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Growth Chamber Setup in the Phytotron

Over the years, we have developed procedures that we hope help improve the quality of research in hosted in the Phytotron. This article is intended to shed a little bit of light on the work Phytotron staff do behind the scenes. It was previously published in the Association of Education and Research Greenhouse Curators (AERGC) Newsleter.

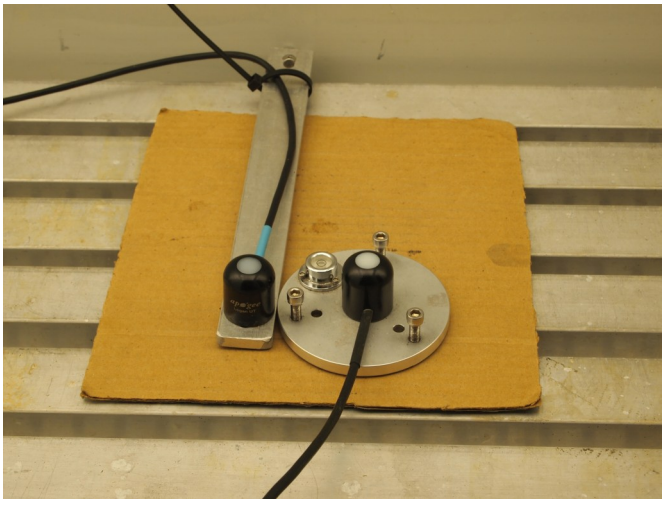
Many of our maintenance protocols and sensor checks have been developed based on the article "Growth Chamber Maintenance Protocols" by Mark Romer, Claire Cooney and Frank Scopelleti of McGill University. This article details the practical application of the protocols set out in the article by Romer et. al., as we have adapted them here at the Phytotron.

Growth Chamber Overview

We have several different models of growth chambers here at the Phytotron. The one common thing in every chamber is the Conviron temperature sensor and Vaisala HMP50 dry humidity sensor. A portion of our chambers are also equipped with Apogee SQ120 electric calibration quantum sensors and Vaisala GMM222 CO_2 sensors. To check conditions in the chambers and ensure all of the sensors are accurate, we use the following test equipment: 1) Apogee QMSW-SS quantum meter; 2) Vaisala M170 indicator with HMP75 temperature and humidity probe and GMP70 CO_2 probe; and 3) Vaisala GMK222 CO_2 calibration unit.

Checking growth chamber light levels

We use the Apogee QMSW-SS quantum meter to check the light levels in our growth chambers. In our older growth chambers without the Apogee SQ120 quantum sensor, the lights operate in ON/OFF step fashion and are programmed as light levels. However, the light level programmed on the controller does not indicate anything about how much light the plants will be receiving; it only tells you how many lights will be turned on. Light levels can vary with the type of bulb, the age of the bulbs, the age of the ballasts, and the distance of the light canopy from the plants. In these growth chambers, we use the Apogee QMSW-SS meter to set the light levels in the chamber to the level requested by the researcher. Often times it takes some trial and error to get the correct levels by programming different light levels



Apogee QMSW-SS (Photo: M. Mucci)

and moving the canopy up or down. Given that there will be some variation in the light levels across the chamber floor, we aim to make the average light level as close to the researcher's request as possible. For example, if the researcher asks for 150 umol, we may get readings as high as 175 umol in the middle of the chamber and as low as 130 umol around the edges.

In our newer growth chambers equipped with the Apogee SQ120 quantum sensor, the fluorescent lamps operate in a dimming, ramp fashion and are programmed as actual light levels in umol. In this case, the sensor inside the chamber senses the amount of light, feeds that information back to the controller and the controller dims the lights up or down, depending on the programmed light levels. The sensor can be moved vertically inside the chamber so that it always stays just above the plant canopy, ensuring that the light level at the plant canopy remains constant. If this sensor is not operating properly or becomes covered by plants or debris, the plants will not be getting the desired amount of light. In these chambers, we use the Apogee QMSW-SS meter to confirm the accuracy of the chamber sensor. If the chamber sensor has drifted more than +/- 10% with respect to our independent meter, we replace it and send it back to Apogee for recalibration. Typically, the chamber sensors hold their calibration for several years (assuming a 16hr day length).

In both cases described above, we also provide the researcher with a 'light scan' of the chamber at the beginning of their experiment. This is done using our Apogee QMSW-SS meter at several points across the chamber floor. New growth chamber users receive a copy of this light scan for their records.

Checking temperature and humidity

We use the Vaisala M170 indicator along with the HMP75 probe to check both temperature and relative humidity in our growth chambers. Before the tests, we ensure that all humidity nozzles and air circulation fans in the chamber are operating properly. We then place the HMP75 probe directly next to the chamber's temperature and humidity sensors, ensuring that the probe and sensors are shielded from light and still receiving proper air flow through the aspirators. We give the HMP75 15 – 20 minutes to acclimate to the chamber's conditions and then come back to compare the readings from the chamber sensor and the HMP75 probe. If we find there is variation in the readings, we replace the chamber's sensors. All readings are noted on the spreadsheet referenced in the lighting section.

Vaisala M170 indicator (left) with HMP75 Temperature and Humidity Probe (middle) and GMP70 CO_2 Probe (right).

(Photo M. Mucci)

Checking growth chamber CO_2

Twenty-one of our growth chambers are equipped with the additive CO_2 capability. Before an experiment involving additive CO_2, we ensure that the injection mechanisms as well as the exhaust damper motors are functioning properly. We then use the Vaisala M170 indicator along with the GMP70 probe to check the accuracy of the chamber's CO_2 sensor. We place the GMP70 probe as close as possible to the chamber's CO_2 sensor (in some models where the aspirator is not located in the growing area the

chamber sensors are all located in the machine compartment aspirator and in smaller chambers where the aspirator is in the growing area, the manufacturer has put the CO_2 sensor in a separate location, to avoid any chance of it getting wet – they are expensive!). Again, we allow the GMP70 probe to become acclimated to the chamber's conditions and then compare the reading to the chamber's sensor. If the chamber sensor has drifted more than +/- 3%, we remove the sensor for re-calibration. With the Vaisala GMK220 CO_2 calibration unit, we are able to re-calibrate our CO_2 sensors on site in about 30 minutes.

CO_2 sensor ready for recalibration using the Vaisala GMK220 calibration unit

(Photo M. Mucci)

Conclusion

Overall, the regular testing and calibration of our growth chamber sensors requires a lot of work, but it does allow us to catch problems early, before they cause problems for the researchers. In addition, providing the researchers with an overview of our sensor checks in their chamber, gives them the confidence that they are beginning an experiment with the environmental conditions they requested. In all cases, we encourage the researchers to continually check conditions throughout their experiment and report them in their publications as outlined in the "Minimum Guidelines for Measuring and Reporting Environmental Parameters for Experiments on Plants in Growth Rooms and Chambers" article published by the NCERA-101 organization.

Archival photo: View of Alexander Hall and Science Complex Atrium/West Wing Construction, September 2005 (M. Mucci).

Archival photo: Alexander Hall greenhouse, June 2006; ~1 year before closing (M. Mucci).

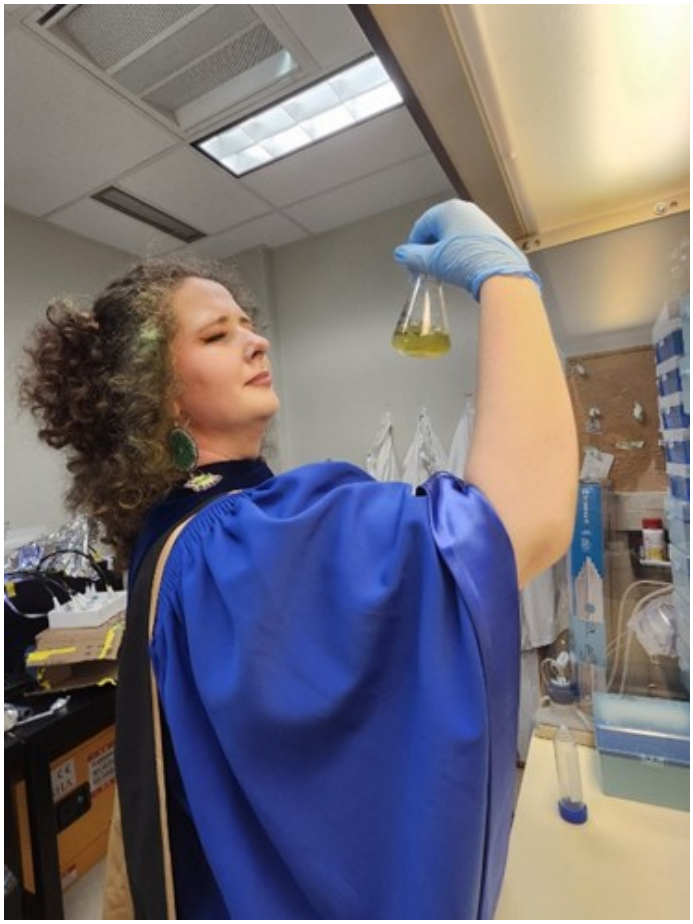
Phytotron Researcher Profile: Kathleen Nolan

Describe your education and career path that has led you to your current research

After finishing Grade 12 at the only high school in Castlegar, BC, I moved to Guelph to complete a BSc. I originally planned to pursue the co-op Biochemistry program, but after taking BIO 1070, I realized that my true passion was for biodiversity – I wasn't as keen on biochemical lab work as I thought I'd be, and I recognized that my true happy place was stomping around in bogs looking for bugs and other interesting creatures. In second year, I decided to transfer into the Biodiversity program, where I completed a capstone project, an independent thesis, and a field course in Churchill, MB. At the same time, I completed a minor in Mathematical Sciences, which gave me a strong foundation in statistics, calculus, and computer programming. I volunteered in several research labs, including Dr. Andreas Heyland's lab supporting algal research, and Dr. Bob Hanner's lab supporting DNA barcoding fish specimens. Once I graduated from my undergraduate program in April 2020, I started grad school right away, pursuing a MSc in Integrative Biology through the Heyland and Hanner labs. After working on my project for a few months, I realized I wanted to answer broad questions that necessitated a longer program, so I transferred into the doctoral program and completed my qualifying exam. Since then, I've been working to characterize algal communities using diverse, integrative methods.

Describe your research. What are your primary research questions?

I'm absolutely obsessed with aquatic biodiversity – especially with respect to the complex interactions between species, trophic levels, and habitats. My research focusses on the biodiversity of microalgae, a generally underappreciated and taxonomically complicated group of organisms. I'm using DNA metabarcoding in conjunction with more traditional approaches like strain isolation, microscopy, and flow cytometry to assess harmful algal blooms (HAB) in a small temperate lake. My aim is to identify key microbial contributors to HABs, from prokaryotic and eukaryotic domains, and to assess how microbial biodiversity interacts with and informs environmental parameters through space and time. If I were to sum it up in simple terms, my research asks: *Who are those little green guys, what are they doing, and why are they doing that?*



Kathleen in the lab. (Photo K. Munford)

Describe your work in the Phytotron. What more needs to be done to complete your current research project?

I have been working in the Phytotron since 2017. My work has been mainly dedicated to the maintenance of algal cultures, which we have used for a variety of purposes, including but not limited to feeding sea urchins, conducting UV-C treatments and photobioreactor experiments to assess water treatment technologies, and conducting large-scale biodiversity

studies on algal isolates from environmental samples. We have published many novel insights from these cultures, characterizing the physiology and growth responses of strains under diverse conditions, and revealing that microalgal biodiversity could serve as a meaningful link between microbial diversity at eukaryotic and prokaryotic levels during ecological assessments. My current research project is largely complete, and I encourage folks who are interested in microalgal biodiversity to come out and listen to my defense presentation which will likely fall sometime in January 2026.

Water colour artwork created using pigments derived from algal cultures. (Photo K. Nolan)

What is your favorite research tool or piece of scientific equipment that helps you carry out your research? Would your work be impossible without this equipment?

My favourite piece of research equipment isn't the scary centrifuge or intimidating autoclave, but rather, the humble pipette. Without this seemingly simple piece of equipment, my research would be impossible, because I would not be able to aliquot precise volumes of liquid, which is an essential task for reactions like PCR or ultra-dilution for algal isolation. Daily, I offer myself to the shrine of the pipette, praying to the pipette gods for mercy as I illuminate my electrophoresis gels to discover the fate of my reactions, and ultimately, my project. So far, they have been merciful, and I hope this continues!

If you had access to unlimited time, funding and equipment, where would you like to take your research? What questions would you like to tackle?

Throughout my life, I've been able to visit many very interesting northern ecosystems, including in BC, Ontario, Manitoba, and Newfoundland & Labrador. I would love to spend more time exploring Arctic ecosystems, and I am especially interested in the microalgal communities that live on sea ice and glaciers. The fact that biodiverse microalgal communities thrive in these seemingly challenging conditions inspires me, and I'm eager to characterize these unique ecosystems before we lose them to climate change.

What is your favorite plant?

How can someone choose a favourite plant? I admire and require many plants. However, I have a soft spot for plants that don't photosynthesize, because I like that they don't do what people expect. Some plants parasitize other organisms to obtain sugar instead of making it from sunlight, which I find extremely cool. The first plant that I encountered in this category was the ghost pipe (*Monotropa uniflora*), and it left a lasting impression on me. I've always been partial to biological rule-breakers, and a plant that can't (or won't) photosynthesize is a wonderful example of why making absolute biological statements or definitions is often difficult, if not impossible.

Share something unique about yourself that isn't related to your research.

Outside of my research, I love creating art and making music. I play guitar and sing, among a bunch of

other artistic proclivities, and you can often find me at karaoke nights downtown or taking in live music across the GTA. I love to paint and create mixed-media compositions that showcase different aspects of the biological world, including this water colour piece overlayed with pigments derived from my algal cultures that I created for the student outreach competition at the 2024 Canadian Ecotoxicity Workshop.

Kathleen Nolan is a doctoral candidate in the Heyland lab, Department of Integrative Biology

Phytotron Researcher Profile: Emily Heagney

Describe your education and career path that has led you to your current research.

I completed my undergraduate degree in Biology with a research specialization at McMaster University. I completed an undergraduate thesis in the Dudley lab that investigated plant kin recognition and leaf dissection as a competitive trait in yarrow (*Achillea millefolium*). My undergraduate work sparked my interest in plant evolutionary ecology. Now, I am working on my master's thesis in the Caruso lab!

Describe your research. What are your primary research questions?

My research examines targets of selection under pollinator decline. Pollinators are experiencing population declines which can strengthen selection for plant traits that increase pollinator attraction. Inflorescence height may be one such trait. Previous work in the lab has found there is stronger selection for taller inflorescences under pollinator decline. However, height may be correlated with another trait that is actually the target of selection, rather than being the target of selection itself. My research questions are:

Lobelia siphilitica plants during the field experiment at the R.J. Hilton center. (Photo: E.Heagney)

Is inflorescence height a target of selection under pollinator decline?

Do bumble bee pollinators preferentially visit taller inflorescences over shorter ones?

Describe your work in the Phytotron. What more needs to be done to complete your current research project?

I grew *Lobelia siphilitica* plants to be used in a field experiment in which I did a phenotypic height manipulation and simulated pollinator decline. I collected pollen from *Lobelia siphilitica* plants in the Phytotron to pollinate some of the plants in the field. I also conducted pollinator observations. The field portion of the experiment is done, but I still need to count and weigh the seeds collected from the field before I can determine if height is a target of selection.

What is your favorite research tool or piece of scientific equipment that helps you carry out your research? Would your work be impossible without this equipment?

My favourite research tool is the mesh pollination bags I used to simulate pollinator decline in the field. They were a key part of my project, and I wouldn't have been able to complete it without them. They allowed me to create differing pollinator abundances at the same site. The irrigation system in the Phytotron was also extremely helpful in completing my research!

If you had access to unlimited time, funding and equipment, where would you like to take your research? What questions would you like to tackle?

If I had unlimited time funding and equipment, I would love to introduce some environmental stressors, such as nutrient deficiencies or drought, to the experiment to understand if and how these stressors impact selection. I would also like to replicate these experiments in other plant species to see if similar patterns emerge in plants pollinated by other insects or mammals.

What is your favorite plant?

My favourite plant is the sensitive plant (*Mimosa pudica*). Their leaves fold inwards when they are touched or shaken. They're very neat plants!

Share something unique about yourself that isn't related to your research.

When I am not working on my research or schoolwork, I love doing pottery!

Emily pictured with Lobelia siphilitica seedlings.

Emily Heagney is a Masters student in the Caruso lab, Department of Integrative Biology.