Carrot is among the ten most economically-important and consumed vegetables worldwide. In order to produce flowers and seeds, many vegetable plants -including carrot- first need to overcome their juvenile stage and reach "adulthood", which is attained when the plant surpasses certain vegetative growth threshold (e.g., in carrot the juvenile stage is considered over when the plant has 8-12 leaves and a root diameter of ~ 4-8 mm), and then they need to accumulate certain amount of hours of cold to shift from the vegetative to the reproductive stage. These physiological and biochemical changes take place in the meristem of the plant. After such changes are produced in the meristem, the plant is ready to flower, which usually happens after the winter is over. Thus, in the presence of the warmer temperatures of spring, the floral stalk elongates and inflorescences are produced, leading to seed set. The cold-induced process leading to the reproductive phase of the meristem and flowering is called 'vernalization'.

The amount of cold that a given species, or a variety within a species, needs to be exposed to in order to initiate flowering is genetically determined, implying that a given plant variant has a gene, or a set of genes, that condition the amount of cold it requires for flowering. Such cold requirement, also called "vernalization requirement" (VR), will determine when the plant flowers. Most carrot cultivars are adapted to temperate regions, and have high VR to induce flowering. These are called 'late flowering' or 'biennial' carrots. In contrast, some cultivars adapted to warmer climates have low VR and are classified as 'early flowering´ or 'annual'. The requirement for vernalization is an important trait because it influences not only seed production but also root development. Carrot roots quickly become fibrous and unpalatable after vernalization, even before the floral stalk elongates, and because of this reason the initiation of flowering results in a complete loss of commercial value. Overall, due its strong influence on root and seed production, carrot VR defines adaptation to different production areas and sowing times.

The genes controlling vernalization requirement in carrot have not yet been discovered, although previous works have delimited the possible chromosome region where this/these gene(s) are located. The discovery and evaluation of the function of the gene(s) controlling VR would have valuable implications for manipulating this trait in carrot breeding program. For example, new cultivars with gene variants conditioning either high or low VR could be developed in order to increase the adaptation of agronomically-valuable carrot lines to a wide range of environments and geographical regions. Also, early flowering and its negative consequences on root quality could be completely avoided in carrots grown in temperate regions for root production. On the other hand, such genes could be manipulated to increase seed yield and uniformity in seed set and seed harvest time, in order to reduce seed losses due to uneven maturation of the seeds.

The aim of this project proposal is to discover the genes controlling carrot VR. To this end, four carrot cultivar with contrasting VR (that is, two early flowering and two late flowering carrots) will be compared with regards to the expression of their complete set of genes (the "transcriptome") in vernalized and not vernalized plants to identify genes that are expressed at different rates in both groups, and are related to flowering or vernalization processes. Additionally, the genomes and methylomes -which include all the protein coding and non-coding regions of the DNA, and the chemical modifications that regulate their expression- of these same contrasting cultivars will be analyzed for structural and chemical DNA variations in the vernalization response genes that may help explain why some gene variants lead to early flowering while other variants result in high VR and late flowering plants. In conclusion, this 'multi-omics' project aims at discovering the gene(s) conditioning VR in carrot, and hopes to identify the DNA mutations that explain the different flowering habits associated with different VR gene variants. The information derived from this project will be of value for carrot breeding programs, since manipulating this trait can improve root and seed production, as well as adaptation to different environments.