The Ohio State University Comprehensive Cancer Center –
Arthur G. James Cancer Hospital and Richard J. Solove Research Institute

Shared Resources and Core Facilities

The James

THE OHIO STATE UNIVERSITY
COMPREHENSIVE CANCER CENTER

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The Shared Resources and core facilities at The Ohio State University Comprehensive Cancer Center – Arthur G. James Cancer Hospital and Richard J. Solove Research Institute (OSUCCC – James) are a National Cancer Institute (NCI)-recognized network of specialized service facilities, which facilitate an investigator's ability to conduct cancer research by reaching across medical disciplines and offering expert leadership and training; clinical, administrative and technical support; and state-of-the-art instrumentation to cancer researchers.

With a focus on three primary research areas – laboratory, clinical and population-based research – the OSUCCC – James Shared Resources are dedicated to maintaining open accessibility to all its members. By providing a cost-effective means for users to advance their investigations, the Shared Resources deliver measurable scientific value to the broader cancer research community while offering an important venue for scientists to explore hypotheses, determine outcomes and communicate findings via numerous platforms and publications.

The Shared Resources and core facilities are funded by the OSUCCC Cancer Center Support Grant from the NCI, by strategic partnerships with various university colleges and departments, and by established chargeback systems. Please be sure to acknowledge any utilized Shared Resource in future publications and cite the CCSG P30 grant, P30CA016058.

The Shared Resources and core facilities to the right are available to investigators (both within and outside the University) who adhere to usage guidelines.

For more information about our shared resources, please visit **go.osu.edu/sharedresources.**

- Bioinformatics
- Biospecimen Services
- Biostatistics
- Clinical Translational Science
- Clinical Treatment Unit and the Clinical Trials Processing Laboratory
- Comparative Pathology and Digital Imaging
- Flow Cytometry
- Genetically Engineered Mouse Modeling
- Genomics
- Leukemia Tissue Bank
- Medicinal Chemistry
- Microscopy
- Nutrient and Phytochemical Analytics
- Pharmacoanalytical
- Proteomics
- Recruitment, Intervention and Survey
- Small Animal Imaging
- Targeted Validation
- Veterinary Clinical Research Support

Biomedical Informatics Shared Resource

The Biomedical Informatics Shared Resource (BISR) supports advanced cancer research conducted by OSUCCC – James members by facilitating high-throughput, novel experiments that link multidimensional phenotypic and biomolecular data sets to address hypotheses related to cancer biology, treatment and prevention.

BISR uses and coordinates data-intensive computational methods for all high-throughput data analysis, as well as pathway and network analysis. BISR also assists researchers with accessing publicly available data to generate new hypotheses and draw new conclusions via integrative analysis of both public and private data sources. BISR fosters collaborations with OSUCCC researchers, customizes analysis workflows to meet the unique needs of their projects, interprets and presents results, works on manuscript preparation and design and plans grant applications.

SERVICES

Computational Biology

- Analysis of next-generation sequencing data, including RNA-sequencing, smRNA-sequencing, ChIP-sequencing, whole exome-sequencing, ATAC-sequencing and whole genome re-sequencing
- Analysis of long-read sequencing (such as PacBio and Oxford Nanopore Sequencing), including QC and error correction of long reads, gene/gene isoform expression, novel gene discovery and full length isoform identification, de novo fusion gene detection and corresponding fusion isoform expression profiles, allele-specific expression and haplotyping, de novo genome assembly, de novo transcriptome assembly, methylation calling, nucleosome positioning and chromatin accessibility

Single-cell RNA-seq data analysis

- Basic scRNA-seq data analyses, including quality control, alignment, trimming, assembly, differentiation expression and clustering, using developed pipelines
- Advanced scRNA-seq data analyses, including cell trajectory discovery, cell type prediction and co-regulated gene module identification.
- Selective scRNA-seq analyses to solve specific issues such as drop-out issue and immense expression data (e.g., 10X scRNA-seq data)
- Interpretation of results
- An all-in-one, user-friendly web server for scRNA-seq analysis
- Integrative analysis of single-cell multi-omics data to enhance effectiveness and efficiency

Metagenomic and metatranscriptomics

- Metagenomic data analysis including species/strain composition profiling, taxonomic analysis, abundance analysis, phylogenetic analysis, whole-genome shotgun analysis
- Metatranscriptomic data analysis including functional profiling, expression activity analysis, 16S ribosomal RNA analysis and whole-transcriptome shotgun analysis
- Advanced joint metagenomic and metatranscriptomics data analysis for more accurate gene-level, species-level and strain-level analysis
- Network studies in microbiome and host-microbiota interactions based on high-throughput multi-omics data
- Causality study between human microbiota and diseases
- Existing tools/pipelines recommendation, analysist training and guidance
- Analysis of microarray datasets, including mRNA (Affymetrix), SNP and micro-RNA
- Analysis of nCounter NanoString data

Proteomics data analysis

- Protein/Peptide identification and quantification from label-free and label-based tandem mass spectrometry data
- Post-translational modification analysis (PTM), such as phosphorylation
- Downstream bioinformatics analysis, such as differential expression analysis, pathway analysis, functional enrichment analysis and network analysis, involving finding pivotal proteins in the networks

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Genomic editing data analysis

- shRNA and CRISPR/Cas9 screen data processing
- Essential gene identification
- Identify genes for re-sensitizing drug treatments if the genomic editing is coupled with drugs

Metabolomics data analysis

- LC-MS data preprocessing, including quality control assessment of raw chromatograms, peak calling, retention time alignment and preliminary identification using MS2 data if available
- Interpretation of liquid-chromatography untargeted metabolomics datasets, which include relative abundances of a broad spectrum of polar and non-polar small molecules (< 1500 Daltons)
- Statistical analysis to identify biologically relevant metabolites
- Pathway enrichment analysis of relevant metabolites
- Integrative analysis of publicly available datasets (dbGaP, GEO, TCGA) using search parameters defined by the OSUCCC researchers
- Pathway analysis of results from sequencing and microarray data
- Custom bio-molecular data management, application development, deployment and support

Precision cancer medicine

- Integrating gene expression profiles, mutations and phenotype features to predict target, drug and biomarker in precision cancer medicine
- Identification of potential druggable targets
- Assessment of efficacy of drugs and associated biomarkers
- Application of novel algorithms to identify the key molecular mechanism, including mutation associated with disease progression, or drug resistance
  - Application of novel algorithms to predict drug response for either single drug or drug combinations in both in vitro and clinical setting (precision medicine) molecules (< 1500 Daltons)
  - Statistical analysis to identify biologically-relevant

Training and Workshops:

- Offer short one- or two-day workshops and seminars that cover various areas of bioinformatics and contain hands-on activities to help CCC researchers understand the process of data analysis and the interpretation of the results

Co-Directors: Lang Li, PhD, and Kevin Coombes, PhD

For more information about computational biology services, call 614-688-9721 or email Maciej.Pietrzak@osumc.edu.

go.osu.edu/bisr-bmi

Biospecimen Services

The Biospecimen Services Shared Resource (BSSR) supports cutting-edge translational research to advance the prevention, diagnosis and treatment of cancer.

The BSSR comprises three arms:

The first arm is a universal consenting and biobanking protocol, Total Cancer Care® (TCC). The TCC protocol includes a broad informed consent allowing for access to pathologic and clinical data for life, with the ability to recontact patients at any time for clinical follow-up and to offer participation in clinical trials for which they are eligible.

TCC allows for the collection of blood in conjunction with clinically indicated draws and remnant tissue from surgical procedures from patients 18 years of age and older, with and without cancer, who are seen at The James. The study of blood and tissue will help researchers find better ways to prevent, detect and treat cancer.

Plasma, serum and DNA, along with snap-frozen tissue, are stored for future research at the College of American Pathologists-approved BSSR biorepository located at Ohio State's Polaris Innovation Centre. Researchers may receive samples and data with subject identifiers with prior IRB-approval, or de-identified and coded-limited data sets without additional prior IRB approvals.

TCC is the single protocol used by the Oncology Research Information Exchange Network (ORIEN), which was formed through a partnership between the OSUCCC – James and Moffitt Cancer Center as a collaboration to accelerate cancer research discoveries that can translate to more effective clinical care. Using TCC, ORIEN will create a collaborative "rapid-learning" environment that will share de-identified patient data to hasten the development of targeted treatments and more quickly match eligible patients to clinical trials.

The second arm of the BSSR provides prospectively procured biospecimens from surgical procedures to OSUCCC investigators from all five OSUCCC research programs who are in need of pathology samples. Fresh (unfrozen) tissue procurement is available as needed through OSUCCC tissue procurement. Researchers may receive samples and data with subject identifiers with prior IRB-approval. Samples are processed according to protocol.

Arm three of the BSSR provides biospecimen processing and banking services to investigators for IRB-approved and grant-funded projects, including SPOREs, P01s, R01s and statewide Pelotonia-funded initiatives.

Access to biospecimen and data from the TCC arm is available by entering a request in REDCap. To access tissue procurement and biorepository services, an order should be created in eRAMP. The BSSR operates according to best-practices standards, including the NCI Best Practices, International Society for Biological and Environmental Repositories and the College of American Pathologists Biorepository Accredita¬tion Program. The BSSR maximizes the value of and access to annotated biospecimens, promoting both basic and translational research.

Contact Information:

Arm 1 – TCCP
Director: Heather Hampel, MS
For general TCC questions and protocol coordination:
Heather Hampel, MS
2012 Kenny Road, Room 257
614-293-7240
Heather.Hampel@osumc.edu

Nancy Single, PhD
1590 N. High St., Suite 535
614-293-7516
Nancy.Single@osumc.edu

For specimen and data access:
Laura Monovich, MBA
590 N. High St., Suite 525
614-293-3675
Laura.Monovich@osumc.edu

Arm 2 – Prospectively Procured Biospecimen Samples
Scott Scrape, MD
Sandy Banky, PA
N343 Doan Hall, 410 W. 10th Ave.
614-366-1579
Scott.Scrape@osumc.edu

Arm 3 – BSSR Biorepository
Jason Bacher, BA
Polaris Innovation Centre
2001 Polaris Parkway
614-366-7993
Jason.Bacher@osumc.edu

Biostatistics

The Biostatistics Shared Resource (BSR) offers cancer investigators responsive and expert planning, design and analysis support for unfunded studies. Utilizing BSR services, researchers from the OSUCCC – James can collaborate on all facets of study design, data management and statistical analysis of clinical, epidemiological, public health and laboratory research data. These BSR efforts have resulted in funded biostatistics support for numerous new and renewed programmatic grants as well as a large number of R awards.

BSR is staffed by members of The Ohio State University Center for Biostatistics' Division of Biostatistics in Ohio State's College of Public Health. All BSR members obtain grant funding predominantly through their collaborations with cancer center investigators, and most have developed long-term collaborative relationships with OSUCCC – James investigators.

SERVICES

Study Design and Planning

The most frequent BSR activities involve study design and planning, especially in preparation of grant proposals. Biostatisticians collaborate with OSUCCC – James investigators in the formulation of hypothesis-testing strategies that are consistent with specific aims, statistical analysis approaches that avoid ambiguities and sample size estimation and re-estimation procedures that ensure aims are achieved.

Clinical, Population-Based and Laboratory Research Support

The BSR works with OSUCCC – James principal investigators on clinical trials conducted in cancer prevention, detection, diagnosis and treatment. Our biostatisticians are involved early in the planning and design of these trials and provide oversight and data analysis for the ongoing studies. All phases of clinical trials are supported through the BSR, including pilot and feasibility studies. Our collaborations with lab investigators are designed to enhance the separate processes of hypotheses-testing and discovery through detailed discussions of the background science, optimal designs and analytic strategies. Our biostatisticians are also involved and have expertise in observational and population-based studies.

Some areas of expertise include:

- Hypothesis testing strategies
- Interim analyses for safety and utility
- Adaptive designs for both small and large trials and for animal experiments
- Data display methods for secondary analyses
- Selection of primary outcomes
- Sample size calculations, including sample size re-estimation
- Complex modeling
- Propensity score matching

Biostatistics (continued)

High Dimensional Design and Data Analysis

Several biostatisticians in the BSR provide support for design and analysis of high-dimensional data, including GWAS, sequencing, microarray, NanoString, Ingenuity Pathway Analysis, proteomics and pharmacogenomics. Because of the complexities of these analysis and the ambiguities about best practices, we make every effort to use the most advanced statistical methods and are engaged in methods research with a focus on developing reliable and revealing methods with small sample sizes. High-dimensional methods research includes:

- Methods for sample size calculations
- Optimal methods for variance (noise) smoothing
- Data filtering and normalization
- Control of expected false discoveries
- Validation designs and methods
- Likelihood-based methods
- Data visualization methods
- Hypothesis-driven approaches

Director: Soledad Fernandez, PhD

For more information on services offered through the Biostatistics Shared Resource, call 614-293-6899 or email biostatistics@osumc.edu or visit biostatistics.osu.edu.

go.osu.edu/BSR

Clinical Translational Science

The Clinical Translational Science Shared Resource (CTSSR) team works closely with clinical and translational scientists on the design and development of customizable portfolio validation assays to provide the most innovative correlative science studies associated with early-phase solid tumor oncology clinical trials. The mission of the CTSSR is to facilitate the translation of basic science oncology research to the clinical setting and vice-versa, with the ultimate intention of improving diagnosis and treatment strategies for patients with cancer.

The primary goals of the CTSSR are to:

- Work closely/collaboratively with investigators to develop and manage a strategic correlative science plan for clinical trials; provide consultation, navigation services, project management and guidance to investigators related to assay development and analysis for clinical trials
- Serve as consultative project management and central laboratory providing support for short-term needs for correlative science and other testable hypotheses
- Provide project management for studies that utilize resources available through other OSUCCC – James Shared Resources, investigator laboratories and outside vendors
- Develop a customizable portfolio of validated assays not available in other Shared Resources
- Identify and help develop strategic partnerships between clinical investigators and appropriate pharmaceutical/ biotech companies to gain greater access to new drugs/compounds

The primary goals of the CTSSR are to:

- Clinical Sample receiving, processing (PBMC, plasma, buffy coat isolation), storage and distribution
- Automated DNA, RNA, miRNA purification from cells, blood, FFPE or fresh frozen tissue samples
- Circulating nucleic acid (DNA, miRNA) purifica¬tion from plasma, urine and other bodily fluids
- Absolute quantification of target DNA or RNA molecules using EvaGreen® or TaqMan probes on the QX200 Droplet Digital PCR System
- In collaboration with SR and partnering laboratories, develop Targeted, Whole Exome (WES) and Whole Genome DNA sequencing on FFPE-derived DNA poly(A)-selected, Ribo-depletion or captured-based RNA-Seq library preparation

Consultation:

- Identification of relevant laboratory correlates
- Generation of correlative science sections for LOIs and protocols
- Budget development
- Development of lab manuals, SOPs and validation documents
- Cell culture, maintenance, passage storage and mycoplasma testing
- Drug efficacy analysis using in vitro model system, for example, cytotoxicity assay, IC50 value detection, drug combination assessment and growth inhibition assays
- Pilot data generation using molecular assays (cell culture, cell migration, invasion, growth, western blot)
- Target/Biomarker validation
- Immunohistochemistry and immunofluorescence assays
- Immunoassay, cytokine profiling using MAGPIX® by Luminex
- Mitochondrial respiration, glycolysis, cellular metabolism function in cultured cells and ex-vivo samples using the Seahorse XFe24 Analyzer

- Data analysis
- External partnership
- Strategic translational assay development
- Planning, identifying, and onboarding Ohio State/ external resources for a trial or a project

Director: Pravin Mishra, PhD

Laboratory Manager: Rajbir Singh, PhD

For more information about services available through the STTS resource, email Pravin.Mishra@osumc.edu or Rajbir.Singh@osumc.edu.

460 Biomedical Research Tower

go.osu.edu/STTS

Clinical Treatment Unit and the Clinical Trials Processing Laboratory

The Clinical Treatment Unit and the Clinical Trials Processing Laboratory (CTU/CTPL) Shared Resource enables investigators at the OSUCCC – James to conduct successful phase I through phase III clinical translational research in a methodologically sound, expedient and cost-effective manner.

The CTU, an ambulatory phase I unit at the OSUCCC – James, specializes in treating early clinical trial patients who require intense monitoring or complex correlative sample collection and processing.

The CTPL enhances research quality by providing dedicated staff for high-volume procurement, processing, storage, delivery and shipment of research specimens critical to the correlative studies component of OSUCCC – James clinical trials.

SERVICES

- Protocol review and consultation
- Specialized clinical staff with research training
- Budget preparation
- Specimen collection kit storage, preparation and labeling
- Specimen procurement, processing and storage
- Specimen shipment
- Specimen chain of custody documentation for protocol compliance
- 24/7 electronic temperature monitoring of freezers and refrigerators by Rees Scientific
- Correlative specimen in-service
- Pre-study and study support activities

The CTPL procures, processes and stores research specimens collected within the CTU, other ambulatory and inpatient units within the OSUCCC – James, Brain and Spine Hospital, Martha Morehouse Outpatient Care and Stefanie Spielman Comprehensive Breast Center.

Director: Gregory Otterson, MD

For more information about services offered through the CTU/CTPL, call Megan Jukich at 614-293-3038 or email Megan.Jukich@osumc.edu.

460 W. 10th Ave., Room B502

go.osu.edu/CTPL

Comparative Pathology and Digital Imaging

The Comparative Pathology and Mouse Phenotyping Shared Resource (CPMPSR) provides expert, affordable, experimental pathology support to OSUCCC – James members who utilize animal models to study human disease.

The CPMPSR comparative pathologists are experts in normal anatomy and physiology as well as back-ground age- and strain/breed-related lesions, infectious pathogens and husbandry practices of various animal models, all of which may influence preclinical studies. CPMPSR pathologists interpret hematological, biochemical and morphological changes resulting from genomic alterations and experimental manipulations, and correlate the findings with disease processes in various species. Lesion recognition and interpretation within individual investigations provide a critical component to research that incorporates animal models. The CPMPSR offers a full array of pathology services, and can tailor its support to the needs of a client.

SERVICES

- Animal blood and other biofluid analyses, including hematology, biochemistry and cytologic evaluations
- Macroscopic and microscopic examination of full tissue sets from various species of laboratory animals
- Necropsies, biopsies and embryo and slide evaluations
- Preclinical efficacy and toxicity studies
- Phenotypic characterization of genetically engineered mice
- Comprehensive histology services on frozen and paraffin-embedded animal and human tissues
- Histochemical, immunohistochemical and immunofluorescence staining
- Tissue microarray and transmission electron microscopy grid preparation
- Whole-slide digitization, quantitative image analysis and machine learning
- Hands-on training for necropsy technique and sample submission
- Animal model development, experimental design and data interpretation
- Grant, presentation and manuscript preparation

Director: Krista La Perle, DVM, PhD, Dipl. ACVP
Co-Director: Anil Parwani, MD, PhD, MBA
Associate Director: Sue Knoblaugh, DVM, Dipl. ACVP

For more information about services offered through the Comparative Pathology and Digital Imaging Shared Resource, email CPDISR@osu.edu or visit vet.osu.edu/CPDISR or cancer.osu.edu/for-cancer-researchers/resources-for-cancer-researchers/shared-resources/comparative-pathology-and-digital-imaging. Online sample submission, fiscal approval and result reporting can be reached at eramp.osumc.edu.

Main Lab: 467/471 Veterinary Medicine Academic Building, 1900 Coffey Road, 614-247-8122
Animal Histology: 302 Goss Lab, 1925 Coffey Road, 614-292-3327

go.osu.edu/CPMPSR

Flow Cytometry

The Flow Cytometry Shared Resource (FCSR) provides comprehensive services for any and all needs of OSUCCC members involving cell immunophenotyping and cell sorting. OSUCCC members enjoy priority access to technical and scientific training for instrumentation usage, experimental design, troubleshooting and optimization on state-of-the-art equipment maintained at the highest QC/QA standards.

The FCSR is supported by the OSUCCC as a crucial shared resource central to the research goals of all scientific programs in the OSUCCC. Investigators work with FCSR staff in a collaborative fashion to achieve their research objectives and drive the development of innovation for both instrumentation development and use as well as for novel experimental methodologies continually under development.

The FCSR supports OSUCCC member training at all levels, from undergraduate to principal investigators, to continually build the foundation and expansion of knowledge and skills related to flow cytometry. The FCSR staff is routinely engaged as collaborators in OSUCCC member research projects and is recognized for these efforts by co-authorship on high-impact factor publications and for assistance in preparing data and material for new funding opportunities to assist the acquisition of new funding for cancer research.

SERVICES

- Support and access for all OSUCCC needs related to analytical cytometry (Cytek Northern Lights, BD LSRII and Fortessa) and cell sorting (BD FACSAria I and II) on a 24/7/365 level
- Assess up to 28 biomarkers simultaneously using spectral cytometry analytical instrumentation and sort up to 15 biomarkers with equipment configured to meet the recommended guidelines of the International Society of Analytical Cytometry to meet BSL2+ conditions if needed
- Specialized services for imaging cytometry (Amnis Imagestream) that images single cells in flow to gain signal localization information while simultaneously performing traditional flow cytometry measurements
- The capability to measure very small particles (NanoSight) from 3 nanometers to 1 micron to assess extracellular vesicles, protein aggregation, drug delivery particles and virus counting
- Scientific seminars, cancer-specific meetings, instrumentation overviews, application workshops and full-day training sessions for researchers to learn to use and apply flow cytometry
- Lab focused-training and troubleshooting upon request for personalized support as needed

Co-Directors: Bei Liu, MD, MPH, and Kevin Weller
Lab manager: Bryan McElwain, MS, MBA

To contact the FSCR leadership, email Bei.Liu@osumc.edu and Kevin.Weller@osumc.edu.
To contact the facility, call 614-292-3569 (FLOW) or email Bryan.McElwain@osumc.edu .

1055/1063 Biomedical Research Tower, 460 W. 12th Ave.

go.osu.edu/ACSR

Genetically Engineered Mouse Modeling

Mouse modeling is a powerful tool—highly effective for elucidating disease mechanisms and interrogating novel experimental therapeutics. Not to mention, the use of mouse models adds to the significance of a study, strengthens grant proposals and increases chances to secure funding. The Genetically Engineered Mouse Modeling Core (GEMMC) is a shared resource available to all investigators on the Ohio State University campus who currently work or intend to work with mouse models of human diseases.

The GEMMC team has extensive experience both in generating and in maintaining genetically engineered mouse lines. This shared resource is able to efficiently create mutant mouse lines routinely using CRISPR/Cas9 on a C57Bl/6 pure background. However, other genetic backgrounds can be used at the investigator's request.

The team can also assist in producing classical transgenic lines by pronuclear injection of DNA and targeted lines (knock-out, knock-in, conditional) by embryonic stem cell technology. It also offers a full array of ancillary services, including sperm or embryo cryopreservation, rederivation and in vitro fertilization.

The GEMMC's director and staff are always available to help investigators with minimal experience who would like to start using mouse models to complement and strengthen their in vivo studies or grant proposals.

SERVICES

- GEMM line generation by CRISPR/Cas9
- Gene targeting to generate ES cells with desired mutation
- Blastocyst microinjection to generate chimeras
- Transgenic line generation by pronuclear injection
- Sperm cryopreservation
- Embryo cryopreservation
- Rederivation of mouse lines by in vitro fertilization
- Rederivation of mouse lines by embryo implantation
- Consultation and grant support letter, provided at no cost

Director: Vincenzo Coppola, MD

For more information about the Mouse Modeling Shared Resource, call: 614-688-8838 or email Vincenzo.Coppola@osumc.edu.

Director's Office: 988 Biomedical Research Tower, 460 W. 12th Ave.

go.osu.edu/GEMMC

Genomics

SERVICES

The Genomics Shared Resource (GSR) provides a centralized, comprehensive resource of high-throughput genomics technologies to OSUCCC – James researchers. Additionally, the GSR provides consultation and assistance in experimental design, troubleshooting, training and development of novel methodologies.

LIBRARY GENERATION FOR NEXT-GENERATION SEQUENCING SERVICES

Automated NGS library generation

- Agilent Bravo robotic instrument: Illumina TruSeq RNA, Illumina TruSeq Exome and Agilent SureSelect XT and Haloplex probe libraries
- PerkinElmer Sciclone robotic instrument
- BioMek i7: NEBNext Ultra II, IDT xGen, KAPA library quantification

Single Cell Sequencing

- Chromium 10X Genomics single cell libraries (3' and 5' mRNA, Genomic VDJ, ATAC-Seq)
- "Plate-Seq" – single cell and limited cell libraries using Formulatix Mantis and TTP Mosquito microfluidics systems and Takara SMARTeR HT and Nextera XT kits

Manual NGS library generation:

Whole Genome/Exome: Twist exome panel (mouse and human) KAPA HyperPrep, NEBNext Ultra II FS, Agilent XT HS, Nextera XT

- Transcriptome: Illumina TruSeq stranded, NEBNext Ultra II Whole Transcriptome, Directional RNA and small RNA-seq, QIAseq smRNA-seq Libraries, Clontech SMARTer v4 and pico
- Target Enrichment: Adaptive Bio, IDT xGen, IDT CNV, Agilent SureSelect XT HS, NEBNext Direct, HaloPlex probe libraries
- Library Quantification: KAPA Library Quantification of Illumina

Other instrumentation for library preparation

- Covaris sonicator (available for user signup)
- gentleMACS Octo Dissociator

NEXT-GENERATION SEQUENCING

Next-generation sequencing and high-throughput data generation are offered through the lab at Nationwide Children's Hospital (NCH). The shared resource at NCH has expertise in multiple aspects of genomics analysis, including consultation and assistance with experimental design, quality control of starting material (DNA or RNA), next-generation sequencing and basic data processing.

- Illumina NovaSeq (two instruments): Read lengths 50-300 bp; variety of flow cell options, max output of 3000 GB/run enabling 48 human genomes in a two-day instrument run
- Illumina HiSeq 4000 (two instruments): 900 GB per flow cell benchtop systems
- Illumina MiSeq (three instruments): 15 GB of 2 x 300 bp reads in 40 hours
- Illumina I-Seq (one instrument): 1.2 GB of 2 x 150 bp reads in 24 hours
- Illumina MiniSeq (two instruments): 7.5 GB of 2 x 150 bp reads in 24 hours
- Long-read data generation
- PacBio Sequel

SANGER SEQUENCING

- Sanger sequencing and genotyping: Applied Biosystems 3730xl (two instruments)
- Capillary electrophoresis DNA sequencing
- Sequencing of bisulfite-treated DNA for DNA methylation analysis
- SNP genotyping, relative fluorescent quantification (LOH), microsatellite analysis
- Cell line verification (human only) by microsatellite genotyping
- SHAPE analysis (Selective 2'-Hydroxyl Acylation of RNA analyzed by Primer Extension)

HYBRIDIZATION-BASED METHODS

- Affymetrix microarrays for RNA expression profiling (Clariom D assay, Clariom S assay)
- nCounter system (NanoString Technologies) gene expression analysis (Pre-built Panels, Virtual Panels, Custom CodeSets), miRNA expression analysis (human, mouse, rat pre-designed panels), DNA assay (CNV and SNP assays), nCounter Human Karyotype Panel, customized nCounter miRGE assay, nCounter single cell expression assays
- nCounter Digital Spatial Profiling (coming in mid-2021)

PCR METHODS

- Real-Time PCR (qPCR) (QuantStudio 5K and QuantStudio 12K Flex Systems) for gene expression (mRNA) analysis (TaqMan and SYBR® Green assays), microRNA and noncoding RNA analysis, genetic variation analysis (SNP, CNV), TaqMan mutation detection assays (castPCR), TaqMan protein assays, digital PCR
- Biomark HD-Juno system for gene expression (mRNA) analysis (TaqMan and EvaGreen assays), microRNA and noncoding RNA analysis (TaqMan), genetic variation analysis (TaqMan SNP and CNV assays, Fluidigm SNPtype assay), TaqMan mutation detection assays (castPCR), TaqMan protein assays, digital PCR

QUALITY CONTROL

- Agilent 2100 Bioanalyzer and 2200 TapeStation – RNA integrity
- Agilent Fragment Analyzer – quality and quantity analysis of DNA or RNA samples
- Invitrogen Qubit Fluorometer – DNA/RNA Mass

LEADERSHIP

Co-Director: Amanda Toland, PhD

Co-Director: Richard K. Wilson, PhD

Technical Director at OSU: Pearlly Yan, PhD

Technical Director at NCH: Vincent Magrini, PhD

Co-Directors: Amanda Toland, PhD and Richard Wilson, PhD

For more information about services available through the Genomics Shared Resource please call 614-247-8185 or email Amanda.Toland@osumc.edu

For more information about high-throughput sequencing and library generation please call 614-685-9164 or email Pearlly.Yan@osumc.edu

For more information about services offered through the lab at Nationwide Children's Hospital please call 614-355-3530 or email Amy.Wetzel@nationwidechildrens.org or Vincent.Magrini@nationwidechildrens.org

go.osu.edu/GSR

Leukemia Tissue Bank

The Leukemia Tissue Bank Shared Resource (LTBSR) facilitates the successful translation of basic research in blood disorders to the clinical setting via an extensive repository of tissue samples and accompanying pathologic, cytogenetic and clinical data for ready correlation of clinical and biological results.

Committed to furthering translational research efforts for OSUCCC – James members and the cancer research community, the LTBSR provides investigators with training and technical support as well as procurement, processing, storage, retrieval and distribution of clinical research materials from patients with any hematologic cancer. In many cases, the LTBSR also serves as the central processing laboratory for local and multi-institutional trials for which the principal investigator is an OSUCCC – James member.

SERVICES

- A central collection, processing and state-of-the-art repository for samples collected from patients with any blood disorders being evaluated at the James Cancer Hospital and Solove Research Institute or treated on OSUCCC – James protocols
- Provides materials to investigators involved in collaborative studies with other researchers (at Ohio State or elsewhere) who examine the cellular, molecular and genetic properties of hematologic cancers and correlate these properties with clinical or population-based outcomes

An NCI-sponsored biorepository, the LTBSR has more than 80,000 vials of cryopreserved viable cells and 18,000 vials of matched frozen plasma and/or serum samples from more than 6,500 patients treated for leukemia and other hematologic malignancies.

Director: Lapo Alinari, MD, PhD

Laboratory Supervisor: Chris Manring

For more information about the Leukemia Tissue Bank Shared Resource, call 614-292-5888 or email Lapo.Alinari@osumc.edu or Christopher.Manring@osumc.edu

326 Tzagournis Medical Research Facility, 420 W. 12th Ave.

go.osu.edu/LTBSR

Medicinal Chemistry

The Medicinal Chemistry Shared Resource (MCSR) integrates the expertise of multiple disciplines, including synthetic and process chemistry, instrumental analysis, chemical biology and molecular pharmacology, to provide medicinal chemistry support to investigators at the OSUCCC – James as well as at other academic and commercial institutions.

The goal of the MCSR is to provide investigators with many different aspects of medicinal chemistry service, including chemistry consultations, designing and synthesizing new molecules of biological interest, sample purity analyses and custom syntheses of known agents. In collaboration with other OSUCCC – James Shared Resources, the MCSR aims to translate basic science findings from investigators into small-molecule agents for testing individual hypotheses, adding an important dimension in translating basic science to the clinic.

SERVICES

- Consultation and general medicinal chemistry service: MCSR works with investigators to design new derivatives of a lead structure with the goal of improving biological properties such as potency, efficacy and bioavailability. We can also scale-up agents to support more in-depth studies, such as in vivo efficacy and pharmacokinetic/pharmacodynamics studies. If mechanistic probes are needed, MCSR collaborates with investigators to design and synthesize tool molecules for probing biological pathways.
- Custom synthesis of agents not available from commercial sources: chemists of the MCSR consult with interested investigators regarding the synthetic feasibility of the requested agents and carry out the synthesis if deemed feasible.
- Commercially available small molecules: The MCSR consults with investigators regarding the chemical stability, commercial sources and purity of chemical agents available from vendors. It also conducts nuclear magnetic resonance spectrometry and mass spectrometric analyses when the identity and/or purity of a chemical agent is in question.
- Developing services: We are currently renovating laboratory space in Parks Hall that will allow us to enhance our capabilities in chemical synthesis and add new services for small molecule screening. We will in the future offer access to libraries of diverse small molecules, high-content screening using imaging and flow cytometry and luminescence-based high-throughput screening of these libraries against biological pathways and proteins. We anticipate offering these new services in summer 2021.

Co-Directors: Chad Bennett, PhD, and Blake R. Peterson, PhD
Sr. Chemist: Sandip Vibhute, PhD
Research specialist: Tyler Wilson, PhD

For more information about the Medicinal Chemistry Shared Resource, call 614-685-9230 or email Chad.Bennett@osumc.edu or Peterson.1119@osu.edu.

436A Biomedical Research Tower, 460 W. 12th Ave.

go.osu.edu/MCSR

Microscopy

The Microscopy Shared Resource (MSR), part of the larger Campus Microscopy and Imaging Facility (CMIF) under The Ohio State University Office of Research, provides timely and high-quality services to support OSUCCC – James researchers with access to instrument, technical advice and training support on a variety of sophisticated microscopy approaches. The instrumentation is provided in a centrally organized facility located in the Biomedical Research Tower as well as in the Center for Electron Microscopy and Analysis (CEMAS) on West Campus. All microscopy equipment is available to OSUCCC – James researchers.

The MSR enhances the ability of OSUCCC – James researchers to perform cancer-related research using super-resolution, confocal, multiphoton, live-cell light microscopy and electron microscopy. The MSR also has specialized instrument for preparing biomedical samples for various forms of microscopy.

SERVICES

- 24 hour a day, seven day a week access to microscopes and instruments for qualified researchers
- Customized training for independent microscope use
- Cryo-ultramicrotomy of tissues and cells for observation by light and electron microscopy
- Sample preparation services for transmission electron microscopy (TEM) and scanning electron microscopy (SEM)
- TEM for the examination of ultra-thin sections of cells or tissues and negatively stained nanostructures
- SEM through collaboration with CEMAS that provides high-resolution digital images of sample surfaces, including biofilms, cultured cells and tissues
- Cryo-TEM in collaboration with CEMAS for high-resolution imaging of cryo-protected tissues and nano-structures
- Wide-field fluorescence and bright-field microscopy to examine tissues and cells prepared using fluorescent and chromogenic stains
- Confocal microscopy to visualize fluorescently expressed or labelled cells and tissues in three dimensions
- Live-cell confocal microscopy of cultured cells and tissues
- Spectral separation of fluorescence signals using spectral unmixing microscopy
- Multi-photon excitation imaging (MPE) with the potential for live animal imaging in collaboration with the Small-Animal Imaging Facility
- Collagen detection using second-harmonic generation (SHG) detection with MPE and polarized microscopy
- Super-resolution microscopy with TIRF, SIM and STORM functions
- Access to and training with image analysis software including Imaris (Bitplane), FluoView (Olympus), Elements (Nikon) and ImageJ (NIH).

Co-Directors: Allan Tsung, MD; Paul Stoodley, PhD; Richard Fishel, PhD

Associate Director: Tong Zhang, PhD

For more information, contact 614-292-9786 or weinberger.12@osu.edu.
245 Biomedical Research Tower, 460 West 12th Ave.

cmif.osu.edu

Nutrient and Phytochemical Analytics

The Nutrient and Phytochemical Analytic Shared Resource (NPASR) provides OSUCCC – James and other investigators with expert bioanalytical quantitative analysis, targeted/untargeted metabolomics and lipidomics capabilities.

The NPASR develops liquid chromatography-mass spectrometry (LCMS) methods to quantitatively determine nutrients and phytochemicals in foodstuffs as well as to identify these compounds and respective metabolites in biological samples from human clinical trials, animal models and cell culture experiments. The NPASR personnel are specialists in the field of analytical chemistry, with extensive experience examining the bioavailability, metabolism and physiological significance of a variety of phytochemical classes including carotenoids, isothiocyanates, polyphenolics and isoflavones. Metabolomics and lipidomics experiments take a broader view and can reveal novel biomarkers for validation and metabolic phenotyping.

NPASR houses four UHPLC/photodiode array/tandem mass spectrometry systems delivering both qualitative and quantitative results. Our multidimensional analysis combines chromatography, UV-vis and MS/MS features for confident compound detection. Accurate mass capabilities (QTOF) support untargeted metabolomics experiments and compound identification. Ion mobility-MS enables our targeted lipidomics platform, while supercritical fluid chromatography-QTOF MS allows us to conduct untargeted lipidomics experiments.

SERVICES

- Targeted LCMS of phytochemicals and their human metabolites
  - Anthocyanins, isoflavones, glucosinolates/isothiocyanates, carotenoids/cleavage products, urolithins, polyphenols, phenolic acids, glycoalkaloids/alkaloids, ellagitannins, procyanidins, ellagic acid derivatives
  - Vitamin Status – Vitamins A, C, E, D (25OHD)
- Targeted MS Lipidomics (>1,000 lipids), Oxylipins
  - Plasma, cell culture, tissues
- Targeted and untargeted LCMS metabolomics
- Custom targeted LCMS method development

Co-Directors: Steven Clinton, MD, PhD and Devin Peterson, PhD
Technical Director: Ken Riedl, PhD
Lab Services Coordinator: Jenny Panescu
NPASR Co-Directors: Drs. Steven Clinton (Medical Oncology) and Devin Peterson (FST)

For more information, email Ken Riedl at Riedl.7@osu.edu. To schedule service, email Jenny Panescu at Panescu.1@osu.edu.

260 Parker Food Science and Technology Building, 2015 Fyffe Court 614-292-4069

Pharmacoanalytical

The Pharmacoanalytical Shared Resource (PhASR) supports preclinical and clinical drug development at the OSUCCC – James by providing high-quality and cost-effective bioanalytical assay development, quantitative sample analysis and experimental design, data analysis and modeling for pharmacokinetic and pharmacodynamic studies.

SERVICES

PhASR offers these services:

- Quantitative analytical assay development and validation for small molecule, peptide and protein therapeutics using liquid chromatography-tandem mass spectrometry (LC-MS/MS) or enzyme-linked immunosorbent assays (ELISAs)
- Sample analysis for quantification of drugs (small molecule, peptide and protein thera¬peutic agents) and metabolites in biological samples
- Experimental design for pharmacokinetic and pharmacodynamic studies
- Analysis and modeling of pharmacokinetic and pharmacodynamic data

PhASR also offers additional services based on the methodological needs of the OSUCCC – James members:

- Quantification of endogenous compounds, including small molecules, peptides and proteins
- Quantification of oligonucleotide therapeutics
- Drug binding and transport

Director: Mitch Phelps, PhD

For more information about services available through the Pharmacoanalytical Shared Resource email phasr@osumc.edu.

441 and 436 Biomedical Research Tower, 460 W. 12th Ave.

go.osu.edu/PhASR

Proteomics

The Proteomics Shared Resource (PSR) is a joint venture between the OSUCCC – James and the Campus Chemical Instrumentation Center that supports high-quality cancer research by providing technical expertise and state-of-the-art instrumentation to the OSUCCC and the Ohio cancer research community. The PSR provides expert consulting, sample preparation, advanced protein and metabolite identification, spatial imaging, peptide characterization and comparative quantitation services to support and enhance cancer research at Ohio State.

Sample preparation and support services provided by the PSR include early project planning and consulting, protein expression/purification and protein extraction from cells, tissue or other biological media along with protein quantitation. PSR supports investigators by assisting labs with method development optimization for protein purification, immunoprecipitation and SDS PAGE.

Advanced instrumentation available to investigators in PSR include a modern Bruker ultrahigh resolution 15T FT-ICR, four Thermo Orbitraps, Bruker timsTOF Pro, Bruker MALDI-TOF-TOF, Agilent QTOF and Thermo Quantiva triple quadrupole (QQQ) instruments. High-resolution mass spectrometers are equipped with modern separations systems for high-depth, high-coverage proteomics analysis.

- The Bruker timsTOF Pro provides the highest sensitivity and scan speeds of any instrument, which facilitates the challenging clinical proteomics experiments.
- Alternative fragmentation modes (ETD and HCD) are available on the Orbitrap Fusion to facilitate informative tandem MS/MS fragmentation to facilitate peptide sequence characterization.
- The PSR state-of-the-art 15T FT-ICR mass spectrometer provides ultra-high resolving power and mass for unambiguous chemical formula identification of small molecules, small molecule MALDI imaging, metabolomics and lipidomics.
- The Quantiva triple quadrupole and Agilent QTOF instruments are used for custom metabolomics services in collaboration with the Nutrient and Phytochemical Analytics Shared Resource (NPASR) and targeted protein quantitation by MRM.
- The Bruker MALDI-TOF-TOF and the FT-ICR are used for mass spectrometry MALDI imaging services to visualize the distribution of proteins, lipids and small molecules in tissues, tumors, xenografts, cell cultures and organoids.

Proteomics (continued)

SERVICES

Please contact Dr. Wysocki, Dr. Freitas, Dr. Somogyi, Dr. Zhang, Dr. Harvey or Dr. Reed for full project consultation.

- Expert consultation on proteomics experiment design
- Training and workshops
- Cell lysis
- Protein quantitation
- Phosphorylation enrichment
- Protein purification
- 1D gel (mini gels 8 x 10 cm) and large format (20 x 24 cm)
- Coomassie stain, Sypro ruby or deep purple stain, silver stain
- Protein ID – LC-MS/MS
- 2D LC-MS/MS proteomic analysis
- Modification analysis (PTM or mutation)
- Protein complex identification from IP
- Label-free quantitation
- Proteomics quantitation via TMT and SILAC
- Targeted and untargeted metabo¬lomics
- Top-down mass spectrometry and native MS
- MALDI mass spectrometry small molecule/ protein tissue imaging

Co-Directors: Michael Freitas, PhD, and Amanda Hummon, PhD

For information about services available through the Proteomics Shared Resource, email Liwen Zhang, Sophie Harvey or Andrew Reed (zhang.287@osu.edu; harvey.486@osu.edu or reed.1287@osu.edu).

250 Biomedical Research Tower, 460 W. 12th Ave.

go.osu.edu/PSR

Recruitment, Intervention and Survey

The Recruitment, Intervention and Survey Shared Resource (RISSR) provides services to support behavioral, epidemiological and non-therapeutic clinical research at the OSUCCC.

SERVICES:

- Research design: Assist with finalizing study design, including measures selection consistent with research aims and hypotheses, the development of recruitment and data collection plans and staff training
- Population-based data retrieval: Assist investigators in locating, accessing, retrieving and interpreting population-based data on cancer incidence, mortality, survival and cancer-related behaviors (e.g., OCCIS, SEER, BRFSS) for grant applications or research papers
- IRB/Regulatory: Assist with Clinical Scientific Review Committee submissions, Institutional Review Board (IRB) submissions, amendments, continuing IRB reviews and other regulatory oversight
- Participant recruitment and retention:
  - o Complete participant recruitment and consenting (e.g., electronic; in-person).
  - o Collaborate with staff from the Center for Cancer Health Equity to recruit participants who are representative of the target populations (e.g., race, age)
  - o Develop and periodically analyze retention procedures to maximize adherence to study requirements and completion
- Data collection (qualitative and quantitative) and management:
  - o Develop data collection forms using technology (e.g., REDCap) for use in varying modes of administration (e.g., electronic, interviewer-based, scannable)
  - o Recruit and/or facilitate focus groups, conduct semi-structured interviews, transcription and complete reports of resulting data
  - o Provide periodic analyses of data collection methods to ensure optimal procedures, perform quality control checks and implement changes in procedures as required to meet study goals.

Sr. Faculty Advisor: Michelle Naughton, PhD

Director: For more information on services available through the Recruitment, Intervention and Survey Shared Resource, call Heather Aker at 614-293-7846 or email Heather.Aker@osumc.edu.

1590 N. High St., Suite 525

go.osu.edu/RISSR

Small Animal Imaging

The Small Animal Imaging Shared Resource (SAISR) is an imaging facility available to investigators at the OSUCCC – James as well as at Ohio State and other academic and commercial institutions.

SAISR houses high-resolution imaging equipment, an X-ray therapeutic system, a body composition analyzer and X- and γ-irradiation. Its professionals are experts in the imaging modalities and small animal handling procedures as well as in analytical software support for quantitative image analysis.

The SAISR offers on-site suites for surgical procedures and animal care provided by the University Laboratory Animal Resources. Image reconstruction, multimodality fusion, high-resolution graphics and networking to the facility's server are also available to investigators using this Shared Resource.

SERVICES

SAISR offers these services:

- High-resolution image data acquisition: micro-CT, micro-MRI, high-frequency ultrasound, optical imaging (bioluminescence and fluorescence)
- CT and therapeutic-localized X-Ray, X- and γ-irradiation
- Body, tissue and biopsy composition analyzer
- Data interpretation
- Image post-processing and quantitative image analysis
- Consultation on design imaging studies
- Training and education

Director: Kimerly Powell, PhD

For more information about the Small Animal Imaging Shared Resource, email: DHLRI-SAIC@osumc.edu or call 614-292-7271 \ email Kimerly.Powell@osumc.edu

204 Biomedical Research Tower, 460 W. 12th Ave.

go.osu.edu/SAIC

Targeted Validation

The Targeted Validation Shared Resource (TVSR) assists investigators in generating reliable proof-of-concept preclinical mouse model data for grant applications, publications and IND applications for the FDA.

Preclinical mouse models of cancer have become indispensable for in vivo target validation studies, such as determining in vivo efficacy of therapeutics, unraveling in vivo off-target effects of therapeutics including unexpected adverse side effects in a whole organism and elucidating significance of biological pathways toward disease initiation/progression. The TVSR assists investigators with these in vivo target validation studies.

We have expertise in conducting preclinical studies with GEMM (genetically engineered mouse models) and xenograft/allograft mouse models of cancer.

SERVICES

- Breeding programs for GEMM models of cancer
- Breeding programs for immune-compromised mouse strains (athymic nude and NSG [NOD-SCID-IL2γR])
- Xenografting and allografting of tissues and cells (subcutaneous, orthotopic and intraperitoneal) including PDXs (patient-derived xenografts)
- Administrating therapeutics via various routes (e.g., intraperitoneal, intravenous, oral gavage, subcutaneous, intramuscular)
- Monitoring animals post-administration of therapeutics (e.g., body weight, body score)
- Necropsy including tumor and other tissue harvest for downstream applications
- Tumor monitoring by standard caliper measurement and automated imaging system (TumorImager) for subcutaneous tumors or using other imaging modalities (the latter is conducted in collaboration with Small Animal Imaging Core (SAIC)
- Stereotaxic surgery instrumentation and expertise
- Consultation toward animal model development, experimental design and data interpretation
- Grant, presentation and manuscript preparation

Director: Reena Shakya, PhD

For more information about services offered, please reach us at (614)293-1675, or email Reena.Shakya@osumc.edu.

go.osu.edu/TVSR

Veterinary Clinical Research Support

The Veterinary Clinical Research Support (VCRS) Shared Resource, encompassing the Blue Buffalo Veterinary Clinical Trials Office and Biospecimen Repository, designs and conducts clinical trials in companion animals with spontaneous diseases to evaluate novel diagnostics and therapeutics. It collects biospecimens, such as tissue biopsies, serum, plasma and urine, in support of comparative research projects. The overriding goal of this resource is to advance the diagnosis and treatment of disease in veterinary patients while enhancing the health of humans through comparative and translational studies.

SERVICES

- Provides guidance for clinical trial design, including formulating a testable hypothesis, determining patient entry criteria, selecting appropriate toxicity assessments, reviewing appropriate statistical end points and developing an accurate budget
- Confirms compliance with applicable hospital, IRB and/or IACUC requirements
- Assists with an assessment to determine the risk of adverse events
- Reviews proposals prior to submission to funding agencies
- Establishes and maintains a network of regional specialists, veterinarians and breed clubs to assist with patient enrollment
- Provides education in GCP, GLP and the requirements of individual organizations sponsoring trials
- Oversees and verifies correct and complete data entry and compliance with established study guidelines
- Creates electronic data-capture instruments and CRFs in REDCap
- Provides a structured, centrally organized system of procurement and storage of biospecimens from patients
- Generates and manages a database supporting the annotation of samples to follow for outcome
- Provides biospecimens to Ohio State, Nationwide Children's Hospital and biotech industry communities for collaborative translational research

Director: Sarah Moore, DVM, DACVIM (Neurology)

For more information about the services offered through the Blue Buffalo Veterinary Clinical Trials Office, please visit our website at vet.osu.edu/vmc/cto, email cvm-clinicaltrials@osu.edu or make an appointment through the online BBVCTO service request.

0121 Veterinary Medical Center, 601 Vernon L. Tharp St.

go.osu.edu/VCRS

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Research reported in this publication was supported by The Ohio State University Comprehensive Cancer Center and the National Institutes of Health under grant number P30 CA016058.

We thank the XX* Shared Resource at The Ohio State University Comprehensive Cancer Center, Columbus, OH for XX**.

**Please specific which Shared Resource(s) were utilized.*

***Please describe the type of support provided by the Shared Resources (i.e. genotyping, mass spectrometry, biostatistical analysis).*

The James

THE OHIO STATE UNIVERSITY
COMPREHENSIVE CANCER CENTER

Biomedical Informatics

Biospecimen Services

Biostatistics

Clinical Translational Science

Clinical Treatment Unit and the Clinical Trials Processing Laboratory

Comparative Pathology and Digital Imaging

Flow Cytometry

Genetically Engineered Mouse Modeling

Genomics

Leukemia Tissue Bank

Medicinal Chemistry

Microscopy

Nutrient and Phytochemical Analytics

Pharmacoanalytical

Proteomics

Recruitment, Intervention and Survey

Small Animal Imaging

Targeted Validation

Veterinary Clinical Research Support

The James

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The Ohio State University Comprehensive Cancer Center –
Arthur G. James Cancer Hospital and Richard J. Solove Research Institute

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Columbus, Ohio 43210

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