SUBJECT:	**STRUCTURE AND FUNCTION OF THE CARDIOVASCULAR, RESPIRATORY AND RENAL SYSTEMS**				
CREDITS:	Total:	**13**	Theory:	**6.5**	Practical: **6.5**

SPECIFIC OBJECTIVES

- Develop skills in spoken, written and graphic communication related to the course content through the creation and presentation of posters and participation in the discussion forum.
- Develop creative abilities and manual skills by carrying out a research project related to the content of the practical content of the course.
- Develop the habit of consulting bibliographical material through the activities proposed above.
- Develop the ability to give precise definitions and to identify the most suitable definitions from a glossary of terms corresponding to the subject.
- Develop the ability to accurately present and interpret graphs relating functional parameters of the cardiovascular, respiratory and renal systems.
- Develop the ability to establish cause-effect relationships between functional parameters of the cardiovascular, respiratory and renal systems.
- Develop the ability to identify and analyze microscopic preparations of the different organs of the cardiovascular, respiratory and renal systems.
- Develop regular work patterns through continuous assessment.
- Develop self learning capabilities by setting problems to be solved.
- Develop critical reading abilities through the discussion forum.
- Develop critical skills in practical experiments, considering potential limitations of measuring apparatus and sources of error in data acquisition.

The specific learning objectives will be outlined in the subject *Teaching Guide* which will be distributed at the end of the first semester of the course.

PROGRAMME

Theory

1. The cardiovascular, respiratory and renal systems and homeostasis.

The cardiovascular, respiratory and renal systems and the internal medium. Functions of the cardiovascular, respiratory and renal systems in homeostasis.

2. Histological structure of the heart, arteries, veins, capillaries and lymph vessels.

Microscopic organography of the heart. General structure of arteries. Classification: arterioles and small arteries. Muscular or distribution arteries. Large elastic arteries. Transitional arteries and special types of arteries. Special sensory organs of arteries. Physiological implications of the structure of artery walls. Changes in arteries with age. Arteriosclerosis. General structure of veins. Classification: venules and small-calibre veins. Middle-calibre veins. Large-calibre veins. Special types of vein. Venous valves. Arteriovenous anastomosis. Nutrition and innervation of blood vessels. Structure of capillaries. General structure of capillaries. Classification of continuous, fenestrated and sinusoidal capillaries. Histophysiology of capillaries: large and small pore systems. Capillary permeability. Lymph vessels and capillaries.

3. Genesis and conduction of cardiac electrical activity.

Rest potential of myocardial cells. Action potential of myocardial cells. Fast response and slow response action potentials. Ionic mechanisms involved in the rest potential of ventricular myocardial fibres. Ionic mechanisms involved in the action potential of ventricular myocardial fibres. Stability of the rest potential of myocardial fibres. Propagation of electrical activity in myocardial cells. Action potential of sinus node cells. Ionic mechanisms responsible for pacemaker potential. Auriculo-ventricular conduction. Nervous regulation of cardiac electrical activity. Electrocardiogram

4. Mechanical activity of the heart.

Mechanisms involved in myocardial contraction. Mechanisms involved in the excitation-contraction coupling. Mechanisms involved in myocardial relaxation. Determining factors of isometric contraction of the heart. Determining factors of isotonic contraction of the heart. Determining factors of cardiac inotropism. Determining factors of the magnitude of systolic volume. Ventricular function curve. Adaptation of the heart to a chronic overload

5. Cardiac cycle.

Chronology of the cardiac cycle. Chronological relationship between the electrocardiogram waveform and cardiac cycle. Chronological relationship between the phonocardiogram waveform and cardiac cycle. Pressure and volume variations in cardiac cavities during the cardiac cycle.

6. Foundations of hemodynamics.

Mechanical structure of the cardiovascular circuit. Application of the laws of conservation of mass and energy to blood circulation.

7. Hemodynamic resistance.

Energy dissipation due to friction. Resistance of a vessel and vascular circuit. Pressure and flow distribution gradients in a vascular circuit. Energy transformations in a vascular circuit. Turbulent regime.

8. Effect of vessel elasticity on blood circulation.

Effect of vessel distensibility on resistance. Effect of vessel elasticity on pressure oscillation.

9. Arterial circulation.

Functions of the arterial system in blood circulation. Circulatory resistances in the arterial system. Functions of the endothelium in the arterial system.

10. Microcirculation.

Function of microcirculation. Arrangement of vessels in microcirculation. Functional significance. Exchange mechanisms in microcirculation. Interstitial liquid. Lymphatic circulation. Angiogenesis.

11. Venous circulation.

Functions of the venous system in blood circulation. Determining factors of venous return.

12. Local circulations.

Pulmonary circulation. Splanchnic circulation. Cutaneous circulation. Adipose tissue circulation. Circulation in the skeletal musculature. Renal circulation. Cerebral circulation. Coronary circulation.

13. Regulation of circulatory function.

Regulation of the cardiovascular system and homeostasis. Nervous regulation of arterial pressure. Regulation of arterial pressure by baroreceptor reflexes. Modifications of arterial pressure through the reflexes of low-pressure system receptors. Modifications of arterial pressure due to stimulation of "chemoreceptors" in the carotid and aortic glomus and cerebral ischemia. Endocrine regulatory mechanisms of arterial pressure. Long-term regulation of arterial pressure through blood volume.

14. Structure of the respiratory apparatus: the conductive zone.

Structure of the nasal cavity: respiratory mucous, vascularization and histophysiology. Paranasal sinuses. The nasopharynx. The larynx: histological structure. Role of the larynx in phonation. The glottis. Structure of the trachea and the extrapulmonary bronchi. The lungs: internal structure. Histological structure of the bronchi, bronchioles and terminal bronchioles. Bronchial epithelial cells.

15. Structure of the respiratory apparatus: the respiratory zone. The pleura.

The pulmonary lobe. The respiratory bronchiole. The alveolar duct. The alveolar sac. Alveoli. Structure of the alveolar wall: types of pneumocyte. Alveolar macrophages. Septal region. Blood circulation in the pulmonary lobe. Histophysiology of respiration. The pleura.

16. Pulmonary circulation.

Functions of pulmonary circulation. Hemodynamic characteristics of the pulmonary circuit. Effect of gravity: Regional distribution of blood flow. Effects of the respiratory cycle on pulmonary blood flow. Hypoxic vasoconstriction. Exchange system.

17. Ventilation-perfusion relations.

O_2 transfer from the air to the tissues. Shunt. Ventilation-perfusion relation. Regional gas exchange in the lung. Effect of ventilation-perfusion inequality on gas exchange.

18. Peripheral gas transfer and exchange.

Oxygen transfer in blood. Oxygen dissociation curve. C_{02} transport. C_{02} distribution curve. Control of the acid-base balance. Gas exchange between blood and tissues.

19. Respiratory mechanics: static.

Mechanical structure of the respiratory apparatus. Action of respiratory muscles in the expansion and compression of the thoracic cavity. Elastic properties of the lungs. Forces at the gas-liquid interface. Measurement of pulmonary distensibility. Elastic properties of the thoracic box. Elastic properties of the pulmonary system - thoracic box.

20. Properties of gases.

Partial pressure of a gas in a mixture of gases. Partial pressure of water vapour. Partial pressures of inspired, alveolar and expired gases. Conditions determining gas volume. Measurement of partial pressure of gases. Solubility and partial pressure of gases in the blood. Measurement of partial pressure of gases and pH of the blood.

21. Ventilation.

Pulmonary volumes and capacities. Measurement of pulmonary volumes. Pulmonary ventilation. Alveolar ventilation. Dead space. Measurement of dead space. Regional differences in ventilation.

22. Respiratory mechanics: dynamic.

Resistive properties of the lungs. Measurement of the resistance of airways. Dynamic compression of airways. Limitation of respiratory flow. Forced spirometry. Regional differences in ventilation. Measurement of inequality of ventilation. Measurement of closure volume. Dynamics of the ventilatory cycle. Work of breathing. Mechanical ventilation.

23. Alveolar surfactant.

Functions. Composition; lipids and proteins. Characteristics of the superficial monolayer. Metabolism; stages and regulation mechanisms.

24. Gas diffusion in the lungs.

Gas diffusion. Diffusion capacity. O_2 uptake in the pulmonary capillaries. CO_2 elimination from the pulmonary capillaries. Measurement of CO transfer factor.

25. Regulation of respiratory function.

Respiratory neurons. Afferent and efferent pathways of the respiratory circuit. Regulation of air flow resistances. Regulation of ventilation. Regulation of the secretion of water and electrolytes in respiratory pathways.

26. Adaptations of the cardiovascular and respiratory systems.

Adaptation to orthostatism. Adaptation to increase in intrathoracic pressure (Valsalva manoeuvre). Adaptation to physical exercise. Oxygen consumption and muscular vasodilation during exercise. Hemodynamic modifications during physical exercise. Control mechanisms of cardiovascular and respiratory adaptation to physical exercise. Thermoregulation during physical exercise. Cardiovascular and respiratory adaptation to immersion. Cardiovascular and respiratory adaptation to altitude.

27. Histology of the nephron and excretory pathways.

Structure of the glomerulus. Bowman's capsule, glomerular basal membrane, intraglomerular mesangia. Microscopic structure of the different segments of renal tubules: proximal tubules, Henle´s loop, distal tubules and collector tubules. The renal and extrarenal urinary pathways. Structure of the renal pelvis, ureter, urinary bladder and urethra.

28. Physiology of the nephron:

Renal blood flow. Glomerular filtration. Renal tubular function. Absorption and secretion mechanisms. Functions along the nephron.

29. Regulation of renal function.

Autoregulation of renal function. Nervous regulation of renal function. Endocrine regulation of renal function.

30. Mechanism of dilution and concentration of urine and other renal functions.

Mechanisms involved in the control of diuresis. Acid-base balance. Calcium homeostasis. Erythropoietin secretion.

31. Determining factors of the hydroelectric balance.

Homeostasis of water and electrolytes. Fluid compartments in the body. Respiratory, hepatic and renal regulation of pH.

32. Determining factors of arterial pressure.

Participation of the cardiovascular and renal systems. Endocrine regulation of arterial pressure: renin-angiotensin, vasopressin, auricular natriuretic peptide and catecholamines. Prostaglandins and other paracrine mediators.

33. Histogenesis of urine.

Urine transport by urinary pathways. Miction reflex.

PRACTICAL TRAINING

1. Electrical cardiac exploration.
2. Exploration of the cardiac cycle.
3. Determination of arterial pressure.
4. Experimental project using the methodology for determination of arterial pressure.
5. Hemodynamic exploration.
6. Extracorporeal cardiopulmonary function.
7. Analysis of cardiovascular parameters.
8. Role of mechanical parameters of the vascular circuit in equilibrium conditions. Vascular function.
9. Microscopic observation of the structure of the respiratory apparatus.
10. Pressure variations during the respiratory cycle.
11. Spirometry.
12. Forced spirometry.
13. Oxygen consumption.
14. Arterial gasometry.
15. Ventilation and CO_2 exchange.
16. Partial pressures blood oxygen content.
17. Microscopic study of renal structures.
18. Analysis of renal parameters.
19. Analysis of hydroelectrolytic parameters.
20. Analysis of parameters of the acid-base balance.

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LEARNING RESOURCES AND TEACHING METHODOLOGIES

Seminars are aimed at solving numerical exercises and difficulties with the application and development of topics with particular scientific or clinical relevance.

Students will carry out the following tasks in experimental practice:

- Calibrate transductors and measuring equipment
- Obtain data from the experimental process, considering possible sources of error in the measurement process
- Produce graphical representations of the relations between the different measurements recorded
- Derive functional relations between them
- Write a report describing the methods and results

Students will have access to a website (http://www.fisiologia.net) and discussion forum as complementary materials for a part of the programme.