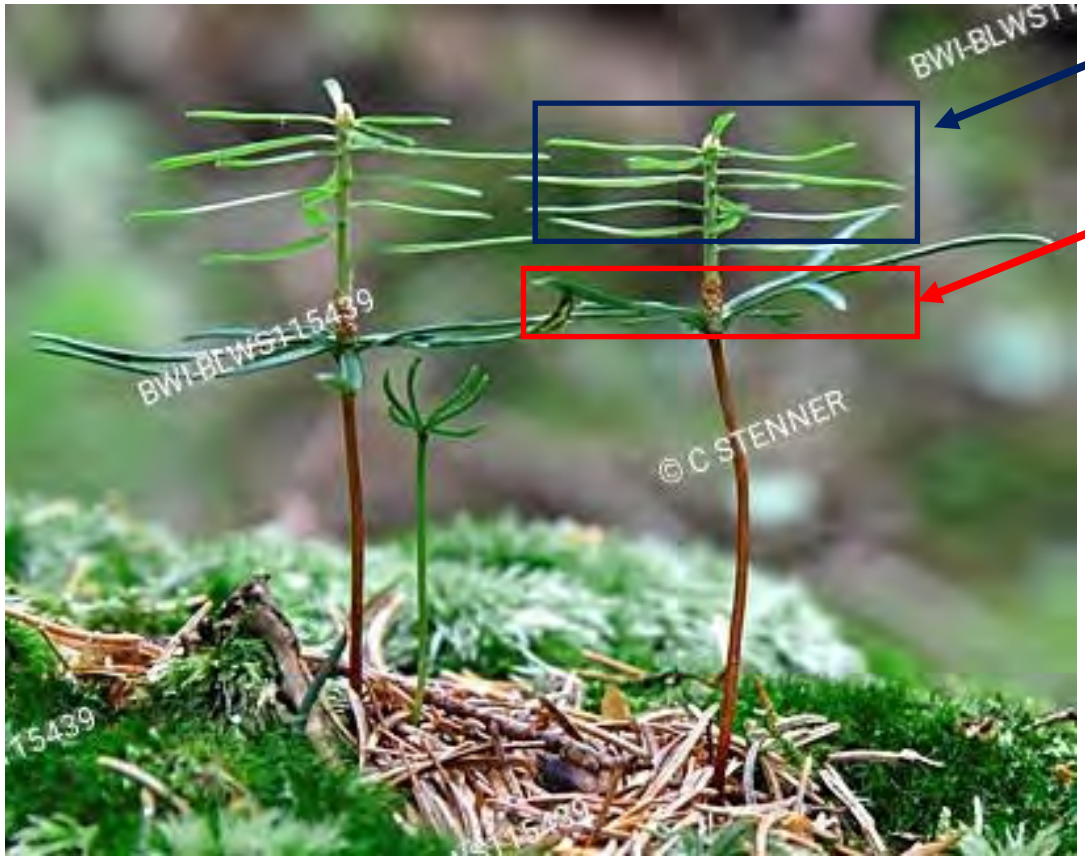
Using Math in Plant Science

BC: conifer trees

Spruce tree seedlings



~10 cm tall

needles
(leaves)

Cotyledons
(seed ‘leaves’)

Spruce tree embryo

~3 mm tall

From UBC Research Associate to BCIT researcher (early 2000's)

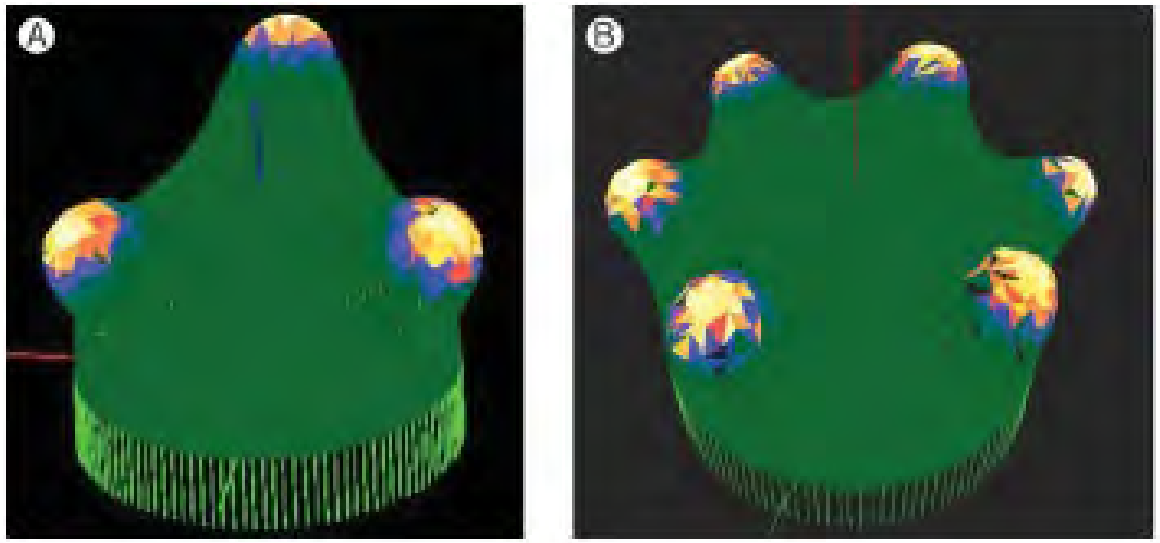
Annals of Botany **101**: 361–374, 2008
doi:10.1093/aob/mcm295, available online at www.aob.oxfordjournals.org

OXFORD JOURNALS
OXFORD UNIVERSITY PRESS

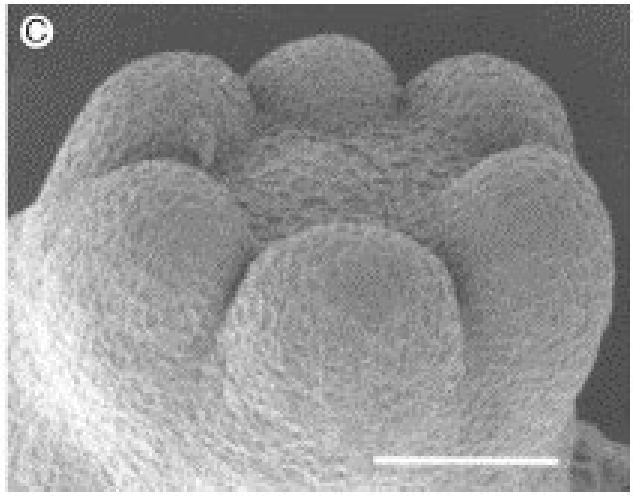
Pattern Selection in Plants: Coupling Chemical Dynamics to Surface Growth in Three Dimensions

DAVID M. HOLLOWAY[1,2,3,*] and LIONEL G. HARRISON[3]

[1]*Mathematics Department, British Columbia Institute of Technology, 3700 Willingdon Ave., Burnaby, B.C., Canada, V5G 3H2,* [2]*Biology Department, University of Victoria, Victoria, B.C., Canada and* [3]*Chemistry Department, University of British Columbia, Vancouver, B.C., Canada*



Cotyledons on a larch embryo



- Supported by BCIT research funds

- Software development by Computer Systems Technology diploma and BTech students

NSERC CRSNG

supported BCIT research

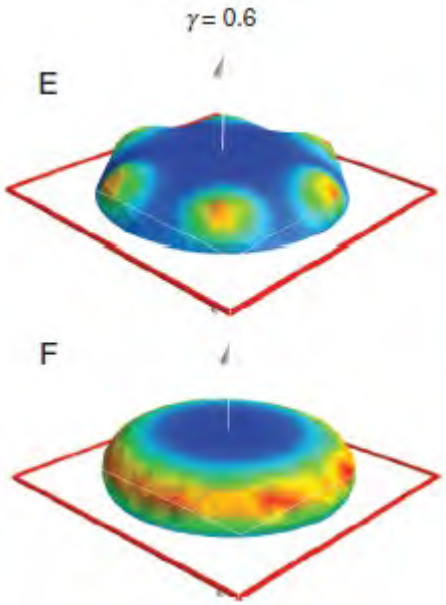
A quantitative study of cotyledon positioning in conifer development[1]

Botany 94: 1–12 (2016)

D.M. Holloway. Mathematics Department, B.C. Institute of Technology, Burnaby, BC V5G 3H2, Canada; Biology Department, University of Victoria, Victoria, British Columbia, Canada.
B. Brook, J.H. Kang, C. Wong, and M. Wu. Biotechnology Program, B.C. Institute of Technology, Burnaby, BC V5G 3H2, Canada.

Biotechnology experiments

Math simulations



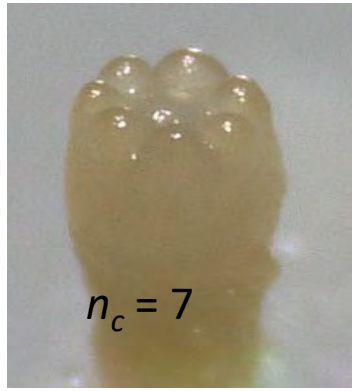
Annals of Botany **121**: 525–534, 2018
doi:10.1093/aob/mcx185, available online at www.academic.oup.com/aob

ANNALS OF BOTANY

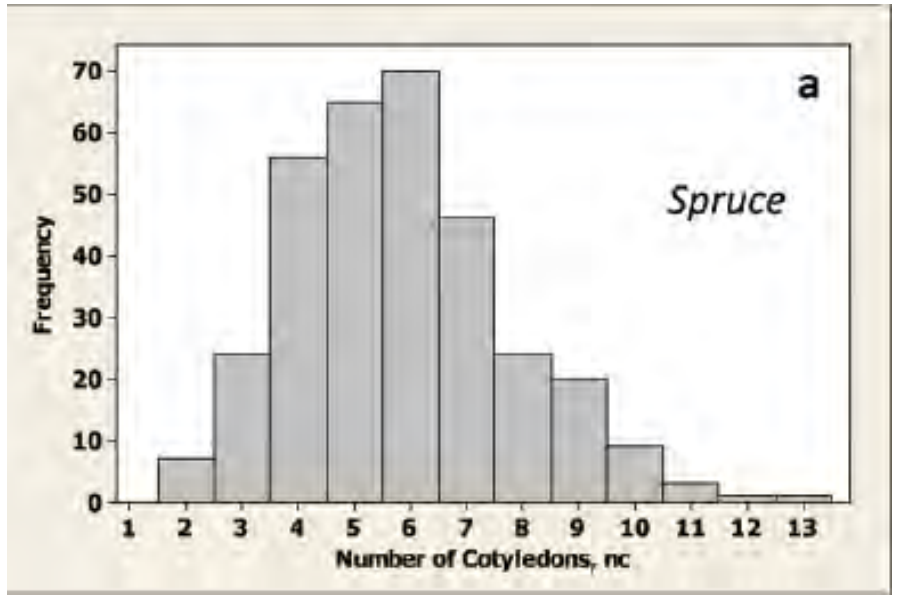
Two-stage patterning dynamics in conifer cotyledon whorl morphogenesis

David M. Holloway[1,2*], Ignacio Rozada[1†] and Joshua J. H. Bray[3]

[1]*Mathematics Department, British Columbia Institute of Technology, Burnaby, B.C., Canada,* [2]*Biology Department, University of Victoria, Victoria, B.C., Canada and* [3]*Biotechnology Program, British Columbia Institute of Technology, Burnaby, B.C., Canada*

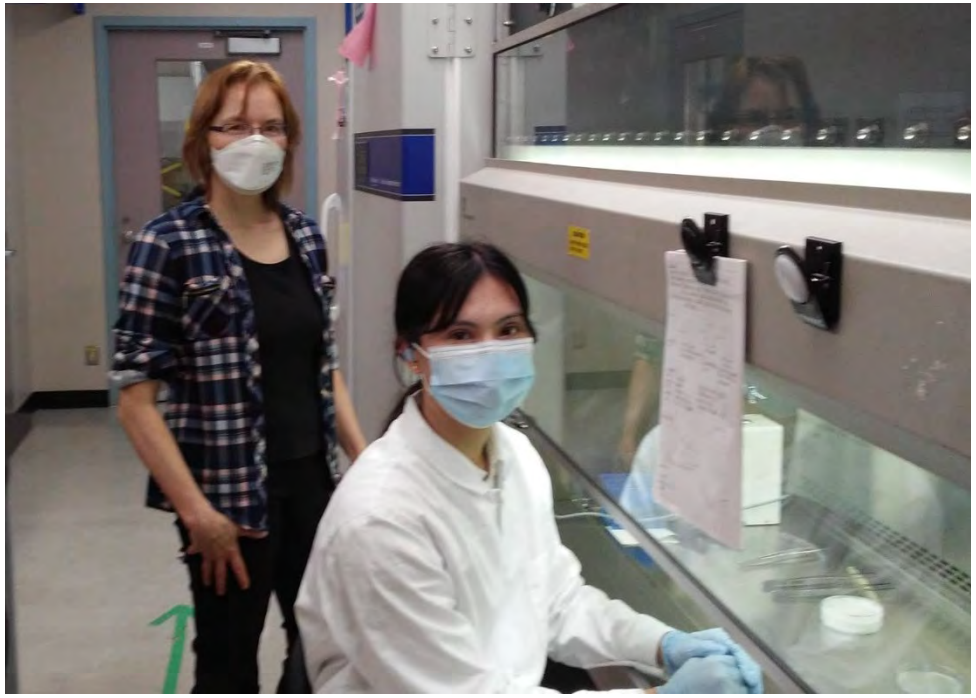


Conifer embryos have variable numbers of cotyledons, n_c, in normal development



NSERC CRSNG

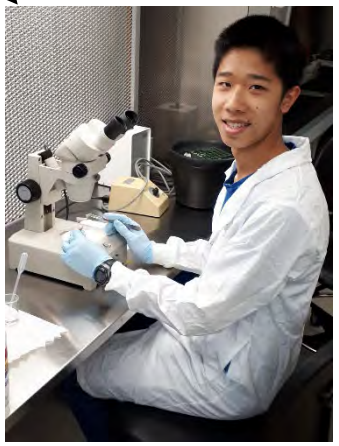
support renewed



Biotechnology Students

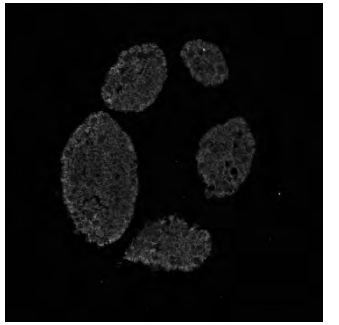
Josh Bray
Matt Richardson

Kit Martens
Brandon Wong

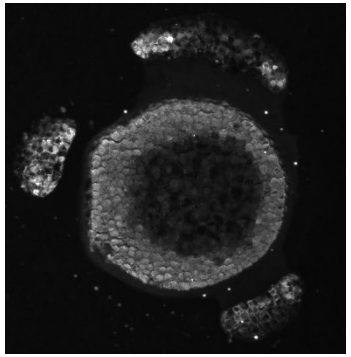


Hannah Ly
Rebecca Saunders

Auxin growth hormone in cotyledons



Auxin growth hormone in tree buds



Anatomy of needle formation in tree buds

Understanding how molecular interactions control cotyledon number

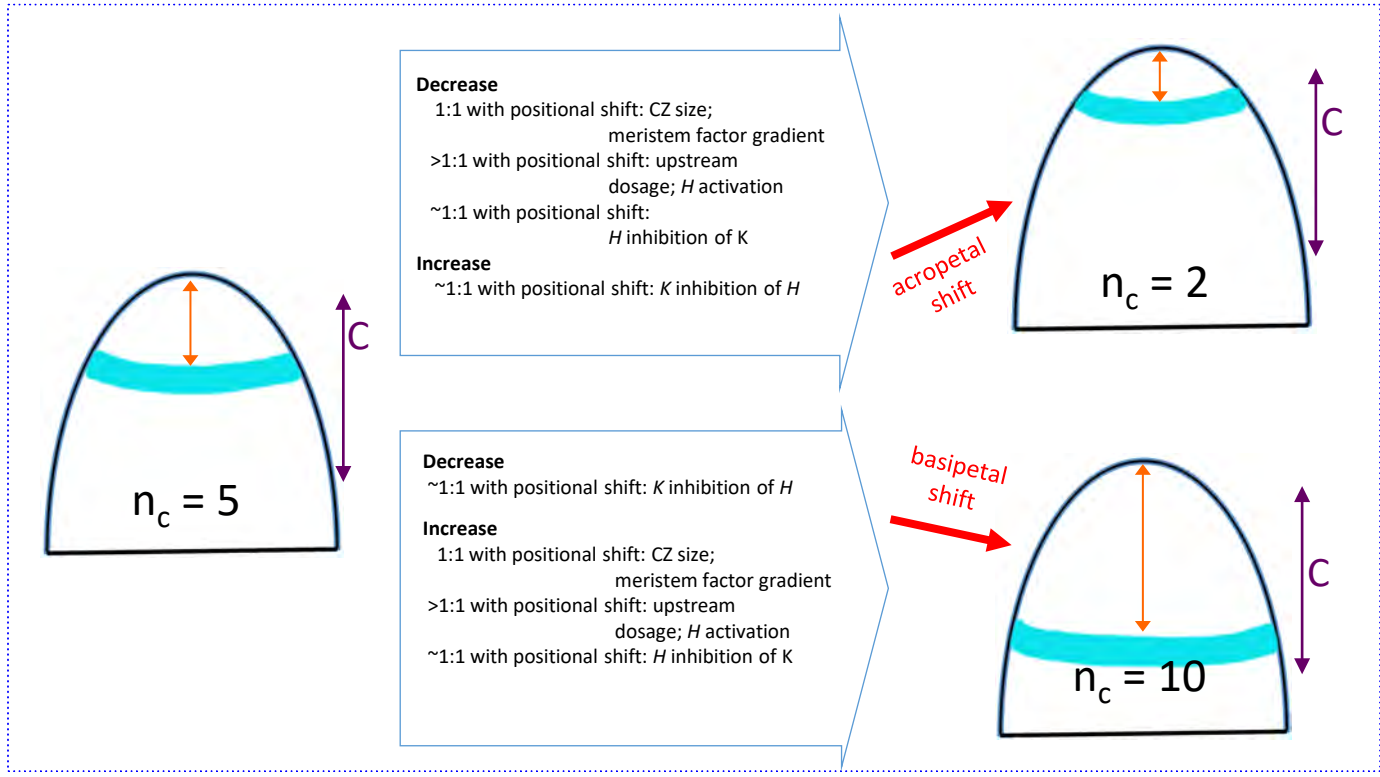
Size regulation of the lateral organ initiation zone and its role in determining cotyledon number in conifers

David M. Holloway[1*], Rebecca Saunders[2†] and Carol L. Wenzel[2]

[1]Mathematics Department, British Columbia Institute of Technology, Burnaby, BC, Canada,
[2]Biotechnology Department, British Columbia Institute of Technology, Burnaby, BC, Canada

frontiers | Frontiers in Plant Science

May 2023



How are branches made in mature trees? (spruce by NE1)

Trees
https://doi.org/10.1007/s00468-024-02518-5

ORIGINAL ARTICLE

Check for updates

Needle and bud scale development in *Picea abies*

Carol L. Wenzel[1] · Anny Y. Xia[1,2] · Rebecca Saunders[1,2] · Han Han Ly[1,2] · Anson Mo[1,2] · David M. Holloway[3]

Received: 10 November 2023 / Accepted: 7 April 2024
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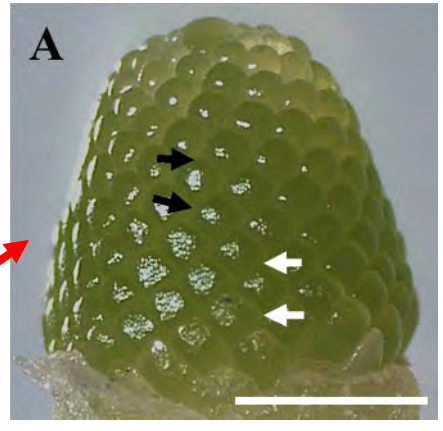
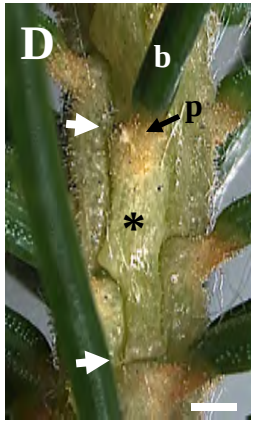
Production of the stem in Norway spruce

Carol L. Wenzel[1], Bonita Chan[1], Anson Mo[1,2], Anny Xia[1,2], Rebecca Saunders[1,3], David M. Holloway[4*]

In preparation, 2024

Future math project: to understand how this spiral pattern is made



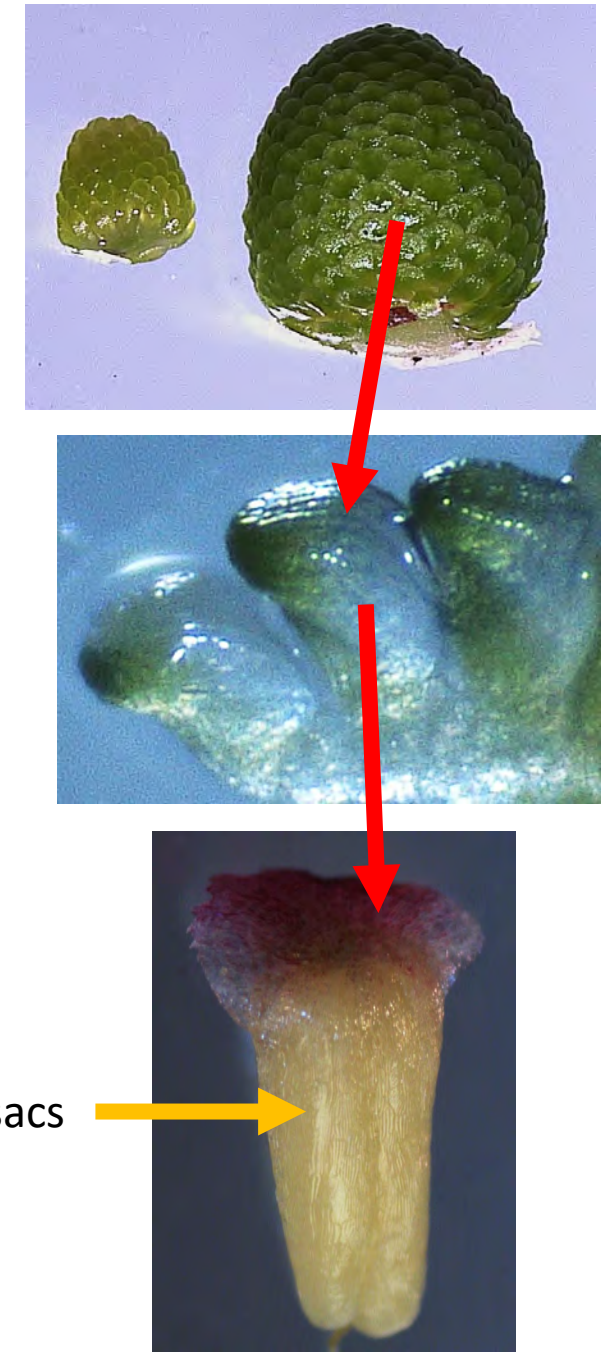


2025…

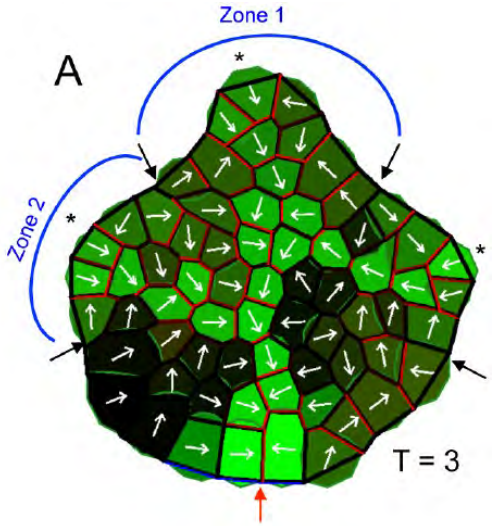
- Male cones: Carol L. Wenzel, Bonita Chan, Anson Mo, Anny Xia, Rebecca Saunders, David M. Holloway

In preparation

- RNA transcriptome: Carol L. Wenzel, Bonita Chan, Anson Mo, Anny Xia, Rebecca Saunders, David M. Holloway
  - Samples currently being run at the UBC Sequencing and Bioinformatics Consortium
  - This will show <u>all</u> the genes that are being expressed at shoot tips, and should tell us which genes contribute to the change between bud scales and needles, for instance
  - Future summer students can follow this up with PCR for specific genes in the BCIT lab



Math and leaf veins



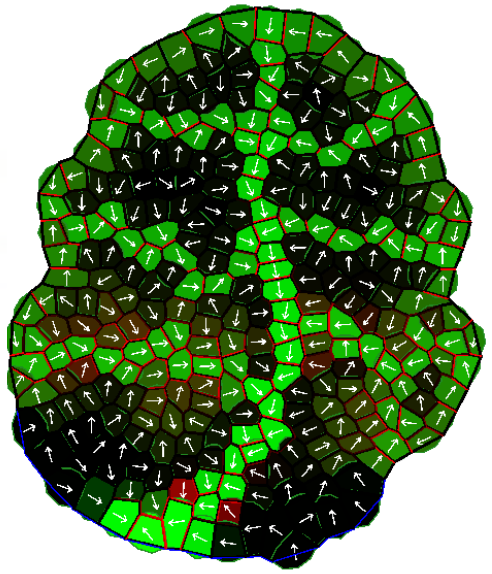
in silico Plants Vol. 3, No. 2, pp. 1–17
https://doi.org/10.1093/insilicoplants/diab030
Advance Access publication 09 October 2021
Original Research

in silico Plants

OXFORD

Polar auxin transport dynamics of primary and secondary vein patterning in dicot leaves

David M. Holloway[1,*,•] and Carol L. Wenzel[2]



plants

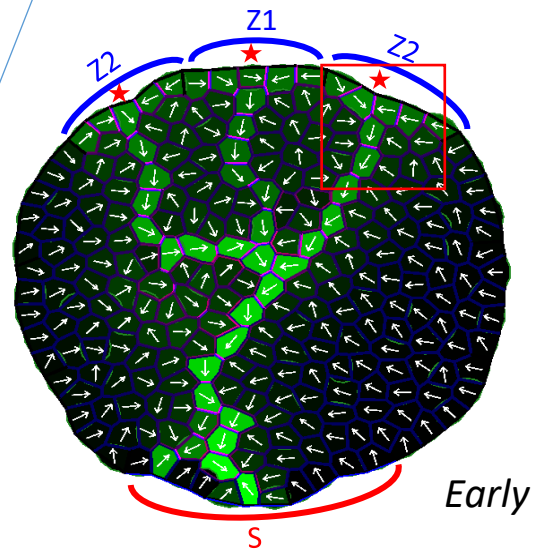
an Open Access Journal by MDPI

The Effects of Auxin Transport Inhibition on the Formation of Various Leaf and Vein Patterns

Carol L. Wenzel; David M. Holloway; Jim Mattsson

BCIT and SFU

Plants 2024, Volume 13, Issue 18, 2566



Early stage, first veins

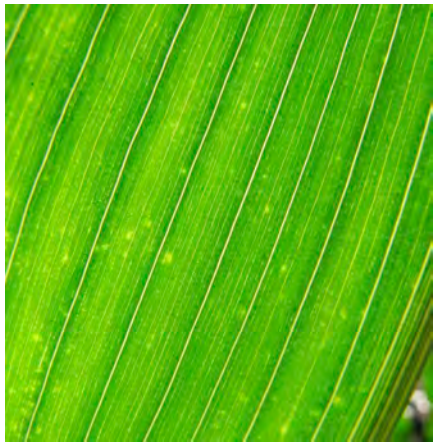
The role of auxin transport through plasmodesmata in leaf vein patterning

David M. Holloway[1,*], Trausti K. Eiriksson[1,2] and Carol L. Wenzel[3]

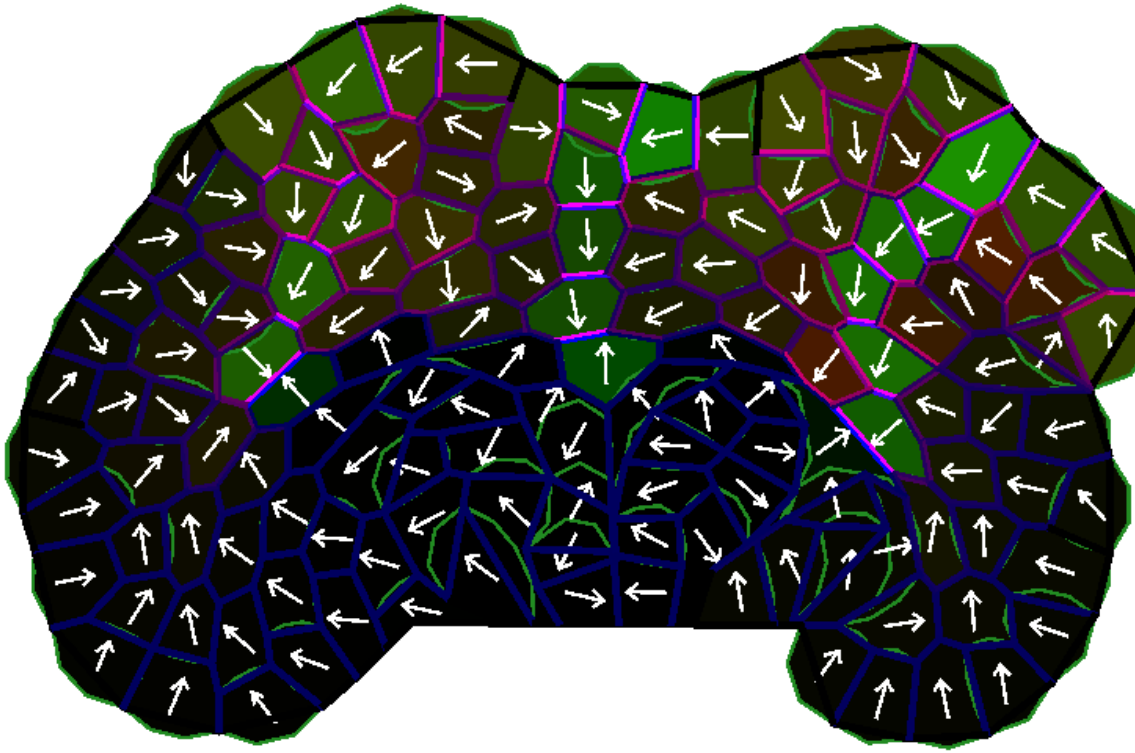
[2] University of Toronto chemistry student

In preparation, 2024

Modelling leaf veins in grasses: parallel veins



- Use of Machine Learning to find model parameters (BCIT Professional Development support)
- Collaboration with Dr. Takashi Nakamura (Math Department)
- Supervision of student projects in the new MSc program in Applied Computing



And in the classroom:

Data and approaches from these research projects get used in:

- MATH 2444 (Statistics and Information Tech for Biotechnology):
    - e.g. linear regression to find cotyledon spacing
    - RNA sequencing: bioinformatics analysis for differential gene expression

and

- MATH 4442 (Statistics for Biotechnology):
    - e.g. t-tests to distinguish different complexity levels in leaves