



Field of study	Aquaculture and Fisheries					
Mode of study	stationary	Level	first cycle			
Graduate's qualification	inżynier					
Fields of science	agricultural sciences					
Disciplines of science	animal science and fisheries (100%)					
Educational profile	general academic					
Module						
Course unit	Fish anatomy and embriology					
Code	WNOZIR/AQF/S1/					
Field of specialisation						
Administering faculty	Department of Hydrobiology, Ichthyology and Biotechnology of Reproduction					
ECTS	4.0	ECTS (forms)	4.0			
Form of course credit	examination	Language	english			
Electives		Elective group				
Form of instruction	Cod	Semester	Hours	ECTS	Weight	Credit
laboratory course	L	2	30	2.0	0.50	credits
lecture	W	2	30	2.0	0.50	examination
Leading teacher	Formicki Krzysztof (Krzysztof.Formicki@zut.edu.pl)					
Other teachers						
Prerequisites						
W-1	Basic knowledge of biology					
Module/course unit objectives						
C-1	The goal of the course is to introduce students with the macroscopic and microscopic structure of fishes and other aquatic organisms, taking into account comparative structural differences					
C-2	To introduce the students with the relationships between the histological structure of tissues and organs, and obtaining specific technological effects in food production; This is how anatomical knowledge is perceived (enriched with topography of organs) is indispensable for acquiring knowledge in other disciplines such as embryology, aquaculture and food technology					
Course content divided into various forms of instruction						Number of hours
T-L-1	Osteology - division of the skeleton into individual elements, structure, Latin - scientific terminology. Topography of fish muscles, structure, location of individual muscles. Origin, structure, topography of individual internal organs, interspecies differences.					5

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<i>Course content divided into various forms of instruction</i>	<i>Number of hours</i>
<p>Histological structure of individual tissues and organs. Border tissues; epithelium - types, structure of the epithelium as an expression of adapting its macro- and microstructure to the place of occurrence and its function; epithelial origin. Skin: structure, functions, layers, skin color, specificity and diversity of skin and the functions it performs; technological value of the skin and its products - collagen; usefulness of hard leather products for biology and taxonomy research. proper connective tissue cells, intracellular structures, collagen and non-collagen matrix components; chemical structure and mineral structure of tissue, types of bone joints; blood as a suspension of cells (blood cells) and platelets in a liquid intercellular substance; blood composition Structural elements of the fish body - cells, tissues, organs, systems (external and internal structure of the cell, intracellular structures, differentiation of size, shape and external and internal structure depending on the function performed; types of tissues - the participation and role of tissues in structures with a higher degree of integration morpho-functional - organs and systems; Organs - topography, the participation of various tissue structures in individual organs, morphological modifications of cells in individual organs; Systems - the diversity of structure and topography of systems as an expression of functions by related organs forming the system, structural and functional interdependence of individual organs inside the system Tissues - general characteristics, classification, development of tissue science as an effect of progress in research techniques and methods; types of microscopes - light and electron; tissue culture observed in vitro and in vivo; Tissue classification: Muscle tissues as a collection of cells capable of contraction and relaxation - types, origin, muscle fiber - myocyte, sarcomer structure, thin and thick myofilaments; sliding theory of muscle contraction; molecular contraction mechanism, microtubules; type of muscle fibers; cardiac muscle tissue; smooth muscle tissue; Circulatory system (blood and lymphatic) - arteries and veins, capillaries, heart; construction and topography; fish heart structure; irrigation of individual organs - biological and differences importance; vessel construction and so-called lymphatic hearts, specific structure, topography, importance; cardiovascular muscles; centers and structures regulating cardiovascular activities. Respiratory system - gill apparatus, formation, structure, gas exchange, respiration of cartilaginous and skeletal fish; adaptations to air breathing - fish, additional respiratory organs in embryos, larvae and adult fish Excretory and osmoregulatory systems; kidney structure; topography, division into sections, internal structures, differences in the structure and microstructure of the kidneys of sea and freshwater fish; the liver and its contribution to the excretion and neutralization of toxins and products of metabolism; structure; gills and swim bladder - role in the excretion of CO₂ and excess salt, chloride cells; Endocrine system - structure (glands) and topography of the fish endocrine system; cell structure of glands, hormonal regulation and influence of hormones on fish's body; morpho-functional effects; participation of endocrine glands in regulating and preparing the fish's body for breeding; possibilities of practical applications. Nervous tissue, nervous system - neuron, development of nerve tissue, nerve endings, development of the nervous system, conception and structure of the nerve; brain, cerebral nerves, spinal cord, autonomic system. Sensory organs - definition, receptors, anatomical diversity of sensory organs. Light and electrical organs in fish - the arrangement of light organs on the body of the fish and their sizes; phenomenon of lighting and its biological significance. Electrical organs: the occurrence and location of electrical organs in fish; electric fish organs; mechanism of current generation in biological structures; examples of physiological phenomena accompanying electrical discharges; strong and weak electrical discharges; electrostatic sense and electrolocation; communication of fish using electric signals. Fish electroreceptors - discovery of the phenomenon of shark locating prey (electroreception),</p>	20
<p>Fish reproduction - reproduction as a processes ensuring the preservation of species and populations and playing an essential role in breeding economy, morphological adaptations to reproduction; reproductive system and organs - gonads; biological significance; Changes in the endocrine system; gonads, gonads, germ cells - sperm and eggs; spermatogenesis, ovogenesis; embryonic development, essence and meaning. Influence of external - environmental factors - on germinal development, influence of ambient temperature, thermal units (degree days, degree hours, optimal and lethal temperatures), influence of dissolved oxygen in water, water and gas exchange; exposure to light, salinity. Embryogenesis - detailed structure of gametes (eggs and spermatozoa) and their species diversity, embryonic development, impact of environmental conditions.</p>	5
<p>Basic anatomical concepts and definitions, place and usefulness of anatomical knowledge for other areas of fisheries knowledge; Methods of anatomical examinations (macroscopic, microscopic - in vivo and in vitro); Anatomical nomenclature. Structural elements of the fish body - cells, tissues, organs, systems (external and internal structure of the cell, intracellular structures, differentiation of size, shape and external and internal structure depending on the function performed; types of tissues - the participation and role of tissues in structures with a higher degree of integration morpho-functional - organs and systems; Organs - topography, the participation of various tissue structures in individual organs, morphological modifications of cells in individual organs; Systems - the diversity of structure and topography of systems as an expression of functions by related organs forming the system, structural and functional interdependence of individual organs inside the system</p>	10



<i>Course content divided into various forms of instruction</i>		<i>Number of hours</i>
T-W-2	<p>Tissues - general characteristics, classification, development of tissue science as an effect of progress in research techniques and methods; types of microscopes - light and electron; tissue culture observed in vitro and in vivo;</p> <p>Tissue classification:</p> <p>Border tissues; epithelium - types, structure of the epithelium as an expression of adapting its macro- and microstructure to the place of occurrence and its function; epithelial origin.</p> <p>Skin: structure, functions, layers, skin color, specificity and diversity of skin and the functions it performs; technological value of the skin and its products - collagen;</p> <p>usefulness of hard leather products for biology and taxonomy research.</p> <p>Internal environment tissues - connective, types, intracellular substance (matrix), proper connective tissue cells, intracellular structures, collagen and non-collagen matrix components; chemical structure and mineral structure of tissue, types of bone joints; blood as a suspension of cells (blood cells) and platelets in a liquid intercellular substance; blood composition</p> <p>Muscle tissues as a collection of cells capable of contraction and relaxation - types, origin, muscle fiber - myocyte, sarcomer structure, thin and thick myofilaments; sliding theory of muscle contraction; molecular contraction mechanism, microtubules; type of muscle fibers; cardiac muscle tissue; smooth muscle tissue;</p> <p>Circulatory system (blood and lymphatic) - arteries and veins, capillaries, heart; construction and topography; fish heart structure; irrigation of individual organs - biological and differences importance; vessel construction and so-called lymphatic hearts, specific structure, topography, importance; cardiovascular muscles; centers and structures regulating cardiovascular activities.</p> <p>Respiratory system - gill apparatus, formation, structure, gas exchange, respiration of cartilaginous and skeletal fish; adaptations to air breathing - fish, additional respiratory organs in embryos, larvae and adult fish</p> <p>Excretory and osmoregulatory systems; kidney structure; topography, division into sections, internal structures, differences in the structure and microstructure of the kidneys of sea and freshwater fish; the liver and its contribution to the excretion and neutralization of toxins and products of metabolism; structure; gills and swim bladder - role in the excretion of CO₂ and excess salt, chloride cells;</p> <p>Endocrine system - structure (glands) and topography of the fish endocrine system; cell structure of glands, hormonal regulation and influence of hormones on fish's body; morpho-functional effects; participation of endocrine glands in regulating and preparing the fish's body for breeding; possibilities of practical applications.</p> <p>Nervous tissue, nervous system - neuron, development of nerve tissue, nerve endings, development of the nervous system, conception and structure of the nerve; brain, cerebral nerves, spinal cord, autonomic system.</p> <p>Sensory organs - definition, receptors, anatomical diversity of sensory organs.</p> <p>Light and electrical organs in fish - the arrangement of light organs on the body of the fish and their sizes; phenomenon of lighting and its biological significance.</p> <p>Electrical organs: the occurrence and location of electrical organs in fish; electric fish organs; mechanism of current generation in biological structures; examples of physiological phenomena accompanying electrical discharges; strong and weak electrical discharges; electrostatic sense and electrolocation;</p> <p>communication of fish using electric signals.</p> <p>Fish electroreceptors - discovery of the phenomenon of shark locating prey (electroreception), Algorithm for locating prey by sharks and rays, distribution, orientation of fish in the magnetic field.</p>	10
T-W-3	<p>Fish reproduction - reproduction as a processes ensuring the preservation of species and populations and playing an essential role in breeding economy, morphological adaptations to reproduction; reproductive system and organs - gonads; biological significance;</p> <p>Changes in the endocrine system; gonads, gonads, germ cells - sperm and eggs; spermatogenesis, ovogenesis; embryonic development, essence and meaning.</p> <p>Influence of external - environmental factors - on germinal development, influence of ambient temperature, thermal units (degree days, degree hours, optimal and lethal temperatures), influence of dissolved oxygen in water, water and gas exchange; exposure to light, salinity - tolerance range, sensitivity to shocks and mechanical injuries, influence of magnetic field, influence of other environmental factors.</p>	10
<i>Student workload - forms of activity</i>		<i>Number of hours</i>
A-L-1	Participation in laboratories	30
A-L-2	Studying scientific literature on current laboratories	20
A-L-3	Preparation for passing the laboratories	10
A-W-1	Participation in lectures	30
A-W-2	Studying scientific literature	20
A-W-3	Preparation for passing lectures	10
<i>Teaching methods / tools</i>		
M-1	<p>Informative lecture with the use of multimedia presentation, explanation, problem lecture, seminar lecture</p> <p>Discussion related to the lecture, film, demonstration, laboratory exercises (fish and crayfish section - recognition of individual muscles, arrangement of muscle fibers, shape, size, color; location and course of the muscle myomers; head muscles, dissection of muscles, recognition of individual organs, histological preparations of individual tissues and systems of various fish species)</p>	
<i>Evaluation methods (F - progressive, P - final)</i>		
S-1	F	Assessment of the student's activity in the classroom



Evaluation methods (F - progressive, P - final)

S-2	P	Written test
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Designed learning outcomes	Reference to the learning outcomes designed for the fields of study	Reference to Learning Outcomes for qualifications at PQF 6, 7 or 8	Reference to learning outcomes for qualifications at level 6 or 7 that enable acquiring engineering competences	Course objectives	Course content	Teaching methods	Evaluation methods
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Knowledge

AQF_1A_C04_W01 After completing the course, the student will be able to characterize in detail the anatomical structure of fish of various animal species and will have knowledge of the mechanisms governing the embryogenesis of fish and crayfish belonging to separate families, which differ in terms and method of natural spawning, which translates into different patterns of the course of early ontogenesis and has knowledge about the changes taking place in the body of juvenile fish and crayfish after leaving the egg envelopes (level of maturity of individual systems depending on the species, adaptation to larval life and transitional organs)	AQF_1A_W05	P6S_WG		C-1 C-2	T-L-1 T-L-2 T-L-3 T-W-1 T-W-2 T-W-3	M-1	S-1 S-2
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Skills

AQF_1A_C04_U01 After the classes, the student is able to use specialist terminology regarding the anatomy of fish and selected aquatic invertebrates in verbal and written form, and can understand the literature on anatomical research. The student is able to collect samples of the different organs of fish and other selected invertebrates in order to assess the condition of their internal organs	AQF_1A_U21	P6S_UW	P6S_UW	C-1 C-2	T-L-1 T-L-2 T-L-3 T-W-1 T-W-2 T-W-3	M-1	S-1 S-2
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Social competences

AQF_1A_C04_K01 The student is aware of the responsibility for their own work and the rules of teamwork and responsibility for jointly performed tasks.	AQF_1A_K01	P6S_KK P6S_KR		C-1 C-2	T-L-1 T-L-2 T-L-3 T-W-1 T-W-2 T-W-3	M-1	S-1 S-2
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Outcomes	Grade	Evaluation criterion
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Knowledge

AQF_1A_C04_W01	2,0	
	3,0	The student knows the basic stages of embryonic development and is able to describe the general body structure of juvenile fish.
	3,5	
	4,0	
	4,5	
	5,0	

Skills

AQF_1A_C04_U01	2,0	
	3,0	The student is able to perform the section of fish without damaging internal organs and isolate at least some of the internal organs
	3,5	
	4,0	
	4,5	
	5,0	

Other social competences

AQF_1A_C04_K01	2,0	
	3,0	The student has a basic awareness of responsibility for their own work and the rules of working in a team and taking responsibility for jointly implemented activities
	3,5	
	4,0	
	4,5	
	5,0	

Required reading

1. Datta Munchi (ed.) and Hiran M. Dutta, Fish morphology, Science Publishers, in, Enfield, U.S.A., 1996
2. F. Kirschbaum and K. Formicki (eds.), The histology of fishes, CRC Press, Taylor & Francis Group, Boca Raton, London, New York, 2019

Supplementary reading

1. Moyle P>B. and Cech J.J. Jr., Fishes. An Introduction to Ichthyology, Prentice-Hall, INC, Englewood Cliffs, New Jersey, 1982
2. Finn RN, Kapoor BG, Fish Larval Physiology, Science Publishers, USA, 2008