



SPARTAN RESEARCH RESOURCES

CORE FACILITIES +
RESEARCH SERVICES

SPARTAN

Research Resources

*Shared Research Resources at
Michigan State University*

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This booklet highlights a selection of Michigan State University's shared research resources, offering a snapshot of the tools, expertise, and capabilities that support collaborative research.

View the **Shared Research Resources Webpage** for a comprehensive listing of resources available to MSU researchers.
research.msu.edu/srr

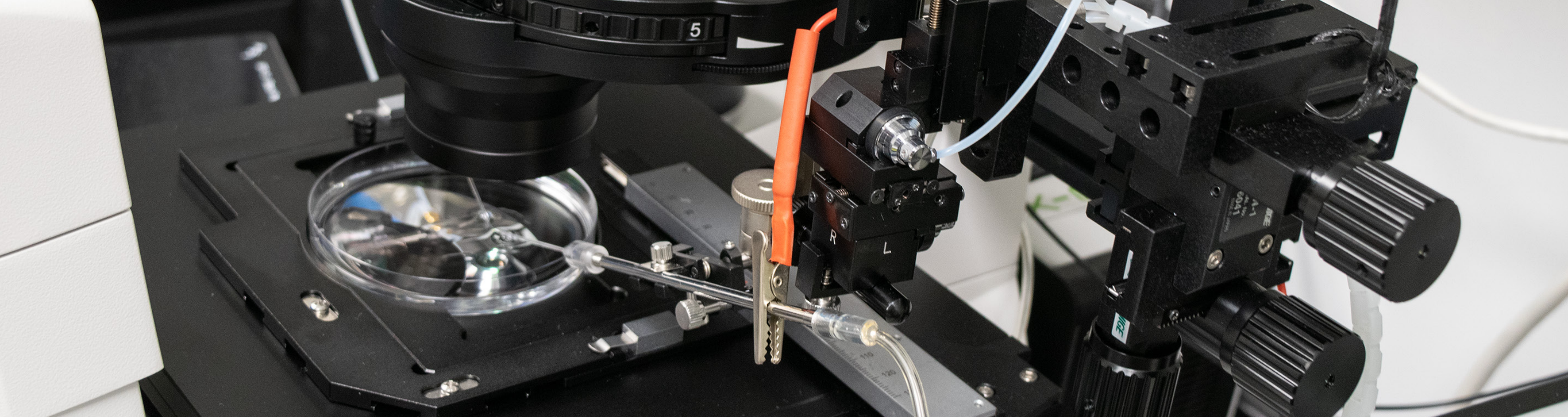


Spartans Will.

*Design: Tanya Bakija
Photography: Tanya Bakija, Michelle David
Project Lead: Matthew Bernard
Portfolio Version 1 • September 2026
This portfolio was printed using MSU Publishing Services*



The Center for Object Research and Engagement (The CORE)



A Message from Vice President for Research and Innovation

Michigan State University’s research enterprise thrives on the people, facilities, technologies, and services that turn bold ideas into breakthrough discoveries. Across our campus, shared research resources provide the essential foundation for researchers pushing the boundaries of science, scholarship, and creative activity.

This guide was created to help researchers more easily identify and connect with the specialized resources available at MSU. From advanced instrumentation and technical expertise to analytical services, consultation, training, and collaborative support, these resources form the infrastructure that makes innovative, cross-disciplinary work possible.

As research challenges grow more complex and interconnected, shared research resources become ever more vital to discovery and innovation. Our continued success depends not only on individual excellence, but on our collective ability to work across disciplines, build strong teams, and connect researchers with the tools and expertise needed to pursue ambitious ideas. Collaboration and team science are central to this vision, and to MSU’s future as a research leader.

I encourage you to use this guide as a starting point for discovery. For a more comprehensive listing of MSU’s shared research resources, including additional details and access information, please visit research.msu.edu/srr. I also encourage researchers to connect with their college research deans and with the Office of Research and Innovation to discuss opportunities, identify resources, and strengthen collaborative projects. I have personally found the CORD group to be an excellent forum for brainstorming big ideas, and I encourage Associate Deans for Research in your college to bring infrastructure-related topics before this group as we work together to strengthen our shared research ecosystem.

The resources featured in this guide reflect the depth of expertise, innovation, and commitment that define research at MSU. They are more than equipment, facilities, or services, they are connection points within our research ecosystem, helping researchers and collaborators forge new partnerships, expand the scope of their work, and drive discoveries that make a lasting impact. Together, let us continue building a culture of collaboration, discovery, and innovation: one that propels MSU forward as a leading research university and a destination for transformative scholarship.



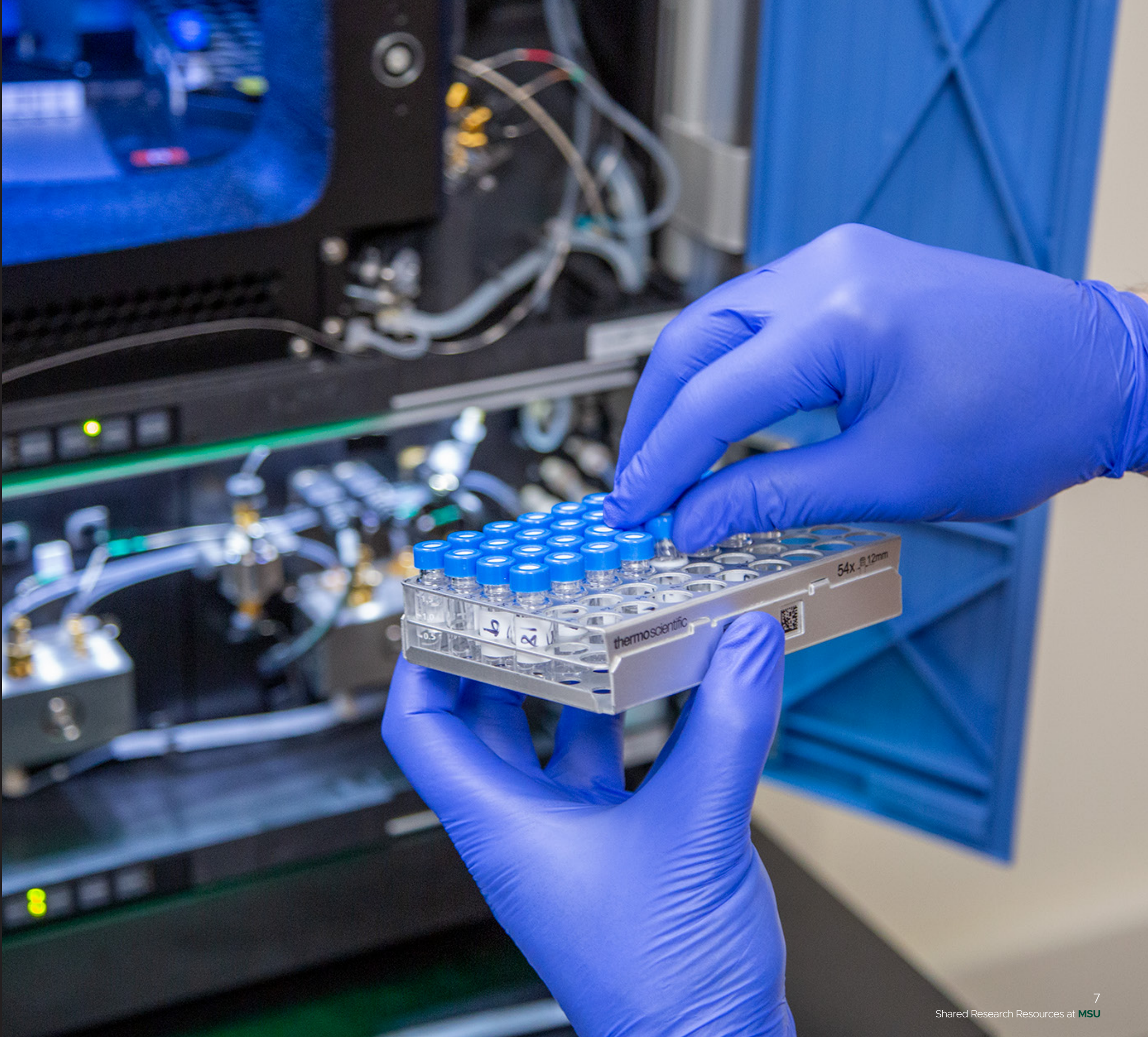
Shashank Priya
Vice President for Research and Innovation
Michigan State University

Elemental, Molecular, and Structural Analysis

Break matter down.
Build understanding
up.

Advanced technologies
reveal molecular composition,
chemistry, and structure.

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Quantitative Bio Element Analysis & Mapping (QBEAM)

QBEAM provides researchers with a comprehensive suite of state-of-the-art elemental analysis and imaging equipment allowing for ultra trace analysis, isotopic measurement, speciation analysis, and quantitative elemental imaging of biological, biomedical, agricultural, environmental, and materials research samples. By integrating advanced mass spectrometry, X-ray imaging, and custom informatics workflows, QBEAM enables investigators to determine the elemental composition of a variety of sample types including cells, tissues, soils, plants, and advanced materials.



LOCATION
Interdisciplinary Science and Technology Building
766 Service Road
Offices 1100 | Labs 1307 and 1308
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/qbeam

EQUIPMENT

ELEMENTAL/METALS ANALYSIS

ICP-QQQ-MS (Agilent 8900)

Equipped with a valve system, autosampler, and H, He, and O₂ gases for fine control of reaction chemistry capable of ppt levels of detection. Can be equipped with a HPLC, laser ablation, or single cell autosampler.

ICP-OES (Agilent 5800)

A vertical dual view (VDV) system equipped with a valve and autosampler that allows analysis in radial or axial views over the full 167 to 785 nm wavelength range from ppb to ppm with up to 10% TDS.

HPLC (Agilent 1260 Infinity II Bioinert)

A metal-free flow path HPLC capable of low volume sampling or speciation analysis of a variety of elements including As, Hg, Fe, Zn, etc. when connected to the Agilent 8900 ICP-QQQ-MS.

Combustion Analysis for C, H, N, O (Thermo FlashSmart Elemental Analyzer)

A combustion analyzer with a 120-sample capacity autosampler capable of C, H, N, O, and S analysis.

Single Particle (SP)/Single Cell (SC) Autosampler (ESI microFAST SingleCell)

Autosampling system equipped with CytoSpray spray chamber and CytoNeb low flow nebulizer for single cell/particle analysis using either ICP-TOF-MS (full spectrum) or ICP-QQQ-MS (high sensitivity).

ELEMENTAL/HIGH THROUGHPUT IMAGING

(2) LA-ICP-TOF-MS (Tofwerk S2 ICP-TOF-MS w/ ESL BioImage 266 nm Laser Ablation)

State-of-the-art systems that allow for full spectrum coverage (~13 μs). Can be coupled to a 1000 Hz Nd:YAG 266 nm laser ablation system or single cell autosampler.

iXRF Atlas Apex M

Energy Dispersive X-ray Fluorescence (EDXRF) Spectrometer for non-destructive elemental mapping, hyperspectral XRF imaging, and quantitative micro-scale down to 10 μm spot sizes.

Zeiss Axioscan 7 High Throughput Slide Scanner

A high-throughput whole slide scanner (100 slide capacity) for brightfield, color, and multispectral fluorescence imaging. 4 objectives (5x, 10x, 20x, and 40x) and HE, GFP, Cy3, Cy5, and Cy7 filters.

SAMPLE PREPARATION

Acid Distillation (Savillex)

Sub boiling point distillation that produces ultra-trace acids such as HF, HCl, HNO₃, and H₂O.

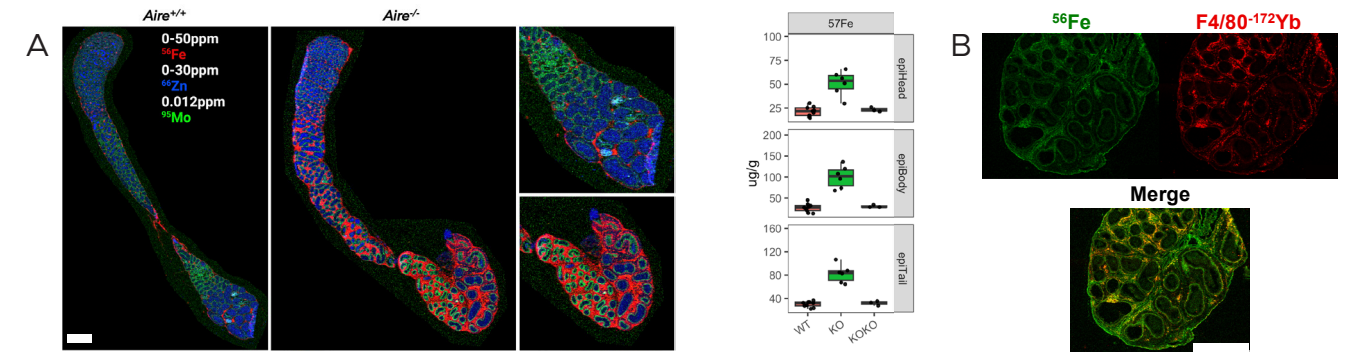
Microwave Digestion (CEM MARS6)

Closed-vessel acid digestion system with up to 300 °C and 1500 psi.

SERVICES

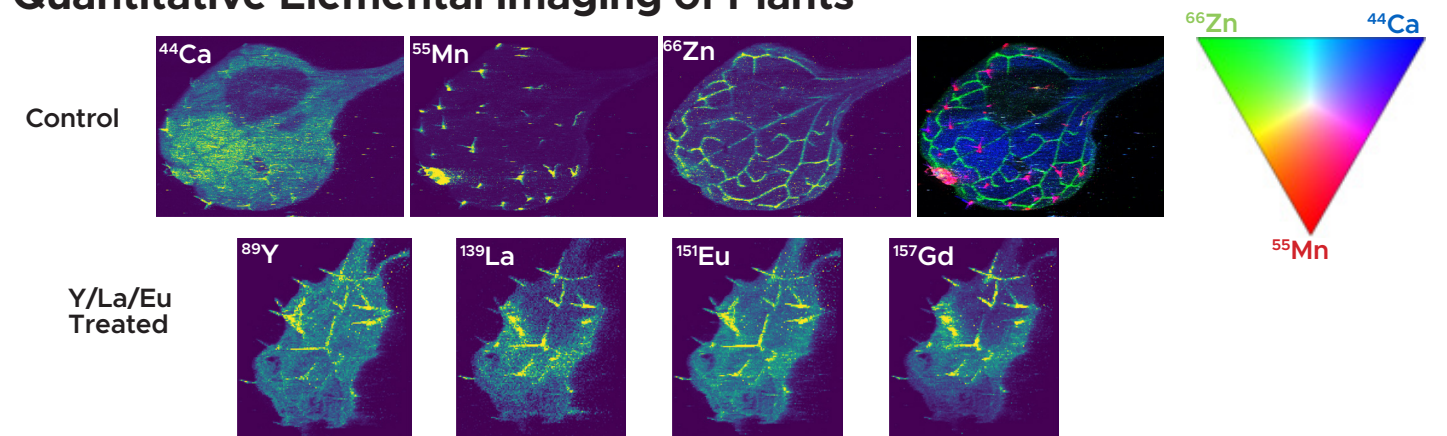
- Hands-on graduate level chemistry and biology course (MGI991/CEM913)
- Comprehensive training program to develop independent analytical chemists
- Full-service analytical chemistry including sample preparation, data acquisition, and analysis
- Experimental design and method development
- Training, workshops, and user support
- Access to data analysis software on 2 high end workstations
- Manuscript/grant review

Elemental Imaging Reveals Metal Dysregulation in Autoimmune Disease



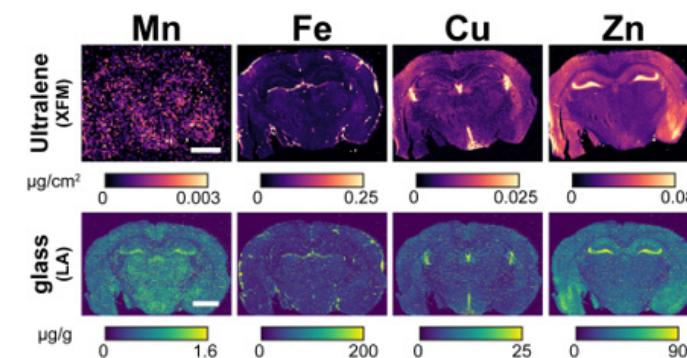
Quantitative elemental imaging was used to investigate how autoimmunity alters the reproductive microenvironment. **(A)** Iron accumulation and zinc depletion were observed throughout the epididymis of autoimmune mice. **(B)** Fibrosis was associated with macrophage infiltration using an Yb-tagged antibody for F4/80+ macrophages. These results demonstrate how elemental imaging can uncover disease-associated changes. Scale bar = 1000 μm. Adapted from: Ahn, S.H. et al. J. Immunol. DOI: 10.1093/jimmun/vkaf054.

Quantitative Elemental Imaging of Plants



Elemental distribution in plants helps explain inorganic physiology and plant health. The elemental composition of the soil and surrounding environment are the main contributors to plant physiology. An elemental map of a control Arabidopsis thaliana leaf from a plant grown in a growth chamber as well as a A thaliana leaf after exposure to Y/La/Eu in soil. Scale bar = 200 μm.

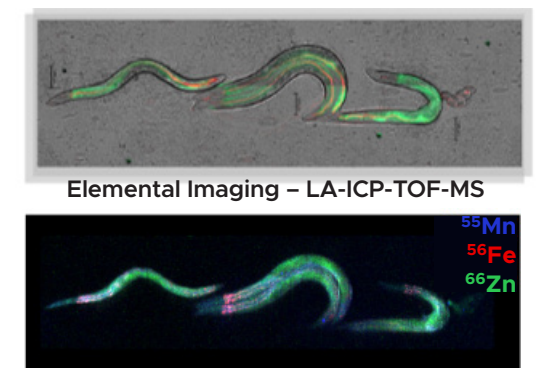
Multimodal Elemental Imaging



20 μm thick mouse brain sections imaged using XFM at APS and LA-ICP-TOF-MS at QBEAM. Scale bar = 1000 μm. Adapted from: Zee, D.Z. et al. J. Anal. At. Spectrom. DOI: 10.1039/D5JA00371G

QBEAM develops analytical workflows and through systematic evaluation of substrates, researchers established robust approaches for correlative LA-ICP-TOF-MS and XFM. These advances improve data quality and expand opportunities for multimodal elemental imaging studies.

Brightfield & Autofluorescence

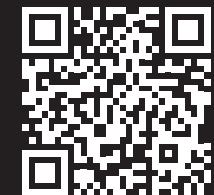


Whole *C. elegans* prepared using petrolatum and imaged via LA-ICP-TOF-MS at QBEAM. Scale bar = 100 μm. Adapted from: Reynolds, A.J. et al. bioRxiv DOI: 10.64898/2026.01.08.698490

QBEAM develops sample preparation methods to enable elemental imaging of whole intact organisms such as *C. elegans* (Pictured above). Through evaluation of sample preparation protocols, researchers established a novel method for *C. elegans* allowing for accurate assessment of elemental distributions.

Max T. Rogers NMR Facility

The Max T. Rogers NMR facility strives to provide cutting-edge NMR instrumentation and research support to facilitate transformative science. Nuclear Magnetic Resonance (NMR) is a nondestructive technique that can probe the nature of molecular structures and dynamics at the atomic level. NMR is used to determine structures of unknown compounds, probe molecular interactions, investigate molecular diffusion and dynamics, study reaction kinetics, and much more in both the liquid- and solid-state.



LOCATION
Chemistry Building
 578 South Shaw Lane
 Rooms B7, B8, B10, 582
 East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/nmr
email: @msu.edu

EQUIPMENT

INSTRUMENT TYPE (SOLUTION / SOLID STATE)

Avance NEO 800 MHz (Bruker)

- High field NMR spectrometer equipped with a 5 mm HCN helium cryoprobe for exceptional $^1\text{H}/^{19}\text{F}$ sensitivity and indirect experiments as well as best-in-facility signal dispersion.
- Solid-state NMR capability includes 1.6, 2.5, and 3.2 mm MAS probes for multinuclear NMR studies up to 40 kHz spinning speed.

Avance NEO 600 MHz (Bruker)

- High field NMR spectrometer equipped with a 5 mm HCN liquid nitrogen cryoprobe for outstanding $^1\text{H}/^{19}\text{F}$ sensitivity.

Avance NEO 600 MHz (Bruker)

- High field NMR solid-state spectrometer equipped with multiple NMR probes ranging from 1.3 to 4 mm MAS. The 1.3 mm can spin up to 60 kHz enabling proton-detection in the solid state.

Avance NEO 500 MHz (Bruker)

- High field NMR spectrometer equipped with a 5 mm X-nucleus liquid nitrogen cryoprobe for outstanding ^{13}C , ^{31}P , ^{11}B , ^{15}N , etc. sensitivity.

Avance III HD 500 MHz (Bruker)

- High field NMR spectrometer equipped with a 5 mm BBFO probe with low gamma capabilities down to ^{109}Ag as well as $^1\text{H}\{^{19}\text{F}\}$ or $^{19}\text{F}\{^1\text{H}\}$ detection.

DirectDrive II 500 MHz x 2 (Varian)

- High field NMR spectrometers equipped with a 5 mm OneNMR probe and a 96 sample autosampler for high-throughput automated acquisition of both proton and heteronuclear experiments.

Avance NEO 400 MHz x 2 (Bruker)

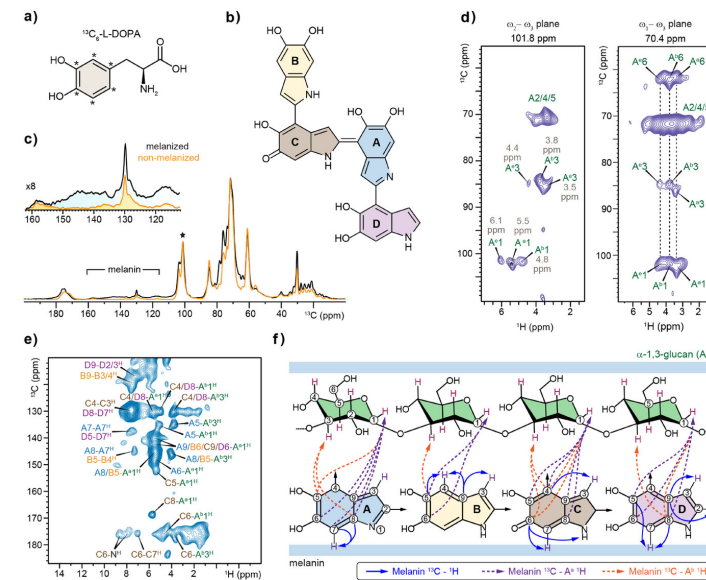
- NMR solid-state spectrometers equipped with multiple NMR probes ranging from 2.5 to 4 mm MAS including a 4 mm HRMAS probe for studying semisolids and gels.

SERVICES

- Thorough one-on-one training for solution- and/or solid-state NMR enabling independent instrument operation and data analysis.
- Sample service for both academic and industrial clients including data acquisition, processing, and analysis.
- Collaborative research with grant writing support, experimental design and execution, data analysis, and manuscript preparation.

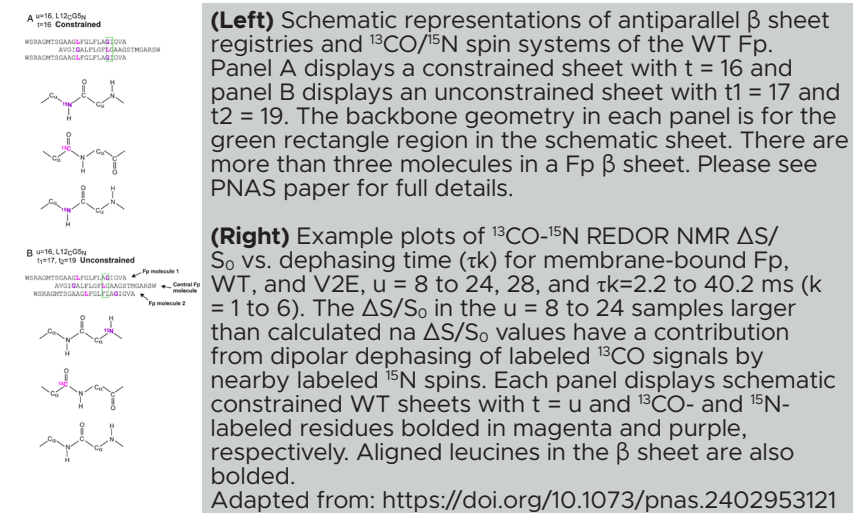


Polymorphic α -Glucans as Structural Scaffolds in *Cryptococcus* Cell Walls for Chitin, Capsule, and Melanin: Insights From ^{13}C and ^1H Solid-State NMR



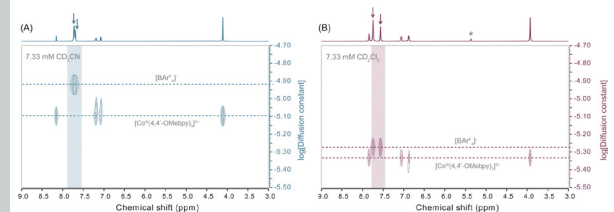
^1H -detected solid-state NMR shows interactions of α -1,3-glucan with melanin. **(a)** Structure of melanin precursor ring- $^{13}\text{C}_6$ -labeled L-DOPA. Asterisks indicate the ^{13}C -labeling sites. **(b)** Representative structure of DHI melanin formed by covalently linked subunits. **(c)** 1D ^{13}C CP spectra of non-melanized (orange) and melanized (black) *C. neoformans* H99 cells. The spectra are normalized by the α -1,3-glucan carbon 1 peak at 101 ppm (asterisk). The zoom region shows the aromatic signals from melanin (8x). **(d)** Polymorphic forms of α -1,3-glucans (A^a , A^b , and A^c) resolved using ^1H -detected 3D hCCH TOCSY. ^1H chemical shifts (ppm) are in gray. Key strips are extracted for $\omega 2$ – $\omega 3$ (^{13}C – ^1H) and $\omega 1$ – $\omega 3$ (^{13}C – ^1H) planes. **(e)** 2D hCchH with 0.8 ms RFDR mixing showing intermolecular interaction between melanin non-protonated carbons and α -1,3-glucan protons. **(f)** Structural summary of observed interactions between cell wall α -1,3-glucan and melanin units. Blue solid lines: cross peaks observed between non-protonated carbons and protons in protonated sites within melanin. Dashed lines in purple and orange indicate the intermolecular interactions between melanin carbons and protons in type-a and type-b α -1,3-glucans, respectively. The experiments were performed on 600 MHz NMR at 60 kHz MAS. Adapted from: <https://doi.org/10.1002/anie.202510409>

Very Broad Distribution of β Sheet Registries of the HIV gp41 Fusion Peptide Supports Mutational Robustness for Fusion and Infection



Probing the Influence of Ion-Pairing on Ligand-Field Excited-State Dynamics

^1H DOSY NMR spectrum of $[\text{Co}(\text{4,4}'\text{-OMebpy})_3](\text{BAR}^{\text{F}})_3$ complex in CD_3CN **(A)** and CD_2Cl_2 **(B)**, collected under identical conditions of concentration (7.33 mM), volume (600 μL), and temperature (25°C). For clarity, only the chemical shift region characteristic of the complex under investigation is shown; the dotted lines on the plots are provided to guide the eye regarding the diffusion constant. The arrows represent the ^1H signals originating from the BAR^{F}_4 counter anion in the two solvents. The asterisk on the NMR spectrum shown in panel B represents a solvent peak. The relative gaps between the dotted lines can be directly correlated to the extent of ion-pairing in solution: see text for further details. Analysis of data acquired from both variable-temperature diffusion ordered spectroscopy (DOSY) NMR and 1-D rotating-frame nuclear Overhauser effect (ROE) experiments allowed us to identify and differentiate between solvent-separated ion pairs in high-dielectric media and contact ion pairs in a low-dielectric solvent.



Genomics Core

The MSU Genomics Core provides DNA and RNA library preparation and sequencing services for researchers. Our mission is to keep pace with the world of genomics technology and to provide the best possible advice to researchers about their projects. The Genomics Core maintains an ever-changing portfolio of state-of-the-art instruments and services.



LOCATION
Plant Biology Building
612 Wilson Road
Room S-18
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/genomics
email: gtsf@msu.edu

EQUIPMENT

AVITI sequencing instruments

- **Illumina-style short read sequencing**
- DNA, DNA methylation & RNA sequencing
- Multiple read formats
 - 2x75, 1x150, 2x150, 2x300
- Multiple flow cell capacities
 - 100 M to 1,500 M read pair outputs

10X Genomics

- **Single-cell library preparation and spatial transcriptomics**
- RNA-seq, ATAC-seq & multiomic library preparation
- Species agnostic

Nanopore Promethion P2 instruments

- **Long read sequencing**
- Read lengths of 1 kbp to 50 kbp
- DNA, cDNA, RNA & amplicon sequencing

TapeStation

- **Automated, high-throughput DNA/RNA electrophoresis**
- Provides quality control for samples and libraries

Qubit Flex

- **Accurate quantification of DNA & RNA**
- For high-throughput projects

Qubit Single Channel

- **Accurate quantification of DNA & RNA**
- Self-service instrument

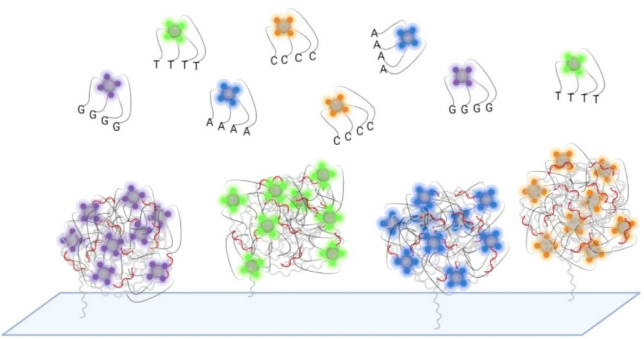
Covaris Sonicator

- **Ultrasonic fragmentation of DNA**
- Highly reproducible and isothermal shearing
- Used for fragmentation of DNA
- Self-service instrument

SERVICES

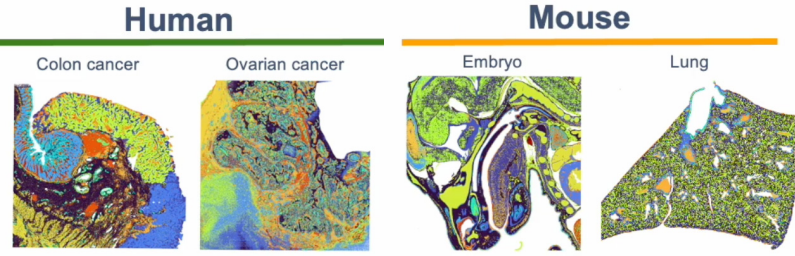
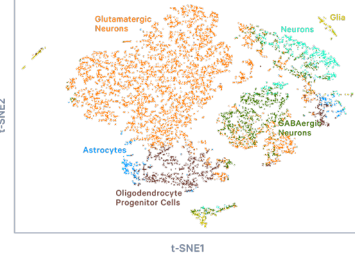
- Consulting on project design
- Self-serve Qubit DNA/RNA quantification
- High throughput Qubit DNA/RNA quantification
- DNA/RNA TapeStation QC assays
- Flat-rate DNA/RNA library prep + sequencing
- Quantabio SparQ DNA-seq library prep
- Low cost, ultra high throughput DNA library preparations with Twist FlexPrep
- IDT xGen DNA-methylation library prep
- Watchmaker RNA-seq library prep
- Qiagen QIASeq RNA-Seq with FastSelect rRNA depletion
- Lexogen QuantSeq 3' mRNA-seq library prep
- Lexogen small RNA-seq library prep with or without unique molecular identifiers16S V4 amplicon library prep
- 10X Genomics single cell library preparations
- 10X Visium spatial transcriptomics assays
- Amplicon barcoding library prep
- Short-read sequencing of user-prepared libraries
- Oxford Nanopore long-read libraries with PromethION sequencing
 - DNA ligation libraries
 - Native and rapid barcoding libraries
 - cDNA libraries with or without barcoding
 - Direct sequencing of RNA libraries

AVITI Short Read Sequencing



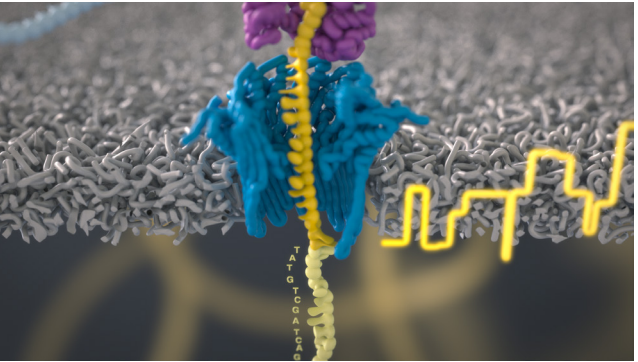
AVITI short read sequencing uses regular Illumina-style libraries and produces regular fastq output files. Existing bioinformatic pipelines can be used for data analysis. Before sequencing, library fragments are amplified on the flow cell using rolling-circle amplification to form a hairball-like polony. AVITI sequencing makes use of avidites containing a central fluorescent signal molecule tethered to several nucleotides. Sequencing involves multiple tethered nucleotides annealing within polymerase binding pockets. Avidite fluorescence on the polony allows base detection. Single base extension with ddNTPs is separate from base detection. Images from Element Biosciences.

10X Genomics Single Cell and Spatial Omics



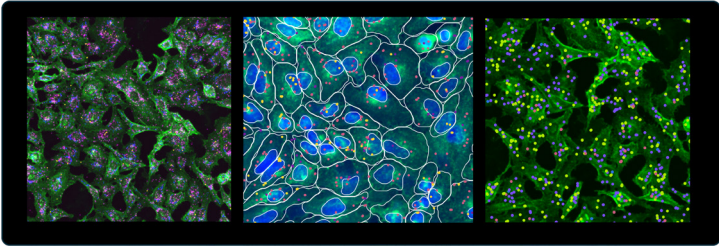
Single cell and single nuclei libraries are prepared with our Chromium X instrument from 10X Genomics. 5' and 3' RNA-seq libraries, ATAC-seq libraries and new human/mouse specific probe-based libraries can be prepared. Spatial transcriptomics can be performed with our Visium CytAssist from 10X Genomics using panels of human or mouse probes or with species-agnostic mRNA capture and sequencing. Images from 10X Genomics.

Oxford Nanopore Long Read Sequencing



Long read sequencing in the Genomics Core is performed on our PromethION P2. Nanopore flow cells contain thousands of protein pores within isolated membranes. As single stranded DNA or RNA passes through each pore, a changing current is decoded into fastq sequences. Image from Oxford Nanopore.

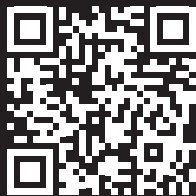
AVITI24 Spatial Omics



Our AVITI24 sequencer can perform multiomic analyses in the flow cell. Morphology, protein and RNA can be detected in a single assay. The detection area is 10 cm². Both spatial and dynamic relationships can be recognized in cell cultures and soon in fixed tissue sections. Images from Element Biosciences.

Proteomics Core Facility

The MSU Proteomics Facility provides expertise and advanced mass spectrometry resources for protein identification, characterization, and quantitative proteomics. We support projects ranging from purified protein characterization to deep proteome profiling, post-translational modification analysis, and quantitative studies in complex biological samples. We're happy to consult with investigators, at no charge, to help design the best experimental strategy for each project.



LOCATION
Biochemistry Building
603 Wilson Road
Rooms 5 and 17C
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/proteomics
email: rtsf.proteomics@msu.edu

EQUIPMENT

MASS SPECTROMETERS

ThermoScientific Excedion Pro

Hybrid quadrupole-Orbitrap with high-capacity transfer tube and electrodynamic ion funnel. High scan speed, ultra-high mass resolution, and high sensitivity support deep proteome coverage, confident peptide identification, and analysis of low-abundance species in complex biological samples.

ThermoScientific Q-Exactive

Hybrid quadrupole-Orbitrap well suited for peptide mapping, and routine analysis of purified proteins and simpler samples, while also supporting high-resolution MS workflows for a broad range of protein and peptide applications.



SOFTWARE TOOLS

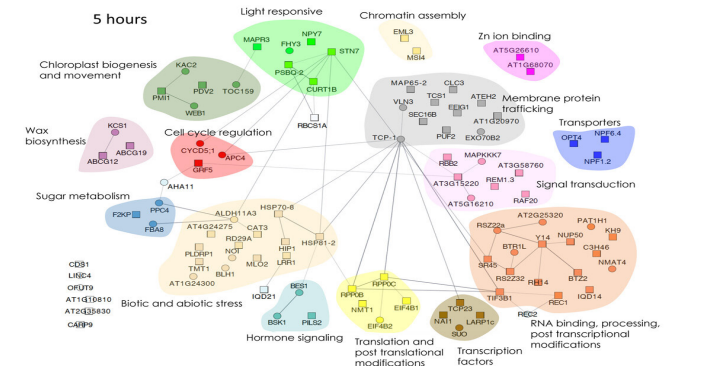
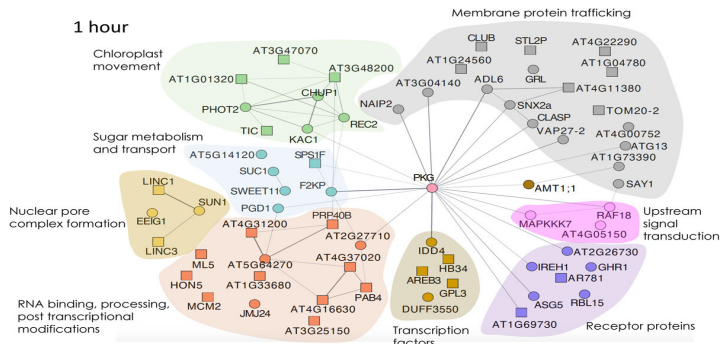
We provide end-to-end data analysis using widely adopted proteomics software for peptide identification, quantification, DIA analysis, statistical interpretation, and visualization.

SERVICES

- Purified protein characterization
- Peptide mapping
- Protein and peptide identification (DDA and DIA)
- Protein/peptide quantification (Label-free, SILAC and TMT)
- Interaction Proteomics (AP-MS)
- Post Translational Modification (PTM) analysis
- Experimental design and consultation
- Data analysis support
- Grant application support



The Isoprene-Responsive Phosphoproteome Provides New Insights into the Putative Signaling Pathways and Novel Roles of Isoprene

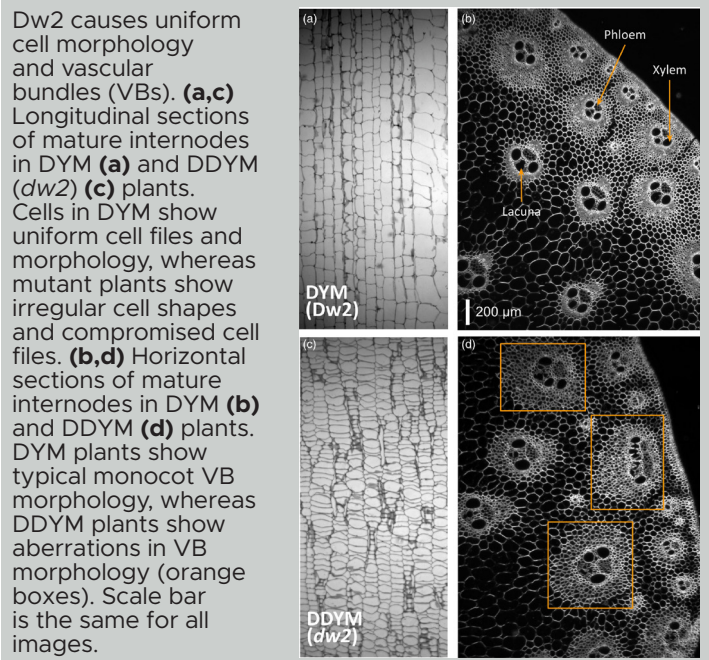


Important biological functions of differentially expressed phosphoproteins in *Arabidopsis* leaves fumigated with isoprene. STRING protein-protein interactions are shown for phosphoproteins differentially expressed in response to fumigation with 1 (top) or 5 (bottom) with isoprene. The nodes represent phosphopeptides upregulated (spheres) or downregulated (squares) in expression.

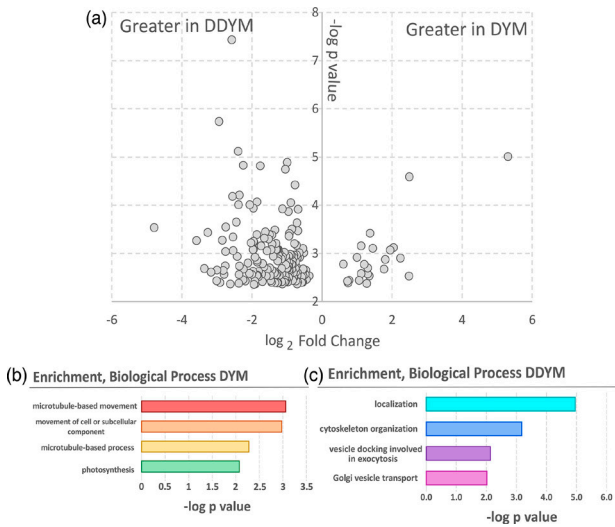
Edges or the lines connecting nodes represent evidence supporting interactions between a pair of proteins; thicker the edge stronger the evidence supporting an interaction. Nodes sharing the same color represent a cluster of phosphoproteins with similar biological functions.

Adapted from: Weraduwege, S.M., Whitten, D., Kulke, M., Sahu, A., Vermaas, J.V. & Sharkey, T.D. (2024) **The isoprene-responsive phosphoproteome provides new insights into the putative signaling pathways and novel roles of isoprene.** *Plant, Cell & Environment*, 47, 1099–1117. <https://doi.org/10.1111/pce.14776>

The AGCVIII Kinase Dw2 Modulates Cell Proliferation, Endomembrane Trafficking, and MLG/Xylan Cell Wall Localization in Elongating Stem Internodes of Sorghum Bicolor



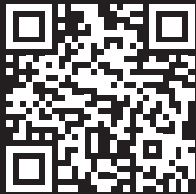
Adapted from: Oliver J, Fan M, McKinley B, Zemelis-Durfee S, Brandizzi F, Wilkerson C, Mullet JE. **The AGCVIII kinase Dw2 modulates cell proliferation, endomembrane trafficking, and MLG/xylan cell wall localization in elongating stem internodes of Sorghum bicolor.** *Plant J.* 2021 Feb;105(4):1053-1071. doi: 10.1111/tj.15086



Phosphoproteomics of internode tissue revealing endomembrane and cytoskeleton proteins. (a) Volcano plot of the phosphoproteomic experiment on growing Int(P5) tissue. Most differential phosphorylation events occur in DDYM (Dw2) tissue. (b) GO enrichment analysis of the phosphoproteins in the right section of (a). Significant enrichment is observed for many processes involved in cytoskeletal maintenance. (c) GO enrichment analysis of the phosphoproteins in the left section of (a). Significant enrichment is observed for cytoskeletal organization, as well as localization, exocytosis, and vesicle transport. A complete list of enriched terms for both phosphoprotein datasets can be found in the supplementary information.

Mass Spectrometry & Metabolomics Core

The MSMC integrates state-of-the-art mass spectrometry and advanced bioinformatics to reveal biochemical networks across human health, plant and soil biology, environmental systems, agriculture, nutrition, veterinary medicine and more. We help researchers uncover hidden metabolites, identify biomarkers, and define molecular mechanisms across diverse biological systems.



LOCATION
Biochemistry Building
603 Wilson Road
Room 11
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/metabolomics
email: RTSF.MassSpec@msu.edu

EQUIPMENT

HIGH RESOLUTION MASS SPECTROMETERS

- **SCIEX ZenoTOF 7600**
The only high resolution TOF instrument with EAD capability providing sensitive and highly specific molecular structures.
- **ThermoScientific Q-Exactive**
Hybrid quadrupole-Orbitrap with resolution up to 140,000 allowing for robust global profiling and quantitative analysis.
- **Waters Xevo G2-XS**
Quadrupole TOF providing most comprehensive and high-quality data on the broadest range of compounds in complex matrices.
- **LECO GC-HRT+ GC-TOFMS**
High performance GCMS capable of full range allowing for high-confidence compound identification.

IMAGING MASS SPECTROMETER

- **Bruker ultrafleXtreme MALDI-TOF/TOF**
Next generation MALDI-TOF/TOF with imaging capabilities and low fmol level sensitivity.
- **HTX M3+ matrix sprayer**
Automated MALDI imaging sample preparation system.

QUANTITATIVE/TANDEM QUADRUPOLE MASS SPECTROMETERS

- **Waters Xevo TQ Absolute XR UPLC/MS/MS**
- **Waters Xevo TQ-S UPLC/MS/MS**
- **Waters Xevo TQ-XS UPLC/MS/MS**
A fleet of LC/MS/MS instruments for absolute quantitation of compounds in various complex matrices.

GCMS

- **Agilent 5975 single quad GCMS**
- **Agilent 7010 triple quad GCMS**
- **LECO GC-HRT+ TOFMS**
Robust and quantitative analysis of known panels of metabolites from various metabolic pathways.

SOFTWARE TOOLS

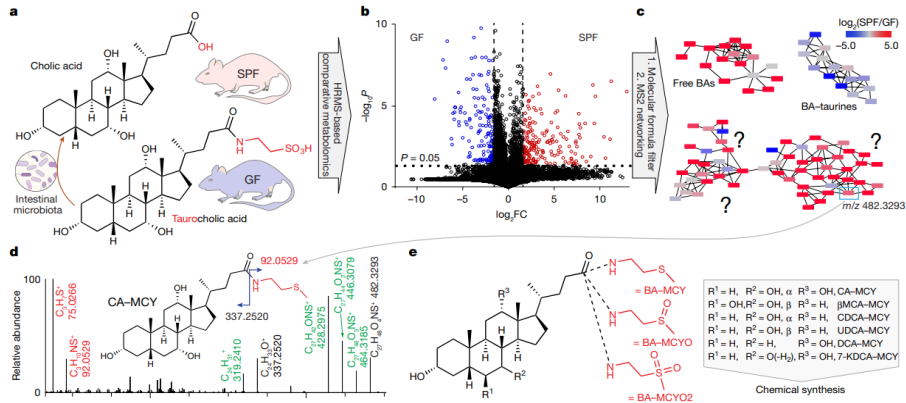
- Thermo Compound Discoverer 3.3
- Waters Progenesis Q1
- A gamut of open-source software including XCMS, MZmine, MetaboLyzer, MS-DIAL, MetaboAnalyst, GNPS suite of tools
- In-house bioinformatics and specialized tools
- Multi-omics analysis and pathway enrichment analysis

SERVICES

- **Comprehensive** metabolite profiling (targeted & untargeted)
- **Quantitative** metabolite measurement
- **Imaging** mass spectrometry (MALDI-TOF/TOF)
- Advanced LC-MS/MS and GC-MS capabilities
- **Bioinformatics** support and data integration
- Experimental design and method development consultations
- Manuscript and grant proposal preparation
- Lipidomics and microbiome analysis

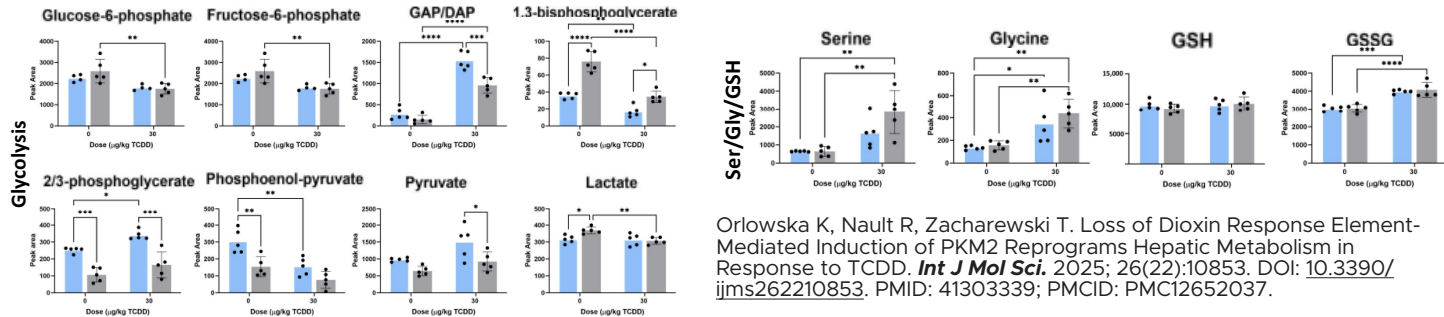
Untargeted Metabolomics: Comprehensive Profiling, Accurate Metabolite Annotation and Full Bioinformatics Analysis

Identification of novel conjugates of bile acids (BAs) via mass spectrometry (MS), regulated by host and gut microbiota. MS data revealed clusters representing free BAs, BA-aurine conjugates and previously unannotated BA-MCY conjugates. The red and blue nodes are downregulated and upregulated, respectively, in serum of germ-free (GF) compared with SPF mice.



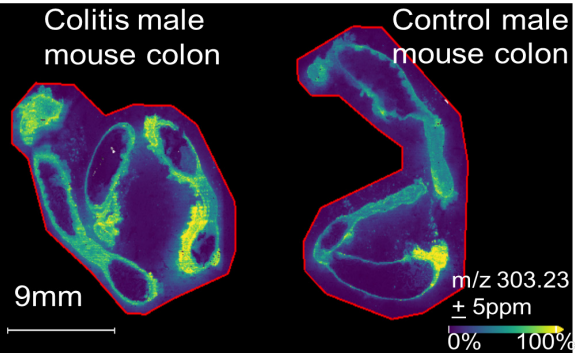
Won TH, Arifuzzaman M, Parkhurst CN, et al. Host metabolism balances microbial regulation of bile acid signaling. *Nature*. 2025; 638(8049):216-224. DOI: [10.1038/s41586-024-08379-9](https://doi.org/10.1038/s41586-024-08379-9). PMID: 39779854; PMCID: PMC11886927.

Targeted Metabolomics: Quantitation, 20+ Validated Assays, Novel Assay Development and Full Data Processing



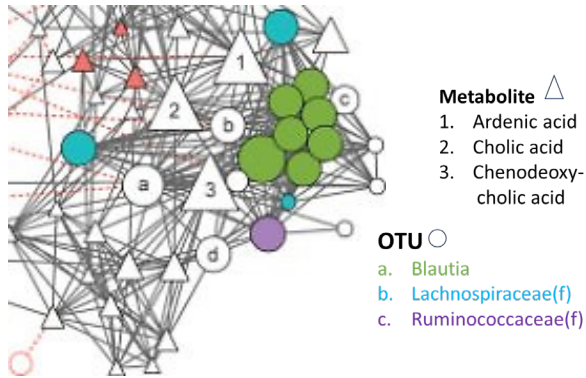
Levels of glycolytic and Ser/Gly/GSH metabolites in WT (blue) and PkmΔDRE (grey) mice treated with sesame oil (vehicle) or dioxin-like compound (30 µg/kg TCDD) every 4 day for 28 days.

Imaging Mass Spectrometry



Ion image heatmap of m/z 303.2329, putatively annotated as arachidonic acid, in colon of mice with DSS-induced colitis. [unpublished]

Multi-Omics and Pathway Analysis

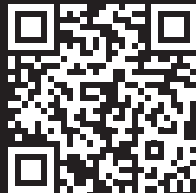


Identifying metabolotypes associated with predisease risk state in inflammatory bowel disease (IBD): An inter-omic network of OTU-type-associated microbes and metabolite-associated metabolites in a children with IBD and their healthy siblings/parents.

Jacobs JP, Goudarzi M, Singh N, et al. A Disease-Associated Microbial and Metabolomics State in Relatives of Pediatric Inflammatory Bowel Disease Patients. *Cell Mol Gastroenterol Hepatol*. 2016; 2(6):750-766. DOI: [10.1016/j.jcmgh.2016.06.004](https://doi.org/10.1016/j.jcmgh.2016.06.004). PMID: 28174747; PMCID: PMC5247316.

PFAS Analytical Laboratory

The PFAS Analytical Laboratory at the MSU Center for PFAS Research provides advanced analytical expertise and state-of-the-art instrumentation to support environmental, biological, agricultural, and public health studies. We partner with academic, government, and industry researchers to deliver high-quality data to support preliminary analysis and grant development as well as publication-ready results. Our lab is committed to addressing complex challenges to advance PFAS science.



LOCATION
Michigan Bioeconomy
Institute Building
3815 Technology Boulevard
Offices: A146, B119, B148
Lansing, MI 48910

CONNECT
web: research.msu.edu/srr/pfas
email: pfas@msu.edu

EQUIPMENT

CORE ANALYTICAL INSTRUMENTATION

Liquid chromatography coupled with a QQQ mass spectrometer (LC-MS/MS) (Thermo Scientific, TSQ Altis)
Vanquish core UHPLC coupled to a TSQ Altis QQQ Mass Spectrometer Provides highly sensitive, selective, and quantitative PFAS analysis at trace levels across diverse environmental matrices.

Combustion ion chromatography Platform (Thermo Scientific DIONEX Integrion HPIC + Mandel Scientific Inc. AQF-2100H)
Measurement of Total Organic Fluorine (TOF) enables fluorine mass-balance studies and identification of fluorinated compounds that are not detectable by LC-MS/MS methods.

SUPPORTING LABORATORY EQUIPMENT

- **TurboVap II** (Biotage) – Evaporates up to 24 extracts simultaneously.
- **TurboVap 96 Dual** (Biotage) – Evaporates 96-well plate samples, including serum extracts.
- **Waters OTTO Specialist SPE manifold** – For filtration of serum samples on 96 well plates
- **Bead Mill 24 homogenizer** (Fisher) – Homogenizes small samples (<5 g) quickly and efficiently.
- **Centrifuge 5920 R** (Eppendorf) and **Drying oven** (Fisher Scientific).
- **Walk-in Freezer (-20 °C)** – Cold room for sample storage.

MULTI-MATRIX PFAS EXTRACTION/ANALYSIS

- Aqueous (Ground water, surface water, Leachate, etc.)
- Solids (Soil, sediment, biosolids, dust, etc.)
- Tissues (Animal muscles, livers, plant species, etc.)
- Milk, Blood and Serum
- Food samples, and others

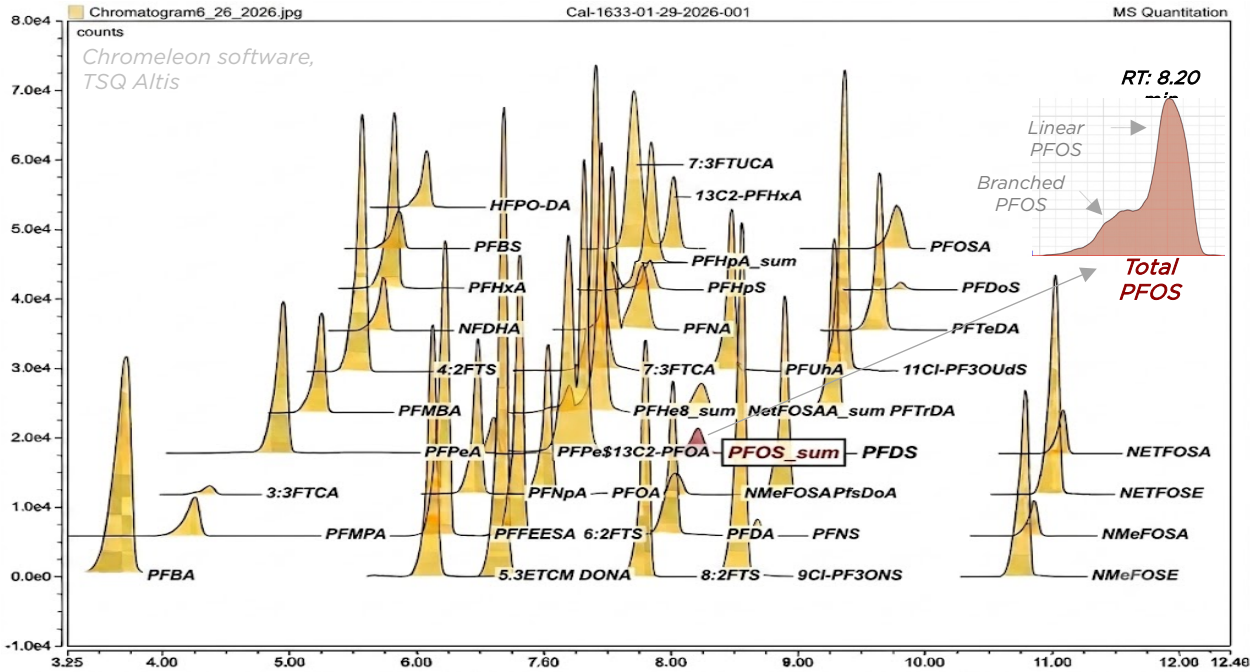
AVAILABLE ANALYTICAL METHODS AND PROTOCOLS

- EPA 1633A
- EPA 537.1
- Michigan DHHS Blood Protocol
- FDA and USDA
- ASTM D8421 dilute and shoot
- Lab developed methods for biological tissues

OUR ADVANTAGES

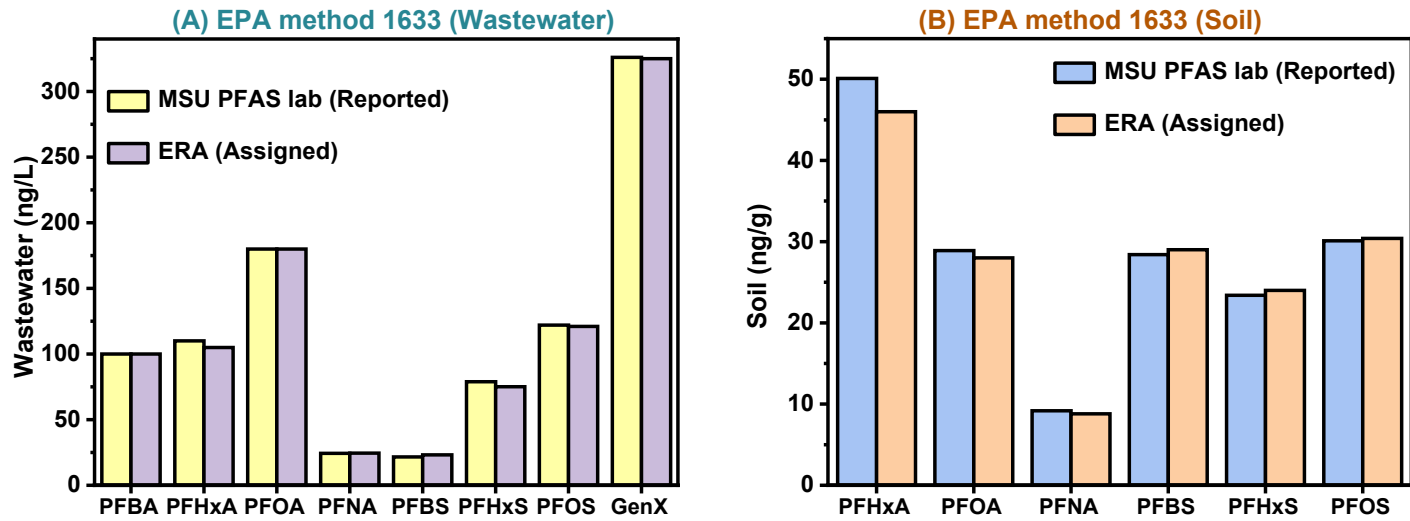
- Support for preliminary data generation and grant proposals
- High quality, research-grade analytical data
- Affordable PFAS analysis
- Collaborative support from experienced research scientists
- Method development, validation, and troubleshooting
- Fast turnaround (2-3 weeks)

High Confidence PFAS Detection by LC-MS/MS



Representative LC-MS/MS chromatograms demonstrate sensitive detection and excellent chromatographic separation of 40 native PFAS compounds. The expanded PFOS chromatogram illustrates the characteristic linear and branched PFOS isomer pattern used for total PFOS quantification, supporting reliable compound identification at low-ng/L concentrations.

Proficiency Testing Results



Proficiency testing for EPA Method 1633 analyses of wastewater, and soil matrices demonstrates that the MSU PFAS Analytical Laboratory meets certified laboratory performance benchmarks, supporting the accuracy and reliability of our PFAS testing capabilities

Biomass Analytical Facility

The Biomass Analytics Facility (BAF) offers advanced, fee-for-service analytical services specializing in biomass composition analysis. Our capabilities include detailed secondary cell wall characterization, comprehensive carbohydrate and lignin profiling, and optimization of biomass digestibility.

These robust analytical tools provide critical insights into biomass structure and conversion potential, accelerating the development and optimization of biomass feedstocks and supporting research in bioenergy, materials science, and other applications.



LOCATION
Food Safety & Toxicology Building
1129 Farm Lane
Room 177K
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/biomass
email: glbrc.baf@msu.edu

EQUIPMENT

GC/MS (SINGLE QUADRUPOLE)
Agilent 5975 GC/single quadrupole Inert Plus EI MS with autosampler
Our GC/MS systems can quantify nanogram-level polysaccharide and lignin monomers, enabling researchers to submit mg quantities of samples.

THERMOGRAVIMETRIC ANALYZER (TGA)
Mettler Toledo TGA/DSC3+ thermal analysis
This precision unit allows quantitation of moisture, organics, and ash content using less than 10mg of sample

LIQUID CHROMATOGRAPH (LC-RID)
Agilent LC 1260 Infinity with refractive index detector
The LC system is used to quantify polysaccharides, acetyl, and fermentation products.

ION CHROMATOGRAPH SYSTEM WITH ELECTROCHEMICAL DETECTOR (ICS-ED)
Dionex ICS-6000 HPIC System
The IC system is used to quantify monosaccharides, oligosaccharides, polysaccharides and uronic acids.

ELEMENTAL ANALYZER (CARBON AND NITROGEN)
Thermo Fisher Scientific FlashSmart with autosampler
Combined with our weighing robot, the lab can quickly pack and run samples for carbon and nitrogen content.

SOLID GRINDING/WEIGHING ROBOTS
Labman Automation - iWall
A custom system that automates µg to mg dispensing of 2mL samples with barcode/LIMS tracking. Samples are pulverized using SS beads at 5,000 cycles per minute.

UV/VIS SPECTROPHOTOMETER
Spectramax PLUS 384 Cuvette and Plate reader
Used for the determination of acid-soluble lignin, glucose, and pentoses.

NEAR-INFRARED SPECTROMETER
DS2500 Solid Analyzer
Rapid analysis of lignocellulosic composition of switchgrass or sorghum biomass varieties. Constituents are predicted using NIRS models developed at the BAF.

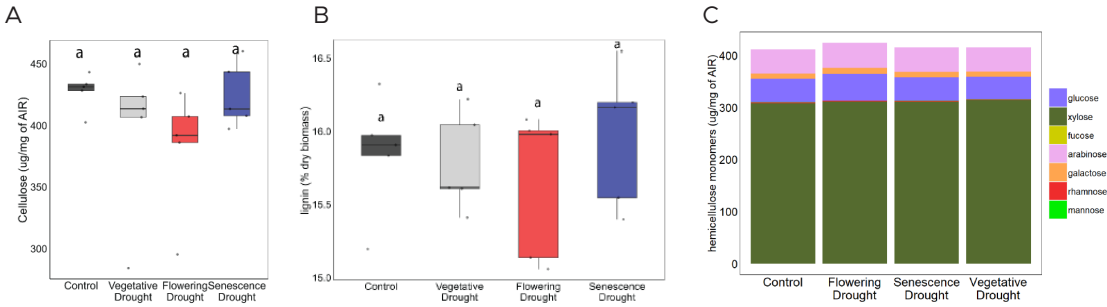
GRINDING AND MILLING

- Labman iWall 2mL vial pneumatic bead beater
- Qiagen/Labconco TissueLyser II
- Foss Cyclotec Mill (0.5mm - 5mm grind size)
- RO-TAP Sieve Shaker
- Accelerated Solvent Extractor
- Dionex ASE 350
- High pressure extraction of biomass for wet-chemistry analysis. Enables 30-minute extraction using 10mL or 66mL cells. Solvent controller allows mixing and delivery of up to three solvents.

SERVICES

- Biomass Processing (Grinding/weighing/aliquoting)
- Biomass Extraction (Alcohol Insoluble Residue)
- Structural Polysaccharide Composition
- Matrix Polysaccharide Quantitation
- Crystalline Cellulose Content
- Lignin Content (Klason/Acid Insoluble, Acid Soluble, Lignin Ash, Acetyl Bromide Soluble)
- Lignin Monomer Composition (S/G/H Ratio)
- High-throughput Enzyme Digestibility with customized pretreatments
- High-throughput Compositional Tests (Free Sugars, Starch)
- Thermogravimetric Analysis (Ash / Organic / Moisture)
- NREL Mass Closure Analysis
- Nitrogen / Carbon / Protein Elemental Analysis
- NIRS Prediction (Glucan, Xylan, Lignin, Extractives, Ash)
- Oligosaccharide / Uronic Acid Quantitation

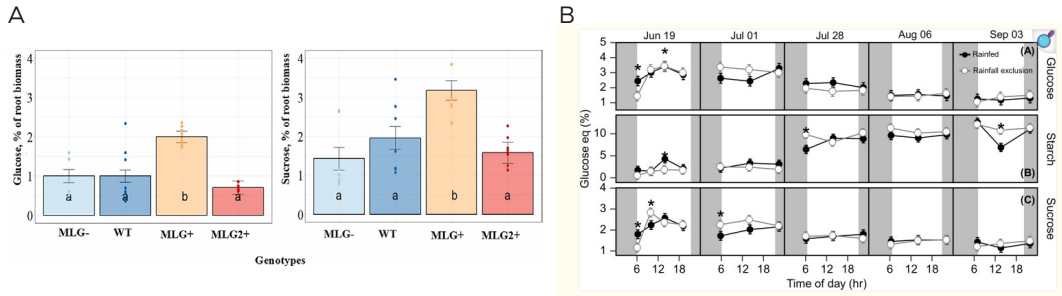
Determination of Physiological and Metabolic Responses of Switchgrass to Drought Stress



Adapted from: Basyal, B., et al. 2025. **Developmentally-specific physiological and metabolic responses support drought resilience in switchgrass and constrains biofuel yield.** bioRxiv. DOI: 10.1101/2025.05.29.656847

(A-C) Aboveground biomass Alcohol Insoluble Residue (AIR) composition showed no significant changes in cellulose, lignin, or hemicellulose under any drought condition (mean ± SE, N=10). Metabolic profiling revealed strong accumulation of glucose, fructose, quinic acid, shikimate, and GABA during vegetative-stage drought, whereas flowering and senescence stages showed minimal shifts. Specialized metabolites followed similar stage-dependent patterns, with the greatest changes during vegetative drought. Leaf starch was significantly depleted at senescence, likely reflecting reduced photosynthesis and reliance on stored carbohydrates for maintenance.

High-Throughput Metabolite Screening of Biomass and Cell Wall Genotypes (Free Sugars, Starch)

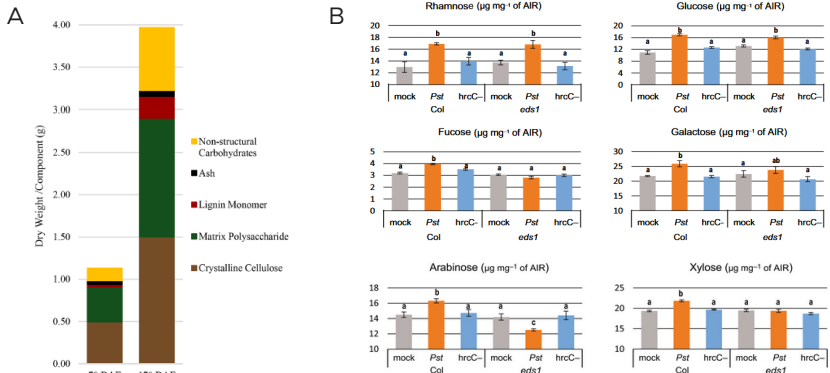


Adapted from: Chakraborty, P., et al. 2025. **Higher levels of mixed-linkage (1,3;1,4)-β-glucan in transgenic grasses may impact soil C processing.** Soil Biology and Biochemistry, 210, 109946. DOI: 10.1016/j.soilbio.2025.109946

Adapted from: Tejera-Nieves, M., et al. 2023. **Seasonal decline in leaf photosynthesis in perennial switchgrass explained by sink limitations and water deficit.** Frontiers in Plant Science, 13:1023571. DOI: 10.3389/fpls.2022.1023571

(A) The trends in total soluble sugars differed from those in cell walls. The glucose levels in MLG2+ and MLG-roots were comparable to those in WT. In contrast, the glucose levels in MLG+ roots were twice as high as those in the other genotypes. Similarly, the sucrose level in MLG+ was higher than in the other tested genotypes. The trends in soluble sugar contents in the roots were consistent with those in the leaves, while no differences among the genotypes were detected within the stems. (B) Rhizome carbohydrates were not affected significantly by the imposed water-deficit condition in most comparison. Leaves had an average 12-22% higher mean sucrose and starch concentrations outside the shelters.

Bioenergy Crop and Cell Wall Compositional Analysis



Adapted from: Yu, K.M.J., et al. 2025. **Bioenergy sorghum stem density increases threefold following internode elongation due to continued accumulation of lignified cell walls and complex regulation of genes involved in cell wall biosynthesis.** Biotechnol. Biofuels Bioprod, 18, 58. DOI: 10.1186/s13068-025-02659-w

Adapted from: Kim, S.J., et al. 2023. **Immune activation during Pseudomonas infection causes local cell wall remodeling and alters AGP accumulation.** Plant J., 116(2): 541-557. DOI: 10.1111/tpj.16393

(A) Stem internode composition analyzed at 70 and 170 DAE. Cell wall biomass composed of cellulose, matrix polysaccharides and lignin. Starch also accumulated in stems over the period. (B) Among the increased pentoses, in this work, we found a remarkable increase in arabinose in the CW upon infection. Arabinose is commonly found in pectic polysaccharides, proteoglycan, and hemicelluloses such as arabinoxylan or xyloglucan. In addition, arabinose decorates AGPs, whose functions in the CW are not clearly understood yet.

Stable Isotope Core Facility

Stable isotope analysis is a powerful tool for a wide range of scientific disciplines including geosciences, microbiology, chemistry, soil science, physiology, forensics etc., but requires specialized instrumentation. The vision of the MSU light stable isotope core facility is to provide the analytical capabilities and staff expertise to provide analytical measurements, assist with experimental design, and contribute to stable isotope data interpretation to help ensure success of MSU researchers.



LOCATION
Plant and Soil Science Building
1066 Bogue Street
Rooms A540, A545
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/stable-isotope
email: stableisotopefacility@msu.edu

EQUIPMENT

Four isotope ratio mass spectrometer (IRMS) instruments including Elemental Vision, 100, and two PreciSION

These instruments are specialized for making high precision stable isotope measurements of both natural abundance and stable isotope labeled materials.

Various peripheral devices integrated with our IRMS instruments including **Elemental Analyzers** (Vario Isotope Cube, two Vario Isotope Select systems), **Greenhouse Gas Interfaces, pyrolysis system** (PyroCube), **dissolved organic carbon systems** (IsoTOC), and **acid reactors** (Elementar isoFlow).

These devices enable sample processing and introduction into the IRMS instruments for analysis.

Shimadzu GC-2014 gas chromatographs

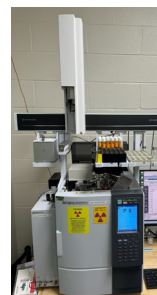
Specialized for quantification of greenhouse gases for use independently or in preparation for isotope analysis.

Unicube Elemental Analyzer

Perform stand alone compositional analysis (C and N) of solid samples

Sample preparation equipment

Lyophilizer, ball mill, high precision balances, muffle furnace, etc. to help facility users prepare their samples for stable isotope analysis



Clockwise, from top left
Shimadzu GC-2014 Gas Chromatographs, specialized for quantification of greenhouse gases for use independently or in preparation for isotope analysis; **Unicube Elemental Analyzer**, perform stand alone compositional analysis (C and N) of solid samples; **Sample Preparation Equipment**, Lyophilizer, ball mill, high precision balances, muffle furnace, etc. to help facility users prepare their samples for stable isotope analysis

SERVICES

- A full array of capabilities for performing stable isotope analysis of hydrogen, carbon, nitrogen, and oxygen
- Analyses of solid, liquid, and gas sample types
- Some compound specific stable isotope measurement capabilities
- Site preference analysis of N₂O
- Access to basic sample preparation equipment
- Spatially resolved (10-100 μm) analysis of solid samples

Types of Questions Previously Addressed using the Elemental Analyzer Coupled to Isotope Ratio Mass Spectrometry System

- Understanding fate of organic carbon in soil
- Identifying whether specific substrates can be consumed by an organism
- Assessing animal nutritional status and trophic levels
- Quantifying rates of carbon dioxide or nitrogen fixation
- Identifying inputs to textiles
- Animal migration studies



Types of Questions Previously Addressed using the Advanced Gas Handling and Isotope Analysis Systems

- Site preference nitrogen isotope analysis of N₂O to identify biochemical production pathway
- Tracking dissolved inorganic carbon in aqueous samples

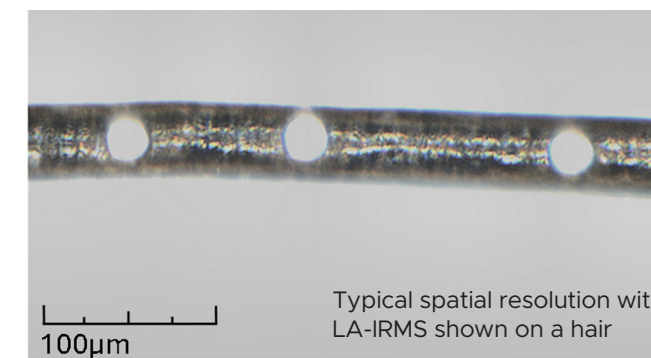
Types of Questions Previously Addressed using Compound Specific Stable Isotope Analysis (CSIA)

- Tracking and helping to source methane production
- Identifying evidence of microbial bioremediation of contaminants
- Chemical forensics, stable isotope fingerprinting



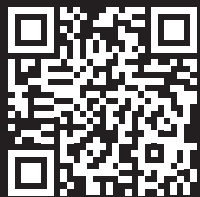
Types of Questions Previously Addressed using Laser Ablation Coupled to Isotope Ratio Mass Spectrometry System (LA-IRMS)

- Revealing spatial extent of root exudates into rhizosphere
- Unlocking temporal dietary signatures from hairs
- Evaluating yearly nutritional status in teeth



(LA)-ICP-MS Material Characterization Core Facility

The Laser Ablation (LA)-ICP-MS Material Characterization Core Facility offers high precision elemental analysis of solid and aqueous samples on a fee-for-service basis. Most analyses in our facility involve laser ablation of solid Earth materials. We also characterize liquid samples in a solution mode.



LOCATION
Chemistry Building
578 South Shaw Lane
Room 223
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/icp-ms

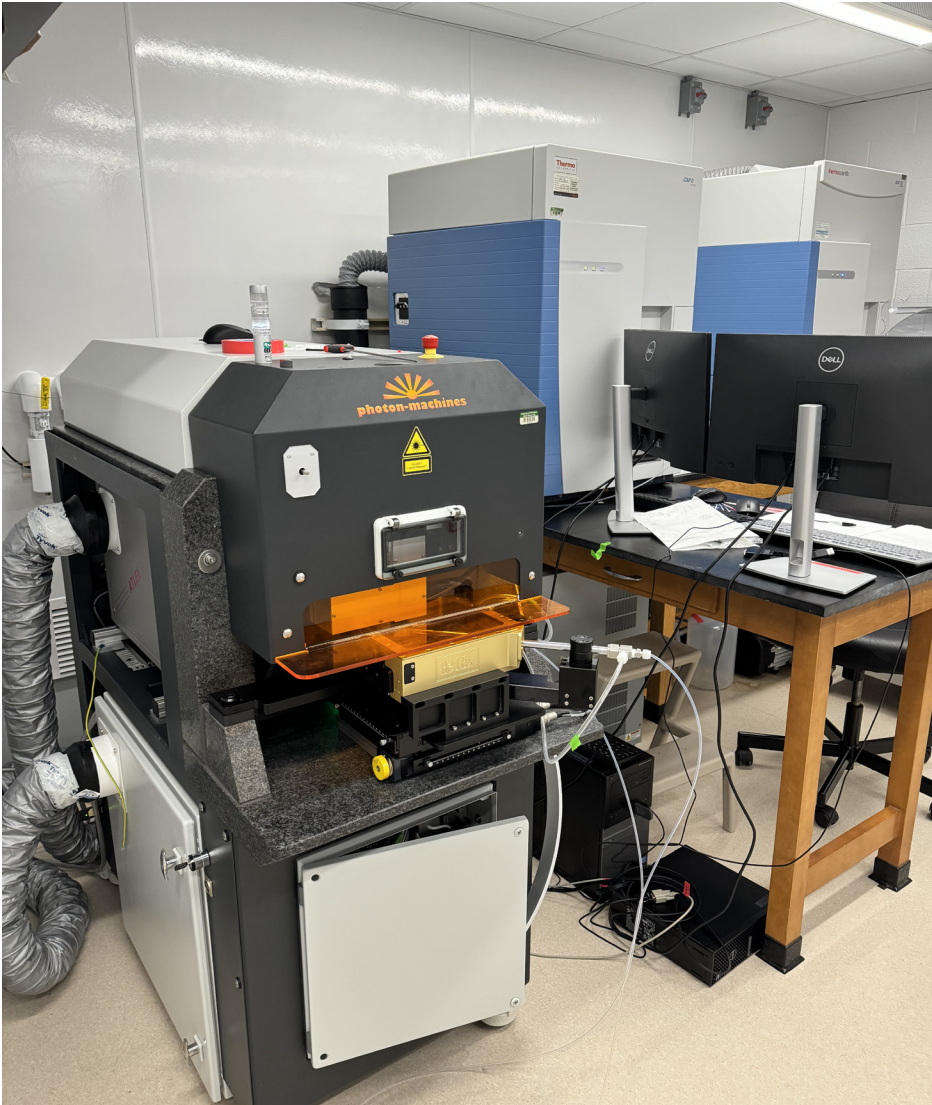
EQUIPMENT

Photon Machines Laser Ablation System
Our laser system allows us to analyze solid materials by ablating them with a high energy excimer laser. This technique may be constrained to spot sizes as small as ~65 microns allowing for an added spatial component to the chemical analysis.

Thermo iCAPQ ICP-MS
Ablated material from the Photon Machines laser ablation system is transported to our Thermo iCAPQ inductively coupled plasma mass spectrometer, capable of analyzing masses ⁶Li to ²³⁸U with high precision and accuracy. We also have solution mode capabilities to analyze aqueous samples using an autosampler.

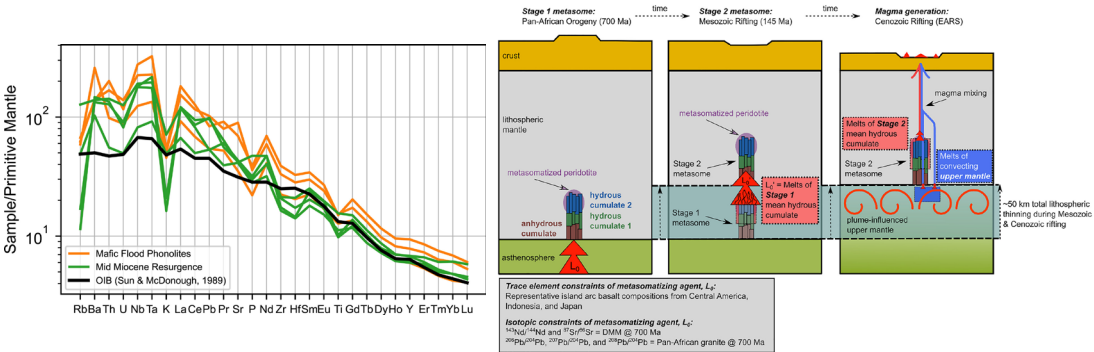
SERVICES

- Sample preparation and elemental quantification of solid Earth materials: rocks, minerals, soils, fossils.
- Quantified elemental analysis of biologic materials, usually as aqueous sample introduction.
- Quantified elemental analysis of solid industrial materials.



Photon Machines Excimer Laser (left) and Thermo iCAPQ ICP-MS (right)

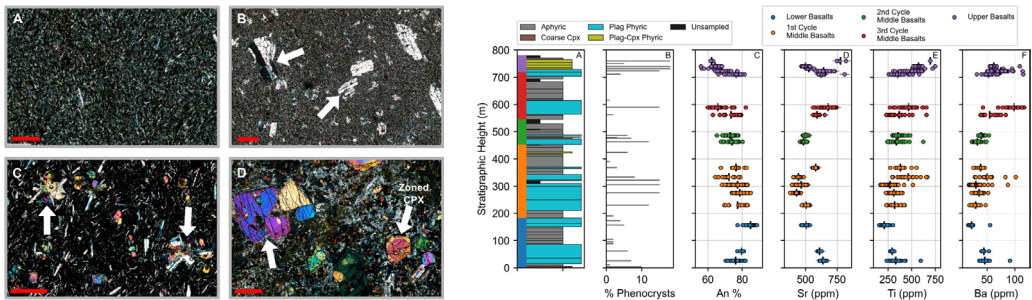
A HIMU-Like Endmember Hiding in the Turkana Depression Continental Lithospheric Mantle



Bollinger, A., Rooney, T.O., Brown, E.L., Ramos, F.C., 2025, A HIMU-Like Endmember Hiding in the Turkana Depression Continental Lithospheric Mantle. *Geochemistry, Geophysics, Geosystems* 26 (7), e2024GC012086. doi: 10.1029/2024GC012086

High precision trace element geochemistry of whole rock lava samples is obtained through our LA-ICPMS Core Facility. These data allow us to constrain the potential mantle sources of magmas generated in an active continental rift system. When these data are applied to geochemical models and coupled with radiogenic isotopic ratio data, we can identify a complex mixture of mantle sources that contribute to magmatism in the Turkana Depression region.

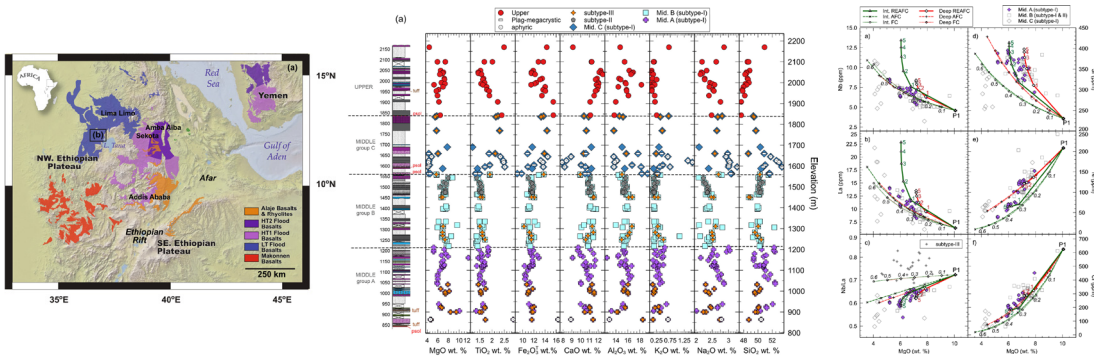
Messengers from the Magma Chambers: Petro-stratigraphic Analysis of Plagioclase-Rich Flood Basalt Lavas in Turkana, Kenya



Steiner, R.A., Rooney T.O., Kappelman J., Girard, G., Mariita, N., Phillips, R., Messengers from the Magma Chambers: Petro-stratigraphic Analysis of Plagioclase-Rich Flood Basalt Lavas in Turkana, Kenya. 2024, *Journal of Petrology*, V.65(6), pp. egae044, doi: 10.1093/petrology/egae044

Using a 65-micron spot size, the laser ablation system allows us to analyze the geochemistry of individual mineral grains that originally grew in a magma chamber. These magma storage systems can be complex, but crystal chemistry acts as a time capsule for the conditions and changes in the system over time. This project investigates a large stack of lavas containing plagioclase crystals. These crystals were used to track the storage time of magmas prior to eruption by applying their chemical composition to a diffusion model.

Magma Evolution During Main-Phase Continental Flood Basalt Volcanism: A Case for Recharge-Evacuation-Assimilation-Fractional Crystallization in the Ethiopian Low-Ti Province

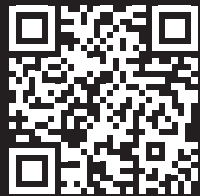


Krans, S. R., Rooney, T. O., Kappelman, J., Yirgu, G., and Ayalew, D., Magma Evolution During Main-Phase Continental Flood Basalt Volcanism: A Case for Recharge-Evacuation-Assimilation-Fractional Crystallization in the Ethiopian Low-Ti Province. 2024, *Geochemistry, Geophysics, Geosystems*. V.25, e2023GC011289, doi:10.1029/2023GC011289

Large outpourings of lava, known as flood basalts, are often highly modified in the crust through a complex system of storage, crystallization, eruption, and recharge. These combined processes result in changes in geochemical patterns throughout several pulses of magmatism. We can model this pattern of flood basalt evolution using the trace element geochemical composition of lavas obtained through our LA-ICPMS Core Facility.

XRF Material Characterization Core Facility

The XRF Material Characterization Core Facility seeks to provide a fee-for-service model to characterize materials at the elemental level using X-Ray Fluorescence techniques. The facility is available to those at MSU and beyond. XRF can be used to provide quantitative or semi-quantitative values for: powders, filter paper deposits, films, and solid flat objects if they fit within the sample holder. We are happy to discuss your needs and welcome collaboration on method development.



LOCATION
Natural Sciences and Chemistry Building
288 Farm Lane
Room 207
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/xrf
email: geosci@msu.edu

EQUIPMENT

RIGAKU SUPERMINI WD-XRF

This unit is a wavelength dispersive XRF for superior peak separation that can run under vacuum or helium atmosphere. Our setup makes it easier to measure the more difficult to detect lighter elements while providing excellent resolving power for heavier elements. We have PET, LiF(200), and RX26 crystals with a PC and SC detector.

AUXILIARY EQUIPMENT

- **Diamond tipped rock saw**
For use with natural earth materials only
- **Steel jaw crusher**
For use with natural earth materials only
- **BICO flat plate grinder with contamination control plates**
For use with natural earth materials only
- **Fusion equipment for Li-borate glass prep**
For use with natural earth materials only
- **30 Ton Press**
For use in generating pressed powder pellets

SERVICES

XRF ELEMENTAL ANALYSES

- Quantitative calibration for earth materials
- Semi-quantitative values for unknown material

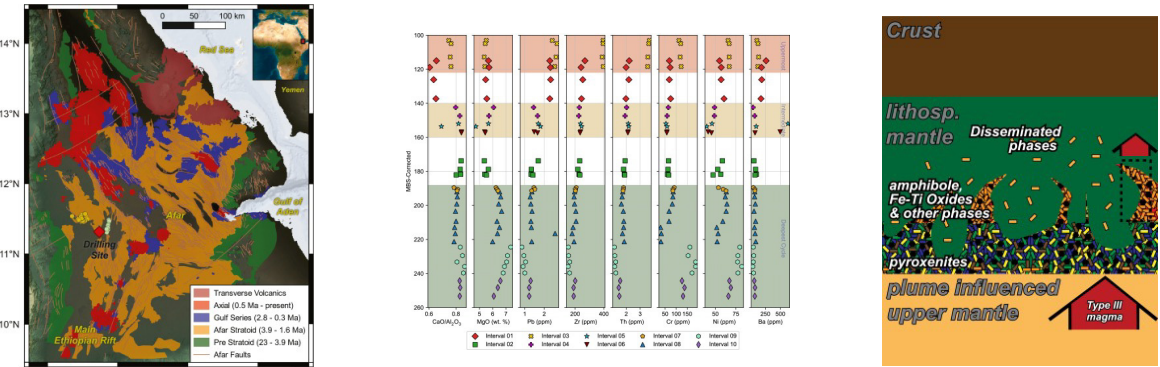
SAMPLE PREPARATION

- Earth materials can be cut, powdered and fused into glass disks
- Other samples can be converted to pressed powders



Rigaku Supermini XRF

Magmatism During the Continent–Ocean Transition

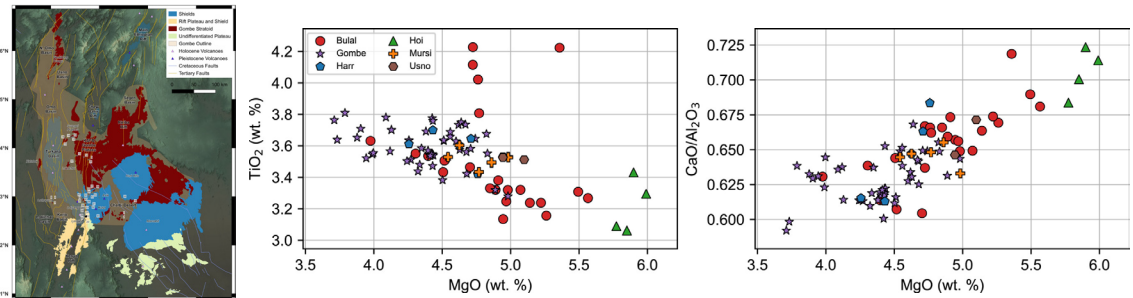


Establishing the source of magmatism during the terminal stages of continental rifting can be challenging and requires the high precision analysis of erupted lavas. This project examined the major and trace element composition of a suite of lavas using data generated from our XRF and ICPMS core facility.

Rooney, T.O., Brown, E.L., Bastow, I.D., Arrowsmith, J.R., and Campisano, C.J., 2023, Magmatism during the continent–ocean transition: Earth and Planetary Science Letters, v. 614, p. 118189.

<https://doi.org/10.1016/j.epsl.2023.118189>

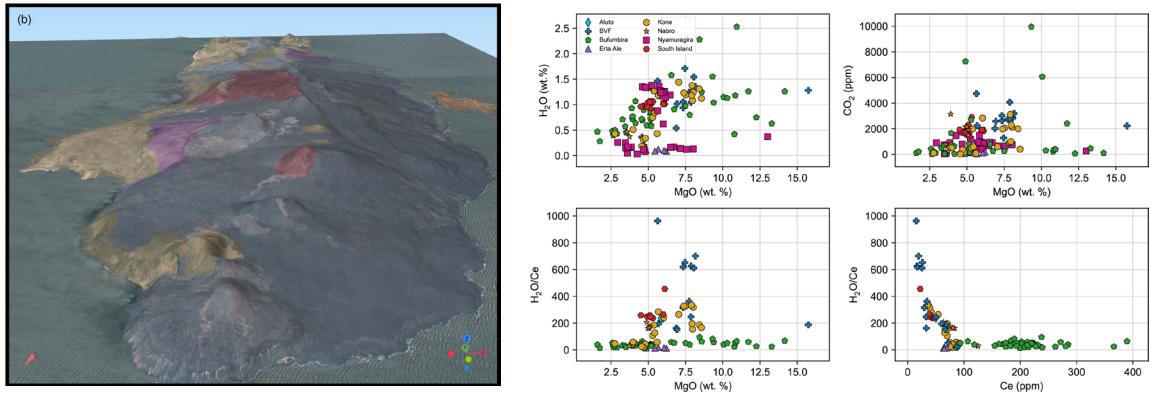
Basaltic Pulses and Lithospheric Thinning–Plio–Pleistocene Magmatism and Rifting in the Turkana Depression (East African Rift System)



Cancel Vazquez, S.M., Rooney, T.O., Brown, E.L., Bollinger, A., Bastow, I.D., Steiner, R.A., and Kappelman, J., 2024, Journal of Geophysical Research: Solid Earth, v. 129, p. e2024JB029166, doi:10.1029/2024JB029166

Magmatism in East Africa manifests as a series of basaltic pulses followed by periods of quiescence. The reason for this cadence remains elusive – there is no evidence of changes in the flux of material derived from the deep mantle. This project explores whether changes in the rate of plate thinning might cause such pulses and if the magnitude of erupted magmas are consistent with such a model.

Transition to Magma-Driven Rifting in the South Turkana Basin, Kenya



Rooney, T.O., Wallace, P.J., Muirhead, J.D., Chiasera, B., Steiner, R.A., Girard, G., and Karson, J.A., 2022, : Journal of the Geological Society, v. 179, p. jgs2021-160. <https://doi.org/10.1144/jgs2021-160>

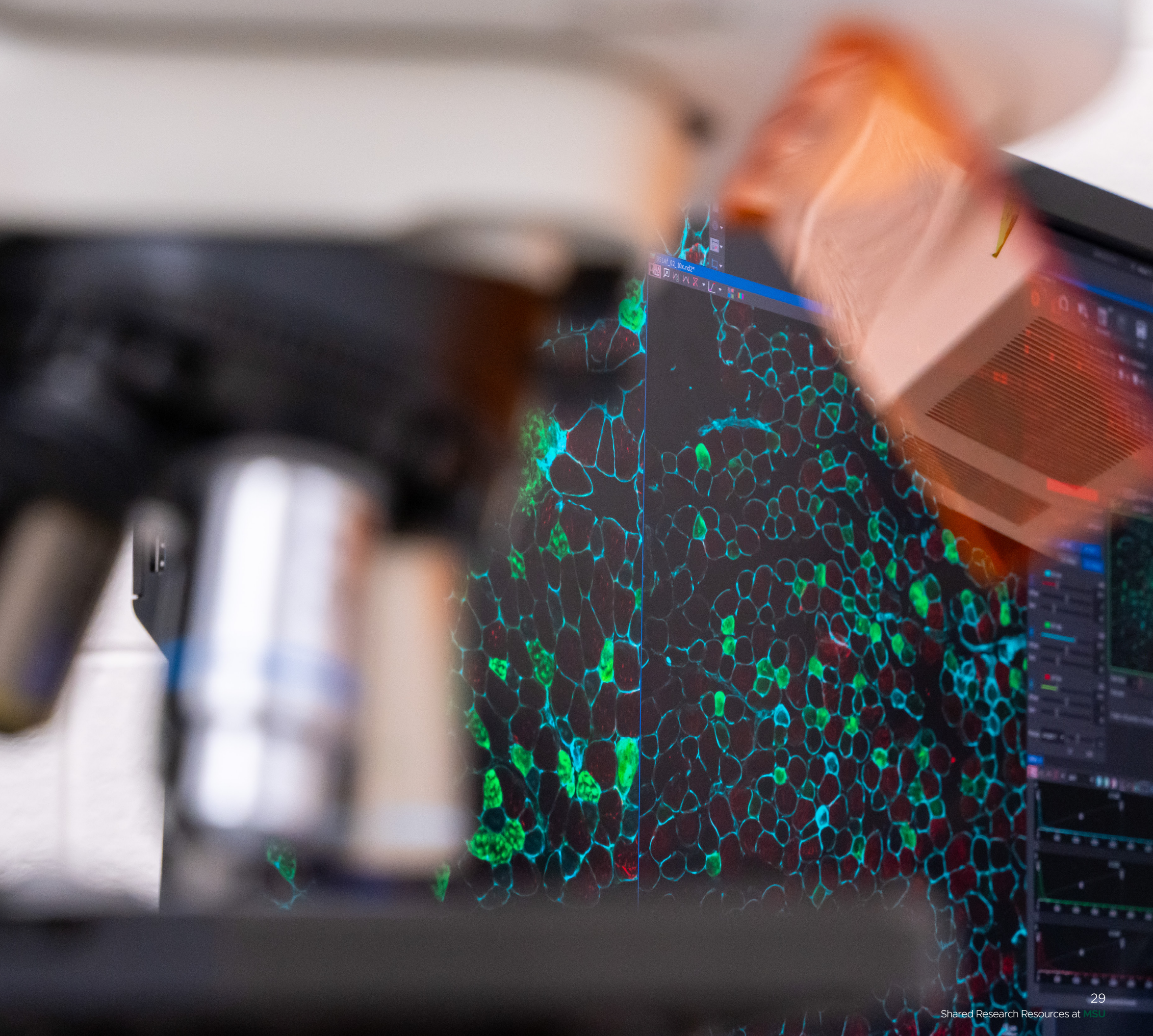
In a continental rift extension based on plate thinning must eventually give way to extension based on the construction of new magmatic crust. This transition is currently underway in parts of the East African Rift System. This project uses data from our core facilities to demonstrate that this focusing of magmatism is occurring within the Turkana Basin.

Imaging & Visualization

Go deeper than the surface.

From molecules to living systems, advanced tools bring hidden structure and function into focus.

Cryo-EM Core Facility.....	30
Center for Advanced Microscopy.....	32
IQ Microscopy Core Facility.....	34
Flow Cytometry Core Facility.....	36
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Cryo-EM Core Facility

The Cryo-EM Core Facility provides investigators with access to cutting-edge cryo-electron microscopy instrumentation, as well as support in training and experimental consultation. Cryo-electron microscopy is extensively used for determining structures of biological materials such as isolated proteins and complexes, small particles including viruses and bacteria, isolated organelles, whole cells, and FIB-milled tissues.



LOCATION
Engineering Research Complex
1449 Engineering Research Ct.
Room D122
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/cryo-em
email: RTSF.cryoEM@msu.edu

EQUIPMENT MAIN MICROSCOPES

Talos Arctica (ThermoFisher)
The Arctica is a 200 keV cryo-electron microscope equipped with an autoloader, a Selectris energy filter and a Falcon 4i camera. It is great for sample screening and data collection of specimens using single particle analysis.

Titan Krios (ThermoFisher)
The Krios is a 300 keV cryo-electron microscope equipped with an autoloader, a Selectris X energy filter and a Falcon 4i camera. It is great for high resolution data collection using single particle analysis. In addition is great for cryo-electron tomography and micro-electron diffraction.

Helios Hydra Bio (ThermoFisher)
The Helios is a FIB-SEM electron microscope used for focused ion beam milling of cryogenic specimens. The Helios is also capable of correlated light and electron microscopy.

AUXILIARY EQUIPMENT

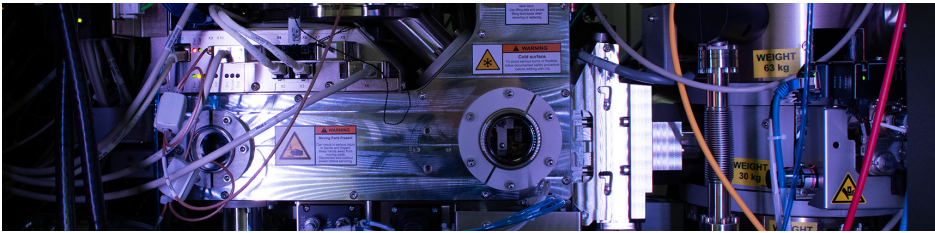
EasiGlow (Pelco) & GloQube Plus (Quorum)
Glow discharger for grid preparation

ACE-600 carbon coater (Leica)
Carbon coating and metal shadowing

Vitrobot Mark IV (ThermoFisher) & GP2 (Leica)
Robotic plunge freezing device for cryo-EM grid preparation

Compresstome (Precisionary)
Vibratome for tissue sectioning

High Pressure Freezer (CryoCapCell)
Freezing device for thick tissue samples



SERVICES

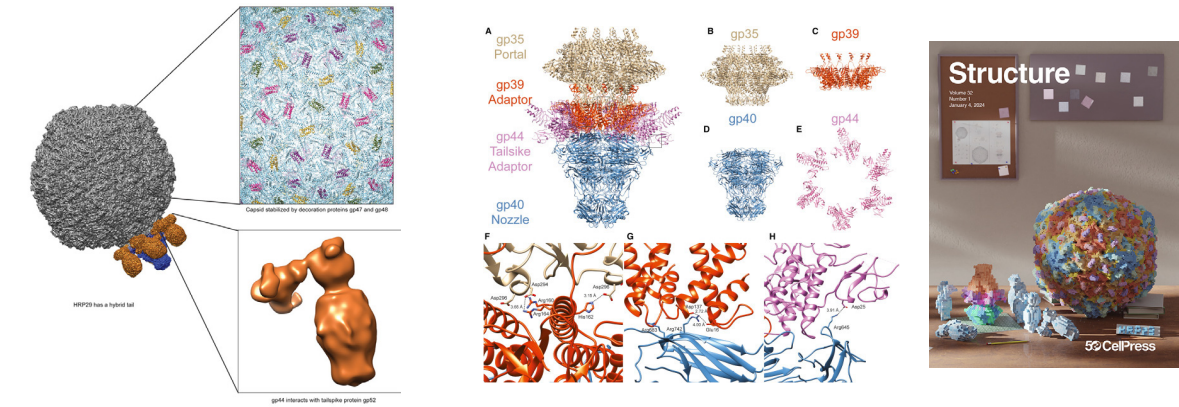
Cryo-EM imaging including:

- Single particle analysis
- Cryo-tomography
- FIB-Milling
- Micro-ED

Computational support including:

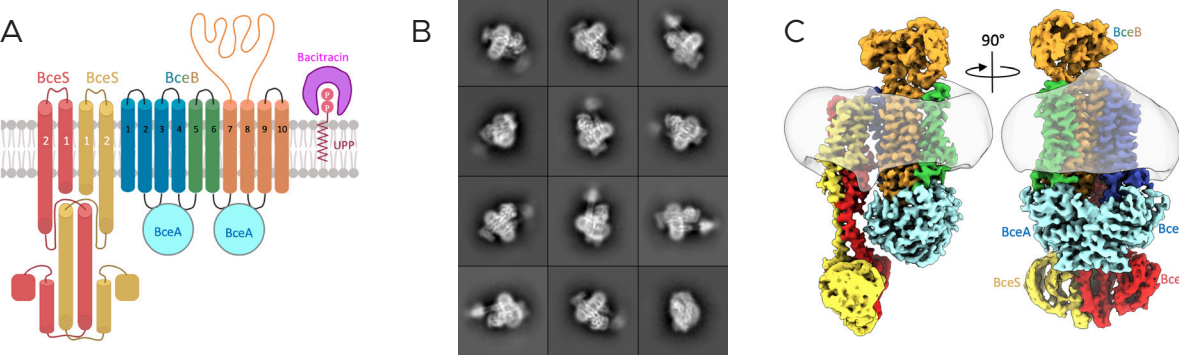
- Live image processing
- Access to computers with standard image processing programs (RELION, cryoSPARC, IMOD, etc.)
- Raw data storage for 30 days

Cryo-EM Structure of an Entire Bacteriophage with a Hybrid Tail



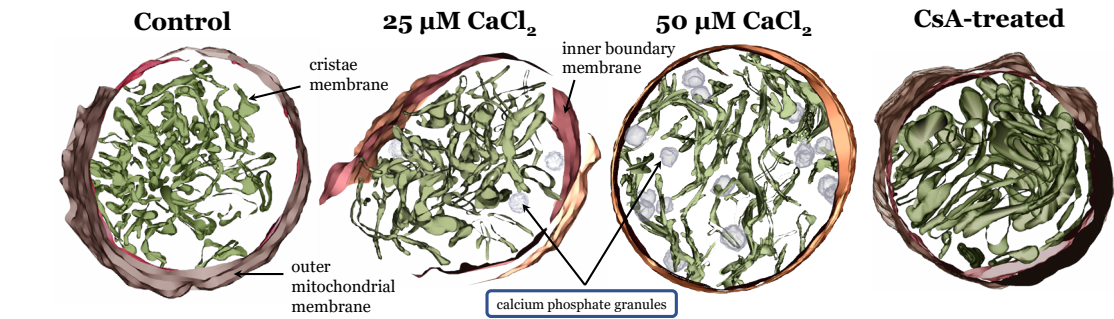
There is a paucity of high-resolution structures of phages infecting *Shigella*, a human pathogen and a serious threat to global health. HRP29 is a *Shigella* podophage belonging to the Autographivirinae family, and has very low sequence identity to other known phages. Single particle analysis cryo-EM was used to resolve the structure of the entire phage HRP29 virion. These results show that Phage HRP29 has a highly unusual tail, which is a fusion of a T7-like tail tube and P22-like tailspikes mediated by interactions from a novel tailspike adaptor protein. Understanding phage tail structures is critical as they mediate hosts interactions.

Structure of an Antimicrobial Peptide Sensing and Detoxification Complex



Antibiotic resistance is a growing global health problem. Most Gram-positive bacteria contain membrane protein complexes known as Bce modules (A) that consist of an ABC transporter working in tandem with a histidine kinase to sense and mediate resistance against diverse antimicrobial peptides. Single-particle cryo-EM was used to visualize the structure and dynamics (B & C) of the prototypical Bce module BceABRS from *B. subtilis*. These structures provide key insight into the assembly and dynamics of Bce modules, and the first ever structure of a full-length membrane embedded histidine kinase.

How Structure Impacts Mitochondrial Function in Health and Disease

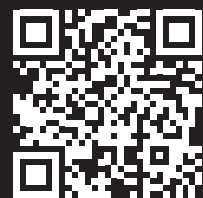


Mitochondrial ultrastructural changes associated with calcium overload will reveal the answer to an over 50-year-old question, and cryo-EM is currently the best way to visualize them with minimal disturbance to native states. Mitochondrial reconstructions from cryo-EM data reveal striking and newly discovered ultrastructural effects of calcium and a mitoprotectant called CsA. Calcium causes a decrease in cristae volume in a titratable manner, and CsA leads to an expanded cristae volume and altered outer membrane morphology. These images help inspire new perspectives on this 50-year-old question.

Center for Advanced Microscopy

The Center for Advanced Microscopy is the central microscopy laboratory for the East Lansing campus. We provide MSU researchers with formal graduate level instruction and 24/7 access to scanning electron microscopes, transmission electron microscopes, a digital light microscope, and confocal laser scanning microscopes.

We support all research disciplines, and we serve more than 500 MSU researchers per year from 40 different University departments, as well as many off-campus researchers.



LOCATION
Center for Integrated Plant Sciences Building
578 Wilson Road
Room B2
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/cam
email: cam.microscopy@msu.edu

EQUIPMENT

Confocal Laser Scanning Microscopy (CLSM)

- 3i Spinning Disk, live-cell or tissue incubation
- Leica Stellaris 5 with white light laser
- Nikon A1Rsi with TIRF and STORM
- Nikon AXR upright / large FOV
- Nikon C2+
- Olympus Fluoview 1000 Spectral
- Zeiss 980 with Airyscan 2 super resolution

Digital Light Microscopy

- Keyence VHX-6000 Digital Microscope

Laser Capture Microscopy

- Zeiss Palm MicroBeam IV

Scanning Electron Microscopy (SEM)

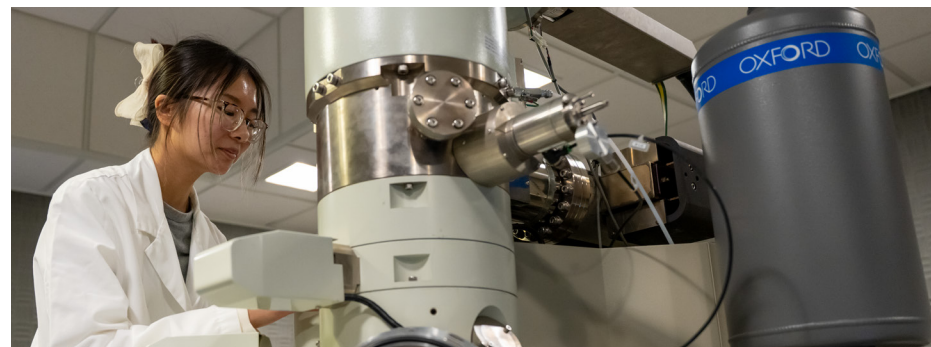
- JEOL 6610LV with Oxford EDS, includes low-vac
- JEOL 7500F with Oxford EDS, high resolution

Transmission Electron Microscopy (TEM)

- JEOL 1400 'Flash', 120 kV
- JEOL 2200FS, 200kV with EDS
- ThermoFisher probe-corrected Spectra 200 STEM with EDS and EELS (coming 2027)

Sample Preparation

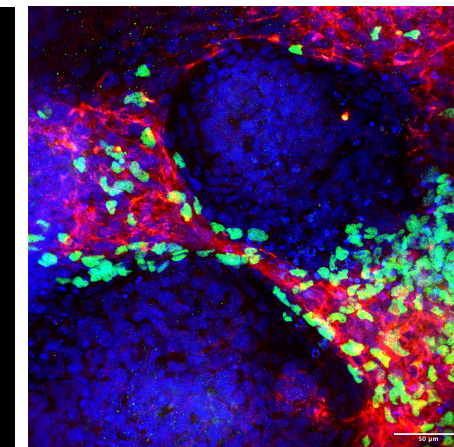
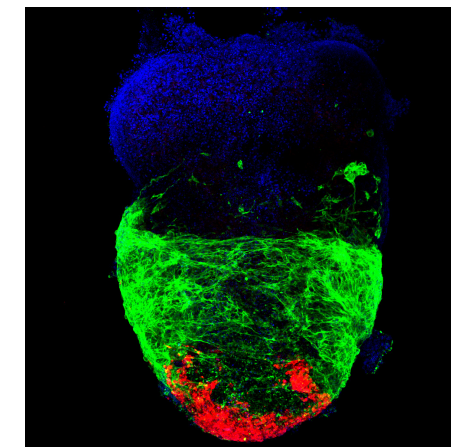
- State-of-the-art ultramicrotomy
- Many coaters (C, Au, Ir, Os, Pt)
- Critical point drying and freeze-drying
- Cryostat
- Disc cutter, dimple grinder, ion mill



SERVICES

- Graduate-level microscopy courses and training
- Confocal microscopy applications including: Multi-channel fluorescence imaging, high speed imaging, live-cell, FLIM, FRAP, FRET, BiFC, spectral imaging, high-resolution large area scanning, TIRF, super resolution (Airyscan, lightning, STORM), heating / cooling incubation, etc.
- Biological and soft-matter TEM services, including fixation and embedding, negative staining, immunogold experiments, and TEM imaging / data collection.
- Sample preparation, imaging, and analysis of a wide range of samples for SEM-EDS
- Physical sciences TEM-EDS services
- Experimental design, image acquisition and analysis
- Assistance with grant planning and writing

Confocal Laser Scanning Microscopy (CLSM) and Transmission Electron Microscopy Contribute to the Development of More Realistic Human Heart Model Systems



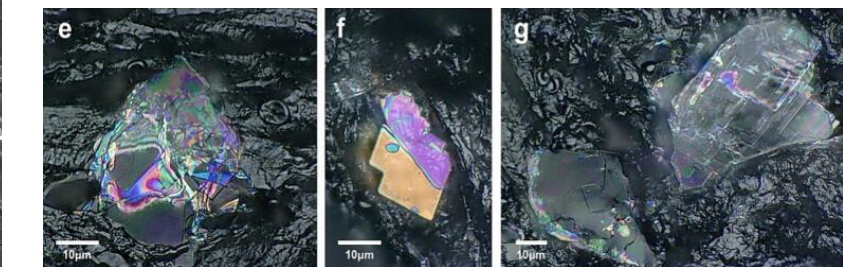
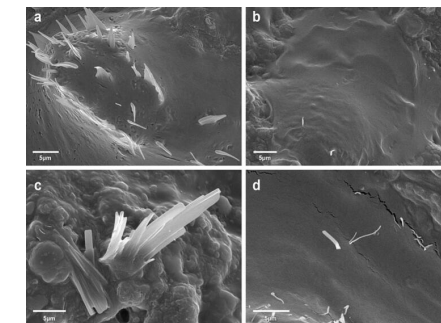
Thanks to advancements in the development of patented synthetic human-like hearts first created at MSU, researchers can study human heart development and congenital heart disease on highly accurate models.

Left: A heart organoid with a well-developed ventricle (green) and cardiac neural crest cells (mCherry) incorporating to the structure. Blue is cell nuclei.

Right: Neural crest cells in green (SOX10) migrating along red cardiomyocytes (TNNT2) in a developing heart organoid. Blue is cell nuclei. Scale bar 10 microns. Collected on the CAM Nikon A1 CLSM.

Research from the Aguirre lab; for details see: Volmert et al. Nat Commun 14, 8245 and MSU Today 2024 issue 02.

Scanning Electron Microscopy (SEM), Digital Optical Microscopy, and CLSM Demonstrate Cholesterol Crystals Induce Damage in Solid Cancers as in Arterial Plaques



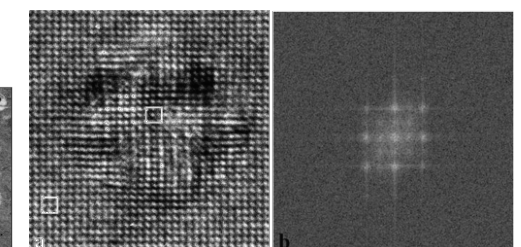
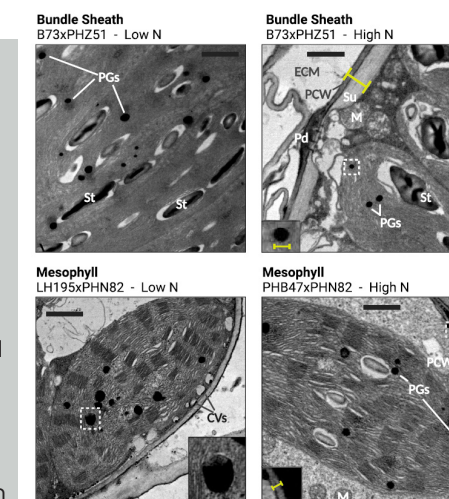
Scanning and 3D-digital microscopy of colon cancer and marginal tissue: Scanning electron micrographs of colon cancer (a, c) and matching marginal tissue (b, d) demonstrate larger and prominent cholesterol crystal formations in the cancer but not in the normal marginal tissue. CCs are seen traumatizing and perforating the tumor surface. Digital microscopy of fresh unprocessed tissue demonstrates the presence of large cholesterol crystal formations in the colon cancer (e, f, g).

Research from the Abela lab. For details: Abela GS et al. Am Heart J Plus, PMID: 37981958.

Transmission Electron Microscopy (TEM) Advances Plant Resilience and Materials Research

Thickening of maize hybrid mesophyll and bundle sheath cell walls occurs as a general response to low N, increases in plastoglobuli size and abundance, and unusual plastoglobule features. Yellow markings indicate how cell wall thickness and plastoglobule diameter were measured. Extracellular matrix (ECM), primary cell wall (PCW), the suberin layer of the cell wall (Su), starch grains (St), mitochondria (M), plasmodesmal pits (Pd), cytosolic vesicles (CVs), and plastoglobules (PGs). Regions highlighted in the insets are marked with dashed white boxes. All scale bars indicate 1 μ m. Lunquist lab.

For details, see: Plant Physiology, "Multi-scale physiological responses to nitrogen supplementation of maize hybrids"



High-resolution TEM image from a Lead Antimony Silver Tellurium (LAST)-18 sample (a) and the corresponding FFT's from nanocrystal (b). The electron beam is parallel to one of the [100] directions. The results reported here provide experimental evidence for a conceptual basis that could be employed when designing high performance thermoelectric materials and dispel the decades long belief that these systems are solid solutions. JACS 127(25) 9177-9190.

IQ Microscopy Core Facility

The IQ Microscopy Core facility provides researchers with some of the most advanced fluorescence-based microscopes for imaging a wide range of biological samples including live cells and tissues in vivo. The microscopy core staff provide training and consultation to new users and support internal and external investigators.



LOCATION
IQ/Bioengineering Building
775 Woodlot Drive
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/microscopy
email: iq@msu.edu

EQUIPMENT

WIDE-FIELD MICROSCOPE

Leica Thunder Imager

A 3D cell culture imaging system that features a computational clearing method to remove out-of-focus blur; equipped with eight excitation wavelengths (LED source) and an environmental chamber for controlling the temperature and CO₂.

CONFOCAL MICROSCOPES

Leica Stellaris 5

An inverted laser scanning confocal microscope with white light laser (WLL) from 485 nm to 685 nm and up to eight excitation lines that can be used simultaneously; equipped with an environmental chamber for controlling the temperature and CO₂.

Leica SP8

An upright laser scanning confocal microscope with WLL from 470 nm to 670 nm and up to eight excitation lines that can be used simultaneously.

MULTI-PHOTON MICROSCOPE

Leica SP8 Dive two-photon

An upright two-photon and laser scanning confocal microscope well-suited for imaging thick tissues and live animal imaging. The second harmonic generation capability of the instrument enables label-free imaging of specific samples (e.g., collagen).

TIRF SUPER RESOLUTION

Olympus TIRF/HiLo

An inverted microscope equipped with a TIRF/HiLo illumination system and four laser lines (405 nm, 488 nm, 561 nm, and 647 nm). An environmental chamber (cellVivo) is included to control humidity, temperature, and CO₂ level for live cell imaging.

RAMAN

HORIBA

A Raman with two lasers (532 and 785 nm), four motorized gratings, independent slit and confocal pinhole that is ideal for non-destructive identification of a wide range of samples.

HYPERSPECTRAL DARK-FIELD MICROSCOPE

CytoViva

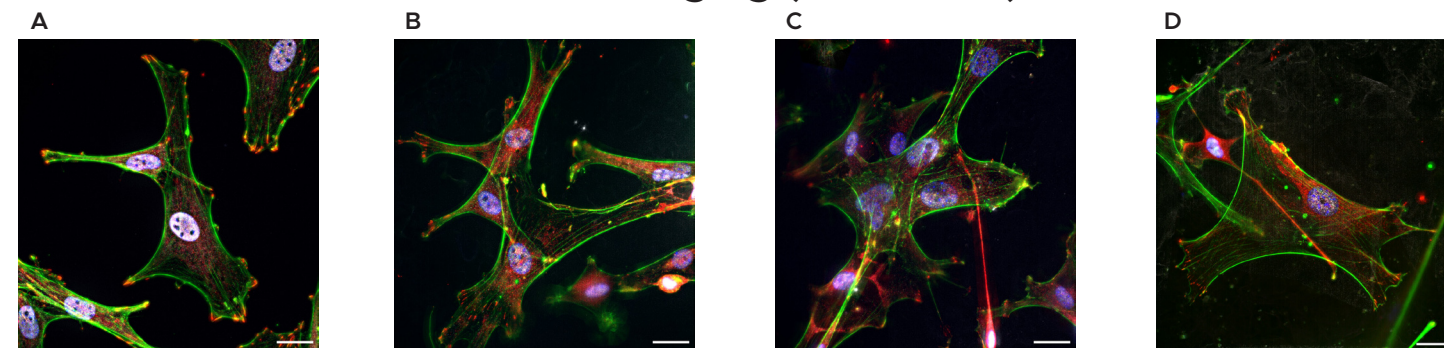
An upright microscope with enhanced dark-field capability that can be utilized for hyperspectral imaging to detect nanoparticles as small as 10 nm.

SERVICES

- Comprehensive training provided for new users
- Consultation (sample preparation, designing experiments)
- Imaging samples provided by researchers
- Manuscript/grant review



Leica Thunder Fluorescence Imaging (wide-field)



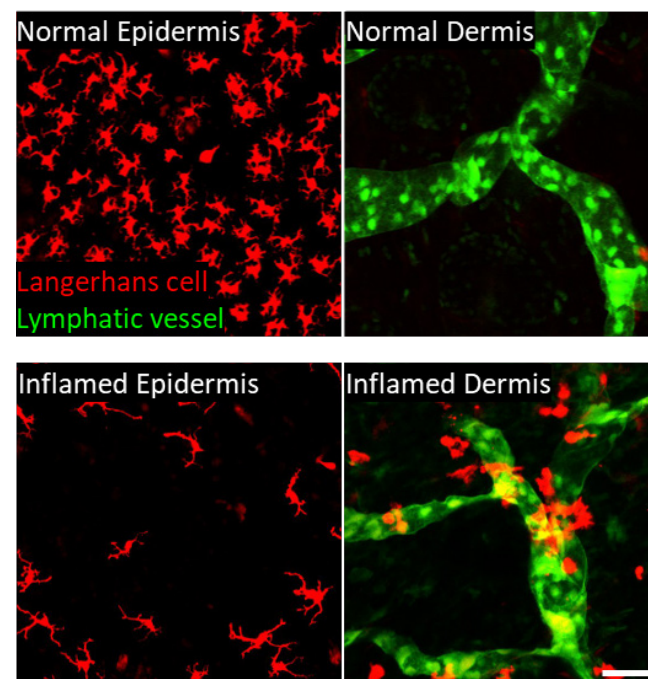
Mouse Schwann cells one day post-seeding on various substrates: (a) glass, (b) microporous polycaprolactone (PCL), (c) microporous poly(lactide-co-glycolide) (PLGA) 85:15, and (d) microporous PLGA 50:50. Blue: nucleus (DAPI), green: cytoskeleton (actin), red: paxillin, white: sox10. Scale bar: 25 μm.

Courtesy of Dr. Kendell Pawelec

Two-photon Fluorescence Imaging

Egress of Langerhans cells to lymphatic vessels. Barrier disruption by the skin inflammation activates Langerhans cells. Three days after the skin inflammation, activated Langerhans cells leave the epidermis and egress to the lymphatic vessels in the dermis. Scale bar: 50 μm.

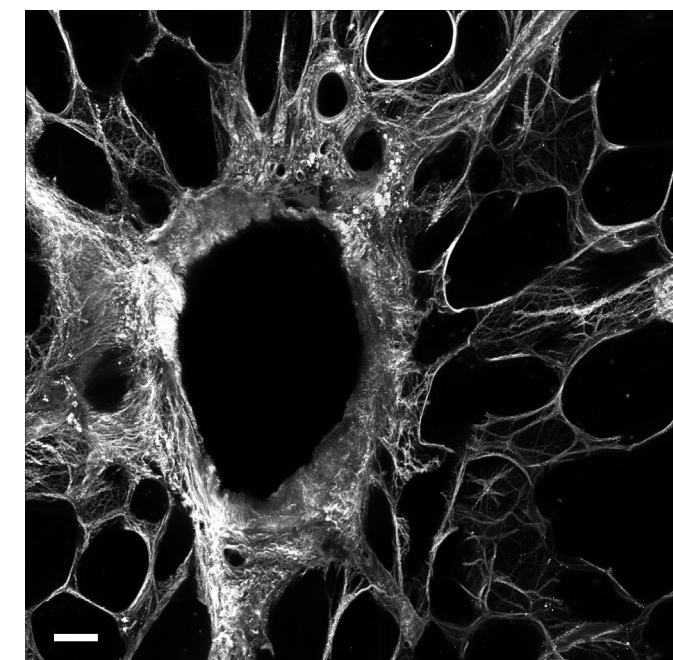
Courtesy of Dr. Sangbum Park



Two-photon SHG (label-free) Imaging

Small airway in a human lung sample. This is a label-free, second harmonic generation (SHG) image captured using the Leica SP8 Dive two-photon microscope with a 25x magnification. The collagen structure is shown without any fluorescence labeling. Scale bar: 100 μm.

Image was captured by Dr. Sara Makaremi. The lung sample was provided by Dr. Xiaopeng Li from Grand Rapids Research Center



Flow Cytometry Core Facility

The MSU Flow Cytometry Core Facility provides investigators with access to cutting-edge analytical flow cytometry instrumentation and cell sorting services, as well as training and experimental consultation. Flow cytometry is extensively used for a variety of applications including evaluation of viability/apoptosis, immunophenotyping, intracellular cytokines/transcription factors, ROS, cell cycle, ploidy, kinetics, protein-protein interactions, and RNA transcript levels.



LOCATIONS
North Campus Hub
Biomedical & Physical Sciences Building
 567 Wilson Road
 Rooms 4120 & 5115
 East Lansing, MI

South Campus Hub
IQ/Bioengineering Building
 775 Woodlot Drive
 Rooms 2521 & 2522
 East Lansing, MI

CONNECT
web: research.msu.edu/srr/
 flow-cytometry
email: FACS@msu.edu



EQUIPMENT

BENCHTOP ANALYZERS

Attune CytPix (ThermoFisher Scientific)

- Brightfield imaging capable cytometer, image acquisition ≤6,000 events/second; machine learning-based image analysis tools

Cytek Aurora (Cytek Biosciences)

- Spectral for high parameter panel acquisition (>45 fluorescent parameters); autofluorescence extraction; and identification of unique autofluorescent signatures with ≤97% similarity

ZetaView NTA (ParticleMetrix)

- Small particle (nanoparticles, extracellular vesicles) size (50nm – 1µm), fluorescence, & concentration

Luminex 200 (Luminex)

- 96-well based multiplex analysis of cytokines; growth factors; signaling proteins

IMAGING

CQ1 Cell Voyager (Yokogawa)

- Automated high content spinning disk confocal imaging (96-well plate in 4 min), environmental control (Temp, CO₂, O₂), 2x – 60x objectives, free AI/machine learning analysis software

CELL SORTERS

SONY MA900 (SONY Biotechnology)

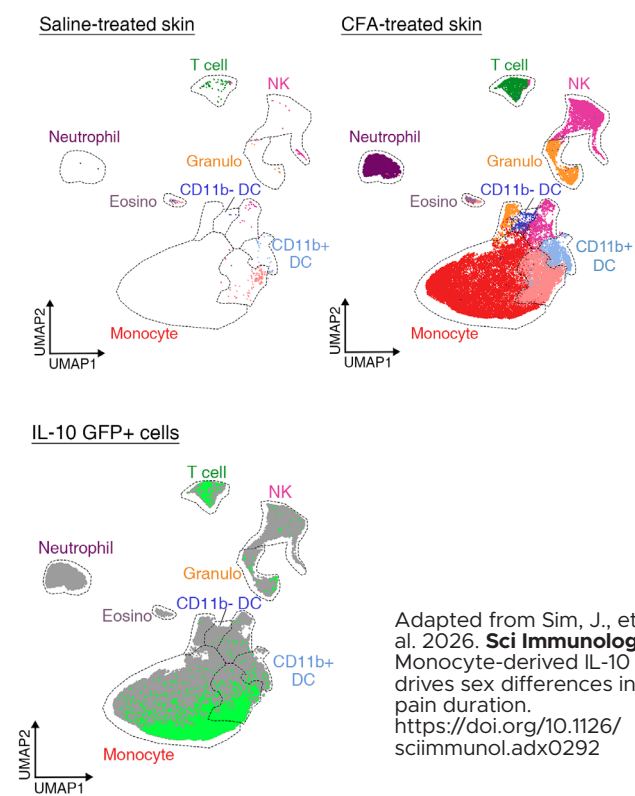
- Features automatic setup, calibration, and cleaning for ease of use

BD FACSAria IIu (BD Biosciences)

SERVICES

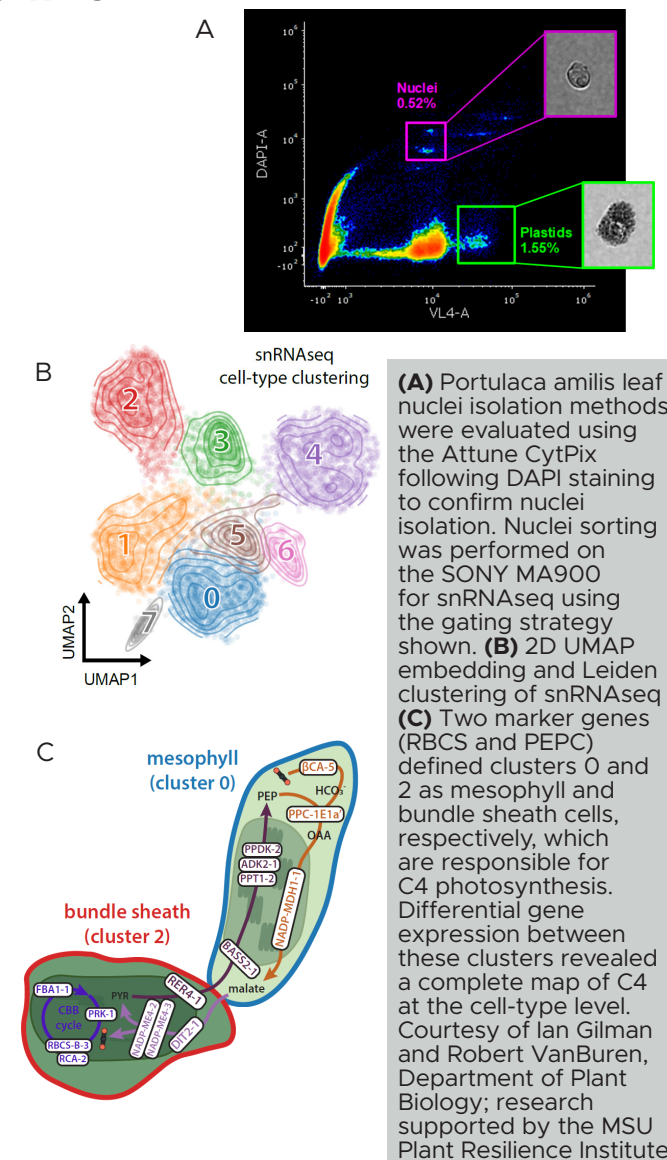
- Comprehensive training program to support development of independent flow cytometrists
- Full-Service Cell Sorting
- Assay Development & Experimental Design
- Multi-parameter Panel Design
- Access to data analysis software for Core Users
- Manuscript/Grant Review

Spectral Cytometric Immunophenotyping in a Mouse Model of Inflammatory Pain

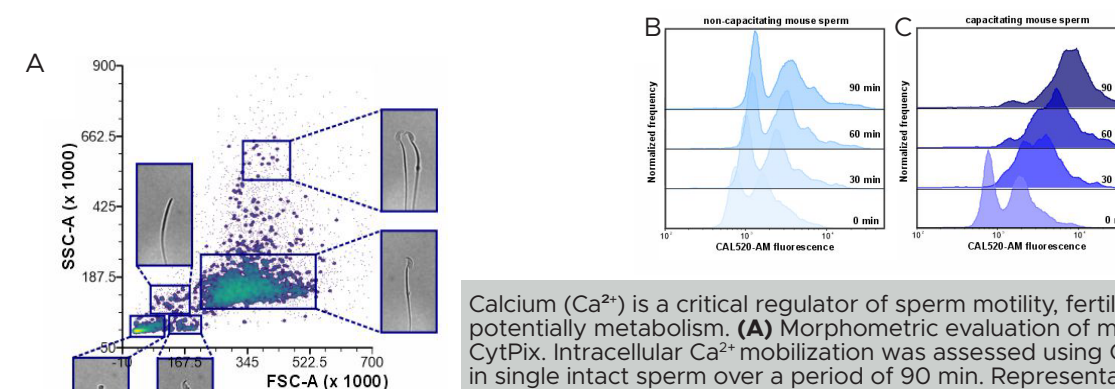


Intraplantar immune populations were evaluated from IL-10 GFP reporter mice using a Cytek Aurora spectral cytometer following saline (left) or Complete Freund's Adjuvant (CFA; middle) administration. A dimensionality reduction (UMAP) and clustering pipeline was used to identify CD11b+Ly6C+Ly6G-F4/80^{mid} monocytes as one of the major immune cell source of IL-10 (right), a cytokine that plays a role in pain resolution. Flow cytometric assessment of immune cell subsets revealed elevated levels of IL-10 producing monocytes in males compared to females that correlated with improved pain resolution rate, demonstrating sexual dimorphism of pain resolution. Courtesy of Geoffroy Laumet, Department of Physiology

Developing a Single-Nuclei RNAseq-based Model of C₄ Photosynthesis in *Portulaca amilis*



Dynamic Monitoring of Intracellular Ca²⁺ Levels in Mouse Sperm



Calcium (Ca²⁺) is a critical regulator of sperm motility, fertilization capacity, and potentially metabolism. **(A)** Morphometric evaluation of mouse sperm using the Attune CytPix. Intracellular Ca²⁺ mobilization was assessed using Cal-520 AM (AAT Bioquest) in single intact sperm over a period of 90 min. Representative histograms show Ca²⁺ levels measured following incubation in TYH buffer alone **(B)** and in the presence of HCO₃⁻ **(C)**, which induces capacitation. Courtesy of Melanie Balbach, Department of Biochemistry & Molecular Biology

Investigative HistoPathology Lab

The Investigative HistoPathology Core supports MSU investigators by providing routine and custom tissue processing, staining, and imaging services, including paraffin and frozen sectioning, special stains, immunohistochemistry, and TUNEL, to advance a wide range of research projects. Through one-on-one consultations, the core assists with study design, troubleshooting, and optimal use of research materials, enriching faculty research programs and supporting education for lab staff and students.

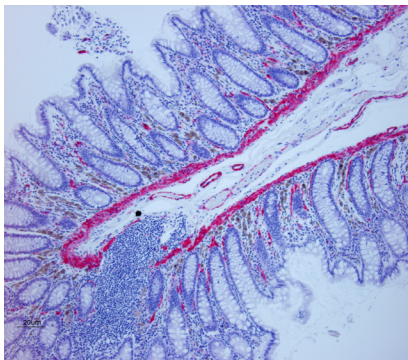
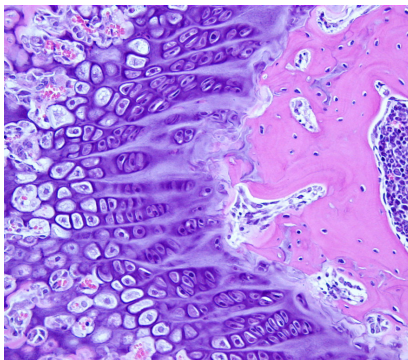


LOCATION
Biomedical Physical Sciences Building
567 Wilson Road
2133 - Secure Hall
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/histopathology

EQUIPMENT

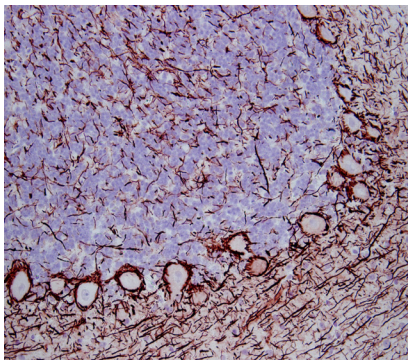
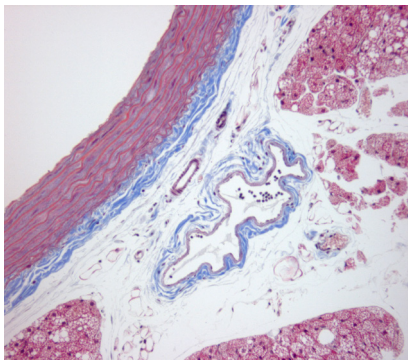
- Leica ASP300 Tissue Processor
- Tissue Tek VIP Tissue Processor
- Leica EG1160 Embedding Center
- ThermoFisher HistoCentre III Embedding Center
- Rotary Microtomes
- *Reichert Jung 2030, Leica RM2235, Leica RM2255*
- Leica AutoStainer XL
- *Consistent Automated Hematoxylin & Eosin Staining*
- Biocare IntelliPath Flex
- *Open platform for use with reagents from multiple vendors for FFPE and FS staining for Immunohistochemistry utilizing brightfield or fluorescent techniques*
- Thermo-Fisher Gross Station
- *Available for scheduled use to trim in research subjects*



SERVICES

One-on-One consults regarding research studies

- Goal of project & design
- Potential pitfalls with histology
- Maximize use of research materials
- Formalin/PFA fixed tissues for paraffin embedding
- Fresh Frozen & Fixed Frozen tissue
- Routine & Custom Protocols for:
 - Hematoxylin & Eosin Staining
 - Special staining to identify cellular structures
 - Immunohistochemistry – Brightfield & Immunofluorescence
 - TUNEL



Von Willebrand Factor Delays Liver Repair After Acetaminophen-induced Acute Liver Injury in Mice

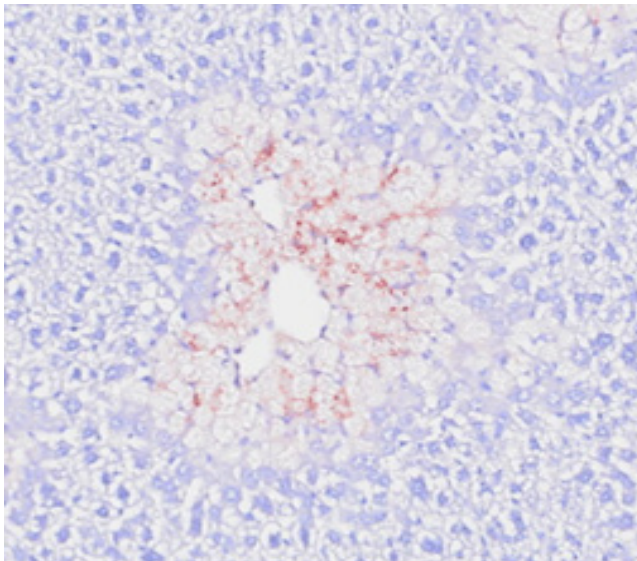
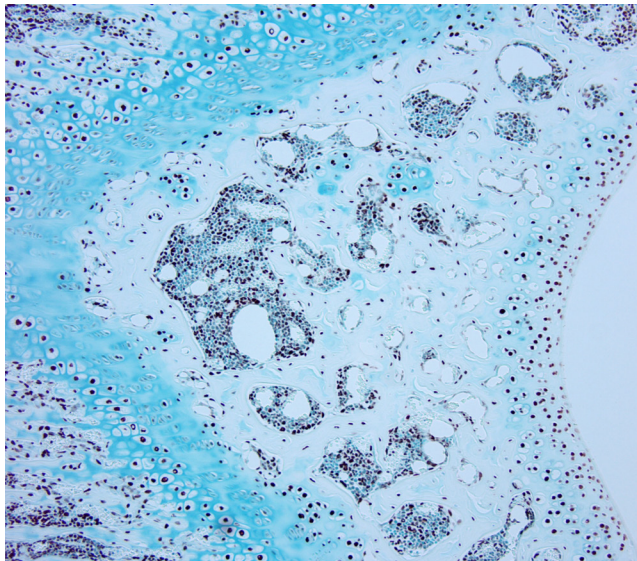
This publication in *Journal of Hepatology* features results, products of the Investigative Histopathology Laboratory, which among other results produced by Amy Porter's team, led to receipt of a 2.8-million-dollar R01 grant in which the laboratory figures centrally. Histological analyses driven by related immunohistochemical stains led to grant support for clinical-translational science supported by the Tetrad grant program. Moreover, presentation of these results at leading edge conferences prompted investigators external to MSU to send sections to the laboratory for processing for these specific stains, based largely on the exceptional quality provide by the IHP Lab team.
DOI: <https://doi.org/10.1016/j.jhep.2019.09.030>
James (Jim) P. Luyendyk, PhD, Albert C. and Lois E. Dehn Chair, Professor, Department of Pathobiology and Diagnostic Investigation, College of Veterinary Medicine, Michigan State University

Divergent Pathogenetic Outcomes in BALB/c Mice Following Omicron Subvariant Infection

"The Laboratory of Investigative Histopathology at Michigan State University has provided us with invaluable histology services for thirty years that has resulted in 225 peer-reviewed publications in pathology, toxicology and infectious disease, as well as over 10 million dollars in extramural federal funding. Their high-quality production of whole glass slides with exquisitely prepared histochemical and immunohistochemical stained tissue sections is essential for our designed-based, unbiased, quantitative histopathology analyses. Examples of their work are found in these selected scientific articles."
DOI: <https://doi.org/10.1016/j.virusres.2024.199319>
Jack Harkema, DVM, PhD, DACVP, ATSF, University Distinguished Professor, Department of Pathobiology and Diagnostic Investigation, College of Veterinary Medicine, Michigan State University

Insight into Mammary Gland Development and Tumor Progression in an E2F5 Conditional Knockout Mouse Model

This publication in the *Journal Oncogene* features images generated from H&E as well as immunohistochemistry (IHC) by the IHP Labs team in several of the figures. This was indispensable for publication, from the routine H&E to the IHC that required the lab to go through multiple rounds of testing to determine the optimal staining conditions. This publication is the first of the publications stemming from an R01 from the NICHD, which also featured a number of these images. Amy Porter and the histopathology lab are intricately involved in the majority of the projects in the lab, with many new antibodies being profiled in tumor development by the IHP Lab team.
DOI: <https://doi.org/10.1038/s41388-024-03172-4>



MSU Digital Slide Scanning Core

The mission of Michigan State University's (MSU) Digital Slide Scanning Core Facility is to provide high-resolution and high-throughput digital scans (virtual images) of whole glass slides containing tissues or cells for advanced microscopy research and education.

LOCATION
Food Safety and Toxicology Building
1129 Farm Lane
Room 218G
East Lansing, MI 48824

CONNECT
email: harkemaj@msu.edu

EQUIPMENT

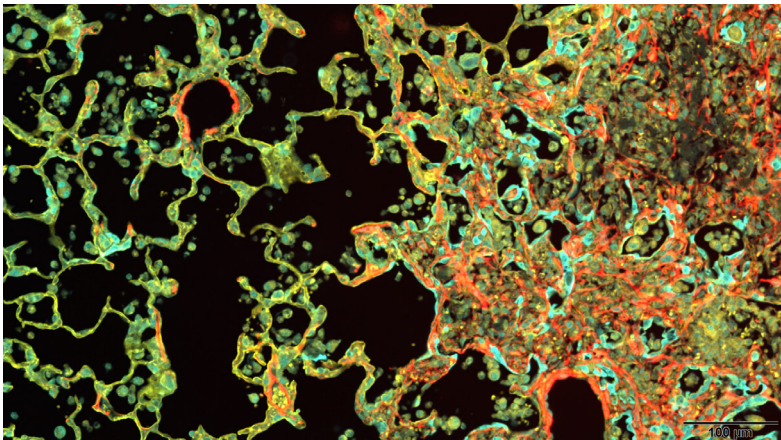
SLIDEVIEW (formerly Olympus) VS200 slide scanner

- Converts high-resolution microscopic images of biologic tissues or cells on whole glass slides into digitized images through a fully automated high-speed scanning and tiling process
- Provides flexibility with five imaging modes, multiplexing capabilities, and multiple magnifications up to 60X
- Generates high quality digitized images for accurate quantitative and spatial analyses

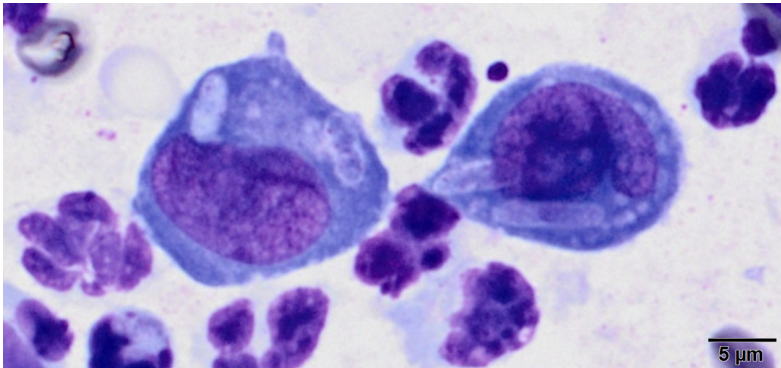


SERVICES

- Digitization of whole glass slides
- Multiple imaging modes: Brightfield, darkfield, fluorescence, polarization and phase contrast
- 20x or 40x magnification for histologic scans, and 60x oil for cytologic scans
- Scanning of 1 x 3 in. or 2 x 3 in. glass slides

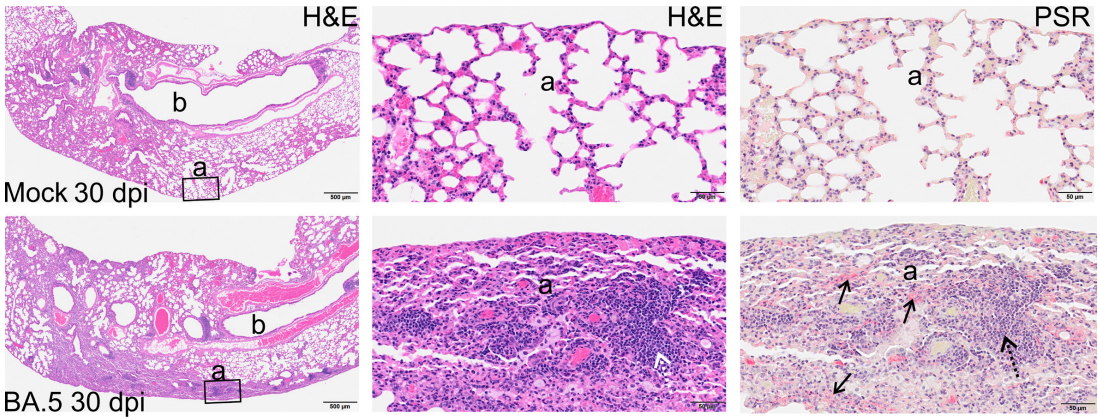


Immunofluorescence, Histologic Digital Scan



60x Oil, Brightfield, Cytologic Digital Scan

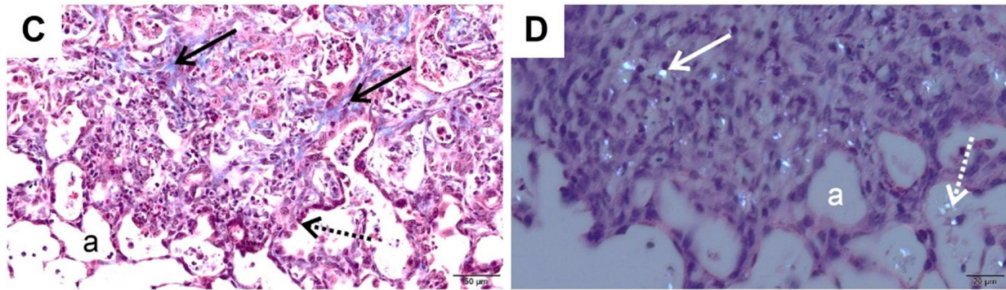
Mouse-Adapted SARS-CoV-2 Omicron BA.5 Infection Induces Post-Acute Lung Fibrosis in BALB/c Mice



Light photomicrographs, at low (scale bar 500 μ m) or high magnifications (scale bar 50 μ m), of left lung lobe tissue sections stained with hematoxylin and eosin (H&E) or Picrosirius red (PSR). Lung lobes were taken at 30 days post infection(dpi) from mock-infected mice (controls) or mice intranasally instilled with BA.5. Pulmonary histopathology was not observed in mock-infected mice. In contrast, BA.5 mice at 30 dpi had subpleural chronic alveolitis with scattered tertiary lymphoid structures (stippled arrows) and areas of PSR-stained interstitial fibrosis in the alveolar parenchyma (a). (b) bronchiolar airways; small rectangular boxes, location of the photos taken at high magnification.

Powers JM, Leist SR, Suryadevara N, Zost SJ . . . Harkema JR, Baric RS. J Virol. 2025 Nov 25;99(11): e0140625.

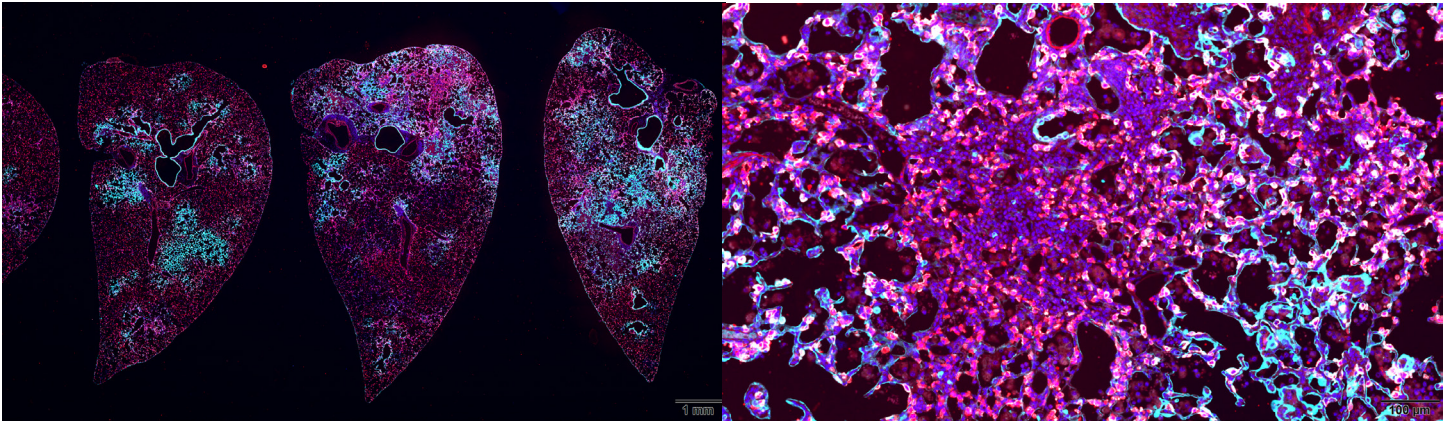
Impact of Soluble Epoxide Hydrolase Inhibition on Silica-Induced Pulmonary Fibrosis, Ectopic Lymphoid Neogenesis, and Autoantibody Production in Lupus-Prone Mice



(C) Centriacinar lung lesion (7 days post infection) stained with Masson's trichrome illustrating areas of interstitial fibrosis (blue stain; solid black arrows). (D) H&E-stained centriacinar lung lesion taken with polarized light exposing birefringent cSiO2 particles embedded in the fibrotic lesion (solid white arrow) and associated with degenerating and necrotic phagocytic cells in alveolar airspaces (stippled white arrows).

McDonald OF, Wagner JG, Lewandowski RP, Heine LK, Estrada V, Pourmand E, Singhal M, Harkema JR, Lee KSS, Pestka JJ. Inhal Toxicol. 2024 Aug-Sep;36(7-8):442-460.

Immunofluorescent Imaging of Pulmonary Histopathology After Air Pollutant Exposure



Immunofluorescent imaging of murine pulmonary tissue from KKAY diabetic mice repeatedly exposed to 1 ppm ozone. Exposed mice had persistent injury and early fibrotic lesions in alveolar parenchyma with epithelial remodeling: Type 2 alveolar epithelial cells (AEC2, Red), Krt-8 Transitional AEC (Cyan), and DAPI nuclear stain (blue)

Precision Health Program Tissue Analysis Core

The mission of the MSU Precision Health Program Tissue Analysis Core Facility is to provide investigators with access to cutting-edge instrumentation for multiplex tissue staining, image scanning, and computer-assisted image analysis. Multiplex tissue analysis is extensively used for a variety of applications (IHC, ISH, RNAscope™) for detailed in situ molecular characterization of diseased tissues and validation of RNAseq data.



LOCATION
Interdisciplinary Science
Technology Building
766 Service Road
Room 2310
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/
precision-health-tissue
email: phpinfo@msu.edu

EQUIPMENT

TISSUE STAINER

Bond Rx (Leica)

- Fully automated open system for research applications
- Up to 8 markers (DNA, RNA, glycans, and/or protein) per slide
- Up to 30 slides per run

SCANNING SYSTEM

Versa (Aperio)

- 8-slide brightfield, fluorescence, and FISH digital pathology whole tissue–slide scanner
- Scans multiplex whole tissue–slides of up to 8 fluorescent channels with customizable dichroic filters at any magnification from 5x to 63x

Zeiss Axioscan 7* (Zeiss)

- 100-slide multispectral fluorescence imaging system, with swift and reproducible LED illumination, fast filter wheels, and a sophisticated filter concept to efficiently separate a broad range of fluorescence channels

*Located at MSU Quantitative Bio-Element Analysis and Mapping (QBEAM) Center

IMAGE ANALYSIS

ImageScope (Leica)

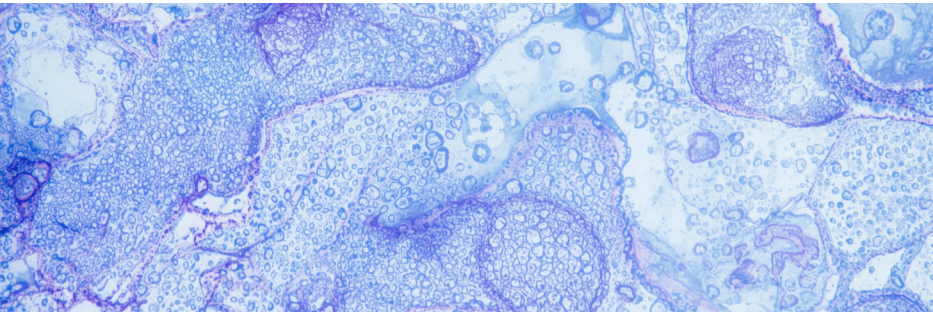
- Free software package to navigate, annotate, and analyze any field or all fields of the whole tissue section within its original context in a single file image (.scn)
- Specialized algorithms (fee for service). The Aperio Cellular IF Algorithm is used to quantify location, area, intensity, and colocalization of up to 8 fluorescence-labeled markers within same cell or cellular compartment

QuPath (multi-platform open source)

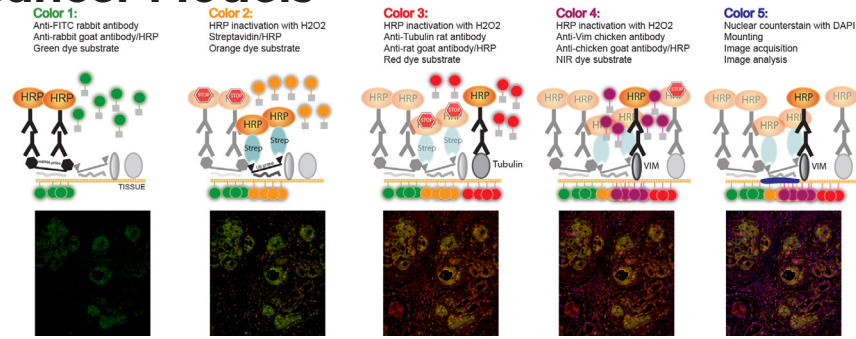
- Ability to navigate, annotate, and analyze any image file (.scn, .czi, .tiff, others)
- Intuitive tools for cell segmentation, cell classification, and marker quantitation

SERVICES

- Experimental design, optimizing marker combination
- Tissue staining
- Tissue scanning
- Tissue analysis
- Access and training on software analysis



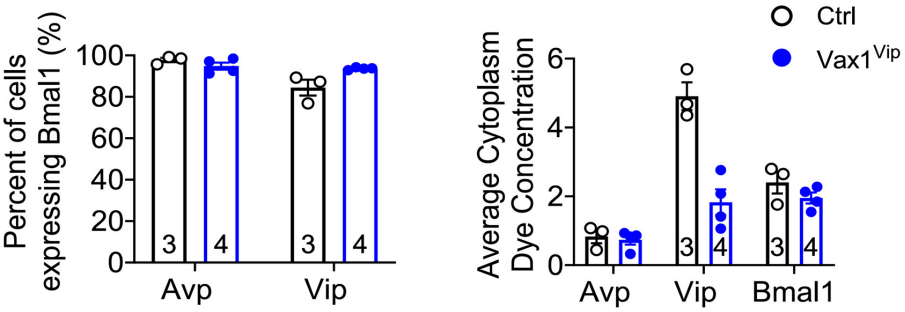
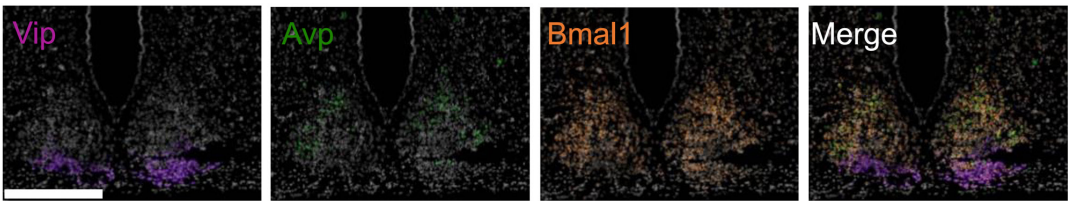
Multiplex Co-detection of MicroRNA and Protein Markers in Cancer Models



Adapted from: Sempere et al. 2020, *Methods Mol Biol.* **Automated Five-Color Multiplex Co-detection of MicroRNA and Protein Expression in Fixed Tissue Specimens**
DOI: 10.1007/978-1-0716-0623-0_17

Cartoon representation of post-hybridization steps for automated co-detection of miR-21, U6 snRNA, tubulin, and vimentin. Horseradish peroxidase (HRP) activates the tyramide moiety conjugated to the fluorochrome, resulting in covalent deposition of the signal in close proximity of the RNA probe or target protein. Sequential rounds of HRP inactivation with H₂O₂ followed by a new protein or antibody conjugated to HRP can be used to reveal the expression of multiple markers. Representative cumulative staining of RNA and protein markers.

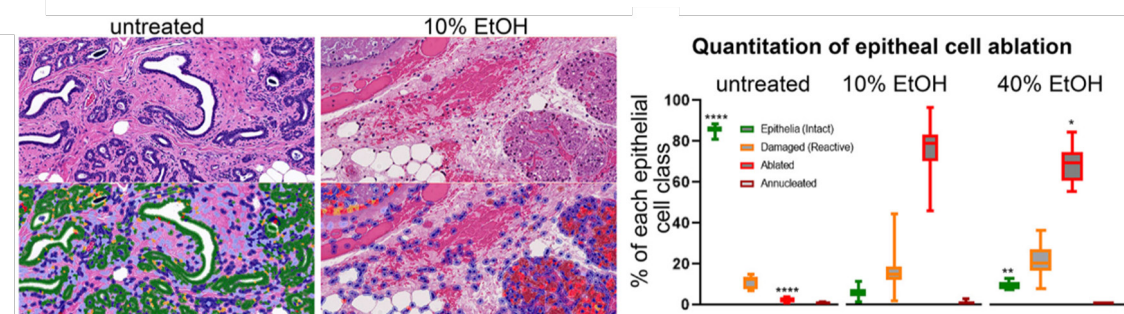
Multiplex Co-detection of mRNAs (RNAscope) in SCN Mouse Brain Region



RNAscope® assay at ZT16 in the SCN of proestrus Ctrl and Vax1^{Vip} females. Example images of RNAscope® assay for Vip (blue), Avp (red) and Bmal1 (green). N = 3-4 per group. Scale bar 300 µm. Percentage of cells that co-express Bmal1 with Avp or Vip. Mann-Whitney, p > 0.05. Average cytoplasm dye concentration reflecting mRNA transcripts for Avp, Vip, and Bmal1.

Adapted from: Van Loh et al. 2023, *Front Endocrinol.* **The transcription factor VAX1 in VIP neurons of the suprachiasmatic nucleus impacts circadian rhythm generation, depressive-like behavior, and the reproductive axis in a sex-specific manner in mice**
DOI: 10.3389/fendo.2023.1269672

Tissue Analysis of Rabbit Mammary Glands after Intraductal Ablative Procedure



Morphological and chromatic effects of ethanol ablation on H&E stain (upper panels) and deduced epithelial and stromal cell classes based on QuPath computer-assisted trained classifier (lower panels). Graph bar displays cell class distribution in ductal trees (n > 4 per group) treated with different concentrations of ethanol (EtOH) or left untreated.

Adapted from: Pavlik et al. 2025, *J Vis Exp.* **X-ray Visualization of Intraductal Ethanol-based Ablative Infusion for Prevention of Breast Cancer in Rabbit Models**
DOI: 10.3791/68334

Advanced Molecular Imaging Facility

Our facility provides a variety of preclinical imaging instruments: we can image small animals using optical imaging (fluorescence and bioluminescence), PET/MRI, μ CT, opto-acoustic imaging and magnetic particle imaging. We have a space for surgeries, and a suite of computers for image analysis. For all modalities, we will assist with experimental design and animal protocols, and either train users on image acquisition or acquire images for you.



LOCATION
IQ/Bioengineering Building
775 Woodlot Drive
Rooms 1700-1706
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/molecular-imaging

EQUIPMENT

PET/MRI (Bruker 7 T)

- Full set of built in preclinical MRI sequences and coils for dedicated brain and body MRI with simultaneous PET acquisition
- Anatomical imaging eg tumor size, cardiac imaging, neuro-imaging (fMRI, diffusion tensor imaging, perfusion), liver and brain PET-MRI

μ CT (Revvity Quantum GX)

- High resolution or anatomical co-registration at low x-ray dose.
- Bone density, scaffold degradation, fat quantification, quality control of manufactured parts
- Resolution as low as 4.5 μ m, typically ~100 μ m

Fluorescence and Bioluminescence

- (Revvity IVIS and Licor Pearl Trilogy)
- Tumor growth, bioluminescent bacteria, nanoparticle tracking, implanted organoids

Magnetic Particle Imaging (Magnetic Insight Momentum Scanner)

- 2D and 3D imaging for nanoparticle and macrophage tracking to tumors, drug delivery, lung imaging
- Coregister with μ CT

3D Cryofluorescence Tomography (EMIT Xerra)

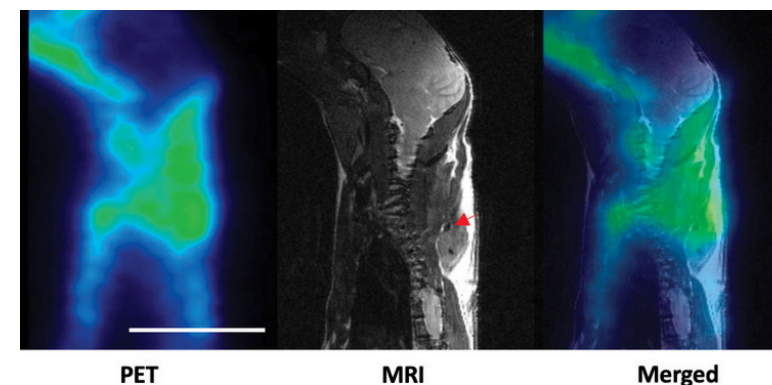
- Ex vivo cryosectioning and imaging of whole mice and rats, or organs
- 7 fluorescent channels and white light
- Gene expression in mouse models, nanoparticle distribution

SERVICES

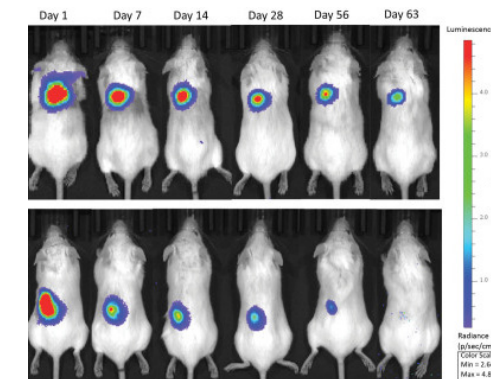
- Experimental design, image acquisition and analysis
- Training
- Animal procedures
- Full study
- Assistance with IACUC submissions, grant planning



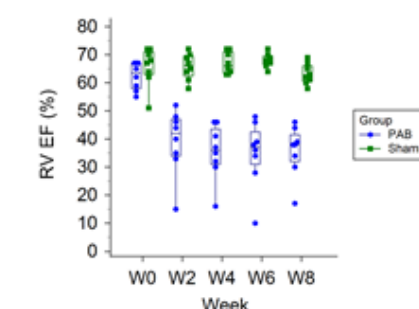
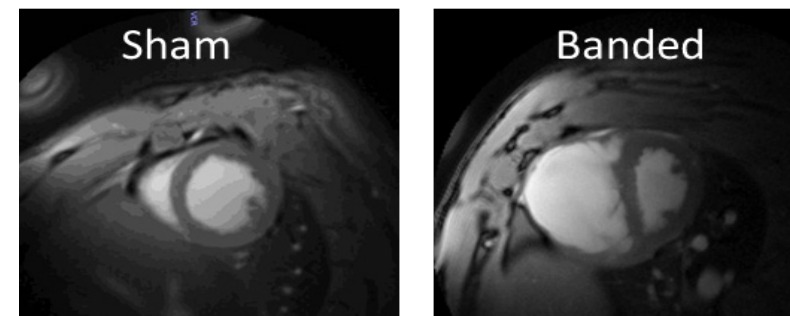
Survival of Transplanted Islet Organoids with PET/MRI and Bioluminescence



Brown adipose tissue (BAT) was evaluated as a transplant location for islet organoids. Placement in the brown fat was confirmed by labeling the islets with an iron oxide nanoparticle, then imaging by MRI and PET. The red arrow shows the signal void caused by the iron oxide nanoparticles, and the PET signal shows the location of the scapular BAT after cooled mice were injected with FDG. Bioluminescence imaging confirms that islets in the BAT survive longer than those in the kidney capsule. Sun et al Transplantation Direct. 2024 Jul; 10(7): e1658.

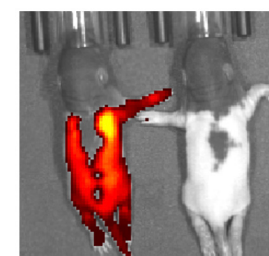


Cardiac Magnetic Resonance Imaging

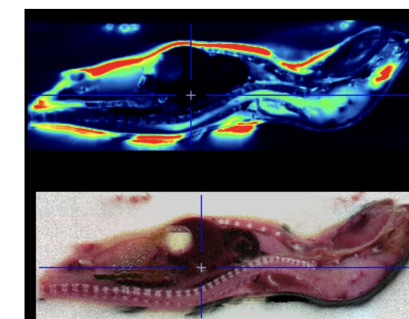


The pulmonary artery was banded in rats, to examine the effect on tricuspid valve regurgitation and the timeline of functional and anatomical changes. Rats were scanned by MRI at baseline and every 2 weeks after surgery to measure the progression of functional changes in the heart such as ejection fraction and ventricular strain, as well as anatomical changes like valve size. The changes are apparent on the MRI images – the right ventricle is much bigger on the banded animal. These changes were detectable even 2 weeks after banding, for example, the right ventricle ejection fraction was significantly different from the sham at 2 weeks. This study was a collaboration with investigators at Corewell Health in Grand Rapids and the In Vivo Facility at MSU. (Tomasz Timek lab, Corewell Health/MSU. Manuscript in preparation, used with permission.)

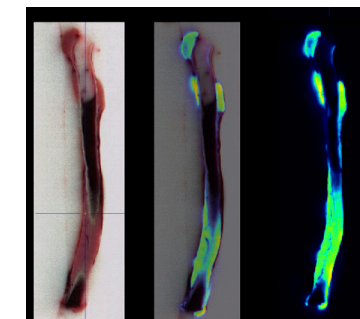
Phenotyping with In Vivo Imaging and Ex Vivo Cryofluorescence Tomography



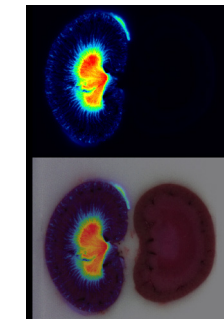
In vivo fluorescence



Whole body, P10 pup



PVAT, adult



Kidney, adult

The transgenic core developed a mouse model for studying fat. In this model TdTomato was expressed using an adiponectin promoter. Homozygous mice had high expression of TdTomato as seen by in vivo fluorescence imaging at P4 (left). Whole pups at P10 were sectioned by automated cryofluorescence tomography, and fat expressed TdTomato. In adult rats, perivascular adipose tissue and kidney (among other tissues) expressed TdTomato. (Elena Demireva, Huirong Xie, Stephanie Watts and the PVAT PPG at MSU.)

Precision Health Program Imaging Facility

The mission of the Precision Health Program (PHP) Imaging Facility is to provide investigators with access to state-of-the-art *in vivo* small-animal imaging services, along with comprehensive training and experimental consultation. The facility's advanced instrumentation enables *in vivo* optical and positron emission tomography (PET) imaging integrated with high-resolution anatomical information obtained from low-dose microCT or X-ray. In addition, all instruments may be utilized for *in vitro* testing and optimization of imaging reagents prior to initiating animal studies.



LOCATION
Interdisciplinary Science
Technology Building
766 Service Road
Room 6109B
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/precision-health-imaging
email: phpinfo@msu.edu

EQUIPMENT OPTICAL IMAGING

IVIS SpectrumCT (Revvity)

The IVIS SpectrumCT enables *in vivo* bioluminescence, fluorescence, and Cherenkov imaging, supporting both high-throughput and longitudinal studies integrated with low-dose microCT. Its horizontal gantry motion, flat-panel detector, and 360° animal platform deliver reliable low-dose 3D imaging and seamless optical-microCT integration. Multiple animals can be scanned simultaneously with an average dose of ~13 mGy and total scan/reconstruction times under one minute. Optical and microCT modes may also be used independently.

Accurate topographic data is critical for 3D tomography, and the IVIS SpectrumCT provides true surface mapping of the animal. Its intuitive workflow and imaging wizard also simplify both 3D tomographic imaging and 2D bioluminescence, fluorescence, and Cherenkov screening.

PET IMAGING

Genisys G4 PET/ X-ray (Sofie Biosciences)

The Genisys G4 PET/X-ray scanner is a compact, cost-effective system for translational research, providing safe imaging for valuable animal models. Designed to operate like a full imaging lab, it offers an intuitive, streamlined workflow.

SURGERY STATION

Isoflurane Vaporizer (Somni Scientific)

Fully equipped surgery station available free of charge for procedures related to imaging experiments utilizing the core. Maintain anesthesia, body temp and sterile instruments without needing to transfer animals from another facility. Stereoscope and stereotactic frame available for use with permission.

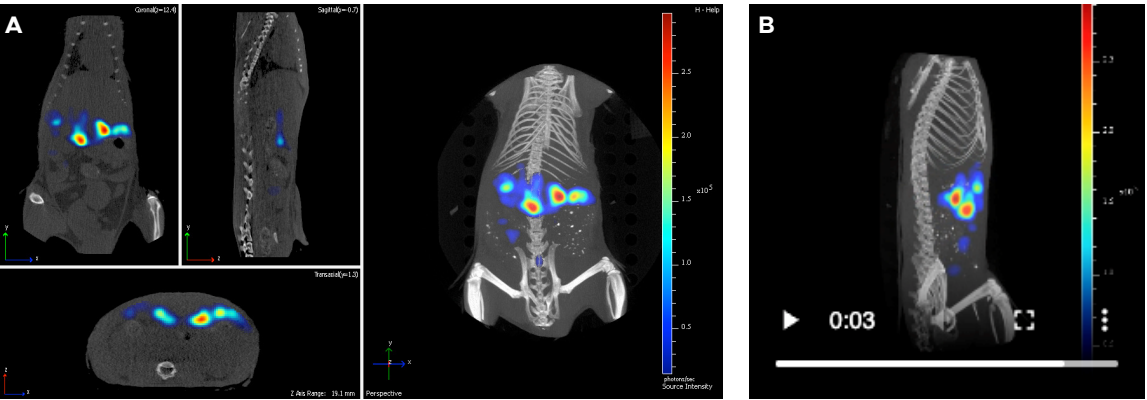


credit: Ping Wang, Elizabeth Kenyon, Precision Health Program

SERVICES

- Training for independent use of both imaging modalities
- Technician-run imaging experiments
- Technical assistance with training or completion of tail vein injections or other techniques
- Access to data analysis software for core users
- Free plate/tube scans for model validation
- Manuscript/Grant review

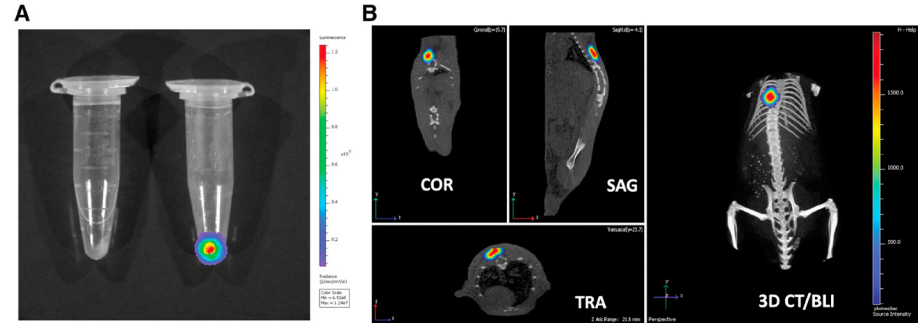
Development of a Bioluminescent Genetic Mouse Model of Pancreatic Cancer



In vivo bioluminescence images (A) demonstrating a pancreatic tumor expressing luciferase driven by Pdx1-cre captured with IVIS SpectrumCT. microCT incorporated in this instrument allows for additional localization information. (B) Still image from the video generated by the system for dynamic representation of the data. *Courtesy of the Sempere Lab.

Experimental mouse lines still being developed by lab. No published data currently available.

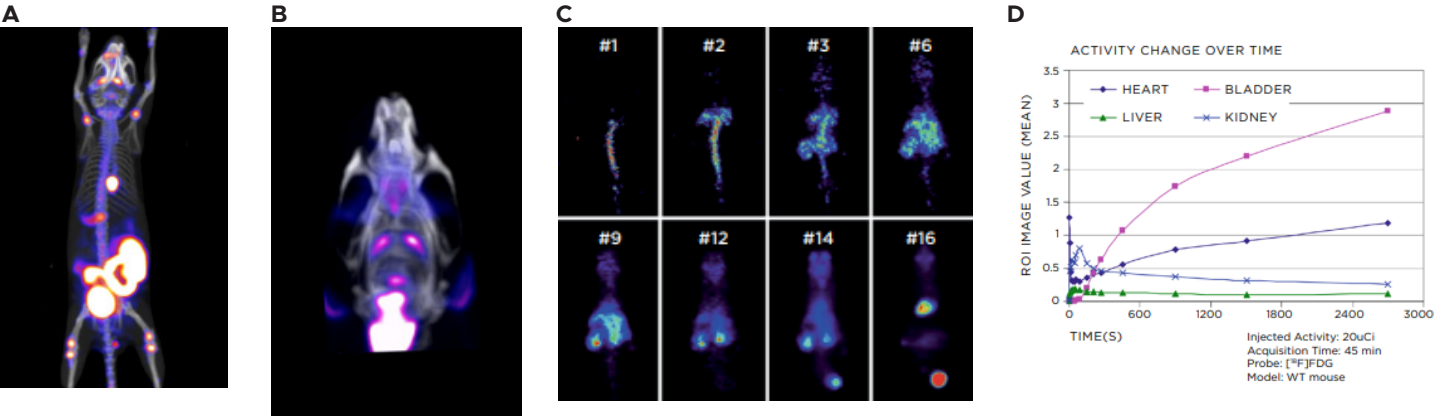
BLI of Islet Organoids Transplanted into the Brown Adipose Tissue (BAT) in a Mouse Model



Bioluminescence imaging (BLI) of stem cell derived islet organoids *in vitro* and *in vivo*. (A) BLI of islet organoids (25 IEQ) derived from control human-induced pluripotent stem cells (hiPSC-L1) without luciferase (left) and from luciferase expressing hiPSC-L1 (right). (B) BLI reregistered with CT images of islet organoids graft in the BAT on day 14 post-transplantation (3D CT/BLI). BAT, brown adipose tissue; BLI, bioluminescence imaging; COR, coronal view; SAG, sagittal view; TRA, transverse view. *Courtesy of the Wang Lab.

Adopted from: Sun AX, *et al.* Brown adipose tissue as a unique niche for islet organoid transplantation: Insights from *in vivo* imaging. Transplantation Direct. 2024. 10(7): e1658 DOI: 10.1097/TXD.0000000000001658

Dopamine D2/3 Receptor Imaging and Biodistribution Examples

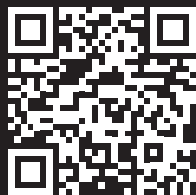


[¹⁸F]Fallypride allows for non-invasive *in vivo* imaging of dopamine D2/3 receptors, providing invaluable mechanistic insights into neurodegenerative disease. (A) Full body scan of 20uCi [¹⁸F]Fallypride imaged for 10min 1hr post-injection in a Balb/c mouse, (B) Head scan of 50uCi [¹⁸F]Fallypride imaged for 30min 1hr post-injection in a Sprague Dawley rat. (C) Dynamic [¹⁸F]FDG study of biodistribution over time in a WT mouse with quantification (D). *Courtesy of Sofie Biosciences.

Center for Imaging & Image-Guided Therapy

The Center for Imaging and Image-Guided Therapy (CIIGT) advances precision imaging by integrating simultaneous PET-MR research in humans and large animals to accelerate translational discovery.

CIIGT enables simultaneous PET-MR imaging for translational research spanning cardiovascular disease, oncology, neuroimaging, metabolic disorders, and image-guided therapies. The facility uniquely supports animal and human imaging within the same clinical-grade PET-MR environment.



LOCATION
Clinical Center D-Wing
840 Service Road
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/ciigt
email: hixjerem@msu.edu

EQUIPMENT

SIMULTANEOUS PET/MR SYSTEM

- Siemens Biograph One PET-MR
- Simultaneous PET and MRI acquisition
- Advanced neuro, cardiac, and body imaging
- fMRI, diffusion, perfusion, spectroscopy
- Quantitative and accelerated imaging packages

LARGE ANIMAL SUPPORT

- MRI-conditional anesthesia systems
- MRI-conditional physiologic monitoring
- Dedicated caging and transport systems
- Separate uptake/dosing rooms for animals

HUMAN RESEARCH SUPPORT

- Separate radiotracer uptake area
- Clinical-grade imaging workflows
- Diagnostic interpretation coordination

SERVICES

- PET-MR research protocol development
- MR imaging including fMRI
- Large animal translational imaging
- Veterinary coordination
- Human research imaging
- Study design consultation



credit: Derrick L. Turner

Emerging Research Programs at CIIGT and Potential Applications

Translational Cardiovascular PET-MR Imaging

- Myocardial perfusion and viability
- Imaging response to cardiac resynchronization therapy
- Theranostic development
- Large animal cardiac physiology studies

Neuroimaging and Neurodegeneration

- Simultaneous PET-fMRI
- Dopamine receptor imaging
- Alzheimer's and Parkinson's disease models
- Cross-species functional connectivity studies

Precision Oncology Across Species

- Imaging spontaneous tumors in companion animals
- PET-based metabolic tumor profiling
- Monitoring immunotherapy response
- Molecular endoscopy integration with whole-body PET-MR

Diabetes and Endocrine Imaging

- Islet transplantation tracking
- Hepatic metabolic imaging
- Glucose metabolism studies
- Cross-species metabolic imaging validation

Image-Guided Therapy Development

- Targeted radiopharmaceutical validation
- Monitoring therapeutic response
- Multimodal imaging biomarker



credit: Derrick L. Turner

Biomedical, Clinical, & Translational Resources

Where discovery
becomes medicine.

Integrated capabilities
accelerate translational
research and drug discovery
to improve human and animal
health.

Assay Development and Drug Repurposing Core.....	52
Medicinal Chemistry Facility.....	54
PhmTox Comprehensive Research Cores.....	56
Stem Cell Core.....	58
Transgenic and Genome Editing Facility.....	60
Metabolic Phenotyping & Preclinical Imaging Core.....	62
Veterinary Diagnostic Laboratory.....	64
Radiochemistry and Radiopharmacy Solutions.....	66
Clinical Research Support Core.....	68



Assay Development & Drug Repurposing Core

The Department of Pharmacology & Toxicology ADDRC bridges the drug discovery gap that often exists between research and preclinical drug development. The ADDRC is a campus-wide resource, providing expertise in adapting biological and biochemical bench-top assays into high-throughput screening (HTS)-compatible assays and generating screening data with the goal of identifying chemical probes to further interrogate a particular biological process or potential leads for drug development.



LOCATION
Life Sciences Building
1355 Bogue Street
Room B338
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/
addr: addrc



EQUIPMENT

Biotech Synergy Neo

Multi-mode microplate reader: Fluorescence, Luminescence, AlphaScreen, UV/Vis Absorbance, FP & BRET

Biotech Cytation 3

Wide-field imaging system providing live cell imaging capabilities, temperature/gas control, automated cell counting, subpopulation analysis, image statistics

Hamamatsu Function Drug Screening System

Fluorescence/Luminescence plate imager with simultaneous addition and reading of plates

Akta Pure 25M

FPLC System with 6 column holders, 3 wavelength detection, sample pump, and fraction collector

Pioneer SPR

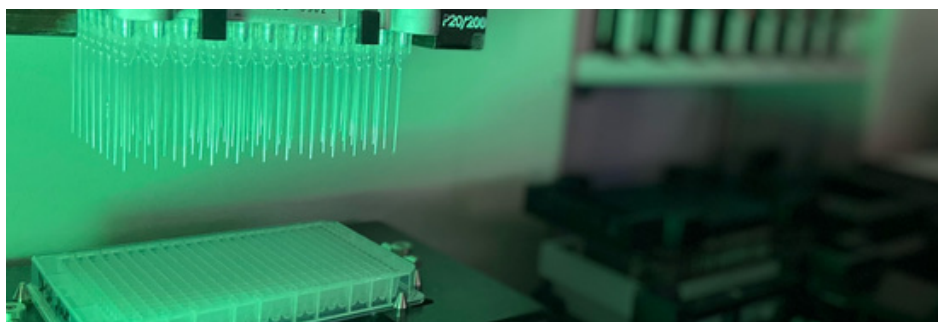
Measure high affinity binding in labeled or unlabeled biologics and produce high quality kinetic data (K_a , K_d)

Microcal VP-ITC

Directly measure mM to nM affinities, no labeling or immobilization required

Biomek

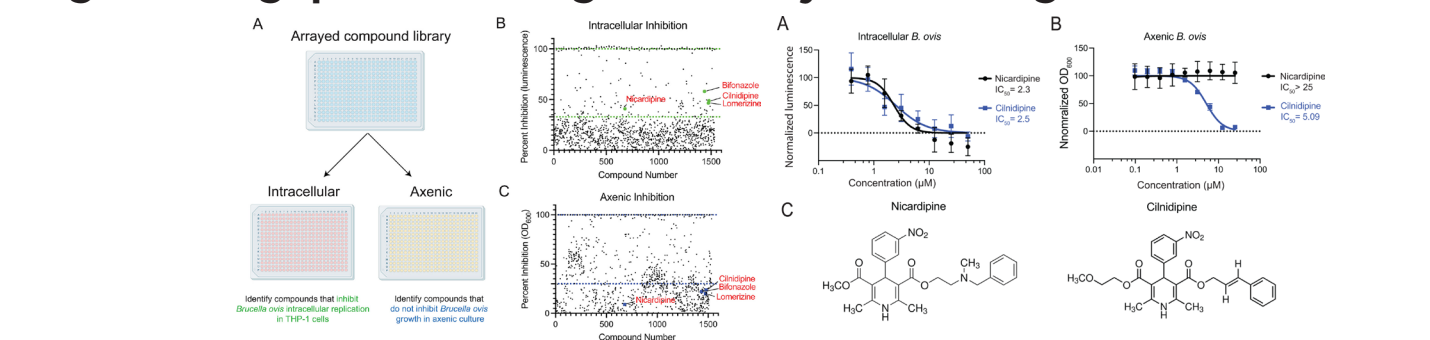
Robot liquid handling system for high-throughput workflows



SERVICES

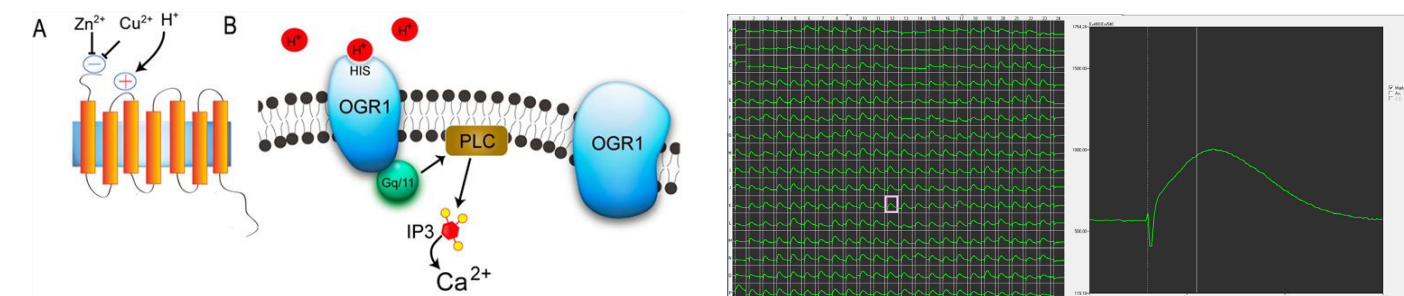
- High-Throughput Screening (HTS) Assay Development and Validation
- Small/Large Scale Chemical Screens
- HTS Data Analysis and Management
- Hit Picking and Dose Response Follow-up
- Core Instrument Operation Training
- Access to Compound Libraries
- Access to Automated Laboratory Robotics
- Grant Support

High-Throughput Screening to Identify Novel Targets in *Brucella Ovis*



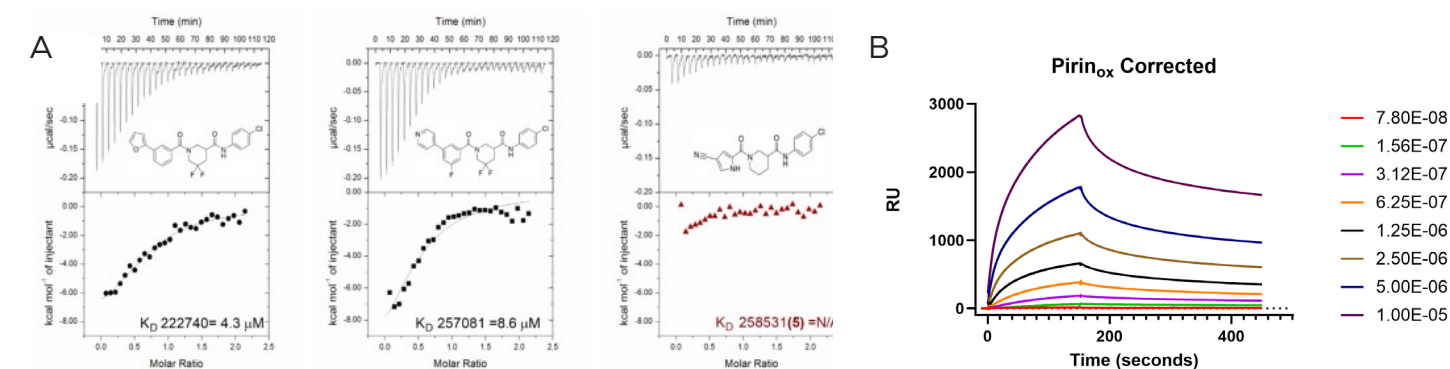
Left panel: (A) Diagram of the drug screening pipeline for the identification of small molecules that selectively inhibit *B. ovis* intracellular growth with minimal axenic activity. **(B and C)** Intracellular inhibition of all tested small molecules, shown as percentage of luminescence emitted by *B. ovis* cells harboring the *lux* operon. Highlighted in green are drug candidates that inhibited *B. ovis* intracellular growth in THP-1 macrophages and highlighted in blue are ones that inhibited growth in Axenic culture. **Right panel: (A)** Intracellular inhibitory activities of nicardipine and cilnidipine during *B. ovis* THP-1 macrophage infection. *B. ovis* luminescence was measured 48 h post-treatment and normalized to signal from infected untreated cells. IC_{50} values based on curve fits are shown. **(B)** Axenic inhibitory activity of nicardipine and cilnidipine during *B. ovis* growth in liquid medium. Optical densities at 600 nm were measured after 48 h of growth and normalized to untreated cultures. **(C)** Chemical structures of nicardipine and cilnidipine. **“Reversion of a RND transporter pseudogene reveals latent stress resistance potential in *Brucella ovis*”** Kim et al, 10.1371/journal.pgen.1011795

High-throughput Calcium assay to examine GPR68 Structure Activity Relationships



GPR68 is a class A GPCR that is activated by pH [EC_{50} = pH 6.8]. GPCRs can couple to many G-proteins, resulting in a plethora of second messengers, including (but not limited to) inositol phosphate, calcium ions (Ca^{2+}), cAMP, and Rho. In developing the first GPR68 inhibitor, OGM, we used Chem1-OGR1(GPR68) [Millipore] cells, that when activated, results in Ca^{2+} release from the endoplasmic reticulum, and GPR68. Real time calcium traces were measured using the Hamamatsu FDSS uCell in a 384-well format and varying concentrations of novel inhibitors were used. Data courtesy of the Hong Lab. <https://www.transfectedw.creative-biolabs.com/gpr68-membrane-protein-introduction.html>

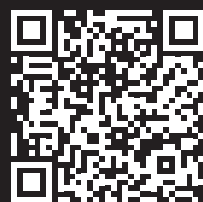
Binding of small molecules to protein targets using ITC and SPR



(A) Isotherm generated by ITC shows that CCG-222740 (left) and CCG-257081 (middle) have greater enthalpy changes upon binding to pirin, as compared to that of CCG-258531 (right), indicative of better binding to recombinant pirin. **(B)** SPR sensorgrams of binding of recombinant pirin to an immobilized CCG-257081 analog **“Identification of Pirin as a Molecular Target of the CCG-1423/CCG-203971 Series of Antifibrotic and Antimetastatic Compounds”** Lisabeth et al, ACS Pharmacol Transl Sci. 2019 Apr 12;2(2):92-100. doi: 10.1021/acspsci.8b00048

Medicinal Chemistry Facility

The Department of Pharmacology & Toxicology Medicinal Chemistry Facility contributes to the universal mission of MSU to enhance human health via drug discovery and chemical biology efforts. It partners on multidisciplinary projects by advancing the discovery and development of novel therapeutics. The medicinal chemistry team uses a variety of research resources that aid in the design, synthesis, scale up, optimization of bioactive compounds, and ADME and pharmacokinetic studies. It offers research support services for university and outside researchers.



LOCATION
Life Science Building
 1355 Bogue Street
 Rooms B347, B331
 East Lansing, MI, 48824

CONNECT
web: research.msu.edu/srr/medicinal-chemistry

EQUIPMENT

LCMS (Advion)

Low resolution liquid chromatography mass spec. Enables synthetic efforts by monitoring reactions progress and isolation of compounds of interest.

Microwave reactor (Anton Parr)

Useful for running reactions safely at higher pressure and temperature conditions leading to improved reaction efficiency. It has proved to be a great tool for enhancing reactions yields for difficult chemistries.

Analytical HPLC (Agilent)

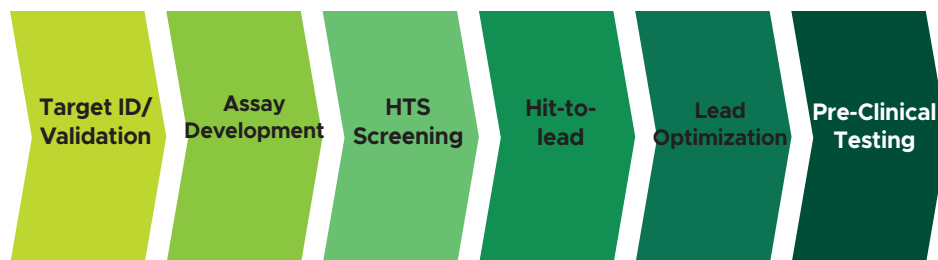
High pressure liquid chromatography. Utilized for purity analysis and separation/purification of reaction mixtures and final products. This instrument is equipped with semi-prep. column for small and medium scale separations.

CombiFlash Purification MPLC systems (Teledyne ISCO)

Moderate pressure liquid chromatography for purification of small to large scale quantities (up to few hundred grams). Operates under normal phase and reverse phase conditions. Uses UV-VIS detection and operates in a semi-robotic fashion.

Lyophilizer (LABCONCO)

Operates at lower temperature and pressure for larger water amounts removal under freeze dry conditions. Complements very well with the reverse phase purification techniques.



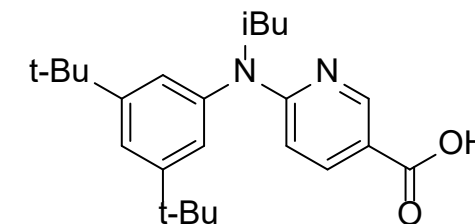
SERVICES

- Drug discovery and medicinal chemistry support
- Chemical biology support
- Proposal and grant preparation
- Series triage-High throughput screening
- Custom compound synthesis and scale-up
- Analytical separation and purifications
- in vitro ADME
- Pharmacokinetic studies
- Metabolite ID studies
- IP/ patent development / early company formation

RXR Agonists for Treatment of Various Cancers

In collaboration with Karen Liby (Department of Pharmacology and Toxicology)

- **RXR agonists:** New series of immunomodulatory that modulate PD-L1 (macrophages) that were active against KRAS mediated Cancers (Lung, Pancreatic, Colorectal, NFI cancers)
- Over **200** analogs have been prepared
- Current lead drug (MSU-42011) is in preclinical characterization for *Investigational new drug* IND



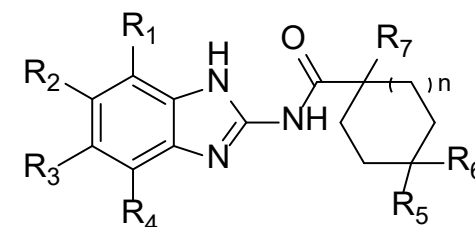
MSU-42011

Pei-Yu Hung, Jessica A. Moerland, Ana S. Leal, Bilal Alewi, Edmund Ellsworth, D Wade Clapp, Verena Staedtke, Renyuan Bai, Karen T. Liby. The RXR agonist MSU-42011 is effective for the treatment of preclinical NF1-deficient models. *Cancers*, 2025, 17(12), 1920.

MmpL₃ for TB and NTM Infections

In collaboration with Robert Abramovitch (Department of Microbiology, Genetics, & Immunology)

- **MmpL₃ inhibitors:** Has proven to be excellent drug target for the treatment of mycobacterial infections
- Over **500** analogs have been prepared
- Current leads are in preclinical characterization for *Investigational new drug* IND

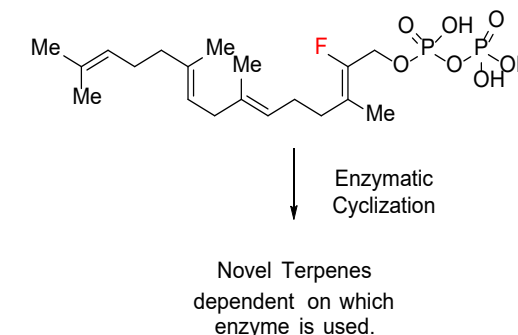


Williams JT, Giletto M, Haiderer ER, Alewi B, Krieger-Burke T, Ellsworth E, Abramovitch RB. The *Mycobacterium tuberculosis* MmpL3 inhibitor MSU-43085 is active in a mouse model of infection. *Microbiol. Spectr.* **2024**,12(1): e0367723. doi: 10.1128/spectrum.03677-23.

Preparation of Non-Natural Terpene Products

In collaboration with Prof. Bjoern Hamberger (Department of Biochemistry & Molecular Biology)

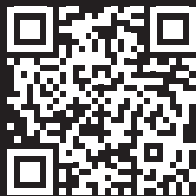
- Discovery of plant pathways for bioactive diterpenoids found in medicinal plant species.
- Preparation of substrates for the biosynthesis of non-natural terpene products.



U.S. Patent Application Serial No.: 62/930,898
 Title: BIOSYNTHESIS OF CHEMICALLY DIVERSIFIED NON-NATURAL TERPENE PRODUCTS
 Inventors Ellsworth, Giletto, Hamberger, Miller, Neubig (November 2019, provisional)

Pharmacology and Toxicology Comprehensive Research Cores

The Department of Pharmacology & Toxicology Comprehensive Research Cores are multi-functional research laboratory spaces. These Cores, open to the MSU community, are primarily self-service and provide a wide array of equipment with expert users available to provide training and assistance in appropriate instrumentation operation.



LOCATION
Life Science Building
1355 Bogue Street
3rd and 4th Floors
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/phmtx
email: phmtx.cores@msu.edu



MOLECULAR & BIOCHEMISTRY CORE

QuantStudio 6/7 dual 384- & 96-well
Real-Time qPCR system workstations

StepOnePlus (Applied Biosystems)
96-well RT-PCR system

NanoDrop Spectrophotometers
Single and 8-sample systems for assessing DNA, RNA, protein concentration and sample purity.

LI-COR Odyssey Fc, M, & CLx
Imaging for Western blots, protein arrays, ELISAs, and tissue slides. Chemiluminescence and fluorescence capable.

eZwest L1 (GenScript)
Automated Western Blotting device. Automatically blocks, stains, and washes membranes.

Tecan and BioTek plate readers
Real-Time PCR system workstations available for absorbance and fluorescence.

MICROSCOPY CORE

Nikon Ti2-E Confocal Microscope
Inverted microscope, 5-channel fluorescence, LED Epifluorescence DIC/AX (resonant scanner)/ NSPARC/ Spectral detector 2x (non-oil)-60x oil

Zeiss Axioskop 40
Upright fluorescence microscope (DAPI, FITC, Rhod)

Olympus BX1
Brightfield and epifluorescence microscope

LARGE EQUIPMENT CORE

- Microm Cryostats for cryo-tissue sectioning
- Ultra and Super Speed centrifuges
- Tissue Homogenizers/ Sonicators

SUPPLEMENTAL CORES

- Tissue/Cell Culture Core
- Autoclave Core
- Dark Room Core
- -80°C Freezer Core
- Large-Format Printing Core
- Survival Surgery Core

Cell Culture Core rooms are equipped with BSL-2 cabinets, incubators, refrigerators, freezers, cell counters (including fluorescence), cell culture microscopes, as well as an EVOS fluorescence microscope. Room B220 is set up for Inducible **Pluripotent Stem Cell**/Organoid cultures.

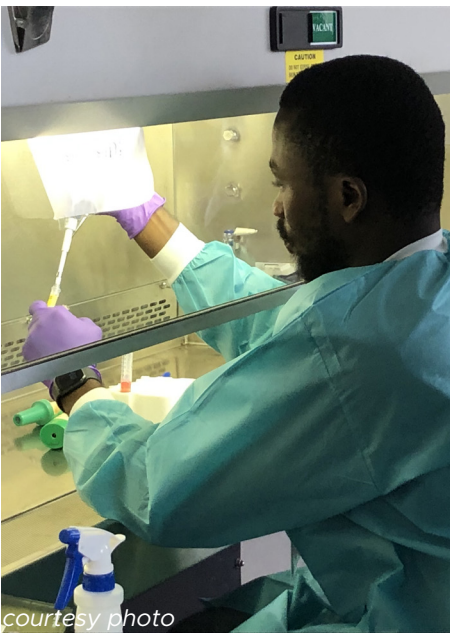
The **Molecular & Biochemistry Core** includes Western Blot room with (eBlot L1) & eZwest Lite blotting system. Scan gels & blots with Licor Odyssey M or the CLx. Read samples with nanodrops & run qPCR with QuantStudio Flex 6 & 7 (96 & 384 blocks), Plate readers include Varioskan ALF, BioTek SYNERGY Neo or Tecan Infinite M1000 plate readers.



The **Microscopy Core** is equipped with a fully motorized Nikon Ti2-E microscope with AXR resonant confocal NSPARC, extra long working distance objectives, and live-cell High Content software with G3 analysis. Olympus BX41 with color camera & EVOS FL AM microscopes are also available for fluorescence imaging.

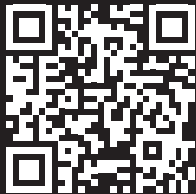
Homogenizers, bacterial shakers, cryostats and floor centrifuge (including an ultracentrifuge) are available in the **Large Equipment Core**. The core has a Slee MEV routine cryostat with space to store samples, as well as an HM525 and an HM550. Multiple centrifuge rotors can be utilized with speeds up to 100,000 rpm.

Supplemental Cores include cold rooms on each floor for storage and/or overnight transfers. There is a large -80-freezer core with liquid nitrogen dewar storage and liquid nitrogen for research. The Autoclave Core provides sterile processing of liquids and instruments. Dry ice is available at cost. We also offer poster and banner printing using a large-format printer.



Stem Cell Core

The mission of the SCC is to advance the in-house adoption of stem cell approaches for both basic and translational research and to accelerate their application to biomedical and regenerative therapies. SCC provides faculty with comprehensive expertise, resources, and support in stem cell culture, reprogramming, genome engineering, and lineage-specific differentiation.



LOCATION
IQ/Engineering Building
775 Woodlot Drive
Room 3114
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/stem-cells

CORE SERVICES

Training and Education Services

- We provide hands-on training in human iPSC culture for researchers at all experience levels.
- Hands-on training in human iPSC culture, techniques include expansion, maintenance, passaging, cryopreservation, and recovery. Introductory and advanced skill development available.
- Training conducted in the Stem Cell Core tissue culture facilities.

Cryo Banking of Stem Cell Lines

- Cryo-banking for stem cell lines (limited PI storage available)
- Access to a repository of select publicly available hESC and hiPSC lines

iPSC Reprogramming Services

- Somatic cell reprogramming to iPSCs (human and select animal species)
- Reprogramming from PBMCs or fibroblasts
- Multiple vector platforms available: episomal, Sendai virus, lentiviral, and RNA-based
- Patient-derived hiPSC model generation support

Genome Editing of Stem Cell Lines

- CRISPR RNP-based gene editing for knockouts and small modifications
- Assistance with design, screening, and clonal validation workflows



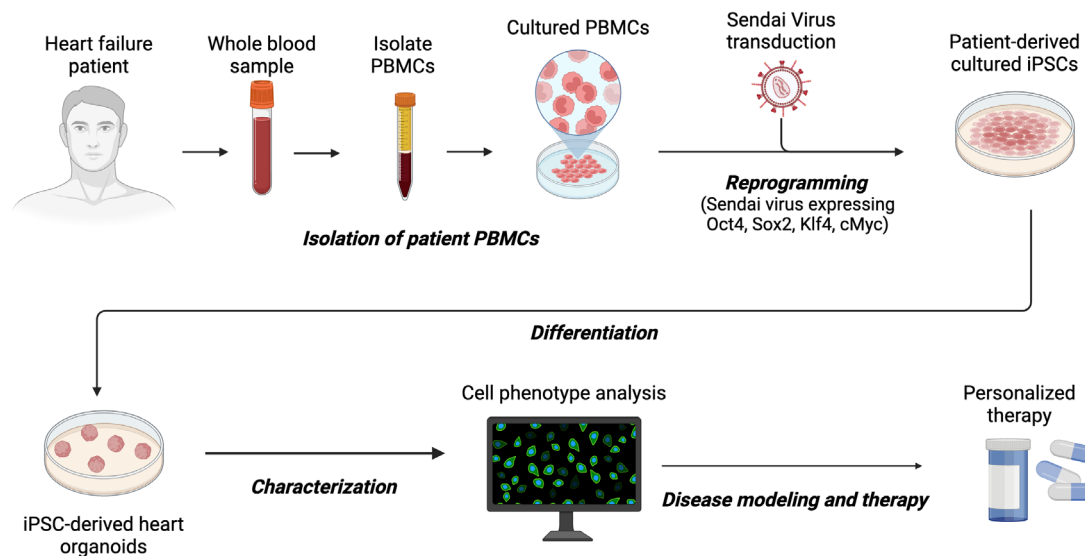
MODEL SYSTEM DEVELOPMENT & TECHNICAL SUPPORT

- Differentiation protocol selection, optimization, and troubleshooting
- Organoid and assembloid culture guidance
- Support in adapting and implementing new reprogramming and differentiation methodologies

CONSULTATION & GRANT SUPPORT

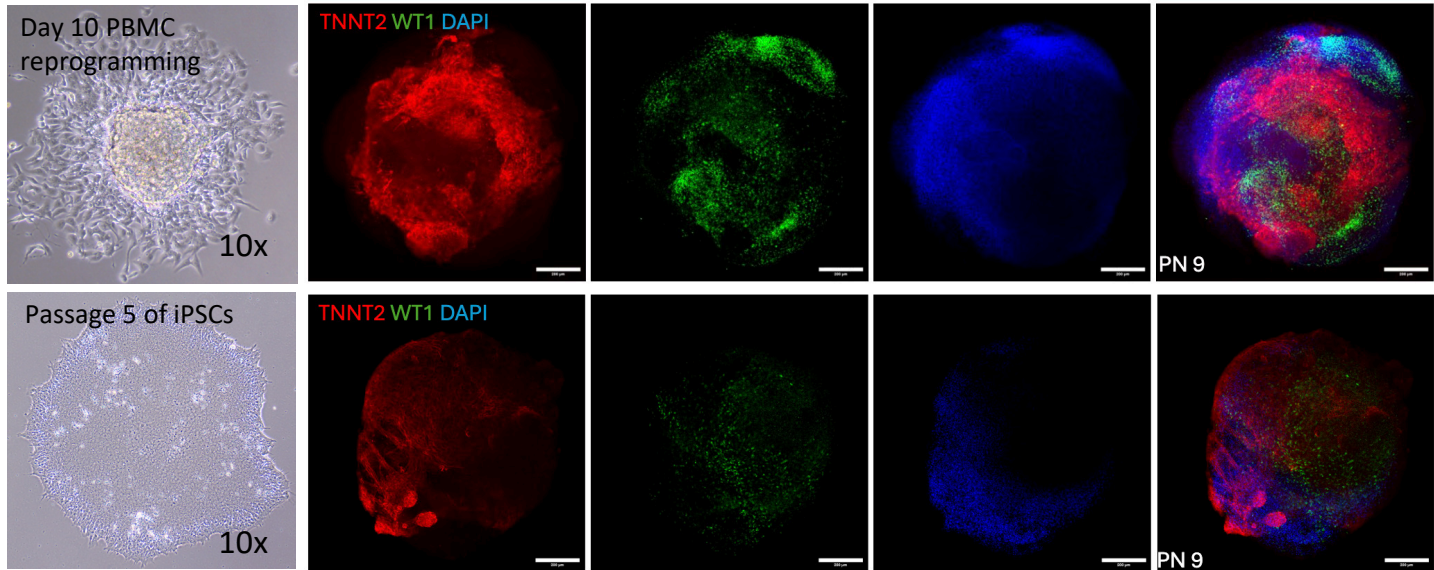
- Experimental design guidance for SC projects
- Pre-award proposal support
- Editing of stem cell-related grant research sections
- Letters of support available upon request

PBMC Reprogramming for Generation of iPSC-Derived Cardiac Organoids



Patient-to-organoid pipeline for investigating GDMT responsiveness in heart failure using iPSC-derived heart organoids. Peripheral blood mononuclear cells (PBMCs) are isolated from a heart-failure patient's whole blood, cultured, and reprogrammed with non-integrating Sendai virus vectors expressing OCT4, SOX2, KLF4, and c-MYC to generate patient-derived induced pluripotent stem cells (iPSCs). iPSCs are then differentiated into cardiac lineages and assembled into iPSC-derived heart organoids. The organoids are characterized and their cellular phenotypes analyzed for disease modeling and drug testing, with results used to guide personalized therapy.

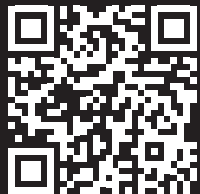
Cardiac Organoids from Reprogrammed iPSCs from GDMT Non-Responder Heart Failure Patients



The goal of this project is to establish a patient-specific *in vitro* model of heart failure to study responsiveness to guideline-directed medical therapy (GDMT). To that end, we have begun collecting blood from heart-failure patients classified as GDMT responders or non-responders. Patient-specific hiPSC lines are generated by reprogramming PBMCs isolated from these samples at MSU's Stem Cell Core. The Aguirre lab differentiates the hiPSCs to produce patient-specific heart organoids, which will be used for downstream phenotyping, including assessment of neurohumoral responses characteristic of heart failure with reduced ejection fraction (HFrEF), such as activation of the renin-angiotensin-aldosterone and sympathetic (adrenaline) axes.

Transgenic & Genome Editing Facility

- The TGEF provides Genome Editing services of multiple experimental systems (animals, cell-lines, in-vivo)
- Comprehensive ‘start-to-finish’ pipeline from targeting design to genotyped edited organisms, as well as modular service offerings for individual project stages
- Serves as a knowledge hub for faculty interested in using genome or epigenome editing approaches



LOCATION
IQ/Bioengineering Building
 775 Woodlot Drive
 Room 3114
 East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/tgef
email: tgef@msu.edu

CAPABILITIES ANIMAL MODELS SUPPORTED

- CRISPR editing of *Mouse, Rat, African Grass Rat*
- CRISPR Small Modification (knockout, point mutation, small knockin, small deletion) and large deletion
- CRISRP Conditional knockout (loxP/Cre or Flp/FRT)
- CRISPR large insertions or replacements
- Conventional transgenic generation

EMBRYO MANIPULATION SERVICES

- Microinjection (pronuclear or cytoplasmic): zygote, 2-cell embryo, or blastocyst ESC
- Embryo electroporation: in vivo and in vitro
- Consultation on non-mammalian embryo microinjection

MOLECULAR SERVICES

Gene Editing & Molecular Cloning

- CRISPR targeting and molecular cloning design
- Genome editing with nucleases (CRISPR-Cas), recombinases (Cre, FLP), and conditional/inducible systems: construct and component design and cloning
- gRNA design and validation for CRISPR-Cas targeting
- GE modification screening strategies
- Genotyping and optimization

New CRISPR Technology Testing and Adoption

- In vivo delivery of CRISPR components
- Transcriptional and epigenetic regulation
- Base editors, Prime editing and new Cas variants
- Pooled CRISPR library screens

SERVICES

Cryopreservation and Cryorecovery Services:

- Cryopreservation of sperm and fertilized embryos
- Rat and mouse cryorecovery from frozen embryos
- Mouse cryorecovery from sperm
- Frozen germplasm banking, export and import

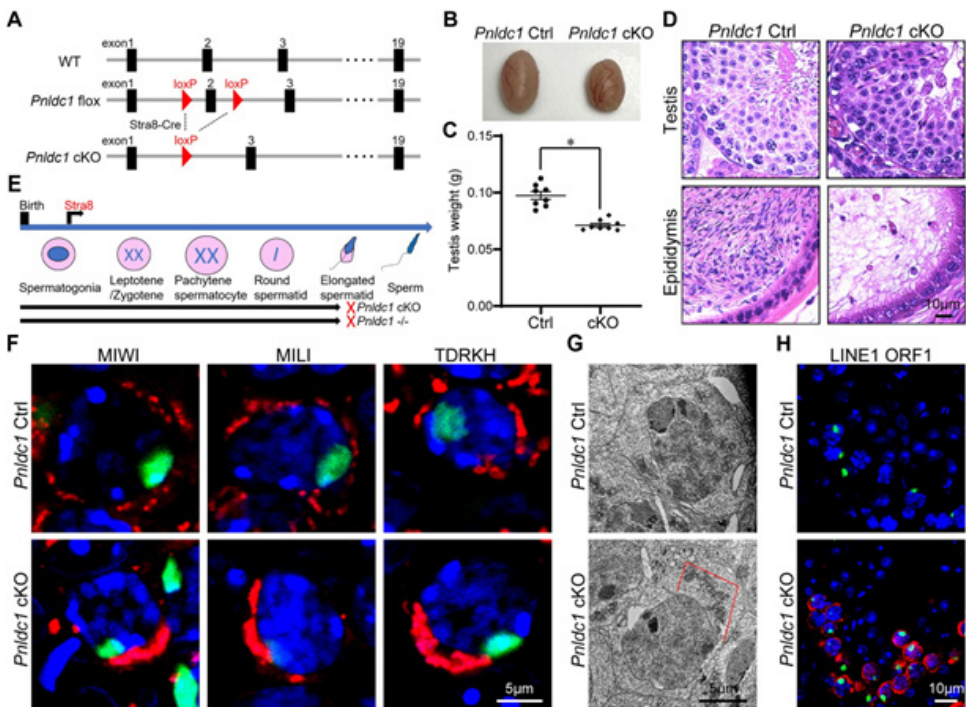
Additional Rodent Services:

- Rederivation of mouse or rat lines on campus (both for imports and internal, small and large scale)
- Rodent import/export assistance: fresh or cryopreserved sperm/embryo
- Speed congenics and speed expansion
- Mouseline - IVF, ICSI

CONSULTATION & GRANT SUPPORT

- Project and experimental design consultation
- Information on available GE resources and tools
- Training on molecular, GE and reproductive bio approaches
- Grant editing related to GE approaches
- Letters of support for grant applications
- Publication/manuscript editing
- Genotyping strategy development and support

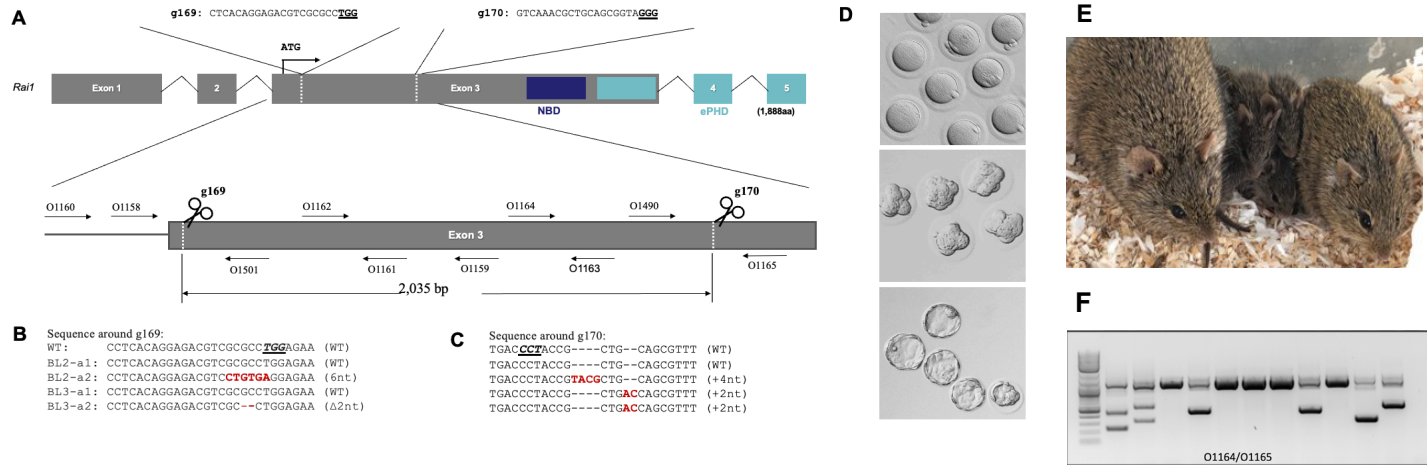
Conditional Deletion of Pnldc1 in Postnatal Germ Cells Causes Defective piRNA Trimming, LINE1 Upregulation, and Male Infertility



Wei et al. 2024. PNLD1 catalysis and postnatal germline function are required for piRNA trimming, LINE1 silencing, and spermatogenesis in mice. *PLoS Genetics* 20(9):e1011429. PMID: 38234819

(A) Gene targeting strategy for the generation of Pnldc1 cKO. Cre-mediated deletion removed the exon 2 of Pnldc1. (B) Images of adult control and Pnldc1 cKO testes. (C) Testis weights of adult control and Pnldc1 cKO mice. (D) Hematoxylin and eosin-stained testis and epididymis sections from adult control and Pnldc1 cKO mice. (E) Spermatogenic arrest stage in Pnldc1 cKO and Pnldc1 KO mice. (F) Co-immunostaining of MIWI, MILI, or TDRKH (red) with γH2AX (green) in adult control and Pnldc1 cKO spermatocytes. (G) Transmission electron microscopy was performed on pachytene spermatocytes from adult control and Pnldc1 cKO testes. The mitochondria aggregation is indicated by red line. (H) Co-immunostaining of LINE1 ORF1 (red) with γH2AX (green) in adult control and Pnldc1 cKO spermatocytes. DNA was stained with DAPI.

First Successful Demonstration of CRISPR Editing in the African Grass Rat



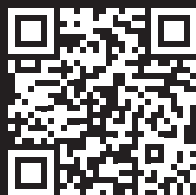
CRISPR-Cas9 Mediated Deletion of the Rai1 Gene in the Nile Grass Rat, *Arvicanthis niloticus*

(A) A locus map denoting the targeting strategy for generation Rai1 KO grass rat. (B) and (C) Alignments with reference genome demonstrate the presence of indel mutations around CRISPR gRNA targeting sites. (D) Grass rat embryos that were cultured in vitro were able to develop to blastocyst stage. (E) A litter of Nile grass rats. (F) PCR demonstrating that multiple deletions from 2 Rai1 KO founders were transmitted to G1 offspring.

Xie et al. 2023 CRISPR-based Genome Editing of a Diurnal Rodent, Nile Grass Rat (*Arvicanthis niloticus*). *BMC Biology* 22(1):144. doi: 10.1186/s12915-024-01943-9. PMID: 37662225

Metabolic Phenotyping & Preclinical Imaging Core

The mission of the Metabolic Phenotyping & Preclinical Imaging Core is to advance biomedical discovery by providing investigators with access to specialized expertise, rigorous training, and cutting-edge imaging and metabolic phenotyping technologies. Through non-invasive *in vivo* assessment of physiological function, disease progression, and treatment response, the Core supports innovative preclinical research in metabolic disease, cancer, aging, and other health-related fields.



LOCATION
IVIS & X-RAD320
Biomedical Physical Sciences
 567 Wilson Road
 East Lansing, MI 48824

TSE SYSTEM/BRUKER MINISPEC
Interdisciplinary Science and Technology Building
 766 Service Road
 East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/ivis
email: rtsf.ivis@msu.edu

EQUIPMENT

PRECLINICAL OPTICAL IMAGER

IVIS Spectrum (Revvity)

A versatile, advanced *in vivo* bioluminescent and fluorescent pre-clinical imaging system combining high-throughput and full tomographic optical imaging in one platform.

Features include:

- Light tight imaging chamber, heated stage with integrated gas anesthesia
- High throughput screening – 5 position manifold
- Versatile field of view – high sensitivity, high resolution
- Spectral un-mixing algorithms – 28 high efficiency filters spanning 430-850nm – visualize multiple reporters in the same animal
- 3D Reconstruction – DLIT, FLIT
- Living Image Software – seamless workflow from image acquisition to data analysis

METABOLIC CAGES

PhenoMaster NG (TSE Systems)

A sophisticated, modular platform designed for automated, non-invasive monitoring of mice in a stress-free home cage environment. Enables simultaneous tracking of:

- Metabolic parameters via Indirect Calorimetry: VO_2 , VCO_2 , RER, Energy Expenditure
- Ingestive Behavior – tracks food and liquid intake
- Activity and Exercise – spontaneous locomotor activity, voluntary running wheel
- This integrated system supports detailed phenotyping by capturing metabolic function, behavior and activity patterns in real-time under minimally stressful conditions

BODY COMPOSITION ANALYSIS

Minispec LF90II (Bruker)

A state-of-the-art Body Composition Analyzer for measuring lean tissue, fat, and fluid in live animals; excised organs/tissue.

The LF90II probe in probe design permits measurement in: Rats up to 700g; Mice and organs up to 130g; Biopsies from 50mg to 500mg

BIOLOGICAL IRRADIATOR

X-RAD320 (Precision X-Ray)

High-precision, self-contained biological X-Ray irradiator for cellular (e.g., survival curves, preparation of feeder layers), and small animal studies (e.g., whole-body irradiation with adoptive transfer). User friendly TouchRAD Control Panel. Pre-programmed password protected Lab accounts.

ANCILLARY EQUIPMENT

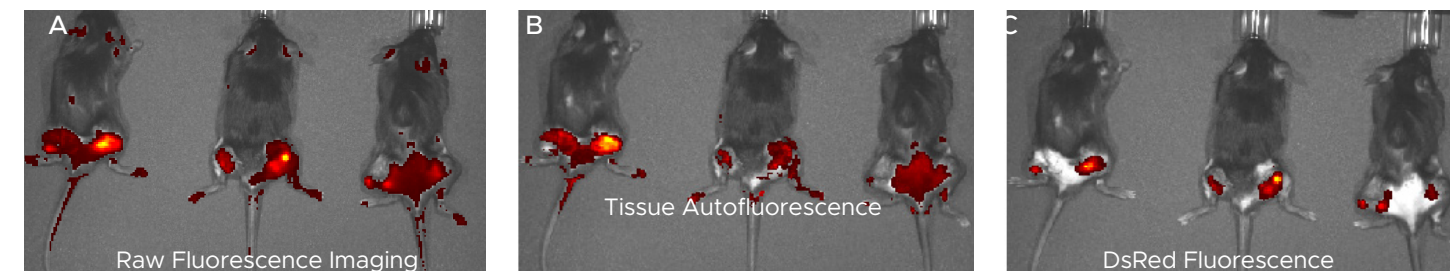
Located in the imaging suite and adjoining animal facility

- 4ft Class II Type A2 Biosafety cabinet with UV light (Labconco)
- SMZ-800 Stereo Microscope with boom stand (Nikon)
- SMZ-745T Stereo Microscope with DS-Vi1 2 Megapixel high speed color Digital Camera (Nikon)
- Benchtop Non-Rebreathing Anesthesia Machine with 6 position manifold (Supera Anesthesia Innovations formerly LEI Medical)
- RT7 Plus Centrifuge with adaptors (Sorvall)

SERVICES

- Comprehensive hands-on training provided for IVIS Spectrum, X-RAD320, and Bruker LF90II
- Assistance with:
 - Study design, image acquisition and analysis
 - Animal handling techniques, manipulations, procedures & colony management
 - Information for IACUC submissions
 - Letters of support for grant applications

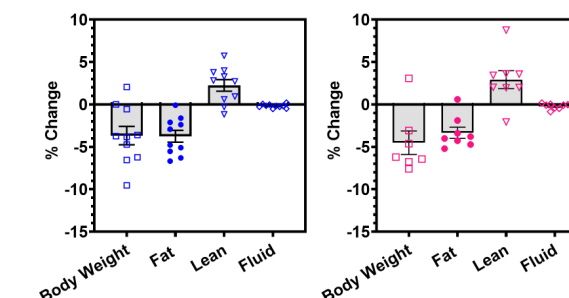
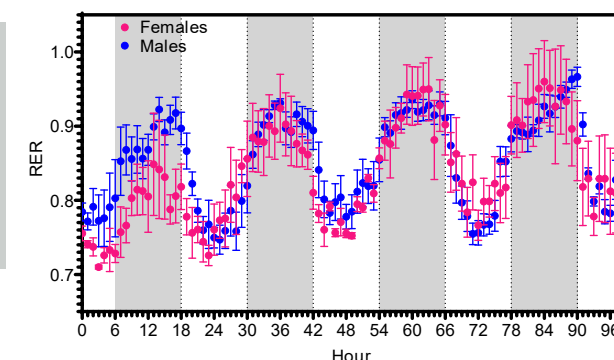
Optimizing *In Vivo* Fluorescence Imaging: The Importance of Mouse Strain Selection



DsRed-expressing mouse pancreatic tumor cells were injected subcutaneously into the flank of C57BL/6 mice. Prior to imaging, fur at the injection site was removed to minimize background signal. Fluorescence imaging was performed using the IVIS Spectrum imaging system (A). Spectral unmixing enabled separation of endogenous tissue autofluorescence (B) from the true DsRed fluorescence signal (C). These images illustrate that dark fur and melanin-rich skin can markedly attenuate fluorescence signal detection, underscoring the importance of strategic mouse strain selection to achieve sensitive *in vivo* fluorescence imaging.

Metabolic Phenotyping (TSE systems) & Body Composition Analysis (Bruker LF90II)

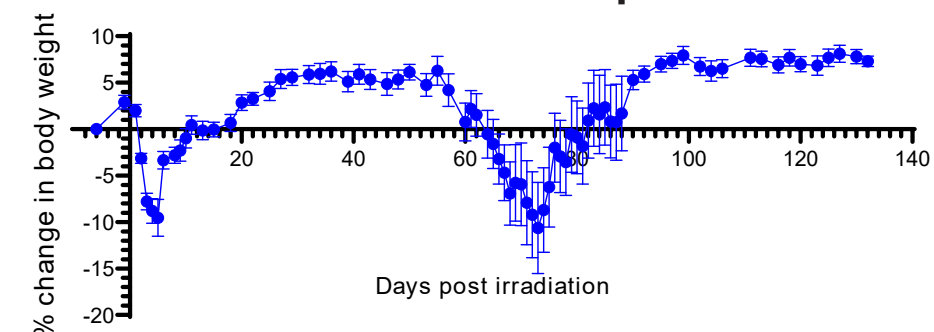
The TSE PhenoMaster NG System is an integrated, modular platform for metabolic, behavioral, and physiological phenotyping in rodents. Enabling continuous monitoring of indirect calorimetry (VO_2 , VCO_2 , RER), ingestive behavior (meal patterns, food and water intake), and locomotor activity within a low-stress home-cage environment. The representative plot illustrates Respiratory Exchange Ratio (RER) measurements collected over a 96-hour period, showing characteristic diurnal fluctuations in substrate utilization across this time course.



The Bruker LF90II enables non-invasive, longitudinal quantification of rodent body composition. The representative graphs to the left show fat and lean mass measurements after short-term (3-day) housing in TSE PhenoMaster NG metabolic cages equipped with voluntary running wheels. The decrease in fat mass accompanied by an increase in lean mass indicates a shift toward a more metabolically active state, consistent with increased physical activity during the monitoring period.

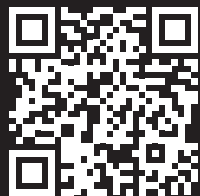
Murine Total-Body Irradiation and Bone Marrow Transplantation

C57BL/6 mice received 11 Gy total-body irradiation using the X-RAD320 Biological Irradiator (two 5.5 Gy fractions, 3 hours apart) followed by adoptive transfer of bone marrow transplant 18–24 hours later. Mice showed early weight loss days 1–5 (consistent with radiation-induced gastrointestinal injury), recovery by days 7–10, coat color changes around days 40–45, and a second weight-loss phase around days 65–70 consistent with hematopoietic dysfunction.



Veterinary Diagnostic Laboratory

The Michigan State University Veterinary Diagnostic Laboratory (formerly Diagnostic Center for Population and Animal Health) is a full-service diagnostic laboratory known for endocrinology and cancer diagnostics. Our core diagnostics, expert service, and innovative solutions have earned us clients nationwide and across the globe.



LOCATION
Veterinary Diagnostic Laboratory
4125 Beaumont Rd.
Lansing, MI 48910

CONNECT
web: research.msu.edu/srr/vdl

FEATURED CAPABILITIES

ENDOCRINOLOGY

International leader in veterinary endocrinology with an extensive offering of tests for canine, feline, equine, and exotics including thyroid and calcium disorders, adrenal function, IGF-1, and aldosterone.

NUTRITION AND TOXICOLOGY

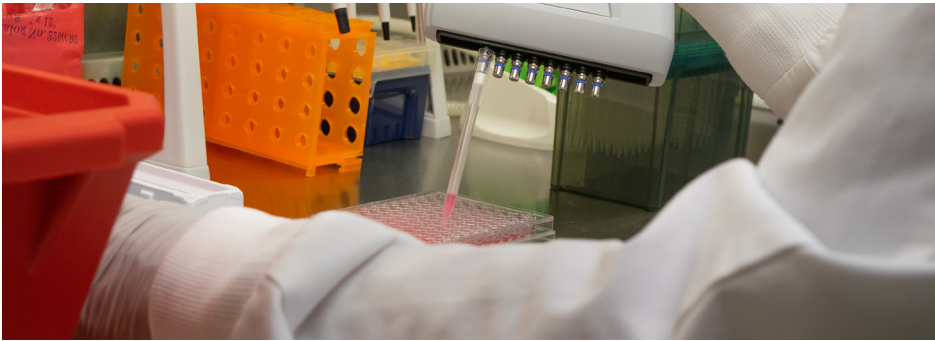
Assessment of nutritional status and the diagnosis of chemical poisonings and pharmacokinetic modeling in companion, production, and exotic animals utilizing LC-MS-MS, GC-MS-MS, and ICP-MS instruments.

ANATOMIC, SURGICAL AND MOLECULAR PATHOLOGY

Necropsy, biopsy, and immunohistochemistry services; molecular assays for diagnosis and prognosis of cancer and genetic testing.

CLINICAL PATHOLOGY

CBC and chemistry testing for all species using standard or customizable panels for research projects; established expertise in cytologic and histologic bone marrow examination



INFECTIOUS DISEASE

BACTERIOLOGY AND MYCOLOGY

Identification of novel, emerging, and re-emerging veterinary pathogens; bacterial and fungal culture from complex matrices; bacterial identification and subtyping; antimicrobial susceptibility.

GENOMICS AND BIOINFORMATICS

In-house sequencing and bioinformatics capabilities, including Sanger, Next- and Third-generation sequencing; digital PCR; syndromic disease surveillance and detection of emerging and novel pathogens.

IMMUNODIAGNOSTICS AND PARASITOLOGY

Parasite identification; tick-borne disease testing; blood donor testing.

VIROLOGY

Classical virology; emerging and re-emerging companion animal viral diseases; foreign animal diseases; mammalian herpesviruses and coronaviruses.

Recent Research Partnerships in Endocrinology

Recent collaborative research explores hormone concentrations and validates endocrine assays (including adrenal, calcium metabolism, thyroid, reproduction) for nontraditional species (such as lemurs, sea lions, stingrays, sea turtles, manatees, red pandas, snakes, mules, primates, rabbits).

Service to researchers across campus and nationwide to provide diagnostic insights in companion animals, livestock, exotic and wildlife species to support research goals using a catalog of more than 30 assays and ability to process large or small batches of samples using high-throughput workflows.

The MSU VDL Endocrinology Section utilizes chemiluminescent and radioimmunoassay technology and has Immulite, DiaSorin and IDS instruments.

Another example includes a cross-sectional (Endocrinology + Toxicology and Nutrition), multidisciplinary, multidepartment (VMC Internal Medicine + VDL) study integrating clinical management of an endocrine disease with the analytical capabilities of LC-MSMS. This study addressed a knowledge gap in veterinary medicine in which the lack of an integrated pharmacokinetic–pharmacodynamic understanding of deoxycorticosterone pivalate (DOCP) in dogs with hypoadrenocorticism affected optimal treatment plans given current standards of care and dosing guidelines.

Recent Research Partnerships in Toxicology and Nutrition

Cross-sectional (Anatomic Pathology + Toxicology/Nutrition) study coupling veterinary expertise in animal handling, dosing, clinical monitoring and postmortem necropsy with analytical expertise in the measurement of neonicotinoid compounds and their metabolic breakdown products using LC-MS/MS. This combined effort demonstrated the use of a high-sensitivity testing platform to perform validated, multi-matrix, multi-analyte toxicology testing in the assessment of regulatory compliance and food-safety.

The MSU VDL Toxicology and Nutrition Section utilizes two LC-MS/MS instruments, one GC-MS/MS and two ICP-MS instruments.

Multi-college (COM, CANR, and CVM VDL) study utilizing a fully validated analytical method to assess mono- and di-hydroxyvitamin D2 and D3 in serum to address questions of nutritional inequities in risk-prone, underserved populations. The development of a method to simultaneously monitor multiple vitamin D metabolites in low volume study samples, allowed for metabolic profiles to be constructed and compared between groups.

Recent Research Partnerships in Anatomic Pathology

Postmortem examination of any avian species (commercial poultry, zoo, small flock, or pet birds) can be performed by a board-certified pathologist who specializes in avian pathology and includes gross examination, histopathology, and ancillary testing to meet study goals in infectious agents, nutritional imbalances or toxicoses.

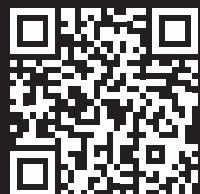
Recent collaborative research combines specialists in zoo medicine, histopathology, and mycology to investigate antifungal resistance to common azole drugs in captive penguins with Aspergillosis, which is their primary cause of death in captivity.



courtesy photo

Radiochemistry & Radiopharmacy Solutions (RadCore)

The RadCore provides synthesis of drugs and radiolabeled agents for imaging and therapeutic applications in animals and humans. The core serves as a central resource for drug manufacturing, radiolabeling services, and regulatory support to researchers engaged in in vitro, preclinical, and clinical trials. The RadCore **meets FDA guidelines (cGMP compliant)** under 21 CFR parts 210, 211, 212, and USP <797>.



LOCATIONS
Radiochemistry Labs
 IQ/Bioengineering Building
 775 Woodlot Drive
 Room 1S
 East Lansing, MI, 48824

Radiopharmacy
 Clinical Center East – D Wing
 840 Service Road
 Suite E20
 East Lansing, MI, 48824

CONNECT
web: research.msu.edu/srr/
 radcore
email: radiopharmacy@msu.edu

EQUIPMENT

cGMP-COMPLIANT MANUFACTURING

- **Clean Room** (ISO5 areas inside ISO7)
Siemens Designo-monitored gowning room, anteroom, and clean room for temperature, humidity, and pressure differentials with 24/7 alarms; biannual ISO certifications and environmental monitoring. Monitored refrigerator and freezer.
- **Radiosynthesis Modules** (Synthra GmbH)
RN-Plus automated radiosynthesizers for complex synthesis of small molecules and drugs
- **Lead-Shielded Hot cells** (Van Gahlen)
Two large shielded hot cells with manipulators for safe handling of high levels of radioactivity (10 Ci)
- **Radiation Detection Instruments**
Dose calibrators, well counter, HPLC radiation detectors, Radio iTLC scanner, CZT detector for gamma-ray spectroscopy; all to enable accurate measurements of radioactivity & purity.

QUALITY CONTROL AND RELEASE TESTING

- **HPLC:** *For Identity & purity of drug substance*
- **Gas Chromatography:** *For Residual Solvent Analyses following synthesis & safety*
- **Endotoxin and Sterility testing:** *For safety*
- **Potency Assays:** *For biological activity after radiolabeling*
- **Stability testing:** *To determine expiration date*

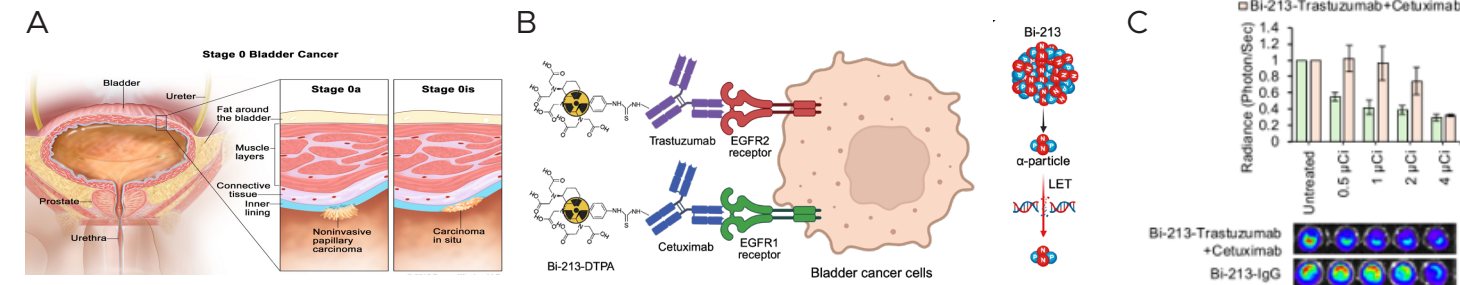


SERVICES

- Manufacturing radiopharmaceuticals for binding assays, preclinical studies, and clinical studies
- Radiolabeling small molecules, peptides and proteins (e.g., antibodies) with a wide array of different radioisotopes: F-18, Tc-99m, Cu-64, Ga-68, Zr-89, Y-86/90, Lu-177, Pb-203, Pb-212, Bi-213, Pb-214/Bi-214, Ac-225,
- Manufacturing non-radioactive drugs/precursors
- Quality control and release testing for manufactured compounds
- Preparation of Chemical Manufacturing and Control (CMC) section of IND for clinical trial
- Extensive Training Program

A Prospective, Open-Label, Phase 1 Study of Safety, Tolerability, and Efficacy of Intravesical Radiolabeled-Trastuzumab/Cetuximab Therapy in Patients with Non-Muscle Invasive Bladder Cancer

Dr. Kurt Zinn with Corewell Health Partner, Dr. Conrad Tobert

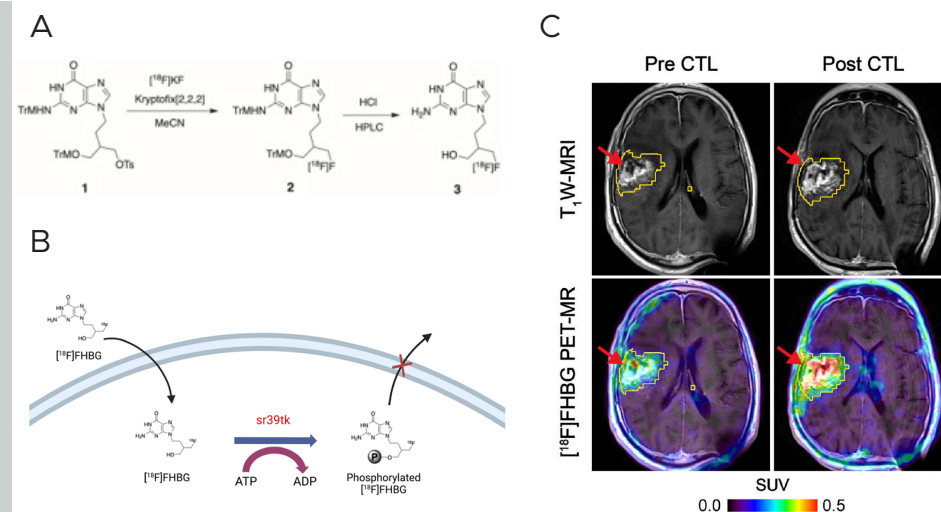


This collaborative project (Corewell, MSU, Niowave) addresses the lack of effective treatments for bladder cancer by creating a novel radiopharmaceutical for effective and safe targeted radiation therapy. The standard of care treatment for high-grade, non-muscle-invasive bladder cancer (A) is immunotherapy with BCG (Bacillus Calmette-Guerin, a bacterium to “turn on” the immune system) administered into the bladder. Intravesical BCG is relatively well-tolerated but is effective in only two-thirds of patients. To provide a better treatment, we attached alpha-particle emitting Bi-213 to trastuzumab and cetuximab, two FDA-approved antibodies that target EGFR1/2 that are overexpressed on bladder cancer (B). As shown (C), this treatment is highly effectively in killing human bladder cancer cells (SCaBER) compared Bi-213 attached to a control, non-targeted isotype antibody (C). A phase I clinical trial is planned.

Cancer Gene Therapy and [F-18]FHBG PET Imaging of HSV1-sr39tk gene expression

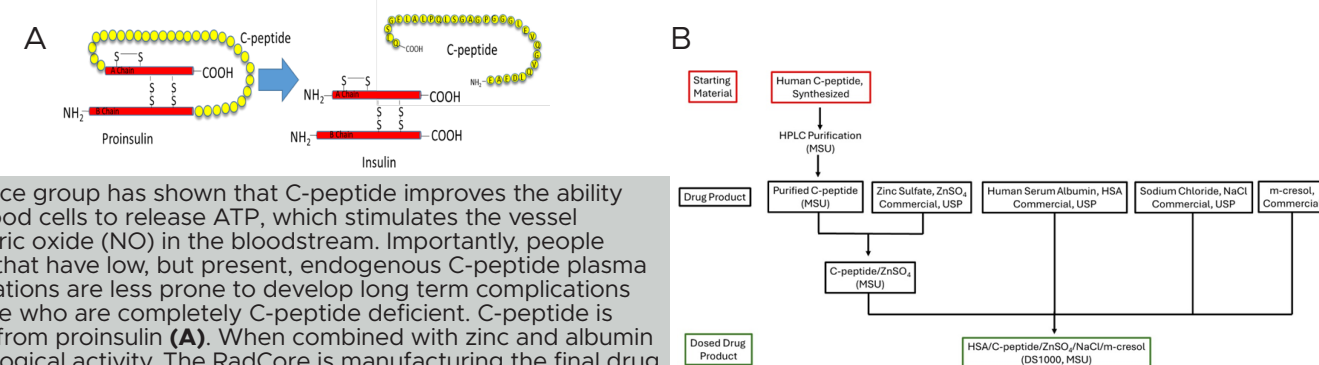
Dr. Jinda Fan with Henry Ford Health Partner, Dr. Tobias Walbert

This project focuses on developing a robust automated radiosynthesis method to produce and purify [F-18] FHBG, a small-molecule substrate for the HSV1-sr39tk (thymidine kinase) reporter enzyme. The synthesis steps are shown (A). Following injection in the human patient undergoing gene therapy for cancer, the [F-18]FHBG is trapped (B) and provides contrast for non-invasive imaging with Positron Emission Tomography (PET) to show the areas of gene transfer and HSV-sr39tk expression (C). The example in (C) is from a Stanford group[#] after CTL (CD8+ cytotoxic T lymphocytes) were given as glioma therapy and followed by PET/MRI.
[#]Sci Transl Med. 2017 January 18; 9 (373): doi:10.1126/scitranslmed.aag2196. Fig. 4



A Prospective, Open-Label, Phase 1 Study of Safety, Tolerability, and Efficacy of DS1000 in people with type 1 diabetes (T1D)

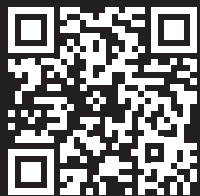
Dr. Dana Spence and Dr. Kurt Zinn are co-PIs of the project and are collaborating with clinical partner Dr. Littlejohn, Sparrow-Michigan Health (Funded by Helmsley Charitable Trust)



The Spence group has shown that C-peptide improves the ability of red blood cells to release ATP, which stimulates the vessel dilator nitric oxide (NO) in the bloodstream. Importantly, people with T1D that have low, but present, endogenous C-peptide plasma concentrations are less prone to develop long term complications than those who are completely C-peptide deficient. C-peptide is released from proinsulin (A). When combined with zinc and albumin it has biological activity. The RadCore is manufacturing the final drug product (DS1000) for this phase I clinical study, as shown in (B).

Clinical Research Support Core

The mission of CRSC is to assist researchers across the different colleges with development, implementation, management and completion of government and industry funded clinical research and clinical trial projects conducted through MSU and its community partners, to expedite the research administration process, and to facilitate research compliance.



LOCATION
Clinical and Translational Sciences Institute
909 Wilson Road
Room B500
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/crsc

BACKGROUND

The Clinical Research Support Core is staffed by seasoned clinical research professionals representing the University’s investment in clinical research and trials management who have extensive knowledge in the intricacies of both internal and external clinical research processes and requirements. Support is available throughout a research study’s lifecycle.

RESEARCH SUPPORT AREAS

REGULATORY SUPPORT

MSU IRB and Central IRB submissions

COORDINATOR SUPPORT

Qualified research coordinators specifically trained to provide efficient study start up, protocol implementation, study management, and study closeout

ADMINISTRATION

Feasibility analysis, study budget development and negotiation, recruitment support, training of new study staff and ancillary departments for study related activities

PARTICIPANT RELATED SERVICES

Prescreening/eligibility, obtaining informed consent, performing or assisting with required procedures, completing require visit documentation, billing, AE & SAE reporting, phlebotomy support, sample collection, processing, and handling

RECRUITMENT SUPPORT

Advise and contribute to recruitment planning, provide participant recruitment support, use of ResearchMatch as a feasibility and recruitment tool

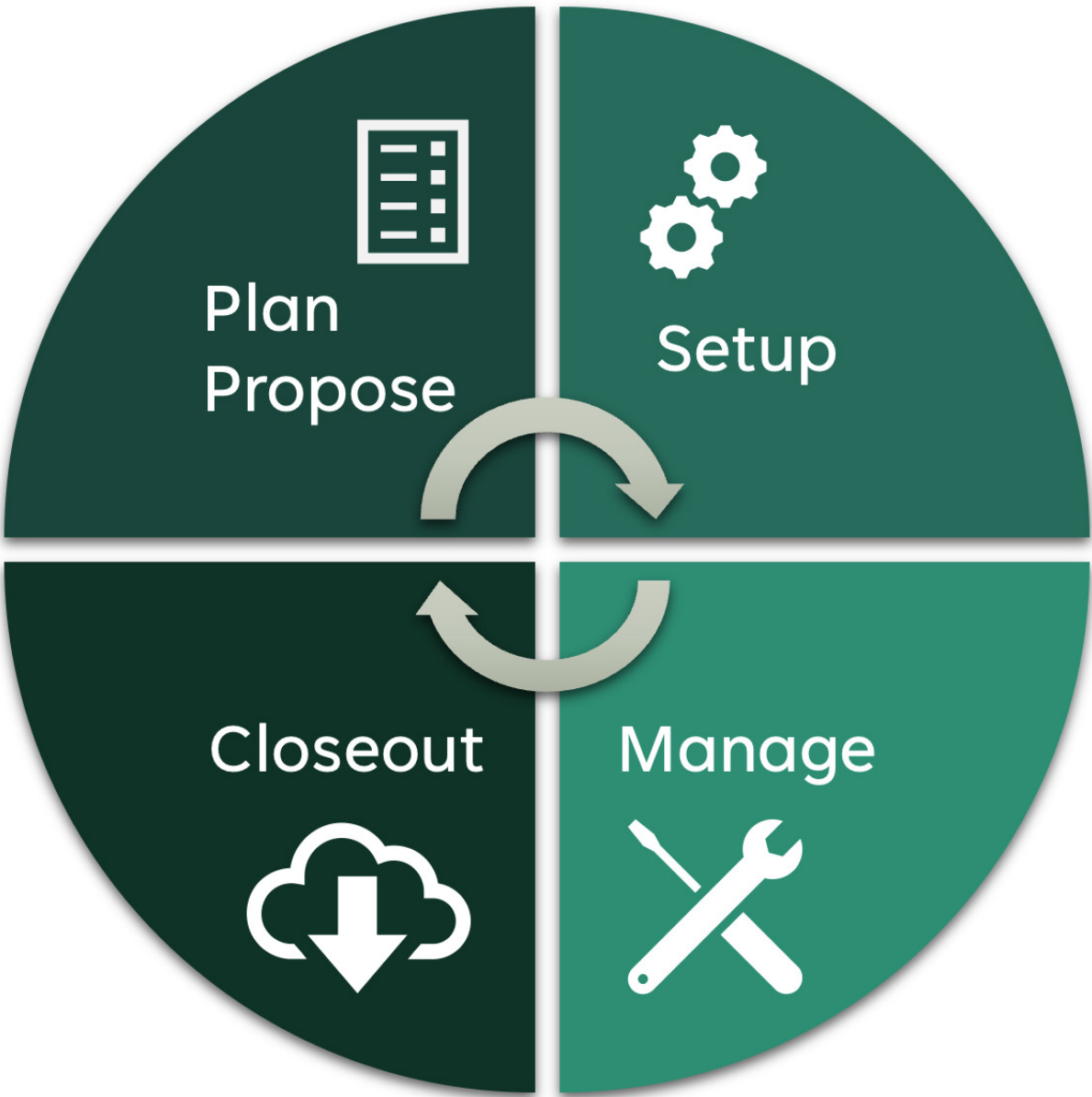
PROCESS NAVIGATION

Mobilization and connection to resources, coordination with central departments, facilitation of access to internal and external service providers

RESEARCH FACILITIES

- Blood draw station
- Certified biological safety cabinet
- Calibrated centrifugation equipment
- Temperature controlled/monitored refrigerator and -20 freezer
- Waiting room
- Outpatient interaction space for exams, Interviews, specialized testing, and completing questionnaires
- Storage area

RESEARCH STUDY LIFE CYCLE



ResearchMatch

ResearchMatch is an online recruitment platform that connects researchers with volunteers who are interested in learning about health-related research opportunities. Visit **ResearchMatch.org** to register as a researcher or scan the QR code.



Plant Science, Ecology & Agricultural Resources

Grow discovery from
the ground up.

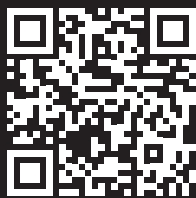
As a land-grant institution, MSU advances research from controlled environments to field systems, strengthening sustainability, resilience, and food systems.

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Research Greenhouse Complex

The mission of the MSU Research Greenhouse Complex is to provide users with greenhouse space that matches the project goals with the environmental management capability of individual greenhouse compartments. Ongoing and recently completed renovations are improving the quality and functional capability of our greenhouses, allowing for more precise control of the greenhouse environment.



LOCATIONS
Main Campus Headhouse
1059 Farm Lane
East Lansing, MI 48824

Horticulture Teaching and Research Center
3291 College Road
Holt, MI 48842

Crop and Soil Sciences Teaching and Research
4450 Beaumont Road
Lansing, MI 48910

CONNECT
web: research.msu.edu/srr/greenhouse

EQUIPMENT

GREENHOUSE ENVIRONMENTAL CONTROL SYSTEMS

Wadsworth Seed, Bartlett Climate Boss, Microgrow Growmate

Environmental control systems are programmed to keep maintain desired temperature and photoperiod settings. Both Seed and Climate Boss collect data. If needed, additional equipment can be added to greenhouse compartments with Seed system. Environmental control systems also record the temperature and humidity in the greenhouses, and this data is available to users.

GREENHOUSE SUPPLEMENTAL LIGHTING

Philips GreenPower LED Toplighting

These fixtures provide a mixture of Deep Red/White/Medium Blue light and are 70% more energy efficient than high-pressure sodium fixtures.

TREATED IRRIGATION WATER

Acidified water, acidified + fertilized water, and RO water

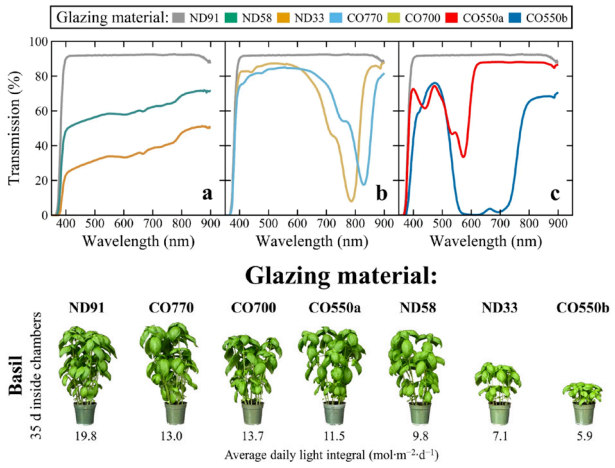
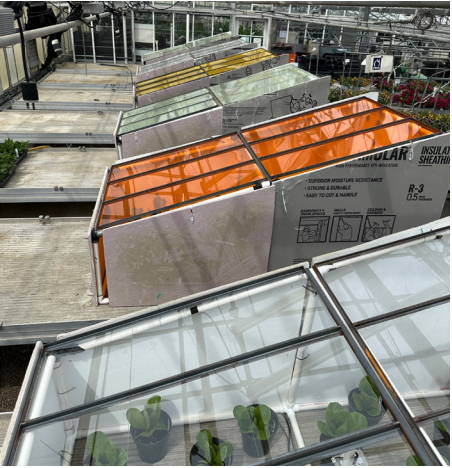
By summer 2025, all greenhouses on the west side of the main campus facility will have access to treated water, eliminating problems with high root zone pH caused by the alkalinity of campus water.

SERVICES

- Maintenance – either by PSRG staff or by Infrastructure, Planning, and Facilities
- Pest management – greenhouses are scouted weekly, and pests are treated on an as-needed basis
- Custom-built equipment such as mist chamber and irrigation systems (fee-based)
- Plastic pots and potting media
- Fertilizer
- Hoses, watering wands, and nozzles



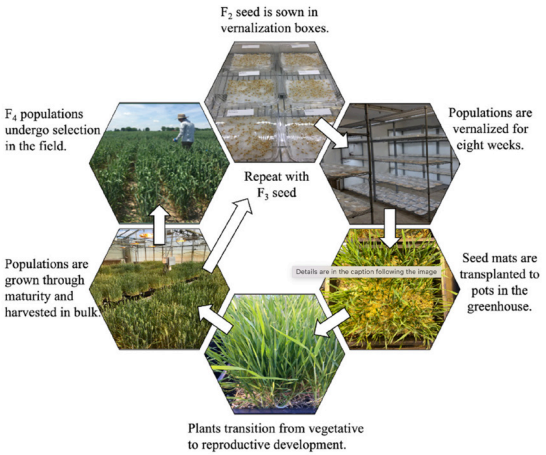
Designing Plant-Transparent Agrovoltaics



Adapted from: Stallknecht, E.J., Herrera, C.K., Yang, C., King, I., Sharkey, T.D., Lunt, R.R., Runkle, E.R.(2023) **Designing plant-transparent agrivoltaics.** *Sci Rep* 13, 190.3
<https://doi.org/10.1038/s41598-023-28484-5>

Researchers are examining how photovoltaic panels can help grow various crops in greenhouses. The panels transmit photosynthetically active radiation from the sun to the plants, while also generating electricity from light not useful for crop growth. Different panels transmit different wavelengths and total amounts of light to plants. This futuristic technology can potentially be used to glaze greenhouses or other agricultural systems to simultaneously produce sustainable electrical energy and agricultural crops, including floricultural crops.

The ‘Minibulk’ System for Advancing Winter Cereal Breeding Populations



Adapted from: Olson, E., Brown-Guedira, G., Noble, A., Smith, J., Forsberg, L., Brisco, E., Brown, L. (2022) **The ‘Minibulk’ system for advancing winter cereal breeding populations.** *Crop Sci.* 62(3), 1011-1023.
<https://doi.org/10.1002/csc2.20718>

The development of the Minibulk system for wheat breeding allows for rapid and cost-effective production of inbred lines under greenhouse conditions. Populations of hundreds of wheat seeds are grown together at a high density to save space, while an extended photoperiod accelerates development and allows for three generations per year for winter wheat. Using the Minibulk method in MSU greenhouses has shortened the winter wheat breeding cycle by four years.

Biological Control of Greenhouse Insect and Mite Pests



Aphidius colemani is a commonly-used parasitoid wasp for control of aphids. The photos (R-L) show how the wasps are released in the greenhouse, a female wasp laying eggs in an aphid, and a parasitized aphid from which juvenile wasps will soon emerge.

The Plant Science Research Greenhouses began using beneficial organisms to control insect and mite pests in the greenhouses in late summer 2023, due to both suspected pesticide resistance and to reduce the number of pesticides used. Since then, there has been a 67% reduction in the number of insecticide and miticides applications, and resistance to traditional pesticides seems to have been broken. Pest control has also been improved, leading to healthier research plants.

Growth Chambers/ Phytotron Facility

The core mission of the Growth Chamber/Phytotron Facility is to provide research support through management, maintenance, and procurement services, to principal investigators conducting research on or with plants. The facility provides centralized management of growth chamber, greenhouse and phytotron space, coordination of equipment acquisition and maintenance, implementation of IPM practices and distribution of supplies, all necessary to meet the challenges of modern plant research.



LOCATION
Plant Biology Laboratories
612 Wilson Road
Room 16
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/growth-chamber

EQUIPMENT

BioChambers Growth Chambers

- Growing areas from 7 ft² to 120 ft²
- Chambers can be monitored remotely from our control room
- Advanced scheduling options, multi-day and multi-line schedules, setpoint ramping
- No tool conversion of some units from short plant to tall plant mode
- Operation from 10°C to 35°C lights on and 4°C to 40°C lights off
- Some units have extended temperature ranges, some as low as -10°C and others as high as 55°C
- CO₂ monitoring and addition, CO₂ scrubbing also available
- Additive humidity
- Dehumidification options on some units
- Variety of lighting options available (LED, Fluorescent T5 and T8, HID)

Convion Growth Chambers

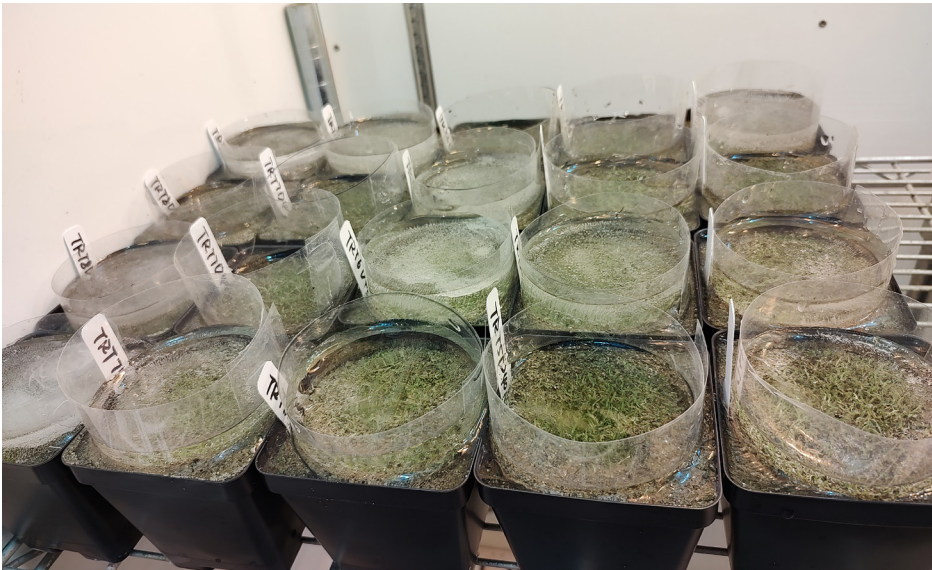
- Growth Areas from 7 ft² to 40 ft²
- Temperature range from 5°C to 40°C lights on/off
- T8 fluorescent with incandescent lighting
- Multi-line schedules, setpoint ramping available

Light Measurement

- Li-Cor 250A with quantum PAR sensor
- Li-Cor 180 Spectral sensor

SERVICES

- Facility is staffed 365 days a year
- Site-planning, site-renovation, delivery management, installation, maintenance, cleaning, and decommissioning of chambers
- Stocked and clean prep areas
- Biohazardous waste disposal
- Facility access control
- WPS compliance
- Integrated Pest Management (IPM)



Death Valley Chambers, Bringing the Harsh Desert Right to your Lab!

Our facility is host to several chambers that can replicate the harsh temperature and light conditions found in Death Valley. Research groups use the chamber's capability to ramp from 30°C to 46°C and 100 $\mu\text{mol}/\text{m}^2/\text{s}$ to almost 2,000 $\mu\text{mol}/\text{m}^2/\text{s}$ throughout that day which enables them to study plants that grow in these conditions. This is an excellent opportunity to learn more about how plants can be resilient and thrive in these conditions, without having to do extensive travel and fieldwork. The desert can be only a few steps away with this exciting addition to the Growth Chamber Facility.



Read more: msutoday.msu.edu/news/2025/11/plant-reveals-blueprint-for-building-heat-resilient-crops

Replicating the Understory with Minute-by-Minute Scheduling

Researchers often need to replicate unique conditions found in the natural environment in controlled environment spaces. To replicate the dynamic light conditions found in the understory researchers have used our equipment's advanced scheduling options to vary the light intensity minute-by-minute throughout the day to mimic what a plant would see as sunlight filters through the canopy.



Facility Expansion, Phytotron Construction, New Opportunities



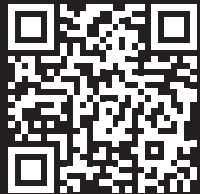
The facility is expanding with the construction of the Plant and Environmental Science Building (PESB). This new research building will add space for 97 new growth chambers as well as a 12-module Phytotron on the roof, greatly increasing the capacity of the facility to support a wide range of plant research projects. The building is set to be completed in March of 2027.

Read more: ipf.msu.edu/construction/current-projects/plant-and-environmental-science-building



Center for Photosynthetic Light Use and carbon eXchange (PhLUX)

We are facing unprecedented challenges that directly involve the plant sciences. The United Nations estimates that food production has to increase by at least 70% over the next 30-50 years. So, there is an urgent need to develop highly productive and sustainable food production sources. Our center's technologies can measure photosynthetic parameters, in real-time, and identify biophysical processes and genes that contribute to photosynthetic efficiency and productivity.



LOCATION
Plant Biology Laboratories
612 Wilson Road
Room 310
East Lansing, MI 48824

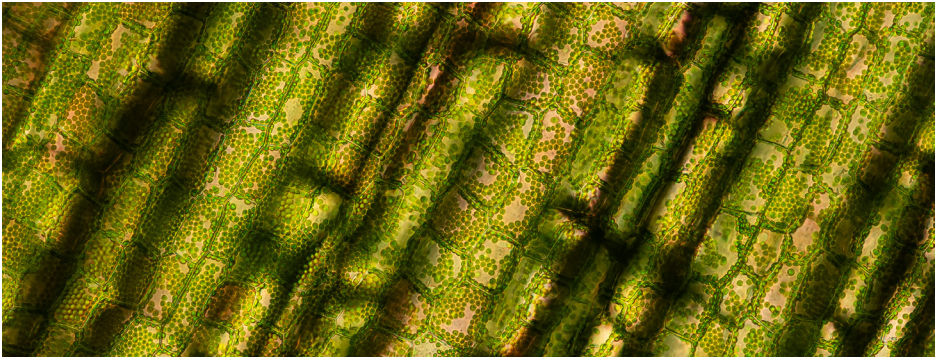
CONNECT
web: research.msu.edu/srr/phlux

EQUIPMENT

Dynamic Environmental Photosynthetic Imager (Custom built)
Dynamic Environmental Photosynthetic Imaging (DEPI) captures environmental conditions in the field, including light and temperature, and replays them under controlled conditions in our growth facilities. Photosynthetic efficiencies and other traits are monitored real-time using chlorophyll fluorescence imaging and onboard cameras.

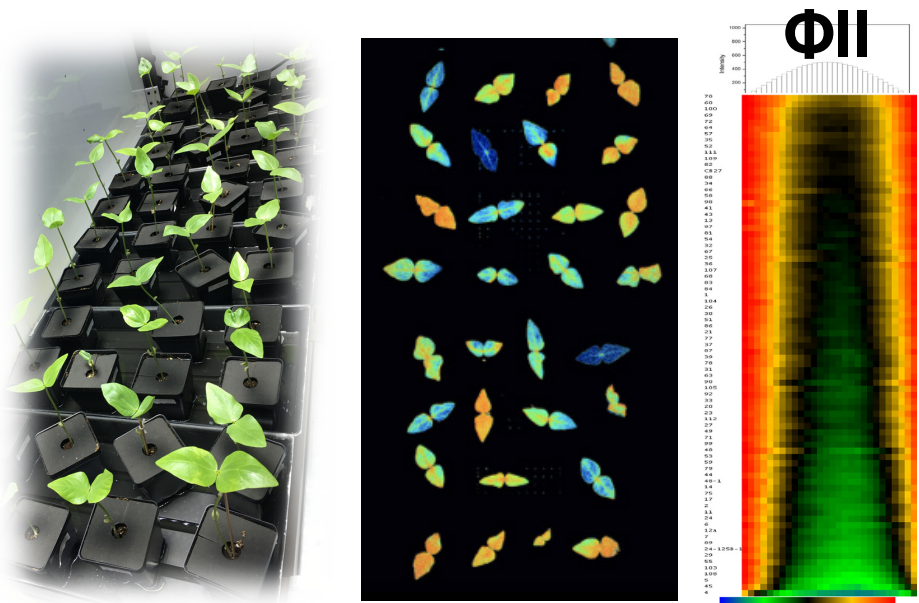
GAS EXCHANGE ANALYSIS
LI-6800 (LI-COR Biosciences)
Measure CO₂ and H₂O gas exchange of leaves, insects, and root tissues. We have many chambers that can be adapted for different tissue types and sizes. Ability to control CO₂ concentration and temperature. Many instruments allows parallel deployment in the field.

LI-600 (LI-COR Biosciences)
Measure photosynthetic efficiency and stomatal conductance in the field using a 15 second measurement.

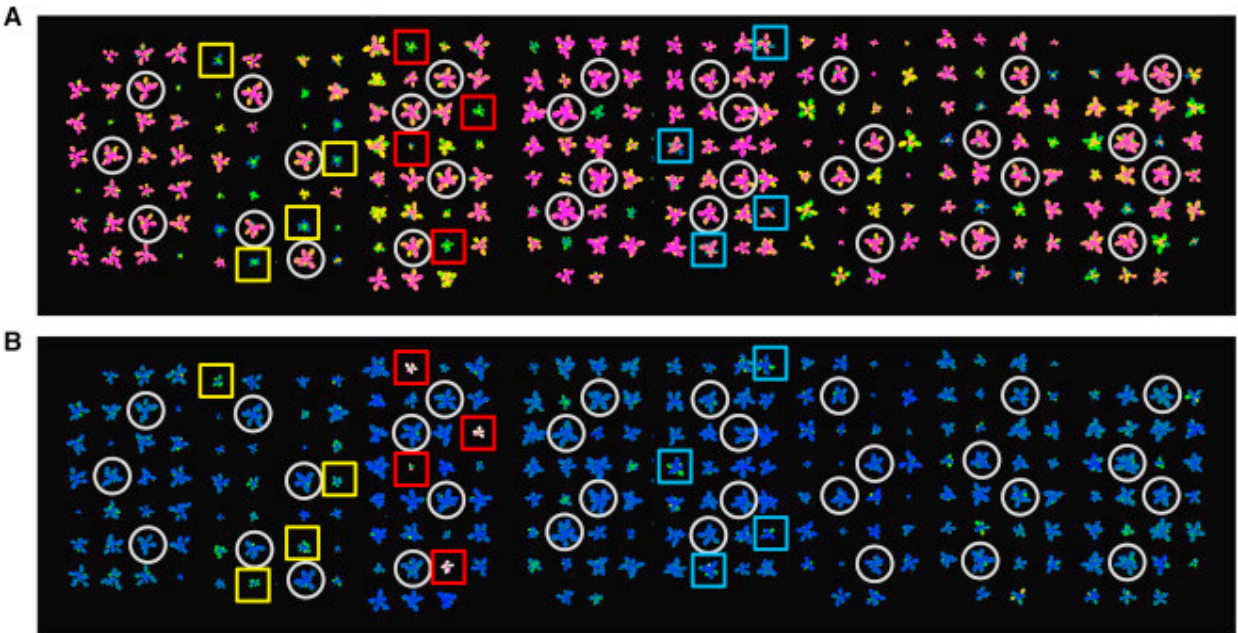


SERVICES

- Full-service experiments imaging photosynthetic efficiency in hundreds of plants
- Instrument rental for lab and field use



Dynamic Environmental Photosynthetic Imaging Reveals Emergent Phenotypes

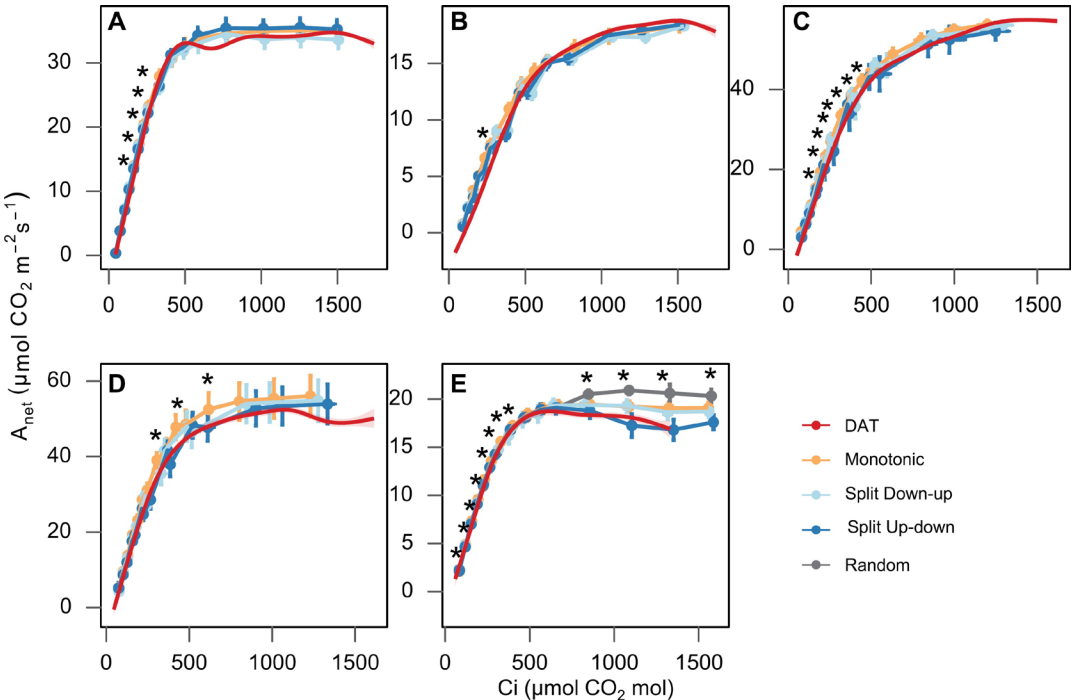


DEPI Imaging under fluctuating light revealed photosynthetic phenotypes not present in mutant lines under steady-state conditions. Hundreds of plants can be imaged simultaneously during a five-day regime of fluctuating conditions.

Cruz JA, Savage LJ, Zegarac R, Hall CC, Satoh-Cruz M, Davis GA, Kovac WK, Chen J, Kramer DM. Dynamic Environmental Photosynthetic Imaging Reveals Emergent Phenotypes. *Cell Syst*. 2016 Jun 22;2(6):365-77.

doi: 10.1016/j.cels.2016.06.001. PMID: 27336966.

Rapid Approaches in Gas Exchange

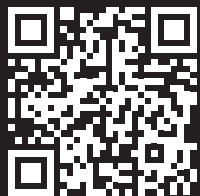


Our lab helped validate a novel strategy for rapidly determining the photosynthetic response to changing carbon dioxide conditions. These methods can be used with our LI-6800 for more rapid phenotyping experiments.

Mauricio Tejera-Nieves, Do Young Seong, Lucas Reist, Berkley J Walker, The Dynamic Assimilation Technique measures photosynthetic CO₂ response curves with similar fidelity to steady-state approaches in half the time, *Journal of Experimental Botany*, Volume 75, Issue 10, 20 May 2024, Pages 2819–2828, <https://doi.org/10.1093/jxb/erae057>

Plant & Pest Diagnostics

MSU Plant & Pest Diagnostics provides plant health analyses and identification of nematodes, weeds, insects, and other arthropods.



LOCATION
Center for Integrated Plant Systems
578 Wilson Road
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/pestid
email: pestid@msu.edu

LABORATORY SERVICES

Please visit website or contact lab for current fees and general questions.

PLANT HEALTH ANALYSIS

- *Basic sample submission:* Visual inspection for diseases, insect and herbicide injury; culturing; soil pH and soluble salts
- *Add-on testing services:* Serological (ELISA) tests; bacterial pathogen identification; molecular (PCR) tests

WEEDS/PLANTS

- Plant identification

HERBICIDE RESISTANCE

- Multiple sites of action, based on seed quantity and quality
- MI soybean growers qualify for free testing courtesy of the Michigan Soybean Committee for Palmer amaranth, waterhemp, horseweed/marestail, common lambsquarters, common and giant ragweed

NEMATODES

- Soil/root nematode analysis
- Foliar/garlic bloat nematode analysis
- Nematode trophic composition
- Full SCN type testing
- Mini SCN type testing

VERTICILLIUM SOIL ANALYSIS (Potato soil only)

- Wet sieving

INSECTS/ARTHROPODS

- Insect identification
- Evaluation for insect injury

SERVICES NOT OFFERED

- Medical/recreational marijuana testing
- Soil and plant nutrient analysis
- Pesticide residue testing
- Mushroom identification
- Household mold identification
- Examination of bites/skin irritations

courtesy photos



insect identification

SAMPLE SUBMISSION

To get an accurate diagnosis, you must quickly get fresh and representative samples to us. A completed submittal form must accompany all samples. Submittal forms are available at our lab on campus, local MSU Extension offices and at our website (www.pestid.msu.edu).

Samples can be dropped off at our reception area or shipped by US mail, FedEx or UPS. Mail samples in a box rather than an envelope to preserve their quality. Avoid mailing samples on Fridays.

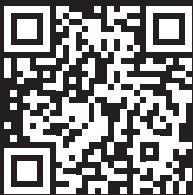
Please submit photos to pestid@msu.edu

For more information, including tips for sample submissions, visit the website: canr.msu.edu/pestid/submit-samples/



MSU Herbarium

The MSU Herbarium is a repository of over 520,000 curated plant specimens and associated data for use in documenting biodiversity, aiding in research, informing conservation, and facilitating student learning and public outreach.



LOCATION
Plant Biology Laboratories
612 Wilson Road
Rooms 40 – 54
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/herbarium

EQUIPMENT

- Dryer (Precision Scientific)**
- Larger volume dryer/ventilation system for removing moisture from plant and soil samples
- Imaging Station (Nikon)**
- Illuminated photo box with camera arm for high-quality specimen images
 - High-quality scanning of flat images available
- Microscope Stations (Leica)**
- Pest & insect-free bench space
 - Several dissecting and compound microscope stations available

- Wet Lab**
- Bench space for limited chemical analysis and sample processing

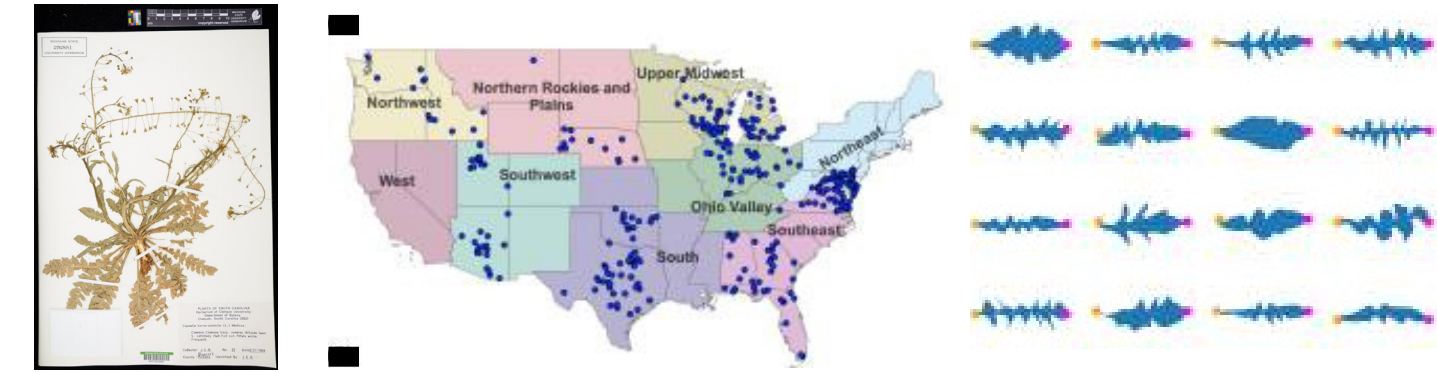
SERVICES

- Support for accessioning and mounting specimens in the collection
- Access to over half a million specimens and their associated data
- Large library of plant sciences textbooks and floras for use in plant identification
- Resources for vouchering samples and linking vouchers with GenBank data
- Support for requesting specimen loans from other institutions



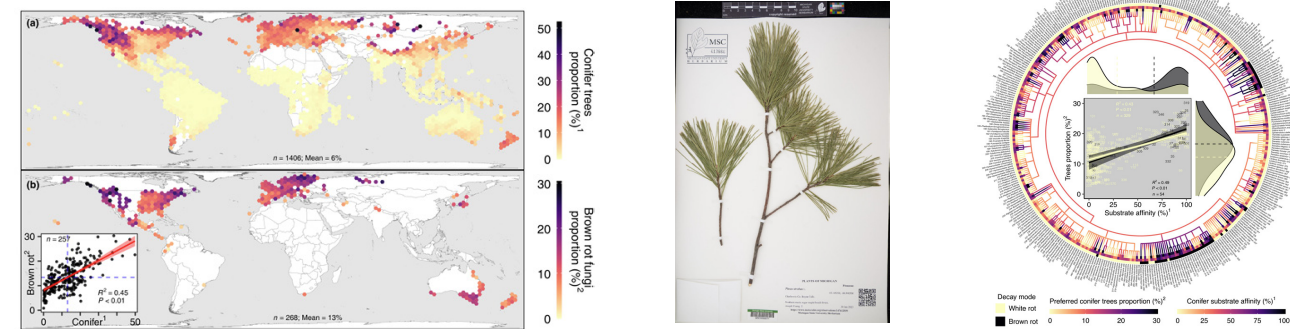
courtesy photo

Using Herbarium Specimens and Machine Learning Tools to Assess Adaptive Plasticity



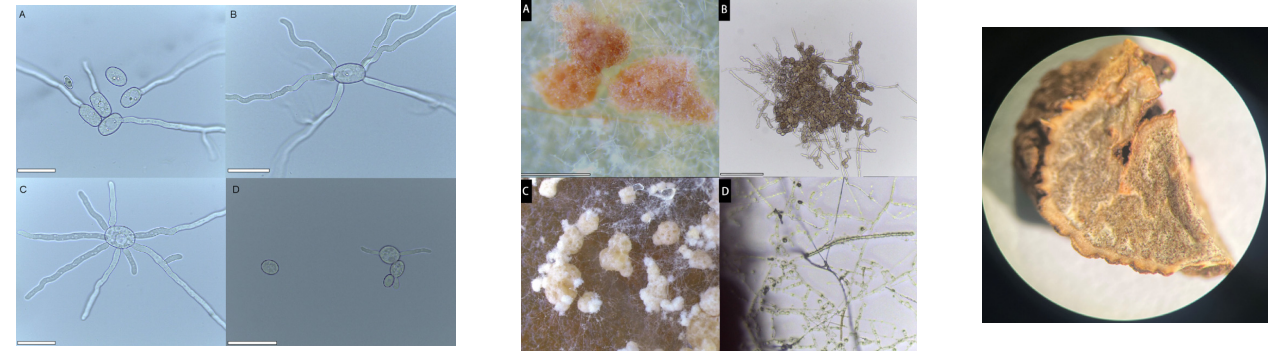
Asia Hightower, PhD student in Emily Josephs' lab, used digital landmarks on herbarium specimens of *Capsella bursa-pastoris* to assess how leaf shape varies across time and space. She found that leaf shape is correlated with the growing season temperature, and that this relationship varied across different geographic regions in the US. She also saw that leaf shape has remained relatively constant within each geographic region across a 100-year period. She will continue to build on this project by sampling DNA from herbarium specimens to see how leaf shape is influenced by genotype. <https://doi.org/10.1002/ajb2.16435>

Determining Global Patterns of Fungal Rot on Trees Using Aggregated Collections Data



Using records from the MSU herbarium and herbaria across the globe, these researchers were able to generate a comprehensive global estimate for the relative abundance of brown rot and white rot fungi and determine whether these fungi preferred specific groups of trees or specific habitats. Have a large scale understanding of these patterns of abundance enable more accurate predictions for global carbon fluxes from one of the largest sources of above-ground terrestrial carbon. <https://doi.org/10.1111/nph.19723>

Understanding the Evolution and Genomics of Morels and Truffles Using Vouchers



The phylum Pezizales contains economically important fungi, such as morels and truffles, and the diversity of the group is not well understood. By contributing to and utilizing herbarium specimens, fungal researchers can build phylogenies, study morphological characteristics, and have access to original biological types. MSU researchers in Gregory Bonito's lab developed a method to collect single-spore isolates before vouchering specimens to use in culturing, microscopy, and DNA extraction. <https://doi.org/10.3390/d16030165>

Data Science & Informatics



Turn data into insight.

Expertise and computational infrastructure support study design, omics analysis, and interpretation to advance discovery.

Bioinformatics Core.....	84
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Center for Statistical Training and Consulting.....	88
Institute for Cyber-Enabled Research.....	90



Bioinformatics Core

The Bioinformatics Core brings together expertise from across MSU to support research through advanced omics data analysis, grant proposal assistance, and tailored training for researchers at all career stages.



LOCATION
Biomedical Physical Sciences Building
567 Wilson Road
Room 1440
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/bioinformatics
email: bioinformatics@msu.edu

CAPABILITIES

- Bulk and single-cell RNA-seq
- Bulk and single-cell ATAC-seq
- Single-cell multi-omics
- ChIP-seq and CUT&RUN
- Genome-wide methylation analysis
- Metagenomics/microbiome analyses
- Variant calling
- Causal variant prediction
- Population genomics
- Genome assembly

SERVICES

Short term projects
Discrete omics data analysis projects with well-defined deliverables. Charged per sample or per hour.

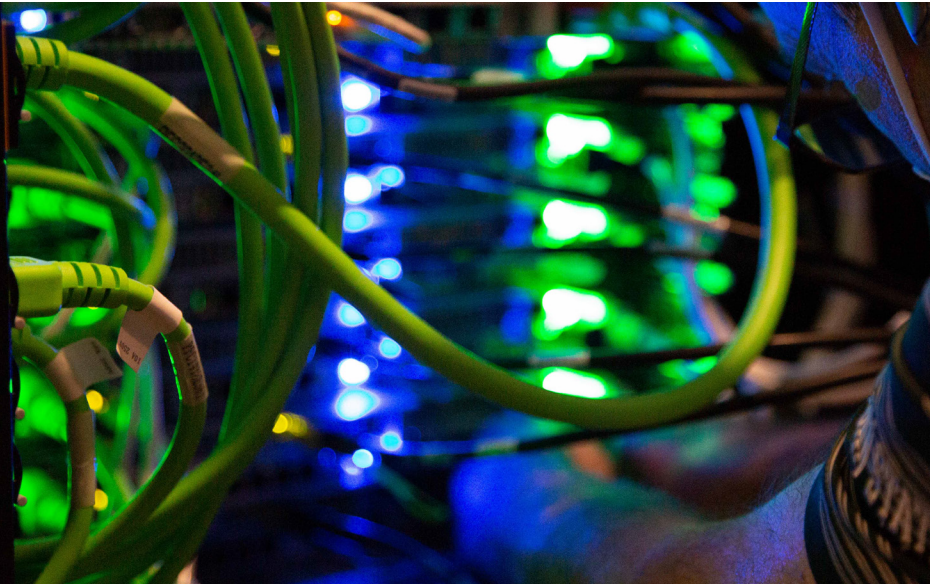
Long-term collaborations
Complex or exploratory projects that necessitate flexible, long-term collaborations for a % FTE/year.

Proposal support

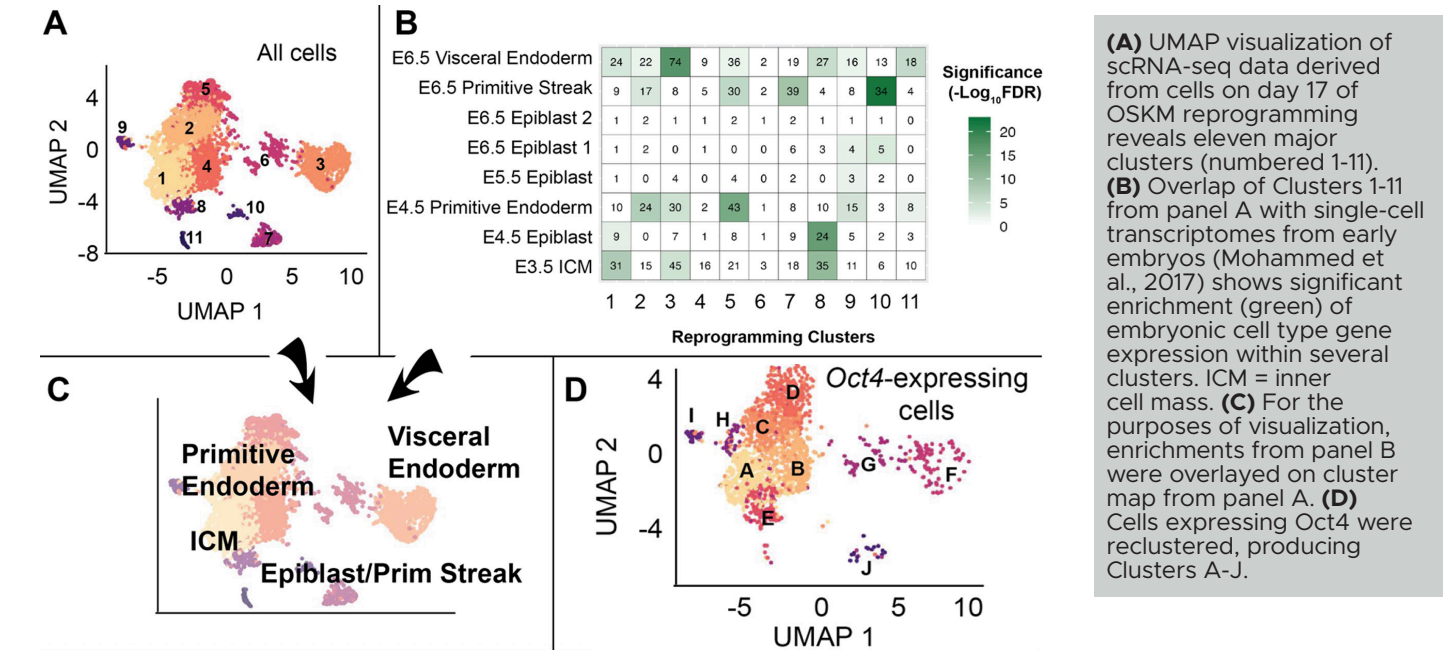
- Experimental design and methods consultation
- Letters of support
- Facilities statements
- Budget planning

Training
We provide individualized training on custom omics analysis pipelines

Virtual help desk and office hours
Encountering challenges with your own bioinformatics analysis? Message our Microsoft Teams Virtual Help Desk channel for free guidance from expert consultants, on demand. Or visit our weekly in-person office hours. For more information see <https://bioinformatics.msu.edu/help-desk>

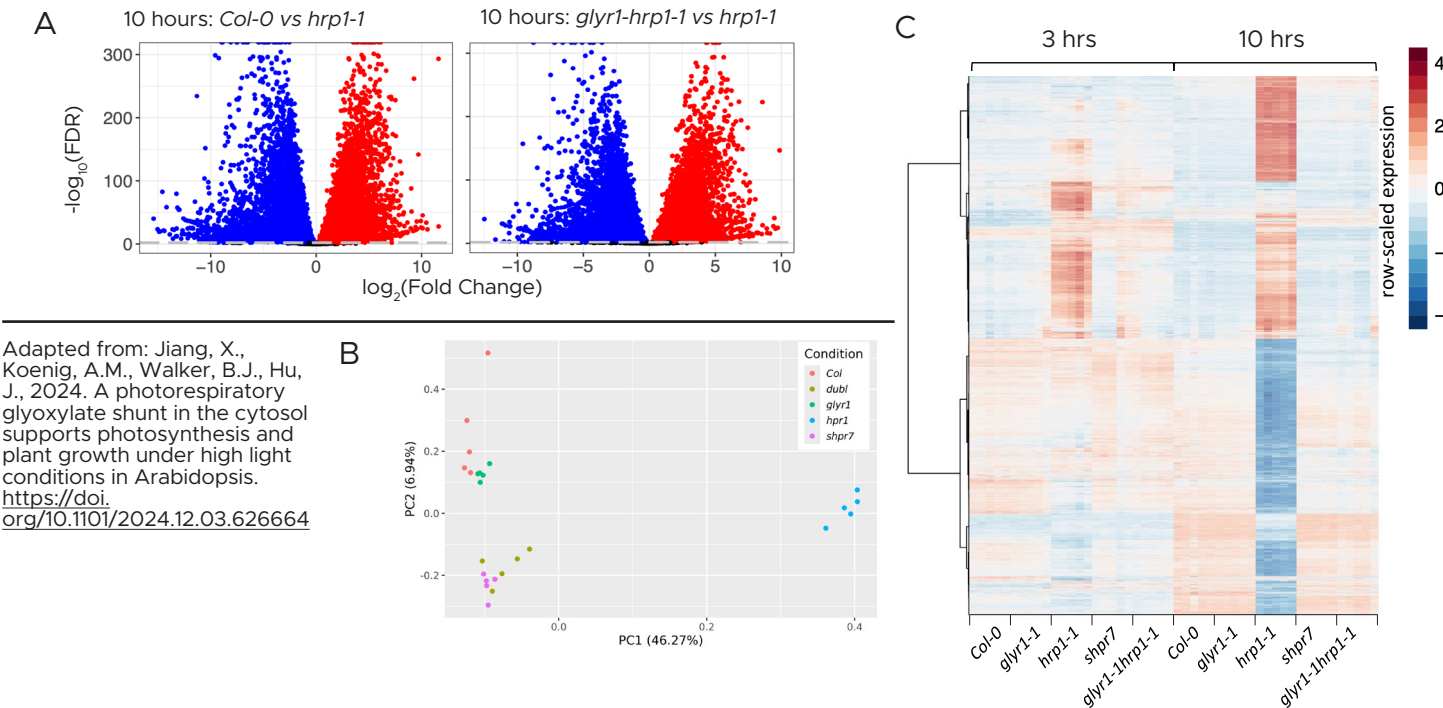


Identification of Oct4-Expressing Cells with Primitive Endoderm Character during OSKM Reprogramming by Single-Cell RNA-Sequencing



Adapted from: Moauro, A., Hickey, S.L., Halbisen, M.A., Parenti, A., Ralston, A., 2024. OCT4 is expressed in extraembryonic endoderm stem (XEN) cell progenitors during somatic cell reprogramming. <https://doi.org/10.1101/2024.01.22.576724>

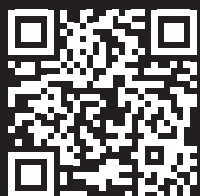
Deficient GLYR1 Largely Reverts the Transcriptional Reprogramming in Arabidopsis hpr1-1 Mutants



Plants were grown for 3 weeks under high CO₂ in normal light and then transferred to ambient air and high light during the dark period. Leaf tissue was sampled after 3 h and 10 h for RNA-seq. Biological replicates: n=5. **(A)** Volcano plots displaying differentially expressed genes (DEGs) in glyr1-1 vs. Col-0, and glyr1-1 hpr1-1 vs. hpr1-1 at 10 h. **(B)** Principal Component Analysis (PCA) at 10 h. Col-0 and glyr1-1 cluster together and shpr7 and glyr1-1 hpr1-1 (dubl) cluster together, with both groups clustering discretely from hpr1-1. **(C)** A heatmap in which hpr1-1 shows dramatic transcriptional reprogramming that is restored to near Col-0 levels in glyr1-1 hpr1-1 (dubl) and shpr7. Genes with at least a 4-fold change in the Col-0 vs. hpr1-1 are represented.

Biomedical Research Informatics Core (BRIC)

BRIC works closely with study teams to help facilitate the data capture, management, and sharing needs of research protocols. This collaborative relationship starts from the pre-award stage, through the data collection period and continues through the analysis and presentation of findings. BRIC services are available to all MSU colleges and units. All BRIC personnel are trained in human subject confidentiality and human health research requirements.



LOCATION
Clinical and Translational Sciences Institute
West Fee Hall
909 Wilson Road
Room B500
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/bric

SERVICES

- **Pre-Award Planning:** Our team will create a customized data management plan and provide supporting material for the Human Subjects Protection and Resource/Facilities sections of your proposal.
- **Databases:** Databases are constructed to organize and integrate information from multiple data sources.
- **Data Management:** Our data managers can support studies in many ways, including building a custom database, testing electronic versions of study instruments, monitoring for data quality, report writing, managing user access, data imports, data cleaning, and user study specific database training.
- **Data Sharing:** Our teams can assist with preparing and processing data uploads for submission to meet data sharing requirements.
- **Data Storage and Security:** BRIC partners with facilities on campus to provide dependable data storage and security.
- **Custom Application Development:** Innovative studies often require unique informatics solutions. If your study demands features beyond what is available, BRIC can build a solution to fit your requirements.
- **Co-Investigation:** BRIC senior staff are available to participate as a co-investigator for your study.

REDCap

REDCap (Research Electronic Data Capture) is a web-based data capture system that is widely used by members of the REDCap Consortium, a collaboration of over 7,000 institutions.

As a contributing REDCap consortium member, BRIC has maintained and managed REDCap installations at MSU for over fifteen years.

BRIC has a tiered support model to increase accessibility to the REDCap service.

- **Base:** Intended for when study teams can manage most project tasks within their research group without additional support.
- **Premium:** For projects that require significant support from BRIC staff, require study-specific development, or data management.



Data Sharing

The National Institute for Mental Health mandates data sharing through its Data Archive (NDA). BRIC has been responsible for satisfying this funding agency's data sharing requirement for over five years across multiple projects. This service allows the study team to focus on conducting their research while placing the data sharing task with experienced data managers. BRIC manages GUID generation, pseudoGUID assignment, data structure creation, data element modifications, and the transformation code necessary to prepare data for import into NDA.



REDCap to Epic Interface

BRIC has been supporting the Flint Registry since it was created in 2017. The Flint Registry is a project that connects people to services and programs to promote health and wellness and helps understand how the Flint water crisis has affected the Flint community. Since beginning recruitment, the Flint Registry has enrolled more than 22,000 subjects into the registry and has made more than 35,000 referrals to services, helping improve the health and wellness of the community.

BRIC has collaborated with registry staff to complete many projects that help facilitate and improve registry data management and collection. One recent example is a collaboration with Hurley Medical Center where BRIC created a tool to move registry data from REDCap directly into the Epic Electronic Health Record System. This integration has completed over 400,000 updates to Epic system records since it was originally implemented. This automated process enables the registry team to leverage the advantages of both REDCap and Epic in response to the protocol requirements and community input.

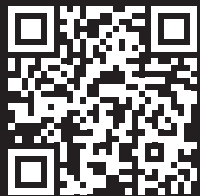
Details regarding this integration have been published in the Health Information Journal.
<https://doi.org/10.1177/14604582241249927>

eCap Data Integration

Medication adherence can be a difficult variable to reliably determine due to inaccuracy and variability in self-reporting by study subjects. To help address these problems, BRIC has collaborated with investigators studying diabetes management including a subject's medication adherence. To collect adherence data, each subject is given an eCAP™ medication container manufactured by Information Mediary. The cap tracks each time a study subject opens their container, and at each study event the cap is scanned to send these data to the manufacturer's servers. BRIC interfaces with the external API to pull the raw data, calculate adherence rates, and store these data directly in the study's REDCap project.

Center for Statistical Training & Consulting (CSTAT)

At CSTAT we are dedicated to helping researchers thrive by collaborating on research projects and providing accessible and accurate guidance in study design and statistical analysis. We provide statistical expertise to MSU faculty, research staff, and graduate students, as well as off-campus clients.



LOCATION
Giltner Hall
293 Farm Lane
Room 100
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/cstat
email: cstatinf@msu.edu

OUR ROLE

Statisticians play a critical role in comprehensive study design and statistical analysis as well as interpretation and dissemination of ethical, reproducible, and high-quality research.

High quality and impactful research does not emerge in isolated environments but rather thrives from diverse input, communication, and cultivating partnerships.

KEY ACTIVITIES

- We provide expertise and guidance on **study design** and **statistical methods**.
- We **conduct statistical analyses** and provide accurate interpretation of results.
- We advise on **machine learning, AI, large language models** from algorithmic selection to model training, validation, and interpretation of output.
- We participate in **grant proposal** development and serve as **key personnel**.
- We collaborate on **manuscripts** and serve as co-authors.
- We provide **research data management** services.
- We offer **seminars** and workshops



Access and Partnership models

CSTAT is funded by contracts and grants and by contributions from the Office of Research and Innovation, colleges, departments, and programs. CSTAT team members collaborate on research projects and provide statistical expertise to MSU-affiliated faculty, research staff, and graduate students, and off-campus clients.

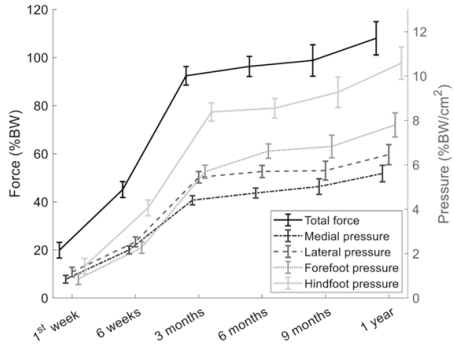
Partner units engage with CSTAT via joint appointments, staffing agreements, or fixed contributions. Researchers from these units will receive free statistical support as outlined in a memorandum of understanding.

Grant proposal development is free if CSTAT's statisticians are appropriately included in the post-award budget (minimum 5-10% FTE).

MSU graduate students receive free statistical support for their **dissertation research** (9 hours per fiscal year; more hours if they are members of partner colleges or departments).

Post-award grant collaborations or work on **individual projects** not covered by partnerships are subject to hourly fees or percent effort payments.

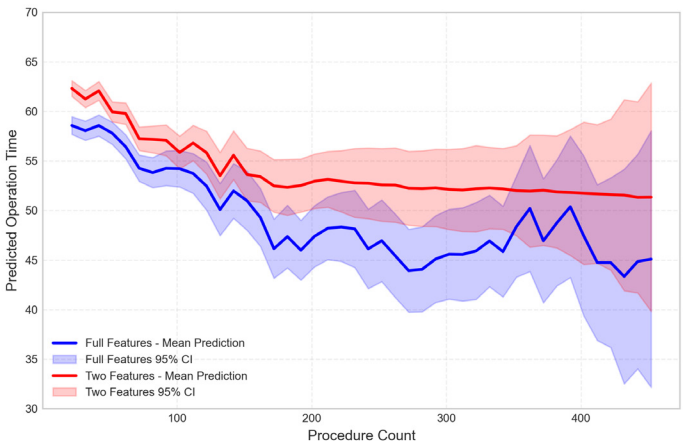
Recovery After Tibial and Malleolar Fractures Measured by Gait Parameters Obtained by Instrumented Insoles and Quality of Life



Adapted from Warmerdam E, Huebner M, Stoll C, Lange AI, Ganse B. Recovery of Patient-Reported Outcome Measures vs Gait Parameters Obtained by Instrumented Insoles After Tibial and Malleolar Fractures: Prospective Longitudinal Observational Study. JMIR Mhealth Uhealth. 2025 Jun 16;13:e71022

Progress of leg fracture healing may be discerned by examining gait parameters (max force, lateral, medial, forefoot, hindfoot) from the injured leg as well as from symmetry indices. Results can be used to guide patients in their recovery or alert clinicians of potential interventions.

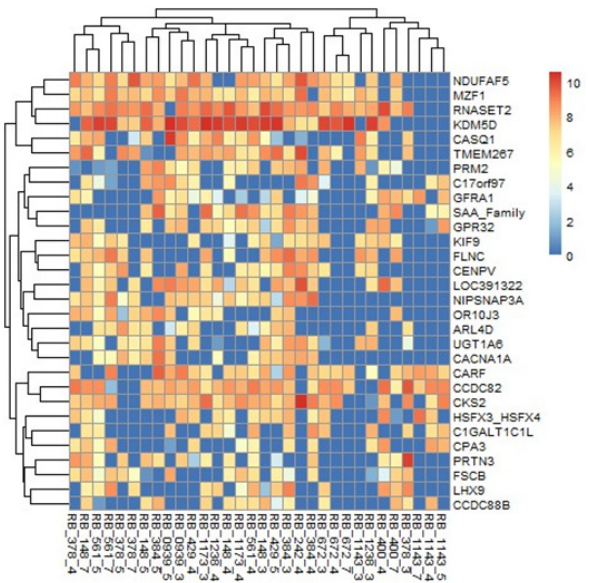
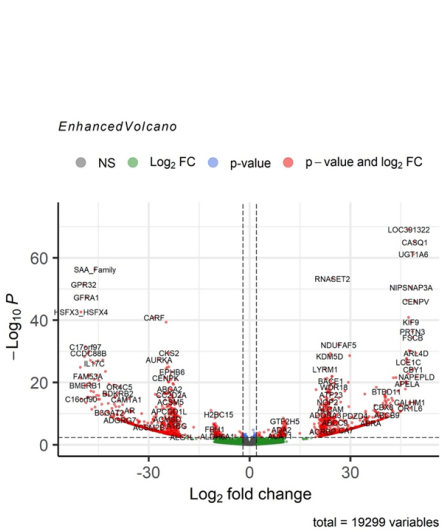
DEEP-LC: Unlocking Surgical Proficiency with AI, Attention-Based Deep Networks, and Memory



Learning curves provide a framework for understanding how learners acquire new skills and knowledge over time. By analyzing learning curves, educators can identify areas for improvement, optimize training strategies, and ensure competency in clinical practice. Focusing on the time-series nature of the data regarding operative time as outcome, we benchmarked several Recurrent Neural Network (RNN) architectures, including the Transformer Encoder, Single-Layer LSTM, Stacked GRU, and a CNN-GRU Hybrid, to model skill advancement as a function of experience. Performance metrics revealed that while the Single-Layer LSTM improved at a rate comparable to other tested algorithms, it notably achieved a lower initial Mean Absolute Error. Credit: Wenjuan Ma, Rayleigh Lei

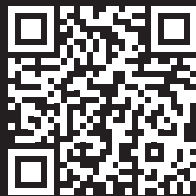
Decoding the Placental Circadian Clock: Bioinformatics/Biostatistics-Driven Insights into Adverse Pregnancy Outcomes

Shift work and circadian disruption are known risk factors for preterm birth, pre-eclampsia, and other complications. Identifying the molecular underpinnings in the placenta offers a path to precision prevention strategies (e.g., timed interventions, circadian aligned medication delivery). This is accomplished by integrating high throughput transcriptomics, single nucleus RNA sequencing, and spatial profiling and using Bayesian hierarchical clustering of lncRNA expression across cell types, longitudinal mixed model analysis of gene expression dynamics, and structural equation models linking lncRNA, clock gene, and clinical outcomes. Credit: Guoli Zhou



Institute for Cyber-Enabled Research

Michigan State University's Institute for Cyber-Enabled Research (ICER) provides MSU researchers with free access to state-of-the-art high-performance computers, generous file storage, user training, expert consulting, grant-writing support, and popular software installation to support computational needs for research. Additional file storage and priority access to compute resources are available via a buy-in program that allows faculty to purchase hardware, which ICER system administrators provision and maintain.



LOCATION
Biomedical and Physical Sciences Building
567 Wilson Road
Room 1440
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/icer

EQUIPMENT

ICER provides system administration, data center space, networking, and software for HPCC hardware.

HARDWARE

- 71,008 Cores
- 643 Nodes
- 288 GPUs
- 386 TB Memory
- 9 PB Storage
- 8.8 PFLOP Theoretical peak performance
- Data Hub: Utilize for data storage, sharing, and archiving through fast, reliable, open-source tools for transferring large amounts of data
- Data Machine: Utilize for data-intensive and interactive computing with high memory nodes, fast 64 TB solid state disk system, and large number of GPUs

SOFTWARE

- ICER provides a variety of software packages and assists researchers with installing new software, including open source and licensed software upon request.

SERVICES

TRAINING AND RESEARCH

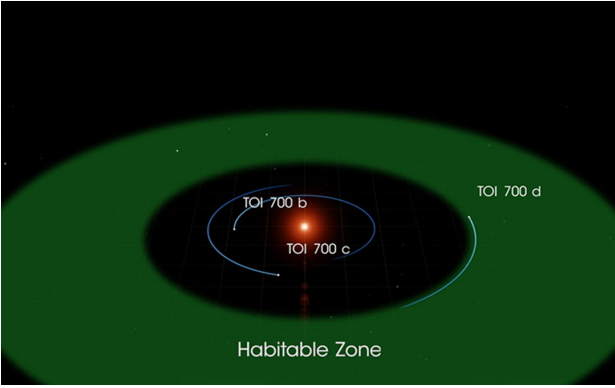
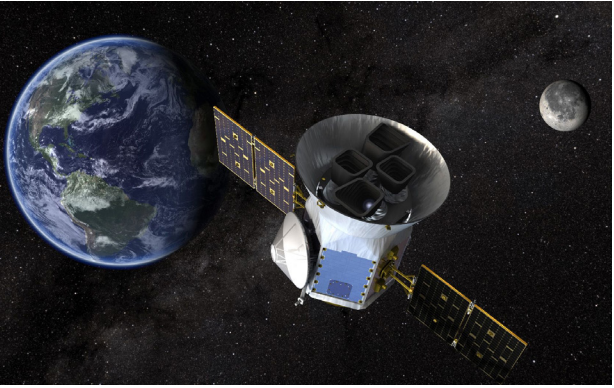
- Academic Research Consulting Services (ARCs) providing software and workflow development
- Synchronous and Asynchronous Training and User Support
- Undergraduate Computational and Data Science REU (ACRES)
- Cloud Computing Foundations Program

GRANT WRITING SUPPORT

- Letters of support
- Template facilities statements, data management plans, and budget justifications (NSF and NIH)

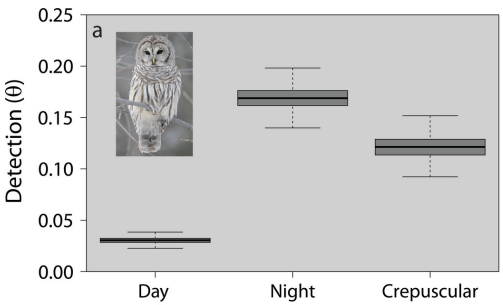
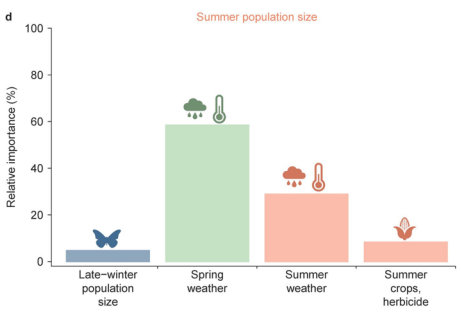


Giant Planet Migration and the Search for Earth-Like Worlds in Distant Solar Systems



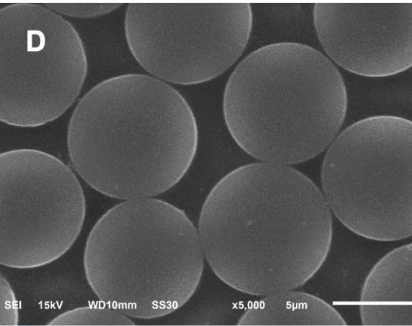
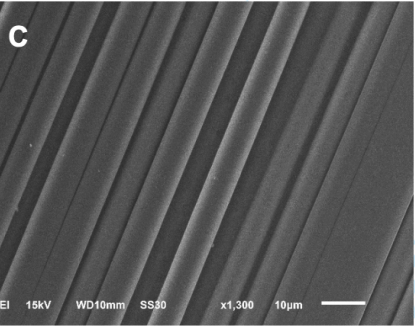
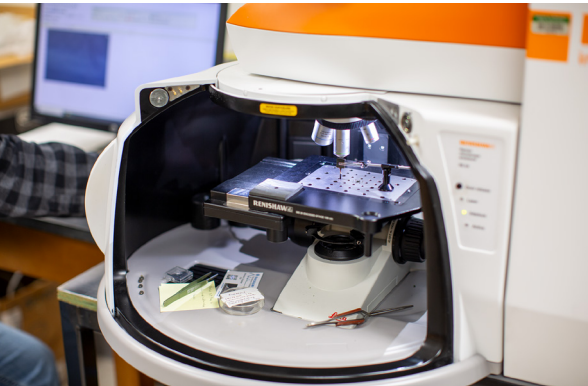
Dr. Joey Rodriguez and his team are using observations from NASA's Transiting Exoplanet Survey Satellite (TESS) mission to discover and characterize new worlds orbiting distant stars. Specifically, his team is trying to understand the processes that cause Jupiter-sized worlds to migrate close to their host star and the impact this evolution has on smaller planets similar to the Earth. Additionally, his team is characterizing Earth-sized worlds that reside within their star's habitable zone to understand if they are truly similar to the terrestrial worlds in our own solar system. ICER's computational hardware is used to create computer models of the planets and their movements.

Predicting the Future of Biodiversity with High-Performance Computing



The Zipkin Quantitative Ecology Lab develops statistical and data science models to understand and predict changes in biodiversity. Working across community ecology and conservation biology, the lab studies insects, birds, fish, amphibians, reptiles, and mammals from local to continental scales. They advance methods to estimate species trends, identify drivers of decline or recovery, evaluate environmental and climate impacts, and inform conservation and management decisions. The high-performance computing resources provided by ICER are essential for analyzing massive, complex datasets representing the populations they study and modeling potential future outcomes for these species.

Designing Single-Layer Molecular Shields to Protect Aircraft from Corrosion



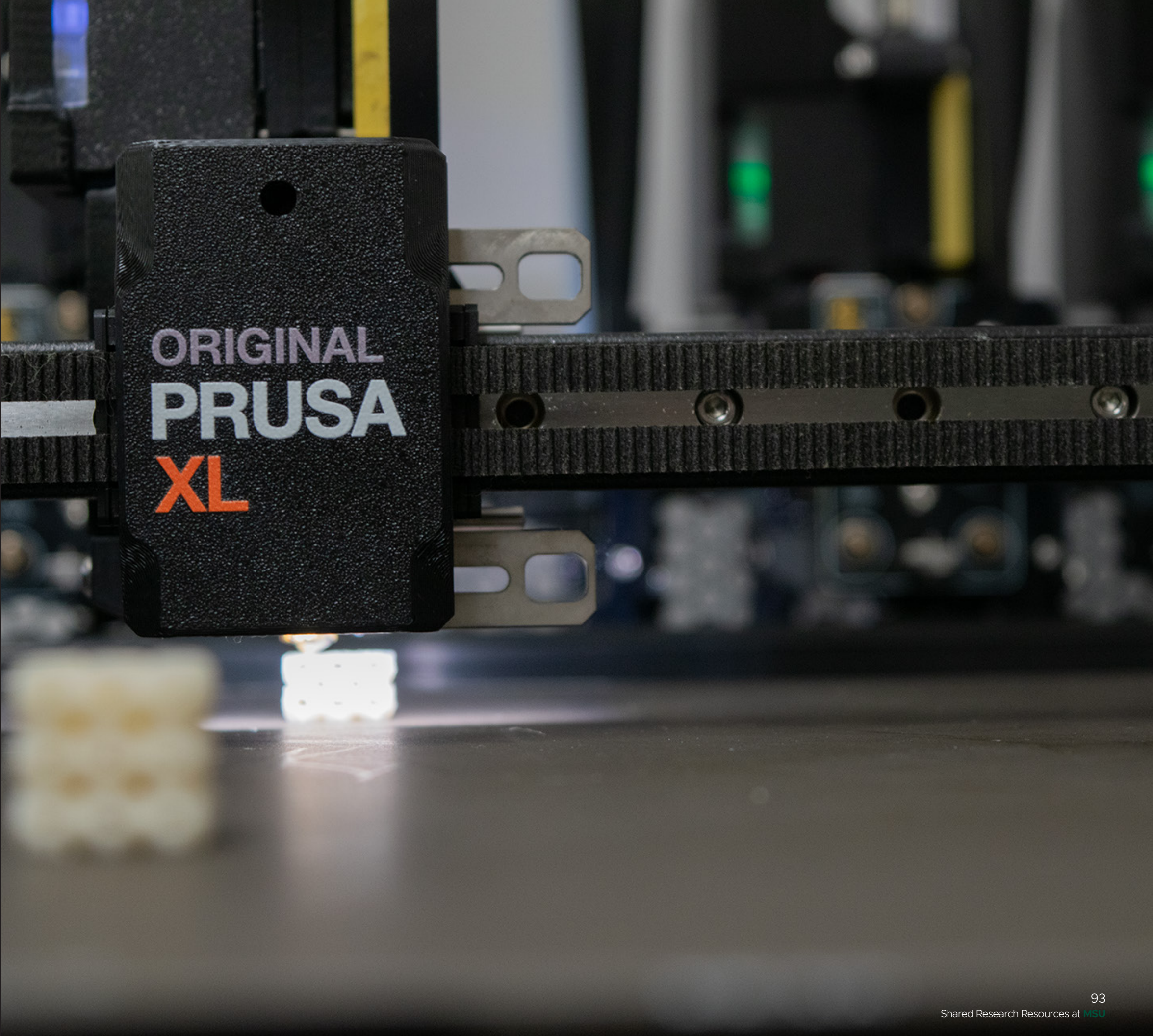
Ben Wenig, PhD student in the Swain Research Group, investigates ways to protect aircraft from corrosion using molecular shields. In aerospace, traditional anti-rust paints add weight and often contain toxic materials. Wenig is developing a more efficient solution: a single layer of molecules that blocks corrosion without the heavy mass of industrial coatings. ICER allows him to refine these coatings by simulating how molecules bind to surfaces. These models require immense power to test performance under flight stress. By using ICER, Ben runs multiple complex simulations simultaneously, finishing in weeks what would take years on a personal laptop. This speed helps him identify durable, sustainable materials for aerospace technology.

3D Printing and Fabrication

Make it possible.

Rapid prototyping and custom manufacturing turn research needs into functional tools and devices.

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Cubi³c Core Facility

The Cubi³c Core Facility helps everyone imagine, invent, and implement new devices for scientific exploration. Our team specializes in solving complex problems with simple solutions that are fabricated in-house.



LOCATION
Life Science Building
1355 Bogue Street
Core Facility: Room B431
Main Offices: Room B436
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/cubi3c
email: cubi3c.core@msu.edu

EQUIPMENT

FILAMENT DEPOSITION (FDM) PRINTERS

Prusa i3 MK3S (Prusa Printing)
Printing a wide array of plastics, including ABS, PETG, and flexible materials. Multiple nozzle sizes for speed and accuracy.

Prusa i3 MK4S (Prusa Printing)
Even greater versatility in materials, coupled with increased speed and leveling control, makes this instrument ideal for high-resolution printing at high speeds.

STEREOLITHOGRAPHY (SLA) PRINTERS

Form3 (Formlabs)
This UV laser-based system creates resin polymer prints with 50 μ m resolution per layer. A wide array of plastic resin is available to meet nearly every need, including high temperature and high flexibility applications.

Form3B+ (Formlabs)
In addition to the features of the Form3, the Form3B+ can print in certified biocompatible resins that can be surgically implanted for long-term use. Additionally, items can be printed with up to 25 μ m resolution per layer.

CNC MACHINING

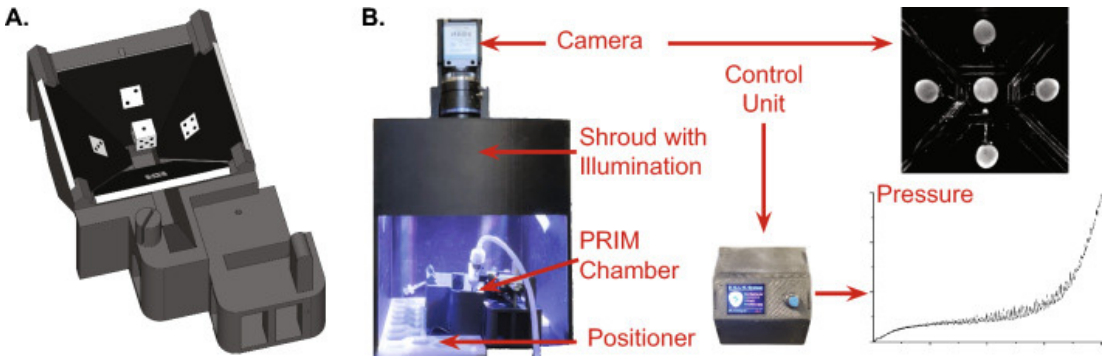
Nomad 883 (Carbide 3D)
Able to accept traditional STL formatted printing files, this benchtop CNC is capable of milling wood, plastic, polycarbonate, brass, and aluminum. This is ideal when the material needs careful control.

SERVICES

- Invention consultation
- 3D rendering, measuring, and design
- Electronics design, fabrication, and coding
- Full-service 3D printing with post-printing finishing and assembly
- Custom-made scientific equipment designed to your specific needs
- Assistance with Intellectual Property filing for new devices
- Prices are usually 90% lower than off-campus

cubi³c imagine.
invent.
implement.

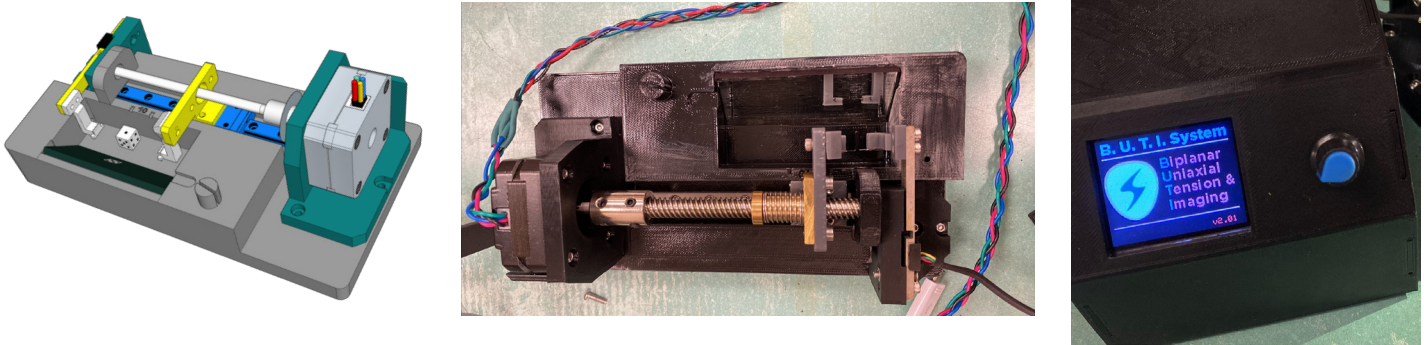
Pentaplanar Reflected Image Macroscopy System



Adapted from: Hennig G, et al (2023)
Quantifying whole bladder biomechanics using the novel pentaplanar reflected image macroscopy system
Biomech Model Mechanobiol 22(5):1685-1695. <https://doi.org/10.1007/s10237-023-01727-0>

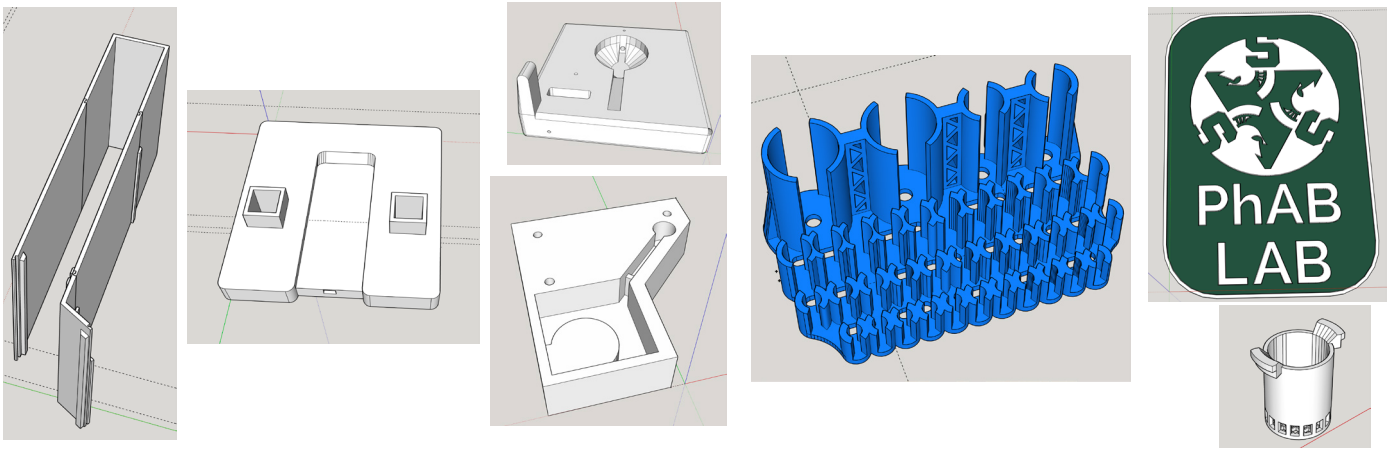
The Pentaplanar reflected image macroscopy (PRIM) system. (A) Rendering of the PRIM chamber and mirrors, illustrating each of the five captured visual planes. (B) The entire system consists of the chamber, shroud, positioner, camera, and control unit. In addition to video images, other data (e.g., pressure) can be recorded. Time-linked pressure and imaging data can be combined to calculate the mechanical properties of the sample over time (e.g., Cauchy stress versus stretch of a mouse urinary bladder during filling). **U.S. Patent 10,585,270.**

Biplanar Uniaxial Tension Imaging System



The Biplanar Uniaxial Tension Imaging (BUTI) System. Using similar technology to the PRIM System, the BUTI uses a camera and mirrors to measure uniaxial tension on rings or strips of biological tissue. The controller regulates the rate and distance of carriage movement while simultaneously measuring force. Other modes allow for measuring length under constant load and stress relaxation after tensioning.

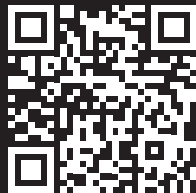
Assorted Custon Lab Equipment



A myriad of devices – large and small – invented by the Cubi³c Core Team. These include imaging chambers, tube racks, signage, 6-well plate filters, and a modular elevated Y maze.

MSU Libraries Hollander Makerspace

The Hollander Makerspace is an alternative learning environment that encourages multidisciplinary collaboration, experimentation and learning. Open to all students, staff, faculty and community members. This space provides low barrier-to-entry access to fabrication and prototyping technologies.



LOCATION
Main Library
366 West Circle Drive
W217A, 2 West
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/makerspace

EQUIPMENT

3D PRINTING

- **Filament (Prusa MK4)**
PLA 3D printing. Multiple color options. Contact us for all other filament materials.
- **Resin (Elegoo Saturn 4 Ultra 16k)**
Resin 3D printing, Siraya-Tech Fast ABS-Like Resin, grey color only.

LASER CUTTER

- **CO2 Laser (Thunder Nova 35)**
- 100-watt CO2 laser cutter, max bed size 2 ft x 3 ft, max engraving area is 23 in x 35 in, works with materials up to 1/4" thick. Variety of wood and acrylic materials available. Custom materials require staff approval and a consultation.

Submit fabrication files online through our website:
MakeAtState.lib.msu.edu

Additional equipment includes:

- Hakko soldering iron and hotair rework station
- Formech 450DT Vacuum Former
- Sewing machines, serger, mending
- Audio, visual, lighting equipment
- Microcontrollers (arduino, raspberry pi, flora gps, makeymakey)
- Cricut electronic cutting machine
- Button maker and sticker printer

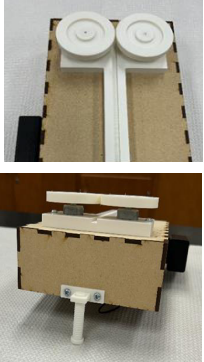
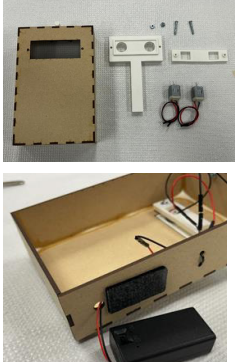
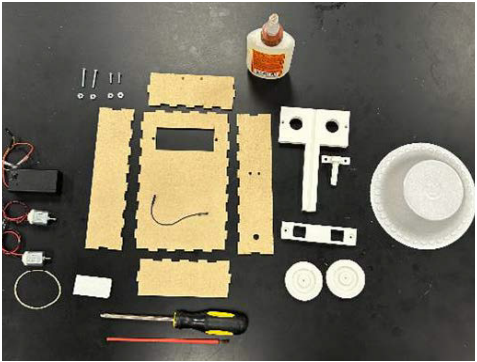


SERVICES

- Staff Mediated Fabrication – 3D printing and laser cutting / engraving
- Self-Service MakeStations
- Lending Technology Collection
- Workshops and events
- Consultations for project assistance*

*The Makerspace does not do design work. Our goal is to help you find the resources needed to accomplish your project.

MSU CISGS K12 Engineering Workshop



courtesy photos

Matthew Oney, a faculty member and doctoral candidate used the Makerspace's laser cutting and 3D printing services to create a paper airplane launcher for K–12 teacher workshops. The launcher introduces engineering concepts aligned with Next Generation Science Standards (NGSS), helping teachers integrate hands-on design activities into their classrooms. This project highlights how the Makerspace supports outreach and STEM education through precision fabrication.

3D-Printed Dogfish Shark Model for Comparative Anatomy Course

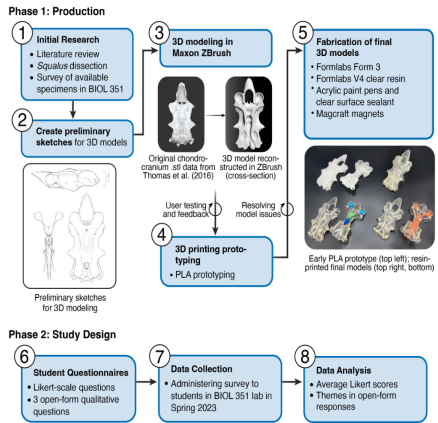
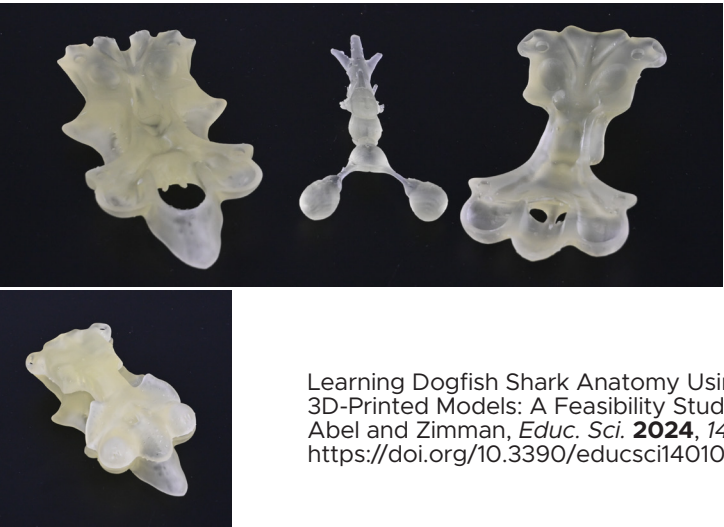


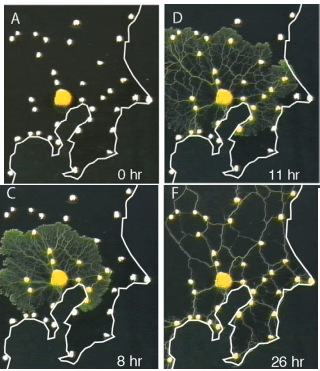
Figure 1. Flowchart illustrating the project overview. Phase 1: production (3D modeling and fabrication) and Phase 2: study design (data collection and analysis).



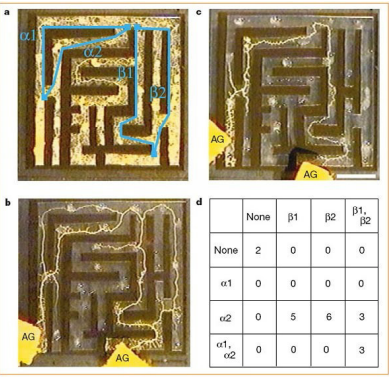
Learning Dogfish Shark Anatomy Using 3D-Printed Models: A Feasibility Study
Abel and Zimman, *Educ. Sci.* **2024**, 14(1), 34
<https://doi.org/10.3390/educsci14010034>

A faculty member utilized the Makerspace to **resin-print** a dogfish skull model that splits in half to reveal its fragile brain structure. Cartilaginous skulls are difficult to preserve, making this durable, anatomically accurate model a valuable teaching tool for comparative anatomy labs. The project demonstrates how advanced 3D printing enhances STEM education and research.

3D-Printed Slime Mold Maze to Identify Optimized Bike Routes at MSU



Tero, et al. (2010). Rules for Biologically Inspired Adaptive Network Design. *Science* (New York, N.Y.). 327. 439-42. <https://doi.org/10.1126/science.1177894>



Nakagaki, T, et al. (28 September, 2000). Maze-solving by an amoeboid organism. *Nature*. 407, 470. <https://doi.org/10.1038/35035159>

An undergraduate student organization used the Makerspace's 3D printing capabilities to create 3D printed maze-like structures to study optimized routes for bike paths on MSU's campus. The students were inspired by studies of how biological systems can inspire sustainable transportation solutions. By observing how slime molds find efficient routes to food sources, the student group applied these principles to identify optimized bike paths connecting residence halls to main dining facilities and provided their findings to IPF.

Physics & Astronomy Machine Shop

The Department of Physics and Astronomy Machine Shop helps turn research and teaching ideas into working instruments, parts, and prototypes. The shop supports MSU faculty, students, and staff by designing, fabricating, modifying, and maintaining high-quality scientific and instructional equipment with a focus on safety, precision, practicality, and cost-effective solutions.



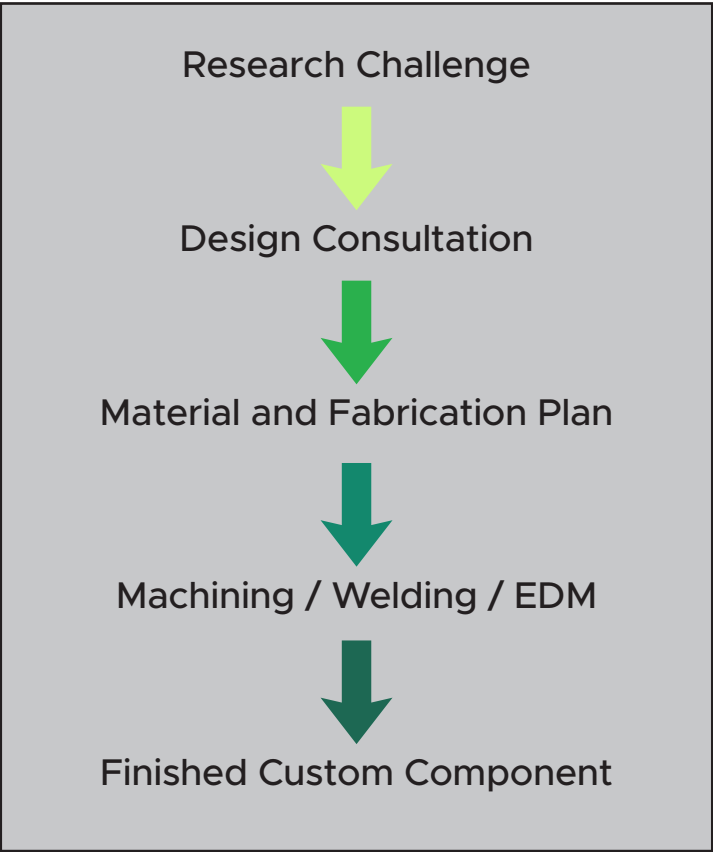
LOCATION
Biomedical and Physical Sciences Building
567 Wilson Road
Room 1213
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/machine-shop

SERVICES

- Custom design and fabrication for research, teaching, and prototype needs
- CNC/manual machining, turning, drilling, threading, and grinding
- Wire and sinker EDM for precision or complex components
- TIG, MIG, gas, and vacuum-compatible welding
- Mechanical equipment repair, maintenance, and modification (non-electrical)

FROM NEED TO PART



Hurco VM20: Computer operated machining center
Photo credit: Anne Weitzel

EQUIPMENT

CNC Machining Center — Hurco VM20

Computer-controlled milling system used to create precise, repeatable parts from metal and other machinable materials. Useful for fabricating custom flanges, brackets, housings, plates, mounts, fixtures, and components with complex hole patterns or contoured shapes. The shop's Hurco VM20 is equipped with a 4th-axis rotary head.

CNC Lathe — Hurco TM6

Computer-controlled turning system used to manufacture precise cylindrical components from metal and other machinable materials. Ideal for producing shafts, bushings, spacers, threaded parts, and other precision round components. Supports custom research, prototype, and small production machining.

Wire Electrical Discharge Machining — Mitsubishi MD-Pro III and Brother HS-70A

Wire EDM uses a thin electrically charged wire to cut conductive materials with high precision. It is useful for intricate shapes, narrow slots, delicate features, precision plates, and parts that would be difficult to cut with standard tools. Typical applications may include fine-feature components such as masks, slots, and custom profiles.

Manual and CNC Milling Machines

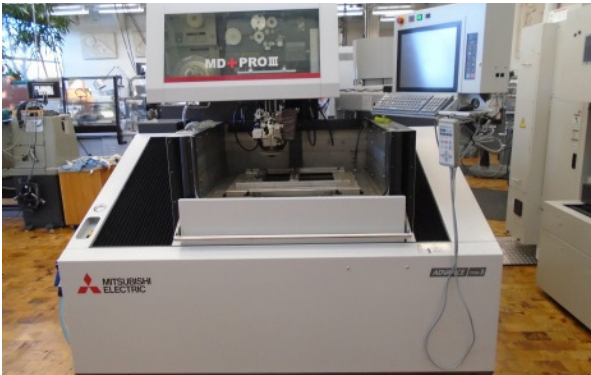
Milling machines remove material to create flat surfaces, holes, slots, pockets, and shaped features. These are commonly used to make instrument frames, mounting plates, adapters, clamps, brackets, enclosures, and research fixtures.

Lathes

Lathes rotate material while cutting tools shape the outside or inside of a part. They are used to make round parts such as shafts, collars, threaded pieces, spacers, bushings, rings, tubes, pins, and cylindrical instrument components.

Precision Surface Grinding

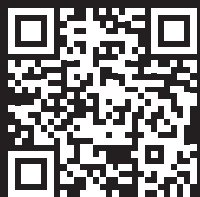
Surface grinding produces very flat, smooth, and accurate surfaces. It is useful for parts that need tight tolerances, clean mating surfaces, precise thickness, or reliable alignment in instruments and experimental setups.



Clockwise from top left: Mitsubishi MD-Pro III Wire EDM, Brother HS-70A Wire EDM, Derbyshire Precision Lathe (Model 750)
Photo credit: Anne Weitzel

IQ 3D Printing Core

The IQ 3D Printing Core at Michigan State University empowers investigators, educators, and industrial makers with a myriad of state-of-the-art 3D printing solutions, catering to a wide choices of materials including plastics, metals, and living materials (cells & microbes), and crossing a wide spectrum of dimensions, encompassing nanometer precision all the way up to grand scales.



LOCATION
IQ/Bioengineering Building
775 Woodlot Drive
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/3d-printing

EQUIPMENT

Nanoscribe Quantum X bio (Nanoscribe)
High-resolution bioprinting process with feature sizes down to $\leq 1 \mu\text{m}$ for subcellular structures based on Two-Photon Polymerization (2PP). Includes humidity control, a premixed air/CO₂ connection and HEPA-filtered airflow.

Brinter ONE (Brinter)
Multi-material 3D bioprinter platform; up to 3 different or similar print heads can be used during a single print job. Printer comes with build-in UV/Visible light LEDs for photo crosslinking at 365 nm or 405 nm and 265 nm.

Stratasys J750 (Stratasys)
Able to produce the boldest full color, multi-material parts in a single print, letting users choose from more than 360,000 different color shades, plus multiple material properties – ranging from rigid to flexible and opaque to transparent.

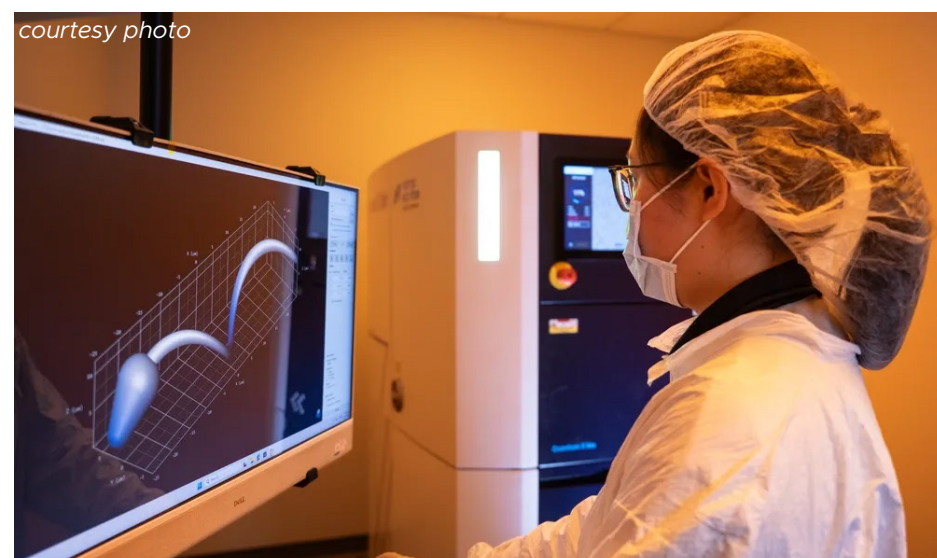
Formlabs Form 3B+ (Formlabs)
Advanced desktop 3D printer designed for rapid prototype and healthcare industries, featuring Low Force Stereolithography (LFS) technology. Printer use liquid photopolymer resins, designed to mimic common production thermoplastics like ABS, polypropylene (PP), acrylic, and silicone.

Other printers

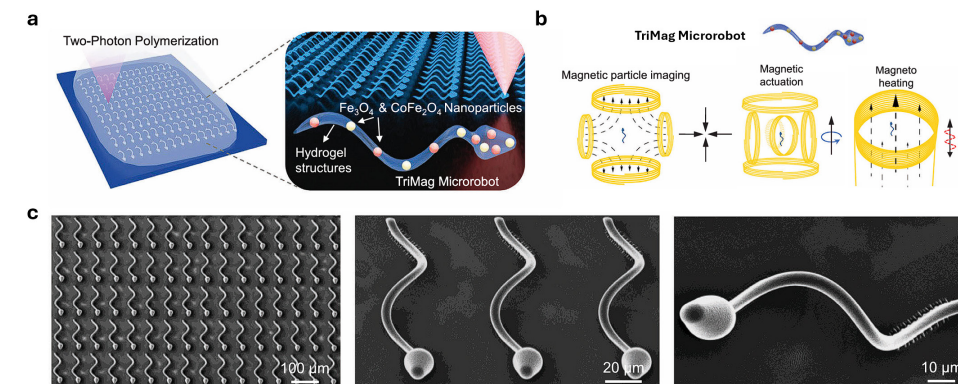
- FLASHFORGE Adventurer 5M
- LulzBot TAZ 6
- Allevi 3,
- Markforged Metal X
- 3D Potter 10 PRO

SERVICES

- User-assisted run or self-operated after equipment training with any of our listed 3D printer.
- 3D printing resin or filament can be supplied by the core or self-provided.
- Rates per run or per hour are listed on the website.



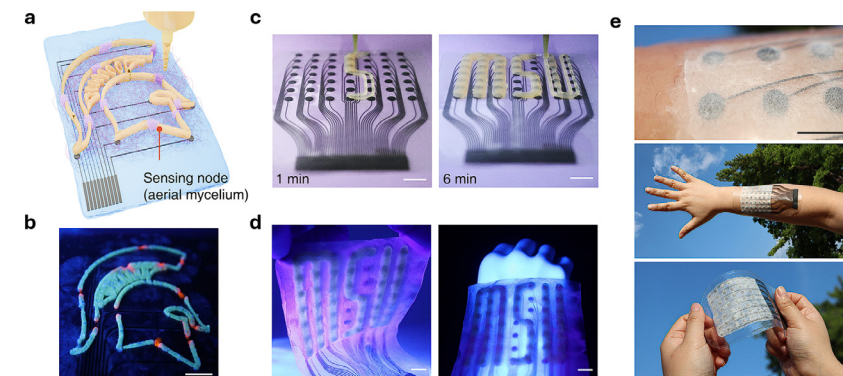
TriMag Microrobots: 3D-Printed Microrobots for Magnetic Actuation, Imaging, and Hyperthermia



(a) The schematic of the TPP fabrication process for the microrobot using a custom made photosensitive hydrogel, including the schematic of the 3D-printed hydrogel and the chemical reaction to produce magnetic nanoparticles within the hydrogel. (b) The schematic of the three magnetic operations of the TriMag microrobots, including magnetic imaging using an MPI scanner, magnetic actuation, and magnetic hyperthermia. (c) Scanning electron microscope (SEM) images showing the top view of an individual helical microrobot and a microrobot array used in this research.

Xing, L., Cai, Y., Zhang, Y., Mozel, K., Tang, Z., Tang, T., Mottini, V., Nigam, S., Smith, B. R., Lee, I. Y., Nagaraja, T. N., Wang, P., Li, X., Gao, T., & Li, J. (2025). *TriMag microrobots: 3D-printed microrobots for magnetic actuation, imaging, and hyperthermia*. *Advanced Materials*, 37(45), Article e19708. <https://doi.org/10.1002/adma.202419708>

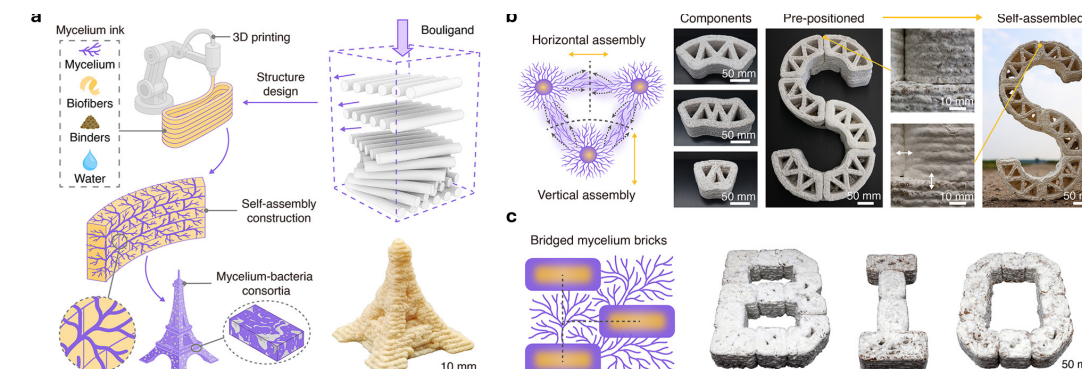
Mycoelectronics: Bioprinted Living Fungal Bioelectronics for Artificial Sensation



(a) Schematic of the 3D bioprinting layout, where black lines represent LIG electrode arrays and purple paths indicate the printed mycelium-gel bioink. (b) Photograph of 3D bioprinting process in which an array with the living bioink printed as a “Spartan logo” (Scale bars, 1 cm.) (c) Time-lapse images of the fungal bioprinting process on a 49-electrode array at 1 min and 6 min. (Scale bars, 1 cm.) (d) Photographs of a printed mycoelectronics array after 5 d of growth (Left) and demonstration of mycoelectronics thermoreceptor’s flexibility by conformal attachment to a human hand (Right). (Scale bars, 1 cm.) (e) Photographs show the mechanical flexibility and wearability of the 3D-bioprinted living fungal mycoelectronics sensor array. (Scale bar, 1 cm.)

Cai, Y., Yuan, H., Ronders, C., Mottini, V., Singh, K., Xing, L., Singh, I., Fu, D., Zhao, K., Heller, L., Nguyen, K., Waller, B., Wang, T., Bonito, G., & Li, J. (2026). *Mycoelectronics: Bioprinted living fungal bioelectronics for artificial sensation*. *Proceedings of the National Academy of Sciences*, 123(26), e2530456123. <https://doi.org/10.1073/pnas.2530456123>

Biosynthetic Additive Manufacturing through Mycelium-Bacteria Consortia



(a) Potential of biosynthetic additive manufacturing for building construction. The ink composition (mycelium, biofibers, binders, and water) enables 3D printing of designed structures such as helicoidal stacking structures (Bouligand), followed by mycelial growth for self-assembly and initiation of biomineralization, leading to mycelium-bacteria consortia with enhanced structural performance. **Bottom right:** An Eiffel Tower model printed with MEA-based mycelium ink. (b), (c) Demonstration of self-assembly behaviors in printed mycelium modules. An “S”-shaped pattern formed from pre-positioned bricks of varying sizes assembled by hyphal adhesion (b). The letters “BIO” are printed as discrete modules and connected through hyphal bridging across air gaps (c)

Yuan, H., Heller, L. J. J., Xing, Y., Wang, L., Nguyen, K., Cai, Y., Waller, B., Chen, C., Hubbard, G., Yong, R., DelPlace, E., Inamdar, S., Shan, X., Zang, X., Huang, J., Li, T., Bonito, G., & Li, J. (2026). *Biosynthetic additive manufacturing through mycelium-bacteria consortia*. Manuscript under review.

Specialized Research Facilities

Research without limits.

Unique environments and large-scale platforms expand what researchers can ask, and answer.

RS&GIS Research and Outreach Services.....	104
Bioeconomy Institute - Lansing and Holland.....	106
Biochemistry Research Store.....	108



RS&GIS Research and Outreach Services

Remote Sensing & GIS (Geographic Information Systems) Research Outreach Services (RS&GIS) specializes in solving geospatial-focused problems for the MSU community, government agencies, not-for-profits, and the private sector.

The mission of RS&GIS is to have a positive impact on peoples' lives and the environment through developing, enhancing, and deploying cutting-edge geospatial technologies to help advance knowledge and address the greatest local, regional, national, international, and planetary challenges in a sustainable manner



LOCATION
RS&GIS
1407 S. Harrison Road
Suite 301
East Lansing, MI 48823

CONTACT INFORMATION
web: research.msu.edu/srr/rsgis
email: RSGIS.info@msu.edu

EQUIPMENT

Geospatial Analysis

RS&GIS maintains multiple high-performance workstations for geospatial analysis. For applications requiring additional computing, we have an established relationship with the MSU ICER High-Performance Computing Center.

UAS/Drones

RS&GIS also administers the MSU Drone Loan Program and Photogrammetry Processing Service (new in 2026), providing MSU researchers with access to U.S. Federally compliant drones.

Available UAS/Drones

- Vertical takeoff and landing (VTOL)
- Quadcopters
- Hexacopters

Sensors

- Natural color, Thermal, Multispectral,
- Hyperspectral, and LIDAR

Software Tools

RS&GIS maintains active licenses for multiple GIS and remote sensing software, including ArcGIS Enterprise for larger applications. Our available software supports small and big projects alike.

- **ArcGIS Pro and Enterprise**
- **ESRI Experience Builder**
- **Agisoft Metashape Professional & Pix4D**
- **Custom Machine Learning Applications**

Machine learning applications can be developed and integrated into other services on an as-needed basis with our experienced research specialists.

Aerial Imagery Archive

Our archive consists of hundreds of thousands of historic aerial photographs dating from the 1930s to the early 2000s. These data are useful for environmental site assessments, real-estate activities, planning, mitigation, land use change, shoreline erosion, property disputes and more.

SERVICES

Geospatial Consulting

RS&GIS trained staff of geospatial analysts and research specialists can help develop efficient and accurate scalable solutions to complex geospatial challenges in any discipline.

GIS/Remote Sensing Training and Instruction

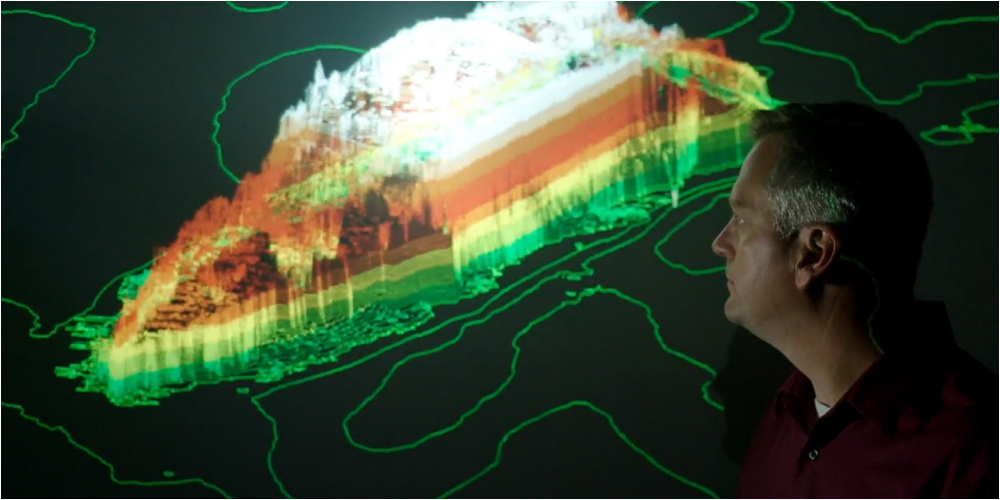
A series of courses are available to train users in quality data collection and processing with drones, geospatial analysis within ArcPro, how to use ESRI Experience Builder for online site development, and others. RS&GIS has the expertise to develop quality custom training material if the current courses do not meet your needs.

Web Development

Our team of developers utilize different content management systems and modular code to develop quality web and application interfaces that are scalable to meet client needs.

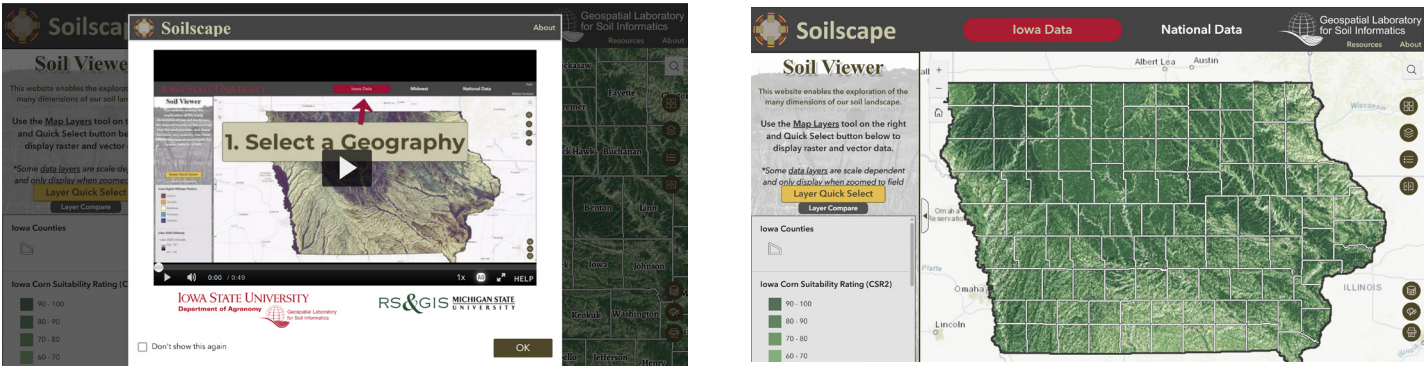


RMS Titanic



Since its discovery in 1985 the RMS Titanic has been studied, documented, and modelled for a variety of purposes. RS&GIS has worked on mapping the Titanic wreck site and artifacts over the north Atlantic seabed. The maps, analyses, and insights from this work was featured in the National Geographic *Drain the Titanic* documentary. New in 2026! RS&GIS is entering a new phase of work with RMS Titanic beginning 2026, partnering to analyze new data and deliver exciting online immersive experiences of never-before seen information and artifacts.
Collaborator: RMS Titanic, Inc.

Soilscape | soilscape.org

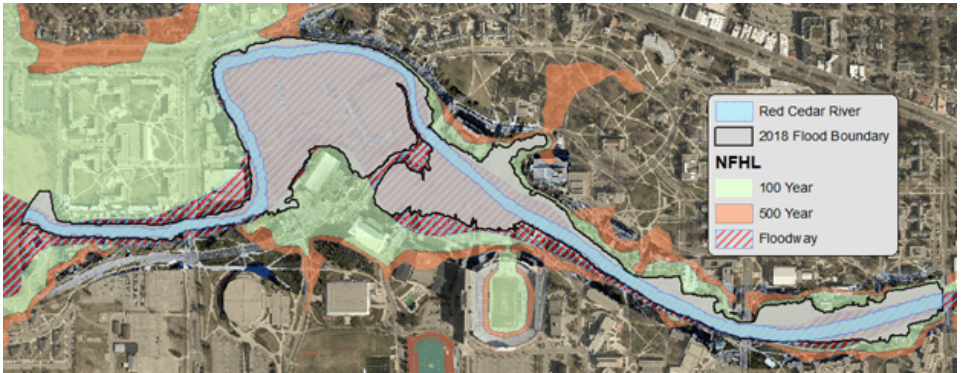


Soilscape is a collaborative initiative between researchers at Iowa State University's Geospatial Laboratory for Soil Informatics (GLSI) aimed at enhancing public access to comprehensive soil information. It integrates data from the National Cooperative Soil Survey (NCSS) with advanced landscape analytics to improve the accuracy and resolution of soil maps.

These user-friendly tools and visualizations empower researchers, land managers, and the public to explore and understand soil and environmental data like never before.

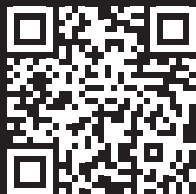
MSU Flood Mapping with Historic Aerial Imagery Archive

RS&GIS maintains the largest collection of historical aerial imagery across Michigan, including 300,000+ images from the 1930s to the present. This collection is now available free of charge to the MSU community through an online map viewer where users can download individual images. Our Archive is one of the only ways to travel back in time and complete historical landscape analysis. The Aerial Imagery Archive continues to grow as new datasets are added. Look for specialized shoreline datasets, color infrared images, historic county mosaics and more.



Bioeconomy Institute – Lansing

The Bioeconomy Institute Lansing advances fermentation and downstream processes to bridge the gap between proof of concept and commercialization. We support external partners and MSU researchers with our deep experience and adaptable equipment. Working with your strain and your product recovery strategy, we develop and scale fermentation processes and optimize downstream steps. If you are in the proposal-writing phase, we are happy to provide a letter of support.



LOCATION
Bioprocess Fermentation and Downstream Processing Facility
3815 Discovery Drive
Lansing, MI 48910

CONTACT INFORMATION
web: research.msu.edu/srr/bioeconomy
email: bioeconomy@msu.edu

EQUIPMENT BIOREACTORS

- Maximum Working Volumes:
 - 10 bench units that can run 1-10L bioreactors
 - Pilot Scale:
 - 2 x 30L
 - 100L & 150L
 - 500L
 - 2 x 3000L
- All vessels can be operated aerobically or anaerobically
- Off-gas mass spec (all except 30 & 500L sizes)
- Customizable control software

DOWNSTREAM PROCESSING

- High-speed, disc stack centrifugation (pilot scale)
- Microfiltration, Ultrafiltration, and Nanofiltration (bench and pilot scale)
- Wiped Film Evaporation (bench and pilot scale)
- Homogenization (bench and pilot scale)
- Ion exchange (bench and pilot scale)
- Forced air tray dryers
- Lyophilization (bench scale)

ANALYTICAL

- HPLC, UPLC, GC, GC/MS
- LC/MS
- UV-Vis Spectroscopy
- YSI Biochemistry Analyzer



Bench Fermentors



Continuous Disc Stack Centrifuge



3000L Fermentor

Note that we are not equipped nor operated to comply with FDA current Good Manufacturing Practices (cGMPs), with the Food Safety Modernization Act (FSMA), with the Federal Food, Drug, and Cosmetic Act (FD&C Act) or with similar government regulations.

SERVICES

- Fermentation process development and scale-up
- Downstream process development and scale-up
- Sample and/or product production
- Extensive data package
- Process feedback, advice, and ideas for improvement
- Tours are welcome

EQUIPMENT STILLS AND REACTORS

- -20 – 130°C
- Full vacuum to 50 psig
- Stainless Steel, Hastelloy, and Glass-Lined
- 80L – 4000L

FILTERS

- Niagara Filters, 316 SS
- Basket Centrifuge, Hastelloy
- Bag and Cartridge filters

DRYERS AND FILTER DRYERS

- 20 – 95°C
- Atmospheric to full vacuum
- Vacuum tray dryers
- 200 – 2000 L filter/dryers

ADDITIONAL

- Hastelloy Low-Temperature Reactor, 400L,
- -100 – 95°C
- Glass-Lined Still with Hastelloy
- Fractionation Column or SS Riser, up to 230°C
- Analytical Laboratory: GC, GC/MS, HPLC, NMR, KF, DSC, LOD



4000L Reactor Train



800L Reactor Train



400L Reactor Train

SERVICES

- Specialty chemical development and scale-up
- Sample and/or product production
- Process feedback, advice, and ideas for improvement
- Student tours are welcome

Bioeconomy Institute – Holland

The Bioeconomy Institute Holland provides specialty chemical process development, proof of concept and manufacturing to bridge the gap from innovation to commercialization. The facility is Class I, Division I, Group D rated and is Process Safety Management compliant. While most of the work performed in the Holland facility serves external clients, the decades of collective experience from the multidisciplinary team and unique equipment are available to support MSU research. The Bioeconomy Institute of Holland offers pilot capacity in the specialty chemical industry, helping customers get from the lab to production.

LOCATION
Holland Specialty Chemical Facility
242 Howard Avenue
Holland, MI 49424

Biochemistry Research Store

The Biochemistry Storeroom opened its doors in 1964. Since then, it has offered a variety of chemical, laboratory and office supplies to our growing community campus-wide. The store is self-supported, with the goal of helping researchers obtain the materials they need with convenience, at a low cost.



LOCATION
Biochemistry Building
603 Wilson Road
Room 110
East Lansing, MI 48824

CONTACT INFORMATION
web: research.msu.edu/srr/biochem-research-store
email: bmb.store@msu.edu

BENEFITS OF ORDERING THROUGH THE BMB STORE

- **Same-day order placement** for requests emailed by 12 p.m. Monday through Thursday.
- **Order tracking** – updates and notifications regarding non-stock orders.
- **Many great discounts** through various vendors.
- **Vigorous price-shopping** – we can often find products from multiple vendors, and work hard to find our customers the lowest price possible.
- **Free S&H through most vendors**, often overnight.
- **Prompt receipt and storage** of ordered items; we'll keep it safe until you can come get it — no rush!
- **Continual customer support** – we'll be the liaison between the vendor and you; we'll help you with replacements, defective items, etc.

SERVICES OFFERED

- **In-stock purchases** – the BMB Store carries hundreds of commonly-used scientific supplies in stock and available for immediate purchase.
- **Non-stock orders** – the BMB Store has discounted pricing and free shipping set up with many trusted and well-known scientific vendors.
- **Oligo orders** – researchers may order oligos through the BMB Store through one of our popular vendors.

ABOUT US

- Our freezer program includes restriction enzymes, PCR and modification enzymes, and molecular weight markers.
- Our non-stock ordering system allows us to cater to your needs at a convenient price with excellent service.
- Periodically our vendors show their products throughout the different science buildings in our campus to promote them, and answer all your questions.

OFFERING

- In-stock chemical, laboratory and office supplies
- Non-stock order system to cater to your needs
- Economical pricing
- Excellent service
- Freezer program
- Vendor meet and greets



credit: Derrick L. Turner

Libraries & Research Collections

Start with what's known. Discover what's next.

Curated collections, primary sources, and research expertise provide context while opening new paths for inquiry.

Libraries Research Collections and Services.....112

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The Center for Object Research and Engagement.....116



Libraries Research Collections and Services

The MSU Libraries ranks among the top 25 research libraries in North America. In addition to our extensive circulating collection of print and digital resources, accessible at lib.msu.edu, the Libraries are home to many unique collections and services noted here.



LOCATION
Main Library
366 West Circle Drive
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/libraries

UNIQUE COLLECTIONS

MURRAY AND HONG SPECIAL COLLECTIONS AND UNIVERSITY ARCHIVES

The Murray and Hong Special Collections holds over 500,000 printed works, manuscript and archival collections. Some of our notable collections include the Africana Collection, Comic Art Collection, Cookery and Food Collection, José F. Treviño Chicanx/Latinx Activism Collection, LGBTQ+ Collection, and Veterinary Medicine Collection. The Russel B. Nye Popular Culture Collection is one of the largest collections of its kind in the world while the Radicalism Collection features extensive holdings on a wide range of political, social, and economic viewpoints. All of the materials may be seen and used in the Special Collections reading room during open hours.

KLINE DIGITAL AND MULTIMEDIA CENTER AND VINCENT VOICE LIBRARY

The Kline Digital and Multimedia Center offers both online and traditional media collections, designed to meet research needs across many different disciplines and subject areas. The center includes gaming labs and a podcasting/recording studio that is open and free to use. The Vincent Voice Library is a collection of over 100,000 hours of spoken word recordings, dating back to 1888. The collection includes the voices of over 500,000 persons from all walks of life.

TURFGRASS INFORMATION CENTER

The Turfgrass Information Center houses the most comprehensive publicly-available collection of turfgrass research and educational materials in the world and has also continuously produced the Turfgrass Information File (TGIF) database since 1983. The TGIF database contains more than a quarter million records, with over 60% of those records linking the user directly to the full-text of the item.

MAPS AND GEOSPATIAL SERVICES LIBRARY

GIS services are free to the MSU community, including GIS-related research projects, selecting and accessing GIS software, finding geospatial data, research consultations and troubleshooting, and assistance in map design and production for a variety of projects.

The Map collection contains more than 250,000 maps and atlases, spanning from the 17th century to the present.

HEALTH SCIENCES DIGITAL LIBRARY

The Health Sciences Digital Library provides an online gateway to our expansive resources in medicine, nursing, veterinary medicine, public health, and allied health disciplines, including databases, books, ebooks, journals, point of care tools, and other specialized health resources. Health sciences librarians collaborate on curricular and teaching integrations, provide publication and grant support, and offer guidance on research practices, strategies, and methodologies.

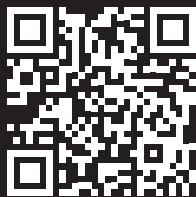
DIGITAL SCHOLARSHIP LAB

The Michigan State University Libraries and the College of Arts & Letters partnered to build a state-of-the-art Digital Scholarship Lab, opened in February, 2018. The 10,000-square-foot space in the Main Library features a 360-degree immersive visualization room that accommodates up to 15 students along with a Virtual Reality room for experimentation with VR headsets.



MSU Museum Collections

Since 1857, the MSU Museum has collected objects and specimens. The Museum's collections support the University's mission by providing a foundation for research, scholarship, and learning; they empower researchers seeking to answer questions and create solutions; they facilitate outstanding undergraduate, graduate, and professional education; and they advance outreach and engagement activities that are innovative and lead to a better understanding of our world.



LOCATION
MSU Museum
409 West Circle Drive
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/museum

COLLECTIONS

NATURAL SCIENCE COLLECTIONS

The Natural Science Collections contain more than 117,000 specimens of mammals, birds, reptiles, amphibians, fishes, and vertebrate fossils. Specimens are preserved as skins, skeletons, skulls, fluid-preserved materials, tanned hides, frozen tissues, feathers, nests, eggs, taxidermy mounts, microscope slides, fossils, and casts. While emphasizing Michigan and the Great Lakes Region, the collections are worldwide in scope and provide a record of biodiversity that ranges from 1844 to the present day. The Natural Science Collections are a critical resource for the University and the global scientific infrastructure. The collections include rare and unique specimens and materials that are difficult or impossible to find elsewhere. The collections focus on Mammalogy, Ornithology, Herpetology, Ichthyology, and Vertebrate Paleontology.

ARCHAEOLOGY COLLECTIONS

The MSU Museum's archaeological collection, consisting of well over a million artifacts, emphasizes Michigan archaeology, with a geographic focus on the Lower Peninsula and the pre-contact eastern Upper Peninsula. This includes a robust assemblage from the Saginaw Basin, Traverse Corridor, and eastern Upper Peninsula of Native American artifacts, as well as historical fort site collections from Michigan's early colonial history. Noteworthy sites from the MSU campus, such as Saint's Rest, are also included.

CULTURAL COLLECTIONS

MSU Museum's Cultural Collections contains over 125,000 objects, interviews, field notes, and photographs that serve as primary source materials for multi-, cross-, and interdisciplinary studies. These collections are worldwide in scope and include 63,000 historical artifacts, as well as approximately 25,000 ethnographic artifacts, many of which originate from Michigan. The collections encompass materials that are thousands of years old to contemporary creations including both handmade and mass-produced items. It features cultural objects from around the world with a special emphasis on Michigan and the Great Lakes. Additionally, it houses unique items and collections that cannot be found in any other repository in the world. Some are accompanied by extensive documentation and associated information; others are primary source materials that will enable scholarly research.

ACCESS AND USE

Due to the Native American Graves Protection and Repatriation Act (NAGPRA), access to some collections may be limited, prohibited, or require consultation prior to use. You can learn more about the University's NAGPRA efforts by visiting nagpra.msu.edu.



Silent Spring by Rachel Carson with robin skins used to study the decline of birds
Image: Barbara L. Lundrigan

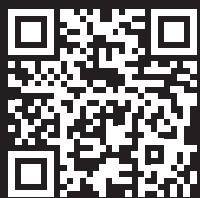


The MSU Museum, a Smithsonian Affiliate, was selected as one of four organizations participating in a cultural heritage preservation project led by the Smithsonian's Center for Folklife and Cultural Heritage.

The Center for Object Research & Engagement (The CORE)

The CORE is an active, educational space featuring art from the MSU Broad Art Museum's permanent collection. On view is a wide range of works that span 5,000 years of history. Through study and appreciation, these works offer a portal to different time periods and cultures.

The MSU Broad Art Museum's collection of over 10,000 works represents an inclusive array of artistic productions from the ancient to the present. This living collection continues to grow and diversify, with an emphasis on collecting the art of our time.



LOCATION
Eli and Edythe Broad Art Museum
547 East Circle Drive
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/broad-core
email: eebam@msu.edu

FEATURED COLLECTIONS

Architecture + Design

Architecture and design shape the objects we use and the spaces we inhabit, giving physical form to ideas while blending function and aesthetics. The MSU Broad Art Museum, designed by Zaha Hadid, is itself an architectural landmark. This category includes architecture, decorative arts, textiles, crafts, and other works—both unique and mass produced—that influence the environments we create and experience.

Biodiversity + Ecology

Art has long documented biodiversity and explored relationships between people, organisms, and environments. Works in this category examine how human activity affects the natural world and reveal diverse cultural perspectives on ecological thinking. Through a range of media and genres, these artworks illuminate connections between humans and their surroundings.

Body + Movement

The human figure has been a central subject in art across cultures and time periods, with meanings that vary widely by context. Works in this category explore representations of the body and movement as expressions of beliefs, values, and identity. Themes such as athletics, dance, ritual, recreation, and rest reveal how cultures understand and interpret human experience.

Citizenship + Democracy

Citizenship extends beyond political status to encompass ideas of belonging, participation, and community. Art can serve as a form of civic engagement, shaping public discourse and reflecting political and social realities. Works in this category explore citizenship, democracy, and the many ways people participate in collective life.

Diaspora + Refugees

Diaspora describes the movement and dispersal of people from their homelands, whether by choice or circumstance. Millions of people continue to be displaced by conflict, inequality, and limited access to basic rights and resources. For the artists in this category, experiences of migration and displacement—personal or ancestral—play an important role in shaping their creative practices and traditions.

Environment + Land Use

Themes of environment, landscape, and land use appear throughout the collection. This category connects Michigan State University's roots as the nation's first land-grant university with broader histories of humanity's relationship to the land. Works explore agriculture, industrialization, and infrastructure, revealing how people have shaped and transformed the environment over time.



Credit: Broad Art Museum

Gender + Identity

Gender influences how we understand ourselves and others and is shaped by social and cultural expectations. Artworks in this category explore the many ways gender is expressed across cultures and history. They highlight how gender shapes identity, sometimes reinforcing and often challenging societal norms.

Home + the Domestic Sphere

Ideas of home are deeply connected to place, family, memory, and emotion. Works in this category examine how art has reflected and shaped understandings of domestic life across cultures and time periods. These artworks both reinforce and question traditional views of home and the private sphere.

Industrialization + Technology

Industrialization and technological innovation have transformed economies, societies, and everyday life. The artworks in this category document changes in landscapes, labor, and production while exploring the benefits and consequences of technological progress. Topics include factory work, urban growth, pollution, and innovation.

Innovation + Creativity

Art encourages new ways of thinking and can inspire solutions to complex challenges. Many artists in this category take interdisciplinary approaches that connect art, science, and technology. Their works explore contemporary issues, spark imagination, and demonstrate the power of creative innovation.

Labor + Emancipation

Art has both documented labor and challenged traditional ideas about work and value. Works in this category examine labor in many forms, from industrial production and paid employment to less visible types of work. Together, they reveal labor's central role in shaping society and everyday life.

Race + Identity

Race is a social construct that shapes identity, experience, and access to power. Artists in this category examine race and racism through personal and cultural perspectives. Their works explore ideas of race, blackness, whiteness, and intersecting identities while challenging assumptions and encouraging dialogue.

Strategic Research Support

Support for every stage of research.

From idea development to real-world impact, programs, platforms, and expertise support every stage of the research journey.

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Digital Scholarship Lab.....	132
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Center for Interdisciplinary Research, Collaboration, Learning, and Engagement (CIRCLE).....	136



Research Development and Proposal Services

The Research Development and Proposal Services team provides tailored services to help MSU researchers successfully compete for external funding for their research and creative pursuits.



LOCATION
Hannah Administration Building
426 Auditorium Road
Suite 249
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/proposal-services
email: ORI.editors@msu.edu

SERVICES

The services provided by the OR&I Research Development and Proposal Services team include grant editing, consultations, facilitating writing groups, and delivering grant-related presentations, panel discussions, and workshops. These services are available at no cost to MSU researchers.

OFFERINGS

PROPOSAL STRATEGY CONSULTATIONS

- Exploring potential funding opportunities
- Identifying program officers
- Discussing ways to improve proposal readability and logical flow
- Coordinating with other MSU proposal service providers
- Discussing reviewer feedback

PROPOSAL DEVELOPMENT AND EDITING

As time allows, we provide help with refining proposal language to ensure it is clear, logical, and highlights key elements that influence reviewer scoring.

WRITING GROUP FACILITATION

We offer a combination of recurring general offerings and tailored offerings in response to specific requests or needs

- NSF CAREER Faculty Writing Group
- NIH Proposal Writing Bootcamp
- Peer review workshops

GRANTSMANSHIP EVENTS

- Webinar and seminar presentations
- Expert panel discussions
- Writing and peer-review workshops

QUICK LINKS TO RESEARCH DEVELOPMENT RESOURCES



Explore research development events

Watch past event recordings
(MSU login required)



Service Request Form



NIH Proposal Bootcamp

This writing group is designed to support faculty at Michigan State University (MSU) as they develop their application for an NIH research grant. Weekly meetings will include didactic instruction, dedicated writing time, and peer review sessions focused on writing the aims page, the significance, innovation, and approach sections, and developing figures and tables. This writing group has been offered annually since January 2024.

NSF CAREER Faculty Writing Group

This writing group is designed to prepare early-career faculty at MSU to submit a strong CAREER proposal to the National Science Foundation (NSF). Participants receive information and advice on all aspects of the grant writing process during cohort meetings and personal mentoring sessions. Participants participate in group discussions and provide feedback to other group members on proposal documents. This writing group has been offered since March 2021.

Grantsmanship Events

The Research Development & Proposal Services team hosts grant-focused events designed to help MSU researchers strengthen their proposals and navigate the funding landscape. Offerings include webinars, panel discussions, and presentation-based sessions that provide practical guidance on proposal development, sponsor expectations, and other key aspects of competitive grant writing. Events cover topics such as navigating MSU's proposal development resources, identifying funding opportunities, writing effective research narratives, and understanding shifts in research funding priorities. These sessions bring together experts from across campus to share insights, answer questions, and support faculty as they prepare high-quality proposals.

NIH GRANT WRITING SERIES

Webinars

- Introduction to NIH and Planning a Successful Proposal
- Writing an NIH Specific Aims Page
- Writing the NIH Research Strategy Section
- The NIH Peer Review Process

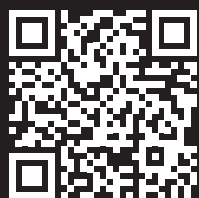


Research and Innovation
MICHIGAN STATE UNIVERSITY



Toolbox Dialogue Initiative

The Toolbox Dialogue Initiative (TDI) Center provides services designed to increase the collaborative capacity of crossdisciplinary teams. The services are centered around dialogue structured to help crossdisciplinary collaborators increase their mutual understanding and their ability to communicate effectively. Services are typically delivered in dialogue-based workshops or in sessions structured by team science curricula.



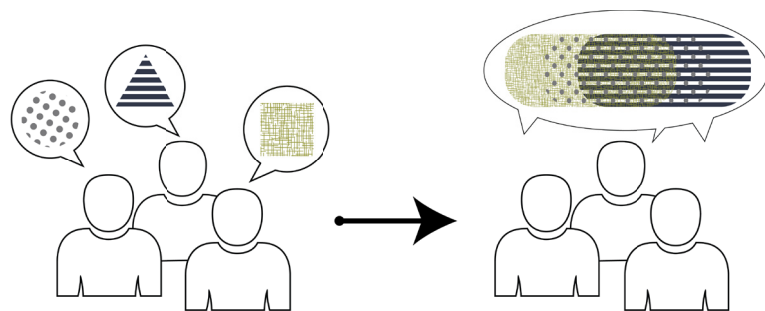
LOCATION
South Kedzie Hall
368 Farm Ln
Room 524
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/tdi
email: toolbox@msu.edu

CAPABILITIES

Improve Crossdisciplinary Collaboration

Dialogue structured to reveal unacknowledged differences among collaborators enhances mutual understanding and improves communicative effectiveness, which supports knowledge and project integration.



Faculty participating in One Health Research Spring Sprint 2026 workshops, facilitated by Toolbox Dialogue Initiative and CIRCLE.

SERVICES

Toolbox Dialogue Sessions

Our main service is a structured dialogue session designed to enhance mutual understanding among collaborators

Team Science Instruction

We offer instruction in team science, e.g., communication, collaboration planning, team dynamics, team management

Early-Career Professional Development

We design and deliver professional development opportunities for early career researchers interested in pursuing complex, crossdisciplinary research

Webinar Series

We have organized several webinar series for NSF programs aimed at expanding knowledge about topics such as convergence and network science

Project Meetings

We have organized and delivered large knowledge synthesis gatherings annually for several programs at NSF and NASA

BEACON Science and Technology Center

The Toolbox Dialogue Initiative (TDI) was integrated into BEACON from the start to build collaborative capacity across the disciplines and institutions involved in the consortium. TDI Center provided BEACON with the following services:

- Scientific research-focused Toolbox dialogue sessions designed to enhance mutual understanding among teams of biologists, engineers, computer scientists and philosophers
- Regular Responsible Conduct of Research trainings for graduate students and early career scientists that were developed in partnership with VERITIES and the Scientific Virtues Project; these were customized to foreground ethical issues at the interface of the life sciences and engineering



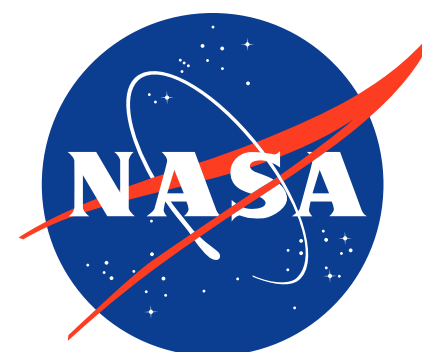
NSF Accelerating Research through International Network-to-Network Collaborations

TDI Center is a founding partner with the NSF Accelerating Research through International Network-to-Network Collaborations (AccelNet) program. Launched in 2019, the program has built international networks of scientific networks, and TDI Center has supported this effort by:

- Conducting customized Toolbox dialogue sessions for funded teams in all program cohorts
- Building and administering a community of practice involving members of all the funded teams across all cohorts
- Designing and delivering multi-day professional development workshops for early career scientists in the AccelNet projects
- Designing and delivering interactive annual meetings for all awardees



NASA Heliophysics DRIVE Science Centers



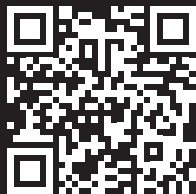
TDI Center is a founding partner with the NASA Heliophysics DRIVE Science Center (DSC) program which focuses on creating center-based research hubs for central heliophysics research topics. TDI Center has aided the DSC program by:

- Designing and delivering customized, targeted Toolbox dialogue sessions for DSC projects to help build collaborative and communicative capacity
- Working with both Phase 1 and Phase 2 DSCs on issues related to organization, management, and decision-making
- Support DSCs in reflecting on their integrative successes so that they can communicate those more effectively to their stakeholders and other public audiences

University Outreach and Engagement

MSU's Office of University Outreach and Engagement (UOE) is an academic support unit that convenes community and academic partners in mutually beneficial ways to address pressing societal challenges.

- UOE advances MSU's land-grant mission by:
- Helping faculty, staff, and students build strong community partnerships
 - Creating meaningful opportunities for engaged scholarship
 - Translating research into practical applications to improve lives



LOCATION
Kellogg Hotel and Conference Center
219 S. Harrison Road
Room 93
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/engagement
email: engage@msu.edu

WHAT IS COMMUNITY-ENGAGED RESEARCH?

Community-engaged research is done in collaboration with community partners on issues that are relevant and based on needs identified by communities. Research in this tradition includes such practices as: community-based participatory research, participatory action research, collaborative inquiry, etc. Some key features that distinguish community-engaged research are: Community members are often involved at all stages, from defining the issues to dissemination; it emphasizes equitable, trust-based collaboration between researchers and community partners, and; both the researchers and the community benefit from the partnership.

RECOGNITION FOR COMMUNITY-ENGAGED RESEARCH

- UOE recognizes faculty, academic staff, and graduate students for their community-engaged scholarship with the following awards:
- Distinguished Partnership Award for Community-Engaged Research
 - Graduate Student Award for Community Engagement Scholarship
 - Graduate Student Award for Science Communication and Outreach

Learn more: engage.msu.edu/awards



courtesy photos

SERVICES

RESEARCH CONSULTATION

Do you need help conceptualizing how your research might reach wider audiences or to developing a Broader Impacts (BI) statement and evaluation plan for your next National Science Foundation grant proposal? UOE's Office for Public Engagement and Scholarship offers individual consultations, can help you make connections with organizers of MSU programs for the public, and provides online workshops throughout the year as well as in-person writing retreats in the fall and spring semesters.

- UOE maintains an extensive list of BI resources at: engage.msu.edu/broaderimpacts-resources
- UOE maintains a list of readings and resources for community-engaged researchers at: engage.msu.edu/learn/resources-for-community-engaged-researchers
- UOE hosts the MSU Science Festival, where faculty, academic staff, and students can achieve broader impacts by presenting their research in interactive ways to the public

PROFESSIONAL DEVELOPMENT

UOE hosts professional development opportunities for faculty, academic staff, Extension professionals, and students to enhance their practice of community-engaged scholarship. Offered in person and virtually, our professional development is geared toward scholars at all levels, from those who want to learn the basics to those who have more advanced knowledge about community-engaged scholarship.

- Topics include:**
- Strategies for writing about community engagement and publishing
 - Community-engaged, participatory research
 - Community-university partnership building
 - Integrating community-engaged learning in courses and curriculum
 - Broader impacts planning and evaluation
 - Science outreach and communication, including to policymakers
 - And many more

UOE's signature programs include the Community-Engaged Research Fellows Program, Urban Community Engagement Fellows Program, Summer Intensive on Community-Engaged Scholarship, and the Graduate Certification in Community Engagement.

RESEARCH PARTNERSHIP DEVELOPMENT AND CONSULTATION

UOE assists MSU faculty and staff in facilitating partnerships with communities on community-identified issues to ensure that the research is relevant and beneficial to them. The partnerships that UOE facilitates are grounded in reciprocity and trust, with the assumption that both community and university partners have expertise. Researchers should approach partnerships willing to learn from community members and collaborate to create meaningful opportunities for community participation and shared decision-making.

- Consulting on Topics:**
- Arts and culture
 - Tribal
 - Latino/a
 - Children/youth/K-12
 - Community and economic development

COMMUNICATIONS AND WEB DEVELOPMENT

UOE provides project consulting and development services in website design, information systems, graphic design, publications, event management, and integrated communication to MSU faculty and their community partners on their community-engaged initiatives.

RESEARCH SPACE IN DETROIT

Space can be reserved at the MSU Detroit Center by MSU-related groups/units, university partners, and other community organizations. Space is available for either short- or long-term use.

Office of Survey Research

The Office for Survey Research (OSR) supports survey research, dedicated to producing the highest quality data in the most cost-effective ways, guided by industry best practices. OSR supports academic research, program evaluation, organizational assessment, and climate surveys through expert survey design, multi-mode data collection, and rigorous analysis and reporting. Its full-service approach enables researchers and partners to generate reliable, actionable data for research and decision-making purposes



LOCATION
Office of Survey Research
1407 S. Harrison
Suite 343
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/survey-research
email: ippsr.osr@msu.edu

CAPABILITIES

20+ years of expertise and knowledge of industry best practices for getting quality, reputable results. Streamlined implementation across MSU’s purchasing and IT requirements.

Instrument Development & Programming

- Population and Sampling Assessment
- Survey programming
- Respondent-centered expertise

Trusted Data Collection

- MSU-centric respondent trust and engagement through public institution
- Multi-mode centralized online, mail, focus group provider

Analysis

- Standard Deliverables include comprehensive methods report and data files (SPSS, Stata, CSV, Excel)
- à la carte analytical services

SERVICES

- Designing data collection methodologies
- sampling strategies
- Data collection using a variety of modes
- Data entry/data coding
- Double-blind data entry
- Consulting
- Cost estimates for grants/proposals
- IRB assistance
- Focus groups
- Questionnaire and instrument design
- Training your staff for data collection
- Data weighting
- Analysis
- Report writing
- Presentation of results and guest lecturing

REPORT EXAMPLES AND PUBLICATIONS



11th Michigan Policy Insiders Panel (MPIP) and
84th State of the State Survey Brief Report



2024 Eli Broad College of Business Employee
Climate and Culture Survey

State of the State, State of the Nation, and Michigan Policy Insiders Panel

SOSS and SOTNS

- Leader in tracking public perception within Michigan
- Cost-effective, calculated by questions length
- Web panel via YouGov
- Question(s) review and feedback to fit mode of data collection
- IRB approved
- Weighted data
- Six-month embargo period
- Average of 2-4 week turn around

MPIP

- Data from State of Michigan policymaking elites
- Compare MPIP with corresponding views from Michigan citizens in SOSS
- Question(s) review and feedback to fit sample and mode of data collection
- IRB approved
- Six-month embargo period
- Average of 4-6 week turn around



State of the State (SOSS) and State of the Nation (SOTN) webpage



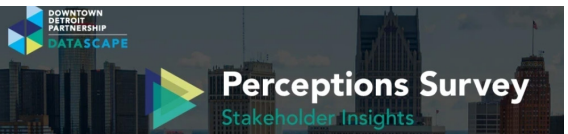
Michigan Policy Insiders Panel (MPIP) webpage

Social Norms Research — MSU and Nationwide



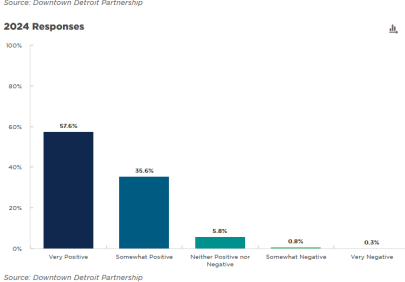
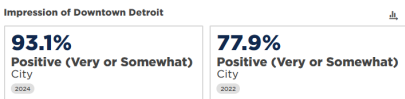
Since 2000, OSR has collected the data for the National Social Norms Center’s “Duck” Campaign designed to counter misperceptions about alcohol consumption by MSU students. In 2016, OSR continued to work with The National Social Norms Research Center within the College of Communication Arts and Sciences by expanding this research on campuses across the nation.

Downtown Detroit Partnership (DDP) Perception Surveys

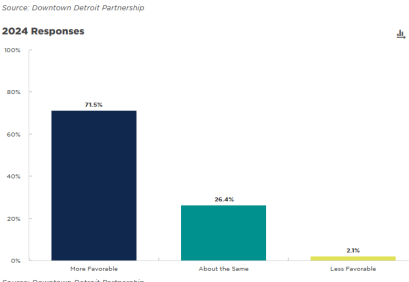


OSR assisted by developing the methodology, collecting the data, and analyzing the Downtown Detroit Partnership Perceptions Survey in 2020, 2022, and 2024. In 2024, we also worked with DDP to conduct two surveys about the NFL draft in Detroit.

Is your overall impression of Downtown Detroit...



Would you say your opinion of Downtown Detroit today - compared to a year ago is...



Lab for the Education and Advancement in Digital Research (LEADR)

LEADR is a collaborative initiative between the History and Anthropology departments at Michigan State University. We provide a space for both undergraduate and graduate students to engage in hands-on learning experiences with digital tools and techniques. Students collaborate with peers, faculty members, and digital technology specialists to create innovative projects that go beyond conventional essay writing.



LOCATION
Old Horticulture Building
506 East Circle Drive
Room 112
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/leadr

EQUIPMENT

Fully equipped AV Studio
Podcasting, video-making and green screen projects

3D Printing and Modelling
MakerBot, PRUSA, and Ulti-maker capabilities with Blender and SketchUp

High-powered Computing Hardware and Software
Mac and Windows machines, LLM capabilities

Book and Object Digitization
Photogrammetry equipment, Polycam software, and high-powered OCR scanning

Microcomputing
Raspberry Pi, Makey Makey and accessories

Immersive Capture
Drone, 360 camera, and Go Pro cameras

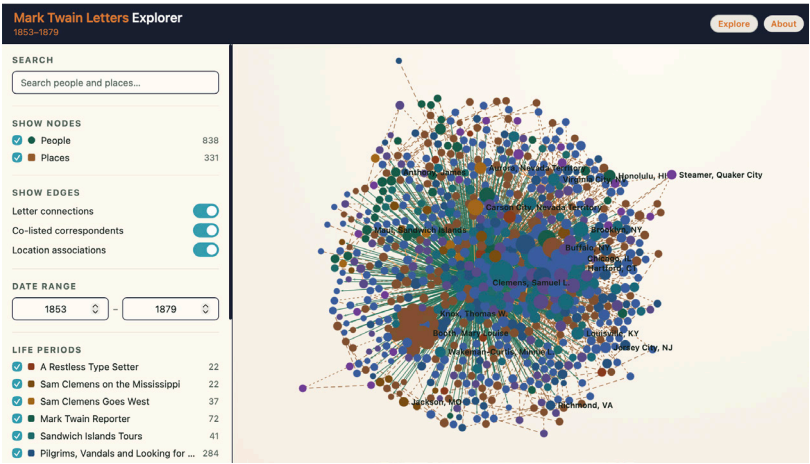
SERVICES

- Digital project and Classroom consultations
- Undergraduate and Graduate digital research design and consultation
- Data visualization and implementation
- Immersive technologies and classroom design
- Digital pedagogy training and practice
- Digital history and cultural heritage project design and management
- Equipment checkout services
- Collaborative space for research and study



courtesy photo

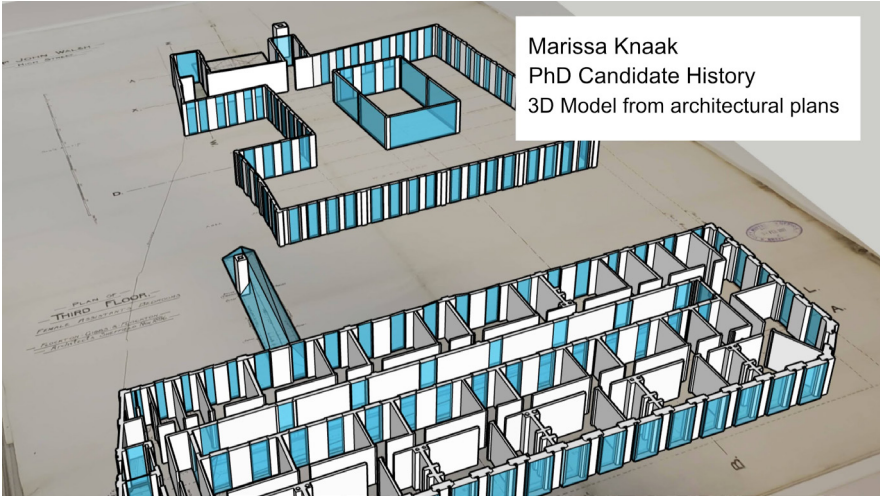
Digital Mark Twain Day By Day – Dr. Stephen Rachman & MATRIX: Ongoing



The project, Digital Mark Twain Day-By-Day (DMTDBD), imagines a total revision of David Fears’s seminal work, Mark Twain Day by Day. The project would link 27,000+ days of Twain’s life to all his works, places he visited, and people he knew. It will create an immensely rich resource for not only researchers and students, but the public as well. LEADR is using network analysis to map out Mark Twain’s social network across his life in terms of places and people.

Learn more: <https://tinyurl.com/dmtdbd26>

John Walsh Department Store, 1899 – Dr. Marissa Knaak (2025 Dissertation Project)



Marissa Knaak
PhD Candidate History
3D Model from architectural plans

Whilst a fellow in the Computational Cultural Heritage Program in LEADR, History PhD student Marissa Knaak decided to create a cultural heritage 3D model of the department store she was studying in 19th century Sheffield. Working with LEADR staff she modelled the store from architectural plans on Sketch-Up and used it as a spatial and immersive tool in her dissertation defense.

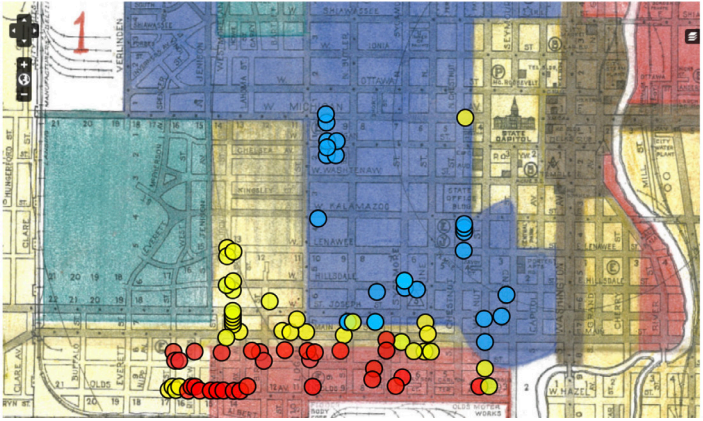
Learn more: <https://tinyurl.com/johnwalsh1899>

Lansing Urban Renewal – RCAH Digital Class Project: Ongoing

Stories of Urban Renewal in Lansing

This georectified map traces the development and impact of urban renewal in Lansing, Michigan since 1950.

[View Fullscreen](#)

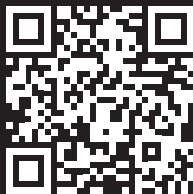


This project was created by students in Michigan State University’s Residential College in the Arts and Humanities (RCAH) as part of RCAH 192: Urban Renewal in the spring of 2018, added to in the spring of 2019, and in the fall of 2026. It seeks to tell the stories of homeowners affected by Urban Renewal and the process of redlining in Lansing, Michigan. The focus is the area cleared for the construction of Interstate 496 from 1963-1970 and the area around the Oldsmobile/General Motors Grand River Assembly Plant.

Learn more: <https://lansingurbanrenewal.leadr.site/home>

MSU Commons and KCWorks

MSU Commons is an open, adaptable collection of tools that support the human work of education and research and make that work more visible and impactful. Whether you're looking to create a website for a project or upload datasets to our KCWorks repository, there are countless ways you can integrate MSU Commons into your research process.



CONNECT
web: research.msu.edu/srr/commons

MSU COMMONS CAPABILITIES

Profiles

Central source of information about you on the Commons. Upload a CV, add projects, and develop your scholarly presence

Groups

Collaborate with peers in a public, private, or hidden space. Features include a discussion board, file sharing, and integration with KCWorks collections

Sites

Develop basic Wordpress websites to serve as a portfolio, project site, or course site

hcommons.social

A federated Mastodon server moderated by the Commons team. Integrated with profiles

KCWORKS CAPABILITIES

- Built on the same platform as Zenodo, KCWorks is the open access repository of the Knowledge Commons network
- Serves as an institutional repository at MSU, with thousands of uploads in a broad range of research categories
- Designed to ensure access, facilitate dissemination, and prevent gatekeeping

Features include:

- Record versioning, with persistent access to earlier versions
- Metadata-only records allow inclusion of works stored elsewhere, assigning them a Digital Object Identified (DOI) and making them discoverable
- Non-public draft records and restricted-access published records support the need for privacy during some phases of the research and editorial cycles
- Multiple files per work: up to 100 files attached to one record
- Up to 500 GB combined storage space per work, allowing storage of small research datasets
- In place previewers for most file formats
- Download a work's files as a single zip archive

User-generated collections include:

- Flexible public or private collections supporting both open-access publication and private collaboration during the research and writing phases
- Detailed stats dashboard for administrators to view authors, downloads, and publish



iTeachMSU Commons



Welcome to the iTeach Commons: MSU's platform where educators find resources, grow their teaching skills, connect with groups, and share knowledge.

Learn what's possible with iTeach

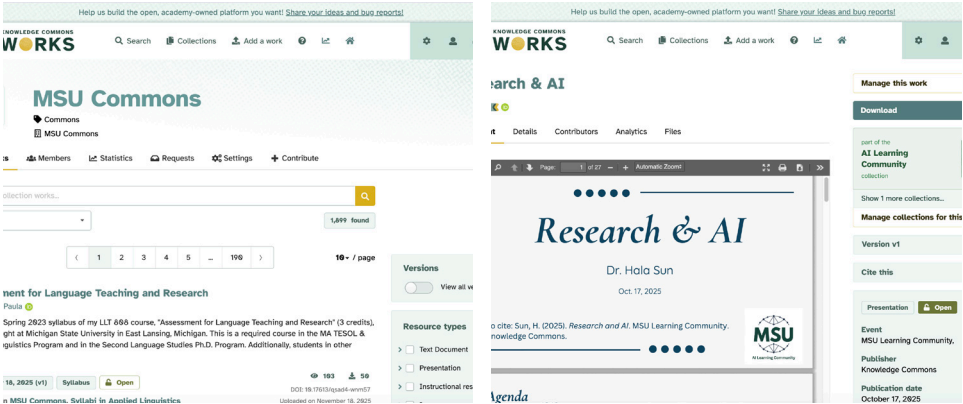
iTeachMSU Commons is a vibrant, educator-driven digital space at Michigan State University designed to celebrate and advance teaching and learning. Managed by the Center for Teaching and Learning Innovation (CTLI), it serves as a collaborative hub where professors, graduate assistants, advisors, and learning designers can share insights, exchange resources, and connect across disciplines.

Learn more: iteach.commons.msu.edu

MSU Commons Collection in KCWorks

The MSU Commons collection serves as an open-access hub for a wide array of materials from MSU faculty, staff, and students. Ranging from traditional journal articles and book sections to more varied instructional resources like syllabi, datasets, and presentation slides, this collection is an ideal place to browse for research materials.

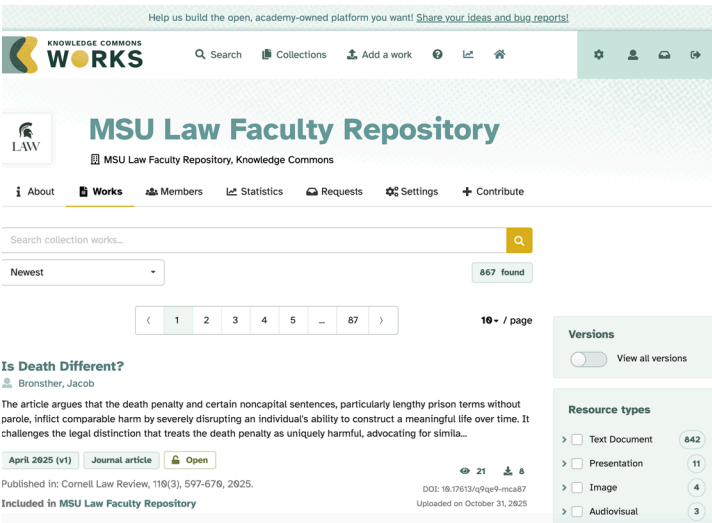
Learn more: works.hcommons.org/collections/msu



MSU Law Faculty Repository Collection in KCWorks

The MSU Law Faculty Repository is an open-access digital collection within the Knowledge Commons (KCWorks) that centralizes and preserves the scholarly contributions of the Michigan State University College of Law faculty. By providing a permanent, searchable home for faculty work—covering topics from immigration law and environmental policy to corporate governance—the repository ensures that MSU's legal scholarship is freely available to a global audience of practitioners, students, and fellow researchers.

Learn more: works.hcommons.org/collections/msu-law-faculty-repository/



Digital Scholarship Lab

The Digital Scholarship Lab offers a range of services and programs that support the transformation of teaching and research using digital tools and platforms, including immersive visualization, digital scholarship, and data services.

The 10,000-square-foot Digital Scholarship Lab in the Main Library features a 360-degree immersive visualization room that accommodates up to 20 people, a Virtual Reality Room for experimentation with VR headsets, a high-powered computer lab, and a digitization room. Through its Flex Space, Computer Classroom, project rooms, and research incubator space in the DSL Extension, the DSL offers formal gathering areas to facilitate cross-disciplinary collaboration.



LOCATION

Main Library
366 West Circle Drive
West Wing, Second Floor
East Lansing, MI 48824

CONNECT

web: research.msu.edu/srr/dsl
email: DSLdesk@lib.msu.edu

EQUIPMENT

- 360-degree Immersive Visualization Room
- Virtual Reality Room for experimentation with VR headsets (available for use/checkout)
- High-powered computer lab with multiple research-focused software packages
- Anatomage Table, the only fully segmented real human 3D anatomy platform. The Anatomage Table is the most technologically advanced 3D anatomy visualization and virtual dissection tool for anatomy and physiology education
- Digitization room with flatbed scanners, photo-negative scanners, 3d scanners and audio/video/scan processing workstations
- VR headsets (HTC Vive and Meta Quest) for checkout and use onsite
- Insta360 One X Cameras
- Einstar 3d Scanner
- RevoPoint Mini 3d Scanner
- Canon 80D DSLR



SERVICES

- Consultations on the use of digital technologies in research and to learn about DSL expertise, technology, and spaces
- Immersive visualization
- Digital scholarship project design/consulting
- Data visualization
- Virtual reality development/testing/use
- Digital scholarship project management
- Research data management
- Digital preservation
- For classes, researchers and individuals
- Collaborative spaces to support research projects leveraging DSL technology



Doctoral Dissertation Study, Dr. Francesca Genoese, 2024

PAIN CATASTROPHIZING IN INDIVIDUALS WITH ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Utilized 360 Room immersive technology in the DSL to complete assessments; participants completed the lower extremity P-MC task and the jump-landing task in an immersive condition with sport-specific visual and auditory distraction and in a non-immersive condition without distraction. Dr. Genoese received the National Athletic Trainers' Association 2026 Doctoral Dissertation Award for this work.

Dissertation: <https://doi.org/doi:10.25335/kkwh-g875>

Peer-reviewed article reporting on findings:
<https://doi.org/10.1123/jsr.2025-0099>

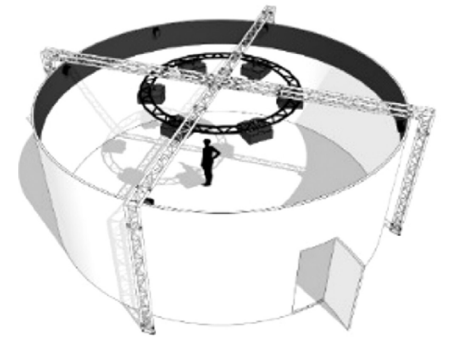


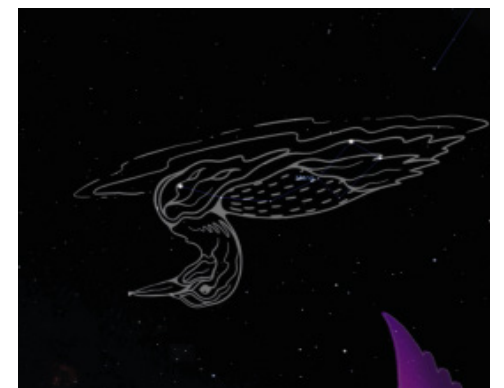
Diagram of 360 Room included in Dr. Genoese's published study

Potawatomi Star Knowledge Project, Dr. Blaire Morseau, 2025

As a participant in the DSL/Digital Humanities Project Incubator, Dr. Morseau developed an interactive digital map using an open-source platform, Stellarium,; the purpose and rationale of this project is to preserve Potawatomi traditional knowledge for future generations by digitally documenting Potawatomi knowledge related to astronomy, celestial navigation, and cosmology focusing on constellations, their names, associated stories, and seasonally specific practices.

This work was also included in a recently published book by Dr. Morseau: *Mapping Neshnabé Futurity, Celestial Currents of Sovereignty in Potawatomi Skies, Lands, and Waters* (ISBN: 9780816553143)

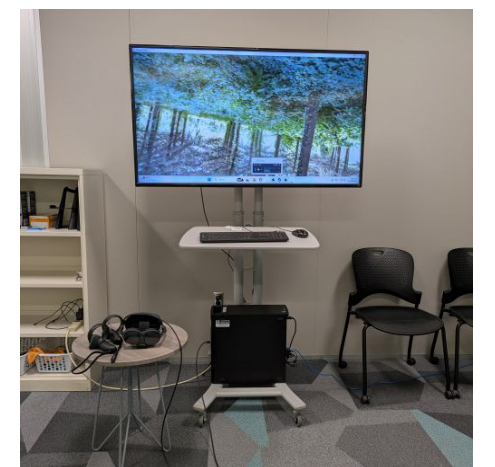
Learn more: <https://tinyurl.com/potawatomi-star-knowledge>



Screenshot of Mang – Loon constellation in Stellarium

Forest Virtual Reality Wellbeing Project: Dr. Emily Silver and Samantha Gailey: Ongoing

Used the VR Room, Virtual Reality Headsets, 360 cameras, and DSL Extension Space to host a study into participants' responses to different kinds of virtual forest types. The project leads Dr. Silver and Dr. Gailey consulted with DSL staff and used the DSL's 360 cameras to create immersive video of different forest times. The study then exposed participants to a stressful situation and evaluated their stress signals afterward as they view forests of different types and densities. The research team used the DSL space for pre- and post-interviews. The study has occurred during the 2025-26 academic year, with results expected to be published in the future.

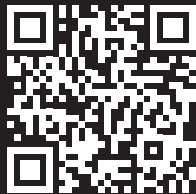


VR terminal showing forest landscape

Hollander Print and Production Center, Publishing Services

Located on 2-West in MSU's main Library, the Hollander Print and Production Center offers a variety of services to students, faculty, and the community.

We are a self-service, same-day printing department. You can visit our space anytime we are open and quickly print out all of your materials. We accept credit/debit cards and departmental accounts.



LOCATION
Main Library
366 West Circle Drive
West Wing, Second Floor
East Lansing, MI 48824

CONNECT
web: research.msu.edu/srr/publishing
email: lib.makecentral@msu.edu

SERVICES

- Poster Printing
- Foamboard Printing
- Copying
- Scanning
- Faxing
- Color Printing (including ledger sizes)
- Black and White Printing (including ledger sizes)
- Comb and Spiral Binding
- Poster Lamination
- Self-Serve Lamination
- Basic Office Supplies
- Microfilm Reader

EQUIPMENT



HP Pagewide 4000 and 5200 XL

- Printing for posters both on regular or premium paper, up to 36" wide
- Printing for foamboard posters on regular foamboard and corrugated foam board



TBS BookScan Station

- Scan to USB Drive or send to email as attachment
- Scans up to 1400 DPI

PUBLISHING SERVICES

We help people achieve their publishing and print production goals within the scope of our services, guiding authors during their process and directing them to additional resources when necessary. Typically, Publishing Services provides economical print production for on-demand paperback books, staple-bound brochures, zines, and miscellaneous bound materials. Additionally, Publishing Services offers individual consultations.

SERVICES

- Print-on-demand perfect bound books (glue)
- Print-on-demand saddle-stitch booklets (staple)
- Binding Loose Pages
- Book and Cover Design
- 1-on-1 Design and Publishing Consultations
- Group Workshops for Book Design and Publishing
- Convert File Formats (DOC, PDF, ePub)

PRODUCTION EQUIPMENT

Canon imagePRESS v800

- Prints on text and cover stocks in full color
- Inline saddle/staple binding and trimming

Sterling Digibinder

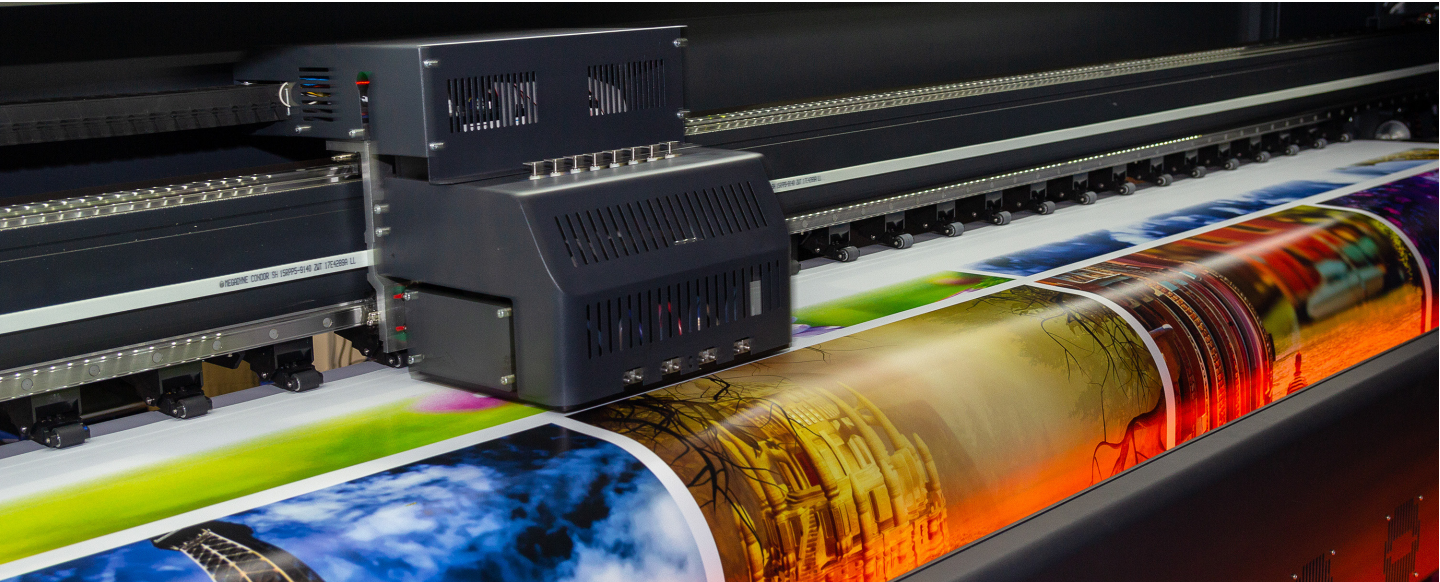
- Perfect binding machine for glue-bound paperback books

Triumph Cutter

- Trim bound materials to finished size

PROJECT EXAMPLES

- | | | |
|----------------------------|---------------------------|----------------|
| • Journals | • Procedural Guides | • Cookbooks |
| • Research Documentation | • Biographies and Memoirs | • Yearbooks |
| • Dissertations and Theses | • Genealogies | • Field Guides |
| • Open Access | • Proposals | • Proposals |
| • Class Anthologies | • Maps | • Poetry |
| • Brochures | • Out-of-Copyright Books | • Essays |
| • Workbooks | • Gift Books | • Monographs |
| • Equipment Manuals | • Reproductions | • Class Notes |
| • Legal Documents | • Art and Photography | • Lab Reports |
| • Government Documents | | |



Center for Interdisciplinary Research, Collaboration, Learning, and Engagement (CIRCLE)

CIRCLE builds individual, team, and institutional capacity for interdisciplinary scholarship, learning, and practice through facilitation, training, evaluation, and strategic consulting.



LOCATION
Olds Hall
408 West Circle Drive
Room 15
East Lansing, MI 48824

CONNECT
web: research.msu.edu/circle
email: ORI.circle@msu.edu

MSU PROGRAMMING

The Center for Interdisciplinary Research, Collaboration, Learning, and Engagement (CIRCLE) The center provides training, facilitation, evaluation, and support for faculty, academic staff, and students engaged in interdisciplinary research, teaching, and engagement. In addition, CIRCLE produces original on the nature of interdisciplinary and transdisciplinary research, teaching, and engagement.

CIRCLE prioritizes process over product, infusing creativity and play through its unique blend of arts-based research, design research, and social science.

CONSULTING SERVICES

- CIRCLE offers a robust consulting menu, ranging from one-time workshop facilitation to comprehensive interdisciplinary team development and evaluation. Services include:
- Interdisciplinary team building
 - Workshop design and facilitation
 - Funding proposal support for interdisciplinary projects
 - Project facilitation
 - Interdisciplinary research and evaluation
 - Consultation on interdisciplinary strategic planning
 - Consultation on interdisciplinary communication

One Health Research Sprint

Spring 2026: CIRCLE designed and led of set of large, open workshops as part of the One Health Research Sprint. The aim was to engage faculty in collaboratively developing a framework for identifying institutional priorities for One Health Research at MSU.



Faculty participating in One Health Research Spring Sprint 2026 workshops, facilitated by Toolbox Dialogue Initiative and CIRCLE.

Growing Convergence Research: Growing REstorative Agroenergy (REAL)

2025-2030: CIRCLE is leading training, facilitation, and evaluation of the integration and convergence aims for this NSF awarded project.
NSF Award Number 2524054, \$2,664,678,
PI: Anthony Kendall

MSU research faculty developed the themes, focus, and scope of the One Health Research Network, Spring 2026



Woven Together. Advancing Discovery.

Research thrives through connection. Across Michigan State University, shared facilities, advanced technologies, and specialized experts form an integrated ecosystem that brings disciplines together, supports collaboration, and moves discovery forward.

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