Facilities and Resources

QBEAM: The Quantitative Bio Element Analysis and Mapping (QBEAM) Center was established as a center within the Elemental Health Institute (EHI) in an unprecedented effort to bring together interdisciplinary teams of scientists, including chemists, biologists, computational scientists, engineers, and clinicians. QBEAM's mission is to examine elemental quotas in biology from single cells to whole organisms and how the interplay between metals and systems biology can be harnessed to develop therapeutics, elucidate the mechanisms of disease, and further our understanding of the ecological and environmental consequences of metal exposure. We enable teams of physical, life, and material scientists to quantitatively analyze metal content to part per trillion levels in samples ranging from nanoparticle and materials formulations to cells and entire tissues. Founded by Professor Thomas V. O'Halloran at Michigan State University (MSU) in the fall of 2021 and operating under the direction of Keith W. MacRenaris, the Center has facilitated this investigation by developing a suite of high-resolution instruments consisting of state-of-the-art imaging and quantification instrumentation while supporting its use with an expert technical staff that offers a range of services, including instrument training, sample preparation and analysis, experiment design and method development, and grant proposal assistance.

Laboratory Space/Offices: QBEAM instrumentation is housed in ~800 sq. ft. of newly constructed wet chemistry laboratory space on the first floor of the Interdisciplinary Sciences and Technology Building (ISTB) (Rooms 1307 and 1308). Office space for the QBEAM director, Keith MacRenaris, and associated staff is provided adjacent to the laboratory space on the first floor of ISTB (Suite 1100). The office and laboratory space of the founding faculty director Prof. O'Halloran is located on the third floor of ISTB.

Elemental Imaging Instrumentation (ISTB Room 1307)

***Tofwerk Inductively Coupled Plasma Time-of-Flight Mass Spectrometer* (*ICP-TOF-MS, Tofwerk, Thune, Switzerland*):**

The Tofwerk S2 ICP-TOF-MS couples the source and interface hardware of a Thermo Scientific iCAP RQ to a TOFWERK TOF mass analyzer. The iCAP RQ hardware provides versatile sample introduction, robust ICP, simple access to cones and lenses and the Q-cell technology. The TOF adds simultaneous all-element detection, linear response with a mass resolving power > 1000. With high-speed mass spectral acquisition and simultaneous analysis of all isotopes, the icpTOF is the ideal ICP-MS detector for multi-element single particle analysis or fast laser ablation imaging.

***Elemental Scientific Lasers BioImage 266 nm laser ablation system* (*ESL, Bozeman, MT, USA*):**

The ESL Bioimage 266 is specifically designed for high resolution, high-speed bioimaging by LA-ICP-TOF-MS. With a wavelength of 266 nm, repetition rate from 1-1000 Hz, and fluence of up to 10 J/cm^2 the Bioimage 266 can scan whole tissues in less than 30 minutes. In addition, users can select spot sizes between 1-65 μm in 1 μm increments to truly solve any bioelement imaging needs. The Bioimage 266 is also equipped with a cryo cell allowing for bioimaging at -20 °C to maintain tissues in their pristine state.

***Elemental Scientific Inc. microFAST SC single cell autosampler* (*ESI, Omaha, NE, USA*):**

For metallomics analysis. This allows proper sample mixing, loading, and low flow nebulization where one single droplet or cell/nanoparticle event is analyzed at a time producing unique single cell/nanoparticle elemental signature.

Optical Imaging Instrumentation (ISTB Room 1307)

Zeiss Axioscan 7 High Throughput Slide Scanner (Carl Zeiss Microscopy, White Plains, NY, USA):

The Zeiss Axioscan 7 is a high-performance slide scanner for fluorescence, brightfield, and polarization imaging. It allows for fast automated scanning of up to 100 slides in a single run with robust scan performance for continuous 24/7 operation. Additionally, the software provides easy-to-create scan profiles with intuitive wizards, rapid switching among fluorescence, brightfield, and polarization, and a sophisticated filter concept for demanding fluorescence imaging.

Elemental and Ultra-Trace Analysis (ISTB Room 1308)

Agilent 8900 Triple Quadrupole Inductively Coupled Plasma Mass Spectrometer (QQQ-ICP-MS, Agilent, Santa Clara, CA, USA):

The Agilent 8900 QQQ-ICP-MS is an ICP with MS/MS that can control the reaction chemistry ensuring consistent, reliable results, even for previously difficult elements like Si, P, and S. The reaction chemistry resolves isobaric overlaps, which are beyond the capability of high-resolution ICP-MS, and with four-channel cell gas control provides fast, flexible, multi-mode operation. With the expanding scope of elemental analysis and the need for higher sensitivity and higher resolution ICP-MS for clinical samples and complex matrix analysis for plant and soil samples.

Accessories: Ultra High Matrix Introduction (UHMI) technology tolerates samples with up to 25% total dissolved solids (TDS), integrated ISIS3 valve allows for increased sample throughput, and APS4 autosampler provides up to 240 positions for 15 mL conical tubes.

Agilent 5800 Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES, Agilent, Santa Clara, CA, USA):

The Agilent 5800 ICP-OES has a Vertical Dual View (VDV) configuration for analysis in radial or axial view expanding instrument dynamic range and minimizing interferences. Along with a CCD detection system that delivers fast, simultaneous measurement over the full 167 to 785 nm wavelength range. Additionally the Agilent 5800, has a vertical torch with Freeform optical technology that enhances sensitivity and performance and tracks instrument health with a variety of sensors to minimize downtime.

Accessories: AVS 6/7 integrated valve for ultrafast sampling and an APS4 autosampler provides up to 240 positions for 15 mL conical tubes.

Agilent 1260 Infinity II Bioinert High Performance Liquid Chromatography System (HPLC, Agilent, Santa Clara, CA, USA):

The Agilent 1260 Infinity II Bioinert HPLC has a metal-free sample flow path with up to 600 bar of pressure that offers reliable analysis of biological samples. With a high salt tolerance (2 M), wide pH range (1–13, short term 14), and AdvanceBio column portfolio for SEC, IEX, reversed-phase LC, and peptide mapping for highest flexibility. In addition, the HPLC can be coupled to the Agilent 8900 QQQ-ICP-MS to perform quantitative metal speciation analysis.

Accessories: The 1260 Infinity II Bio-Inert Multisampler is designed for low carryover using multi-wash capability and up to 8, 96-well plates for high throughput applications. The 1260 Infinity II Diode Array Detector for provides a wide wavelength range from 190 to 950 nm and up to 8 simultaneous wavelength detection.

Thermo FlashSmart Elemental Anzlyzer (Thermo Fisher Scientific, Waltham, MA, USA):

The Thermo FlashSmart EA provides C,H,N,S, O analysis in a variety of sample types including chemicals, soils, clinical, and biological samples based on the modified Dumas method.

Accessories: MAS200 Plus 128 position autosampler, and Dual EA Furnace.

Sample Preparation (ISTB Room 1308)

CEM MARS6 Microwave Digestion System (CEM Corp., Matthews, NC, USA):

The CEM Mars6 is a closed-vessel acid digestion system with precise temperature control for each vessel via infrared sensors up to 300 °C and 1500 psi. This provides high throughput digestion of a variety of samples including biological and materials samples, plants, soils, ceramics, oxide powders, chemicals, pharmaceuticals, and clinical samples.

Accessories: 40-position rotor for 55 mL Xpress vessels for high throughput digestion of biological and material samples, 40-position rotor for 10 mL Xpress vessels for low volume samples such as chemicals, pharmaceuticals, and clinical samples, and 12, 110 mL iPrep Vessels for challenging samples such as zeolites, oxide powders, soils, and ceramics. All components are high-density Teflon for minimal metal contamination.

CEM Acid Purification System (CEM Corp., Matthews, NC, USA):

Produce ultra-trace acids such as HF, HCl, and HNO3 as well as H2O. Sub-boiling point distillation without cooling water or a pump for safe and easy-to-use operation.

Mettler Toledo WXTS3DU Microbalance (Mettler Toledo, Columbus, OH, USA):

The rugged WXTS produces stable and accurate results even under challenging weighing conditions with a capacity up to 1.2 g / 3.2 g and Readability 0.001 mg / 0.01 mg.