

The table below shows the diameter of the lumen and the rate of blood flow in a number of human blood vessels.

Vessel	Diameter of lumen	Rate of blood flow/cm s <sup>-1</sup>
Artery	0.4 cm	40-10
Arteriole	30.0 µm	10-0.1
Capillary	8.0 µm	less than 0.1
Venule	20.0 µm	less than 0.3
Vein	0.5 cm	0.3-5

- (a) (i) Describe the general relation between the rate of blood flow and the diameter of the lumen of the blood vessel.
- (ii) Explain how the diameter of a blood vessel affects the resistance to blood flowing through it.
- (b) (i) Which of the blood vessels mentioned has most elastic tissue in its walls?
- (ii) How does the possession of elastic tissue affect flow through blood vessels?

A fish such as a trout has a single circulation while a mammal has a double circulation.

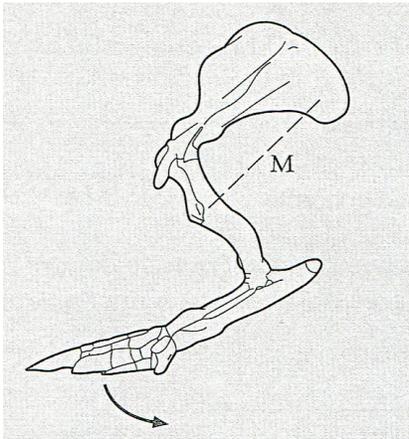
(a) Explain one advantage of a double circulation.

The table below shows how certain factors which affect the supply of oxygen to the tissues of a trout increase during the maximum activity.

Factor	Number of times factor is increased from resting level
heart rate	1.36
heart stroke volume	2.24
oxygen released by haemoglobin	2.66

(b) Suggest how the nervous system might produce the change in heart rate shown in the table.

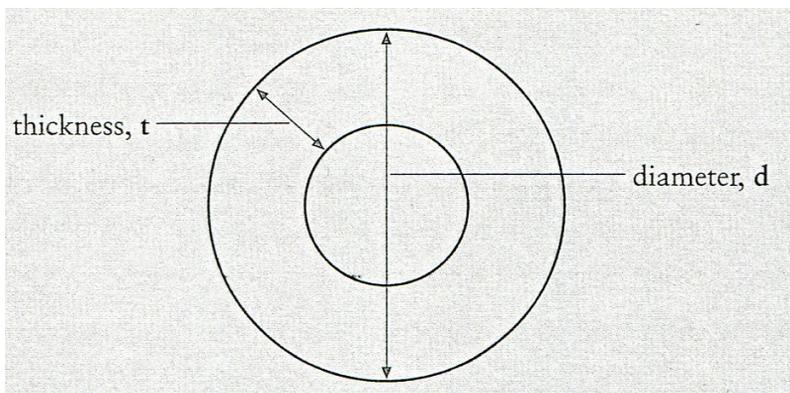
The figure below shows the skeleton of a front leg from an armadillo.



(a) Copy the figure and draw on a straight line to represent a muscle which would cause the lower leg

(b) Suggest two features of the muscle **M** which would indicate that this mammal has powerful limbs suited to digging.

The figure below shows a cross-section through a mammalian leg bone.



(c) In mammals the average value of the diameter to thickness ratio ( $D/t$ ) is 4.4. In birds this value is 13.

(i) Give one advantage of high diameter to thickness ratio to a bird.

(ii) Give one way in which the structure of a bird bone provides sufficient strength to resist bending despite having a high diameter to thickness ratio.

The relationship between the force applied to a material and the resulting change in its length is called the modulus of elasticity. Rubber has a low modulus of elasticity because a fairly small force produces a considerable change in length; concrete has a high modulus because a very large force produces only a small change in length.

The table below shows the values of the modulus of elasticity for some biologically important materials.

Material	Modulus of Plasticity
bone	$1.2 \times 10^{10}$
cellulose	$4.9 \times 10^9$
elastin	$5.9 \times 10^5$

- (a) Use the information in the table to explain why bone is particularly suitable as skeletal material.
- (b) Suggest whether the modulus of elasticity for lignin would be most similar to that bone, cellulose or elastin. Give a reason for your answer.
- (c) Elastin is a protein. Suggest one feature of the structure of an elastin molecule which might explain its modulus of elasticity.