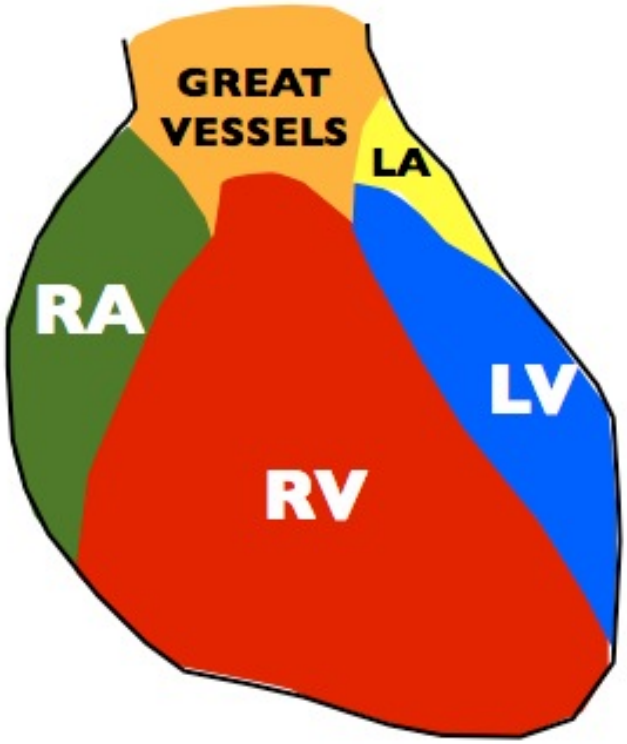
Anterior view of the heart



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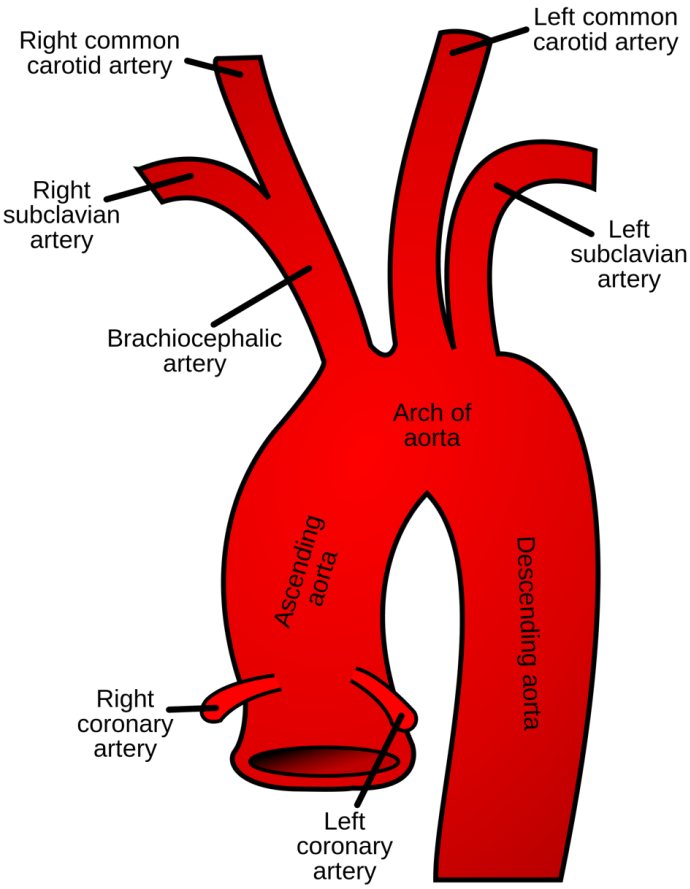
Position of the heart in the chest

- **Anterior** & **inferior** border: right atrium + right ventricle
- **Left** border: left ventricle
- **Posterior**: left atrium + left ventricle
- **Right** border: right atrium + right ventricle



Arch of the aorta and its initial branches

4

Superior mediastinum:

- SVC → brachiocephalic veins = internal jugular + subclavian
- **Arch of aorta**, branches:
  - 1st: coronary arteries
  - 2nd: right brachiocephalic
  - 3rd: left common carotid
  - 4th: left subclavian
- Ligamentum arteriosum:
  - Remnant of ductus arteriosus
  - Connecting pulmonary artery and aorta
  - Opposite the branch of left subclavian artery

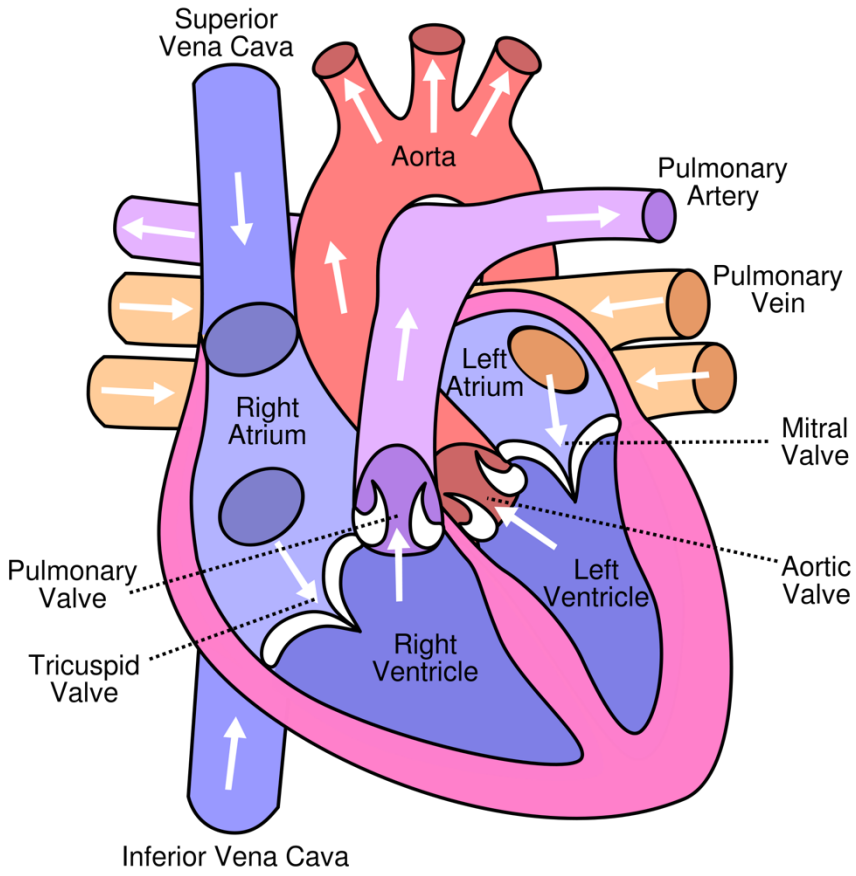
5

Nerves

- Vagus - **posterior to hilum** of lung
  - **Left**: under arch of aorta to give **recurrent laryngeal nerve** → passes posteriorly to give cardiac & oesophageal plexi and pass into abdomen
  - **Right**: under right subclavian to give r**ecurrent laryngeal nerve** → passes posterior to give oesophageal plexus
- Phrenic nerves
  - Left and right both run **anterior to hilum** of lung and over anterior surface of heart
    - **Right** passes through diaphragm with IVC
    - **Left** innervates from above diaphragm

Recurrent laryngeal nerve palsy (secondary to cardiac/thyroid surgery):

- Hoarse voice
- Vocal cord palsy
- Airway obstruction



6

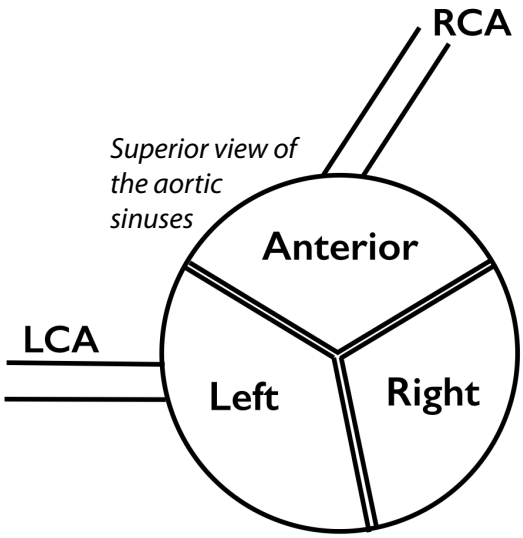
Cardiac anatomy

- **Fibrous skeleton** at atrio-ventricular junction level
- **Right atrium**, contains:
  - Sino-atrial node (SAN) in wall of RA
  - SVC
  - IVC
  - Coronary sinus opens into RA
  - Fossa ovalis (remnant of foramen ovale) in atrial septum
- **Right ventricle**:
  - Tricuspid valve between RA and RV
  - Infundibulum is area proximal to the pulmonary valve (semi-lunar valve with 3 cusps)
  - **Pulmonary trunk passes anterior** to aorta → then divides into right and left pulmonary arteries
- **Left** side:
  - Atrium receives blood from 4 pulmonary veins
  - Mitral valve held in place by **chordae tendinae** (fibrous strands that attach cusps) connected to **papillary muscles**
- Aortic arch loops around right pulmonary artery, moving posteriorly
- Atrial auricles are extensions that open in high cardiac-output states

Posteromedial papillary muscle rupture, secondary to inferior (right coronary) MI results in acute mitral valve incompetence, causing left ventricular failure

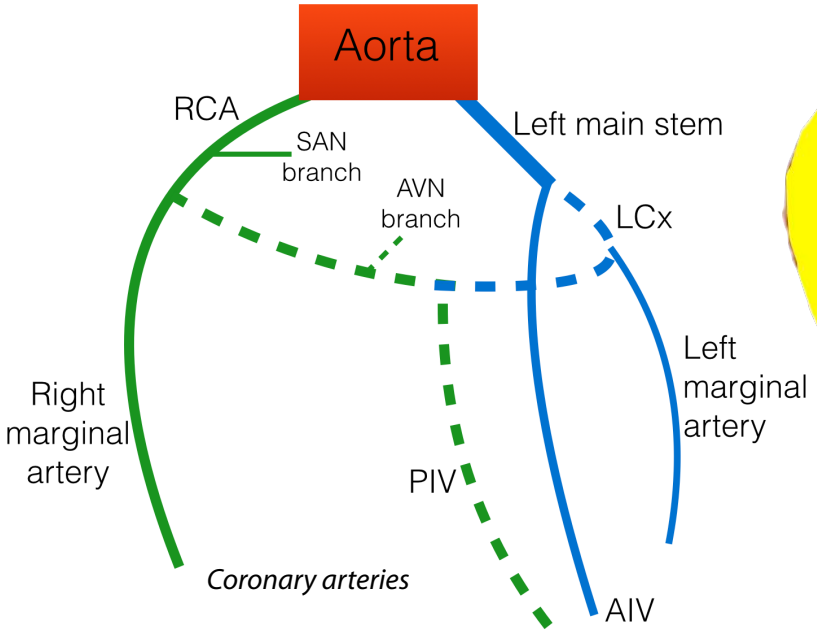
7 Coronary anatomy

- **Aortic sinuses (of Valsalva)**: bulges in wall of aorta distal to the valve origin of right and left coronary artery
- **Right coronary artery** (RCA) divides into:
  - Right marginal artery
    - Runs over the lateral aspect of right ventricle
  - **Posterior interventricular artery** (PIV)
- RCA curves around to the posterior atrio-ventricular groove
- RCA supplies:
  - Right atrium & ventricle
  - **Sinoatrial node (SAN)**
  - **Atrioventricular node (AVN)**
  - Posterior interventricular septum
- **Left coronary artery (left main stem)** initially as the left main stem then becomes:
  - **Left circumflex artery** (LCx)
    - Runs in posterior atrio-ventricular groove
    - Gives off the left marginal artery
      - Runs over lateral aspect of left ventricle
  - **Anterior interventricular** (AIV, previously known as left anterior descending [LAD])
- LCA supplies:
  - Left atrium
  - Left ventricle
  - Anterior part of interventricular septum

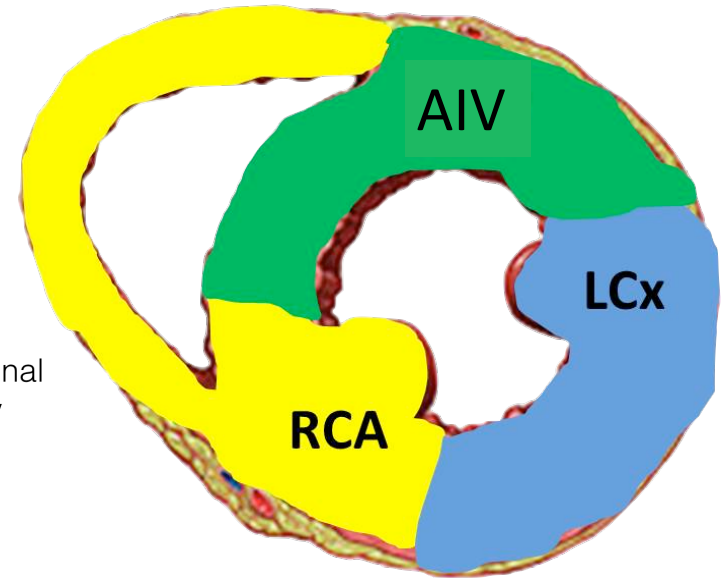


Myocardial infarction

- **Anterior MI** =anterior interventricular artery
  - V1-V4
- **Lateral MI** = left marginal artery
  - I, aVL, V5-V6
- **Antero-lateral MI** = left main stem
  - I, aVL, V1-V6
- **Inferior MI** = right coronary (marginal)
  - II, III, aVF
- **Posterior MI** = posterior interventricular artery
  - V1-3 (ST-depression & upright T-waves)



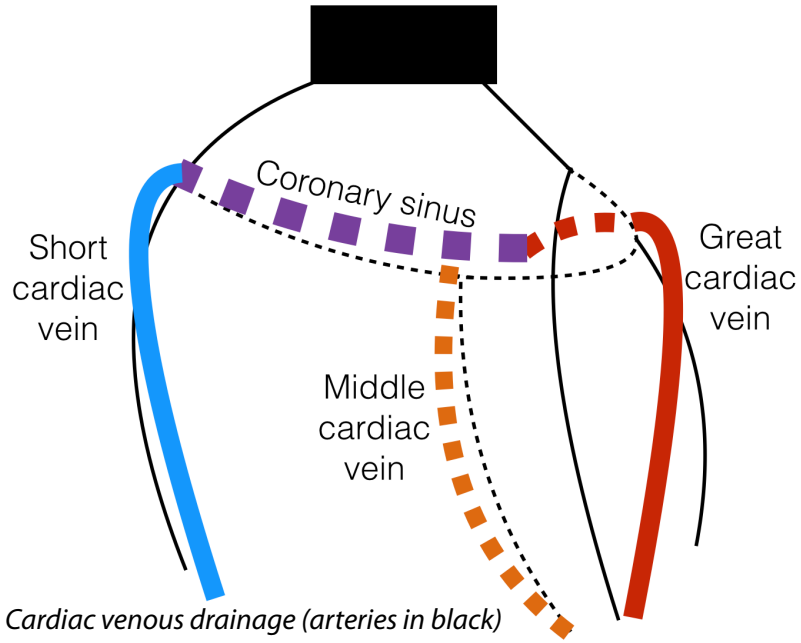
Coronary arteries



Blood supply to the myocardium

8 Cardiac venous drainage

- **Coronary sinus**: in posterior atrio-ventricular groove, empties into right atrium.
- **Great cardiac vein**: in anterior interventricular groove and curves posteriorly to join coronary sinus
- **Middle cardiac vein**: in posterior interventricular groove
- **Short (small) cardiac vein**: lateral aspect of right ventricle



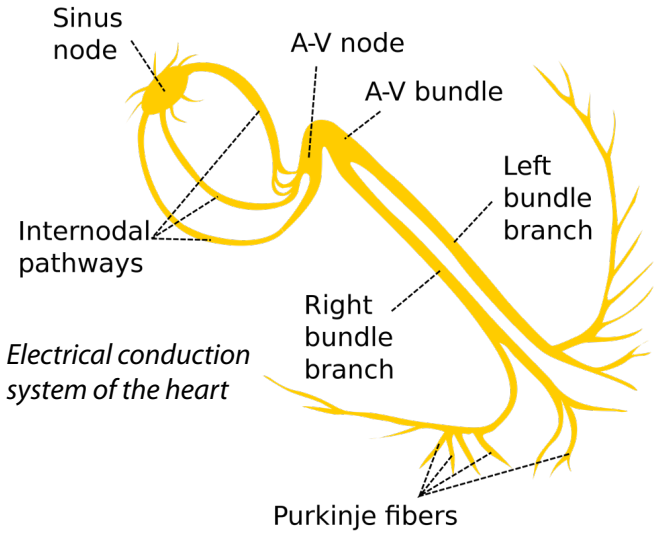
Cardiac venous drainage (arteries in black)

AVN dysfunction causes **heart block**, where atrial depolarisation is not conducted to the ventricles. Most due to ischaemic cardiomyopathy, but also with digoxin or beta-blocker overdose.

Ischaemic damage to part of the **bundle of His** causes **bundle branch block**. Ventricular contraction is less co-ordinated and this is seen as a prolonged QRS (>120ms) on ECG.

9 Electrical system of heart

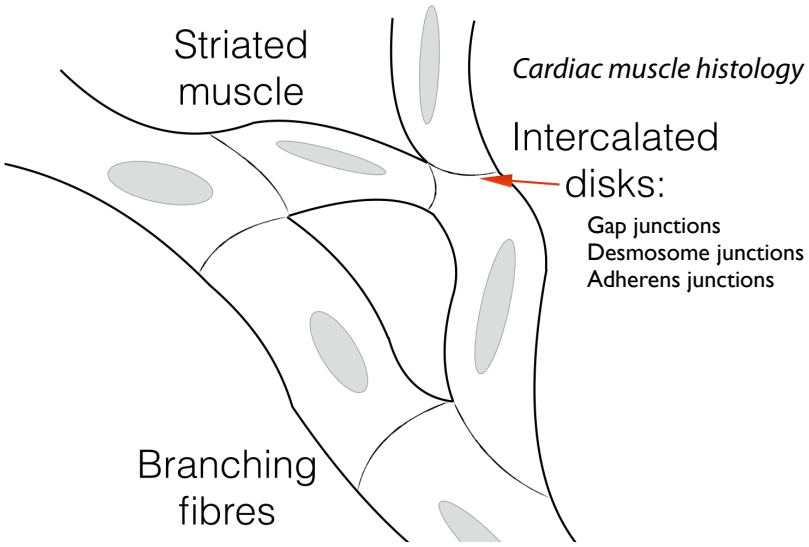
- Initiated in **sino-atrial node** (SAN), then spreads across atria
    - No organised conduction system
- Reaches **atrio-ventricular node** (AVN), which **delays** the action potential to allow efficient ventricular filling
- Passes into specialised conducting fibres (**Purkinje fibres** - wide and no glycogen) in the **bundle of His**
- Divides into 3: right, left anterior, and left posterior bundles
    - Action potential passes to apex rapidly
    - Contraction from apex to base and endomycium to epimycium



Electrical conduction system of the heart

10 Myocyte Ultrastructure

- Striated muscle
- Branching fibres
- Intercalated disks
- T-Tubules



- **Right ventricle** forms inferior border; left ventricle forms left border
- **Left main stem** divides to circumflex (lateral wall) and anterior interventricular (anterior septum)
- **Right coronary** supplies SAN and posterior septum
- **Coronary sinus** receives all cardiac venous drainage

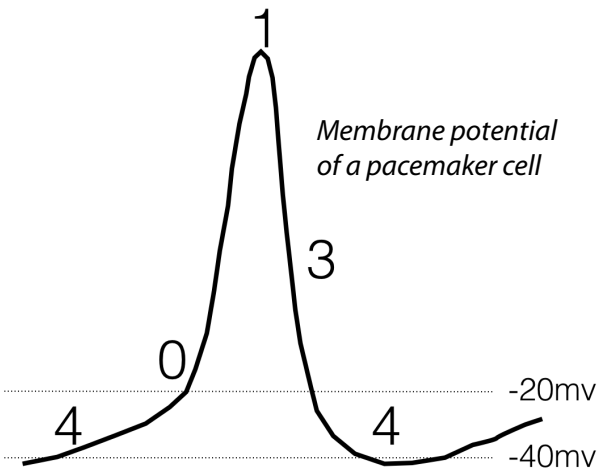
Cardiac myocytes

11 Myocyte physiology

- Negative resting membrane potential
- Intracellular ions:
  - High K^+
  - Low Na^+
  - Low Ca^{2+}
- Calcium stored in **sarcoplasmic reticulum** by active uptake via **SERCA pump**

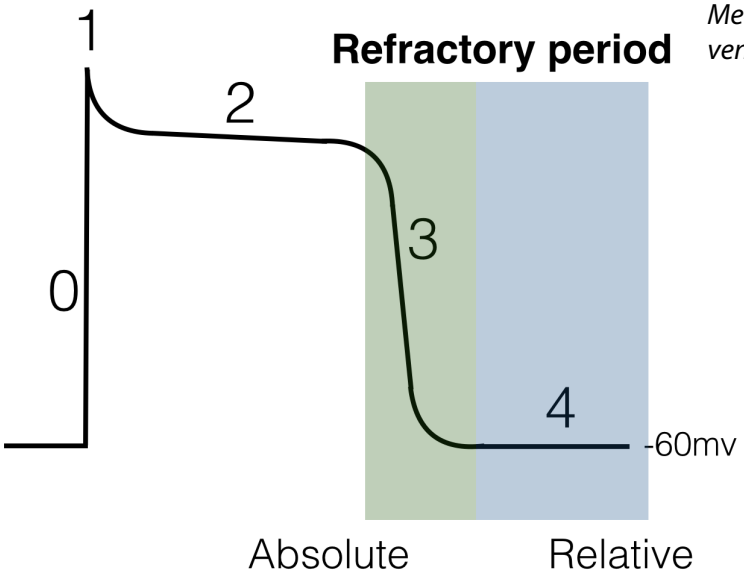
12 Pacemaker cells - electrically unstable

- **Pre-potential** ↑P_{Na+} (high sodium permeability - due to 'funny channels') causes a slow rise in membrane potential [4] (also known as 'funny current')
- Eventually passes **threshold** [0] → action potential fires due to opening of **voltage-gated calcium channels**
  - Causing ↑P_{Ca2+}, and Ca^{2+} influx
- At the peak of the action potential (AP) the **voltage-gated K^+ channels open** [1] → ↑P_{K+}
  - [No (plateau) phase 2]
  - This causes K^+ efflux → re-polarisation [3]



13 Ventricular cells

- **Electrically stable** [4]- under steady conditions there is no change membrane potential
- When threshold is passed, **fast voltage-gated Na^+ channels** open [0]:
  - ↑P_{Na+}, with Na^+ influx
- **Fast Na^+ close**, causing a small fall in membrane potential [1]
- **Slow Na^+ & Ca^{2+} voltage-gated channels** open, causing the plateau [2]:
  - ↑PCa_{2+} with sodium and calcium influx
- **Voltage-gated K^+** open during the plateau phase:
  - ↑P_{K+} → Re-polarisation and refractory periods [3] then returns to resting E_m [4]



Membrane potential of a ventricular myocyte

Hyperkalaemia increases the 'refractoriness' of the myocardium. Hyperpolarisation [3] increases (causing **tall, tented T-waves**), reduces atrial depolarisation (**flat P-waves**), slows ventricular depolarisation (**broad QRS complex**), ending in asystole.

14 Refractory periods

Absolute

- Fast Na^+ channels in 'inactive' state
- No AP regardless of stimulus intensity
- Insufficient channels

Relative

- Some fast Na^+ channels available
- AP possible with large stimulus

15

	Sympathetics	**Parasympathetics**
Heart rate	Increase	Decrease
AVN delay	Decrease	Increase
Ventricular contractility	Increase	No effect
Receptor involved	β-1-adrenoreceptor	Muscarinic acetylcholine
Mechanism	Increase cAMP Increase Na+ & Ca2+ permeability	Reduce cAMP Increase K+ permeability