School of Medicine
& Health Sciences
THE GEORGE WASHINGTON UNIVERSITY

Cores, Facilities, and Other Resources

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GW is a private, midsized research university with a main campus in the highly urban center of Washington DC. Founded in 1821 as Columbian College, the university has grown to contain 14 colleges and schools. The main GW campus is 43 acres in historic Foggy Bottom, only a few blocks from the White House. GW has 11,000 undergraduate and 15,000 graduate students enrolled at all locations. Home to traditional disciplines as well as more than 80 centers and institutes, our research spans science, technology, health, policy, global security, arts and humanities. The Foggy Bottom Campus contains most of the residential dormitories in which GW students live, as well as the GW Hospital, the medical school laboratories in Ross Hall, the Milken Institute School of Public Health, and the adjacent Science and Engineering Hall.

The George Washington University School of Medicine and Health Sciences (GW SMHS) was established in 1824, due to the need for doctors in the District of Columbia. The School of Medicine and Health Sciences has more than 3,000 faculty members, including 859 full-time and 2,165 limited-service members, who are committed to training the next generation of physicians and scientists. GW is one of three medical schools in the District of Columbia (the others are Howard and Georgetown), and is a large medical school with 728 total medical students. As described below, GW has embarked upon an ambitious plan to increase research and researchers, and is currently ranked #59 best medical schools in Research (US News & World Report, 2017).

Animal Behavior Core

The Animal Behavior Core is located in Ross Hall and is well equipped with sophisticated software to automatically record and analyze animal behavior. It allows trained users to perform various behavioral assays, including tests for motor activity (open field, ladder running), anxiety (elevated plus maze), social behavior, home cage behavior, and learning and memory (fear conditioning). The core has several rooms dedicated to different testing.

Animal Research Facility

https://research.gwu.edu/office-animal-research

The George Washington University Animal Research Facility (ARF) is the core or centralized laboratory animal support facility for the School of Medicine and Health Science (SMHS) and other University teaching and research programs using animals. The ARF is fully accredited by the Association for the Assessment and Accreditation of Laboratory Animal Care International (AAALAC) with continuous accreditation since April 1974. The modern 17,000 square foot facility is located primarily in Ross Hall and occupies facility housing and support space on five floors. The core is arranged in a vertical array with floors connected by a service elevator from the basement (B1) to floors 4, 5, 6 and 7. The facility also provides an examination and treatment room, quarantine, a diagnostic laboratory, isolation, cage sanitation, radiology, necropsy and a surgery suite.

The highly experienced and qualified ARF veterinary and laboratory animal care staff maintain eight species of research animals as well as multiple breeding colonies and provide animal care and technical support for the animal research community. The animal health care program is under the direction of a fully qualified veterinarian and managed by a facility manager who oversees the trained animal technicians. Animals in each room are observed daily for signs of illness by the animal technician responsible for husbandry. Routine veterinary medical care is provided to all animals by veterinary technicians under the direction of the attending veterinarian.

Bioinformatics Core

https://smhs.gwu.edu/isb/core-services
https://smhs.gwu.edu/mgpc/resources

The McCormick Genomics and Proteomic Center (MGPC) provides wet laboratory, proteomics and computational genomics support to GW researchers. The center's focus is to harness emerging, in-house genomic, transcriptomic, proteomic, and bioinformatics knowledge to build and test new biologically relevant hypothesis.

The Cancer Informatics Core pilot project (CIC-p) provides collaborative informatics support for cancer research, through guidance for software use and by acting as liaison for various NGS data services. **https://cancercenter.gwu.edu/research/cancer-informatics-core-pilot-cic-p**

MGPC provides a rigorous, collaborative research environment that can be harnessed by the research community at GW to expand the horizons of genomic and proteomic knowledge, to open new avenues in basic and translational cancer research, and to train the next generation of bright minds in cancer genome research.

The MGPC team has valid licenses for the following commercial software tools and databases:

- Geneious: A genome browser reference mapping and sequence assembly tool. Features include:
  - NGS Analysis and Genomics
  - Sequence and Chromatogram Analysis
  - Alignment and Tree Building
  - Molecular Cloning
  - Searching, Sharing, and Automation
- HGMD (Human Gene Mutation Database): A gold standard resource for comprehensive data on published human inherited disease mutations
- TRANSFAC (Transcription Factor Database): A tool that provides data on eukaryotic transcription factors, their experimentally-proven binding sites, consensus binding sequences and regulated genes
- Oncomine: Compute gene expression signatures, clusters, and gene-set modules, for extracting biological insights from the data
- MetaCore: A high quality biological systems content in context, producing essential data and analytical tools to accelerate scientific research
- Ingenuity® Pathway Analysis (IPA®): IPA is a powerful analysis and search tool that uncovers the significance of 'omics data and identifies new targets or candidate biomarkers within the context of biological systems. IPA may be used for the analysis, integration, and interpretation of data derived from 'omics experiments, such as RNA-seq, small RNA-seq, microarrays including miRNA and SNP, metabolomics, and proteomics.
- OriginLab: Data analysis and graphics software to make technical charts for scientists and engineers displaying 2D and 3D plotting, statistics, curve fitting, and peak fitting

Biomarker Discovery and Analysis facility
https://smhs.gwu.edu/neuroscience/core-facilities
Services in the Biomarker discovery and Analysis facility include: 1) Quantitative PCR that allow analysis of transcripts in a 384 well platform and provide high quality cDNA from tissues; 2) In situ hybridization on cryostat sections and access to a library of probes targeted to neural development and pathological conditions. Facilities include quantitative western blotting, luminescence and fluorescence microplate assays, primary cell culture and electroporation systems and a cell culture and ES cell facility.

Biorepository Core
https://smhs.gwu.edu/mitm-gwbiorepository/about
Founded in 1994 and operating under National Cancer Institute's Best Practices for Biospecimen Resources, the GW Biorepository assists researchers in the medical school by housing samples in the secured repository staffed with experienced biobankers and under the direction of the director. With more than 22 years of experience, the Director and staff oversee the integrity of over 100,000 biospecimens and clinical data, comprised of specimens related to HIV malignancies, neurology and cancer cases at GW, as well as individual GW investigator specimens.

Biostatistics Center
http://www.bsc.gwu.edu/bsc/index.php
The Biostatistics Center within the Milken Institute School of Public Health, serves as the coordinating center for large-scale multi-center clinical trials and epidemiologic studies. Established in 1972, the Center participates in major medical research programs of national and international scope under the auspices of NIH and other Federal agencies, frequently leading to major medical advances. In addition, the Center participates in population-based epidemiologic studies, and conducts grant-supported research in biostatistical methods. The Biostatistics Center is staffed by masters and doctoral level statisticians and computer systems analysts.

The staff has extensive experience and expertise in biostatistics, epidemiology, clinical trial study design and data management, and administration and coordination of multi-center research studies.

The Biostatistics Center's primary objective is to provide statistical leadership for the design, execution, and analysis of multi-center clinical trials and epidemiologic investigations. The team ensures that studies are of the highest scientific integrity and meet rigorous biostatistical standards.

Activities of the Biostatistics Center:

- Statistical methods: The Biostatistics Center is instrumental in the evaluation and development of new statistical methods to meet the unique needs of planned or ongoing investigations and the application of state-of-the-art statistical methods is required to ensure that collaborative clinical trials and epidemiologic studies meet rigorous scientific and biostatistical standards.
- Study design: The Biostatistics Center participates in the statistical design of all types of medical investigations including multicenter therapeutic and intervention clinical trials, and epidemiologic cohort and case-control studies. Principal activities include protocol preparation, sample size evaluation, generation of randomization sequences and the implementation of quality assurance programs.
- Data management: The Center has established procedures for all aspects of data management for the projects in which it participates to ensure that the data which is analyzed and reported in scientific publications is of the highest quality. Data management activities include forms design (and revision), centralized and distributed data entry procedures (with verification), extensive computerized data editing, computerized updating of corrections to master files, and organization of summary data files for specific statistical analyses.
- Statistical analysis and publications: The Center performs state-of-the-art statistical analyses of study results in order to address the scientific objectives of each study. These results are used as the basis for the development of scientific manuscripts for publication. Periodically during each study, interim analyses are also performed to protect the welfare of patient participants.

Biostatistics and Epidemiology Consulting Service (BECS)
https://publichealth.gwu.edu/projects/biostatistics-and-epidemiology-consulting-service-becs#resources
The Biostatistics and Epidemiology Consulting Service (BECS) is embedded in the Milken Institute School of Public Health Department of Epidemiology and Biostatistics and provides biostatistical, epidemiological, and study design support for health-related research projects. The priority services of the BECS are:

- pre-award consultation on best practices for biostatistical methods, sample size selection, and study design for health-related grant proposals; and
- pre-award statistical analysis assistance (by faculty and/or graduate students in biostatistics and in epidemiology) of preliminary data to support a grant application.

Statistical material for download: **http://www.bsc.gwu.edu/bsc/webpage.php?no=6&rnd=74**

Cancer Clinical Trials Office
The Clinical Trials Office (CTO) of the George Washington Cancer Center (GWCC) assists with the planning, conduct and compliance of any cancer-related clinical trials, including those using pharmacologic or radiation therapies or investigational devices, as well as non-interventional trials. The CTO is overseen by an Associate Center Director of Clinical Investigations and a Senior Administrative Director, and is staffed by nurses, regulatory personnel, data mangers and study coordinators. The CTO can provide protocol support regarding scientific review, HIPAA compliance, Human Subjects protection and IRB requirements and submissions, as well as ongoing regulatory and reporting requirements. The CTO can also assist in the design, implementation and execution of investigator-initiated clinical trials and correlative studies, including blood collection and processing and tissue procurement. A state-of-the-art software package for protocol and data management is being implemented.

Cellular Therapy Laboratory (CTL) at Children's National
https://childrensnational.org/departments/center-for-cancer-and-blood-disorders/blood-and-marrow-transplantation/programs-and-services/cellular-therapy-program/cellular-therapy-labs
The CTL is a Food and Drug Administration (FDA)-registered current Good Manufacturing Practices (GMP) facility charged with translating and manufacturing cell therapy products for use in clinical trials and stem cell transplantation. The facility is Foundation for the Accreditation of Cellular Therapy (FACT) accredited for processing of minimal and more-than-minimal manipulation products. It has expertise manufacturing a broad array of cell therapy products, including dendritic cells, T cells, cell lines, monocytes, mesenchymal stromal cells (MSCs) and genetically modified cells. In addition to manufacturing the cells, the CTL supports quality assurance and quality control functions as required by the FDA, and has a quality program that details the process by which new cell therapy protocols are transferred to the CTL, including validations, process development, training, audits, documentation, product release, and also budget creation.

Classroom Resources
https://acadtech.gwu.edu/classroom-search

- Foggy Bottom Campus:
  - University
    https://acadtech.gwu.edu/classroom-search
  - Science & Engineering Hall
    https://facilities.gwu.edu/reserving-event-and-study-space-science-engineering-hall
  - School of Medicine & Health Sciences
    https://smhs.gwu.edu/resourcemanagement/classroom-services/reservations

- Mount Vernon Campus:
  https://acadtech.gwu.edu/classroom-search

- Virginia Science and Technology Campus:
  https://acadtech.gwu.edu/classroom-search

Academic Technologies supports over 200 technology-enhanced classrooms and labs on the Foggy Bottom, Mount Vernon, and Virginia Science and Technology campuses. These learning spaces are equipped with innovative technology, which enhances the teaching and learning experience at GW. GW Lecture Capture is also available in select spaces. Classroom selection available at https://acadtech.gwu.edu/classroom-search

- Foggy Bottom Campus
  - The School of Medicine and Health Sciences (SMHS) Classroom Services supports the technological and educational needs of the faculty, staff, and students through 35 different classrooms, with seating sizes ranging from 8 to 180. They provide a multitude of services structured to support the teaching, learning and research needs of the SMHS community. Videoconferencing, an equipment loan service, and on-site technical support are just a few of the services available. They coordinate scheduling, AV and technical support for learning spaces.
    - **Audio Conferencing -** Polycom Soundstation
    - **Video Conferencing -** Polycom Realpresence, MondoPad, WebEx, Skype.
  - The rest of the Foggy Bottom campus has 14 locations with classrooms. Number of classrooms ranges from 3 – 19, with seating capacity ranging from 15 - 293. List of equipment and software in each classroom can be found here: https://registrar.gwu.edu/buildings-rooms
- Mount Vernon Campus has 7 buildings with between 1 and 10 classrooms
- Virginia Science and Technology Campus has 4 buildings with between 6 and 9 classrooms

Clinical Research Office
The Clinical Research Office (CRO) of the Medical Faculty Associates unifies clinical research operations for the clinical faculty practice to support research growth, streamline operations and ensure regulatory

compliance, as well as to assure its practices conform with GWU requirements and processes. The CRO maintains responsibility for all aspects of administration and oversight of industry-designed, industry-sponsored multi-center clinical trials including contract negotiation, financial management, conduct and compliance functions. The CRO also provides education and mentoring for staff and faculty

Clinical Translational Science Institute at Children's National (CTSI-CN)
http://www.ctsicn.org
The CTSI-CN is a partnership between Children's National and The George Washington University which provides highly integrated, cost effective, investigator-focused resources, designed to overcome research barriers, promote collaborative research and provide research training. CTSI-CN places an emphasis on health disparities and childhood antecedents to adult diseases. The CTSI-CN is supported through the National Institutes of Health Clinical and Translational Science Award program UL1TR000075/UL1TR001876. The CTSA program is led by the NIH's National Center for Advancing Translational Sciences.

Colonial One (Division of IT)
https://it.gwu.edu/colonial-one-high-performance-computing

- Software and Business Apps
  https://it.gwu.edu/software-business-apps

- Research Computing
  https://it.gwu.edu/research-technology-services

- Web and Collaboration
  https://it.gwu.edu/web-collaboration

Colonial One is a high-performance computing cluster available to support research needs that use high-performance computing for data analysis. Colonial One is implemented and managed by the Research Services Group within the Division of Information Technology, assisted by GW-sponsored computational staff in the Computational Biology Institute and the Columbian College of Arts and Sciences. Access to Colonial One is open to the GW community. Located on the Virginia Science and Technology Campus in one of GW's two enterprise-class data centers, Colonial One is housed in an optimal facility featuring:

- Professional IT management by the Division of IT, including 24-hour on premise and remote environment monitoring with hourly staff walkthroughs.
- Redundant power distribution, including UPS (battery) and generator backup.
- Redundant cooling systems using a dedicated chilled water plant and a glycol refrigeration system.
- Direct network connectivity to GW's robust 100-Gigabit fiber optic network.

Colonial One's initial compute capacity features a total of 2,924 CPU cores and 1132,288 CUDA cores in the following compute node configurations:

- 64 CPU nodes featuring dual Intel Xeon E5-2670 2.6GHz 8-core processors with varying ranges of RAM capacity (64GB, 128GB, and 256GB nodes).
- 79 CPU nodes featuring dual Intel Xeon E5-2650v2 2.6GHz 8-core processors with 128GB of RAM each.
- 32 GPU nodes featuring dual Intel Xeon E5-2620 2.0GHz 6-core processors with dual NVIDIA K20 GPUs, 128GB of RAM.
- 1 Large-Memory node featuring four Intel Xeon E7-8857v2 3.0GHz 12-core processors with 2TB of RAM.
- FDR Infiniband network interconnect featuring 54.5 Gbps total throughput, with 2:1 oversubscription per compute node.

The Colonial One cluster has both a primary storage system and a high-speed scratch storage system connected to the Infiniband network fabric. Both are accessible throughout the entire cluster, and remote file transfer services are provided through dedicated login nodes.

- Dell NSS primary storage with 120 TB of usable capacity.

- Dell / Terascala Lustre HSS high-speed scratch storage with 250TB of usable capacity.

Computing: *Hardware and Software:*
GWU is well connected to research and education communities. The wireless access service, Eduroam, is a secure, worldwide roaming access service developed for the international research and education community. It allows users from member institutions to connect to the Internet when visiting other participating institutions. GWU is also part of the Internet2Network, which is a computer networking consortium led by members from research and education communities, industry and government. It gives our researchers the ability to use ultra-high-speed networking speeds when working with large dataset transfers that are used in much of our current research.

The SMHS has a fully staffed IT unit that includes a director, network, and technical support staff to assist users with all projects and support requests. The software offerings are also comprehensive. Our capabilities will allow for any required references retrieval, any other data retrieval or exchange, and online databases access. All faculty, staff, and students have access to electronic mail and collaboration software. SMHS faculty and staff members also have access to licenses that include an extensive range of word processing, analytic, graphics, mapping, and presentation software such as, SPSS, Stata, SAS, Atlas.Ti, MPlus, Adobe Creative Suite, Nvivo, Qualtics, and ArcGIS.

DC Center for Aids Research (DC CFAR)
https://dccfar.gwu.edu/core-services

Administrative Core
https://dccfar.gwu.edu/administrative-core
The Administrative Core provides leadership for the DC CFAR cores and scientific working groups, promotes synergies across the six collaborating academic institutions, and supports partnerships with government, community and academic collaborators. The core promotes multidisciplinary and multi-institutional science through administrative and fiscal oversight and management of resources and the facilitation of effective communication.

Developmental Core
https://dccfar.gwu.edu/developmental-core
The primary goals are to support the development of next-generation HIV researchers in Washington, DC and to promote innovative, multi-institutional, and multi-disciplinary HIV scientific research. The core provides competitive pilot funding, mentoring and educational and training opportunities to early stage, new and newly transitioning HIV investigators, with an emphasis on women and underrepresented minorities. Available services: Pilot Awards Program, Microgrants, Mentoring Program, and Education and Training.

Basic Sciences Core
https://dccfar.gwu.edu/basic-sciences-core
The mission of the core is to develop, refine, and provide services and training in relevant basic sciences to DC CFAR investigators. The Core offers virologic and molecular, immunological and imaging services and training that are designed to support basic, clinical and translational research in HIV/AIDS prevention, detection and treatment.

Clinical and Population Sciences Core
https://dccfar.gwu.edu/clinical-and-population-sciences-core
The mission of the Clinical and Population Sciences Core is to provide services to support the growth of clinical, translational and population-based research in Washington, DC. The Core provides access to services, specimens and clinical data and promotes collaborations between clinical, translational and population-based investigators. Services include consultative clinical, biostatistical, and epidemiologic design expertise as well as culturally appropriate community outreach to at-risk and HIV-infected populations.

Social and Behavioral Sciences Core

https://dccfar.gwu.edu/social-and-behavioral-sciences-core

The mission of the Social and Behavioral Sciences Core is to facilitate the development and implementation of research related to the prevention, treatment and care of HIV/AIDS that utilizes social and behavioral perspectives and that is innovative, theoretically driven, methodologically rigorous, interdisciplinary and high impact. The Core encourages collaborations between social and behavioral investigators and their counterparts in clinical and basic sciences. It also emphasizes the development of strong relationships with community partners in the DC area. In this way, the Core ensures that DC CFAR research is innovative and has maximum potential for impact.

Flow Cytometry Core Facility

https://smhs.gwu.edu/flow-cytometry/

The Flow Cytometry Facility maintains 2 cytometers and a workstation for data analysis.

- Cell Sorter: 4-laser, 15-color BD Influx high speed cell sorter
  Features include:
  -4 nozzle size options-optimal for sorting a wide range of cell and particle sizes
  -Small particle detector
  -Up to 6-way sorting
  -Plate with Index sorting
- Cell Analyzer: 3-laser, 12 color BD Celesta cell analyzer
  Features include:
  -Automated QC
  -High Throughput Sampler (HTS) compatible with 96-well and 384-well microtiter plates
- PC workstation with the latest cytometry data analysis software and educational resources.

Genomics and Proteomics Core (GPC) Resources at CTSI-CN

https://www.ctsicn.org/gen-pro

The Genomics and Proteomics Core (GPC) is housed in the Research Center for Genetic Medicine at Children's National, in open laboratories totaling 22,000 sq. ft. of space. Specialized equipment dedicated to core proteomic facilities includes:

- **Thermo Q Exactive HF mass spectrometer for LC-MS and LC-MS/MS analysis.** This newly acquired mass spectrometer is a quadrupole-orbitrap hybrid similar to our Q Exactive instrument but with improved high field orbitrap mass analyzer. The QE-HF is coupled online to a nano-flow EasynLC UPLC system.
- **Thermo Q Exactive mass spectrometer for LC-MS and LC-MS/MS analysis.** This mass spectrometer is a quadrupole-orbitrap hybrid that can aquire spectra at 12 Hz and 140,000 resolution. This system offers state-of-the-art speed, sensitivity, dynamic range and resolution and is ideally suited for discovery and targeted proteomic applications. It is coupled online to a nano-flow EasynLC UPLC system.
- **Thermo LTQ-Orbitrap XL mass spectrometer for LC-MS and LC-MS/MS analysis**. This mass spectromter has up to 60,000 resolution and 3 ppm accuracy and is coupled online to an Eksigent nano-hplc. The high resolution and fast scan speeds are ideal for protein identification and quantitation.
- **ABI 4700 MALDI-TOF-TOF mass spectrometer with a Nd:YAG laser** that can operate at 355 nm to ionize samples with pulses of 3 to 7 nsec. duration and frequency of 200 Hz resulting in high speed analysis (1000 MS and MS/MS analysis per hour). Some other characteristics of the instruments are: 10 to 15,000 resolution in reflectron mode, up to 10 ppm accuracy and sensitivity in the subfmole range. GPS explorer software employing a web based protein data base and Mascot search engine is interfaced to the instrument for data analysis and protein identification.

Separate computing resources are available for analysis of mass spectral data. Proteome Discoverer, Mascot and Bioworks software are available for routine protein identification. Additionally, we license IP2 and ProteoIQ software packages dedicated for both label free and stable isotope quantitative proteomics. The core also uses open source software packages MaxQuant, Perseus and Skyline for quantitative and targeted studies. The proteomics core has also full equipment for protein and peptide separation (2-dimensional gel electrophoresis and a Shimadzu HPLC system with integrating software and fraction collector to use offline).

Specialized Genomics Core equipment includes, for standard DNA analysis, one 96-well MJ Tetrad PCR system (4 blocks total), eight ABI 9700 dual block thermocyclers (16 blocks total), and eight ABI 2720 thermocyclers (8 blocks total).

The core is fully equipped to offer both Affymetrix and Illumina array services, utilizing their complete line of arrays (DNA /RNA/miRNA). The center houses two complete Affymetrix GeneChip® stations, including two GeneChip® Fluidics Stations, two GeneArray® scanners, and two GeneChip® hybridization ovens, in a dedicated room. Illumina arrays (expression profiling, SNP and methylation) are scanned through an agreement with the Georgetown University Lombardi Cancer Center Genomics Core (Core Director, David Goerlitz). This group uses our Affymetrix scanner in exchange for our access to their Illumina iScan scanner.

The core has an Illumina NextSeq500 next-generation sequencer (NGS). Related equipment includes a Covaris DNA shearing station, and Blue Pippin and Pippin Pulse (Sage Technologies) instruments for nucleic acid sizing. A ThunderBolts RainDrop NGS target enrichment and RainDrop Sense™ (RainDance Technologies) system is also available for generating NGS libraries and digital droplet PCR. An AutoGen QuickGene-810 system is available for automated extraction of DNA and RNA from a variety of tissues. For DNA/RNA quality checks, the center also has 2 NanoDrop spectrophotometers, a bioanalyzer and 2 Qubit(s). The core also has a QuantStudio 7 with 96-well, 384-well and TLDA card attachments.

Computational resources are continuously upgraded. The current infrastructure includes the latest Vmware vSphere 4.1 on six HP ProLiant DL380 G6 servers, 10gb backbone on our iSCSI SAN storage, 10mg Ethernet line and one backup 3mg T-1 line, with wireless ISP for external transfer of files, core switching with dedicated LAN core switch and iSCSI core switch, and internal Cisco Wireless Controller 4402 with 12 Access Points. In addition, we employ a Dell Poweredge 720xd Server and Vm License, Dell PowerVault NX3610 Filer/MD3660 Storage Array and Advanced Computer Concepts 16-port 10 Gigabit Ethernet Module. Physical servers are virtualized to save energy, enabling robust internal cloud computing. In addition, the infrastructure includes redundancy at many levels, including internet firewalls, spam-mail firewalls and Internet Filters to provide a high availability (no down time). This system accommodates most standard usage and in addition allows very active users to purchase their own blades for enhanced computational power as needed. For very data intensive sequencing experiments, we also have individual accounts within the GWU super-cluster, Colonial One.

The core is the single largest contributor of microarray data in the public domain (15% of NCBI GEO). Array data is routinely made publicly available upon investigator approval at publication via upload to GEO, adhering to MAIME guidelines (http://www.ncbi.nlm.nih.gov/geo/info/MIAME.html). Data analysts use shareware programs on R, and also have access to the Illumina BaseSpace analysis environment. We also purchase Partek software for array data analysis, and maintain an institutional license for Ingenuity Pathways Analysis (IPA) software for pathway/network analysis. Over the years, investigators within the core have designed and implemented a series of public domain software packages (see http://bioinformatics.cnmcresearch.org), including HCE, CONSET, GENESHELF, GOTREEPLUS.

For direct digital counting of miRNA/mRNA and selected DNA applications, we also have access to a complete NanoString nCounter System, provided by agreement with the clinical pathology department, which is chaired by Ashley Hill, MD, who also has a faculty appointment in GenMed. Within our genomics center, an additional NanoString prep station is available, as the prep portion of NanoString methods is the most rate-limiting step. For RT-PCR, the core has a ThermoFisher QuantStudio 7 with blocks for TLDA cards, and 96 and 384 well plates.

The core is also equipped with a MesoScale Diagnostics QuickPlex SQ 120 scanner for multiplex ELISA assays over a wide dynamic range. The system uses cutting edge electrochemiluminescence detection system on a carbon electrode surface that has 10 times greater binding capacity than polystyrene wells. The core also has an Illuminex reader for standard ELISA assays.

The core also has the following dedicated refrigerator/freezer space: 6 refrigerators, 3 -20º non-defrost freezers and 3 -80º ultralows. It also has a dedicated BSL2/organics hood. General equipment includes a Beckman XL-90UC ultracentrifuge, Savant speedvac plus, Brinkman polytrons, Hitachi GeneSpec III spectrophotometers, Nikon Microphot FXT microscope with fluorescent filter blocks and Optonics PE750 digital camera, a Perseptive Biosystems Cytoflour 96-well plate reader, 2 cryostats, 2 general purpose laboratory ovens, 4 refrigerated benchtop ultracentrifuges, 2 standard laboratory centrifuges, 4 power sources and gel boxes for standard agarose gels, 3 rotating plate holders, and a Licor infrared imager for western blots.

George Washington University Hospital
https://www.gwhospital.com/about
The George Washington University Hospital is owned and operated by a subsidiary of Universal Health Services (UHS) one of the largest healthcare management companies in the nation. The George Washington University Hospital has approximately 385 beds, 20+ operating suites and 1 hybrid operating room along with a level III neonatal intensive care unit. The GW Hospital is accredited by The Joint Commission and licensed by the District of Columbia Regulatory Affairs Department. In 2016 there were 19,937 admissions, 25,892 surgeries, 3,395 births, 74,680 emergency room visits and 125,995 outpatient visits.

George Washington University Medical Faculty Associates
https://www.gwdocs.com/research
Medical Faculty Associates (MFA) is an independent multispecialty physician group practice encompassing more than 52 medical specialties. Committed to providing comprehensive, thorough and accessible patient care, MFA physicians see patients at the main campus as well as at the George Washington University Hospital and several other area hospitals and community-based medical practices. MFA physicians serve as full-time faculty of the GW School of Medicine and Health Sciences providing mentorship and teaching to medical students, residents and fellows. The MFA faculty is extensively involved in a wide variety of research activities including NIH-, foundation- and industry-sponsored studies. Research by MFA physicians include inpatient hospital-based studies as well as studies in the outpatient setting. These studies include investigations of new oral, parenteral agents and infusion-based agent. Among the many research activities include new treatments for cardiovascular diseases, infectious diseases including HIV infection, neurologic disorders among many others. MFA surgeons are examining new devices that improve cardiovascular, neurosurgical and orthopedic conditions.

Health Sciences
https://smhs.gwu.edu/academics/health-sciences-programs/research
Uniquely positioned within the George Washington University School of Medicine and Health Sciences, the Health Sciences programs provide a training ground for the nation's experts in patient care, health care quality, medical laboratory sciences, clinical management and leadership, and numerous other disciplines. Health Sciences offers four entry-level clinical training programs (Emergency Medical Services, Medical Laboratory Sciences, Physical Therapy, and Physician Assistant) in addition to professional programs for advanced training in a wide range of health fields including clinical research administration, regulatory affairs, clinical management and leadership, clinical and translational research, translational health sciences, biomedical informatics, integrative medicine and health, health care quality, disaster response, and occupational therapy. The GW Physician Assistant program is ranked 3rd out of more than 225 accredited programs nationally. Health Sciences is active in continuing education and professional development activities, operates numerous military affiliated programs, and jointly operates a health sciences academy with Alexandria City Public Schools. Health Sciences is a global leader in online and blended education, with national experts in curriculum development, instructional design, and program evaluation.

Human Research Office
https://humanresearch.gwu.edu/research-tools
The Office of Human Research (OHR) is the administrative support office for The George Washington University Institutional Review Boards (IRBs). The IRB is responsible for the review of all research activities that involve human subjects in accordance with federal regulations.

Impact Initiative and SMART Lab
https://smhs.gwu.edu/impact/smartlab
The SMART Lab (Supported Media for Administration, Research, and Teaching) provides assistance related to the technical design and development of course materials and any technology issues. The team provides hardware, software, and personal assistance to support faculty in the use of technology for the Health Sciences Programs. The SMART Lab support faculty and staff in producing and using media, technology, and novel instructional methods in order to create state-of-the-art learning experiences and curricula.

Initiatives to Enhance Diversity
Overall, GW university ranks above average in ethnic diversity among undergraduates, with 6.4% African American and 7.6% Latino students. In 2016, Caroline Laguerre-Brown joined the University from Johns Hopkins as the Vice Provost for Diversity, Equity and Community Engagement to lead GW's efforts to advance diversity and inclusion throughout the university.

As a major school at GW, and one that trains future clinicians and scientists, GW SMHS continues a deep commitment to students from different cultural and ethnic backgrounds, sexual orientations, socioeconomic backgrounds, and those with a range of previous life experiences. The medical school works to diversify the MD class. Important development goals include additional scholarship funds to lower costs and diversify the class.

Among the Fall 2017 entering MD Class of 175 students drawn from 86 undergraduate schools in 30 states and DC, 62% are female and 38% are male. The class includes many individuals from groups underrepresented in biomedical science (9.7% African American, 7.4% Latino,1% Native American/Pacific Islander; slightly higher than the national average; Figure 7, AAMC Facts https://www.aamc.org/data/facts/).

In 2013, Dean Jeffrey S. Akman, MD, established the GW SMHS Office of Diversity and Inclusion and appointed Yolanda Haywood, MD as the founding Associate Dean for Diversity and Inclusion. In response to concerns about faculty diversity, SMHS working with the Offices of Faculty Affairs and Diversity and Inclusion established a policy that every search committee include a Diversity Advocate, and efforts are made to engage faculty in additional training opportunities. SMHS faculty experts also participate at regional meetings of BNGAP (http://bngap.org/) an organization committed to recruit women and under-represented minorities into careers in academic medicine. *Dr. Haywood will serve on the Internal Advisory Committee for the proposed program.*

The SMHS Office of Diversity and Inclusion coordinates a number of diversity outreach and recruitment programs that augment the proposed summer undergraduate program, including:

- The DC Health and Academic Prep Program (DC HAPP) led by Dr. Haywood is a pre-college program for rising high school juniors and seniors with an interest in a medical education and career. During a four-week summer experience and clinical internships during the academic year, DC HAPP scholars learn about potential healthcare professions, and are mentored through the college application process.
- The GW SMHS Upward Bound Program led by Jessica Castillo serves grades 9-12 from partnered public and public charter schools in Wards 5, 6 and 7 in the District of Columbia. The program identifies students with an interest in medical and allied health careers and offers Saturday Academy, Tutorial Services, Summer Institute, SAT seminar and student ambassador program.
- The Mentored Experience To Expand Opportunities in Research (METEOR) program offers a competitive fellowship for medical students from groups underrepresented in medicine who are interested in an academic research career to matriculate into GW's M.D. program. Dr. Alison Hall, PhD coordinates this program, as well as the School of Medicine Research Scholarly Concentration that encompasses about 50 MD students per year.
- The MD Pre-Matriculation four-week Program for about a dozen incoming medical students invited by the Committee on Admissions to develop skills needed to successfully navigate through the medical school curriculum.

PhD Programs in the School of Medicine are coordinated through the Institute for Biomedical Sciences (IBS). Established in 1996, the IBS has over a hundred faculty members who participate in the PhD programs focused on Genomics, Microbiology & Immunology, Cancer Biology, Neurosciences, and Pharmacology & Physiology. The IBS oversees a core curriculum and assists students in navigating the first year of graduate training and laboratory rotations with potential mentors. After the student has chosen a Ph.D. Program and has a program-specific academic advisor and research mentor, the role of the IBS becomes one of facilitation and integration. Together, the PhD programs currently include 73 students, of whom 56% are female and 11% from underrepresented groups. The percentage of PhD students from underrepresented groups is similar to the proportion nationwide who earn a PhD in Biology each year.

International Medicine Programs
https://smhs.gwu.edu/imp/programs
For over 23 years, the Office of International Medicine Programs (IMP) at the GW School of Medicine and Health Sciences (SMHS) has cultivated global partnerships to develop and facilitate transformational mutual exchange in medical education, training, and research. IMP's goal is to provide transformational learning opportunities to build the human healthcare workforce capacity of other countries and share the latest advances in medicine and healthcare. As a pioneer in international medical education, training, and research, IMP has developed, coordinated, and completed over 150 projects in over 50 countries, touching the lives of more than 15,000 healthcare professionals, students, and patients around the globe. IMP promotes international research partnerships by convening SMHS and international researchers at scientific summits, where they can share the latest advances in their fields and identify opportunities for collaboration. In addition, IMP partners with GW faculty to design and implement medical and research training programs both at GW and abroad. IMP further serves the SMHS community by facilitating strategic international partnerships, providing safety and security resources for SMHS faculty and student travelers, and supporting incoming international students and visiting scholars.

Internet2
https://www.internet2.edu/news/detail/6235/
GW has made significant investments to support advanced research in the Washington DC metro region by establishing the nation's newest regional research network Capital Area Advanced Research and Education Network (CAAREN). CAAREN connects to Internet2's Advanced Layer 2 Service, a nation-wide 100G software defined network (SDN). GW is part of the Internet2Network, which is a computer networking consortium led by members from research and education communities, industry and government. It gives our researchers the ability to use ultra-high-speed networking speeds when working with large dataset transfers that are used in much of our current research.

Institute for Biomedical Sciences
https://smhs.gwu.edu/ibs/
The Institute for Biomedical Sciences (IBS) is the administrative and academic home for interdisciplinary Ph.D. training in the Biomedical Sciences. Established in 1996 to integrate our partner institutions, including the GW School of Medicine & Health Sciences, the Columbian College of Arts & Sciences and the Children's National Health System, we bring together a wealth of teaching and research opportunities for the outstanding matriculating graduate student. The IBS has approximately 105 faculty members who participate in the 5 graduate programs in which the student may choose to earn a PhD. The IBS oversees a core curriculum and assists the student in navigating their first year of graduate training while he or she selects a PhD Program and explores research opportunities available for dissertation projects. After the student has chosen a PhD Program, and has a program-specific academic advisor and research mentor, the role of the IBS becomes one of facilitation and integration.

Laboratory Safety Office
https://labsafety.gwu.edu
OLS is a service organization within the Office for Vice President for Research with specialized knowledge and expertise in biological, chemical and radiological health and safety. OLS manages a broad range of regulatory obligations for George Washington University and works closely with allied departments (Office of Health &

Safety, Police, Facilities Management, Risk Management, etc.) within the University and in our surrounding communities. OLS has an office on the Foggy Bottom campus.

Library Facilities:

- Eckles Library
  https://library.gwu.edu/eckles

- Gelman Library
  https://library.gwu.edu

- Himmelfarb Health Sciences Library
  https://himmelfarb.gwu.edu

- Jacob Burns Law Library
  https://www.law.gwu.edu/library

- Virginia Sciences and Technology libraries
  https://library.gwu.edu/virginia

The University has an extensive network of libraries, databases, computer facilities, and other resources located on and off campus that are available to researchers. Our network of on-campus libraries includes the Eckles (main) Gelman, Himmelfarb, joint Milken Institute SPH and the Medical School, plus Virginia Sciences and Technology libraries. Faculty, staff, and students also have access to eight additional branches located throughout the Washington, DC metropolitan area – including the Library of Congress, the libraries of the National Institute of Health, and the National Library of Medicine – that permit inter-library loans.

Nanofabrication and Imaging Center
https://nic.gwu.edu
The George Washington University (GW) Nanofabrication and Imaging Center (GWNIC) features state-of-the-art microscopy instrumentation and a newly constructed Class 100 cleanroom. GWNIC provides university-wide core infrastructure for research in engineering, chemistry, physics, biology, public health, medicine and biomedical sciences. The Center ensures the maximal utilization of state-of-the-art equipment and it provides both new and established investigators with proper training on basic operation of the equipment as well as focusing on tailored training and advice with the goal of acquiring the most informative images. The GWNIC will provide access, training and use of confocal microscopes, a Leica Multiphoton confocal microscope, Thermo Fisher Scientific (FEI) electron microscopes (SEM, FIBSEM, TEM) in the Imaging Core and Raith Pioneer and Voyager E beam lithography instruments, deposition and etching tools, along with measurement, characterization and analysis tools in the Cleanroom.

- Nanofabrication Core
  - Lithography:
    - The Raith PIONEER combines ultra-high resolution electron beam lithography (EBL) and scanning electron microscopy (SEM). The PIONEER features 30kV column technology and a full rotation and tilt stage.
    - The Raith VOYAGER is a high performance electron beam lithography (EBL) instrument featuring:
      - 50kV eWrite column technology
      - 50MHz pattern generator
      - 200mm wafer handling capability
      - High throughput single digit nanolithography
      - Stitch-free lithography due to fixed-beam-moving-stage (FBMS traxx) and modulated-beam-moving-stage (MBMS periodixx) technologies
    - The Neutronics NXQ4000 Series Semi-Automatic Mask Aligner combines innovative design with precision alignment and exposure features. The automatic sequencing makes the system very easy to learn and use. The versatile platform:
      - Supports soft/hard pressure contact and vacuum contact printing

- Supports printing in manual proximity mode
- Processes partial and whole substrates up to 150mm (6) inch diameter
- Can be configured with Backside Alignment and UV Nano Imprint Lithography

- The Laurell Spin Coating Systems at GWNIC feature programmable push button recipe management which allows control of spin speed, acceleration, and duration. They feature a PTFE chamber and chuck for easy cleanup and will accommodate up to four-inch wafers.
- The FEI Helios NanoLabTM 660 DualBeamTM is a fully digital, Extreme High Resolution (XHR) Field Emission Scanning Electron Microscope (FE SEM) equipped with Focused Ion Beam (FIB) technology. It allows for fast characterization of nanometer details and analysis in 2D and 3D, very high quality thin sample preparation and flexible nanoprototyping. The FIB SEM can be used for nanofabrication as well as 3-D reconstruction of biological structures.

- Deposition & Etching
  - The Versaline Deep Silicon Etch III (DSE III) system is designed to etch very high aspect ratio features while providing very smooth sidewall profiles. The DSE system is capable of etching silicon, SOI and oxides in the same chamber configuration. The DSE III chamber features:
    - Fast-gas switching capabilities for Bosch etching (SF6 and C4F8)
    - Process pressure control
    - Heated chamber components
  - The Versaline Plasma Enhanced Chemical Vapor Deposition (PECVD) system features an isothermal chamber designed to deposit high-quality dielectric films such as SiO2 and SiNx. Both high-quality films and low stress films are achievable due to the unique chamber design allowing for a very clean environment with very high mean time between cleans (MTBC). The system features EndPointWorks^{TM} optical emission interferometry (OEI) endpoint detection for optimal film thickness control.
  - The Apex SLR is a very flexible system platform for both III/V semiconductor etches and dielectric etchings. The Apex system features single wafer substrate loading with ease-of-use 4-button recipe control from the load lock. The Apex SLR system uses well-established reactor technology that provides reliable performance and is supported with guidance from a continuously evolving process library. The Apex SLR has superior process flexibility for a wide range of applications.
  - The Cambridge NanoTech Fiji series Atomic Layer Deposition (ALD) system with Load Lock is a modular, high-vacuum ALD system that accommodates a wide range of deposition modes using a flexible architecture and multiple configurations of five precursor lines and various plasma gases.

- Thermal
  - The CHA Criterion Electron Beam (E-beam) Evaporator and Criterion Pulsed Vapor Deposition (PVD) system offers midrange sizing that incorporates both load lock and source isolation options. The Criterion systems feature a hinged, water-cooled front door and a new frame design. The new Criterion chamber design with load lock and water cooled chamber will accommodate many tooling configurations and a variety of deposition sources and combinations of sources. System and recipe control is achieved via a touch screen PC/PLC. The GWNIC has two E-Beam Evaporators to prevent backlog due to deposition times and runs and one Sputter PVD, all based on the Criterion platform.
  - The Rapid Thermal Processor (RTP) features:
    - Ramp rate: 100 degrees C/sec
    - Temperature range: ambient to 1300 deg C max
    - Ramp rate: 1 degC/s to 400 degC/s
    - Cold Wall Chamber technology
    - Vacuum = 10-2 mbar max

- Thermocouple: ambient to 1000 degrees C
- Pyrometer control: 150 to 1000 degrees C
- System chiller
- Vacuum pump
- Purge gas line: Argon, Nitrogen, or Oxygen

- Measurement, Characterization & Analysis
  - The Micromanipulator Probe Station provides a highly accurate test environment for Capacitance-Voltage (C-V) measurement with all the power and stability required by semiconductor professionals. Features include:
    - ±1.5mm repeatability and accuracy with a resolution of 0.1mm
    - User-friendly pcProbe II software
    - Thermal system provides a single chuck with a temperature range from –65 degrees C to 400 degrees C
  - The KLA-Tencor P-7 stylus profiler offers measurement repeatability for reliable measurement performance. The surface measurement system has a 150 mm scan length standard. The profiler's surface measurement system includes point-and-click operation and the productivity package to offer the easiest to use tool on the market with the features required by university, R&D, and production environments.
  - The four point probe system allows a wide variety of samples to be measured from glass slides with TCOs or metal layers, to wafers and even ingots up to 250mm deep. Features include:
    - Multi-height probe stand
    - Removable X-Y microposition table
  - GWNIC provides access to the Kulicke & Soffa Model 4123 Manual Wedge Bonder and Kulicke & Soffa Model 4126 Ball Bonder. Features include:
    - Motorized table making available 'auto step-back' / reverse motion
    - Available in 30°/45° configurations
    - Designed for aluminum or wire
    - Control of individual bond parameters
    - Large bonding area
    - Easy operation
    - Gold = 12.7 to 76µm; aluminum = 20 to 76µm; gold ribbon = option up to 25 x 250µm; spool = 12.7mm option 50.8m
    - High Q 60kHz transducer PLL ultrasonic generator
    - Semi-auto, manual Z, stitch
    - Manual height adjustable, heated work holders
  - The F20-UV is a general-purpose film thickness measurement instrument that can measure films ranging from 1nm to 40um optically using a190-1100 nm light source.

- Microscopy Core
  - Light Microscopy
    - The Leica M80 Stereomicroscope is a dissecting microscope with a platform, lighting, excellent Leica M80 optics and digital camera to image samples at any point during sample preparation, analysis or documentation
      - Leica EC3 camera
      - LAS software for image capture
      - LED illumination from above or below

  - Confocal Microscopy
    - The Zeiss LSM 710 laser scanning confocal microscope can be used for long-term whole live-embryo, tissue slices and cell imaging at high resolution. This upright microscope with x/y/z scanning stage, controlled via Zen software to execute complex multipoint temporal acquisition patterns, is supported by custom-designed on-stage

incubation. This allows for long-term observations of explanted tissues and control of the temperature and environment either via perfusion or CO2 control.

- 32-channel spectral detector
- Two single channel photomultipliers and a photomultiplier on the forward pathway
- Six laser lines for excitation (458, 488, 514, 561 & 633 nm plus additional 405 nm diode laser)
- A customized high-end computer for large data sets (50GB).
- Objectives: W Plan-Apo 20x/1.0 DIC VIS-IR WD=1.8 water and 25x/0.8 multi-immersion LD LCI Plan-Apochromat (WD=0.55); Plan-Apochromat 10x/0.45 D=2.0; Plan-Apochromat 20x/0.8 M27 D=0.55; Plan- Apochromat 63x/1.40 Oil DIC; Alpha Plan Apochromat 100x/1.46

▪ A Zeiss Cell Observer Spinning Disk Confocal microscope is fully integrated for live-imaging at high resolution. It allows for complex time-lapse imaging experiments to be programmed and executed in high throughput manner.

- Two Photometrics Delta (64 fps, at 512x512) EM CCD cameras, for simultaneous acquisition of two channels
- Environmental control for CO^2 and hypoxia
- A combination of high numerical aperture (i.e., 100x/1.46) and multi-immersion corrected objective lenses (i.e., 25x/0.8, 560 µ working distance)
- Virtual slides using high resolution/high magnification objectives (i.e., 100x/1.46 and 150x/1.35) and a color CCD camera
- Definitive focus
- Deconvolution, physiological analyses and stitching applications

▪ The Leica TCS SP8 Multiphoton Flexible Supply Unit features White LASER and 2-photon excitation. The White Light Laser is a fully tunable supercontinuum laser with up to eight simultaneously usable lines in the range of 470 – 670 nm for maximal spectral flexibility in combination with AOBS and SP detector. Recording of two dimensional excitationemission spectra turns the system into a spatially resolved fluorescence spectrophotometer for characterization. The White Light Laser offers pulsed excitatation for FLIM with Pulsepicker for adjustable pulse intervals in FLIM. This multiphoton microscope with high power femtosecond laser allows for deep tissue imaging. Precompensation for optimization of pulse width is fully integrated in LAS AF for easy control. It is equipped with Leica HyDRLD nondescanned detector. Its supersensitive photon detection with extraordinary quantum efficiency visualizes even faint details from deep tissue sections. The TCS SP8 SMD FLIM system combines the single photon counting technology FLIM with flexible confocal imaging. The system series integrates hardware and software from PicoQuant with the highend confocal system Leica TCS SP8 MP.

- Upright Stand DM6000 CFS flex
- Objective nosepiece H, 6pos,
- DM 6000 CFS stand Optical Outfit EL6000 with Transmitted Light Brightfield Detector
- SMD Software Package FLIM, 2 HyD SMD, FOV scanner SP8
- Switchable beam expander
- Scanhead: Two HyDs SMD, three Internal PMTs
- Laser 405 nm AOTF Flexible
- Laser Kit WLL2 + Pulse Picker
- IR Laser Chameleon Vision II, 680-1080nm

o Electron Microscopy

▪ The FEI Teneo LV SEM instrument is a Field Emission Scanning Electron Microscope (FESEM) that combines high and low-voltage ultra-high resolution capabilities with the world's only low-vacuum, high-resolution imaging solution. Through lens detector for

(TLD) SE and BSE detection capable of high-resolution imaging at both high and low kV's, as well as an *Everhart-Thornley* SE detector for conventional SE detection. This microscope allows for large area imaging as well as elemental analysis on biological and materials science samples.

- High-resolution FEG column with Schottky source
- 110 x 110 mm, 5-axes motorized (x-y-z-tilt-rotate stage), eucentric stage
- CCD IR inspection camera (NavCam)

- The FEI Helios NanoLab 660 DualBeam is a fully digital, Extreme High Resolution (XHR) Field Emission Scanning Electron Microscope (FE SEM) equipped with Focused Ion Beam (FIB) technology. It allows for fast characterization of nanometer details and analysis in 2D and 3D, high quality thin sample preparation for TEM and flexible nanoprototyping. The FIB SEM can be used for nanofabrication as well as 3-D reconstruction of biological structures.
  - Schottky field emitter electron source for landing energies 20 V - 30 kV
  - Gallium ion source
  - Everhart-Thornley detector for conventional SE detection
  - Through-the-lens detector (TLD), collecting SE and high-loss BSE, specially designed for high-resolution imaging at both high and low kV's
  - The MD mirror detector is designed for excellent contrast of materials at landing energies down to 500 eV
  - GIS: W, Pt, insulator deposition and etching
  - EDAX Octane Pro detector for elemental analysis
  - AutoSlice and View G3 MAPS and Correlative Workflow software modules
- The FEI Talos™ F200X is a 200 kV FEG Scanning Transmission Electron Microscope (S/TEM), which is designed for fast, precise and quantitative characterization of biological and materials samples. It combines outstanding quality in high resolution STEM and TEM imaging with advances in EDS signal detection and 3D characterization with compositional mapping. In addition, the Talos F200X is equipped with the new Ceta™ 16M camera, which combined with an embedded Piezo-enhanced stage, provides large field-of-view, drift-free imaging with high sensitivity and precise sample navigation. All detectors are silicon solid-state detectors, and can support a beam current up to 3 nA. System Hardware for Talos is STEM Tomography 4.x Data Acquisition Software.
  - TEM and STEM imaging modes
  - Special applications such as Differential Phase Contrast (DPC)
  - X-FEG high-brightness electron source
  - Super-X EDS Detector for fast EDS acquisition, mapping and analysis (Silicon Drift Detector (SDD) technology)
  - High-Angle, Annular Dark Field detector (HAADF)
  - On-axis Bright-Field/Dark-Field STEM detector

- Sample Preparation
  - The Leica VT1000 S Fully Automatic Vibrating Blade Microtome is designed for special applications associated with the sectioning of fresh biological tissues. Due to its unique design, the VT1000 microtome is also the ideal instrument for sectioning of various industrial and plant materials.
    - Automode with autofeed, specimen retraction and a cutting window
    - Semi-automated and fully automated modes
    - Special blade holder design for minimal vibration and tissue damage
  - The Leica EM KMR3 Glassknife Maker is designed to produce consistent, perfect glass knives for microtomy from glass strips
    - Easy to use
    - Balanced break method
    - Automatic reset of cutting wheel and scoring mechanism

- The Leica Ultracut R Ultramicrotome provides ease of use for cutting resin embedded samples for microscopy. Automated thick and thin resin section cutting modes.
- The Leica EM UC7 Ultramicrotome is a fully configurable system, with a UC7 basic instrument and eucentric movement of a stereo microscope carrier. It can be used for preparation of semi and ultrathin sections, as well as the perfectly smooth surfaces required for LM, TEM, SEM, and AFM sample preparation.
    - M80 binocs are complete with 0.8x objective, 45° binotube, ergowedge and eyepieces
    - Advanced touch sensitive control unit (10.4" display), antivibration table
    - Improved visibility of knife specimen area
- The Leica EM AFS2 Automatic Freeze Substitution System performs freeze substitution and progressive lowering of temperature (PLT) techniques along with low temperature embedding and polymerization of resins.
    - Flat Embedding and Microtube Embedding System with Freeze Substitution Processor (FSP)
    - An automated reagent handling system
    - LED chamber illumination
    - Stereomicroscope
- The Tousimis 931 Critical Point Dryer offers automated precision process control for a wide array of samples.
    - Sample holders: small tissue pieces, large tissue pieces, and 22 mm coverslips
    - Stasis software for drying gels
    - Program and save recipes
- The Cressington 208HR Sputter Coater is a versatile coater for a multi-user facility. It is capable of working at various pressures, coating thicknesses and materials.
    - Rotary & tilting stage
    - MTM-20 high resolution thickness controller
    - Iridium sputter target for coating for high resolution imaging
    - High/low chamber configuration

- Data Analysis
    - The Arivis Workstation runs Zen, LASX, Volocity and Arivis software for image analysis. High-profile computers and monitors accommodate 3D and 4D data analysis of large data sets (30-50GB).
        - Arivis Vision 4D software
        - Large 4K 56-inch monitor
        - Large data capacity hard drive
        - Connected to big data storage solution
    - The IMARIS Workstation features
        - IMARIS
        - Large 4K 56-inch moitor
        - Large data capacity hard drive
        - Connected to big data storage
        - Image J
        - Metamorph
        - Image Pro Plus

Research Pathology Core
https://smhs.gwu.edu/pcl/
The Research Pathology Core Laboratory is a research core facility housed in the Department of Pathology. The facility is located in room 124 Ross Hall. The Pathology Core Laboratory is available to provide research services for both human and animal tissues, including tissue processing, embedding, sectioning, routine H&E and special stains, frozen sections, optimization and performance of immunohistochemistry, and electron microscopy. Pathology consultative services are also available.

Research Workforce Development
The Office of Research Workforce Development enhances research professional skill development at all career levels including undergraduate, medical student, postdoctoral fellow, and faculty. Created searchable faculty researcher database, blog and funding announcements for faculty, graduate students and postdoctoral trainees. Assist in development of NIH F, K, T and related mentored training activities and applications. Produces researcher on-boarding and scientific and professional development workshops, grant writing courses.

Responsible Conduct of Research
https://research.gwu.edu/responsible-conduct-research
The George Washington University encourages all of its faculty and students to become familiar with professional and ethical standards in academia in general as well as in their chosen fields. In fulfilling its responsibility to prepare the next generation of responsible researchers, GW offers the following assistance:

- **Responsible Conduct of Research Training**
  All faculty and students participating in research are required to complete the Responsible Conduct of Research training provided at GW. Discussion of the issues raised by this training among faculty and students is an important element of professional development in all of our research and graduate programs.
- **NIH RCR Training Plan:**
  Students, faculty and other researchers supported on certain NIH training, career development, research education, and dissertation research grants 1 are also required to take RCR training. For the NIH RCR Training Plan, eight (8) hours of live RCR training must be undertaken at least once during each career stage throughout a scientist's career: i.e., at the undergraduate, post-baccalaureate, predoctoral, postdoctoral, and faculty levels. This training is required at a frequency of no less than once every four years. GW provides this training through lectures, workshops, and courses provided each year, including lecture series offered by the Office of the Vice President for Research that are qualified for RCR live RCR Training credit.

- **NSF RCR Training Plan:**
  Completion of RCR Training is mandatory for all undergraduate students, graduate students, and post-doctoral researchers supported on a full-time or part-time basis on any National Science Foundation award resulting from a proposal due after January 4th, 2010. The RCR program must be completed in accordance with GW's NSF RCR Training Plan within the first budgetary period (usually the first year) of the date you begin charging such a new NSF award. This Training Plan requires completion of the online RCR course offered through GW's arrangement with the Collaborative Institutional Training Initiative (CITI) found at https://www.citiprogram.org/.
    - **RCR Topics covered include**:
      • Research Misconduct
      • Data Acquisition and Management
      • Responsible Authorship and Publication
      • Peer Review
      • Mentoring
      • Conflicts of Interest and Commitment
      • Collaborative Relationships
      Students and post-doctoral researchers also have the option of taking additional RCR courses that are available in lecture/classroom settings. For those students who wish to take in-person

lecture/classroom training in lieu of the taking the NSF RCR Training Plan Online, students and post-doctoral researchers on NSF awards also have the option of documenting that they have taken a minimum of eight (8) hours of approved in-person RCR coursework from the schedule of such courses offered by semester.

Translational Health Sciences PhD
https://smhs.gwu.edu/translational-health-sciences/
This online program enrolls 15-20 students per year, preparing candidates with the knowledge and skills needed to facilitate and lead innovation in health care. This program prepares early career professionals to take leadership roles as change agents in rapidly evolving health care environments. Students develop expertise in complexity theory, organizational analysis, mixed methods research design, program theory and evaluation. As a low residency program, most learning occurs online. Students are on campus at VTSC two weekends per semester to participate in collaborative, interactive workshops that integrate material across courses in that semester.

Vice President for Research Office (OVPR)
https://research.gwu.edu
The OVPR provides grants management services from pre-award through post-award. They provide support and resources for researchers to successfully apply for grant funding. In addition to proposal development and financial oversight and compliance, the OVPR provides support for many of GW's core facilities. OVPR coordinates research salons designed to connect and engage GWU faculty from diverse disciplines in collaborative intellectual and scholarly exchange around research-themed issues, questions, and challenges. GW's Research Enhancement Unit (REU) is focused on increasing students' and faculty members' capacity to conduct research by providing the necessary training, environment, support, and information to enable them to further develop their skills and pursue research opportunities. With more than 100 centers and institutes and cutting-edge research in science and technology, health, public policy, global security, and the arts and humanities, research and innovation are driving forces at GW. At present, GW holds over $200M in research funding. Research is a centerpiece of the new Vision 2021 strategic plan, with an anticipated investment up to $243M in coming years. REU helps GW investigators increase the competitiveness of their research proposals by:

- Providing consultative and scientific editing services;
- Delivering professional development workshops, trainings and seminars; and
- Facilitating collaboration for large, complex, international and multi-/cross-disciplinary proposals.

Writing Resources
https://writingcenter.gwu.edu
GW also offers a variety of resources to assist students and faculty in academic writing. RefWorks is an online tool supported by Gelman Library that helps writers organize their research and create bibliographies. The WID Studio offers a range of resources and references on writing.