UW Biology (LSB) – presentation to TEDV Committee



Martha Bosma, Ph.D. (Chair)

March 2025

Goal- Describe skills that our undergraduates learn, and what types of jobs and businesses rely on those skills.



UW Biology Undergraduates

500-600 Graduates every year

Divided into sub-areas areas of Biology:

Cell Biology/Development
Ecology
Evolution
General Biology
Plant Biology
Physiology



Undergraduates are crucial to the research mission lab – every lab has 3-4 undergraduates learning research and problem-solving skills.

Our programs are in the College of Arts & Sciences so our students also study biology in a historical/social context and learn critical thinking skills along with scientific reasoning.

Undergraduate students take hands-on data-based course material at every level of the Biology series

100-Level	**200-Level**	**300-Level**	**400-Level**
Intro health sciences	**Intro Biology**	**Science literature -based Biology**	**Experi-ment-based Biology**



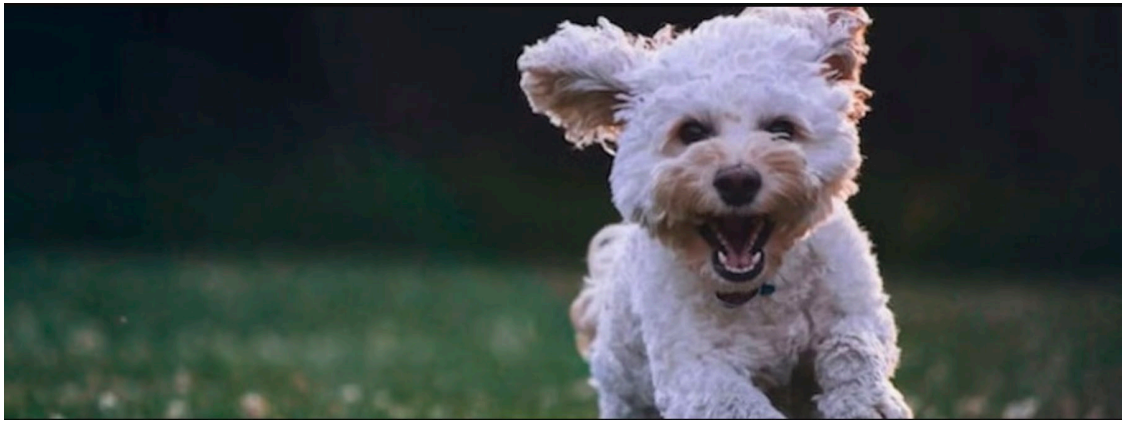
At the 100-level, students get a wide-ranging introduction to health sciences topics

<u>100-Level</u>
Intro health sciences

Biol 118/119 is often used by students as hands-on training for allied health jobs. Most of these students do not become Biology majors; many will find jobs as CNAs, health aides, phlebotomists, medical lab, imaging/radiology techs; others go on to graduate programs like medicine and nursing.

- **These students are trained to occupy health care jobs, which are a large drive on the economic sector.**

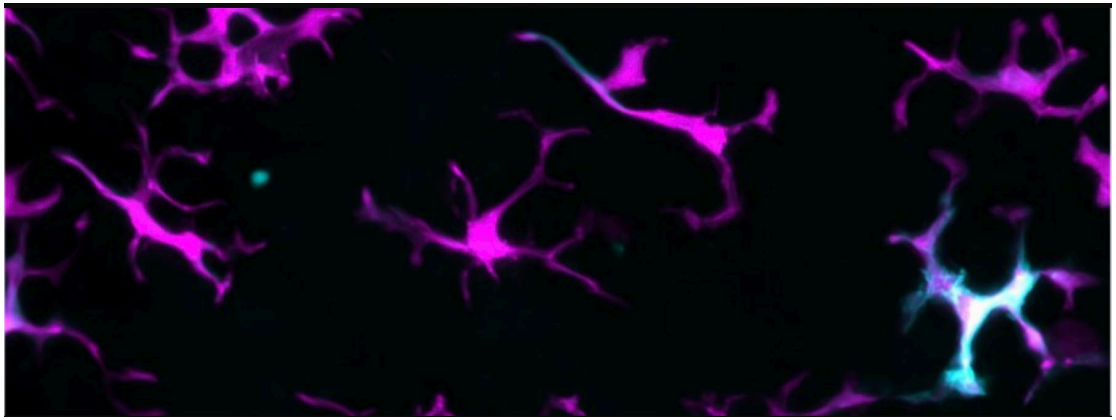
Economic Contribution of Healthcare to the City of Seattle



Students in the 200-level classes take 90 hours of lab classes, in addition to 120 hours of lecture.

<u>200-Level</u>
Intro Biology

Science Communication Skills (written, oral, posters and presentation skills)
Problem solving (all labs and research experiences)
Analytical skills (data assessment, statistical modeling, research review and design)
Statistics and quantitative reasoning (R, R Studio, Excel)
Collaborative teamwork and problem solving
Skills with lab equipment
Assessment of biological and societal interactions



200-level subject matter includes basic ecology, evolution, cell biology, development, molecular biology, physiology.

<u>200-Level</u>
Intro Biology

Oral and written communication
Collaboration/team science
Open science (including preprints, sharing code & data)
Rigor and reproducibility in science
Statistical analysis
Coding (primarily R and Python, as well as use of software like Pymol and AlphaFold)
Molecular biology (nucleic acids, proteins) wet lab skills (and conceptual underpinnings)
Biochemistry wet lab skills (and conceptual underpinnings)



Students in the 200-level series also take chemistry, possibly physics (with lab components). They can then apply to other Life Sciences majors.

Other Science disciplines, including labs (chemistry, physics)

200-Level Intro Biology

Biology Majors 300- and 400-level (500-600 students/year)

Other Life Science majors [Neuroscience (labs), Biochemistry, Microbiology (labs), Public Health]



Biology majors in the 300-level classes take 30 hours of discussion section and 30 hours of lecture/class.

300-Level Lab and Literature -based Biology

How to effectively read & summarize the scientific literature
How to identify an important knowledge gap in science
Experimental design
Responsible conduct of research (ethical science)
Data analysis, interpretation, and hypothesis testing

- **Scientific literature competence, putting data into context, planning next experimental steps.**

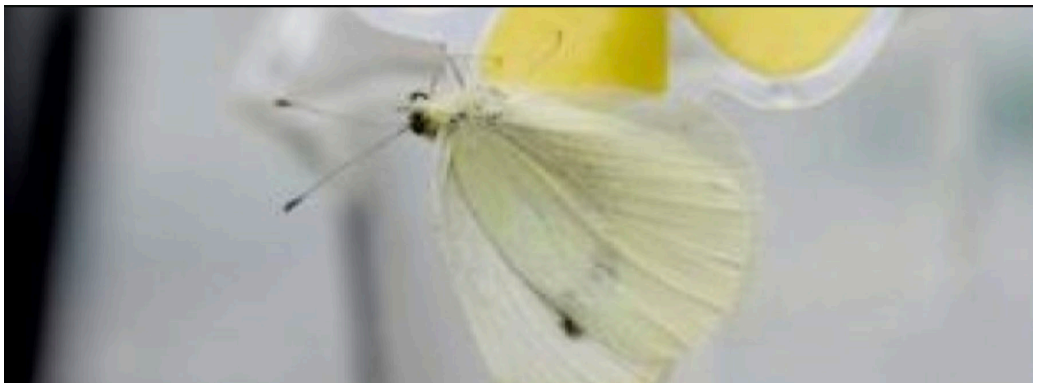


Biology majors in the 300-level LAB classes take 40 hours of lab/class.

<u>300-Level</u>
Lab and Literature -based Biology

Lab classes include rigorous molecular biology techniques:
Making solutions
Pipetting, working with small volumes and reagents
Design primers for PCR
Run/Analyze PCR gels
Lab Safety

- **Analyze DNA sequences, identify mutations, modify DNA, design experiments**



CURE (Course-Based Undergraduate Research Experience) Poster

The Impact of Soil Acidity on Nicotiana Growth: Investigating the Physiological Effects of pH-Induced Stress

Abstract

Soil pH plays a critical role in plant physiological responses and overall growth. This study investigated the effects of varying soil pH levels on stomatal density and plant biomass (above-ground and below-ground mass) in *Nicotiana* species. Plants were grown in controlled conditions across a range of soil pH treatments. Stomatal density was measured using leaf impressions and microscopy, while biomass was determined by measuring the dry weight of shoots and roots. A one-way ANOVA revealed a statistically significant difference in stomatal density among pH groups ($F = 41.06$, $p < 0.0001$), indicating that soil pH has a strong influence on stomatal development. In contrast, there was no statistically significant difference in total biomass across the pH groups ($F = NaN$, $p = NaN$), suggesting that within the parameters of this study, soil pH did not markedly affect *Nicotiana* biomass production. These findings highlight a potential decoupling between stomatal density and overall growth responses to soil pH variation.

Background

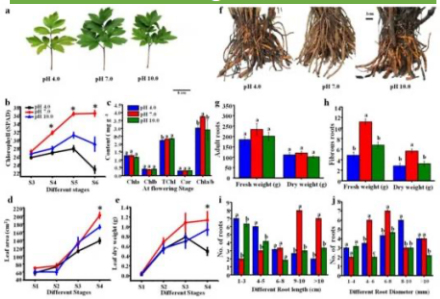


Fig. 1: Influence of different pH treatments on the leaf and root growth of *P. suffruticosa* 'Luoyanghong'. (a) Morphological changes of leaf, bar = 5 cm; (b,c) chlorophyll and carotenoid contents; (d) leaf area; (e) leaf biomass; (f) morphological changes of root, bar = 1 cm; (g,h) biomass of adult roots and fibrous roots; and (i,j) the distribution of root [Aung et. Al]

Methods

pH	soil (g)	pH adjustment (mL/g)
4	5	1.75
5	5	1.5
6	5	-
7	5	0.03g NaOH
8	5	0.04g NaOH
9	5	0.05g NaOH
10	5	0.06 g NaOH

Fig. 2: pH adjustment protocol for watering solutions

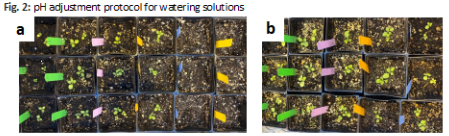
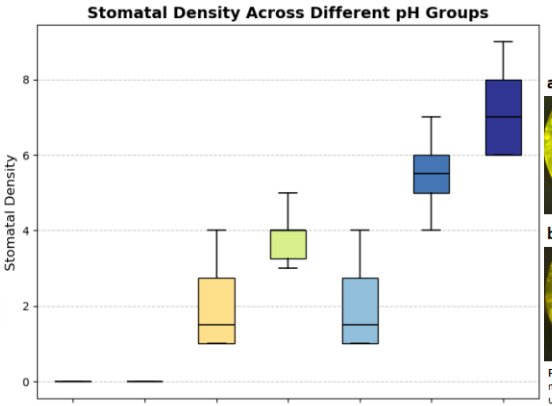


Fig. 3: Nicotiana on 2/27 (after planting post-germination), and 2/6/25 (directly prior to data collection)

Stomatal Density



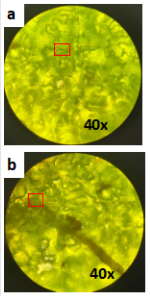


Fig. 5: Stomatal Density measurements were taken under a compound microscope at 40X

Fig.4: One-way ANOVA results: F-statistic = 41.06, p-value = 0.0000. There is a statistically significant difference in stomatal density among the pH groups.

Plant Biomass

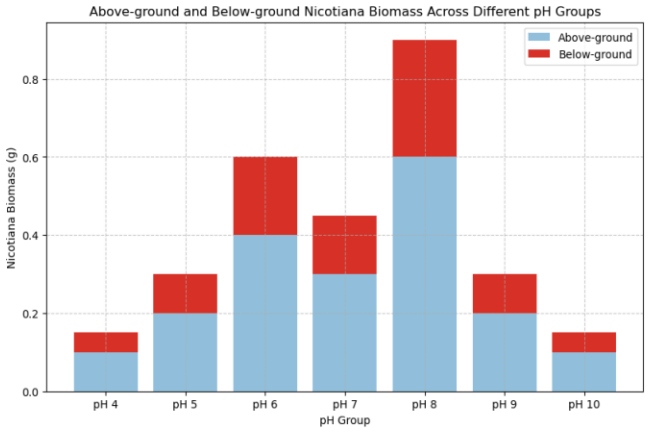


Fig. 6: Nicotiana above and below ground mass one-way ANOVA results: F-statistic = nan, p-value = nan. There is no statistically significant difference in total biomass across the pH groups

pH Fluctuations

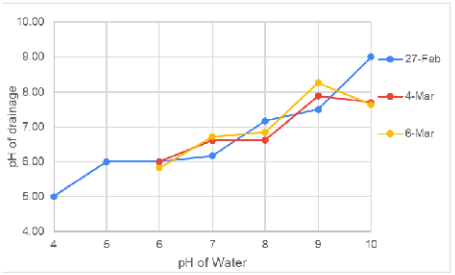


Fig. 7: pH was measured both in the solutions used for watering and in the runoff collected after irrigation. Consistent data showed that the soil buffered the treatments, often neutralizing the pH of the runoff regardless of the initial solution pH. Monitoring these fluctuations was important to confirm the soil's buffering capacity and ensure accurate interpretation of treatment effects.

Discussion

This study demonstrates that soil pH significantly affects stomatal density in *Nicotiana* plants, with clear variation observed among pH treatments. However, no significant differences were found in total biomass across the different pH levels. These results suggest that while stomatal density is sensitive to changes in soil pH, this response may not directly translate to differences in plant biomass under the conditions tested. Notably, *Nicotiana* plants exposed to the most acidic treatments exhibited high mortality. This suggests that extreme soil acidity may exceed the tolerance threshold for *Nicotiana*, leading to plant death rather than gradual reductions in biomass. Further research could explore longer-term growth effects, additional physiological responses, and the mechanisms underlying *Nicotiana*'s pH sensitivity.

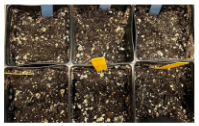


Fig. 8: *Nicotiana* plants exposed to the most acidic treatments (pH 4 and pH 5) did not survive past D4 of treatment

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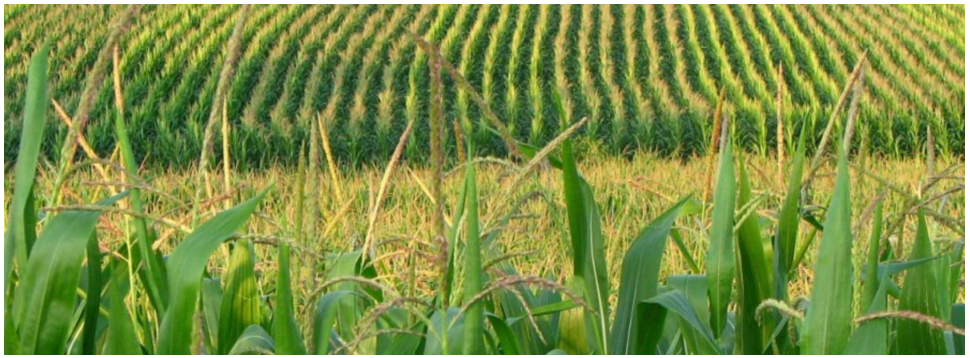
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Students in 400-level classes specialize in specific areas of Biology

400-Level Experi-ment-based Biology

- Cell Biology/Development
- Ecology
- Evolution
- General Biology
- Plant Biology
- Physiology



400-level classes emphasize working with analysis of large data sets, modeling, and predicting.

400-Level Experi-ment-based Biology



R programming skills learned in upper level undergraduate course -- used in an internship at the CDC to determine health risk predictors.

- **Lost work-days of personnel.**

Methods of machine learning for classification and prediction

Integration of tools/methods from different disciplines

Training predictive computational and mathematical models

The development and testing of findable, accessible, interoperable, and reproducible code bases for scientific discovery and research

- **Understanding how external factors influence networks – use modeling to predict response to specific modifications.**

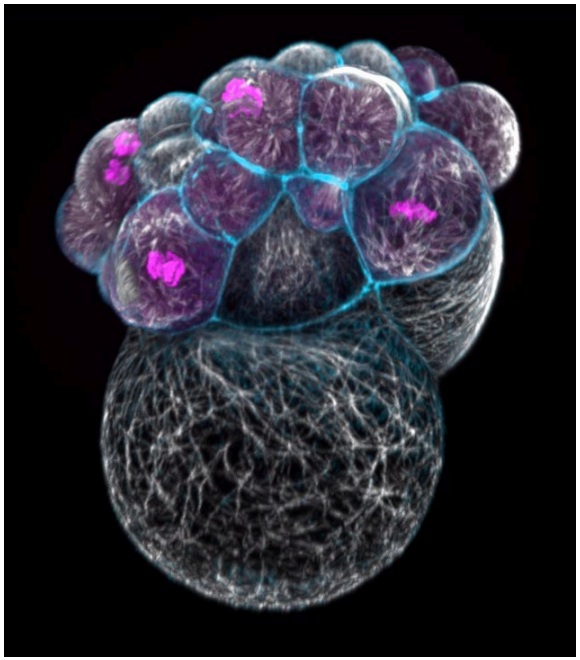
Undergrad and grad student skills – in research labs, learning image analysis, using AI to predict cell shape or animal movement.

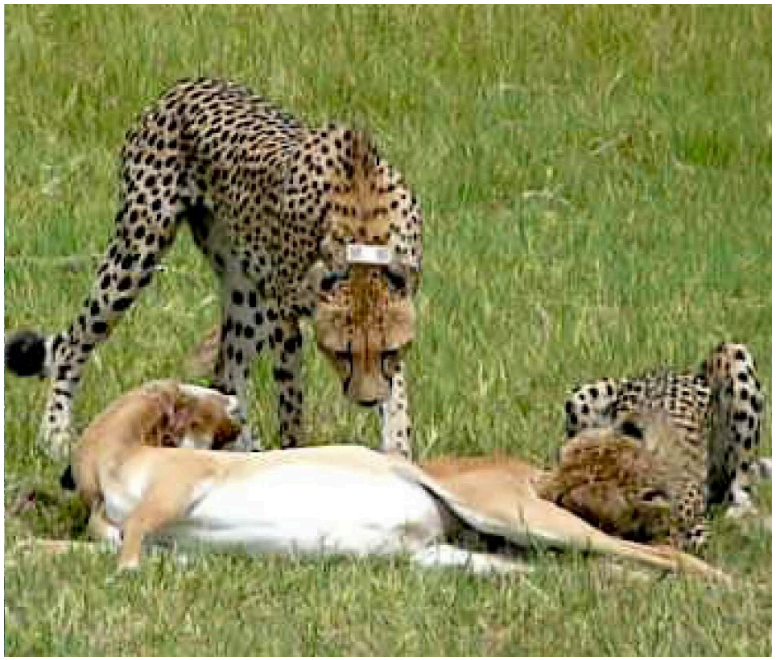
Movement of particular proteins within cell determine cell division.

- Cancer diagnosis and treatment

Movement of predators and prey allow understanding of ecosystem.

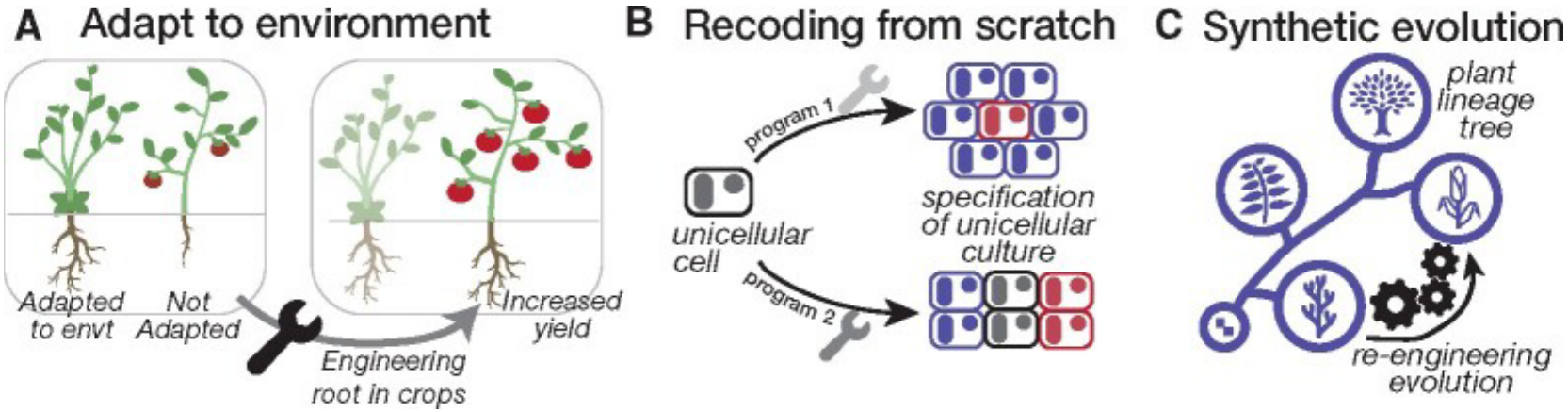
- Environmental consequences of weather or human intervention.





Undergrad and grad student skills – in research lab using synthetic biology to understand steps of hormonal signaling and plant growth

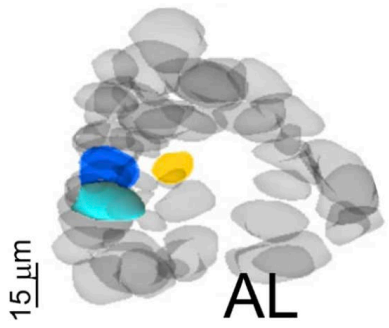
- **Multiple patents**
- **10 former undergrad research interns work in biotech (in coding, regulatory & wet lab positions), including one who founded a biotech company called Asimov.**

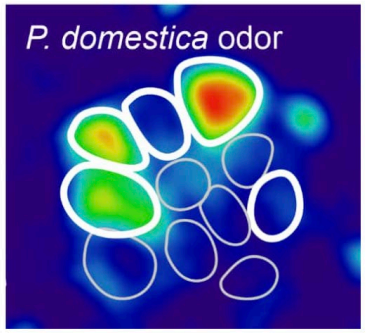


Undergrad and grad student skills – in research lab studying neural circuits and behaviors in response to olfactory cues

Both nectar-feeding insects and mosquitoes use olfactory plumes to find their food source. Use wind tunnels and synthetic flowers while recording from neurons in response to stimuli.

- **Multiple patents**
- **Former students include Computer Scientist (Amazon), Data Analyst(s) (Microsoft, Insight Data Analytics), Program Manager (Allen Institute for Brain Science), Information Designer (New York Times)**







Individual Undergraduate Research Poster

Studying the Function of Signal Proteins in Plant Immune Responses

Department of Biology, University of Washington



Abstract

Plants utilize cell surface protein receptors to recognize insect herbivory through the detection of molecular patterns (MPs). Following the detection of MPs, plants initiate specific immune responses, often measured by the increased production of the hormone ethylene gas and by Reactive Oxygen Species (ROS). The Inceptin Receptor (INR), which is specific to legumes, recognizes the herbivory-associated MP Inceptin11 (In11).[1, 2] The binding of In11 to INR initiates a signaling cascade, leading to an immune response. [2] However, the signaling mechanism activated by INR is unknown. Certain signaling proteins called receptor-like cytoplasmic kinases (RLCKs) are often involved in plant immune signaling. The receptor-like cytoplasmic kinase gene Herbivore Induced Kinase 1 (HIK1)[3] is upregulated by In11 treatment in common bean plants. The goal of this research is to determine if HIK1 or other RLCKs are downstream proteins required for INR signaling. In this study, I transform *Arabidopsis thaliana* with RLCK genes, where theses plants are then used to analyze RLCK function in immune signaling.[4]

Significance

Aim: To understand the function of HIK1 and related RLCKs in INR signaling.
Significance: An understanding of INR signaling will aid the engineering of crops that are more resilient to pests.

Background

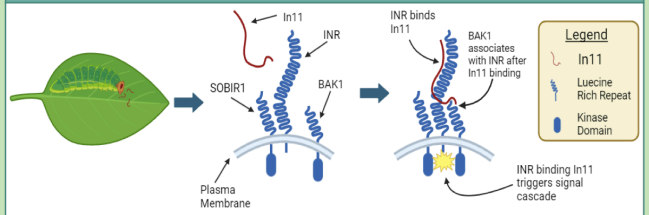


Figure 1: Cartoon depiction of INR activation. **(Left)** Caterpillar digesting plant tissue, producing In11. **(Middle)** Unbound INR receptor complex. **(Right)** Bound INR receptor complex. Created with BioRender.com.

- Studying HIK1 and related RLCKs.
- After binding a ligand, receptor proteins phosphorylate RLCKs.[3]
- HIK1 is upregulated upon In11 treatment.

Hypothesis: Plants that express RLCKs have more pronounced immune responses.

Experiment Process

1. Transformation

Flowering *A. thaliana* is dipped in *Agrobacterium tumefaciens* carrying DNA plasmids to make transgenic seeds.

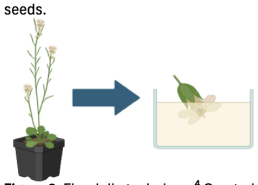


Figure 2: Floral dip technique.[4] Created with BioRender.com.

2. Seed Screening

A. Thaliana seeds are sprouted on antibiotic plates to screen for successful transformants. Successful transformants are moved to individual pots after 2-3 weeks.



Figure 3: (Top Left) Antibiotic plate with 1 week old seedlings. **(Top right)** The same plate at 2w. In red is a successful transformant. **(Bottom Left)** Zoomed in view of 2w successful transformant. **(Bottom Right)** Successful transformant in individual pot.

3. Protein Analysis

Genotype Analysis and Western Blots are used to determine the presence of RLCK gene and protein product. Any RLCK seed plates that lack successful transformants will redo methods.

4. MP Treatment

RLCK positive and wild type plants are treated with either an MP or water to trigger an immune response.

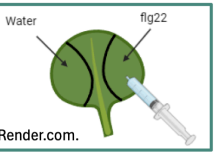


Figure 4: Leaf infiltration technique. Created with BioRender.com.

Expected Results

Data Analysis: Tissue samples of RLCK positive and wild type plants that are treated with either an MP or water are measured for ROS production.

Expected Results: I predict RLCKs will have a positive effect on immune signaling. Due to previous results and the upregulation of the HIK1 gene after MP treatment in INR signaling, I expect HIK1 and related RLCKs to be involved in positive downstream signaling.

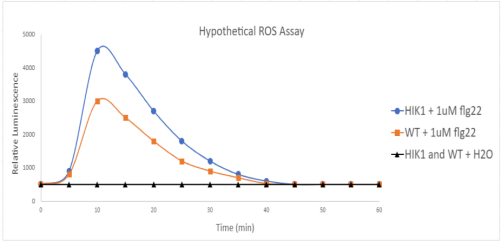


Figure 5: Possible ROS assay data for proposed hypothesis. HIK1 and other RLCK ROS assays show increased relative luminescence when compared with wild-type individuals.

Experimental Design

- RLCK function is investigated in *A. thaliana*, the model organism for plants.
- Studying RLCK function in FLS2 immune response, which is similar to INR.[5, 6]
  - *A. thaliana* plants are transformed with DNA plasmids that contain RLCK genes and antibiotic resistance genes using *Agrobacterium tumefaciens*.
- Immune response measured with relative luminescence of ROS.
  - Relative luminescence corresponds directly with immune response strength.

Acknowledgements

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