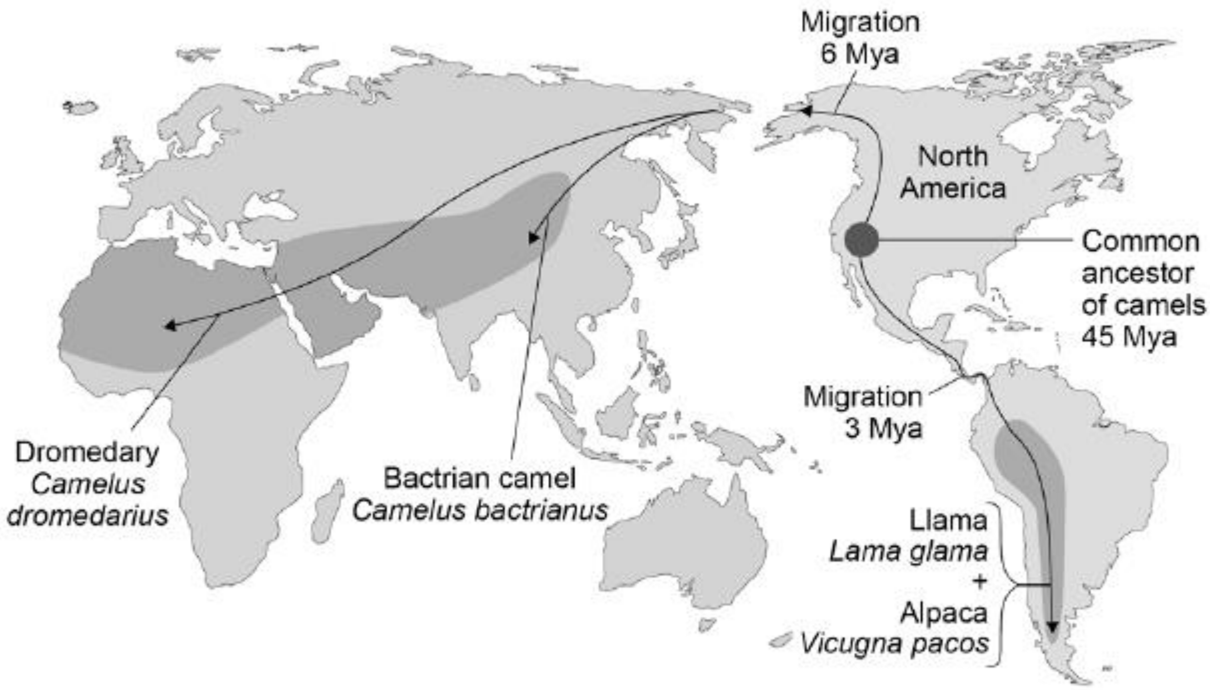
There are several species of the camel family alive today.

Scientists think these species evolved from a common ancestor that lived in North America about 45 million years ago (Mya).

Figure 2 shows:

- where four modern species of the camel family live today
- how the ancestors of these camels migrated from North America.

Figure 2



(c) Which **two** of the four modern species of camel do scientists believe to be most closely related to each other?

Give the reason for your answer.

______________________________ and ______________________________

Reason ____

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(1)

(d) Describe the type of evidence used for developing the theory of camel migration shown in **Figure 2**.

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(2)

(e) Explain how several different species of camel could have evolved from a common ancestor over 45 million years.

(6)

(Total 14 marks)

Q9.

Blood is part of the circulatory system.

(a) (i) Give **one** function of white blood cells.

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(1)

(ii) Which of the following is a feature of platelets?

Tick (✓) **one** box.

They have a nucleus.	☐
They contain haemoglobin.	☐
They are small fragments of cells.	☐

(1)

(b) Urea is transported by the blood plasma from where it is made to where the urea is excreted.

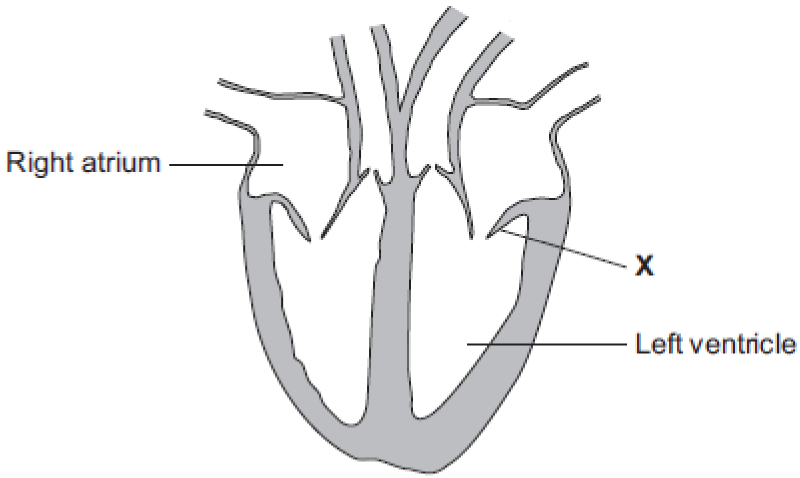
Complete the following sentence.

Blood plasma carries urea from where it is made in the __________________

to the _______________________ where the urea is removed from the blood.

(2)

(c) The illustration shows a section through the human heart.



Structure **X** is a valve. If valve **X** stops working, it may need to be replaced.

A scientist is designing a new heart valve. The scientist knows that the valve must be the correct size to fit in the heart.

Suggest **two** other factors the scientist needs to consider so that the newly designed valve works effectively in the heart.

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(2)

(Total 6 marks)

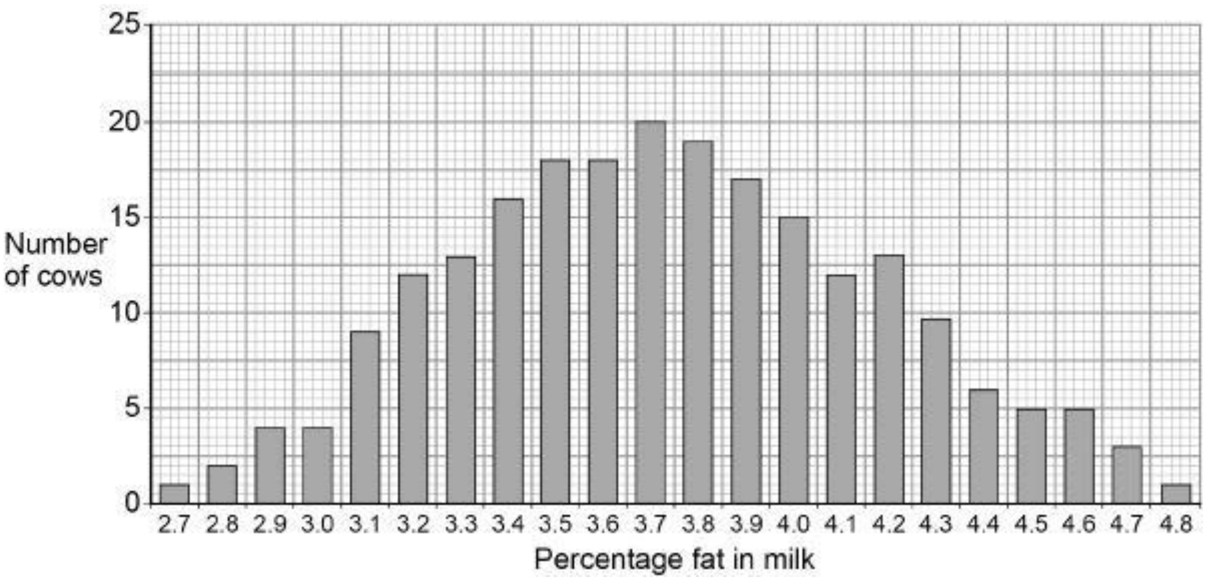
Q10.

Scientists want to breed cows that produce milk with a low concentration of fat.

Figure 1 shows information about the milk in one group of cows.

The cows were all the same type.

Figure 1



(a) In **Figure 1** the mean percentage of fat in the milk is equal to the modal value.

Give the mean percentage of fat in the milk of these cows.

Mean percentage = ___________________

(1)

(b) A student suggested:

'The percentage of fat in milk is controlled by one dominant allele and one recessive allele.'

How many different phenotypes would this produce?

Tick **one** box.

2		3		22		46	

(1)

(c) Give the evidence from **Figure 1** which shows the percentage of fat in the milk is controlled by several genes.

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(1)

(d) One of the genes codes for an enzyme used in fat metabolism.

A mutation in this gene causes a reduction in milk fat.

The mutation changes one amino acid in the enzyme molecule.

Explain how a change in one amino acid in an enzyme molecule could stop the enzyme working.

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(3)

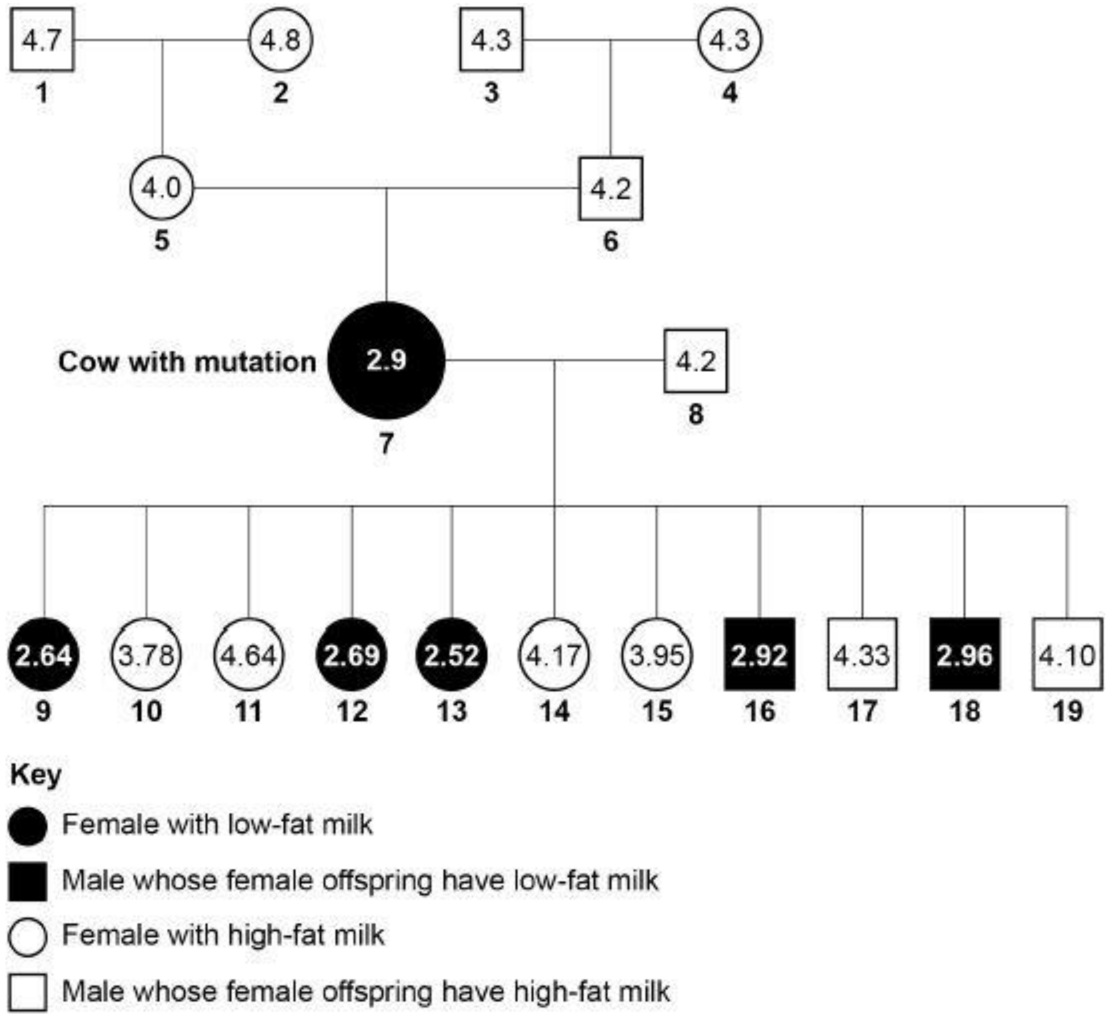
The scientists found one cow with a mutation.

The cow's milk contained only 2.9% fat.

Figure 2 shows the percentage of fat in the milk of cattle related to the cow with the mutation.

The values for male cattle are the mean values of their female offspring.

Figure 2



(e) Animal **8** is homozygous.

The mutation in animal **7** produced a dominant allele for making low-fat milk.

Give evidence from **Figure 2** that animal **7** is heterozygous.

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(1)

(f) Animals **7** and **8** produced 11 offspring. These offspring were produced by in vitro fertilisation (IVF).

The embryos from IVF were transferred into 11 other cows.

Suggest why IVF and embryo transfer were used rather than allowing animals **7** and **8** to mate naturally.

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(1)

(g) Draw a Punnett square diagram to show a cross between animals **7** and **8**.

Identify which offspring produce low-fat milk and which offspring produce high-fat milk.

Use the following symbols:

D = dominant allele for making low-fat milk

d = recessive allele for making high-fat milk

(4)

(h) The scientists want to produce a type of cattle that makes large volumes of low-fat milk.

The scientists will selectively breed some of the animals shown in **Figure 2**.

Describe how the scientists would do this.

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(4)

(Total 16 marks)

Q11. Cell division is needed for growth and for reproduction.

(a) The table below contains three statements about cell division.

Complete the table. Tick **one** box for each statement.

	Statement is true for		
Statement	**Mitosis only**	**Meiosis only**	**Both mitosis and meiosis**
All cells produced are genetically identical			
In humans, at the end of cell division each cell contains 23 chromosomes			
Involves DNA replication			

(2)

Bluebell plants grow in woodlands in the UK.

- Bluebells can reproduce sexually by producing seeds.
- Bluebells can also reproduce asexually by making new bulbs.

(b) One advantage of asexual reproduction for bluebells is that only **one** parent is needed.

Suggest **two** other advantages of asexual reproduction for bluebells.

1. ____

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2. ____

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(2)

(c) Explain why sexual reproduction is an advantage for bluebells.

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(4)

(Total 8 marks)

Q12.
Cows are reared for meat production.

The cows can be reared indoors in heated barns, or outdoors in grassy fields.

The table shows energy inputs and energy outputs for both methods of rearing cows.

	kJ / m² / year		
	Energy input		**Energy output**
	Food	**Fossil fuels**	**Meat production**
Indoors	10 000	6 000	40
Outdoors	5 950	50	**X**

(a) The percentage efficiency for rearing cows **outdoors** is 0.03%

Calculate the energy output value **X**.

Use the equation:

$$\text{percentage efficiency} = \frac{\text{energy output}}{\text{total energy input}} \times 100$$

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Energy output value **X** = ____________________ kJ / m² / year

(3)

(b) The percentage efficiency for rearing cows **outdoors** is 0.03%

Calculate how many times more efficient it is to rear cows indoors than to rear cows outdoors.

Use the equation from (a).

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Answer = ____________________ times

(3)

(c) A large amount of energy is wasted in both methods of rearing cows.

Give **two** ways in which the energy is wasted.

1. ___

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2. ___

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(2)

(d) Suggest **two** reasons why it is more efficient to rear cows indoors than to rear cows outdoors.

1. ___

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2. ___

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(2)

(Total 10 marks)