**Circulation System**

**Blood**

55% **plasma**: carries CO₂; glucose, urea, amino-acids, hormones, heat, cells!

45% **cells**: all made in bone marrow; short life; destroyed in liver; only WBC’s have nucleus, reproduce

RBC’s carry O₂; no nucleus; biconcave (↑ SA); contain haemoglobin; small (8µm so ↑SA)

WBC’s: 3 sorts: Lymphocytes (antibodies); Monocytes (‘eat’ bacteria); Granulocytes (many jobs)

Platelets: bits of cells vital for blood clotting (and tissue repair)

**Blood Vessels**

Blood pressure falls around system;

highest, and varies most, in ventricles;

Falls most in arterioles; travels slowest (most resistance) in capillaries; only veins have valves.

Heart ventricles → arteries → arterioles → capillaries → venules → veins → heart atria

**Arteries**: aorta (body); carotid (neck); renal (kidney); pulmonary (lungs, − O₂); hepatic (liver)

**Veins**: vena cava (body); jugular (neck); renal (kidney); pulmonary (lungs, + O₂); hepatic portal (gut → liver); hepatic (liver).

**Arteries**: thick, muscular walls, help to pump blood along (elastic recoil); narrow lumen (= high pressure);

smooth lining (lowers resistance)

**Arterioles**: muscular walls so blood flow follows demand (gut after meal, muscles for exercise, skin for cooling).

Supply to **brain** is constant.

**Capillaries**: site of exchange with cells; walls 1 cell thick (thus leak); high resistance, slow flow;

**Veins**: thin walls, large lumen (thus very low pressure); run between muscle blocks (contraction squeezes blood along);

**pocket valves** ensure blood flows one way (→ heart)

**Tissue fluid**

Fluid surrounding body cells; isotonic with all cells in body

**Formation**: High blood pressure at artery end forces fluid out; low pressure at venous end not a problem; water and small molecules forced out (10%); proteins and cells remain behind (too big);

thus water potential lowers

**Lower water potential at venous end** so water re-enters by osmosis, down water potential gradient. Remaining fluid; drains into lymphatic system.

**Lymphatic system**: Drains tissue fluid – no ‘pump’; many valves; relies on muscle contraction to force fluid along; collects at ‘lymph nodes’ = site of lymphocyte production (tonsils); also drain fats from guts in lacteals. Lymph returns to blood just outside the heart (right atrium).
**The Heart**

**Dual pump:** all 4 chambers have same volume; myogenic (does not need nerves to stimulate)

**Diastole:** = filling chamber (low pressure); **Systole** = contracting chamber (high pressure)

- Right side – deoxygenated, blood **from** vena cava **to** lungs; lower pressure (short artery, no gravity)
- Left side: oxygenated, blood **from** lungs **to** body; highest pressure (long trip, problem of gravity)

**Blood flows:** right atrium $\rightarrow$ right ventricle $\rightarrow$ lungs $\rightarrow$ left atrium $\rightarrow$ left ventricle $\rightarrow$ body (aorta)

**Valves:**
- **Semi-lunar valves** between ventricles and main arteries; **open** at start of ventricular systole; close at end of ventricular systole (pressure in ventricle < artery)
- **Atrio-ventricular (a-v) valves** are between atria and ventricles ($L =$ bicuspid, $R = $ tricuspid)
- A-V valves **open** when atria contract (systole); (pressure > than ventricles);
- A-V valves **close** when ventricular systole begins (pressure > that in atria)

**Diastole**

Blood returning from the body flows into the right atrium, and oxygen-rich blood flowing from the lungs flows into the left atrium.

**Atrial systole**

The right and left atria contract to push blood into the ventricles. The semi-lunar valves close to stop the blood flowing back into the heart.

**Ventricular systole**

The ventricles contract to push blood out of the heart through semi-lunar valves. **Both** sets of AV valves close to prevent backflow.

**Control:** regulated by autonomic nerves (vagus↓, cardiac↑) and by hormones (adrenalin, insulin)

Nerve impulse arrives at sino-atrial node (SAN); impulse travels over atria, causing contraction; to **Atrio-ventricular node** (AVN); DELAY (allows time for ventricles to fill); impulse $\rightarrow$ down **Bundle of His;** causes ventricles to contract from **bottom** (thus fully emptying)

**Cardiac Output** = stroke volume $\times$ heart rate ($=$ pulse rate)

**Heart rate affected by:** stress; exercise; drugs (caffeine); hormones; volume of blood returning