

A Collaborative Approach to Incorporating Undergraduate Research and MALDI-TOF Mass Spectrometry Into a Two-Year College

<http://webs.anokaramsey.edu/MaldiEducation>

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Undergraduate research is a high-impact practice, but it's still in its infancy at most two-year colleges.

What barriers are preventing you from incorporating undergraduate research (or research-like experiences) into your department?

“MALDI-based Research-like Experiences in a 2YC/4YC Collaboration with a Renewable Fuels Industry Partner”

- Year two of a three-year NSF-funded Advanced Technical Education grant
- MALDI-TOF is a state of the art analytical technique, especially for biomolecules
 - Matrix-Assisted Laser Desorption Ionization Time Of Flight mass spectrometry
 - Not widely covered in the Chem/Bio texts
 - Several 4-year colleges have these instruments
- This situation is ripe for collaboration!



Supporting Collaboration

- Develop materials and processes to:
 - Train students in MALDI-TOF MS
 - Train Faculty on how to teach MALDI-TOF MS
 - Provide a resource for professional mass spectrometrists
- Develop a ready-made technique for instant collaboration
- Broadly distribute the materials to faculty and professionals for use





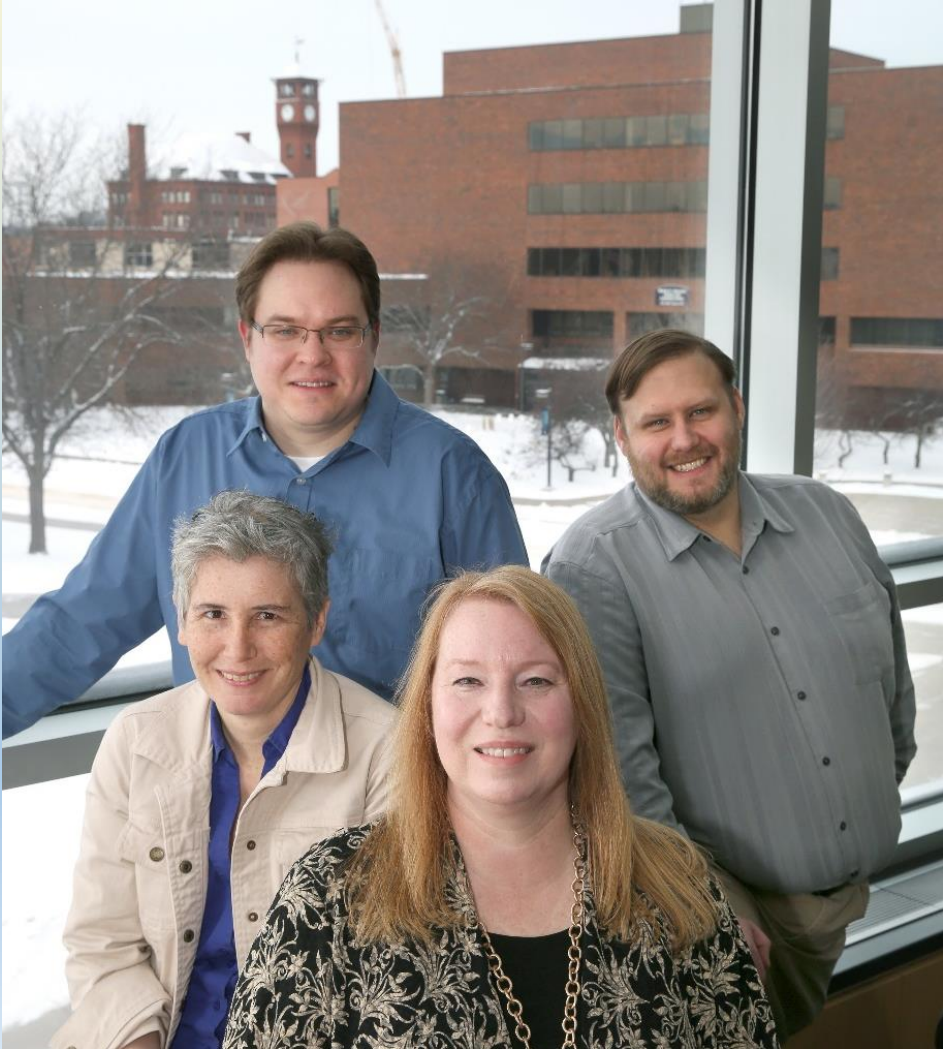
- 9100 students (5500 FTE) each semester across two campuses
- Draws primarily from suburban, working-class counties north of Minneapolis and St Paul.

University of Wisconsin-Stout



- About 9400 students both undergraduate (88%) and graduate (12%)
- Located in rural central Wisconsin
- Students drawn mainly from Wisconsin (65%)



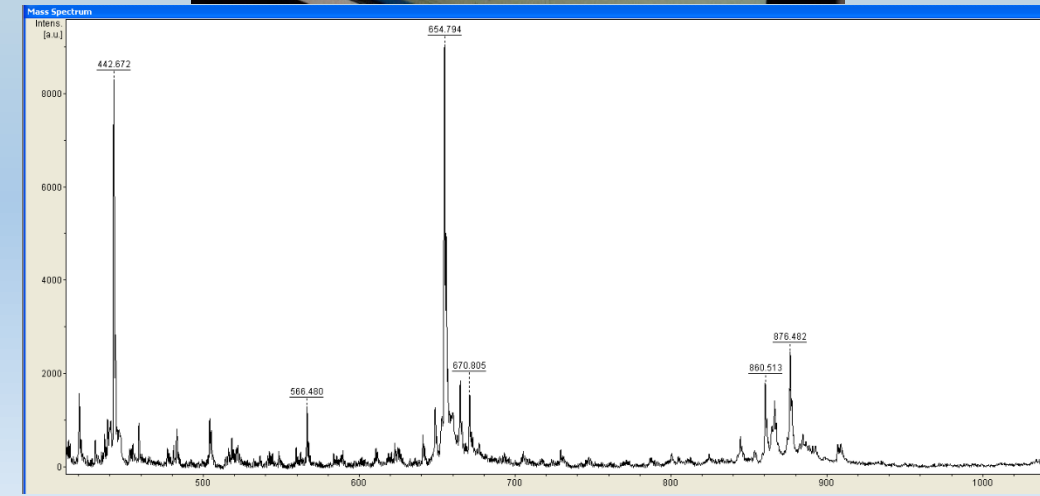
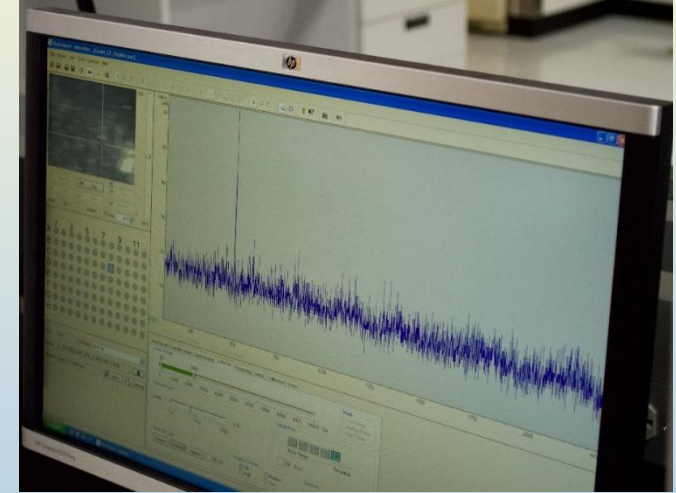


Team Members

Christopher Lutz	PI, Communications, web design
Jennifer Grant	Co-PI, MALDI Expert, faculty training
Patty Pieper	Curriculum development chair
Andrew Aspaas	Videographer and archivist

Support of STEM Education and Retention

- Research/research-like activities support student engagement and retention
- Competitive STEM education needs to incorporate modern techniques
- Hands-on (minds-on!)
- Expose students to instrumentation, such as MALDI-TOF, that scientists and technicians use in their careers



1. Alexander BB, Foertsch J, Daffinrund S. and Tapia R. **2000**. Council on Undergraduate Research Quarterly 20:127-133.
2. Thiry H, and Laursen S. **2009**, Howard Hughes Medical Institute, Ethnography and Evaluation Research

I don't have time to develop all new curriculum!

Fear not; we have done most of the work for you!

Faculty and Professional Resources

- Faculty MALDI-TOF training manual (2YC)
- Professional Mass Spectrometrists training manual (4YC or industry partner)

Student and General Resources

- Training videos with associated quizzes
- Four POGIL activities including a student training manual
- MALDI Wiki
- Data analysis tools for use with plant oils



Ask me! I'd love to help!

I don't have time to fit this in my classes!

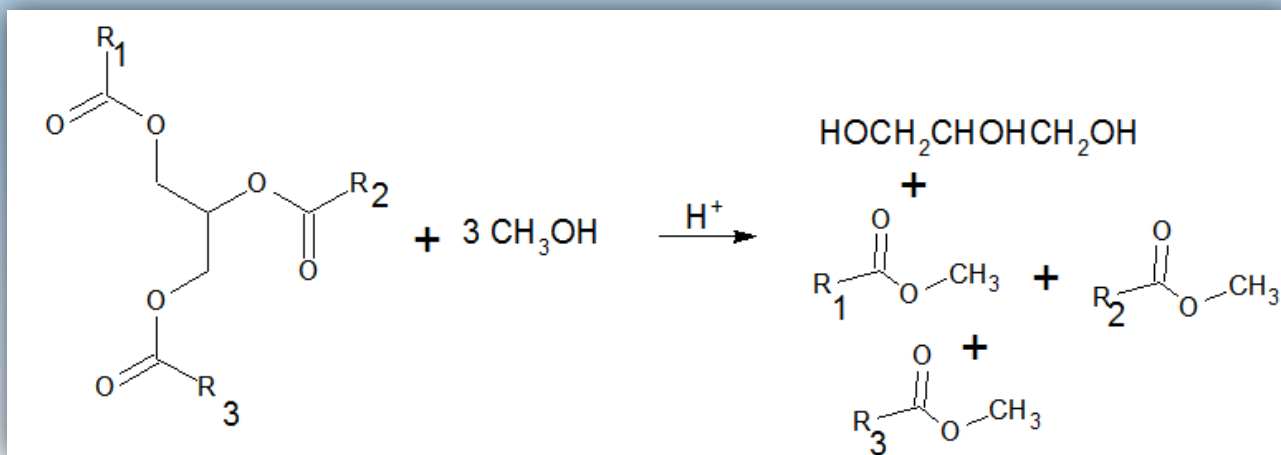
- Incorporate modules into existing down-time during lab
- MALDI-TOF is valuable for any project involving macromolecules

There aren't any big institutions nearby!

- A single trip may be sufficient
- There may be institutions closer than you think!

Implementation In Our Course

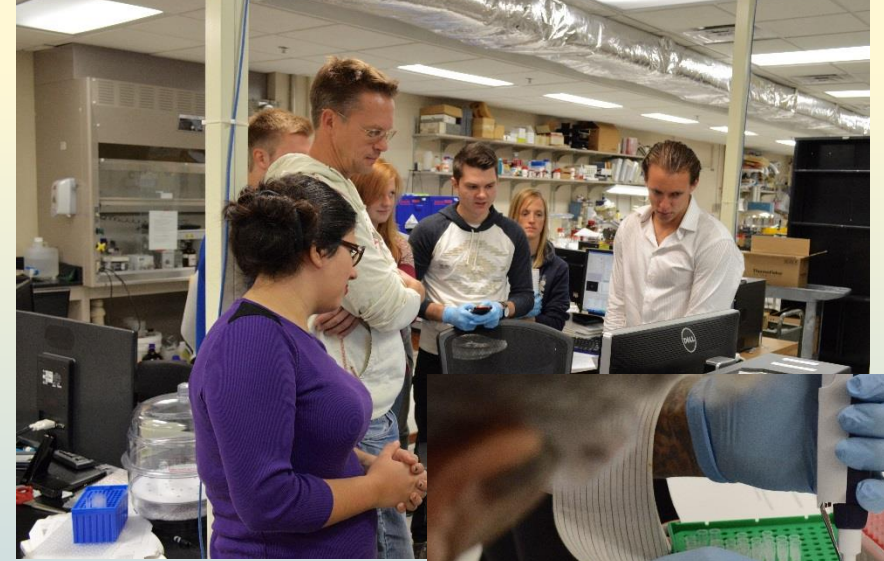
- Existing Organic Chemistry II Biodiesel Project (8 years)
 - Optimization of acid-catalyzed biodiesel production from seed oils
 - Seed oil extraction (seeds provided by Ever Cat Fuels)
 - Saturday field trip for lipid profiling of seed oils using MALDI
- **P**rocess-**O**riented **G**uided **I**nquiry **L**earning (**POGIL**) activities
- Instructional videos
- Presentation for Ever Cat Fuels personnel



Camelina Seeds and flowers

Field Trips!

UW Stout



University of
Minnesota



Curricular Materials

- Videos:
 1. Theory of MALDI-TOF Mass Spectrometry
 2. MALDI-TOF Sample Preparation

Video: Theory of MALDI-TOF Mass Spectrometry



<https://youtu.be/bZbty0r8GPM>

Curricular Materials

- Videos:

1. Theory of MALDI-TOF Mass Spectrometry
2. MALDI-TOF Sample Preparation

- POGIL Group Activities:

1. Introduction to MALDI-TOF Mass Spectrometry
2. MALDI Ionization
3. MMass for MALDI-TOF
4. MALDI-TOF Data Analysis

POGIL Activities

Process- Oriented Guided- Inquiry Learning

CHEM 2062 – MALDI Activity 1

Introduction to MALDI-TOF Mass Spectrometry

MALDI-TOF Mass Spectrometry is an acronym that stands for Matrix-Assisted Laser Desorption Ionization - Time of Flight Mass Spectrometry. Molecular mass determinations of large synthetic or biological polymers by mass spectrometry (MS) use either Electrospray Ionization (ESI) Mass Spectrometry or MALDI-TOF Mass Spectrometry. These types of MS are typically used for molecules that are too polar and/or non-volatile to be vaporized in a heated chamber as is required in Electron Impact (EI)-MS. Although both ESI and MALDI are used in to analyze such macromolecules, our focus will be on MALDI-TOF Mass Spectrometry. Figure 1 shows a schematic of collecting MALDI data and a spectrum.

Model 1: Obtaining a MALDI-TOF Mass Spectrum

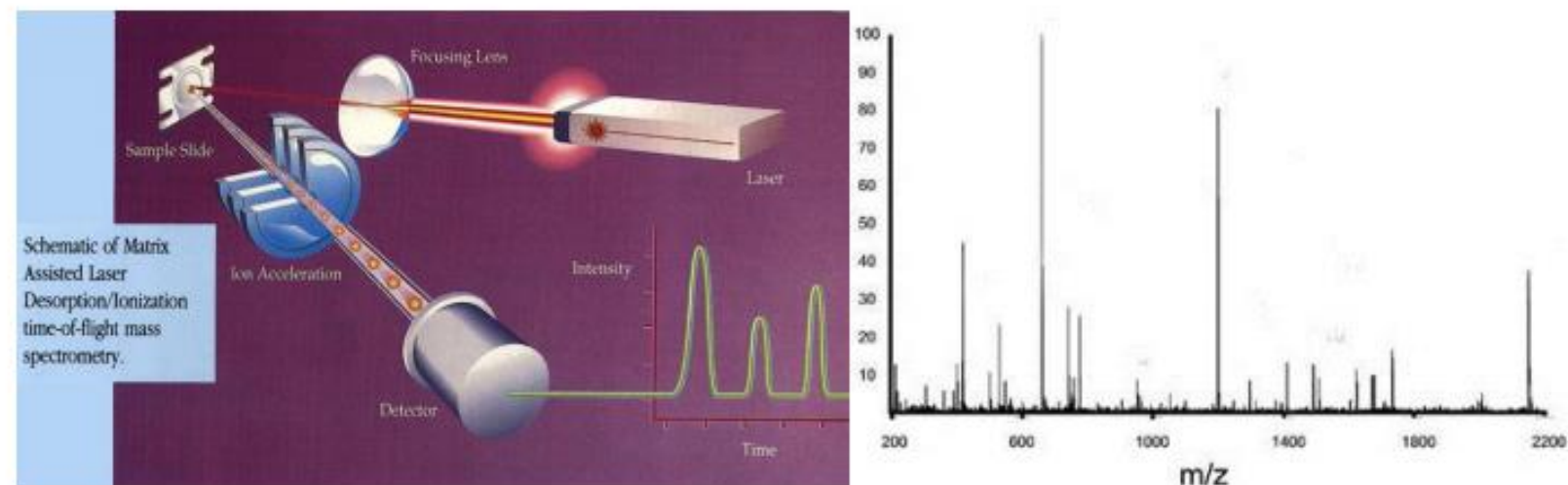


Figure 1: Schematic taken from <http://www.protein.iastate.edu/maldi.html> and data from reference 1.

Model 2: EI or MALDI Mass Spectrometry?

As you have learned in previous chemistry classes, as the molecular weight of a molecule increases, its boiling point increases as well. In many instances, when attempts are made to vaporize a large molecule with a high MW using heat, the molecule will often decompose into a complex mixture of smaller molecules at a temperature below the boiling point. Some molecules do not have a boiling point as they decompose before they can boil.

Table 1

Compound	Molecular Weight (amu)	Boiling Point (°C)	Decomposition Point (°C)
Trypsin (a polypeptide)	~23,300	---	130
Cotton (a polysaccharide)	~81,000	---	106
Polyethylene (Low Density)	~20,000	---	217
3,5-dichlorobiphenyl	223	324	1000
Stearic acid (a fatty acid)	284	361	232
Limonene (a terpene)	136	176	~400
Triglyceride composed of palmitic, oleic and α -linoleic acid side chains	855	300	~400

Table 1 shows a number of compounds of varying molecular weight, along with their corresponding boiling points and/or decomposition points. The decomposition point is the temperature at which a compound breaks down into smaller molecules.

Using the data in Table 1, answer the following questions.

(E) 4. Which molecules:

a) have a boiling point that is BELOW its decomposition temperature (T_d)?

b) have a boiling point that is ABOVE its T_d ?

c) have no boiling point listed?

(CTQ) 5. Identify which mass spectrometry technique, **Electron Impact**, **MALDI** or **BOTH**, can be used to analyze each compound. *(Place an X in the appropriate box).*

Table 2

Compound	Molecular Weight (amu)	Electron Impact (EI)	MALDI	BOTH EI and MALDI
Trypsin (a polypeptide)	~23,300			
Cotton (a polysaccharide)	~81,000			
Polyethylene (Low Density)	~20,000			
3,5-dichlorobiphenyl	223			
Stearic acid (a fatty acid)	284			
Limonene (a terpene)	136			
Triglyceride composed of palmitic, oleic and α -linoleic acid side chains	855			

Interested in using these materials or learning more?

- Visit our web page:

<http://webs.anokaramsey.edu/MaldiEducation>

- Visit our Facebook page: Search STEM-MALDI-Education

- E-mail our Pls:

Christopher.Lutz@anokaramsey.edu or grantje@uwstout.edu



Project Team

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Patty Pieper	Curriculum development chair
Andrew Aspaas	Videographer and archivist



Evaluation Team

Joseph Dalluge	External MALDI-TOF expert
Douglas Huffman	External project evaluation

Thank you!

Funding



**“MALDI-based Research-like Experiences in
a 2YC/4YC Collaboration with a Renewable
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Ever Cat Fuels, LLC