1.3 Heart, blood vessels and the cardiac cycle

Name: _____ Class: _____ Date: _____ **Total: 20 marks**

KEY WORDS mass transport • atrial systole • ventricular systole • diastole • endothelium

Objective

Practise statements 1.6–1.8: why large animals need a circulation, the structure–function match of arteries, capillaries and veins, the mammalian heart, and the cardiac cycle with its pressure changes.

1 Key knowledge and worked examples

■ Diffusion cannot feed a big body

A cell more than roughly 1 mm from a supply has to wait too long: diffusion time grows with the square of distance. **Mass transport** – a pump, pipes and a transport medium – takes supplies to every cell and waste away, with exchange by diffusion only across the thin walls of capillaries.

■ Three vessels, three jobs

Vessel	Key structure	Function it serves
Artery	thick wall of elastic fibres and smooth muscle, narrow lumen	carries high-pressure pulsing blood; elastin recoils to even the flow
Capillary	endothelium one cell thick, total cross-section huge	exchange; short diffusion path, low resistance
Vein	thin wall, wide lumen, pocket valves	low-pressure return; valves + surrounding muscle squeeze stop backflow

■ Reading the cardiac cycle

Atrial systole tops up the ventricles. **Ventricular systole** closes the atrio-ventricular valves (first sound), opens the semilunar valves and drives blood out. **Diastole** relaxes the muscle; semilunar valves snap shut (second sound); the chambers refill.

■ Worked example: valve states from pressures

Given atrial pressure 0.6 kPa, ventricular 14.0 kPa, aortic 11.0 kPa: ventricular exceeds atrial, so the AV valves are shut (prevents backflow to the atria); ventricular exceeds aortic, so the semilunar valves are open (ejection). Never memorise valve order – always compare the two pressures either side of each valve.

2 Practice

2.1 Explain why the left ventricle wall is thicker than the right ventricle wall. [2]

2.2 Capillaries have no elastic fibres or smooth muscle in their walls. Explain why this absence suits their function. [2]

2.3 State two features of a vein, other than valves, that help return blood to the heart. [2]

3 Exam-style questions

3.1 The table gives pressures at one moment in the cardiac cycle.

Region	Pressure / kPa
Left atrium	0.7
Left ventricle	8.5
Aorta	10.2

State whether the left atrio-ventricular valve and the aortic (semilunar) valve are open or shut, justifying each answer from the pressures, and name the phase of the cardiac cycle. [4]

3.2 A student claims that arteries "push blood along by squeezing in peristaltic waves like the gut." Correct the student: describe how blood actually moves through an artery, name the tissue responsible for the artery's recoil, and explain why artery walls must be thick. [5]

3.3 During diastole, the atria fill while the ventricles are relaxed. Explain how blood moves from the atria into the ventricles during diastole without any muscular contraction, and why the final third of ventricular filling needs atrial systole. [5]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 The left ventricle drives blood around the whole body against a higher resistance/pressure than the right, which only drives it to the nearby lungs; a thicker muscular wall generates the greater force.

2.2 The single-cell endothelium gives a short diffusion path for exchange; absence of muscle/elastin keeps the wall thin and the total cross-sectional area vast, slowing flow to give time for exchange.

2.3 Any two: wide lumen lowering resistance to flow; surrounding skeletal muscle contraction squeezes the deep veins; the negative thoracic pressure during breathing helps draw blood upward; one-way valves (already excluded).

3.1 AV valve: ventricular (8.5) exceeds atrial (0.7), so it is shut. Semilunar: aortic (10.2) exceeds ventricular (8.5), so it is also shut. Both shut with falling ventricular pressure after ejection – early diastole.

3.2 Blood is pushed by the heart's pressure pulse, not by the artery's own muscle. As the pulse stretches the wall, the elastic fibres store energy and recoil between beats, smoothing pulsatile flow into continuous flow. Walls must be thick to withstand and contain the high, rapidly changing pressure without bursting or excessive expansion.

3.3 As the ventricle relaxes, its pressure falls below atrial pressure, so the AV valve opens and blood flows in passively down the pressure gradient – the atrium has been filling during systole and is already pressurised. The ventricle stiffens as it fills, so the passive gradient fades; atrial systole then raises atrial pressure to deliver the final ~30 % of the stroke volume.