



IPGD_x

PHASE ANGLE: A NEW VITAL SIGN

An Index of Frailty & Survival

Impedance plethysmography (IPG) is the gathering of a variety of physiologic data based upon measured electrical values of voltage drop in ohms without any mathematical or statistical manipulation.

Impedance (Z) is the overall opposition to the electrical signal which is the combined resistance and reactance/capacitance.

Resistance (R) is the measured vector of impedance that opposes and is inversely proportionate to ECW fluid volume.

Reactance/capacitance (Xc) is the measured ability of a cell membrane to act as a capacitor and 'hold' the current resulting in its lag behind voltage and is proportionate to cell mass and ICW.

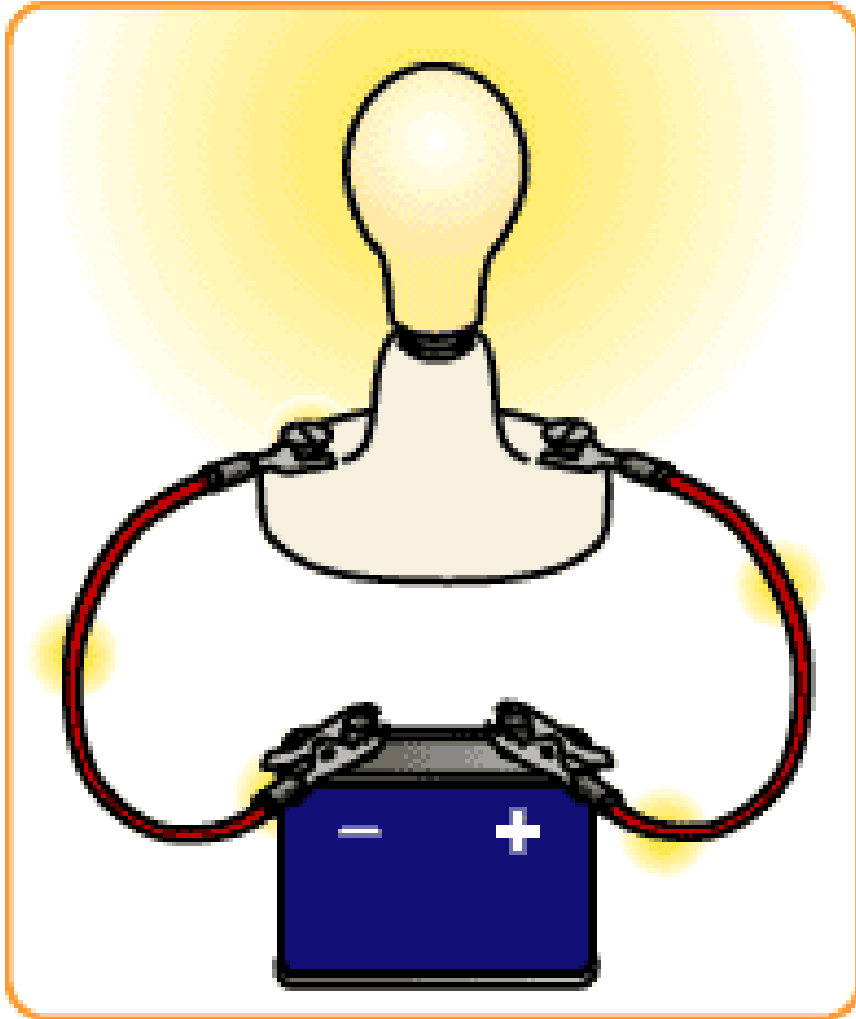
Phase angle (Pa): the measured phase shift that results from the cell membranes and water encountered by an electrical signal current as it lags behind the voltage in a circuit .

Impedance Analysis

- Measured in Ohms
- Low voltage: ~800 micro amps
- Constant Current: 50 KHz
 - Harmless (without contraindications)
- Precision: $R^2 = 0.99$
- Economical
- Immediate Results

Electrical Circuit

Electrical circuits involve 3 basic components:



Voltage

the force created by the separation of charges.

Resistance

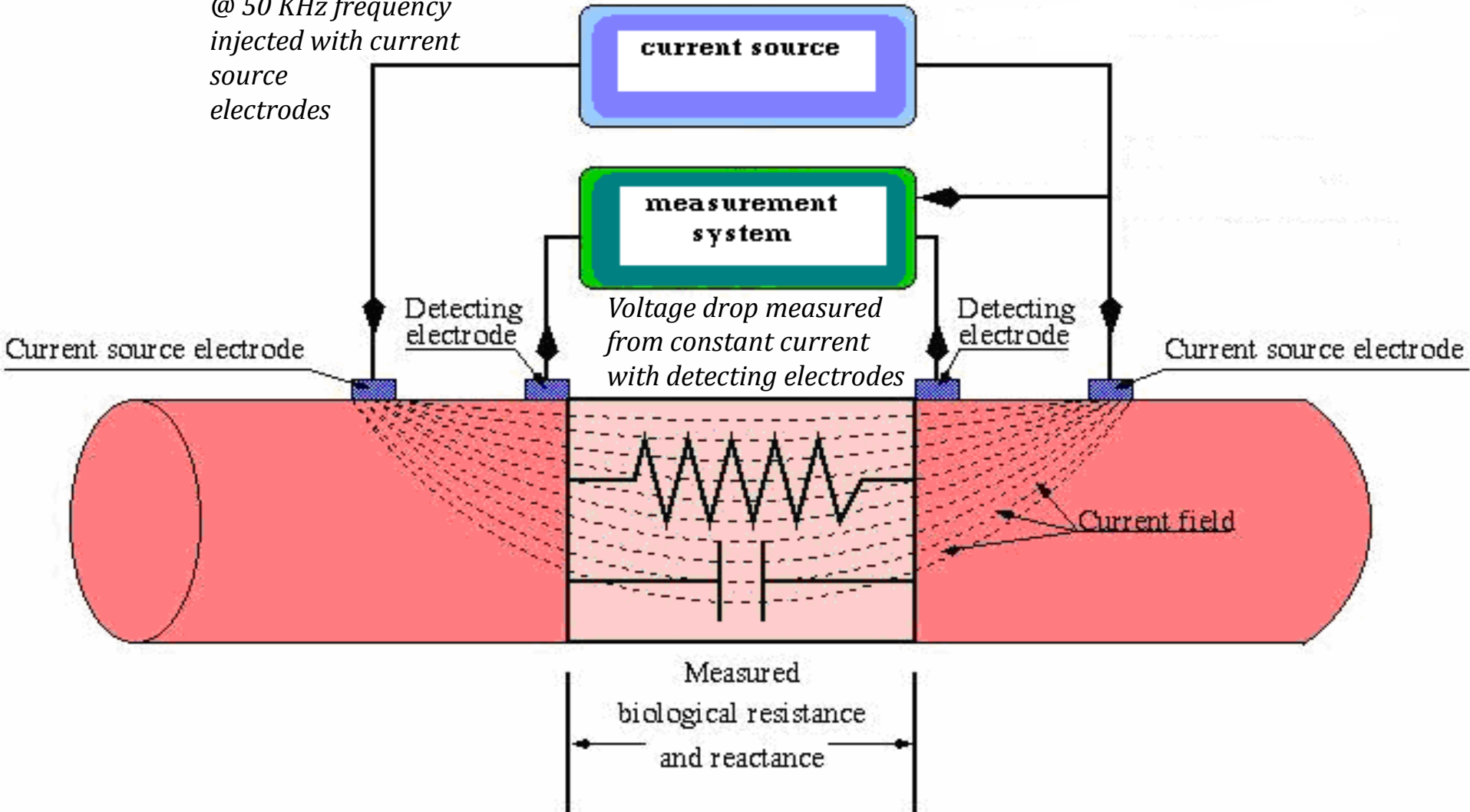
is a measure of how hard it is for charges to move in the system.

Current

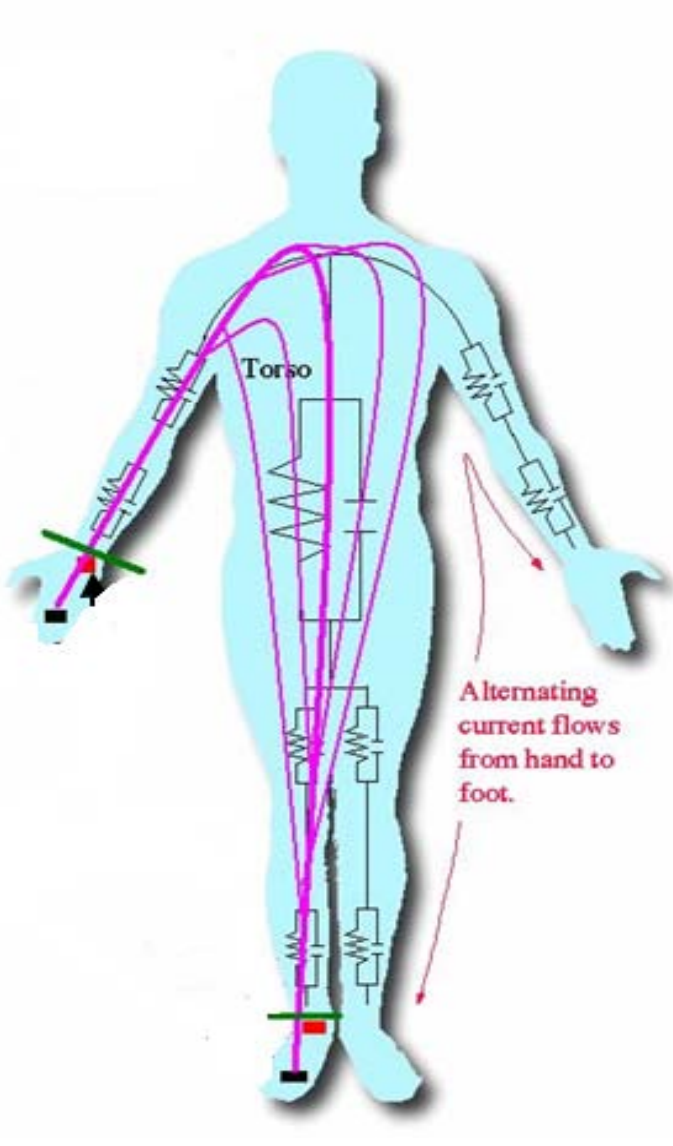
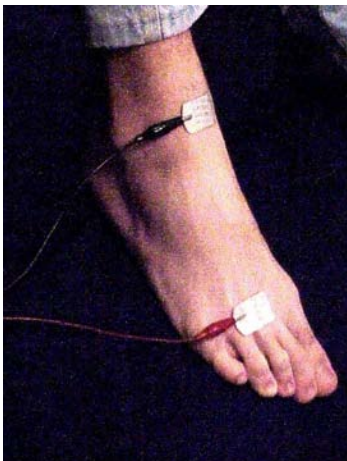
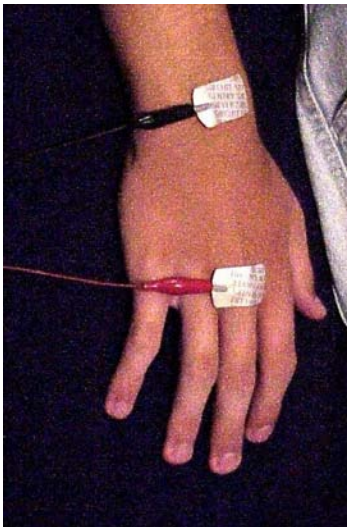
the movement of charges;
in an electrical circuit,
electrons move from the
negative pole to the positive pole

IPG Constant Current Circuit Model: Tetrapolar Electrode Scheme

*800 microamps
@ 50 KHz frequency
injected with current
source
electrodes*



Patient Circuit Model



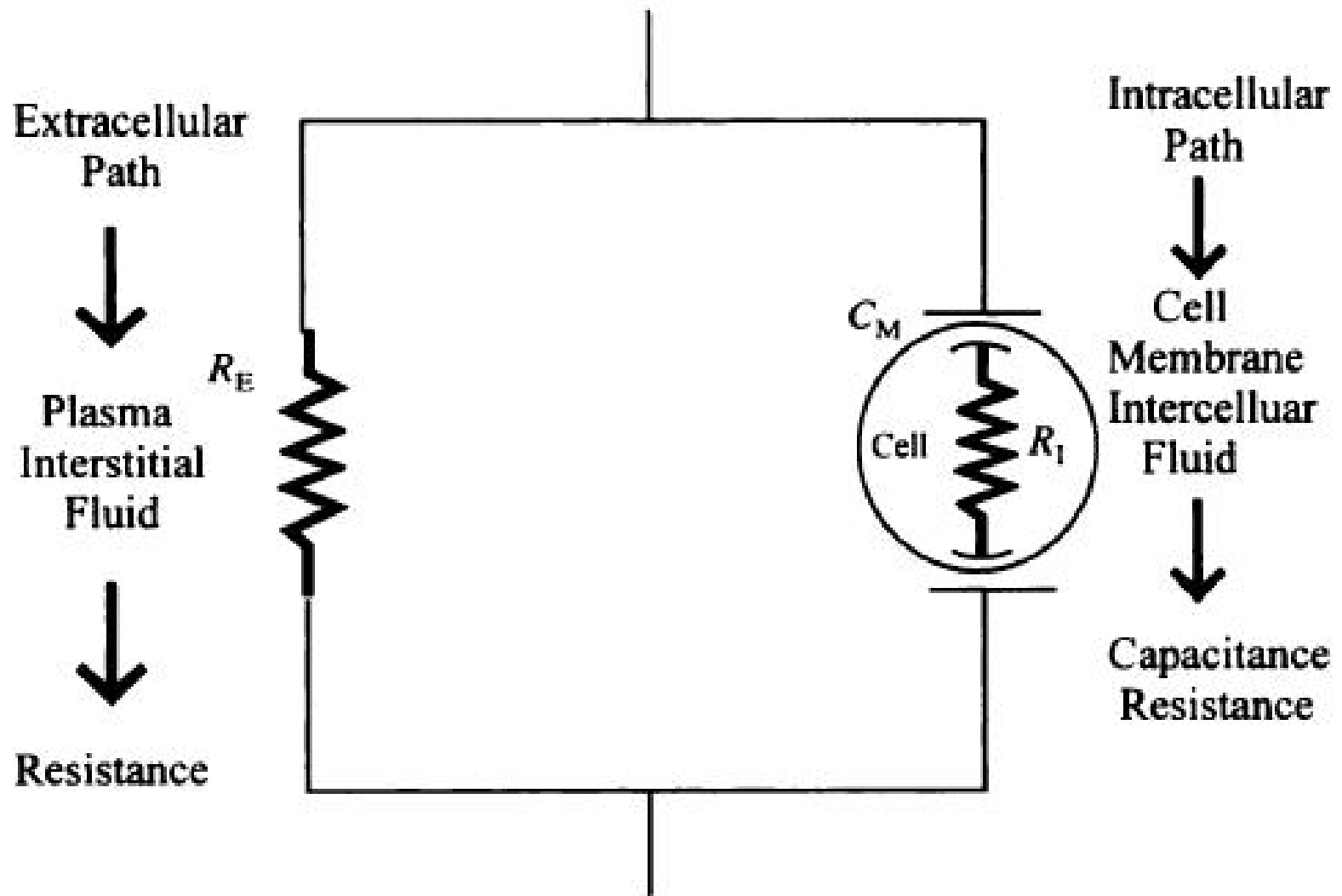
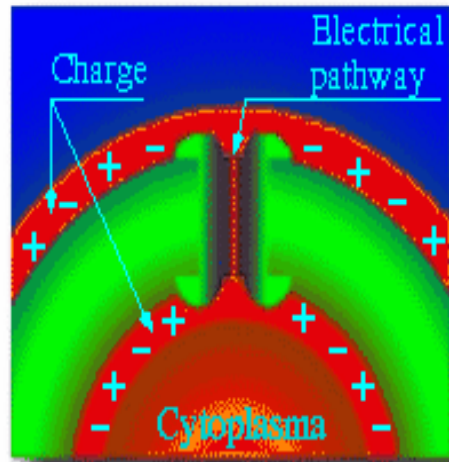
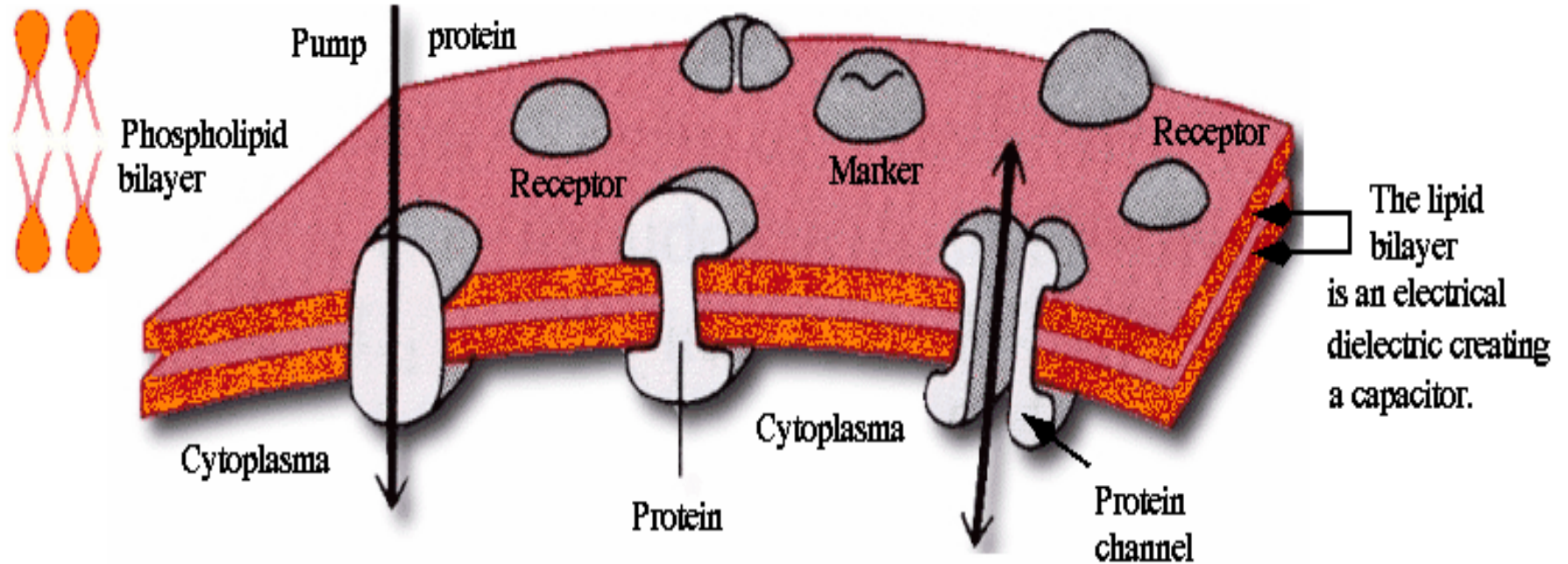
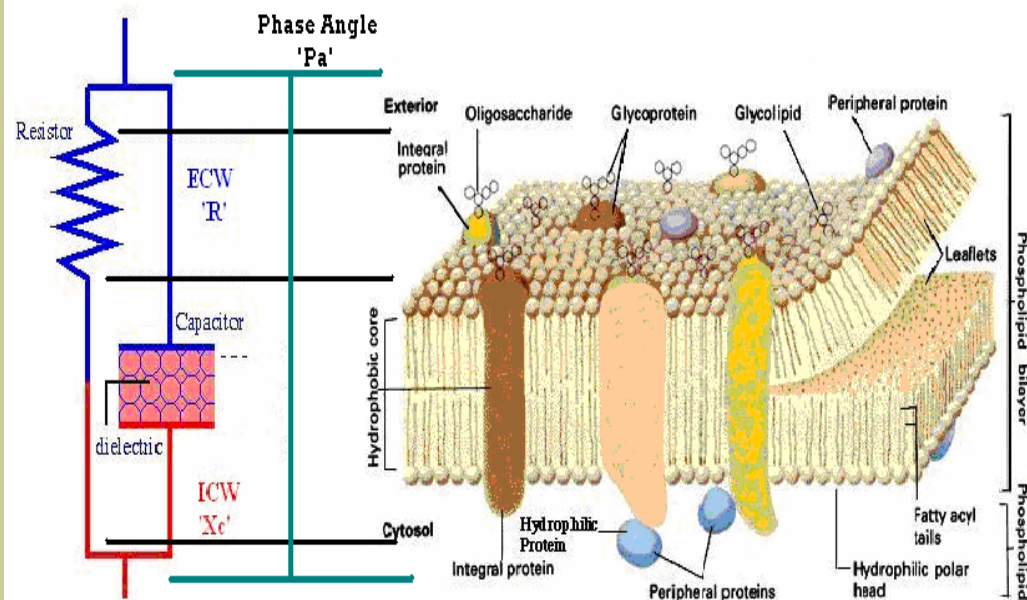
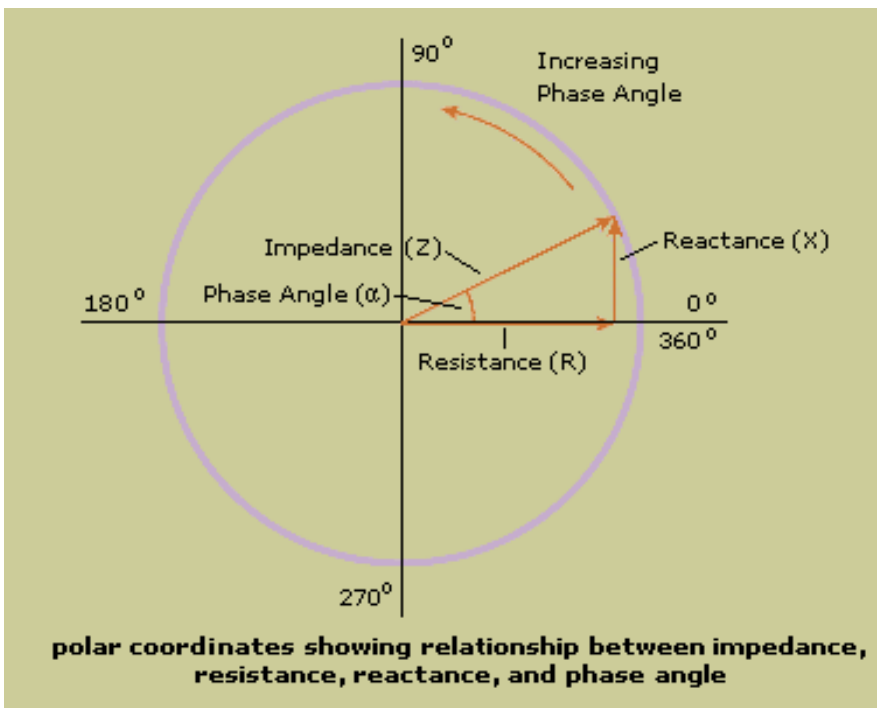
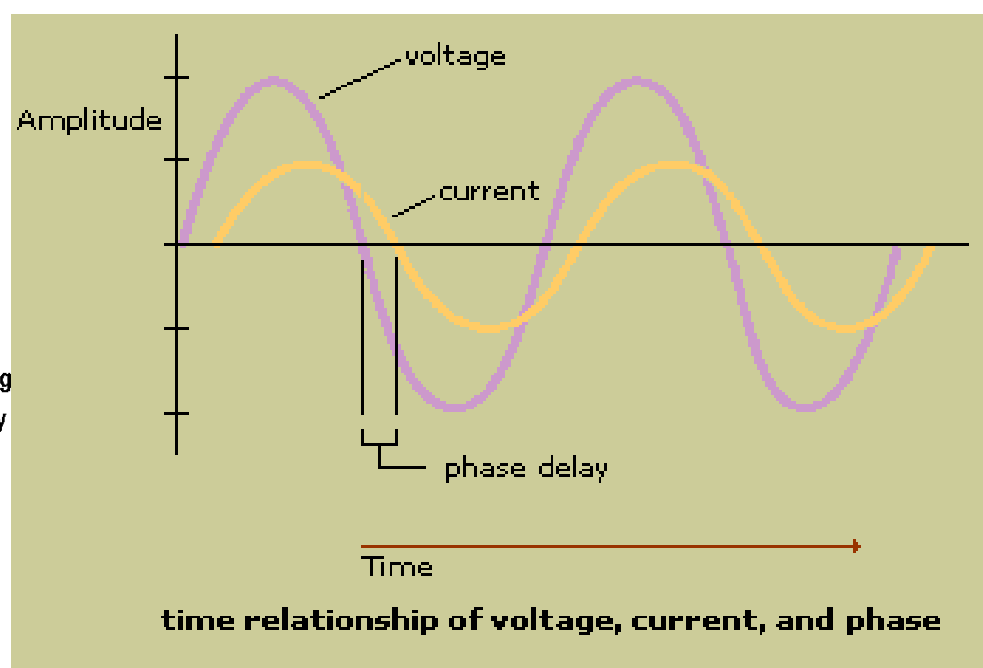
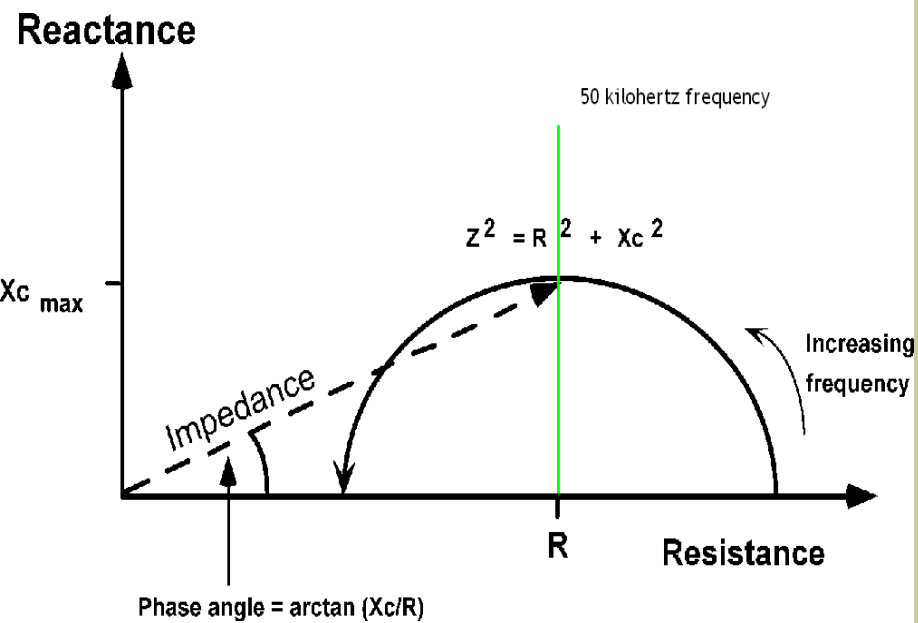


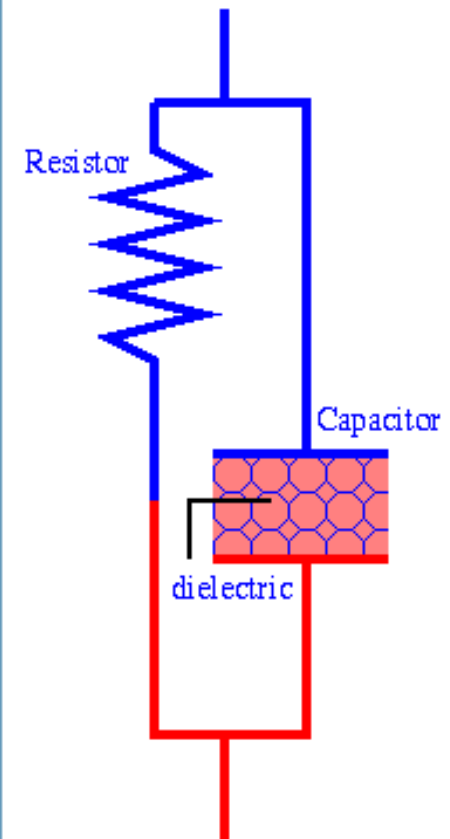
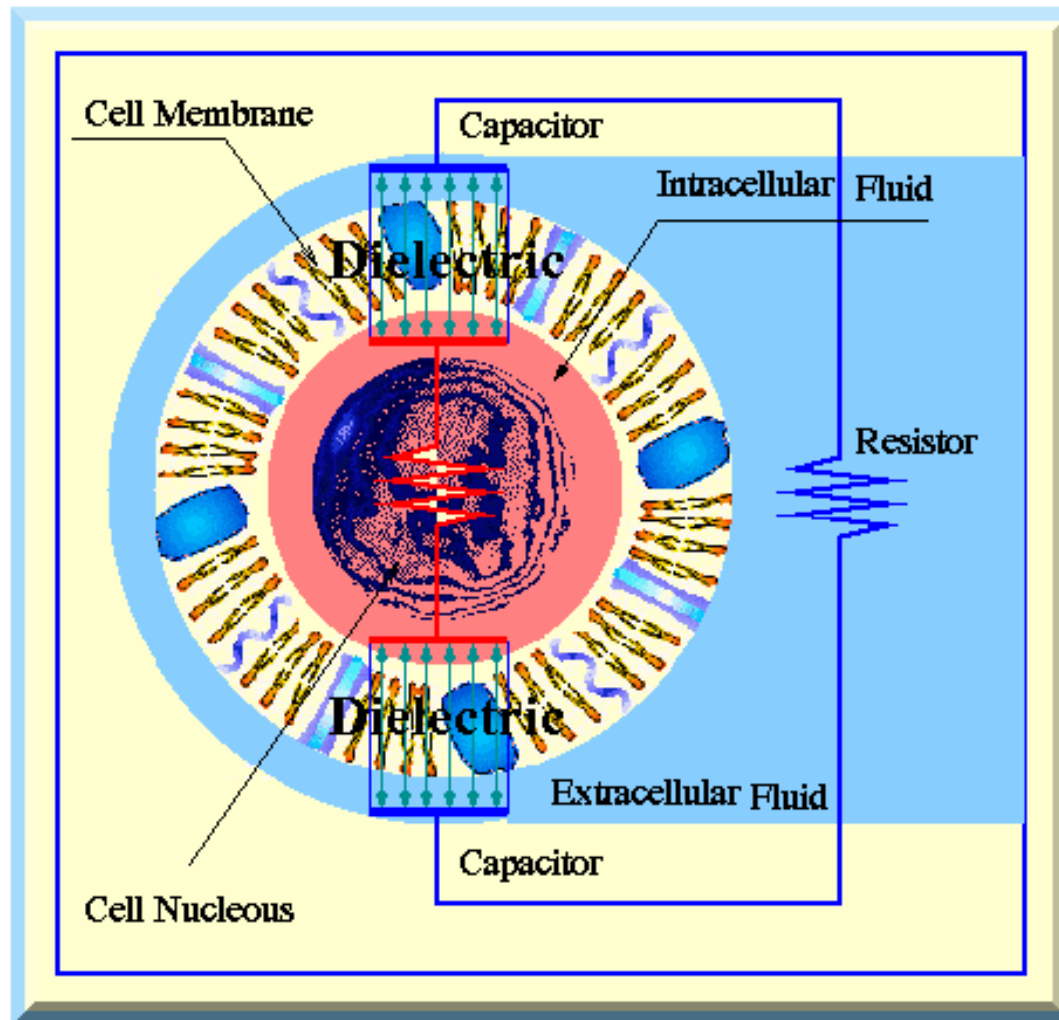
FIGURE 2. Circuit model of a cell. R_E , extracellular resistance; C_M , capacitive influence of cell membranes; R_I , intracellular resistance.



The electrical signal from a bioelectrical impedance analyzer (BIA) is leaked through the protein channel charging the inside of the cells lipid bilayer. The same charge with opposite polarity exists on the outside of the cells bilayer. This forms a capacitor that gives BIA instruments reactance values. When the cell dies reactance is reduced to zero.



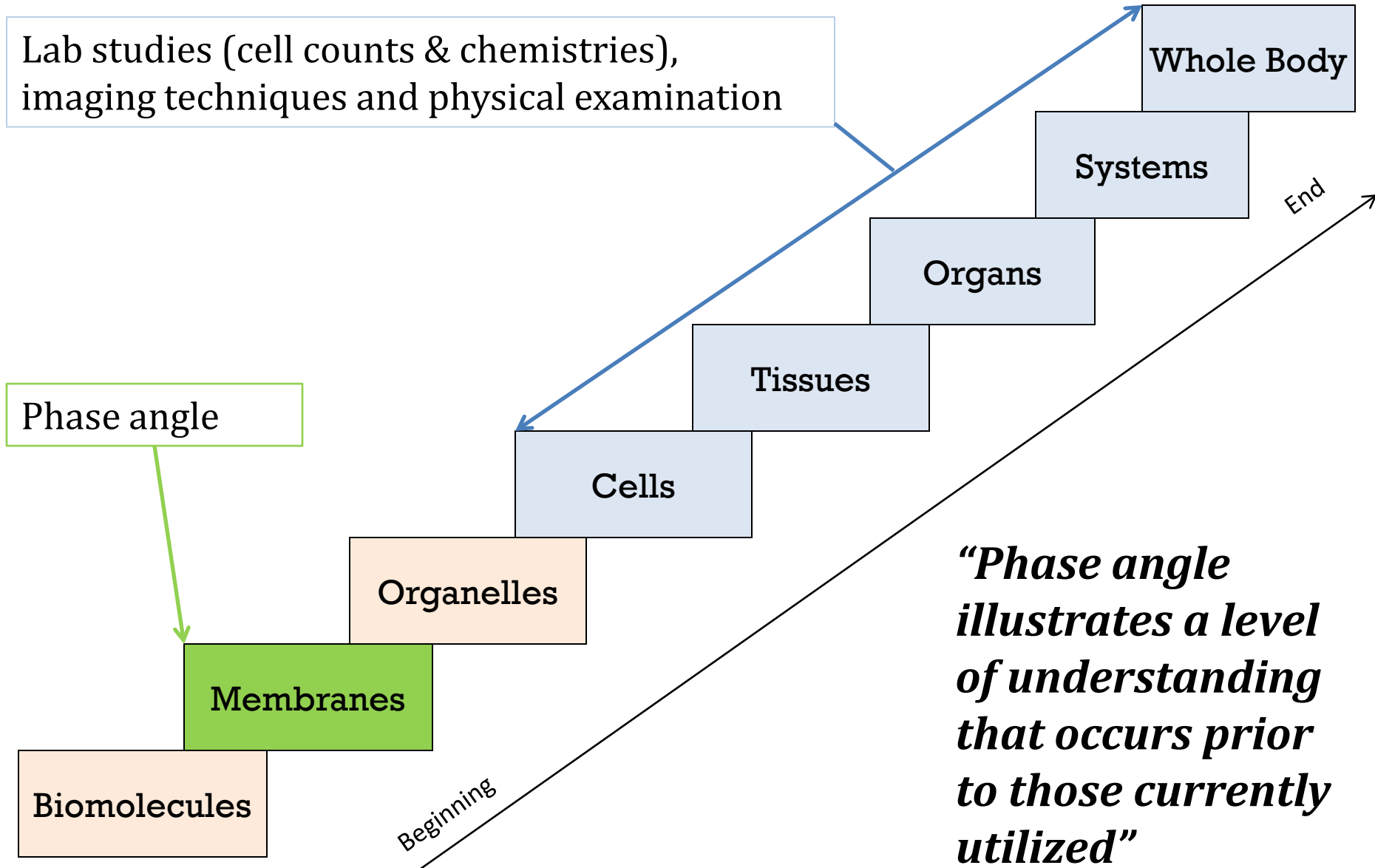
The Plasma Membrane of a Cell and its Electrical Equivalent



The outer boundary of the cell is a plasma membrane of phospholipid molecules which become a dielectric to form an electrical capacitor when a radio frequency signal is introduced to the cells environment.

Electrical capacitor in PARALLEL with a resistor.
Capacitance is analogous to intracellular volume
and resistance is analogous to extracellular volume.

Clinical Studies and the Hierarchical Organization of the Body



Phase Angle Values

Phase angle illustrates the vitality of cell membranes by their ability to act as an electrical capacitor.

The ability of a patient's cell membranes to act as an electrical capacitor is proportional to their frailty and survival.

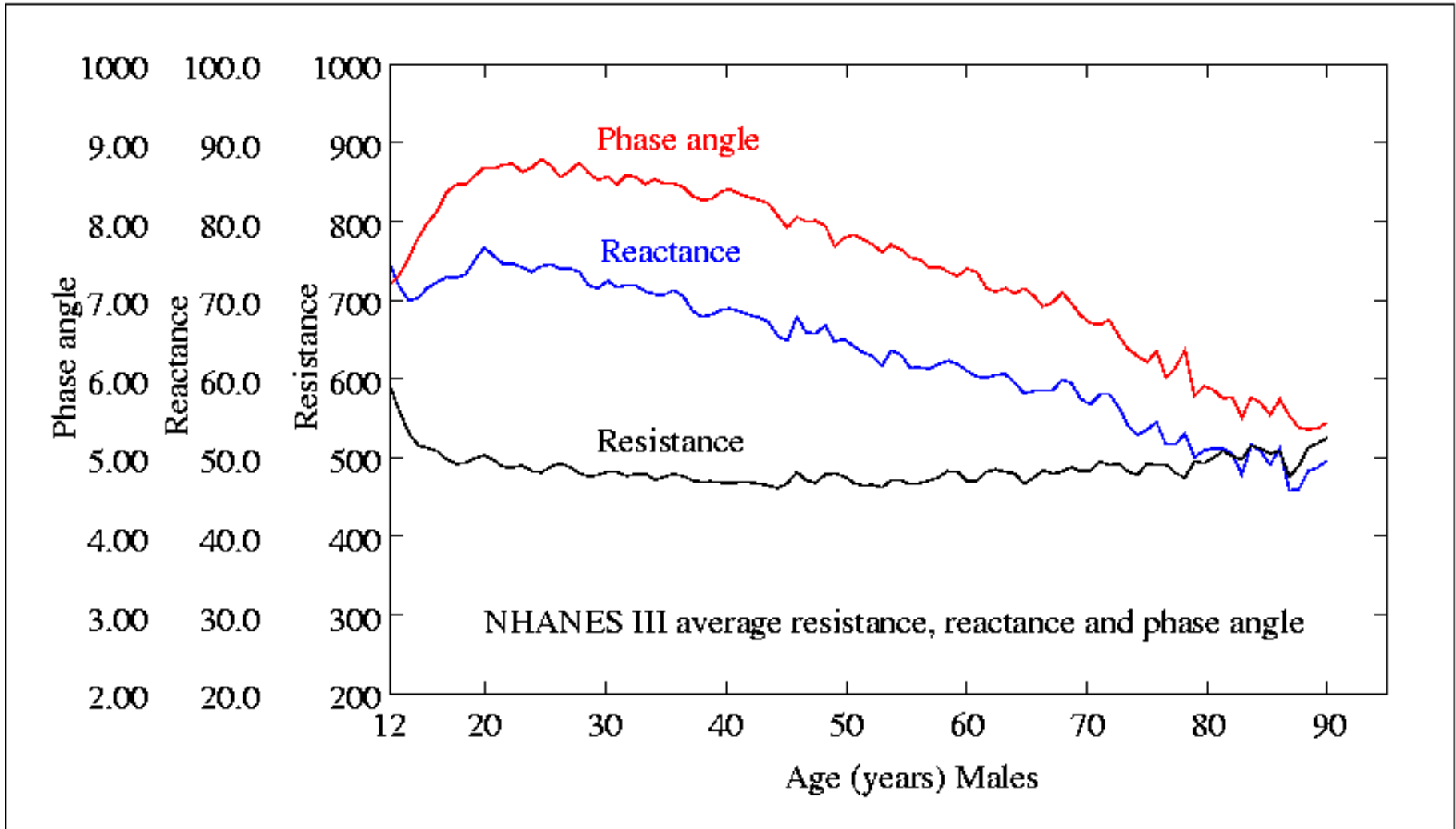
Higher phase angle values are associated with greater robustness and longer survival.

Lower phase angle values are associated with greater frailty and shorter survival.

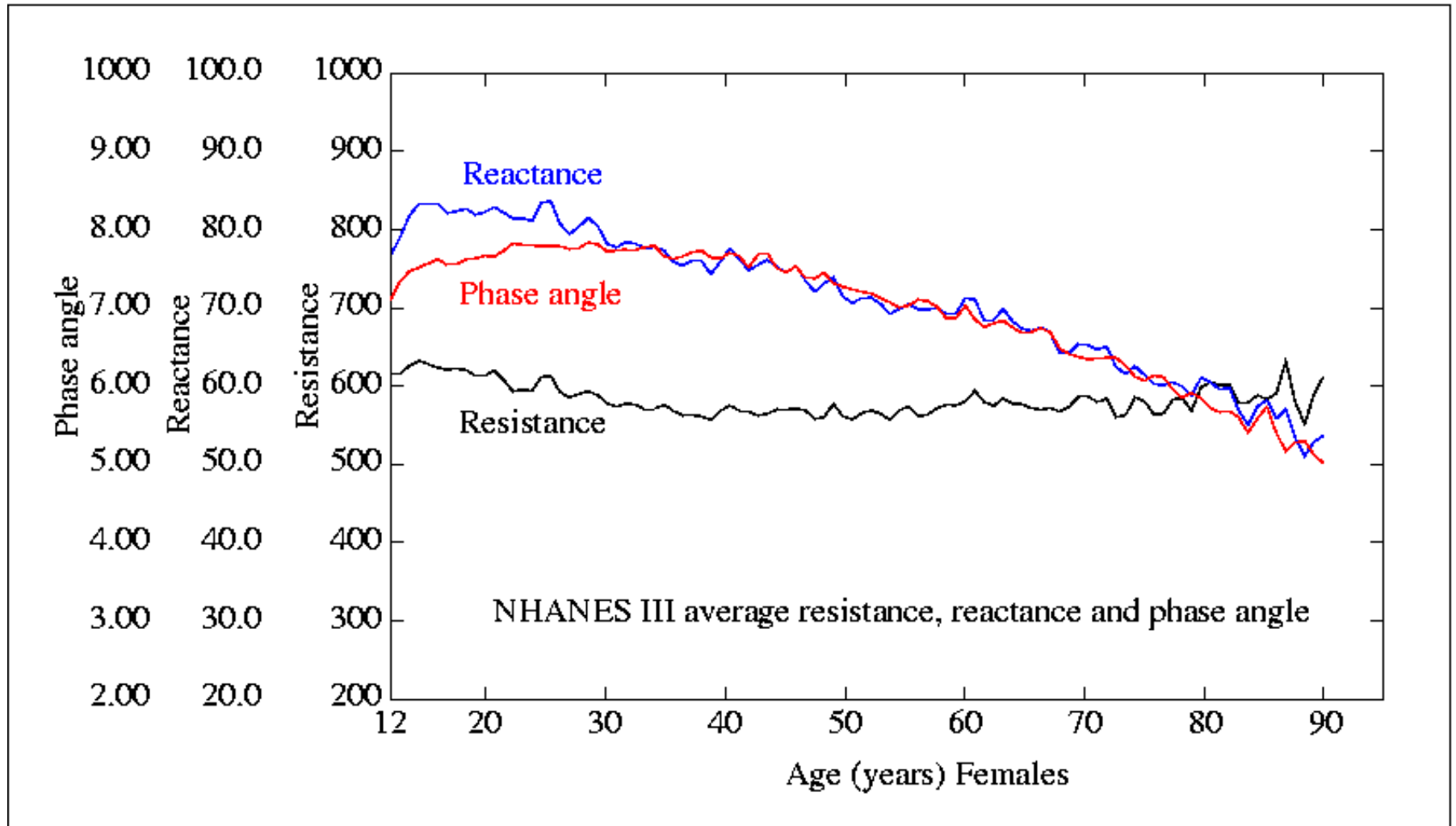
Phase angle is related to age and gender, it is reduced with age, lower in females and on average ranges from 5 (five) to 9 (nine) degrees.

Optimal phase angle values in females are $>8^\circ$ and in males $>9^\circ$.

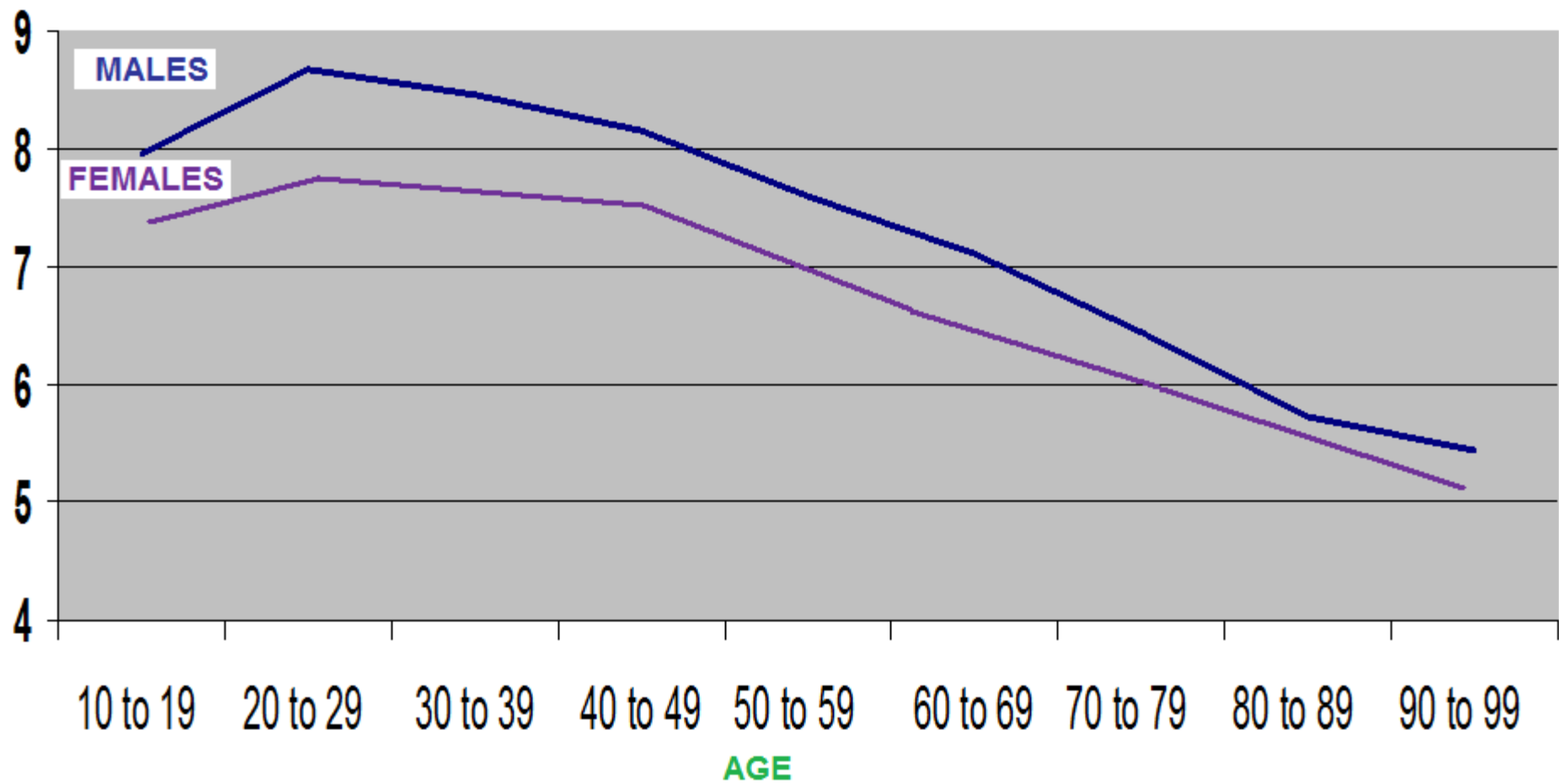
Average Impedance Values



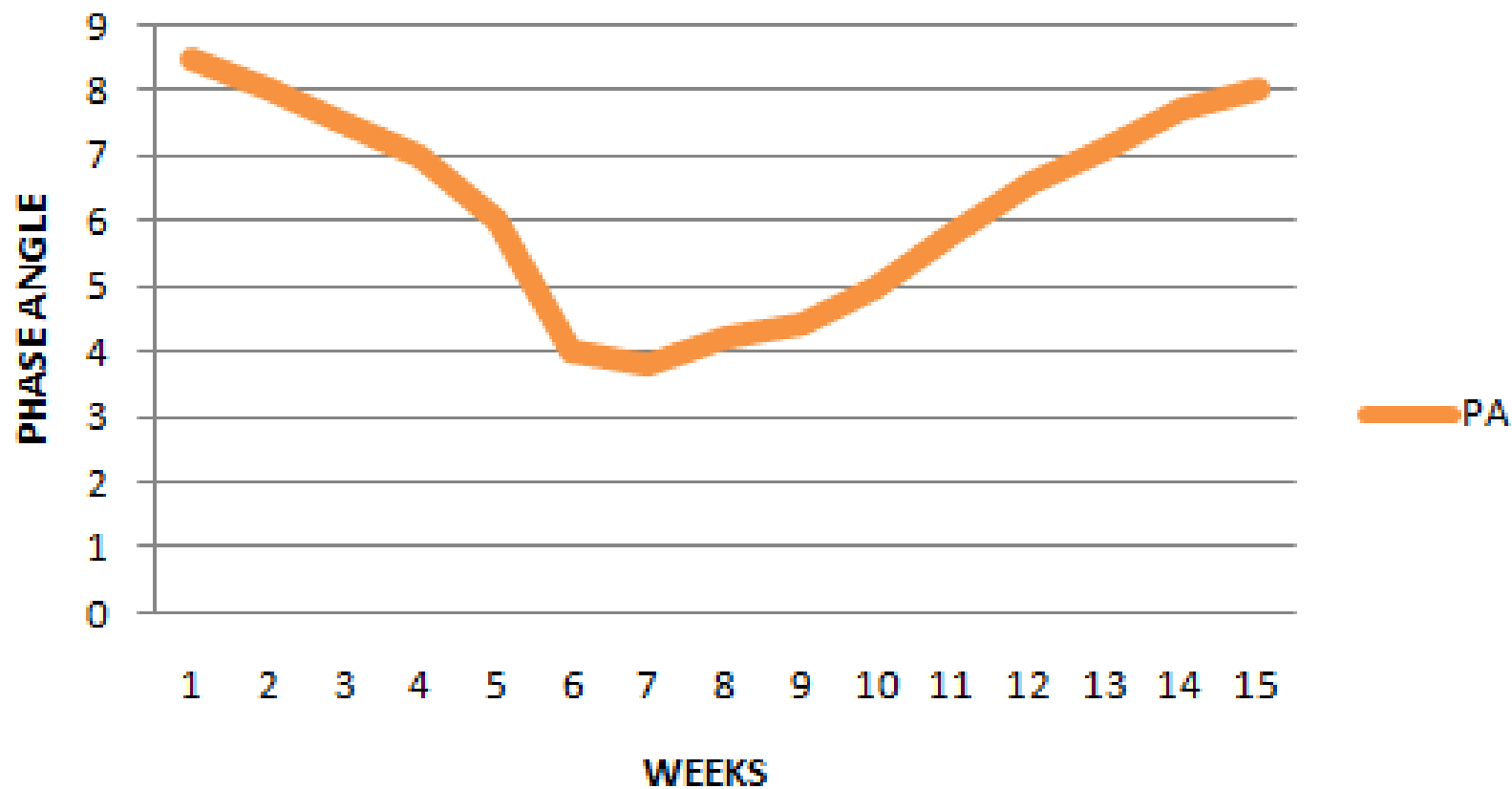
Average Impedance Values



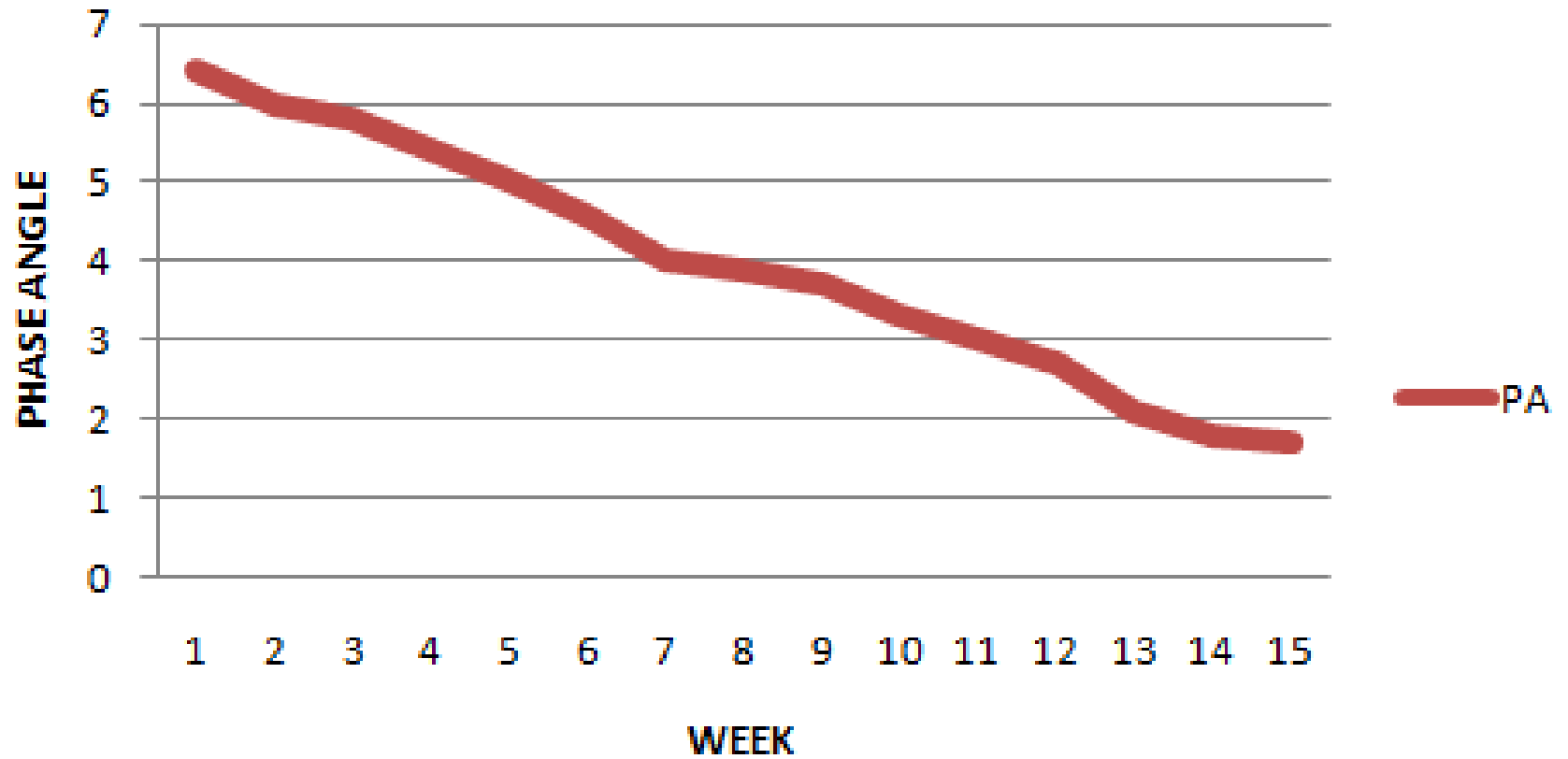
AVERAGE PHASE ANGLE VALUES BY AGE & GENDER

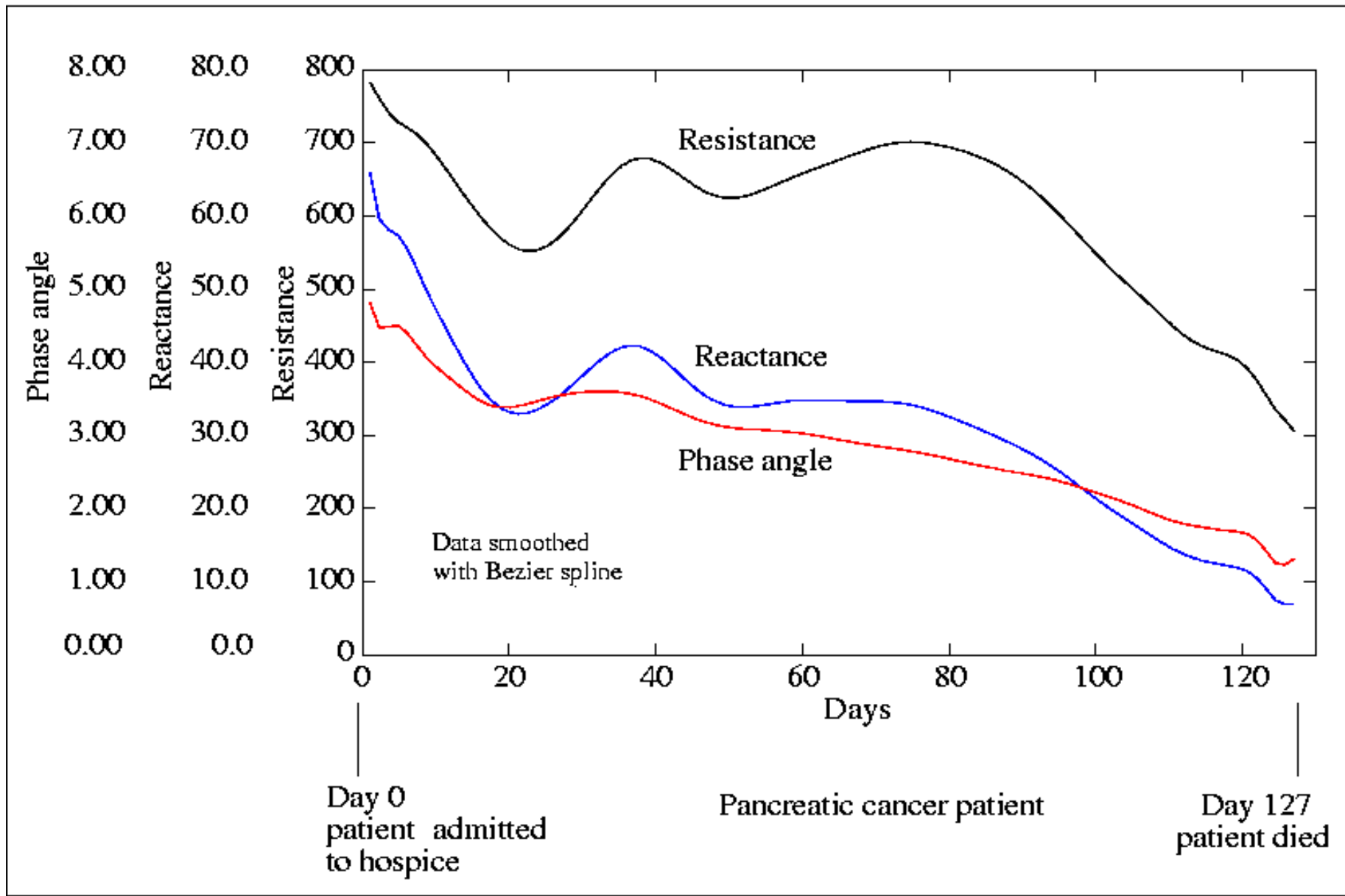


Serious Illness with Recovery Upon Effective Treatment



End of Life Trajectory





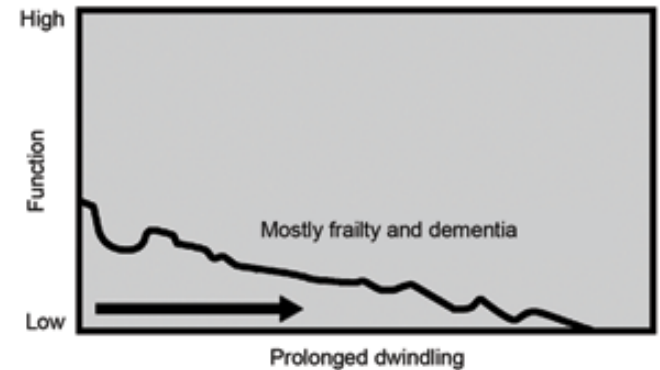
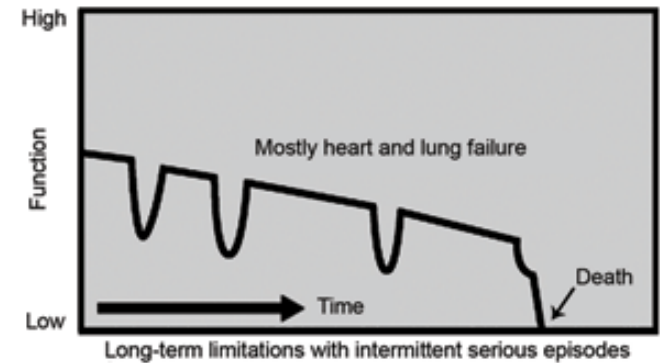
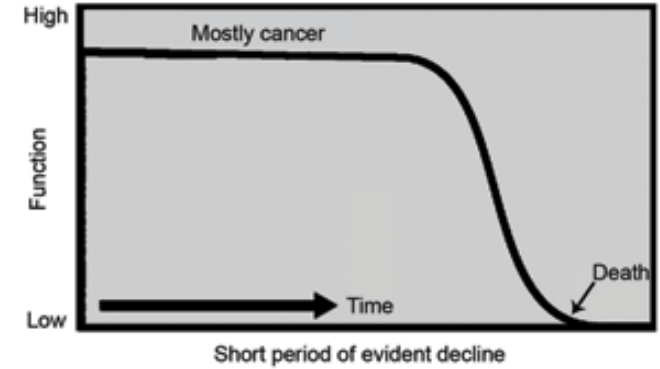
Frailty = Burden of Disease

Frailty is measured by subtracting the patient's phase angle value from the average for their age and gender.

If the average value is 7° and the measured value is 5.5° then the Frailty index is 1.5

The reduced value on the vertical axis is the lost vitality and reduced distance to mortality.

Typical Chronic Illness Trajectories



Phase angle is a highly precise and sensitive index of a patient's individualized expression of their disease condition that includes the cumulative frailty (Burden of Illness), disease progression, treatment effectiveness and timing of non-acute death (survival). It provides the Physician, Patient and Family with better information to make better healthcare decisions.



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