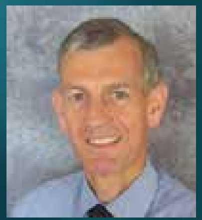
RESEARCH TECHNOLOGY PLATFORMS

WARWICK
THE UNIVERSITY OF WARWICK

WHAT ARE THE RESEARCH TECHNOLOGY PLATFORMS?



The University of Warwick's Research Technology Platforms (RTPs) provide an integrated network of world-class facilities and expertise that enable researchers to perform outstanding science.

We aim to enhance local, regional and international research outcomes by providing researchers with access to a network of cutting-edge technology platforms, operated with world-best expertise and leadership principles, to enable innovative research of the very highest quality.

A key feature of the RTP programme is that access is open to researchers across all disciplines within the University, as well as external partners from academia and industry. Equally, the RTP programme acts as an access point for industry to make use of a wider range of experimental techniques and the ability to talk directly to the technical experts who can provide bespoke analysis.

Each RTP has a dedicated support team who are devoted to the smooth running of their facility, with maximum available usage time, and to helping researchers optimise the benefits from using the RTP. As experts in their techniques, they can provide specialised training and advice on data analysis; often they will be pioneering new methodologies from which users subsequently benefit.

The RTP programme, overseen by myself as the Deputy Pro-Vice-Chancellor (Research), enables Warwick to take a coordinated approach to its key research technologies and ensure they remain at the state-of-the-art. By listening to the needs of our multi-disciplinary user base, we determine the strategic future direction of each RTP and identify new areas that can be supported in this expanding programme.

I hope that this brochure provides you with some ideas of the range of opportunities available within the RTPs and that we will soon be able to help with your research and/or address your technical challenges.

Professor David Leadley
Deputy Pro-Vice Chancellor (Research)

40 Academic and Technical Staff

Use from **200+** research groups

700+ external contracts

£14m Investment in capital

OUR STAFF

This brochure highlights the cutting-edge technologies that the RTPs provide access to. However, without our knowledgeable technical professionals the RTPs simply could not operate. We are extremely fortunate to have dedicated and approachable experts in their fields to underpin both the research at Warwick as well as helping solve challenges brought to us by industry and other institutions. Our staff add great value to the investment that we have made and deserve recognition for the work they do.

If you are publishing work that has benefitted from the support our staff have provided, please do check out our fair attribution policy and help us ensure the correct level of visibility and recognition for the contribution they have made:
warwick.ac.uk/research/technicians/fairattribution

ADVANCED BIOIMAGING

www.warwick.ac.uk/go/bioimaging

Professor Corinne Smith, Advanced Bioimaging RTP Director
corinne.smith@warwick.ac.uk | 024 7652 2461

Dr Saskia Bakker, Advanced Bioimaging RTP Manager
s.bakker@warwick.ac.uk | 024 7657 4095

The Advanced Bioimaging RTP was established in 2015. It supports the investigation of complex biological problems by researchers at Warwick and externally, through the application of cutting-edge imaging technologies. The RTP specialises in advanced light and electron microscopy.

The RTP houses two electron microscopes. The JEOL2200FS (2016) is equipped with a field emission gun electron source, an in-column energy filter, and a Gatan K2 Direct electron detector. The JEOL2100Plus (2018) is fitted with a LaB6 filament and a Gatan OneView IS CMOS camera. Additionally, the suite boasts a Leica GP plunge-freezer, an RMS cryo-ultramicrotome, and other supporting equipment such as a glow discharger and a carbon coater.

External users can be trained to use the equipment or imaging can be carried out as a service.

AT A GLANCE

Imaging temperature down to **-176°C**

£2m worth externally funded equipment

70nm slice thickness

CAPABILITIES

Thin section TEM
Room-temperature TEM of thin sections of embedded cells or tissues can give information about cell morphology and changes in cellular ultrastructure. By using immunogold labelling techniques, certain protein locations can be identified. Tomography can give a 3D view of smaller cellular structures.

Negative stain TEM
Negative stain TEM is a quick and cheap way of looking at purified samples such as nanoparticles, proteins and viruses. The sample is surrounded by a heavy-metal containing stain and dried, which provides contrast in the electron beam. Negative stain TEM is a good method to answer questions about particle morphology, sample homogeneity and particle size.

Cryo-TEM
Cryo-TEM provides information on the interior structure of samples including nanoparticles, soft materials including polymers, purified protein, protein complexes and viruses. The sample is flash-frozen and imaged at liquid nitrogen temperatures. This provides a more native-like environment for biological samples and allows for imaging of polymer samples that are unsuitable for dry-state TEM. By collecting a large amount of data and processing the images, 3D structures can be obtained for suitable purified proteins. Low-resolution 3D structures can also be obtained by cryo-tomography.

DiSPIM
The dual inverted light-sheet microscope (DiSPIM) allows for fluorescent imaging of relatively large and living specimens with low phototoxicity. Because the sample is imaged from two orthogonal angles, the data has good resolution in three dimensions.

"It's a really professional setup. We've never had any issues and we've always been able to access the kit when we need it. Everything happens smoothly and it's a really easy relationship."

XERION HEALTHCARE

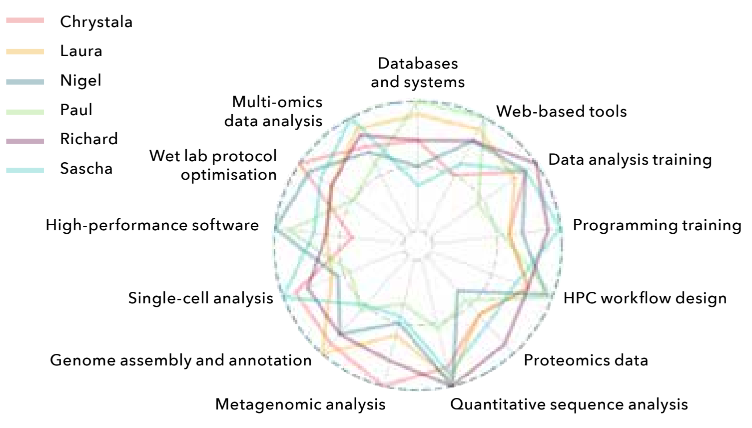
BIOINFORMATICS

www.warwick.ac.uk/bioinformatics

Dr Sascha Ott, Bioinformatics RTP Director
s.ott@warwick.ac.uk | +44 (0)24 7615 0258

Richard Stark, Bioinformatics RTP Manager
r.stark@warwick.ac.uk | +44 (0)24 7657 4266

Over the past few decades there has been a rapid increase in the size and complexity of biomedical data produced as a result of advances in technologies underpinning DNA sequencing, proteomics, metabolomics, and imaging. This is allowing researchers ever deeper insights, but also brings an ever increasing demand for the expertise to handle such large scale data sets. The Bioinformatics RTP provides the necessary expertise, with a focus on delivering the best quality analysis and aiding accurate interpretation of data from high-throughput biomedical experiments.



CAPABILITIES

Our services include:

- Planning of experimental and computational workflows to enhance data processing and interpretation.
- Collaboration on complex bioinformatics analysis challenges.
- Adaptable computing cluster technologies to meet your needs.
- Strengthening of grant applications with a range of bioinformatics input.
- Support generating figures and submitting data to repositories.
- Bioinformatics training and clinics for one-to-one advice.
- Provision of bioinformatics tools on the web or as mobile phone apps.

Computing hardware

The Bioinformatics RTP has access to several HPC cluster systems. Some we manage ourselves, and some are managed for us by the Scientific Computing RTP. These provide computational power far beyond that available on a desktop machine in terms of both CPU core count and available RAM. You can apply for accounts on these machines, or RTP staff are able to run analyses on your behalf.

List of Instruments /techniques

Our team provides assistance in bioinformatics across a broad range of data types and platforms and at all stages of the experimental procedure; from experimental design, through analysis and interpretation, to delivering results as figures and as interactive web tools.

Techniques on which we regularly work with researchers include (meta)genomics, transcriptomics and proteomics, single-cell sequencing technologies, sequence assembly and regulatory sequence analysis. This is not a comprehensive list of the ever-evolving techniques with which our team has expertise and our experience can prove useful in other fields, so please contact us to discuss how we can help with your research.

"The Bioinformatics RTP have been invaluable in the installation and setup up of a new database systems which will help us manage and distribute our seed resources. Their expertise and flexible, professional approach has been key to enabling the timely installation, and I very much look forward to working with them on other projects."

**DR CHARLOTTE ALLENDER,
WARWICK GENETIC RESOURCES UNIT**

MICRO-FOCUSED COMPUTED TOMOGRAPHY

Professor Mark Williams, Micro-focus CT RTP Director
m.a.williams.1@warwick.ac.uk | 024 7657 5361/07824 540945

Alex Attridge, Micro-focus CT RTP Manager
a.attridge@warwick.ac.uk | 024 7657 5420

X-ray Computed Tomography
X-ray Computed Tomography (CT) is an established 3D imaging technique, well known for its medical applications, that is becoming an increasingly valuable method for the non-destructive characterisation of micro structures, material samples and components across a broad range of industrial and cultural sectors.

The CT scanning systems collect a large number of 2D radiographs, which with a 360° rotation of the sample are then reconstructed to create 3D volumetric models, using algorithms such as Filtered Back Projection (FBP). The resulting data set can be visualised and/or analysed in a variety of ways; including images, slice-through videos, geometric quantification, porosity analysis etc.

Whilst CT systems have limitations in terms of the size and density of objects that can be scanned, and resolutions that can be achieved, the Micro-focus CT RTP at the University of Warwick has a suite of systems with the ability to scan and image a broad range of samples, from grains of rice through to automotive engine blocks.

The Micro-focus CT RTP provides high-resolution X-ray CT scanning capabilities to enable the 3D imaging of a wide range of materials and geometries. Located within the Centre for Imaging, Metrology and Additive Technologies (CiMAT) at WMG, our nationally-leading facility currently has four CT scanners, ranging from a high power/high penetration system capable of scanning large metallic objects such as automotive engines, gearboxes and electric drive units, through to a lab grade ultra-high resolution system, capable of achieving resolutions of just a few hundred nanometres for material samples of a few millimetres in size. We also have a high speed CT system capable of 4D imaging of samples in dynamic states (e.g. under load in compression rigs).

We have a dedicated team of researchers and scientists who provide scanning and imaging services, as well as more complex data analysis, visualisation and reporting, to both external and internal customers, including automotive, aerospace, bio medical engineering, police forensics, heritage and archaeology. We have a Measurement Management System and are aligned to ISO10012 for data capture, handling and analysis, and can provide a range of services including basic scanning and imaging, data analysis and consultancy, and research.

Mix of high resolution, power and speed scanners and dedicated image processing equipment with secure storage

Sectors worked with:

Wide range of applications including automotive, aerospace, forensics and historical artefacts

University departments worked with to date:

Engineering, Physics, Maths and Statistics, Psychology, Warwick Medical School

25 **days of instrument use each month (300 per year)**

CAPABILITIES

List of Instruments /techniques

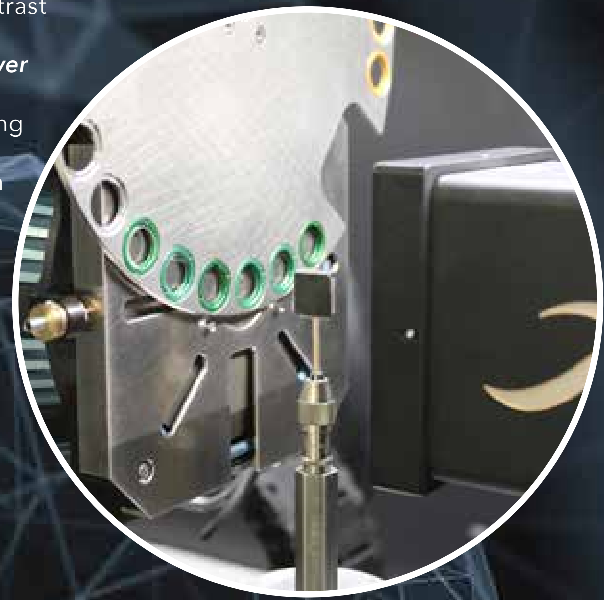
Zeiss Versa 520 - High resolution system
- 160kV source
- 170nm - 25µm voxel resolution
- Maximum object diameter = 45mm (90mm in wide field mode)
- Phase contrast and local tomography

Nikon XT H 225/320 LC
- 225/320kV source
- 5 – 170 µm voxel resolution
- Maximum object diameter = 280mm
- Large cabinet - scan 600mm in height

TESCAN UniTom XL - High speed system
- 180kV max
- Down to 1.5 micron voxel resolution
- 300mm maximum object diameter in standard mode, 450mm using detector tiling
- High resolution 2.8k detector
- High frame rate detector – up to 100fps - Scans possible in as fast as 10 seconds
- Large source-detector distance for propagation phase contrast

Nikon XT H 450RT - High power system
- 450kV/450W source Rotating Target
- 80 - 113µm voxel resolution (Micro-focus)
- 3D and 2D detector (Flat panel and CLDA)
- Penetrate 30mm Steel – 120mm Aluminium
- Large cabinet, max object diameter Ø600mm

Software
- Volume Graphics VG StudioMax (Hexagon Manufacturing Intelligence)
- FEI Avizo (Thermo Fisher Scientific)
- Simpleware (Synopsis)
- Matlab
- ImageJ
- Geomagic
- Polyworks



"The Micro CT facility at Warwick has provided invaluable scanning support for our Homicide investigations and has provided vital evidence for a large number of high profile cases. Our partnership is seen as a national model for academic partnership with law enforcement."

DETECTIVE CHIEF SUPERINTENDENT MARK PAYNE
HEAD OF FORCE CID, WEST MIDLANDS POLICE

ELECTRON MICROSCOPY

www.warwick.ac.uk/electronmicroscopy

Dr Richard Beanland, Electron Microscopy RTP Director
r.beanland@warwick.ac.uk | 024 7657 3884

Steve York, Electron Microscopy RTP Manager
s.j.york@warwick.ac.uk | 024 7652 3391

The Electron Microscopy RTP is a central facility for the University of Warwick and is one of the leading centres in the UK. It contains a wide range of microscopes in a purpose-built suite, including: high resolution scanning electron microscopes (SEM); focused ion beam (FIB); several transmission electron microscopes, from simple imaging to atomic resolution; and state of the art scanning probe microscopes (SPM/AFM). There are currently more than 200 registered users of the microscopes, both within the University as well as external commercial and academic users.

Work can be performed by highly experienced RTP staff. We also provide training and offer self-use of equipment.

8 instruments

22 external clients

1000+ hours of instrument use each month

CAPABILITIES

List of Instruments /techniques
Scanning electron microscopy (SEM); energy-dispersive X-ray (EDX) analysis; cathodoluminescence (CL); cryo-SEM; focused ion beam (FIB) microscopy; transmission electron microscopy (TEM); electron energy loss spectroscopy (EELS); scanning probe microscopy (SPM); atomic force microscopy (AFM); optical microscopy; specimen preparation.

3 TEM: The Jeol 2100 TEM can be used in scanning mode. Bright field and annular dark field images can be collected simultaneously and has an energy-dispersive X-ray detector to provide information on the chemical composition of a sample.

The Jeol ARM200F is a high-resolution aberration-corrected transmission electron microscope. This allows atomic resolution imaging both in STEM and TEM modes. The microscope has an electron energy loss spectrometer to allow detection and quantification of the elemental composition down to the atomic level. The microscope also has a energy-dispersive X-ray detector. This also yields composition maps with atomic resolution; both EDX and EELS spectra can be collected simultaneously.

SEM: Two scanning electron microscopes are able to image surfaces and handle a wide variety of samples, from conducting and semiconducting materials, beam sensitive or non-conducting samples. It has a resolution of 1-4nm and secondary electron, backscattered and in-lens imaging modes. There is an energy-dispersive X-ray (EDX) spectrometer that allows elemental composition analysis and a Cathodoluminescence spectrometer for analysing the luminescence of materials such as semiconductors and diamond. A STEM detector and multi-TEM-sample holder is also available.

FIBSEM : The FIBSEM has two columns; a column used in taking scanning electron microscopy images (SEM), and a ion column to allow focused ion beam (FIB) cutting. The FIB allows for very precise cutting of samples, with the SEM able to image the process in real time. A micromanipulator is also available to allow the user to pick up small objects. This opens up many possibilities, including picking up individual particles a few micrometers in size, making a TEM specimen from a specific site with nm precision.

ATOMIC FORCE MICROSCOPY: The atomic force microscope is suitable for use with a wide range of samples and features a vast array of modes. The AFM is able to image conductive, semiconducting and insulating samples in both air and liquid environments. The head can be adjusted to fit a wide range of sample sizes. A heating stage (30 to 250 Celsius) is also available with the ability to image under a constant flow of N2.

SPECIMEN PREP: Cutting; Polishing; Ion beaming for TEM samples.

"The technical staff in the Electron Microscopy RTP have been excellent at carrying out the measurements we need and using their experience to input on experimental design. They help fulfil the potential of the state-of the-art equipment they provide access to."

BYK ADDITIVES

PHOTOEMISSION SPECTROSCOPY

www.warwick.ac.uk/photoemission

Professor Giovanni Costantini RTP Director
G.Costantini@warwick.ac.uk | 02476 524934

Dr Marc Walker RTP Manager
M.Walker@warwick.ac.uk | 02476 151776

The Photoemission RTP was first established as the Warwick Photoemission Facility in 2012 before becoming a RTP in 2021 and thus has many years of experience in dealing with both academic and industrial surface characterisation projects across the full spectrum of the sciences. The research undertaken in the RTP is broadly divided into two categories, routine surface analysis and more fundamental surface science. The RTP hosts two modern instruments, both capable of performing surface characterisation experiments with X-ray photoelectron spectroscopy (XPS) and ultraviolet photoelectron spectroscopy (UPS).

The Kratos Axis Ultra DLD spectrometer is a high throughput instrument with automated sample positioning and data acquisition for XPS and UPS. The instrument is also capable of XPS-imaging of surfaces to a resolution of 3 microns, depth profiling of surfaces and annealing to 600 °C. Samples can be loaded via an inert transfer vessel from a suitable N_2 or Ar glovebox.

The Omicron Multiprobe spectrometer also provides routine XPS and UPS, in addition to depth profiling, annealing to 850 °C in vacuum, examining the periodicity of crystalline surfaces with low energy electron diffraction (LEED) and transfer from compatible vacuum systems using a vacuum suitcase. The preparation chamber also houses a thermal gas cracker and a port for user deposition sources.

Users can be trained to use the equipment and carry out data analysis, or this can be provided as an all-inclusive service.

2 instruments

50+ active users per year

1000+ samples per year

CAPABILITIES

X-ray photoelectron spectroscopy

X-ray photoelectron spectroscopy (XPS) is uniquely placed as a quantitative surface analysis technique which can provide elemental composition as well as the chemical and electronic state of the top ~10 nm of a solid material. Both conducting and insulating samples can be studied as the instruments are equipped with charge neutralisation. Wafers, solid samples and powders can be loaded directly in to the instrument, while solutions can be drop-cast or spin-coated on to an appropriate substrate and dried before being loaded in to the vacuum. The valence band and core energy levels are accessible with our Al Ka x-ray sources.

Ultraviolet photoelectron spectroscopy

Ultraviolet photoelectron spectroscopy employs He I and He II photon emission to study the electronic structure of the most loosely bound electrons at the surface. UPS can be used to determine the work function of a material, as well as locating the valence band maximum energy with respect to the Fermi level. Samples generally need to be conductive or consist of thin films on conductive substrates.

Complementary techniques

The spatial distribution of elements on the surface can be mapped in imaging XPS. The sampling depth of the XPS experiments can be reduced to improve surface specificity via variation of the take-off angle, while a composition profile deeper in to the sample can be extracted from a depth profiling experiment using the in-situ ion guns. The periodicity of crystalline surfaces can be studied using LEED.

Additional capabilities

In-situ surface modification is possible via gas dosing, ion bombardment to remove material, annealing of the sample, or by depositing organic and inorganic material on to the surface using a user-supplied deposition source. Samples which are sensitive to air can be transferred from a glovebox under nitrogen or argon to the Kratos instrument, or under vacuum to the Omicron instrument from a compatible system.

> "Warwick's facilities have been indispensable to our R&D at Oxford PV. Their state-of-the-art equipment and expert data analysis have helped us to achieve world-record solar PV efficiencies and to move our technology towards industrial production."
>
> **OXFORD PHOTOVOLTAICS**

POLYMER CHARACTERISATION

www.warwick.ac.uk/go/polymercharacterisation

Professor David Haddleton, Polymer Characterisation RTP Director
d.m.haddleton@warwick.ac.uk | 024 7652 3256

Dr. Daniel Lester, Polymer Characterisation RTP Manager
d.lester@warwick.ac.uk | 024 7657 4147

The University of Warwick is a globally-recognised centre of excellence in polymer research, which is underpinned by the state-of-the-art Polymer Characterisation RTP. The RTP houses a world class size exclusion chromatography (SEC) suite, a wide range of thermal analysis equipment, particle sizing from nanometre to micrometre scales, materials analysis, such as rheology and mechanical testing, and contact angle measurement. On top of this we have access to more general analytical techniques such as, GC, IR and HPLC.

In addition to experiments using the analytical techniques above, external users can take advantage of formulation development and analysis, plus bespoke project design to meet your requirements.

>25 instruments

50+ external clients

1250 hours of instrument use each month

CAPABILITIES

Gel Permeation Chromotography (GPC) / Size Exclusion Chromotography (SEC)
GPC/SEC separate on the basis of size, allowing for the accurate measurement of molecular weight averages and distributions. With advanced detectors (LS/VS), properties such as molecular size (R_g and R_h) and true molecular weight can also be measured. The Polymer Characterisation RTP is one of the few facilities world-wide that can offer SEC/GPC for a range of organic solvents (DMF, THF and $CHCl_3$ – but expandable to solvents such as DMAc), in addition to specialist aqueous and high temperature measurements. This includes a new BioSEC instrument for size separating and analysing biomaterials (such as proteins).

Thermal Analysis
The Polymer Characterisation RTP has three techniques for thermal analysis: thermogravimetric analysis (TGA), differential scanning calorimetry (DSC) and dynamic mechanical analysis (DMA). The two TGAs (including a TGA/MS) can be used to determine the thermodynamics and kinetics of processes involving weight loss, such as corrosion or oxidation. The two DSCs provide quantitative measurement of phase transitions used to determine composition and properties of materials. The two DMAs allows the study of the viscoelastic behaviour of polymers from temperature/frequency sweeps or dynamic stress-strain testing. DMA also allows analysis of polymers analogous to DSC but with greater sensitivity.

Materials Testing
The Polymer RTP has a universal testing rig for characterising the mechanical properties of materials. This is tailored towards polymer materials, having a relative small load cell (500N). Typical measurements are tension, compression and peel, allowing determination of properties such as upper tensile strength, Young's modulus and elasticity.

The facility also has a rheometer with parallel plates in various diameters, which compliments the DMA and mechanical testing, allowing determination of properties such as elasticity and viscosity.

Particle Size Determination
The particle size determination equipment in the Polymer Characterisation RTP is able to size materials from 0.6 nm to 500 µm *via* dynamic light scattering (DLS) or laser diffraction (LD). This provides an adaptable platform for a wide range of samples in a multitude of dispersants. We have three instruments available for this including two that are brand new.

Drop Shape Analyser
The RTP has a drop shape analyser (DSA) that allows for the measurement of static and dynamic contact angles of liquids on surfaces, interfacial and surface tension of liquids and surface energies of solids.

Infra-Red Spectroscopy
IR (sometimes FTIR) is a ubiquitous but under used technique that can give insight into chemical composition by analysis of bending and stretching modes of certain functional groups. This technique is suitable for solid state and can be applied to almost any analytical challenge.

GCFID/GCMS
The facility has two GC instruments with different detectors, allowing the gas phase separation and analysis of high-volatility analytes. These can be used for concentration determination of analytes via FID (flame ionisation detection) or chemical identification via MS (mass spectrometry).

HPLC
The facility has an HPLC with PDA detector and access to four more for liquid phase separation and analysis.

"WSS / The Polymer RTP have provided us with an outstanding service, delivering leading edge science to help advance our research."

DR DAVID BELL, UNILEVER

PROTEOMICS

www.warwick.ac.uk/go/proteomics

Dr Alex Jones, Proteomics Facility RTP Director
alex.jones@warwick.ac.uk | 024 7652 8144

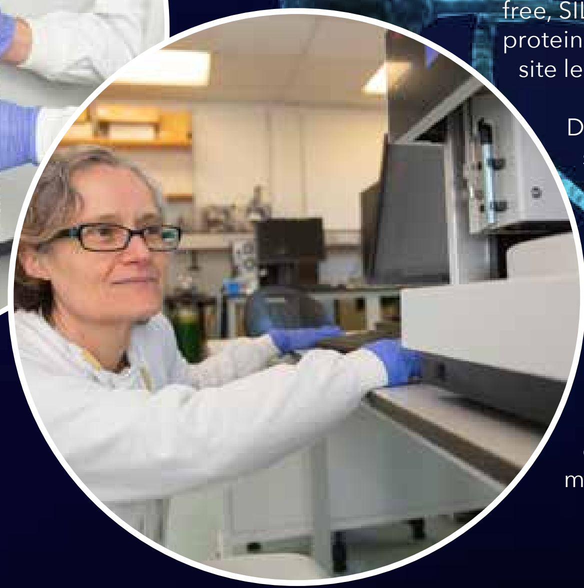
Dr Andrew R. Bottrill, Proteomics Facility RTP Manager
proteomics@warwick.ac.uk | 024 7657 4182

The Proteomics RTP provides service and support to academic and commercial researchers seeking to identify and quantify proteins and their modifications. The analysis of protein mixtures from gel slices, co-immunoprecipitations or enrichments is routine and we can identify several thousand proteins in complex samples such as, cell lysates and tissue extracts. Our favourite challenges include the analysis of protein phosphorylation and post-translational modification mapping. You will find support from an enthusiastic proteomics team to help with scientific discussion, experimental design, sample preparation, analysis of data and provision of training.

2 instruments

Bespoke experimental design

126 users from 65 research groups



CAPABILITIES

Experimental design and sample preparation
Sample quality is critical to obtain outstanding mass spectrometry results. Using the right protocol for your sample will maximise the quality of your results.

We can help with cell/sample labelling (SILAC or TMT) and selecting the most appropriate experiment and protocol to investigate the full proteome, cell fraction proteomes, protein immune precipitations, peptide enrichment and PTM experiments. And, we are open to new ideas!

Protein digestion is adapted for optimal recovery and deep proteome analysis. We have a broad range of sample preparation protocols including in gel, in solution and FASP protein digestion. Additionally, we can clean up and concentrate peptides (StageTip) or enrich phosphorylated peptides using specific resins.

List of Instruments /techniques

timsTOF Pro with nanoLC

- Ion Mobility and ultra-fast LC-MS/MS.

Ion mobility allows separation of ions based on their collisional cross-section. This facilitates separation of isomers, such as phosphopeptides or proteins folded in different ways. Ion mobility call also be used to separate based on charge-state which is effective pulling out for cross-linked peptides. Together with nano UPLC and an ultra-fast Q-ToF mass spectrometer this is a sophisticated platform for all proteomics and metabolite investigations.

Orbitrap Fusion with UltiMate 3000 RSLCnano System (Thermo Scientific)

- Identify and Quantify unknowns from complex mixtures.

Chromatography and mass spectrometry analysis are adapted to your sample for protein/peptide identification and quantification. Reverse phase C18 nano-chromatography is available using a range of gradients (30 to 240 min) and columns (15 to 50 cm long). The Orbitrap Fusion has the power and versatility to analyse with high resolution (Max. 500,000 Hz) in the Orbitrap or high speed and sensitivity using the linear trap (LTQ). It can identify and quantify 2,000 proteins per hour in a standard experiment.

Quantiva triple quadrupole with UltiMate 3000 RSLCnano System (Thermo Scientific)

- Validate targets generated from analysis of complex mixtures

Targeted quantification of known compounds (peptides or metabolites) with high accuracy and sensitivity using selected reaction monitoring (SRM). A range of chromatographic options are available including nano-LC (as Orbitrap above) and high flow rate analytical UPLC for ultrafast identification with high accuracy and sensitivity.

Data analysis
The Proteomics RTP utilises powerful workstations to interrogate databases for protein identification and quantitation. A range of search tools are provided including MaxQuant, Mascot and Sequest. Label free, SILAC and TMT quantification is possible at protein/peptide and post-translational modification site level.

Data return to users is provided via Scaffold software for basic needs and via Perseus where detailed statistical analysis is required. Skyline is utilised for targeted experiments.

We do basic comparative quantitation analysis and more detailed data analysis as Principal component analysis (PCA), sample correlation test, heat map hierarchical clustering, gene ontology category enrichment analysis and kinase motif analysis.

SCIENTIFIC COMPUTING

www.warwick.ac.uk/scrtp

Professor David Quigley, Scientific Computing RTP Director
d.quigley@warwick.ac.uk | 024 7657 4100

Dr Matt Ismail, Scientific Computing RTP Manager
matthew.ismail@warwick.ac.uk | 024 7657 4267

Dr Chris Brady, Research Software Engineer
rse@warwick.ac.uk

The RTP provides a Linux-based shared infrastructure for research computing. We manage a Linux research computing environment deployed to hundreds of user PCs, workstations and servers, also accessible via remote desktop. The RTP hosts Warwick's High Performance Computing (HPC) clusters for batch processing of computationally intensive workflows, such as large-scale simulations, high throughput parameter searches and analysis of large datasets. Our Research Software Engineering (RSE) team provide training and consultancy as well as more direct support via secondment to research projects.

270 managed Linux hosts

3 HPC clusters

used by **135** research groups

CAPABILITIES

List of facilities/services

- Managed Linux research computing environment coupled to high capacity user and group network storage.
- Shared "taskfarm" servers for batch computing jobs.
- Two large HPC clusters for large-scale parallel computing workloads.
- The Sulis tier 2 HPC service operated on behalf of HPC Midlands+
- Research Software Engineering (RSE) team providing training and consultancy to users of the RTP facilities, and longer-term software engineering support via secondment to research projects.

Please contact us to check compatibility ***before*** purchasing hardware or software to use with our systems.

Managed Linux desktop computing environment
Users registered with the RTP have access to our systems via remote desktop, or by deploying our managed Linux configuration onto local desktop hardware. Each user has access to networked data storage, software development tools including the GNU and Intel compiler suites plus a library of standard Python packages for simulation, analytics and machine learning., numerical libraries and a managed scientific software stack. Commercial scientific packages (Matlab, Maple, Mathematica) licensed centrally by the university are also available. We deliver a large (currently 1 Petabyte) group storage system to these desktops, suitable for large datasets shared by multiple users.

Avon
HPC cluster with 180 compute nodes, each with 2 x Intel Xeon Platinum 8268 (Cascade Lake) 2.9 GHz 24-core processors and 192GB DDR4 memory per node. The nodes are linked by Mellanox HDR100 (100 Gbit/s) InfiniBand allowing all 8640 compute cores to operate as a single parallel computer.

Avon also contains 16 nodes equipped with 3 x NVIDIA RTX 6000 Graphics Processing Units (GPUs) per node for GPU-accelerated applications such as machine learning, molecular dynamics, image processing etc. 4 additional nodes contain 1.5TB of memory for applications requiring large amounts of RAM. All Avon nodes are connected to a high speed parallel file system of 1PB storage. Access to a 200TB scratch space based on high performance SSDs is also available.

Orac
84 compute nodes each with 2 x Intel Xeon E5-2680 v4 (Broadwell) 2.4 GHz 14-core processors and 128 GB DDR4 memory per node. These nodes are linked with Intel Omni-Path X16 100 Gbit/s fibre.

An additional node contains 2 x IBM POWER8 3.259 GHz 8-core processors with 256 GB DDR4 memory and 4 x NVIDIA P100 GPUs. This is well suited to machine learning based on very large data sets.

Sulis
Sulis is a national tier 2 HPC service focussed on high throughput and ensemble computing, funded by a £3M "World Class Labs" award from UKRI. It is available to Warwick researchers via an internal application mechanism. The system consist of 167 dual processor compute nodes with AMD EPYC processors (128 cores per node) and 512GB of RAM. An additional 30 nodes are equipped with 3x NVIDIA A100 GPUs per node. See sulis.ac.uk for details.

> "The RSEs are an extremely useful knowledge resource, teaching new PhD starters to optimising previously written code for our research."
>
> **PROFESSOR, DEPARTMENT OF PHYSICS**

SPECTROSCOPY

www.warwick.ac.uk/spectroscopy

Dr Ben Green, Spectroscopy RTP Director
b.green@warwick.ac.uk

Dr Ben Breeze, Spectroscopy RTP Manager
b.breeze.1@warwick.ac.uk | 024 7657 2865

General enquiries spectroscopy@warwick.ac.uk

The Spectroscopy RTP has enabled easier access to the facilities and tailored training for spectroscopic data that supports Warwick's world class scientific research. The range of complementary techniques available at the RTP enables non-destructive investigation and characterisation of liquid, solid and gaseous samples.

Services include Raman, photoluminescence and optical absorption spectroscopy, in addition to fluorescence microscopy and electron paramagnetic resonance. In addition to these techniques we are able to create custom experiments to meet specific non-standard needs. The RTP has access to specialised data analysis software and databases of reference spectra to aid material characterisation.

14 instruments

70+ active users in the last 6 months

used by **5** departments

"The spectroscopy RTP facility at Warwick University provides excellent training and access to high specification Renishaw Raman spectrometers. The RTP facility provides exceptional support for characterisation of materials enabling world leading research."

JAI GUPTA,
WMG

CAPABILITIES

Raman Spectroscopy and Microscopy
Raman spectroscopy measures inelastically scattered light from a sample. Laser light focused onto a sample interacts with molecular vibrations or phonons with the lattice and is scattered with a lower energy (Stokes) or higher energy (anti-Stokes). The Raman spectrum gives insight into the structural properties of a material and each material provides a unique fingerprint.

Combining Raman spectroscopy with a microscope allows a precise point on a surface to be analysed and maps of samples to be built up. The RTP equipment is able to perform Raman measurements and maps using different excitation wavelengths ranging from UV to NIR and has stages capable of making measurements at temperatures from 4 K to 1450 K.

Photoluminescence Spectroscopy and Microscopy
Photoluminescence (PL) spectroscopy provides information on the electronic structure of a material, such as the band gap or defects present in semiconductors. This non-destructive technique focuses laser light onto a sample, exciting electrons which absorb this light into a higher-energy state; these electrons relax to ground states emitting light that is collected.

FT-IR Absorption Spectroscopy and Microscopy
FT-IR Absorbance spectroscopy can be used for both qualitative and in some cases quantitative investigations. Samples can be characterised in bulk or spatial maps can be built up using a Microscope. The Infrared absorption spectrum is produced from the light interacting with chemical bonds at vibrational and rotational frequencies allowing identification materials and defects.

UV Vis Optical Absorption Spectroscopy
The absorption equipment available at the RTP allows investigation of the optical properties of materials using monochromatic light of wavelengths in the UV and visible regions. UV-VIS Absorbance spectroscopy gives an indication of electronic structure but is most often used to determine concentrations of samples using the Beer-Lambert Law.

Electron Paramagnetic Resonance
EPR is used for study and quantification of chemical species that have one or more unpaired electrons such as organic and inorganic free radicals or inorganic complexes possessing a transition metal ion. EPR spectroscopy is used in various branches of science, such as chemistry and physics, for the detection and identification of free-radicals and paramagnetic centres. EPR is a sensitive, specific method for studying both radicals formed in chemical reactions and the reactions themselves.

WARWICK CENTRE FOR ULTRAFAST SPECTROSCOPY

www.warwick.ac.uk/go.warwick.ac.uk/ultrafast

Dr James Lloyd-Hughes, Ultrafast Spectroscopy
RTP Director

J.Lloyd-Hughes@warwick.ac.uk | 02476 522043

Dr Mick Staniforth, Ultrafast Spectroscopy
RTP Manager m.staniforth@warwick.ac.uk | 02476 151013

The Warwick Centre for Ultrafast Spectroscopy was established in 2017 and became an RTP in 2021. The use of cutting-edge ultrafast (femtosecond = 10^{-15} s) lasers allows for the observation of atomic and charge carrier motion. This is used to investigate novel materials and molecules from semiconductors to new sunscreen filters.

The RTP houses an ultrafast Ti:sapphire laser system (Newport Spectra-Physics Spitfire PA Pro) with four independently-compressible beam outputs. Through use of several optical parametric amplifiers (TOPAS, Light Conversion) the 800 nm fundamental of the Spitfire can be converted into any wavelength from the UV (235 nm) to the mid-infrared (20 microns), while we use custom non-linear effects to produce far-infrared (terahertz) pulses (75 to 600 microns). These sources serve four major beamlines in the facility: Transient Electronic Absorption, Transient Infrared Absorption, Optical Pump/Terahertz Probe and High Field Terahertz Spectroscopy. Additionally, the facility has a Cary60 UV-Vis absorption spectrometer, a Bruker 70V Fourier Transform IR spectrometer and a Horiba Fluorolog 3 fluorescence spectrometer, which performs time-resolved fluorescence measurements down to 1 ns time resolution over the 300nm to 1700nm wavelength range. We can run experiments in a number of environments, including air, dry N_2 atmosphere and vacuum, and have a number of cryostats available to test samples from liquid helium temperatures to room temperature or above.

External users can be trained to use some of the simpler equipment (UV-Vis/FTIR/Fluorolog) for occasional use, or on the ultrafast system if they require long-term use. Measurements can be carried out as a service.

Wide range of working wavelengths from 200-20000 nm and 0.5-3 THz

£2M
worth externally funded equipment

40 femtosecond time resolution

CAPABILITIES

Transient Electronic Absorption Spectroscopy

Using a tunable excitation laser ranging between 200-2500 nm, and a broadband white light probe laser which spans 320-720 nm with every shot, the population of excited electronic states can be probed with a femtosecond time resolution. We use this technique e.g. to develop new sunscreens and solar cell materials and to understand the photophysics of fluorophores and photocatalysts.

Transient Infrared Absorption Spectroscopy

Similar to transient electronic absorption, a tunable excitation laser, this time from 200 nm down to 9 microns IR excitation, pumps the system. IR light from 2500-20000 nm then measures the transient IR spectra, giving a picture of the changes in vibrational energy over time. This allows us to observe structural changes, vibrational dynamics and low-energy electron states within such systems as diamond defects, carbon nanotubes, and much solution phase photochemistry.

Optical Pump Terahertz Probe Spectroscopy

A pump beam of between 200 and 9000 nm photoexcites the sample which is probed by far IR terahertz light. Through this technique we can observe very low energy vibrational states, photoconductivity, and charge carrier dynamics after excitation with light. We have used this technique to study such systems as carbon nanotubes, semiconductor materials, and novel halide perovskites of interest in optoelectronics and energy applications.

High Field Terahertz Spectroscopy

By passing 800 nm light through a lithium niobate crystal, we generate terahertz pulses with strong electric fields (1MV/cm). By using this to drive the system under study, we can observe unique photophysics as free charges or terahertz vibrational modes are pushed far from equilibrium, and then recover. Synchronised terahertz or visible pulses can be used to probe the relaxation dynamics.

> "WCUS is absolutely fantastic! This facility is run by experts in ultrafast spectroscopy, who provide high-quality measurements on an 'ultrafast' timescale. The team are extremely helpful and accommodating to ensure that you get the data to do the science you need. I can't recommend enough!"

DR JESSICA BOLAND – PHOTON SCIENCE INSTITUTE, MANCHESTER UNIVERSITY

X-RAY DIFFRACTION

www.warwick.ac.uk/go/x-ray

Professor Richard Walton, XRD RTP Director
r.i.walton@warwick.ac.uk | 024 7652 3241

Dr David Walker, XRD RTP Manager
d.walker.2@warwick.ac.uk | 024 7615 1299

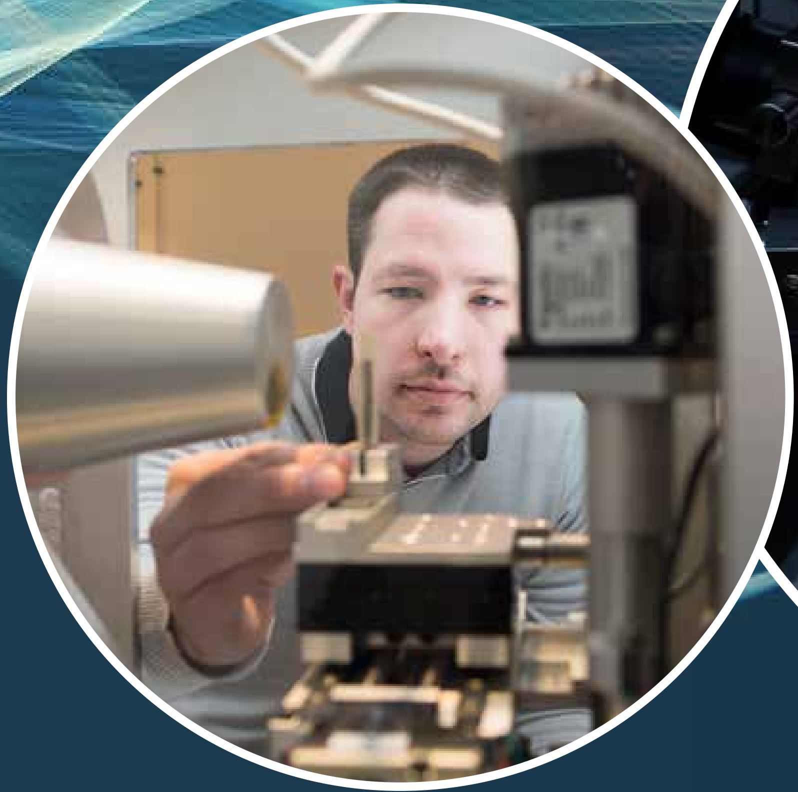
Dr Steven Huband, SAXS Specialist
s.huband@warwick.ac.uk | 024 7615 1782

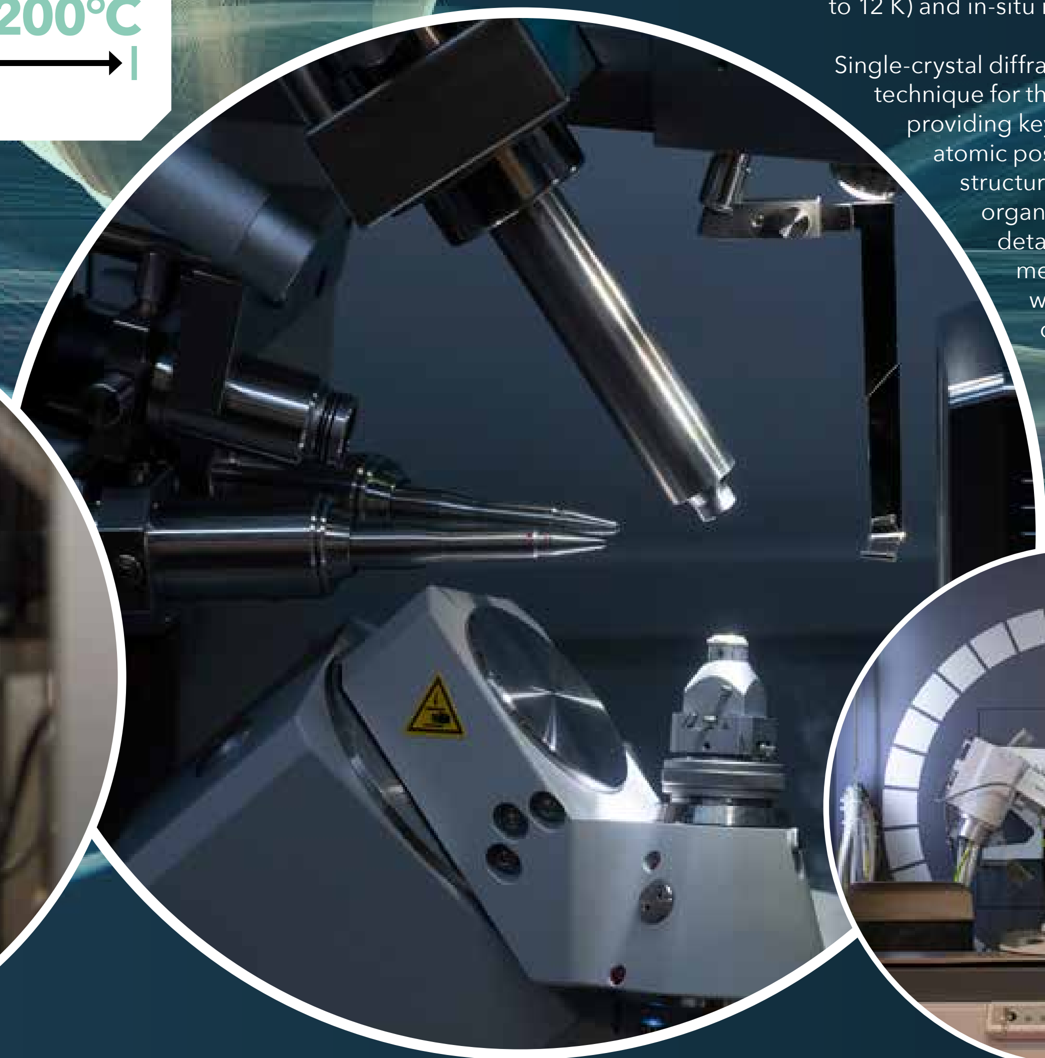
The X-ray Diffraction (XRD) RTP has a wide range of x-ray technologies and expertise in data analysis. A dedicated team of three members of staff can help train you, provide access to state-of-the-art equipment or carry out experiments on your behalf. The RTP houses 5 powder diffractometers, 2 single-crystal diffractometers, 2 high-resolution diffractometers, a wavelength dispersive x-ray fluorescence (WD-XRF) spectrometer and a small angle x-ray scattering (SAXS) system.

5 metre long SAXS

490+ publications since 2008

Measurements from -261°C to 1200°C





CAPABILITIES

The XRD RTP has a range of x-ray centric techniques. Typical measurements include phase identification, structural determination, Rietveld refinement; determination of phase contamination and sample purity; layer thickness, composition and roughness; stress and texture measurements. Advanced functional materials such as power electronics, coatings, solar cells, catalysts steels and energy storage materials are a particular focus, but we also have growing experience in the study of soft matter such as polymers and organic materials.

X-ray Diffraction
XRD is a powerful non-destructive technique for characterizing crystalline materials. At Warwick we have powder, single-crystal and high-resolution diffraction capabilities.

Powder XRD relies on diffraction from randomly orientated grains to produce a semi-unique 1D pattern, which can be matched against a database of known structures or to refine a structural model (Rietveld refinement) for atomic level crystal structure information. Warwick has 5 diffractometers covering high-throughput, high-resolution, high-temperature (up to 1200 °C), low-temperature (down to 12 K) and in-situ reactions.

Single-crystal diffraction is a powerful X-ray technique for the solution of crystal structures, providing key information on symmetry and atomic positions. Usage spans from routine structural work on organic and metal-organic small molecules to highly detailed investigations of heavy metal oxides. Warwick is equipped with two powerful single-crystal diffractometers, including a Rigaku Oxford Diffraction Synergy S with a HyPix 6000SE hybrid photon counting detector, for the most demanding samples, and a SuperNova equipped with an Oxford Cryosystems N-Helix cryo cooling system allowing for data collection down to 25 K.

High-resolution XRD uses highly monochromatic X-rays to study individual Bragg peaks of bulk single-crystal and thin-film materials, allowing precise measurement of layer thicknesses, composition analysis and diffuse scatter measurements. Typical routine applications of high-resolution XRD include reflectivity, rocking curves and reciprocal space mapping, stress and texture measurements. A high temperature stage (up to 1100 °C) is available.

Small angle X-ray scattering
SAXS is an X-ray technique for non-destructive investigation of nanoscale particle size, distribution and morphology. Typical measurements include particle size, distribution and morphology determination, tensile strain and temperature variation measurements. Applications include polymers, nanocomposites, magnetic nanoparticles, powders, fibres, pastes, gels, liquid dispersed particles and thin-films (Grazing-Incidence SAXS).

The Xenocs Xeuss 2.0 SAXS system is equipped with dual microfocus sources; Cu for standard measurements and Mo for more absorbing samples. It has a *q* range of 0.025 to 30 nm^{-1}, giving a maximum measurable particle diameter up to roughly 250 nm. We have Linkam HFSX350, TS700 and TST250V stages for measurements as a function of temperature (-196 to 700 °C) and/or strain (-196 to 250 °C).

X-ray Fluorescence
A full-size Rigaku Primus IV WD XRF is available for the determination of elemental composition from B to U with a focus on light-element sensitivity. Samples can be in solid form, pellets, fused beads, loose powder, liquids or thin-films.

> "The training and data analysis help we have had on the SAXS has really helped us push the boundaries of our research. In particular, Steve has been excellent at supporting our exploration of a new technique."

PROFESSOR SEBASTIEN PERRIER, DEPARTMENT OF CHEMISTRY

BIOLOGICAL SUPPORT UNIT

To see how we can help you, contact
biotech4@warwick.ac.uk

Research involving animals has made, and continues to make, a vital contribution to understanding, treating and curing many major health problems. Whilst new methods have enabled scientists and medical researchers to reduce and replace experiments involving animals, some animal studies must continue for further progress in science and medicine to be made.

Cognisant of the many ethical and legal issues surrounding the use of animals in biomedical research, the University of Warwick Biological Services Unit (BSU) contributes to the advancement of biomedical research through the supply of high quality research animals and allied professional services.

140 individually ventilated rat cages with a total holding capacity of **420** rats

1150 individually ventilated mice cages with a total holding capacity of **3500** mice

Recirculating aquatic system with holding capacity of **15000** zebra fish

CAPABILITIES

- Compliance with UK and EU legislation concerning the breeding and use of animals for research
- Transgenic service licences to enable breeding and supply of genetically altered animals (rodents and fish) for research
- Antibody service licence: custom antibodies can be generated in mice
- Transportation and ordering of animals arranged on your behalf
- Breeding of animals and maintaining of colonies to meet your experimental requirements
- Licenced and competent staff to assist with procedures
- Procedure and surgical rooms available for general use
- Containment level 2 holding facility and procedure room

HOW DO I ACCESS THE RTPS?

USERS AT WARWICK

Each RTP has a Manager, listed below, who will be best positioned to indicate what training or services are available and the timeframe for gaining access. They will also be able to provide the latest internal costing for accessing the RTP if applicable. Once trained, many of the RTPs run online booking systems to provide users with the most convenient access possible.

RTP	Contact details
Advanced Bioimaging	s.bakker@warwick.ac.uk – Dr Saskia Bakker
Bioinformatics	r.stark@warwick.ac.uk – Dr Richard Stark
Biological Services Unit	biotech4@warwick.ac.uk – BSU Manager
Electron Microscopy	s.j.york@warwick.ac.uk – Mr Stephen York
Polymer Characterisation	d.lester@warwick.ac.uk – Dr Daniel Lester
Proteomics	proteomics@warwick.ac.uk – Dr Andrew Bottrill
Scientific Computing	matthew.ismail@warwick.ac.uk – Dr Matthew Ismail
Spectroscopy	b.breeze.1@warwick.ac.uk – Dr Ben Breeze
X-ray Diffraction	d.walker.2@warwick.ac.uk – Dr David Walker

EXTERNAL USERS

Access to both equipment and expertise at the University of Warwick is processed through Warwick Scientific Services (WSS), for both industry and other higher education institutions (HEIs).

WSS is a central point of contact for any enquiry, whether you need access to a specific model of instrumentation, or to discuss options around a complex problem that is outside your company's current expertise. WSS will put you in direct contact with the person with the knowledge and skills to handle your investigation and has an online portal for quick turnaround of contracting – which includes an NDA and MTA for your convenience.

To discuss access to the RTPs, or any other scientific enquiry you may have, please contact Dr Ian Hancox (i.hancox@warwick.ac.uk, 024 7615 0380).

RESEARCH TECHNOLOGY PLATFORMS

Contact **RTP@Warwick.ac.uk** (internally)
or **Scientific.Services@warwick.ac.uk** (externally)