Plants are sessile life forms that rely on a multitude of environmental stimuli (e.g., light, gravity, water, nutrients) to direct their growth for survival. Phenomena of plant "movements" towards cue is called tropism. Plants can adjust their response to given stimuli in situations where their needs are not fully satisfied. For example, gravity, the most dominant cue in optimal environmental conditions, can be overcome in conditions of water stress where plants start to follow water gradient. Plant chemotropism is a growth toward nutrient stimulus, and it was documented for many plant species in relation to many nutrients: e.g. ammonium, nitrate, phosphate, iron and zinc. Despite our interest in these phenomena for the last century, we still do not fully understand the mechanisms governing tropisms. While we have observed that plants can detect nutritional cues in soil and adapt their architecture to changes in nutrient supply, we do not know how it is done. As a result, we lack the understanding needed to select or modify plant for use in the environments where nutrients are scarce. In this project I will aim to uncover how a plant decides about the direction of growth in soil with uneven distribution of Zn and/or Fe. .

The particular questions and hypothesis behind the project:

1. What is driving Zn, and what is driving Fe chemotropic root growth??

Hypothesis1: The chemotropic response could be stimulated by:

(i) plant detection of continuous increasing Zn or Fe gradient or/and

(ii) presence of internal signaling (hormonal or cell wall related) that redirects roots growth based on detection of Zn or Fe patches in the environment (without presence of gradient cue)

To verify that hypothesis and answer question 1 I will perform root growth analysis in environments designed expressly for the purpose of this project with the use of groundbreaking tools I co-authored**: (i) Transparent Soil which in principle are "Jell-O"-like beads to grow plants and (ii) 2D paper device that by simple laser printing confine regions of high and low nutrient availability.**

2. What are the molecular mechanisms that drive Zn chemotropic response and are they different from Fe chemotropic response?

Hypothesis2: There is a connection between Zn or Fe homeostasis (uptake, distribution, tolerance or stress response) regulation and hormonal regulations that enables chemotropic response (root growth redirection).

To verify that hypothesis and answer question 2 I will find which gene expression is most altered during Zn or Fe chemotropism by mRNA sequencing analysis. Additionally, I will develop plants with impaired expression of genes that may play main role in Zn or Fe chemotropism.

3.What can enables control over root growth direction in Zn or Fe chemotropism?

Hypothesis3: Cell wall component modification that include change in pectin methylesterification and cellulose microfibril arrangement enables control over direction of root growth under Zn/Fe chemotropism

To verify that hypothesis and answer question 3 I will make differential analysis of pectin cell wall localization and analysis of cell wall nanostructure as well as Zn and Fe content of cell wall.

The research planned for this project are multifaceted and will: (i) show the cue that lead root to follow Zn or Fe in chemotropism, (ii) showcase for the first time potential molecular mechanisms of Zn chemotropism and their interactions with Zn and Fe homeostasis, (iii) shed a light on the physiological role of pectin and cellulose microfibril in control over root growth toward chemotropic cue. To my knowledge this is first approach to understand Zn or Fe chemotropism, its molecular mechanisms and effects on Zn-Fe homeostasis. Integration of these results with studies of cell wall components modification makes it even more unique.