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**SEMMELWEIS  
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**Development of Complex Curricula for Molecular Bionics and Infobionics Programs within a consortial\* framework\*\***

Consortium leader

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Consortium members

**SEMMELWEIS UNIVERSITY, DIALOG CAMPUS PUBLISHER**

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# ELECTROPHYSIOLOGICAL METHODS FOR THE STUDY OF THE NERVOUS- AND MUSCULAR-SYSTEMS

(Az ideg- és izom-rendszer elektrofiziológiai vizsgálómódszerei)

## LECTURE 1

# INTRODUCTION

(Bevezetés)

**RICHÁRD CSERCSA, ISTVÁN ULBERT  
and GYÖRGY KARMOS**

## AIMS OF THE COURSE:

- In this course the students will become familiar with the topic of electrophysiology, the major recording techniques, and the relationships among the fields of bioelectromagnetism.
- They will see examples of electrophysiological techniques and devices used in neuroscience research and in every day's clinical practice.

## LECTURES OF THE COURSE:

1. Introduction
2. History of electrophysiology
3. Membrane properties, resting potential
4. Action potential
5. Properties and characteristics of electrodes
6. Methods of intra- and extra-cellular microrecording
7. Electroencephalography
8. Event-related potentials
9. Processes responsible for the generation of brain bioelectric signals
10. Magnetoencephalography
11. Electromyography
12. Methods for analysing the bioelectric signals

# INTRODUCTION

- Definition of electrophysiology
- Bioelectric signals
- Bioelectromagnetism
- Psychophysiology
- Body area network
- Review questions

## DEFINITION:

Electrophysiology (from Greek ἤλεκτρον, ēlektron, "amber"; φύσις, physis, "nature, origin"; and -λογία, -logia) is the study of the electrical properties of biological cells and tissues. It involves measurements of voltage change or electric current on a wide variety of scales from single ion channel proteins to whole organs like the heart. In neuroscience, it includes measurements of the electrical activity of neurons (and glia), and particularly action potential activity.

(<http://en.wikipedia.org/wiki/Electrophysiology>)

# ELECTROPHYSIOLOGY ON THE INTERNET

**Science Direct:** >120 neuroscience journals

e.g. „Journal of Neuroscience Methods”  
„Clinical Neurophysiology”

**Google:**

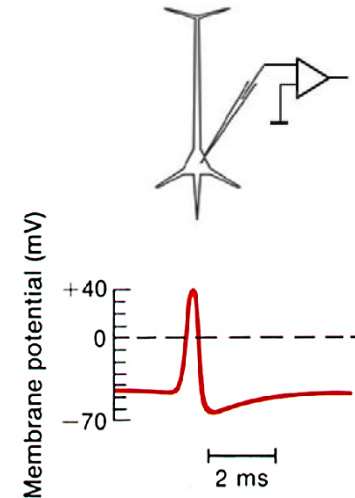
1 750 000 matches for „*electrophysiology*”

**Wikipedia:**

Category: Electrophysiology: 91 pages  
+Cardiac electrophysiology: 116 pages

## BIOELECTRIC SIGNALS

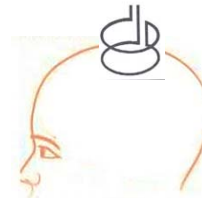
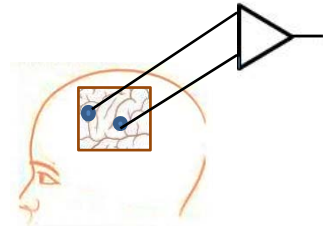
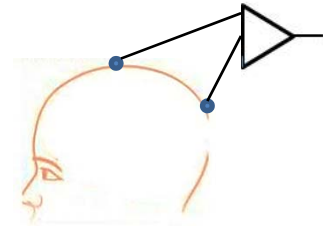
- **Membrane Potential (MP):** voltage difference measured between the interior and exterior of a cell (see lecture 3)
- **Action Potential (AP):** a rapid rise and fall in membrane potential, with a defined shape. Brief all-or-none regenerative process that propagates across an axon or muscle fiber (see lecture 4)
- **Single neuron activity (SUA):** action potentials of a given cell (see lecture 6)
  - intracellular unit activity: measured inside the cell
  - extracellular unit activity: measured outside the cell
- **Multiunit activity (MUA):** action potentials of multiple cells (always measured outside the cell) (see lecture 6)





## BIOELECTRIC SIGNALS

- **Electroencephalogram (EEG):** summated electrical activity of large number of neurons of the brain measured by electrodes on the scalp (see lecture 7)
- **Electrocorticogram (ECoG):** summated electrical activity of large number of neurons of the brain measured on the surface of the neocortex (see lecture 7)
- **Magnetoencephalogram (MEG):** magnetic activity of the brain (see lecture 10)



## BIOELECTRIC SIGNALS

- **Event-related potential (ERP):** electrical response of the brain to an internal or external stimulus, or event with a defined shape (see lecture 8)
  - Evoked potential (EP):** response of the brain to an external stimulus
    - Visual (VEP): response of the brain to a visual stimulus
    - Auditory (AEP): response of the brain to an auditory stimulus
    - Somatosensory (SEP): response of the brain to a somatosensory stimulus
- **Optical imaging: brain (electrical) activity measured with optical devices**
  - Voltage sensitive dyes (VSD): dyes that change their color due to change in voltage

## BIOELECTRIC SIGNALS

- **Electromyogram (EMG):** electrical activity of muscles (see lecture 11)
  - Surface EMG (SEMG): measured on the surface of the skin
  - Single Fiber EMG (SFEM): measured in the muscle
  - Motor Unit Action Potential (MUAP): the action potential of one motor neuron
- **Electroneurogram (ENG):** collective name of compound action potentials recorded from peripheral motor or sensory nerves
- **Electroretinogram (ERG):** electrical activity of the retina
- **Electrooculogram (EOG):** measure of electrical signals created by the movement of the eyes, measured by electrodes placed on the skin around them
- **Electrodermal activity (EDA) / galvanic skin response (GSR):** a change in the ability of the skin to conduct electricity

# BIOELECTRIC SIGNALS

- Electrocardiogram (ECG): electrical activity of the heart
  - High frequency ECG (HFECG): additional information in the 150-250 Hz band
  - His-Bundle Electrogram (HBE): intracardiac electrogram from near the right atrioventricular valve
  - Right Atrial Electrogram (RAE): electrical activity of the right atrium
  - Right Ventricular Electrogram (RVE): electrical activity of the right ventricle
  - Vectorcardiogram (VCG): magnitude and direction of the electrical currents of the heart in the form of a vector loop
- Magnetocardiogram (MCG): magnetic activity of the heart

# BIOELECTROMAGNETISM

BIOELECTRICITY	BIOELECTROMAGNETISM	BIOMAGNETISM
MEASUREMENT OF FIELDS		
Electric field from bioelectric source	Magnetic field from bioelectric source	Magnetic field from magnetic material
STIMULATION		
Electric stimulation with electric field  Electrotherapy	Electric stimulation with magnetic field  Magnetoelectrotherapy	Magnetization of material  Magnetotherapy
MEASUREMENT OF INTRINSIC PROPERTIES		
Electric measurement of electric impedance	Magnetic measurement of electric impedance	Magnetic measurement of magnetic susceptibility

PRINCIPLE OF RECIPROCITY

← MAXWELL'S EQUATIONS →

# PSYCHOPHYSIOLOGY

Psychophysiology is the study of the physiological basis of human and animal behavior.

**Independent** variable: *psychological*, **dependent** variable: *physiological*.

*Systemic psychophysiology (underlying physiological systems):*

- central nervous system variables,
- cardiovascular system variables.

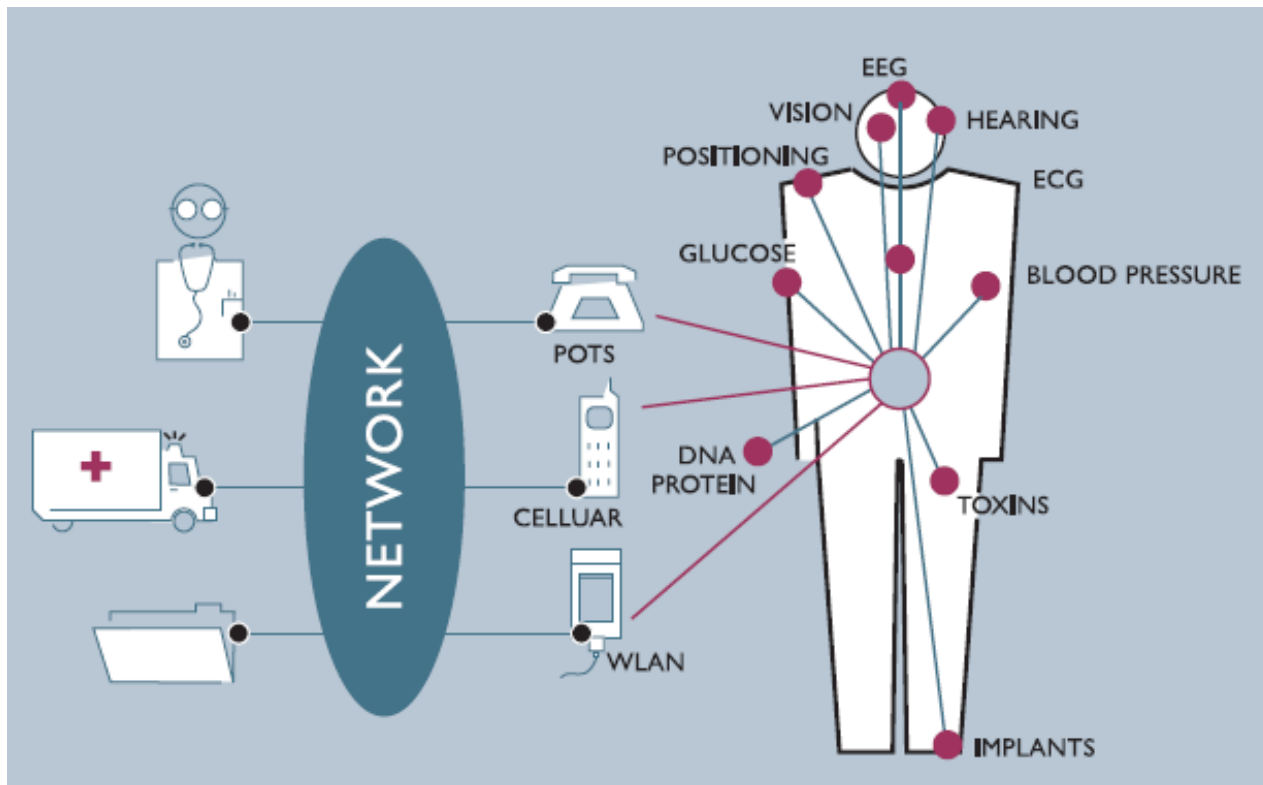
*Thematic psychophysiology (topical areas of research):*

- cognitive psychophysiology,
- affective psychophysiology
- developmental psychophysiology,
- social psychophysiology,
- clinical psychophysiology.

# IN THE LAB OF A PSYCHOPHYSIOLOGIST



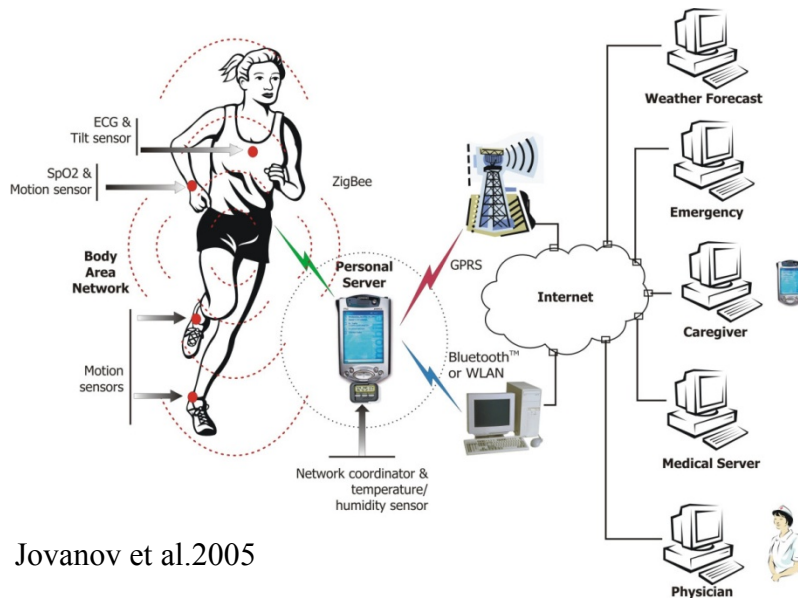
# FUTURE OF PSYCHOPHYSIOLOGY WIRELESS BODY AREA NETWORK



([www.imec.be](http://www.imec.be))



# WIRELESS BODY AREA NETWORK



Jovanov et al.2005

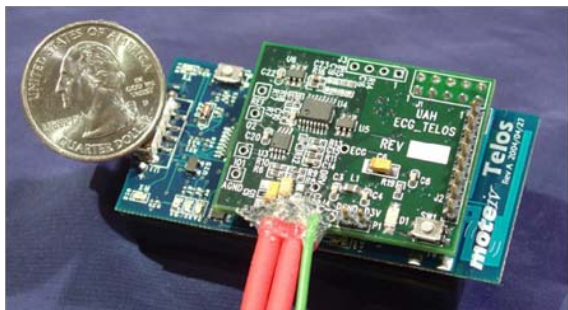
The Body Area Network (BAN) comprises a series of miniature sensor/actuator nodes, each of which has its own energy supply, consisting of storage and scavenging devices, and is also able to communicate with other sensor nodes or with a central node worn on the body. The central node communicates with the outside world by using a standard telecommunication infrastructure such as wireless local area and cellular phone networks. The network can deliver services to the person using the BAN. These services can include the management of chronic disease, medical diagnostics, home-monitoring, biometrics, and sports and fitness tracking.

<http://www.imec.be/ScientificReport/SR2007/html/1384156.html>

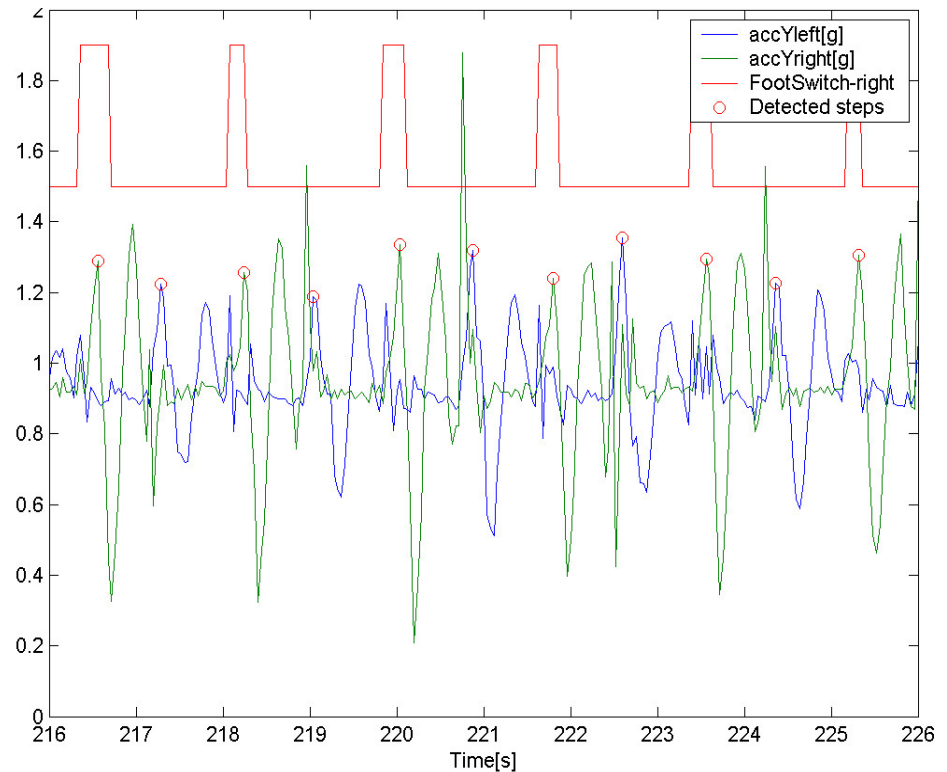
# STEP DETECTION USING ANKLE SENSORS



Activity sensor on an ankle with symbolic representation of acceleration components.



Telos wireless platform with intelligent signal processing daughtercard (ISPM)



Jovanov et al.: A wireless body area network of intelligent motion sensors for computer assisted physical rehabilitation.  
*Journal of NeuroEngineering and Rehabilitation*  
2005, 2:6 doi:10.1186/1743-0003-2-6 open access

## REVIEW QUESTIONS

- What is the topic of electrophysiology?
- What signals are used in electrophysiology?
- What are the fields of bioelectromagnetism?
- What is psychophysiology?
- What is a body area network?

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