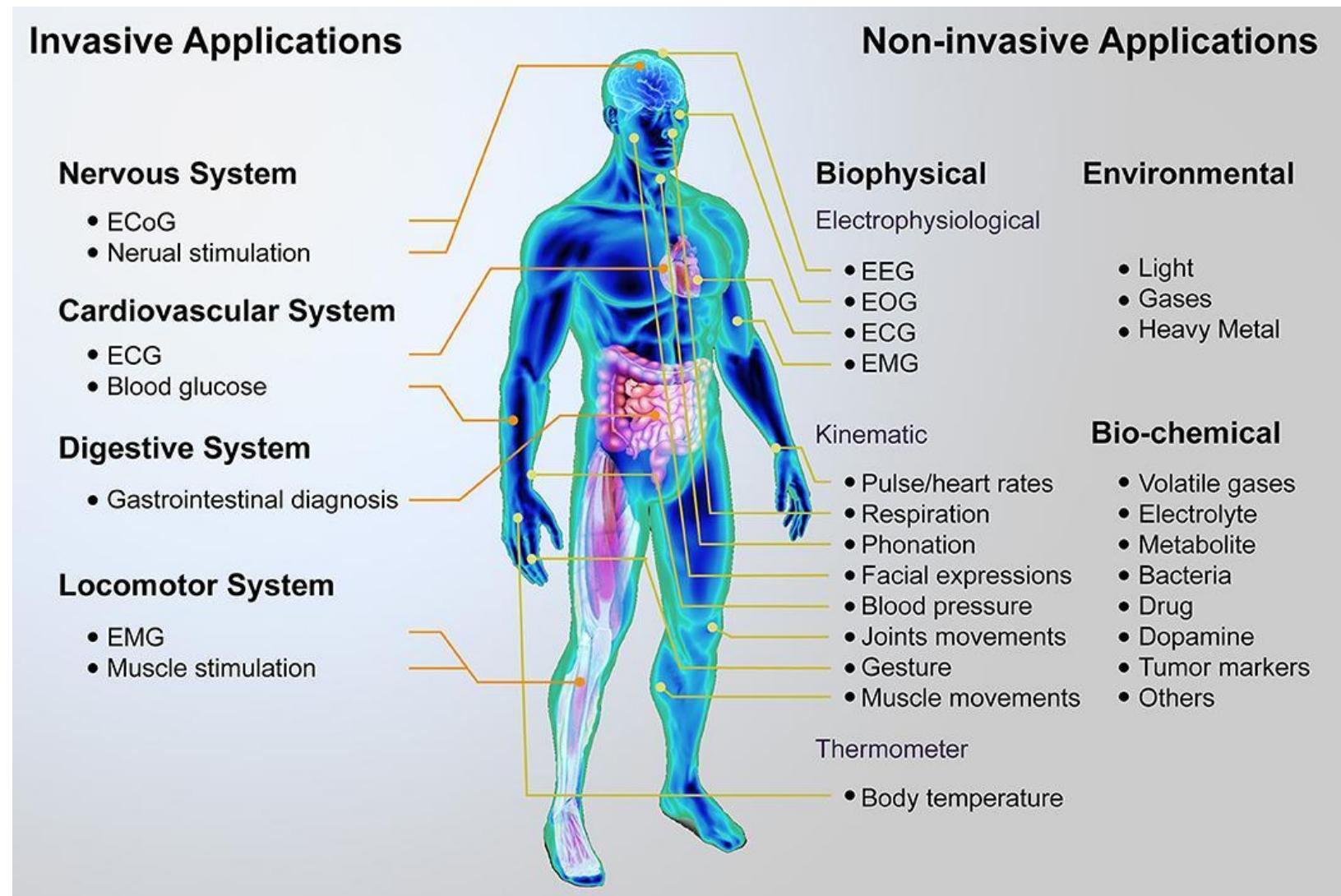
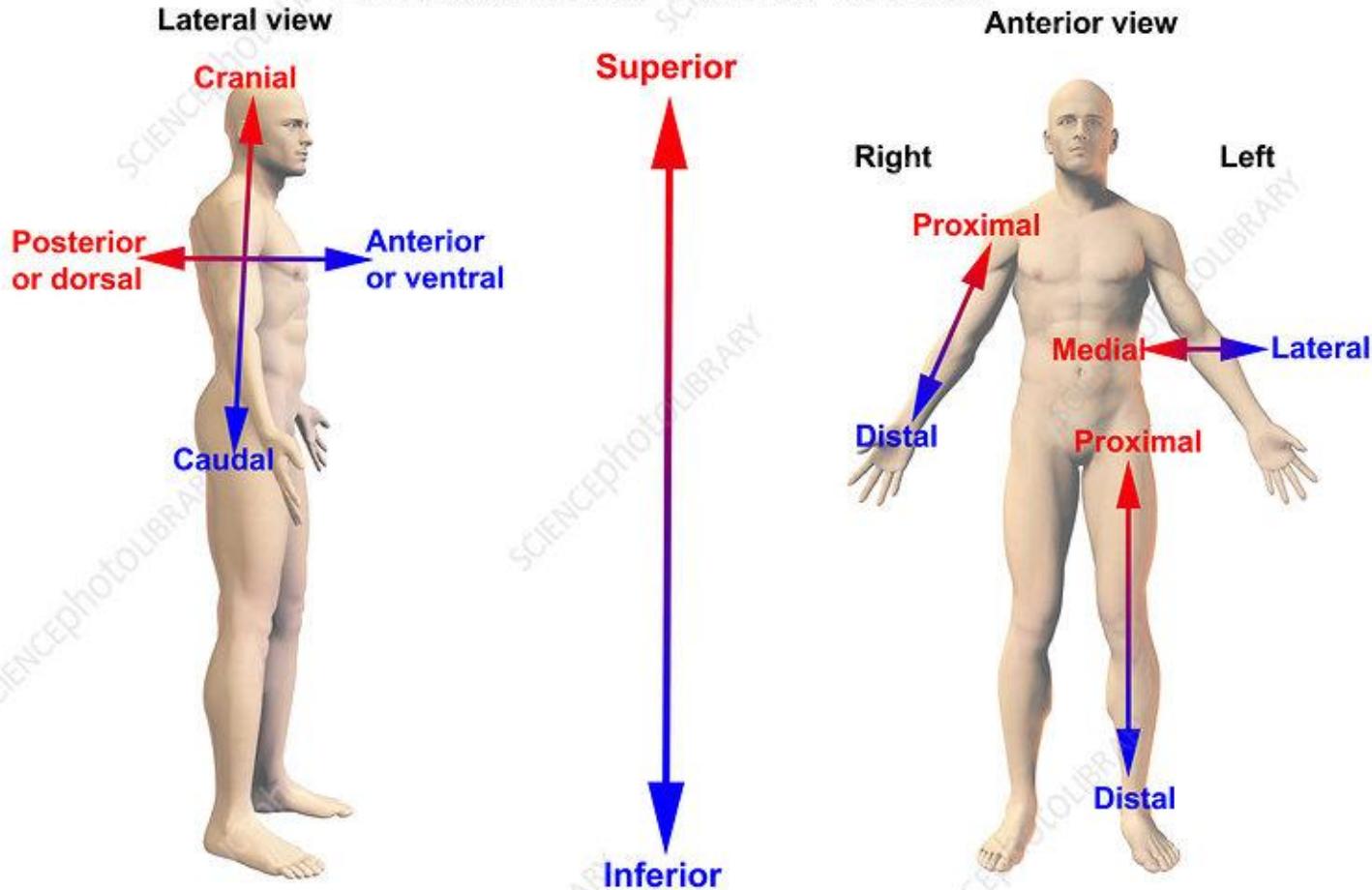


Genesis of Bio-signal

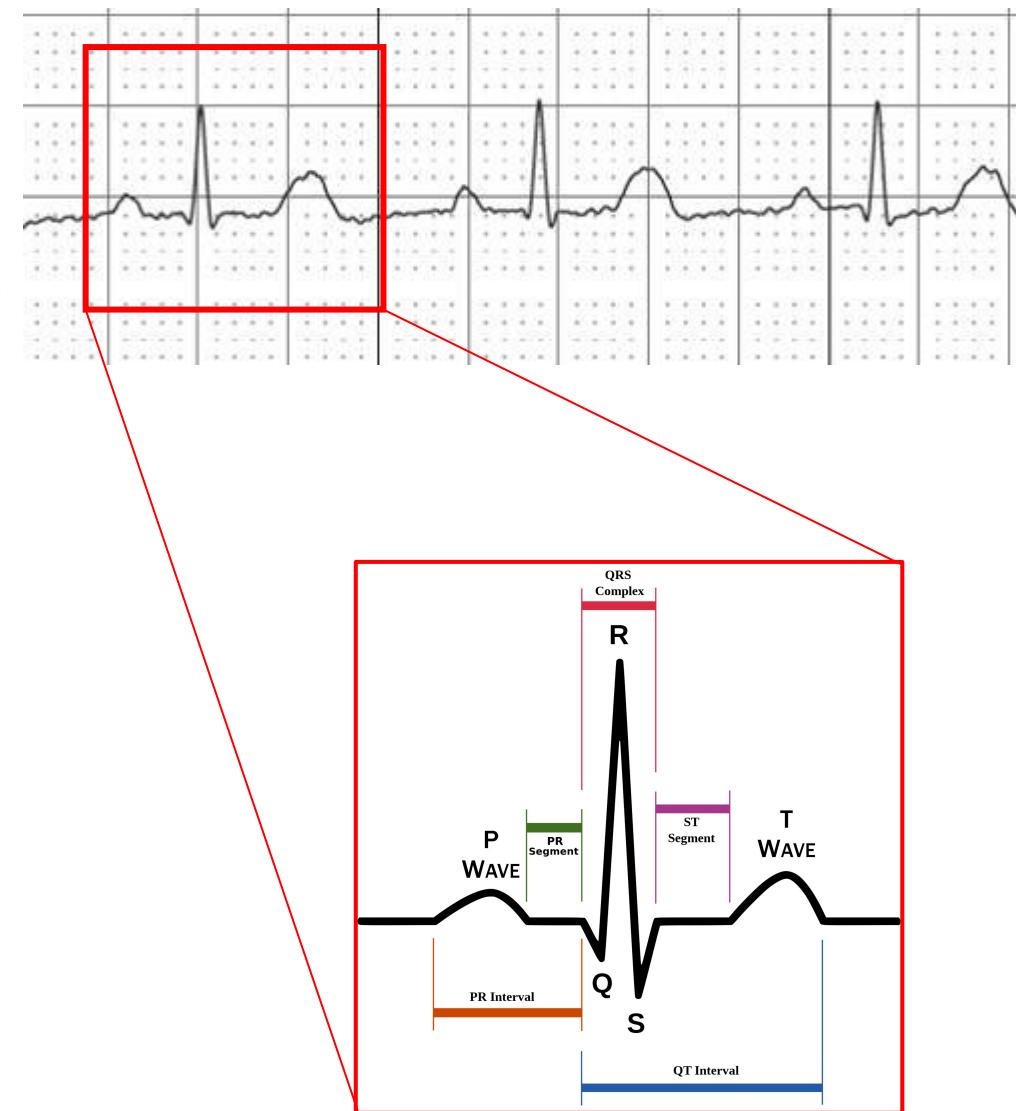
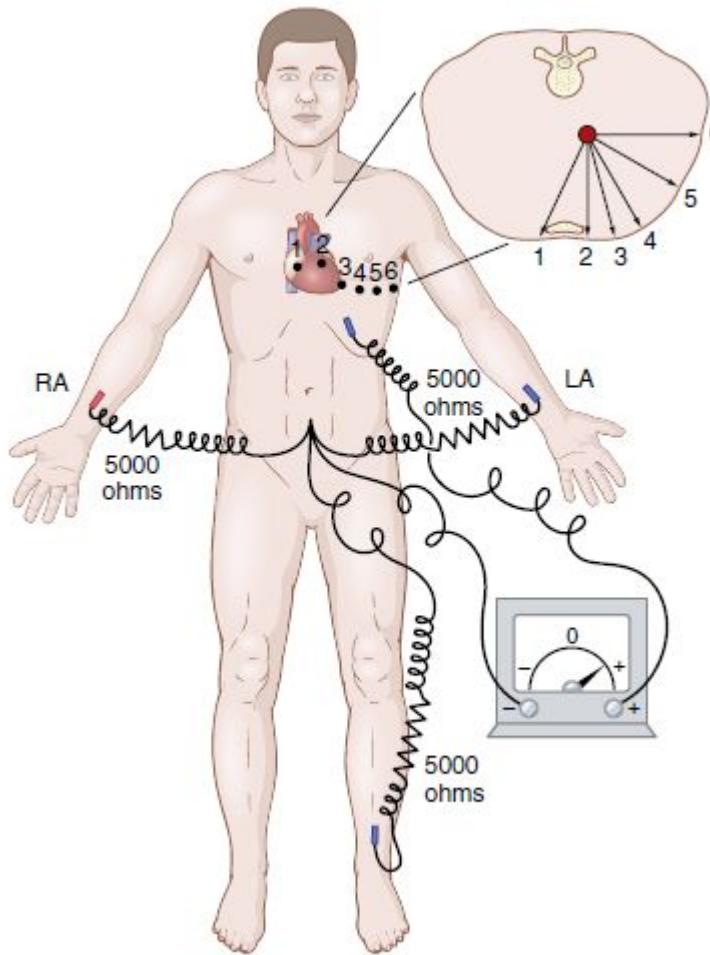
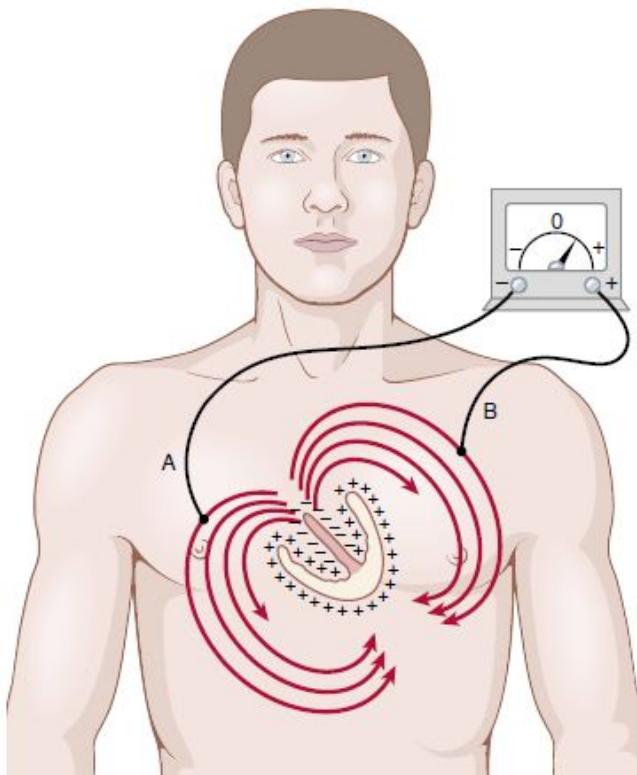


Definition of directional human

Directional References

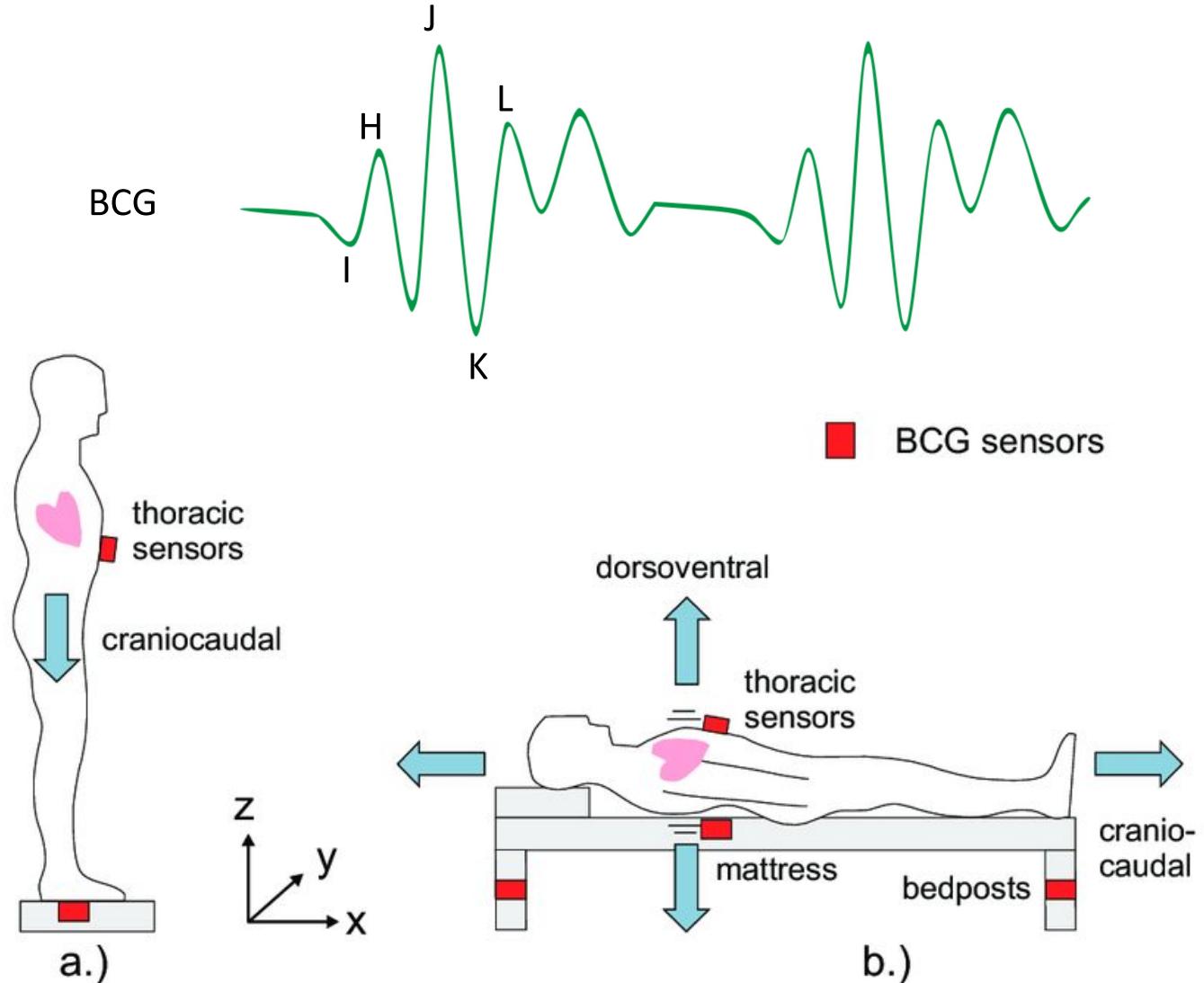


Electrocardiogram (ECG)



Ballistocardiogram (BCG)

- Motion imparted to the body from the motion of the blood and the heart during each cardiac cycle.
- These repeated motions happen due to the rapid acceleration of blood when it is ejected and transferred into other vessels of the body during periods of relaxation and contraction
- Measured at wrist, ear, feet or back (embedded sensor in bed/chair)



Phonocardiogram (PCG) - heart sound

- A diagnostic graphical method of recording sounds with the help of a specific equipment, namely phonocardiograph.
- Two dominant types of heart sounds (S1 and S2), corresponding to the beginning of the ventricular systole and the onset of the ventricular diastole
- Collected by an acoustic device (i.e., stethoscope) attached at the surface of the chest wall.

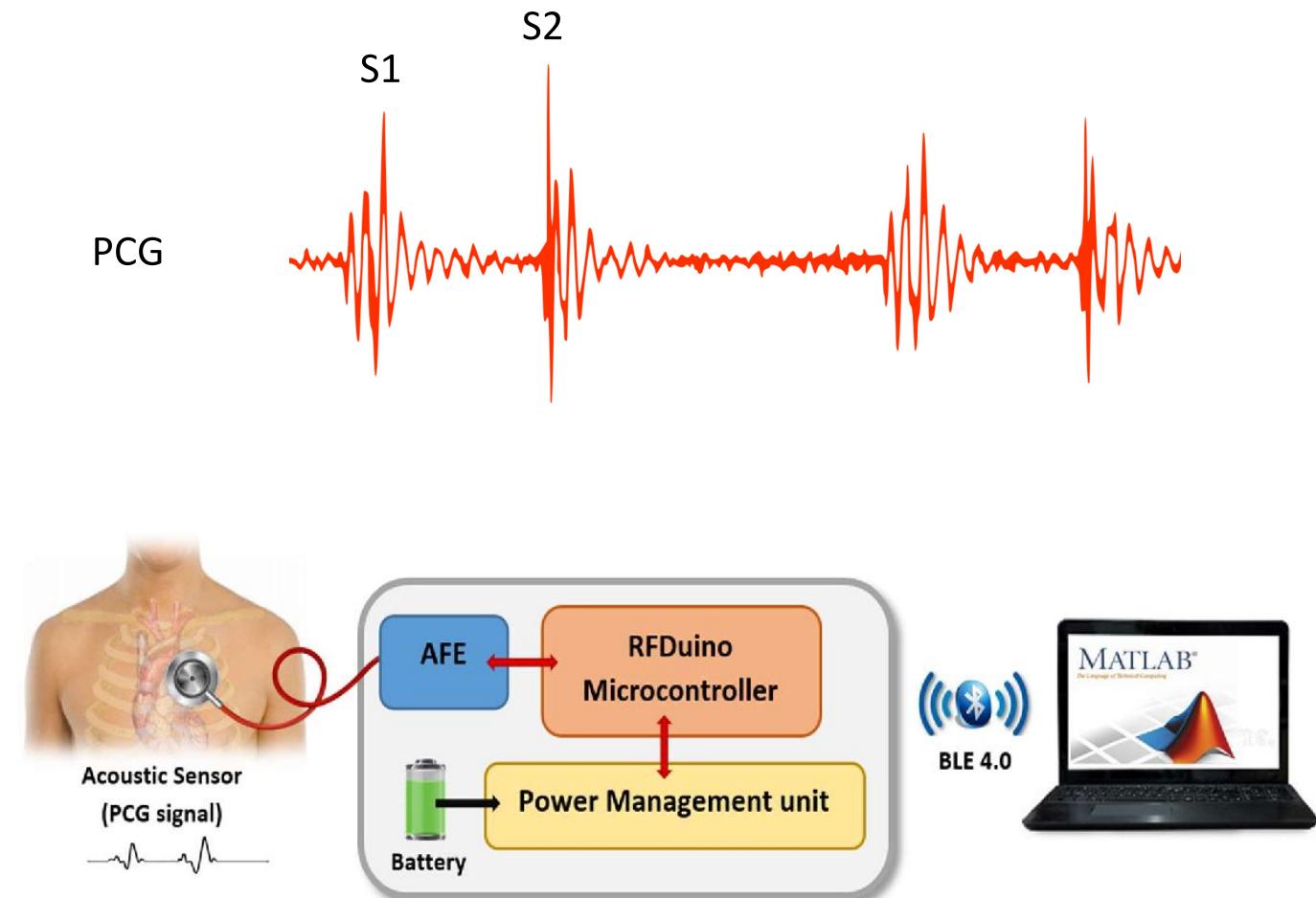
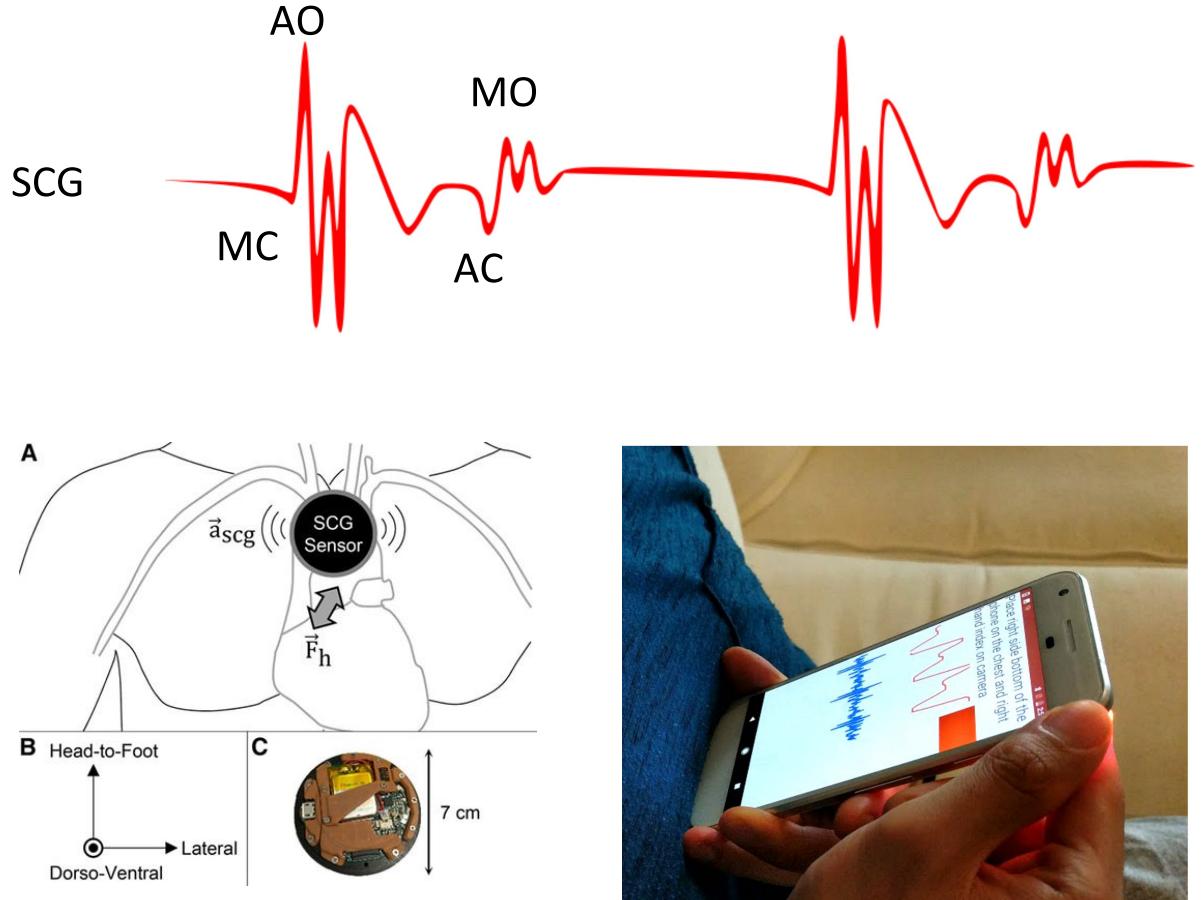


Figure 2. Overall system block diagram.

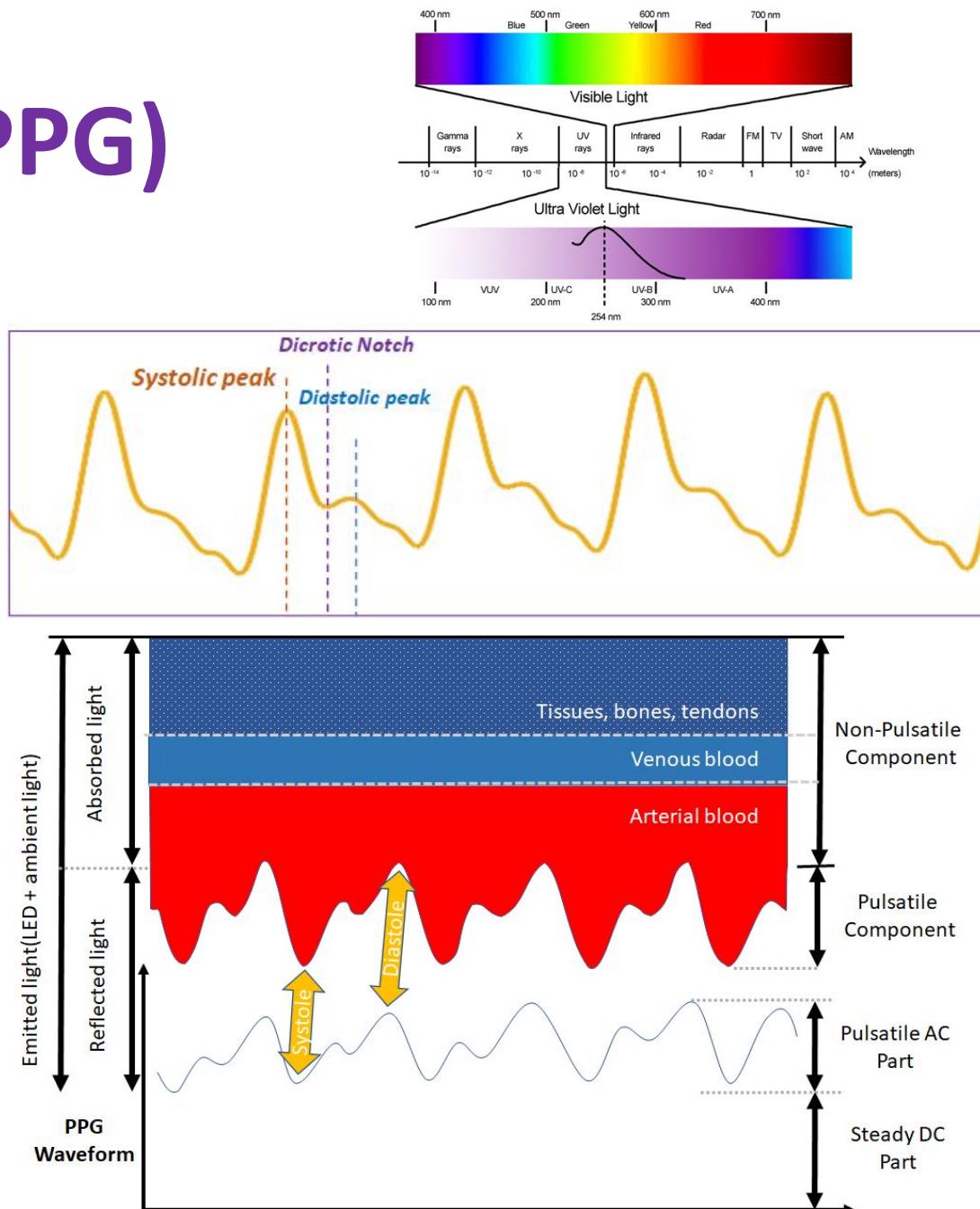
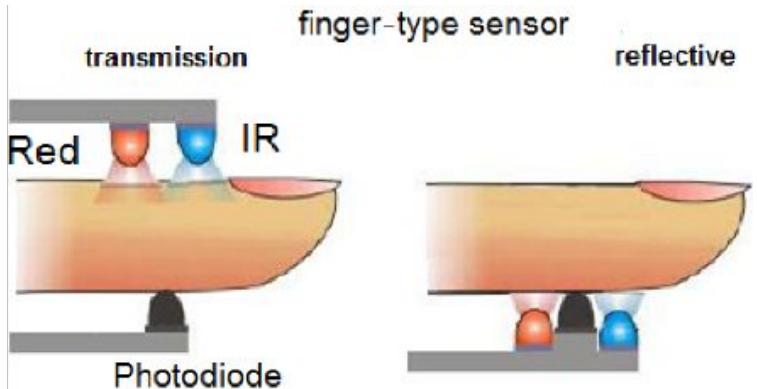
Seismocardiogram (SCG)

- Cardiac-induced mechanical vibrations on the chest surface, including frequencies below the human hearing threshold.
- Characterized by opening and closure of the aortic valve (AO and AC) and the opening and closure of the mitral valve (MO and MC).
- Measured by a lightweight low-noise accelerometers embedded inside portable or even wearable systems.
- Commonly placed sensor on the sternum or on its left lower border



Photoplethysmography (PPG)

- PPG is an optical sensor with a LED and a PD.
- These are two types of PPG techniques:
 - Transmission PPG
 - Reflectance PPG
- Measured based on the variation of light intensity caused by blood flow in the vessels.
- The PPG waveform includes AC and DC parts
- Common sensor places are fingertips, wrist, forehead, earlobe, thigh, ankle etc.
- Applying to measure SpO₂, HRV, BP etc.

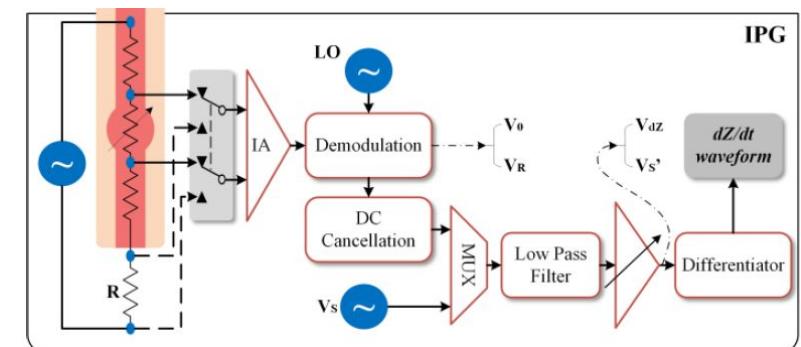
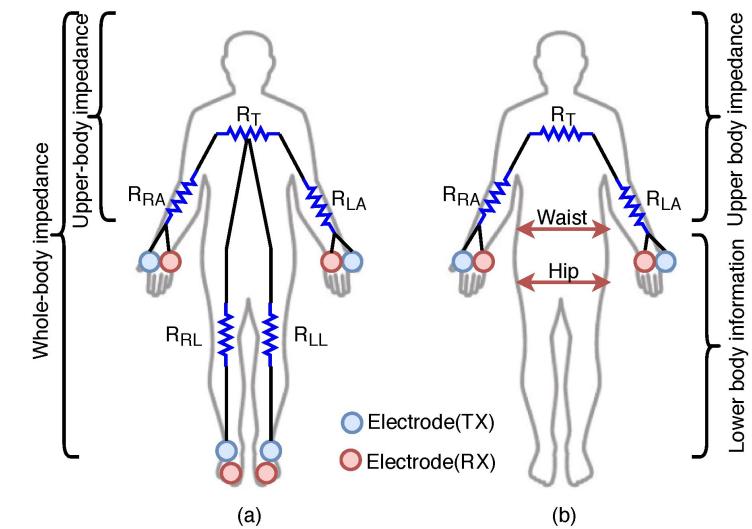
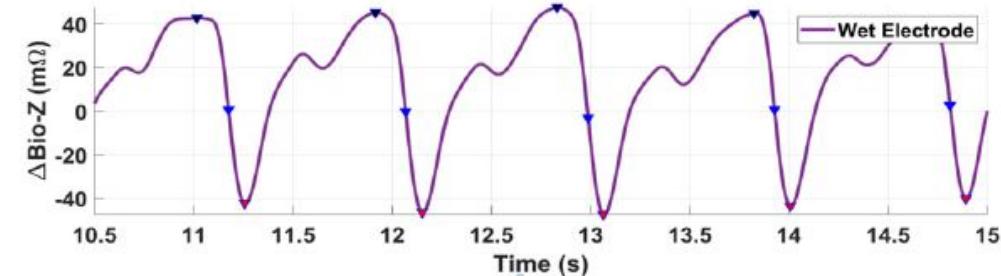
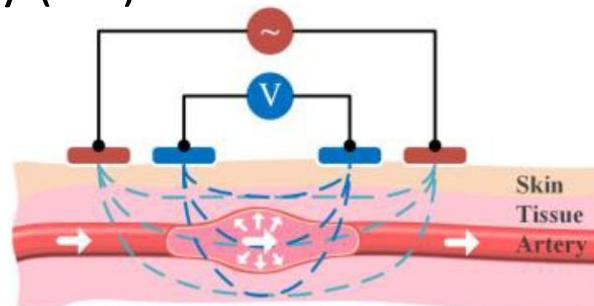


Impedance Plethysmography (IPG) or Bio-impedance (Bio-Z)

- Measured based tissue impedance between two V-electrodes (RX) while injecting high frequency current from two I-electrodes (TX).
- There are two types of IPG circuit
 - Bi-electrodes IPG
 - Terra-electrodes IPG (higher accuracy)
- Maximum current is obeyed IEC60601 standard

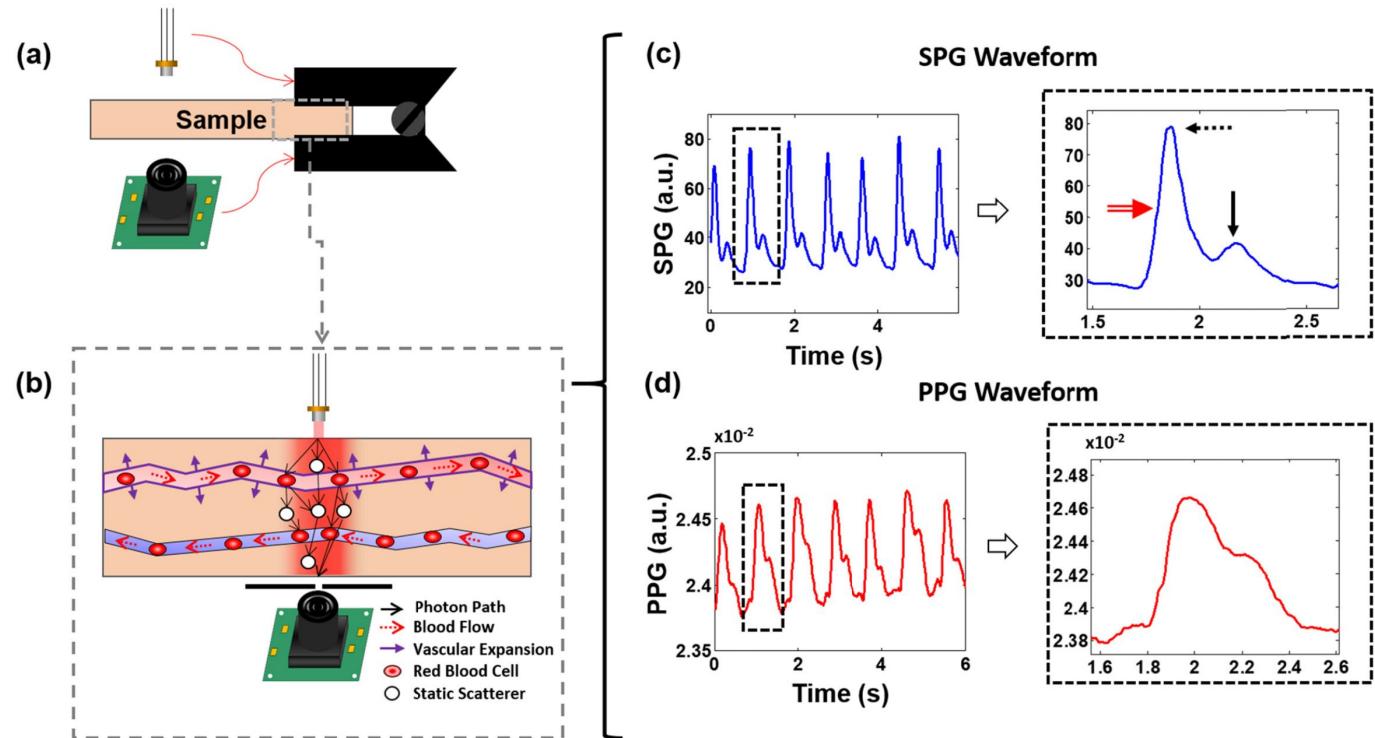
$$I_{AC_{MAX}} = \begin{cases} 10\mu A_{rms} & (f \leq 1Khz) \\ \frac{f}{1000Hz} \times 10\mu A_{rms} & (f > 1Khz) \end{cases}$$

- Applying to measure HR, body composition analysis (BIA), Electrical Impedance Tomography (EIT)



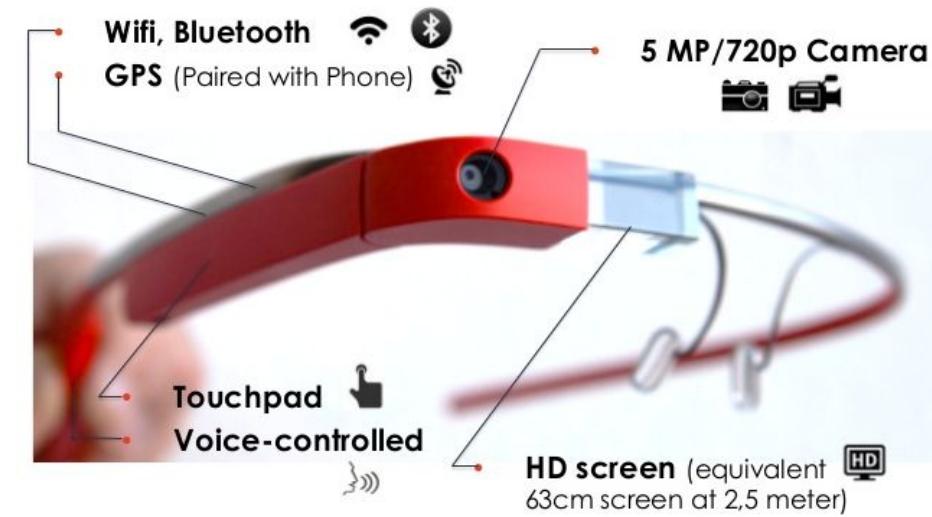
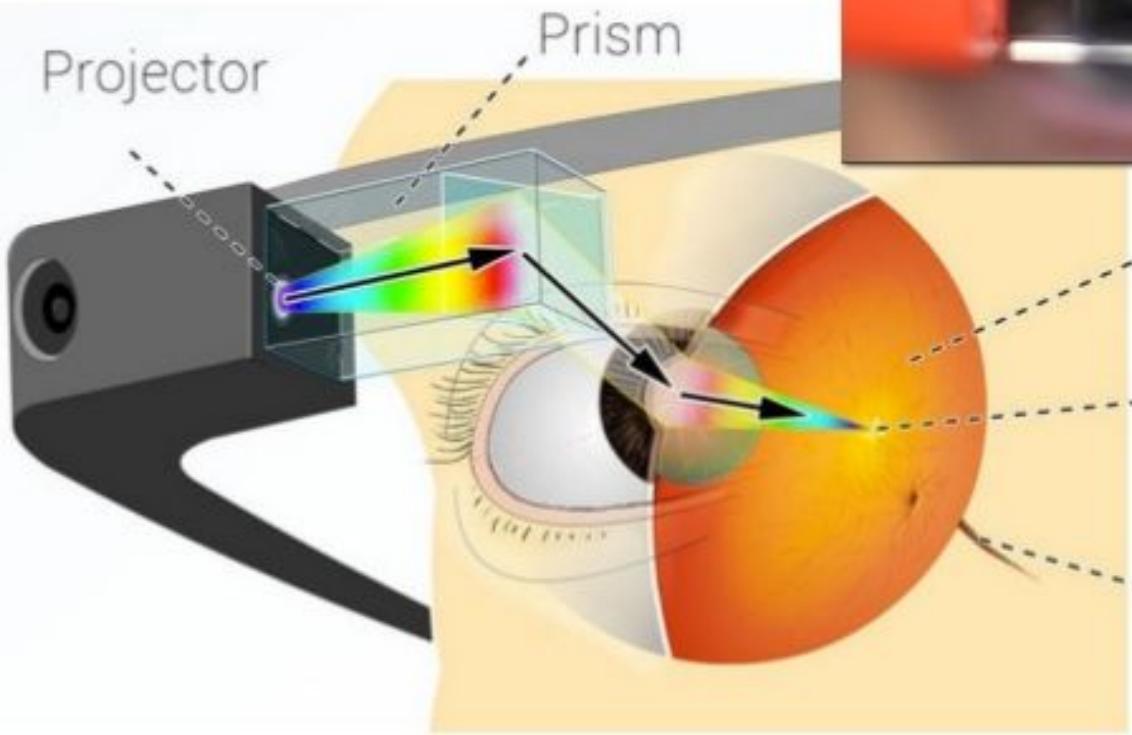
Speckleplethysmogram (SPG)

- An optical method based on laser speckle contrast imaging (LSCI) to monitor changes in blood flow.
- Amount of speckles detected in the image correlates to the volume of blood present at that time point, and the change over time forms the SPG waveform
- Measured at finger tip with a camera and laser source placing opposite direction.



Medical and Wearable Devices

- Google Glass:
 - Prism Projection



Medical and Wearable Devices

- FDA-cleared, personal EKG monitor
- Detect Atrial Fibrillation, Bradycardia, Tachycardia or Normal heart rhythm
- Store your EKGs on your phone, and email your EKG to your doctor with the press of a button



Source: [KardiaMobile EKG Monitor - Instant EKG on Your Phone | AliveCor – AliveCor, Inc.](#)

Medical and Wearable Devices

- Simultaneously measure PCG and ECG.
- Detect early-stage heart murmurs and AFib with Eko AI analysis algorithms.
- Removable earpieces support wireless auscultation.



Source: [DUO ECG + Digital Stethoscope - EKG Stethoscope | Eko \(ekohealth.com\)](https://ekohealth.com)

ECG + PPG for estimation Blood Pressure

