# Whiskeroscope: rodent whisker inspired sensor for use in analysis of plant tissue structure.

**Jan Lyczakowski**
Email Address: jjl55@cam.ac.uk

## The Idea

We would like to develop a sensor to precisely determine mechanical properties of plants which have changed sugar composition or polysaccharide structure within their secondary cell walls.

## Who We Are

Jan Lyczakowski (jjl55@cam.ac.uk) – 1st year PhD student, working with Prof Paul Dupree in the Department of Biochemistry, University of Cambridge. My research focuses on developing synthetic biology tools for plant cell wall engineering.

Abhimanyu Singh (abhimanyu.new@gmail.com) – Information and Computer Engineer, BA, MEng, Cambridge University (2010-2014). I am a software and electronics engineer specialising in instrumentation and signal processing.

Christie Nel (christie.nel@gmail.com) – Computer Engineer, BEngSci, Stellenbosch University (2001-2004). I am a software engineer and specialize in embedded control systems, instrumentation, communications, user interfaces and signal processing/presentation.

## Implementation

The aim of the project is to develop a prototype of sensor designed based on rodent whiskers. We predict that the tool will be able to provide detailed information on mechanical properties of analysed material. We would like to use the "whiskeroscope" to quantify values such as stiffness of *Arabidopsis thaliana* stem with changed composition/ structure of secondary cell walls.

**Design:**
We aim to implement a sensor array system with artificial whiskers surrounding a conical shape which is functionally comparable to a natural rat whisker system. The sensor head consists of an array of thin, elongated, curved, hair-shaped flexible Nitinol wires protruding from it (referred to as e-whiskers from here). The e-whiskers are provided with a rotational mechanism which is driven by a linear actuator at the proximal end of the "whiskeroscope". The flexible e-whiskers each rotate back and forth around their rotational axis by small angles at a high frequency (25 Hz to 50 Hz). The e-whiskers deform their shape on contact with plant tissue. This deformation of the whiskers causes fluctuating voltage signals to be generated at the base sensors. The voltage signals encode the sensory information related to the contact of the whiskers with the tissue. The voltage signals are relayed to a processing unit where they are decoded to extract relevant tactile information e.g. plant texture or stiffness.

**Responsibilities:**
Jan Lyczakowski will be responsible for growth and provision of plant material to be analysed by the team. *A. thaliana* will be grown in purpose-built facility available to the Dupree group.
Abhi Singh and Christie Nel will be responsible for the development of the sensor head, electronics, data processing and visualisation software.

## Benefits and outcomes

We anticipate that by the end of this interdisciplinary project we will develop a prototype of a "whiskeroscope" sensor and test it on plant material. Generated data will be directly beneficial to the synthetic biology work carried out in the Dupree lab as a part of the OpenPlant partnership. Moreover, the design of the device and the prototype will be fully available to scientists interested in analysing mechanical properties of plant tissue. We predict that the proposed sensor will be able to analyse living material without destroying it – this makes "whiskeroscope" applicable in multiple areas of plant sciences. In addition to that, the project will be a collaboration of University of Cambridge based biologist with external engineers. We hope that by working together we will be able not only to achieve the goal of creating and testing the proposed sensor but also exchange knowledge from our particular fields what will benefit our future work.
We would like to focus the implementation of "whiskeroscope" on analysis of mechanical properties of plants with modified secondary cell wall structure. Cell walls are the largest renewable source of saccharides on Earth. Following extraction from plant material sugars can be used to fuel different biotechnological processes, including biofuel production. In order to carry out sugar extraction cell wall structure needs to be disrupted in a process of pre-treatment. In my research I am using different synthetic biology methods, such as enzyme engineering, in order to modify the polysaccharide composition of plant cell walls. Up until now, I was evaluating primarily biochemical properties of generated cell wall variants. Using the "whiskeroscope" I will be able to gain an insight into the mechanical properties of plants with modified cell walls. Mechanical resistance needs to be evaluated to assess the viability of plants and their suitability for different pre-treatment processes. Thus, using the "whiskeroscope" we will be able to check if developed cell wall engineering strategies are suitable for industrial applications. We predict that thanks to its flexibility "whiskeroscope" will be able to provide valuable information to plant synthetic biologists working in other fields, such as developmental biology or crop improvement programme at the John Innes Centre.

## Budget

Budget Total = £3980 (including £100 miscellaneous costs)
Plant growth – 6 months @ £1.62 / m2 per day = expected cost £1000
Development of custom electret microphones with embedded whiskers = £500
Whisker materials (Nylon, Nitinol, Piezo materials) = £250
Mechanical sensor mounting structure = £500
CAD work for sensor mounting and assembly (external) = £500
Electronics for sensor data acquisition = £500
Workshop Rental – 6 months @ £80/ month = £480
Software packages = £150
Miscellaneous = £100