Lecture 5: ECG (Part 1)

(Quiz)

0. Review

1. ECG Intro

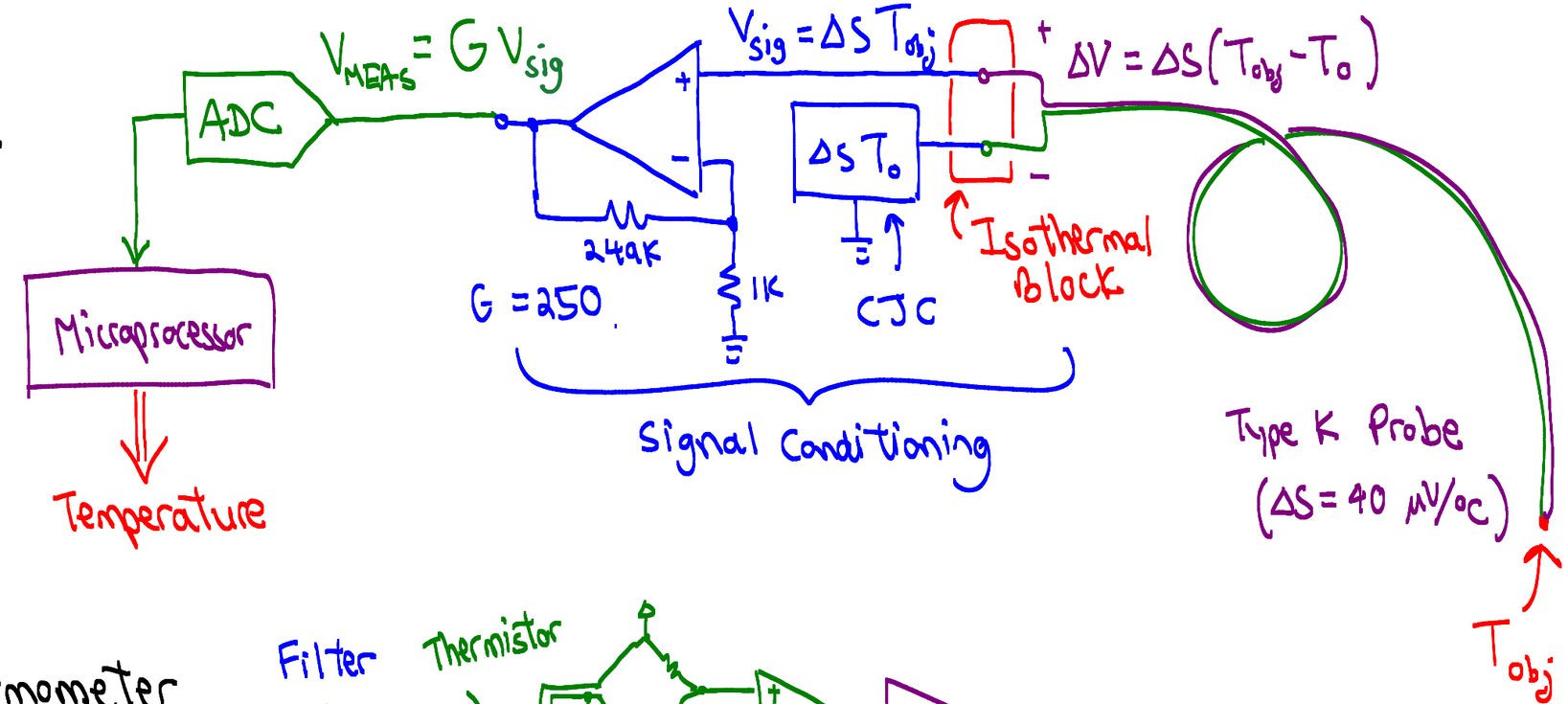
2. Basic Heart Physiology

3. ECG Leads

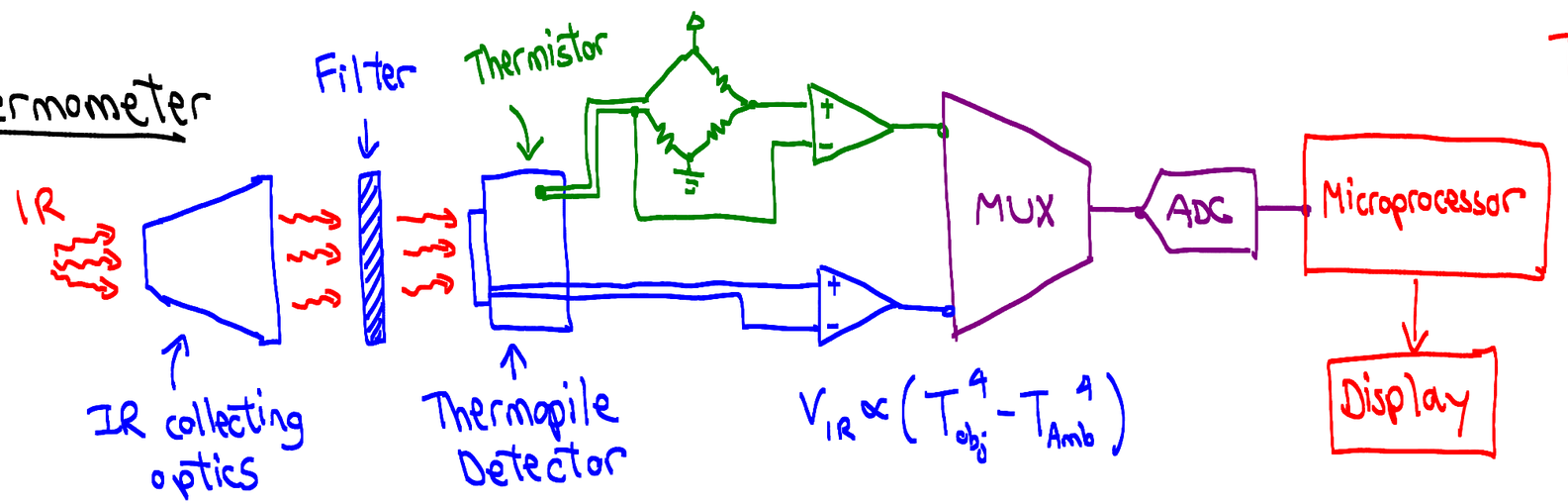
- PreLab 2 due at lab session
- HW 2 due this Thu (Jan 23)
- Lab 1 report due Fri (Jan 24)
  - ↳ see course website for template

0. Review

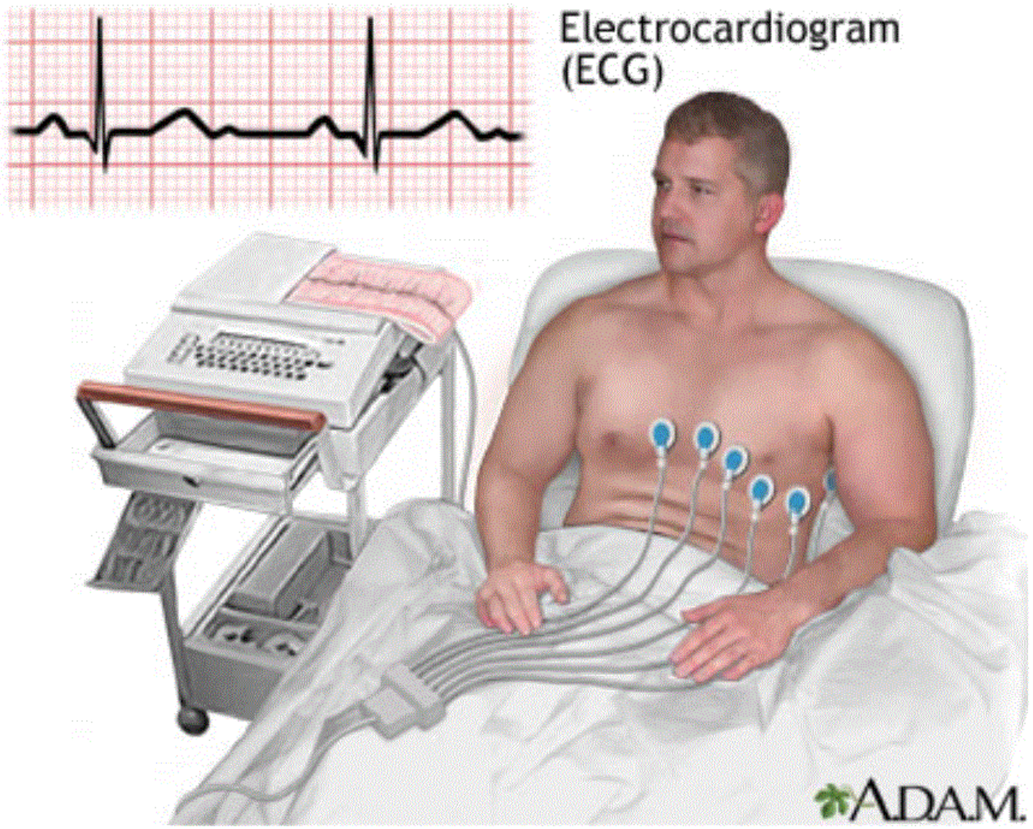
① Thermocouple



② Infrared Thermometer



1. ECG Intro



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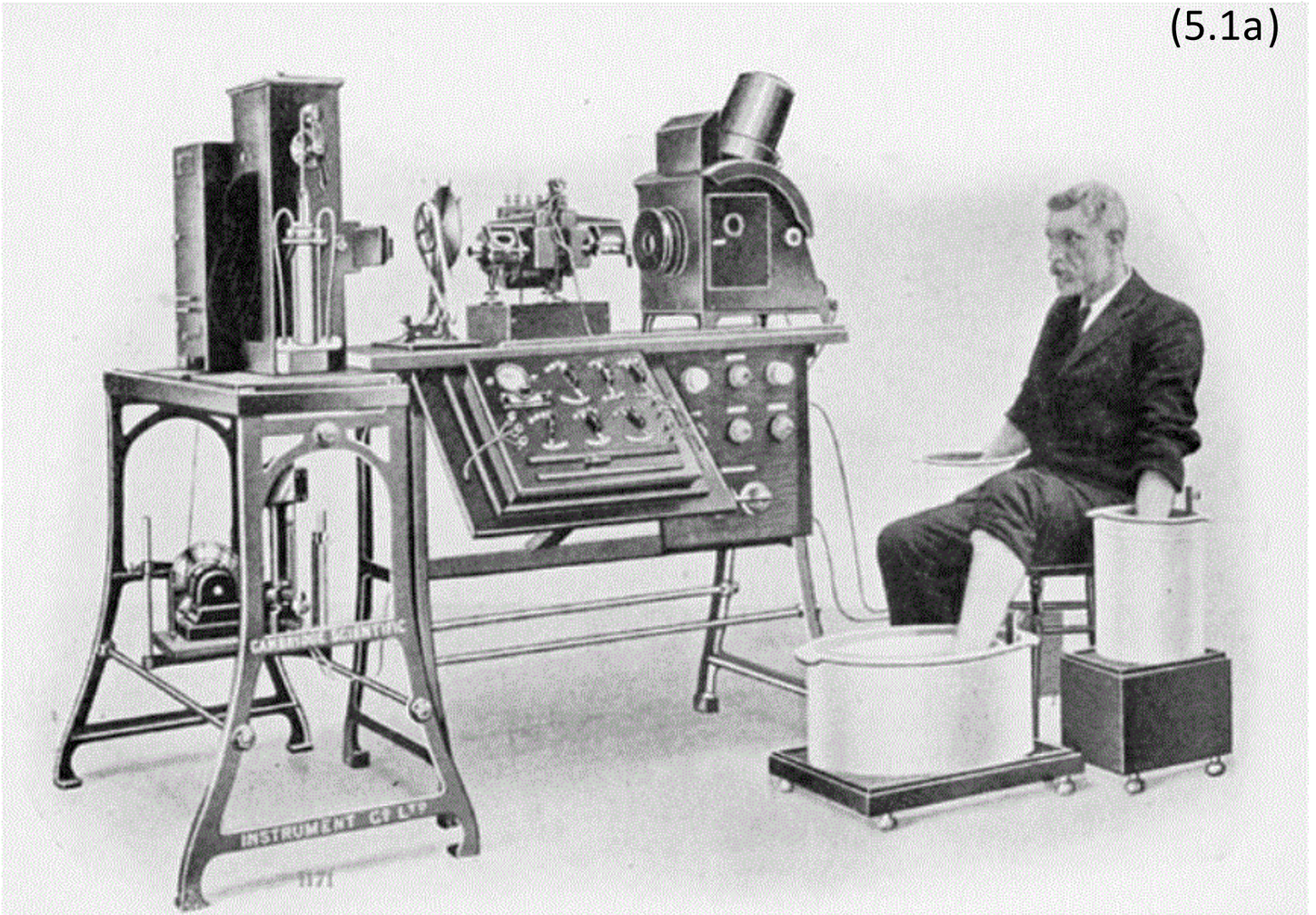
(5.1a)



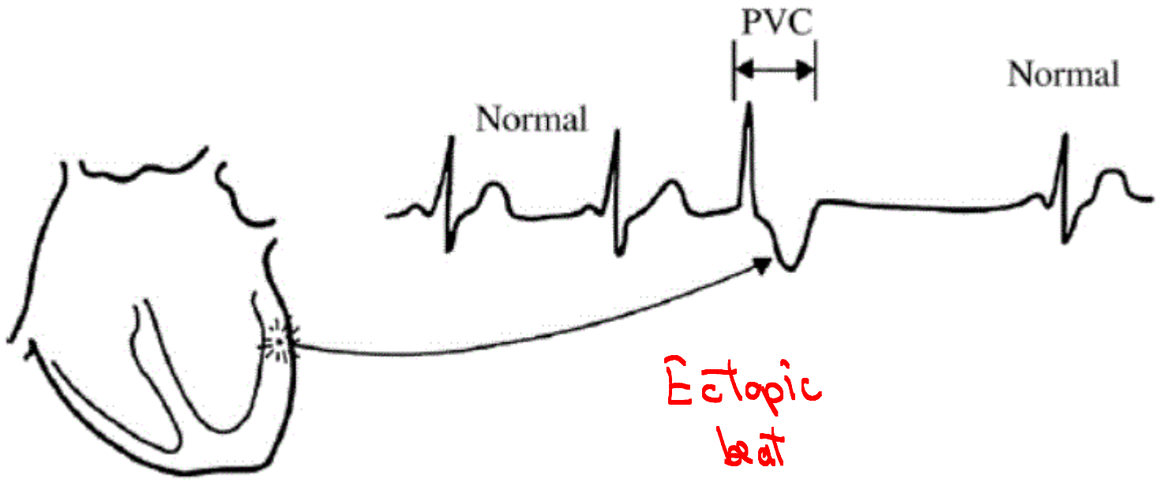
PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSED IN JARS OF SALT SOLUTION

dax2.wordpress.com

- Why is ECG useful?

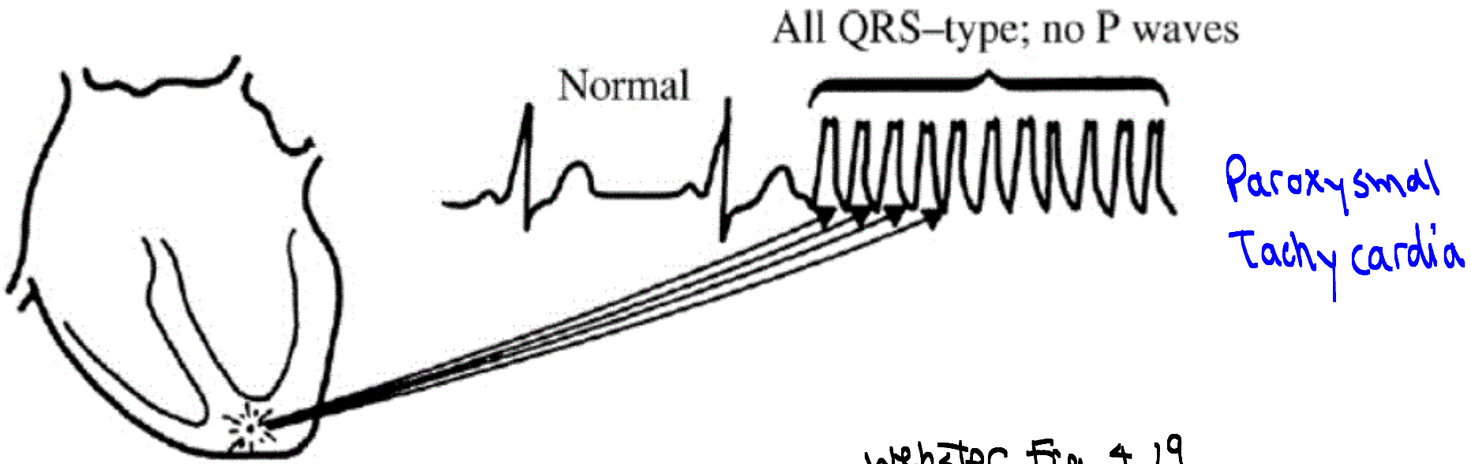
Waveform details can reveal many types of heart conditions!

Ex:



Ectopic beat

Ectopic beat



(a)

Paroxysmal tachycardia

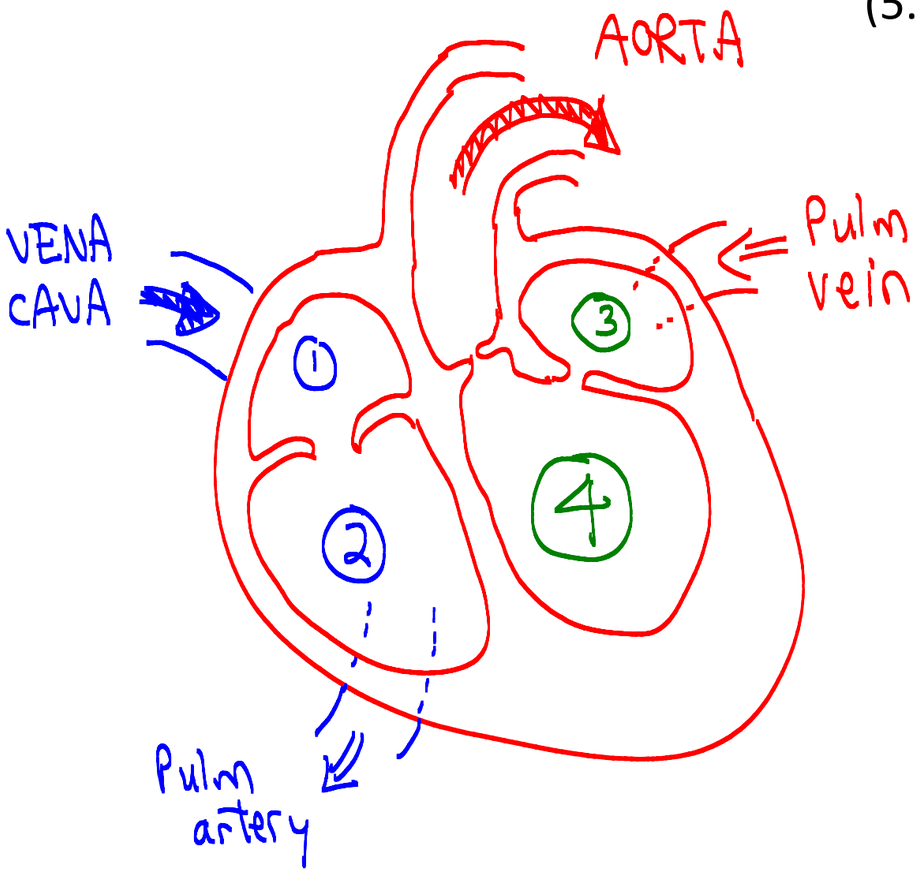
Webster Fig. 4.19

2. Basics of Heart Physiology

- **Cardiac Cycle**

Heart has 4 chambers!

(From body) Vena Cava → ① Right atrium → ② Right ventricle → Pulmonary Artery → LUNGS → Pulmonary Vein → ③ Left atrium → ④ Left ventricle → (To Body) AORTA



☆ The 4 chambers do NOT contract one after another!

Contraction #1: R+L Atria

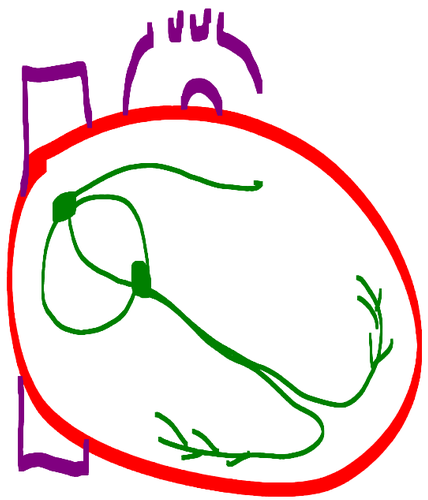
Contraction #2: R+L Ventricles

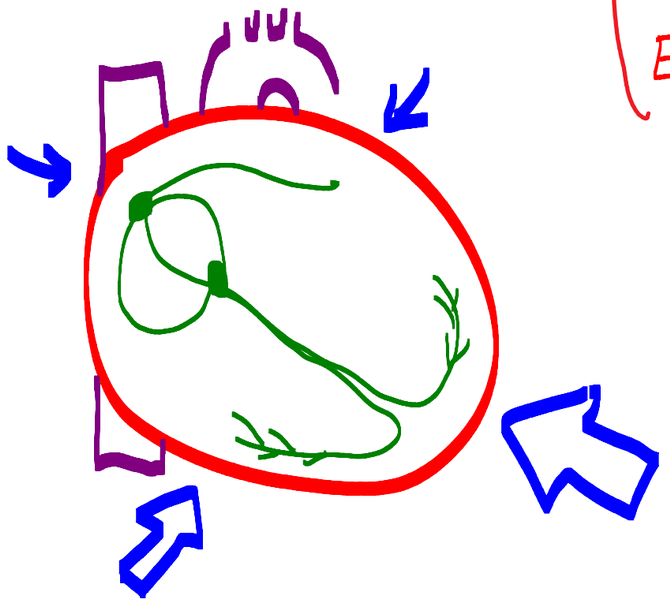
✡ The heart is essentially an electro mechanical device!

① Electrical excitation from nerve signals

② Force production from muscle contraction

(Primary source of ECG signal!)





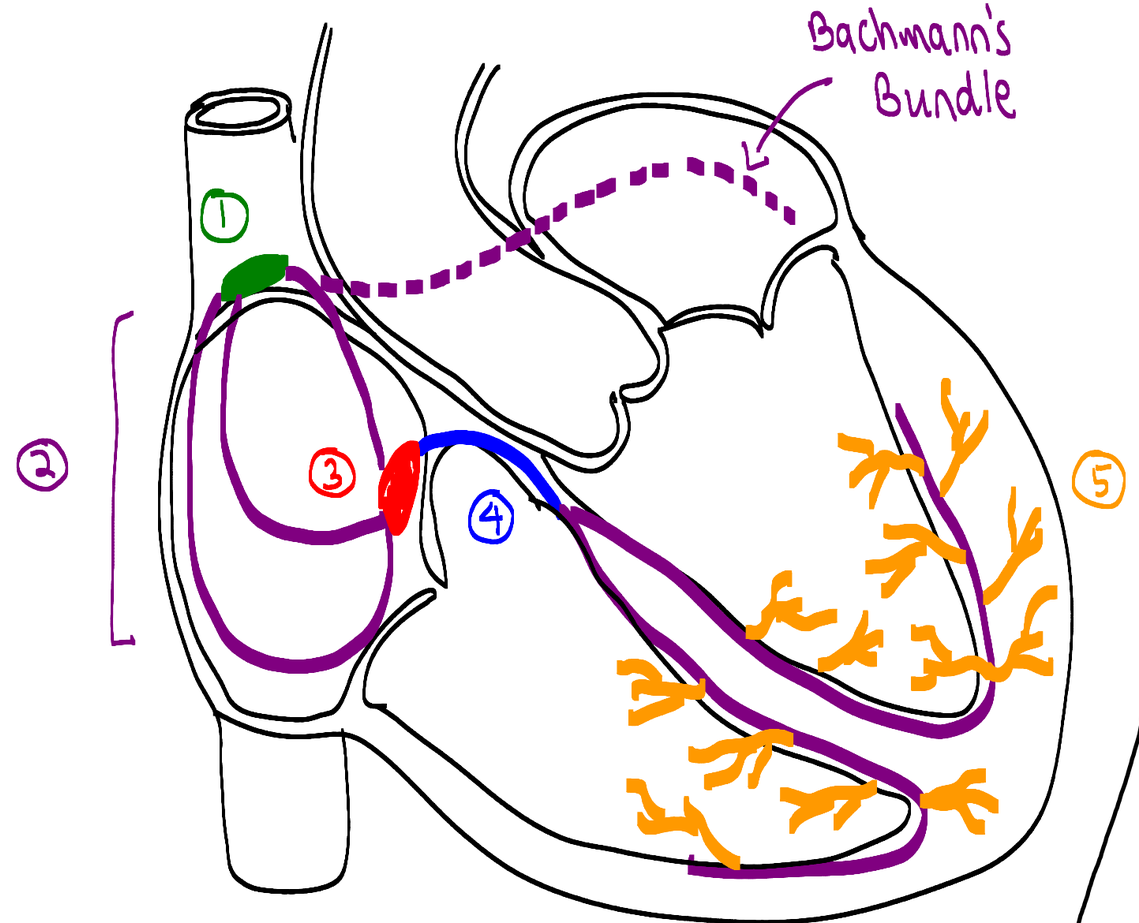
• Electrical Network of the Heart

① Sinoatrial Node (SA node)
starts the entire process
→ body's natural pacemaker!

② Internodal Tracts + Bachmann's Bundle carry signal across the atria

③ Atrioventricular node (AV node)
delays the signal

④ Bundle of His and left + right bundles
Carry signal across the ventricles



⑤ Purkinje fibers stimulate ventricle muscle fibers

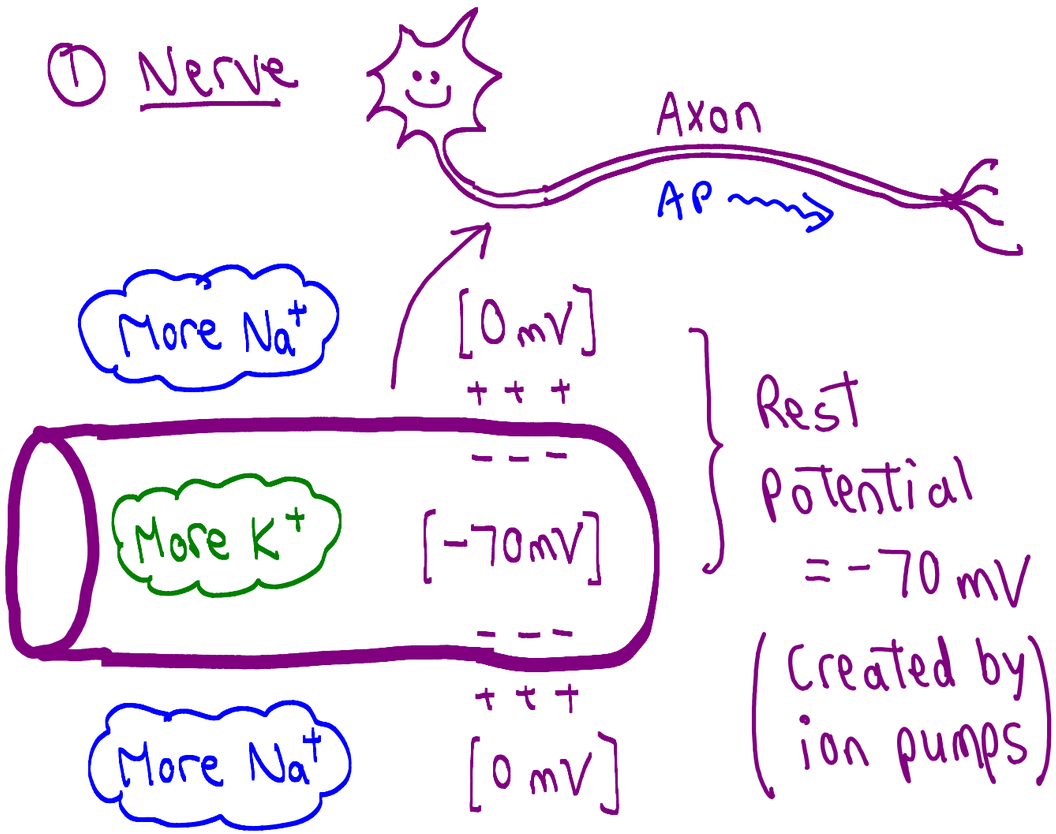
Q: Origin of bioelectrical signals?

A: Flow of ions (Na, K) in and out of excitable cells

Nerve, muscle

- Action Potential (AP):

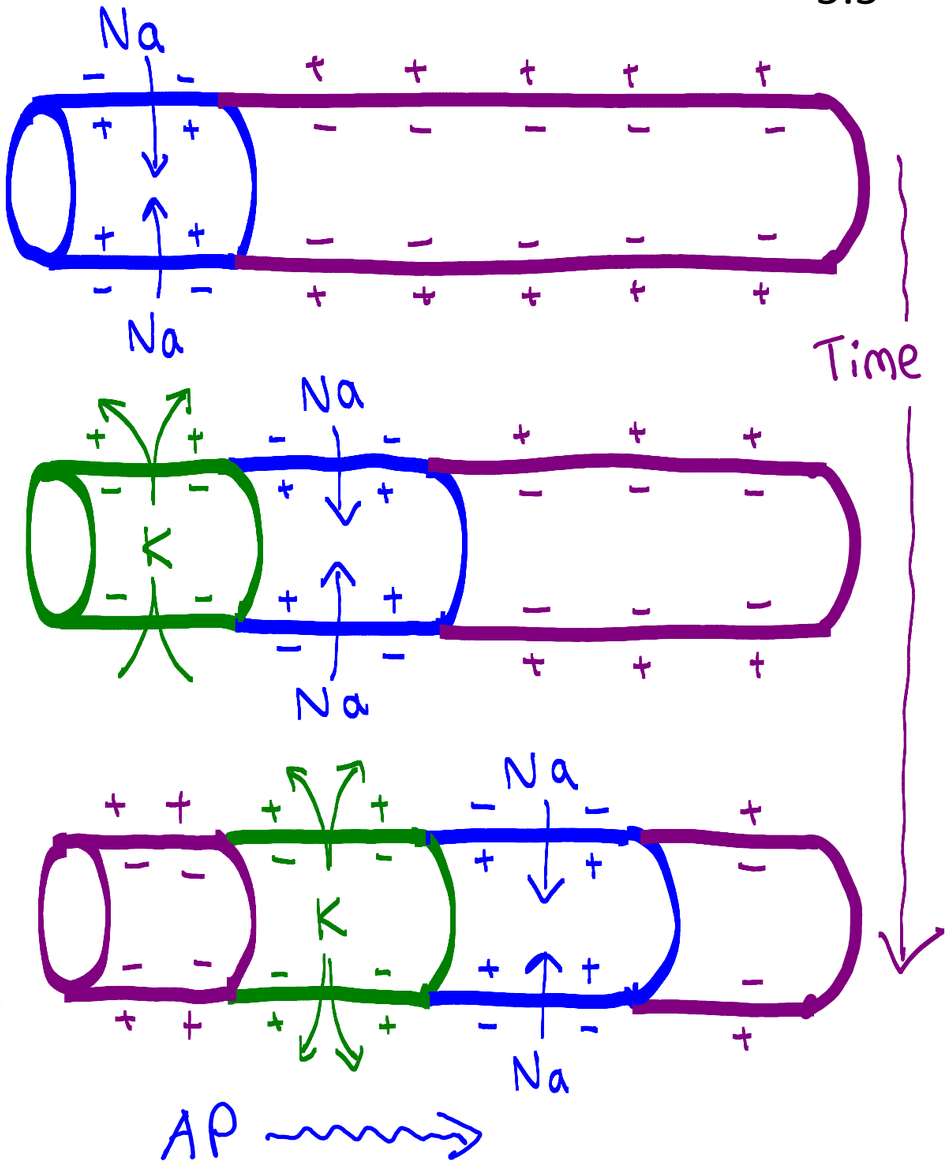
① Nerve



① "chain reaction" is due to travelling depolarization

② followed by a travelling repolarization

③ followed by eventual recovery of rest potential

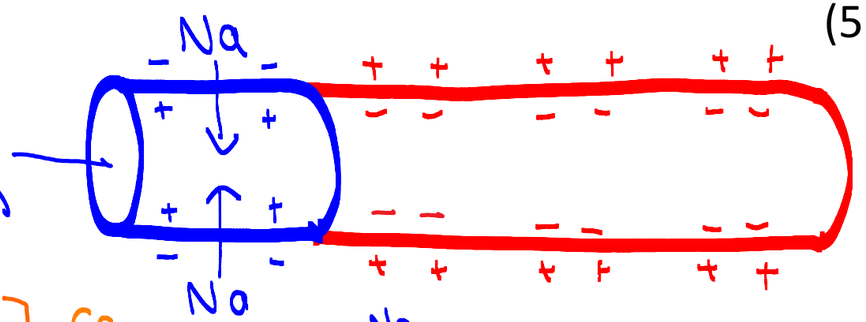


② Muscle

- → Skeletal
- → Smooth
- → Cardiac * ECG

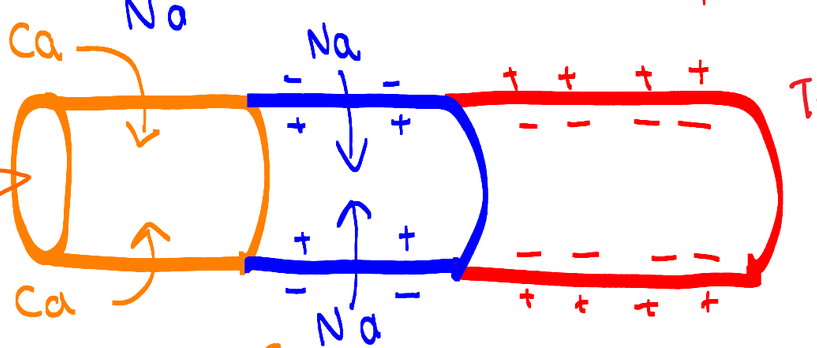
⓪ Electrical stimulation from nerve

① Rapid depolarization

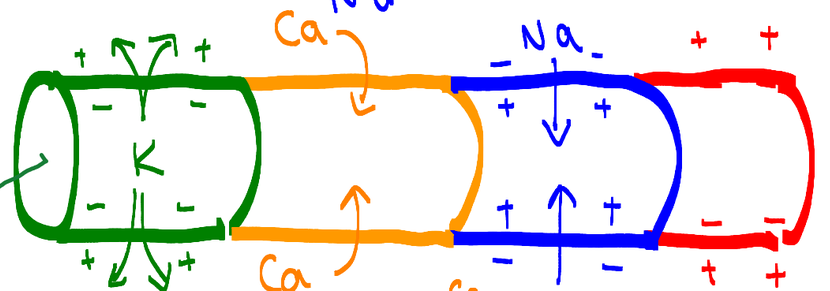


② Influx of extracellular Ca^{++}

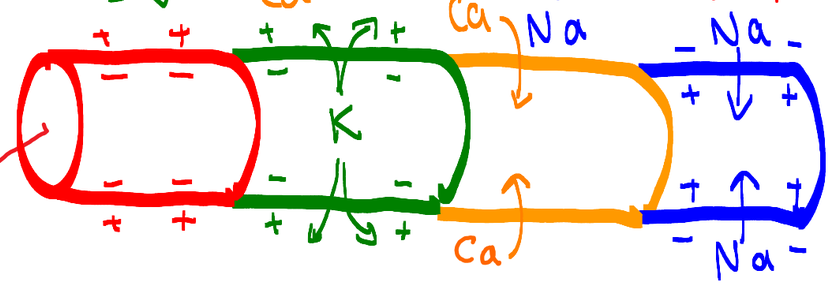
- Triggers release of intracellular Ca^{++}
  - → Actin-Myosin (contraction)



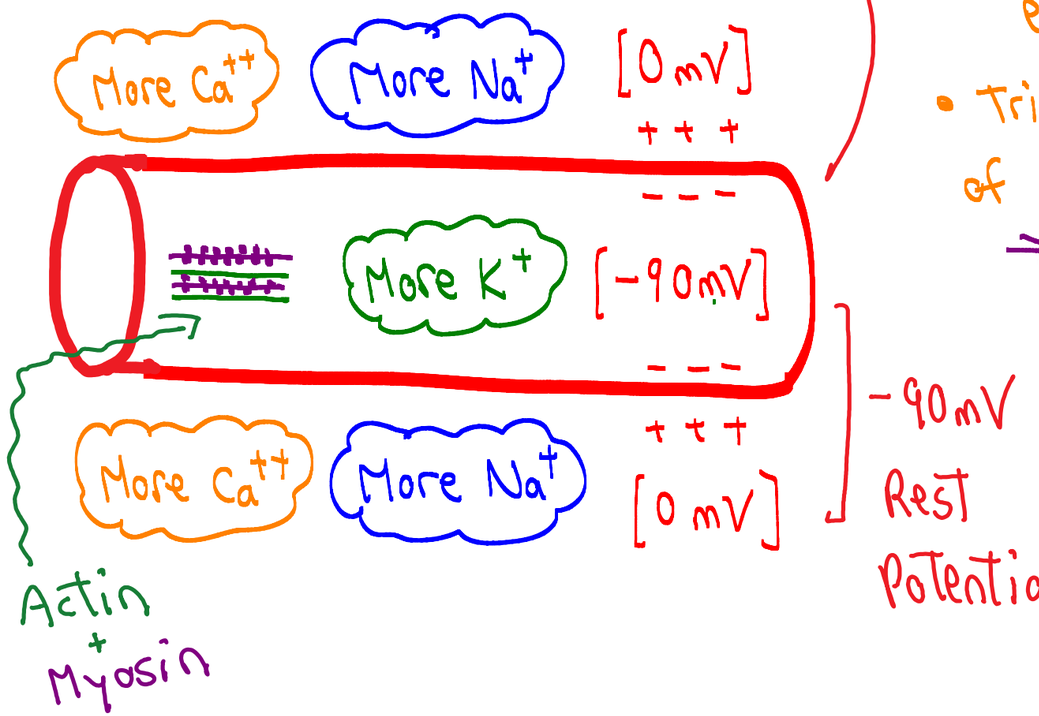
③ Repolarization



④ Recovery



Time

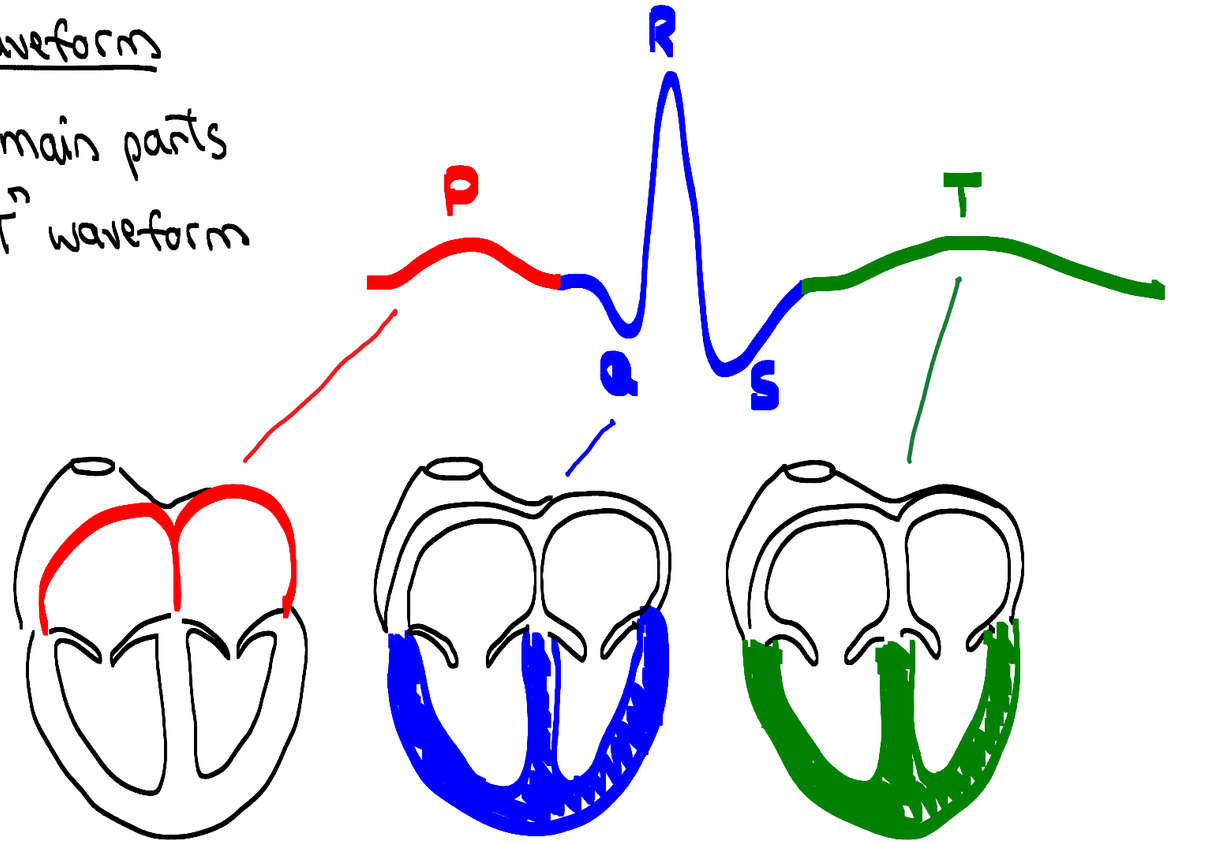


-90mV Rest Potential

- **ECG Waveform**

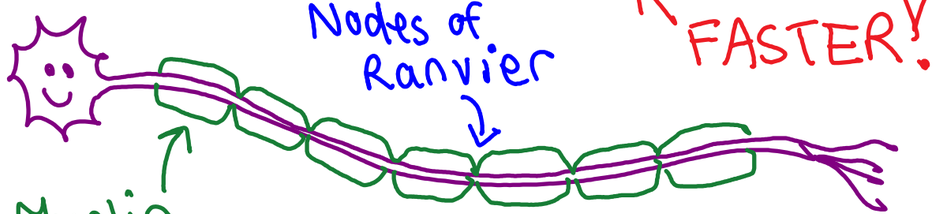
→ Has 5 main parts

→ "PQRST" waveform

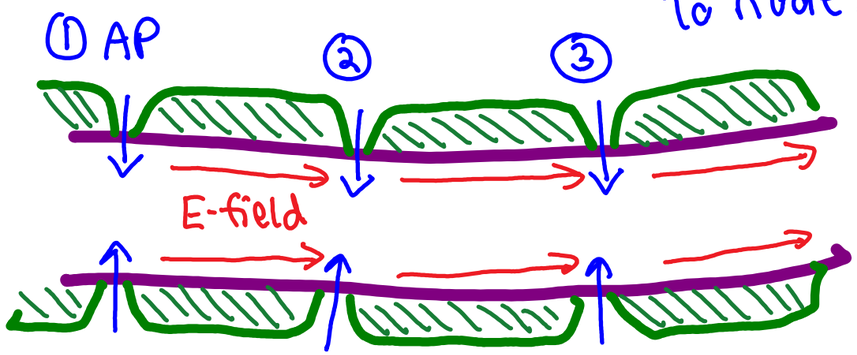


NOTE: Central Nervous System / Peripheral Nervous System

In CNS and PNS, nerve signals travel by saltatory conduction. ↑ FASTER!



- Reduces capacitance
- AP "jumps" from node to node!



- **Body Surface Potential**

ECG does not directly measure the heart
→ measure voltages at skin surface!

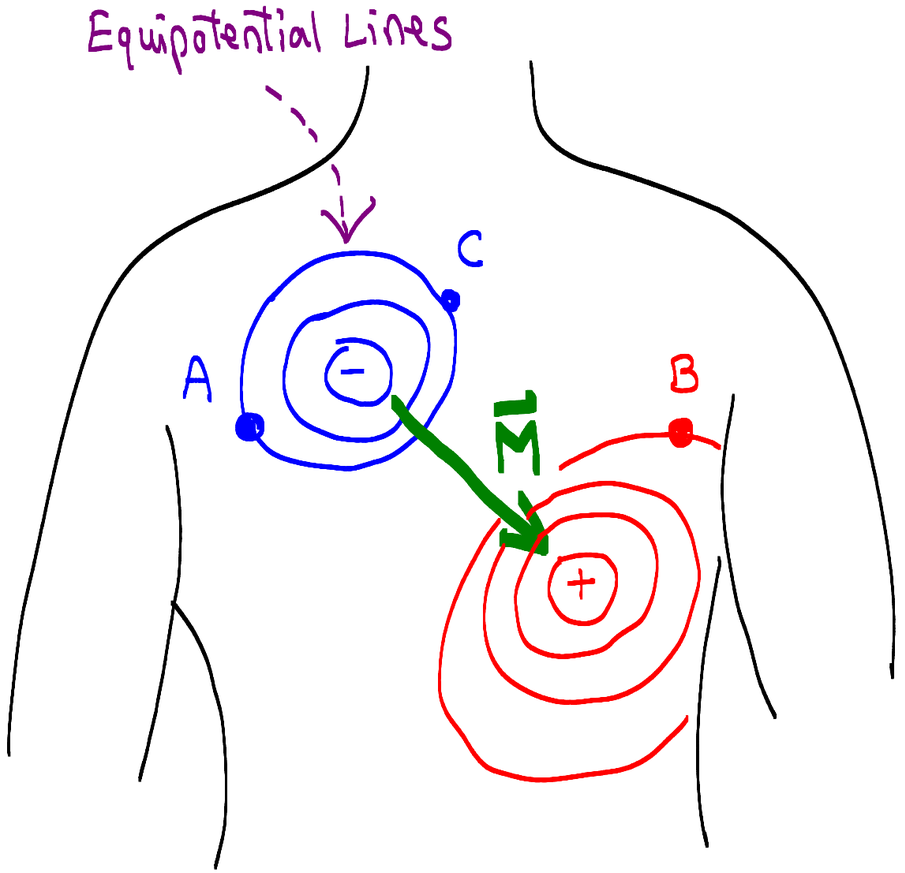
Heart can be modeled as an electric dipole

Dipole Moment

$\vec{M}$ ≡ Cardiac Vector

↳ changes magnitude and direction during cardiac cycle!

✱ we measure the potential difference between two points on the skin surface!



Example: Positions A and B ☺
A and C ☹

3. ECG Leads

- Einthoven's triangle defines

  3 leads in frontal-plane ECG

  ⇒ "ECG Lead" ≠ ECG wire !

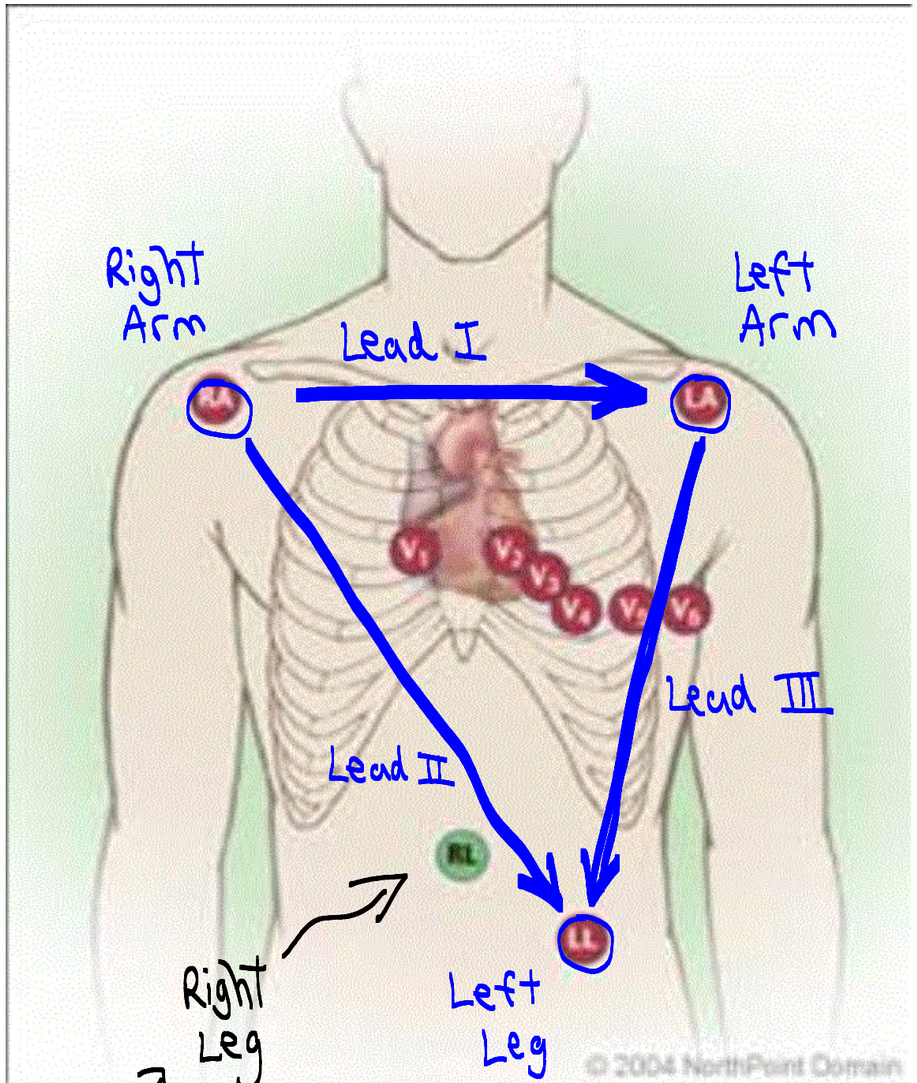
  ≠ ECG electrode !

  ⇒ ECG Lead = Pair of electrodes !

  real ↙ ↘ equivalent

- The "Right Leg" electrode is NOT part of any lead!

  It reduces common-mode voltage that degrades ECG signals



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