Analysis of molecular structure and chemical distribution of heme proteins: from model studies to functional animal cells (supervisor dr. habil. Katarzyna M. Marzec) – one position for PhD student

The main goal of the research will be spectroscopic analyzes of the chosen heme proteins with the diagnostic potential inside animal cells and tissue specimens. To the detail goals may include especially application of the Raman spectroscopy (RS) and complementary techniques for studies of molecular structure and analysis of distribution of hemoglobin (Hb) and cytochrome c (Cc) *in situ* in cells and tissues. Such heme proteins are a major mediator in maintaining vascular homeostasis and participate in life-supporting processes. We have previously demonstrated the possibility of Hb analysis and its distribution in both *in vitro* studies at the level of erythrocytes, as well as in *ex vivo* examinations for blood smears and tissue specimens. It has been shown that structural changes of Hb, and their distribution show diagnostic potential in the assessment of: Hb adducts demonstrating endothelial dysfunction for functional erythrocytes; malaria parasite detection; erythrocyte alterations as well as formation of non–functional Hb adducts; and thrombi and clots analysis that may be a biomarker of their origin. These types of research will be continued and broaden by analysis of other hemoporphyrine compounds including mainly cytochromes. Despite extensive studies of group of cytochromes, it remains obscure how structural changes of these heme proteins affects their functionality. Application of RS will allow to track these changes at various cell life cycle and differentiate between ferrous and ferric forms which ratio may be crucial in the cell physiological state evaluation.

Studies using RS spectroscopy to analyze the molecular structure of chemical compounds have been conducted for many years, but only the last decade has brought a huge development of this method in animal tissue and cell research for diagnostic and pharmaceutical purposes. RS spectroscopy overcomes many limitations of current techniques of examining cells and animal tissues however, it cannot be used by biologists and physicians for diagnostic purposes, without previously performed structural, chemometrics and vibrational analysis. An important aspect is also the development of an appropriate methodology. We are seeking for a motivated PhD candidate interested in working in this project to join the interdisciplinary team of this project and JCET lab. The candidate will gain opportunity to extend knowledge about resonance Raman application in heme proteins studies, starting from studies on model compounds and isolated proteins as well as *in vitro* application for cell lines and isolated red blood cells. All the measurements will be supported with chemometric analysis and other reference techniques available at JCET facility.

Selected papers relevant to the topic:

1. A. Blat, J. Dybas, K. Chrabaszcz, K. Bulat, A. Jasztal, M. Kaczmarska, R. Pulyk, T. Popiela, A. Slowik, K. Malek, M. G. Adamski, K. M. Marzec, An Analysis of Isolated and Intact RBC Membranes—A Comparison of a Semiquantitative Approach by Means of FTIR, Nano-FTIR, and Raman Spectroscopies, **Anal Chem. 2019***, 91, 9867–9874.*

2. M. Kaczmarska, M. Grosicki, K. Bulat, M. Mardyla, E. Szczesny-Malysiak, A. Blat, J. Dybas, T. Sacha, K. M. Marzec, Temporal sequence of the human RBCs' vesiculation observed in nano-scale with application of AFM and complementary techniques, **Nanomedicine: NBM 2020***, 28,102221.*

*3. J. Dybas, K. Bulat, A. Blat, T. Mohaissen, A. Wajda, M. Mardyla, M. Kaczmarska, M. Franczyk-Zarow, K. Malek, S. Chlopicki, K.M. Marzec, Age-related and atherosclerosis-related erythropathy in ApoE/LDLR–/– mice***, BBA – Molecular Basis of Disease 2020***, 1866 (12),165972.*

4. E. Szczęsny-Małysiak, J. Dybas, A. Blat, K. Bulat, K. Kuś, M. Kaczmarska, A. Wajda, K. Malek, S. Chlopicki, K. M. Marzec, Irreversible alterations in the hemoglobin structure affect oxygen binding in human packed red blood cells, **BBA – Molecular Cell Research 2020***,1867 (11),118803.*

5. J. Dybas, T. Chiura, K.M. Marzec, P.J. Mak, Characterization of cyanide ligand binding to hemoglobin inside functional RBCs versus isolated protein by resonance Raman spectroscopy, **Journal Phys. Chem. B 2021***, 125, 3556-3565.*