URSMD SHARED RESOURCE LABORATORIES AND FACILITIES SUMMARY

Overview and environment: The University of Rochester School of Medicine and Dentistry (URSMD) is committed to providing and supporting Shared Research Laboratories (SRL) and Shared Research Resources (SRR) to support the research mission of the URSMD investigators in basic, translation and clinical research. These facilities cut across all departments and centers, and in 2012 were brought together under central leadership and administration. Over the last 6 years, the SRL and SRR have been a key component of the URSMD strategic plans. This can be highlighted by the continued subsidized support of the operation of these facilities, (~$1.6 million for FY2017 [excluding an additional ~$400,000 annual Animal Resource subsidy]), as well as a major commitment to support the acquisition of new instrumentation and resources, highlighted by over $1M commitment of new resources and renovation of lab space from over the last five years.
Leadership: Timothy Bushnell, Ph.D., Director of Shared Resource Laboratories

New equipment and research enhancements: In the past several years, using a combination of institutional commitment and grant support, the URSMD Shared Resources have seen significant improvements and enhancements of the tools available to support the research mission. These recent enhancements include:

2013 – Acquisition of a Triple Quadruple mass spectrometer for the Mass Spectrometry Resource Laboratory
2013 – Upgrades purchased for the Multiphoton Resource microscope to change to a 4-channel configuration, with SIM capabilities; via a 405 diode laser or a 488 argon laser
2013 – Awarded an NIH SIG grant for the acquisition of an Illumina HiSeq 2500 (PI S. Gill) to enhance the Genomics Research Center
2013 – Awarded $3 million from New York State for a high performance computing and big data initiative for Health Sciences Center for Computational Innovation
2013 – Acquisition of an Illumina MiSeq to enhance the Genomics Research Center
2013 – Acquisition of a Celigo Adherent Cell flow cytometer for the foundation of the Pathways Discovery Resource
2014 - Acquisition of a Q-Exactive Plus for the Mass Spectrometry Resource Laboratory
2014 - Official Establishment of the Pathways Discovery Resource, including a new Perkin Elmer Zephyr compact liquid handling workstation and genome-wide RNAi library
2014 - Awarded $500K from New York State for research equipment to the Health Sciences Center for Computational Innovation
2014 – Acquisition of next-generation Linux cluster (“BlueHive”) for Center for Integrated Research Computing
2014 – Genomics Research Center acquired a ABI QuantStudio 12k FLEX real-time PCR instrument with funds from a Finger Lakes Regional grant proposal to replace an aging instrument and to provide high throughput digital PCR capabilities.
2014 – Completion of VISTA Collaboratory (visualization center) for Health Sciences Center for Computational Innovation
2014 – Genomics Research Center acquired a Sage Science Pippin DNA size fractionation system with funds from a Finger Lakes Regional grant proposal to enhance micro RNA research workflows.
2015 – Genomics Research Center awarded NIH S10 (PI: S. Gill) for purchase of a Fluidigm C1 Single-cell AutoPrep instrument.
2015 - Genomics Research Center purchased EpMotion 5075 liquid handling system to be dedicated for NGS library preparation.
2016 – Mass Spectrometry Resource awarded NIH S10 (PI: Ghaemmaghami) for the payout of the Lease on the Q-Exactive Plus.
2016 – NIH S10 grant (PI: Williams) for the acquisition of an XSTRAHL Small Animal Radiation Research Platform (SARRP) and the creation of the Model Imaging and Tomotherapy Facility, a new URMC Resource supported by the Wilmot Cancer Institute.
2016 - Acquisition of a second Illumina MiSeq to enhance the Genomics Research Center capacity

2016 – Genomics Research Center founds a Bioinformatics analysis group to provide analytical and research support for investigators using genomic approaches
2017 – Genomics Research Center enhances single-cell genomics capability through purchase of a 10X Genomics Chromium Controller from internal UR investigator collaborations
2017 – Genomics Research Center hires Technical Scientist dedicated to custom genomics applications, including single-cell genomics
2017 – NIH S10 grant (PI: Butler) for the acquisition of a Typhoon FLA 9500 for the Molecular Imaging Facility
2017 – Acquisition of the Olympus FVMPE-RS multiphoton scanning system with two excitation lasers and a Gantry Frame to expand live animal imaging capabilities.
2017 – Appointment of Dr. Kaye Thomas as the Technical director of the Confocal Microscopy Resource
2017 – Appointment of Dr. Yurong Gao as the Technical Director of the Multiphoton Resource.

Additionally, the UR Clinical Translational Research Institute (CTSI), the Center for AIDS Research (CFAR) and the Rochester Human Immunology Center have provided critical and incremental support to multiple research resources.

Shared Resource Laboratories

The UR Medical Center has a number of successful core research facilities that provide services to all researchers at the Medical Center. These facilities are listed below.

- **Confocal and Conventional Microscopy Resource:** This resource provides UR researchers the ability to obtain high quality imaging data using state-of-the-art microscopy instruments. It also serves as one of the information hubs for UR resources centering around histological processing, imaging, and image processing and as a conduit for communication between imaging researchers on campus. Substantial one-on-one guidance is provided for obtaining and assessing high quality, quantifiable image-based data for each instrument. Staff also is continuously available for updating and discussing results in real time. Specialized instrumentation includes: *Confocal*: an Olympus FV-1000 Laser Scanning Confocal Microscope is available which is configured with 4 lasers spanning the blue to far red spectrum and multiple high resolution objectives. Experimental capabilities include: multi-dimensional (z-stack, time-lapse, multi-point and tiling) data acquisition and multiple FRET applications. Additional capabilities are provided by a SIM scanner which provides capability for synchronized continuous imaging during photo-manipulation experiments. *Laser Capture Microdissection:* A Palmbeam (Zeiss) laser capture microdissection instrument equipped with multiple long working distance objectives and both brightfield and immunofluorescence capabilities is available. *STED Microscope*: an Abberior Stimulated Emission Depletion Super-Resolution Microscope is available with is configured with 4 excitation (imaging) lasers and 2 depletion lasers. Two STED quality objectives are available for use on the system as well as two high-quality imaging objectives. The Abberior Instruments easy3d STED system offers variable 2D to 3D STED imaging and aberration correction via adjustment of a Spatial Light Modulator (SLM) and various modules for light dose management to reduce photobleaching and phototoxicity. *Image Analysis Capabilities*: The in conjunction with the MP facility LM Shared Resource Image analysis software capabilities currently include: FV1000 post-processing analysis software, FIJI/ImageJ2 and Amira. *Director: Kaye Thomas, Ph.D.*
- **Electron Microscopy.** The principal mission of the Electron Microscopy Resource Laboratory is to provide University of Rochester researchers support in high magnification (**700 to 600,000x** range) for ultrastructural analysis of cells and tissue in the fields of Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM) and combined Scanning/Transmission EM (STEM). Specialized instrumentation includes a Hitachi 7650 III Analytical Scanning/Transmission Electron Microscope (STEM) with a side mount Gatan Erlangshen 11 megapixel digital camera, an electron dispersive x-ray spectrometer (EDAX Instrument) for elemental analysis of nanoparticles and a Gatan Digiscan II undermount camera for STEM mode imaging (brightfield and darkfield with fine probe elemental analysis) (TEM occupies 470 sq.ft). Auxiliary equipment includes a new (2011) Boeckeler P-XL ultramicrotome, 2 Olympus double headed light microscopes, a 45 year old Bausch & Lomb stereo

dissecting microscope, various centrifuges, a new 2013 acquired Touisimis 931 automated critical point dryer (for SEM specimens), Leica glass knife breaker and several diamond knives for 70nm thin sectioning of epoxy blocks (wet bench space occupies 670 sq.ft). For SEM imaging, the EM Core utilizes a 2008 Zeiss Auriga field emission SEM/STEM housed in the Hajim Engineering School on the University's non-medical River Campus. *Director: Karen Bentley, M.S*.

- **Flow Cytometry.** The mission of URMC Flow Cytometry Resource Laboratory is to provide investigators with state-of-the-art instrumentation along with the technical expertise to support all that is possible now, while pushing the limits of what can be done with flow cytometry. The Core currently has traditional analytical tools including an Accuri C6 (4-colors) and 5 LSR-II's (one 12-color and four 18-color instruments) from BD Biosciences. We also have three sorters available including a 17 and an 18 color FACSAria-II and a 4 color BioRad S3e. In addition we have several non-traditional analytical cytometers. The Amnis ImageStream GenX allows for imaging flow cytometry and the detection of up to 10 fluorescent parameters with cellular localization information. The CyTOF Mass Cytometer, which came online late 2012, uses lanthanide metal mass spectrometry as opposed to traditional fluorescent tags, allowing the analysis of upwards of thirty parameters to be studied simultaneously. The resource also added the Nanosight NS3000 in 2015 for the detection of nano-sized particles. The Nanosight is capable of measuring the size distribution and concentration of particles as small as 10 nanometers by using light scatter and Brownian motion. Instrumentation is only part of what we offer. We also offer comprehensive training for staff, consultation for maximizing the effectiveness and cost of experiments, as well as an environment that fosters success in both existing methods and crossing the boundaries into new frontiers. *Director: Timothy Bushnell, Ph.D.; Technical Director: Matthew Cochran, M.S.*
- **Genomics Research Center.** The UR Genomics Research Center (GRC) provides collaborative assistance with experimental design and data analysis for investigators using high-throughput next generation sequencing (NGS), genotyping and gene expression in their research programs. Services include RNA-Seq, Dual RNA-seq, Bar-seq, CHiP-Seq, ATAC-seq, Methyl-Seq, small RNA-Seq, REP-Seq, targeted and whole exome sequencing, whole genome sequencing, 16S rRNA microbiome sequencing, metatranscriptomics, Sanger sequencing, qRT-PCR, Affymetrix microarrays, purification of RNA/DNA, as well as custom applications and approaches. In addition, GRC staff lead collaborative projects with URMC investigators to develop new methodologies and incorporate emerging genomic technologies into faculty research programs and the GRC workflow. Dedicated computational support for hardware, data analysis and storage of high-throughput sequence data is provided by the Center for Integrated Research Computing (CIRC). The following major equipment is located in the GRC: one Illumina HiSeq2500v4 high-throughput DNA sequencer, two Illumina MiSeq DNA sequencers, one C1 Single-Cell Auto Prep System, one 10X Genomics Chromium Controller, one Sage Science Pippin DNA size fractionation system, one QX100 Droplet Digital PCR System, one ABI QuantStudio 12K Flex Real-Time PCR System with autoloader and microfluidic card module, two ABI 9700 PCR machines, two BioRad DNA Engine PCR machines, four BioRad C1000 Thermocyclers, one Eppendorf 5070 liquid handling robot for qPCR setup, one Eppendorf 5075 liquid handling robot for library construction automation, one Covaris S2 sonication system, one Agilent 2200 TapeStation System, two Agilent 2100 Bioanalyzers, one BioRad gel documentation system, one Qubit flourometer and multiple NanoDrop ND-1000 spectrophotometers. *Director: Steven Gill, Ph.D.; Co-Director: John M. Ashton, Ph.D., MBA.*
- **Mass Spectrometry Resource Laboratory.** The Mass Spectrometry Resource Laboratory (MSRL) provides instrumentation and technical expertise to UR researchers seeking to conduct MS-based protein or small molecule assays. Technicians within the MSRL provide assistance with project design and planning, proper sample preparation (sample clean-up, protein concentration, 1D gel electrophoresis, liquid chromatographic separations and proteolytic digestion) and interpretation of mass spectrometric data. Common analyses include the identification of unknown proteins, characterization of protein complexes, mapping of post-translational modifications (PTMs) and relative quantification of peptides and small molecules from a range of sample types, including complex clinical

matrices, tissue extracts and cell lysates. Specialized MS instrumentation operated and maintained by the core include a Thermo Q Exactive Plus Hybrid Quadrupole-Orbitrap and a Fusion Lumos Tribrid mass spectrometer. In addition, the laboratory has access to a variety of automated database searching software as well as resources to facilitate discovery-based proteomics projects. *Director: Sina Ghaemmaghami, Ph.D.; Technical Director: Kevin Welle*

- **Mouse Genome Editing Resource.** The Mouse Genome Editing Resource Facility provides expertise and assistance in the production of transgenic mouse models by either DNA microinjection, CRISPR, or gene targeting in embryonic stem (ES) cells. For gene targeting and transgenic projects, The Facility assists in all phases of the project, including design and construction of DNA constructs, homologous recombination in ES cells, microinjection of DNA/RNA and Cas9 into oocytes and of ES cells into mouse blastocysts in order to generate founder mice, breeding founder mice to germline transmission, and PCR and Southern genotyping. Other services include mouse embryo and sperm cryopreservation, re-derivation of mice to obtain Specific Pathogen Free (SPF) status, generation of congenic mice (backcrossing), colony management, and providing mice of common strains (C57BL/6, ICR, Cre, and FLP; regular and pregnant females or litters). The laboratory consists of a barrier facility for procedures involving production and maintenance of genetically modified mouse strains, a tissue culture facility for ES cells, and a molecular laboratory for generating gene-targeting constructs and genotyping experiments. *Director: Lin Gan, Ph.D.*

- **Multiphoton Imaging Resource:** The mission of the URMC Multiphoton Shared Resource Laboratory is to provide state-of-the-art multiphoton imaging capabilities to further the biomedical and bio-optical research with emphasis on intravital imaging and systems physiology. The Core is devoted to facilitating researchers with high quality quantitative imaging, and enhancing the chances of successful funding.
  Multiphoton microscopy: The Multiphoton Core Facility is currently equipped with a state-of-the-art *Olympus Fluoview FVMPE-RS Twin Lasers Imaging System* which was newly installed in January 2018. The system uses a MaiTai HP DeepSee Ti:Sa laser and an Insight X3 laser as two laser sources which offer a wide range of excitation wavelength for various chromophore options as well as high imaging qualities. The FVMPE-RS system also combines a high-speed resonant scanner with a conventional galvanometer scanner to provide high speed as well as high definition imaging in a single system, flexible for both structure imaging as well as dynamic imaging. The system has four high-sensitive photomultiplier tubes (PMT) and multiple options of filter cubes specialized for multi-color imaging. The system is also capable of doing large image area tiling and stitching with high speed and resolution. Comparing to traditional one-photon microscope, the system has the advantage to be capable of imaging thick, highly light scattering biological tissues up to 500μm deep, and cleared tissue up to 2mm deep without tissue sectioning or fixing. The FVMPE-RS system combines high speed, deep observation capability with multi-color imaging, which will meet a myriad of experiment needs.
  Animal Physiology: The Multiphoton Core facility supports animal intravital imaging and physiology studies by providing two fully outfitted surgical stations with Leica Surgical Dissecting Scopes for delicate surgeries, two Kent Scientific Isoflurane Vaporizers for animal anesthesia, two Transonic System Laser Doppler Flow Meters for blood flow measurements, a World Precision Instruments Pressure Monitor for blood pressure monitoring, and a Siemens RAPIDLAB Blood Gas Analyzer for blood gas and pH measurements.
  Image Analysis: The Mulitphoton Core facility provides access to a higher performance analysis workstation with multiple image analysis software, including Matlab, ImageJ, Amira, and Imaris. The core staff members with expertise in image analysis routinely support specialized analysis projects.
  Director: Yurong Gao, Ph.D.

- **Pathway Discovery Resource.** The Pathway Discovery Resource (PDR) is a high throughput screening facility providing cost effective screening methodologies for cell based assays. Currently, the PDR offers cell based screening with the Silencer® Select Human Druggable Genome siRNA Library V4 and three chemical compound libraries (Spectrum, Chembridge, and Prestwick). The following major equipment is located in the PDR: one Celigo S Cell cytometer, one Perkin Elmer Zephyr compact

liquid handling workstation, ThermoFisher MultiDrop, one Envision High Throughput Plate Reader equipped with optics for Fluorescence, Luminescence, Fluorescence Polarization (FP), Time Resolved Fluorescence (TRF), Absorbance, Alpha Screen, and FRET based detection in 96 or 384 well formats, one Janus dual-arm robotic liquid handling system, and one Flexdrop plate filler. The PDR is Co-directed by two Faculty-level Instructors experienced in high throughput cell and molecular biology techniques. In addition, the PDR is operated by a full time Technical Associate with significant experience in high throughput technologies. The PDR integrates with various other shared resource facilities at University of Rochester including; genomics, flow cytometry, and proteomics. *Co-Directors: Wojciech Wojciechowski, Ph.D. and John M. Ashton, Ph.D., MBA.*

Other Research Resources

- **Animal Resource.** The Animal Resource is a centralized resource facility with staff and programs that support the research and educational uses of laboratory animals. These facilities are fully accredited by AAALAC, International and are in compliance with state law, federal statute and NIH policy. The Division of Comparative Medicine (DCM), formerly known as Division of Laboratory Animal Medicine (DLAM) consists of two board certified laboratory animal veterinarians, two additional laboratory animal veterinarians, & a staff of six trained and NYS licensed veterinary technicians. Support is provided for research with all major animal species. Services provided by DCM include colony health monitoring, quarantine services, animal acquisition from other research facilities, surgical support/anesthetic services, 24/7 on-call veterinary emergency services, clinical management of any cases of spontaneous or experimental disease, necropsy and histopathology services, training in specialized techniques (including inhalation anesthesia of all species , blood collection, aseptic surgical technique) and rodent breeding colony management for PIs. Core services provided by the Animal Resource include daily husbandry practices, daily observations for health problems, special request services (special diets, water, fasting), provision of federally mandated enrichment to animals, and cage wash, autoclave and room sanitation services. Major equipment includes HEPA filtered ventilated cages & hoods for barrier maintenance of SPF mice, "gnotobiotic mouse flexible film isolator units, dedicated BSL2 mouse housing & procedural space", inhalation anesthesia machines for rodents and large animals, diagnostic "digital" X-ray machine, autoclave for surgery packs, Intensive Care Unit, CO2 euthanasia stations, MRI capabilities and a Gammacell 40 Exactor Low Dose-rate Research Irradiator for irradiation of small animals within the resource (used principally in support of bone marrow transfer studies in mice). The UR Medical Center has recently expanded large animal (sheep, pig, cattle) surgical services with long term post-operative housing available at an AAALAC accredited sister institution located 35 minutes from the university. *Director: Jeffrey Wyatt, DVM*
- **Biosafety Level 3 (BSL-3) Facility.** The Biosafety level three facility (BSL-3) is available for the use of any researcher at the university whose work requires manipulation of biological agents which may cause serious or potentially lethal disease as a result of exposure by the inhalation route (such as TB). The BSL-3 Core laboratory is a fully self-contained facility and includes 4 biosafety cabinets, several incubators as well as -80 freezers and a liquid nitrogen storage tank. Additional equipment includes a tabletop centrifuge with high and low speed rotors, an inverted microscope (Olympus CK40), a sonifier, visible light spectrophotometer, electroporator, and cell lysis equipment. *Director: Martin Pavelka, Ph.D.*
- **Center for Integrated Research Computing (CIRC):** The UR established the Center for Integrated Research Computing (CIRC) to provide researchers across the University with technology, software, training, and support necessary to utilize high-performance computing (HPC) and big data technology fully in research activities in all areas of academic scholarship. CIRC presently supports faculty-led research projects from over 40 departments and centers across the Medical Center and River Campus. CIRC offers University researchers state of the art computing technology and software, and currently maintains about 550 teraFLOPS of high performance computing systems, including an IBM Blue Gene/Q system (see HSCCI, below). CIRC has over 4.5 petabytes of storage for data-intensive applications, and a variety of scientific software applications and tools.

- CIRC's Linux compute cluster (known as "BlueHive") delivers a computing capacity of approximately 340 teraFLOPS. This system consists of 350 nodes of IBM's iDataPlex architecture with a high-speed, low-latency, FDR InfiniBand interconnect. Each node houses 2 x 18-core Intel "Broadwell" processors (for a total of 36 cores per node) or 2 x 12-core Intel "Ivy Bridge" processors (for a total of 24 cores per node) and ranges in memory from 64 GB up to 3 TB. 10 of the nodes contain 2 dedicated Nvidia K80 ("Kepler") GPU (graphics processing unit) cards that each provides 4,992 CUDA cores with 24 GB of GPU RAM per card for accelerated computing. 30 of the nodes have two dedicated Nvidia K20X ("Kepler") GPU (graphics processing unit) cards that each provides 2,688 CUDA cores with 6 GB of memory. 8 of the 64 GB nodes also have 2 dedicated Intel Phi 5110P accelerator cards, which provide an additional 60 cores and 8 GB RAM per card. In addition, 4 nodes of the cluster are dedicated to running "big data" analytics applications, such as Hadoop and large databases. The IBM System x3630 big data nodes have 112 TB of dedicated local storage and a total of 384 GB of RAM. The entire BlueHive cluster has an InfiniBand-attached storage system that consists of 4 IBM/Lenovo GSS 24 system storage units providing approximately 4 PB of configurable raw disk within a parallel file system running IBM's enterprise GPFS software on a declustered array of disks. 3 PB is allocated to high performance scratch, and 1 PB has been made available for storage and archiving of files. A separate series of IBM DCS3700 storage shelves provide approximately 0.5 PB of redundant backup storage for the GSS units. Access controls and limitations are provided by file system ACLs (access control lists). An additional 120 compute nodes with varying capacity have been integrated into the BlueHive cluster for faculty investigators who have purchased additional priority-based compute capacity for the environment. CIRC runs the SLURM resource scheduler and queuing system to optimize usage and to support multiple users of the BlueHive Linux cluster environment.
- Supported developer tools in the BlueHive environment include C/C++ and Fortran compilers from Intel and GNU and math libraries from Intel (i.e. MKL). Parallel communications libraries are provided by Open MPI and MPICH2. Over 300 software packages for domain-specific scientific applications are also available. In addition, CIRC hosts numerous cross-domain scientific computing applications (e.g. R, Python, MATLAB, and Mathematica).
- The Center's efforts in collaboration, consultation, expertise, and community building are essential for facilitating the research mission of the UR. CIRC provides resources to faculty, staff, and students to ensure access to technology and knowledge necessary for effective computational research. These resources include technology (computer systems, software, storage, etc.), 8 full-time staff members (director, assistant director, 3 computational scientists, 3 system administrators), 3 part-time student research assistants, information sharing and collaboration tools, and an education and training program. Every summer, CIRC provides a six-week long program in training for computational and data science. Known as the "CIRC Summer School" this program is open to all University of Rochester faculty and students and provides hands-on, workshop-style training on a number of techniques and programming languages useful for developing tools and exploring research data. Past modules of the summer school include: Using Linux, Programming Python, Using Databases, Parallel Programming with MPI and OpenMP, Code Acceleration with NVIDIA CUDA, Using MATLAB, and Data Analysis with STATA, SAS, and R. This program has recently expanded to include an offering in the winter months. Known as the "CIRC Winter Boot Camp," classes focused on programming and tools for data analysis are open to students, faculty, and staff at the University of Rochester. *Director: Brendan Mort*

- **Cold Storage Core (CSC).** The CSC provides a discrete controlled access area where investigators can maintain freezers for long-term storage of research materials. Each unit can be alarmed via data line to a central monitoring system (APOGEE), all units are power protected by emergency backup generators. Each unit receives semi-annual preventive maintenance, and CSC staff record daily temperatures. There are also spare units (4^{o}C, -20^{o}C, -80^{o}C, and -140 ^{o}C) available to all URMC investigators in case of emergencies. *Director: Christopher Lane.*

- **Health Sciences Center for Computational Innovation (HSCCI).** The UR recognized a growing need to improve support for Data Sciences related to biomedical research and has built state of the art infrastructure in response. Beginning in 2008 the UR created the HSCCI, a world-class center for the advancement of health-related research supported by high-performance computational (HPC) resources. The mission of the HSCCI is to facilitate collaboration among research faculty, computational biologists, programmers, and software developers to advance biomedical research. The Center will provide pilot funding for both research staff and HPC computational resources. The HSCCI is supported through a mix of corporate partnerships, direct institutional support, federal research grants, and state programs. The heart of the HSCCI is IBM's next-generation BlueGene/Q supercomputer, one of the first of its kind deployed in an academic setting in North America. The UR's current BlueGene/Q is a 209 teraflop system, providing 1024 compute nodes, each having 16 cores for 16,384 processing cores total, and is housed in University's new state-of-the-art, high-reliability, newly completed UR **Research Data Center (RDC)** and managed by the CIRC (see CIRC listing above). HSCCI research domains include projects concentrated in the following areas:
    - Modeling Complex Biological Systems and Integration of Big Data: Vertical integration of multiple high-dimensional data sets from different levels of a complex biological system-incorporates genomics, microbiomics, proteomics, and organ-level data.
    - Biomedical Imaging: Improved computational methods for analyzing images collected by a variety of technologies including MRI, ultrasound, and multiphoton microscopy. Includes development of analytical tools and computational methods for four-dimensional (3D over time) data.
    - Molecular and Fluid Dynamics: Structural simulation and prediction of RNA, protein, and intermolecular interactions; fluid dynamics related to medical diagnostics and biological processes (eg. microfluidic devices and blood or air flow).
    - Biomedical Informatics: Personalized medicine, mining Electronic Medical Records, perform virtual clinical trials

  The HSCCI recently completed the construction of a state-of-the-art data visualization research lab - Visualization-Innovation-Science-Technology-Application (VISTA) Collaboratory. The mission of the VISTA is to provide collaborative space to house technology, research, and education in the data visualization sciences. Our approach is to bring together expertise in computer science, software, vision research, brain and cognitive sciences, statistics, and mathematics to work with experts in imaging, medicine, and biology to use, develop, and teach visualization technologies for large complex data. The VISTA houses an 8' x 20', 50 megapixel HD CineMassive display connected directly to the Blue Gene/Q and BlueHive supercomputers through a dedicated high speed, high bandwidth optical cable to the RDC. *Executive Director: David J. Topham M.S., Ph.D.; Associate Director: Benjamin Miller, Ph.D.*
- **Model Imaging and Tomotherapy Facility:** The new Model Imaging and Tomotherapy Facility offers researchers at the University of Rochester access to a Small Animal Radiation Research Platform (SARRP, Xstrahl) which allows delivery of radiation therapy protocols to animal models of human tumors through a means that is directly comparable to those used in current clinical practice. To this end, the SARRP is capable of delivering beams that make use of collimators varying from 0.5 mm to 10 cm, with an accuracy of 0.25 mm. Since this platform allows the generation of beams that can be rotated in directions ranging from vertical to 30° below horizontal, with 4-dimensional control over positioning of the model, recognized through the use of a laser-based positioning system, it provides flexibility for use in multiple applications and for diverse needs. The SARRP includes on-board cone-beam computed tomographic imaging, which is amalgamated with treatment planning and image fusion software. This component can be used independently as a small animal imaging device or, in conjunction with the dedicated dose planning system, can be used to generate individual conformal radiotherapy plans for preclinical studies or image fusion with other imaging data sets, including MR (any orientation) PET, etc. This technology is currently being developed to provide clinically-relevant protocols to a range of tumor models (brain, lung, pancreatic, bone), as well as investigate the development and prevention of post-therapeutic effects in normal tissues that affect cancer survivors,

e.g. the bladder (cystitis), lung (pneumonitis and fibrosis), salivary glands (xerostomia), brain (necrosis; cognitive dysfunction), and post-therapy bone disease. *Director: Jackie Williams, Ph.D.*

- **Molecular Imaging Facility.** The Molecular Imaging Facility provides researchers at the UR with access to state of the art instruments capable of detecting and quantifying the levels and positions of radio- and fluorescently labeled molecules in a variety of formats including gels, blots and microtiter plates. Major instrumentation includes a Typhoon FLA 9500 (acquired in 2017). The Typhoon FLA 9500 is housed within the Center for RNA Biology, and handles gel sandwiches, agarose and polyacrylamide gels, membranes, microplates, and microarrays, with the capacity for multiplexed detection of chemiluminescence, fluorescence and ionizing radiation. *Director: Scott Butler, Ph.D.*

- **Rochester Center for Brain Imaging (RCBI).** The Rochester Center for Brain Imaging (RCBI) provides researchers at the UR, as well as neighboring institutions, with access to a state-of-the-art 3T scanner for research using magnetic resonance imaging (MRI). The Center is able to provide structural images of any part of the human body, functional imaging of the brain, and spectroscopy of living tissues. The heart of the RCBI is a recently upgraded Siemens Prisma 3T whole-body human scanner, with maximum gradient amplitude of 80 mT/m and a slew rate 200T/m/s. A variety of RF coils are available for head, knee, and body imaging, including a 64-channel phased array head coil (capable of 3D parallel imaging) for brain studies. Pulse sequences installed on the Prisma system allow capability for many types of research applications, including high-resolution structural MRI (3D T1 and T2 weighted), functional MRI (BOLD fMRI), diffusion-weighted scans including diffusion tensor imaging (DTI - for imaging white matter tracts in the brain), blood vessel and perfusion imaging, single- and multi-voxel spectroscopy and MR elastography (MRE). The new capability for simultaneous multiple-slice (SMS) acquisition allows substantially faster and higher spatial resolution imaging for both structural and functional studies. Custom RF coils are available through the staff of the RCBI, permitting high resolution imaging of small animals. Active Master Research Agreement allows addition of new research capability from Siemens and world-wide researchers. *Acting Director: John Foxe, Ph. D.; Technical Director: Jianhui Zhong, Ph.D.*

- **Rochester Human Immunology Center Core (RHIC).** The Rochester Human Immunology Center (RHIC) and its core laboratory are an important resource enabling clinical translational research. The RHIC was established to acquire, refine and develop expertise in cutting-edge techniques supporting applications in Human Immunology research and to provide quality management expertise for Good Research practices, GCP, GLP and regulatory compliance. The RHIC serves to enhance multi-disciplinary research initiatives catalyzing key clinical and basic immunology research in vaccines, HIV/AIDS, autoimmunity, allergy/asthma, transplantation as well as cancer immunology. The Center's core lab provides assistance and expertise in immunological method development, standardization and validation through individual and group training programs as well as collaborative projects through its fee for service cost center. The RHIC has served over 50 individual research projects over the past fourteen years, resulting in multiple new grant awards. The RHIC expertise covers techniques such as 18-color flow cytometry, 40 parameter CyTOF™ mass cytometry, multiplexed bead array assays (Luminex Xmap™), ELISPOT and EIA as well as quality and regulatory expertise in GLP and GCP for support of clinical translational research. The RHIC Core Lab also provides specimen processing and management, analytical and sorting flow assays and panel development, Luminex and ELISA assays on a fee for service basis. *Director: Sally Quataert, Ph.D.*

- **Small Animal Multispectral Imaging Core**. The Small Animal Multispectral Imaging Core offers state-of-the-art longitudinal multispectral (bioluminescence and fluorescence) imaging capabilities, to compliment and boost the extensive imaging resources available to University of Rochester Medical Center (URMC) researchers engaged in wide ranging areas of biomedical research with emphasis on clinical translation in alignment with the mission of the Clinical and Translational Sciences Institute (CTSI). The Core houses an IVIS® Spectrum system with unique capabilities for sensitively imaging both bioluminescent and fluorescent reporters within the same animal without mixing the multi-spectra. The system performs both epi- and trans-illumination fluorescent imaging and uses high efficiency

narrow band-pass filters coupled with spectral unmixing algorithms to differentiate between multiple shallow and deep fluorescent sources. *Director: Hani Awad, Ph.D.*