Faculty of Medicine, University of Rijeka

Course: Physiology and Pathophysiology II
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Department: Department of Physiology, Immunology, and Pathophysiology
Study: Integrated Undergraduate and Graduate University Study of Medicine in English
Year of the study: 2.
Academic year: 2021/2022

COURSE SYLLABUS

Course information (basic description, general information, teaching overview, required equipment and preparation, etc.)

PHYSIOLOGY AND PATHOPHYSIOLOGY II is a compulsory course in the second year of the Integrated Undergraduate and Graduate University Study of Medicine in English, taking place in the IV semester. It consists of 45 hours of lectures, 35 hours of seminars, and 40 hours of laboratory practicals, which overalls in 120 hours (**11 ECTS**). Lectures and seminars are held in lecture halls of the Faculty of Medicine according to the course schedule.

The **aim** of the integrated course is to enable the student to, by applying previously acquired knowledge of physics, chemistry, biology, biochemistry, and normal morphology (anatomy and histology), primarily acquires knowledge of the normal function of the organism, and then to acquire knowledge of pathophysiological mechanisms that lead to disease. This is followed by a review of a clinical correlation, i.e. a computer simulation of different pathophysiological conditions, which prepares the student for an independent troubleshooting of a health care problem. There is an attempt to explain individual functions at a molecular level, as well as at a level of an organism as a whole, and to analyze it in the processes of an organism adapting to changing external environmental conditions. The emphasis of the course is on learning basic and "applicable" physiology, i.e. on the vertical upgrade of the knowledge acquired during the explanation of basic physiological functions.

Content of the course *Physiology and Pathophysiology II*:
Physiology and Pathophysiologies of the Heart and the Circulation: Heart – structure and function. Creating and spreading impulses. Creating a normal electrocardiogram. Cardiac arrhythmias and their electrocardiographic interpretation. Heart sounds. Overview of the circulation. Cardiac output regulation. Arterial pressure regulation.

Arterial and venous pulse. Microcirculation and lymphatic system. Hypertension and hypotension. Coronary circulation and ischemic heart disease. Cardiac failure. Syncope. Circulatory shock and the basics of its treatment. ***Physiology and Pathophysiology of the Kidney:*** Kidney – structure and function. Filtration and reabsorption. Creating concentrated and diluted urine. Prerenal, renal, and postrenal kidney disorders. Disorders of water and electrolytes turnover. Acute and chronic renal insufficiency.
Physiology and Pathophysiology of Respiration: Respiratory system – structure and function. Pressures and volumes. Pulmonary ventilation. Gas exchange through the respiratory membrane. Regulation of respiration. Pulmonary function tests. Obstructive and restrictive respiration disorders.
Acid-base Balance Regulation and Disorders: Pathophysiological factors of acid-base balance disorders. Metabolic and respiratory acidosis and alkalosis. Compensation mechanisms and consequences of acid-base balance disorders.

LEARNING OUTCOMES FOR THE COURSE:
I. COGNITIVE DOMAIN - KNOWLEDGE

1. to describe and explain a **normal function** of the cardiovascular, uropoetic, and respiratory organic system, and to describe and explain interrelations of certain organic systems in a healthy human
2. to describe **control mechanisms** responsible for a normal function and maintenance of homeostasis of the cardiovascular, uropoetic, and respiratory system, to analyze it according to the activation rate, strength, and duration of action, to match its effects in maintaining homeostasis, to analyze the principles of the **feedback mechanism**
3. to describe and classify the most important **etiologic factors** that cause disorders in the cardiovascular, uropoetic, and respiratory system, and to analyze **mechanisms** of its harmful effects on organs and organic systems, to describe and explain **general patterns of organism's reactions to noxious stimuli**, and to describe and analyze branching of basic pathophysiological processes in an organism's systemic reaction
4. to describe and analyze **pathogenetic mechanisms** of principal systemic and organ-specific diseases, and to match it with etiologic factors and basic clinical signs of a disease, to **classify diseases** of the cardiovascular, uropoetic, and respiratory system according to etiopathogenesis
5. to explain and define **the functional reserve of the organic system** and to describe tests for the detection of latent organ insufficiency, to explain mechanisms of **organ decompensation**
6. to describe **principles of basic functional and laboratory tests** and to distinguish deviations from normal values, to analyze it within individual pathophysiological conditions in these organic systems
7. to describe and interpret the mechanisms of **the most important clinical signs** in the most common disorders in the function of the cardiovascular, uropoetic, and respiratory system

II. PSYCHOMOTOR DOMAIN - SKILLS

1. to record a normal ECG by means of the simulation system, to read and to interpret a normal ECG, to analyze basic heart rhythm disturbances, to perform vectorial analysis, and to analyze disturbances of a mean electrical axis in the most common disorders of electrical activity or the heart structure,
2. to measure arterial blood pressure and to analyze the causes of blood pressure disorders, to palpate the arterial pulse and to explain the reasons for possible pulse changes,
3. to analyze the composition of normal urine, to determine the presence of pathological components in the urine by applying basic qualitative and quantitative methods, to calculate clearances according to the given parameters,
4. to determine individual pulmonary volumes and capacities, to compare the given values with the expected ones, to perform basic static and dynamic pulmonary function tests, to interpret pathogenic mechanisms that cause its changes,
5. to elaborate pathogenesis algorithmically in certain examples of diseases of the cardiovascular, uropoetic, and respiratory system (according to the problem-solving assignments from the additional literature).

Class organization:
Teaching is performed in the form of lectures, seminars, and laboratory practicals. Active participation of the student within the curriculum may be achieved by performing practicals on animal models and computer programs (Biopack), as well as by the application of computer simBioSys programs that simulate pathological conditions and provide clinical correlates of certain diseases. Part of the seminars is conducted as problem-based classes so that students can,

based on typical anamnestic and diagnostic data, solve complex physiological and pathophysiological problems with the help of the teacher. At seminars and practicals, the student actively discusses with the teacher about the physiological and pathophysiological mechanisms. During the course classes, the student obtains credits/grade points, which make up 50% of the final grade on the exam. A student who obtains **25 grade points or more** may access the final exam that is organized immediately after the completion of the classes.

Compulsory literature:

1. Guyton A. C. and Hall J. E. Textbook of Medical Physiology , thirteenth edition, Elsevier Inc., 2016.
2. Gamulin S., Marušić M., Kovač Z. (Eds). Pathophysiology – basic mechanisms of disease - textbook (book one: volume one and volume two), Medicinska naklada, Zagreb, 2014.
3. Ravlić-Gulan J. et al. Textbook „Practicals of Physiology and Pathophysiology II“ (first edition), University od Rijeka, Faculty of Medicine, Department of Physiology, Immunology and Pathophysiology; Rijeka, 2018.

Additional literature:

Kovač Z., Gamulin S (Eds). Pathophysiology, study guide algorhythms – problem solver, Medicinska naklada Zagreb, 2014.

Course teaching plan:

List of lectures (with titles and learning outcomes):

Lecture 1. Introduction to Cardiovascular System. Physiology of the Cardiac Muscle. Cardiac Cycle

Learning outcomes:

To describe the anatomical and functional characteristics of the cardiac muscle and the cardiovascular system. To explain and to analyze core principles of cardiac function. To describe the role of valves and to evaluate their importance in the cardiac function. To describe cardiac muscle as a pump. To analyze phases of systole and diastole. To analyze and to evaluate the importance of different mechanisms for regulating cardiac function.

Lecture 2. Membrane Potentials and Action Potentials. Rhythmical Excitation of the Heart. Vectorial Analysis and a Normal Electrocardiogram

Learning outcomes:

To explain mechanisms for creating membrane and action potentials. To describe a cardiac system for creating and spreading impulses. To clarify mechanisms that regulate the occurrence and spreading of impulses in the heart. To explain the occurrence of the plateau in action potentials, the rhythmicity, and the repeated triggering. To analyze the relation of ECG towards cardiac cycle. To construct a mean electrical axis of the heart from the ECG finding.

Lecture 3. Cardiac Arrhythmias and Their Electrocardiographic Interpretation

Learning outcomes:

To describe and to analyze the mechanisms of rhythm disturbances occurrence. To describe changes in spontaneous diastolic depolarization, changes of threshold and potentials in resting. To analyze and to evaluate the importance of disturbances in excitation of impulses. To describe SA-node disorders and the occurrence of premature depolarizations. To explain the effect of ions on the heart rhythm. To analyze and to evaluate the importance of the disturbances in the spreading of impulses: atrial and atrioventricular blocks. To analyze and to evaluate the importance of complex rhythm disorders. To clarify the mechanisms of flutter and fibrillation occurrence. To evaluate the effects of atrial and ventricular fibrillation.

Lecture 4. Overview of the Circulation

Learning outcomes:

To explain the physical properties of the circulatory system. To describe the functional features of the aorta, arteriola, capillary, and vein walls. To describe differences in the properties of systemic and pulmonary circulation. To define basic physical principles of blood flow, and the relationship between pressure, flow, and resistance. To analyze the principles of hemodynamics and Starling's Capillary Dynamics Law. To describe and to analyze and evaluate the importance of capillary exchange and interchange of pressures on the capillary membranes. To describe and to evaluate the importance of the lymph system in the organism.

Lecture 5. Regulation of Blood Flow and Arterial Pressure

Learning outcomes:

To describe and to define mechanisms for blood flow regulation in microcirculation. To define the mechanisms of acute, mid-term, and long-term blood flow regulation. To explain the structure of the autonomic nervous system and mechanisms for rapid control of arterial pressure. To explain reflex mechanisms for maintaining blood pressure and to understand the changes in pressure that arise during muscle work and other types of stress. To define the dominant role of the kidney-body fluids system in the control of arterial pressure. To understand the role of the renin-angiotensin system in pressure regulation.

Lecture 6. The Coronary Circulation and Ischemic Heart Disease. Cardiac Failure

Learning outcomes:

To describe the features of the coronary blood flow. To describe and to analyze the causes of coronary blood flow disorders and the pathogenesis of ischemic heart disease. To describe and to evaluate the importance of biochemical, mechanical, and electrophysiological consequences of ischemia. To describe the reasons for the reflected pain occurring in ischemic heart disease. To describe the main features of ECG findings in ischemia and cardiac failure. To describe and to analyze pathogenic mechanisms of cardiac failure. To describe differences between the compensated and the decompensated heart. To describe the mechanisms and symptoms of unilateral and bilateral cardiac failure. To explain the total regulation of cardiac output and venous return in the example of a cardiac failure.

Lecture 7. Disorders of Arterial Pressure and Pulse

Learning outcomes:

To explain basic pathogenic mechanisms of hypertension, hypotension, and pulse disorders. To analyze the mechanisms of essential hypertension and secondary hypertension. To describe and to analyze the consequences of hypertension and accompanying changes in an ECG. To describe the mechanisms of hypotension occurrence. To describe and to analyze the mechanisms of occurrence of arterial and venous pulse disorders.

Lecture 8. Circulatory (Hemodynamic) Shock

Learning outcomes:

To explain and to analyze the pathogenic mechanisms of hemodynamic shock occurrence. To define and to analyze a compensated and a decompensated stage of a shock. To explain and to analyze the consequences of hemodynamic shock on the function of individual organs and the whole organism.

Lecture 9. Overview of the Renal System Functions – 1st part

Learning outcomes:

To define and to analyze all the functions of a kidney in the organism. To describe and to analyze the features of glomerular and peritubular capillary nets. To understand the function of basic functional structure - nephron. To describe the specificity of the glomerular membrane and its function. To define a minute glomerular filtration and to analyze the factors that affect it.

Lecture 10. Overview of the Renal System Functions – 2nd part

Learning outcomes:

To describe the function of certain parts of the tubular system. To describe and to evaluate the importance of mechanisms of glomerular filtration autoregulation, regulation of body fluids osmolarity, regulation of certain ions concentration, mechanisms for urine concentration and dilution, mechanisms for regulating arterial pressure.

Lecture 11. Overview of the Renal Functions Disorders

Learning outcomes:

To describe the mechanisms of prerenal, renal, and postrenal failure. To describe the pathogenesis of glomerulonephritis and nephrotic syndrome. To describe and to analyze pathogenicity of tubule-interstitial diseases. To understand the pathogenesis of acute and chronic kidney failure. To explain changes in the amount and composition of urine.

Lecture 12. Overview of the Respiratory System Functions

Learning outcomes:

To describe the mechanics of pulmonary ventilation and the physical principles of gas exchange. To define pulmonary

volumes and capacities, respiratory output and alveolar ventilation. To analyze the functions of respiratory airways. To describe the diffusion of oxygen and carbon dioxide through the respiratory membrane. To describe ways of transferring oxygen and carbon dioxide through blood. To describe the regulation mechanisms of respiration.

Lecture 13. Overview of the Respiratory System Disorders

Learning outcomes:

To explain disorders in lung ventilation. To describe the pathogenesis of gas diffusion disorders and fluid and blood flow disorders in the respiratory system. To explain the disorders in the breathing rhythm. To describe the differences between hypoxemic and hypercapnic forms of respiratory insufficiency. To describe the disorders in the metabolic functions of the lungs. To distinguish disorders as a result of obstructive and restrictive pulmonary diseases.

Lecture 14. Acid-Base Regulation and Disorders

Learning outcomes:

To describe the regulation systems for maintaining acid-base balance. To clarify the activities of cellular and extracellular buffer systems. To describe the regulatory function of the respiratory and renal system. To describe the adaptation mechanisms in the lungs and kidneys. To know the mechanisms of bicarbonate reabsorption, titration of urinary tracts, and ammonia secretion. To explain the pathophysiological consequences of acid-base balance disorders and the principles of their assessment.

Lecture 15. Body Fluids and Edema

Learning outcomes:

To describe body volumes and the composition of body fluids. To explain Starling's Capillary Law and its disorders. To describe the occurrence of cellular and extracellular edema. To know the pathogenesis of edema classification.

List of seminars (with the titles and learning outcomes):

Seminar 1. Physiology of the Heart

Learning outcomes:

To explain the occurrence of membrane and action potentials in the heart. To describe the structure and the specificities of the cardiac muscle. To describe the conduction system and to clarify the rhythmical excitation of the heart.

Seminar 2. Electrocardiography

Learning outcomes:

To describe the basis for creating and recording the electrical impulse. To understand and to describe the occurrence of a normal ECG, the construction of a vector and electrical axis.

Seminar 3. Cardiac Arrhythmias

Learning outcomes:

To interpret electrocardiographic findings of cardiac muscle disorders and the flow in blood vessels. To describe the mechanisms of vectorial change. To explain the pathogenic mechanisms of cardiac arrhythmias occurrence and to know how to interpret it electrocardiographically.

Seminar 4. The Circulation

Learning outcomes:

To describe the circulatory system. To explain the physical properties of the circulation. To define the biophysical relationship between pressure, flow, and resistance. To explain pressure and volume curves in the arterial and venous system. To describe the microcirculation and lymphatic system. To explain the mechanisms of capillary fluid exchange on the capillary membrane. To explain disorders in the distribution of extracellular fluid.

Seminar 5. Regulation of Blood Flow and Arterial Pressure

Learning outcomes:

To describe tissue and humoral regulation of local blood flow. To describe circulation regulation and rapid control of arterial pressure by the nervous system. To explain the dominant role of the kidney in a long-term regulation of arterial

pressure and hypertension. To describe the integrated system of pressure control. To describe pathogenic mechanisms of hypertension occurrence.

Seminar 6. Cardiac Output and Venous Return; Specificities of the Coronary Circulation

Learning outcomes:

To define cardiac output and cardiac index. To define venous return. To explain peripheral and cardiac mechanisms and the importance of the nervous system in regulating the cardiac output. To explain the causes of pathologically large and small cardiac output values. To understand the quantitative analysis of cardiac output regulation. To describe the specificity of coronary circulation. To describe the blood flow through muscles and coronary arteries in muscular work and ischemia.

Seminar 7. Disorders of Heart Function – 1st part

Learning outcomes:

To analyze and to explain disorders in myocardial function. To describe the consequences of heart valve damages. To describe disorders of heart filling and the consequences of cardiac output disorders.

Seminar 8. Disorders of Heart Function – 2nd part

Learning outcomes:

To describe the causes and mechanisms of coronary circulation disorders. To list the most important cardiac errors and mechanisms of hemodynamic disorders occurrence. To describe ways of adjusting a cardiac heart muscle to a load. To describe the compensated and decompensated stage of cardiac decompensation, as well as the impact on organic systems.

Seminar 9. Physiology of the Kidney – 1st part

Learning outcomes:

To describe the general structure of the kidney and urinary system. To clarify the structure of the nephron. To explain the functions of glomeruli and tubules. To describe the specificity of the renal flow and its regulation. To describe the mechanism of glomerular filtration.

Seminar 10. Physiology of the Kidney – 2nd part

Learning outcomes:

To describe the formation of urine in the kidneys and the processes of reabsorption and secretion in tubules. To describe renal supervision over the osmolarity of body fluids and over the sodium concentration in the extracellular fluid.

Seminar 11: Renal Disorders

Learning outcomes:

To describe the etiopathogenesis of the renal disease occurrence, and to classify nephropathies and uropathies according to etiopathogenesis. To describe the etiopathogenesis and the consequences of prerenal diseases. To describe the etiopathogenesis and the consequences of renal diseases.

Seminar 12. Physiology of Respiration – 1st part

Learning outcomes:

To describe the mechanisms of pulmonary ventilation. To describe pulmonary circulation and to explain the occurrence of pulmonary edema and changes in the pleural fluid. To understand the physical principles of gas exchange; diffusion of oxygen and carbon dioxide through the respiratory membrane.

Seminar 13: Physiology of Respiration – 2nd part

Learning outcomes:

To describe the transfer of oxygen and carbon dioxide through blood and body fluids. To describe the regulation of respiration.

Seminar 14. Acid-base balance regulation

Learning outcomes:

To describe the mechanisms of acid-base balance regulation. To describe the importance of each individual mechanism of acid-base balance regulation.

Seminar 15. Acid-base balance disorders
Learning outcomes:
To describe acid-base balance disorders and ways of regulating them.

List of laboratory practicals (with the titles and learning outcomes):

Practical 1. Working with experimental animals
Learning outcomes:
To analyze heart function *in situ*. To analyze the influence of different ions or neurotransmitters on heart function *in situ*. To isolate n. vagus and to analyze the effect of its stimulation on heart function *in situ*.

Practical 2. Electrocardiography
Learning outcomes:
To record a normal electrocardiogram (ECG) using a simulation system. To read and to interpret a normal electrocardiogram. To perform vectorial analysis and to determine the mean electrical axis. To conclude and to evaluate the importance of measuring individual waves, complexes, intervals, and segments in the interpretation of an ECG.

Practical 3. Cardiac Arrhythmias and the Pathological Electrocardiogram
Learning outcomes:
To analyze and to interpret ECG in various disorders of initiating and spreading an electrical impulse. To analyze disturbances of a mean electrical axis in the most common disorders of electrical activity or heart structure. To analyze pathogenic mechanisms of arrhythmia occurrence and their consequences by means of problem-solving assignments. Algorithmic detection of pathogenesis. To analyze the principles of feedback mechanisms in disorders of cardiac electrical activity.

Practical 4. Disorders of Blood Flow and Arterial Pressure
Learning outcomes:
To measure arterial blood pressure and to analyze the causes of pressure disorders. To palpate the arterial pulse, to conclude and to explain the causes of the arterial pulse disorder occurrence. To analyze the function of heart valves and the formation of heart sounds. To analyze the mechanisms of heart murmurs occurrence and to evaluate their importance. To describe and to conclude the importance of hemodynamic consequences in congenital heart diseases. To measure jugular venous pulse, to analyze and to evaluate its diagnostic importance. To analyze mechanisms that maintain blood pressure based on the measurement of blood pressure by means of a direct method. To analyze pathogenic mechanisms of hypertension and hypotension occurrence by means of problem-solving assignments. To algorithmically elaborate the pathogenesis of various types of pressure and pulse disorders. To analyze the principles of feedback mechanisms in arterial pressure disorders.

Practical 5. Circulatory Shock
Learning outcomes:
To establish and to analyze the mechanisms of various types of circulatory shock occurrence. To observe the effects in animals. To analyze pathogenic mechanisms by means of problem-solving assignments. To algorithmically elaborate the pathogenesis of various types of circulatory shock. To analyze the principles of feedback mechanisms in the course of a circulatory shock occurrence.

Practical 6. Physiology and Pathophysiology of the Kidney
Learning outcomes:
To analyze the composition of normal urine. To determine the presence of pathological components in urine by applying basic qualitative and quantitative methods. To explain the principle of basic kidney tests. To calculate the clearances according to the given parameters. To analyze pathogenic mechanisms of renal disease occurrence and their consequences by means of problem-solving assignments. To algorithmically elaborate the pathogenesis of

various types of prerenal, renal, and postrenal disorders. To analyze the principles of feedback mechanisms in kidney diseases.

Practical 7. Physiology and Pathophysiology of the Respiratory System

Learning outcomes:

To determine individual pulmonary volumes and capacities and to compare the given values with the expected one. To perform basic static and dynamic pulmonary function tests and to interpret the pathogenic mechanisms that cause their changes. To analyze the pathogenic mechanisms of respiratory system disease occurrence and their consequences by means of problem-solving assignments. To algorithmically elaborate the pathogenesis of various types of respiratory disorders. To analyze the principles of feedback mechanisms in diseases of the respiratory system.

Practical 8. Acid-base Balance and Disorders

Learning outcomes:

To analyze the pathogenic mechanisms of various acid-base balance disorders occurrence and their consequences by means of problem-solving assignments. To algorithmically elaborate the pathogenesis of various types of acid-base disorders. To analyze the principles of feedback mechanisms in acid-base balance disorders.

Student obligations:

Exam (exam taking, detailed exam description of the oral/written/practical part, point distribution, grading criteria):

ECTS grading system:

Student grading will be conducted according to the current **Ordinance on Studies of the University of Rijeka** and the **Ordinance on Student Grading at the Faculty of Medicine in Rijeka.**

Student work will be assessed and graded during the course and on the final exam. During the course, students may obtain a total of **100 grade points**. Students may achieve up to **50 grade points** during classes, and up to **50 grade points** at the final exam.

I. The following components are evaluated during the course (maximum of 50 grade points):

a) acquired knowledge (up to 46 grade points)
b) class attendance (up to 4 grade points)

a) Acquired knowledge (up to 46 grade points)

During classes, acquired knowledge will be evaluated on **two tests:**

Test 1 (1st midterm exam): Heart and Circulation – a student may obtain a maximum of 23 grade points

Test 2 (2nd midterm exam): Kidney, Respiration, and Acid-base Balance – a student may obtain a maximum of 23 grade points

A student may access the correction of the first and the second midterm exam if they did not obtain a minimum number of grade points for accessing the final exam, if they did not access the midterm exam, or if they are not satisfied with the obtained grade points. If a student retakes the midterm exam because they are not satisfied with the obtained grade points, only the grade points obtained from the retaken midterm will be considered. Correction of the midterm exams will be held in the period between the 1st and the 2nd exam date.

Correct answers	Grade points
58,59,60	**23**
55,56,57	**22**
52,53,54	**21**
49,50,51	**20**
46,47,48	**19**
43,44,45	**18**
40,41,42	**17**
37,38,39	**16**
35,36	**15**
33,34	**14**
31,32	**13**
30	**12**

b) Class attendance (up to 4 grade points)

Attendance at all forms of classes (lectures, seminars, practicals) is graded as follows:

Class attendance	Grade points
100%	**4**
90%-99,9%	**3**
80%-89,9%	**2**
70%-79,9%	**1**

II. Final exam (up to 50 grade points)

The final exam evaluates specific competencies that are established for each section, and it consists of a **written** and an **oral** part.

a) **Final exam** consists of 70 questions, and grade points (minimum of 11 – maximum of 20) are obtained if the student solves correctly more than **50%** of questions as shown in the table:

Correct answers	Grade points
67,68,69,70	**20**
63,64,65,66	**19**
59,60,61,62	**18**
55,56,57,58	**17**
51,52,53,54	**16**
47,48,49,50	**15**
43,44,45,46	**14**
39,40,41,42	**13**
36,37,38	**12**
35	**11**

b) A student may access the **oral part of the final exam** if they obtained a minimum of 11 grade points at the written part of the final exam. At the oral part of the final exam, a student may obtain grade points as shown in the Table:

Grade obtained at the oral part of the final exam	Number of grade points obtained at the oral part of the final exam
excellent A	**26-30**
very good B	**21-25**
good C	**16-20**
sufficient D	**5-15**
insufficient F	**0**

In order to pass the final exam, a student must achieve a minimum of 11 grade points at the written part and a minimum of 5 grade points at the oral part of the exam. The final exam is an integral part, therefore, if the student does not achieve a positive assessment of the oral part of the final exam, the results of the written part of the final exam are invalid in the following final exam terms.

Who may access the final exam:

- **Students who obtained 25-50 grade points during classes** are obligated to access the final exam at which they may obtain a maximum of 50 grade points.

Who may not access the final exam:

- **Students who obtained 0-24,9 grade points during classes or those who were absent for more than 30% of all forms of classes.** Such a student is graded as **unsuccessful/failed (1) F** and may not access the final exam, which means they have to re-enter the course in the next academic year.

III. The final grade represents a sum of all grade points (ECTS credits) obtained during classes and at the final exam:

Final grade at the final exam	
excellent A (90-100%)	5
very good B (75-89,9%)	4

good C (60-74,9%)	3
sufficient D (50-59,9%)	2
F (students who obtained less than 25 grade points during all course classes or did not pass the final exam)	1

Exam terms during classes:

(a)Test (Heart and Circulation):**29/04/2022** (Friday) at 16-17h (60 questions)

(b)Test (Kidney, Respiration, and Acid-base Balance): **10/06/2022** (Friday) at 16.00 to 17.00h (60 questions)

Other important information regarding the course:

Course content and all the notifications regarding the course may be found on the *Share-portal* for internal communication of the Department of Physiology and Immunology.

IMPORTANT NOTIFICATION

If the epidemiological instructions related to Covid-19 infection in the second semester determine some precautions regarding student gathering at the faculty, we will adjust the Syllabus and the method of assessment to the current situation. In that case, teaching would be performed online (using the MS teams platform, etc.), and the writing of tests would be carried out via the Merlin system. Students will be notified of any changes to the Syllabus on time.

COURSE SCHEDULE for academic year 2021/2022

Date	Lectures (time and place) (or ONLINE-MS Teams)	Seminars (time and place) (or ONLINE-MS Teams)	Laboratory practicals (time and place) (or ONLINE-MS Teams)	Lecturer
01/03/2021	L1 (13,15-16,00) 3h Lecture hall 1			Jagoda Ravlić-Gulan
01/03/2022		S1A (16,15-18,00) Lecture hall 9		Silvija Lukanović Jurić
02/03/2022		S1B (11,15-13,00) Lecture hall 9		Gordana Blagojević Zagorac
02/03/2022			P1A (16,00-19,45)	Božena Ćurko-Cofek
03/03/2022			P1B (16,00-19,45)	Silvija Lukanović Jurić
08/03/2022	L2 (13,15-16,00) 3h Lecture hall 8			Jagoda Ravlić-Gulan
08/03/2022		S2A (16,15-18,00) Lecture hall 9		Gordana Blagojević Zagorac
09/03/2022		S2B (11,15-13,00) Lecture hall 9		Božena Ćurko-Cofek
15/03/2022	L3 (13,15-16,00) 3h Lecture hall 8			Jagoda Ravlić-Gulan
15/03/2022		S3A (16,15-18,00) Lecture hall 9		Jagoda Ravlić-Gulan
16/03/2022		S3B (11,15-13,00) Lecture hall 9		Božena Ćurko-Cofek
16/03/2022			P2A (16,00-19,45)	Gordana Blagojević Zagorac
17/03/2022			P2B (16,00-19,45)	Jagoda Ravlić-Gulan
22/03/2022	L4 (13,15-16,00) 3h Lecture hall 1			Hrvoje Jakovac
22/03/2022		S4A (16,15-18,00) Lecture hall 9		Damir Muhvić
23/03/2022		S4B (11,15-13,00) Lecture hall 9		Hrvoje Jakovac
29/03/2022	L5 (13,15-16,00) 3h Lecture hall 8			Hrvoje Jakovac
29/03/2022		S5A (16,15-18,00) Lecture hall 9		Gordana Blagojević Zagorac
30/03/2022		S5B (11,15-13,00) Lecture hall 9		Ines Mrakovčić-Šutić
30/03/2022			P3A (16,00-19,45)	Jagoda Ravlić-Gulan
31/03/2022			P3B (16,00-19,45)	Vlatka Sotošek

05/04/2022	L6 (13,15-16,00) 3h Lecture hall 8			Jagoda Ravlić-Gulan
05/04/2022		S6A (16,15-18,00) Lecture hall 9		Gordana Blagojević Zagorac
06/04/2022		S6B (11,15-13,00) Lecture hall 9		Silvija Lukanović Jurić
12/04/2022	L7 (13,15-16,00) 3h Faculty hall (vijećnica)			Jagoda Ravlić-Gulan
12/04/2022		S7A (16,15-18,00) Lecture hall 9		Jagoda Ravlić-Gulan
13/04/2022		S7B (11,15-13,00) Lecture hall 9		Silvija Lukanović Jurić
13/04/2022			P4A (16,00-19,45)	Hrvoje Jakovac
14/04/2022			P4B (16,00-19,45)	Natalia Kučić
19/04/2022	L8 (13,15-16,00) 3h Lecture hall 8			Ines Mrakovčić-Šutić
19/04/2022		S8A (16,15-18,00) Lecture hall 9		Damir Muhvić
20/04/2022		S8B (11,15-13,00) Lecture hall 9		Jagoda Ravlić-Gulan
26/04/2022	L9 (13,15-16,00) 3h Lecture hall 8			Jagoda Ravlić-Gulan
26/04/2022		S9A (16,15-18,00) Lecture hall 9		Zlatko Trobonjača
27/04/2022		S9B (11,15-13,00) Lecture hall 9		Jagoda Ravlić-Gulan
27/04/2022			P5A (16,00-19,45)	Silvija Lukanović Jurić
28/04/2022			P5B (16,00-19,45)	Gordana Blagojević Zagorac
	29/04/2022 Test (Heart and Circulation) (16-17h)			
03/05/2022	L10 (13,15-16,00) 3h Lecture hall 1			Jagoda Ravlić-Gulan
03/05/2022		S10A (16,15-18,00) Lecture hall 9		Zlatko Trobonjača
04/05/2022		S10B (11,15-13,00) Lecture hall 9		Jagoda Ravlić-Gulan
10/05/2022	L11 (13,15-16,00) 3h Lecture hall 8			Jagoda Ravlić-Gulan
10/05/2022		S11A (16,15-18,00) Lecture hall 9		Jagoda Ravlić-Gulan
11/05/2022		S11B (11,15-13,00) Lecture hall 9		Zlatko Trobonjača
11/05/2022			P6A (16,00-19,45)	Silvija Lukanović Jurić
12/05/2022			P6B (16,00-19,45)	Hrvoje Jakovac
17/05/2022	L12 (13,15-16,00) 3h			Gordana Blagojević Zagorac

	Lecture hall 1			
17/05/2022		S12A (16,15-18,00) Lecture hall 9		Silvija Lukanović Jurić
18/05/2022		S12B (11,15-13,00) Lecture hall 9		Božena Ćurko-Cofek
24/05/2022	L13 (13,15-16,00) 3h Lecture hall 8			Gordana Blagojević Zagorac
24/05/2022		S13A (16,15-18,00) Lecture hall 9		Silvija Lukanović Jurić
25/05/2022		S13B (11,15-13,00) Lecture hall 9		Božena Ćurko-Cofek
25/05/2022			P7A (16,00-19,45)	Gordana Blagojević Zagorac
26/05/2022			P7B (16,00-19,45)	Hana Mahmutefendić Lučin
31/05/2022	L14 (13,15-16,00) 3h Lecture hall 1			Jagoda Ravlić-Gulan
31/05/2022		S14A (16,15-18,00) Lecture hall 9		Gordana Blagojević Zagorac
01/06/2022		S14B (11,15-13,00) Lecture hall 9		Tamara Gulić
07/06/2022	L15 (13,15-16,00) 3h Lecture hall 8			Zlatko Trobonjača
07/06/2022		S15A (16,15-18,00) Lecture hall 9		Silvija Lukanović Jurić
08/06/2022		S15B (11,15-13,00) Lecture hall 9		Zlatko Trobonjača
08/06/2022			P8A (16,00-19,45)	Tamara Gulić
09/06/2022			P8B (16,00-19,45)	Hrvoje Jakovac
	10/06/2022 Test (Kidney, Respiration, and Acid-base Balance) (16-17h)			

List of lectures, seminars, and practicals:

	LECTURES (topics)	Teaching Hours	Lecture Room (or ONLINE-MS Teams)
L1	Introduction to Cardiovascular System. Physiology of the Cardiac Muscle. Cardiac Cycle	3	Lecture hall 1
L2	Membrane Potentials and Action Potentials. Rhythmical Excitation of the Heart. Vectorial Analysis and a Normal Electrocardiogram	3	Lecture hall 8
L3	Cardiac Arrhythmias and Their Electrocardiographic Interpretation	3	Lecture hall 8
L4	Overview of the Circulation	3	Lecture hall 1
L5	Regulation of Blood Flow and Arterial Pressure	3	Lecture hall 8
L6	The Coronary Circulation and Ischemic Heart Disease. Cardiac Failure	3	Lecture hall 8
L7	Disorders of Arterial Pressure and Pulse	3	Faculty hall (vijećnica)
L8	Circulatory Shock	3	Lecture hall 8
L9	Overview of the Renal System Functions – 1st part	3	Lecture hall 8
L10	Overview of the Renal System Functions – 2nd part	3	Lecture hall 1
L11	Overview of the Renal Functions Disorders	3	Lecture hall 8
L12	Overview of the Respiratory System Functions	3	Lecture hall 1
L13	Overview of the Respiratory System Disorders	3	Lecture hall 8
L14	Acid-base balance regulation and disorders	3	Lecture hall 1
L15	Body Fluids and Edema	3	Lecture hall 8
	Total	**45**	

	SEMINARS (topics)	Teaching Hours	Lecture Room ONLINE-MS Teams
S1	Physiology of the Heart	2,33	Lecture hall 9
S2	Electrocardiography	2,33	Lecture hall 9
S3	Cardiac Arrhythmias	2,33	Lecture hall 9
S4	Circulation	2,33	Lecture hall 9
S5	Regulation of Blood Flow and Arterial Pressure	2,33	Lecture hall 9
S6	Cardiac Output and Venous Return; Specificities of the Coronary Circulation and an ECG in Ischemic Heart Disease	2,33	Lecture hall 9
S7	Disorders of Heart Function – 1st part	2,33	Lecture hall 9
S8	Disorders of Heart Function – 2nd part	2,33	Lecture hall 9
S9	Physiology of the Kidney – 1st part	2,33	Lecture hall 9
S10	Physiology of the Kidney – 2nd part	2,33	Lecture hall 9
S11	Renal disorders	2,33	Lecture hall 9
S12	Physiology of Respiration – 1st part	2,33	Lecture hall 9
S13	Physiology of Respiration – 2nd part	2,33	Lecture hall 9

S14	Acid-base balance regulation	2,33	Lecture hall 9
S15	Acid-base balance disorders	2,33	Lecture hall 9
	Total	**35**	

	LABORATORY PRACTICALS (topics)	Teaching Hours	Lecture Room ONLINE-MS Teams
P1	Working with experimental animals	5	Laboratory of the Department
P2	Electrocardiography	5	Laboratory of the Department
P3	Cardiac Arrhythmias and the Pathological Electrocardiogram	5	Laboratory of the Department
P4	Disorders of Blood Flow, Arterial Pressure, and Pulse	5	Laboratory of the Department
P5	Circulatory Shock	5	Laboratory of the Department
P6	Physiology and Pathophysiology of the Kidney	5	Laboratory of the Department
P7	Physiology and Pathophysiology of the Respiratory System	5	Laboratory of the Department
P8	Acid-base balance and disorders	5	Laboratory of the Department
	Total	**40**	

	FINAL EXAM DATES
1.	17/06/2022
2.	01/07/2022
3.	15/07/2022
4.	05/09/2022
5.	19/09/2022

Seminars – prepare the course content

S1: Physiology of the Heart
Guyton and Hall:
Ch. 5. Membrane Potentials and Action Potentials (p. 61-74)
Ch. 9. Cardiac Muscle; The Heart as a Pump and Function of the Heart Valves (p. 109-122)
Ch. 10. Rhythmical Excitation of the Heart (p. 123-129)

S2: Electrocardiography
Guyton and Hall:
Ch. 11. The Normal Electrocardiogram (p. 131-137)
Ch. 12. Electrocardiographic Interpretation of Cardiac Muscle and Coronary Blood Flow Abnormalities: Vectorial Analysis (p. 139-145, i.e. to the title "Abnormal Ventricular Conditions That Cause Axis Deviation")

S3: Cardiac Arrhythmias
Guyton and Hall:
Ch. 12. Electrocardiographic Interpretation of Cardiac Muscle and Coronary Blood Flow Abnormalities: Vectorial Analysis (p. 145-148, i.e. from the title "Abnormal Ventricular Conditions That Cause Axis Deviation" to the title "Current of Injury")
Ch. 13. Cardiac Arrhythmias and Their Electrocardiographic Interpretation (p. 155-165)

Gamulin et al.:
Ch. 27. 5. Heart Rhythm Disorders (p. 1239-1252)

S4: The Circulation
Guyton and Hall:
Ch. 14. Overview of the Circulation; Biophysics of Pressure, Flow, and Resistance (p. 169-178)
Ch. 15. Vascular Distensibility and Functions of the Arterial and Venous Systems (p. 179-188)
Ch. 16. The Microcirculation and Lymphatic System: Capillary Fluid Exchange, Interstitial Fluid, and Lymph Flow (p. 189-201)

S5: Regulation of Blood Flow and Arterial Pressure
Guyton and Hall:
Ch. 17. Local and Humoral Control of Tissue Blood Flow (p. 203-213)
Ch. 18. Nervous Regulation of the Circulation and Rapid Control of Arterial Pressure (p. 215-225)
Ch. 19. Role of the Kidneys in Long-Term Control of Arterial Pressure and in Hypertension: The Integrated System for Arterial Pressure Regulation (p. 227-243)

S6: Cardiac Output and Venous Return; Specificities of the Coronary Circulation and an ECG in Ischemic Heart Disease
Guyton and Hall:
Ch.20. Cardiac Output, Venous Return, and Their Regulation (p. 245-258)
Ch. 21. Muscle Blood Flow and Cardiac Output During Exercise; the Coronary Circulation and Ischemic Heart Disease (p. 259-269)
Ch. 12. Electrocardiographic Interpretation of Cardiac Muscle and Coronary Blood Flow Abnormalities: Vectorial Analysis (p. 148-153, i.e. from the title "Current of Injury" to the end of the chapter)

S7: Disorders of Heart Function – 1st part
Gamulin et al.:
Chapter 27. Disorders of Heart Function (listed chapters):
Ch. 27. 1. Etiopathogenesis of cardiovascular diseases (p. 1209-1213)
Ch. 27. 2. Disorders of myocardial function (p. 1213-1226)
Ch. 27. 3. Disorders of heart valve function (p. 1226-1234)
Ch. 27. 4. Disorders of heart filling (p. 1234-1239)

S8: Disorders of Heart Function – 2nd part
Gamulin et al.:
Chapter 27. Disorders of Heart Function (listed chapters):
Ch. 27. 6. Disorders of the coronary circulation (p. 1253-1266)
Ch. 27. 7. Congenital heart diseases (p. 1267-1270)
Ch. 27. 8. Heart adaptation to the functional load (p. 1271-1281)
Ch. 27.9. Heart failure (p. 1281-1294)
Ch. 27.10. Cardiac function tests (p. 1294-1299)

S9: Physiology of the Kidney – 1st part
Guyton and Hall:
Ch. 26. The Urinary System: Functional Anatomy and Urine Formation by the Kidneys (p. 323-333)
Ch. 27. Glomerular Filtration, Renal Blood Flow, and Their Control (p. 335-345)

S10: Physiology of the Kidney – 2nd part
Guyton and Hall:
Ch. 28. Renal Tubular Reabsorption and Secretion (p. 347-368)

Ch. 29. Urine Concentration and Dilution; Regulation of Extracellular Fluid Osmolarity and Sodium Concentration (p. 371-387)

S11: Renal disorders

Gamulin et al.:

Chapter 30. Pathophysiology of Kidney and Urine Excretion System:

Ch. 30.1. Etiopathogenesis and classification of nephropathies and uropathies (p. 1390-1394)

Ch. 30.2. Prerenal disorders of the renal functions (p. 1394-1398)

Ch. 30.3. Renal disorders of the renal functions (p. 1398-1417)

Ch. 30.5. Etiopathogenesis of nephrotic syndrome (p. 1420-1423)

S12: Physiology of Respiration – 1st part

Guyton and Hall:

Ch. 38. Pulmonary Ventilation (p. 497-507).

Ch. 39. Pulmonary Circulation, Pulmonary Edema, Pleural Fluid (p. 509-516)

Ch. 40. Principles of Gas Exchange; Diffusion of Oxygen and Carbon Dioxide Through the Respiratory Membrane (p. 517-526)

S13: Physiology of Respiration – 2nd part

Guyton and Hall:

Ch. 41. Transport of Oxygen and Carbon Dioxide in Blood and Tissue Fluids (p. 527-537)

Ch. 42. Regulation of Respiration (p. 539-548)

S14: Acid-base balance regulation

Guyton and Hall:

Ch. 31. Acid-Base Regulation (p. 409-426)

S15: Acid-base balance disorders

Gamulin et al.:

Chapter 9. Acid-base Balance Disorders:

Ch. 9. 1. Pathophysiological factors in acid-base balance disorders (p. 449-455)

Ch. 9. 2. Overview of compensatory mechanisms in acid-base balance disorders (p. 455-460)

Ch. 9. 3. Acidosis (p. 461-473)

Ch. 9. 4. Alkalosis (p. 473-478)

Ch. 9. 5. Mixed forms of acid-base balance disorders (p. 478-480)

Practicals – prepare the course content

P1: Working with experimental animals

Repeat the course content from the S1:

Guyton and Hall:

Ch. 9. Cardiac Muscle; The Heart as a Pump and Function of the Heart Valves (p. 109-122)

Ch. 10. Rhythmical Excitation of the Heart (p. 123-129)

Textbook for practicals (Ravlić-Gulan J. et al.):

- Practical 1.1.

Practical part: experimental animals (exploratory laparotomy; opening the cervical region; thoracotomy; vagus stimulation; injecting neurotransmitters and observing effects on the heart *in situ* and under *in vitro* conditions)

Student presentations

P2: Electrocardiography

Repeat the course content from the S2:

Guyton and Hall:

Ch. 11. The Normal Electrocardiogram (p. 131-137)

Ch. 12. Electrocardiographic Interpretation of Cardiac Muscle and Coronary Blood Flow Abnormalities: Vectorial Analysis (p. 139-145, i.e. to the title "Abnormal Ventricular Conditions That Cause Axis Deviation")

Textbook for practicals (Ravlić-Gulan J. et al.):

- Practical 1.2.
- Practical 1.3.

Student presentations

P3: Cardiac Arrhythmias and the Pathological Electrocardiogram

Repeat the course content from the S3:

Guyton and Hall:

Ch. 12. Electrocardiographic Interpretation of Cardiac Muscle and Coronary Blood Flow Abnormalities: Vectorial Analysis (p. 145-148, i.e. from the title "Abnormal Ventricular Conditions That Cause Axis Deviation" to the title "Current of Injury")

Ch. 13. Cardiac Arrhythmias and Their Electrocardiographic Interpretation (p. 155-165)

Gamulin et al.:

Ch. 27. 5. Heart Rhythm Disorders (p. 1239-1252)

Textbook for practicals (Ravlić-Gulan J. et al.):

- Practical 1.4.

Additional material for practicals: Book of arrhythmias – examples; Kovač et al.: problem-solving assignments

Student presentations

P4: Disorders of Perfusion, Arterial Pressure, and Pulse

Prepare the new course content:

Gamulin et al.:

Chapter 28. Disorders of Blood pressure and Perfusion:

Ch. 28. 1. Cardiac output disorders (p. 1302-1309)
Ch. 28. 2. Arterial pressure disorders (p. 1309-1326)
Ch. 28. 3. Disorders of arterial and venous pulse (p. 1326-1333)
Ch. 28. 4. Local tissue perfusion disorders (p. 1333-1344)
Ch. 28. 5. Test for blood pressure and blood flow (p. 1344-1348)

Textbook for practicals (Ravlić-Gulan J. et al.):

- Practical 1.5
- Practical 1.6.
- Practical 1.7.
- Practical 1.8.

Additional material for practicals: Kovač et al.: problem-solving assignments
Student presentations

P5: Circulatory Shock

Prepare the new course content:
Guyton and Hall:
Ch. 24. Circulatory shock and its treatment (p. 293-302)
Gamulin et al.:
Chapter 18. Hemodynamic Shock:
Ch. 18.1. Basic derangements in circulatory shock (p. 843-847)
Ch. 18.2. Pathogenesis of shock conditions (p. 847-850)
Ch. 18.3. Pathophysiological course of the circulatory shock (p. 850-856)
Ch. 18.4. Circulatory shock manifestations on particular organs (p. 856-858)
Ch. 18.5. Pathogenetically complex forms of circulatory shock (p. 858-860)
Ch. 18.6. Hemodynamic disorders pathogenetically related to the circulatory shock (p. 860)
Ch. 18.7. Clinical and laboratory assessment of the circulatory shock stage (p. 861)

Textbook for practicals (Ravlić-Gulan J. et al.):

- Practical 1.9.

Exercise: Circulatory shock in animals (video recording)

Additional material for practicals: Kovač et al.: problem-solving assignments
Student presentations

P6: Physiology and Pathophysiology of the Kidney

Repeat the course content from the S11 and prepare the new course content:
Guyton and Hall:
Ch. 30. Renal Regulation of Potassium, Calcium, Phosphate, and Magnesium; Integration of Renal Mechanisms for Control of Blood Volume and Extracellular Fluid Volume (p. 389-407)

Gamulin et al.:
Chapter 30. Pathophysiology of Kidney and Urine Excretion System:
Ch. 30.4. Postrenal disorders of renal functions (p. 1417-1420)
Ch. 30.6. Renal insufficiency (p. 1423-1434)
Ch. 30.7. Disorders of urine quantity and composition (p. 1434-1445)
Ch. 30.8. Pathophysiological basis of kidney diagnostic tests (p. 1445-1450)

Textbook for practicals (Ravlić-Gulan J. et al.):

- Practical 2.1.
- Practical 2.2.

Additional material for practicals: Kovač et al.: problem-solving assignments
Student presentations

P7: Physiology and Pathophysiology of the Respiratory System
Repeat the course content from the S12 and S13, and prepare the new course content:
Gamulin et al.:
Chapter 29. Pathophysiology of Respiration:
Ch. 29.1. Disorders of ventilation of alveoli (p. 1351-1363)
Ch. 29.2. Impairment of gas diffusion (p. 1363-1366)
Ch. 29.3. Disorders of fluids and blood circulation in the lungs (p. 1366-1373)
Ch. 29.4. Breathing rhythm disorders (p. 1373-1375)
Ch. 29.5. Respiratory insufficiency (p. 1375-1378)
Ch. 29.6. Disorders of the metabolic functions of the lungs (p. 1378-1379)
Ch. 29.7. Mutual effects of pulmonary functional disorders and other organ disorders (p. 1379-1380)
Ch. 29.8. Tests of pulmonary functions (p. 1381-1386)

Textbook for practicals (Ravlić-Gulan J. et al.):
- Practical 3.1.
- Practical 3.2.
- Practical 3.3.
- Practical 3.4.
- Practical 3.5.

Biopack
Additional material for practicals: Kovač et al.: problem-solving assignments
Student presentations

P8: Acid-base Balance and Disorders
Repeat the course content from the S14 and S15, and prepare the new course content:
Gamulin et al.:
Chapter 9. Acid-base Balance Disorders:
Ch. 9. 1. Pathophysiological factors in acid-base balance disorders (p. 449-455)
Ch. 9. 2. Overview of compensatory mechanisms in acid-base balance disorders (p. 455-460)
Ch. 9. 3. Acidosis (p. 461-473)
Ch. 9. 4. Alkalosis (p. 473-478)
Ch. 9. 5. Mixed forms of acid-base balance disorders (p. 478-480)
Ch. 9. 6. Pathophysiological consequences of acid-base balance disorders (p. 480-484)
Ch. 9. 7. Pathogenetic role of local acid-base disorders (p. 484)
Ch. 9. 8. Assessment of acid-base balance disorders (p. 484-487)

Textbook for practicals (Ravlić-Gulan J. et al.):
- Practical 4.1.

Biopack

Additional material for practicals: Kovač et al.: problem-solving assignments
Student presentations