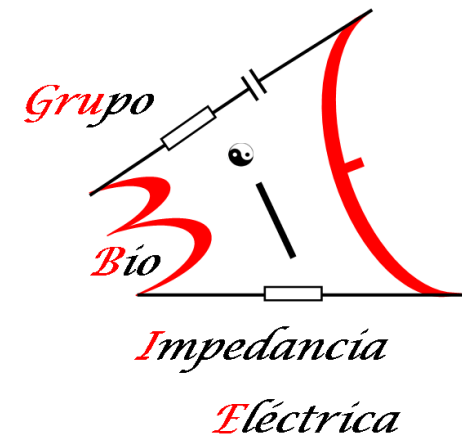


A PLEA FOR SOME STANDARDIZATION IN ELECTRICAL BIOIMPEDANCE



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MD, PhD.**

**Emeritus Researcher at the
Colombian Ministry of
Science (Min-Ciencias).**



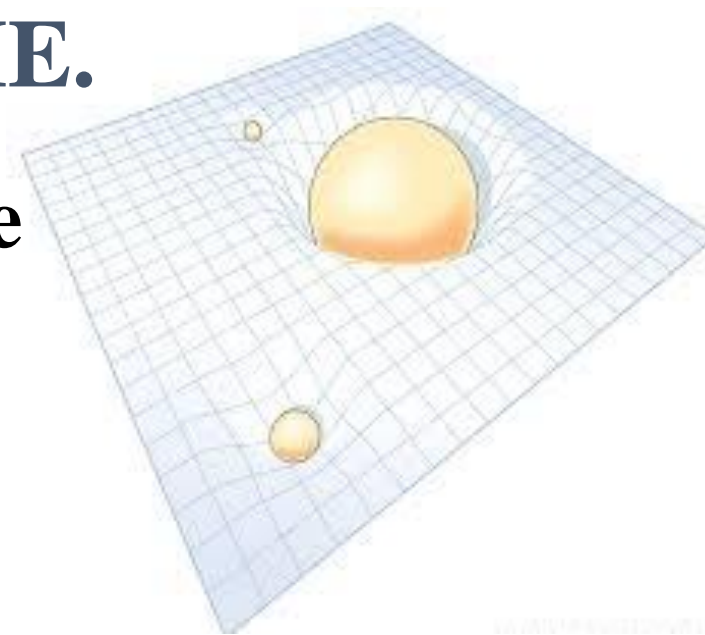
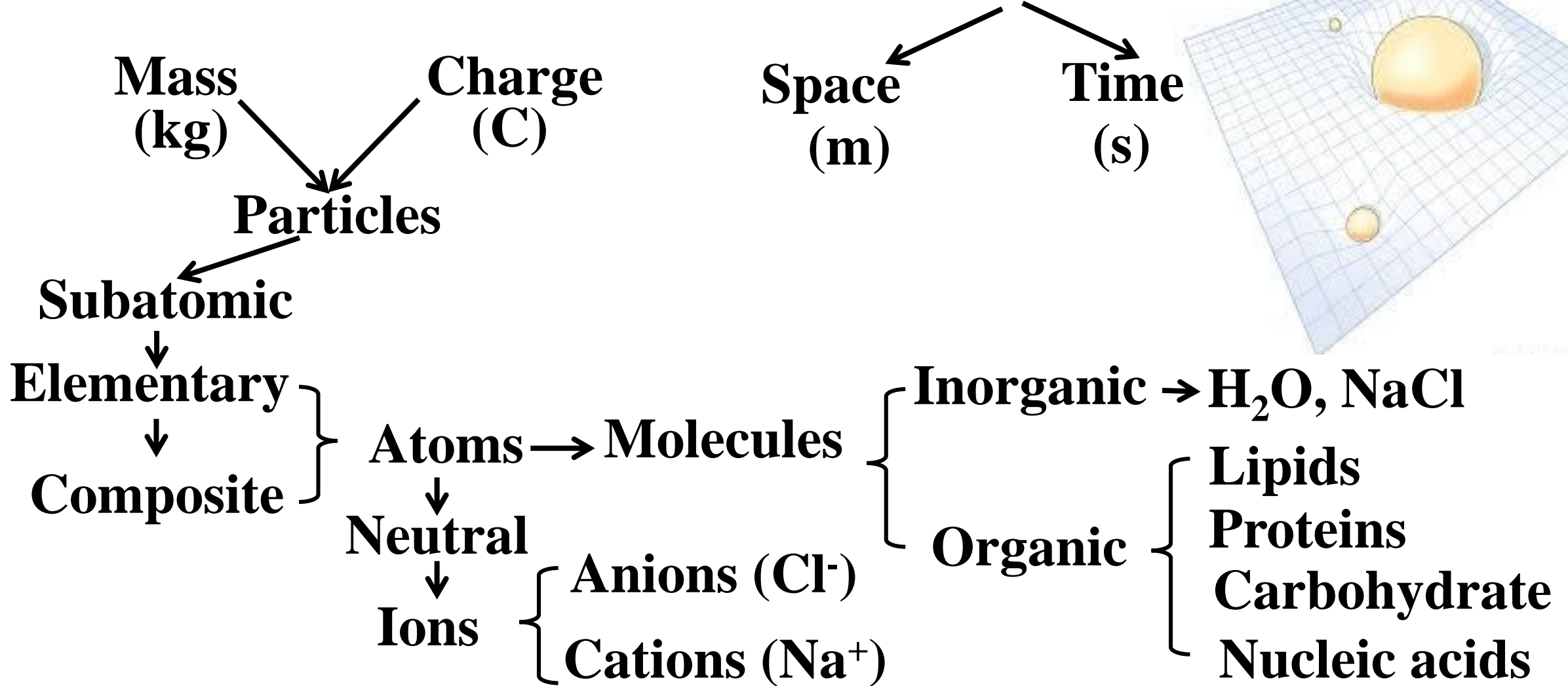
c.gonzalez@ucaldas.edu.co

**Creator of the Doctoral Program (in network)
in Biomedical Sciences at the Colombian Coffee
Ecoregion**



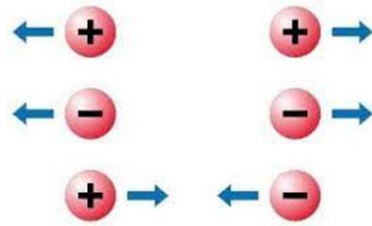
UNIVERSITY OF OSLO

UNIVERSE: MATER IN THE SPACETIME.

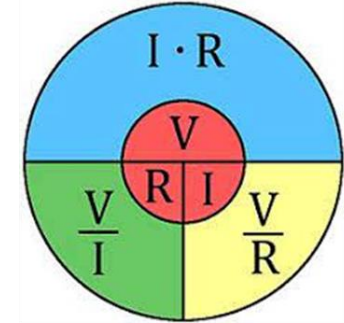


PHYSICAL ASPECTS

Coulomb's law of electrical charges



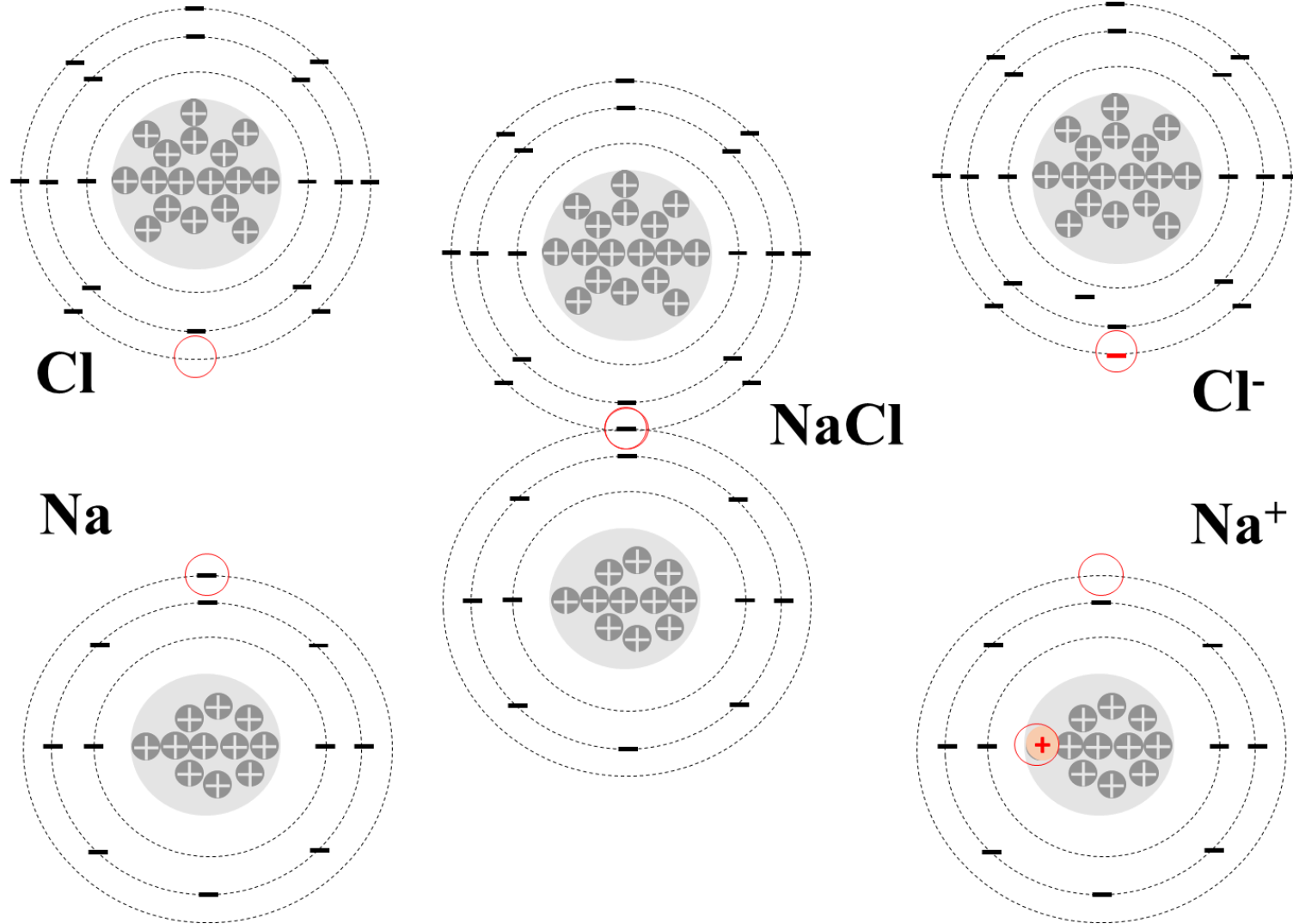
Ohm's law



Electric current is nothing else than the **movement of electrical charges** (whatever they are: electrons, protons or ions) through a medium. The forces that produce this movement can be either a voltage or a chemical concentration gradient (as in excitable cells).

Electrical impedance is the ratio between the force (V) needed to generate a specific alternate current at a specific frequency through a specific object.

BIOELECTRICITY



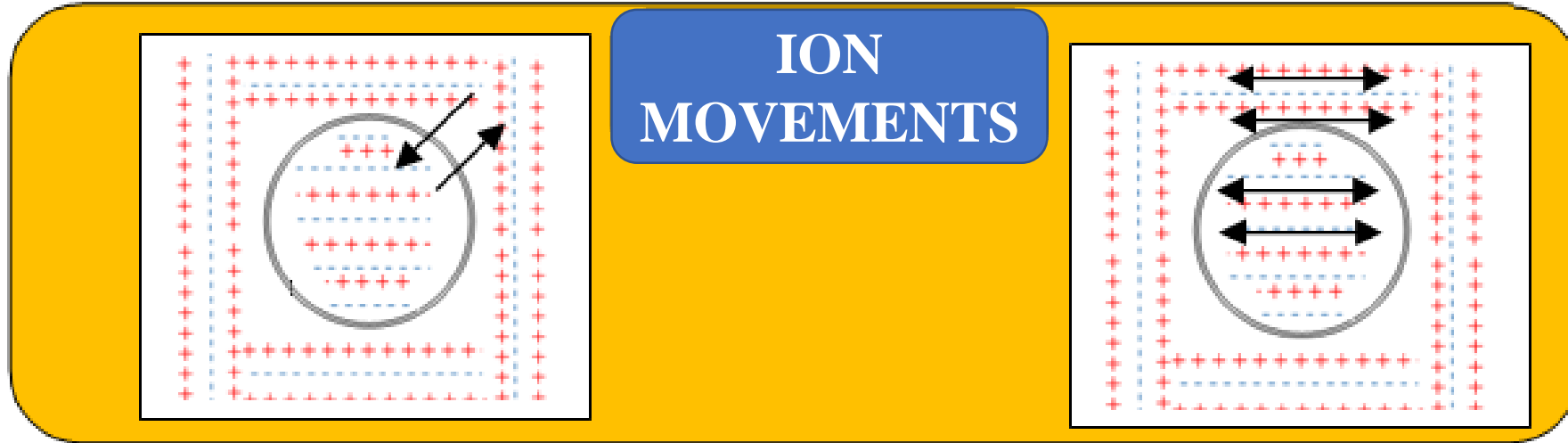
ELECTRICITY

Electronics: (electrons)

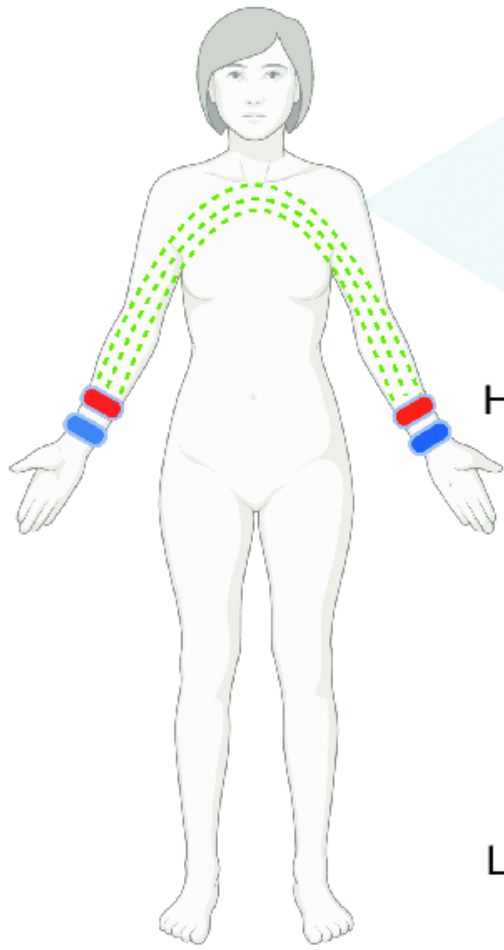
Bioelectricity: (ions)

Electrophysiology

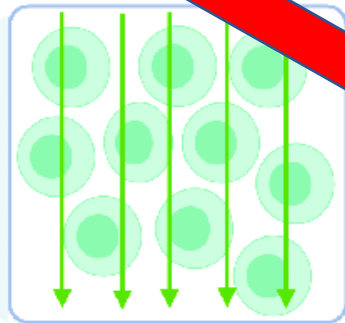
Electrical Bioimpedance



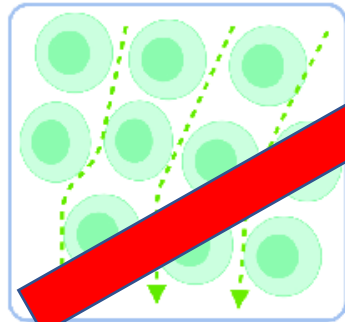
!!!THIS IS NOT TRUE!!!



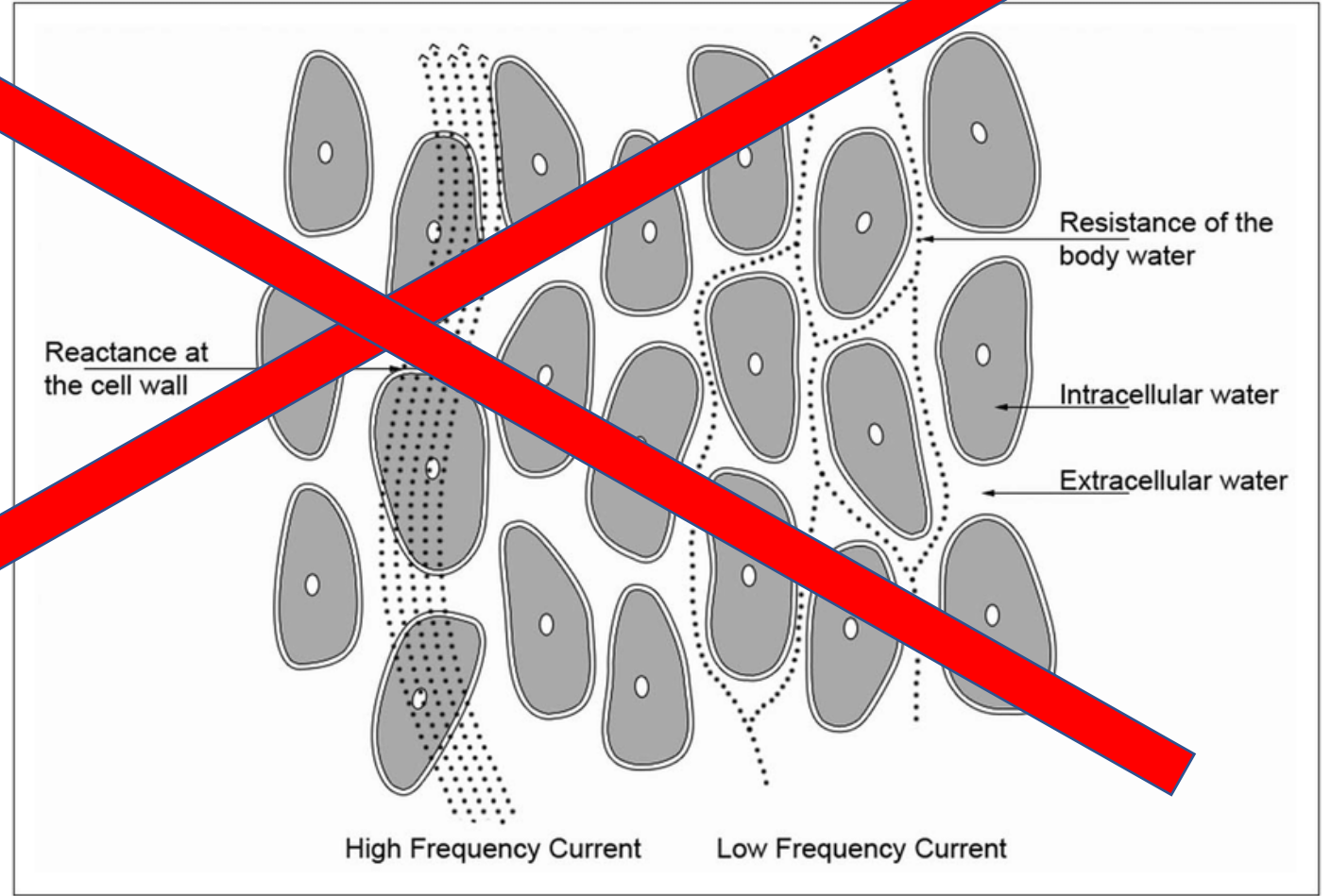
Subcutaneous tissue



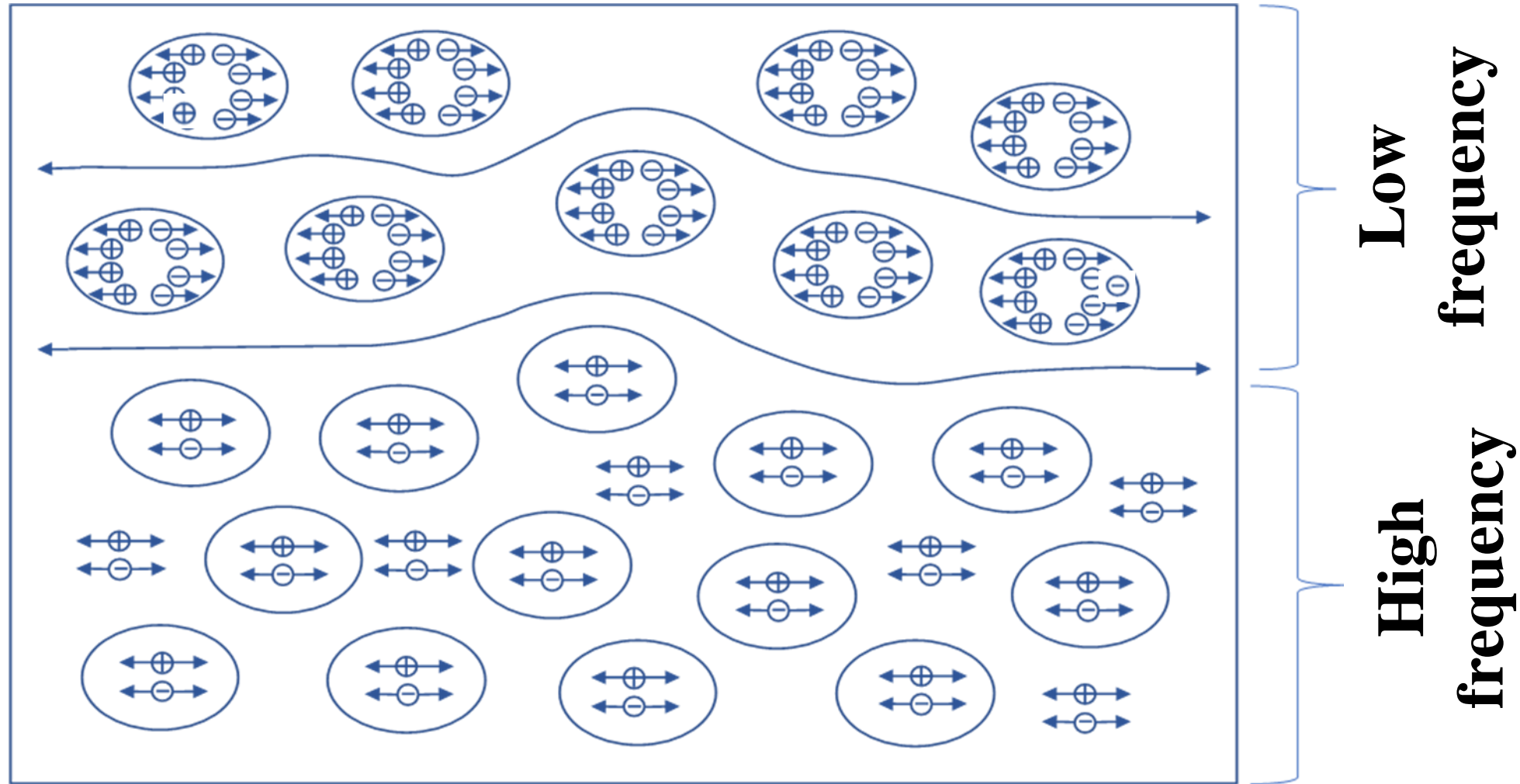
High frequency current flow



Low frequency current flow



THE TRUTH IS:



Low
frequency

High
frequency

TERMINOLOGY

| f | R | Xc | Z | ϕ (AF) |
|-----|----------|----------|----------|-------------|
| kHz | Ω | Ω | Ω | $^{\circ}$ |
| 5 | 866.4 | 40.7 | 867.3 | 2.7 |
| 10 | 847.6 | 60.2 | 849.8 | 4.1 |
| 20 | 813.1 | 80.3 | 817.1 | 5.6 |
| 31 | 784.2 | 88.6 | 789.2 | 6.4 |
| 50 | 751.4 | 91.7 | 757.0 | 7.0 |
| 100 | 706.9 | 87.5 | 712.3 | 7.1 |

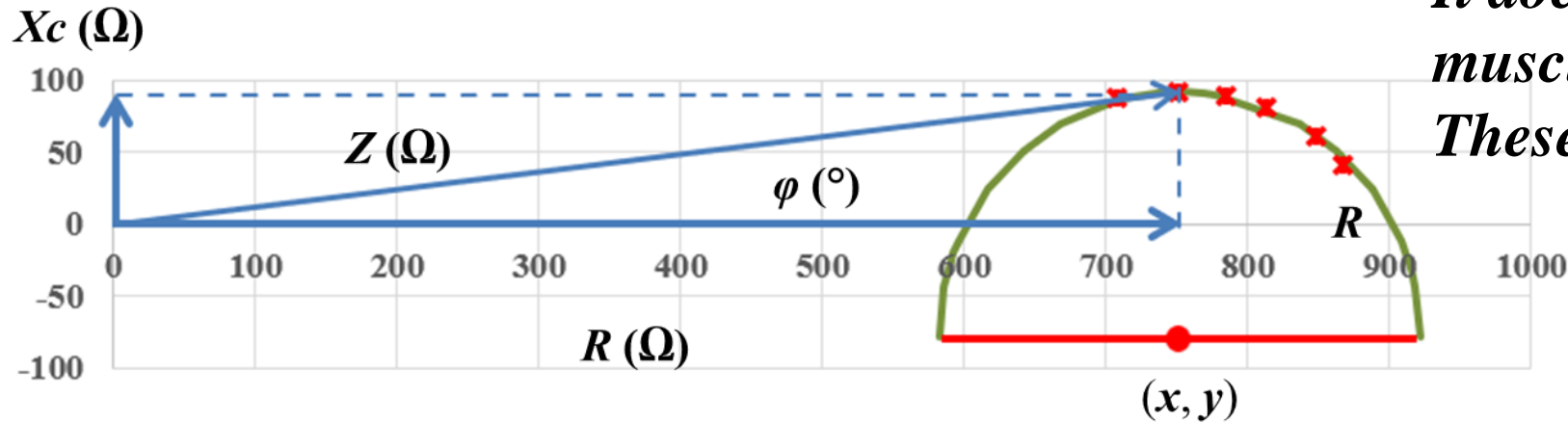
$x = 752.1$ $y = -77.8$ $r = 169.5$

$R = Z'$ = real part of the impedance

$Xc = Z''$ = imaginary part of the impedance

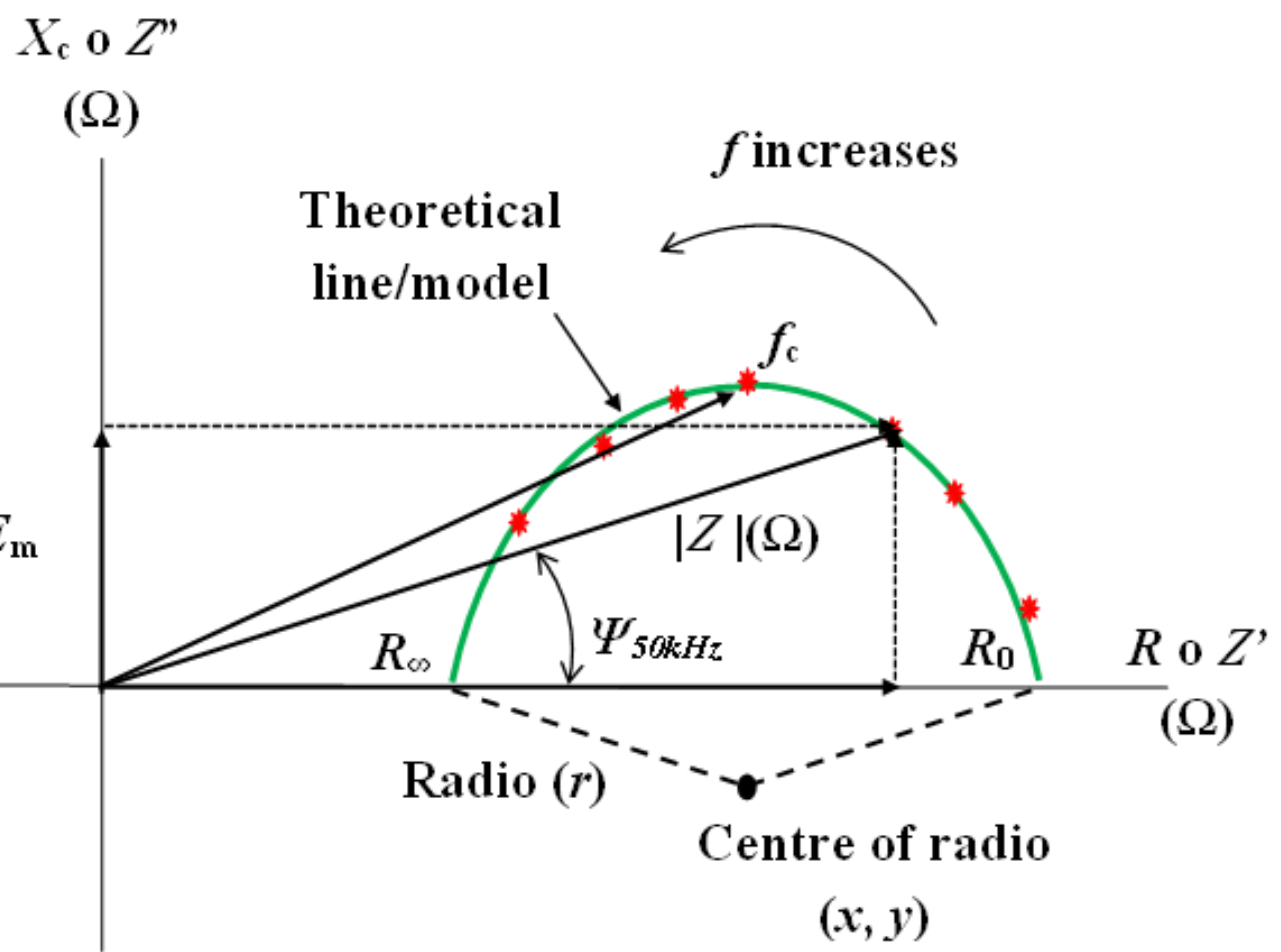
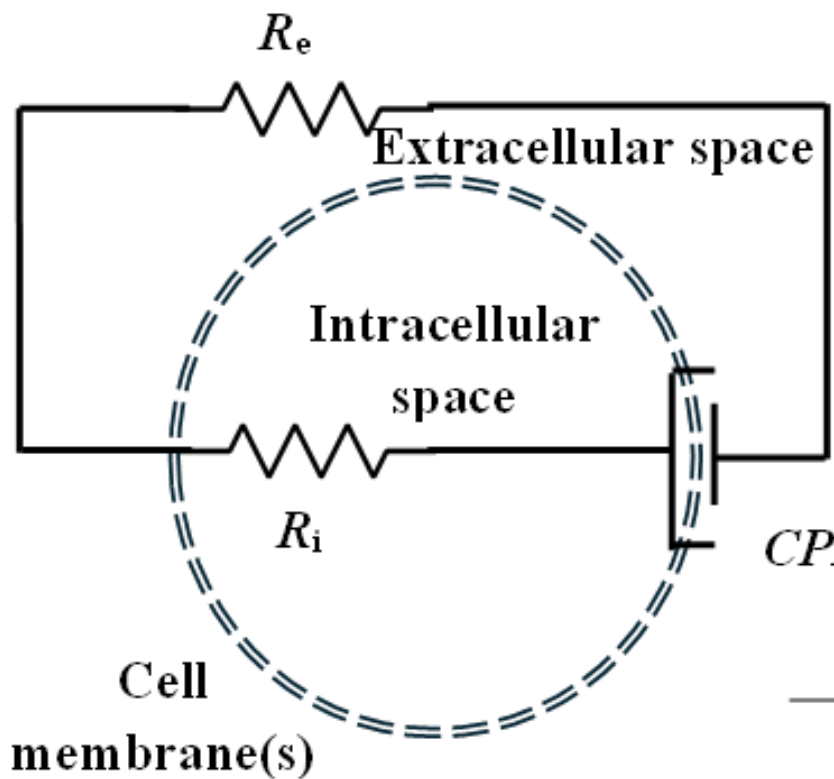
$Z = R + jXc$

$Z = \sqrt{R^2 + Xc^2}$



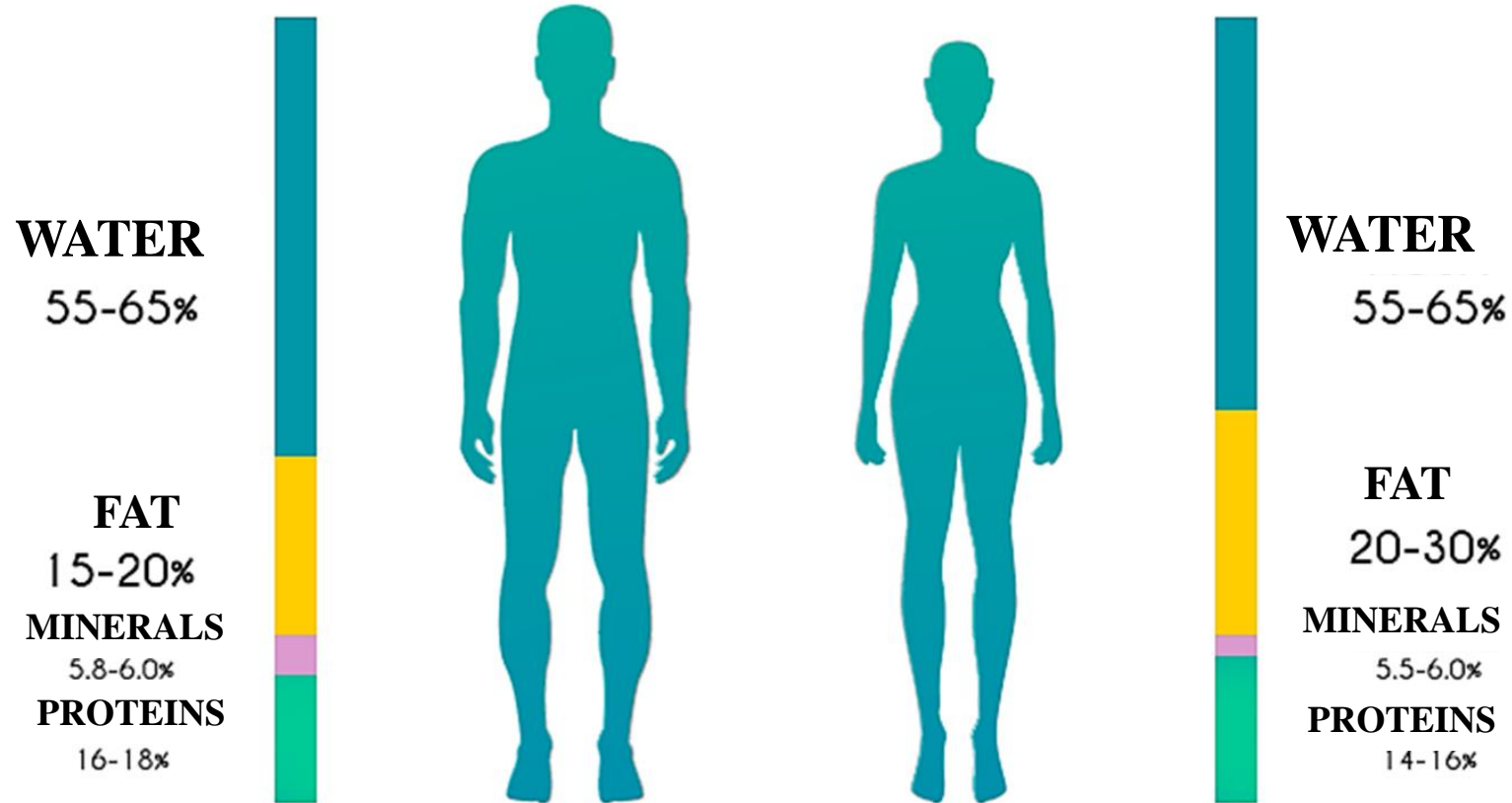
*This is all what EBIS measures.
It does not measures water,
muscle, fat or anything else.
These are all CALCULATED.*

MODELS: PHYSICAL, ELECTRICAL, MATHEMATICAL AND GEOMETRICAL



$$Z(\omega) = R_\infty + \frac{R_0 - R_\infty}{1 + (j\omega\tau)^\alpha}$$

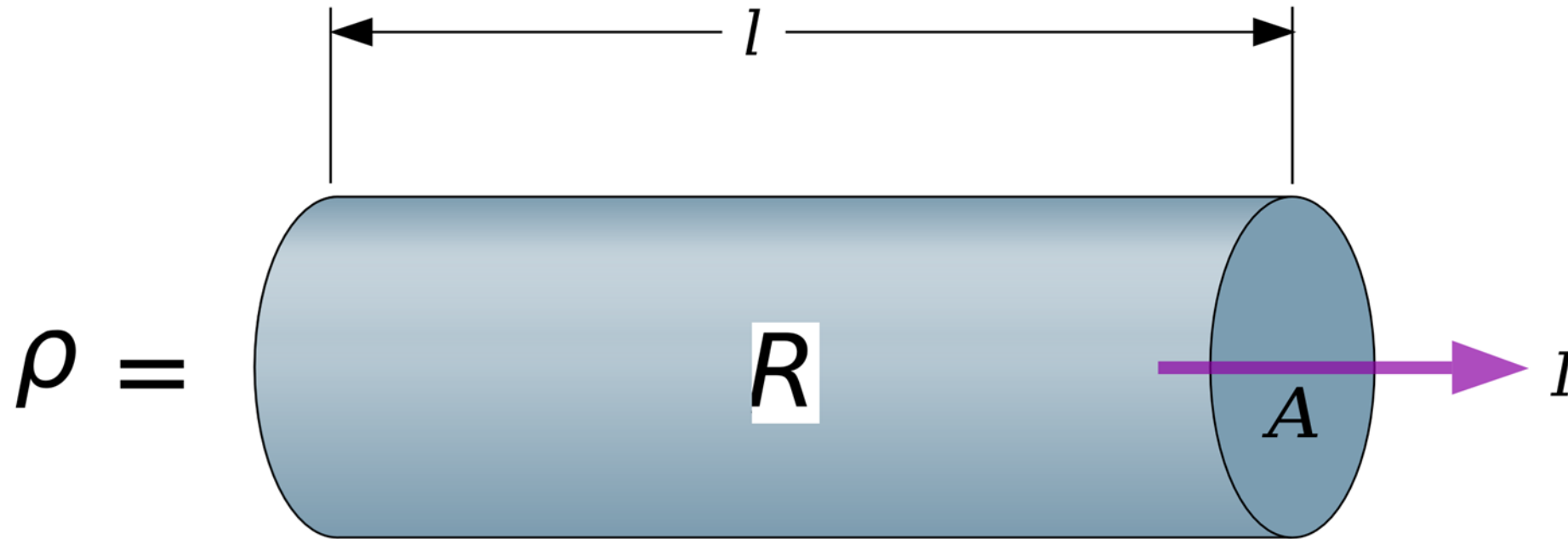
BODY COMPOSITION



HUMAN MICROBIOTA \approx 3%, MOST OF IT IN THE GUT(HIMB), ESPECIALLY IN THE COLON.

<https://help.trainingym.com/es/knowledge/interpretaci%C3%B3n-datos-b%C3%A1sculas-bioimpedancia>

RESISTIVITY vs RESISTANCE

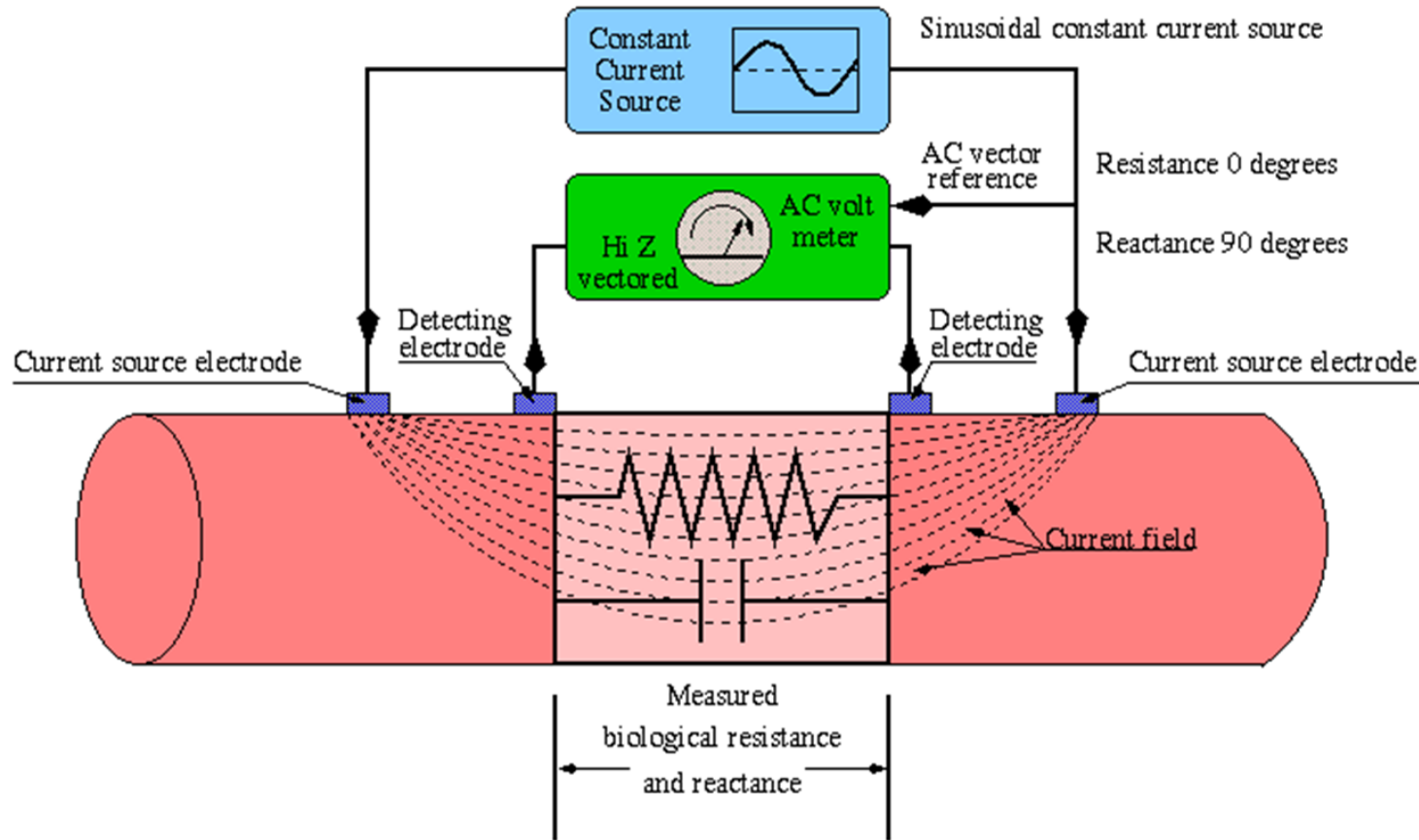


$\rho =$

$$\rho = R \frac{A}{l}$$

PHYSICAL MODEL IN BIA

How the RJL BIA Instruments work



M Abdel-Mageed S, I Mohamed E. Total Body Capacitance for Estimating Human Basal Metabolic Rate in an Egyptian Population. Int J Biomed Sci. 2016 Mar;12(1):42-7.

FACTORS AFFECTING BIA RESULTS



Campa *et al* 2024. High-standard predictive equations for estimating body composition using bioelectrical impedance analysis: a systematic review. *J Transl Med.* 2024 May 29;22(1):515. doi: 10.1186/s12967-024-05272-x.

Device used and the subject's:

- age,
- geographical ancestry,
- healthy status,
- physical activity level,
- gender.

106 predictive equations
19 (underage), 26
(adults), 19 (athletes), 26
(elderly), 16 (diseases)

Lukaski et al.-1988
Heitman et al.-1990
Zillikens et al.-1991
Guo et al.-1993
Jakicic et al.-1998
Janssen et al.-2000
Morrison et al.-2001
Leman et al.-2003
Pietrobelli et al.-2003
Kyle et al.-2003
Masuda et al.-2004
Kontogianni et al.-2005
Rush et al.-2006
Nielsen et al.-2007
Wickramasinghe et al.-2007
Sluyter et al.-2010
Oshima et al.-2010
Van Zyl et al.-2019
Dasgupta et al.-2019
Nguyen et al.-2020
Kanellakis et al.-2020
Xu et al.-2020
Gutiérrez Marin et al.-2021
Da Costa et al.-2022
Sardinha et al.-2023

EBIS AND TISSUE DAMAGE

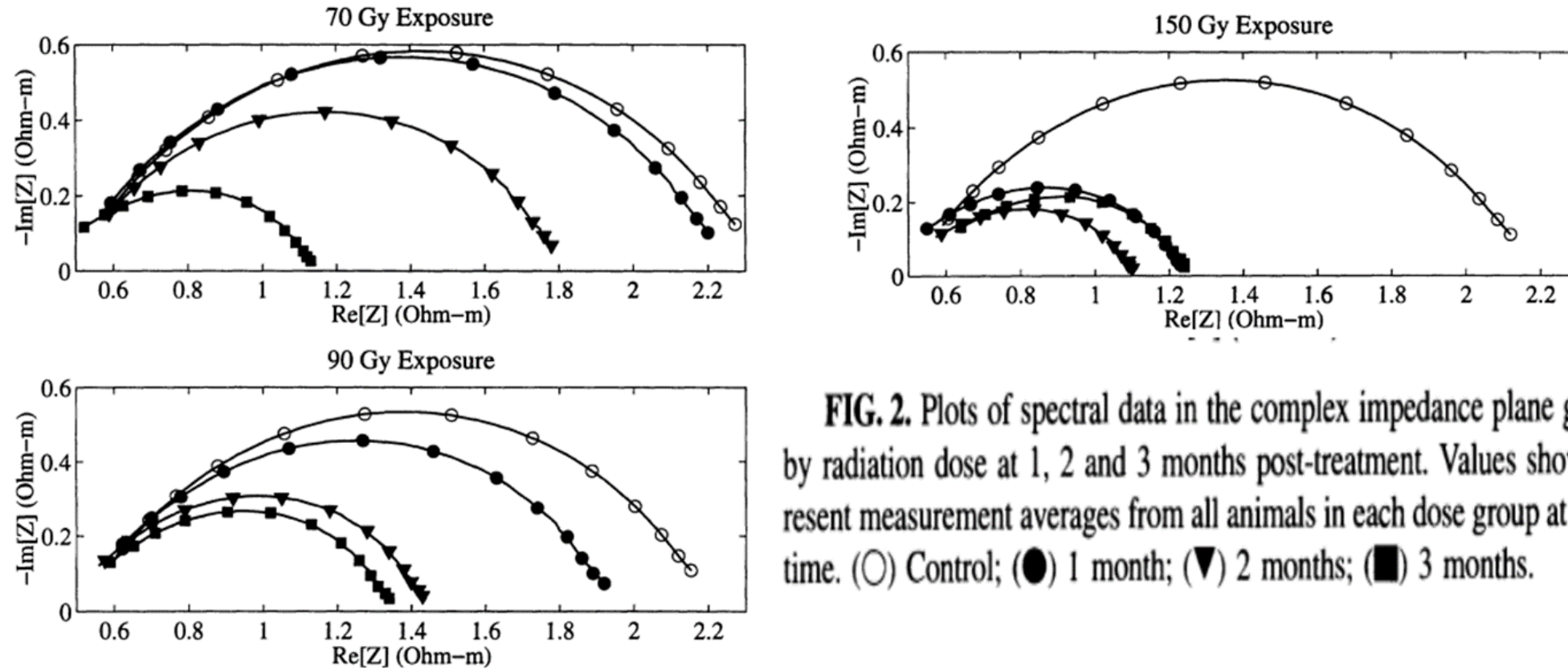
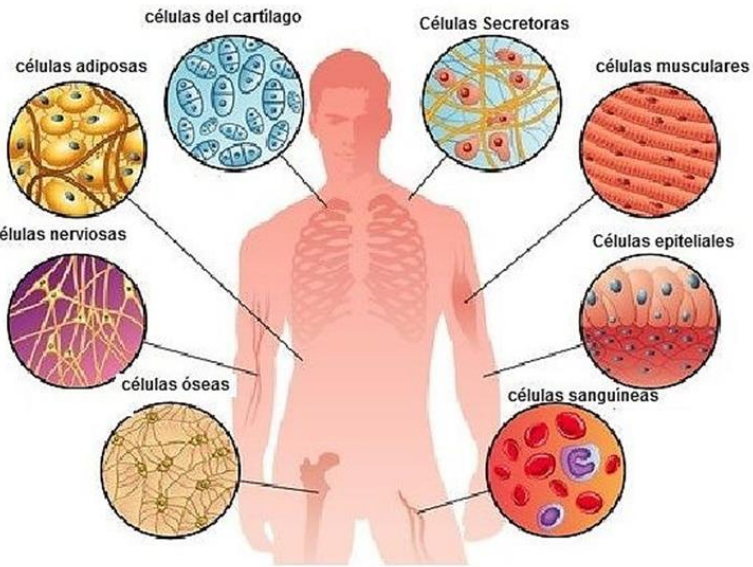


FIG. 2. Plots of spectral data in the complex impedance plane grouped by radiation dose at 1, 2 and 3 months post-treatment. Values shown represent measurement averages from all animals in each dose group at a given time. (○) Control; (●) 1 month; (▼) 2 months; (■) 3 months.

Paulsen *et al.* 1999. In vivo electrical impedance spectroscopic monitoring of the progression of radiation-induced tissue injury. *Radiat Res*;152(1):41-50. (Tissue: normal muscle, male Sprague-Dawley rats).

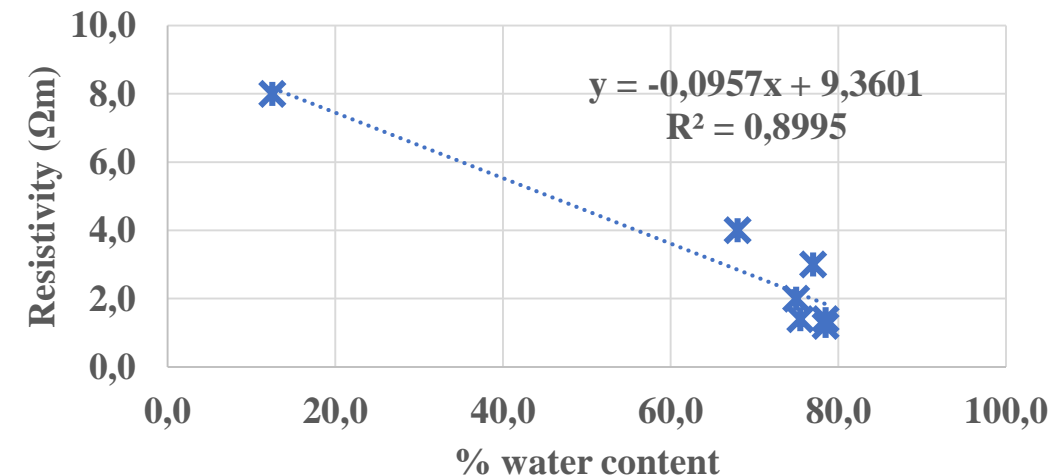
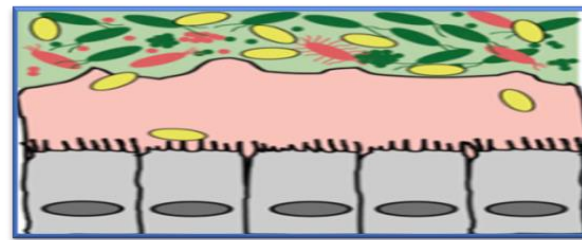
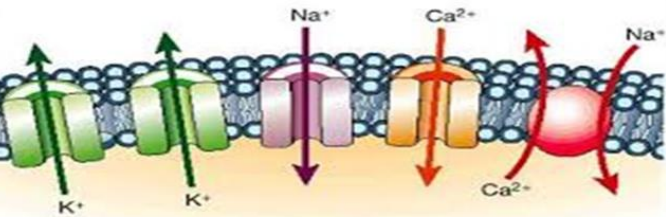
BIOLOGICAL TISSUES AND BARRIERS



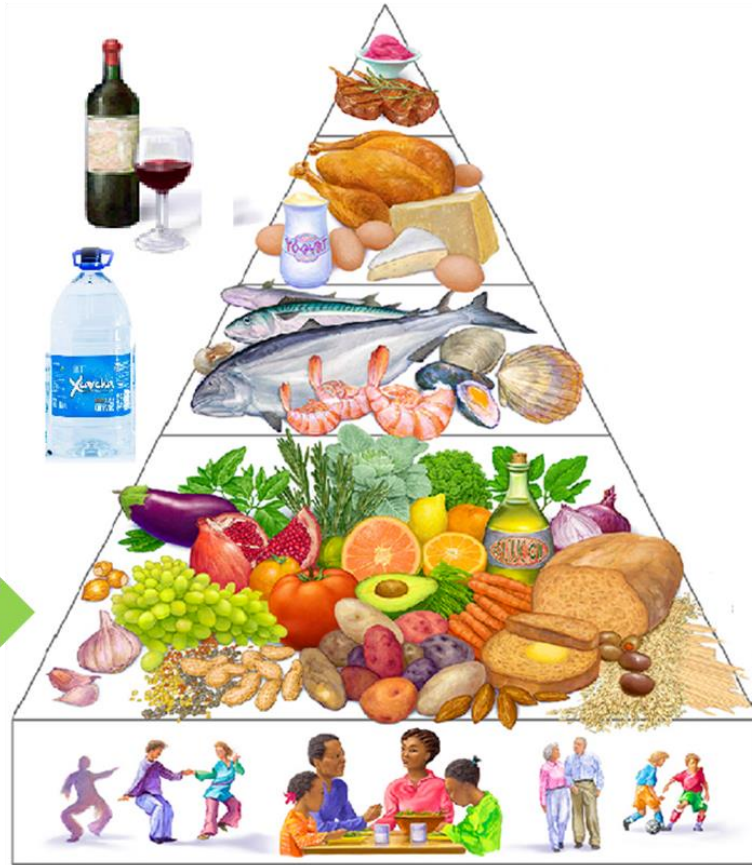
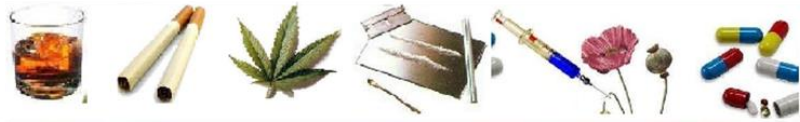
| Tissue | Water % | Resistivity Ωm |
|--------|---------|------------------------------|
| Kidney | 78.5 | 1.4 |
| Spleen | 78.5 | 1.2 |
| Brain | 77.0 | 3.0 |
| Liver | 75.0 | 2.0 |
| Mucle | 75.5 | 1.4 |
| Skin | 68.0 | 4.0 |
| Fat | 12.5 | 8.0 |

Correlation between water content and resistivity in human tissues

Cell membranes and epithelia



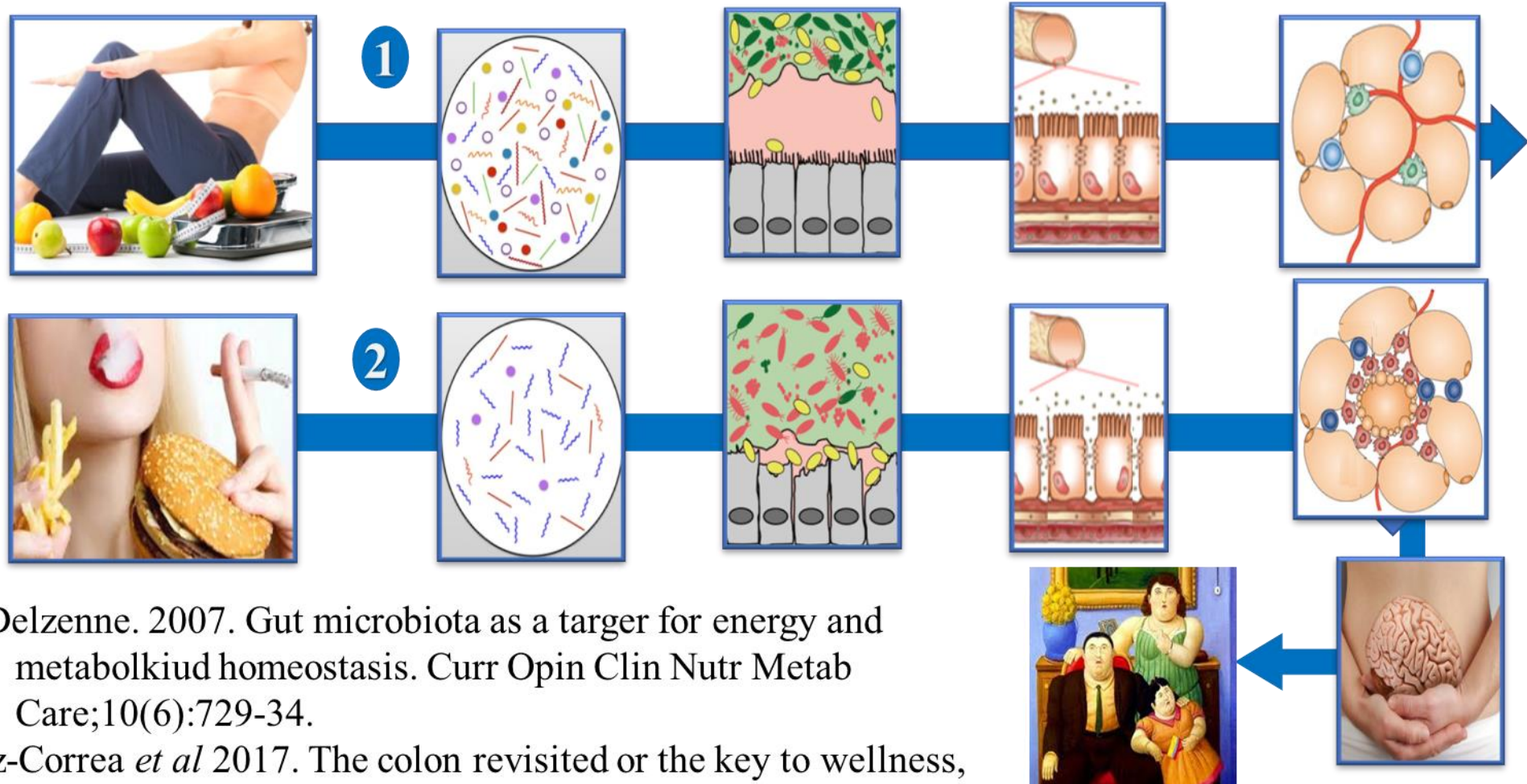
LIFE STYLE, HEALTH AND DISEASE



<https://www.pinterest.com/pin/461056080573868400/>

Healthy nutrition pyramid, according to the School of Nutrition at Harvard University

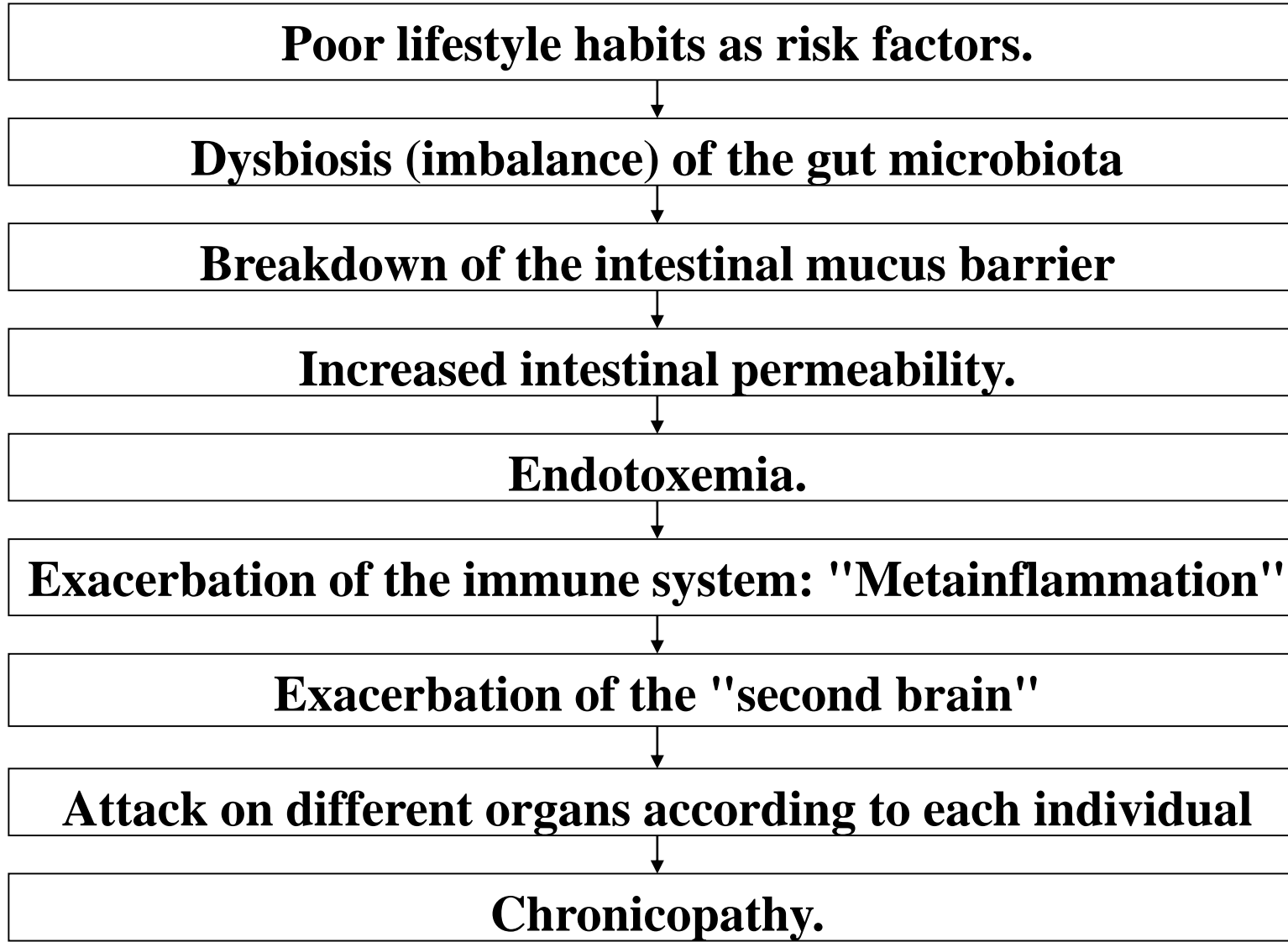
PHYSISOPATHOLOGY OF CRONICOPATHOLOGY



Cani & Delzenne. 2007. Gut microbiota as a target for energy and metabolite homeostasis. *Curr Opin Clin Nutr Metab Care*;10(6):729-34.

González-Correa *et al* 2017. The colon revisited or the key to wellness, health and disease. (*Medical Hypothesis*; 108:133-143).

PATHOPHYSIOLOGY OF CHRONICOPATHY



Medical Hypotheses

journal homepage: www.elsevier.com/locate/mehy

The colon revisited or the key to wellness, health and disease ^{††}

C.A. Gonzalez-Correa ^{2,*}, E. Mulett-Vásquez ², D.A. Miranda ³, C.H. Gonzalez-Correa ¹, P.A. Gómez-Buitrago ²

González-Correa et al
2017. The colon revisited
or the key to wellness,
health and disease.
(Medical Hypothesis;
108:133-143).

METAINFLAMMATION & EBIS

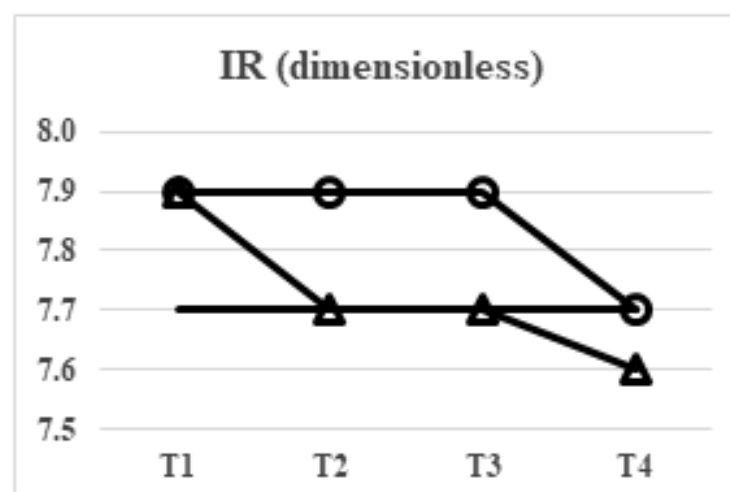
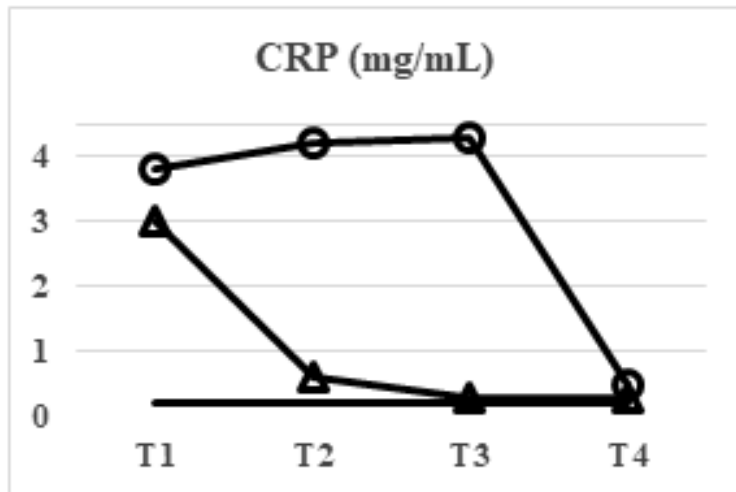
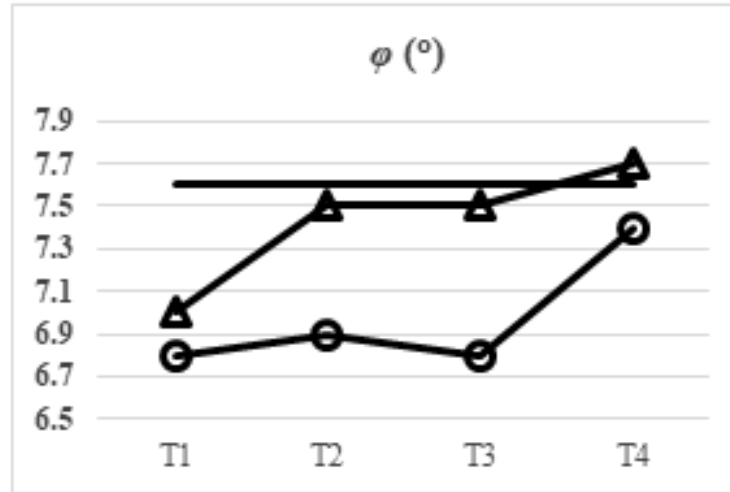
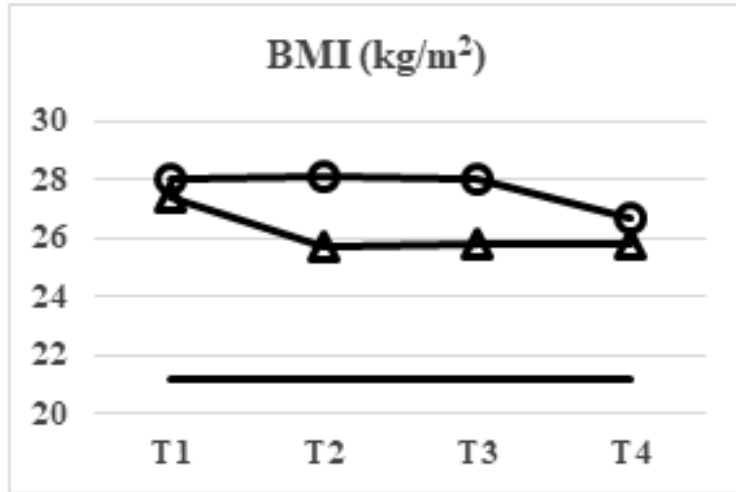
HIMB modulation (T1: start, T2 12 days, T3 24 days, T4 36 days).

Experimental Group ($n=6$)

○ Control Group ($n=5$)

△ Lean Group ($n=9$)

Tapasco-Tapasco LO, Gonzalez-Correa CA, Letourneur A. 2023. Phase angle and impedance ratio as meta-inflammation biomarkers after a colon cleansing protocol in a group of overweight young women. En revision.



I ADVOCATE FOR:

1. Not stating anymore that the electrical **current “crosses” the cells** at higher frequencies.
2. All devices should provide readings for a minimum of **3 well established frequencies** (i.e., 5, 50 & 100 kHz), as well as give the **parameters for the Cole and the geometrical model**.
3. All devices should give the possibility of using **any of the published equations**.
4. All devices should be **calibrated against a well-defined electrical dummy** so that they give the same readings.
5. Values should be converted to **resistivity**, rather than using raw data.
6. Researchers should try to develop **a universal equation** for body composition.
7. Many **other impedance indexes** should be explored, like PA_{max} (instead of PA_{50kHz}) and Z_{∞}/Z_0 (instead of Z_{200kHz}/Z_{05kHz}) and geometrical factors developed for planar arrays.
8. **Metainflammation** is common to all chronic diseases and should be more explored, for instance with PA_{max} .

!Thanks!

