As pollinator insects, bees play an important role in the ecosystem and economy. As many as 75% of crop plant species worldwide are pollinated by bees and other insects. Since 2003, there has been a rapid decrease in bee abundance in Europe and the USA. The decline in the number of pollinators has negative ecological effects on the diversity of plant species and an adverse economic impact on crop productivity. Bee colony collapse results in shortages of basic commodities such as oil products or fruits and vegetables and in huge economic losses in the production of honey and bee products. This dangerous phenomenon is thought to be associated with e.g. bee diseases, with nosemosis as the most prevalent problem. Nosemosis is a contagious disease of adult bees, well known in beekeeping and veterinary medicine as one of the invasive diseases of the *Apis mellifera* honeybee. In our climate, nosemosis is caused by intracellular parasites representing microsporidia, i.e. *Nosema apis* and *Nosema ceranae.* In 2008, intense infestation with *Nosema* spp. was reported from over half of apiaries in Poland. The disease causes anatomical and physiological changes in bees, affecting the fitness of the entire colony. Bees die within a very short time, i.e. 8-10 days after infection. Death is a result of the development of *Nosema* spores (microsporidia) in the midgut epithelium and the resulting high level of hunger leading to energy stress. Microsporidia are extremely resistant to adverse environmental conditions and can survive for several years retaining germinability and ability to infect healthy hosts. Hence, nosemosis control is difficult and the search for new drugs against the disease proves extremely important. Until now, no effective drugs against nosemosis, which would also be harmless to bees, has been developed. The antibiotic fumagillin that was used from the 50s of the last century has been withdrawn in the European Union. Fumagillin does not exhibit 100% effectiveness; moreover, many reports indicate development of resistance to the antibiotic in Nosema spp.
As shown by preliminary investigations conducted by our team, porphyrins can become the basis for development of future formulations for nosemosis control. Porphyrins, i.e. the so-called “pigments of life” constitute a group of extremely important compounds that play a key role in essential life processes. They are involved in many biochemical processes, e.g. oxygen transport and storage [hemoglobin/myoglobin], biocatalytic oxidation, and detoxification of organic compounds (peroxidase and cytochrome P-450), electron transfer (cytochromes b and c), and photosynthesis (chlorophyll). These compounds appear to have high application potential that can be used in many areas, e.g. chemistry, biotechnology, and medicine. In particular, the interactions of porphyrin with light arouse great interest due to the possibility of using photochemical properties of porphyrins in photodynamic therapy targeted at destruction of tumour tissues and control of pathogenic microorganisms.
Scientific literature provides little information about the light-independent antimicrobial properties of porphyrins. Our previous laboratory research showed that these compounds contribute to substantial reduction of the number of spores detected in nosemosis-infected bees. The use of these unique, newly discovered properties requires elucidation of the mechanisms of the anti-microsporidial activity of porphyrinoids and investigations of the effect of these compounds on living organisms. Therefore, the aim of the project is to analyse potential mechanisms involved in inhibition of nosemosis development by porphyrinoid compounds and to characterise their novel biological properties.
In the implementation of the proposed research objective, we are planning to carry out synthesis of amide derivatives of protoporphyrin IX (characterised by increased bioavailability) and to use commercial water-soluble porphyrins with various functional side groups. The tested compounds will be administered the form of sugar syrup to healthy and *Nosema* microsporidia-infected honeybees, in which the level of infestation will be monitored in the so-called cage tests. We intend to determine the level of porphyrinoid bioactivity towards nosemosis based on the ability of the compounds to reduce the number of spores and bee survivability. We want to analyse the effects of the selected compounds on the parameters of the bees’ immune system as well as their direct impact on *Nosema* microsporidia and secretory and reproductive functions in bees. An important task of the project is to analyse correlations between the ability of porphyrinoids to destroy spores, their photochemical stability, and doses and bee survival and fitness (in apiary tests).
The proposed investigations will provide guidelines for rational synthesis of derivatives with biological properties relevant for *Nosema* spp. control. In turn, elucidation of the mechanisms of the action of porphyrinoids will be important in future studies on the optimisation of the conditions of using these compounds in combating these parasites in honeybees and other animals infected by microsporidia. Since acquisition of one-third of all food products is dependent on pollination by bees and other pollinators, the prospective results of the project may have great importance to economy. In this context, it is worth recalling the well-known thought attributed to Albert Einstein: “If the bee disappeared off the face of the Earth, man would only have four years left to live. No more bees, no more pollination, no more plants, no more animals, no more man”.