1. Cardiovascular + Renal Summary

This document is your main **theory summary** for cardiovascular and renal physiology.

Cardiovascular physiology

Blood flow through the heart

Know the sequence:

SVC/IVC → RA → tricuspid valve → RV → pulmonary valve → pulmonary artery → lungs → pulmonary veins → LA → mitral valve → LV → aortic valve → aorta → systemic circulation

- Right heart → **pulmonary circulation**
- Left heart → **systemic circulation**
- Valves open and close according to **pressure gradients**.

Electrical conduction

$$\boxed{SA\ node \rightarrow atria \rightarrow AV\ node \rightarrow Bundle\ of\ His \rightarrow bundle\ branches \rightarrow Purkinje\ fibres}$$

- **SA node** = normal cardiac pacemaker.
- Atrial depolarisation → atrial contraction.
- **AV node delays conduction** → allows ventricular filling.
- Purkinje fibres rapidly distribute excitation → coordinated ventricular contraction.
- Ventricular repolarisation → relaxation/diastole.

Cardiac contraction

Cardiac muscle contracts through the **sliding filament mechanism**.

Ca^{2+} binds **troponin** → tropomyosin moves → actin binding sites exposed → myosin forms cross-bridges → sarcomere shortens.

Importantly, cardiac contraction depends on **extracellular Ca^{2+}**, which triggers further Ca^{2+} release from the SR (**calcium-induced calcium release**).

Sympathetic stimulation → ↑ intracellular Ca^{2+} → ↑ contractility.

Stroke volume and cardiac output

$$\boxed{SV = EDV - ESV}$$
$$\boxed{CO = HR \times SV}$$

Stroke volume increases with:

- ↑ EDV/preload → **Frank-Starling mechanism**
- ↑ sympathetic stimulation → ↑ Ca^{2+} → ↑ contractility
- ↓ afterload

Frank-Starling: ↑ ventricular filling → ↑ cardiac muscle stretch → ↑ force of contraction → ↑ SV.

Blood pressure

Important equations

$$PP = SBP - DBP$$
$$MAP \approx DBP + \frac{1}{3}(PP)$$
$$\boxed{MAP = CO \times TPR}$$

Therefore BP can be altered through:

- Cardiac output
- Total peripheral resistance

Baroreceptor reflex

Baroreceptors detect **arterial stretch**.

Example: standing suddenly:

↓ venous return → ↓ SV → ↓ CO → ↓ MAP → ↓ baroreceptor firing → ↑ sympathetic activity

Results:

- ↑ HR
- ↑ contractility
- Arteriolar vasoconstriction → ↑ TPR
- Venoconstriction → ↑ venous return

→ restores MAP.

Exercise

During exercise:

- ↑ HR

- ↑ SV
- ↑ CO
- Vasodilation in active skeletal muscle → ↓ TPR
- Blood flow redistributed toward active tissues.

Renal Physiology

Urine formation

Three major processes:

Process	Direction	Purpose
Glomerular filtration	Blood → Bowman's capsule	Produces filtrate
Tubular reabsorption	Tubule → blood	Recovers useful substances
Tubular secretion	Blood → tubule	Adds substances for excretion

Small molecules such as water, glucose and ions can normally filter freely; **large plasma proteins and blood cells generally do not**.

Glomerular filtration

Net filtration pressure can be represented as:

$$\boxed{P_{GC} - (\pi_{GC} + P_{BC})}$$

Where:

- P_{GC}= glomerular capillary hydrostatic pressure → **favours filtration**
- π_{GC}= plasma oncotic pressure → **opposes filtration**
- P_{BC}= Bowman's capsule hydrostatic pressure → **opposes filtration**

GFR = volume of filtrate produced by the kidneys per unit time.

Changes in these pressures can alter GFR.

Sodium and water

Na^+ is particularly important for:

- ECF volume
- Blood volume