FUNCTIONAL ARCHITECTURE OF THE HUMAN BODY (MSK/HEART/VASCULAR SYSTEM) (A002232)

1. lingua insegnamento/language

English.

2. contenuti/course contents

Coordinatore/Coordinator: Prof. LUCA TAMAGNONE
Anno di corso/Year Course: I
Semestre/Semester: 2°
CFU/UFC: 12
Moduli e docenti incaricati /Modules and lecturers:
- ANATOMY PRACTICALS (A002312) - 0.5 CFU - SSD BIO/16 - Prof. Cinzia Caggiano, Chiara Naro, Vittoria Pagliarini
- ANATOMY PRACTICALS (A002318) - 0.5 CFU - SSD BIO/16 - Prof. Chiara Naro, Veronica Ruta, Marco Pieraccioli
- BONES AND MUSCLES ANATOMY (A002311) - 2.5 CFU - SSD BIO/16 - Prof. Vittoria Pagliarini, Camilla Bernardini
- BONES AND MUSCLES HYSTOLOGY AND EMBRYOLOGY (A002313) - 0.5 CFU - SSD BIO/17 - Prof. Luca Tamagnone
- BONES AND MUSCLES PHYSIOLOGY (A002315) - 1.5 CFU - SSD BIO/09 - Prof. Roberto Piacentini
- HEART ANATOMY (A002317) - 0.5 CFU - SSD BIO/16 - Prof. Claudio Sette
- HEART HYSTOLOGY AND EMBRYOLOGY (A002319) - 0.5 CFU - SSD BIO/17 - Prof. Bianca Maria Scicchitano
- HEART PHYSIOLOGY (A002320) - 1.5 CFU - SSD BIO/09 - Prof. Lucia Leone
- HYSTOLOGY PRACTICALS (A002314) - 0.5 CFU - SSD BIO/17 - Prof. Ilaria Marrocco, Roberta Mastrantonio, Barbara Peruzzi
- PHYSIOLOGY PRACTICALS (A002316) - 0.5 CFU - SSD BIO/09 - Prof. Raimondo Sollazzo, Raimondo Sollazzo, Raimondo Sollazzo, Raimondo Sollazzo
- PHYSIOLOGY PRACTICALS (A002321) - 0.5 CFU - SSD BIO/09 - Prof. Marco Rinaudo, Marco Rinaudo, Marco Rinaudo, Marco Rinaudo
- VASCULAR ANATOMY (A002322) - 1 CFU - SSD BIO/16 - Prof. Claudio Sette, Camilla Bernardini
- VASCULAR HYSTOLOGY AND EMBRYOLOGY (A002323) - 0.5 CFU - SSD BIO/17 - Prof. Bianca Maria Scicchitano
- VASCULAR PHYSIOLOGY (A002324) - 1 CFU - SSD BIO/09 - Prof. Lucia Leone

3. BIBLIOGRAPHY

ANATOMY:
Susan Standring: Gray’s Anatomy, The Anatomical Basis of Clinical Practice, 41st Edition, Elsevier.

Frank H. Netter: Atlas of Human Anatomy, 7th Edition, Elsevier.
Anastasi G. Human Anatomy; Edi. Ermes
For clinical correlates, see also: Keith L. Moore, Arthur F. Dalley and Anne M.R. Agur: Clinically Oriented Anatomy, 6th Edition: Hardcover Edition, Lippincott Williams and Wilkins.

EMBRYOLOGY:
Keith L. Moore, T.V.N. Persaud, Mark G. Torchia: The Developing Human- Clinically Oriented Embryology, 11th Edition, Elsevier, 2019.
Gary C. Schoenwolf, Steven B. Bleyl, Philip R. Brauer, Philippa H. Francis West: Larsen's Human Embryology, 6th Edition, Churchill Livingstone, Elsevier, 2020.

HISTOLOGY:
Wojciech Pawlina: Histology- A Text and Atlas with correlated cell and molecular biology, Eighth Edition, Wolters Kluwer, 2019.
V. De Felice, B.M. Scicchitano, G. Dobrowolny, G. Ricci, M.T. Viscomi, Fundamentals of Histology, Structure and Function of Human Body Tissues and Systems, Edizioni Scientifiche Falco.

PHYSIOLOGY:
W. F. Boron and E. L. Boulpaep: Medical Physiology, 3rd Edition, Elsevier, 2017.
See also: Guyton and Hall: Textbook of Medical Physiology, 14th Edition, Elsevier, 2020.

4. LEARNING OBJECTIVES

The integrated course is designed to give students a comprehensive understanding of the Musculo-Skeletal and Cardio-Vascular (heart and vessels) systems. This is achieved through an integrated systemic approach that combines Anatomy, Embryology, Histology, and Physiology. Specifically, the Anatomy modules focus on the gross structure, microscopic anatomy, and functional correlations of the various organs. The Histology and Embryology modules discuss the principles of development and detail the histological structures of various systems, linking them to cell and molecular biology. The Physiology modules explain the fundamental mechanisms that underpin system functioning, with an emphasis on their interactions.
Significant importance is placed on the clinical implications of these disciplines. Students are furthermore guided to the acquisition of accurate scientific terminology.

In detail, by the end of the course, students must demonstrate having accomplished the following objectives:

Knowledge and understanding abilities – To acquire knowledge of the different levels of organization of the human musculoskeletal and cardiovascular systems, at macroscopic and microscopic levels. Acquire knowledge of cellular functions and physiological mechanisms for the implicated tissues and organs. Understand basic embryological mechanisms of musculoskeletal and cardiovascular system development.

Applied knowledge and understanding skills – To understand and appreciate the clinical relevance of the acquired knowledge about the Anatomy, Histology, Embryology, and Physiology of musculoskeletal and cardiovascular systems, concerning basic implications in pathology and diagnostic and therapeutic applications. Acquisition of practical skills in microscopic examination of musculoskeletal and cardiovascular tissue specimens. Awareness about methods used to better understand cells, tissues and organ functions.

Making judgments – The student will integrate the acquired knowledge and skills to identify the fundamental structures of musculoskeletal and cardiovascular systems and the associated physiological mechanisms relevant for the application in the medical field.

Communication skills – The student should be capable of communicating the acquired scientific knowledge and applied know-how in a clear and unambiguous way, using appropriate technical language.

Learning skills – Students should learn how to keep up-to-date and expand their knowledge by autonomously consulting reference textbooks, scientific literature, and databases.

5. prerequisites

Students must have attended the following propaedeutic course and successfully passed the respective exam: *Life of Cells, Tissues and Microbes*.

6. TEACHING METHODS

The course is organized into lectures and practical sessions covering the topics included in all the teaching modules to provide specialized elements of Anatomy, Histology/Embryology, and Physiology, concerning the human musculoskeletal and cardiovascular systems. All the lessons are supported by visual aids (slides, animated movies, etc.) that stimulate the interest of learners and help the teachers to explain the concepts easily. The teaching methods implement active learning activities, such as problem-based learning, self-learning, flipped classrooms, and practical activities. Required student learning includes individual work and activities in small groups. Students will have individual and personalized access to anatomical models, optical microscopes and histological specimens, instruments for the evaluation of physiological parameters such as electromyographs, sphygmomanometers, stethoscopes, and electrocardiographs for practical training under teacher's supervision, and in subsequent self-learning sessions.

Knowledge and understanding: During theoretical lessons, the teachers will illustrate the main aspects of musculoskeletal and cardiovascular systems from the viewpoint of Anatomy, Histology, Embryology, and Physiology, underscoring the connections between these disciplines and the relevance of this knowledge for medicine and surgery.

Applying knowledge and understanding: During the frontal lessons and practical activities, teachers encourage an open dialogue and solicit student feedback. Students are invited to interact with the teacher to clarify specific points and achieve a deeper knowledge of the various topics. Written questions can be administered to the students during classes to facilitate learning and help them to prepare for the exam.

Making judgments: During the Anatomy and Histology practicals, teachers begin with a content briefing and then discuss relevant specimen slides and anatomical models. During the practical training in microscopy, teachers attend to students individually for any clarification and stimulate their critical attitude in identifying the characteristics of the specimens and making a differential diagnosis. Physiology practicals emphasize measuring heart rate, electrical activity of heart and skeletal muscles, function of heart valves, and blood pressure with a range of medical instruments. Students engage in group discussions to analyze this data, formulating hypotheses about physiological processes and predicting the outcomes of experimental adjustments. These activities reinforce their theoretical knowledge and advance their analytical and problem-solving abilities.

Communication skills: During lessons and practicals, students are stimulated to ask and answer questions. If necessary, teachers suggest the appropriate terminology and the best way to give definitions and express concepts and data. The development of communication skills is promoted by working in small groups.

Learning skills: While theoretical lessons are focused on the fundamental aspects of the course contents, the students are expected to develop this knowledge by in-depth studying suggested textbooks and consulting additional references, such as interactive iconography or animated movies, available online. At any phase of their learning process, the students may request the teacher's clarification of specific aspects or additional references to expand their basic knowledge.

7. OTHER INFORMATIONS

The teachers can meet students individually upon request (by e-mail).

According to regulation, at least 65% of class attendance is required for direct admission to the final exam. Failure to fulfil this requirement, or any student's violations in the registration of attendance, will implicate further obligations or restrictions to access exam sessions. Do not refer to the Instructors for seeking technical assistance on class attendance or exam registration as they could not help with these issues, which would rather be checked with the administrative offices.

During the exams, any portable electronic devices, including mobile phones, must be switched off

and put over the desk inside an envelope given by the Course Coordinator. The Course Coordinator may permit individuals to use certain devices in specific authorized cases. Violations will be referred to the Disciplinary Committee.

Students found by the Instructors to be cheating during an exam will receive a failing grade and will be reported to the Chairman of the MD program.

8. METHODS FOR VERIFYING LEARNING AND FOR EVALUATION

The exam consists in two parts, respectively verifying the acquired competences about: the Muscle-Skeletal System and the Cardio-Vascular System. To pass the exam, the student is required to obtain a sufficient grade (minimum 18/30) in each of the two parts, which will equally impact in the calculation of the final grade (between 18 and 30/30 with laude).

Both parts will be verified at large by a multiple-choice questionnaire (MCQ, globally including at least 70 questions) concerning aspects of Anatomy, Histology/Embryology, and Physiology of the concerned systems; for each question, a single correct answer needs to be identified. In order to pass the test, the student must answer correctly to more than 51% of the questions relative to each of the three disciplines. To achieve the highest score, the student must correctly answer over 97% of the questions. In case of controversial issues, students may be called into a brief oral interview, aimed at validating the results of the multiple-choice questionnaire.

Notably, the assessment of Histology competences will also include a preliminary test at the microscope, analyzing one of the specimens illustrated during the professional training. This practical test is mandatory, it will be scheduled at the end of the Histology Practicals series, and it will impact by one third on Histology/Embryology scores generated by the subsequent MCQ; the practical test can be repeated before a following exam date in case of unsatisfactory results.

Upon passing the MCQ, the student will accomplish an integrated grade, calculated by the weighted average (based on respective CFU) of the results concerning Anatomy, Histology/Embryology and Physiology modules.

In case the student passes the tests only for one of the two Systems (Musculo-Skeletal or Cardio-Vascular), the partial grade will be put on hold and kept valid for a few subsequent exam dates, namely until the extraordinary Christmas session for tests passed in Summer/Fall, or until the Easter session for tests passed in Winter.

Knowledge and understanding: A multiple-choice questionnaire will allow to verify the acquired knowledge about musculo-skeletal and cardio-vascular systems, in the integrated fields of macroscopic anatomy, histology/embryology, and physiology.

Applying knowledge and understanding: Based on exemplified clinical cases, some of the questions in the written test will verify students' understanding of the relevance of the acquired theoretical knowledge in applied medicine and surgery. Moreover, a subset of histology questions is aimed at assessing the acquired skills in the analysis of microscopic images of tissue specimens representative of skeletal and muscular systems.

Making judgments: For some of the questions in the written test, the students are required to select the most appropriate and informative answer among proposed acceptable ones. Questions exemplifying clinical cases will request student's judgments about the most relevant theoretical knowledge to answer the question.

Communication skills: The questions in the multiple-choice questionnaire will assess students' acquaintance with the currently applied technical language in various disciplines. The discussion of histological specimens during the practical test will furthermore assess the communication skills of the students.

Learning skills: Student's preparation for the exam will implicate referring to complementary textbooks for the different integrated disciplines. The students will be guided to identify fundamental information, to be integrated with relevant details and updated knowledge provided

during the lessons and the practical sessions.

9. program

MUSCLE-SKELETAL SYSTEM

ANATOMY: Anatomical nomenclature: planes, directions and relationship, movements. Functional anatomy of the musculoskeletal system, general system anatomy. Introduction to osteology: definitions, vocabulary, classification and macroscopic structure of bones, bone sexual dimorphism. Introduction to arthrology: definitions, vocabulary, classification and macroscopic structure of joints. Systemic anatomy of the axial skeleton: skull bones and joints; spine: general structure, vertebrae, vertebral defects and spine malformations, intrinsic and extrinsic vertebral joints, thorax bones and joints. Systemic anatomy of the appendicular skeleton: bones and joints of the shoulder and pelvic girdles, bones and joints of the upper and the lower limbs. Introduction to myology: definitions, vocabulary, classifications and macroscopic structure, blood supplies and innervation of muscles; accessory organs of skeletal muscles (tendons, aponeurosis, bursae). Systemic anatomy of axial muscles: cranial and cervical muscles and aponeurosis, spinal and thorax muscles and aponeurosis. Systemic anatomy of appendicular muscles, upper limb muscles and aponeurosis, the axillary cavity, lower limb muscles and aponeurosis, the femoral triangle, the popliteal cavity; clinical correlates: congenital and injury-related muscle disorders. Practical training: anatomy lab practicals on human bones; identification of anatomical structures, main landmarks and movements on interactive anatomical modeling software.

EMBRYOLOGY: The Axial Skeleton, Skull, Vertebrae and the Vertebral Column, Ribs and Sternum. Developmental skeletal defects. Muscular System: Striated Skeletal Musculature. Innervation of Axial Skeletal Muscles. Skeletal Muscle and Tendons. Regulation of Muscle Development. Head Musculature. Limb Growth and Development. Limb Musculature.

HISTOLOGY: Cartilage: Overview of Cartilage, Hyaline Cartilage, Elastic Cartilage, Fibrocartilage. Chondrogenesis and Cartilage Growth. Repair of Hyaline Cartilage. Joints. Ligaments. Clinical correlations: cartilage diseases and degeneration. Bone: Overview of Bone: Bones and Bone Tissue. General Structure of Bones. Bone cells: Osteoprogenitor Cells, Osteoblasts, Osteocytes, Osteoclasts. Bone Formation. Intramembranous Ossification. Endochondral Ossification. Development of the Osteonal (Haversian) System. Bone Mineralization and Matrix Vesicles. Regulation of bone growth and bone remodelling. Nutritional factors in bone formation. Clinical correlates: Osteoporosis and other bone diseases. Muscle Tissue: Overview and classification of muscles. Skeletal Muscle. Myofibrils and myofilaments. The contraction cycle. Motor innervation. Sensory innervation. Development, repair, healing and renewal. Smooth Muscle. Structure and functional aspects. Muscle metabolism and ischemia. Clinical Correlates: Muscular Dystrophies. Myasthenia gravis. Practical training: Use of light microscope to understand the microanatomy and the differentiated cellular features in skeletal tissues, such as cartilage and bone. In case of inability to carry out practical training with a microscope (e.g. due to exceptional circumstances or restrictions), online training sessions will be organized for the analysis of histological images.

PHYSIOLOGY: Skeletal muscles: molecular aspects of muscle contraction, neuromuscular junction and neuromuscular signals, electro-mechanical coupling, mechanical events, isometric and isotonic contraction, tension, length, velocity relations, passive properties, motor units, contraction energy, fatigue, muscle energy metabolism. Smooth muscle and functional differences in comparison with skeletal muscle. Muscles and skeletal structures, interactions: biological joints, operative ranges, functional interactions among muscle-tendon complex, joint elements, and ligaments, joints as muscle-tendon integrators, joint mechanical impedance: its control, functional and clinical implications, the passive and active role of ligaments. Controls: Fundamentals about adaptive controls in the skeletal system: nerve, muscle cartilage, and bone functional relations: clinical implications. Practical training: muscle physiology simulator, electromyography (EMG).

HEART

ANATOMY: Mediastinum: limits, division in the superior and inferior mediastinum, the topography of visceral structures. Overview of the cardiovascular system, systemic and

pulmonary circulations, and fetal circulation. Heart: topography, position, and relations within the thoracic cavity, wall structure, fibrous skeleton, external and internal anatomy: chambers, valves, conducting system, coronary vessels, microscopic anatomy of the heart. Pericardium and pericardial sinuses, a brief introduction to congenital anatomical anomalies of the heart. Practicals: Heart dissection; introduction to medical examination and imaging of the vascular system, radiographic anatomy of the heart.

EMBRYOLOGY: Establishment and patterning of the primary heat field. Progenitor heart cells. Secondary heart field. Formation and position of the heart tube. Formation of the cardiac loop. Molecular regulation of cardiac development. Development of the sinus venosus. Formation of the cardiac septa.

HISTOLOGY: Cardiac muscle. Structure of the heart muscle. Differentiation, renovation, damage, and repair. Intrinsic regulation of heart rate. Systemic regulation of the heart function. Practical training: Use of light microscope for understanding the microanatomy and the specific features of cardiac muscle, differentiating it from skeletal and smooth muscles, and correlating structures with functions.

PHYSIOLOGY: Rhythmical excitation of the heart: the cardiac action potential. Specialized conductive system of the heart. Control of excitation and conduction in the heart. Characteristics of the normal electrocardiogram. Electrocardiographic leads. Principles of vectorial analysis of electrocardiograms. The cardiac muscle. The cardiac cycle. Preload and afterload. Stroke volume and cardiac output. Frank-Starling mechanism. Heart pump and artery elasticity. Cardiac work. Contractility modulation. Coronary circulation. Practicals: Electrocardiographic recording, auscultation of heart sounds.

VASCULAR SYSTEM

ANATOMY: A basic introduction to Pulmonary circulation, Systemic circulation, and the Lymphatic system. Blood vessels: structure and function. Arteries. Arterioles. Capillaries. Venules. Veins. Anastomoses. Vessels of the systemic circulation. Arterial System: aorta's origin, distribution, and main branches. Ascending aorta and its branches. Arch of the aorta: arteries of head and neck- arteries of the upper limb. Descending aorta: thoracic aorta; abdominal aorta and arteries of the lower limb. Venous system. Superior vena cava and its tributaries: veins of head, thorax, and upper limb. Inferior vena cava and its tributaries: veins of abdomen, pelvis and lower limb. Practicals: Microscopic examination of the structure of the aorta, vena cava, and other main vessels. Introduction to medical examination and imaging of the vascular system.

EMBRYOLOGY: Vasculogenesis and angiogenesis. Formation of primitive blood vessels associated with endocardial tube. Development of lymphatic system. Development of thymus, spleen and lymph nodes. Angiomas.

HISTOLOGY: Layers of the vascular wall. Vascular endothelium. Large, medium and small arteries. Classification and functional aspects of capillaries. Large and small veins. Lymphatic vessels. Lymphatic nodules. Cells of the reticular meshwork. The architecture of thymus, spleen, and lymph nodes. Atherosclerosis. Hypertension. Ischemic heart disease. Practical training: Use of light microscope to analyze histological sections of blood vessels and lymphoid organs, such as thymus, spleen and lymph nodes, learning to recognize and describe the different structures and cellular components.

PHYSIOLOGY: Hemodynamic premises. Arteries and veins. Microcirculation. Microcirculation regulation. Special circulation. Coagulation. Practicals: Measurement of blood pressure.