

Vincent E. Ziffle  
Indigenous Knowledge and Science Program  
First Nations University of Canada



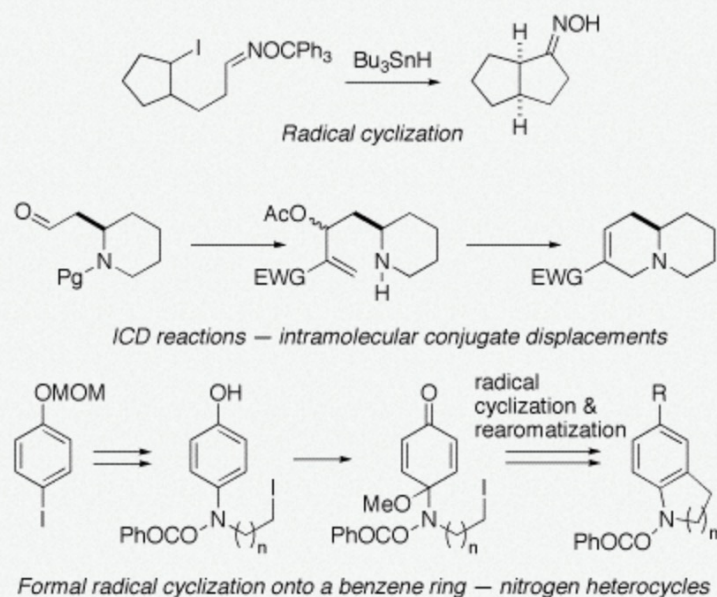
▶ **Chemistry and Indigenous Knowledge:** Development of Novel Chemistry Courses and Labs Highlighting Indigenous Traditions in Food, Medicine and Fine Art



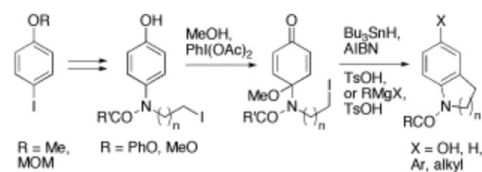
Skylight Speaker Series  
Faculty of Science  
October 26<sup>th</sup>, 2022

# Organic Synthetic Methodology

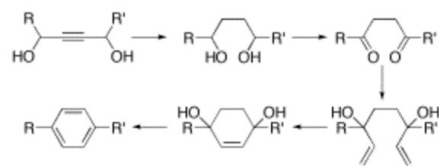
## Methodology:



184. Synthesis of Diverse 2,3-Dihydroindoles, 1,2,3,4-Tetrahydroquinolines and Benzo-fused Azepines by Formal radical Cyclization onto Aromatic Rings. Clive, D.L.J.; Peng, J.; Fletcher, S.P.; Ziffle, V.E.; Wingert, D. *J. Org. Chem.* **2008**, *73*, 2330-2344.



200. Conversion of 1,4-Diketones into *p*-Disubstituted Benzenes. Ziffle, V. E.; Cheng, P.; Clive, D.L.J. *J. Org. Chem.* **2010**, *75*, 8024-8038.





First Nations University of Canada  
atim kê-mihkosit (Red Dog) Urban Reserve

*Situated on Treaty 4 Territory, the original  
lands of the Cree, Saulteaux, Dakota, Lakota,  
Nakoda, and homeland of the Métis Nation*



## Challenges Faced in Introductory Chemistry at FNUniv and Elsewhere

- Connecting disparate subject matter
- Rapid development of higher-order cognitive skills (HOCS)
- Balance of theory and application: connecting *principles to practice—*is it relevant?**
- Lack of experiential elements in lesson plan

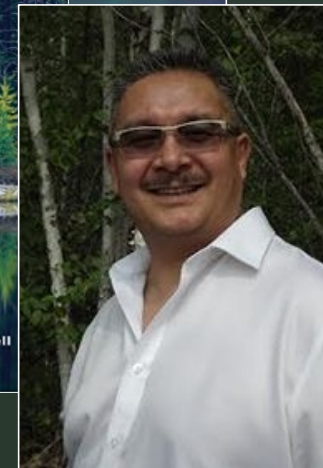
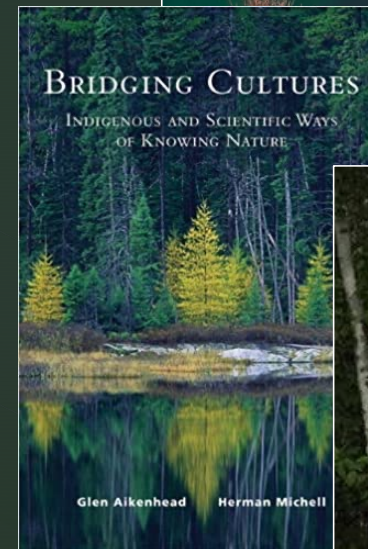


- Conventional scientific worldview is not exclusive way to view nature/NSE
- Use of “either/or” dichotomy undermines Indigenous Knowledge and Science within conventional coursework
- Limited pedagogies for ~~The~~ Many Ways of Knowing in science curricula: Traditional Ecological Knowledge (TEK) and scientific past-practice often orthogonal

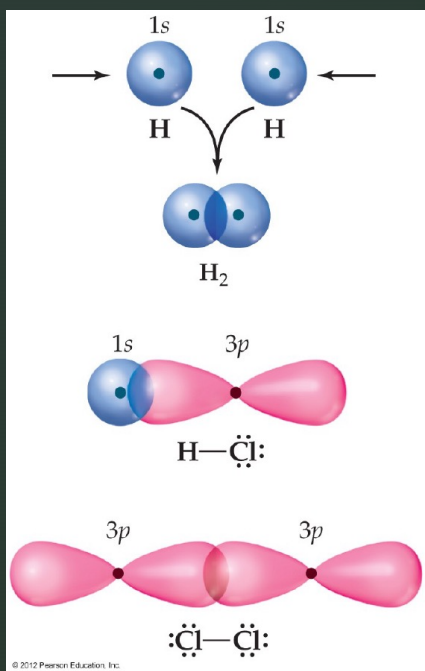
## Direction from Dr. Herman Michell

- More than one Knowledge System combined meets challenges or tasks better than one alone
- Students and teachers can produce “hybridized” knowledge, creatively combining parts as required
- Indigenous Science and science “are no longer binary”
- Two-eyed Seeing has become “Multi-eyed Seeing”

Aikenhead, G.; Michell, H. *Bridging Cultures: Indigenous and Scientific Ways of Knowing Nature*, Pearson, 2011

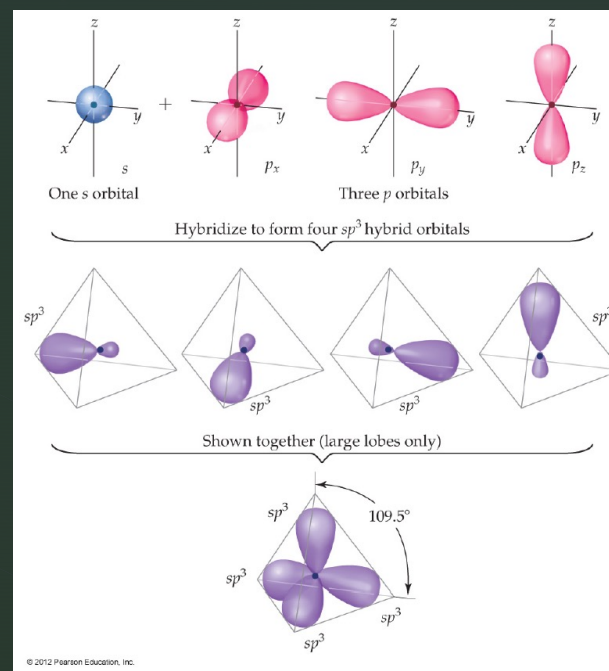


## So Too, Hybridization Allows Stable, More-complex Structures



Some relationships thrive in inflexibility (read: status quo)...

...but *many* require integration (read: multiple skill-sets) to get the orbital angles right!





Elder Norma-Jean Bird

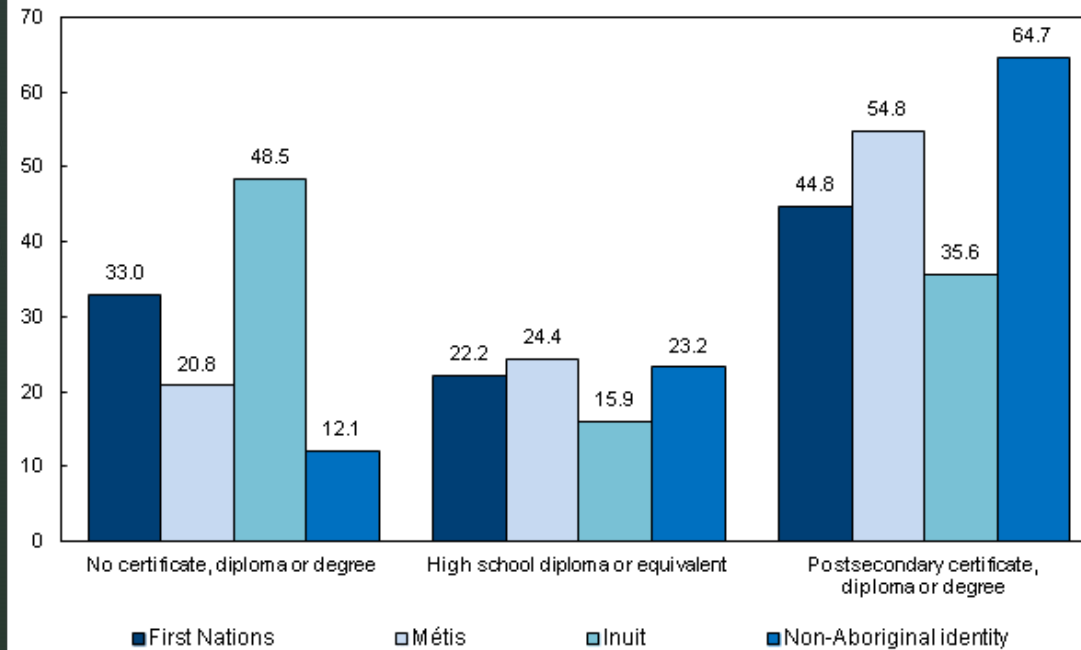


- Marginalized and equity-seeking groups have been disproportionately impacted by the ongoing COVID-19 pandemic
- A shift from in-person courses and experiential pedagogies to remote, online, distanced “learning” is challenging in many ways
- Resilience through community, Ceremony, Elders and other Traditional Knowledge Keepers



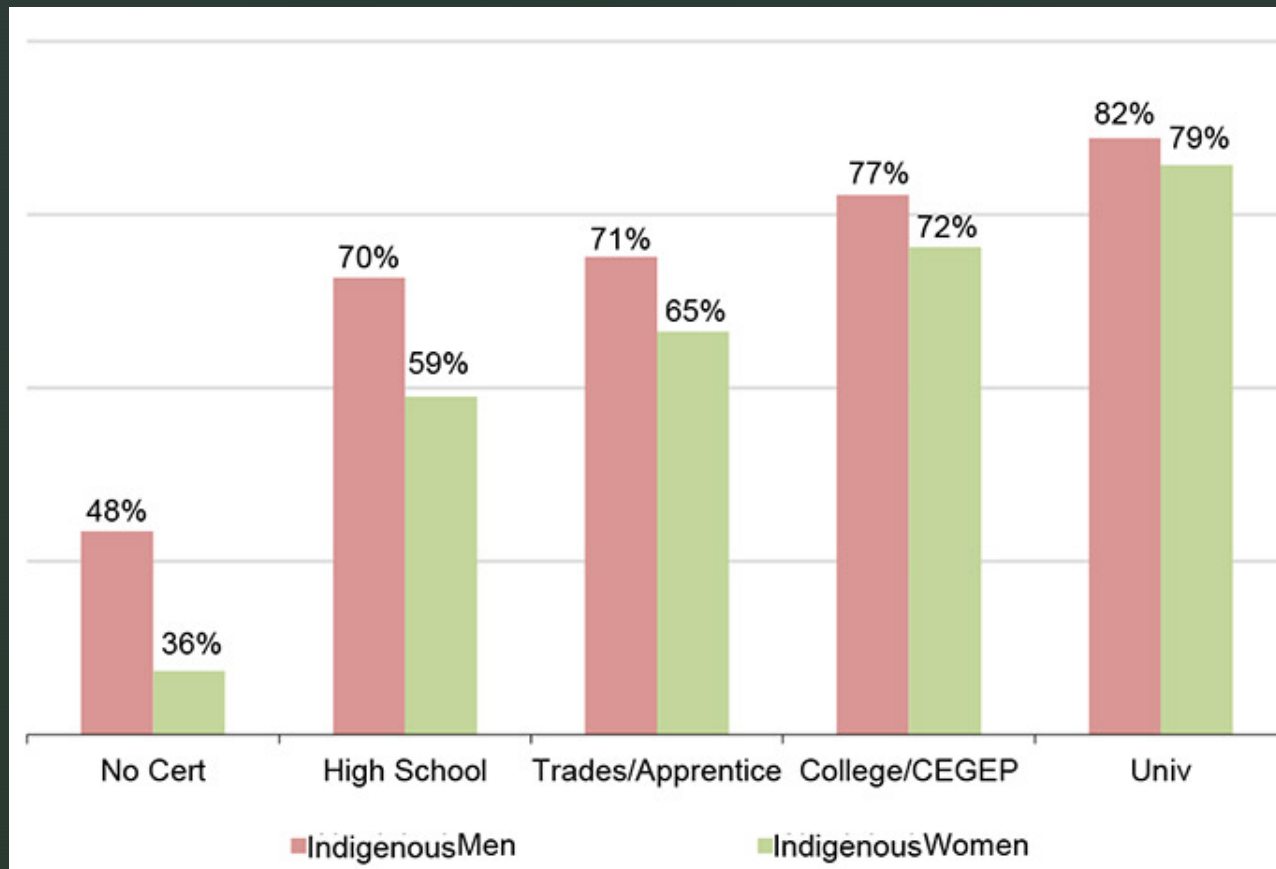
**Chart 13**  
**Highest level of educational attainment, population aged 25 to 64**  
**years, by Aboriginal identity, Canada, 2011**

percent



**Notes:** Excludes data for one or more incompletely enumerated Indian reserves or Indian settlements.  
 'High school diploma or equivalent' refers to graduation from a secondary school or equivalent. It excludes persons with a postsecondary certificate, diploma or degree.  
 'Postsecondary certificate, diploma or degree' includes 'apprenticeship or trades certificates or diplomas', 'college, CEGEP or other non-university certificates or diplomas' and 'university certificates, diplomas and degrees'.  
 The three Aboriginal groups are based on the population reporting a single identity of 'First Nations,' 'Métis,' or 'Inuit.'

**Source:** Statistics Canada, National Household Survey, 2011.



Employment Rates for Indigenous Population 24-65 Years Old by Gender\* and Highest Level of Certification, Stats Canada 2011

- “Indigenous people continue to be underrepresented in STEM occupations, which carry political as well as economic weight in our society.” (FSC, Indigenous Foundation 2019)
- “Indigenous representation in STEM careers is roughly two percent and Indigenous women make up about a third of Indigenous people enrolled in STEM-related education.” (*lightsource.ca*, Saskatchewan MentorSTEP program)

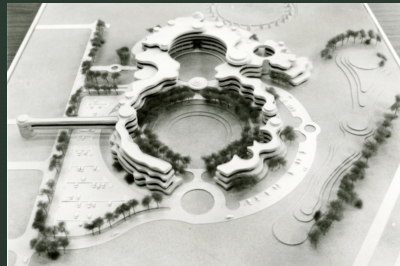
From Saskatchewan Indian Federated College (1976-2003) to First Nations University of Canada (2003-present)



Milton Tootosis and Elders



Architect Douglas Cardinal w/Dr. Blair Stonechild (right)



From concept to reality...





From combustion to  
*Home Fire...*



University of Regina AdHum "Pit", early 80's



# First Nations University of Canada

- Campuses on Treaty 4 and Treaty 6 territories
- Offer courses from all disciplines, including math, statistics, biology and chemistry
- Unparalleled access to Indigenous Knowledge for students interested in science and Many Ways of Knowing





Elder Betty McKenna



## Bringing Together Experiential Learning and Indigenous Knowledge

- Working with Elders and other Traditional Knowledge Keepers in class, laboratory and field
  - Successful incorporation of Indigenous Knowledge in science classes strengthening course content

# High-Altitude Balloon Experiment



Nakoda Oyade Education Centre, Carry the Kettle (2016-2019)  
HABEx supported by NSERC PromoScience

S. Cheng, F. Gendron, V. Ziffle and D. Gerhard. Engaging Indigenous Youth in Science with the High Altitude Balloon Experiment.

*Creative Education* 2019, 10, 319-331.

S. Cheng, D. Gerhard, F. Gendron and V. Ziffle. Incorporation of High Altitude Balloon Experiment in High School Science Classrooms.

*Creative Education* 2019, 10, 262-272.





Carry the Kettle FN →  
Cowessess FN  
**80 km**



Carry the Kettle FN → North Dakota/US Border  
**280 km**

## LTS Indigenous Outreach in STEM



Volunteer Outreach supported by FNUniv and Faculty of Science, reaching nearby and distant Education Centres





## CHEM 101: Chemistry of Food and Cooking

- Combination of Chemistry and Food and Cooking Still Unprecedented in Western Canada
- Food Science + Food Chemistry: A mature subject
- Precedent at Queens University (Joseph A. Schwarcz) Harvard and HarvardX Online (*Science and Cooking: From Haute Cuisine to Soft Matter Science*)
- Many useful texts and cookbooks—many highlighting Indigenous Food Traditions



First Nations University of Canada

*tradition innovation leadership*

## Chemistry of Food and Cooking - Fall 2023

CHEM 101-S01/S02, Tues./Thurs., 13:00-14:15, FN 3002

Lab: Tues. 14:30-17:15, Wed. 11:30-14:15 & 14:30-17:15

Lab Location: First Nations University of Canada, FN 1010



**Course Description:** An introductory science course connecting chemical and biochemical principles with food and its preparation. Major components of food (lipids, proteins, carbohydrates, water) will be discussed alongside chemical foundations (atomic structure, acids and bases, enthalpy, reactivity). Traditional Knowledge of food preparation by First Nations will also be explored. Lab component: A kitchen-based food lab will highlight the scientific method. **Prerequisites:** CHEM 30 or CHEM 100 (minimum 65%), BIOL 30 (minimum 65%). Note: CHEM 101 serves as a Natural Sciences requirement for Faculty of Arts Core Curriculum. Biochemistry and Chemistry majors can use this course in their program as an open elective only.

**Why Take CHEM 101 at First Nations University of Canada:** CHEM 101 offers an opportunity for non-Science majors to take an introductory science course with a lab component that links food chemistry, the culinary arts, nutrition and First Nations food traditions in a unique setting. The innovative "food labs" will occur *on-campus* in an experimental kitchen where you will have a chance to use chemistry to improve food and cooking. Students will be able eat their experiments and see and sample the cooking of guest Traditional Knowledge holders and chefs. This hands-on course will provide key chemical foundations and plenty of practical know-how for use in the lab, kitchen and anywhere you prepare and/or eat good food.

## CHEM 101 in a nutshell:

- 2 x 1h 15m class component
- In-class demos, guest speakers/Traditional Knowledge Keepers
- 5 x Remote Food Labs
- End-of-semester term paper: Indigenous Science of food and cooking paired with Indigenous Food Traditions
- Working with Cooks and Chefs (CCF)





## Topics Covered

1. A Brief History of Food and Cooking
2. Measurement and Calculations
3. Introduction to Food Chemistry
4. From Growing Grass to Breaking Bread
5. Advanced Reactions in Food: Acids and Bases
6. Chemical Reactions in the Context of Cooking: Defining the key chemical transformations of food when heat and other factors are applied.
7. The Science of Taste and Smell: Molecular mass and other properties as a determinant in the strength of scent of aromatic molecules

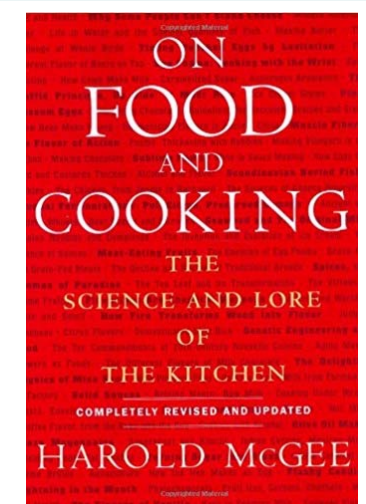
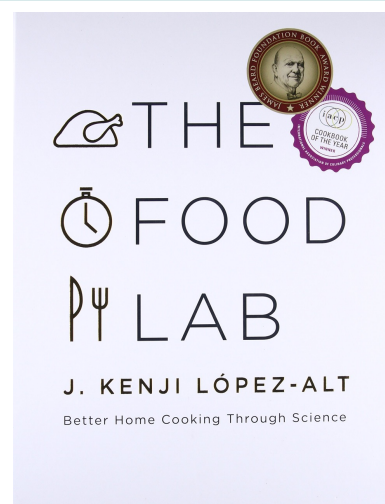
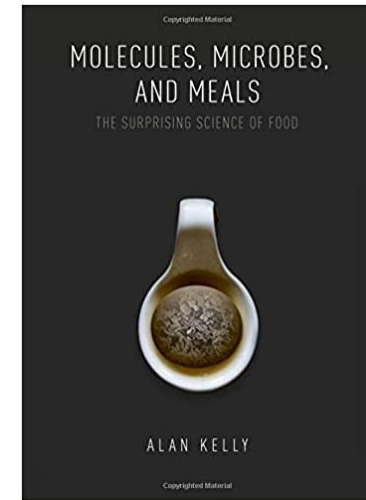
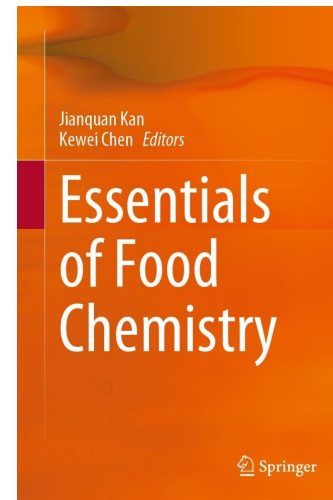


## Topics Covered cont'd

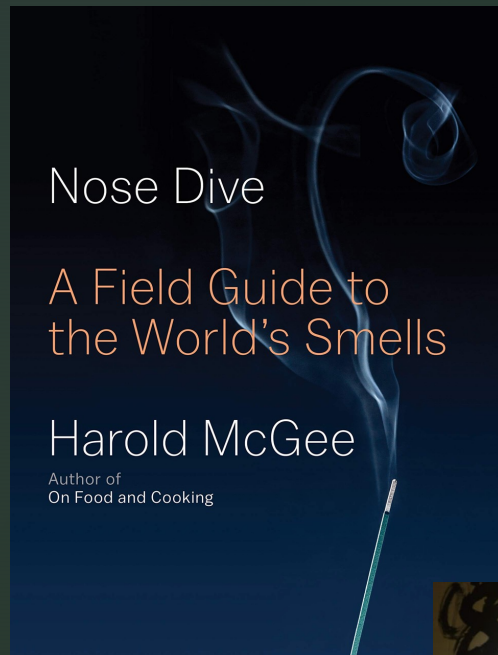
8. Fruit and Vegetables as the Ideal “Ready-Cooked” Food
9. Eggs and their Numerous Applications in Cooking: The biochemistry of the egg as a reproductive vehicle and energy powerhouse
10. From Milk to Butter, Cheese, Yoghurt and Sour Cream
11. Meat and Fish
12. Selected Topics I: Chemical Reactions in the Context of Metabolism
13. Selected Topics II: Bread, Cakes and Pastry

# Food for Thought: Required Reading

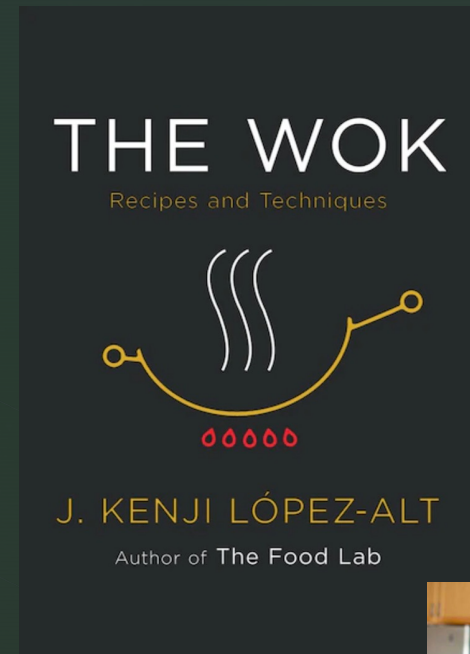
- Harold McGee's seminal text: ideal reference throughout the course
- Kan and Chen for fundamentals
- **FNUiv Libraries:** >100 texts in the growing Food Science and Indigenous Food Traditions section



...and the Food Science Classics don't stop there!



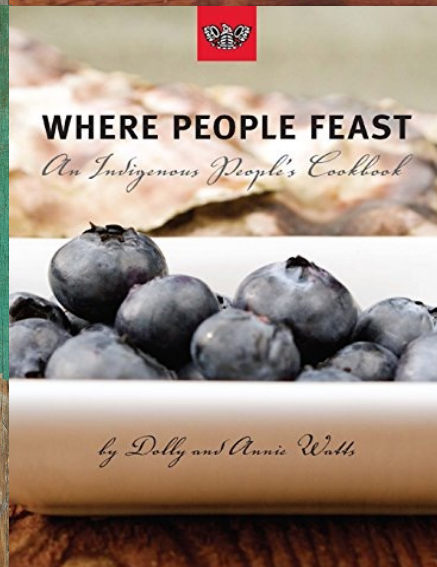
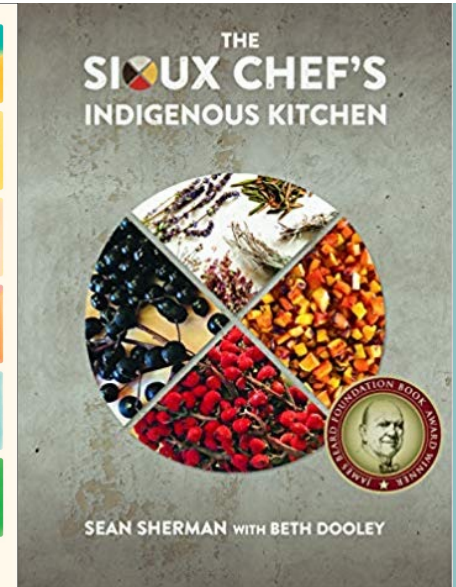
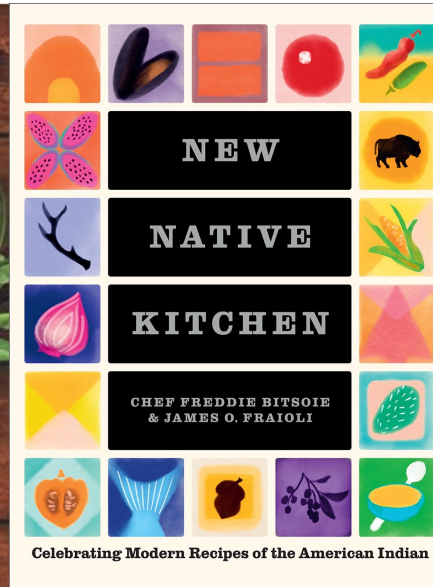
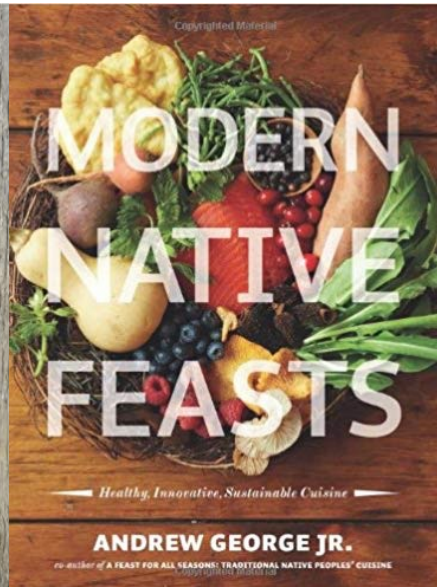
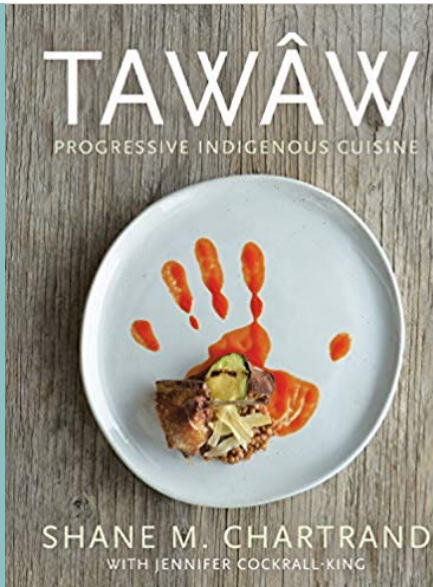
Harold McGee, 2020




Kenji López-Alt, 2022









Many Cookbooks on Indigenous Food Traditions—and the Number is Growing as well!



Chef Shane Chartrand



Chef Freddie Bitsoie



Chef Sean Sherman



Chemistry of food and cooking and Indigenous Food Traditions are important chemical education research interests



# In-class Experiential Learning





## Chemistry of Food and Cooking: Recipe Development and Analysis

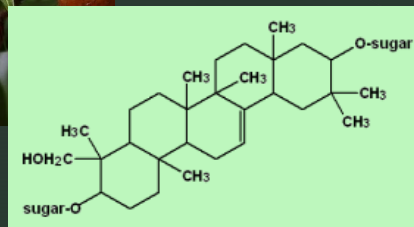
- Research is an extension of curriculum building for *CHEM 101: Chemistry of Food and Cooking* classes and labs
- Mitacs Research Intern Antonio Cillis (Berlin) contributed to recipes focused on development of *kokumi* mouthfeel and umami taste, and contributed to a major document on the chemistry of scent and taste (flavour) and the thermophysics of cooking
- **Indigenous cuisine** a start-point for the project



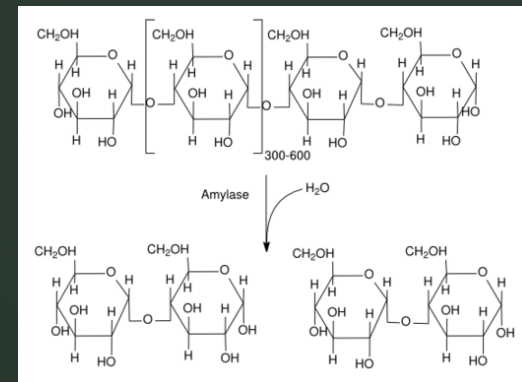
# Soapberry (Buffalo Berry) Ice Cream



Saponin surfactants create  
Stable "ice cream" foam



It is known that Buffalo Berries taste best (sweetest) after first frost—maltose is a cellular *cryoprotectant* decreasing  $A_w$



## Smoked Deer (Venison) and Pemmican



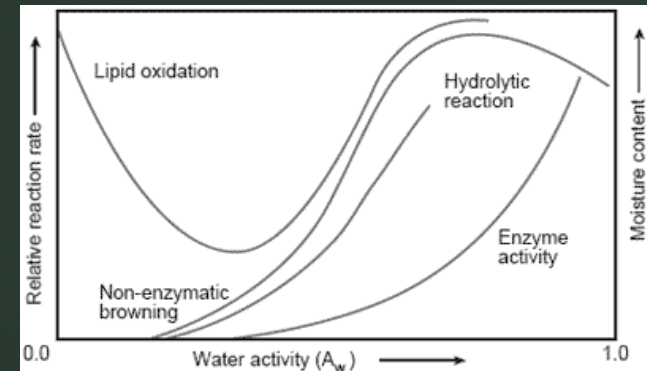
Pemmican was a staple in the NA prairie region (Plains Cree)

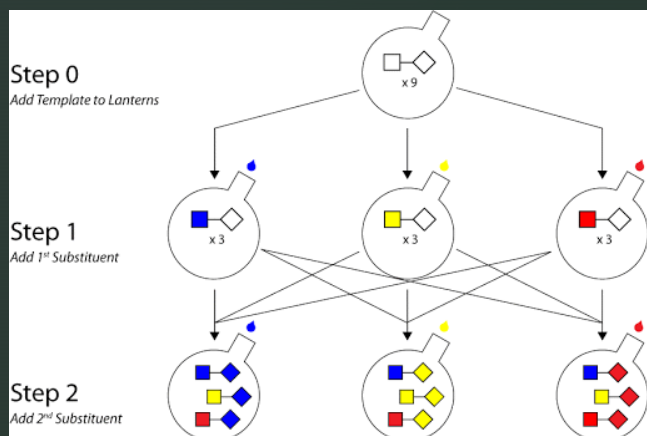


4 oz (~100 g) =  
700-800 Cal =  
<math>8 \times 10^5</math> cal



Pemmican is dried/smoked Deer or Buffalo (ground to powder) distributed in fat, w/added dried berries, etc. W/o berries or sugar, it can have a storage life of several years





Combinatorial chemistry can be Useful in the kitchen in formulating Pemmican and other recipes!



**David Chapman**  
@Meaningness



Applying my background in combinatorial chemistry to the optimization of pemmican [#paleo](#)



5:49 PM · May 14, 2017



26



See David Chapman's other Tweets



## The Three Sisters: Corn, Beans and Squash



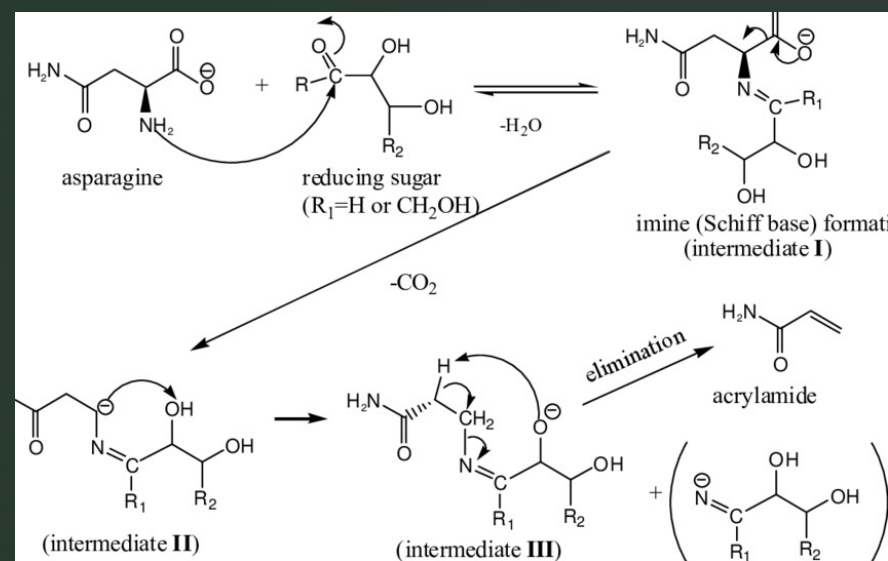
- Corn supports the “Pole” Beans, Squash conserves water, Beans provide nitrogen for Corn
- Precise times for planting in sequence





Fun with the **Maillard reaction!** Reducing sugars and amino acids/peptides unite to form 100+ flavourful organic molecules

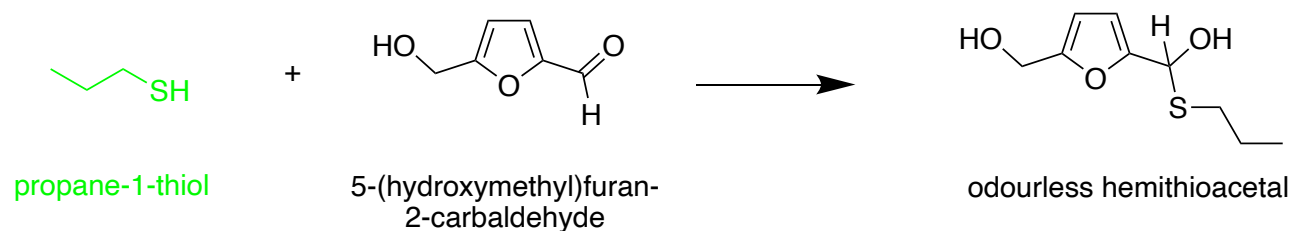
Cooking steak also allows for use of food technologies like sous vide and Searz-all®. Thermodynamics also plays role.



## Taming the King of Fruits: Durian



The protective outer layer of the Durian protects our noses, as well--the spiked skin contains Aldehydes that neutralize thiols!





## An Atypical Chemistry Laboratory

1. Accuracy and Precision of Measurements / Chemistry of Eggs / Recipe: Perfect Poached Eggs
2. Chemistry of Browning / Thermochemistry of Cooking / Recipe: Homemade Caramels
3. Synthesis of Gluten / Recipe: Perfect White Bread Loaf (not attempted) / Recipe: Traditional Bannock
4. Concentration of Sugars / Acids, Bases and pH / Recipe: Sugar-free or Low-sugar Soymilk
5. Various Recipes: Final Team Project / Stoichiometry and Limiting Reagents in the Kitchen (using small burgers/"sliders" instead of hummus and pita)/ Independent recipe projects

Stephen C. Cheng, Vincent E. Ziffle and Ryan C. King. Innovative Food Laboratory for a Chemistry of Food and Cooking Course. *Journal of Chemical Education* 2020, 97, 659-667.

## Food Lab Kits in Development



We were able to put the labs in the hands of our students across Canada.

So far, feedback has been positive—we are working on version 1.2



## Medicinal Plant Research and OCAP®

- The First Nations Principles of OCAP®: Ownership, Control, Access and Possession of data collection and handling processes



- Collaboration with Drs. Omar El-Halfawy and Fidji Gendron  
*“Uncovering Novel Biofilm-associated Virulence Factors and Exploring Indigenous Remedies to Target Bacterial Wound Infections”* (SSHRC NFRF, 2022)



## In the Field



Protocol always



Mitacs Research Intern Matheus Belin (Sao Paulo) and Harold Lavallee  
(Summer, 2019)

Teachings and guidance  
from Harold Lavallee



Wild Sarsaparilla  
Rabbit Root  
(*Aralia nudicaulis* L.)

Roots → energy  
Good for men  
Blood circulation medicine



Wild Red Raspberry  
(*Rubus idaeus* L. Var.  
*Strigosus* (Michx.)  
Maxim.)

Roots → Women  
medicine  
Cleans internal sexual  
organs for fertility



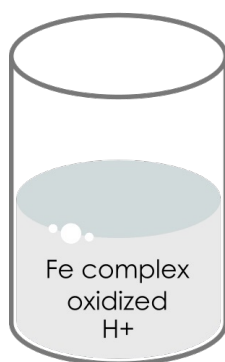
Prairie Rose  
(*Rosa arkansana*  
Porter)

Red and ripe berries →  
↑ vit C  
Bark → eye sickness

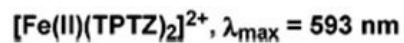
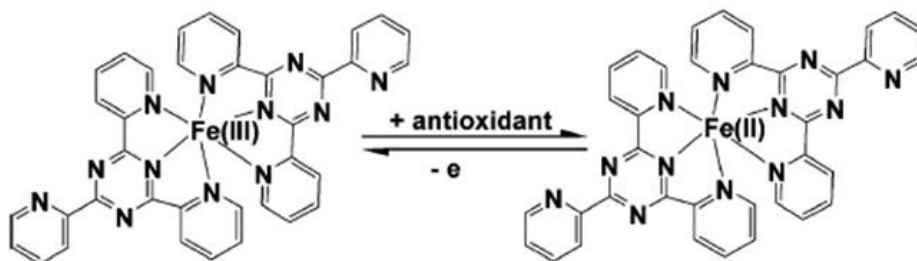
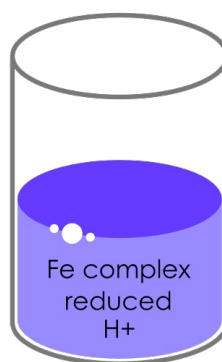


# UV-Vis Analysis

Uncoloured

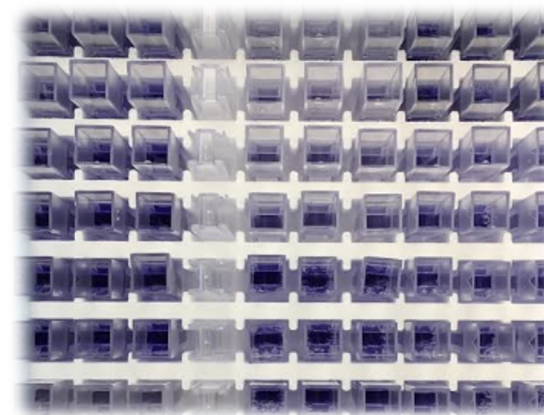


Antioxidant



Total antioxidant capacity (**FRAP**)  
**f**erric **r**educing **a**ntioxidant **p**ower

**Hydrophobic**  
 (mostly)



Benzie and Strain, *Analytical Biochemistry*, 1996



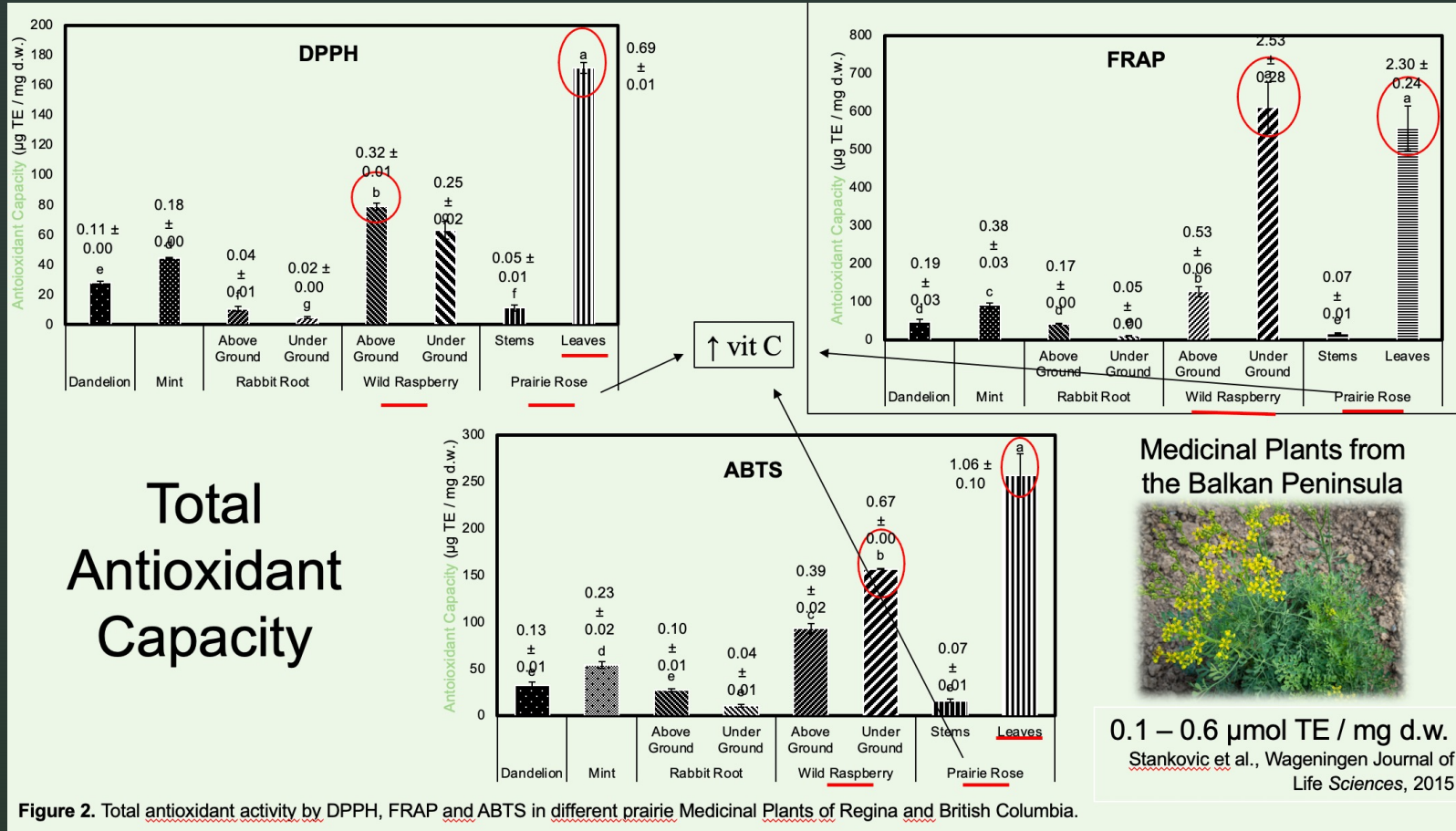
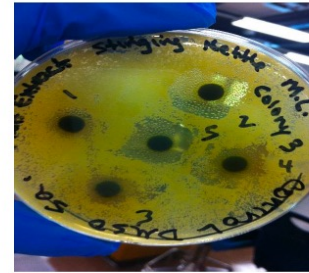


Figure 2. Total antioxidant activity by DPPH, FRAP and ABTS in different prairie Medicinal Plants of Regina and British Columbia.

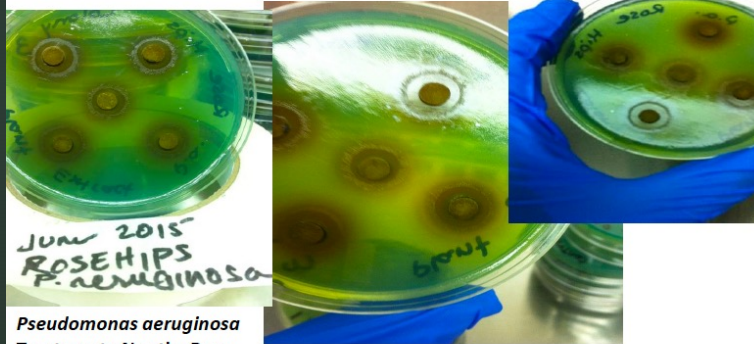
Belin, M.A.F, Gendron, F., Cheng, S, Ziffle, V. Total phenolic compounds, carotenoids and in vitro antioxidant activity of three Canadian Traditional Indigenous Medicinal Plants *Am. J. Plant Sci.* 2021, 12 (8), 1197-1209.



*Micrococcus luteus*:  
Treatment: Nootka Rose



*Micrococcus luteus*  
Treatment: Stinging Nettle



*Pseudomonas aeruginosa*  
Treatment: Nootka Rose



*Pseudomonas aeruginosa*  
Treatment: Stinging Nettle

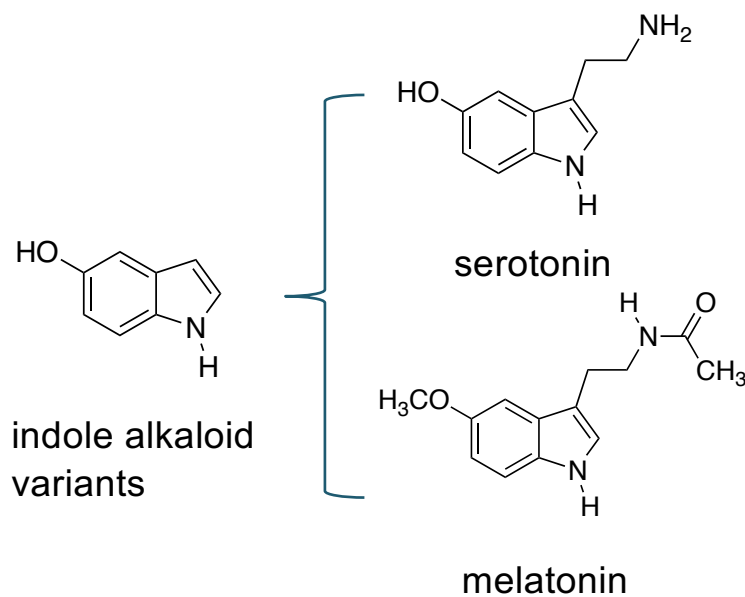
Gendron, F.; Nilson, S.; Ziffle, V.; Johnny, S.; Louie, D.; Diamente, P. Antimicrobial Effectiveness on Selected Bacterial Species and Alkaloid and Saponin Content of *Rosa nutkana* C. Presl (Nootka Rose) and *Urtica dioica* L. (Stinging Nettle) Extracts *Am. J. Plant Sci.* 2021, 12 (5), 720-733.

## Organic Chemistry of Medicinal Plant Secondary Metabolites

- Extension of Chemical Survey of Medicinal Plants project using those picked with the assistance of Elder Betty McKenna, Elder Archie Weenie and Harold Lavallee
- Work by Research Intern Pasha Reheda (Kiev) on environmentally benign extraction of indole alkaloids for purification and elaboration
- Seeking natural starting materials for conventional synthesis and source of privileged structures
- Collaboration with Drs. Omar El-Halfawy and Fidji Gendron “Uncovering Novel Biofilm-associated Virulence Factors and Exploring Indigenous Remedies to Target Bacterial Wound Infections” (SSHRC NFRF, 2022)

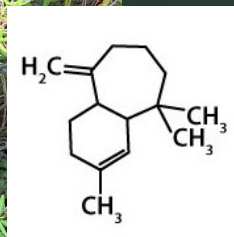
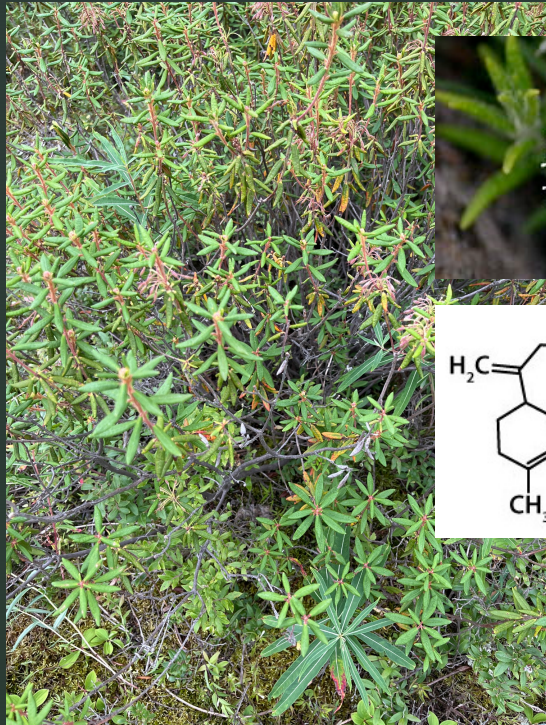


## Elaboration of Indoles and Other Alkaloid Secondary Metabolites



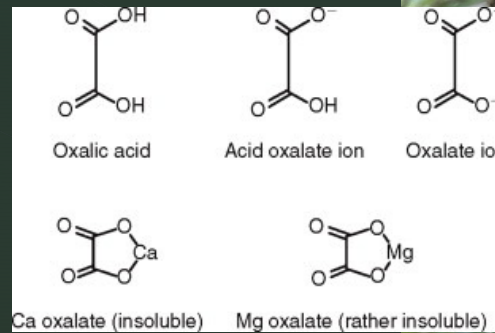
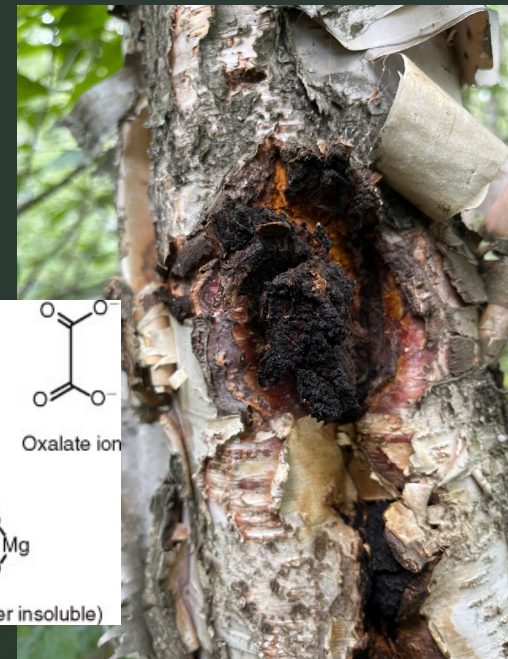
- Alkaloids extracted using green chemistry– waste is reduced in purification of basic indole alkaloids
- Organic synthesis using alkaloids as precursors for formal total synthesis

Medicine Walks with Elder Margaret Reynolds in English River FN and Lac La Plonge River



High in sesquiterpenes

Labrador tea (*Rhododendron tomentosum*)



High in oxalates and other nutrients

Chaga (*Inonotus obliquus*) on White Birch





Elder Margaret and Mitacs Globalink team



Mint (*Mentha canadensis*)



Clover (*Trifolium repens*)





On the hunt for Muskrat Root  
(*Acorus calamus*)

## Medicine Walks with Elder Florence Allen and Lisa Bird Around Montreal Lake FN



Elder Florence and team



Rabbit Root (*Aralia nudicaulis* L.)

## Other Developments in IKS

- Minor in *Indigenous Knowledge and Science* at FNUniv
  - Multidisciplinary course: IKS 100 w/Indigenous Knowledge/TEK, Biology, Chemistry, Physics, Math; Labs w/Elders and other Traditional Knowledge Keepers
  - Collaborative course with Indigenous Fine Arts: Chemistry of Indigenous Dyes, Inks, Pigments

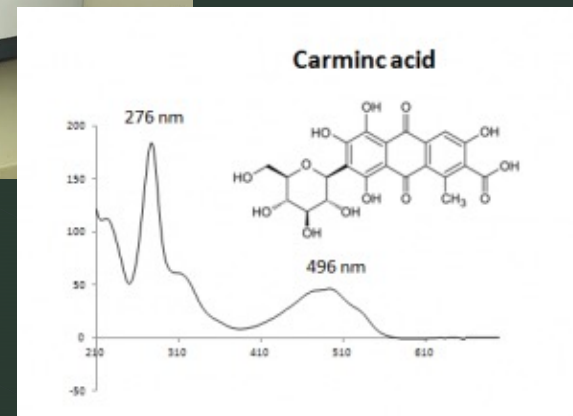
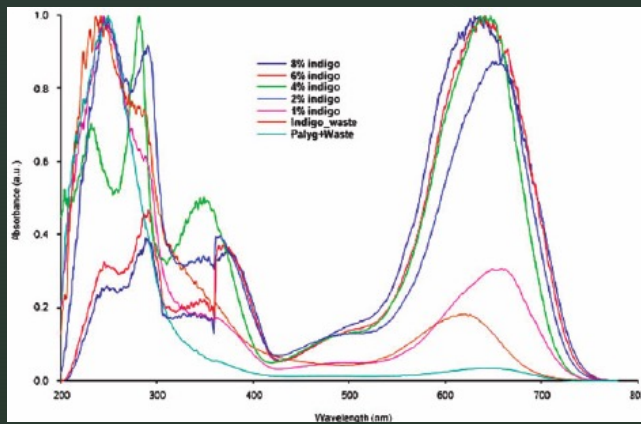


Natural dyed fabrics



Nancy Hager, Yukon Traditional Art





Carmine dye of cochineal beetle



# Making Connections: Interdisciplinary Collaborations for a More Holistic Approach to Science



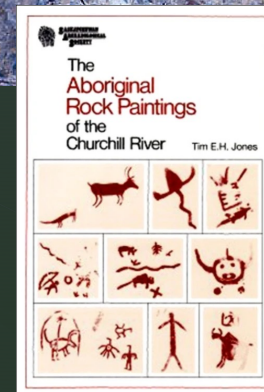
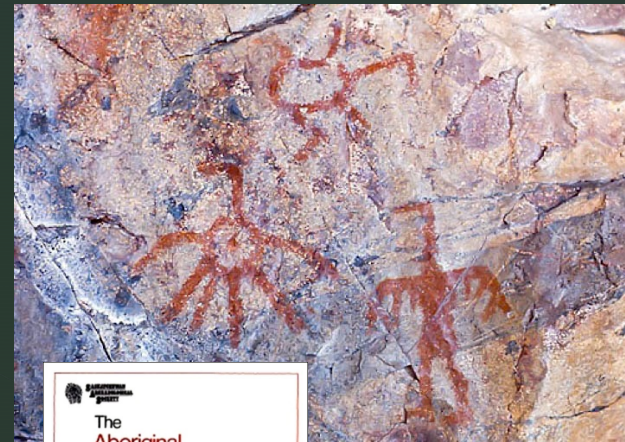
Common Walleye



Elder Betty McKenna



Moss and soil samples from Narrow Hills Provincial Park, summer 2021



Tim Jones and FNUiv IFA Program also provides guidance

Conversation with Elder Betty McKenna  
March 28th, 2022

I spoke with Elder Betty via zoom for around ten minutes, as there was a narrow window that aligned in our schedules. Since we had limited time, I chose not to ask to record the conversation. I mentioned how my attempts at making fish spine glue have not been working as intended. Elder Betty mentioned the following: there was no water or boiling happening, the fish spines were melted. The spines had to be fresh but have no meat on the bone as that would lead to rotting. Elder Betty suggested removing all of the meat with an exacto knife first and then melting the spine. The method she had used as a kid involved putting spine into an emptied can and balancing it on a rock by the fire as shown in Figure 1.

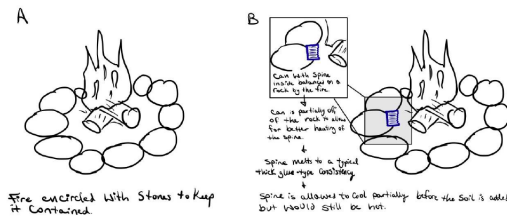


Figure 1. A sketch of the fish spine melting method that Elder Betty described. A) A fire encircled by stones to keep it contained. B) A can with a fish spine in it, fresh and cleaned of meat, balanced on the rock with around a third of the can hanging over the edge of the rock. This would allow for better heating of the bottom of the can.

The can would sit partially off of the rock, near the fire, to allow for better heating of the bottom of the can. Once the spine melts, it turns thick and sticky. The can is then removed from by the fire with two sticks to prevent burns to the person moving the can. It would then be allowed to cool for a while, though the fish spine would typically still be hot by the time the soil is added. The soil is a very black, fine soil with a texture almost like baby powder. The moss that indicates the soil is present has been getting harder to find due to ecosystem disturbances.

## Multiple Conversations with Elders and other Traditional Knowledge Keepers



Elder Betty McKenna



Laura Schnell

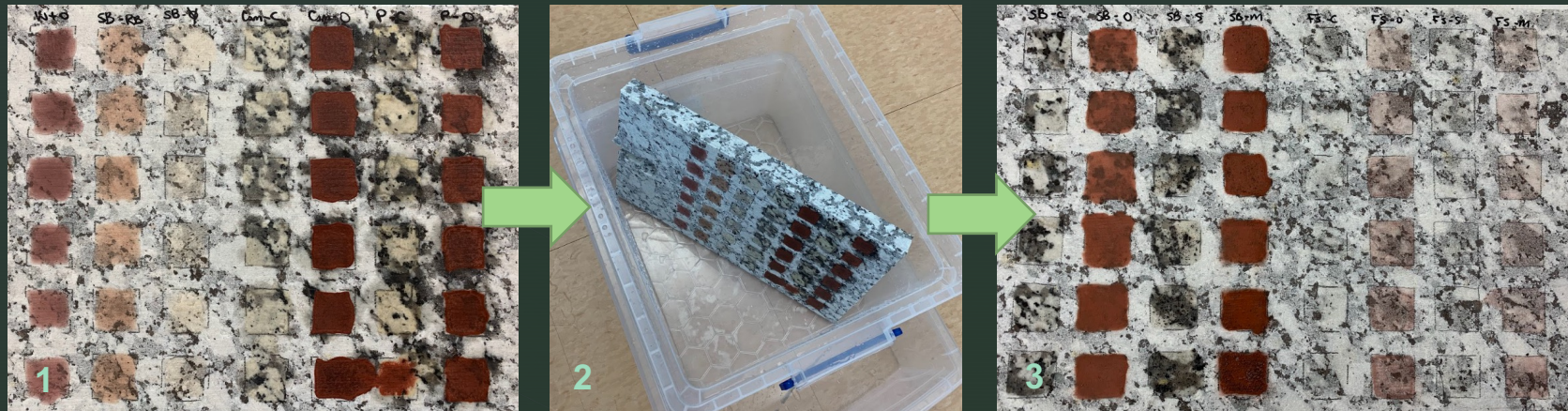


Erin Ennis

Also Tim Jones, Peter Brass, Lionel Peyachew, Audrey Dreaver, Jody Bellegarde and others



## Making Connections BIOC 391 Research *with* Laura Schnell

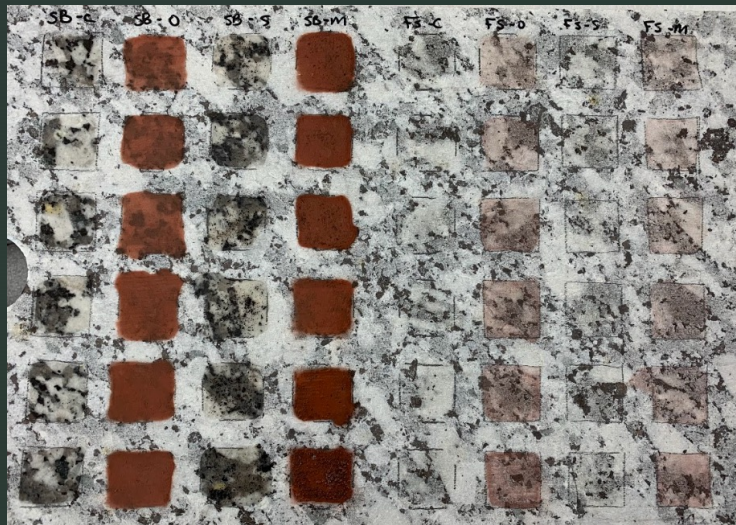


- Paint created using dark soil (analyzed at CLS by Raman – thanks to Joyce Macbeth) from under bright moss, mixed with “melted” fish vertebrae
- Ochre and swim-bladder also employed
- Simulation aging using plexiglass enclosure and water pump w/timer

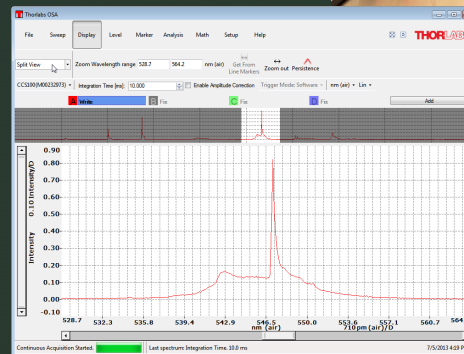


Peter Brass and Laura Schnell





- Paint formulations: spine/vertebrae or swim-bladder (isinglass) and soil mix with and w/o ochre
- Swim-bladder good binder
- Paint/pigment retention analyzed by CCD; also, useful for analyzing Indigenous artifacts and artworks



## Results So Far



Compact CCD Reflectance Spectrometry reveals permanence/fading of multiple paint formulations



Many thanks to our  
Elders and  
Traditional  
Knowledge  
Keepers