8 The mammalian transport system

By the end of this chapter you should be able to:

- describe the structures of arteries, veins and capillaries, and be able to recognise these vessels using the light microscope
- describe the mammalian circulatory system as a closed double circulation
- explain the relationship between the structure and function of arteries, veins and capillaries
- describe the structure of red blood cells, phagocytes and lymphocytes
- state and explain the differences between blood, tissue fluid and lymph
- describe the role of haemoglobin in carrying oxygen and carbon dioxide
- describe and explain the significance of the dissociation curves of adult haemoglobin at different carbon dioxide levels (the Bohr effect)
- describe and explain the significance of the increase in the red blood cell count of humans at high altitude.

The mammalian cardiovascular system

Figure 8.1 shows the general layout of the main transport system of mammals – the blood system or **cardiovascular system**. It is made up of a pump, the **heart**, and a system of interconnecting tubes, the **blood vessels**. The blood always remains within these vessels, and so the system is known as a **closed** blood system.

If you trace the journey of the blood around the body, beginning in the left ventricle of the heart, you will find that the blood travels twice through the heart on one complete 'circuit'. Blood is pumped out of the left ventricle into the **aorta** (Figure 8.2), and travels from there to all parts of the body except the lungs. It returns to the right side of the heart in the **vena cava**. This is called the **systemic circulation**.

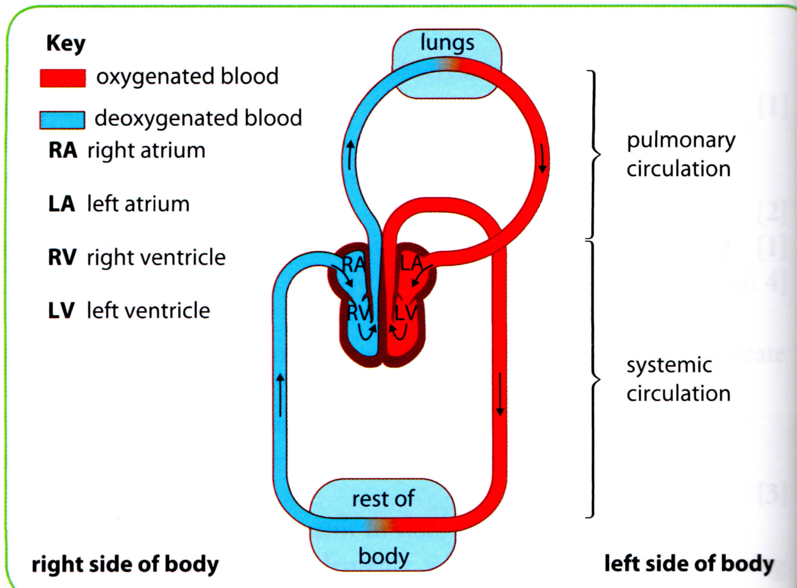


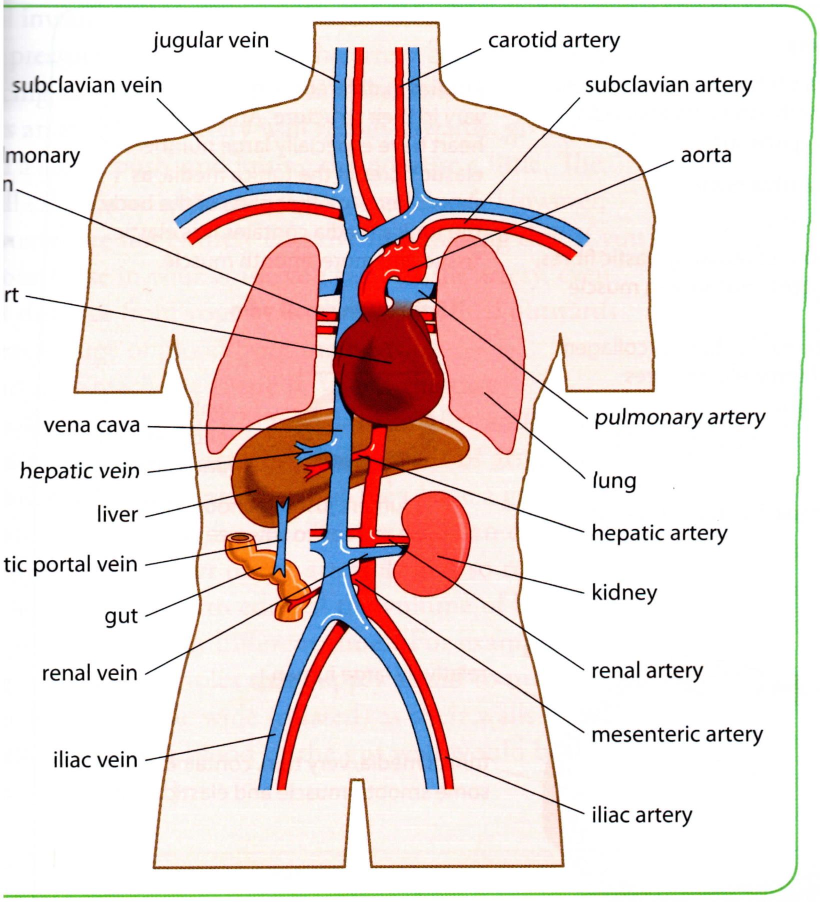
Figure 8.1 The general plan of the mammalian transport system, viewed as though looking at someone facing you. It is a closed double circulatory system.

The blood is then pumped out of the right ventricle into the **pulmonary arteries**, which carry it to the lungs. The final part of the journey is along the **pulmonary veins**, which return it to the left side of the heart. This is called the **pulmonary circulation**.

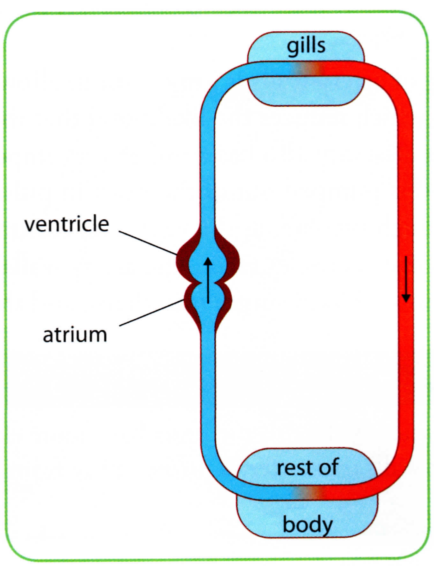
This combination of pulmonary circulation and systemic circulation makes a **double circulatory system**. The mammalian circulatory system is therefore a closed **double circulation**.

The detailed structure and functions of the heart will be looked at in Chapter 9. We now look at the rest of the system.

The vessels making up the blood system are of three main types. Figure 8.4 shows these vessels in transverse section. Vessels carrying blood **away** from the heart are known as **arteries**, while those carrying blood **towards** the heart are **veins**. Linking arteries and veins, taking blood close to



8.2 The positions of some of the main blood vessels in the human body.



3.3 The general plan of the transport system of a fish.

almost every cell in the body, are tiny vessels called **capillaries**.

Arteries

The function of arteries is to transport blood, swiftly and at high pressure, to the tissues.

The structure of the wall of an artery enables it to perform this function efficiently. Arteries and veins both have walls made up of three layers:

- an inner **endothelium** (lining tissue), made up of a layer of flat cells (squamous epithelium) fitting together like jigsaw pieces; this layer is very smooth, minimising friction with the moving blood, and rests on elastic fibres)
- a middle layer called the **tunica media** ('middle coat'), containing smooth muscle, collagen and elastic fibres (the **tunica intima** or 'inner coat')
- an outer layer called the **tunica externa** ('outer coat'), containing elastic fibres and collagen fibres.

The distinctive characteristics of an artery wall are its strength and elasticity. Blood leaving the heart is at a very high pressure. Blood pressure in the human aorta may be around 120 mm Hg, or 16 kPa. (Blood pressure is still measured in the old units of mm Hg even though kPa is the SI unit. mm Hg stands for 'millimetres of mercury', and refers to the distance which mercury is pushed up the arm of a U-tube. 1 mm Hg is equivalent to about 0.13 kPa.) To withstand such pressure,

SAQ 8.1

Figure **8.3** shows the general layout of the circulatory system of a fish.

a How does this differ from the circulatory system of a mammal?

b Suggest the possible advantages of the design of the mammalian circulatory system over that of a fish.

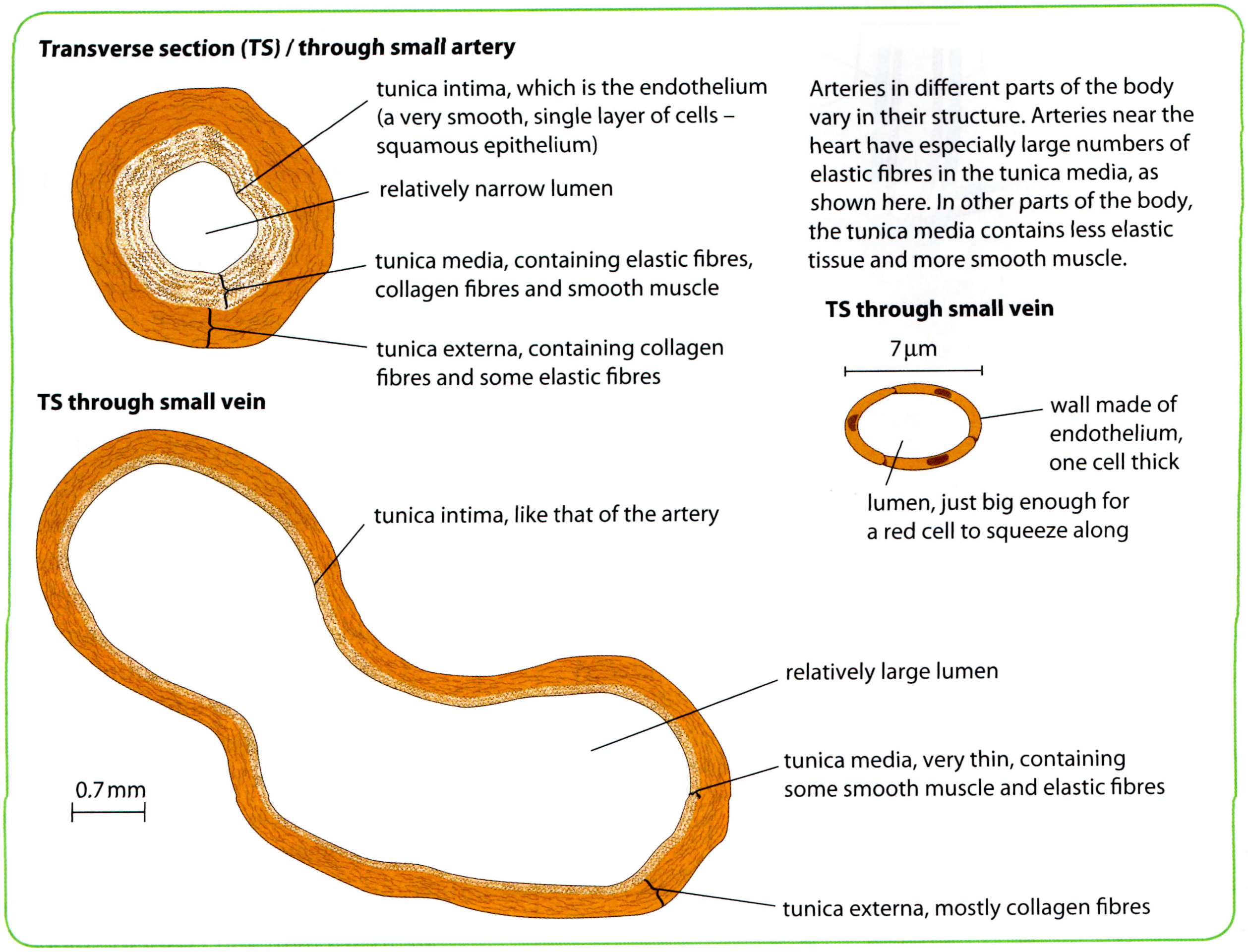


Figure 8.4 The tissues making up the walls of arteries, capillaries and veins.

artery walls must be extremely strong. This is achieved by the thickness and composition of the artery wall.

Arteries have the thickest walls of any blood vessel (Figure **8.5**). The aorta, the largest artery, has an overall diameter of 2.5 cm close to the heart, and a wall thickness of about 2 mm. Although this may not seem very great, *the composition of the wall provides great strength and* resilience. The tunica media, which is by far the thickest part of the wall, contains large amounts of elastic fibres. These allow the wall to stretch as pulses of blood surge through at high pressure. Arteries further away from the heart have fewer elastic fibres in the tunica media, but have more muscle fibres.

The elasticity of artery walls is important in allowing them to 'give', which reduces the likelihood that they will burst. This elasticity also has another very important function. Blood is pumped out of the heart in pulses, rushing out at high pressure as the ventricles contract, and slowing as the ventricles relax. The artery walls stretch *as the high-pressure blood surges into them, and then*

SAQ 8.2

Suggest why arteries close to the heart have more elastic fibres in their walls than arteries further away from the heart.