Capability Statement

Biomedical and biomaterial devices

The University of Wollongong (UOW) has an international reputation for the strength of our biomedical research and capacity to develop biomaterial devices resulting from our longstanding excellence in materials research.

This work ranges from developing synthetic biosystems such as structures for nerve regeneration, bionic muscles and 3D-printed structures for islet cells, to developing devices like the Axcelda Pen, which allows surgeons to design customised implants on-site while conducting surgical procedures for cartilage regeneration.

UOW's Innovation Campus is home to the Australian Institute for Innovative Materials (AIIM), which houses the Institute for Superconducting and Electronic Materials (ISEM), the Intelligent Polymer Research Institute (IPRI) and the Electron Microscopy Centre (EMC). IPRI is the lead node of the Australian Research Council (ARC) Centre of Excellence for Electromaterials Science (ACES) and the Australian National Fabrication Facility (ANFF) Materials Node.

ACES is committed to expanding knowledge of materials to create the next generation of "smart devices" to provide new health and energy solutions. The centre's strength is its expertise in end-to-end biofabrication solutions, with skills in forming printable bioinks, stem cell biology and customised 3D printing that assists researchers to develop concepts into actual products.

ACES, IPRI and ISEM collaborate with other researchers - particularly from the School of Chemistry, the School of Medicine and the Illawarra Health and Medical Research Institute (IHMRI) - on biomedical and biomaterial projects. These collaborations have given rise to the development of localised controlled delivery of drugs to treat pancreatic cancer. In other work, 3D printing has been used to create a benchtop airway model to better understand sleep apnoea.

The IPRI/ACES group has a strong bionics program closely connected with St Vincent's Hospital Melbourne, which provides access to surgeons and other clinicians. Researchers and clinicians are focusing on the use of novel electromaterials and advanced manufacturing techniques to build devices for biomedical applications such as nerve regeneration and regrowth, skin and bone regeneration, implantable devices, artificial (bionic) muscles and epilepsy detection and control.

Prototyping and device development facilities at AIIM allow researchers to design and build prototypes, taking their ideas from concepts to products that are closer to commercialisation. The facility is the first in Australia to bridge the gap between research breakthroughs and prototyping.

UOW's School of Mechanical, Materials, Mechatronic and Biomedical Engineering offers a unique mix of study areas, including postgraduate industry training and continuing professional development.

SOLUTIONS FOR MEDICAL CHALLENGES

The Intelligent Polymer Research Institute (IPRI) at UOW is recognised as a world leader in the development of intelligent materials and nanotechnology, including expertise in the electrochemistry of organic conductors in applications such as artificial muscles, wearable and implantable energy sources, and biomedical applications.

Researchers are collaborating on projects from developing 3D-printed body parts to building robotic systems that have the high dexterity found in humans (soft robotics). 3D printing technology researchers at IPRI are developing biomedical devices that replicate organs and other body parts. Meantime, ink-jet printing, 3D extrusion printing and wet-spinning methods are being adapted to produce biomaterials.

UOW and St Vincent's Hospital Melbourne have worked together to create the Axcelda Pen. This is a handheld 3D printer that allows surgeons to repair damaged and diseased bone material by delivering live cells, within a specialised bio-ink formulation, directly to the site of the injury to accelerate regeneration of bone and cartilage. This printing approach is also being used in the iFix system, which incorporates 3D printing to repair corneal ulcerations.

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UOW is working with an ear, nose and throat surgeon from Royal Prince Alfred Hospital in Sydney to design a 3D printer named 3D Alek that can treat microtia, a congenital deformity where the external ear is underdeveloped. The IPRI team has built a customised multi-materials biofabrication 3D printer as well as the required bioinks to support this project, which aims to regenerate cartilage for use in reconstructive ear surgery.

The IPRI team, in conjunction with Royal Adelaide Hospital, has demonstrated a breakthrough in 3D bioprinting insulin-producing islet cells to treat type 1 diabetes. Central to this work is the cutting-edge biomedical printing device, 3D PICT, and customised bioink formulation - both designed and built by ACES researchers.

Researchers at IPRI have also teamed up with world-renowned burns specialist Professor Fiona Wood and researchers from Curtin University to develop technology to treat skin wounds. Together with industry partner Inventia Life Science, UOW researchers are developing a protoype for bioprinting skin tissue. The Wollongong team is responsible for developing the bioinks for the projects. The technique - which could one day replace skin grafting - would use the patient's own stem cells in a bioink that would be inserted into a specialised 3D bioprinter and applied to the wound.

FAST-TRACKING BIOPRINTING TECHNOLOGY

IPRI has launched an entity that is focusing on research commercialisation – the Translational Research Initiative for Cellular Engineering & Printing (TRICEP). Drawing on expertise and facilities available at ACES and the Australian National Fabrication Facility (ANFF) Materials Node, TRICEP is connecting research and industry to fast-track bioprinting solutions to combat significant clinical challenges.

TRICEP houses world-leading research infrastructure to develop innovative technologies in 3D bioprinting, including printer manufacturing, biomaterials, and bioinks and was responsible for the design and production of the 3D Genii and 3DREDI. The 3D Genii printer costs between $2000 and $3000, compared with up to $250,000 for a commercial 3D printer.

TRICEP offers SMEs, research institutions and industry the opportunity to partner with leading researchers to develop and commercialise 3D printing technologies for use in the medical industry.

The ability to arrange living cells in 3D advanced material structures enables researchers to tackle significant challenges including cartilage regeneration, corneal regeneration, 3D printed ears, and 3D printed structures for islet cell transplantation. As part of this work, UOW has partnered with the University of British Columbia to develop a biomaterial bridge to help regrow nerve fibres in the spine.

GLOBAL BIOMEDICAL TIES

In 2019, UOW expanded our biomedical ties with India, signing a strategic collaboration with Andhra Pradesh Medtech Zone (AMTZ), bringing our expertise in 3D bioprinting techniques to India's first integrated medical devices manufacturing zone. Several research and training initiatives primarily focusing on 3D biofabrication are being established under the MoU.

One of the key collaborative research initiatives being pursued by AMTZ and UOW is a project to develop a scan-and-printing package to produce 3D-printed ears. The project will be coupled with innovative programs to support widespread deployment of the technology in both India and Australia.

SEAWEED FOR CLINICAL APPLICATIONS

Marine bioproducts available on the NSW South Coast have been identified and are being processed through UOW research. This includes bioactive ulvan (extracted from green seaweed to promote wound healing) and alginate (extracted from brown seaweed for use in bioinks and medical formulations that are widely used in bioengineering applications).

Other marine examples investigated with local industry to date include fish waste products and skins for collagen biomaterials, including marine chitosan. UOW also intends to explore the use of naturally occurring sources of biomaterials such as spinifex grasses, and to engage with meat processing plants to explore waste streams as sources of collagen.

UOW is developing biomaterial-based bioinks and examining their use in additive manufacturing for medical applications. Biomaterials derived from primary produce are essential in the emerging field of tissue engineering for nerve and muscle repair, skin and bone regeneration, and cosmetics.

A biotech collaboration between IPRI and Shoalhaven seaweed biomass producer Venus Shell Systems (VSS) highlights how our researchers are helping a primary producer to create value-added products from their primary or waste products. While VSS has been producing and exporting a seaweed extract for use in food and health products, its recent collaboration with UOW is fast-tracking the development and commercialisation of medical applications such as wound healing by extracting gel molecules from seaweeds.

DEVELOPING ARTIFICIAL MUSCLES

UOW researchers from ACES are working with international partners from the United States, China and South Korea to develop sheath-run artificial muscles (SRAMs) that can be used to create intelligent materials and fabrics that react by sensing the environment around them.

This builds on the work over the past 15 years by researchers from UOW and our international colleagues who have invented several types of strong, powerful artificial muscles using materials ranging from high-tech carbon nanotubes (CNTs) to ordinary fishing line. The new SRAMs are made from common natural and man-made fibres – such as cotton, silk, wool and nylon – which are cheap and readily available.

Meanwhile, UOW researchers have mimicked the supercoiling properties of DNA to develop a new type of artificial muscle for use in miniature robot applications. The development of the next generation of non-invasive surgery or robotic surgical systems, like miniature tweezers, prosthetic hands or dexterous robotic devices, is bringing researchers a step closer to matching the performance of a natural muscle using artificial muscles created in the lab.

TRAINING FUTURE RESEARCHERS

UOW was a partner of the ARC Training Centre in Additive Biomanufacturing, helping position Australia as a world leader in 3D bioprinting for medical applications.

A Graduate Certificate in Biofabrication online course is also currently offered at UOW. In 2014, UOW launched the world's first Masters degree in medical treatments based on printing and regrowing human tissue, in partnership with three other world-leading biofabrication research institutes.

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GROUNDBREAKING ELECTROCEUTICAL RESEARCH

Researchers at ACES have partnered with the University of Houston to progress electroceutical research for the treatment of diseases including rheumatoid arthritis, colitis and sepsis.

The field of electroceuticals, where electrical stimulation is used to modify biological functions, has the potential to treat medical conditions with minimal invasion and side effects. This work has widespread implications for regulating the function of the spleen, particularly the efficient regulation of the immune response for electroceutical treatment of a range of diseases.

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NEW MATERIALS AND TECHNOLOGIES

Researchers at UOW's Institute for Superconducting and Electronic Materials (ISEM) are working on new materials and technologies for applications including medical equipment and biomedical applications.

They are pioneering the development of advanced nanoceramics for several health protection applications including free radical scavengers for neurodegenerative diseases and radiation protection, smart theranostic nanoparticles for highly selective cancer therapies based on induction of controlled oxidative stress in malignant cells, and next-generation highly efficient multifunctional inorganic UV filters for sunscreens. Researchers are also developing "smart liposomes" based on magnetic nanoparticles, to be used for targeted drug delivery in cancer treatment.

WEARABLE TECHNOLOGIES

UOW's Biomechanics Research Laboratory (BRL) is developing innovative strategies to decrease injury potential and optimise the quality of life for individuals of all ages.

Members of the BRL regularly pursue collaborative projects with researchers from ACES and IPRI. This has lead to the development of some innovative projects, such as the Intelligent Knee Sleeve and the Bionic Bra.

The Intelligent Knee Sleeve is a device that uses conducting polymer-coated materials as strain gauges to provide real time audible feedback to users based on their knee motion.

The Bionic Bra has the potential to revolutionize breast support by creating a bra that provides individualised support for the wearer, based on sensing and responding to changes in breast motion.

Researchers are currently also investigating new electromaterials to monitor joint and breast motion for applications in sport and rehabilitation, as well as developing wearable technologies for patients who experience breast cancer-related lymphoedema.

SYSTEM EDUCATES BIOFABRICATORS

A wide range of technologies are under development at TRICEP, including a range of 3D printers such as the in-house built 3D REDI.

3D REDI aims to educate the next generation of biofabricators by equipping them with the skills and tools to tackle big medical challenges, as well as serving as a biomaterials research tool. It features an intuitive bioprinting platform and performs as both a research and education tool.

TRICEP Director Distinguished Professor Gordon Wallace AO says the realisation of the 3D REDI system is an exciting advance in establishing a new, innovative and sustainable 3D bioprinting industry in the Illawarra.

In 2022, TRICEP delivered one of its 3D REDI bioprinters to collaborators in Finland at Åbo Akademi University (ÅAU), providing the platform to their Laboratory of Natural Materials Technology to further facilitate research plans.

UOW WELCOMES THE OPPORTUNITY TO WORK WITH GOVERNMENT AND INDUSTRY PARTNERS TO DELIVER EXCEPTIONAL OUTCOMES

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