# **Virginia Commonwealth University: College of Humanities and Sciences, Research Facilities**

## **Department of Chemistry**

### ***Instrumentation Facility***

The departmental instrumentation facility houses several modern instruments for use by upper-level undergraduates and graduate students. Instruments in the facility include liquid chromatography, gas chromatography-mass spectrometry, ion chromatography, inductively coupled plasma spectrometry, and infrared, Raman and fluorescence spectroscopy.

### ***Chemical and Proteomic Mass Spectrometry Core Facility***

The core offers a wide range of mass spectrometric services, from basic mass measurement to complex proteome analyses. Basic mass measurement is typically done on either the QToF II or the AB Sciex 5800 MALDI TOF-TOF. Samples are introduced into the mass spectrometer by direct infusion, and the investigators receive a mass spectrum either by print-out or by email which shows the mass of the species in the sample. This service is often used to verify the product of synthesis, for example. The expected mass can range from small molecules to medium-size proteins. Samples need to be approximately 100 µL in volume, with a concentration of 25-50 µM. Pure water is the solvent of choice, but solvents such as methanol or acetonitrile are also acceptable. Some experiments may require fragmentation of the precursor ion in order to answer the investigator’s questions. The center has several instruments capable of fragmentation, so the selection of the instrument will be determined by availability and the requirements of the sample.

LC-MS is available if a sample has several different species that need separation in order to be properly analyzed, or if a sample has too much salt contamination. The sample concentration can be lower; the typical concentration is 100 fmol of a standard peptide. The volume required is also lower, as no more than 10 µL can be injected on-column. LC-MS can be performed on either the Orbitrap or can be done by spotting a plate and running it on the MALDI TOF-TOF. Exact mass measurement can be performed on either the QToF II or the Orbitrap. Mass measurement with <10 ppm mass accuracy. Protein identification can be performed on either the Orbitrap or the MALDI, the instrument will be selected based on the concentration and complexity of the sample. Protein ID samples can be either gel bands or solutions; concentration can range from light silver-stain to dark Coomassie. Analysis involves enzymatic digestion (usually with trypsin, though other enzymes may be considered), analysis with LC-MS/MS, and subsequent software analysis. Investigators receive a list of their proteins, including the peptides detected, in the form of a Scaffold file.

### ***Nuclear Magnetic Resonance Center***

The Nuclear Magnetic Resonance Center is located in the Temple building. The facility has two NMR spectrometers, Bruker NanoBay AVANCE III 400 MHz NMR spectrometer and AVANCEIII 600 MHz. The NMR Facility serves a large community of users within the Department of Chemistry, other on-campus departments and industrial companies. The spectrometers operate on a 24/7 basis, with fully open access. After preliminary operational training, users are granted permission to perform experiments on their own.

## **Department of Biology (affiliated research facilities)**

The Department of Biology is housed within the Eugene P. and Lois E. Trani Center for Life Sciences. The Trani Center for Life Sciences also houses the Center for Environmental Studies, Environmental Analysis Lab, Center for the Study of Biological Complexity, a satellite lab of the Nucleic Acid Research Facility, Bioinformatics Computational Core Laboratory Suite, and the Center for Life Sciences Education.

### ***Center for Environmental Studies***

The Center for Environmental Studies emphasizes the importance of the life sciences through innovative research, hands-on teaching and community service. Faculty, staff and graduate students in the center conduct nationally and internationally recognized research in environmental science, policy, and technology.

### **Environmental Analysis Lab**

The Environmental Analysis Lab (EAL) was founded in 2007 with a mission to provide centralized analytical services to VCU faculty and graduate students engaged in environmental research. Users of the facility include faculty from the Department of Biology and Center for Environmental Studies. EAL is self-supported through fees charged for sample analyses which offset costs associated with labor, supplies, and equipment maintenance. The EAL performs analyses principally associated with water quality monitoring including measurements of various fractions of carbon, nitrogen and phosphorus, as well as indicators of algal abundance and algal toxins. EAL holds state VELAP accreditation. Core instruments include a Skalar segmented flow analyzer, a Schimadzu TOC analyzer, a Turner Designs fluorometer and a Perkin-Elmer CHN analyzer.

### ***Center for the Study of Biological Complexity***

The Center for the Study of Biological Complexity (CSBC) supports integrative research. The CSBC focuses on five specific research foci: microbial systems biology and pathogenesis; gene networks in cell biology and cellular control mechanisms; structural biology and pharmacogenomics; environmental and ecological systems; and mathematical and computational biology, biomedicine, biophysics and biostatistics. The mission of the CSBC is to build an academic community centered on quantitative and computational discovery science and to promote collaborative and reproducible research and education in basic and applied life sciences across VCU. The center develops and supports critical infrastructure and core capabilities at VCU in bioinformatics, genomics, proteomics, and computational systems biology. Center faculty apply data science and informatics principles to research, instructional and other scholarly activities in the life sciences.

### ***Bioinformatics Computational Core Laboratory Suite***

In 2000, the Bioinformatics Computational Core Laboratories (BCCL) was inaugurated under the umbrella of the CSBC to accommodate the need for bioinformatics support of VCU’s biomedical and life science research community. The mission of the BCCL is to provide bioinformatics research and development support for all VCU investigators. The Bioinformatics Core provides two-tier Bioinformatic services: 1) basic base calling and QC services required for NGS; and 2) functional analysis for project specific applications. These are outlined in more detail below:

QC Analysis, Basecalling, and Demultiplexing – NGS generates gigabase to terabase level data output in millions to billions of short 100-300 base raw reads. Each run of any of the sequencers must meet specific QA/QC standards of output prior to any further analysis. The Bioinformatics Core has established QA/QC pipelines for each of the sequencing platforms that run automatically after each run and are monitored by the bioinformatics staff of the Core. These QC pipelines include but are not limited to: number of reads, number of bases, overall percent GC content, average length of reads, percent variation of A/C/G/T in a position specific manner, levels of duplications/adapter contaminations in the sequences, etc. A majority of these QC steps have been developed in-house, but we also use broadly accepted QC software like FASTQC. The results of the QC pipeline, metrics and graphics, are posted on the secure FTP server.

If requested, the Bioinformatics Core provides in-depth data analysis for a variety of sequencing protocols including but not limited to the following:

Genome Assembly – The preferred platform for small-to-medium sized genome assembly projects is the MiSeq for both cost and efficiency. The MiSeq provides 2 X 300 base Paired End Sequences, which are amenable to efficient assembly. The reads undergo a through quality filtering as outlined above, trimming to eliminate clearly inappropriate length sequences, followed by a low-complexity purge and poly A/T clipping, before being assembled using CLC Bio Assembly Cell (or other) software. We also have extensive experience using Roche 454 sequence reads for assembly, using Roche’s proprietary Newbler software. The high quality reads are mapped back to the assembly to calculate coverage metrics.

Whole Genome/Exome Sequencing with Variant Calling – Specialized Illumina kits are used for Whole Genome/Exome sequencing for Homo sapiens, Mus musculus and samples from other well-characterized genomes. Optimized in-house pipelines are in place for effective and accurate variant calling using the GATK (Genome Annalysis ToolKit), which involves read alignment, duplicate removal, indel realignment, base recalibration, SNP/INDEL calling, variant recalibration and filtering. Variants can further be annotated using ANNOVAR or similar software.

RNA-Seq – Reads from a RNA-Seq experiment are generally processed using the Tuxedo suite of tools including TopHat 2 , Cufflinks and Cuffdiff. The steps involved are performing an exon-aware alignment; gene and isoform level FPKM expression measurements; and case-control differential expression testing. Visualization can also be obtained using CummeRbund.

ChIP-Seq – MACS2 is run to for peak analysis for ChIP-Seq experiments. The pipeline performs alignment to a reference genome, cross-correlation analysis and binding site predictions. Integrated Genome Viewer (IGV) is used visualization purposes.

microRNA – As microRNA tend to be in the 20-50nt size range, i.e shorter than a standard read length, customized trimming is required before performing any downstream analysis. Our pipeline clips off any Illumina adapter sequences before genome alignment or miRNA quantification by aligning against mirBASE

CustomSeq – The BCCL also assists in providing customized bioinformatics support like: aligning raw FASTQ reads using Bowtie2/BWA/CLC Bio to generate SAM/BAM files, Gene Calling and Annotations of Bacterial or other smaller Eukaryotic Genome, and running BLAST with NCBI nt/nr databases.

### ***Nucleic Acid Research Facility (satellite lab)***

The Genomics Core, located within the Nucleic Acids Research Facility at VCU, supports massively parallel high-throughput sequencing using next-generation sequencers. These sequencers can generate billions of bases of data per run to support a wide variety of applications. Researchers can choose either single or paired-end reads. Multiple samples can be indexed (barcoded) and combined in order to optimize the system's output. The Genomics Core of the NARF operates HiSeq 4000, NextSeq 500, and MiSeq platforms from Illumina, a Sequel System from Pacific BioSciences, Ion Torrent and Proton platforms from Thermo Fisher Life Technology, and a 454 FLX+ system from Roche. Oxford NanoPore MinION technology is also available. A BioNano IRYS automated optical mapping platform for detection of large chromosomal rearrangements is also available in the Core.

The Genomics Core in the NARF at VCU is also fully equipped to assist with library preparation. Our facility provides full service library construction for multiple applications, including custom projects. Standard protocols in the Genomics Core include:

* DNA-seq - DNA  (genomic and metagenomic) libraries with different size inserts
* Amplicon-seq (microbiome analysis uisng 16S rRNA)
* RNA-seq libraries (polyA+ enriched and strand-specific)
* RNA-seq libraries (ribosomal depletion and strand-specific)
* small RNA-seq (microRNA and lncRNAs)
* Exome capture

For high throughput applications, the Genomics Core uses CaliperTM liquid handling robots to minimize sample handling variation and to provide fast turnaround times. Our next-generation library service follows the same basic steps which include:

* sample QC (Qubit, BioAnalyzer, FEMTO Pulse or Caliper GX)
* library preparation (barcoded adaptor ligation)
* library QC (BioAnalyzer and qPCR)

### ***Center for Life Sciences Education***

The mission of the Center for Life Sciences Education (CLSE) is to facilitate research and education collaborations for the life sciences community at VCU at large. It includes tenure-track faculty conducting research, and it provides instruction with LFSC courses at the undergraduate and graduate levels to fulfill elective and interdisciplinary needs in the life sciences across VCU.

### ***Other Facilities and Cores Affiliated with the Trani Center for Life Sciences***

#### **Rice Rivers Center**

The VCU Rice Rivers Center supports research and educational opportunities that advance knowledge of the environmental and ecological sciences. Research primarily is focused on large river ecosystems, their riparian habitats and associated wetlands, but also includes terrestrial plant and animal communities, as well as landscape ecology and conservation issues.

#### **Center for High Performance Computing**

The VCU Center for High Performance Computing (CHiPC) occupies approximately 2000 sq. ft. of total space, predominantly on the third floor of Harris Hall on the Monroe Park Campus. The mission of the CHiPC is to provide high performance computing services for the VCU research community. To accomplish this goal, the CHiPC maintains four major supercomputing clusters, each specialized for different computing environments. They may be summarized as follows:

1) teal.vcu.edu is the primary cluster intended for large scale parallel computing, and is especially well suited for applications such molecular dynamics simulations, quantum chemistry and other Physical Sciences jobs. Teal consists of ~5104 64 bit Intel and AMD compute cores, each with 2-4 GB RAM/core, 10.2 TB of total RAM, 180 TB of /home space, and tmp space of between 360 and 787 GB per node and includes several GPU nodes along with a high speed network infrastructure is provided by a 20 Gb/second Infiniband architecture.

2) bach.vcu.edu is the cluster designated for serial and small parallel applications. Bach consists of a total of 920 AMD 64 bit cores, each with a minimum of 2 GB/core RAM, 2 TB total RAM, 12 TB of /home space, and /tmp space of 360 GB per node. Networking infrastructure is gigabit ethernet.

3) godel.vcu.edu is a cluster optimized for bioinformatics applications, with 1624 Intel and AMD 64 bit cores, each with at least 3 GB RAM/core, 4.8 TB of total RAM, 17 TB of /home space, tmp space of at least 180 GB/node, a GPU system and 40 Gb/second Infiniband networking, 1.2TB of GPFS high performance parallel file system storage.

4) fenn.vcu.edu is a cluster designed to support research using data that must comply with federal security and privacy requirements It consists of 1016 Intel 64 bit cores, 2/GB of RAM/core, 900 TB of GPFS high performance parallel file system storage (expandable to 2.2PB), and 54 Gb/second Infiniband networking. The Fenn system employs a security model that requires all access via VPN, and exists on a separate virtual and physical network from other university and CHiPC resources.

To support this infrastructure, the CHiPC employs a Faculty director and 4 FTE positions (J. Mike Davis, Technical Director; Carlisle Childress & Brad Freeman, Systems Analysts; and John Layne, Applications Analyst. In addition to maintaining the hardware, the CHiPC works collaboratively with VCU Reserchers to maintain and optimize a large number of applications and development tools (BLAST, R, MATLAB, NAMD, Gaussian, Gromacs, Charm, C/C++, Fortran compilers) as well as other scientific, statistical and development software.

## **Department of Kinesiology and Health Sciences**

### ***Exercise Physiology Research Laboratory***

The Exercise Physiology Research Laboratory in the Department of Kinesiology and Health Sciences is dedicated to improving human health through research into basic physiological processes. Current research projects focus on investigating specific mechanisms underlying the positive health effects of physical activity and the adverse health effects of mental stress and physical inactivity. At present, there is an emphasis on examining cellular pathways associated with inflammation and vascular vasodilatory capacity in response to acute physical and mental challenges.

An important mission of the Exercise Physiology Research Laboratory is both graduate and undergraduate education in the physiological sciences. Students from the Rehabilitation and Movement Science and Health and Movement Science program conduct their thesis and dissertation experiments in the laboratory. The laboratory has four primary faculty members from the Department of Kinesiology and Health Sciences, as well as faculty collaborators from the departments of Biology, Pediatrics, Psychology, and Surgery. The Exercise Physiology Research Lab is located at the 500 Academic Center building on VCU’s Monroe Park Campus.

## **Department of Mathematics and Applied Mathematics**

### ***Math Exchange***

In 2017, the Department of Mathematics and Applied Mathematics opened a space called the Math Exchange. The space includes a variety of group-oriented study and seminar spaces, through which instructors and teaching assistants can move to assist individualized learning. Equipment for recorded and live video is also available for supplemental learning support. In the fall of 2023, the Math Exchange was moved into the new STEM Building.

## **Department of Statistical Sciences and Operations Research**

### ***Statistics and Analytics Consulting Lab***

The mission of The Statistics and Analytics Consulting Lab (SACL) in the Department of Statistical Sciences and Operations Research is to offer a variety of consulting services which enhance both the educational experiences and research projects of VCU students and faculty. SACL can assist with study and experiment design, statistical planning for grant writing, assistance with data management, statistical analysis of data, and interpretation of results.

Currently enrolled graduate students at VCU are offered 5 hours of no charge consulting per semester. Additional consulting hours can be purchased at a rate of $60.00 per hour, which must be purchased in blocks of 5 hours ($300) with any unused portion remaining with SACL. VCU faculty members are offered 2 hours of no charge consulting per project. Additional consulting hours can be purchased at a rate of $100.00 per hour, which must be purchased in blocks of 5 hours ($500) with any unused portion remaining with SACL.

## **College’s Centers and Institutes**

The College of Humanities and Sciences has four highly research active centers and institutes that bring together faculty across disciplines and schools. Centers and institutes promote collaboration and incorporation of diverse perspectives to solve the world's most complex problems. CHS centers and institutes bring together leading scholars to focus on some of the most critical issues of our time, including youth violence prevention, racial and health disparities, and substance use.

### ***The Center for Cultural Experiences in Prevention***

The Center for Cultural Experiences in Prevention (CCEP) within the Department of Psychology at Virginia Commonwealth University was founded in 2001 to provide a place, forum and means to promote and conduct culturally congruent and community relevant prevention and intervention work primarily with African Americans and other culturally different groups.

### ***Center for the Study of Tobacco Products***

The Center for the Study of Tobacco Products brings together a multidisciplinary group of faculty and staff from VCU, American University of Beirut, Johns Hopkins University, the University of Arkansas for Medical Sciences, the Oklahoma Health Sciences Center and the University of Southern California, as well as several other U.S. and international universities and organizations to focus on an issue of immediate concern to public health — the regulation of tobacco products.

### ***VCU Clark-Hill Institute for Positive Youth Development***

The VCU Clark-Hill Institute for Positive Youth Development includes an interdisciplinary team of faculty from the Departments of Epidemiology and Community Health, Psychology, and Special Education and Disability Policy. The Institute is housed in the Department of Psychology and is located on the Monroe Park Campus of Virginia Commonwealth University in Richmond, Va. The Institute’s activities include research; undergraduate, graduate and post-doctoral training; and community engagement. The Institute is one of six National Centers of Excellence for Youth Violence Prevention funded by the Centers for Disease Control and Prevention.

### ***College Behavioral and Emotional Health Institute***

The College Behavioral and Emotional Health Institute grew out of the Spit for Science study, a university-wide research project focused on substance use and emotional health outcomes in college populations. Spit for Science created a collaborative opportunity for researchers to bring that expertise home to VCU in a way that could engage our students in the research process, raise awareness about substance use and mental health challenges among young people and use this research to benefit our community. COBE’s mission is to promote behavioral and emotional health among young people through the integration of research with coursework, programming and policy.

## **da Vinci Center**

A collaboration of VCU's School of Arts, Business and the *Colleges of Engineering and Humanities and Sciences*, the VCU da Vinci Center is a unique collegiate model that advances innovation and entrepreneurship through cross-disciplinary collaboration. 807 South Cathedral, tucked between a series of row houses across the street from the Cathedral of the Sacred Heart, is the student-named “club house” space is place for students in the da Vinci programs to brainstorm and ideate on the white board walls, prototype with moldable materials, laser cutters, and 3D printers, and host group meetings.

The Pauley Pavilion, the octagonal tower anchoring the School of Engineering East Hall at the corner of Belvidere and Main Streets, is where the core lecture and workshop spaces of the VCU da Vinci Center are located. The design of this multi-purpose space is intended to help enable innovation in all stages of the product development process from initial concepts and graphic renderings to prototypes and testing to product launch and marketing. The da Vinci Workshop, located in E4229 School of Engineering East Hall, is used as a lab space for courses offered by the da Vinci Center and additionally used as a space for student collaboration and product testing and prototyping. It is equipped with several whiteboards, a computer including the Adobe Creative Suite and a printer, arts and crafts tools, and some power tools.

## **Nanomaterials Core Characterization Facility**

The Nanomaterials Core Characterization facility (NCC) is a research core facility of the VCU Office of Research and located in the Institute for Engineering and Medicine, and is an open access, nationally ranked, collaborative materials analysis multi-user facility where researchers from various universities and industries have access to the capabilities of our state-of-the-art instrumentation and expert advice. The NCC is also a partnership between the VCU School of Engineering and the *VCU College of Humanities and Sciences*. As a core research facility, resources and services are available by contract to not only university faculty but industry as well. The NCC offers technologies that benefit multi-disciplinary industrial and scholarly research in a broad range of sciences to modify, manipulate or tailor the surface, size, or shape of a particular material including, but not limited to: regenerative medicine, biotechnology, biology, forensic science, chemistry, pharmaceuticals, materials science, aerospace, and microelectronics. The NCC provides access to over $11 million in sophisticated materials characterization equipment and analytical services unique to the mid-Atlantic region.

Equipment includes:

* Bruker Bioscope AFM
* Hitachi FE-SEM Su-70
* LSM 710 Laser Scanning Microscope
* LabRam HR Evolution
* Nikon Digital Optical Microscope
* Quantum Design VersaLab
* Rame-hart Contact Angle
* Skyscan 1173 microCT
* ThermoFisher ESCAlab 250
* VEECO ICON AFM
* Dimension FastScan AFM
* Zeiss Auriga Crossbeam FIB
* PANalytical X-Ray Fluorescence
* Physical Property Measurement System
* PHI VersaProbe III Scanning XPS Microprobe

## **Other Resources**

### ***STEM Facility***

A $121 million 168,000-square-foot, six-floor building dedicated to science, technology, engineering and math education opened in the fall of 2023 on the Monroe Park Campus. The building, which houses lab, classroom and office space for the College of Humanities and Sciences, was built at the site of the Franklin Street Gym. The building expands existing lab space, facilitate innovative and flexible teaching methods, provides students with instructional and study spaces, and frees up space in other College of Humanities and Sciences buildings to better serve students and faculty.

The STEM building features 32 teaching labs; the Math Exchange, an innovative facility for math instruction; a Science Hub for student/faculty interaction, study groups and specialized support for STEM classes; two 250-seat, team-based learning classrooms; computer labs; and large- and small-capacity flexible classrooms. Instructional wet and dry labs are included in addition to classrooms for STEM subjects.

The STEM building provides resources for anthropology, biology, chemistry, forensic science, kinesiology and health sciences, mathematics and applied mathematics, physics, psychology and the interdisciplinary science program students, and serves more than 10,000 students who will take up to 70 courses in the building each semester.

### ***Computer Resources***

The College has over 2,500 networked desktop/laptop computers that run an array of software. Our current network topology uses Ethernet technology to optimize speed of transfer within the LAN and high speed, Wireless broadband service outside of the LAN. The server profile for H&S features ten virtual servers, including our LAN system of four servers with 10+TB disk storage. The Department of Statistical Sciences and Operations Research has two main computer labs each with 30 Dell Optiplex 790 quad-core machines, with Intel ® Core ™ i5-2500 CPU running at 3.30 GHz, 4GB RAM, 250 GB hard drives and running Windows 7 Enterprise 32 bit.

### ***University Library Services***

VCU Libraries has two main libraries, the James Branch Cabell Library on the Monroe Park Campus and the Health Sciences Library for the Health Sciences on the MCV Campus, as well as auxiliary library operations such as the Learning Center at Hunton Hall; the VCUQatar Library on VCU's Doha, Qatar campus; and the Community Health Education Center (CHEC), operated by the VCU Libraries in partnership with the VCU Health System. University Library Services (ULS) support and enrich the curriculum and research activities of VCU. ULS staff provides educational, informational, and reference assistance including bibliographic and other software instruction. ULS provides resources such as online bibliographic search services, interlibrary loans, and photocopying facilities.

The Health Sciences Library, located on the medical campus, contains a major health sciences collection of more than 200,000 volumes and 3,600 periodical titles. The collections of the Health Sciences Library include resources that support virtually every discipline of medical science. It is the largest health sciences collection in Virginia and ranks in the top 20 percent among US medical libraries in print book titles and print serials. In addition to its own collections, ULS interlibrary loan departments obtain materials from other colleges and universities in Virginia, from institutions in other states, or from the National Library of Medicine.