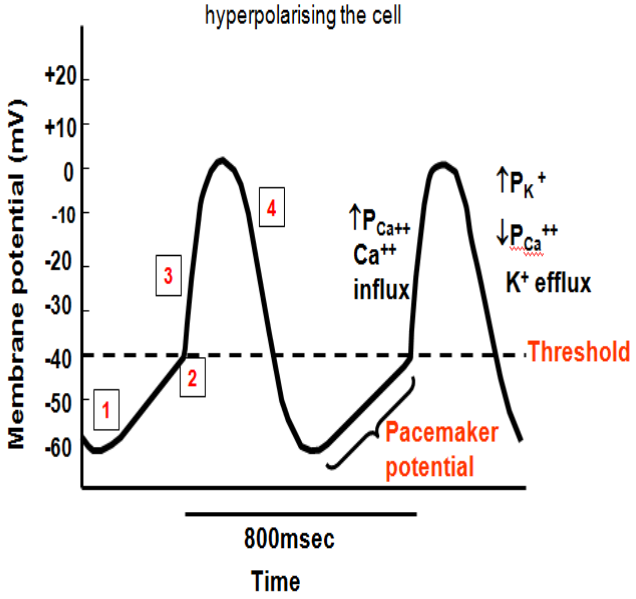
CARDIOLOGY

ELECTRICAL CONDUCTION SYSTEM OF THE HEART

Cardiac Automaticity

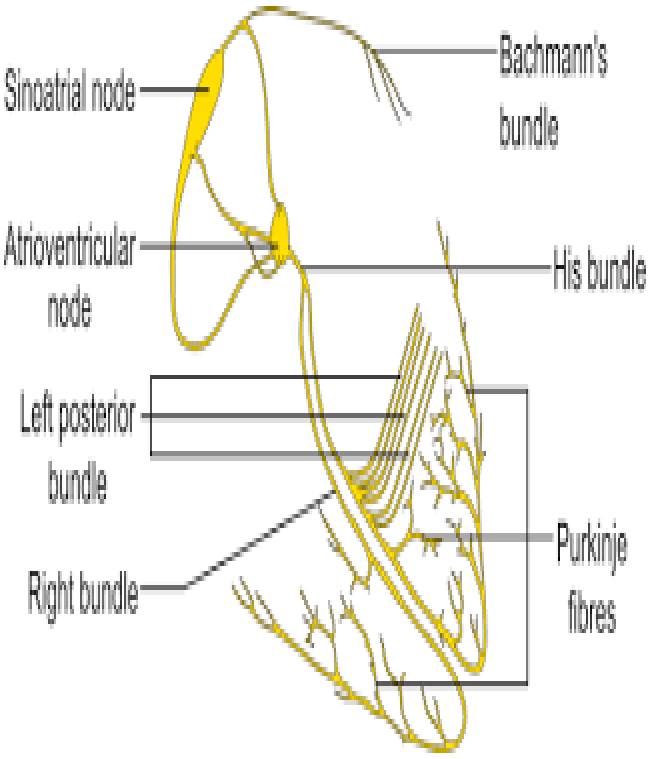
- One of the unique features of the heart is its ability to generate its own action potentials (known as cardiac automaticity)
- This occurs via 'funny sodium channels' which only occur in pacemaker cells and open at maximum negative membrane potential, meaning the membrane never plateaus
- This usually occurs at the Sinoatrial Node (SAN) as it has the fastest rate of depolarization (60-100 bpm) but can occur at other sites e.g. AV junction or Purkinje fibres
- SAN rate can be influence by nerve supply:
  - Adrenergic (sympathetic) increases rate
  - Vagal (parasympathetic) slows rate
- Hence
  - β Blockers slow rate
  - Atropine (antagonises acetylcholine, blocking vagal nerve) speeds rate up
- Antiarrhythmics act on some one of the electrolyte channels

1. 'Funny' sodium channels (I_f channels) are open ($\uparrow P_{Na}^{+}$); and closing K^+ channels.
2. Transient Ca^{2+} (T-type) channels open, pushing the membrane potential to threshold.
3. Long-lasting Ca^{2+} (L-type) channels open, giving rise to the action potential.
4. Opening of K^+ channels, ($\uparrow P_{K}^{+}$), and closing of Ca^{2+} (L-type) channels, hyperpolarising the cell



Conduction System Anatomy

- Action potential generated in SAN spreads in an organised manner via gap junctions of conduction tracts across atria causing contraction (P wave)
- Reaches Atrioventricular Node (AVN) where it is delayed to allow ventricular filling (PR interval)
- Passes to Bundle of His then spreads along right and left bundles (left splints into anterior and posterior fascicles)
- Finally reaches Purkinje fibres and causes ventricular contraction (QRS complex)
- Ventricular repolarisation occurs (ST segment, T wave, QTc)

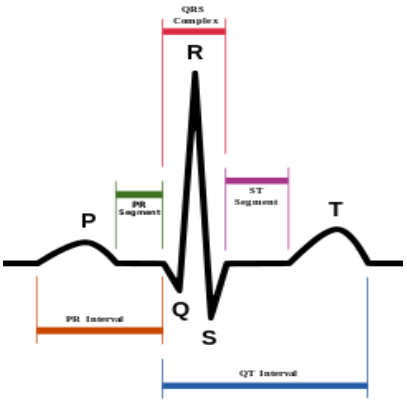


Arrhythmias (and any other ECG abnormality) represent a congenital or acquired defect of this conduction system e.g.

- AF is caused by single (usually at pulmonary trunk) or multiple ectopic stimulation overwhelming SAN
- Bundle branch block causes widened QRS due to delayed ventricular conduction

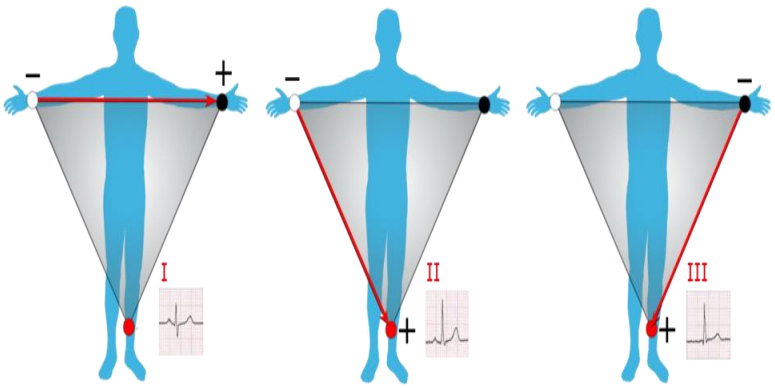
ECG

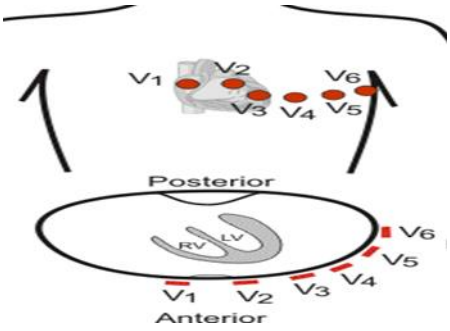
The basics

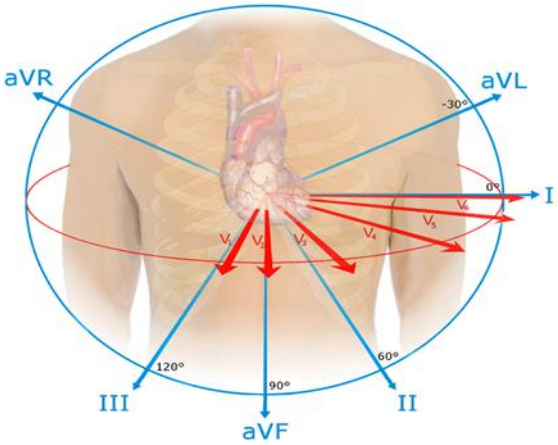


- Leads measure voltage and direction of polarization of myocardium
- Depolarization *towards* the positive electrode causes *upward* deflection
- Depolarization *away from* the positive electrode causes *downward* deflection
- Repolarization *towards* the positive electrode causes *downward* deflection
- Repolarization *away from* the positive electrode causes *upward* deflection

- **Precordial leads** measure in the transverse plane (V1-V6)
- **Limb** (I, II & III) and **augmented limb** (aVF, aVL, aVR) leads measure in the coronal plane







- **The leads correspond to specific areas of the heart as shown below**

I Lateral	aVR	V1 Septal	V4 Anterior
II Inferior	aVL Lateral	V2 Septal	V5 Lateral
III Inferior	aVF Inferior	V3 Anterior	V6 Lateral