**EQUIPMENT**

**Huck Institutes of the Life Sciences Shared Technology Facilities (University Park)**

**Genomics:**  Offers next generation sequencing and expression analysis, traditional Sanger sequencing, genotyping assays. The Genomics Core also performs microarray analysis for model organisms utilizing the Affymetrix GeneChip System and for applications requiring custom arrays, the Agilent platform. Instrumentation includes: Illumina HiSeq 2500 (NSF-MRI award, Axtell et al 2012, DBI-122906), Illumina NextSeq and Illumina MiSeq platforms, Pacific Biosciences Sequel system, ABI Hitachi 3730XL DNA Analyzer (x2), ABI 7300 Sequence Detection System, 10X Genomics Chromium, ABI 7900HT, Nanostring nCounter Analysis system, Agilent Bravo Liquid Handler, Twister Robot, Covaris, Pippin, One Touch and LT QuantStudio 3D, QuantStudio 12K Flex Real-Time PCR system, Agilent Bioanalyzer, Agilent TapeStation 4150. The Facility can also access an Illumina NovaSeq through the College of Medicine.

**Sartorius Cell Culture Facility:** Located in 405 Chandlee Laboratory, adjacent to the Genomics Core Facility, supports research by providing cell cultures, media, supplies and expertise on a recharge basis for more than 30 different laboratories on and off University Park campus. The Facility performs on site experimentation for researchers as well as providing cell cultures and supernatants for researchers to take to their labs for experiments. It also provides media and materials for checkout, and allows for onsite use of laminar flow hoods, incubators, bioreactors, and other equipment for researchers who are using cells provided by the Facility. Equipment will include but is not limited to the following: Sartorius Ambr 250, BioStat BDU twin with RM wave rocker, BioStat STR 50l bioreactor, Biostat Str 200L bioreactor, hollow fiber and adherent bioreactor systems, CO2 incubator rocker system, electroporator, PCR machines, cryopreservation systems and storage, IncuCyte S3 Live cell analysis system, and multiple centrifuges, both refrigerated and room temperature. Initial downstream processing of cell culture products will also be available in this facility.

**Proteomics and Metabolomics Facilities:** Offer mass spectrometric analysis of synthetic compounds, polymers and biomolecules (such as proteins, peptides, oligosaccharides and oligonucleotides or their conjugates). Provides identification and quantitation of metabolites by LC-MS/MS and GC-MS, protein sample preparation and subsequent analysis by nanoflow LC ESI tandem mass spectrometry (nano LC-MS/MS). Biochemical profiling, fingerprinting, metabolomics, pulse chase experimentation (stable isotope), MS-based microorganism identification. Instrumentation includes: Thermo Orbitrap Eclipse with Electron Transfer Dissociation, Bruker UltrafleXtreme MALDI-TOF/TOF, Thermo Q-Exactive, Waters G2 Si for Hydrogen Deuterium Exchange studies, Thermo Exactive Plus, Waters Synapt G2, Waters Xevo TQ-S, AB Sciex Triple TOF 5600, Agilent 5975 GC-MS, Thermo Orbitrap Fusion Lumos (NIH 1 S10 OD021750-01A1; Patterson et al, 2017).

**CSL Behring Fermentation Facility:** Houses a total of 9 fermenters ranging from 5 to 100-liter capacities, including a New Brunswick Bioflo 3000 (5L), two BioStat B – Twin units (4 x 5L), two BioStat Cplus units (2 x 30L SIP), and a BioStat D-DCU (1 x 50L and 1 x 100L SIP units). In addition, bioprocessing applications are facilitated by a Mircofluidics (M-110EH-30) microfluidizer for cell disruption. Separation and harvest of biomass are enabled by a Sharples T-1-P and AS-16 continuous flow tube bowl and a GEA-Westfalia CSA-1 disk stack centrifuges, along with a Beckman Avanti JXN26 high capacity centrifuge. Product purification and concentration possible through an AKTA Pure 150 Fast Protein Liquid Chromatography (FPLC) system, along with Sartorius SARTOFLOW Smart and Advanced platforms for micro- and ultra-filtration. Product or material drying made possible through a Labconco FreeZone 18L system. A Thermo Vanquish HPLC system provides analytical capabilities within the facility with variable wavelength UV-VIS and RI detectors. Added capabilities to support biomass processing work provided by a UV-Vis spectrophotometer, fermentation off-gas analyzers, fermentation online glucose and lactate monitoring, and other sampling processing equipment.

**Microscopy:**  Provides conventional transmission- and scanning electron microscopy, cryo-SEM, cryo-TEM, digitized imaging, microtomy, cryogenic sample preparation, high resolution imaging, elemental analysis, immunogold labeling, freeze-substitution, histology and immunohistochemistry. Instrumentation includes: Scanning Electron Microscope: Zeiss SIGMA VP-FESEM with Gatan 3View2, Transmission Electron Microscopes: FEI Spirit BioTWIN and JEOL JEM 1200 EXII. Zeiss PALM Microbeam with LCM RoboMover, Light microscopes, Accessory equipment, including a Leica HPM100 high pressure freezer. Instrumentation for microscopy includes: Leica SP8 DIVE multi-photon microscope, Olympus Fluoview 1000, Olympus Fluoview 10i, Zeiss LSM880 Airyscan Fast with PicoQuant FLIM, Keyence BZ-9000E, Zeiss AxioZoom v16 fluorescent stereo zoom microscope with ApoTom2 for optical sectioning, Olympus BX60 (digital scope), and an Olympus BX61 (materials scope). Two super resolution light microscopes (Nikon N-SIM, N-STORM and BioVision VT-iSIM) were acquired in late 2016 from a successful NSF-MRI application (Anderson et al, DBI-1625473).

**Flow Cytometry:** Instrumentation includes: Beckman Coulter MoFlo Astrios cell sorter (BSL-1, 2 & 2+) Miltenyi TYTO sorter, Miltenyi VYB and BD LSR Fortessa II flow cytometers and the EMD Millipore FlowSight imaging cytometer.

**Cryo-EM:** Thermo (FEI) Talos Arctica (NIH 1 S10 OD026822-01; Hafenstein et al, 2019) and Titan Krios G2 (microscopes acquired September 2019 and June 2016 respectively). Typically data screenings are performed on the Arctica, datasets are collected on the Krios. The Krios is unique in that it combines material science functions with biological functions without compromising data collection for either one. This Krios was strategically configured to support what we are calling the “Third Revolution” in life sciences research – the translation of tools developed in the physical sciences and engineering to the life sciences.  There are rich scientific opportunities at the convergence of these historically disparate disciplines and as such the Penn State Krios will retain all the functionally necessary for standard life sciences work (cryo-EM data collection, uncompromised use of the GIF and DED, tomography data collection) as well as unique functionality that is established in the physical sciences (STEM, EFTEM, EELS, Cs corrector). The combination will provide powerful new opportunities for the life sciences.  More specifically the Krios is configured with:  CS image corrector, Gatan Quantum GIF (EFTEM/EELS), STEM, on-axis BF/DF detector, Volta phase plate, Falcon 3e DED, and a Gatan K2 DED.

**Computer resources (specific to cryo-EM 3-D image processing).**

The computational architecture was designed to support high-speed automated data collection, analysis, visualization, and long term archival storage of cryo-EM data. Microscopy images are processed in real-time using Scipion for instant feedback for the microscopist. Infrastructure includes large storage pools, thousands of cores, Xeon phi cards, NVIDIA GPUs and high speed networking. When the University Park (UP) Titan Krios was purchased, the underlying support infrastructure was built from the ground up from high speed networking to transfer data off of the microscope to the compute resources used to process the data. Since researchers will need to get access to the micrographs from their labs, a high speed (10Gb/s) network was put into place between buildings. Data from the Krios moves locally at 10Gbps to high performance storage (70 terabytes) serving local GPU-equipped workstations (initial visualization and grid selection), central CPU and GPU compute high performance clusters configured for large data analysis. There is currently 20PB of total storage with 12 PB of archive in spinning disk and tape drives plus 8PB of active on flash based SSDs. There are parallel computer resources at College of Medicine via a 100Gbps link to UP. All primary and processed data will be centrally archived on both intermediate and long term storage. Data from analyses performed centrally will flow back to local GPU-equipped workstations for further visualization and post-processing (Figure 1).



Figure 1. Chart depicts data movement from Krios to researchers for computation and storage

**High Field Magnetic Resonance Imaging Center:** Offers magnetic resonance imaging, high resolution spectroscopy, diffuse optical tomography, RF coil fabrication and electrical characterization. Available equipment includes: 2 magnetic resonance systems; a multi-source, multi-detector near infrared spectrophotometer; network analyzers; oscilloscopes; frequency synthesizers; and software. Instrumentation includes: Varian 14.1 Tesla vertical, Varian 7 Tesla (upgraded to Bruker Avance AVIII HD) horizontal MR imagers.

**X-ray Crystallography and Automated Biological Calorimetry Core Facilities***:* NIH funded X-ray system (1S10RR023439-01, Yennawar, PI 2007, 1S10OD028589-01, Yennawar, PI 2020) include a Rigaku Micromax 007 X-ray generator equipped with a modern HyPix-Arc 150° Curved HPC Detector with a Universal Kappa 4-Axis Goniometer at the right port for single crystal X-ray diffraction data and a BioSAXS-2000Nano for small angle X-ray Scattering studies on the left port. The right port is configured with a VariMax-VHF high flux optics and Oxford Cryosystems COBRA for cryo-cooling the crystals. The BioSAXS port has a variable temperature, an OptiSAXS Confocal Max-Flux (CMF) SAXS Optic and an Automatic Sample Changer for high-throughput SAXS experiments. The core facility also houses a Viscotek 802 Dynamic Light Scattering instrument, an Art Robbins Instruments Phoenix protein crystallization robot, Formulatrix Rock Imager 182 with brightfield and UV microscope, Jasco J-1500 high performance Circular Dichroism spectrometer, Nikon SMZ18 stereo microscope with digital camera and a Jansi UV microscope. Also, two pieces of calorimetry instrumentation from a NSF-MRI award (DBI-0922974 to Bevilacqua, PI 2009) went into this facility, an automated isothermal titration system (AutoITC2000) and a high throughput differential scanning calorimeter (AutoCAP-DSC). A further NIH SIG augmented these with a TA Instruments Affinity ITC system (NIH 1S10OD025145-01, Yennawar, PI 2018). The recently successful NIH grant (1S10OD030490-01, Yennawar, PI 2021) is providing the funds to purchase our newest state-of-the-art protein characterization equipment, an inline Wyatt SEC-MALS-DLS system.

**Transgenic Mouse Facility:** Produces transgenic and gene-targeted (knockout) mice for the Penn State research community. Microinjection suite equipped with an Olympus IX-70 microscope equipped with Hoffman Contrast Optics, which also contains two surgical scopes for embryo collection and transplantation. This facility is accredited with the Association for the Assessment and Accreditation of Laboratory Animal Care, International (AAALAC), and is overseen by a federally mandated Institutional Animal Care and Use Committee (IACUC) established through Penn State's Office for Research Protections.