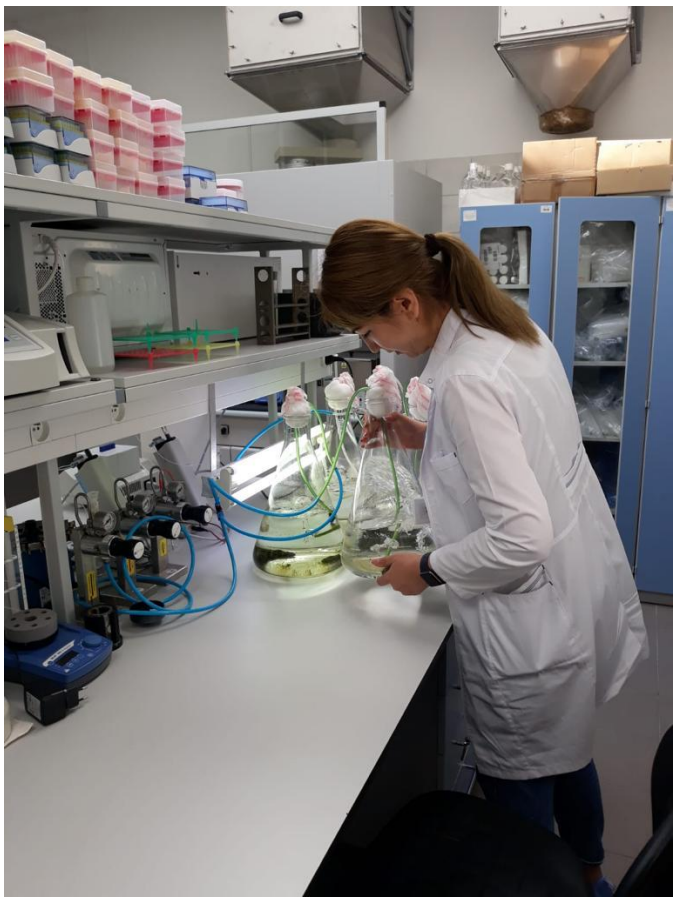
Brief information about the project

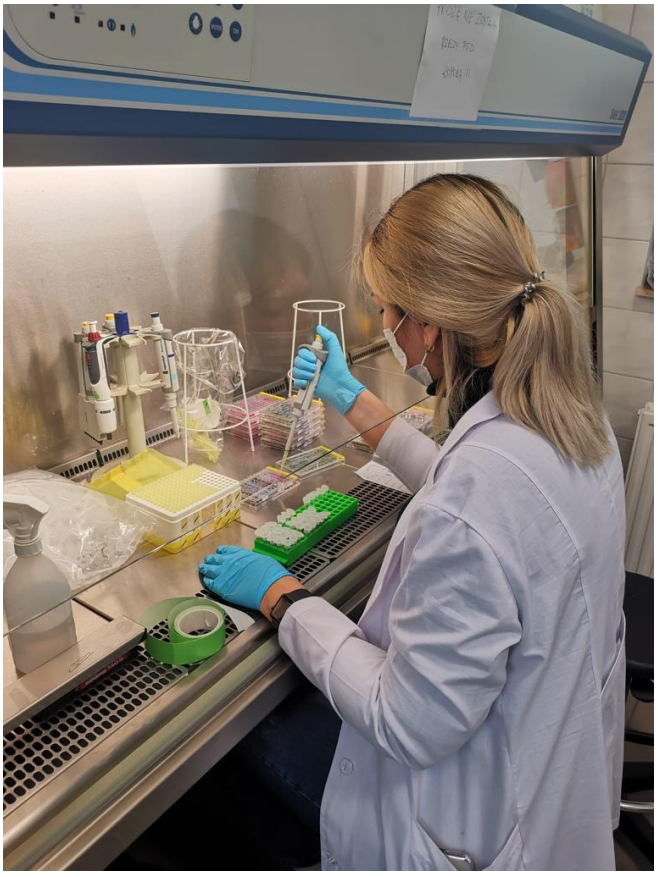
Name of the project	IRN AP14972864 "Synthesis, characterization, photoluminescent and antibacterial properties of europium/biosilica and silver/biosilica based nanomaterials"
Relevance	Diatom algae shells are composed of hydrated silica, which exhibits special properties including biocompatibility, surface chemistry and porosity, chemical inertness and thermal stability. Stems collected from aquatic ecosystems or diatom fossil sediments represent an excellent economic source of biosilica for a wide range of biomedical applications. The porous ultrastructure of the shells presents a large surface area available for coating with various biomolecules using different functionalization techniques. The scientific research of this project is aimed at obtaining biosilica-based nanocomposites with antibacterial and photoluminescent properties.
Purpose	The goal of the work is to obtain environmentally friendly biosilica from diatom algae with traditional microbiological cultivation from diatomite. Synthesis, characterization, and study of antibacterial and photoluminescent properties of nanomaterials based on europium/biosilica and silver/biosilica.
Objectives	1) Conduct a scientifically based selection of methods for preparing diatomite for the cultivation of diatoms. Selection of a method for purifying diatoms from organic substances, selection of the optimal concentration, temperature, pH of the medium and reagents. Scientifically based selection of the synthesis of nanocomposites silver nanoparticles/biosilica, europium/biosilica, silver/europium/biosilica. 2) Obtaining diatom algae from Kazakhstan diatomite. Cultivation and further purification from organic compounds. Synthesis of silver nanoparticles/biosilica nanocomposites. Study of physicochemical characteristics of the obtained nanocomposites. The obtained composites will be studied by SEM, SEM EDX, TEM, X-ray diffraction analysis, IR spectroscopy, TGA-DSC and zeta potential determination. 3) Investigation of antibacterial activity of the obtained silver nanoparticles/biosilica nanocomposite. Investigation of photoluminescent properties by optical spectroscopy. Photoluminescent properties of the obtained silver nanoparticle/biosilica composites will be studied by optical spectroscopy. 1) Synthesis of europium/biosilica nanocomposites and silver nanoparticles/europium/biosilica nanoparticles.

	Study of physicochemical characteristics of the obtained nanocomposites. The obtained composites will be studied by SEM, SEM EDX, TEM, X-ray diffraction analysis, IR spectroscopy, TGA-DSC and zeta potential determination. 2) Investigation of antibacterial activity of the obtained europium/biosilica silver nanoparticles/europium/biosilica nanocomposites against gram-positive Staphylococcus aureus and gram-negative Klebsiella pneumoniae, Escherichia coli bacteria. 3) Investigation of photoluminescent properties by optical spectroscopy.
Expected and achieved results	**Expected Results:** 1) A scientifically based selection of diatomite preparation for the cultivation of diatoms will be carried out. Selection of a method for purifying diatoms from organic substances, selection of the optimal concentration, temperature, pH of the medium and reagents. Scientifically based selection of the synthesis of nanocomposites silver nanoparticles/biosilica, europium/biosilica, silver/europium/biosilica. Preparation of a report on the work done. 2) Silver nanoparticle/biosilica nanocomposites will be synthesized with Ag+ concentrations of 5 and 10% depending on the mass of biosilica used. The morphology and structure of the synthesized composites will be determined using scanning electron microscopy. The elemental composition will be studied by SEM EDX. The mineral composition and formation of silver nanoparticles will be identified by X-ray diffraction analysis. Thermogravimetric analysis will be carried out by TGA-DSC. Functional groups will be identified by IR spectroscopy and the zeta potential of the synthesized nanocomposites will be determined. 3) The antibacterial activity potential of the obtained silver nanoparticles/biosilica nanocomposite against gram-positive Staphylococcus aureus and gram-negative Klebsiella pneumoniae, Escherichia coli bacteria by the minimum inhibitory concentration method will be investigated. Photoluminescent properties of the obtained silver nanoparticle/biosilica composites will be studied by optical spectroscopy. **Achieved results:** 1) Synthesis of silver nanoparticles with Ag+ concentration of 5 and 10% with respect to the biosilica mass. The elemental composition by SEM EDX method of nanocomposites containing 4.61 and 8.49 % silver was determined. The dominant nanoparticles range from 5 to 15 nm. Nanoparticles of 1-2 nm and particles of 20-40 nm are also present. Crystallites called parallel twins are also found.

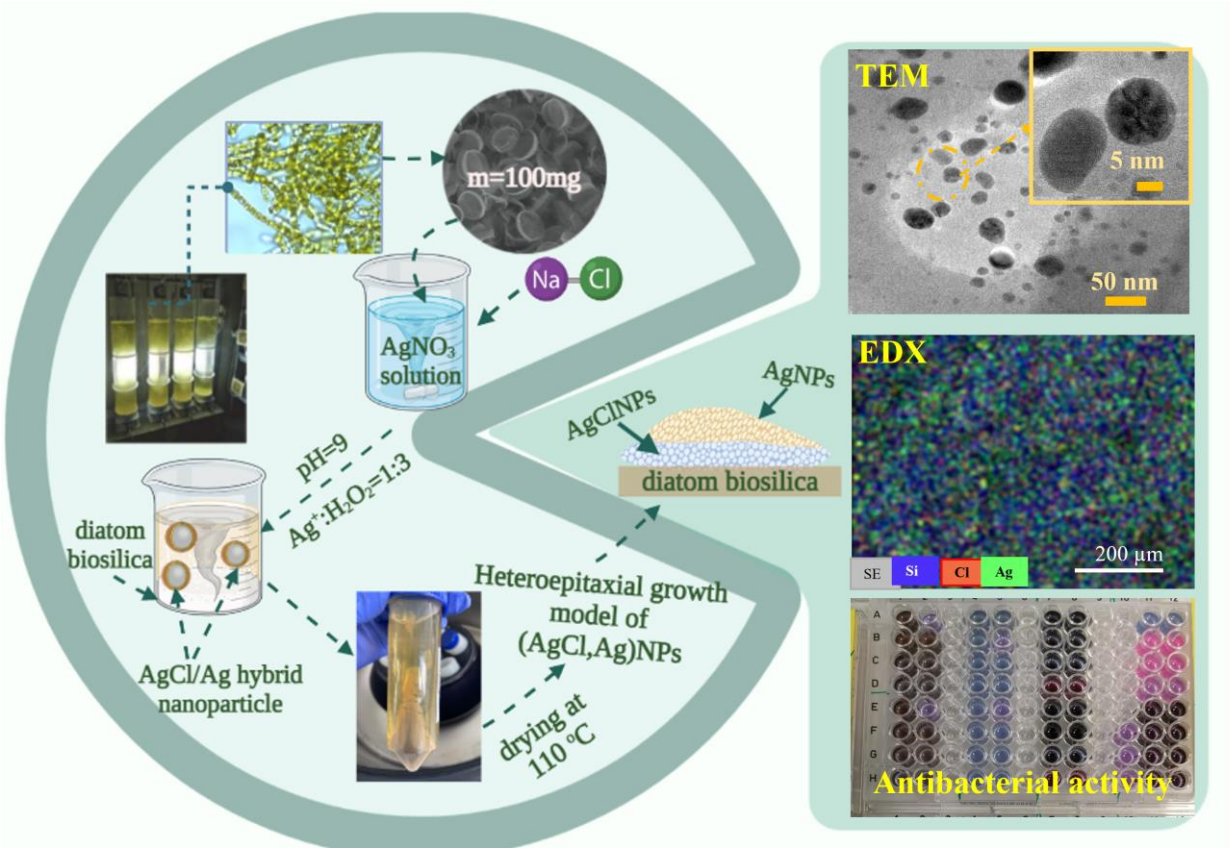
	2) The antibacterial activity potential of silver nanoparticle/biosilica nanocomposite against gram-positive Staphylococcus aureus and gram-negative Klebsiella pneumoniae, Escherichia coli bacteria by the minimum inhibitory concentration method was investigated. The obtained nanomaterials showed antibacterial effect against bacterial strains, American Type Culture Collection and clinical isolates (diabetic foot infection and wound isolates). The MIC value was found to be 1.25 mg/mL in both cases. 2) Photoluminescent properties of the obtained silver nanoparticle/biosilica composites were studied by optical spectroscopy. 3) Photoluminescence spectra of biosilica and obtained (AgCl-Ag) NPs/biosilica composites containing different percentages of silver: 4.61% and 8.49%. According to the obtained photoluminescence spectra, four main types of photoluminescent activity (PL) can be identified in both composites. The initial type of PL is associated with excitation at 270 nm and emission at 335-425 nm in the UV spectrum. The strongest photoluminescence in this region was observed at 335, 380, 395, 397, 413 and 420 nm.
Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	1. Bekissanova Zhanar Bolatovna, Scientific supervisor of the project, postdoctoral fellow, RA, Al-Farabi KazNU, lecturer at the Department of Physical Chemistry, Catalysis and Petrochemistry h-index-3, https://orcid.org/0000-0001-6142-0963, ScopusID= 57218598280 2. Myroslav Sprynskyy, Performer, Lead researcher, scientific consultant, PhD,DSc, Professor, Nicolaus Copernicus University of Torun, Poland, h-index-22, https://orcid.org/0000-0002-4334-3594, ResearcherID: GCQ-0369–2022; Scopus ID: 18438744500. 3. Ospanova Aliya Kapanovna, scientific consultant, Professor of the Department of Physical Chemistry, Catalysis and Petrochemistry h-index-5, https://orcid.org/0000-0001-9954-8575, Scopus ID=55340038000; ResearcherID: ABE-7029-2021.
List of publications with links to them	1. Bekissanova, Z., Railean, V., Wojtczak, I., Brzozowska, W., Trykowski, G., Ospanova, A., & Sprynskyy, M. (2023). Synthesis and Antimicrobial Activity of 3D Micro–Nanostructured Diatom Biosilica Coated by Epitaxially Growing Ag-AgCl Hybrid Nanoparticles. Biomimetics, 9(1), 5. Q2, (IF=4.5). https://doi.org/10.3390/biomimetics9010005
Patents	



Cultivation of diatoms



Study of the antibacterial activity of the obtained composites



Scheme for the production of nanocomposites from biosilicon