

MINISTRY OF HEALTH OF THE REPUBLIC OF BELARUS
EDUCATIONAL INSTITUTION
BELARUSIAN STATE MEDICAL UNIVERSITY

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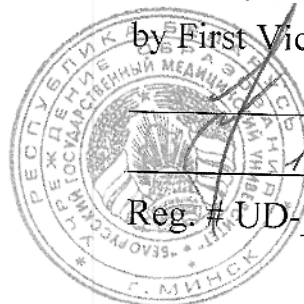
APPROVED

by First Vice-Rector, Professor

S.V. Gubkin

10.08.2018

Reg. # UD-L.517/1.8.19 /edu.



PHARMACEUTICAL CHEMISTRY

Curriculum of higher educational institution
in the educational discipline for the specialty:

1-79 01 08 «Pharmacy»

Minsk, BSMU 2018

Curriculum is based on the standard educational program «Pharmaceutical Chemistry», approved on September 15, 2015, registration # TD-L.517/typ.

COMPILERS:

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RECOMMENDED FOR APPROVAL:

by the Department of Pharmaceutical Chemistry of the Educational Institution «Belarusian State Medical University»
(protocol No. 11 of 22.05.2018);

by the Methodological Commission of pharmaceutical disciplines of the Educational Institution «Belarusian State Medical University»
(protocol No. 9 of 23.05.2018)

EXPLANATORY NOTE

«Pharmaceutical Chemistry» is the educational discipline containing systematized scientific knowledge about the methods of obtaining medicinal substances, the connection of their chemical structure with pharmacological activity, and the methods of quality control of pharmaceutical substances and medicines.

The purpose of teaching and studying the discipline «Pharmaceutical Chemistry» is to form and acquire students a systematic scientific knowledge of the chemical structure and properties of medicinal substances, as well as methods of pharmaceutical analysis.

The tasks of studying the discipline are to develop the students of academic competences, based on the ability to self-search educational and information resources, as well as acquire and understand the knowledge of:

- classification of medicines;
- the most important principles of creating original medicines;
- regularities of the connection of the chemical structure and pharmacological activity of medicinal substances;
- factors affecting the stability of pharmaceutical substances and medicines;
- methods and applications of pharmacopoeial analysis of pharmaceutical substances and medicines;
- the basics of biopharmaceutical analysis.

Teaching and successful learning of the discipline «Pharmaceutical Chemistry» is carried out on the basis of knowledge and skills previously acquired by the students in the following disciplines:

General and inorganic chemistry. The main regularities of the course of chemical processes, the properties of inorganic substances.

Physical and colloid chemistry. Fundamentals of chemical kinetics.

Analytical chemistry. Chemical methods for the detection of inorganic substances. Sampling and sample preparation. Methods of separation and concentration. Statistical processing of analysis results. Gravimetric method of analysis. Titrimetric methods of analysis. Spectrometric methods of analysis. Chromatographic methods of analysis. Electrochemical methods of analysis.

Organic chemistry. Classification and nomenclature of organic compounds. Electronic structure of molecules of organic compounds. Mutual influence of atoms in a molecule. Spatial structure of molecules of organic compounds. Stereoisomerism. Acidic and basic properties of organic compounds. Spectral methods for establishing the structure and identification of organic compounds.

Biological physics. Viscosity of liquid. Methods for determination of viscosity. Natural and polarized light. Methods of obtaining polarized light. Optical activity of a substance. Determination of the concentration of optically active substances by a polarimeter. Laws of refraction and reflection of light. Refraction and refractometry. Radioactivity. The law of radioactive decay. The main types of radioactive decay.

Biological chemistry. Vitamins, their biological role. Hormones. Pharmaceutical Biochemistry. Ways of enzymatic transformation of medicinal substances.

As a result of studying the discipline «Pharmaceutical Chemistry» the student should

know:

- terminology of pharmaceutical chemistry, its goals, objectives and areas of research;
- principles of classification of medicinal products;
- sources and methods of obtaining medicinal substances, the main stages and principles of creating original medicines;
- types of regulatory documentation regulating the quality of pharmaceutical substances and medicines;
- factors and processes affecting the stability of pharmaceutical substances and medicines; requirements for storage conditions;
- methods and applications of pharmacopoeial analysis;
- principles for the determination of medicinal substances in biological fluids;

be able to:

- identify pharmaceutical substances and medicines;
- determine the physical constants and indicators of the good quality of pharmaceutical substances;
- carry out a quantitative analysis of pharmaceutical substances and medicines; carry out statistical processing of experimental data;
- to carry out quality control of medicines of industrial production and pharmacy manufacture;

master:

- experimental skills used in assessing the quality of pharmaceutical substances and medicines of industrial production and pharmaceutical manufacture;
- skills in interpreting the results of the analysis of pharmaceutical substances and medicines;
- methodology of prognosing the physicochemical, chemical analytical and pharmacological properties of medicinal substances according to their structure.

The structure of the curriculum in the educational discipline «Pharmaceutical Chemistry» consists of three sections: 1.General Pharmaceutical Chemistry Issues, 2.Pharmaceutical Analysis, 3.Pharmaceutical Chemistry of the Main Pharmaceutical Therapeutic Groups of Medicines.

Total number of hours for the study of the discipline is 615 academic hours. Classroom hours according to the types of studies: lectures – 132 hours, laboratory studies (practical classes - 210 hours,), student independent work (self-study) -273 hours.

The current knowledge assessment is conducted in accordance with the curriculum in the specialty in the form of a credit (5, 7 semester) and examination (6, 8 semester).

Final assessment – state examination.

Form of higher education – full-time.

**ALLOCATION OF ACADEMIC TIME
ACCORDING TO SEMESTERS OF STUDY**

Code, name of the specialty	semester	Number of academic hours					Form of current assessment
		total	in-class	including		out-of-class self-studies	
				lectures	laboratory studies (practical classes and seminars)		
1-79 01 08 «Pharmacy»	5	144	90	36	54	54	credit
	6	171	88	34	54	83	exam
	7	120	78	30	48	42	credit
	8	180	86	32	54	94	exam
Total hours		615	342	132	210	273	

THEMATIC PLAN

Name of the section (topic)	Number of hours	
	lectures	practical (laboratory or seminars)
1. General questions of pharmaceutical chemistry	8	12
1.1. Introduction to the educational discipline «Pharmaceutical Chemistry»	2	3
1.2. Sources and methods of obtaining medicinal substances	2	3
1.3. Ensuring the quality of pharmaceutical substances and medicines	2	3
1.4. Stability and shelf life of medicines	2	3
2. Pharmaceutical analysis	56	90
2.1. General characteristics of pharmaceutical analysis. Analytical chemistry methods used in pharmaceutical analysis	4	9
2.2. General characteristics of pharmacopeial analysis. Reagents used in pharmacopeial analysis	2	3
2.3. Properties of pharmaceutical substances	2	3
2.4. Identification methods used in pharmacopeial analysis	4	9
2.5. Pharmacopeial testing of pharmaceutical substances	6	6
2.6. Impurities in pharmaceutical substances	4	3
2.7. Methods for the quantitative analysis of pharmaceutical substances	2	6
2.8. Pharmacopeial quality control of inorganic pharmaceutical substances	4	3
2.9. Pharmacopeial quality control of pharmaceutical substances of aliphatic structures	4	6
2.10. Pharmacopeial quality control of pharmaceutical substances of aromatic structures	4	9
2.11. Pharmacopeial quality control of pharmaceutical substances of heterocyclic structures	6	12
2.12. Quality control of medicines of industrial production	2	3
2.13. Quality control of pharmaceutical products (extemporal medicines)	6	9

Name of the section (topic)	Number of hours	
	lectures	practical (laboratory or seminars)
2.14. Determination of medicinal substances and their metabolites in biological fluids	6	9
3. Pharmaceutical chemistry of the main pharmacotherapeutic groups of medicines	68	108
3.1. Modern methodology of creating original medicines	4	3
3.2. Pharmaceutical chemistry of medicines for anesthesia and for local anesthesia	2	3
3.3. Pharmaceutical chemistry of hypnotics, anticonvulsants and antiparkinsonian medicines	2	6
3.4. Pharmaceutical chemistry of neuroleptics and anxiolytics	2	3
3.5. Pharmaceutical chemistry of antidepressants, psychostimulants and nootropic medicines	2	3
3.6. Pharmaceutical chemistry of narcotic analgesics and antagonists of opioid receptors	2	3
3.7. Pharmaceutical chemistry of non-narcotic analgesics and non-steroidal anti-inflammatory medicines	2	3
3.8. Pharmaceutical chemistry of cholinergic medicines	2	3
3.9. Pharmaceutical chemistry of adrenergic medicines	2	3
3.10. Pharmaceutical chemistry of serotonergic medicines	2	3
3.11. Pharmaceutical chemistry of histaminergic medicines and proton pump inhibitors	2	3
3.12. Pharmaceutical chemistry of inhibitors of phosphodiesterase, antitussive and expectorant medicines	2	3
3.13. Pharmaceutical chemistry of medicines for the treatment of heart diseases and antiarrhythmic medicines	2	3

Name of the section (topic)	Number of hours	
	lectures	practical (laboratory or seminars)
3.14. Pharmaceutical chemistry of calcium channel blockers and medicines affecting the renin-angiotensin system	2	3
3.15. Pharmaceutical chemistry of statins, diuretics, anticoagulants and antiagrigants	2	3
3.16. Pharmaceutical chemistry of medicines for the treatment of thyroid diseases, and oral hypoglycemic medicines	2	3
3.17. Pharmaceutical chemistry of corticosteroids	2	3
3.18. Pharmaceutical chemistry of gestagens, androgens and estrogens	2	6
3.19. Pharmaceutical chemistry of vitamins, prostaglandins and their derivatives	6	9
3.20. General characteristics of antibiotics. Pharmaceutical chemistry of beta-lactam antibiotics	4	6
3.21. Pharmaceutical chemistry of the main groups of antibiotics	2	3
3.22. Pharmaceutical chemistry of synthetic antibacterial medicines	4	6
3.23. Pharmaceutical chemistry of antiviral and antifungal medicines	4	6
3.24. Pharmaceutical chemistry of anti-tuberculosis, antimalarial and anthelmintic medicines	4	6
3.25. Pharmaceutical chemistry of antitumor medicines	4	6
3.26. Pharmaceutical chemistry of contrasting and radiopharmaceuticals medicines	2	6

CONTENT OF THE EDUCATIONAL MATERIAL

1. General questions of pharmaceutical chemistry

1.1. Introduction to the educational discipline «Pharmaceutical Chemistry»

The main sections of pharmaceutical chemistry, the field of research and communication with other sciences. Terminology: medicine, pharmaceutical substance, medicine form, homeopathic medicine, original medicine, generic medicine, immunobiological medicine, radiopharmaceutical medicine, etc.

Rules for choosing the names of medicines. International nonproprietary names (INN) of pharmaceutical substances. Trade names of medicines.

Classification of medicinal substances used in pharmaceutical chemistry: the classification of medicinal substances depending on the chemical structure, anatomical-therapeutic-chemical classification (ATC), etc.

The main stages of the history of pharmaceutical chemistry. Modern problems and prospects for the development of pharmaceutical chemistry.

1.2. Sources and methods of obtaining medicinal substances

Use of natural compounds as medicines. Isolation of medicinal substances from natural sources. Preparation of medicinal substances by chemical modification of natural compounds and complete chemical synthesis. Application of microbiological methods and genetic engineering for the production of medicinal substances.

1.3. Ensuring the quality of pharmaceutical substances and medicines

Modern requirements for medicines: safety, efficiency, quality. The system of quality assurance of medicines at all stages of creation and use. Good Practice Standards: Good Practice Research (GRP), Good Laboratory Practice (GLP), Good Clinical Practice (GCP), Good Manufacturing Practice (GMP), Good Pharmacy Practice (GPP), Good Storage Practices (GSP), etc. quality of medicines in the Republic of Belarus. The problem of the falsification of medicines.

Normative documentation regulating the quality of pharmaceutical substances and medicines. State Pharmacopoeia of the Republic of Belarus (GF RB), pharmacopoeial articles. Regional (European Pharmacopoeia) and national pharmacopoeias (British Pharmacopoeia, US Pharmacopoeia, State Pharmacopoeia of the Russian Federation, State Pharmacopoeia of the Republic of Kazakhstan, State Pharmacopoeia of Ukraine, etc.), International Pharmacopoeia of the World Health Organization.

1.4. Stability and shelf life of medicines

Terminology (stability, shelf life of the medicines, date of re-control and period of substance control for pharmaceutical use). Environmental factors (physical, chemical, microbiological) that affect the stability of medicines. Types of chemical reactions that lead to a change in the structure and properties of medicinal substances: oxidation, hydrolysis, polymerization, isomerization, etc. Kinetic regularities of the destruction of medicinal substances. Ways to improve the stability of medicines.

Long-term, accelerated and stressful trials of medicines stability. Forecasting the shelf life of medicines based on the «accelerated aging» method.

Requirements for storage containers and storage conditions for individual medicines groups

2. Pharmaceutical analysis

2.1. General characteristics of pharmaceutical analysis. Analytical chemistry methods used in pharmaceutical analysis

Pharmaceutical analysis as an integral part of pharmaceutical chemistry and a section of applied analytical chemistry. Features of pharmaceutical analysis. Types of pharmaceutical analysis.

The main groups of analytical chemistry methods used in pharmaceutical analysis. Chemical methods of analysis. Gravimetric method of analysis. Titrinetric methods of analysis. Acid-base titration in aqueous, aqueous-organic and non-aqueous media. Determination of nitrogen in organic compounds. Oxidation-reduction titration methods (iodometry, chloridometry, iodometry, nitriteometry, permanganometry, dichromatometry, cerimetry). Methods of complexometric titration (complexometry, mercurimetry). Methods of precipitation titration (argentometry).

Spectrometric methods of analysis. Absorption methods (atomic absorption spectrometry, molecular absorption spectrometry in the ultraviolet and visible regions, infrared spectrometry, nuclear magnetic resonance spectrometry). Emission spectrometric methods of analysis (atomic emission spectrometry, fluorimetry). Spectrometric methods based on the scattering of electromagnetic radiation (Raman spectrometry, nephelometry, turbidimetry). Refractometry. Chiroptic methods of analysis (polarimetry, circular dichroism spectrometry).

Electrochemical methods of analysis. Conductometry, potentiometry (ionometry and potentiometric titration), voltammetry and amperometric titration.

Chromatographic methods of analysis. Gas chromatography. Liquid chromatography (thin layer chromatography, high performance liquid chromatography, exclusion chromatography, ion exchange chromatography). Supercritical fluid chromatography.

Electrophoresis. Capillary electrophoresis.

Mass spectrometry. Combination of mass spectrometry with chromatographic methods.

Thermal analysis methods (thermogravimetry, differential thermal analysis, differential scanning calorimetry).

Protein -binding methods of analysis (immunochemical and receptor). Biological methods of analysis.

Validation of analytical methods used in pharmaceutical analysis. Statistical analysis of the results of a chemical experiment.

2.2. General characteristics of pharmacopeial analysis. Reagents used in pharmacopeial analysis

Basic principles of pharmacopeia analysis. Unification and standardization of similar tests.

Preparation of solutions of reagents, reference and buffer solutions. Titrated solutions (standard solutions) used for titrimetric determinations. Features of preparation and installation of the titer (standardization).

2.3. Properties of pharmaceutical substances

Physical properties of pharmaceutical substances: aggregate state, appearance, color, hygroscopicity, crystalline properties, polymorphism. Solubility of pharmaceutical substances. Conditional terms for solubility. Acid-base properties of medicinal substances.

2.4. Identification methods used in pharmacopoeial analysis

General characteristics of identification methods used in pharmacopoeial analysis (authentication). First and second identification.

Chemical identification methods. General pharmacopoeial article of the State Pharmacopoeia of the Republic of Belarus «Reactions of Authenticity (Identification) to ions and functional groups». Particular identification reactions.

Application of instrumental methods for identification. Spectrometric methods of identification. Chromatographic methods of identification.

2.5. Pharmacopoeial testing of pharmaceutical substances

Determination of the melting point, solidification temperature, dropping point, temperature distillation limits and boiling point. Determination of the density of liquids and solids. Determination of the viscosity of liquids. Determination of specific rotation and refractive index.

Determination of color, transparency and turbidity of liquids. Potentiometric determination of pH. Determination of volatile substances and water, loss in mass during drying, total ash and sulfate ash.

2.6. Impurities in pharmaceutical substances

The concept of an impurity in pharmaceutical substances. Nature of impurities. Terminology: identifiable impurity, unidentifiable impurity, specified impurity, unspecified impurity, potential impurity, concomitant impurities.

General and particular methods for detecting impurities. General pharmacopoeial article of the State Pharmacopoeia of the Republic of Belarus «Tests on the limiting content of impurities». Determination of accompanying impurities.

Identification of residual solvents and control of their quantity. Determination of the microbiological purity of pharmaceutical substances.

2.7. Methods for the quantitative analysis of pharmaceutical substances

Prerequisites for choosing a method for the quantitative determination of a medicinal substance depending on its chemical structure and the object of analysis. Features of the quantitative analysis of pharmaceutical substances. The use of titrimetric, spectrometric, chromatographic and other methods for the quantitative analysis of pharmaceutical substances.

2.8. Pharmacopoeial quality control of pharmaceutical substances of inorganic

Pharmacopoeial water quality control. Water is highly purified, water for injection («in bulk» and sterile), water purified («in bulk» and in containers). Features of production and storage of various types of water. Determination of the specific electrical conductivity of water.

Derivatives of s-elements: barium sulfate, magnesium oxide, magnesium sulfate heptahydrate, calcium chloride hexahydrate.

Derivatives of p-elements: solutions of hydrogen peroxide, iodine, sodium and potassium chlorides, sodium and potassium bromides, sodium and potassium iodides, bismuth nitrate basic, sodium hydrogen carbonate, boric acid, sodium tetraborate, aluminum oxide hydrated, aluminum phosphate.

Derivatives of d-elements: zinc oxide, zinc sulfate heptahydrate, iron sulfate heptahydrate, iron chloride hexahydrate, cuprum sulfate pentahydrate, etc

2.9. Pharmacopeial quality control of pharmaceutical substances of aliphatic structures

Derivatives of alkanes, alcohols, ethers, aldehydes: vaseline, ethyl alcohol, glycerol, anesthetic ether, formaldehyde 35% solution, chloral hydrate.

Derivatives of carbohydrates, carboxylic acids, amino acids, terpenoids: glucose, lactose, saccharose, calcium gluconate, aminocaproic acid, glycine, glutamic acid, DL-methionine, cysteine hydrochloride, levomenthol, camphor, etc.

2.10. Pharmacopeial quality control of pharmaceutical substances of aromatic structures

Derivatives of phenols and aromatic acids: phenol, resorcinol, paracetamol, benzoic acid, sodium benzoate, salicylic acid, sodium salicylate, etc.

Derivatives of aromatic amino acids, phenylalkylamines, sulfanilic acid: benzocaine, procaine hydrochloride, chloramphenicol, sulfonamide, sodium sulfacetamide, etc.

2.11. Pharmacopeial quality control of pharmaceutical substances of heterocyclic structures

Derivatives of furan, benzopyran, pyrazole, benzimidazole, pyridine: nitrofural, ascorbic acid, rutoside trihydrate, metamizole sodium, dibazol, nicotinic acid, nicotinamide, niketamide.

Derivatives of isoquinoline, purine, pteridine, isoalloxazine: papaverine hydrochloride, caffeine, aminophylline (theophylline-ethylenediamine), folic acid, riboflavin, and others.

2.12. Quality control of medicines of industrial production

Sampling and sample preparation in the analysis of various medicines forms. Criteria for choosing methods of identification and quantitative analysis of medicines of industrial production. Features of the analysis of multicomponent medicines.

2.13. Quality control of pharmaceutical products (extemporal medicines)

Features of quality control of medicines of pharmaceutical manufacture. Normative legal acts regulating the quality control of medicines of pharmaceutical manufacture. Quality control of powders, solutions, ointments, suppositories and other medicinal forms of pharmaceutical manufacture.

2.14. Determination of medicinal substances and their metabolites in biological fluids

Features of biopharmaceutical analysis. Objects and the main stages of biopharmaceutical analysis. The separation and concentration methods used in biopharmaceutical analysis. The use of chromatographic, spectrometric, binding

proteins and other methods for the determination of drugs and their metabolites in biological fluids.

Pharmacokinetic studies of medicines. The main pharmacokinetic parameters of medicines: bioavailability, volume of distribution, clearance, elimination rate constant, half elimination period.

Metabolism of medicinal substances. The main phases of the metabolism of medicinal substances: non-synthetic (oxidation, reduction and hydrolysis reactions) and synthetic (conjugation reactions). Change in lipophilicity and pharmacological activity of medicinal substances in the process of metabolism.

Bioequivalent studies of generic medicines. Concepts of therapeutic, pharmaceutical and biological equivalence of medicines. The main stages of bioequivalent studies of generic medicines. Features of the analytical stage of bioequivalent studies.

Relationship between the concentration of medicines substance in biological fluids and its effect. Therapeutic monitoring of medicines.

3. Pharmaceutical chemistry of the main pharmacotherapeutic groups of medicines

3.1. Modern methodology of creating original medicines

The main stages of the creation of the original medicines. Development of a new pharmacologically active chemical compound. The notion of a leader compound and the requirements imposed on it. The main strategies for finding the leader compound are random discoveries, the study of natural compounds, the study of biochemical processes in the body, the study of the side effects of medicines, «classical» screening, combinatorial synthesis and «total» screening, computer modeling, molecular docking. Optimization of the leader compound: QSAR (quantitative correlation of activity with descriptors of structure or properties), bioisostearism. Methods for improving pharmacokinetic and pharmaceutical properties of medicines. Promedicines, double medicines and soft medicines. Stereochemical aspects of the action of medicines.

3.2. Pharmaceutical chemistry of medicines for anesthesia and for local anesthesia

General characteristics and classification of medicines for anesthesia and for local anesthesia.

Medicines for anesthesia: nitrous oxide, halothane, isoflurane, sevoflurane, propofol, ketamine hydrochloride, thiopental sodium, sodium oxybutyrate. Chemical structure, structure and action connection, methods of obtaining, quality control.

Medicines for local anesthesia: procaine hydrochloride, tetracaine hydrochloride, lidocaine hydrochloride, bupivacaine hydrochloride, articaine hydrochloride. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.3. Pharmaceutical chemistry of hypnotics, anticonvulsants and antiparkinsonian medicines

General characteristics and classification of hypnotics, anticonvulsants and antiparkinsonian medicines.

Hypnotic medicines: nitrazepam, midazolam, triazolam, zopiclone, zolpidem tartrate, doxylamine succinate. Chemical structure, structure and action connection, methods of obtaining, quality control.

Anticonvulsant medicines: phenobarbital and its promedicines (benzobarbital, primidone), phenytoin, valproic acid and sodium valproate, clonazepam, carbamazepine, gabapentin, lamotrigine, levetiracetam. Chemical structure, structure and action connection, methods of obtaining, quality control.

Antiparkinsonian medicines: levodopa, carbidopa, selegiline hydrochloride, entacapone, amantadine hydrochloride, bromocriptine mesylate, trihexyphenidyl hydrochloride. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.4. Pharmaceutical chemistry of neuroleptics and anxiolytics

General characteristics and classification of neuroleptics and anxiolytics.

Neuroleptics: chlorpromazine hydrochloride, trifluoperazine dihydrochloride, fluphenazine decanoate, thioridazine hydrochloride, flupentixol hydrochloride, haloperidol, droperidol, clozapine, sulpiride, amisulpride, risperidone. Prokinetics are antagonists of dopamine receptors (metoclopramide hydrochloride, domperidone). Chemical structure, structure and action connection, methods of obtaining, quality control.

Anxiolytics: chlordiazepoxide, diazepam, oxazepam, medazepam, phenazepam, alprazolam, buspirone hydrochloride. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.5. Pharmaceutical chemistry of antidepressants, psychostimulants and nootropic medicines

General characteristics and classification of antidepressants, psychostimulants and nootropic medicines.

Antidepressants: amitriptyline hydrochloride, imipramine hydrochloride, venlafaxine hydrochloride, maprotiline hydrochloride, paroxetine hydrochloride, sertraline hydrochloride, fluvoxamine maleate, fluoxetine hydrochloride, citalopram hydrobromide, mirtazapine, trazodone hydrochloride. Chemical structure, structure and action connection, methods of obtaining, quality control.

Psychostimulants: caffeine. Nootropic medicines: piracetam. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.6. Pharmaceutical chemistry of narcotic analgesics and antagonists of opioid receptors

General characteristics and classification of narcotic analgesics and opioid receptor antagonists. Narcotic analgesics: morphine hydrochloride, hydromorphone hydrochloride, butorphanol tartrate, buprenorphine hydrochloride, trimiperidine hydrochloride, fentanyl and its derivatives, tramadol hydrochloride, methadone hydrochloride. Opioid receptor antagonists: naloxone hydrochloride. Medicines of another action, obtained with the modification of the structure of narcotic analgesics: loperamide hydrochloride. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.7. Pharmaceutical chemistry of non-narcotic analgesics and non-steroidal anti-inflammatory medicines

General characteristics of non-narcotic analgesics and non-steroidal anti-inflammatory drugs. Acetylsalicylic acid, diclofenac sodium, ibuprofen, ketoprofen, naproxen, nimesulide, indomethacin, ketorolac tromethamine, phenylbutazone, piroxicam, meloxicam, celecoxib, metamizole sodium, paracetamol. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.8. Pharmaceutical chemistry of cholinergic medicines

General characteristics and classification of cholinergic medicines. M-cholinergic receptor agonists and acetylcholinesterase inhibitors: pilocarpine hydrochloride, neostigmine methyl sulfate, pyridostigmine bromide, donepezil hydrochloride monohydrate. M-holinoreceptor antagonists: atropine sulfate, scopolamine hydrobromide, ipratropium bromide, tiotropium bromide, tropicamide. Ganglia-blockers and muscle relaxants: hexamethonium benzenesulfate, suxamethonium chloride, atracurium besylate, pipecuronium bromide. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.9. Pharmaceutical chemistry of adrenergic medicines

General characteristics and classification of adrenergic medicines. Adrenoreceptor agonists and sympathomimetics: epinephrine hydrotartrate (adrenaline hydrotartrate), phenylephrine hydrochloride, naphazoline nitrate, tetrisoline hydrochloride, xylometazoline hydrochloride, oxymetazoline hydrochloride, clonidine hydrochloride, methyl dopa, dopamine hydrochloride, dobutamine hydrochloride, clenbuterol hydrochloride, salbutamol sulfate, salmeterol xinafoate, fenoterol hydrobromide, formoterol fumarate dihydrate, ephedrine hydrochloride, pseudoephedrine hydrochloride. Adrenoreceptor antagonists and sympatholytics: prazosin hydrochloride, tamsulosin hydrochloride, derivatives of ergoalkaloids (dihydroergocristine mesylate, nicergoline), propranolol hydrochloride, sotalol hydrochloride, timolol maleate, atenolol, metoprolol tartrate, bisoprolol fumarate, carvedilol, reserpine. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.10. Pharmaceutical chemistry of serotonergic medicines

General characteristics and classification of serotonergic drugs. Triptans (sumatriptan succinate, frovatriptan succinate, etc.), setrons (odnansetron hydrochloride dihydrate, tropisetron hydrochloride, granisetron hydrochloride, etc.), ergot alkaloids and their derivatives (ergometrine maleate, ergotamine tartrate). Chemical structure, structure and action connection, methods of obtaining, quality control.

3.11. Pharmaceutical chemistry of histaminergic medicines and proton pump inhibitors

General characteristics and classification of histaminergic medicines and proton pump inhibitors.

Stabilizers of membranes of mast cells: sodium cromoglycate. H₁-receptor antagonists: diphenhydramine hydrochloride, chloropyramine hydrochloride, promethazine hydrochloride, chlorphenamine maleate, ketotifen hydrofumarate, loratadine, cetirizine dihydrochloride. H₂-receptor antagonists: ranitidine hydrochloride, famotidine.

Proton pump inhibitors: omeprazole, esomeprazole magnesium trihydrate, lansoprazole, pantoprazole sodium sesquihydrate, rabeprazole sodium. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.12. Pharmaceutical chemistry of inhibitors of phosphodiesterase, antitussive and expectorant medicines

General characteristics and classification of phosphodiesterase inhibitors. Phosphodiesterase inhibitors: xanthine derivatives (theophylline, aminophylline, pentoxifylline, etc.), papaverine hydrochloride, drotaverine hydrochloride, vinpocetine, sildenafil citrate. Chemical structure, relationship of structure and actions, methods of obtaining, quality control.

General characteristics and classification of antitussive and expectorant medicines. Antitussive medicines: codeine, dextromethorphan hydrobromide, butamirane citrate. Expectorants: guaifenesin, bromhexine hydrochloride, ambroxol hydrochloride, acetylcysteine. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.13. Pharmaceutical chemistry of medicines for the treatment of heart diseases and antiarrhythmic medicines

General characteristics and classification of drugs for the treatment of heart diseases and antiarrhythmic medicines.

Cardiac glycosides: digoxin, strophanthine-G. Nitrates: glyceryl trinitrate, isosorbide mononitrate and dinitrate. Other medicines for the treatment of heart diseases: trimetazidine dihydrochloride. Chemical structure, structure and action connection, methods of obtaining, quality control.

Antiarrhythmic medicines: procainamide hydrochloride, propafenone hydrochloride, ethacisn hydrochloride, amiodarone hydrochloride. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.14. Pharmaceutical chemistry of calcium channel blockers and medicines affecting the renin-angiotensin system

General characteristics and classification of calcium channel blockers. Calcium channel blockers: nifedipine, amlodipine besylate, verapamil hydrochloride, diltiazem hydrochloride, cinnarizine. Chemical structure, relationship of structure and actions, methods of obtaining, quality control.

General characteristics and classification of medicines affecting the renin-angiotensin system. Angiotensin converting enzyme inhibitors: captopril, enalapril maleate, lisinopril dihydrate, perindopril tertbutylamine, ramipril, fosinopril sodium. Angiotensin receptor antagonists: potassium losartan. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.15. Pharmaceutical chemistry of statins, diuretics, anticoagulants and antiagrigants

General characteristics and classification of hypolipidemic medicines, diuretics, anticoagulants and antiagrigants.

Hypolipidemic medicines. Statins: lovastatin, simvastatin, atorvastatin calcium, rosuvastatin calcium. Chemical structure, structure and action connection, methods of obtaining, quality control.

Diuretics: furosemide, indapamide, chlorthalidone, hydrochlorothiazide, spironolactone. Chemical structure, structure and action connection, methods of obtaining, quality control.

Anticoagulants and antiagrigants: sodium warfarin, acenocoumarol, phenindione, clopidogrel hydrogen sulfate. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.16. Pharmaceutical chemistry of medicines for the treatment of thyroid diseases, and oral hypoglycemic medicines

General characteristics and classification of medicines for the treatment of diseases of the thyroid gland. Medicines with the activity of thyroid hormones: levothyroxine sodium, sodium lyoteronin. Antithyroid medicines: propylthiouracil, thiamazole. Chemical structure, structure and action connection, methods of obtaining, quality control.

General characteristics and classification of oral hypoglycemic medicines. Oral hypoglycemic medicines: glibenclamide, glycidone, gliclazide, glipizide, metformin hydrochloride, acarbose, repaglinide, sitagliptin phosphate monohydrate. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.17. Pharmaceutical chemistry of corticosteroids

General characteristics and classification of steroid compounds. Mineralocorticoids: deoxycortone acetate, fludrocortisone acetate. Glucocorticoids: hydrocortisone, hydrocortisone acetate, prednisolone, methylprednisolone, betamethasone valerate and dipropionate, dexamethasone, dexamethasone sodium phosphate, triamcinolone acetonide, fluocinolone acetonide. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.18. Pharmaceutical chemistry of gestagens, androgens and estrogens

General characteristics and classification of gestagens, androgens and estrogens.

Histagens and progestins: progesterone, medroxyprogesterone acetate, dydrogesterone, norethisterone, levonorgestrel, lynnerrenol. Chemical structure, structure and action connection, methods of obtaining, quality control.

Androgens and anabolic steroids: testosterone, methyltestosterone, methandienone, nandrolone decanoate. Chemical structure, structure and action connection, methods of obtaining, quality control.

Estrogens: estrone, estradiol hemihydrate, estriol, ethinyl estradiol, non-steroid synthetic analogues of estrogens. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.19. Pharmaceutical chemistry of vitamins, prostaglandins and their derivatives

General characteristics and classification of vitamins as medicines. Fat-soluble vitamins: retinol acetate, ergocalciferol, cholecalciferol, *a*-tocopheryl acetate, menadione sodium bisulfite. Water-soluble vitamins: salts and esters of thiamine, riboflavin, pyridoxine hydrochloride, nicotinic acid and nicotinamide, folic acid, cyanocobalamin, ascorbic acid, bioflavonoids and their derivatives. Chemical structure, structure and action connection, methods of obtaining, quality control.

Prostaglandins and their derivatives: alprostadil, misoprostol, dinoprost,latanoprost, travoprost. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.20. General characteristics of antibiotics. Pharmaceutical chemistry of beta-lactam antibiotics

General characteristics and classification of chemotherapeutic medicines. Classification of antibiotics by chemical structure, mechanism and direction of action. Methods of obtaining antibiotics. Methods for assessing the quality of antibiotics.

General characteristics and classification of beta-lactam antibiotics. Penicillins (penams). Natural penicillins: benzylpenicillin salts; phenoxymethylpenicillin. Semisynthetic penicillins: oxacillin sodium monohydrate, ampicillin trihydrate and ampicillin sodium, amoxicillin trihydrate. Cephalosporins (cephemes): cefazolin sodium, cefalexin monohydrate, cefaclor, sodium cefoperazone, cefotaxime sodium, cefuroxime sodium, cefuroxime axetil, ceftriaxone sodium, ceftazidime. Monobactams: aztreonam. Carbapenems: imipenem, meropenem trihydrate, Doripenem monohydrate. Inhibitors of beta-lactamases: sodium sulbactam, potassium clavulanate. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.21. Pharmaceutical chemistry of the main groups of antibiotics

General characteristics and classification of antibiotics related to aminoglycosides, macrolides and azalides, lincosamides, tetracyclines, amphenicolam. Aminoglycosides: streptomycin sulfate, gentamicin sulfate, tobramycin, amikacin sulfate. Macrolides and azalides: erythromycin, clarithromycin, roxithromycin, azithromycin. Lincosamides: lincomycin, clindamycin. Tetracyclines: tetracycline, doxycycline giklat. Amphenicols: chloramphenicol and its ethers. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.22. Pharmaceutical chemistry of synthetic antibacterial medicines

General characteristics and classification of synthetic antibacterial medicines. Sulfonilamides and trimethoprim: co-trimoxazole, argent sulfadiazine, sulfasalazine. Nitrofurans: nitrofurantoin, furazolidone, nifuratel, nifuroxazide. Nitroimidazoles: metronidazole, tinidazole, ornidazole. Derivatives of 8-hydroxyquinoline: nitroxoline, chlorohinaldole. Fluoroquinolones: ciprofloxacin hydrochloride, pefloxacin mesylate, norfloxacin, ofloxacin and levofloxacin, lomefloxacin hydrochloride, moxifloxacin hydrochloride. Oxazolidinones: linezolid. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.23. Pharmaceutical chemistry of antiviral and antifungal medicines

General characteristics and classification of antiviral and antifungal medicines.

Antiviral medicines: antihypertensive medicines - guanine derivatives (acyclovir, ganciclovir, penciclovir and their promedicines), zidovudine, lamivudine, nevirapine, ritonavir, saquinavir mesylate, oseltamivir phosphate, rimantadine hydrochloride, umifenovir, ribavirin. Chemical structure, structure and action connection, methods of obtaining, quality control.

Antifungal medicines: clotrimazole, miconazole nitrate, ketoconazole, fluconazole, voriconazole, terbinafine hydrochloride, griseofulvin, polyene antibiotics. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.24. Pharmaceutical chemistry of antituberculosis, antimalarial and anthelmintic medicines

General characteristics and classification of anti-tuberculosis, antimalarial and anthelmintic medicines.

Antituberculous medicines: isoniazid, prothionamide, pyrazinamide, ethambutol, rifampicin, sodium aminosalicylate dihydrate. Chemical structure, structure and action connection, methods of obtaining, quality control.

Antimalarial medicines: quinine salts, chloroquine phosphate, hydroxychloroquine sulphate, mefloquine hydrochloride, primachin phosphate, pyrimethamine, proguanil hydrochloride, artemisinin and its derivatives. Chemical structure, structure and action connection, methods of obtaining, quality control.

Anthelmintic medicines: albendazole, mebendazole, piperazine adipate, pyrantel embonate. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.25. Pharmaceutical chemistry of antitumor medicines

General characteristics and classification of antitumor medicines. Alkylating antitumor medicines: melphalan, cyclophosphamide, platinum complex compounds (cisplatin, carboplatin, oxaliplatin). Antimetabolites: fluorouracil and its prodrugs (tegafur, capecitabine), methotrexate, fludarabine phosphate, mercaptopurine. Medicines obtained by modifying the structure of mercaptopurine: azathioprine, allopurinol. Protein kinase inhibitors: imatinib mesylate. Natural compounds and their derivatives, antitumor antibiotics: taxanes (paclitaxel, docetaxel), vinblastine sulfate, irinotecan, etoposide, doxorubicin hydrochloride. Hormone antagonists: flutamide, cyproterone acetate, tamoxifen citrate, anastrozole. Chemical structure, structure and action connection, methods of obtaining, quality control.

3.26. Pharmaceutical chemistry of contrasting and radiopharmaceuticals medicines

General characteristics and classification of contrasting medicines. Iodine containing radiopaque medicines: amidotrizoic acid and its salts, yoxexol. Magnetic resonance contrast drugs: gadopentetate dimeglumine, gadodiamid. Contrasting medicines for ultrasound: galactose. Chemical structure, structure and action connection, methods of obtaining, quality control.

General characteristics and classification of radiopharmaceuticals medicines. Diagnostic radiopharmaceuticals (compounds ^{99m}Tc , etc.). Therapeutic radiopharmaceuticals medicines (compounds ^{89}Sr , ^{131}I , ^{32}P , etc.). Chemical structure, methods of production, quality control.

REQUIREMENTS FOR THE COURSE WORK

The purpose of the course work: deepening and expanding theoretical knowledge, mastering the techniques of independent work with scientific literature, logically consistent presentation of the material, the development of the ability to draw conclusions and document the results (writing a course work, preparing a report and presentation), and the acquisition of public protection skills (report, answers to questions, advocacy of one's own point of view, etc.).

Execution of the course work includes the following stages: 1) familiarization with these methodological recommendations for the implementation of the course work; 2) choosing a topic from the list by the department, coordinating it with the supervisor of studies, preparing a task for the course work; 3) selection and study of literature on the chosen topic; 4) drawing up of the working plan and the schedule of performance of work; 5) collection and processing of factual material; 6) adjustment of the work plan and its coordination with the supervisor; 7) writing sections of work, formulating conclusions and generalizations on its results; 8) technical formalization of course work in accordance with established requirements; 9) presentation of work to the scientific supervisor for verification; 10) receiving a written opinion of the supervisor and eliminating the shortcomings noted by him; 11) obtaining admission to defence of the course work and its defence.

Writing courseprojects in the discipline «Pharmaceutical Chemistry» for students of the pharmaceutical faculty should comply with the regulations on course projects in specialty 1-79 01 08 «Pharmacy» BSMU № 117, approved on 11.02.2014.

The subjects, plans and requirements for the design, implementation and protection of term papers, as well as the literature recommended for study are given in the methodological recommendations.

EDUCATIONAL DISCIPLINE CURRICULAR CHART

Section number, topics	Section title, topics	Number of hours		Self-studies	Equipment	Forms of knowledge control
		lectures	practical (laboratory or seminars)			
	5 semester	36	54	54		
1.1	Introduction to the educational discipline «Pharmaceutical Chemistry».	2	3	3		Test, situational tasks
1.2	Sources and methods of obtaining medicines	2	3	3		Test, written accounts of laboratory work
1.3	Ensuring the quality of medicines	2	3	3		Electronic tests, situational tasks
1.4	Stability and shelf life of medicines	2	3	3		Test, final test, interviews
2.1	General characteristics of pharmaceutical analysis. Analytical chemistry methods used in pharmaceutical analysis	4	9	9	refractometer, spectrophotometer	Test, written accounts of laboratory work, colloquium
2.2	General characteristics of pharmacopoeial analysis. Reagents used in pharmacopoeial analysis	2	3	3		Test, written accounts of laboratory work
2.3	Properties of pharmaceutical substances	2	3	3	refractometer	Test, written accounts of laboratory work
2.4	Identification methods used in pharmacopoeial analysis	4	9	9	spectrophotometer	Test, written accounts of laboratory work
2.5	Pharmacopoeial testing of pharmaceutical substances	6	6	6		Test, written accounts of laboratory work
2.6	Impurities in pharmaceutical substances	4	3	3		Test, final test, interviews
2.7	Methods for the quantitative analysis of pharmaceutical substances	2	6	6	spectrophotometer	Test, written accounts of laboratory work

2.8	Pharmacoepial quality control of inorganic pharmaceutical substances	4	3	3	refractometer	Electronic tests, written accounts of laboratory work
	6 semester	34	54	83		
2.9	Pharmacoepial quality control of pharmaceutical substances of aliphatic structures	4	6	9	spectrophotometer	Test, written accounts of laboratory work
2.10	Pharmacoepial quality control of pharmaceutical substances of aromatic structures	4	9	15	spectrophotometer	Test, written accounts of laboratory work, situational tasks
2.11	Pharmacoepial quality control of pharmaceutical substances of heterocyclic structures	6	12	16	spectrophotometer	Test, written accounts of laboratory work
2.12	Quality control of medicines of industrial production	2	3	9	spectrophotometer	Test, written accounts of laboratory work, situational tasks
2.13	Quality control of pharmaceutical products (extemporal medicines)	6	9	12	spectrophotometer	Test, written accounts of laboratory work, situational tasks
2.14	Determination of medicinal substances and their metabolites in biological fluids	6	9	9	spectrophotometer	Test, final test, colloquium
3.1	Modern methodology of creating original medicines	4	3	9	spectrophotometer	Test, written accounts of laboratory work
3.2	Pharmaceutical chemistry of medicines for anesthesia and for local anesthesia	2	3	4	spectrophotometer	Test, written accounts of laboratory work
	7 semester	30	48	42		
3.3	Pharmaceutical chemistry of hypnotics, anticonvulsants and antiparkinsonian medicines	2	6	2,5	spectrophotometer	Test, written accounts of laboratory work

3.4	Pharmaceutical chemistry of neuroleptics and anxiolytics	2	3	2,5	spectrophotometer	Test, written accounts of laboratory work
3.5	Pharmaceutical chemistry of antidepressants, psychostimulants and nootropic medicines	2	3	2,5	spectrophotometer	Test, written accounts of laboratory work
3.6	Pharmaceutical chemistry of narcotic analgesics and antagonists of opioid receptors	2	3	2,5	spectrophotometer	Test, final test, colloquium, visual laboratory-based studies
3.7	Pharmaceutical chemistry of non-narcotic analgesics and non-steroidal anti-inflammatory medicines	2	3	2	spectrophotometer	Test, written accounts of laboratory work
3.8	Pharmaceutical chemistry of cholinergic medicines	2	3	3	spectrophotometer	Test, written accounts of laboratory work
3.9	Pharmaceutical chemistry of adrenergic medicines	2	3	3	spectrophotometer	Test, written accounts of laboratory work
3.10	Pharmaceutical chemistry of serotonergic medicines	2	3	3	spectrophotometer	Test, written accounts of laboratory work
3.11	Pharmaceutical chemistry of histaminergic medicines and proton pump inhibitors	2	3	3	spectrophotometer	Test, written accounts of laboratory work
3.12	Pharmaceutical chemistry of inhibitors of phosphodiesterase, antitussive and expectorant medicines	2	3	3	spectrophotometer	Test, written accounts of laboratory work
3.13	Pharmaceutical chemistry of medicines for the treatment of heart diseases and antiarrhythmic medicines	2	3	3	spectrophotometer	Test, final test, visual laboratory-based studies
3.14	Pharmaceutical chemistry of calcium channel blockers and medicines affecting the renin-angiotensin system	2	3	3	spectrophotometer	Test, written accounts of laboratory work

3.15	Pharmaceutical chemistry of statins, diuretics, anticoagulants and antiagrigants	2	3	3	spectrophotometer	Test, written accounts of laboratory work
3.16	Pharmaceutical chemistry of medicines for the treatment of thyroid diseases, and oral hypoglycemic medicines	2	3	3	spectrophotometer	Test, written accounts of laboratory work
3.17	Pharmaceutical chemistry of corticosteroids	2	3	3	spectrophotometer	Test, written accounts of laboratory work
	8 semester	32	54	94		
3.18	Pharmaceutical chemistry of gestagens, androgens and estrogens	2	6	7	spectrophotometer	Test, written accounts of laboratory work
3.19	Pharmaceutical chemistry of vitamins, prostaglandins and their derivatives	6	9	17	spectrophotometer	Test, written accounts of laboratory work
3.20	General characteristics of antibiotics. Pharmaceutical chemistry of beta-lactam antibiotics	4	6	11	spectrophotometer	Test, written accounts of laboratory work, interviews
3.21	Pharmaceutical chemistry of the main groups of antibiotics	2	3	7	spectrophotometer	Test, final test, visual laboratory-based studies
3.22	Pharmaceutical chemistry of synthetic antibacterial medicines	4	6	11	spectrophotometer	Test, written accounts of laboratory work
3.23	Pharmaceutical chemistry of antiviral and antifungal medicines	4	6	10	spectrophotometer	Test, written accounts of laboratory work
3.24	Pharmaceutical chemistry of anti-tuberculosis, antimalarial and anthelmintic medicines	4	6	10	spectrophotometer	Test, written accounts of laboratory work
3.25	Pharmaceutical chemistry of antitumor medicines	4	6	11	spectrophotometer	Test, written accounts of laboratory work
3.26	Pharmaceutical chemistry of contrasting and radiopharmaceuticals medicines	2	6	10	spectrophotometer	Test, written accounts of laboratory work

LITERATURE**Basic (relevant):**

1. European Pharmacopoeia 8.0, vol. 1 Council of Europe, Strasbourg, 2014. — 1380p.
2. European Pharmacopoeia 8.0, vol. 2 Council of Europe, Strasbourg, 2014. — 2133 p.
3. Japanese Pharmacopoeia 17th edition. — 2016. — 2630 p.

Additional

4. Foye's, Principles of Medicinal Chemistry, Sixth Edition, 2008 Edited by: David A. Williams and Thomas L. Lemke, Lippincott Williams & Wilkins Publishers.
5. Gareth Thomas, Medicinal Chemistry, An Introduction Second Edition. John Wiley and Sons Ltd. Publishers. 2007.

LIST OF AVAILABLE DIAGNOSTIC TOOLS

The following forms are used for competences assessment:

1. Oral form:
 - interviews;
 - colloquiums;
 - situational tasks and tests;

2. Written form:
 - tests;
 - final tests;
 - written accounts of laboratory work;
 - course work (projects);

3. Technical form:
 - electronic tests;
 - visual laboratory-based studies;

LIST OF LECTURES

5 semester

1. Introduction to the academic discipline «Pharmaceutical Chemistry»
2. Sources and methods of obtaining medicinal substances
3. Ensuring the quality of medicines
4. Stability and shelf life of medicines
5. General characteristics of pharmaceutical analysis. Analytical chemistry methods used in pharmaceutical analysis
6. General characteristics of pharmacopoeial analysis. Reagents used in pharmacopoeial analysis
7. Properties of pharmaceutical substances
8. Identification methods used in pharmacopoeial analysis
9. Pharmacopoeial testing of pharmaceutical substances
10. Impurities in pharmaceutical substances
11. Methods for the quantitative analysis of pharmaceutical substances
12. Pharmacopoeial water quality control.
13. Pharmacopoeial quality control of inorganic pharmaceutical substances: derivatives of s-elements

6 semester

1. Pharmacopoeial quality control of inorganic pharmaceutical substances: derivatives of p-elements
2. Pharmacopoeial quality control of inorganic pharmaceutical substances: derivatives of d-elements
3. Pharmacopoeial quality control of pharmaceutical substances of aliphatic structure: derivatives of alkanes, alcohols, ethers, aldehydes
4. Pharmacopoeial quality control of pharmaceutical substances of aliphatic structure: derivatives of carbohydrates, carboxylic acids, amino acids, terpenoids
5. Pharmacopoeial quality control of pharmaceutical substances of an aromatic structure: derivatives of phenols and aromatic acids
6. Pharmacopoeial quality control of pharmaceutical substances of an aromatic structure: derivatives of aromatic amino acids, phenylalkylamines, sulfanilic acid
7. Pharmacopoeial quality control of pharmaceutical substances of a heterocyclic structure: derivatives of furan, benzopyran, pyrazole, benzimidazole
8. Pharmacopoeial quality control of pharmaceutical substances of a heterocyclic structure: pyridine derivatives, isoquinoline
9. Pharmacopoeial quality control of pharmaceutical substances of heterocyclic structure: derivatives of purine, pteridine, isoalloxazine
10. Quality control of medicines of industrial production
11. Quality control of medicines manufactured in a pharmacy
12. Determination of medicinal substances and their metabolites in biological fluids
13. Modern methodology of creating original medicines
14. Means for anesthesia and for local anesthesia

7 semester

1. Pharmaceutical chemistry of hypnotic, anticonvulsant and antiparkinsonian medicines
2. Pharmaceutical chemistry of neuroleptics and anxiolytics
3. Pharmaceutical chemistry of antidepressants, psychostimulants and nootropic medicines
4. Pharmaceutical chemistry of narcotic analgesics and antagonists of opioid receptors
5. Pharmaceutical chemistry of non-narcotic analgesics and non-steroidal anti-inflammatory medicines
6. Pharmaceutical chemistry of cholinergic medicines
7. Pharmaceutical chemistry of adrenergic medicines
8. Pharmaceutical chemistry of serotonergic medicines
9. Pharmaceutical chemistry of histaminergic medicines and proton pump inhibitors
10. Pharmaceutical chemistry of inhibitors of phosphodiesterase, antitussive and expectorant medicines
11. Pharmaceutical chemistry of medicines for the treatment of heart diseases and antiarrhythmic medicines
12. Pharmaceutical chemistry of calcium channel blockers and medicines affecting the renin-angiotensin system
13. Pharmaceutical chemistry of statins, diuretics, anticoagulants and antiagrigants
14. Pharmaceutical chemistry of medicines for the treatment of thyroid diseases, and oral hypoglycemic medicines
15. Pharmaceutical chemistry of corticosteroids

8 semester

1. Pharmaceutical chemistry of gestagens, androgens and estrogens
2. Pharmaceutical chemistry of vitamins, prostaglandins and their derivatives
3. General characteristics of antibiotics. Pharmaceutical chemistry of beta-lactam antibiotics
4. Pharmaceutical chemistry of the main groups of antibiotics
5. Pharmaceutical chemistry of synthetic antibacterial medicines
6. Pharmaceutical chemistry of antiviral and antifungal medicines
7. Pharmaceutical chemistry of anti-tuberculosis, antimalarial and anthelmintic medicines
8. Pharmaceutical chemistry of antitumor medicines
9. Pharmaceutical chemistry of contrasting and radiopharmaceuticals medicines

LIST OF LABORATORY LESSONS

5 semester

1. Introduction to the academic discipline «Pharmaceutical Chemistry»
2. Sources and methods of obtaining medicinal substances
3. Ensuring the quality of pharmaceutical substances and medicines
4. Stability and shelf life of medicines
5. Methods of analytical chemistry used in pharmaceutical analysis: chemical methods of analysis.

6. Methods of analytical chemistry used in pharmaceutical analysis: instrumental methods of analysis.
7. General questions of pharmaceutical chemistry; analytical chemical methods used in the pharmaceutical analysis (final session).
8. General characteristics of pharmacopoeial analysis. Reagents used in pharmacopoeial analysis.
9. Properties of pharmaceutical substances.
10. Chemical methods of identification of inorganic medicinal substances.
11. Chemical methods of identification of organic medicinal substances.
12. The use of instrumental methods for the identification of pharmaceutical substances and medicines.
13. Pharmacopoeial testing of pharmaceutical substances.
14. Impurities in pharmaceutical substances.
15. Methods of quantitative analysis of pharmaceutical substances: chemical methods of analysis.
16. Methods of quantitative analysis of pharmaceutical substances: instrumental methods of analysis
17. General methods and techniques of pharmaceutical analysis (final session)

6 semester

18. Pharmacopoeial water quality control
19. Pharmacopoeial quality control of pharmaceutical substances of inorganic structure: derivatives of s-elements.
20. Pharmacopoeial quality control of pharmaceutical substances of inorganic structure: derivatives of p-elements.
21. Pharmacopoeial quality control of pharmaceutical substances of inorganic structure: derivatives of d-elements.
22. Pharmacopoeial quality control of pharmaceutical substances of inorganic structure (final session)
23. Pharmacopoeial quality control of pharmaceutical substances of aliphatic structure: derivatives of alkanes, alcohols, ethers, aldehydes.
24. Pharmacopoeial quality control of pharmaceutical substances of aliphatic structure: derivatives of carbohydrates, carboxylic acids, amino acids, terpenoids.
25. Pharmacopoeial quality control of pharmaceutical substances of aromatic structure: derivatives of phenols and aromatic acids.
26. Pharmacopoeial quality control of pharmaceutical substances of aromatic structure: derivatives of aromatic amino acids, phenylalkylamines.
27. Pharmacopoeial quality control of pharmaceutical substances of aromatic structure: sulfanilic acid derivatives.
28. Pharmacopoeial quality control of pharmaceutical substances of heterocyclic structure: derivatives of furan, benzopyran, pyrazole, benzimidazole.
29. Pharmacopoeial quality control of pharmaceutical substances of a heterocyclic structure: pyridine derivatives, isoquinoline.
30. Pharmacopoeial quality control of pharmaceutical substances of heterocyclic structure: derivatives of purine, pteridine, isoalloxazine.

31. Pharmacopoeial quality control of pharmaceutical substances of organic structure (final test).
32. Quality control of medicines of industrial production.
33. Quality control of medicines manufactured in a pharmacy (part 1)
34. Quality control of medicines manufactured in a pharmacy (part 2)
35. Exam on practical skills.
36. Determination of medicinal substances and their metabolites in biological fluids.

7 semester

1. Modern methodology of creating original medicines.
2. Pharmaceutical chemistry of medicines for anesthesia and for local anesthesia.
3. Pharmaceutical chemistry of hypnotic, anticonvulsant and antiparkinsonian medicines
4. Pharmaceutical chemistry of neuroleptics, anxiolytics
5. Pharmaceutical chemistry of antidepressants, psychostimulants and nootropic medicines
6. Pharmaceutical chemistry of narcotic analgesics and opioid receptor antagonists.
7. Pharmaceutical chemistry of non-narcotic analgesics and non-steroidal anti-inflammatory medicines
8. Modern methodology of creating original medicines. pharmaceutical chemistry of medicines affecting the central nervous system (final session).
9. Pharmaceutical chemistry of cholinergic medicines.
10. Pharmaceutical chemistry of adrenoreceptor agonists and sympathomimetics.
11. Pharmaceutical chemistry of antagonists of adrenoreceptors and sympatholytics.
12. Pharmaceutical chemistry of serotonergic medicines.
13. Pharmaceutical chemistry of histaminergic medicines and proton pump inhibitors.
14. Pharmaceutical chemistry of cholinergic, adrenergic, serotonergic, histaminergic medicines, inhibitors of proton pump (final session).
15. Pharmaceutical chemistry of inhibitors of phosphodiesterase, antitussive and expectorant medicines.
16. Pharmaceutical chemistry of medicines for the treatment of heart diseases and antiarrhythmic medicines.
17. Pharmaceutical chemistry of calcium channel blockers and medicines affecting the renin-angiotensin system
18. Pharmaceutical chemistry of statins, diuretics, anticoagulants and antiaggregants.
19. Pharmaceutical chemistry of inhibitors of phosphodiesterase, antitussive and expectorant medicines; medicines that affect the cardiovascular system and blood (final session)

8 semester

20. Pharmaceutical chemistry of medicines for the treatment of thyroid diseases, and oral hypoglycemic medicines.
21. Pharmaceutical chemistry of corticosteroids.
22. Pharmaceutical chemistry of gestagens, androgens and estrogens.
23. Pharmaceutical chemistry of water-soluble vitamins.

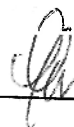
24. Pharmaceutical chemistry of fat-soluble vitamins, prostaglandins and their derivatives.
25. Pharmaceutical chemistry of medicines for the treatment of thyroid diseases, and oral hypoglycemic medicines, steroid hormones, vitamins, prostaglandins and their derivatives (final session).
26. General characteristics of antibiotics. Pharmaceutical chemistry of beta-lactam antibiotics.
27. Pharmaceutical chemistry of the main groups of antibiotics.
28. Pharmaceutical chemistry of synthetic antibacterial medicines (sulfonilamides and trimethoprim, nitrofurans, nitroimidazoles, derivatives of 8-hydroxyquinoline).
29. Pharmaceutical chemistry of synthetic antibacterial medicines (fluroquinolones, oxazolidinones).
30. Pharmaceutical chemistry of antiviral and antifungal medicines.
31. Pharmaceutical chemistry of antituberculosis, antimalarial and anthelmintic medicines.
32. Pharmaceutical chemistry of antitumor medicines.
33. Pharmaceutical chemistry of chemotherapeutic medicines (final test).
34. Exam on practical skills.
35. Pharmaceutical chemistry of contrasting and radiopharmaceuticals medicines.

**PROTOCOL OF THE CURRICULUM APPROVAL
BY OTHER DEPARTMENTS**

The name of the academic discipline with which coordination is required	The name of the department	Suggestion on changes in the content of the curriculum of the institution of higher education in the academic discipline	The decision taken by the department that developed the curriculum (with the date and number of the protocol)
1. Analytical chemistry	Department of bioorganic chemistry	To study the features of sampling and sample preparation in accordance with the requirements of the State Pharmacopoeia of the Republic of Belarus, special attention should be paid to methods of separation and concentration.	To introduce into the section «Quality control of medicines of industrial production» the rules and peculiarities of sampling and sample preparation in the analysis of various medicines forms (protocol №1 of 29.08.2018).
2. Organic chemistry	Department of bioorganic chemistry	To study the features of the spatial structure of molecules of organic compounds, special attention should be given to the effect of stereoisomerism on the pharmacological action of the medicine	Introduce the question on the stereochemical aspects of the action of medicines (protocol No. 1 of 29.08.2018) into the section «Modern methodology for the development of original medicines»

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A.A. Ziatsikau

Curriculum content, composition and accompanying documents comply with
established requirements.

Dean of the Medical Faculty of
International Students

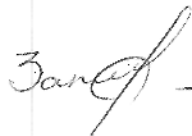
09.08. 2018



O.S. Ishutin

Methodologist of Educational Institution
"Belarusian State medical University"

09.08. 2018





S.V. Zaturanova

Head of the Foreign Languages
Department



M.N. Petrova

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