UNIVERSITÀ DI PAVIA

Anno Accademico 2021/2022

COMPARATIVE ANATOMY

Enrollment year	2020/2021
Academic year	2021/2022
Regulations	DM270
Academic discipline	BIO/06 (COMPARATIVE ANATOMY AND CYTOLOGY)
Department	DEPARTMENT OF BIOLOGY AND BIOTECHNOLOGY "LAZZARO SPALLANZANI"
Course	BIOLOGICAL SCIENCES
Curriculum	PERCORSO COMUNE
Year of study	2°
Period	1st semester (01/10/2021 - 14/01/2022)
ECTS	6
Lesson hours	50 lesson hours
Language	Italian
Activity type	WRITTEN TEST
Teacher	BERTONE VITTORIO (titolare) - 9 ECTS
Prerequisites	Basics of General Biology, with particular reference to the structure of cells and tissues. The contents of the course in Cytology and Histology are preparatory to the topics covered. Basic knowledge of Chemistry, Physics and Genetics. Ability to use the optical microscope
Learning outcomes	The main objective of the course is to provide an in-depth knowledge of the anatomy of Vertebrates in an evolutionary key. Through the training course the student will acquire theoretical and practical skills related to the Embryology and Vertebrate Anatomy, with particular attention to the comparison between apparatuses and systems and to the evolutionary and adaptation processes that led to the differentiation of the different anatomical structures in the various classes . The expected learning results are the following:

• Knowledge of the specific language for the description of Vertebrates, from the microscopic level (structure and cellular functions) to the macroscopic level (morphology and functions of organs and systems).

• Knowledge of the embryonic development and anatomical structure of Vertebrates, understanding of their ontogenetic development modality and their internal organization, correlation between organogenesis and evolution (Evo-Devo Theory) through the study of the peculiar characteristics of tissues, organs and systems.
• Acquisition of descriptive and analytical skills on anatomical structure, as well as development of a critical spirit in the comparison of organs and apparatuses in evolutionary optics.

• Knowledge of morphological characters and their variability in relation to the environment, with particular attention to adaptation phenomena.

• Ability to apply the acquired knowledge in the recognition and interpretation of the anatomical structures of Vertebrates, starting from illustrations, diagrams, anatomical tables and museum preparations, dynamically following the evolutionary process that led to the current Vertebrates.

Course contents

The course provides students with a solid foundation for the knowledge of Comparative Vertebrate Anatomy, based on embryonic development and on the phenomena of adaptation to the environment seen in an evolutionary key.
The following topics are covered:

§ The Protochordates and origin of Vertebrates (or Emicephalochordates or Craniotes; Phylogenetic and general anatomical features aspects (bauplan), centralization, regionalization of anteroposterior axis and genetic control of development (homeotic Hox genes), metamerism and bilateral symmetry, planes and anatomical axes, characterizing structures: notochord, skull, vertebrae, central nervous system, pharynx, body cavities.

§ Basic concepts: analogy, homology, homoplasy, rudimentary and vestigial structures, divergence, parallelism, convergence, ontogeny, phylogeny, von Baer law (evo-devo and phylotypic stage), cladistics (mono-, para-, poliphyletism), archetypes and living fossils.

§ Classification, general characteristics and phylogenetic relationships among the major taxa of Vertebrates; AGNATES (Ostracoderms and Cyclostomes) and GNATHOSTOMES (Placoderms, Chondrichthyes, Acanthodians, Osteichthyes, Labyrinthodonts, Amphibians, Cotilosaurian, Reptiles, Archaeornites, Birds, Therapsids, Mammals).

§ The ontogeny of Cephalochordata and Vertebrates; gametogenesis, types of eggs and associated membranes, segmentation, gastrulation of coeloblastulae (Amphioxus, Fishes, Amphibians) and discoblastulae (Fish, Sauropsidae and Mammals), neurulation, derivatives of the three germ layers (ecto-, meso-, endoderm), neural crests as the fourth germ layer, somatic and germ components, induction, direct and indirect

development (larval stage), oviparity-ovoviviparity-viviparity, fetal membranes (yolk sac, albumen sac, amnios, chorion, allantois, placentas) , the regenerative capabilities of Vertebrates.

§ Skeletal system; a) Types of skeletal tissue (cartilage, bone) and scheletogenous blastema (somites, somitomeri, neural crest, the skeletogenous septa system, etc.), direct or membranous ossification (allostosis) and indirect or endochondral (autostosis). b) axial skeleton: notochord, vertebrae (genesis, acentric and centric vertebrae, diplo- and monospondilia, arcocentric and cordocentric, amphi-, pro-, opisto-, eterocelic, amphyplanar vertebrae), regionalization of the spinal chord, ribs, abdominal ribs (gastralia) , sternum, skull [cranium (platibasia, tropibasia), splanchnocranium, dermatocranium (anapsides, diapsides, sinapsides, parapsides, primary and secondary palate), autostilic, anfistilic, iostilic suspensions, cranial cinetism]. c) zonal skeleton: pectoral girdle, pelvic girdle (saurischian and ornitischian), etc .. d) appendicular skeleton: unpaired and paired fins, chiridium limb and adaptation to locomotion (running, jumping, flying, swimming). e) heterotopic bones.

§ Integumentary system: general organization, embryonal derivation, dermal-epidermal interaction, epidermis and its derivatives (glands, photophores, scales, feathers, hair, beaks, claws, nails, hooves, horns), dermis and its derivatives [bony scales (cosmoid , placoid, ganoid, elasmoid, cycloid, ctenoid) and their phylogenetic relationships, osteoderms, etc., sensory receptors, pigmentary cells (xantofores, iridofores, melanophores, melanocytes, cromatophora units).

§ Digestive System; stomodeum and proctodeum, mouth and oral cavity, salivary glands, teeth (genesis and classification), tongue, microanatomical organization of the intestinal wall, pharynx and its derivatives, esophagus and craw, glandular and muscular stomach, pre-stomach (gastric fermentation), small intestine and pyloric blind cavities, large intestine and blind ileocholic cavities (intestinal fermentation), liver, pancreas.

§ Respiratory system; gill respiration (external gills, internal gills: pouch-like gills, septed gills and comb-like gills, counterflow gas exchange, pseudo-gills, cutaneous and pulmonary respiration, saccular lungs, natatory bladder, lung parenchymal, aeriferous sacs, respiratory tract, body cavity and its distribution.

§ Circulatory system; microanatomical organization of the wall of blood and lymph vessels, blood and emopoiestic / emocatheretic organs, types of circulation (single/double, open/closed, incomplete/complete), genesis and evolution of the heart, the heart and aortic arches of fish with simple and double circulation (Dipnoans), heart and aortic arches of Aamphibians (larval/adult stage), the heart and aortic arches of Reptiles (squamated/loricates), heart and aortic arches of Birds and Mammals, vascularization of brain, Willis circle, embryonic movement of anamniotes and amniotes, main arteries and veins, portal systems (kidney, liver, pituitary).

§ Urogenital; a) osmoregulator and excretory organs, pronephros, mesonephros (opistonephros), metanephros, nephronic vascularization, urinary tract and bladder, chlorides cells of Fishes, rectal gland of Elasmobranchs, salt glands of Sauropsida, nitrogen catabolism (ammoniotelia, ureotelia, uricotelia). b) Genesis of the gonads (genital ridges): somatic and germ components, cystic and tubular testicles, medullo-Wolffian interaction, cavitated and parenchymal ovaries, oviducts and their specializations, cloaca: derivatives (spermatheca, bursa of Fabricius, urinary bladder, copulatory organs , etc.) and its partitions, urinary bladder.

§ Nervous system and sense organs; a) SNC: telencephalon, rhinencephalon and cerebral hemispheres (paleo-, archi-, neo-cortex), diencephalon (epithalamus, thalamus, hypothalamus, neurohypophysis, epiphysis, optic chiasm), midbrain (optic lobes), hindbrain (cerebellum: archi-, paleo -, neo-cerebellum), myelencephalon, spinal cord, cranial nerves. b) nasal olfactory epithelium, vomero-nasal organ (or Jacobson), eye and photoreception, inner, middle and external ear, lateral line system.

§ Endocrine Organs; neurosecretion and pituitary gland, chromaffin tissue and adrenal medulla, interrenal tissue and adrenal cortex, the interstitial cells of the gonads, endostylum and thyroid, parathyroid and ultimobranchial bodies.

In addition to the lectures, practical exercises consisting in the microscope recognition of embryonic structures of anamnes and amniotes are carried out.

Teaching methods

The course uses frontal lessons and laboratory activities

In the first part of the course the basics of embryonic (ontogenetic) development, and its relations with the evolutionary one (phylogenetic) are laid. In parallel, practical exercises are carried out, where the student is guided, through a theoretical introduction and tutorial assistance, to the individual vision of the microscopic preparations related to the embryonic development of anatomical structures in some representative classes of Vertebrates.
In this way the student will be able to achieve the objective of recognizing, describing and comparing the various stages of development of the different anatomical structures in the process of formation.

In the second part of the course the different Vertebrate apparatuses will be reviewed in a comparative way

The lectures will be conducted through PowerPoint presentations made entirely available to students on the teacher's web page, which can be reached directly or through links on the KIRO platform.

In the lectures many illustrative images are presented alternated with definitions, diagrams, lists, traces and keys of comparative reading, as well as some didactic films coming from the network to underline the

	dynamic aspects of the subject. Attendance at lectures and exercises is strongly recommended.
Reccomended or required readings	AAVV a cura di Vincenzo Stingo: Anatomia Comparata- Ed. Edi-Ermes Liem-Bemis-Walker-Grande: Anatomia Comparata dei Vertebrati - Ed. EdiSES Kardong: Anatomia Comparata, funzioni, evoluzione - Ed. McGraw-Hill For further information on Embryology, see the following texts in the Library: Houillon - Embriologia dei Vertebrati Balinski - Introduzione alla embriologia De Luca - Embriologia dei Cordati Giudice - Biologia dello sviluppo Wolpert - Principles of development Casasco - Embriologia generale Gilbert - Developmental biology (...molto molecolare...) Drews - Testo atlante di embriologia De Vos & Van Gausen - Atlas d'embriologie des vértebrés
Assessment methods	Learning is verified through a written exam consisting of various types of questions: - An image of embryology slide to be interpreted, identifying the animal in question and the stage of development, describing the type of preparation and recognizing the single structures indicated with arrows - An open question on the derivatives of embryonic leaflets, to which to answer building a branched scheme - A question on the classification presented in the form of a scheme to be completed - 16 multiple choice questions (with 4 possible answers, of which one is the right one) and variable difficulty on the various apparatuses - A specific 19th question will be used to attribute the Praise, only if the answers to all the other questions are correct. Examples of exam questions are presented during the lessons.
Further information	During the course of the workshops that take place during the course and the week before each exam session tutors are available to assist

	and support students in the preparation of the practical exam. They are also available to clarify the topics in the program .
Sustainable development goals - Agenda 2030	The goals