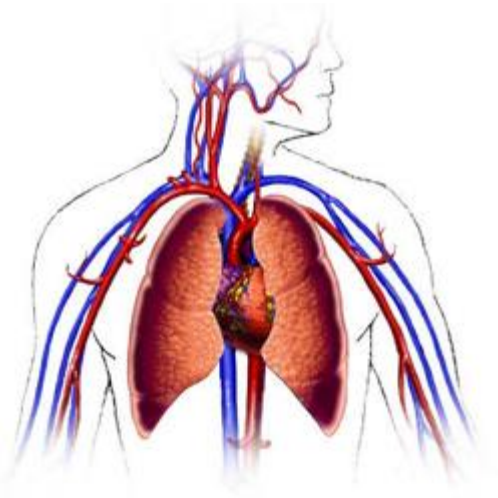
THE BLOOD TRANSPORT SYSTEM IN MAMMALS



"Ah, I see you've taken an interest in our blood plasma TV."

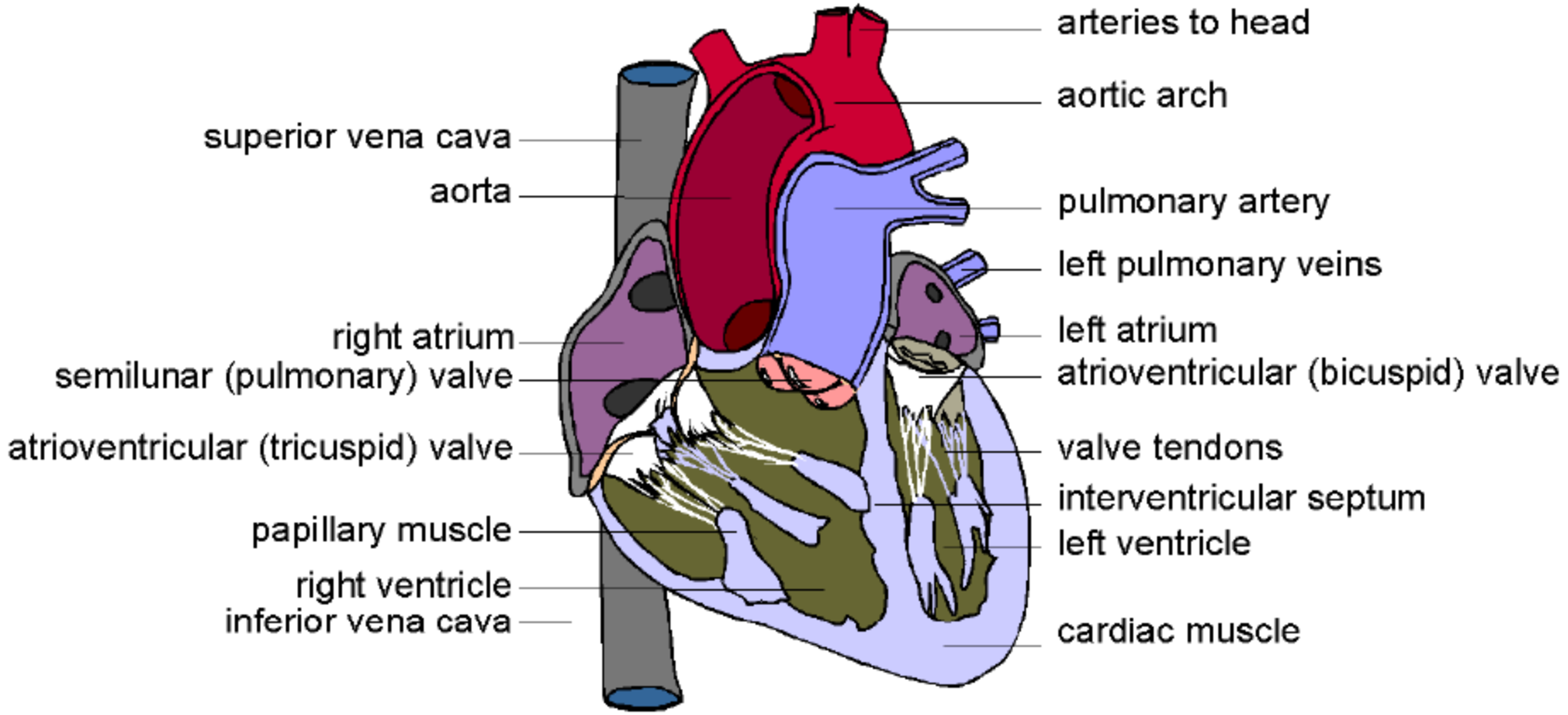
Heart structure revision from GCSE...

...what do you remember?

The human heart has four chambers: two thin-walled [redacted] on top, which receive blood, and two thick-walled [redacted] underneath, which pump blood. [redacted] carry blood into the atria and [redacted] carry blood away from the ventricles. Between the atria and the ventricles are [redacted], which prevent back-flow of blood from the ventricles to the atria. The left valve has two flaps and is called the [redacted] (or [redacted]) [redacted], while the right valve has 3 flaps and is called the [redacted]. The valves are held in place by [redacted] ("heart strings") attached to [redacted], which contract at the same time as the ventricles, holding the vales closed. There are also two [redacted] in the arteries (the only examples of valves in arteries) called the [redacted].

The left and right halves of the heart are separated by the [redacted]. The walls of the right ventricle are 3 times thinner than on the left and it produces less force and pressure in the blood. This is partly because the blood has less far to go (the lungs are right next to the heart), but also because a lower pressure in the pulmonary circulation means that less fluid passes from the capillaries to the alveoli.

The heart is made of [redacted], composed of cells called [redacted]. When myocytes receive an electrical impulse they contract together, causing a heartbeat. Since myocytes are constantly active, they have a great requirement for oxygen, so are fed by numerous capillaries from two [redacted]. These arise from the aorta as it leaves the heart. Blood returns via the [redacted], which drains directly into the right atrium.



The mammalian circulatory system

- Blood passes through the heart twice in each circuit of the body; this is called double circulation
- The RHS of the heart pumps deoxygenated blood to the lungs (pulmonary circulation) and oxygenated blood returns to the LHS of the heart

- Pulmonary circulation is low pressure so blood is pushed slowly to the nearby lungs allowing more time for gas exchange and less chance of too much fluid leaking out OR OF DAMAGING THE DELICATE PULPMONARY CAPILLARIES

- The LHS of the heart pumps the oxygenated blood to the tissues (systemic circulation); deoxygenated blood then returns to the heart
- Systemic circulation is high pressure to ensure blood is pumped to all body organs and so that tissue fluid can form in each organ DELIVERING METABOLITES AND COLLECTING WASTE
- Arteries branch off the systemic circulation to supply each organ with oxygen and a vein brings blood back to the heart from the organs

Remember!

The heart muscle also needs its own supply of blood to provide it with oxygen and nutrients; this is called coronary circulation. The coronary arteries arise from the base of the aorta

The Flow of Blood Through the Body

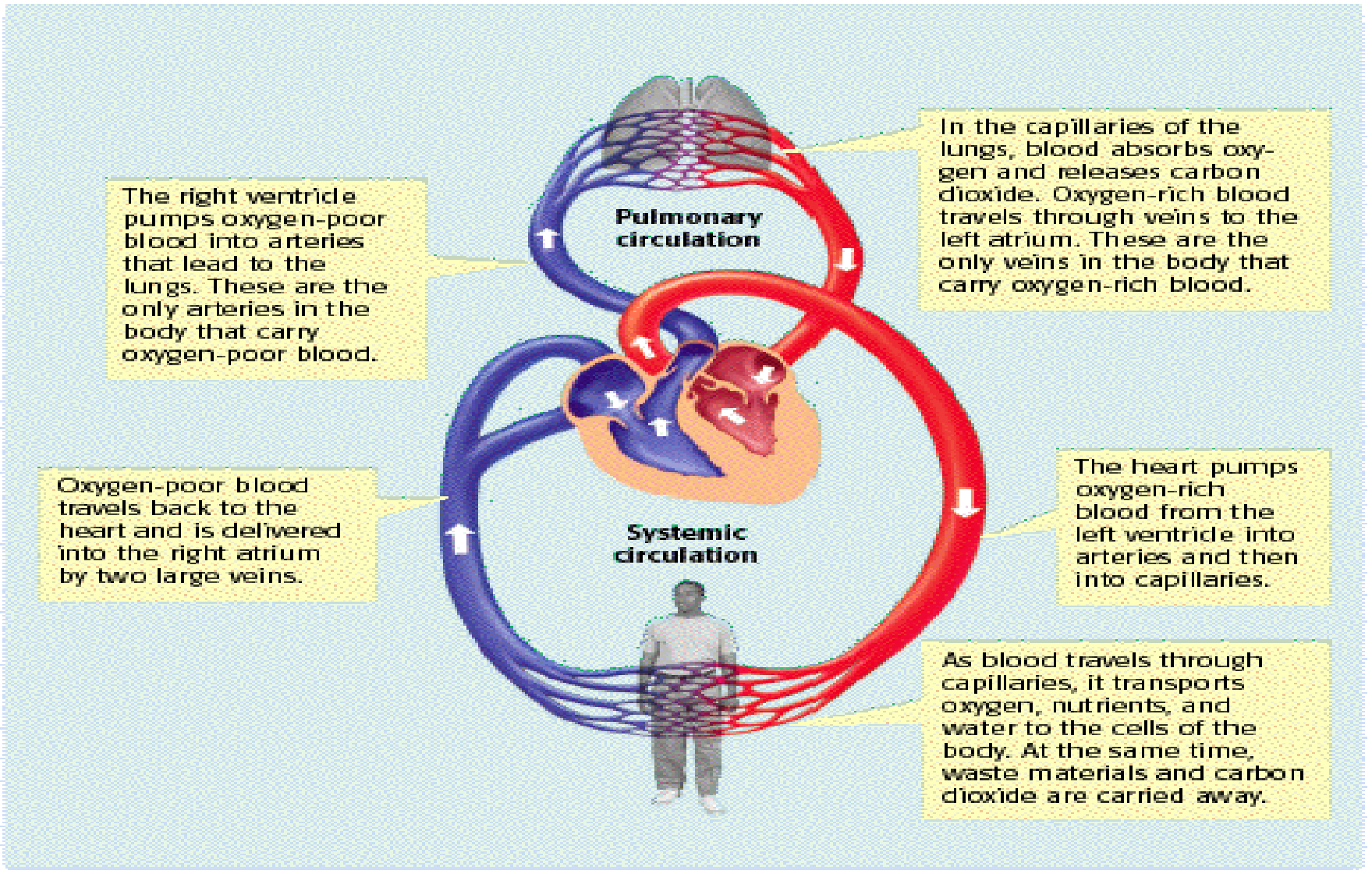
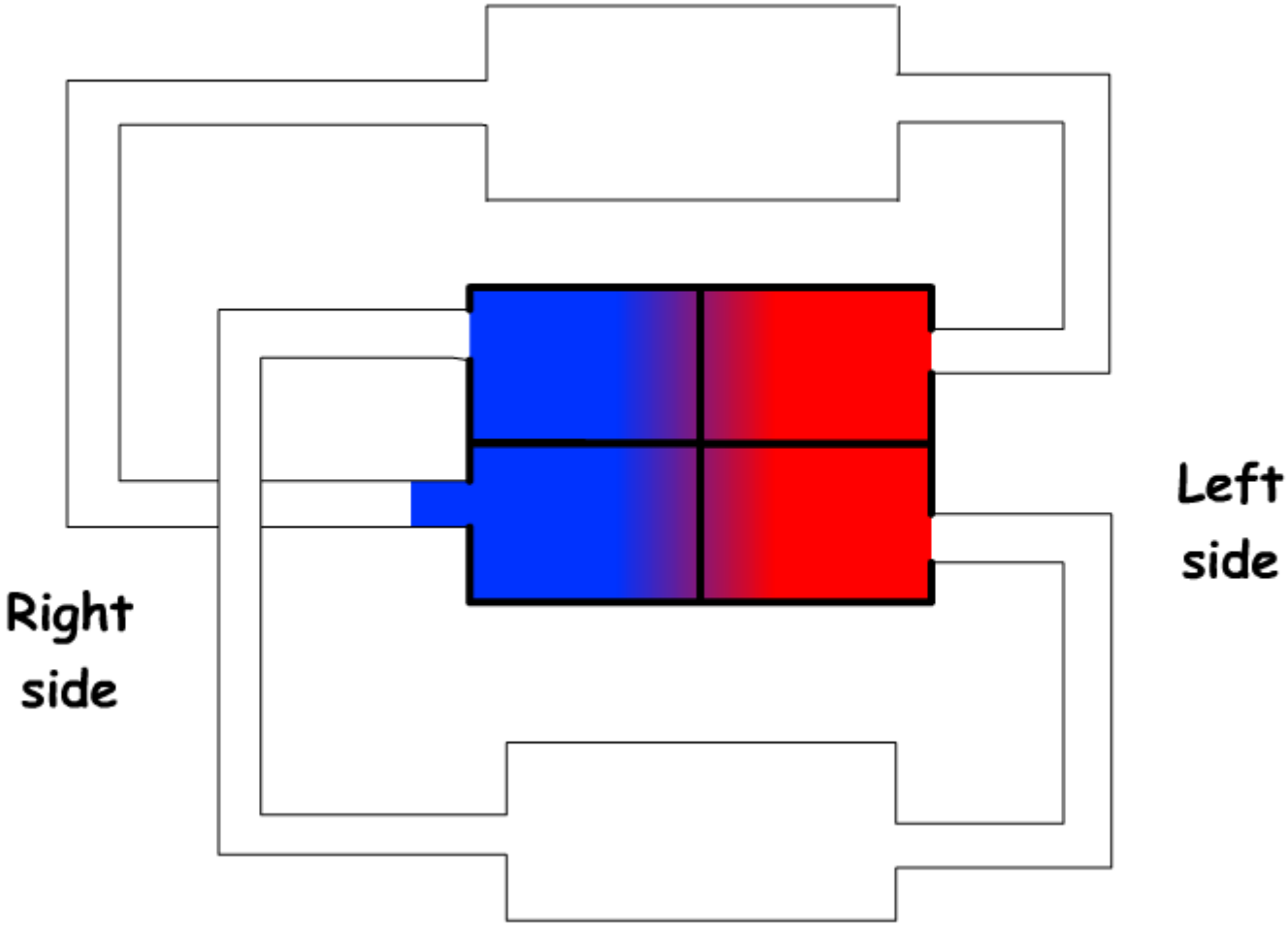
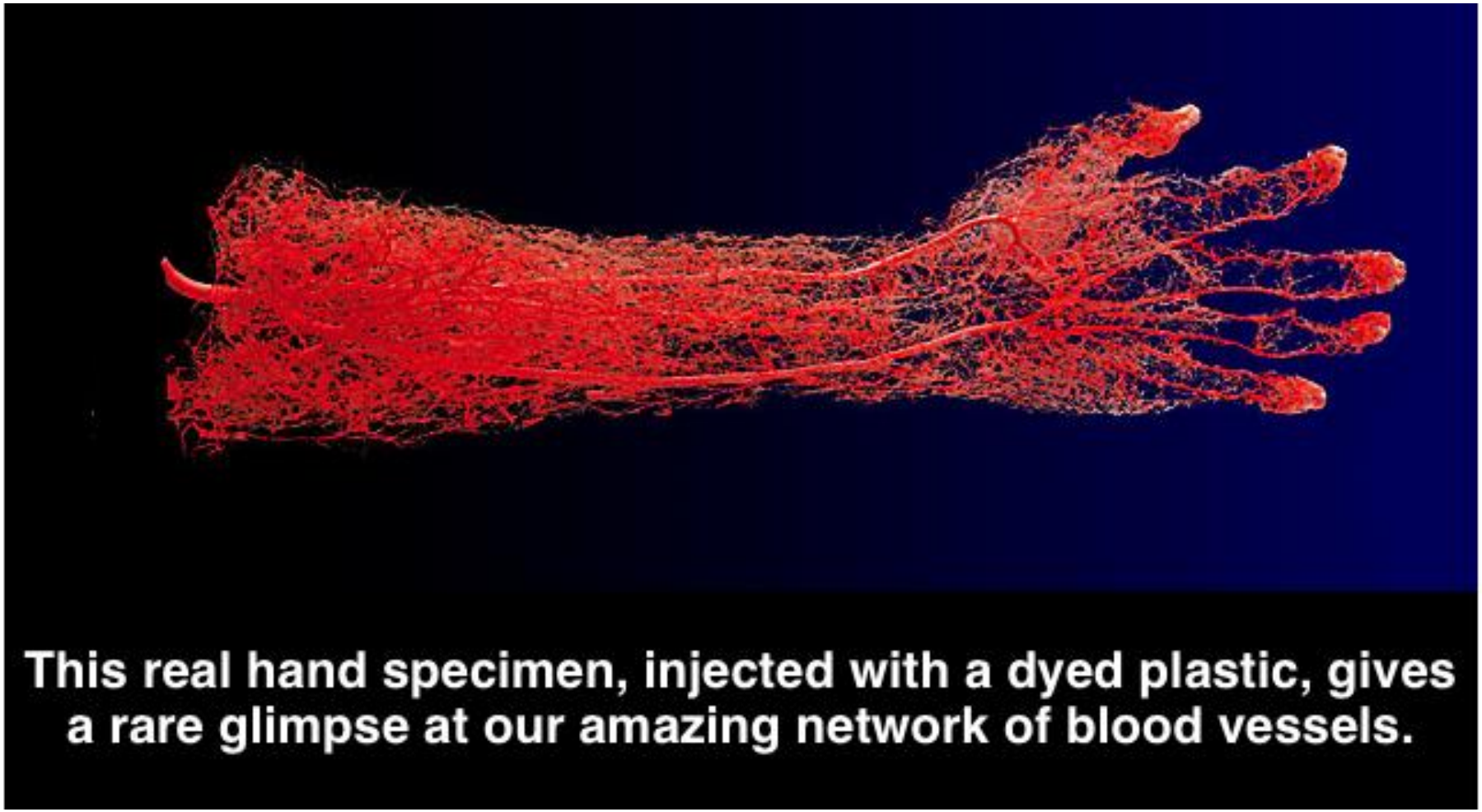


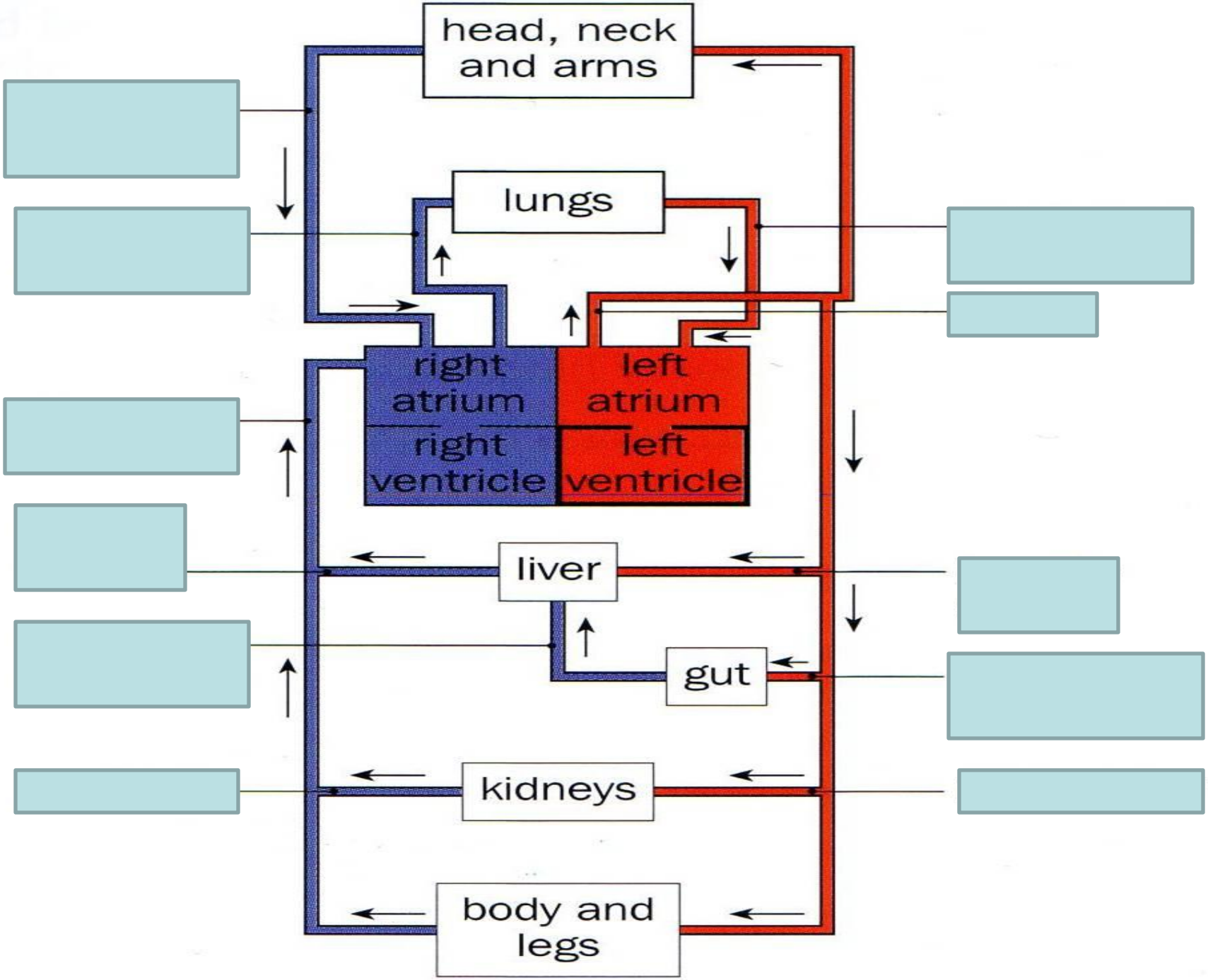
Diagram - Double Circulatory System

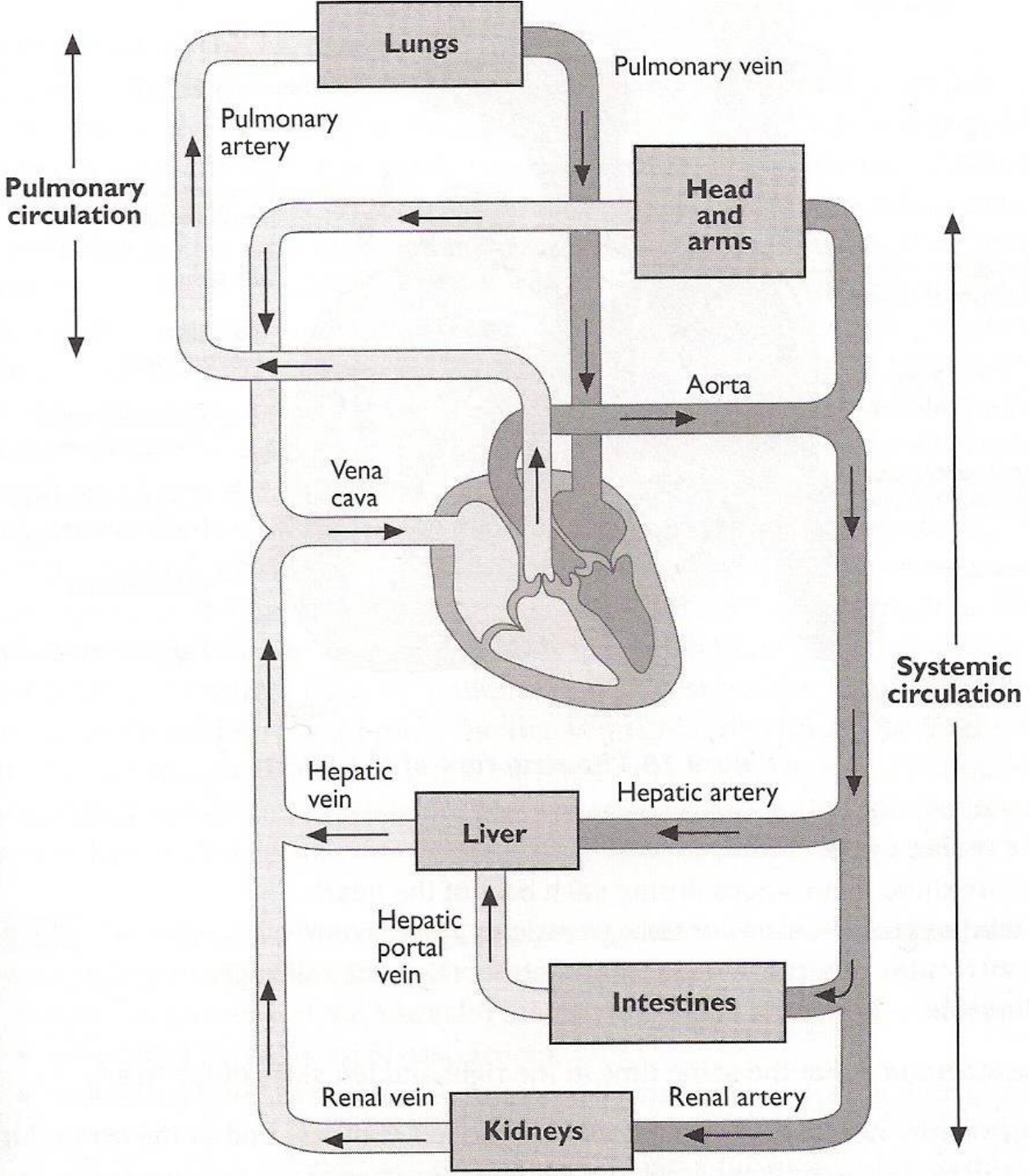


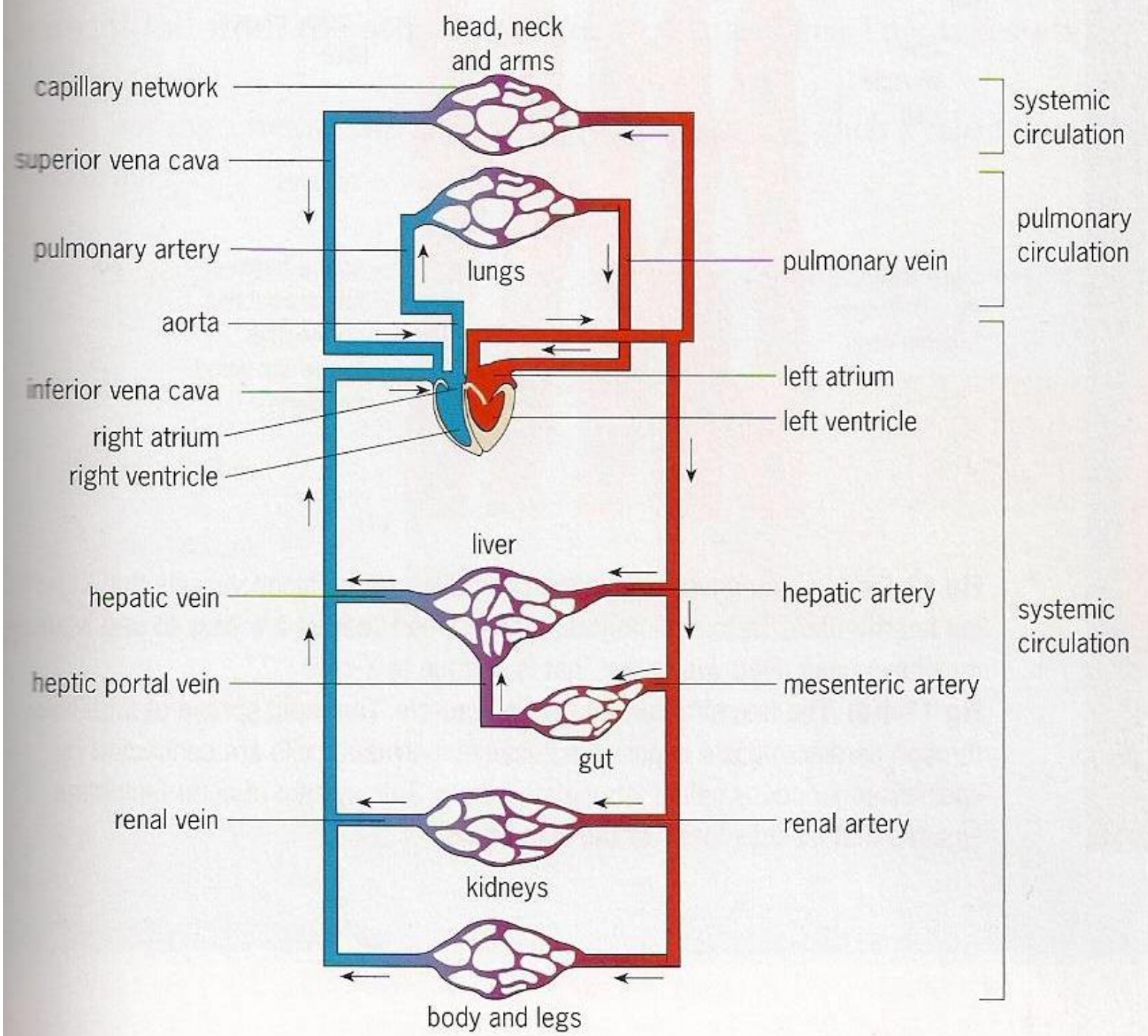


This real hand specimen, injected with a dyed plastic, gives a rare glimpse at our amazing network of blood vessels.

The double circulatory system and the main blood vessels associated with it…


head, neck and arms
lungs
right atrium
left atrium
right ventricle
left ventricle
liver
gut
kidneys
body and legs


Lungs
Pulmonary vein
Pulmonary artery
Pulmonary circulation
Head and arms
Aorta
Vena cava
Systemic circulation
Hepatic vein
Hepatic artery
Liver
Hepatic portal vein
Intestines
Renal vein
Renal artery
Kidneys

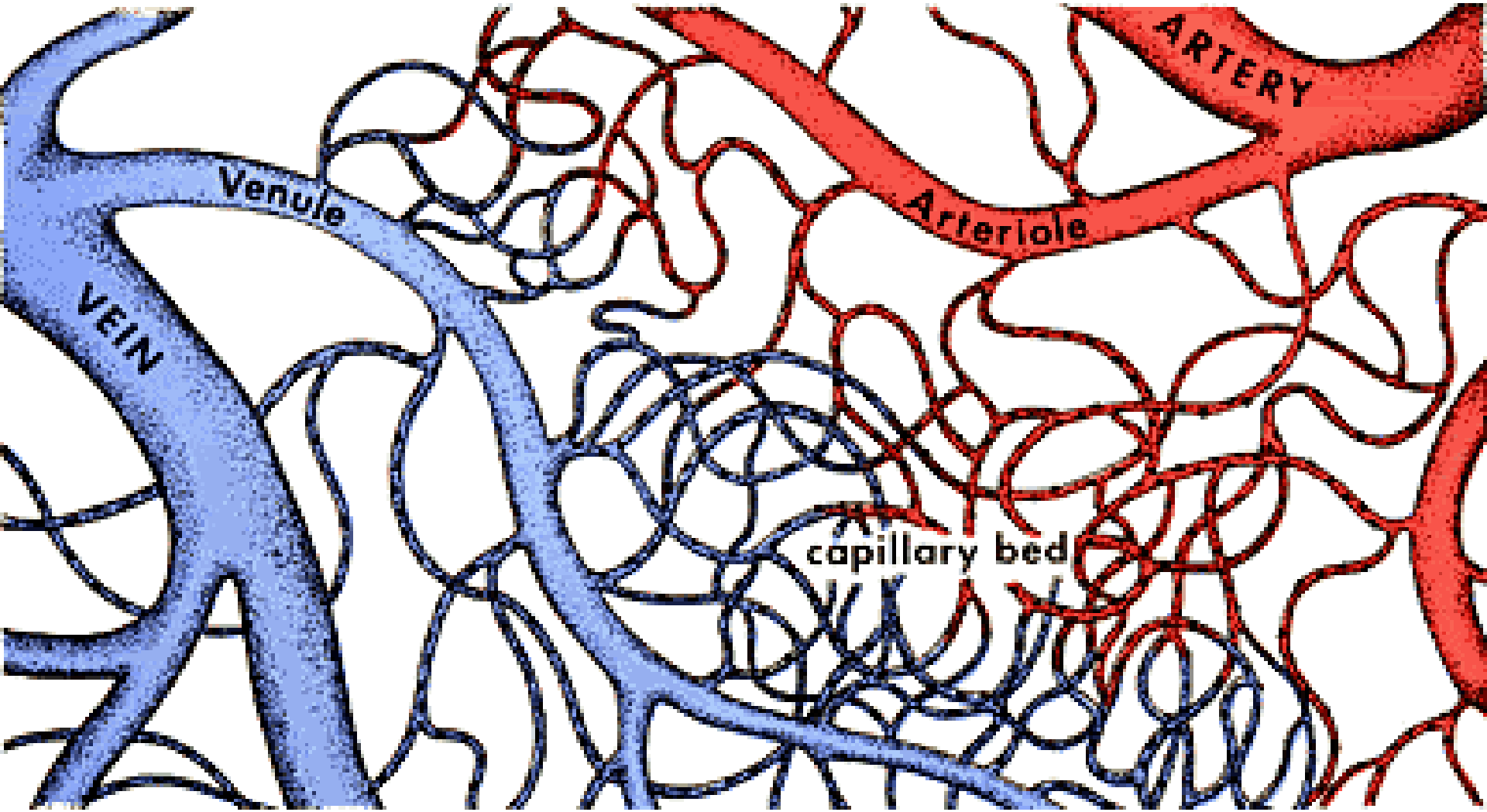

head, neck
and arms
capillary network
superior vena cava
pulmonary artery
aorta
inferior vena cava
right atrium
right ventricle
lungs
pulmonary vein
left atrium
left ventricle
liver
hepatic vein
hepatic artery
heptic portal vein
mesenteric artery
gut
renal vein
renal artery
kidneys
body and legs
systemic
circulation
pulmonary
circulation
systemic
circulation

BLOOD VESSELS

Entire human circulatory system from the "bodies revealed exhibition":

Blood vessels

- Three types; arteries, veins and capillaries
- Arteries carry blood away from the heart under high pressure. They branch to form smaller arterioles. Arterioles sub divide into capillaries. Capillaries join up to form venules. Venules join up to form veins


ARTERY
Arteriole
Venule
VEIN
capillary bed

Capillary bed:

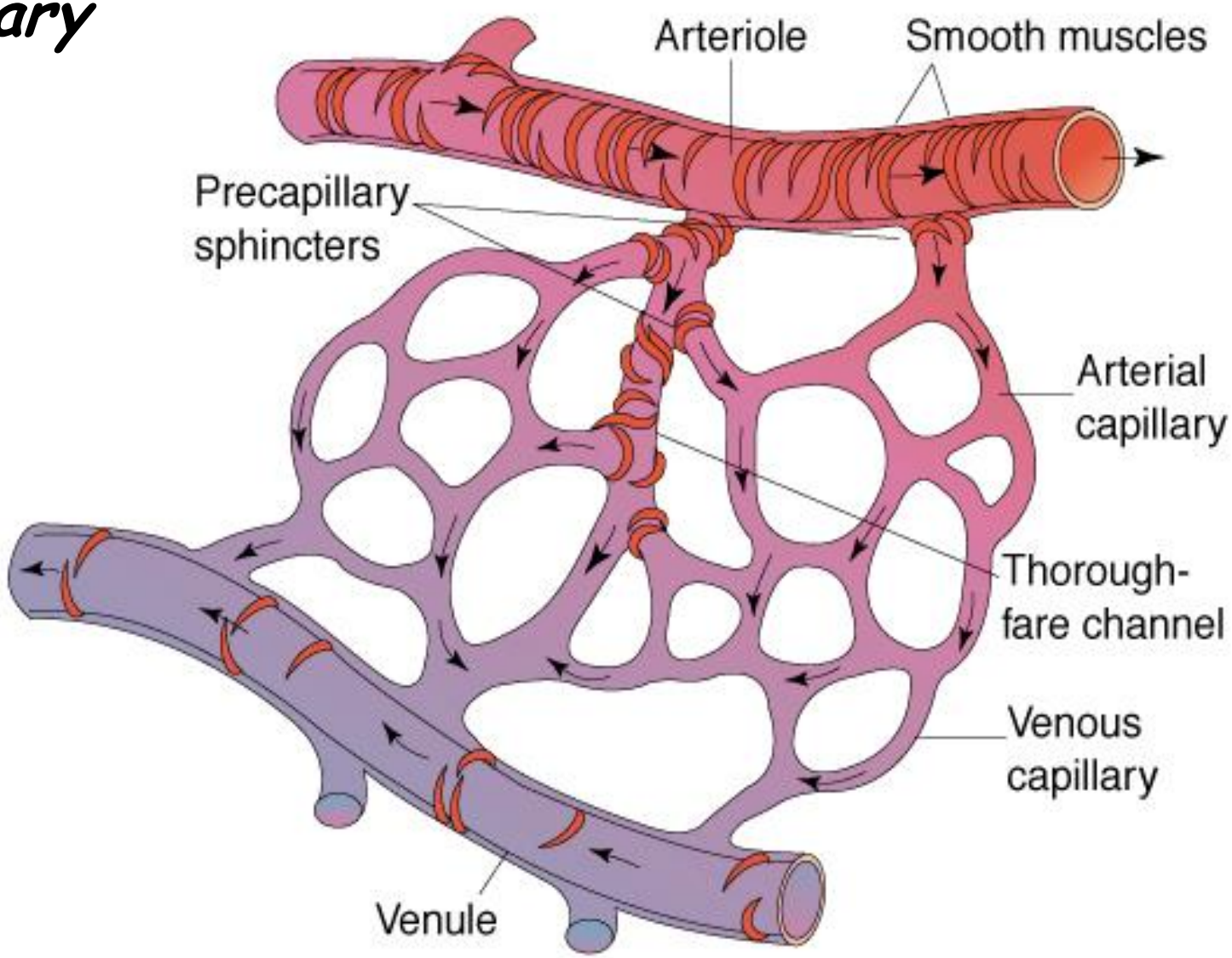
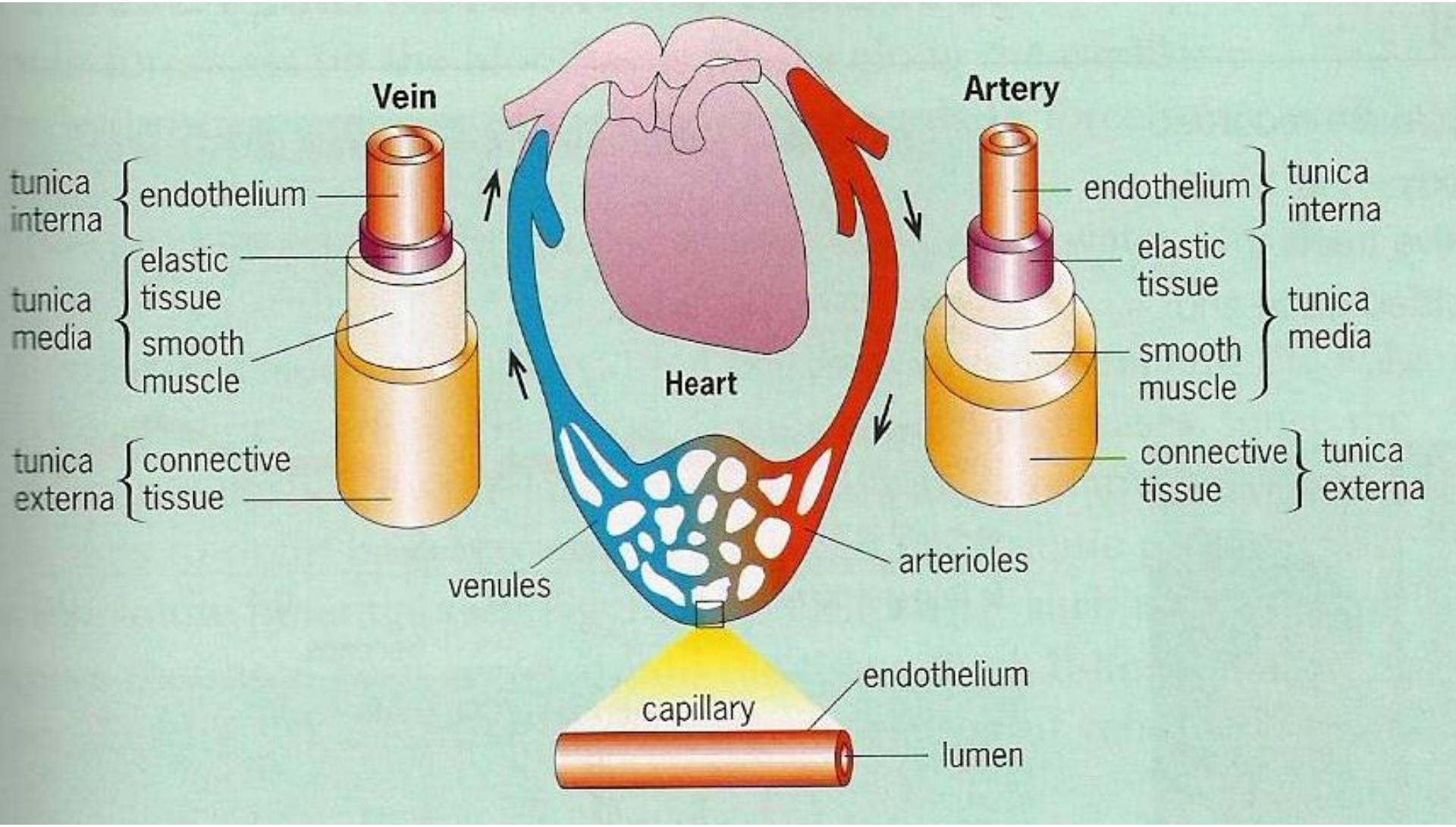


Figure 23-23 Capillary bed. Precapillary sphincters control the flow of blood through the capillary network. Thoroughfare channels (*i.e.*, arteriovenous shunts) allow blood to move directly from the arteriole into the venule without moving through nutrient channels of the capillary.

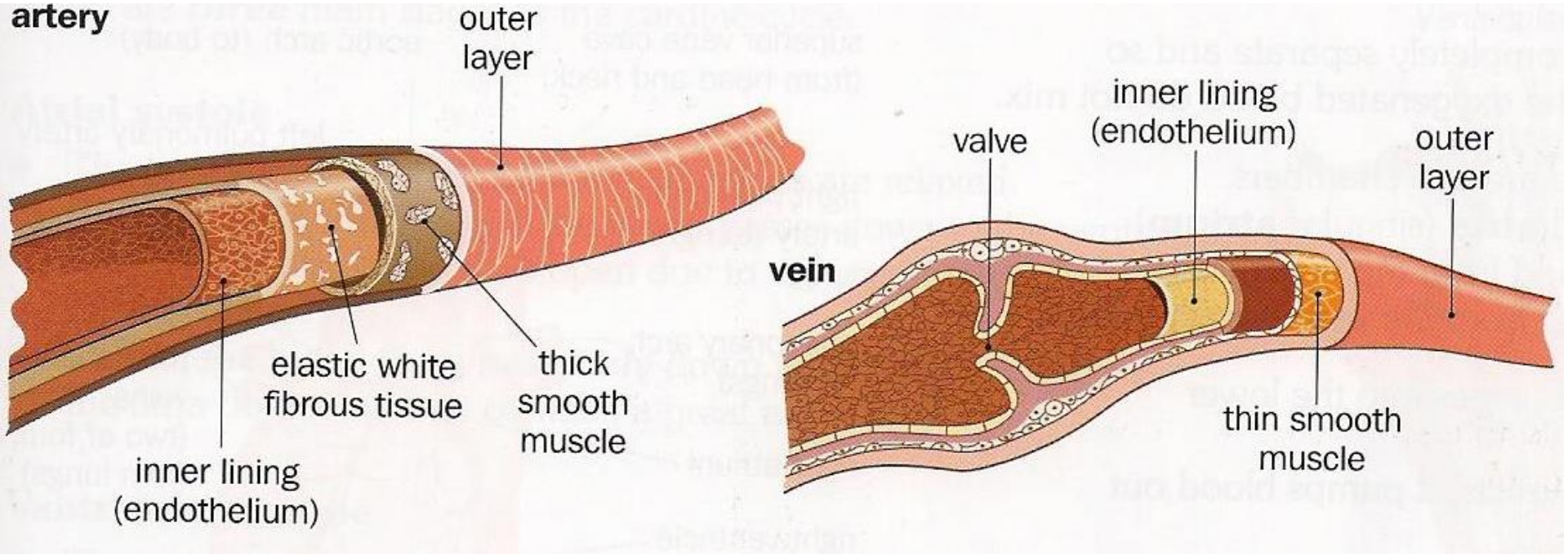
From the lumen out, arteries and veins are made up of 3 layers:

- Outer layer- tough **fibrous layer** (made of collagen and elastic tissue)-protects against the pressure from other organs rubbing against it
- Middle layer has elastic fibres for stretching and recoiling and muscle tissue (more in arteries than veins)
- Inner layer has thin endothelium - smooth to reduce friction

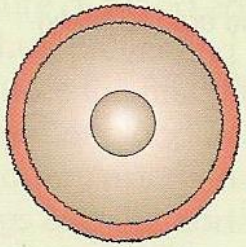
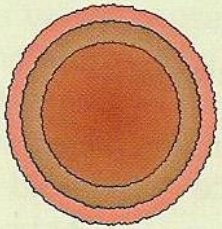
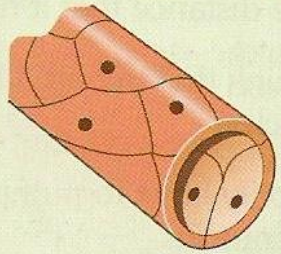
*Remember that **capillaries have only one layer! – just squamous endothelium***

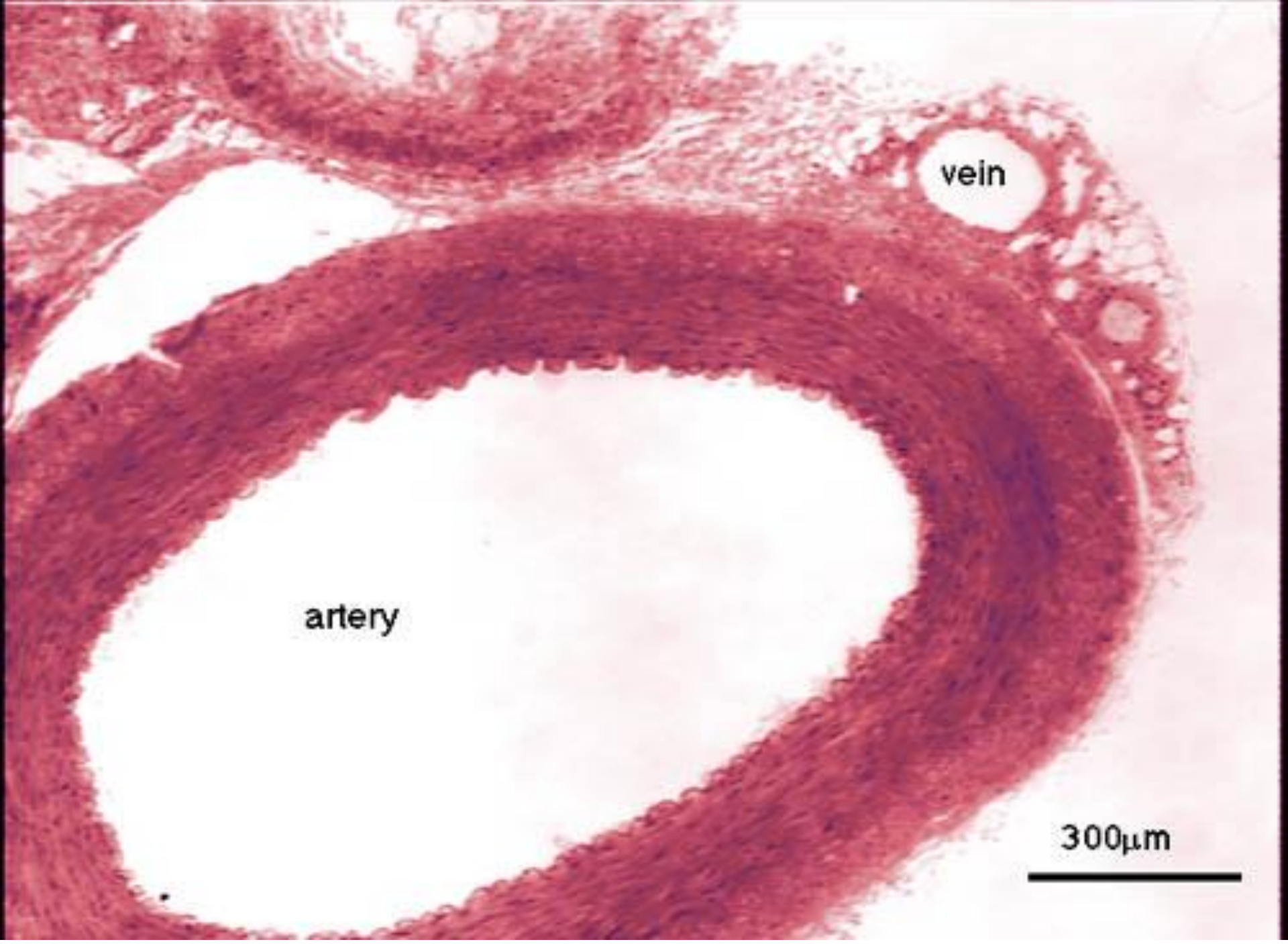

Vein
Artery
Heart
tunica interna
endothelium
tunica media
elastic tissue
smooth muscle
tunica externa
connective tissue
endothelium
tunica interna
elastic tissue
smooth muscle
tunica media
connective tissue
tunica externa
venules
arterioles
capillary
endothelium
lumen

Structure of an artery and vein:



Comparison of blood vessel structure

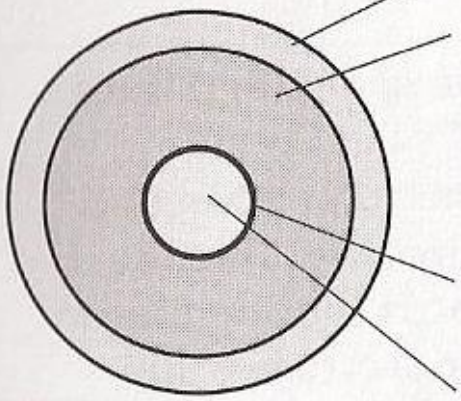
Arteries	Veins	Capillaries
a) 	b) 	c) 
carry blood away from the heart thick muscular walls lots of elastic tissue in wall relatively small lumen blood under high pressure blood flow is rapid blood flows in pulses no valves	carry blood back to the heart thin muscular walls little elastic tissue in wall relatively large lumen blood under low pressure blood flow is slow no pulse valves prevent backflow of blood	link up arteries and veins in the tissues no muscle: wall made up of one cell thick **endothelium** no elastic tissue present small lumen — just large enough for a red blood cell to squeeze through pressure falls as blood passes along capillary blood flow is slowing down no pulse no valves


vein
artery
300µm

Arteries

- They carry blood under high pressure away from the heart, to the organs
- The smaller lumen helps maintain pressure, though can be constricted or dilated depending on smooth muscle
- Therefore arteries contain elastic tissue which allows the vessel to stretch as blood surges through during heart contraction (systole) - this smoothes out the pulse wave
- The elastic fibres also allow the artery to recoil when the heart relaxes (diastole) and thus continue to push blood through the vessel

- The arteries have smooth muscle and can contract (vasoconstriction) to close off the capillary beds to which they lead; or relax (vasodilation) to open up the capillary bed. This controls blood supply to organs and the skeletal muscle
- The large muscle and elastic fibre layers mean they have a thick wall (tunica media)



Outer layer of fibrous tissue — protection

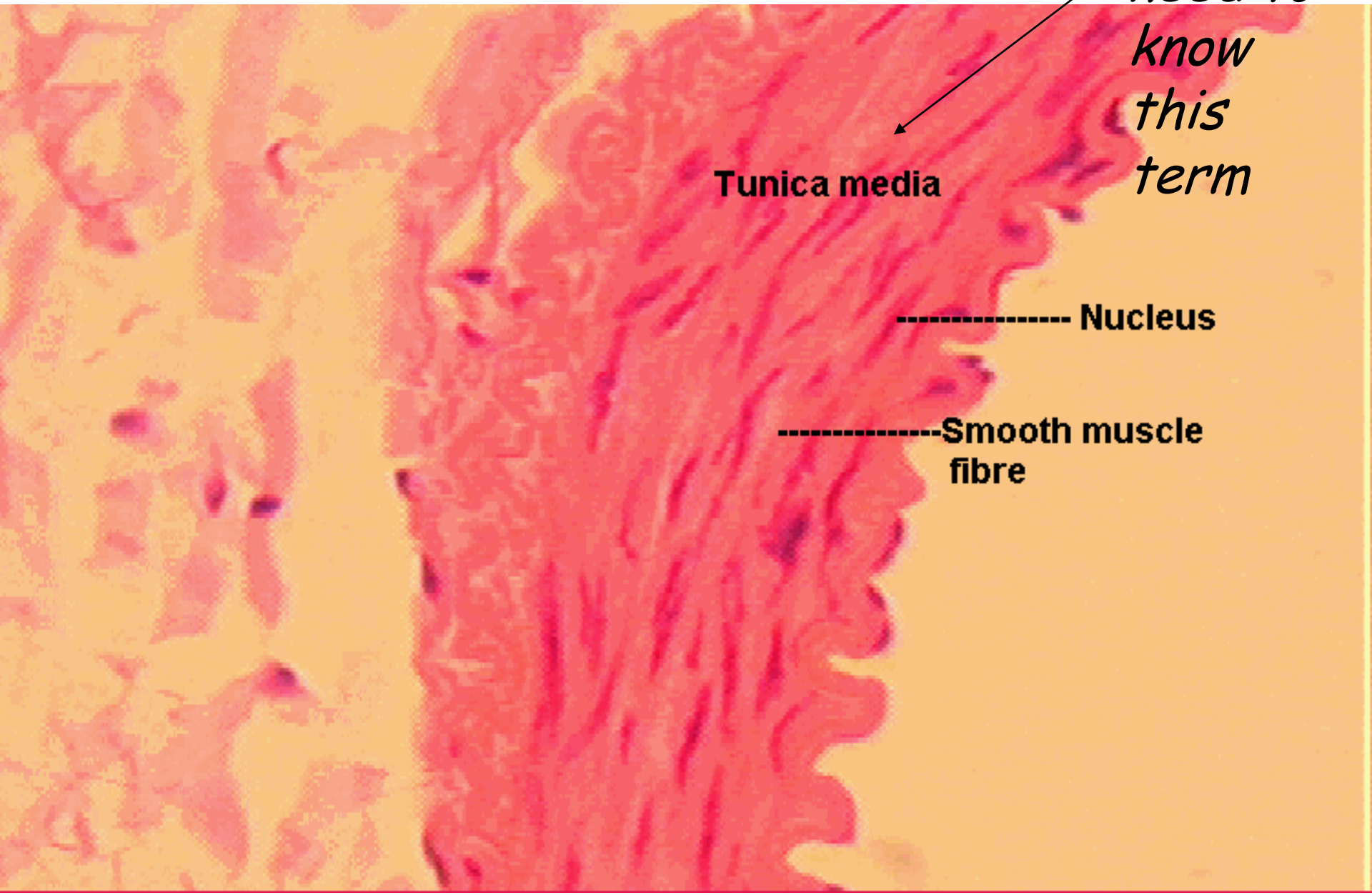
Thick middle layer containing elastic tissue — allows stretching when blood surges (during systole) and recoils to continue pushing blood along (during diastole) — and **muscle tissue** — may contract to narrow the lumen (vasoconstriction) so reducing blood supply to an organ, or relax to increase supply (vasodilation)

Endothelium — provides a smooth inner surface which reduces the friction caused by blood flow through the lumen

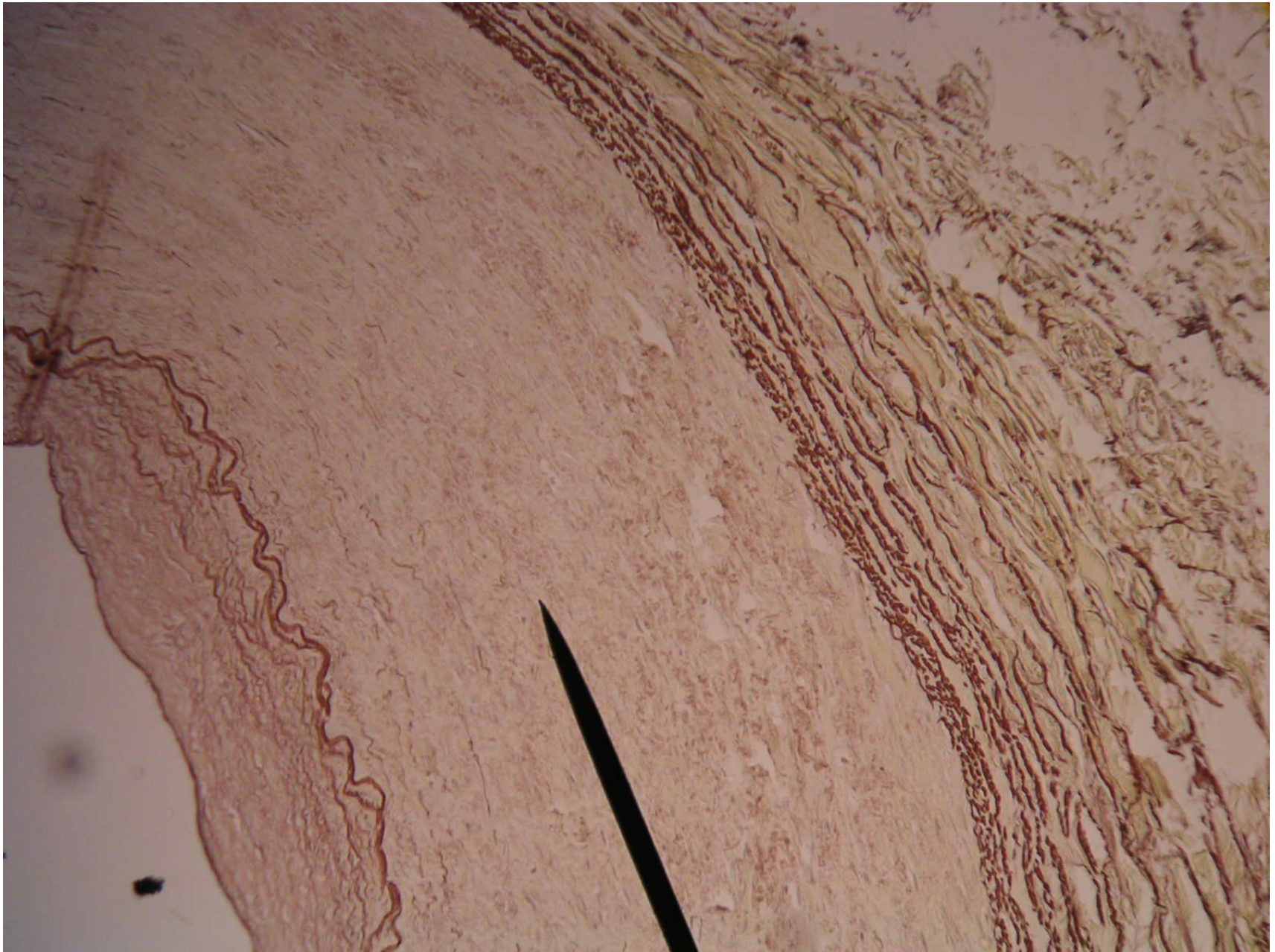
Lumen — small, maintaining a high blood pressure, and may be constricted or dilated

Figure 21 The wall of an artery

Smooth muscle in arteries



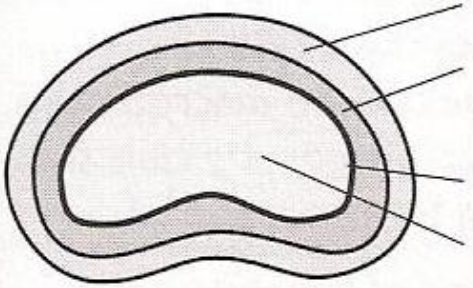
Elastic tissue in arteries



Veins

- Carry blood back to the heart under low pressure (non-pulsatile)
- Contains fibrous tissue for protection (though less than arteries)
- Little elastic tissue as blood is under low pressure, so wall is thin compared to arteries
- Also contain less smooth muscle than arteries
- Have a large lumen to facilitate blood entering from the capillaries, and also lessen the resistance to blood flowing back to the heart WHICH ENSURES THE BLOOD FLOW VELOCITY CAN BE HIGH DESPITE THERE BEING LOW PRESSURE

- They have semilunar valves to prevent backflow of blood, and the surrounding muscle pump system (as skeletal muscle contracts) aids blood flow (especially in the legs)



Outer layer of fibrous tissue — protection

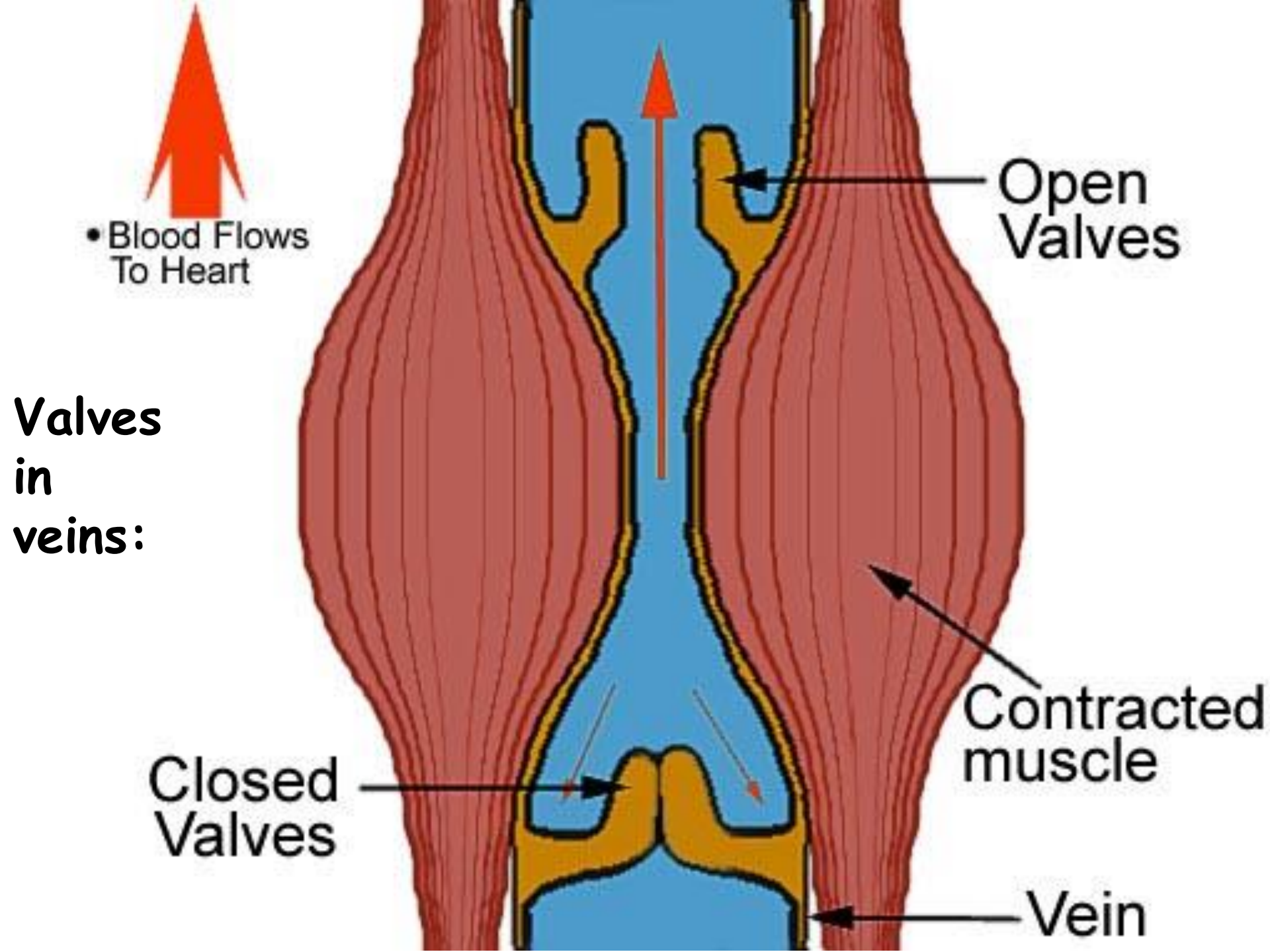
Thin middle layer containing some smooth muscle and few elastic fibres — small layer since blood is under low pressure

Endothelium — provides a smooth inner surface

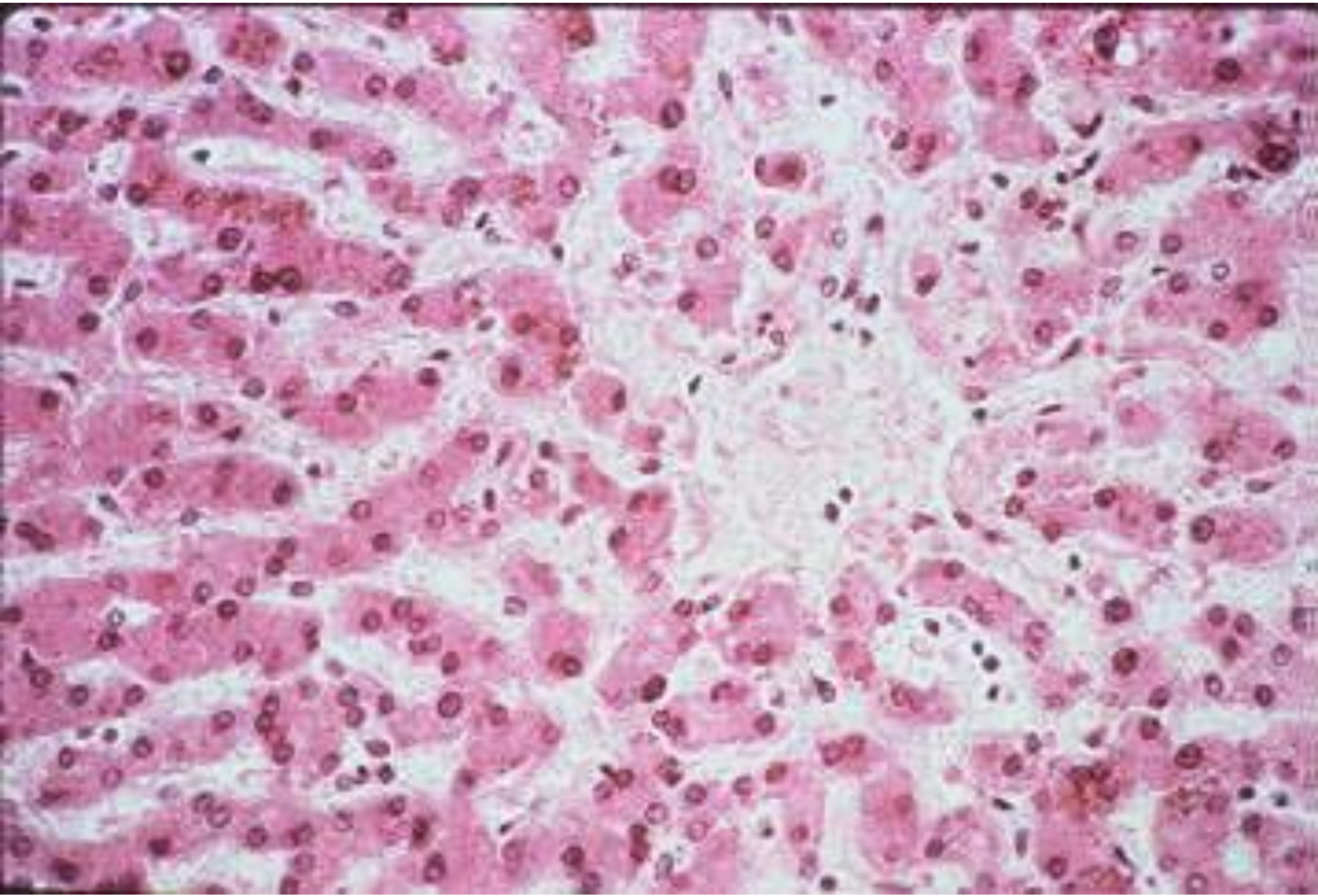
Lumen — large space making it easier for blood to enter from the capillaries while friction is reduced as blood flows back to the heart

Figure 23 The wall of a vein

Valves in veins:



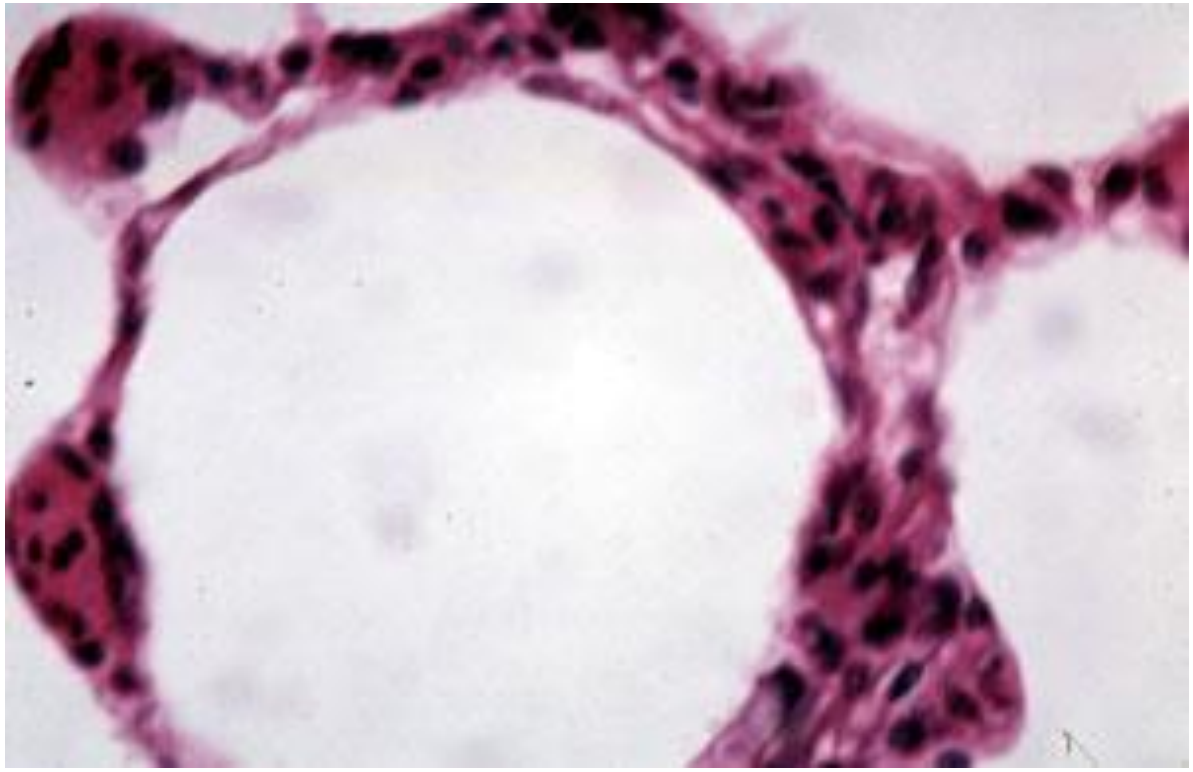
Outer layer of fibrous tissue in veins:



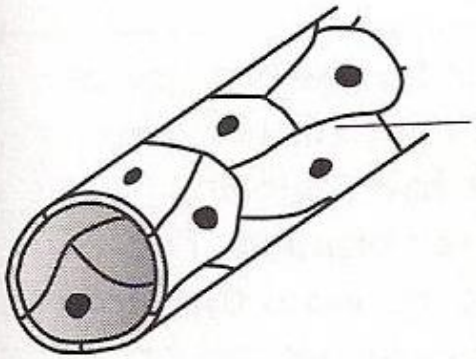
Capillaries:

- Wall made of squamous (pavement) endothelium - a thin wall, only 1 cell thick permeable to water, solutes and dissolved gases
- This reduces diffusion distance to supply oxygen, glucose and metabolites to the tissues
- The total of the capillaries represents a huge surface area AND THIS REDUCES THE PRESSURE AND VELOCITY OF THE BLOOD SIGNIFICANTLY
- The very small lumen aids diffusion by slowing the blood flow and distorting the RBCs to increase their surface area and improve contact with tissue cells

Squamous endothelium in capillaries lining alveoli:



- Contains no elastic or muscle tissue
- Tissue fluid forms at arterial end and is reabsorbed at the venule end of the capillary network surrounding a tissue or organ



Squamous (pavement) endothelium — thin wall, permeable to water and solutes, so providing a short diffusion distance and facilitating the exchange of substances between the blood and tissue cells

Figure 22 A capillary