REQUIREMENTS

Semmelweis University, Faculty of Medicine
Name(s) of the Institute(s) teaching the subject: *Gestor Institute*: Department of Physiology

Name of the subject: Cardiac Electrophysiology

Credits: 2

Total number of hours (semester): 28 lectures: 28 practices: - seminars: -

Type of the course (mandatory/elective): elective

Academic year: 2019/2020 academic year, II. semester

Code of the course[1]: AOVELT694_1A

Course director (tutor): András TÓTH, DSc.

Contact details: Semmelweis University, Department of Physiology; phone: +36-1-459-1500/60436

Position: External lecturer

Date of habilitation and reference number: 2009**; reference number:**

Aim of the subject and its place in the curriculum:

The course is intended to provide up-to-date and extended knowledge based on the latest literature for practically all medical students, especially those planning to be cardiologists or internists in order to meet a predictable future requirement of a strongly established knowledge related to the electrophysiological background and ion channel dependent pathomechanisms of severe, often lethal heart diseases and to facilitate their better understanding of the corresponding scientific literature. Their expected competent knowledge on cardiac electrophysiological mechanisms will significantly help young MDs to introduce novel, highly effective cardiopharmacological agents and/or to select optimal clinical therapeutic strategies. Via providing a detailed introspection into molecular and cellular basis of the electric activity of the heart the course is willing to offer the students an opportunity to collect an important section of these competences during their student years. During the course the motivated students may collect a comprehensive knowledge on:

- the biophysical basis of cardiac electrophysiology; the principles of operation and regulation of major cardiac ion channels
- the kinetic properties and regulation of ion currents generating cardiac action potentials; the significance of the repolarization reserve; the molecular background of substantial differences between atrial and ventricular and among various ventricular action potentials; and the basic pathomechanisms of arrhythmogenesis
- the principles of intracellular Ca^{2+} homeostasis in cardiomyocytes; the major mechanisms of excitation/contraction coupling; functional adaptation of the Ca^{2+}-cycle; pathomechanisms of Ca^{2+}-dependent and Ca^{2+}-facilitated heart diseases and several therapeutic strategies
- common genetic disturbances leading to malfunction of cardiac ion channels
- most important experimental techniques and animal models applied in experimental cardiac electrophysiology and the human/clinical relevance of the collected data

Finally a practical demonstration (13-th week) based on the material of the lectures is organized in order to help realistic, problem-oriented application of the theoretical knowledge via jointly processing experimental data derived from a few running scientific projects.

Location of the course (lecture hall, practice room, etc.): Semmelweis University; EOK; H-1094 Budapest, Tűzoltó u. 37-47.
Competencies gained upon the successful completion of the subject: Understanding of the human physiology which is foundation of medical practice.
Prerequisite(s) for admission to the subject: Medical Physiology 1 (the course is suggested for 2-4 year students)
Minimum and maximum number of students registering for the course: Minimum 5 and maximum 80 students **Student selection method in case of oversubscription:** chronology of registration in the NEPTUN system.
How to register for the course: Registration must be recorded through the NEPTUN system.

Detailed thematic of the course[2]:

1. week: **Introduction**
   - the role and importance of cellular level cardiac electrophysiology in medical practice
   - historical background
2. week: **Basic contexts of electrophysiology; propagation of stimulus in cardiac muscle**
   - biophysical principles of transcellular ion movements, Nernst equation, Donnan equilibrium, equilibrium potential
   - generation and maintenance of the resting potential
   - generation and propagation of the action potential (AP)
3. week**: Ion channels**
4. week: **Action potentials in the heart; major contributing ion channels/ion currents**
   - generation of the cardiac action potentials, fast and slow AP
   - atrial-ventricular and ventricular regional differences in action potentials and distribution of ion channels
   - Na^+ and Ca^{2+} specific ion channels and -currents
   - properties of various of K^+ currents (early/late, ultrarapid/rapid/slow, ATP-dependent, inward rectifying, etc.) and their role in the AP
5. week: **Developmental mechanisms of cardiac arrhythmias**
   - significance of the repolarization reserve, consequences of its decrease
   - mechanisms of generation of afterpotentials; extrasystole
   - ventricular arrhythmias: torsade de point (TdP), ventricular fibrillation
   - atrial fibrillation
6. week: **Experimental techniques in cardiac electrophysiology 1. – Microelectrode based measurements**
   - action potential measurements with conventional microelectrodes
   - ion current determinations using the „patch clamp" technique
7. week: **Ca^{2+} homeostasis in cardiac cells**
   - intracellular Ca^{2+} compartments
   - ion transport mechanisms involved in the Ca^{2+} cycle
   - cardiac Ca^{2+} transporters, their major characteristics and principles of function
   - the relationship between intracellular Ca^{2+} movements and AP repolarization
8. week: **The electromechanical coupling (ECc) and its regulation in cardiac cells**
   - regulation of the Ca^{2+} transport and -homeostasis
   - conditions for steady state activity of the heart
   - mechanisms of functional adaptation of the heart
9. week: **Perturbations of Ca^{2+} homeostasis and their role in development and progress of a number of heart diseases**
   - Pathomechanisms leading to cellular Ca^{2+} overload or Ca^{2+} deficit
   - Ca^{2+}-dependent and Ca^{2+}-facilitated heart diseases
   - afterpotentials and arrhythmogenesis; atrial fibrillation
   - ischemia/reperfusion injury
   - malignant hypertrophy and heart failure
10. week: **Experimental techniques in cardiac electrophysiology 2. Optical techniques**
    - basic principles of the application of fluorescent „tracer" molecules
    - „single" and „multichannel" measurements in isolated cardiomyocytes, isolated heart
    - novel, complex imaging (mapping) experimental techniques
11. week: **Experimental (animal) models and their clinical relevance**
    - the importance of experimental (animal) models in cardiology
    - small animal (mouse, rat, guinea pig) models
    - large animal (dog, rabbit, goat, etc.) models
    - human relevance of data and information derived from animal models
    - significance of human models and samples
12. week: **Genetic background of malfunction of cardiac ion channels**
    - „QT" syndromes and their genetic background
    - consequences of genetics originated disturbances of Ca^{2+} transporters
    - transgenic animal models
13. week: **Demonstration – principles of data evaluation and processing in cardiac electrophysiological measurements**
    - planning and implementation of microelectrode based cellular electrophysiological measurements – examples for processing of experimental data
    - planning and implementation of optical measurements in cellular electrophysiology – examples for quantitative processing of experimental data
    - the „normal" values; the significance of shifts in „measured values" in diagnostics of heart diseases
14. week: **Consultation**

Potential overlap(s) with other subjects: Minimal overlap with Medical Physiology 1 and Cardiology

Special training activities required[3]: -

Policy regarding the attendance and making up absences:

It is required to attend at least 75% of the lectures (10 lectures).

Missing attendance may be partially compensated at a consultation offered during the semester

Means of assessing the students' progress during the semester[4]:

Understanding of the material of the previous lectures will be verified by two „multiple choice" tests (10-10 questions) + interactive during the lectures

Requirement for acknowledging the semester (signature):

It is required to attend at least 75% of the lectures (10 lectures).

Missing attendance may be partially compensated at a consultation offered during the semester

Type of the examination:

Oral exam – five graded mark.

Exam requirements[5]:

The exam is based on material presented during the classroom lectures.

Active participation during lectures and/or good test results may substantially simplify the exam.

Type and method of grading[6]:

Two simple topics from the corresponding topic list will be picked randomly by the examinee.

The overall grade of the exam is the mean of two partial grades:

Excellent (5):	4.51 - 5.00
Good (4):	3.51 - 4.50
Satisfactory (3):	2.51 - 3.50
Pass (2):	2.00 - 2.50
Fail (1):	below 2.00

How to register for the exam:

Registration for the exam must be recorded through the NEPTUN system.

Opportunities to retake the exam:

According to The Study and Examination Policy

Literature, i.e. printed, electronic and online notes, textbooks, tutorials (URL for online material):

Obligatory:

- The material presented during the classroom lectures and made also available on-line.

Suggested:

- Ion channels for communication between and within cells; Erwin Neher Nobel Lecture, 1991
- Heart Rate and Rhythm Ed. O.N Tripathi, U. Ravens and M.C. Sanguinetti; Springer, 2011
- Excitation-Contraction Coupling and Cardiac Contractile Force D. Bers; Springer, 2001
- Basis and Treatment of Cardiac Arrhythmias Ed.: R.S. Kass, C.E. Clancy; Springer, 2006
- Electrical Diseases of the Heart Ed. I. Gussak, C. Antzelevitch; Springer, 2008
- Handbook of Cardiac Electrophysiology Ed. A. Natale; Informa UK, 2007
- Klinikai szív-elektrofiziológia és aritmológia Sz. Fazekas T., Merkely B., Papp Gy., Tenczer J.; Akadémiai Kiadó 2009

Signature of the tutor:

Signature(s) of the head(s) of the Institute(s):

Date:

2020. 01. 26.

Credit Transfer Committee's opinion:
Comment of the Dean's Office:
Signature of the Dean:

[1] Dékáni Hivatal tölti ki, jóváhagyást követően.
[2] Az elméleti és gyakorlati oktatást órákra (hetekre) lebontva, sorszámozva külön-külön kell megadni, az előadók és a gyakorlati oktatók nevének feltüntetésével. Mellékletben nem csatolható!
[3] Pl. terepgyakorlat, kórlapelemzés, felmérés készítése stb.
[4] Pl. házi feladat, beszámoló, zárthelyi stb. témaköre és időpontja, pótlásuk és javításuk lehetősége.
[5] Elméleti vizsga esetén kérjük a tételsor megadását, gyakorlati vizsga esetén a vizsgáztatás témakörét és módját.
[6] Az elméleti és gyakorlati vizsga beszámításának módja. Az évközi számonkérések eredményeink beszámítási módja.