



World-leading research, world-changing impact

The stories on these pages illustrate some of the world-changing projects resulting from Macquarie University's collegial and cross-disciplinary approach to research.

Macquarie University is an international university with a proud reputation for research excellence. Our commitment to world-leading research has been recognised in the results of the Australian Government's most recent Excellence in Research for Australia evaluation. Results highlighted Macquarie's impressive research profile, with 100 per cent of our research ranked at world standard or higher.

As a university, we have an important responsibility to add value with the research we pursue — rigorous research inspired by a quest for deep understanding of disciplinary fundamentals in a context responsive to society's needs at levels of problem selection and research project design.

Seizing the opportunity to collaborate with industries, governments, communities, professions and academic

colleagues around the world is paramount to success. As we continue to attract the best and brightest, and develop the next generation of researchers and leaders, Macquarie will expand its cross-disciplinary and applied research and build on the tremendous depth that underpins our discovery.

Our research expertise is focused on the priorities of Healthy People, Resilient Societies, Prosperous Economies, Secure Planet and Innovative Technologies. These are buttressed by four objectives: accelerate world-leading performance, prepare world-ready higher degree research candidates, engage as a world-recognised collaborator of choice and deliver research with world-changing impact. ■

Professor Sakkie Pretorius
Deputy Vice-Chancellor
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FINDING THE ROOTS OF RESILIENCE

The ability to pick yourself up after life deals a knock is known as resilience. Jennie Hudson wants to know where it comes from.

Life is full of challenges.

Whether a teenager dealing with the onset of puberty or an older person facing cognitive decline, individuals vary in their ability to respond to stress, says psychologist, Professor Jennie Hudson, Director of Macquarie University's Centre for Emotional Health.

Resilience is a term widely used to describe a person's capacity for approaching

challenges positively and functioning in an adaptive way, or recovering from adversity. However, says Hudson, it's a phenomenon not yet adequately understood.

"Many people experience adversity. While some people respond favourably, others find it overwhelming," she says. "There needs to be more research into the factors that affect resilience."

Harnessing expertise at the University in the genetic, biochemical, cognitive, behavioural and environmental factors underlying emotional health across a lifespan, Hudson and her colleagues are now addressing the shortfall in resilience research.

"Both in personal and societal terms, the impact of this work could hardly be higher," she notes. Around one



Distinguished Professor Anne Castles, from the Department of Cognitive Science.



Professor Jennie Hudson, Director of the Centre for Emotional Health.

READING BETWEEN THE LINES

A Macquarie 'brains trust' is working to understand how children's minds develop over time.

Twenty years ago during an undergraduate placement, cognitive scientist, Distinguished Professor Anne Castles, was shocked by the disparity in primary school students' reading abilities — some were devouring the first Harry Potter book, while others barely knew the alphabet. It's a schism that persists today, and Castles is working with partners in academia, industry and the community to address it.

"This has huge implications for everything that they do. Once you can read, that just opens up your world," says Castles, of Macquarie University's Department of Cognitive Science.

Approximately 44 per cent of Australian adults have low literary skills. The legacy of this can include social exclusion, unemployment, reliance on social security systems, and poor health. Reports have shown that the global cost of illiteracy is US\$1.2 trillion.

One way to improve reading ability could be as simple as parents talking to their children, she has found. Using eye-tracking software, Castles, and PhD student Signy Wegener, observed a link between a child's oral vocabulary and their reading ability. Once a child heard a word, they were more likely to be able to read it in the future. "That was quite a big finding, because we've always known that there's a correlation between children's language skills and their reading skills, but this provides one mechanism for this association," remarks Castles.

To understand how individual processes, such as

reading, memory and language work, researchers need to know how they interact over the course of development. The earlier in development this interaction is explored, the better. "Once children get older, everything has interacted in such a complex way that you don't really know what has caused what. You can't separate out chickens and eggs," she says.

Once you can read, that just opens up your world

It's also vital that researchers across disciplines work together to understand how those domains interact. Macquarie is home to an enviable developmental science brains trust, with experts in psychology, education, linguistics, neuroscience and cognitive science.

"There's a real opportunity for interdisciplinary collaboration to really understand the whole child," says Castles.

This unique environment, together with national and international partners, prestigious international universities, government and industry, community groups, professional organisations and peak bodies will help Castles fulfil her goal. "We want to unpack how children's minds develop over time, so that we can give the very best advice about predictors of problems and ways you could intervene to divert a particular developmental trajectory." ■

in four people globally will be affected by anxiety disorders at some point, with flow-on social and economic costs.

While some people respond favourably to adversity, others find it overwhelming

The Macquarie group, including the centre's founding director, Ron Rapee, ARC Laureate Fellow and Macquarie Distinguished Professor, has established a strong reputation in the field, with several world-first findings.

"We have a unique blend of theoretical conceptualisation, experimental expertise and practical development and application," Hudson says.

A key part of the University's approach has been applying findings in a practising research clinic on campus.

"We want to take that basic science to understand what creates a more resilient person and then use our clinic to develop and test interventions that could prevent problems with emotional health," Hudson says.

Approximately 60 researchers and students in the centre are partnering with school groups, education authorities, groups representing older Australians, and others to set the research agenda and make sure the outcomes are translated as effectively as possible.

"Our end goal is to improve Australia's resilience," Hudson says. ■

THE RISE OF BIO BUILDING

Brewer's yeast, harnessed by humans since antiquity, is about to enter the 21st century in an enhanced, upgraded guise.

After a 20-year rush of discovery spurred by advances in genomic science, microbiologists are on the threshold of an even more remarkable era, says Ian Paulsen, ARC Laureate Fellow and Macquarie Distinguished Professor. They are on the cusp of being able to 'build' microorganisms specifically to address some of the world's most significant problems.

We are interested in using the synthetic yeast to turn agricultural biomass into industrial compounds

This research combines advances in chemistry, biology, computer science, and engineering, and promises to revolutionise everything from the fuel we use, to the discovery of new drugs.

"We've gone from being able to sequence an occasional gene to sequencing the genomes of entire microbial communities, and with synthetic biology we are now no longer bound by nature but can build microorganisms to our own specifications," he says.

Now Deputy Director of Macquarie University's Biomolecular Discovery and Design Research Centre, Paulsen was lured back to Australia after 12 years in the United States by Macquarie's

reputation as a world leader in biomolecular technology, and the significant investment it is making in synthetic biology.

"We decided to position Macquarie as a leader in the field in Australia and globally," he says.

Particularly exciting is the centre's contribution to the Yeast 2.0 project, a collaboration of leading international institutions in the UK, US, China, Japan, Singapore and Australia, which aims to create a novel, rationalised version of the genome of *Saccharomyces cerevisiae*, the yeast used in winemaking, baking and brewing since ancient times.

The project will build 16 designer synthetic chromosomes encompassing about 12 million base pairs of DNA. Macquarie's role is to synthesise two complete chromosomes for incorporation into the world's first synthetic eukaryotic genome.

The team has already completed one of the synthetic chromosomes, and Paulsen is confident that the second will be complete by the end of the year.

The project could allow researchers to directly test evolutionary questions about the properties of chromosomes that would otherwise not be possible. The work will also be applied to address resource shortages, Paulsen says. Yeast could be engineered as a method for producing chemicals that are currently derived from oil, for example.

"We are interested in using the synthetic yeast as a starting point to turn agricultural biomass into industrial compounds that are critical elements of our modern world, but are currently made from fossil fuels," Paulsen says. ■



Distinguished Professor Nicki Packer, Director of the Biomolecular Discovery and Design Research Centre.

THE SUGAR CONNECTION

The study of cellular sugars promises a whole new avenue of medical innovation.

For some people, the word sugar represents a substance whose consumption risks expanding the waistline. But for Distinguished Professor Nicki Packer, the word encapsulates a field of research with significant potential to improve medicine.

Packer leads a team of scientists exploring glycomics and glycoscience — the study of sugars — hoping to enhance diagnosis of health problems and treatment of disease.

Thirty years ago, glycans were paid scant attention because they were too difficult to analyse. Packer's research has changed all that. She has shown that glycans play an integral role in many crucial cellular processes including cell growth and development, tumour growth and metastasis, blood coagulation, immune recognition and response, brain function, and cell-to-cell communication.

"Glycans are an overlooked marker of how cells change. Understanding how they function in biological systems gives us new biomarkers of disease and new targets for drugs," she says.

Packer's early years as a scientist on a variety of projects at Macquarie helped her build a diverse research portfolio. After leaving Macquarie in 1999 to help launch a

successful biotechnology spin-off, Proteome Systems, she returned in 2007.

As the focus of biological research shifted from genomics to proteomics, she started approaching glycans differently. "I had started (and continue) analysing these molecules, but now I am studying their function as well as using them as targets in the body."

The translation of glycoscience is now a central plank of her position as Director of Macquarie's Biomolecular Discovery and Design Research Centre, which integrates '-omics' research across the University, and as Discovery Theme Leader in the ARC Centre of Excellence for Nanoscale BioPhotonics at Macquarie, in which the targeting of glycans for cellular sensing and drug delivery is being exploited.

"To me, this is where science is going," she says. "This interdisciplinary mix of physics, biology and chemistry has my group sitting in the middle, because we are attaching the physicist's nanoparticles to something at a molecular level, which then can target specific changes in biology." ■

Associate Professor Andrew Barron, ARC Future Fellow and Cognitive Neuroethology group leader (right).



HIVE MINDS

Insect behaviour reveals insights into consciousness, with implications for disciplines as disparate as health and computing.

A neuroscientist and a philosopher walk into a bar. It sounds like the start of a joke, but a chance meeting triggered a collaboration that is helping unveil the nature of consciousness, with potential outcomes that range from understanding mental illness to artificial intelligence.

The neuroscientist in the story is Associate Professor Andrew Barron, an ARC Future Fellow, and leader of the Cognitive Neuroethology group at Macquarie

University, who studies the behaviour of insects. The philosopher is Dr Colin Klein, an ARC Future Fellow in Macquarie's Department of Philosophy.

After chatting in a Sydney pub one night, the two embarked on a collaboration that led to a 2016 paper titled 'What insects can tell us about the origins of consciousness', in *The Proceedings of the National Academy of Sciences of the USA*.

Barron and Klein proposed that insects such as bees have a capacity for subjective experience, based on functional similarities in their brains to the human midbrain — the part associated with basic awareness.

For Barron, the paper is a great

example of how crossing disciplines can bring new insights.

Understanding how insects organise and regulate their behavioural routine could also provide insight into mental illness, Barron says. "Being able to understand how a normal behavioural program operates will give us new perspectives on how to intervene when it goes wrong". What's more, taking inspiration from how ants achieve fully autonomous behaviour could suggest simple computational solutions for AI, and make errors easier to troubleshoot.

Barron and his colleagues, Dr Ajay Narendra and Professor Ken Cheng, focus on simple organisms, like bees and ants. This 'phenomenal' level of consciousness includes cognition, subjective experience, navigation and behavioural autonomy, but does not include self-awareness

or self-reflection.

Containing less than a million neurons, compared with a human's 84 billion, the honey bee brain is small enough to be modelled both computationally and bio-robotically. "Their behaviour blows other insects out of the water. We're constantly finding new sorts of cognitive tests that bees are solving," says Barron.

Understanding the neuroethology, or 'mechanisms of behaviour' of insects, is essential in moving on to more complex levels. As Barron explains, "if we can't do it at the level of insects, we shouldn't be trying to do it with mammals." ■



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