Medicine is constantly struggling with problems with the treatment of cancer, diabetes, obesity, as well as cardiological and neurological diseases. For years in the world, new and effective therapies have been continuously developed and examined to help in combating these numerous, serious and often lethal diseases. Incessantly, new drugs are developed by chemical synthesis, but they are also obtained from plant extracts. The latter approach is becoming more and more popular, especially since it is possible to obtain bioactive compounds synthesized by plant material in bioreactors, where the parameters of cell and tissue cultures can be easily controlled. It has also been shown, that by stimulating cells with elicitors of various types (e.g. chemical compounds or applying biotic stress), it is possible to effectively increase the production of pharmaceutical secondary metabolites. *Nigella damascena* is one of the plant species with proven therapeutic effects that has been used in traditional medicine for a long time, especially for its analgesic, anti-edema and antipyretic properties. Plants of this species contain β-elemene, which has an anti-cancer effect, and at the same time does not cause any side effects, it also reduces the effects of chemotherapy, it has an antimicrobial activity and prevents blood clotting. Another very important compound of *N. damascena* essential oil is damascenine, an alkaloid which has antipyretic, anti-inflammatory and analgesic properties. However, little is known about the biosynthetic pathways of these compounds and how they can be regulated in this species. Therefore, the main aim of the proposed research is to identify the genetic mechanisms involved in the biosynthesis and accumulation of biologically active metabolites of *N. damascena*, with particular emphasis on β-elemene and damascenine under the influence of elicitor treatment in *in vitro* cell and tissue cultures.

The project will involve the induction and stabilization of *in vitro* cell and callus cultures, which will be treated with chemical elicitors. Treatment with methyl jasmonate, salicylic acid, chitosan or zinc and titanium nanoparticles should cause changes in the chemical composition and thus, cell lines with a unique composition or content of bioactive compounds will be obtained, which will be verified on the basis of the results of biochemical analyzes. Total RNA will be isolated from the selected, unique materials and subjected to next-generation high-throughput sequencing, and the obtained transcriptome reads will be subjected to bioinformatic analysis. As a result, genes with altered expression under the cells elicitors treatment will be indicated. Potentially, these genes will play a significant role in the formation of biologically active compounds. Verification of their participation in the biosynthesis of selected pharmaceutical compounds will be carried out by generating mutations that prevent the formation of functional enzymes or by activating gene expression.

Based on the obtained results, potential genetic mechanisms regulating the biosynthesis and accumulation of important therapeutic compounds in *N. damascena* will be indicated. This is of great importance for the obtaining these compounds from plant material cultured in controlled *in vitro* conditions or in bioreactors. The research will use modern research techniques, such as high-throughput analysis of transcriptomes or advanced bioinformatic analysis that requires the use of computers with high computing power. Moreover, in order to obtain mutants, the latest method allowing for precise editing of genomes will be used, the so-called CRISPR/Cas technology, for the development of which the Nobel Prize was awarded in 2020.