

Questions**Q1.**

Leptin is a protein hormone with a role in the control of appetite in humans.

The leptin gene is located on chromosome 17.

(i) State what is meant by the term gene.

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(ii) Describe the role of tRNA in the production of leptin.

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(iii) Describe how the primary structure of leptin enables it to be soluble in water.

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(Total for question = 8 marks)

Q2.

Mutations to DNA can affect the structure of proteins produced in the cell.

Removing one base from a DNA sequence will affect the primary structure of a protein.

Changing one base for another may not affect the primary structure of a protein.

Explain why these two types of mutation have different effects on protein structure.

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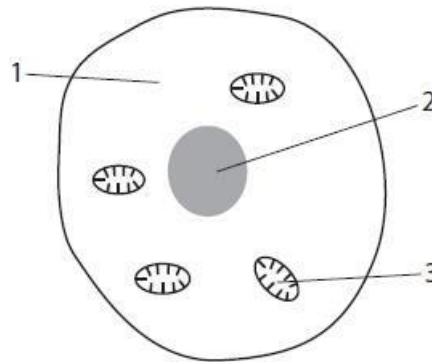
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(Total for question = 4 marks)

Q3.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☐.

The diagram shows some of the features of a human liver cell.



(i) Which of the labelled features in the liver cell contain RNA?

(1)

- ☐ **A** 1 only
☐ **B** 1 and 3 only
☐ **C** 2 and 3 only
☐ **D** 1, 2 and 3

(ii) Cells produce lactate during anaerobic respiration. Lactate travels in the blood to the liver.

Liver cells can absorb lactate from the blood.

Deduce what happens to the lactate in these cells.

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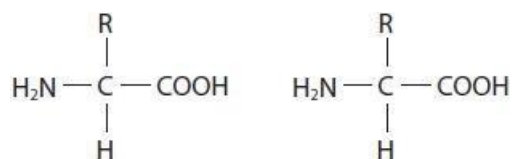
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(iii) During protein synthesis, two amino acids are joined together to form a dipeptide.

The diagram shows two identical amino acids.

Complete the diagram to show how the dipeptide is formed from these two amino acids.

(2)



(Total for question = 5 marks)

Q4.

Thalassaemia is a recessive genetic disorder that affects the production of haemoglobin. It is caused by a gene mutation.

Scientists are developing methods to repair gene mutations such as the one that causes thalassaemia.

One of the most common mutations causing thalassaemia is the substitution of one adenine base with guanine. The diagram shows the location of the mutation in part of the DNA strand coding for four amino acids.



Explain why this mutation affects the function of the haemoglobin molecule.

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(Total for question = 3 marks)

Q5.

Glucosaminoglycans (GAGs) are the by-products of chemical reactions inside cells. GAGs are broken down by enzymes inside lysosomes in cells.

Mucopolysaccharidosis type I (MPS I) is a genetic condition that results in the build-up of GAGs inside cells.

MPS I affects the production of enzyme G that breaks down GAGs inside lysosomes.

Enzymes work by

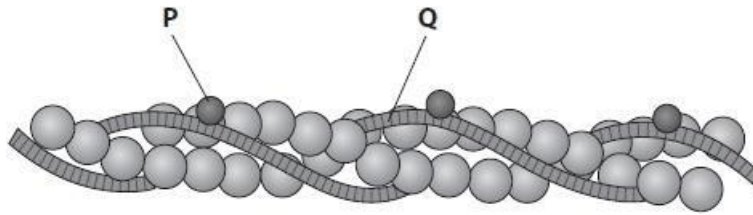
(1)

- ☐ **A** increasing the activation energy of a reaction
- ☐ **B** lowering the activation energy of a reaction
- ☐ **C** providing energy to the reactants
- ☐ **D** removing energy from the products

(Total for question = 1 mark)

Q6.

The diagram shows actin and other components (P and Q) of a thin filament in a myofibril.



(i) Describe the interaction between P and Q that allows muscle contraction.

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(ii) The thick filament in a myofibril contains myosin. The myosin head contains the enzyme ATPase.

Explain the importance of the primary structure for the functioning of this enzyme.

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(Total for question = 5 marks)

Q7.

An experiment was carried out to determine the effect of temperature on the activity of the enzyme catalase in yeast cells.

The substrate was hydrogen peroxide. A suspension of yeast cells was added to hydrogen peroxide.

The volume of oxygen produced during the initial two minutes was recorded. This was repeated at a range of temperatures.

The results are shown in the table.

Temperature / °C	Mean volume of oxygen / mm ³
20	80
30	240
40	540
50	320
60	120

- (i) Calculate the temperature coefficient (Q_{10}) for this reaction between 20 °C and 30 °C.

(1)

Answer

- (ii) Explain the effects of a temperature increase from 20 °C to 30 °C on the initial rate of activity of catalase in the yeast cells.

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- (iii) Explain what happens to the Q_{10} value between 40 °C and 50 °C.

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(Total for question = 6 marks)

Q8.

Haemophilia is a disease that affects blood clotting. People with haemophilia are sometimes given a protein called factor VIII. Factor VIII is an enzyme that is involved in the process of blood clotting.

Explain how a change in the primary structure of factor VIII could cause difficulties with blood clotting.

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(Total for question = 4 marks)

Q9.

Spiders inject a mixture of digestive enzymes into the body of their prey and feed on the products of this digestion.

The photograph shows a spider with its prey.



State why enzymes are described as biological catalysts.

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(Total for question = 1 mark)

Q10.

Glucosaminoglycans (GAGs) are the by-products of chemical reactions inside cells. GAGs are broken down by enzymes inside lysosomes in cells.

Mucopolysaccharidosis type I (MPS I) is a genetic condition that results in the build-up of GAGs inside cells.

MPS I affects the production of enzyme G that breaks down GAGs inside lysosomes.

More than 50 different mutations in the gene for enzyme G have been found to result in MPS I. Most of these mutations involve changing a single base in the gene.

- (i) Explain how a single base mutation can lead to an altered primary structure of enzyme G.

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- (ii) Explain how human genome sequencing can be used to identify the mutations associated with MPS I.

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(Total for question = 6 marks)

Q11.

- (i) Many of the proteins synthesised become extracellular enzymes.

Describe what happens to these proteins following the process of translation until they are released from the cell.

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- (ii) Cells in people with these diseases produce incorrectly folded enzyme molecules.

Explain why enzymes that are incorrectly folded cannot carry out their function.

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(Total for question = 6 marks)

Q12.

Mucopolysaccharides are complex molecules found in the human body.

Mucopolysaccharides can be broken down by enzymes.

Describe how an enzyme could break down the polysaccharide component of mucopolysaccharides.

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(Total for question = 2 marks)

Q13.

A newborn baby can respond to infections.

Interferon is involved in the response to viral infections.

(i) The influenza virus can be lethal to mice.

The effects of interferon on influenza infection in mice was investigated.

Mice were infected with influenza virus and then given interferon.

The results of the investigation are shown in the table.

Interferon dose / units per mouse	Median survival time / days
No dose	3.3
8×10^3	4.4
8×10^4	8.5
8×10^5	>42

Explain these results.

(3)

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- (ii) Interferon can be used to treat people with viral hepatitis.

Interferon can be made by animal cells or by genetically modified bacteria.

The table shows information about interferon made by these animal cells and genetically modified bacteria.

Source of interferon	Type of molecule	Folding	Antiviral activity
Animal cells	Glycoprotein	Correctly folded	High
Genetically modified bacteria	Protein	Incorrectly folded and needs to be refolded before it can be used	Low

Explain why the interferon made by genetically modified bacteria is different from the interferon made by animal cells.

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- (iii) Glycoproteins made in animal cells are released into the extracellular fluid by

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- ☐ A endocytosis
- ☐ B exocytosis
- ☐ C facilitated diffusion
- ☐ D phagocytosis

(Total for question = 6 marks)

Q14.

When astronauts are in space, the force of gravity is less than when they are on a planet such as Earth or Mars.

Scientists need to investigate how varying gravity affects astronauts.



NASA/Science photo library

The scientists proposed a null hypothesis for the rate of breakdown of protein in the muscle cells of the two groups.

The data from this investigation showed that there was no significant difference at the 0.05 probability level.

(i) Explain what is meant by no significant difference at the 0.05 probability level for the rate of breakdown of protein.

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(ii) Some of the myosin in the muscle cells was broken down.

Describe how the tertiary structure of myosin is related to its function.

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(Total for question = 5 marks)

Q15.

Muscle cells contain globular and fibrous proteins.

Compare and contrast the molecular structures of globular and fibrous proteins.

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(Total for question = 4 marks)

Q16.

Sickle cell anaemia is a genetic disorder caused by a mutated allele for haemoglobin.

This causes one amino acid to be changed in one type of polypeptide chain in the haemoglobin protein. This affects the function of the red blood cells.

- (i) An allele is a version of a gene.

State what is meant by the term gene.

(1)

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Two parents who are both heterozygous for the mutated allele are expecting a child.

Use a genetic diagram to determine the probability of this child being homozygous for the mutated allele.

(2)

Answer

- (iii) Explain how a change of one amino acid could lead to a change in the structure and properties of the haemoglobin protein.

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(Total for question = 7 marks)

Q17.

Some species of bacteria have developed resistance to antibiotics.

This has led scientists to investigate many molecules for antimicrobial properties.

Peptides extracted from broad bean plants and cowpea plants have been studied.

Describe how a peptide bond is formed.

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(Total for question = 2 marks)

Q18.

Wasps are insects that live in groups.

One species of wasp (*Vespula germanica*) has been shown to knock its body repeatedly against a hard surface. This signals the presence and quality of food to other wasps.

When threatened by another animal, it may use its stinger to inject a venom to protect itself.



bugguide.net

The stinger injects a venom that contains the enzyme phospholipase. This enzyme hydrolyses phospholipids, releasing fatty acids.

Describe how the structure of phospholipase allows it to hydrolyse phospholipids.

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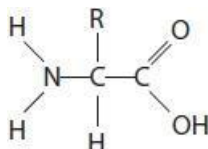
(Total for question = 4 marks)

Q19.

Proteins can be used as a source of energy. This involves the removal of the amine group.

- (i) Draw a circle around the amine group on the diagram of an amino acid.

(1)



- (ii) The R group differs between the amino acids. The R group may contain elements that are not found in a carbohydrate.

Name one of these elements.

(1)

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(Total for question = 2 marks)

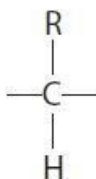
Q20.

Blood plasma contains many different proteins. Prothrombin is a plasma protein that is involved in the blood clotting process.

- (i) The protein prothrombin is composed of monomers called amino acids.

Complete the diagram to show the structure of an amino acid.

(2)



- (ii) Name the products formed when several amino acids are joined together.

(1)

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(Total for question = 3 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> sequence of {bases / nucleotides} in DNA that codes for the {primary structure / amino acid sequence / polypeptide} 	<p>ALLOW that codes for a protein</p>	(2)
(ii)	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> tRNA molecules {transport amino acids to the ribosome} tRNA molecule has an anticodon that {binds to / recognises} a codon on the mRNA each tRNA carries a particular amino acid 	<p>ALLOW the amino acid on the tRNA is determined by the anticodon</p>	(3)
(iii)	<p>A description that makes reference to three of the following:</p> <ul style="list-style-type: none"> {primary structure / sequence of the amino acids} determines the folding (of the polypeptide) forming a globular structure hydrophobic (R) groups located in the centre of the protein / hydrophilic (R) groups located on the outside of the protein water forms hydrogen bonds with { protein / hydrophilic groups} 	<p>ALLOW position of R groups ALLOW determines tertiary structure</p> <p>ALLOW polar for hydrophilic / non-polar for hydrophobic</p> <p>ALLOW dipole-dipole / hydrophilic interactions (between water and the protein)</p>	(3)

Q2.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> deletion could affect every codon (on the mRNA) / substitution will only affect one codon (1) deletion more likely to affect the position of { stop codon / start codon } (1) deletion results in a different sequence of amino acids / substitution may not affect the sequence of amino acids (1) substitution may code for the same amino acid (1) (same amino acid) due to the degenerate nature of the genetic code (1) 	Allow reference to 'frame shift'	(4)

Q3.

Question Number	Answer	Mark
(i)	<p><i>The only correct answer is D because there is RNA in the cytoplasm, nucleus and mitochondria 1, 2 and 3</i></p> <p><i>A is incorrect because there is also RNA in the nucleus and mitochondria</i></p> <p><i>B is incorrect because there is also RNA in the nucleus</i></p> <p><i>C is incorrect because there is also RNA in the cytoplasm (as tRNA, mRNA or in ribosomes)</i></p>	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An answer that makes reference to two of the following:</p> <ul style="list-style-type: none"> (lactate is) { oxidized to form / converted to } pyruvate (1) (pyruvate is) converted to { glucose / glycogen } (1) (pyruvate / glucose) used in respiration (1) 	<p>ALLOW glucose produced from the lactate</p> <p>ALLOW correct named stage e.g. glycolysis for glucose or link reaction for pyruvate</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	<p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> • dipeptide correctly drawn with peptide bond (1) • water molecule released (1) 		(2)

Q4.

Question Number	Answer	Additional guidance	Mark
	<p>An explanation that makes reference to three of the following</p> <ul style="list-style-type: none"> • (because) { one triplet is affected / a different triplet code is produced } (1) • (the mutation) could change one of the amino acids (1) • this would {change the bonds formed between the R groups / cause a change in the tertiary structure}(1) • the haemoglobin would no longer be able to bind to oxygen (1) 	<p>ALLOW produce a stop codon</p> <p>IGNORE reference to secondary or quaternary structure</p>	(3)

Q5.

Question Number	Answer	Mark
	<p>B - lowering the activation energy of a reaction</p> <p><i>The only correct answer is B</i></p> <p>A is incorrect because enzymes do not increase activation energy</p> <p>C is incorrect because enzymes do not provide energy to reactants</p> <p>D is incorrect because enzymes do not remove energy from reactants</p>	(1)

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> { P / troponin } changes shape (1) causing { Q / tropomyosin } to move away from the myosin-binding sites (on actin) (1) 	<p>ALLOW P binds with calcium ions</p> <p>ALLOW Q is displaced away from myosin binding sites</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> (primary structure) determines interaction between {amino acids / R groups} (1) (primary structure) determines { folding / tertiary structure } (1) (therefore) affecting the shape of the active site (1) (active site is) complementary to ATP (1) 	<p>e.g. bonds formed between R groups</p> <p>ALLOW 3D shape</p> <p>ALLOW ATP fits active site</p>	(3)

Q7.

Question Number	Answer	Additional guidance	Mark
(i)	<ul style="list-style-type: none"> correct calculation of Q_{10} value 	<u>Example of calculation</u> $(240 \div 80 =) 3$	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> (between 20°C and 30°C) there is more kinetic energy available (1) therefore there will be more frequent collisions (between enzyme and substrate) (1) more enzyme-substrate complexes formed (1) (the Q_{10} value indicates) the activity triples with the 10°C temperature rise (1) 	<p>ALLOW more frequent collisions between catalase and hydrogen peroxide</p>	(3)

Question Number	Answer	Additional guidance	Mark
(iii)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> Q_{10} value is less than 1.0 (1) because the enzyme is denatured (1) therefore no increase in formation of enzyme-substrate complexes / substrate no longer fits active site (1) 	<p>ALLOW Q_{10} value of 0.59</p> <p>ALLOW fewer enzyme-substrate complexes formed</p>	(2)

Q8.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> • (different primary structure) results in a different sequence of amino acids (1) • change in R groups changes { folding / bonding / secondary structure / tertiary structure } (1) • changing { shape / charge } of the active site prevents substrate from being able to bind (1) • { stopping / reducing } the production of fibrin (1) 	<p>Do not accept peptide bonds</p> <p>ALLOW another specific aspect of blood clotting cascade</p>	(4)

Q9.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> • (proteins which) reduce activation energy of biological reactions (1) 	<p>ALLOW increase rate of biological reactions</p> <p>ALLOW references to {in cells / in living organisms}</p>	(1)

Q10.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> changing a base results in a change in the triplet code this changes the codon(s) in the mRNA resulting in a different { amino acid / amino acid sequence } (in the primary structure) 	<p>ALLOW deletion / substitution / insertion / frameshift. ALLOW illustration of change in triplet code e.g. ATT to ATG</p> <p>ALLOW introducing a stop codon / terminating translation</p>	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> sequence the genome of people with MPS1 sequence the genome of a number of people without the condition compare the base sequences to identify mutations found only in individuals with the condition 	<p>ALLOW comparison of base sequences of people with MPS1 and people without MPS1</p>	(3)

Q11.

Question Number	Answer	Additional guidance	Mark
(i)	<p>A description that makes reference to three of the following</p> <ul style="list-style-type: none"> the proteins are folded in the rough endoplasmic reticulum (RER) (1) the proteins are {packaged into/transported in} vesicles (1) the protein is modified in the Golgi apparatus (1) exocytosis (1) 	<p>ALLOW processed/ description of modification ALLOW description of exocytosis</p>	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>An explanation that makes reference to the following</p> <ul style="list-style-type: none"> • (if the protein is not folded correctly) the {tertiary structure / 3D shape} would be different(1) • therefore the active site of the enzyme would not { fit / bind with } the substrate / it would not be able to form an enzyme substrate complex (1) • therefore it would not be able to catalyse the reaction (1) 	ALLOW not complementary	(3)

Q12.

Question Number	Answer	Additional guidance	Mark
	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> • hydrolysis / description of hydrolysis (1) • of glycosidic bonds (1) 		(2)

Q13.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> • increasing dose of interferon increases the survival time of the mice • because interferon inhibits viral replication (inside cells) • the greater the dose of interferon the fewer virus particles {produced / released} (to infect other cells) 	<p>ALLOW positive correlation between interferon dose and survival time</p> <p>ALLOW interferon prevents virus infecting other cells</p>	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> • bacteria do not possess {rER / Golgi apparatus} • polypeptide chain is not {processed / modified} properly • therefore the protein is {incorrectly folded / carbohydrate is not added} 	<p>ALLOW converse statements for each marking point</p> <p>ALLOW Golgi body</p> <p>ALLOW protein</p> <p>ALLOW is not glycosylated</p>	(2)

Question Number	Answer	Mark
(iii)	<p>B - exocytosis</p> <p><i>The only correct answer is B</i></p> <p><i>A is not correct because endocytosis is the process used to take particles into cells</i></p> <p><i>C is not correct because facilitated diffusion is not used to transport proteins</i></p> <p><i>D is not correct because phagocytosis is a process used to engulf large particles such as bacteria</i></p>	(1)

Q14.

Question Number	Answer	Additional guidance	Mark
(i)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> • there is {more than a 5% likelihood / less than 95% likelihood} (1) • therefore the rate of protein breakdown is the same {in space as it is on Earth / for groups 1 and 2} (1) • the calculated value is less than the critical value (at $p=0.05$) (1) 	<p>ALLOW: 'chance' for 'likelihood'</p>	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>A description that makes reference to three of the following:</p> <ul style="list-style-type: none"> • (part) folded into a specific shape with a globular head (1) • that can bind to actin (1) • (myosin) has a site that can bind with ATP (1) • (part) straight to form a bundle with other myosin molecules (1) 	<p>ALLOW R groups arranged to bind with ATP</p>	(3)

Q15.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer which makes reference to four of the following:</p> <ul style="list-style-type: none"> • both are chains of amino acids joined by peptide bonds (1) • both contain named bonds (holding molecule in its three dimensional shape) (1) • globular proteins have hydrophilic groups on the outside whereas fibrous proteins have hydrophobic groups on the outside (1) • globular have tertiary or quaternary structures whereas fibrous have little or no tertiary structure (1) • globular are folded into compact shapes whereas fibrous have long chains (1) 	<p>i.e. hydrogen bonds, disulfide bridges, ionic bonds</p> <p>Allow converse</p> <p>ALLOW globular being spherical and fibrous being long strands</p>	(4)

Q16.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer which makes reference to the following:</p> <ul style="list-style-type: none"> sequence of {bases / nucleotides} in DNA coding for a {sequence of amino acids / polypeptide / protein} 	ALLOW section of DNA coding for a {sequence of amino acids / polypeptide / protein}	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	<ul style="list-style-type: none">correct genetic diagram with reference to parental and offspring genotypes (1)	<p>ALLOW correct gametes and offspring genotypes e.g. S and s for gametes, offspring SS, Ss and ss (or other letters)</p> <div><div>S</div><div>s</div><div>S</div><div>SS</div><div>Ss</div><div>s</div><div>Ss</div><div>ss</div></div>	
	<ul style="list-style-type: none">correct probability (1)	<p>0.25 / 25% / ¼ IGNORE ratios</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> different {sequence of amino acids / primary structure} (1) {a different amino acid will have a} different R group (1) {therefore} {secondary / tertiary / quaternary} structure will change (1) {due to a} change in a named bond (holding molecule in its three-dimensional shape) (1) {haemoglobin} may not bond to oxygen (1) 	<p>ALLOW different polypeptide chain</p> <p>i.e. hydrogen bonds, disulfide bridges, ionic bonds DO NOT ALLOW peptide bonds</p> <p>ALLOW may not bond to haem group ALLOW may not carry oxygen</p>	(4)

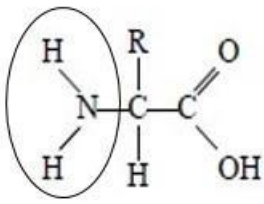
Q17.

Question Number	Answer	Additional guidance	Mark
	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> • (a peptide bond is formed by a) condensation reaction (1) • between the {amine group / NH_2} and the {carboxyl group / COOH} of adjacent amino acids (1) 	<p>ALLOW 'amino' for 'amine' and 'carboxylic acid' for 'carboxyl'</p>	(2)

Q18.


Question Number	Answer	Additional Guidance	Mark
	<p>A description that makes reference to four of the following:</p> <ul style="list-style-type: none"> • the structure of the enzyme is determined by the sequence of amino acids (1) • { tertiary structure / globular shape } provides an active site (1) • active site complementary to { (part of) phospholipid / ester bond } (1) • to break { ester bonds / bonds between glycerol and fatty acids } (1) • relevant detail concerning bonding { within the enzyme molecule / between enzyme and substrate } (1) 	<p>ALLOW primary structure for sequence of amino acids</p> <p>e.g. hydrophilic R groups / hydrophobic R groups</p>	(4)

Q19.

Question Number	Answer	Additional Guidance	Mark
(i)	<ul style="list-style-type: none"> amine group correctly circled on diagram 		(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An answer which makes reference to the following:</p> <ul style="list-style-type: none"> nitrogen / sulfur 	ALLOW N or S sulphur	(1)

Q20.

Question Number	Answer	Additional guidance	Mark
(i)	<ul style="list-style-type: none"> amine group attached to central carbon (1) Carboxylic acid group attached to central carbon (1) 	<p>e.g.</p> 	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	<ul style="list-style-type: none"> polypeptide and water (1) 	Both required for the mark ALLOW oligopeptide	(1)