



Quantifying the Mechanics of Plant Cell Wall Growth

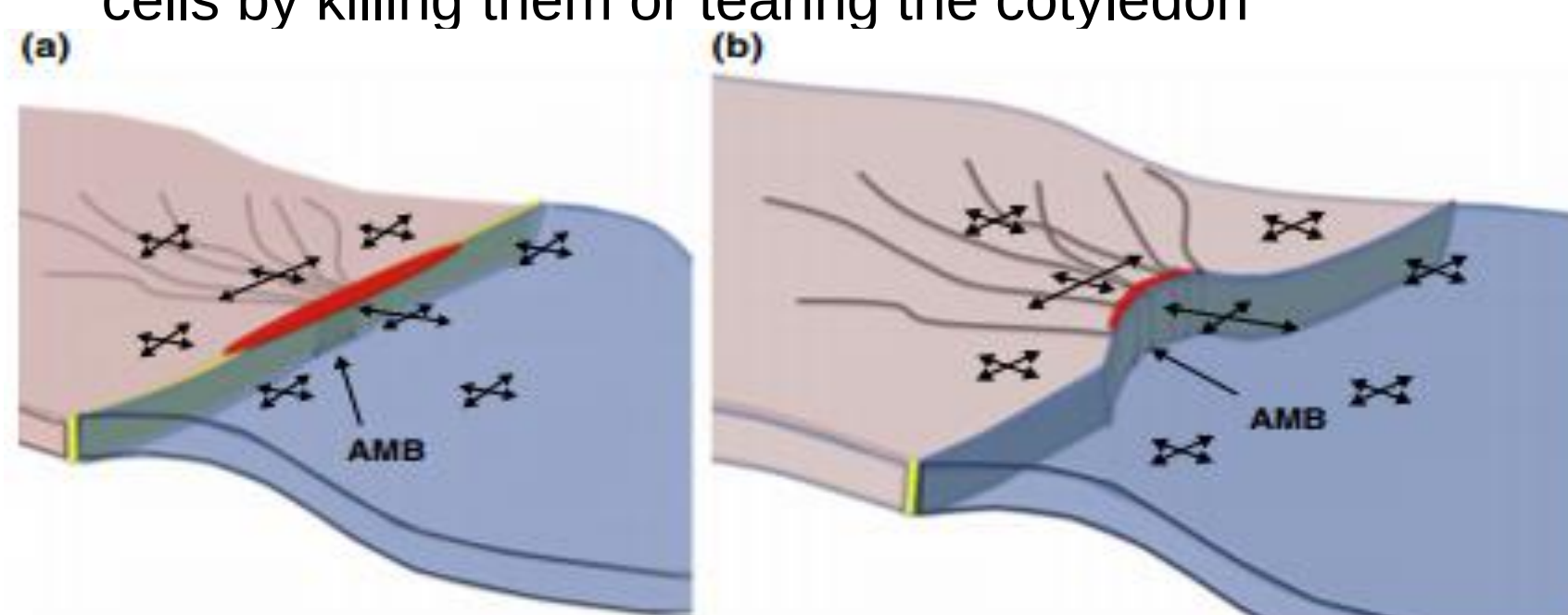
Andrew Myers, Dr. Joseph Turner, Dr. Ehsan Rezaei

Department of Mechanical Engineering, University of Nebraska-Lincoln



Research Goals

- The goal of this research is to lay the foundation for a larger study of plant cell morphology.
- The research is intended to identify possible correlations between plant cell wall mechanical properties and cell morphology.
- The creation of a low cost single plant holder is integral to observe and perform the required measurements.
- Future research goals include quantifying growth in different mutated Arabidopsis, analyzing growth and stress, strain relationships after removing middle lamellae, and observing growth after removing certain cells by killing them or tearing the cotyledon



Szymanski, D. B. (2014). The kinematics and mechanics of leaf expansion: new pieces to the Arabidopsis puzzle

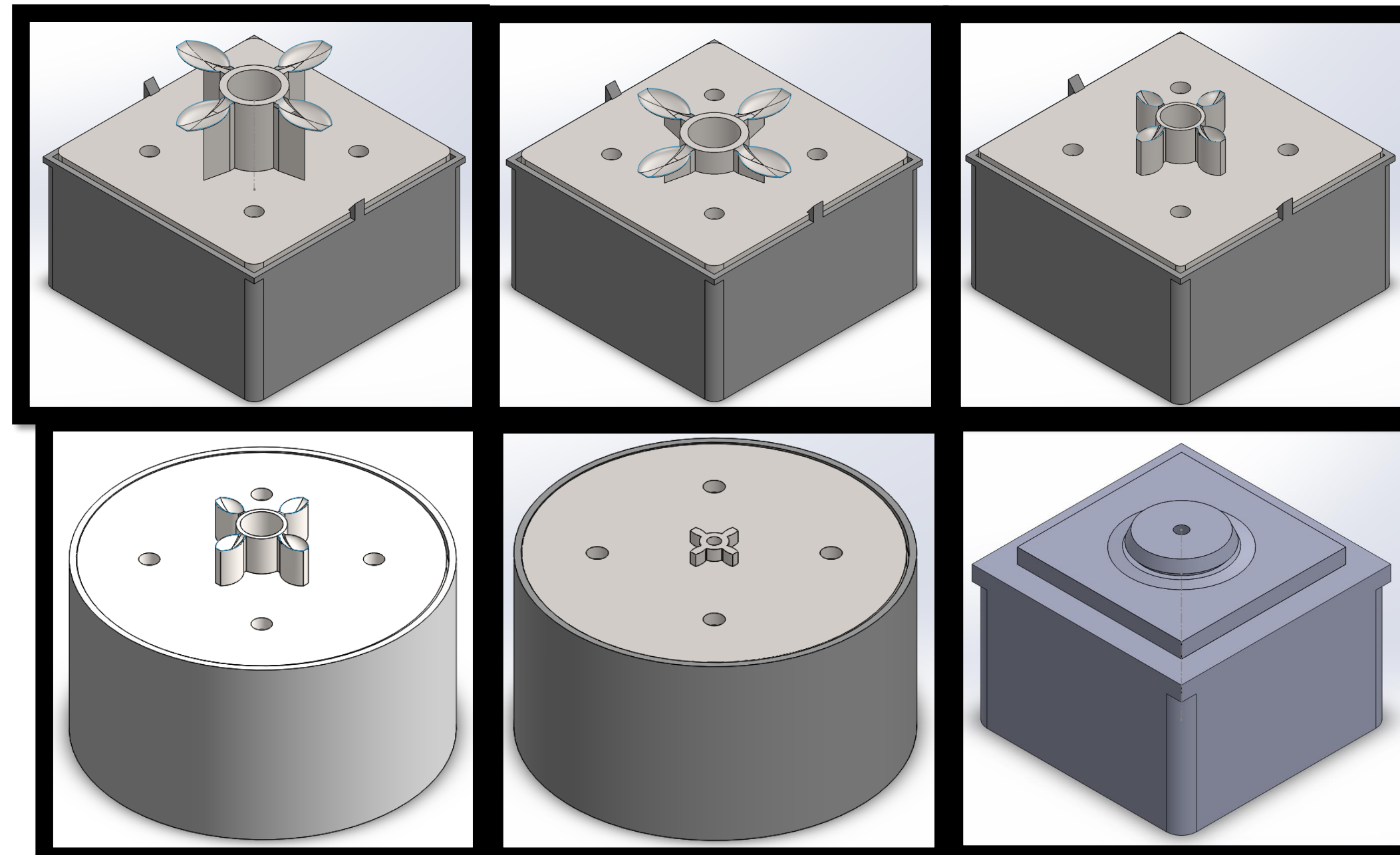
Internal forces including the turgor pressure cause stress and strain along the inner and outer periclinal wall which induces lobing of the cell wall. A major goal of this research is to quantify this process.

Experimental Methods

This experiment breaks into two main components with the first component a larger focus in June-July 2017.

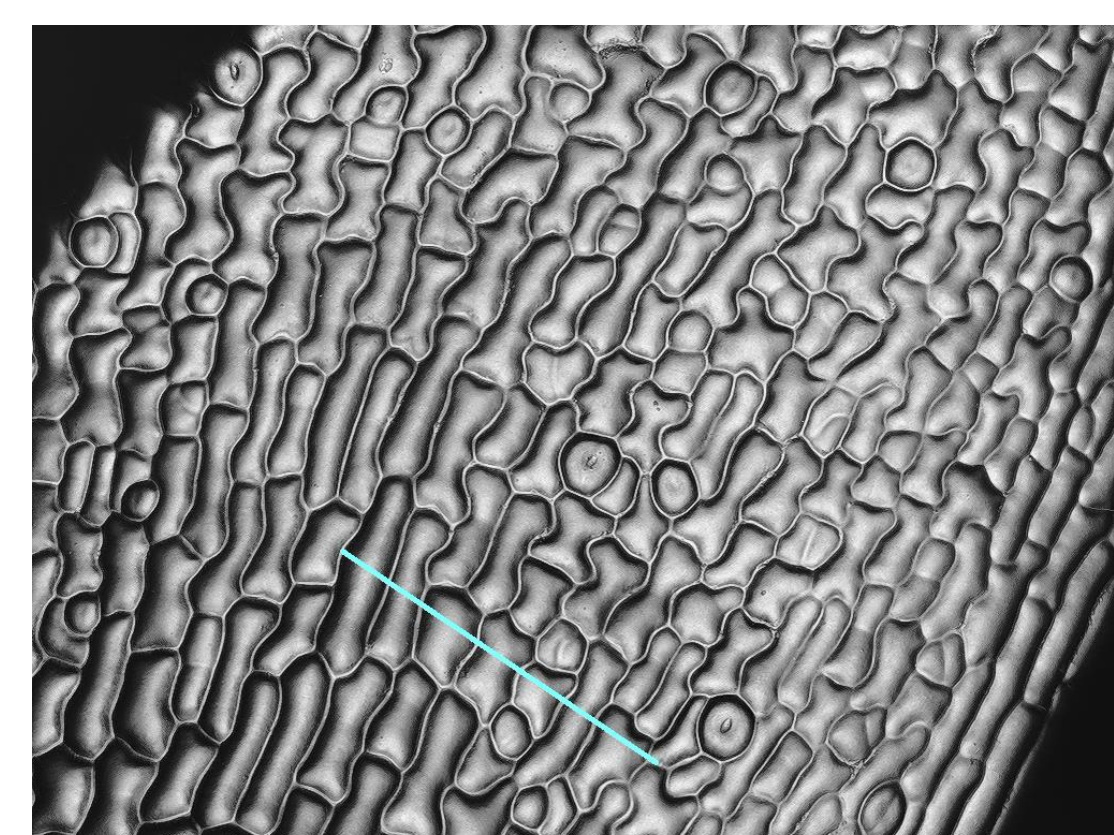
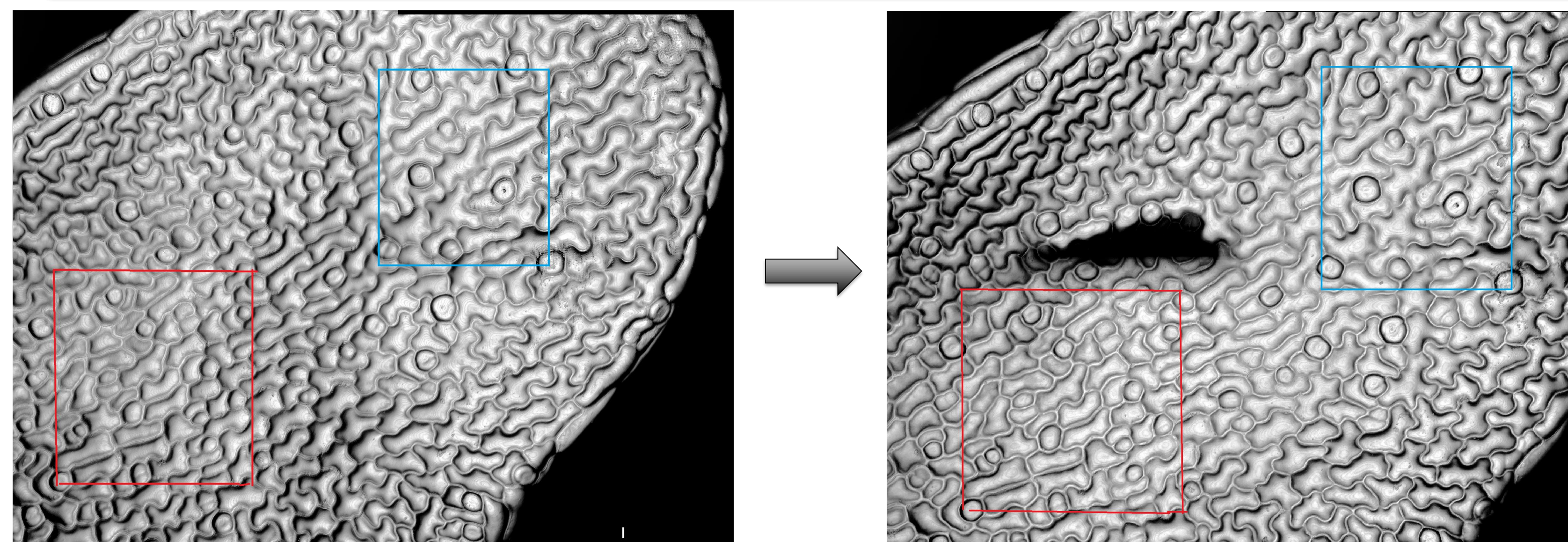
- Designing and testing low-cost, single plant growth containers that will be implemented in current microscopy and other technology.
 - Allows for easy transport from growth chamber to measuring instruments
 - Is optimal size for measurements in range of instruments that utilize optical microscopy, nanoindentation, and atomic force microscopy.
 - Does not stunt growth of plant for the duration of observation.
- Using the optimized plant holder, wild-type *Arabidopsis thaliana* can be observed and studied under different instruments.
 - Cell with straight walls can be found and lobing of the wall can be observed over a period of time.
 - Using the optimized holder, observations can be made continuously with new seed germination happening periodically.
 - Using the large quantity of gathered data, patterns can be seen in the cell wall growth and can be patterned in a computational model.

Creating Growth Containers

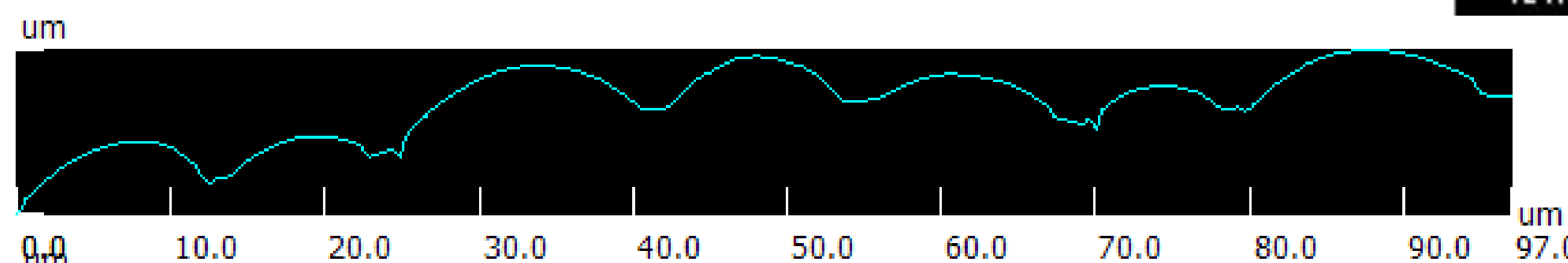
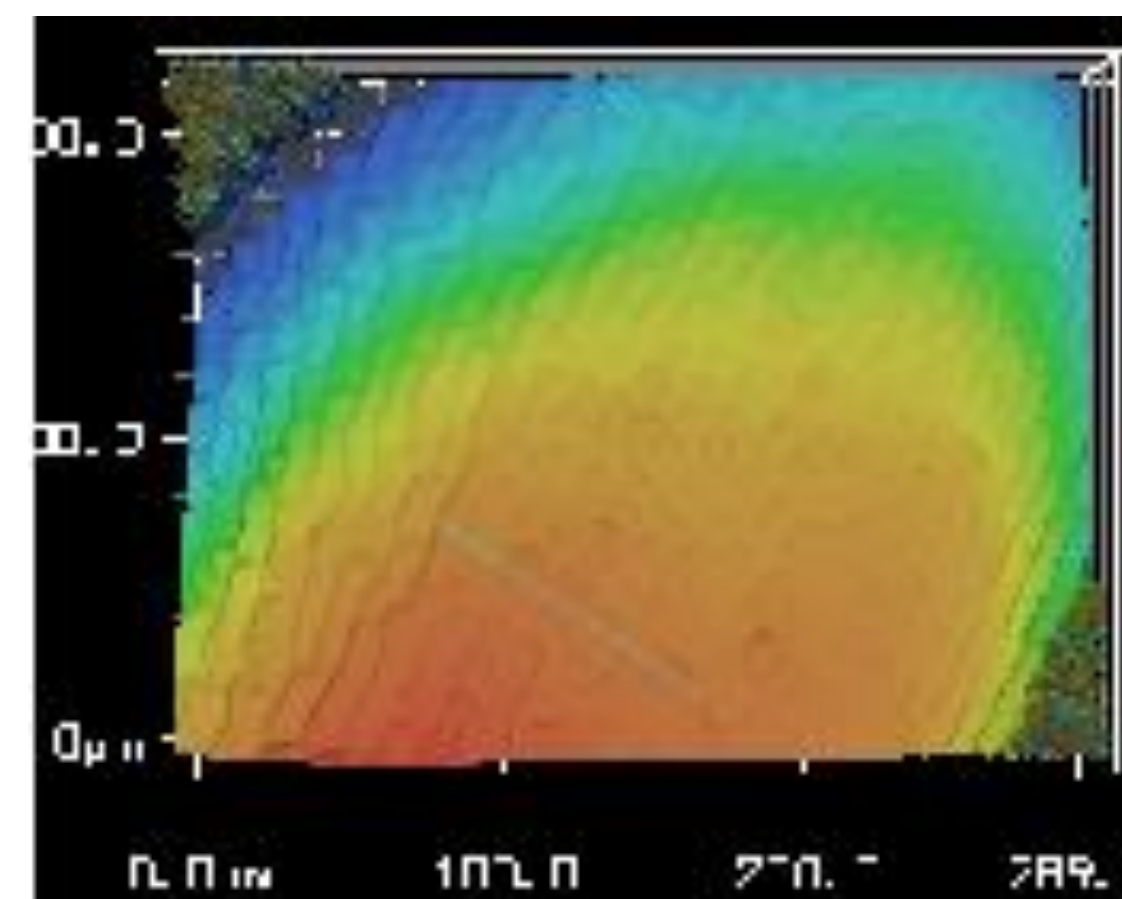


- Changed different parameters including opening size, opening height, and other factors to find the best fit.
- Experimented with different materials to find one that did not alter the growth of the plant.
- Worked with different growth media to find the most efficient way to grow many seeds. This included both soil and Murashige and Skoog Agarose plates.

Observing Geometric Changes in Cell Walls

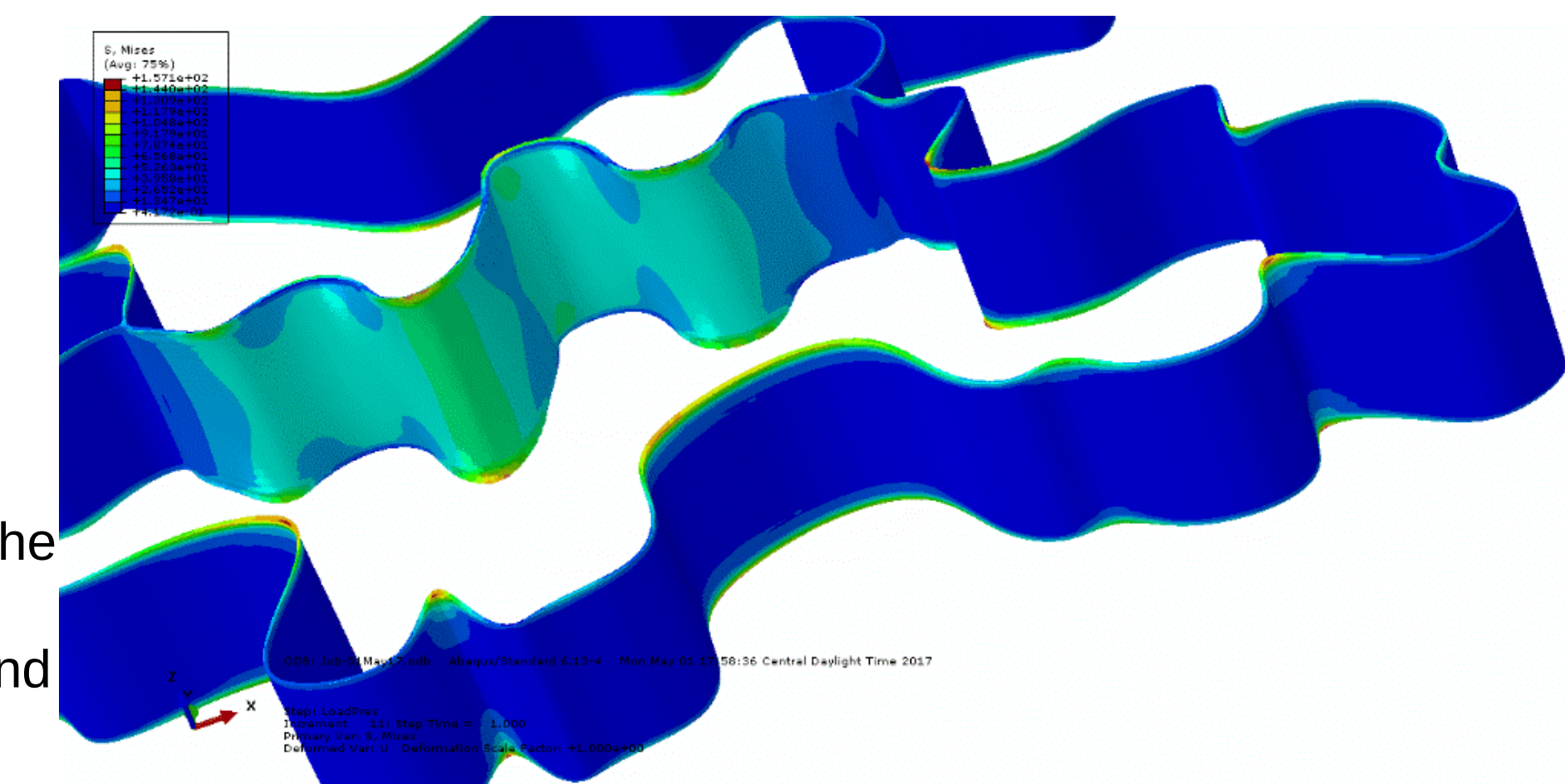


- Watched the plants grow from germination to up to 24 hours after germination
- Looked for changes in geometrical shape, size, cell wall length, height, and formation of lobes.

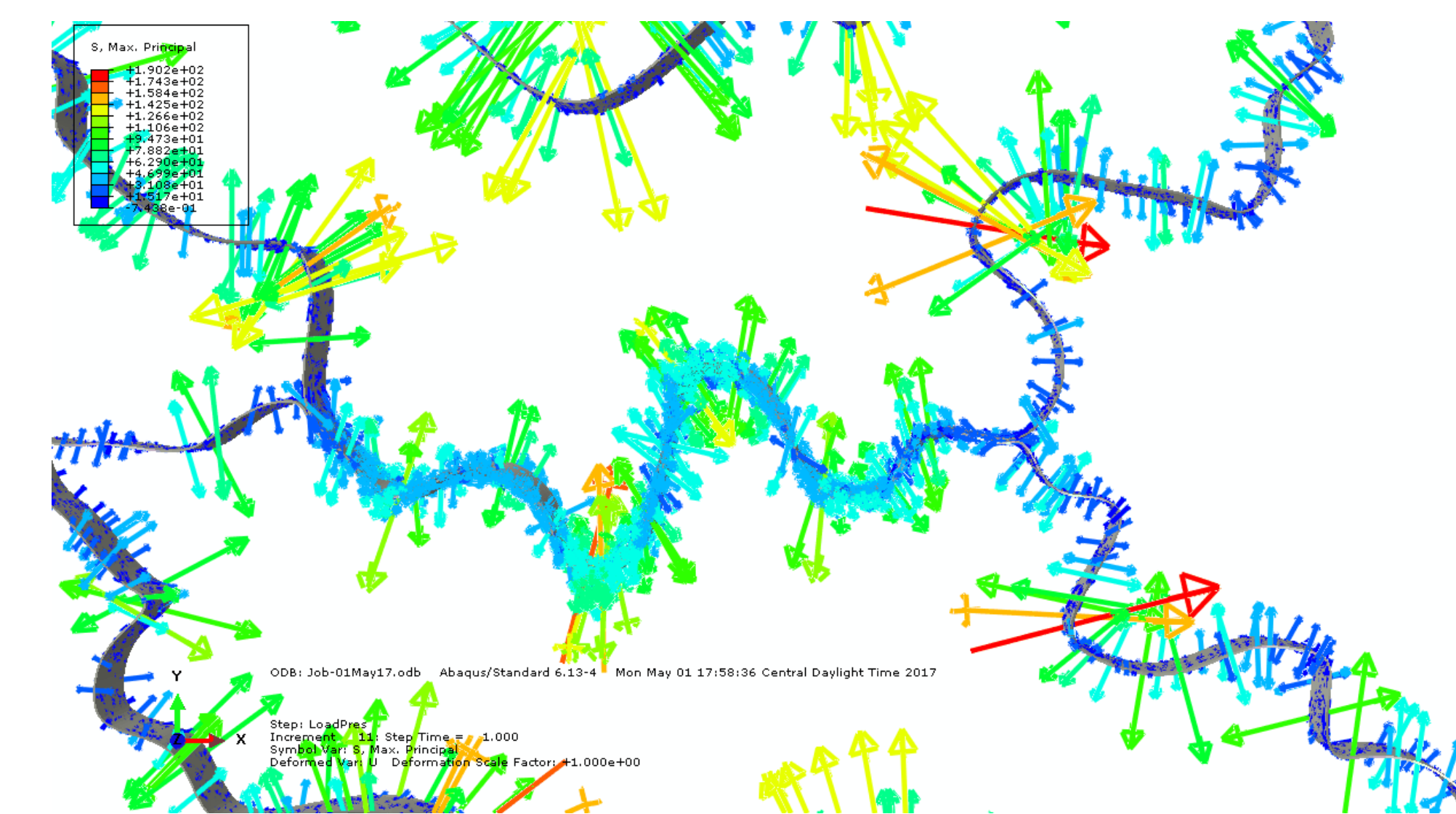


Funding provided by the Darrell J. Nelson Summer Undergraduate Internship in Energy Sciences Research Program Grant

Application of Data



- Using collected data, patterns can be found where lobing occurs and a better understanding of the growth process and correlations between mechanical properties and cell morphology can be identified.
- Gathered data can then be used to improve computational models that incorporate the cell morphology with stress and strain relationships to further improve understanding of cell wall growth.



Importance of Research

This research will be beneficial to many fields. Two of these fields are:

- Biofuel Energy
 - Genetically engineered plants that are useful for biofuels include cell walls that are easier to break down. A better understanding of cell wall mechanical properties and structural integrity is important in creating these modified plants.
- Crop Growth
 - A more predictive understanding of cell growth will positively impact numerous crops and can improve crop yields.