The Rhode Island Consortium of Nanoscience and Nanotechnology (RIN2) is a multi-user materials characterization facility that enables cutting-edge academic and industrial research and education through access to advanced material characterization techniques for research in materials science, nanotechnology and the life sciences. RIN2 aims to service users from different scientific disciplines, with several integrated microscopic and analytical techniques and specialty sample preparation methods such as cryogenic electron microscopy. RIN2 is supported by the College of Engineering at URI, NSF EPSCoR C-AIM #OIA-1655221 and 401 Tech Bridge. RIN2 is managed by Dr. Irene Andreu.

Specific objectives of RIN2 are to 1) offer advanced material characterization to users at URI, other academic institutions, non-profits and industries, 2) provide theoretical and hands-on training on these tools to the next generation of researchers and technologists, at the pre-college, undergraduate, graduate and post-graduate level, 3) enable reaching the highest standards of research in materials science and nanotechnology by expanding the available technique portfolio on an as-needed basis and advising from expert RIN2 personnel, up-to-date with the pertinent literature, and 4) connect researchers from different disciplines to solve grand challenges.

<u>Major equipment includes:</u>

- **Transmission electron microscope** (TEM) with cryogenic and elemental analysis capabilities: JEOL JEM-2100 equipped with a Gatan cryotransfer holder and Oxford Instruments energy dispersive X-ray spectrometer (EDS).
- **Scanning electron microscope** (SEM) with cryogenic and elemental analysis capabilities: Zeiss Sigma-VP field emission SEM equipped with variable pressure, secondary electron, in-lens and backscattering detectors, a Gatan Alto cryogenic preparation and loading module, and Oxford Instruments energy dispersive X-ray spectrometer (EDS).
- **X-ray diffraction** (XRD): Rigaku X-ray diffractometer Ultima IV.
- **Confocal Raman microscope** (CRM): WITec alpha 300 R equipped with motorized XYZ stage for large area acquisition, two excitation laser wavelengths (785 and 532 nm) and 10x to 100x objectives.
- **High-content screening system** (HCS): Perkin Elmer Opera Phenix high-throughput confocal fluorescence microscope.
- **Fourier transform infrared spectrometer and microscope** (FTIR): Shimadzu IRTracer-100 FTIR spectrometer equipped with attenuated total reflection (ATR) for solids and liquids, suitable for transmission and reflection measurements, and coupled to a Shimadzu AIM-9000 microFTIR system.
- **X-ray fluorescence** (XRF): Shimadzu EDX-8100 XRF system for elemental analysis of powder, bulk and liquid samples. Atmospheric, vacuum and helium measurements for low detection limits.

- **Scanning probe microscope** (SPM): Shimadzu SPM-9700 atomic force microscope (AFM) with options for measuring topography, phase analysis, force curves, Kelvin force microscopy, mapping of electrical conductivity at the nanoscale, magnetic force microscopy and analysis in liquid.
- **X-ray microscope** (XRM): Zeiss Xradia Versa 610 XRM for non-destructive 3D imaging of specimens. Absorption and phase propagation contrast, large area image stitching. Maximum spatial resolution 500 nm. For samples 5 cm diameter, resolution is 1 um.

Ancillary sample preparation equipment and tools include:

- Plunge freezer for cryoTEM: Mark II Vitrobot, for vitrification of samples for cryoTEM.
- Gold sputter coating for SEM: Cressington 108 Auto gold sputter coating system with thickness monitor and rotating/tilting stage, for SEM sample preparation.
- Critical point dryer for SEM: Tousimis Samdri-PVT-3B for biological specimen dehydration.
- Ultramicrotome for TEM and SEM: Sorvall MT2-B for analysis of embedded cell or nanoparticle specimens in the TEM.
- Embedding resins and polishing materials for SEM and TEM analysis of cross sections: EpoFix, LR White, hand polishing.
- Negative stains for TEM analysis: UranyLess.
- Vertical stubs for SEM analysis of cross-sections.
- Stub for screening of TEM grids using SEM.
- Antistatic gun and manual pestle and mortar for XRD sample preparation; small volume, low background sample holder for XRD analysis.
- Opentrons OT-2 automated liquid handler for high-throughput cell culture plate fluorescent staining for HCS sample preparation.
- Incubators and biosafety cabinet for preparation of biological samples.
- BioRad KnowItAll Raman database for analysis of data by CRM.
- ICDD database for analysis of data by XRD
- Dragonfly Pro software with machine learning for 2D and 3D image analysis and segmentation

Sensors and Surface Technology Partnership (SSTP) Microscopy Laboratory

This laboratory originated under the direction of Dr. Otto Gregory (Chemical Engineering) and Dr. William Euler (Chemistry). The goal was to form a team of faculty aimed at tackling the challenges of developing thin film sensors and looking at surface coatings for a wide host of problems that our society faces. This laboratory is managed by Michael Platek, an Electrical Materials Engineer and is run as a URI service center.

The major equipment that is available from this facility includes:

- **JEOL 5900 LV environmental scanning electron microscope**

- **Physical Electronics Multitechnique Surface Analyzer:** capable of performing Auger Electron Spectroscopy (AES) and X-ray Photoelectron Spectroscopy (XPS) with a Argon Ion sputter gun for depth profiling.
- **Thermo K-Alpha X-ray Photoelectron Spectrometer** with Argon Ion sputter gun
- **Shimadzu Maxima 7000 XRD:** capable of doing powder & thin film diffraction.
- **Shimadzu Electron Probe MicroAnalysis (EPMA)** system coming in the fall of 2021.
- **MRC 8667 RF Sputtering instruments** (3)
- **Optical Associates Mask Aligner**

Minor equipment includes a full photolithography laboratory, a wide variety of annealing furnaces, Zeiss stereomicroscope, Nikon Optiphot reflective microscope, Dektak for surface morphology studies and polishing tables for metallography.

Engineering Analytical Core is located in the Fascitelli Center for Advanced Engineering and is managed by Dr. Vinka Craver, Professor of Civil and Environmental Engineering. The equipment contained in this core includes:

- **Shimadzu LCMS-8060** . Ultra High-Pressure Liquid Chromatography (UPLC) Triple Quadrupole UPLC/MS/MS system for ultra-trace analysis with high-sensitive Multiple Reaction Monitoring (MRM) component analysis.
- **Shimadzu Nexera-XR ultra.** Fully-integrated high-performance liquid chromatography (HPLC) system with three detectors: the SPD-M20A, RF 20A and Sedex 90 ELSD detector.
- **Shimadzu ICPMS-2030**. Inductively Coupled Mass Spectrometer with autosampler and collision cell.
- **Shimadzu GCMS-TQ8050 NX**. Triple Quadrupole GC/MS/MS for ultra-trace analysis. Includes Purge & Trap autosampler. AOC-6000 autosampler. With three injection tools: liquid, headspace, and solid phase microextraction (SPME)
- **Shimadzu RF-6000 Spectrofluorometer**. Xenon lamp with high-speed scanning of 60,000 nm/min. Extended range scan wavelength up to 900 nm.
- **Shimadzu DSC-60A Plus**. This device can measure phase changes starting at -140ºC. This model also comes with a 24 pan autosampler.

RI-INBRE Centralized Research Core Facility (CRCF) is funded by RI-IDeA Network of Biomedical Excellence (INBRE, P20GM103430, PI: Bongsup Cho) and is managed by Dr. Ang Cai with assistance from technical associate Kim Andrews. The CRCF is a state-wide core facility to promote interdisciplinary and cutting-edge biomedical research and student training opportunities by providing researchers access to advanced chemical and molecular biological instruments.

The CRCF houses over 40 high-end molecular-biology, analytical, and imaging instruments to serve RI's biomedical scientists totaling 3800 sq. ft. in the URI College of Pharmacy building. Inside the main laboratory space, a cell culture suite contains a biosafety cabinet and two incubators. A separate NMR laboratory includes two NMR spectrometers and a mass spectrometer.

The staff trains and assists users to operate any CRCF instrumentation that may be needed in their research. As a training-focused cost center, the CRCF does not provide project-based analytical and technical services.

Major equipment includes:

- **Sciex LC/MS Triple TOF 4600 Mass Spectrometer –** Accurate mass triple quadrupole MS and MS/MS for for qualitative and quantitative workflows with a mass range to 40,000D. LC is a Shimadzu Prominence liquid chromatograph with additional UV detector.
- **Shimadzu Axima Performance MALDI-TOF MS –** Matrix assisted laser desorption and ionization MS for peptides, proteins and DNA with a mass range to 500,000D.
- **Sciex LC/MS IonTrap 4500 Mass Spectrometer –** Nominal mass triple quadrupole MS for quantitative workflows with a mass range to 2000 AMU. LC is a Shimadzu Prominence liquid chromatograph.
- **Nikon Eclipse TI2 Inverted Confocal Microscope –** Imaging for transmitted light, epifluorescence light, and laser confocal techniques. Confocal laser frequencies at 405, 488, 561 and 640 nm. Motorized XYZ stage.
- **Cytiva BiaCore T200 SPR –** a microfluidic platform for measuring binding between biomolecules using surface plasmon resonance optical technology.
- **BD FACSVerse Flow Cytometer –** counts cell populations based on fluorescent labels.
- **Agilent Seahorse Metabolism Analyzer –** measures changes in cellular energetics in real-time using a 96-well format.
- **BioTek Cytation 5 Imager –** Multimode plate reader and imager with temperature- and atmosphere-controlled sample chamber.
- **Bioautomation MerMade 4 DNA Synthesizer –** For preparation of DNA sequences using chemically-modified or standard nucleotides.
- **Applied Biosystems Viia7 qPCR –** Quantitative PCR instrument for measuring DNA amplification and gene expression by detecting fluorescence in real-time.
- **Azure Biosystems Sapphire Imager –** Multi-mode laser imager, capable of RGB, fluorescence and phosphor imaging. Lasers at 488nm, 520nm, 658nm, and 784nm.
- **Li-Core Odyssey CLX IR Imager –** Western blot and gel imager using IR fluorescence dyes at 700 and 800nm.
- **Nanotemper Tycho NT.6 Protein Quality Analyzer –** Verifies protein quality by measuring unfolding in a three-minute assay.
- **Beckman Optima L-100XP Ultracentrifuge –** Capable of 100,000 rpm with multiple acceleration and deceleration profiles. Type 70 Ti, Type 70.1 Ti, Type 90 Ti and SW 40 Ti swinging bucket rotors available.

The RI-INBRE Molecular Informatics Core (MIC) was formed from the merger of the RI-INBRE Bioinformatics Core and the sequencing component of the RI Genomics and Sequencing Center, a URI NSF EPSCoR facility. The MIC is an NIH Data Sciences Core for Biomedical Research facility and provides sequencing and bioinformatics support for URI and other institutions in the INBRE and EPSCoR networks.

The MIC is under the direction of Dr. Chris Hemme (Biomedical and Pharmaceutical Sciences, College of Pharmacy) and sequencing manager Janet Atoyan. The Core offers services in four

general areas: 1) Sequencing and sample prep, 2) Bioinformatics and Data Science, 3) Molecular Modeling, and 4) Virtual Reality. The Core is working to establish start-to-finish pipelines that allow users to access any services from sample prep to sequencing to bioinformatics analysis. We also provide access to molecular modeling software such as Spartan and Molecular Operating Environment. The Core maintains the College of Pharmacy virtual reality hardware and works with URI ITS and other collaborators to develop STEM-based VR apps for use in teaching, training and research.

The Bioinformatics component of the Core focuses on omics data analysis, biostatistics, general data science, and training. The Core primarily utilizes the URI high performance computing resources but is working with URI Research Computing and the NIH STRIDES initiative to increase access to cloud resources.

Bioinformatics Resources and Virtual/Augmented Reality Equipment

- **2 bioinformatics desktops/3 VR laptops** - two desktops located at URI loaded with a variety of software for molecular modeling, bioinformatics and virtual reality applications
- **HTC Vive/3 HTC Cosmos VR Headsets** - Virtual reality headsets available for use for teaching and training
- **Spartan License** - Software for molecular modeling with an emphasis on small molecules
- **Molecular Operating Environment (MOE) License** - Software for molecular modeling with an emphasis on large molecules (eg proteins)
- **Adobe Creative Suite License** - A license for Adobe Creative Suite (Photoshop, Illustrator, etc) available for limited use by INBRE researchers
- **BioRender Team License** - Software for data visualization and illustration of biological applications

The Sequencing component of the Core currently offers both analytical and equipment services. Analytical services include DNA Sanger sequencing and fragment analysis (ABI 3500xl genetic analyzer), NGS gDNA library preparation (Takara Bio Apollo 324 library prep system), NGS amplicon library preparation, and Next Generation Sequencing (Illumina MiSeq).

Additional Sequencing Resources include

- **Agilent 2100 BioAnalyzer –** a microfluidics-based platform for sizing, quantification and quality control of DNA, RNA, proteins and cells.
- **Covaris S220 high performance ultrasonicator –** provides automated acoustic disruption and homogenization of cells and tissue samples.
- **Roche LightCycler® 480 qPCR systems** (1) **–** a multiwell-plate based qPCR platform used for highly accurate qualitative and quantitative detection of nucleic acids and genotyping.
- **PTC-100 thermal cycler –** uses Peltier technology to electronically deliver accurate heating and cooling over the full temperature range of 0°-100°C.

The URI Diving Research & Safety Program oversees all diving operations at the University of Rhode Island (URI), including education, outreach, and research activities following standards as set forth per the American Academy of Underwater Sciences (AAUS). This program falls under the Division of Research and Economic Development as a department. Curricular and regulatory functions are generously supported by annual funding from the

College of Environment and Life Sciences and the Office of the Provost. The College of Arts & Sciences, the College of Engineering, and the Graduate School of Oceanography also provide additional support. The program is directed by Anya Hanson, Director and Diving Safety Officer, and Alexandra Moen, Associate Diving Safety Officer and Dive Lecturer.

The program oversees two facilities at the URI Tootell Aquatic Center and the Narragansett Bay Campus. Both facilities support multi-disciplinary instruction and international research collaborations. The facilities house an air compressor fill station with 6 storage DOT bottles of compressed gas, safety equipment (e.g. oxygen delivery systems), and all scuba diving equipment for a maximum of 12 divers including diving thermal protection, life-support equipment (e.g. cylinders, regulators, buoyancy compensator devices, dive computers, pressure gauges), accessories (weights, masks, snorkels, fins, compasses, depth gauges) and office equipment. Additional resources at GSO include the following underwater research equipment: dive flags, reels, slates, lift bags, surface marker buoys, dive knives, transects, quadrats, t-bars, corers, dive lights, 2 blue-water diving rigs, drysuits, 2 closed-circuit inspiration rebreathers, full-face masks, a safety recall system, diver safety alert systems, service kits for maintenance, storage bags, instructional first aid supplies (e.g. mannikins, oxygen masks, training AEDs, first aid kits), save-a-dive kits, dive logs, and dryer. The program also has photography equipment: Olympus TG-5 and TG-6 cameras and housings, Sea & Sea underwater strobes, Light & Motion video lights, Sony video camera and housing, and Canon 5D Mark IV camera, housing and additional accessories. All equipment is serviced and maintained internally to high industry and manufacturer standards using a magnehelic, cylinder inspection tools, tumbler, and other manufacturer-specific tooling.

Additional components of both facilities include access to showers and restrooms (locker rooms at Tootell), gear cleaning bins, dehumidifiers, and ample storage for URI and divers' personal equipment. A Ford F-250 vehicle transports divers to/from field sites. An NSF-funded portable van designed to support ship-based research diving operations aboard the R/V Endeavor or other UNOLS ships is available.

The Marine Science Research Facility Analytical Labs service center (web.uri.edu/marinefacility/analytical-laboratories) is directed by Dr. Malia Schwartz (URI GSO) and has one technical staff (Dawn Outram). Its goal is to provide the tools necessary for scientific research as well as aid in student training and sample analysis. Lab space is available for bench work (DNA extractions, molecular work, and sample preparation and analysis). General resources include 7 Percival Upright Incubators (6 range from -2 to 44°C, 1 ranges from 2-44°C), autoclaves (2 large, 1 small benchtop) and 2 laminar flow hoods with and without UV light. Services provided include training on equipment usage, consultation on experimental design, and sample analysis.

Major Equipment includes: BD Influx Flow Cytometer with sorting capabilities; Lachat Nutrient Analyzer (Ammonium, Silicate, Phosphate, Nitrate and Nitrite); Beckman Coulter Counter Multisizer 4; QPCR Thermocycler; Flow Cam Imaging Particle Analyzer; Membrane Inlet Mass Spectrometer; Turner Designs Field Fluorometer; Fluorescence Induction Reduction

Fluorometer; Spectramax Plate Reader; PCR machines; and Nikon Epifluorescence Microscope with Digital Camera.

Minor Equipment includes: Microbalances; Eppendorf microcentrifuge; Filter manifold with 25 and 47 mm filter cups; Gel visualization box; Gel Imager; Handheld YSI with DO, pH, salinity and temperature probes; Heating/cooling block; Homogenizer; Laboratory fridge/freezer; Laminar Flow Tank; Biospherical PAR Sensor w/laptop; Micropipettes (12); Milli-Q water system; Nanodrop 1000; Qubit Fluorometer; Nikon Inverted Scope with Hoffman Contrast; Olympus Stereomicroscope; pH meter; Shakers (4); Small Strip tube centrifuge; Stingray Microscope Camera; Vacuum pump; Vortex (2); Jaz Spectrometer; Bead Beater; and PreSens Oxygen meter.

The Marine Science Research Facility Shared Seawater Facilities (SSF) service center at the Narragansett Bay Campus is jointly managed by URI's Graduate School of Oceanography (GSO) and College of the Environment and Life Sciences (CELS). Edward Baker provides day-to-day oversight and technical support. The SSF is housed in four buildings: the Ann Gall Durbin Marine Research Aquarium, the Ark Annex, the Luther Blount Aquaculture Research Lab, and the Marine Ecosystem Research Lab. With 8,000 square feet of indoor wet lab space and nearly unlimited exterior space, any marine environmental condition can be replicated apart from extreme depth and vastness. Tanks range in size from 3m in diameter to smaller aquaria.

Facility features include specialty wet labs for pathology and transgenic research (with dedicated effluent systems), a pier, four seawater intake pipes, a pump house, shallow estuarine mesocosms, and numerous outdoor tanks. Customizable temperature, salinity, photoperiod, filtration, aeration, flow rates, and sunlight are all available.

The facility also includes four environmental chambers (-4 to 24^{o}C) with photoperiod control and high and low alarm controls, a walk-in -20^{o}C freezer, a laminar flow tank, 3 large-scale incubators, and 24/7 generator back-up and emergency response personnel.