WROCŁAW DOCTORAL SCHOOL OF INSTITUTES
OF POLISH ACADEMY OF SCIENCES

List of doctoral projects available for the academic year 2021/2022

INTiBS PAN
WROCŁAW

Wrocław 2021

Chemistry/Physics

Supervisor: Przemysław Dereń, prof. (p.deren@intibs.pl)
Auxiliary Supervisor: Natalia Miniajluk-Gaweł, dr

Subject: ***Study of the spectroscopic properties of solid solutions of double perovskites Ba2MgWO6 and La2MgTiO6 doped with selected lanthanide ions.***
Discipline: Chemistry

Description: The objective of the thesis is to obtain phosphors based on solid solutions of Ba2MgWO6 and La2MgTiO6 with a regular structure of a double perovskite doped with selected lanthanide ions and to study their spectroscopic properties.
Materials whose optical properties are not known until now will be studied. The regular structure of such a matrix can make it possible to obtain transparent or translucent ceramics and therefore new photonic materials.
The samples will be synthesized using a mechanochemical method supported by high-temperature annealing. After their receipt and verification of phase purity, electronic spectroscopy, IR, and Raman measurements will be performed.
We are expecting skilled chemists, experience in synthesizing polycrystalline materials applying different methods will be an advantage. A Ph.D. student should have a basic knowledge and skills to perform structural and spectroscopic measurements and to analyze the obtained research results.

Supervisor: Jan Janczak, prof. (j.janczak@intibs.pl)

Subject: ***Stereochemistry and properties of metallophthalocyanine derivatives.***
Discipline: Chemistry

Description: Metal (II) phthalocyanines (for example MgPc, ZnPc, MnPc, FePc, CoPc), although they have been known for several decades, are still of great interest due to their various applications. The properties of metallophthalocyanines of the transition metals, as representatives of the metallophthalocyanine family with the metal at +2 oxidation state, differ significantly from magnesium and zinc phthalocyanine (Mg, d0, Zn, d10) due to the electronic structure of the central ion (Mn2+ (Ar)3d5; Fe2+, (Ar)3d6, Co2+, (Ar)3d7). Therefore, the aim of the work will be to obtain and characterize new complexes of metal phthalocyanines with additional axially coordinating N and O-donor ligands in the crystalline form as well as perform their structural analysis. In addition, the physicochemical characterization of the obtained metallophthalocyanine derivatives should be performed. Moreover, DFT calculations of the geometry of the obtained derivatives and TD-DFT calculations as well as correlation with the experimental UV-Vis spectra should be performed.

Supervisor: Anna Łukowiak, D.Sc. (dr hab.) (a.lukowiak@intibs.pl)
Auxiliary Supervisor: Marzena Fandzloch, dr

Subject: ***Synthesis of new MOF@biomaterial composites and their characterisation towards bioapplications.***
Discipline: Chemistry

Description: Metal-Organic Frameworks (MOFs) represent a new class of porous materials that are incomparable in their level of tuning as well as structural and chemical diversity. They are distinguished by their large specific surface area and pore volume. They are multifunctional materials due to the variety of substrates used in their synthesis. Their unique physicochemical properties open up new possibilities for their use in many branches of chemistry, materials engineering, nanotechnology, physics, biology, or medicine. Toxicity studies have shown that some MOFs are biocompatible with cells and tissues, suggesting promising applications in drug delivery, biochemical detection, and disease treatment.
The main objective of the PhD thesis will be the design and synthesis of novel MOF@biomaterial composites, where the biomaterial is bioactive glass or hydroxyapatite. MOFs will be based on different metal ions, e.g. Ag+, Cu2+, Zn2+, or Ln3+, to obtain composites with antimicrobial or luminescent properties. The experimental part of the work will consist of several research tasks: i) synthesis and structural, spectroscopic, and textural characterization of the materials using techniques such as XRD, IR, Raman, photoluminescence spectroscopy, XPS, SEM, TEM, N2 sorption measurements; ii) evaluation of biocompatibility and bioactivity of the materials; iii) investigation of potential application as antimicrobial agents, biosensors, biomarkers, or drug carriers.

Supervisor: Łukasz Marciniak, D.Sc. (dr hab.) (l.marciniak @intibs.pl)

Subject: ***Nanocrystalline luminescent manometers based on transition metal ions emission.***
Discipline: Chemistry/Physics

Description: The main research objective of the project is to develop highly sensitive luminescent manometers at nanoscale based on transition metal ions. Therefore within this project, a detailed and systematic studies concerning the influence of the pressure on the spectroscopic properties of nanocrystalline transition metal ions doped luminescent nanomanometers will be performed including theoretical modeling of the process (using rate equations) as well as experimental characterization of synthesized host material and suggested dopant ions. The research which will be performed enables to correlate the host material composition with the sensitivity of luminescent nanomanometers to pressure changes in order to develop a new generation of highly sensitive nanosized noncontact pressure probes.

Additional information: Two Ph.D student positions available. The Ph.D scholarships will be financed by the NCN OPUS project (2020/37/B/ST5/00164) for 48 months (planned cost in the project is 5000 PLN/month) each. In order to select a doctoral students in the project, a competition will be held in parallel with the recruitment to WSD IPAN. Candidates expressing interest in the project should attach to their application to the WSD IPAN an application for participation in the competition as well as any information indicating their suitability for the competition (the competition will assess competencies to implement the topic of the doctoral dissertation and the candidate's academic achievements.

Supervisor: Mirosław Mączka, prof. (m.maczka@intibs.pl)

Subject: ***Soft perovskites - new paradigm of semiconductors engineering.***
Discipline: Chemistry

Description: 2D and quasi-2D lead halide perovskites are crystals with a layered structure often regarded as natural quantum wells consisting of octahedral slabs separated by organic spacers. They are very promising photovoltaic, photoluminescent, non-linear optical and ferroelectric materials. Their properties can be tuned by changing both inorganic and organic components. For instance, distortion of the lead halide octahedra leads to a change of the emission and absorption energy. However, we are still lacking an understanding of the correlation between distortion and other parameters crucial for optoelectronic applications. Therefore, the main aim of the project is understanding a correlation between the crystal structure (distortion and width of inorganic slabs, width and dielectric permittivity of organic layers) and properties of these compounds. To achieve this goal, we are going to perform systematic synthesis of many known and novel 2D perovskites of general formula A'2PbX4 or A"PbX4 as well as quasi-2D perovskites containing Bn-1PbnX3n+1 inorganic slabs. Different monovalent A' and divalent A" spacer cations, and small monovalent B cations will be employed. The grown crystals will be studied in a broad temperature range using X-ray diffraction, thermal, electrical and spectroscopic (optical, Raman, IR) methods. We expect that the comprehensive studies will allow to propose a rational way to design perovskites optimized for the desired application.

Additional information: The PhD scholarship will be financed by the MAESTRO project (2020/38/A/ST3/00214) for 48 months (planned cost in the project is 3000 PLN/month for 15 months, 3325 PLN/month for the next 12 months and 4300 PLN/month for the last 21 months). In order to select a doctoral student in the project, a competition will be held in parallel with the recruitment to WSD IPAN. Candidates expressing interest in the project should attach to their application to the WSD IPAN an application for participation in the competition as well as any information indicating their suitability for the competition (the competition will assess competencies to implement the topic of the doctoral dissertation and the candidate's academic achievements, including publications in reputable scientific journals). The candidate should have master degree in chemistry or materials science. The main duties are: single crystals growth of organic-inorganic hybrids, temperature-dependent Raman and IR studies, data analysis and preparation of publications.

Supervisor: Włodzimierz Miśta, D.Sc. (dr hab.) (w.mista@intibs.pl)

Subject: ***Synthesis, characterization and catalytic activity of metal-organic framework HKUST-1 with encapsulated selected noble metals.***
Discipline: Chemistry

Description: This thesis focuses on the development of a hydro/solvothermal method and or microwave-assisted synthesis for the rapid synthesis of good quality copper benzene-1,3,5-tricarboxylate (Cu-BTC referred also to as HKUST-1) with high yield under mild preparation conditions. Different synthesis conditions and activation methods were studied to understand their influence on the properties of HKUST-1. Additional attempt will be made to in situ synthesis/immobilization of HKUST-1 in macro-/mesoporous silica/nikel monoliths for continuous flow catalysis with low pressure drop.
As synthesized MOF will be activated by encapsulation of selected noble metals (Au, Pt, Pd…). Interactions between metal nanoparticles (NPs) and metal–organic frameworks (MOFs) in their composite forms have proven to exhibit beneficial properties, such as enhanced catalytic performance through synergistic effects. As prepared hybrid MOF materials will be characterized by: XRD , SEM–EDS, HRTEM, thermal analysis (TG), N2 (77K) physisorption analysis, CO2 and H2 volumetric adsorption, termoprogrammed reaction (TPR-H2, TPD-MS, TPO), Raman, IR spectroscopy and by catalytic activity (CO oxidation).

Supervisor: Włodzimierz Miśta, D.Sc. (dr hab.) (w.mista@intibs.pl)

Subject: ***Synthesis, characterization and catalytic activity of selected perovskites ($LaMO_3$; M= Mn,Co, Fe…) doped with noble metals.***
Discipline: Chemistry

Description: This thesis focuses on the preparation, characterization of perovskite materials ($LaMO_3$; M=Mn, Co, Fe…). The following preparation methods will be use:
sol-gel citrate methods, solvothermal methods / microvawe assisted, nanocasting technique using mesoporous SBA-15 silica materials as a template. The perovskite structures ABO_3 can incorporate ions of various size and charge showing great flexibility of composition. Moreover, substitutions of ions into the A- and/or B-sites forming $A_{1-x}A'_xB_{1-y}B'_yO_3$ or deviation from ideal stoichiometry resulted in altering the electronic properties and also catalytic activity of the perovskites. Therefore the effect of substitution of additional different metal cations (Ce^{+4}, Ca^{+2}, …) in A and/or B sites of perovskite cell on catalytic activity will be investigated. Therefore the incorporation of selected noble metals into perovskite lattice will be studied. Exposing the catalyst to oxidizing and reducing atmosphere resulted in the recovery of the high dispersion state of noble metal dispersion state of incorporated metal and the excellent stability of the perovskite structure.
As prepared perovskite samples will be characterized by: XRD, SEM–EDS, HRTEM, thermal analysis (TG), N_2 (77K) physisorption analysis, termoprogrammed reaction (TPR-H_2, O_2-TPD-MS, TPO), Raman and FTIR spectroscopy and catalytic activity for CO, VOC, and soot oxidation.

Supervisor: Piotr Solarz, D.Sc. (dr hab.) (p.solarz@intibs.pl)

Subject: ***Investigation of luminescence and non-radiative energy transfer between lanthanides in double-doped systems.***
Discipline: Chemistry/Physics

Description: The aim of the project is to synthesize and determine the efficiency of energy transfer between sensitizer ions and donor ions in new phosphors.
It is postulated that selected pairs of lanthanides may, by synergy effect, constitute a new type of phosphors with properties distinct from singly doped systems. Particular attention will be given to systems emitting in the red spectrum. The red range is especially important for indoor lighting. Its deficit in the currently used LED sources contributes to a number of diseases such as: cardiological problems, sleep problems, depression, endocrine disorders.
After synthesizing a selected fluoride or oxide system, doped with lanthanide ions, e.g. with Ce + Pr or Tb + Eu pairs, the research will focus on determining the areas of optical pumping and its efficiency depending on the concentration of impurities. The energy transfer rates, luminescence efficiency, its spectral area and mechanisms of interaction will be determined. The obtained material will be subjected to structural and morphological analysis. Spectroscopic measurements will consist in determining the areas of optical pumping (absorption and excitation spectra), determining the lifetime of impurities (activator and acceptor) and detailed luminescence analysis. Time resolving femtosecond spectroscopy using a streak camera will play a special role.

Supervisor: Wiesław Stręk, prof. (w.strek@intibs.pl)
Auxiliary Supervisor: Paweł Głuchowski, dr.

Subject: ***Synthesis of the graphene structures for the photocatalytic conversion of CO2 into methanol in an aquatic environment.***
Discipline: Chemistry

Description: The work will be focused on the technology that allow to storage CO2 by dissolving it in the subcritical water and then thanks to graphene catalyst converting the gas into methanol that could be reused in the CO2 generating unit. The first step will be to increase efficiency of the photocatalysis, what is possible by using graphene structure as a catalyst. Graphene have high surface area and under UV or IR radiation may generate free electrons on the surface that accelerate photocatalysis process. New type of the pure and intercalated with metal particles graphene structures will be developed. Then it will be developed technology where gas dissolution and its processing will operate in one continuous technological process. The biggest challenge of this work will be the increase of CO2 solubility in water, and effective methanol recovery during the photocatalysis process. The preliminary results has shown that it is possible to increase the solubility of CO2 in water due to its earlier interaction with the plasma. Increasing CO2 solubility in water and acceleration conversion process using graphene structures will increase efficiency of the process what thanks to which the process will become profitable also for industry and will allow effective removal of harmful gases in industrial processes. The work allow to possess the knowledge and practical experience in large-scale CO2 storage and processing.

Supervisor: Wiesław Stręk, prof. (w.strek@intibs.pl)
Auxiliary Supervisor: Paweł Głuchowski, dr.

Subject: ***Synthesis of oxide materials stabilized with alkali ions with high ionic conductivity for use as solid electrolytes.***
Discipline: Chemistry

Description: The aim of the work is to develop new oxide materials stabilized with alkali ions (Li, Na) showing high ionic conductivity (σ≥ 10-3 S / cm) and low electronic conductivity (<10-9 S / cm). During the work synthesis methods of the materials with the structure of spinels, perovskites and fluorites will be developed. The syntheses will be carried out using wet chemistry, sol-gel, precipitation and combustion methods. The stoichiometry of the compounds will be optimized so that they show high chemical, temperature and electrical stability. The powders made by various techniques will be sintered into ceramics using high pressure and low temperature technology. This method allows to keep the small size of the crystallites during the whole sintering process and the high density of ceramics also at low sintering temperatures (below 800 °C). The physical properties of the ceramics will be controlled through experimental selection of pressure, time and sintering temperature. Ceramics will be characterized structurally, morphologically and by impedance spectroscopy. For materials showing the best physical properties, electrochemical tests will be carried out in cooperation with foreign partners to determine the application potential of the developed materials.

Supervisor: Tomasz Cichorek, prof. (t.cichorek@intibs.pl)

Subject: ***Determining the gap symmetry of chiral superconductors: A lower critical field study using Hall micromagnetometry.***
Discipline: Physics

Description: Chiral superconductivity is a striking quantum phenomenon in which an unconventional superconductor spontaneously brakes time reversal symmetry and lowers its free energy by eliminating nodes in the gap. Chiral superconductivity is a type of topological state. The odd-parity chiral state provides a natural platform for realizing Majorana edge modes, which are central to several proposals for topological quantum computation. However, despite intensive theoretical study and huge experimental efforts, no material has been proven definitively to be a chiral superconductor.
The main task of a Ph.D. thesis is intended to find experimental evidence for the emergence of the spin-triplet pair state with odd-parity energy gap in candidate chiral superconductors via a detailed investigation of the temperature dependence of the lower critical field Hc1(T) - one of the basic properties of a superconductor. We plan to measure a local magnetization of various unconventional superconductors using a Hall micromagnetomery down to temperatures as low as 10 mK. We expect to observe unusual Hc1(T) characteristics, including an unsaturated behaviour in the limit T = 0. Such experimental findings supported by a numerical analysis should narrow down the possible descriptions of the electron-pair wave function. So far, triplet pairing is rare in nature and has not been unambiguously identified in any bulk compound.
Investigations of an emergence of chiral superconductivity will be conducted in collaboration with École Polytechnique, France and performed among others on newly discovered superconductors UTe2 and 4Hb-TaS2 as well as on long-studied but still unsolved systems like Sr2RuO4, UPt3, and PrOs4Sb12.

Supervisor: Adam Pikul, D.Sc.(dr hab.) (a.pikul@intibs.pl)

Subject: ***Thermal expansion and magnetostriction of uranium intermetallic compounds as potential advanced next-generation nuclear fuel***
Discipline: Physics/Chemistry

Description: Construction of nuclear reactors based on advanced nuclear fuels is one of the conditions for effective decarbonization of the world energy industry. The most commonly used fuel in modern nuclear power plants is semi-conducting uranium dioxide, which (although relatively cheap and easy to produce) is not free from defects and limitations in its use. Problems include swelling and cracking of fuel rods and their low thermal conductivity which is a consequence not only of the burning of uranium dioxide but also of its physical and chemical properties. Therefore, a new generation of nuclear fuels referred to as ATF (accident tolerant fuel) is being searched for i.a. among uranium intermetallic compounds. The proposed PhD thesis will support this search at the level of basic research. Its aim will be to synthesize and study physical properties of selected uranium intermetallic compounds (as potential nuclear fuel) and to attempt to relate these properties to magnetism of the 5f electrons of uranium. The research will consist of growing monocrystals of several carefully selected compounds and their physical characterization mainly through thermal expansion and magnetostriction measurements. Part of the experiments will be carried out in France and the USA (as part of an ongoing collaboration), and the results obtained will be published in specialized journals and presented at international scientific conferences.

Additional information: The condition of admission to work with radioactive isotopes is positive qualification by a doctor of occupational medicine (medical examinations will be conducted at the expense of INTiBS PAN).

Supervisor: Maciej Ptak, D.Sc. (dr hab.) (m.ptak@intibs.pl)
Auxiliary Supervisor: Dagmara Anna Stefańska, dr

Subject: ***Synthesis and physicochemical properties of hybrid formate-based perovskites for applications in luminescence thermometry.***
Discipline: Physics/Chemistry

Description: The main goal of the work will be a synthesis of new luminescent organic-inorganic perovskite-type materials based on formate ligand, as well as containing Cr^{3+} ions, and explaining of the mechanisms of optical processes depending on temperature and pressure.
Metal-organic frameworks (MOFs) are often called multifunctional materials because they exhibit several interesting properties at the same time, such as dielectric, magnetic, ferroelectric, multiferroic, etc. Moreover, these materials can exhibit luminesce properties that are extremely attractive from the viewpoint of luminescence thermometry. The subject of research will be perovskites with a general formula of ABX_3, in which A is an organic cation (protonated amine), B represents a metal cation and X stands for small organic linker – formate ion. The duties of the Ph.D. student will include synthesis of selected MOF materials, structure verification using X-ray diffraction methods, and spectroscopic characterization in a wide range of temperatures (10-400 K), including measurements of Raman, IR, emission spectra and kinetics of luminescence decay.

Additional information: The Ph.D. scholarship will be financed by the Sonata 16 project (UMO-2020/39/D/ST5/01289) for 36 months (planned scholarship is 4000 PLN/month before midterm evaluation and 4200 PLN/month after it). The last 12 months will be financed by the doctoral school WSD IPAN. In order to select a doctoral student in the project, a competition will be held in parallel with the recruitment to WSD IPAN. Candidates expressing an interest in working in the project should attach to their application to the WSD IPAN an application for participation in the competition as well as any information indicating their suitability for the competition (the competition will assess competencies to implement the topic of the doctoral dissertation, including experience in the synthesis of hybrid MOF-type materials, experience in UV-Vis spectroscopy, and the candidate's academic achievements).

Supervisor: Małgorzata Samsel-Czekała, D.Sc. (dr hab.) (m.samsel@intibs.pl)

Subject: ***Theoretical investigations of two-dimensional magnetic topological materials.***
Discipline: Physics

Description: Three-dimensional Dirac/Weyl semimetals are extensively studied due to the variety of their exotic physical properties. However, the corresponding semimetallic states in two-dimensional magnetic materials, which may be the most promising for quantum information technology, have been not well recognized. The PhD studies will be based on first-principles and model calculations of crystal stability, electronic and magnetic structures and related quantities of candidates for topological semimetals among realistic two-dimensional magnetic materials.

Supervisor: Piotr Stachowiak, D.Sc. (dr hab.) (p.stachowiak@intibs.pl)
Auxiliary Supervisor: Daria Szewczyk, dr

Subject: ***Thermal properties of bi-component porous materials***
Discipline: Physics

Description: In the frame of the current research project experimental investigations of thermal conductivity and heat capacity of synthetic opals with fully or partially saturated pores will be carried out in the temperature range 1 – 300K. It is planned to utilize the opals of various, carefully chosen globule dimensions to cover the region from microporous to nanoporous structure. The investigations will be mostly focused on the microstructure size region where the thermal wave length becomes comparable to the linear dimensions of the porous structure, i.e. where start phenomena which have no counterpart in the macro-size region. As it was shown theoretically, in this region substantial changes of thermal vibrations of the porous structure such as change of the phonon density of sates, appearance of non-propagating, diffusive modes or reduction of group velocity of the propagating modes take place. All these changes may influence thermal properties of the material and will be significant part of the investigations carried out in the project.

Supervisor: Vinh Hung Tran, prof. (V.H.Tran@intibs.pl)

Subject: ***Research on hyperfine interactions near the quantum critical point.***
Discipline: Physics

Description: Quantum phase transitions (QPTs) and their related phenomena generally referred to as Quantum criticality have been studied for many years but these issues currently are still ones of hot topics in the modern condensed matter physics. Very frequently, such QPTs have been observed in an unstable regime of magnetic-nonmagnetic phases, being driven by non-thermal control parameters like pressure (hydrostatic, chemical), magnetic/electric fields or electron/hole doping. Up to now, useful methods for investigating various quantum critical materials were these based on the measurements of bulk-properties (specific heat, electrical resistivity, magnetic susceptibility). Obviously, there are few studies using
Mossbauer spectroscopy, which may provide valuable information about local electronic environment of magnetic atoms and further encouragement to identify the influences atomic disorder and magnetic quantum critical fluctuations.
The main aim of this PhD thesis proposal is to locally investigate the development of magnetic/nonmagnetic orders and the related hyperfine parameters at the doped 57Fe site in several solid solutions of uranium intermetallic compounds.
The starting point for the research is proposed the solid solution systems formed between the uranium ferromagnetic superconductors UCoGe, URhGe and nonmagnetic UFeGe. The data obtained so far by bulk property measurements reveal that the Fe substitution in the ferromagnetic superconductors lowers Curie temperature and finally destroys the magnetic order at a critical concentration xcr ≈ 0.22. Simultaneously, the Fe substitution suppresses superconductivity and the Non-Fermi-liquid behavior emerges. It is remarkable that in contrast to the first-order QPT in numerous materials, the QPT in UCo1-xFexGe and URh1-xFexGe is presumably of the second-order.
The 57Fe nucleus served as probe of Mossbauer spectroscopy will be most suitable for establishing the role of short-range interaction, atomic disorder, and fluctuations nearby the QPT.

Supervisor: Maciej Winiarski, D. Sc. (dr hab.) (m.winiarski@intibs.pl)

Subject: ***Studies of electronic structures of 2D materials with ab initio calculations.***
Discipline: Physics

Description: Exceptional electronic properties of two-dimensional materials draw great interest in the scientific community due to potential applications in spintronics and catalysis. Monolayers of such systems, e.g., transition metal dichalcogenides and hexagonal boron nitride may also form some heterostructures. In this study, the structural properties and electronic structures of selected 2D systems are investigated with calculations based on the density functional theory (DFT). The full potential and pseudopotential approaches are employed. A particular emphasis is placed on influence of stress/strain on band gaps of monolayer and multilayer systems as well as functionalization of these materials via adsorption of transition metal ions.

Supervisor Tomasz Zaleski, D.Sc. (dr hab.) (t.zaleski@intibs.pl)

Subject: ***Influence of gauge potentials and topology on phase transitions of bosons in optical lattice.***
Discipline: Physics

Description: The aim of the project is to theoretically study the properties of strongly interacting ultra-cold bosons in optical lattices. Such systems, intensively studied in recent years experimentally, mimic the behavior of strongly correlated electrons in the solid body, while allowing a very wide range of control properties of particles in a model environment. As a result, they are very helpful in giving insight into the quantum phenomena of multibody solid state physics, which in their case are not disturbed by lattice defects, disorder or strong thermal fluctuations.
The theoretical description will be based on the quantum rotors approach. This method is based on the use of phase variables - degrees of freedom naturally appearing in these systems - and allows for a universal description of the phenomena appearing in the ultracold atoms in optical lattices. It goes beyond the mean-field approximation, properly describing phase transitions between low temperature ordered and unordered phases depending on the dimensionality, lattice geometry and taking into account additional modifying factors such as the gauge potentials of "artificial" magnetic fields.
The areas of interest will include investigation of quasiparticle excitations in bands with trivial and non-trivial topology, transport properties in lattices with restricted geometry, in presence of gauge potentials, analysis of role of dissipation in creation and nature of ordered states.

Additional information: The Ph.D scholarship will be financed by the PRELUDIUM BIS 2 project (DEC-2020/39/O/ST3/01148) for 48 months (planned cost in the project is 5000 PLN/month before mid-term evaluation and 6000 PLN/month after it). In order to select a doctoral student in the project, a competition will be held in parallel with the recruitment to WSD IPAN. Candidates expressing interest in the project should attach to their application to the WSD IPAN an application for participation in the competition as well as any information indicating their suitability for the competition (the competition will assess competencies to implement the topic of the doctoral dissertation and the candidate's academic achievements, including publications in reputable scientific journals

Biology

Supervisor: Dariusz Danel, D.Sc. (dr hab.) (dariusz.danel@hirszfeld.pl)

Subject: ***The link between behavioural and classic immunity in shaping attitudes towards vaccinations.***

Description: The classic immune system is one of the adaptations evolved to protect individuals from pathogens. Another defence system is the behavioural immunity. It includes behavioural and psychological responses that are primarily aimed at minimizing the risk of infection. According to the recent hypotheses, both systems are tightly intertwined. The nature of these links is poorly understood, and both systems can operate complementary or compensatory and depend on various environmental and socio-demographic factors. Individual differences in health prophylaxis behaviours may be a consequence of the interactions between both systems. The project aims to understand the role of immunological (*sensu:* classical) correlates of variability in the attitudes towards vaccinations in adults, allowing for potential modifiers of these links. The project has no special organizational requirements. The methods will include laboratory analyzes (saliva, blood; for a subset of approx. n≥100 indivs.), questionnaires, statistical modelling. The exploratory significance of the project is complemented by the practical potential of the results, e.g., while designing pro-vaccination actions tailored to the biological conditions of the recipients.

Supervisor: Krystyna Dąbrowska, prof. (krystyna.dabrowska@hirszfeld.pl)
Auxiliary Supervisor: Zuzanna Kaźmierczak, dr

Subject: ***Phageome in cardiovascular patients.***

Description: The goal of this project is to understand how human phageome affects human health. The role of bacterial part of microbiome in human health has been demonstrated many times, cardiovascular diseases are among those dependant on microbiome composition. Phages are however underestimated or neglected as potential factors affecting health conditions. This project aims at testing and identification of major differences in phageome composition between healthy individuals and cardiovascular patients. Methods within microbiology and molecular biology, with NGS sequencing, epitope scanning, and phage propagation.
A perfect candidate is highly motivated to investigate microbial communities, to sequence metagenomes or amplicons, and to study current health problems. Basic knowledge and education in molecular biology or biotechnology or microbiology is required. Ample experience in laboratory work is not required, but the student must be ready to work hard and to learn a lot.
Additional information: Grant Narodowego Centrum Nauki Opus UMO-2019/35/B/NZ7/01824

Supervisor: Andrzej Gamian, prof. (andrzej.gamian@hirszfeld.pl)

Subject: ***Studies on biosynthesis, cellular and tissue localization of advanced glycation epitope MAGE.***

Description: New epitope has been described in human organism and in animals. The epitope is a protein adduct, the glycation product MAGE (Sci. Rep. 2021. doi:10.1038/s41598-021-82585-7). The epitope studied occurs in a large quantity in diabetes, characterizes the inflammation and damaged tissue. The project concerns the biological characteristics of the epitope, its biosynthesis, cell location and tissue distribution, studied with immunochemical methods and electron microscopy. The project is of fundamental biological importance and as a marker of pathological conditions.

Supervisor: Tomasz Goszczyński, D.Sc. (dr hab.) (tomasz.goszczynski@hirszfeld.pl)
Auxiliary Supervisor: Marta Świtalska, dr

Subject: ***Boron cluster-based molecules: Biological activity and mechanism of action.***

Description: Boron can create extraordinary, three-dimensional, σ-aromatic structures called boron clusters. These unusual entities differ from compounds formed by other elements of the periodic table and are absent in biological systems. Therefore, living organisms have not developed mechanisms capable of metabolizing boron clusters. These properties create wide possibilities for the application of boron clusters in biological chemistry for the synthesis of new biologically active compounds. Studies on the properties of these compounds may create a source of new substances with anticancer and antibacterial properties.
In the Laboratory of Biomedical Chemistry, we have obtained a library of boron cluster derivatives with high biological activity, but the mechanism of action remains unknown.
The main research topic will be the study of interactions of selected derivatives of boron clusters with biological molecules and living cells, with particular emphasis on the molecular mechanisms of action. The presented topic is interdisciplinary - candidates will gain knowledge and skills in the field of chemistry, biochemistry, and cell biology.

Supervisor: Sabina Górska, D.Sc. (dr hab.) (sabina.gorska@hirszfeld.pl)
Auxiliary Supervisor: Agnieszka Razim, dr

Subject: ***Biochemical characterization and biological potential of extracellular vesicles produced by Bifidobacterium species***

Description: In recent years, much attention has been paid to determining the role of extracellular vesicles secreted by both eukaryotic and prokaryotic cells. Their biochemical composition is strictly dependent on the type of cells from which they are released. They contain proteins, lipids, nucleic acids or other biologically active molecules that can modulate the processes taking place in target cells. As part of the proposed research topic, the physicochemical and biochemical characteristics of extracellular vesicles produced by bacteria of the *Bifidobacterium* genus along with the determination of their biological potential in the treatment of allergic diseases were planned. The subject includes research on the vesicles isolation, purification, characteristics of their biochemical composition, their modulatory properties using cell lines and *in vivo* tests on an animal model.

Supervisor: Ewa Jaśkiewicz, D.Sc. (dr hab.) (ewa.jaskiewicz@hirszfeld.pl)

Subject: *Molecular basis of Plasmodium malaria parasites specificity.*

Description: The aim of the project is to explore the host-specificity of molecular interactions between *Plasmodium* malaria parasites and primate erythrocytes. *Plasmodium* parasites infect humans and great apes, and are host-specific. The goal of the work will be to compare the molecular preferences of EBA-140 parasite ligands regarding erythrocyte receptors, including glycophorins C and D and sialic acids.
Expression of the recombinant EBA-140 merozoite ligands will be performed in HEK293E cell line culture in suspension. We have chosen EBA-140 ligand from *P. falciparum, P. praefalciaprum, P. reichenowi* and *P. gaboni* infecting humans, gorilla and chimpanzee, respectively. Using the SPR method we plan to investigate EBA-140 ligands specificity towards Neu5Ac sialic acid present on human RBCs, and Neu5Gc sialic acid present on ape RBCs. Western blotting technique will be used to bind ligands to erythrocyte glycophorins. The project results may enable to explain evolutionary change in *Plasmodium* specificity, which allowed the ape parasite adapt to humans.

Supervisor: Marta Kaszowska, D.Sc. (dr hab.) (marta.kaszowska@hirszfeld.pl)

Subject: *Participation of defined glycoform of lipopolysaccharides on biological activity.*

Description: ***Aim of the research:*** Immunochemical analysis of defined glycoforms of *P. shigelloides* R/SR/S-LPS and study of their biological activities. The main question will be: What is the role of sugar moieties in modulation the biological activity?
P. shigelloides - chosen for research, due to the interesting structural diversity of LPS.
Research concept: *P. shigelloides* R/SR/R-LPS with defined fragments (LA, core oligosaccharide and O antigen) will be selected and then the effect of sugar moieties on activation of the immune system will be checked.
Methodology:
• obtaining the defined glycoforms of R/SR/S-LPS by preparative electrophoresis,
• structural analysis by MALDI-TOF MS, ESI MS^n, HPLC, HPLC-ESI and NMR spectroscopy,
• kinetics of R/SR/S-LPS interaction with MD-2 and TLR4/MD-2 complex using surface plasmon resonance (SPR),
• ELISA tests to determine the level of secreted cytokines.

Supervisor: Sławomir Kozieł, prof. (slawomir.koziel@hirszfeld.pl)
Auxiliary Supervisor: Anna Spinek, dr

Subject: ***Radiomorphometric indices of the mandible as determinants of reduced bone mineral density in historical populations.***

Description: The constantly growing number of osteoporosis cases diagnosed among younger and younger people of both sexes causes an increased interest in the development of non-invasive methods and effective tools to identify higher probability of bone mineral density disorders, also in archaeological context. Radiomorphometric indicators describing the shape and thickness of the mandibular cortex may probably be effective in completing this task.
Aim of the research: to evaluate the radiomorphometric indices of the mandible and their relationship to bone mineral density, sex, age, trauma, and disease affecting bone mineral metabolism. The research material consists of selected archeological series from the osteological collection belonging to the Department of Anthropology IIET PAS in Wrocław.
Methods:
- analysis of skeletal remains for the occurrence of periodontal diseases and injuries, with particular reference to osteoporotic fractures
- evaluation of bone mineral density using DEXA
- assessment of the mandibular body using radiomorphometric indices based on panoramic radiographs
- statistical analysis of the obtained results
There are no comprehensive studies on historical populations, combining the analysis of radiomorphometric indices of the mandible with bone loss, extended with evaluation of the frequency of osteoporotic fractures and periodontal diseases associated directly or indirectly with disorders of bone mineral metabolism. The expected results of the research, disseminated in at least 3 scientific publications and conference presentations, will contribute to bridge this gap.

Supervisor: Łukasz Łaczmański, D.Sc. (dr hab.) (lukasz.laczmanski@hirszfeld.pl)
Auxiliary Supervisor: Dariusz Martynowski, dr

Subject: ***Development of a platform for data analysis from high-throughput nanopore sequencing.***

Description The aim of the project is to develop and validate a bioinformatic platform for analyzing high-throughput nanopore sequencing data. During nanopore sequencing, we obtain a series of long sequences, the further analysis of which is difficult. Requires sequence assembly algorithms that are capable of carrying out the long segment alligment. An additional problem is the use of appropriate computing power for the analysis. PhD student will test various hardware and system solutions as well as optimize the workflow for the analysis of data from: full-blood sequencing (bacteria and viruses); microbiome sequencing; sequencing of transcriptomes.
As a result of the implementation, we will receive a comprehensive bioinformatics tool for analyzing data from the MinION.

Supervisor: Joanna Rossowska, D.Sc. (dr hab.) (joanna.rossowska@hirszfeld.pl)

Subject: ***The influence of modified tumor-derived exosomes on angiogenesis and metastasis in murine Lewis lung carcinoma model.***

Description: The research aims to evaluate the activity of exosomes isolated from genetically modified LLC murine lung carcinoma overexpressing interleukin 12 or 18 and shRNA for TGF-B1 or IL-10, with particular emphasis on their ability to induce angiogenesis and metastasis. The research will be conducted in vitro with the use of conventional and 3D cell cultures as well as in vivo. Methods such as flow cytometry, confocal and electron microscopy, size-exclusion chromatography, western blot, and RT-PCR will be used during the study. The obtained results may be of importance in the future when designing anti-cancer therapies with the use of modified tumor-derived exosomes.

Medicine

Supervisor: Katarzyna Bogunia-Kubik, prof. (katarzyna.bogunia-kubik@hirszfeld.pl)
Auxiliary Supervisor: Milena Iwaszko, dr

Subject: ***Investigation of gamma delta T cells, their receptors and cytokines in rheumatic diseases.***

Description: The project aims to investigate the role of γδ T cells in rheumatoid arthritis (RA) and ankylosing spondylitis (AS) and comprises studying (i) the frequency, comprehensive phenotype as well as cytokine profiles of γδ T cells subpopulations in patients with RA and AS; and (ii) potential influence of anti-TNF therapy on γδ T cells.
Expression of surface markers and cytokine profiles of γδ T cells will be assessed using flow cytometry in blood samples of RA and AS patients, and in healthy controls. Polymorphism studies of genes encoding selected cytokines will constitute an additional aspect.
The project would provide the first comprehensive description of γδ T cells in these most commonly types of inflammatory arthritis and allow to determine a potential involvement of γδ T cells in susceptibility to RA and AS, as well as their possible impact on clinical parameters of these diseases and anti-TNF therapy outcome.

Supervisor: Katarzyna Bogunia-Kubik, prof. (katarzyna.bogunia-kubik@hirszfeld.pl)
Second Supervisor: Magdalena Koszewicz, D.Sc. (dr hab.)

Subject: ***Searching for biomarkers of treatment efficacy for autoimmune polyneuropathies.***

Description: Chronic inflammatory demyelinating polyradiculoneuropathy (CIDP) is a rare autoimmune disease affecting peripheral nerves and nerve roots. The aim of this study is to search for biomarkers related to disease pathophysiology and response to immunoglobulin treatment in patients with CIDP by analysis of: (i) the profile of cytokines and lymphocyte subpopulations in cerebrospinal fluid and serum; (ii) polymorphisms in genes of selected inflammatory factors; (iii) bacterial metabolite levels to determine the relationship between CIDP and intestinal dysbiosis. The results of these laboratory studies will be correlated with the clinical status of the patients and the functional status of the peripheral nerves as assessed by electrophysiological study.
The subject is intended for medical doctors with experience in diagnosing and treatment of peripheral nervous system diseases and in laboratory work (molecular biology).

Supervisor: Andrzej Górski, prof. (andrzej.gorski@hirszfeld.pl)

Subject: ***Research on the occurrence of antiphage antibodies in the sera of patients during phage therapy.***

Description: In recent years (2014-2021), we published 5 original papers antiphage activity of sera (AAS) in patients undergoing phage therapy (PT), with a total IF of 10.442, points MNiSW 205 and 152 citations. Next publication is accepted for publication in the journal *Antibiotics* (IF3,893). The research is aimed at determining the occurrence of antiphage antibodies in the sera of patients with bacterial infections undergoing PT at IIET Phage Therapy Unit and their significance in PT. The level of AAS of patients undergoing PT and controls of healthy people will be tested with the plate phage neutralization test according to the method of Adams (*Methods of study bacterial viruses, In: Bacteriophages, 1959, pp. 443-522*) and Pescovitz et al. (*J. Allergy Clin. Immunol. 2011, 128, 1295-1302*) with own modification Łusiak-Szelachowska et al. (*Future Microbiol., 2017, 12, 109-117).* Preferred candidates in the fields of: Biology or Biotechnology. Knowledge of microbiology, immunology and genetics.

Supervisor: Łukasz Łaczmański, D.Sc. (dr hab.) (lukasz.laczmanski@hirszfeld.pl)
Auxiliary Supervisor: Joanna Jacków, dr

Subject: ***Molecular characterisation cells after based editing of COL7A1 mutations in Dystrophic Epidermolysis Bullosa.***

Description Epidermolysis bullosa (EB) constitutes a group of genetically heterogeneous skin disorders mainly characterized by chronic erosion and blistering of the skin and mucous membrane. In addition, extracutaneous manifestations affecting hair, nails, teeth, gastrointestinal and oesophageal tracts make EB a systemic disease. In severe forms of EB, metabolic perturbations, dehydration, chronic infections and highly aggressive skin cancer lead to mortality by young adulthood. Our aim is to molecular characterize the cell after based editing of *COL7A1* gene to analyse precisely the whole genome, transcriptome, epigenome and proteome to address the potential clinical translation of genome editing technology.
Currently, treatments are limited to clinical management of the symptoms. Wound care and daily dressing remain the cornerstone of treatment and the average annual cost per patient across the EU countries is estimated at approximately £28k. This study is designed to analyze the effectiveness of treatment by introducing repair mutations in the *COL7A1* gene.
Therefore, in this project build on our recently submitted Intermediate grant project to Rosentree PGS21/10222 in which we propose to establish state-of-the-art base-editing systems using ABE or CBE to correct several mutation hotspots within *COL7A1* gene. Our aim of the current project is to molecular characterize the cell after based editing of *COL7A1* gene to analyse precisely the whole genome, transcriptome, epigenome and proteome to address the potential clinical translation of genome editing technology.
Cell transformation steps will be performed at St John's Institute of Dermatology, King's College London under the supervision of Dr. Joanna Jacks (Assistant Supervisor). The stages of genomes, transcriptomes and epigenomes analysis will be performed at the Laboratory of Genomics & Bioinformatics of IITD PAN.

Supervisor: Ryszard Międzybrodzki, D.Sc. (dr hab.) (ryszard.miedzybrodzki@hirszfeld.pl)

Subject: ***Studies on interactions between bacteriophages and antibiotics.***

Description: In light of the growing antibiotic-resistance in bacteria, bacteriophages are considered a reliable alternative to antibiotics. Concomitant use of phages and antibiotics may synergistically influence their antibacterial activity. It may also result in antagonism due, e.g., to the antibiotic effect on phage replication.
The aim of this study is to determine the influence of antibiotics from various chemical groups on the antibacterial activity of phages from the HIIET PAS collection. These interactions will be assessed in *in vitro* tests (such as the influence on bacterial growth and biofilm formation) which should also help to explain what factors may affect those phenomena and what their mechanism are. The most interesting phage-antibiotic systems will be tested *in vivo* in bacterial infection models (e.g. urinary tract infection in rodents).
The expected results will be important for optimization of human phage therapy (selection of antibiotics for combination use with bacteriophages).