2013-2014 Academic Year

Human Physiology (20338)

Qualification/course: Bachelor's Degree in Human Biology

Year: 2
Term: 2
Number of ECTS credits: 8 credits
Student study time: 8 credits in total, which consist of 88 hours attending course activities and 112 hours of individual work. The face-to-face activities are divided into 40 hours of lectures, 16 hours of seminars and 32 hours of practical sessions.
Course language(s): Catalan / Spanish
Teaching staff: The subject coordinator is Dr. Francisco J. Muñoz (Tenured Assistant Professor, UPF). The lecturers are Drs. Miguel A. Valverde (Full Professor, UPF), José M. Fernández (Tenured Assistant Professor, UPF), Rubén Vicente (Lecturer, UPF), Mariano Sentí (Tenured Assistant Professor, UPF), Joaquim Gea (Full Professor, UPF), Jaume Puig (Assistant Professor, UPF), and Anna García-Elías (Visiting Professor), who will be teaching the theoretical and practical parts.

1. Presentation of the course

This subject concentrates on the study of the function and regulation of the different systems governing the functioning of the human body: cardiovascular system, respiratory system, blood tissue, digestive system, hydrosaline metabolism and renal function, hormone physiology and the physiology of reproduction.

2. Competences to be achieved

1. To learn about the morphology, structure and function of the circulatory system.
2. To learn about the morphology, structure and function of the respiratory system.
3. To learn about the morphology, structure and function of the blood.
4. To learn about the morphology, structure and function of the digestive system.
5. To learn about the morphology, structure and function of the excretory system.
6. To learn about the morphology, structure and function of the endocrine system.
7. To learn about the morphology, structure and function of the reproductive system.

3. Contents

3.1. Theory

Each topic is given in 1-hour lectures.

I. Cardiovascular system (Dr. M. Sentí)

Topic 1. Properties of the cardiac muscle
Automatism: origin of the heartbeat in pacemakers. Cardiac impulse conduction. Excitability of the heart. Interpretation of the electrocardiogram (ECG). Extrasystoles (premature ventricular contractions). Contractility. Length-tension relationship in the cardiac muscle. Vegetative control of the cardiac function.

Topic 2. The heart as a pump
The cardiac cycle. Cardiac cavities and valves. Measurement of the pressure and volume of the cardiac cavities and analysis of changes during the cardiac cycle. Temporary correlations with the ECG. Valve function: heart sounds. Changes in the cardiac cycle caused by changes in cardiac frequency. Control of cardiac frequency. Intrinsic regulation: Frank-Starling law, regulation by frequency and postextrasystolic potentiation. Extrinsic nervous and hormonal regulation.

Topic 3. General organization of the circulatory system
Systemic circulation and pulmonary circulation. Functional characteristics of each of the sections of the circulatory system. Pressure, volume and speed of the blood in each section.

Topic 4. Haemodynamics
Concept. Measurement and inter-relationship between pressure, flow and resistance. Factors determining peripheral resistances: Poiseuille's law. Flow in elastic pipes. Concept of critical closing pressure. Arterial and venous capacitance and their functional importance.

Topic 5. Circulation in large arteries
Functions of the arteries. Muscular arteries and elastic arteries. Blood pressure. Measurement techniques and oscillations during the cardiac cycle. Analysis of the factors which modify mean arterial pressure and pulse pressure. Blood pressure measurement in the human body. Normal values and physiological variations. Arterial pulse.

Topic 6. Capillary circulation
General characteristics and function of capillary flow. Capillary types. Exchange of substances within capillaries. Diffusion of solutes. Net movements of fluid. Capillary filtration. Starling's equation. Importance of the lymph vessels in capillary reabsorption. Oedema.

Topic 7. Venous circulation
General characteristics. Central venous pressure and peripheral venous pressure: measurement and factors on which they depend. General factors which aid venous circulation.

Topic 8. Peripheral circulation and its control
Control of tissue perfusion: local factors and auto-regulation of the flow. Blood pressure control as a determining factor in tissue perfusion: Central role of the baroreceptor reflex.

Other cardio-circulatory reflexes. Hormonal factors. Renin-angiotensin system. Role of the kidney in long-term blood pressure control.

Topic 9. Control of cardiac flowrate and coupling between the heart and the veins
Methods of measurement, normal values and physiological variations of the cardiac flowrate. Factors determining the cardiac flowrate. Cardiac factors: cardiac function curves. Vascular factors: vascular function curves. Analysis of the modifications of the cardiac output per minute occurring in different circumstances.

Topic 10. Special circulatory systems
Coronary circulation. General characteristics. Measurement of the coronary blood flow. Normal values and physiological variations. Changes in the pressure and flow of the coronary vessels during the cardiac cycle. Regulation of the coronary blood flow. Cerebral circulation. Mucocutaneous circulation.

II. Respiratory system (Dr. J. Gea)

Topic 11. General functions of the respiratory system
Functional structure: airways and respiratory units. Mechanics of the respiratory movements. Respiratory muscles. Measurement of lung volume and capacity. Defence and metabolic functions of the respiratory system.

Topic 12. Static mechanical properties of the lung and thorax
Elastic properties of the lung: pressure-volume relationship in the isolated lung. Surface tension in the alveoli: pulmonary surfactant. Elastic properties of the chest wall. Elastic properties of the lung/chest wall system. Pleural cavity. Examination of lung compliance curves for the thorax and for the lung/thorax system: resting position of the system.

Topic 13. Dynamic mechanical properties of the lung and thorax
Air-flow resistance: distribution along the airway. Effects of pulmonary volume and bronchial tone. Dynamics of the ventilatory cycle. Airway resistance measurement. Dynamic airway compression. Examination of the curves for respiratory flow and pulmonary volume and for respiratory flow and pleural pressure. Respiratory work.

Topic 14. Alveolar ventilation
Anatomical dead space. Measurement of alveolar ventilation. Pleural cavity. Effects of gravity and regional differences on ventilation. Composition of gas in the airways and the alveoli. Factors that modify the composition of alveolar gas.

Topic 15. Gas exchange in the lungs
Diffusion of gases. Structure of the respiratory membrane. Limitations in the process of diffusion in the alveolocapillary membrane. Diffusion of O_2 and CO_2 in the pulmonary capillary membrane.

Topic 16. Ventilation-perfusion relationship
Measurement of alterations in the ventilation/perfusion ratio. calculation of the

physiological shunt and of the physiological dead space. Regional differences in the ventilation-perfusion ratio. Causes of tissue hypoxia.

Topic 17. Transport of oxygen and carbon dioxide through the blood
Structure and properties of haemoglobin. Oxyhaemoglobin dissociation curve. Oxygen delivery and uptake in the blood. Factors that modify the affinity between haemoglobin and oxygen: normal factors and carbon monoxide poisoning. Anaemia and abnormal haemoglobins. Transport of CO_2 to the blood. CO_2 dissociation curve. The Bohr effect and the Haldane effect. Reactions and changes associated with blood CO_2 movements. Role of CO_2 in the acid-base equilibrium.

Topic 18. Control of pulmonary ventilation
Nervous control. Respiratory centres.Respiratory rhythm generation Pulmonary and extrapulmonary respiratory reflexes. Central and peripheral chemoreceptors. Integrated responses to hypoxia, hypercapnia and acidosis. Respiratory response to exercise. Adaptation to special environments: acclimatization to high altitude.

III. Blood Physiology (Dr. M. Sentí)

Topic 19. Blood
Composition. Plasma proteins. Physicochemical properties: viscosity, globular sedimentation velocity and volemia. Erythropoiesis. Regulation of erythropoiesis. Erythrocyte-maturing factor. Erythrocyte physiology: structure and function. Haematocrit and erythrocyte indices. Metabolism of the red blood cell. Erythrocyte degradation mechanisms. Iron metabolism.

Topic 20. Antigenic properties of the erythrocyte
Blood groups: AB0 system and Rh system. Blood group determination tests. Blood incompatibility. Platelet physiology. Plasma coagulation: factors in coagulation; pathways to coagulation; regulation; clinical tests. Fibrinolysis.

IV. Digestive system (Dr. F. J. Muñoz)

Topic 21. Digestive motility I
Smooth muscle of the gastrointestinal tract and its functional characteristics. Integration and control of digestive motor activity. Chewing. Swallowing and nervous control. The oesophagus and control of the oesophageal sphincters. Clinical alterations.

Topic 22. Digestive motility II
Gastric and intestinal motility. Innervation and influence of hormones. The reflexes of the gastrointestinal tract. Vomit. Defecation. Clinical alterations.

Topic 23. Digestive secretion I
Saliva: composition, functions and regulation. Gastric secretion: types, functions and regulation.

Topic 24. Digestive secretion II
Pancreatic secretion: composition, functions and regulation. Bile secretion: composition and functions. Intestinal secretion: composition, functions and regulation.

Topic 25. Digestive absorption
Digestion and absorption of carbohydrates, lipids, proteins, vitamins, water and electrolytes.

V. Hydrosaline metabolism and renal function (Dr. R. Vicente)

Topic 26. Volume and composition of body fluids
Functional structure of the kidney. The nephron, the cortex and the renal medulla. Functional generalities. Excretory function (concepts of filtration, reabsorption and secretion), homeostatic and endocrine. Urination. Transport of urine.Physiology of the bladder. Control of urination.

Topic 27. Glomerular function
Renal flow, nervous and hormonal regulation and autoregulation. Natriuretic factor. Filtration. Hydrostatic and colloid osmotic pressure. Size and properties of particles. Permeability. Filtrate composition. Evaluation of the renal function. Concept of clearance. Glomerular filtration. Creatinine, urea and inulin clearance.

Topic 28. Tubular function: Reabsorption
Reabsorption and secretion. Active and passive reabsorption. Electrical, chemical and osmotic gradients. Topography of reabsorption.

Topic 29. Tubular function: Secretion
Active and passive secretion. Topography of secretion. Urine concentration: proximal tubule, loop of Henle, descendant and ascendant segments, distal and collector tubule.

Topic 30. Renal regulation of acid-base equilibrium
Concept. Regulatory systems. Secretion of H+, reabsorption and excretion of bicarbonate. Alterations of metabolic origin.

VI. Hormone physiology (Dr. J. Puig)

Topic 31. Introduction to endocrine physiology
Definition of hormone and receptor. Types of hormone and receptor. General forms of hormonal synthesis, secretion, action and regulation. Endocrine glands. Endocrine, paracrine and autocrine systems. Hormone transport and degradation.

Topic 32. Hypophysis and hypothalamus
Neurosecretory pathways. Portal system. Hypothalamic-hypophyseal axis. Hypophyseal factors. Hypothalamic hormones. Adenohypophysis: TSH, ACTH, gonadotrophins, GH and prolactin. Neurohypophysis: antidiuretic hormone and oxytocin.

Topic 33. Thyroid gland
Metabolism of iodine. Thyroid hormones. Synthesis, transport and actions. Regulation and functional exploration of the thyroid.

Topic 34. Hormones related to the bone metabolism (calcium and phosphorus)
Role of mineral ions. Brief review of calcium and phosphorus metabolism. Metabolic physiology of the bone and mineral homeostasis. Parathyroid hormone: synthesis and secretion. Actions and regulation. Methods of evaluation. Calcitonin: synthesis and secretion. Actions and regulation. Methods of evaluation. Vitamin D: synthesis and exogenous contribution; transport and metabolism. Actions and regulation. Functional evaluation of mineral metabolism.

Topic 35. Endocrine pancreas and other hormones of the gastrointestinal tract
Synthesis and secretion of insulin. Actions. Regulation. Functional evaluation. Glucagon, synthesis and secretion. Actions and mechanisms. Regulation. Evaluation. Glucose homeostasis. Incretins: GIP and GLP-1.

Topic 36. Adrenal gland hormones
Suprarenal cortex. Glucocorticoids: synthesis and secretion; transport and metabolism. Actions. Regulation. Functional exploration. Mineralocorticoids: synthesis and secretion; transport and metabolism. Actions. Regulation. Functional evaluation of the glucocorticoid and mineralocorticoid systems.

Topic 37. Adrenal gland hormones II
Suprarenal medulla. Catecholamines: synthesis, actions and mechanisms. Evaluation of sympathetico-adrenal activity. Regulation of body weight. Regulation of intake and energy homeostasis by the central nervous system. Regulation of energy expenditure. The adipocyte as an endocrine cell. Leptin.

VII. Reproductive Physiology (Dr. J. Puig)

Topic 38. Reproductive physiology II
Male reproductory system. Structure. Spermatogenesis and production of semen. Testicular function. Male hormones (adrenal and gonadal). Synthesis, secretion, actions and regulation. Methods of functional evaluation. Erection and ejaculation. Hormonal and vascular regulation. Male orgasm. Methods of evaluation. Puberty and andropause.

Topic 39. Reproductive physiology I
Methods. Sexual reproduction. Aspects of the female reproductive system. Female hormones (adrenal and gonadal). Synthesis, secretion and actions. Ovarian cycle. Ovum migration. Endometrial cycle. Female orgasm. Mammary functions. Hypophyseal and hypothalamic hormonal regulation. Methods of functional evaluation. Puberty and menopause.

Topic 40. Fecundation and gestation
The placenta as an endocrine gland: betaHCG and placental lactogen. Hormonal, metabolic,

respiratory and cardiovascular particularities of the pregnant woman. Physiology of childbirth.

3.2. Practical sessions

These are held in groups of 15 students per session. There are different numbers of sub-groups depending on the types of practical session.

Practical Session 1. Electrocardiography I (Dr. R. Vicente and Dr. Anna García-Elías)
Interpretation of the electrocardiogram. The electrical activity of the heart in relation to the mechanical activity that occurs during the cardiac cycle. Observation of changes in heart rhythm associated with changes in posture. Analysis and interpretation of results. (4 hours). This practical session is held with 4 sub-groups of 3-4 students each.

Practical Session 2. Electrocardiography II (Dr. R. Vicente and Dr. Anna García-Elías)
Simultaneous recordings of precordial and arterial pulse readings. Use of the plethysmograph to evaluate changes in peripheral blood pressure. Analysis and interpretation of results. (4 hours). This practical session is held with 4 sub-groups of 3-4 students each.

Practical Session 3. Respiratory cycle and Pulmonary flows (Dr. R. Vicente and Dr. Anna García-Elías)
Recording of pulmonary ventilation using a pneumograph and ventilated air flow transducers. Determination of forced vital capacity, forced expiratory volume and maximal voluntary ventilation. Analysis and interpretation of results. (4 hours). This practical session is held with 4 sub-groups of 3-4 students each.

Practical Session 4. Blood groups (Dr. M. Sentí)
Taking blood samples for processing and determining blood groups and Rh factor. Analysis and interpretation of results. (2 hours). This practical session is held with 4 sub-groups of 3-4 students each.

Practical Session 5. Galvanic skin response and the polygraph (Dr. Anna García-Elías)
A study will be conducted of the bio-electrical response of the skin, which changes in accordance with levels of perspiration (sympathetic control). The polygraph (lie detector) associates the recording of a galvanic response with other physiological variables such as respiratory and cardiac frequencies, the control of which depends on the vegetative system. Analysis and interpretation of results. (4 hours).This practical session is held with 4 sub-groups of 3-4 students each.

Practical Session 6. Vascular damage (Dr. F. J. Muñoz)
This session studies an element of vascular damage caused by atherogenic processes. It consists of in vitro induction of damage through nitration in plasma proteins (albumin) with a peroxynitrite donor and subsequent evaluation of the protein nitration by measuring the absorption of nitrotyrosines at 412 nm. Analysis and interpretation of results. (4 hours). This practical session is held with 8 sub-groups of 2 students each.

Practical Session 7. Renal function (Dr. R. Vicente)
Renal function simulation using computer models. Analysis and interpretation of results. (4 hours). This practical session is held with 4 sub-groups of 3-4 students each.

Practical Session 8. Endocrine System (Dr. R. Vicente)
Endocrine system simulation using computer models for thyroid hormone, insulin and estrogens. Analysis and interpretation of results. (4 hours). This practical session is held with 4 sub-groups of 3-4 students each

Practical Session 9. Assessment of the practical knowledge acquired in the subject (2 hours). (Dr. R. Vicente)

3.3. Seminars

The seminars are held in groups of 30 students and involve the discussion of real cases in sub-groups of 6-8 students. The aim is to aid the revision of the main physiological concepts and demonstrate, in a practical manner, that pathology is essentially the result of the alteration of physiology. The ability to discuss the cases will be assessed in Seminar 8, which will consist of dealing with a practical problem and two questions, which are to be answered individually. Each seminar lasts for two hours.

Seminar 1. The heart as a pump (Dr. M. A. Valverde)
Seminar 2. The arterial system (Dr. J. M. Fernández)
Seminar 3. Alterations in ventilation (Dr. J. Gea)
Seminar 4. Exchange of gases (Dr. J. Gea)
Seminar 5. Osmolality and ion regulation of the kidney (Dr. R. Vicente)
Seminar 6. Hypersecretion of the growth hormone and of the thyroid hormone (Dr. F. J. Muñoz)
Seminar 7. Hypersecretion of cortisol (Dr. F. J. Muñoz)
Seminar 8. Assessment by problem-solving with notes and books (Dr. Anna García-Elías)

4. Assessment

The assessment of academic performance is done in the following manner (out of a total of 10 points):

- Multiple-choice test based on the theoretical topics covered and will count as a maximum of 2.5 points out of the total mark.

- Theoretical written test with two short questions for each of the topics studied. One short question is to be answered per topic, chosen from two options, and written on one side of A4 paper (maximum). This will count as a maximum of 5 points of the total mark.

- Practical test: assessment of the knowledge acquired from the content of the practical sessions. This will count as a maximum of 1,25 point of the total mark.

- Seminar Test: consisting of problem solving with notes and books. This will count as a maximum of 1,25 point of the total mark.

- Formative assessment: the Faculty of Life and Health Sciences, in keeping with its programme of continuous assessment, holds an examination to measure progress halfway through the term (topics 1 to 9). Up to 0,5 points will be added to the final mark.

July special evaluation: for those who had not passed the June exam there is a second chance at the end of July consisting of multiple-choice tests and theoretical written tests with one short question for each of the topics studied. This will count as a maximum of 7.5 points of the total mark. The knowledge evaluated along the trimester (formative, practical and seminar tests) will be not recovered in this special exam.

REQUIREMENTS

- A good level of English is recommended to follow this subject.
- Notes dealing with each topic, and programmes for practical sessions and seminars, are available in the Aula Global from the start of the academic year.
- Attendance at practical sessions is obligatory, and official justification must be provided for any absences.
- Students for seminars and practical sessions may not change group unless the changes (which must be consistent when exchanged with another student) have been approved beforehand by the Faculty Secretary's office.
- Students must bring the session or seminar plan to all practical sessions and seminars.
- Students must wear lab-coats when participating in the practical sessions.
- Those repeating the examination will not be required to repeat the practical sessions and seminars, but will have to carry out a new examination concerning practical work and seminars.

5. Bibliography and teaching resources

Bibliography recomended

- Tratado de Fisiología Médica (*Medical Physiology*). A.C. Guyton & J. E. Hall. Ed. Elsevier.

- Fisiología (*Physiology*). M.N. Levy, B.A. Stanton & B.M. Koeppen. Eds. R.M. Berne & M.N. Levy.

- Fisiología humana: un enfoque integrado (*Human Physiology: An integrate approach*). D.U.Silverthorn. Ed. Médica Panamericana (*Dee Unglaub Silverthron Eds*.).

Complementary Bibliography

- Atlas de bolsillo de fisiología. S. Silbernagl y A. Despopoulos. Ed. Médica Panamericana.

- Bases fisiológicas de la práctica médica. C.H. Best. Ed. Médica Panamericana

- Estructura y función del cuerpo humano. B.E. Rodríguez. Ed. McGraw-Hill-Interamericana.

- Fisiología humana. S.I. Fox. Ed. McGraw-Hill/Interamericana.

- Fisiología médica. W.F. Ganong. Ed. McGraw-Hill/Interamericana.

- Fisiología y fisiopatología. A.C. Guyton & J. E. Hall. Ed. McGraw-Hill/Interamericana.

- Principios de anatomía y fisiología. G.J. Tortora & B. Derrickson. Ed. Médica Panamericana.

- Principios de fisiología animal. Moyes CD y Schulte PM. Ed. Pearson.

- Principles of Physiology. M.N. Levy, B.A. Stanton & B.M. Koeppen. Eds. R.M. Berne & M.N. Levy, St. Louis.

- Textbook of Medical Physiology. A.C. Guyton & J. E. Hall. Ed. Elsevier Saunders, Philadelphia.