WJEC EDUQAS A-LEVEL BIOLOGY · COMPONENT 3

BIOLOGY



EXAM QUESTION PACK

OPTION B: HUMAN MUSCULOSKELETAL ANATOMY

SCORE	PERCENTAGE
/157	%

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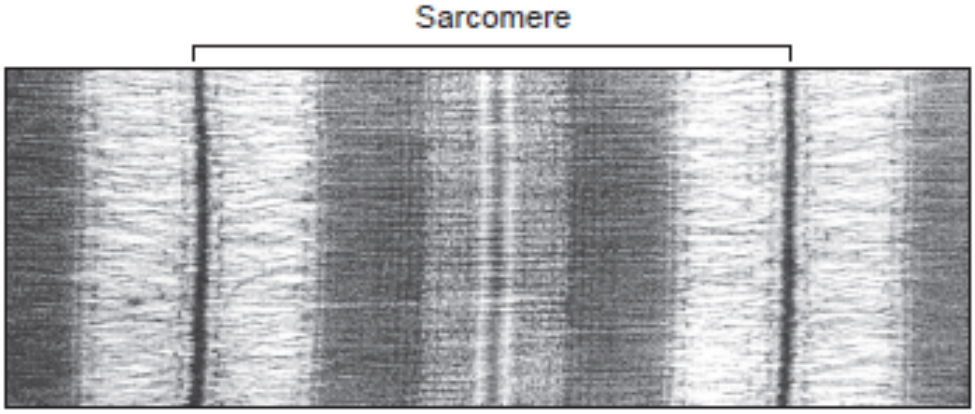
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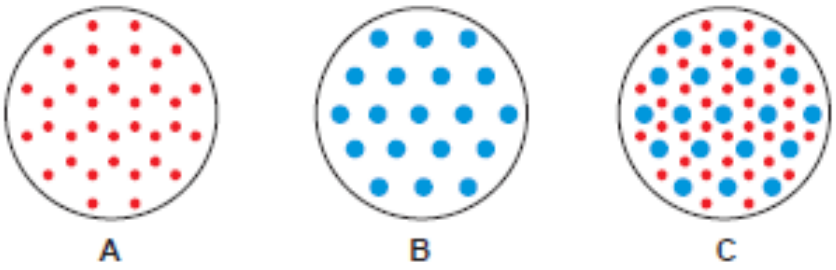
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1. Skeletal muscle is made up of bundles of fibres, which have a striated appearance. Each fibre contains numerous myofibrils. The image below shows a micrograph of a sarcomere.



The drawings below represent the same structure from different regions but in a different plane from the image above.



(a) (i) State whether circles A-C represent transverse or longitudinal sections. [1]

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(ii) With reference to the micrograph, for each of the circles state which region of the sarcomere they are taken from and explain your reasoning. [3]

A .....

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B .....

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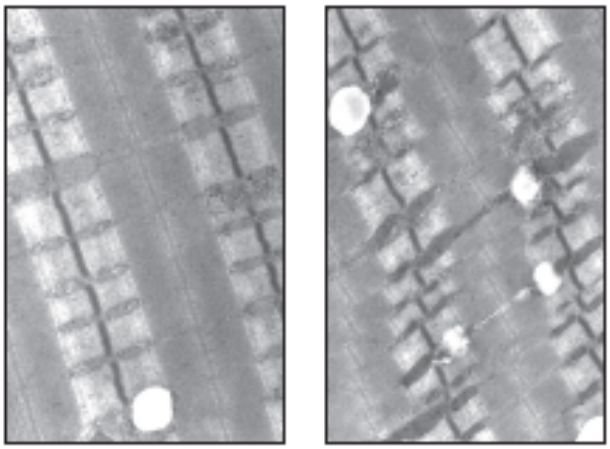
C .....

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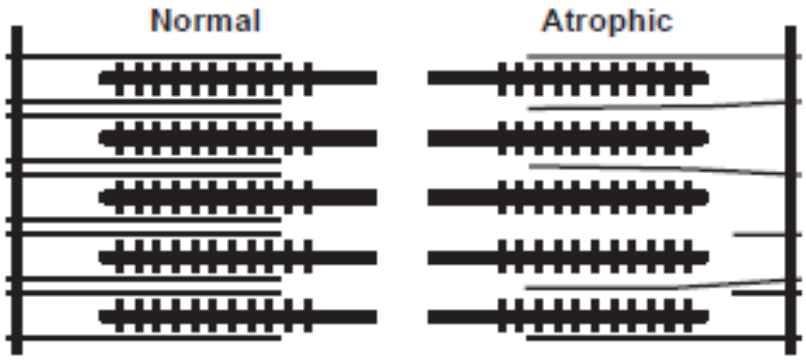
(iii) Describe how the different protein fibres interact to bring about contraction of the sarcomere. [4]

(b) In 2016 Tim Peake was the first British astronaut to spend time on the International Space Station. Research has taken place on astronauts into the effect of prolonged space flight on muscle atrophy. During space flight, astronauts have to exercise, often spending several hours per day on a treadmill.
The images below show electron micrographs of muscle fibres obtained from the muscles of an astronaut before (A) and after (B) a 17-day space flight. The before flight fibres have wider myofibrils whereas myofibrils after flight are narrower, indicating atrophy.

A before flight B after flight



The diagram below represents the atrophy demonstrated in the protein fibres after flight when compared to normal protein fibres.



(i) Why is it important that muscle sample, before and after flight, is taken from the same muscle in the same astronaut? [1]

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(ii) Using the image and your knowledge of muscle contraction, conclude how spaceflight would affect the maximum force that the muscle could generate. [2]

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(c) The bones of the skeleton can fracture for a variety of reasons. The X-rays below show two such injuries:

C Lower right leg



D Left hip



X-ray C is taken from a healthy 19-year-old male with a displaced fracture of the fibula. X-ray D is from a 75-year-old woman, suffering from osteoporosis with a non-displaced fracture of the femur.

(i) Explain why the fracture shown in X-ray C is more likely to heal with the best chance of full recovery than the fracture shown in X-ray D. [2]

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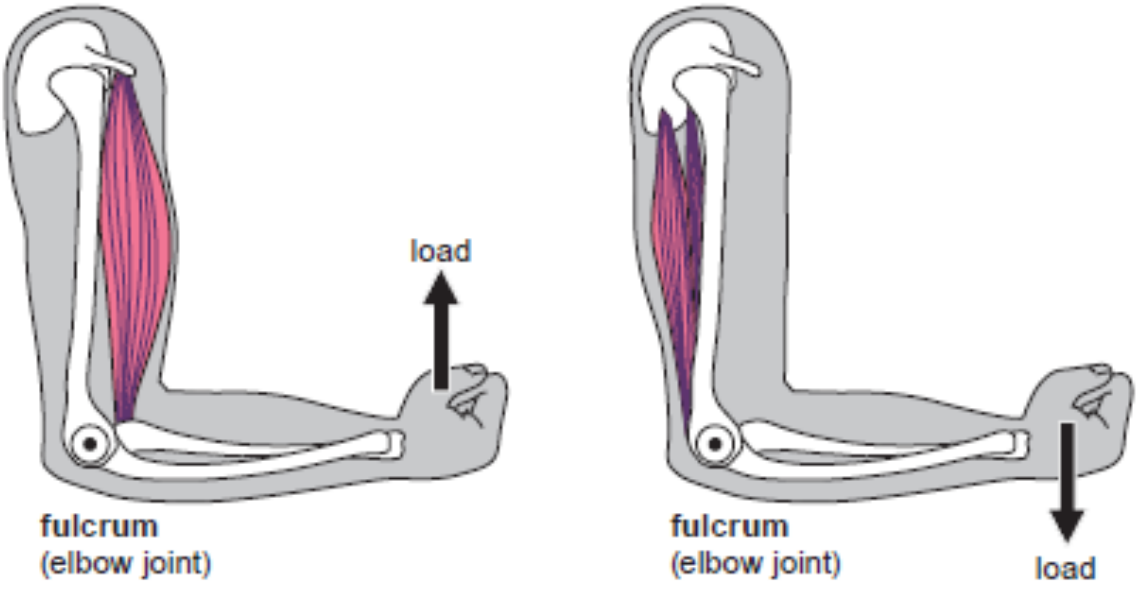
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(ii) Both fractures required surgery and the use of screws and/or metal plates. Suggest why this treatment would lead to a faster recovery than bed rest or immobilisation. [1]

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(d) The drawings below show the muscles that control movement of the lower arm. These muscles work with the elbow joint as levers.



(i) State the orders of lever represented in the elbow joint when the: [1]

Biceps are contracting .....

Triceps are contracting .....

(ii) Explain why there is a difference in the type of lever represented when the arm is being bent and straightened. [2]

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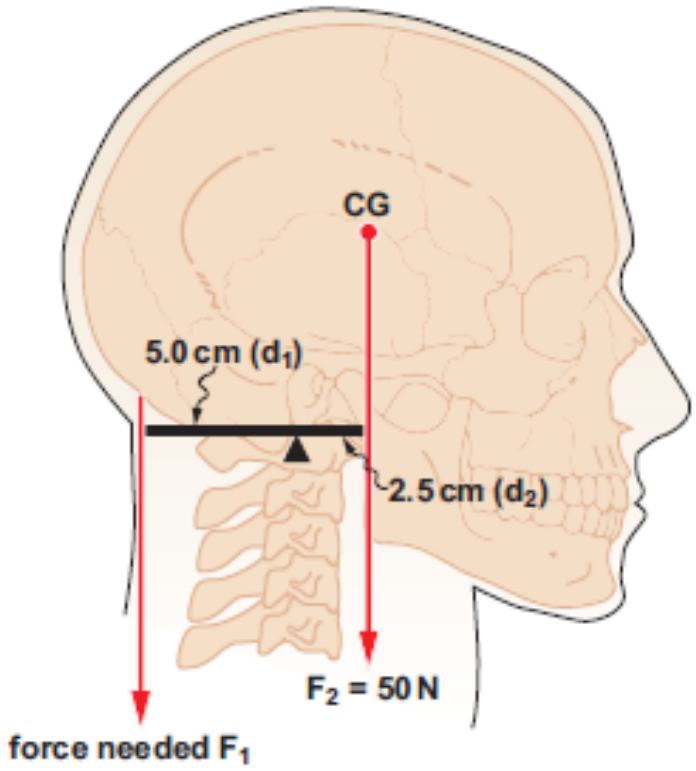
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(iii) In experiments to determine the force generated by the biceps and triceps muscles in individuals, comparisons can be made regarding the relative strength of the two muscles. Suggest **one** feature of the human subjects that should be controlled to make any conclusions valid. [1]

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Even when the head is held erect, its centre of gravity is not directly over the principal point of support (the atlanto-occipital joint). The muscles at the back of the neck exert a force to keep the head erect. That is why your head falls forward when you fall asleep.



(iv) Using the formula below, calculate the force needed to hold the head erect in the position shown [2]

$$F_1 \times d_1 = F_2 \times d_2$$

Force = ... N

2. Vigorous exercise can result in muscle fatigue, which means muscles can no longer contract.

This state is reached very quickly in people who show poor aerobic fitness.

(a) Explain why muscle becomes fatigued after vigorous exercise.

[3]

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Skeletal muscle consists of two types of muscle fibre: fast twitch and slow twitch. The table below shows characteristics of these two types of muscle fibre.

features	muscle fibre	
	fast twitch	slow twitch
time taken to reach maximum contraction	fast	slow
force of contraction	high	low
time taken to become fatigued	fast	slow
aerobic capacity	low	high
anaerobic capacity	high	low
number of mitochondria	few	many
blood supply	poor	good

(b) The leg muscles of long distance athletes, such as marathon runners, contain a high proportion of slow twitch fibres.

Use the information in the table and your own knowledge to explain the advantage of this high proportion to the marathon runner.

[3]

(c) Aerobic training improves the respiratory efficiency of slow twitch fibres.

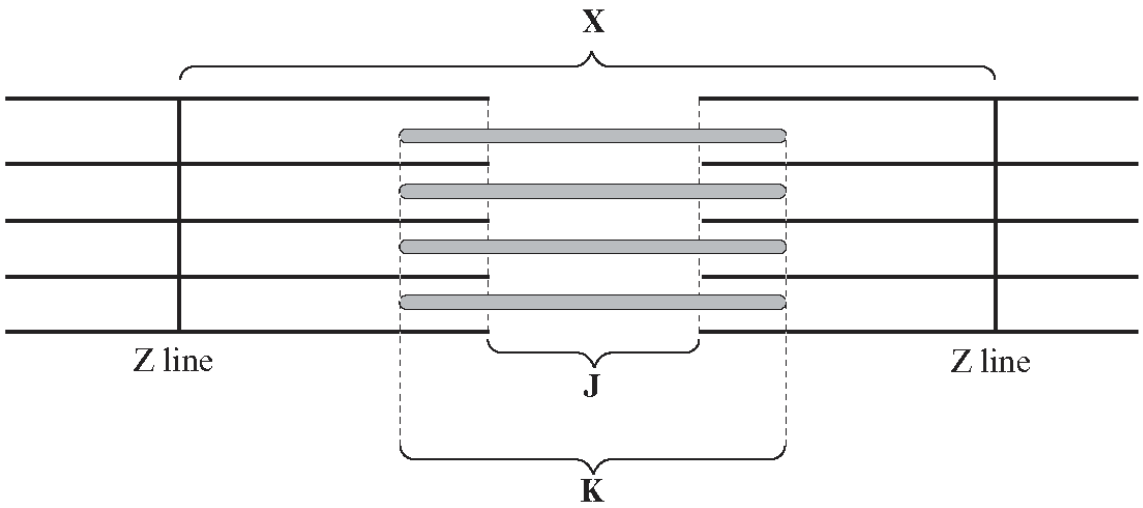
(i) Suggest **two** advantages of having a large number of capillaries around the slow twitch fibres.

[2]

(ii) Suggest **two** *other* changes that may occur in slow twitch fibres during aerobic training.

[2]

3. The diagram shows the arrangement of protein filaments in a muscle myofibril.



(a) (i) Name the functional sub-unit of a muscle myofibril labelled **X** in the diagram. [1]

.....

(ii) Name the regions labelled **J** and **K** on the diagram. [1]

J .....

K .....

(iii) If the muscle fibre contracted, how would the appearance of regions **J** and **K** compare with the diagram? [1]

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(b) With reference to the proteins actin and myosin, describe the changes that can be seen when the myofibril contracts? [3]

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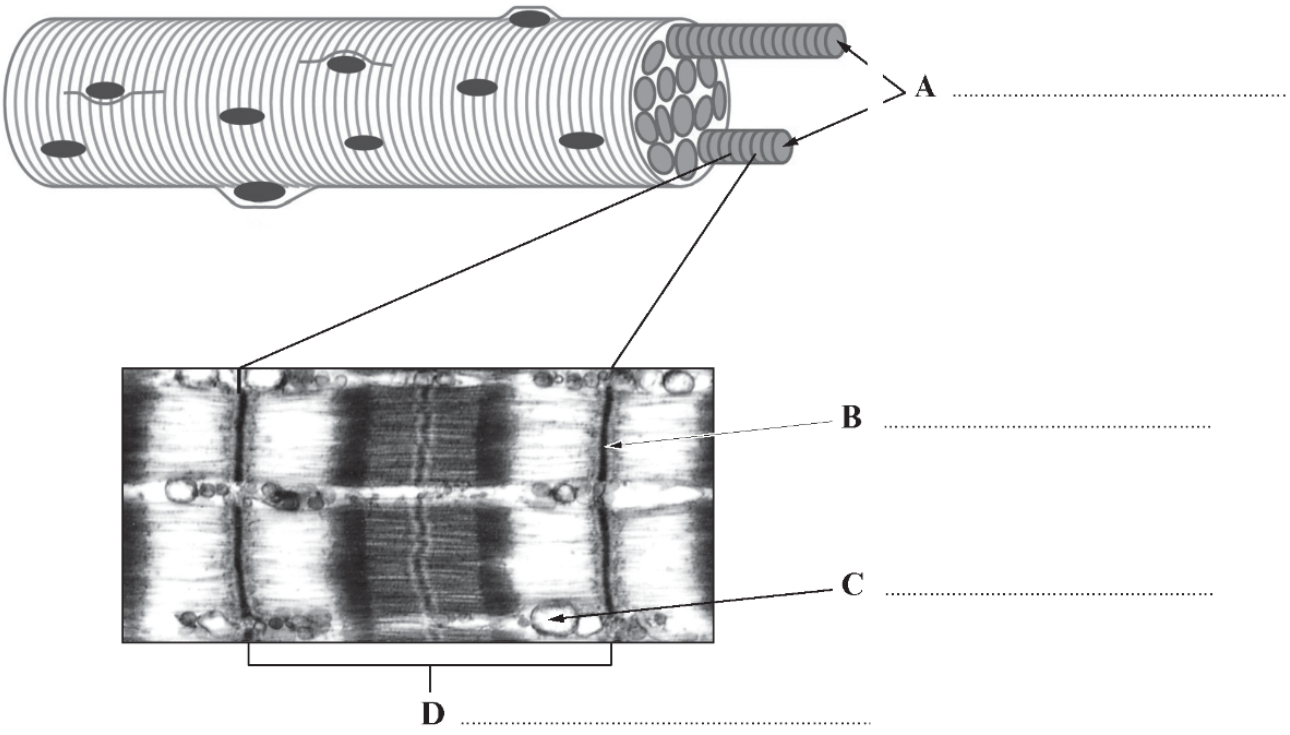
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(Total 6 marks)

4.

The drawing and electron micrograph below show part of a m scle fibre.



(a) (i) Label structures **A-D** on the diagram and photom crograph above. [4]

(ii) Muscle fibres can be treated with digestive enzym s before being observed using an electron microscope.
State which band would disappear if the fibre ha been treated with an enzyme which digests: [1]

The protein actin .....

The protein myosin .....

(iii) Name the polysaccharide found in muscle fibres. [1]

.....

(b) Complete the table below using a tick (✓) in each row to show what happens to the width of each band / zone as a muscle **contracts**. [3]

Band	Increase in width	Decrease in width	Width stays the same
I band			
A band			
H zone			

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(c) Complete the table below to show **four** differences between slow twitch and fast twitch muscle fibres. [4]

Slow twitch fibres	Fast twitch fibres

(d) State **two** roles of ATP in muscle contraction. [2]

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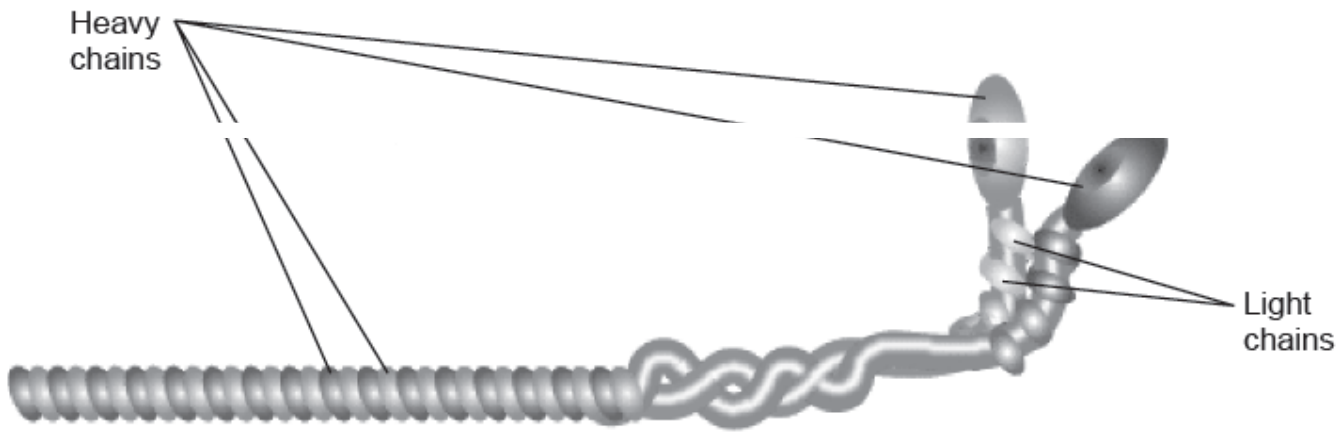
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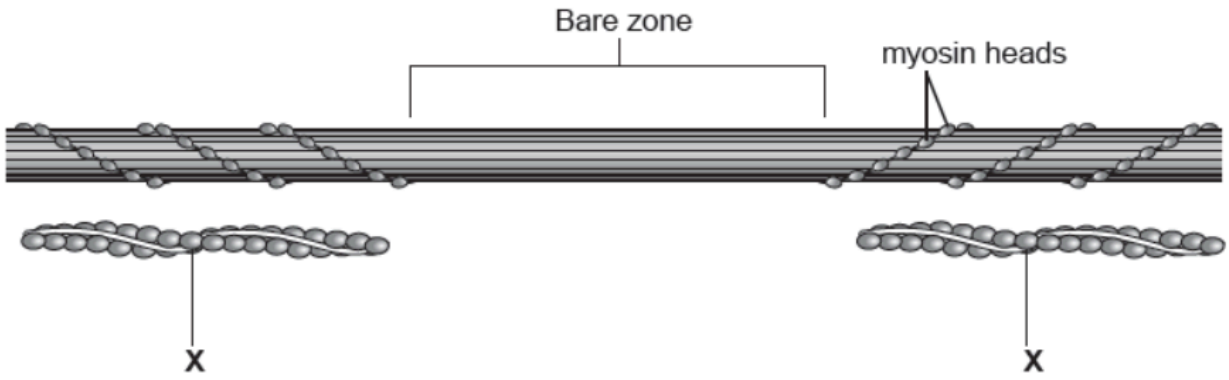
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5. The A band in a sarcomere is made from many thousands of protein molecules called myosin.

The structure of one myosin molecule is shown in the diagram below.



(b) The myosin molecules are arranged as shown in the diagram below with the heads projecting to the outside.



(i) State the name of the protein **X** shown in the diagram above.

[1]

(ii) Draw arrows on the diagram to show the direction of movement of protein **X** when contraction of the muscle takes place.

[1]

(iii) The myosin head is a site of the hydrolysis of ATP. What are the products of this hydrolysis?

[1]

(iv) Explain how the myosin molecules and protein **X** move past each other.

[3]

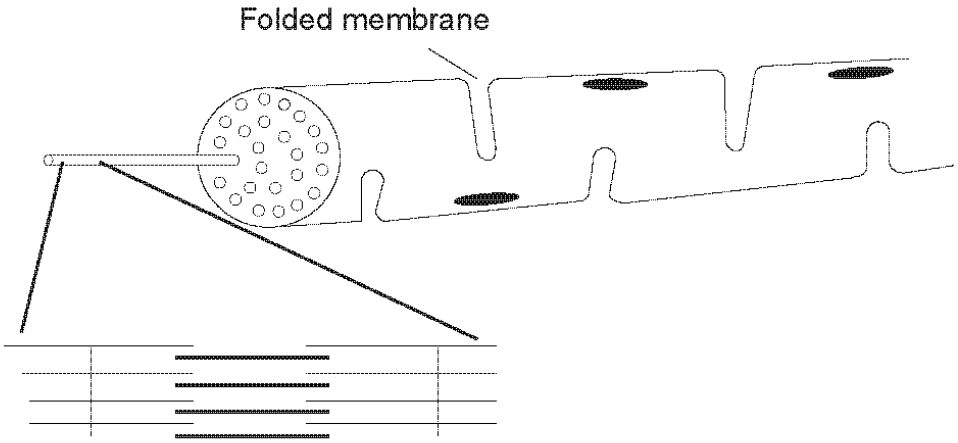
(c) Complete the table below to give **four** differences between slow twitch and fast twitch muscles.

[4]

Slow twitch muscles	Fast twitch muscles

6.

(a) The diagram represents a skeletal muscle fibre.

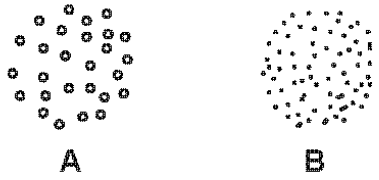


(i) Explain why the muscle fibre has a striated (striped) appearance when viewed using a light microscope. [1]

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(ii) The following diagrams represent transverse sections through a sarcomere.



Name the regions through which the two sections shown above were taken. [2]

A .....

B .....

(iii) Suggest why there are folds in the membrane of the muscle fibre. [2]

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(b) Heart rate, lactate production and oxygen consumption are all related to the level of exercise.

(i) How does the body provide the muscle with more oxygen to meet increased oxygen consumption? [1]

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(ii) Explain the increase in lactate levels in a muscle during intense exercise. [2]

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(iii) What is the effect of the increase in lactate levels in the muscle? [1]

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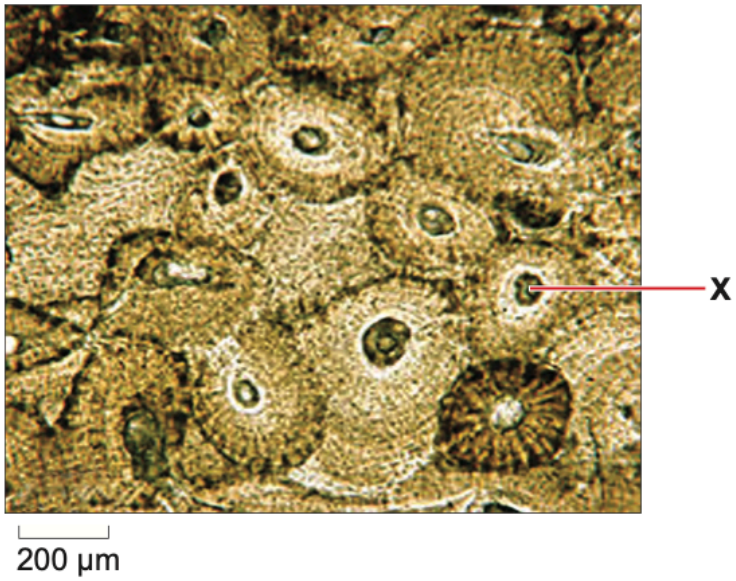
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7.

Limb bones have a strong outer shell of compact bone, surrounding a softer, spongier core called trabecular bone making them light and strong. The electron micrograph shows a cross section through compact bone.



(a) (i) Name structure **X** and describe its role in bone. [2]

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(ii) State the percentages of organic and inorganic material in compact bone. [1]

Organic ..... Inorganic .....

Bone mineral density (BMD) is a useful measure of bone health. Bones undergo continuous remodelling; through the daily removal of small amounts of bone mineral, and equal deposition of new mineral. This process must be balanced if bone strength is to be preserved.

As we age, the bone mineral balance tips toward excessive removal and bones weaken. Over time they can become brittle and prone to fracture, leading to a disease called osteoporosis.

The table below shows the effect of four osteoporosis treatments.

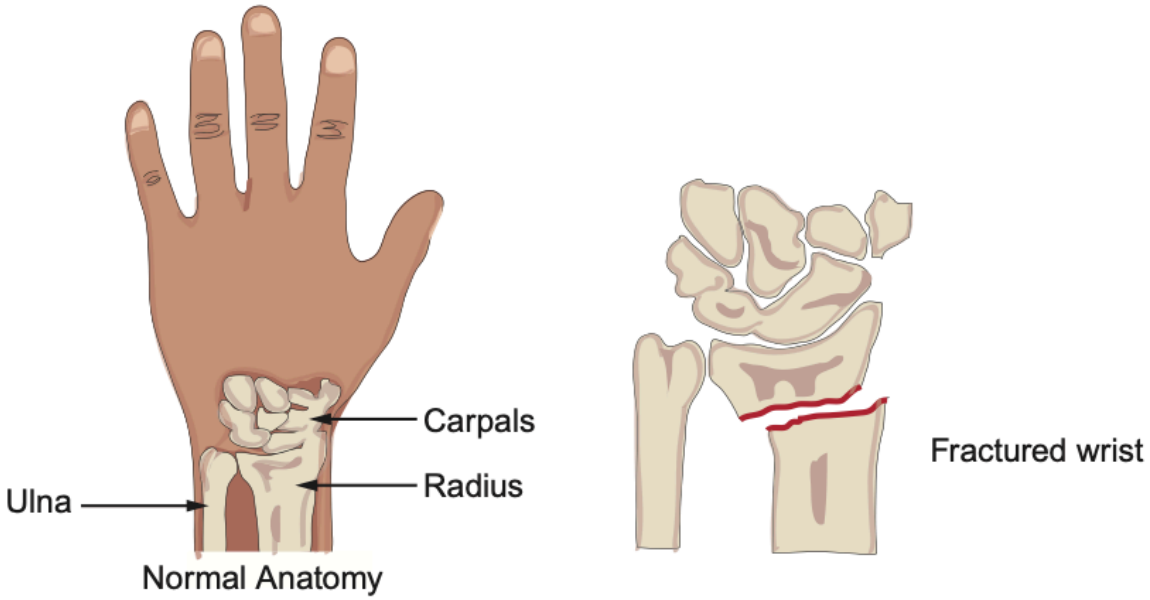
Drugs	Bone mineral density gain (%)	Fracture reduction (%)
Bisphosphonate	**3-5**	**30-45**
Denosumab	**3-6**	**55-70**
Oestrogen	**3-5**	**35**
Calcitonin	**1-1.5**	**20-30**

Data adapted from Department of Pharmacology, Al-Ameen College of Pharmacy, Bangalore-560027, India.

(b) Denosumab is a drug that binds to receptors on osteoclasts and inhibits their activity. With reference to the mineral composition of compact bone and the cells found in the lacunae, describe how bone remodelling takes place in a healthy adult and suggest how Denosumab can be used as a treatment for osteoporosis. [4]

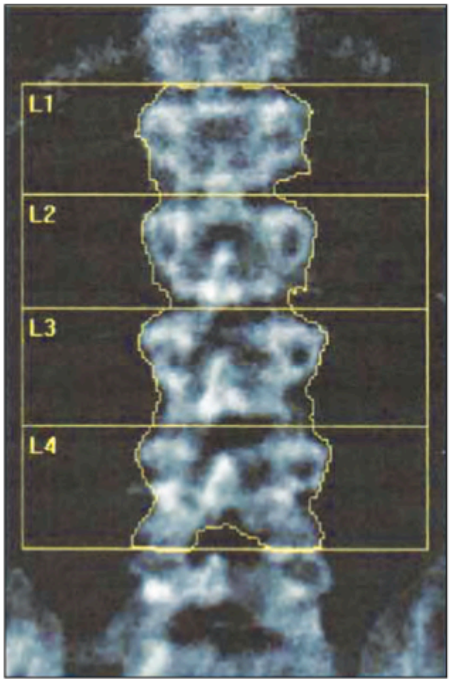
(c) With reference to data provided, conclude whether Denosumab or oestrogen is the most effective treatment for osteoporosis. Give a reason for your answer. [2]

(d) Wrist fractures are very common in women in their 50s, typically after a fall onto an outstretched arm. This can be the first sign of underlying osteoporosis.



(i) The image above depicts a displaced fracture of the wrist. Suggest **one** possible treatment for this. [1]

(ii) Ideally, doctors need to identify and treat patients with osteoporosis before a fracture occurs. A radiograph of the vertebral column can be used to diagnose osteoporosis. A scan identifies the bone area, bone mineral composition (BMC) and bone mineral density (BMD). The results are then compared to the mean results for young adults to calculate a *T- score*, which can then be used to predict fracture risk.
The lumbar spine scan of a 60 year old woman is shown below.



Scan Report:

Scan Date: July 30, 2015

Scan Type: Lumbar Spine

Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	Young adult BMD Mean (g/cm^2)	Young adult BMD Standard deviation (g/cm^2)
L1	11.54	7.41	0.642	1.0	0.1
L2	12.14	9.28	0.765		
L3	12.21	9.93	0.813		
L4	14.80	12.09	0.817		
Mean	12.67	9.68	0.759		

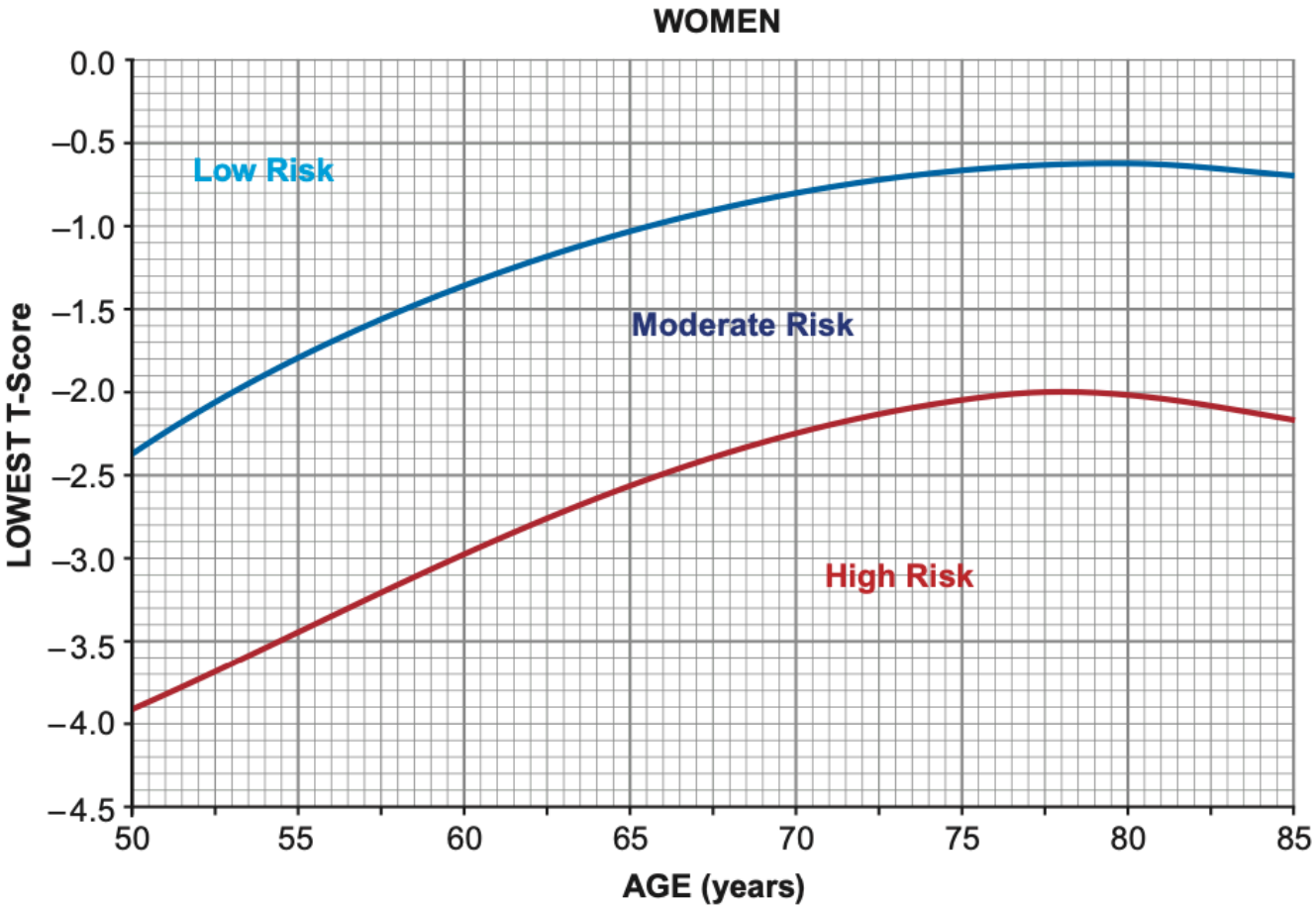
The T score is calculated as:

$$\text{T Score} = \frac{\text{Patient mean BMD} - \text{Young Adult mean BMD}}{\text{Standard Deviation Young Adult BMD}}$$

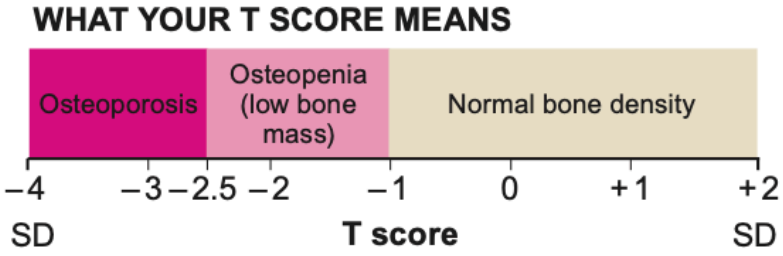
Calculate the T score for the patient. [1]

T score = ...

The graph below can be used to estimate the future fracture risk in women.



The scale below can be used to interpret the T score.



Key: SD = Standard deviation

(iii) Use the T score and the information provided to diagnose her condition and fracture risk. [2]

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(e) Arthritis affects joints, particularly those in the hands and wrists.



Finger Joint Arthritis

(i) Compare and contrast the structure and movement of the wrist joint with those found in the fingers. [4]

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(ii) A patient presents symptoms of pain, stiffness and swelling in their joints. Physical examination reveals an increase in temperature at the swollen areas. Is this patient likely to be suffering from osteoarthritis or rheumatoid arthritis? Explain your conclusion. [3]

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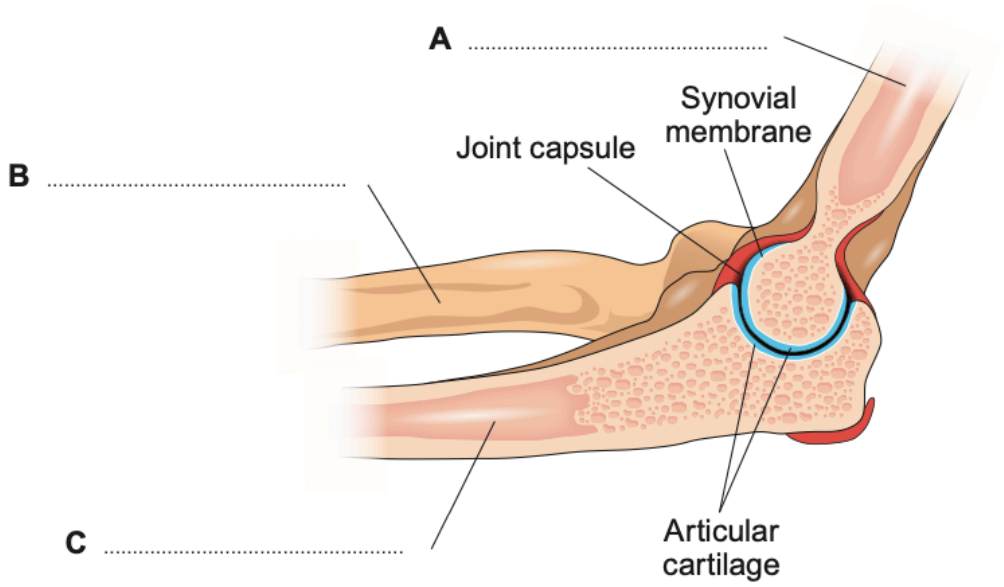
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8.

. *(a)* Figure 9.1 shows the elbow joint, which is part of the appendicular skeleton. Muscles are attached to the bones and move the bones at the joint.

Figure 9.1



(i) Label the bones **A-C** of the arm as indicated in figure 9.1. [1]

(ii) The cartilage in the elbow joint is made of hyaline cartilage. Describe the role of the hyaline cartilage in the elbow joint and how the structure of the joint allows it to perform its function. [2]

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(iii) The external ear in mammals contains yellow elastic cartilage. Compare the structure of hyaline cartilage to yellow elastic cartilage. Explain the benefits of each type of cartilage. [3]

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(iv) When cartilage is damaged, it does not heal quickly, unlike bone and muscle. Use your knowledge of the structures of these tissues to explain why. [1]

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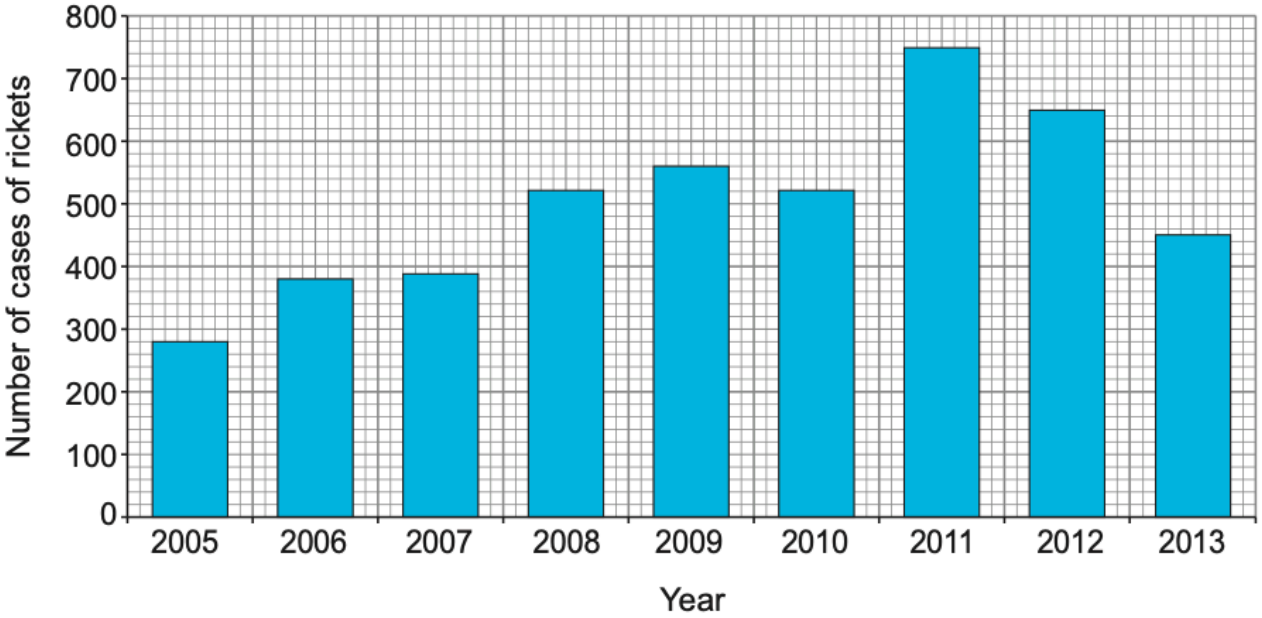
(b) Rickets is a deficiency disease associated with malnutrition resulting from lack of vitamin D or calcium in the diet. The bones in growing children become weak and bend as shown in figure 9.2.

Figure 9.2



From 2012, vitamin D supplements were offered to children under the age of five. Figure 9.3 shows the number of cases of rickets reported in the UK from 2005-2013.

Figure 9.3



(i) I. Calculate the percentage increase in cases from 2005 to 2011. [2]

Percentage increase = ... %

II. Explain the reason for this increase. [1]

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(ii) Suggest why the data collected may be inaccurate in representing the total number of cases in the UK. [1]

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(iii) Some scientists wanted to examine the effects of vitamin D supplements on prevention of rickets in children. They gave 500 children the supplement and compared them to another group of 500 children not taking the supplement. Suggest how the test should be managed to generate valid data and explain **one** ethical issue involved in this study. [3]

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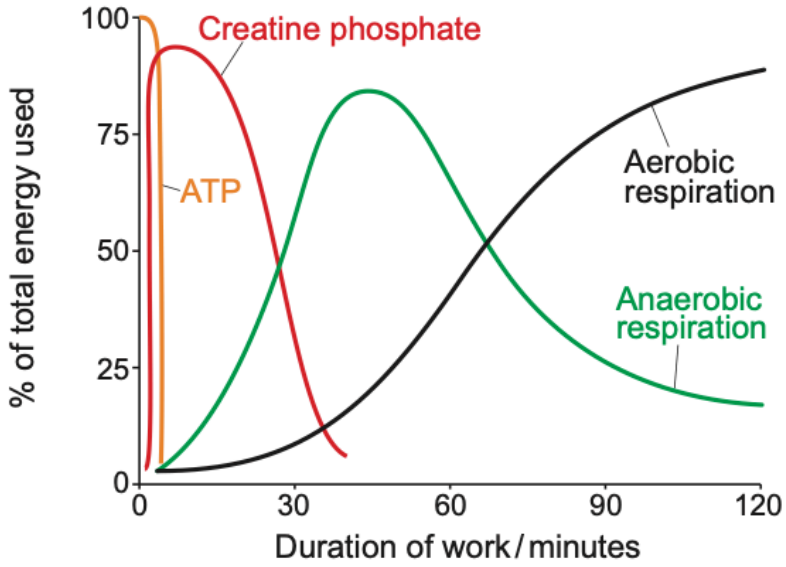
(iv) State the name that is given to the similar, milder condition seen in adults. Explain why it is a less serious condition in adults. [1]

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(c) The percentages of energy used from different energy sources in the muscle of a runner during exercise are shown in figure 9.4:

Figure 9.4



(i) Using figure 9.4 and your own knowledge, explain the shape of the graph for ATP and creatine phosphate and explain why aerobic respiration takes over from anaerobic respiration during sustained exercise. [3]

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(ii) The runner is interested in finding out which distance is suited to her muscle type and undertakes a muscle biopsy. The biopsy showed that her muscles contained 60% fast twitch fibres and 40% slow twitch fibres. State the conclusion that could be made based on this result. [1]

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(iii) The runner is concerned over the shape of her feet. Her footprint on the ground is not entirely normal and is shown next to a normal footprint in figure 9.5:

Figure 9.5



Normal footprint Runner footprint

Suggest which condition the runner maybe suffering from and suggest a treatment that would help. [1]

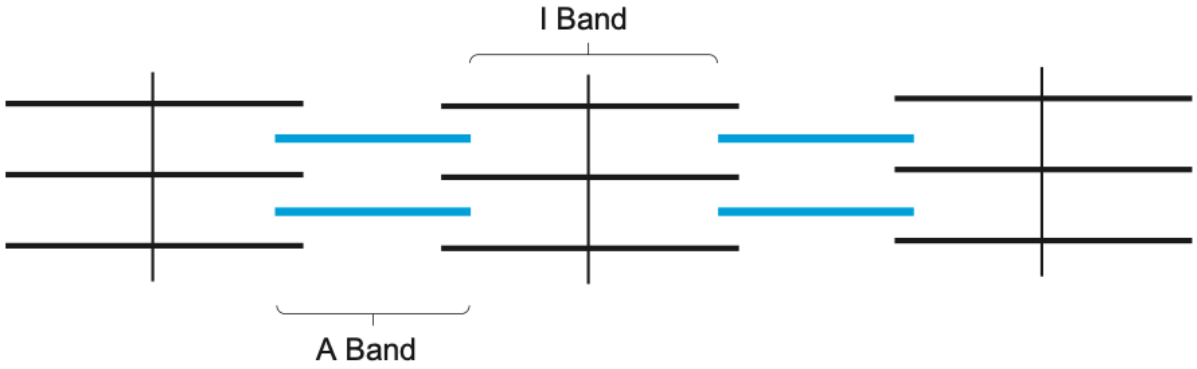
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9.

In 1953, Huxley introduced the sliding filament theory to explain muscle contraction. This theory was based on the idea that muscle proteins slide past each other to generate tension. Below is a diagram of two sarcomeres.



(a) (i) Identify the main proteins found within each of the regions using ticks (✓) to complete the following table. [2]

	Actin	Myosin	Troponin	Tropomyosin
A Band				
I Band				

(ii) Explain how the interaction between actin and myosin results in the contraction of muscle. Reference to the roles of troponin and tropomyosin are **not** required. [2]

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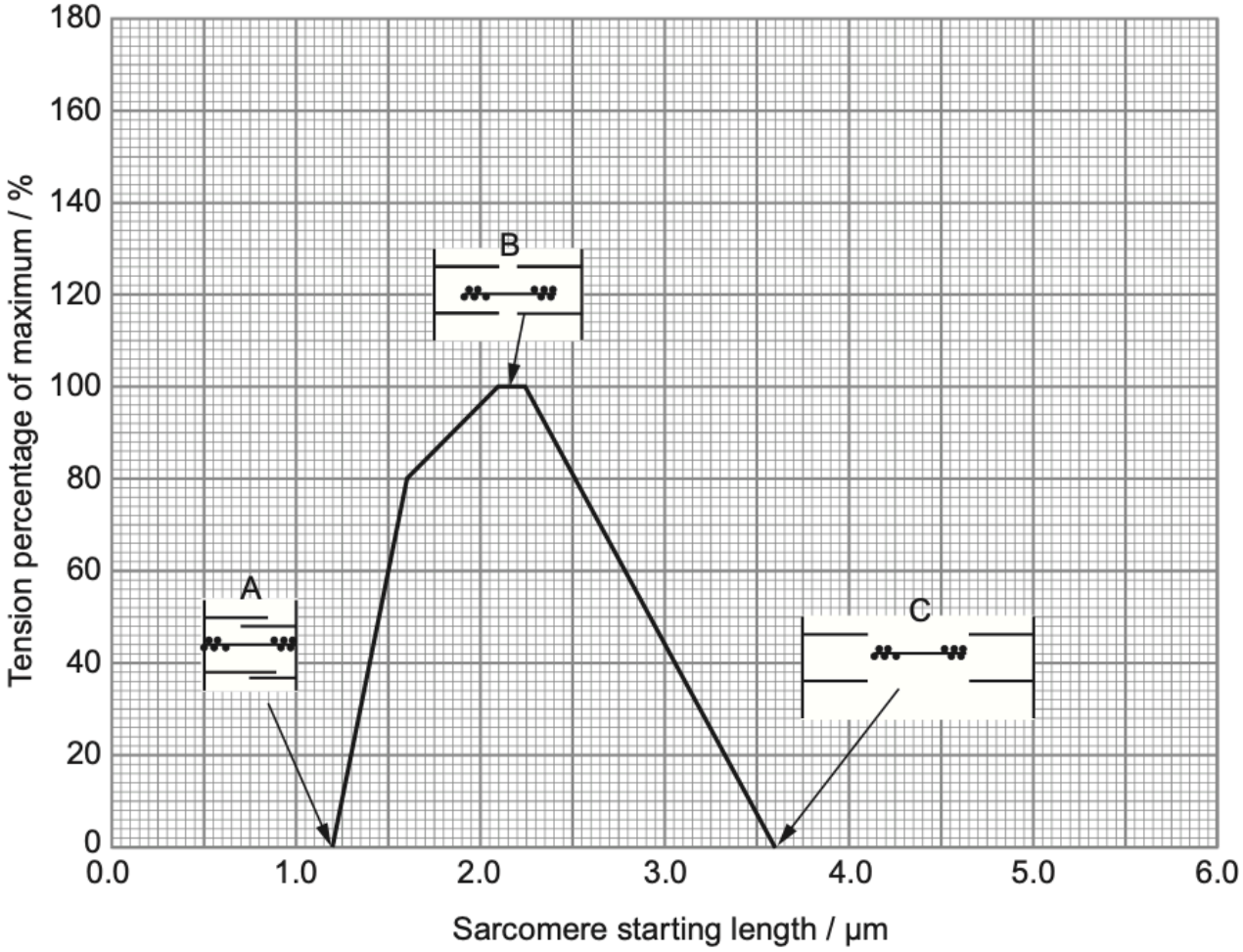
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Muscle samples can be analysed in order to produce a length-tension curve using the following procedure:

- muscle fibres are suspended in a solution
- muscles are positioned so that sarcomeres are at different lengths as shown at A, B and C on the graph below
- muscle fibres are stimulated to contract
- the tension (force) generated as a percentage of the maximum is measured at each sarcomere length (A, B and C)

The results are shown on the graph below **(diagrams of sarcomeres are not drawn to scale)**.



(b) (i) To determine the length of sarcomeres at different resting positions, myofibrils were viewed using a high-powered microscope. The muscle proteins were stained using fluorescent chemicals that bonded to the actin and myosin. Explain why at least 20 sarcomeres were measured. [1]

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(ii) Use the **graph** to calculate the length of the actin fibre. [3]

actin length = ...

(iii) Physiologists conducting these experiments used tissue from the same organism. Suggest **two** other factors that would need to be controlled when carrying out the investigation. [2]

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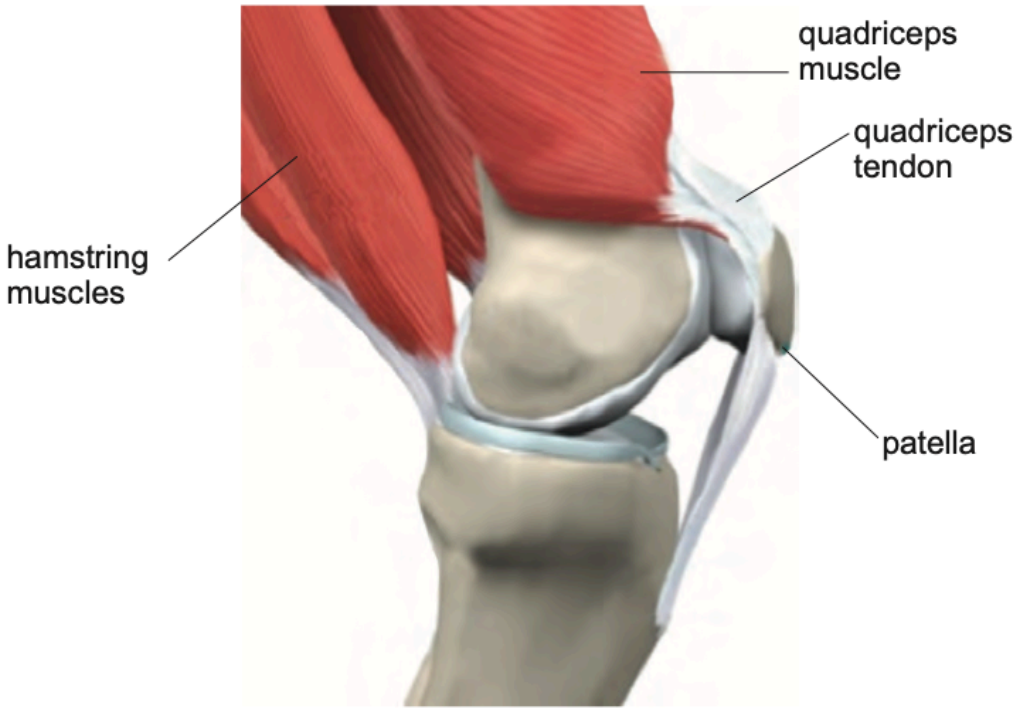
(iv) Suggest an explanation as to why no tension is generated at **C** on the graph. [2]

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(c) Movement of the legs in humans involves the use of muscles attached by tendons to the bones. The quadriceps and hamstring muscles work antagonistically to move the knee joint and raise the leg. The image below shows the arrangement of muscles and tendons in the knee joint.



(i) Explain why skeletal muscles are arranged in antagonistic muscle pairs. [1]

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Scientists studied patients with osteoarthritis and a control group without the condition. Some of the measurements made are shown in the table below.

	Osteoarthritis Group	Control Group
Mean age	65	65
Maximum voluntary contraction force / N	444.50	486.10
Stair climbing time / s	13.08	8.82

(ii) With reference to the role of the quadriceps in movement of the lower leg, explain the differences between the osteoarthritis and control groups. [2]

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Body mass index (BMI) is a measure that relates body mass to height. The mean BMI of the two groups was calculated:

Mean BMI of osteoarthritis group = 30.6

Mean BMI of control group = 24.1

A healthy BMI range is between 21 and 25. Values in excess of 30 are classified as obese.

(iii) Explain the effect of a higher BMI on the results in the table and suggest why increased physical activity would reduce the impact and progression of osteoarthritis. [5]

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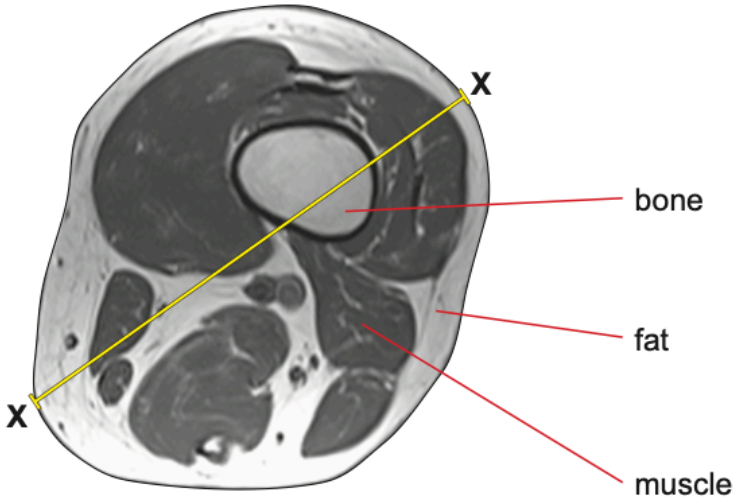
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10.

The image shows a transverse section through the human thigh using an imaging technique called magnetic resonance imaging (MRI). The image shows bone, fat and muscle.



(a) (i) Name the bone shown within the thigh. [1]

.....

(ii) At point X-X on the image the thigh has an actual width of 150 mm.
Calculate the magnification of the image. [2]

magnification = ...

(iii) Bones have an outer layer of compact bone. State which inorganic components strengthen the bone. [1]

.....

.....

(iv) Explain how the structure of the thigh bone enables nutrients to be supplied to the osteoblasts and osteoclasts. [2]

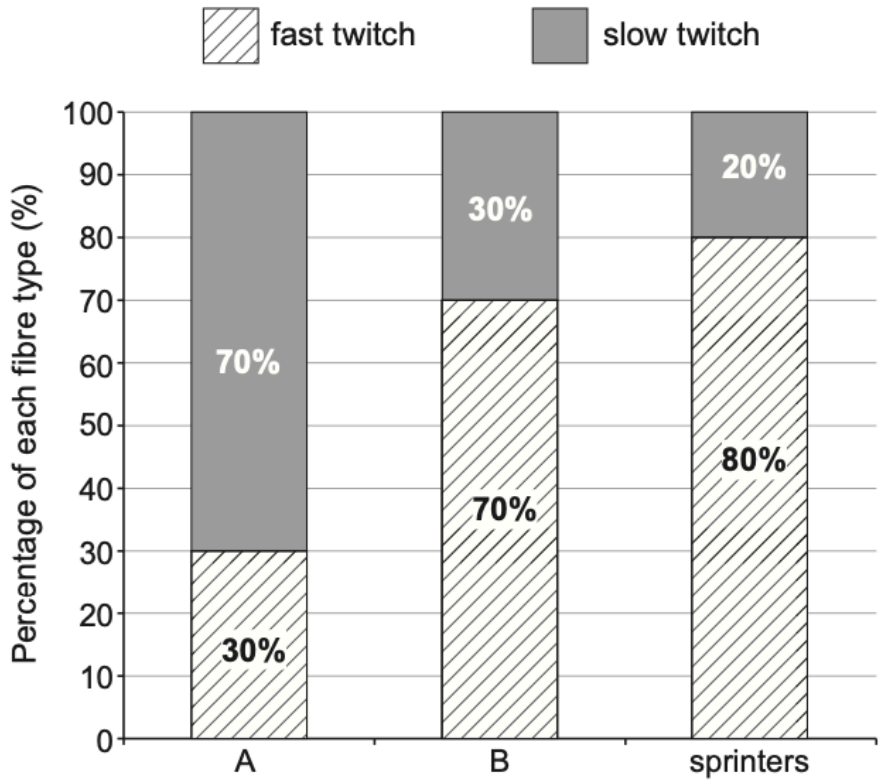
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The proportion of fast and slow twitch muscle fibres was investigated in the muscles of the thigh in a range of athletes. The graph below shows the percentage of slow and fast twitch fibres in the muscle samples.



(v) Investigators observed a difference in colour between fast and slow twitch fibres. Suggest what this difference may be and explain your answer. [2]

.....

.....

.....

(vi) Explain why the percentage of fibres was calculated rather than using the total number of each fibre type. [2]

.....

.....

.....

(vii) Explain why the athletes chosen were of the same age, gender and ethnicity. [1]

.....

(viii) It was concluded that Athlete B was a weightlifter as further analysis of the tissue found high lactate levels. With reference to the graph and your own knowledge explain how they reached this conclusion. [3]

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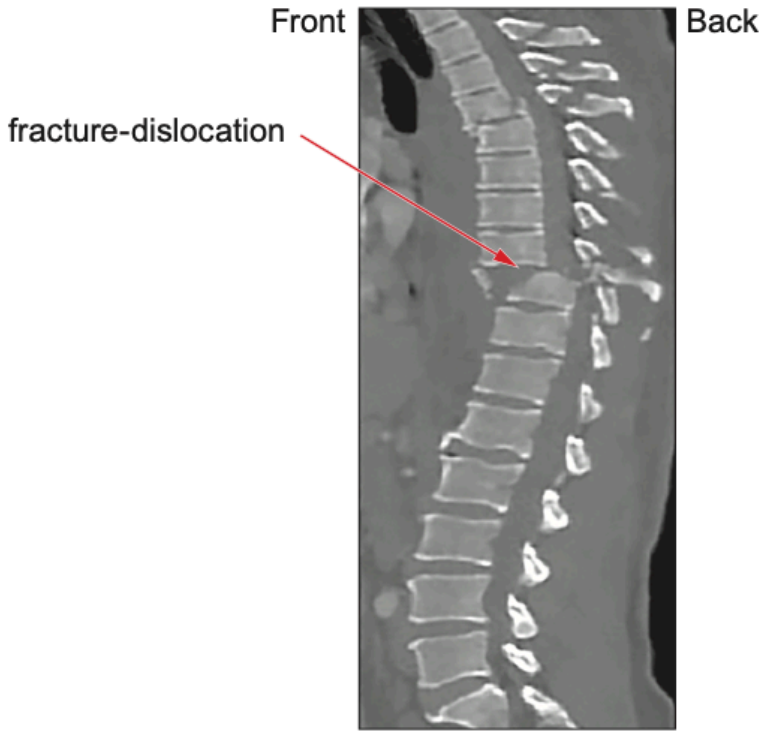
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(b) The image below shows an X-ray of a human vertebral column showing a fracture to the axial skeleton.



(i) State **two** functions of this part of the skeleton. [1]

.....

.....

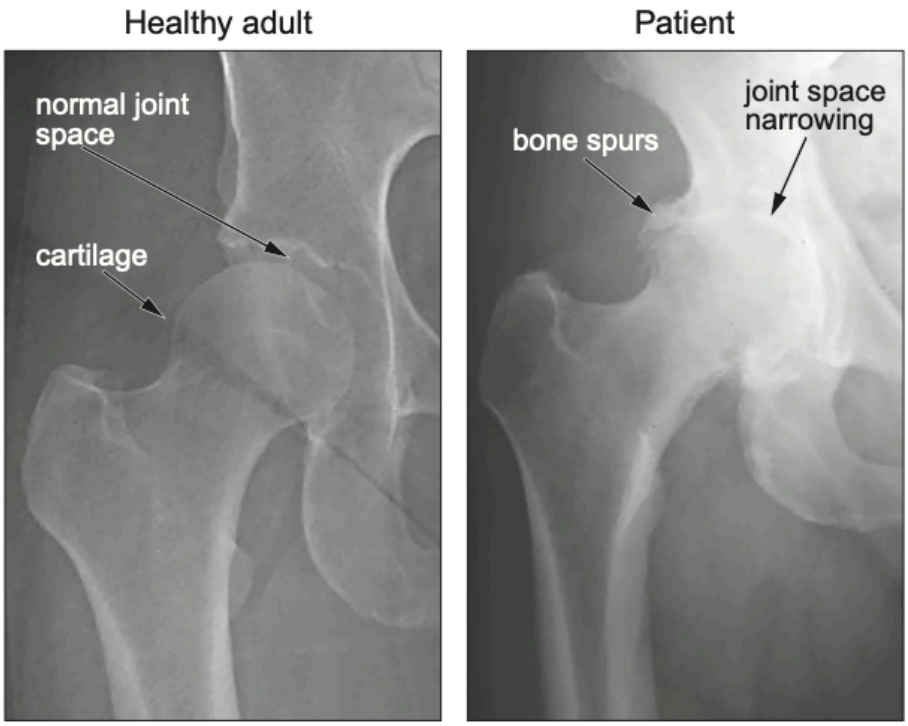
(ii) With reference to the X-ray, state which region of the vertebral column contains a fracture. [1]

.....

(iii) If fractures of the vertebral column are not treated correctly they can lead to problems with posture. Apart from surgery, suggest **one** other type of treatment that could be offered to a patient to avoid posture issues. [1]

.....

(c) Two X-ray images of the hip joint are shown below. The X-ray image on the right, shows the hip joint of a patient aged 56 who was overweight. The patient was in a lot of pain and had difficulty walking but had previously played a lot of sport.



(i) State the type of joint shown. [1]

.....

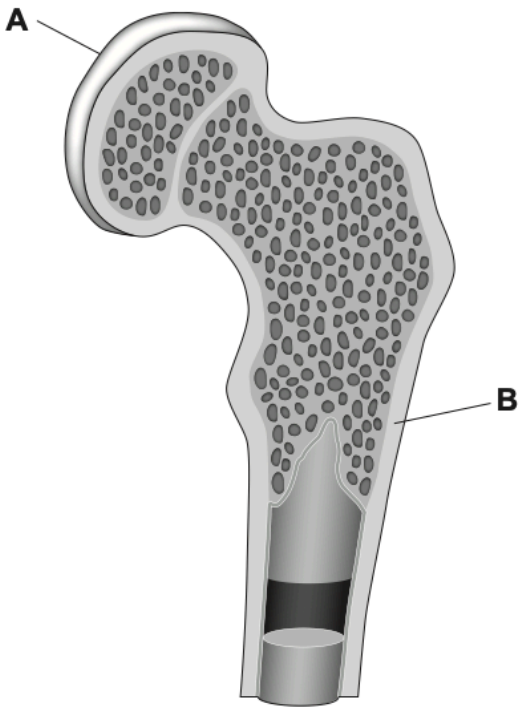
(ii) Using all the information provided, conclude what type of degenerative disease is affecting the patient. Describe the evidence that supports your diagnosis. [2]

.....

.....

.....

11. *(a)* The diagram below shows a longitudinal section through the head of the femur.



(i) Name the type of tissue at **A** and the cells which form it. [2]

.....

.....

(ii) Bones are continually being remodelled for growth and repair, with calcium ions being both deposited and removed from the bone matrix. What is the name of the bone type **B** and the name of calcium compound found there in the highest proportion? [1]

.....

.....

(b) Turners Syndrome (TS) is a condition which occurs in girls who have an incomplete or missing X chromosome. They produce less oestrogen than normal. This has an effect similar to the menopause on bone in reducing the level of calcium compounds, but at a much earlier age if left untreated. Oestrogen at normal levels reduces the number of osteoclasts and their activity.

(i) Describe the functions of osteoclasts and osteoblasts. [1]

.....

.....

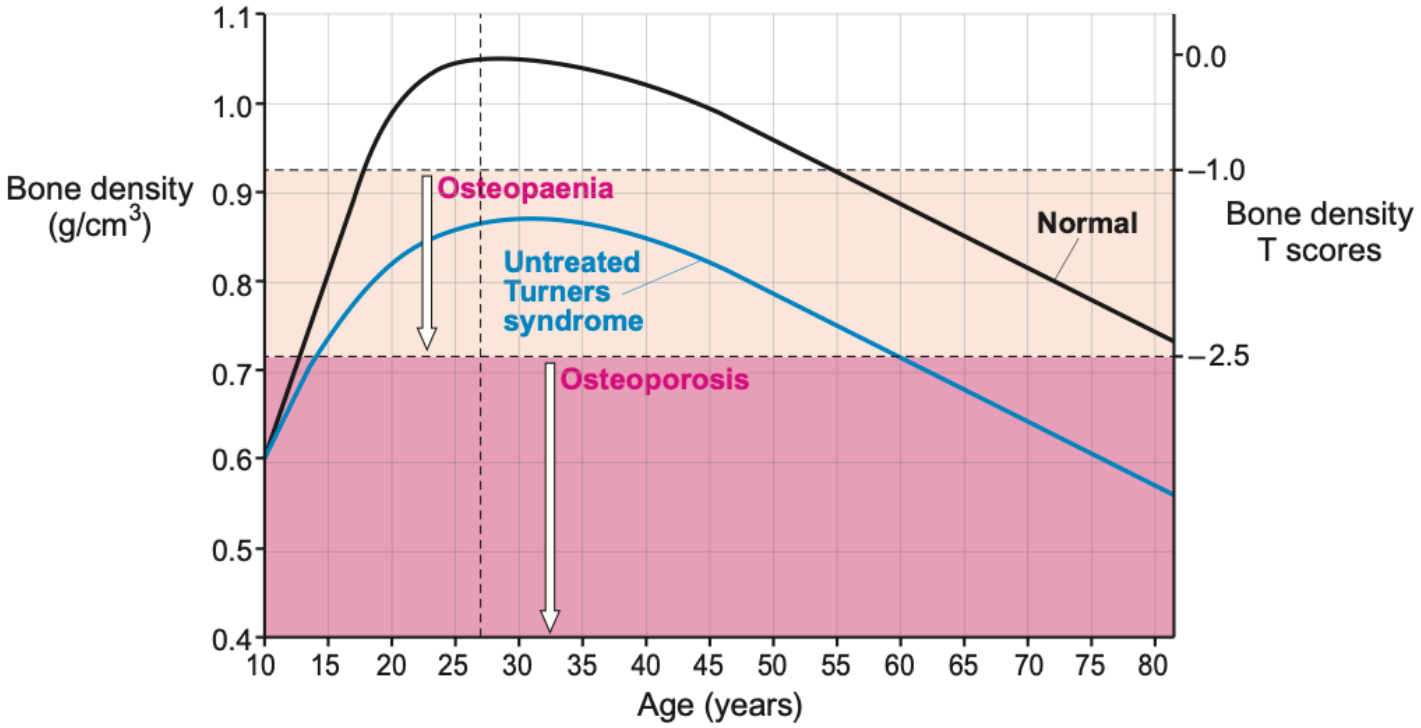
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(ii) Explain why oestrogen treatment might be given to Turners Syndrome patients. [2]

.....

.....

(iii) Turners Syndrome patients have a DEXA scan to assess Bone Mineral Density (BMD). The scan compares density to that of a healthy person of the same age. The difference is then calculated as a standard deviation called a T-score.



A TS patient has a Bone Mineral Density T-score of –2.56. Suggest a possible treatment for a patient which could be used alongside oestrogen and explain the effect of this treatment. [2]

.....

.....

.....

.....

(iv) With reference to the graph, explain why is it difficult to confidently diagnose a 10-year-old girl with Turners Syndrome using the BMD test alone. [2]

.....

.....

(v) Explain why a standard deviation is used for the BMD scan. [1]

.....

.....

(vi) It is estimated that there is a 25% increase in the risk of fractures in Turners Syndrome patients, especially of the long bones of the forearm. What would be the course of treatment for a displaced fracture of the tibia? [1]

.....

(vii) Calcium is needed for the contraction of muscles. Explain how a lack of calcium could cause poor muscle contraction in patients. [4]

.....

.....

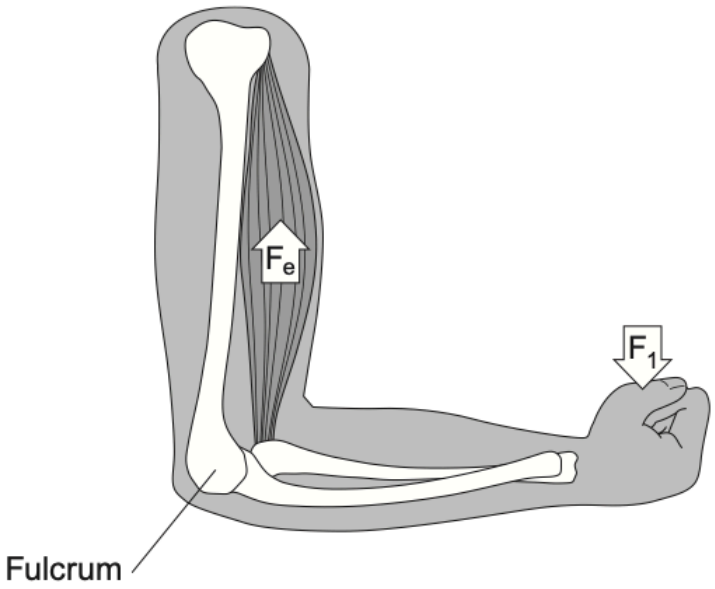
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(c) TS patients have shorter bones than normal, and scientists investigated the effort needed to lift a 4kg hand weight using the biceps muscle.



(i) State the order of lever which is shown in the diagram above. [1]

.....

(ii) Calculate the force effort required to lift the 4 kg hand weight in a patient with TS where elbow to hand distance of 34 cm and elbow to biceps is 4 cm. Show your working.

[2]

Key

F_e = force exerted by the effort

F_1 = mass (kg) × 9.8 N

D_1 = distance from load to fulcrum

D_2 = distance from effort to fulcrum

1 kg = 9.8 Newtons (N)

Using the formula: $F_e = F_1 \times \frac{D_1}{D_2}$

Force effort = ... N

(iii) When testing patients, state the factor that would need to be taken into account to make a valid conclusion. [1]

.....

.....

1.

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)	(i)		Transverse section		1		1		1
		(ii)		A – {I band/ Actin only} as it only contains thin filaments B – {H zone/ myosin only} as it contains thick filaments only C - outer edge/dark region of A band as it shows overlap of thick anc {thin filaments/ actin and myosin} Accept labelled on diagram for location		3		3		
		(iii)		**Any 4 (x1) from:** A. Ca^{2+} ions bind to troponin changing its shape B. moves tropomyosin, exposing binding sites on actin (1) C. Myosin heads make cross bridges to actin by binding to these sites (1) D. ADP and Pi are released causing the myosin head to bend (1) E. ATP joins to myosin head breaking the cross bridge to actin(1) F. Actin filaments slide along myosin (by ratchet mechanism) (1)	4			4		
	(b)	(i)		Myofibril diameter could vary between individuals and within an individual in different muscles			1	1		1
		(ii)		less force generated)(1) Any **one** (x1) from In post-flight muscle the actin and myosin have bigger spaces between them Actin has been broken down/less actin {Fewer cross bridges can form/ less myosin bound to actin}		1	1	2		
	(c)	(i)		C because the patient is younger/ could be more active (1) D (has osteoporosis,) making new bone growth more difficult/ osteoblasts less active (1)			2	2		
		(ii)		Patient will be mobile more quickly **and** this promotes healing/ reduced complications with blood clots/pressure sores/ less muscle wastage/ DVT	1			1		
	(d)	(i)		Biceps – third order **and** Triceps – first order	1			1		
		(ii)		When bicep flexes Effort is between Fulcrum and Load/ effort in middle (1) When tricep flexes Fulcrum is between Load and Effort/ fulcrum in middle (1)		2		2		
		(iii)		Same length arms/age/type of exercise/gender			1	1		1
		(iv)		F = 25N = 2 marks If incorrect allow 1 mark for sight of $\frac{2.5 \times 50}{5}$ $F_1 \times 5 = 50 \times 2.5$		2		2	2	
				Question 1 total	6	9	5	20	2	3

2.

Question			Marking details	Marks Available
2	*(a)*		anaerobic respiration; lactate/lactic acid produced; accumulates in muscle/not removed into blood rapidly enough; low pH in muscle; enzymes less effective; exhaustion of energy glycogen;	3 max
	(b)		endurance events are aerobic; oxygen debt does not develop; little anaerobic respiration; no lactate/lactic acid; maximum energy; from fat/glycogen; longer to reach fatigue; improved blood supply;	3 max
	(c)	(i)	improves supply of oxygen; improves removal of carbon dioxide; improves removal of lactic acid; decreases diffusion distance; increases surface area for exchange;	2 max
		(ii)	increase in number/size of mitochondria; increase in enzymes of Krebs cycle; increase in size of muscle fibres; increase in ETC molecules; increase in myoglobin	2 max
			Question 2 Total	**[10]**

3. (a) (i) sarcomere [1]

(ii) J – H zone and K – A band [**not:** zone or region] [1]

(iii) J shorter / decrease and K same length. [1]

(b) A band == maximum overlap of actin and myosin;

(because) actin slides past myosin;

Z-lines to move closer;

H zone disappears when actin filaments meet. [3]

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4. Question		Marking details	Marks Available
(a)	(i)	A= Myofibril; B = Z line; C = mitochondrion / accept T system; D = sarcomere;	4
	(ii)	I band A band Both for 1 mark	1
	(iii)	Glycogen;	1

(b)

Band	increase	decrease	same
I	×	✓	×
A	×	×	✓
H	×	✓	×

3

(c)

Slow	Fast
More ATP	Less ATP
Contract longer time	Short burst contraction
Fire slowly	Fire rapidly
aerobic	anaerobic
Fatigue slowly	Quickly fatigue
Good blood supply	Poor blood supply
High numbers mitochondria	low numbers mitochondria
More myoglobin	Less myoglobin
Low density myofibrils	high density myofibrils
Small diameter	Large diameter
Low resistance to lactic acid	High resistance to lactic acid

4

(d) Detaching myosin bridge from actin binding site; Max 2
Return of myosin head to original position;
Pumping Ca^{2+} back into sarcoplasmic reticulum;
Creation of creatine phosphate from creatine;

Question 4 Total **[15]**

5.

Question		Marking details	Marks Available
5			
(b)	(i)	Actin;	1
	(ii)	Correct on diagram;	1
	(iii)	ADP, iP;	1
	(iv)	Allows cross bridges to form/ owtte; Clubbed head of myosin moves back and forth/ owtte; Ratchet mechanism;	3

(c) 4

Slow Twitch	Fast Twitch
Good blood supply	Poor blood supply
High numbers mitochondria	Low numbers mitochondria
More myoglobin	Less myoglobin
Low density myofibrils	High density myofibrils
Small diameter myofibrils / fibres	Large diameter myofibrils / fibres
Low glycogen levels	High glycogen levels
aerobic / no lactic acid / low lactate tolerance	Anaerobic / lactic acid / high tolerance to lactate
Slow contraction / weak force / fatigue slowly / endurance.	Quick contraction / strong force / fatigue quickly / speed.

Question 5 Total **[10]**

6.

Question			Marking details	Marks Available
6	*(a)*	(i)	Myosin / thick filaments and actin / thin filaments;	1
		(ii)	A H zone; B I band;	2
		(iii)	transmit action potential / nerve impulse into centre of fibre; so that all myofibrils contract at same time; OR Increased surface area; For increased diffusion;	2
	(b)	(i)	Heart rate goes up / increased blood supply / greater rate and depth of ventilation;	1
		(ii)	Any **2** from: Anaerobic respiration; glycolysis and glucose to pyruvate; pyruvate reduced to lactate by reduced NAD / $NADH_2$.	2
		(iii)	Any **1** from: Muscle fatigue / cramp; pH lowers; increased dissociation of oxyhaemoglobin / Bohr effect;	1
			Question 6 Total	**[9]**

7.

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)	(i)		X = Haversian canal (1) O_2 delivery/ CO_2 removal / nutrients/ named nutrients(1) Accept reference to nerves and pain	2			2		1
		(ii)		Organic: 30 Inorganic: 70	1			1		
	(b)			• osteoblast {lays down/ secrete} the matrix/ ossification of bone (1) Accept components of matrix • osteoclasts break bone down (1) • BMD increases with Denosumab/ less fractures with Denosumab (1) • therefore breakdown not taking place /osteoblasts more active than osteoclasts(1)	1	1 1 1		4		
	(c)			Denosumab (1) treatment with denosumab reduced the risk fractures by 55-70 % / treatment with oestrogen only 35 % (1)			2	2	1	1?
	(d)	(i)		Realignment + {Immobilisation with cast or splint) / Surgery with pins or plates }		1		1		
		(ii)		T- Score:= -2.41 Accept -2.4		1		1	1	1?
		(iii)		Osteopenia (1) Fracture Risk: Moderate Risk (1)			2	2		
	(e)	(i)		Wrist is a gliding joint (1) wide range of movement/ moves in more than one plane (1) finger is hinge joint (1) bends and straightens/ movement in one plane(1)	1 1	1 1		4		
		(ii)		Rheumatoid (1) auto-immune disease (1) involving an {inflammatory response/ increased blood supply to the joint/ ORA for osteoarthritis (1)		2	1	3		
				Question 7 total	**6**	**9**	**5**	**20**	**2**	**3**

8.

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*	(i)		A Humerus B Radius C Ulna **All three** correct = 1 mark	1			1		
		(ii)		It reduces friction in the joint/ stops rubbing. (1) The joint moves in one plane only / (it is a hinge joint) so the forearm can **only** {move up / flex} **and** {down / extend} in relation to the humerus. (1) NOT one direction	2			2		
		(iii)		Hyaline cartilage has collagen fibres **and** yellow elastic cartilage has elastin fibres. (1) Yellow elastic cartilage {more flexible than hyaline cartilage / maintains shape} (1) Hyaline cartilage is firmer/ tougher and can withstand forces in the joint. (1)	1	2		3		
		(iv)		It has no blood vessels + so nutrients are acquired by diffusion.		1		1		
	(b)	(i)	I	167.9 or 167.86 or 168 = 2 marks $\frac{750-280}{280} \times 100$ = 1 mark		2		2	2	
			II	Vitamin D deficiency in the diet/ increased use of sunblock/ children spend less time outside. (1)	1			1		
		(ii)		Not all rickets sufferers will seek medical attention/ misdiagnosis/ data for under 5s only/ cases unreported			1	1		1
		(iii)		Any **two** (×1) from Similar/ same ages (1) Similar/ same ethnic groups/skin tone (1) Similar/ same exposure to sunlight (1) Similar/same diets (1) Proportion of males/ females (1) **Ethics:** not giving vitamin D supplement to children makes them more likely to develop rickets.			2 1	3		2
		(iv)		Osteomalacia **and** Adult bones have stopped growing	1			1		
	(c)	(i)		Limited ATP in muscle, ATP used first/ quickly. (1) Creatine phosphate then used to phosphorylate ADP to provide ATP/ replenish the store of ATP. (1) Aerobic respiration takes over from anaerobic respiration because lactate builds up/ produces more ATP. (1)		3		3		
		(ii)		more suitable for sprinting/ short distances			1	1		
		(iii)		Flat {feet/foot} **and** treat using {special shoes/ exercise/surgery/ physiotherapy}. (1)		1		1		
				Question 8 total	**6**	**9**	**5**	**20**	**2**	**3**

9.

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)	(i)		<table><tr><th></th><th>Actin</th><th>Myosin</th><th>Troponin</th><th>Tropomyosin</th></tr><tr><td>A Band</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>I Band</td><td>✓</td><td></td><td>✓</td><td>✓</td></tr></table> (1 mark per correct row)	2			2		
		(ii)		Any 2 x (1) from: Myosin head binds to actin/cross bridges form between actin and myosin (1) Myosin head {bends/tilts/ power stroke} so actin is pulled past the myosin(1) Detail of ATP involvement in release of head (1)	2			2		
	(b)	(i)		Calculate a mean to improve reliability / Identify that there were a range of sarcomere lengths (1)			1	1		
		(ii)		1.2 µm = 3 marks 1.2 (no units) = 2 marks (3.6-1.2) / 2 = 1 mark		3		3	3	
		(iii)		Any 2 x (1) The temperature of solution (1) pH of solution (1) same type of muscle (1) Same concentration solution (1) OR 2 controlled variables without solution (1)			2	2		2
		(iv)		Any 2 x (1) from: • no overlap between actin and myosin filaments (1) • no cross-bridges form / no possibility of myosin head moving actin (1) • no contraction possible / sarcomeres cannot get shorter (1)			2	2		
	(c)	(i)		each muscle contracts to 'pull' in each direction / as one contracts the other relaxes to move the limb (1)	1			1		
		(ii)		Any 2 x (1) from: Quadriceps contract (1) The osteoarthritic group has a lower contraction force ORA (1)	1	1		2		
		(iii)		Any 5 x (1) from: A. BMI states they are obese / heavier mass to be moved by quadriceps (1) B. Reference to BMI and the effect on contraction force/ stair climb (1) C. Exercise reduces BMI/ mass(1) D. Exercise strengthens the quadriceps (1) E. supports the joint/ strengthens muscles around the joint (1) F. increases flexibility of the joint / stimulates cartilage growth /reduces joint stiffness (1)		5		5		
				Question 9 total	**6**	**9**	**5**	**20**	**3**	**2**

10.

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)	(i)		Femur	1			1		
		(ii)		M=66 or 67/150 (1) = 0.44 or 0.4 / 0.45 or 0.5 (1)		2		2	2	
		(iii)		hydroxyapatite / calcium ions **and** phosphate ions / calcium phosphate (1)	1			1		
		(iv)		Any **two** × (1) from: • {Haversian/Volkmann} canals contain blood vessels (1) • Diffusion of (named substance/O_2/glucose/amino acids) to {osteoblasts/osteoclasts/ cells} (1) • Canaliculi contains {fluid for exchange with the cells/ tissue fluid} (1)	2			2		
		(v)		Slow fibres are {red /darker} **and** fast fibres are {white/lighter} (1) {Increased blood supply to/ more blood in} slow twitch fibres / Increased myoglobin in slow twitch fibres/ ORA for fast twitch fibres (1)			2	2		
		(vi)		Total number of fibres in each sample {varied/different} (1) Allows comparison (between different athletes) (1)		2		2		2
		(vii)		the activity type is the only variable that changes/ owtte		1		1		1
		(viii)		{High/ 70} % fast twitch (1) Anaerobic respiration (1) Because there are short intense bursts of activity (1)		1	2	3		
	(b)	(i)		Flexibility / support / protection of spinal cord/ attachment of ribs **Any 2 for 1 mark**	1			1		
		(ii)		Thoracic		1		1		
		(iii)		Physiotherapy / weight loss / Exercise to strengthen muscles/ or example		1		1		
	(c)	(i)		Ball and socket joint	1			1		
		(ii)		Osteoarthritis (1) reduced joint space / reduced cartilage / inflammation /swelling (1)		1	1	2		
				Question10 total	**6**	**9**	**5**	**20**	**2**	**2**

11.

Question Option B				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)		(i)	cartilage (1) Chondrocytes (1)	2			2		
			(ii)	Compact (bone) **and** Calcium phosphate/hydroxyapatite (1)	1			1		
	(b)		(i)	Osteoblasts – build up bone **and** Osteoclasts – break down bone (1)	1			1		
			(ii)	Oestrogen would decrease osteoclast activity/bring osteoclast activity to normal level/reduce loss calcium from bones(1) Less bone broken down (1)			2	2		
			(iii)	Vitamin D supplements/Calcium supplements (1) increases calcium absorption (in the gut)/increase bone formation (1)		2		2		
			(iv)	10 yr old girls have same BMD as 10 yr olds with TS (1) Difference between normal and TS not obvious til 12+ years (1)			2	2		1
			(v)	Compares the result with the mean/Shows how far the value is from the mean		1		1		1
			(vi)	Bone realignment/immobilisation (in a cast or splint)	1			1		
			(vii)	Less calcium ions bind to troponin so no shape change (1) (No shape change results in) less tropomyosin being moved (1) Exposing less myosin binding sites (on the actin) (1) Resulting in less force exerted (1)		3	1	4		
	(c)		(i)	Third (order lever)	1			1		
			(ii)	333.2/333 =2 marks 39.2 x (34/4) (1)		2		2	2	
			(iii)	Age of the patients/other health issues/general fitness		1		1		1
				Question 11 Option B total	**6**	**9**	**5**	**20**	**2**	**3**