Cardiovascular System: Heart

Conducting cells:
Cardiac cells specialized to quickly spread action potentials across myocardium
  • Weak force generators

Intrinsic Conduction System:

Sinoatrial node: (SA node)
  • Located in right atrial wall
  • Initiates action potentials (APs)
    • Pacemaker (~ 80 beats / min)

Atrioventricular node: (AV Node)
  • Connects atria to ventricles
  • Slowed conduction velocity
  • Ventricular filling

Normal sinus rhythm:
1) AP originates at SA node
2) SA node fires at 60 – 100 beats / min
3) Correct myocardial activation sequence

Cardiac Electrophysiology

System allows for orderly, sequential depolarization and contraction of heart
Cardiac Electrophysiology

The autonomic nervous system can directly affect the heart rate; these effects are called **chronotropic effects**

**Positive** chronotropic effects:
- (increase heart rate)
  - Under sympathetic control
    - NE \(\rightarrow\) Sinoatrial node
      - \(\beta_1\) receptors
      - Leads to \(\uparrow\) \(g_{Na}\) cells reach threshold more rapidly
      - Pharmacology: \(\beta\)-blockers (e.g., propanolol)

**Negative** chronotropic effects:
- (decrease heart rate)
  - Under parasympathetic control
    - ACh \(\rightarrow\) Sinoatrial node
      - Muscarinic receptors
      - Leads to \(\downarrow\) \(g_{Na}\) cells reach threshold less rapidly
      - Leads to \(\uparrow\) \(g_{K}\) cells hyperpolarized during repolarization stage (further from threshold)

Cardiovascular System – Heart

The autonomic nervous system can also directly affect conduction velocity at the AV node; these effects are called **dromotropic effects**

**Positive** dromotropic effects:
- (increase conduction velocity)
  - Under sympathetic control
    - NE \(\rightarrow\) AV node
      - \(\beta_1\) receptors
      - Leads to \(\uparrow\) \(g_{Na}\) cells depolarize more rapidly following threshold

**Negative** dromotropic effects:
- (decrease conduction velocity)
  - Under parasympathetic control
    - ACh \(\rightarrow\) AV node
      - Muscarinic receptors
      - Leads to \(\downarrow\) \(g_{Na}\) & \(\uparrow\) \(g_{K}\) cells depolarize more slowly following threshold
      - Heart block: Signals fail to be conducted at AV node
Cardiovascular System – Heart

The autonomic nervous system can directly affect heart contractility; these effects are called **inotropic effects**

**Positive inotropic effects:**
- Under sympathetic control

1. Faster tension development
2. ↑ peak tension
3. Faster recovery

Mechanisms of action:
1. Phosphorylation of Ca\(^{2+}\) channels in sarcolemma
   - ↑ Ca\(^{2+}\) enters during plateau / released from SR
2. Phosphorylation of phospholamban (regulates Ca\(^{2+}\) ATPase activity)
   - ↑ uptake / storage of Ca\(^{2+}\) in SR
   - Faster relaxation time
   - Increased peak tension during subsequent ‘beats’

**Negative inotropic effects:**
- Under parasympathetic control

Cardiac Muscle Contraction

Inotropism: Intrinsic ability of myocardial cells to develop force at a given length

Marieb & Hoehn (Human Anatomy and Physiology, 8th ed.) – Figure 18.12