VNIVERSITAT DE VALÈNCIA

Course Guide
44753 Mechanisms of control and regulation of the body functions

COURSE DATA

Data Subject	
Code	44753
Name	Mechanisms of control and regulation of the body functions
Cycle	Master's degree
ECTS Credits	1.5
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
2231 - M.D. in Biomedical Engineering	Faculty of Medicine and Odontology	1	First term

Subject-matter

Degree	Subject-matter	Character
2231 - M.D. in Biomedical Engineering	3 - Mechanisms of control and regulation of the body functions	Obligatory

Coordination

Name	Department
CALVO SAIZ, CONRADO JAVIER	190 - Physiology

SUMMARY

The central goal of this course is to provide advanced knowledge on the basic mechanisms of control and regulation of major body functions procuring stability and normal function of the human body. It is intended that students acquire knowledge and skills derived from discussions emphasizing the key elements and driving mechanisms maintaining stable control and regulation of the classically so-called, in Physiology, ‘Major physiological functions’ (circulation, respiration, metabolism, reproduction, thermoregulation, acid-base equilibrium, etc). The normal development of these functions allows that the *Internal Medium* or *Milieu Intérieur*, as first described by Claude Bernard in late XIX century, maintain its key characteristic, the fundamental physicochemical preservation. This phenomenon, called homeostasis, is responsible for the normal function of the human body. On the contrary, when these mechanisms deteriorate or fail, the lack of ability to adapt to the fundamental needs of the body, leads to pathophysiology and disease. Likewise, through the didactic lectures in this course the students will establish solid rational thinking on therapeutic strategies led to modify, in one way or another, the mechanisms underlying maintenance and control of any major function, from the Biomedical Engineering perspective.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

Prior studies should have dealt with at least general physiology and, morphology and function of the human body at different levels, as well as, basic mechanisms of control.

OUTCOMES

2231 - M.D. in Biomedical Engineering

- Students should demonstrate self-directed learning skills for continued academic growth.
- Ser capaz de aportar ideas y soluciones de amplia originalidad, prácticas y aplicables, flexibles y complejas, que afecten tanto a las personas como a los procesos.
- Saber emplear de forma efectiva la instrumentación y los métodos de observación del área biomédica para el estudio y análisis de los sistemas complejos del área.
- Ser capaz de modelar matemáticamente y simular procesos complejos en el ámbito de la ingeniería biomédica.
- Ser capaz de diseñar, implementar y gestionar experimentos adecuados, analizar sus resultados y sacar conclusiones en el ámbito de la ingeniería biomédica.

LEARNING OUTCOMES

LEARNING OBJECTIVES

To provide students with:

* Fundamental knowledge on feedback control and regulation of major body functions such as the feedback processes and mechanisms involved in systems physiology.

* Understanding on how physiological control systems function to provide the underpinnings for devising therapeutic strategies from the human-centered biomedical engineering perspective.

* Rational thinking on quantitative control physiology towards analysing, simulating and/or estimating its properties.

DESCRIPTION OF CONTENTS

1. PHYSIOLOGY

Each of the topics of the program listed below will correspond approximately to 45-60 periods. Some lectures will be partially covered by final term projects.

Lecture I. Control systems: Introduction to the physical principles of control systems and their fundamental characteristics. (60). Introduction to control systems in biomedical engineering and physiology. Review of feedback control theory. Closed-loop control general block diagram. Quantification of gain and feedback loop properties and elements. Static analysis of physiological systems. Dynamic analyses. Quantitative aspects. Sensitivity and robustness of physiological networks. Computational tools for the analysis and design of control systems.

Lecture II. Feedback control in systems physiology: automatism and organic control. (45). Some general characteristics of the regulatory processes of the so-called "great functions": their role and their relation to homeostasis. Basic mechanisms of feedback control at the organic level. Classification of feedback types in physiological systems and examples. Analysis and quantification in feedback control loops. Oscillatory characteristics of feedback control in human biology and physiology. Robustness of oscillations and examples.

Lecture III. Functional systems of the organism and its contribution to homeostasis: Overview. (45). Fundamental homeostatic control systems, and their interaction controlling other systems: nature of neuroendocrine control. Quantification and analysis of the major neuro-endocrine axis feedback systems.

2. PHYSIOLOGY

Lecture IV. Voluntary motor control. (45). Analysis of cerebellar and basal ganglia control of voluntary motor function. Role of the premotor area. Analysis of cerebellar circuitry and connectivity. Major basal ganglia circuits. Quantification and implication of major neurotransmitter circuits. Vestibular connections. Analysis of the feedback control loops in normal and pathological conditions. Evaluation of motor control: traditional tests and new technologies. Myoelectric control.

Lecture V. Regulation of circulatory function and cardiovascular adaptation (I): Local blood flow control. (45). Control of blood flow through different tissues and organs: Feedback mechanisms of local control and mechanisms of humoral control. Analysis, identification and quantification of local and humoral feedback systems. Regulation mechanisms. Resistance and vascularization. Active and reactive hyperemia. Myogenic and metabolic mechanisms and feedback control loops. Fluid mechanics of blood flow control. Mid vs long-term control. Key factors, substances, mechanisms and pathways.

Lecture VI. Regulation of circulatory function and cardiovascular adaptation (II): Blood pressure and volume control. (45). Mechanisms of rapid control of blood pressure: Mechanical transducers and chemical transducers. Control in emerging situations. Role of central nervous control. Regulation of blood pressure through an integrated system. Cardiovascular adaptation. Role of the renal-corporal fluid

system. Pathophysiological connotations. Quantification and analysis of the feedback system. Modifications during exercise. Hemorrage and shock: compensatory and decompensatory mechanisms.

3. PHYSIOLOGY

Lecture VII. Regulation of respiration (I). (45). Levels of control: Internal and cellular respiration and external breathing. Levels of central integration: bulbar, diencephalic and cortical control. Central control mechanisms. Pattern and rate control. Major ventilation control factors. Ventilation/Perfusion matching. Quantification and analysis of the feedback system.

Lecture VIII. Regulation of respiration (II). (45). Chemical regulation of respiration and its basic mechanisms. Quantitative aspects. Feedback control analyses in response to altitude and exercise. Long-term responses.

Lecture IX. Control of behavior and emotions. (30). Limbic functions. Emotional networks and major behavioral circuits. Hypothalamic integration. Implications to feedback control. Neural control of emotional responses. Fear-conditioning circuits. Motivation-reward circuits. Sexual-drive circuits. Behavioral control circuits.

4. PHYSIOLOGY

Lecture X. Regulation of metabolism (I). (60). Hydromineral metabolism: hormonal control and participation of different organs and systems. Osmotic balance. Regulation and control of major ions. Renal and hormonal control. Implications of natriuretic peptides in feedback control. Quantification and analysis of the major feedback loops.

Lecture XI. Regulation of metabolism (II). (45). Metabolism of carbohydrates, lipids and proteins: hormonal control and participation of different organs and systems. Basic mechanisms. Hormono-sensitive lipase control. Quantification and analysis of metabolism feedback control.

Lecture XII. Regulation of reproduction. (45). Hormonal control and participation of different organs and systems. Hypothalamic control. Feedback regulation of female and male function. Positive and negative feedback control. Quantification and analysis of major feedback loops.

Tema XIII. Growth regulation. (45). Neuroendocrine participation. Genetic and nutritional considerations. Types, factors and rate of growth. Hormonal control of growth. Somatomedin regulatory processes and mechanisms. Growth and aging. External and environmental factors. Corticotropin regulatory mechanisms. Insulin effects on growth. Mechanisms. Quantification and analysis of the major feedback loops.

5. PHYSIOLOGY

Lecture XIV. Regulation of food-intake. (45). Structures and mechanisms involved: Rapid, medium-term and long-term regulation. Control of appetite and structures involved. Regulatory factors. Leptin feedback loop. Analysis and quantification of feeding regulation. Effects and key elements. Pathophysiological connotations.

Lecture XV. Body temperature regulation. (45). Physical principles. Basic Regulatory Mechanisms: Heat Generators and Heat Sinkers. Thermoregulatory structures: The hypothalamic thermostat and the receptors. Role of the skin circulation. The "set point", the fever and its abnormal control mechanisms. Quantification and analysis of the feedback system.

Lecture XVI. Regulation of acid-base balance. (45). Buffer systems and the participation of different organs and systems. Bicarbonate and phosphate buffer systems. Special analysis of kidney involvement and detailed mechanisms. Quantification and analysis of the acid-base feedback system and interactions with other systems. Analysis of factors and conditions affecting acid-base homeostasis. Acid-base disturbances. Respiratory and metabolic acidosis and alkalosis conditions.

6. PHYSIOLOGY

Lecture XVII. Regulation of neuronal plasticity. (45). Implications and manifestation of neuronal plasticity the physiological functions. Basic mechanisms and implications for motor control and development of cognitive function. Synaptic plasticity mechanisms. Implications in the regulation of higher brain functions (memory, learning and language). Neuronal plasticity in the development of mass reflexes. Implications to control of urinary and defecation function in paraplegic patients. Advances on myoelectric control of powered prostheses. BCI.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	15,00	100
Development of group work	4,00	0
Study and independent work	12,50	0
Readings supplementary material	2,00	0
Preparation of evaluation activities	2,00	0
Preparing lectures	2,00	0
TOTAL	**37,50**	

TEACHING METHODOLOGY

In general, the teaching methodology will include didactic lectures, critical analyses of the current state of the art on feedback control in physiology, a public defence of an original research small-sized team-projects, and complementarily, questions and quantitative problem-solving exercises related to feedback control of physiological systems, which will necessarily require student to be prepared for unexpected questions and quizzes.

1. **Didactic lectures** supported by audiovisual digital media and TIC-driven ativities. Group discussion of relevant scenarios were physiological key-factors are modified. This will enhance rational thinking and promote the identification of the possible responses to homeostatic control. Furthermore, this strategy will aid to follow-up on problem-solving applied learning of students to fundamental and real raised scenarios.

2. Group and individual **supervision** while preparing the final term original research and/or review projects related to new contributions to the feedback control systems and their public defenses. Tutoring hours will also be at disposal for discussing topics, concepts and problems raised in class.

EVALUATION

The assessment of academic performance will be done according to the following strategy:

1. **A final exam (80%) to evaluate objectively the learning process comprising**:

1. i. A test of 24 multiple-answer questions that will score up to 50%.
2. ii. Six short-length questions (30%), with maximum extension of quarter to half-sheet size.

1. **Continuous evaluation (5%)**. Students will be tested at the end of each class with short questions or tests and activities to follow up their knowledge on the contents.

1. **Final term project (15%)**. Students are required to do a review or original literature research on one of the recommended topics at the beginning of the course in small teams up to 3 members related to new contributions to control systems to be defended and communicated effectively in a limited time.

Requirements: To overcome a 4,5 in the objective evaluation will be necessary to average with the rest of the programmed evaluation activities. Theoretical classes will be 100% mandatory in the classroom (face-to-face). It will be considered not presented the student who does not show up for any evaluation element programmed in the evaluation call.

REFERENCES

Basic

- Referencia b1: Barret KE, Barman SM, Boitano y Brooks HL. Ganong. Fisiología Médica. 24 ed. McGraw-Hill. Lange. Madrid. 2013.
  Referencia b2: Mountcastle VB. Fisiología médica. The C.V. Mosby Company. Saint Louis. 1977.
  Referencia b3: Levy MN, Koeppen Bm y Stanton BA. Berne y Levy Fisiología. Elsevier España S.A. 4ª ed. 2006. Madrid.
  Referencia b4: Boron, WF and Boulpaep EL. Medical Physiology, 2nd Ed. (2012) Saunders, Elsevier, Philadelphia, PA, USA
  Referencia b5: Hall, JE. Guyton y Hall. Tratado de Fisiología Médica. 13ª ed. Elsevier. Barcelona. 2016
  Referencia b6: Wood AW. Physiology, biophysics and biomedical engineering. CRC Press. A Taylor and Francis Group. Boca Raton, FL. 2012.

Additional

- Referencia c1: Constanzo, LS. Fisiología. 5ª ed. Elsevier España SL. Barcelona. 2014. Conti F. Fisiología Médica. McGraw-Hill. México. 2010
  Referencia c2: Fox SI. (2008). Fisiología Humana. 8ª ed. Madrid. ed. McGraw-Hill Interamericana de España S.A.U. 2008.
  Referencia c3: Kandel ER, Schwartz JH, Jessell TM, Siegel SA, Hudspeth AJ. Principles of Neuroscience. 5ª ed. McGraw-Hill. New York. 013
  Referencia c4: Pocock G, Richards CD. (2005) Fisiología humana. 2ª ed. Masson. Barcelona. 2005.
  Referencia c5: Tresguerres JAF. (2010). Fisiología Humana. 4ª ed. Madrid. McGraw-Hill. 2010.