BME 301
Bioinstrumentation

1-Why do we study this subject?

Why Do We Study Bioinstrumentation?

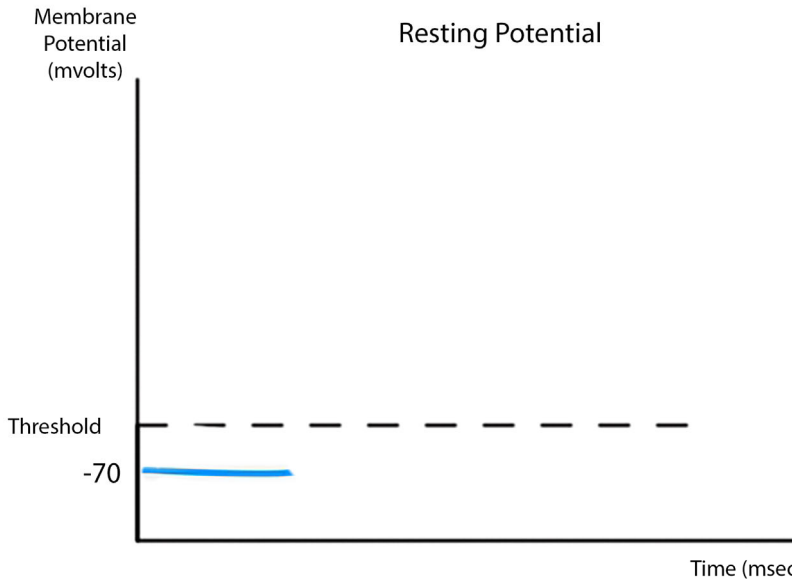
- The human body is basically a electro-chemical system
- Examples of electrical biosignals
  - Action Potentials
    - Created by cells
    - Muscle cells
      - Heart activity – ECG: ElectroCardioGram
      - Muscle activity – EMG: ElectroMyoGram
    - Nerve cells
      - EEG: ElectroEncephaloGram
  - Electrocardiograms

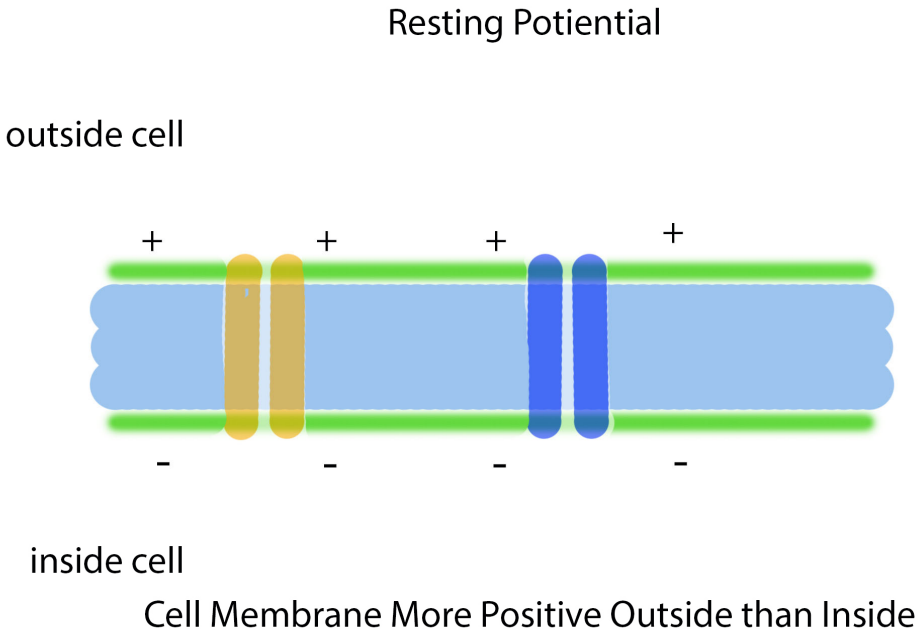
Action Potential

- Action Potential is a change in the voltage and its polarity across a cell membrane
- This is due to some sort of stimulation within the body
- Basic states
  - Resting
  - Depolarization
  - Repolarization

Resting State

- No stimulation has occurred
- Voltage across the membrane is ~-70mvolts

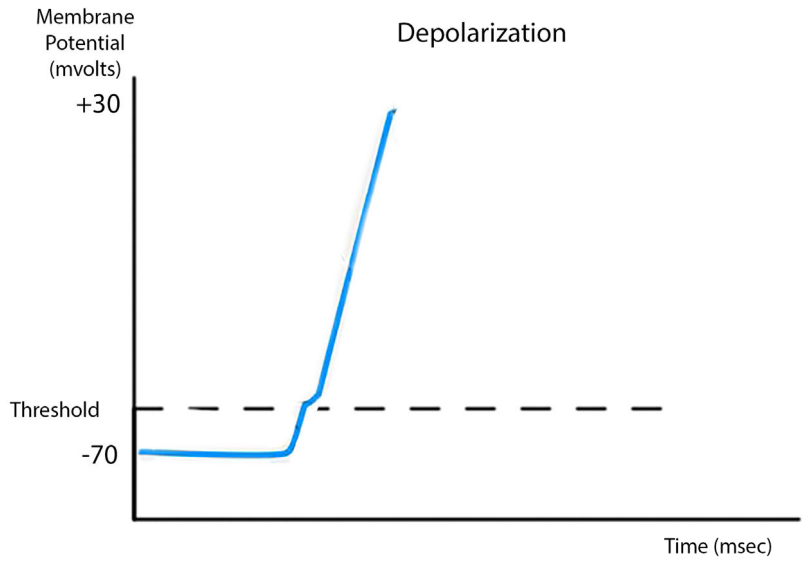


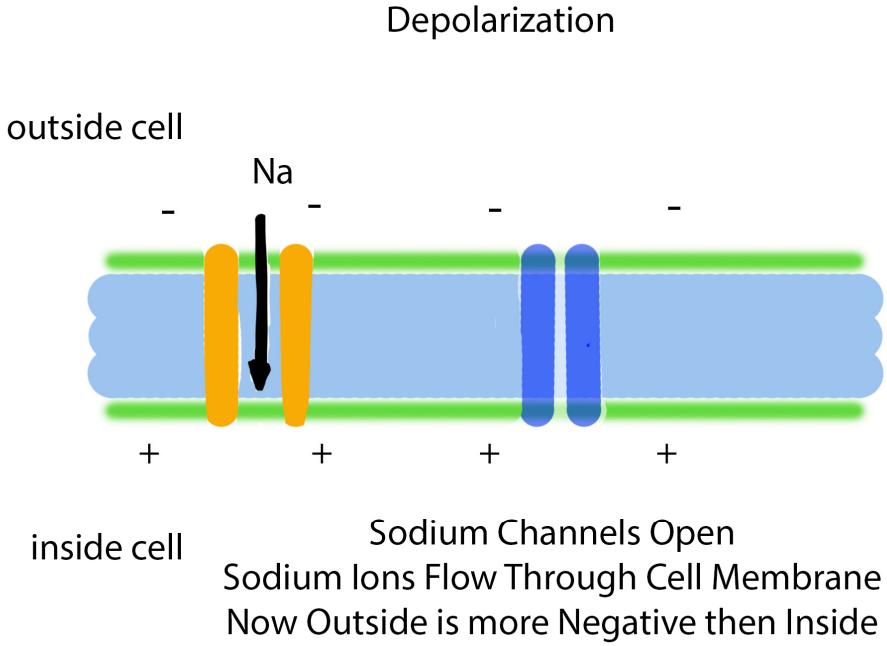


Cell Membrane More Positive Outside than Inside

Depolarization State

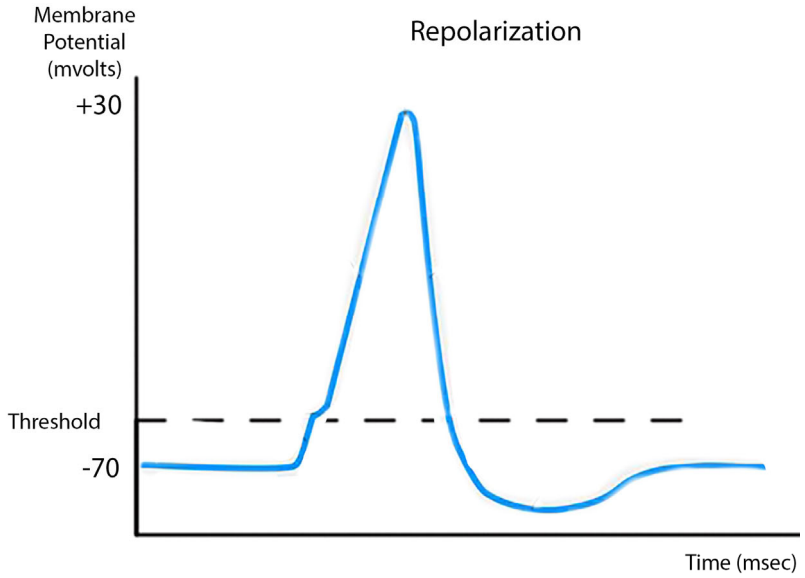
- Stimulation has occurred provided a threshold is passed
- Voltage across the membrane is ~+30mvolts

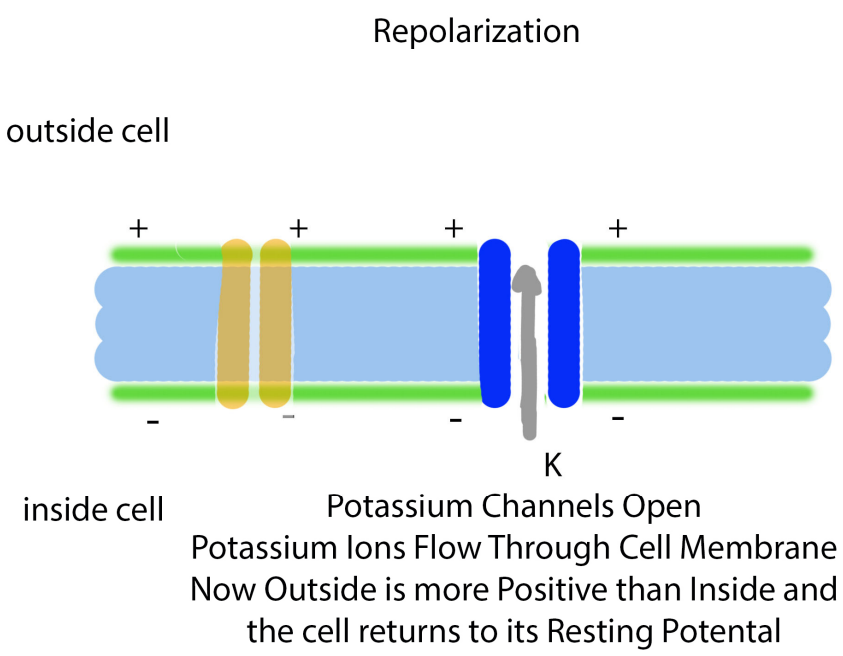




Repolarization State

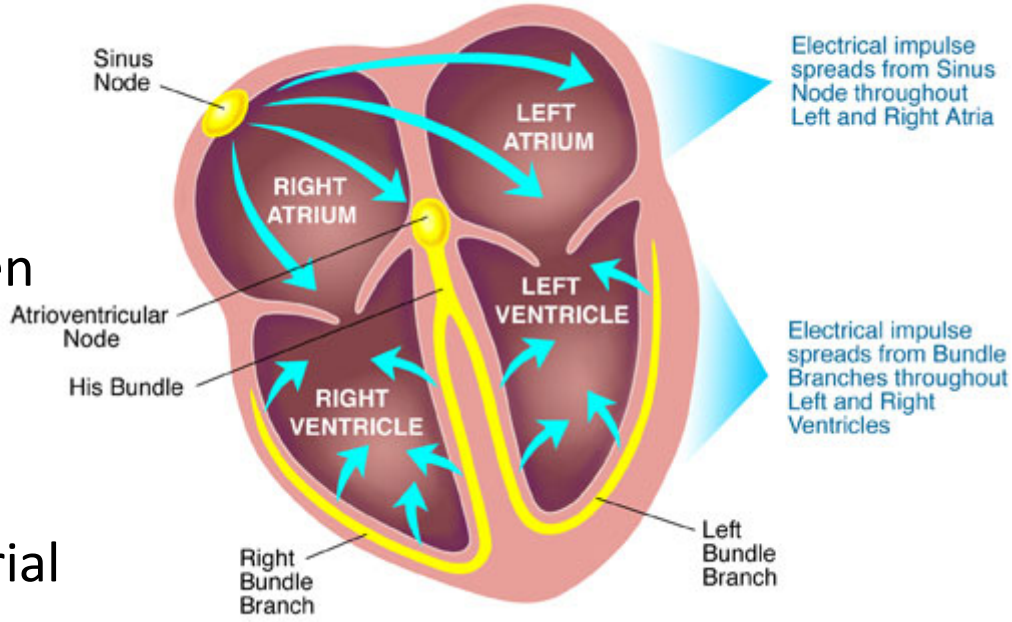
- Stimulation has passed and a short refractory period occurs to prevent further depolarization for that cell
- Voltage across the membrane goes back to -70mvolts





ECGs

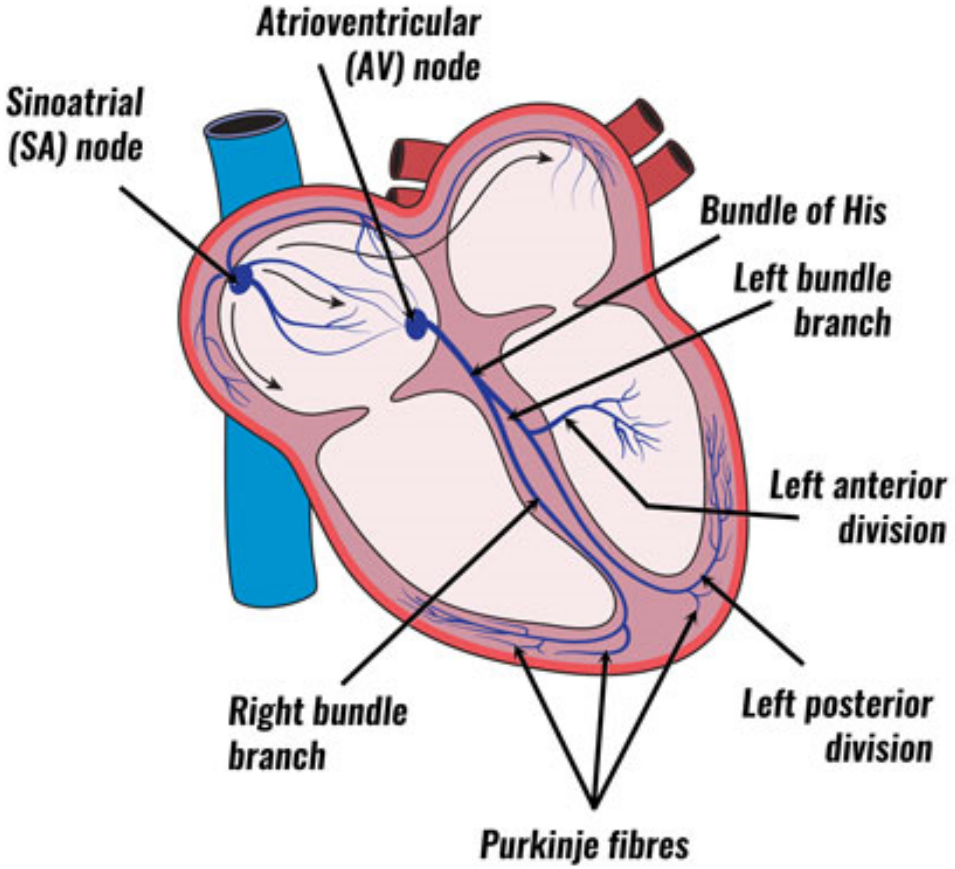
- The heart is a four chambers pump
- There are two atria and two ventricles
- The two atria contract (depolarize) together and then the two ventricles contract (depolarize).
- The way the heart chambers contract is governed by two simulating nodes: the SinoAtrial (SA) node and the Atrioventricular (AV) node and a network of nerves: Bundle of HIS and Purkinje Bundle of fibers.



https://www.teachpe.com/anatomy-physiology/the-heart-conduction-system

ECGs

- The SA starts the process off by causing the atria to depolarize and sending a “signal” to the AV node
- The AV node causes the ventricles to depolarize in a coordinated way via the Bundle of HIS and Purkinje fibers



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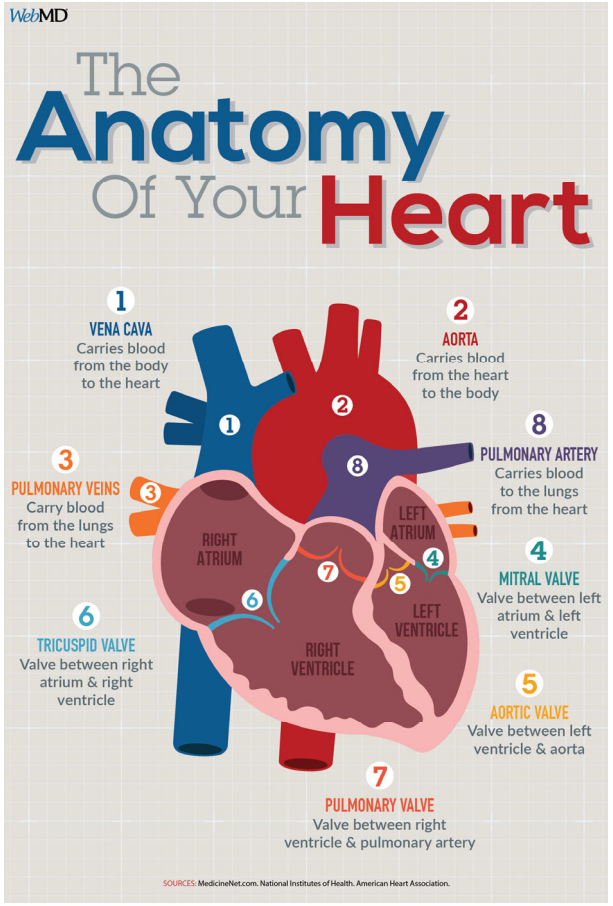
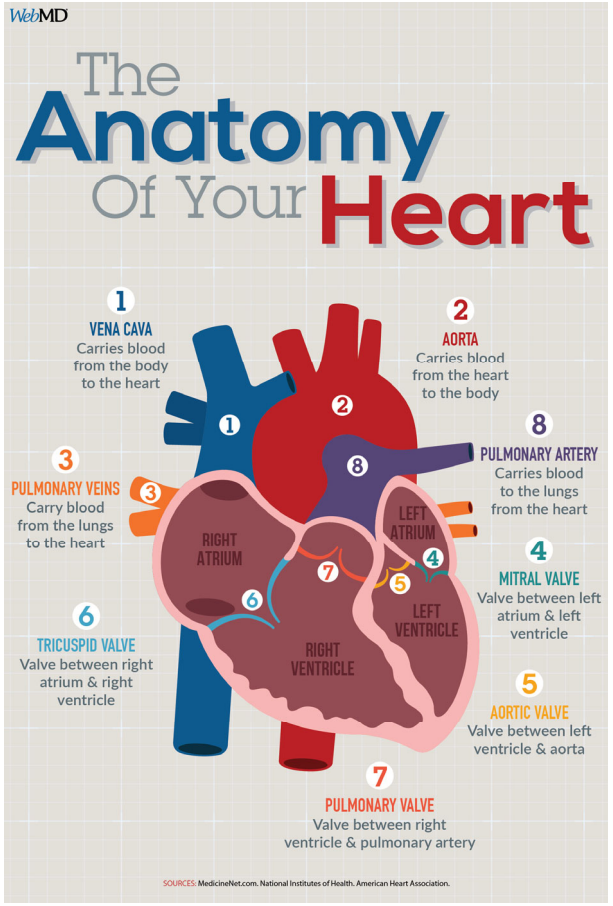
ECGs

- Oxygenated blood flows from the lungs to the left atrium from the pulmonary veins (3).
- When the atria contract (de-polarize due to the SA node), the oxygenated blood in the left atria is sent to the left ventricle via the mitral valve (4).
- When the ventricles contract (de-polarize due to the AV node), the left ventricle then sends the oxygenated blood through the aortic valve (5) to the body via the aorta (2). During this de-polarization of the ventricles, the re-polarization of the atrium occurs.
- Sometime later the ventricles re-polarize.



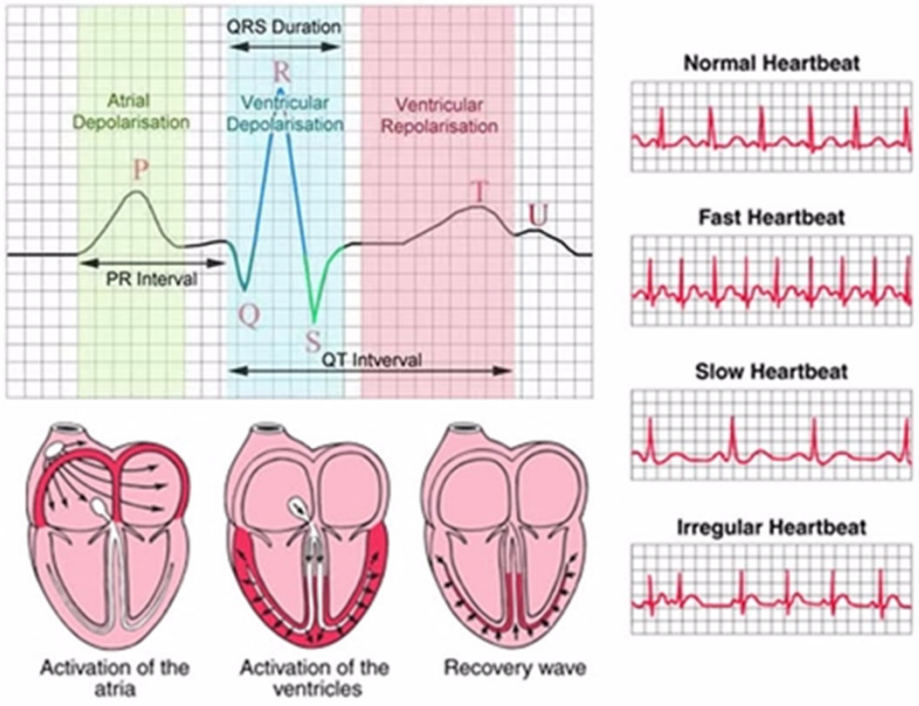
ECGs

- The body removes the nutrients and oxygen from the blood and send this de-oxygenated blood to the right atria via the vena cava (1).
- When the atria contract (de-polarize due to the SA node), the de-oxygenated blood in the right atria is sent to the right ventricle via the tricuspid valve (6).
- When the ventricles contract (de-polarize due to the AV node), the right ventricle then sends the de-oxygenated blood through the pulmonary valve (7) to the lungs via the pulmonary artery (8). During this de-polarization of the ventricles, the re-polarization of the atrium occurs.
- Sometime later the ventricles re-polarize.



ECG

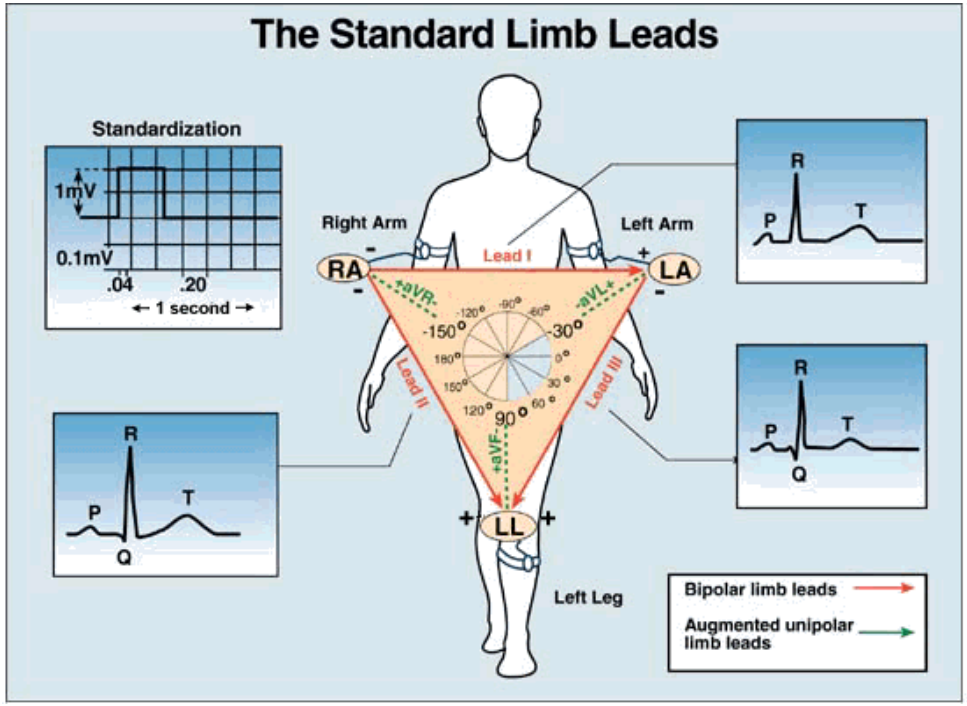
- The ECG is just the electrical signal due to the de-polarizations and re-polarizations of the ventricles.
- Since the atria are smaller than the ventricle, re-polarization signal from the atria is much smaller signal than the de-polarization signal of the ventricles and are not observable in the ECG.
- The ECG has 5 discernable extremes called the P, Q, R, S, and T waves.



https://imgur.com/gallery/PCzWX9p

ECG

- ECGs are obtain by connecting electrode around the heart called Einthoven's Triangle
- Since the R wave is the strongest point on the ECG, this pare to the signal is used to determine the heart rate.



Other Bio-potential Signals

- Electroencephologram (EEG) Signals from the brain
- Electromyogram (EMG) Signals from the muscles
- Electroneurogram (ENG) Signals from the neurons muscles
- Electrooculogram (EOG) Signals from the eye muscles
- Electroretinogram (ERG) Signals from the retina
- Electrogastrogram (EGG) Signal from the gastrointestinal system.

Other Types of Biosignals

- Imaging
  - X-rays
  - MRIs – Magnetic Resonance Imaging
  - PET- Positron Emission Tomgraphy
  - FNIRS – Functional Near-Infrared Spectroscopy
- Optical
  - Pulse Oxymeters
- Sonic
  - Ultrasound
  - Echo Cardiogram

Why do we study Bioinstrumentation?

- Other reasons
  - Historical
    - Mid 1960's – Electrical Engineers began designed devices for medical applications
  - Capstone
    - In the last 5 Capstone classes:
      - 73 projects
      - 50 or 68% (62%) had instrumentation/software components
      - 25 or 34% (52%) had no instrumentation track students on the project

Homework

1. The Action Potential process described is a simplification. Develop a more detailed view showing all of the types of channels, pumps, ions, etc. that are involved in this process.
2. In Einthoven's triangle, the electrodes connected to what sort of electrical amplifier? Why? Answer this later; when we get to Amplifiers.
3. HONORS STUDENTS ADD THE FOLLOWING

   Determine a method to calculate the Heart Rate

   from the ECG bio-signal. Name the type of circuit needed to perform this calculation.