Neuroscience Honours Program

Welcome to information about Neuroscience Honours. This information is intended for students who have completed undergraduate degrees at any university in Australia.

Aims of the program

Neuroscience Honours at the Australian National University is designed to

- further students' knowledge of the molecular, cellular and systems basis of brain function in health and disease;
- teach students how to interpret and critique original papers published in neuroscience;
- teach students how to write fluently and logically; and
- teach students how to analyse and present data that they have collected themselves.

Students should expect the program to provide them with not only specialist knowledge of brain function but also with a range of generic skills for use in a wide range of workplaces. The course is also an appropriate qualification for entrance to PhD study in any branch of the neurosciences at universities within Australia and overseas.

Admission to the program

Criteria for admission to Honours programs can be found in the CMBE/CPMS Honours Handbook (http://science.anu.edu.au/files/honours_handbook.pdf). For neuroscience, relevant subjects would normally include neuroscience, completed as a stand-alone subject or within physiology or pharmacology. Additional subjects for consideration are molecular biology, biochemistry, cell biology, pharmacology and psychology (but not social psychology). Students who have a background in computing science, physics or engineering are welcome to apply but such students must be willing to undertake coursework which will strengthen their knowledge of neuroscience. The relevance of their undergraduate degree to their Honours research project will be a strong factor in determining acceptability for admission.

Students must also have the agreement of a neuroscience Honours supervisor. Potential supervisors can be contacted directly, or prospective students can seek help from the neuroscience Honours convenor.

Enrolment process

ANU students complete an internal application form and return it to the Neuroscience Honours Convenor. The closing date is late November for start-of-year or May for mid-year Honours enrolment. Students
transferring from other universities must first enrol at ANU before enrolling in Honours.

**Organisation of the Year**

The Neuroscience Honours program commences at the beginning of February or in mid-July of each year. The course is 10 months of fulltime study. Assessment is based primarily on the presentation of a research thesis (60%). However, all students attend a journal club program in Feb-May / Aug - Sep. Assessment of this part of the course is through presentation of one journal club, and two written critiques of two other papers (20%). This provides an opportunity for the student to learn to carefully study and critically analyse research papers. Over the same period of time, the research project is developed and assessed (10%); an oral presentation of the proposed project is required early in the year and one at the end of the research project (10%).

After completion of the journal club program, students work full-time on their research projects. This can be undertaken in any one of the many neurobiological laboratories at the ANU, for example, within The John Curtin School of Medical Research, The Research School of Biology, the ANU Medical School and the Research School of Population Health. Students are expected to keep in close contact with their supervisors and to work collaboratively, but also independently on some of the technically less demanding aspects of the project. An extensive reading program must be undertaken. The course culminates with the presentation of a thesis and an oral communication documenting the research project.

Progress throughout the year is monitored by the Neuroscience Management Committee and the results achieved are assessed by the Committee using the same criteria for the award of grades of Honours as are current for Honours Programs in the College of Medicine, Biology & Environment and the College of Physical & Mathematical Sciences; details of the assessment are provided in the Neuroscience Honours Handbook.

**JCSMR Honours Year Scholarships**

*Paul Bunyan Memorial Scholarship in Medical Sciences*

This is a scholarship awarded in memory of Paul Bunyan. The Scholarship provides a stipend of $6,000 for one year for a Medical Science Fourth Year (Honours) student in a field normally related to cancer research.

*Alexander McTaggart Memorial Scholarship*

This is a scholarship awarded in memory of Alexander McTaggart. The Scholarship provides a stipend of $6000 for one year for a fourth year (Honours) student in medical science related to cancer research and allied fields.

*The Joyce Fildes Scholarship in Medical Science*

This scholarship has been generously endowed by Dr Joyce Fildes, an original member of the John Curtin School of Medical Research. The Scholarship provides a stipend of $ 6000 for one year for a fourth year (Honours) student in medical science.

*Eccles Institute of Neuroscience Scholarships*

A number of scholarships may be available to high-calibre students wishing to undertake Honours. The scholarship provides a stipend of AUD$ 6000 for one year for projects in neuroscience.
Neuroscience Honours Supervisors

**Associate Professor Ehsan Arabzadeh | Neuronal Coding Group – Eccles Institute of Neuroscience**

The Neural Coding Group has a broad interest in systems neuroscience spanning areas such as sensory coding, adaptation and behaviour. We work on the following topics:

- Signal processing in the sensory cortex
- Sensory decision making in rodent whisker system
- Neuronal mechanisms underlying selective attention in rodents
- Sensory adaptation

We perform neuronal recording from cortex and deep brain structures in anaesthetised as well as awake behaving rodents, and apply methods such as information theory to quantify the way by which single neurons or neuronal ensembles code for sensory stimuli or for the animal's behaviour.

**Associate Professor M Arcos-Burgos | Translational Genomics Group | Department of Genome Biology**

The research in Associate Professor Arcos-Burgos’ laboratory focusses on a long term initiative aimed to define functional coding and non-coding genomic variation underpinning the susceptibility to highly prevalent inherited genetic disorders i.e. ADHD, Alzheimer’s disease and other dementias, Minimal Cognitive Impairment (MCI), and Multiple Autoimmune Syndrome (MAS). The work involves thousands of DNA samples ascertained from multigenerational and extended pedigrees clustering many affected with these conditions. This has lead to published and preliminary data from either genome wide association studies or whole exome capture, as well as the identification of genes/loci throughout wide genome screening.

**Professor John Bekkers | Olfaction Group – Eccles Institute of Neuroscience**

We study olfaction in mice as a model system for understanding how the cerebral cortex processes sensory information about the outside world. Projects are available in the following areas:

- The electrical properties of neurons in the primary olfactory (piriform) cortex
- A cell culture model of the development of olfactory circuits
- Epileptic activity in the primary olfactory cortex
- Odour-learning behaviours in mice

The techniques we use include patch clamping (in cultures, in brain slices, and ‘in vivo’), 2-photon microscopy, optogenetics, animal behaviour and computer modelling.

**Dr Brian Billups | Synaptic Mechanisms Group – Eccles Institute of Neuroscience**

Astrocytes are the glial cells that surround neurons in the central nervous system. My laboratory aims to understand how astrocytes can sense the activity at adjacent synapses and how in-turn they can release substances that modulate these synapses. Astrocytic activation and its effects on neurotransmission are studied by fluorescent imaging and electrophysiological recording in acutely isolated brain slices.

Possible project areas include:

- The role of astrocytes in synaptic physiology
- Glutamate recycling and the maintenance of neurotransmission
- The role of membrane transporters at central synapses
Our primary research effort is aimed at elucidating how membrane ion channels work. Making use of a powerful supercomputer, we are attempting to follow the motion of ions as they move through a channel, study how a channel can select only the correct type of ions to traverse it and determine how many ions a single channel is capable of processing per second. We are also attempting to understand how the channel is switched from closed to open. Main Research Interests:

- Computational biophysics of biological ion channels
- Stochastic and molecular dynamics
- Synthetic nanotubes
- Drug-ion channel interactions

Understanding how networks of neurons in the mammalian brain process sensory inputs and shape motor outputs is one of science's great challenges. Using 3D holographic projection of multiple light probes, we aim to understand information flow in the mammalian brain. The light probes are directed into living brain tissues to manipulate neuronal signalling in three dimensions. This project is a multi-disciplinary collaborative venture between physics and neuroscientists to make use of novel optical techniques to analyse the brain. From the neuroscience perspective, the project aims to understand neuronal information processing, synaptic signalling and integration. However, the project will also entail design of novel optical-based methodologies to target neuroscience problems that could not be achieved by existing methods.

Regulation of calcium during contraction in normal and skeletal and cardiac muscle. We focus on the very important and essential ryanodine receptor calcium release channel and its regulation by the calcium binding protein, calsequestrin. We examine effects of mutations in these proteins that lead to debilitating skeletal myopathies and to sudden cardiac death. The topics are approached using single ion channel studies in conjunction with other electrophysiological biochemical and structural techniques.

We conduct clinical human brain research quantifying structural magnetic resonance imaging (MRI) with persons with neurodegenerative and neuropsychiatric disease and healthy volunteers to understand brain structure and relation to cognition, emotion and motor function to assist in diagnosis, staging and treatment of disease. We work in the following areas:

- Dementias (Alzheimer's, frontotemporal), movement disorders (Parkinson's disease, Huntington's disease)
- Epilepsy, strokes and cerebrovascular disease
- As well as other neurodegenerative and neuropsychiatric disease
- Collaborative studies with brain and motor electrophysiology

The techniques we use for quantitative morphology and correlation include manual and automated MRI computer segmentation, 3D modelling and shape analysis.
**Professor T Maddess**  |  *Diagnostics for Eye Diseases Group – Eccles Institute of Neuroscience*

- Multifocal pupillographic objective perimetry
- Retest variability of ophthalmic instruments
- Testing for neurological disorders
- Higher order image statistics and image texture

Our group is interested in methods for measuring dysfunction caused by ophthalmic and neurological diseases, especially visual dysfunction. We are primarily interested in non-contact measurement methods including pupillography, and psychophysical methods. Diseases of primary interest are glaucoma, macular degeneration, and diabetic retinopathy; but we have also worked on epilepsy, multiple sclerosis, and migraine. Possible future projects include concussion, Parkinson, and Alzheimer disease. We work closely with the Ophthalmology, Neurology and Diabetes Departments at The Canberra Hospital.

**Professor R Maleszka**  |  *From Molecules to Behaviour – Research School of Biology*

- Epigenetics of behavioural maturation including the role of environmental stimuli in shaping brain plasticity
- Epigenetic mechanisms controlling memory storage in the brain
- Epigenetic basis of contrasting phenotypic and behavioural outputs produced from the same genome
- Effects of epigenetic inhibitors on behaviour and memory formation

Our lab combines genome-wide and single gene-focused molecular and biochemical techniques with behavioural approaches to address several unresolved issues in biomedical sciences. Our principal model organism is the social honey bee *Apis mellifera*. We also use cell cultures derived from pluripotent imaginal discs for in vitro manipulations.

**Professor J Provis**  |  *Foveal Development and Aging Group – Eccles Institute of Neuroscience*

- Retinal development and degeneration, particularly in relation to the macula.
- Mechanisms of age-related macular degeneration, including the role of complement.

**Dr Z-M Song**  |  *Brain Development Group – Eccles Institute of Neuroscience*

1. Some infants are born with a blocked gut due to the absence of nerve cells in the gut wall, a congenital condition known as Hirschsprung’s disease (HSCR). Many HSCR patients also exhibit abnormalities of the brain. We used a rat model of HSCR caused by a spontaneous deletion in the gene of endothelin receptor B and showed a marked decrease in cell production and increase in cell death in the brain.
2. We will characterize the cell types involved from different brain regions by using specific cellular markers and confocal microscopy and investigate the underlying cellular and molecular mechanisms.
3. We will analyse the functional consequences in the cerebellum and hippocampus of adult HSCR rats.
4. We also aim to correct the structural and functional deficits by transplanting healthy neural progenitor cells into diseased brains and analysing the restoration of brain structures and functions.
**Associate Professor C Stricker**  |  *Neuronal Networks Group – Eccles Institute of Neuroscience*

We investigate how the properties of synaptic transmission in the cerebral cortex are altered by neuromodulators like noradrenaline and serotonin and how these change the short- and long-term dynamics of these synapses and how this affects information transfer, learning and memory. In addition, we are interested in calcium homeostasis, the role of calcium stores in synaptic transmission, and the changes that occur during neurodegenerative disorders such as Alzheimer's disease. We work on the following topics:

- Mechanisms of modulation of transmitter release by noradrenaline and serotonin
- Calcium homeostasis, store release and buffer capacity in nerve terminals
- Molecular mechanisms involved in the changes in firing characteristics in layer IV cells
- Calcium influx/homeostasis in immune cells during differentiation in the thymus

The techniques we use are the whole-cell recording technique, calcium imaging, immunohistochemistry, FACS, and computational modelling.

**Professor Greg Stuart**  |  *Neuronal Integration Group – Eccles Institute of Neuroscience*

The brain is made up of billions of neurons connected to each other to form specific neuronal networks. The main objective of my group is to understand how individual neurons within these networks integrate the thousands of synaptic inputs they receive. In addition, we are interested in how activation of these networks changes during learning and memory formation, and disease (epilepsy). We do this by recording from individual neurons *in vitro* and *in vivo* using both electrophysiological (patch-clamp) and imaging techniques (confocal and 2-photon).

**Associate Professor K Valter**  |  *Retinal Cell Damage and Repair Group – Eccles Institute of Neuroscience*

My research has focused on degenerative diseases of the retina, from the molecular and cellular level, to the clinical. This research has had an impact in two particular areas: (1) The role of oxygen levels in the stability and degeneration of photoreceptors; and (2) the retina's ability to self-protect against stress, using the regulated expression of protective factors. In the former area I was the first to demonstrate the oxygen dependence of several forms of photoreceptor degeneration; in the latter I have shown the sites of trophic factor binding to organelles of the photoreceptor. These lines of research have led to the formulation and testable hypotheses concerning the mechanisms that either damage or protect photoreceptors. Using the light-induced model of retinal degeneration, I was able to test the effects of protective factors and investigate their action mechanism on the stressed retina. To characterise this model further, I started to investigate the role of mitochondrial damage, metabolic changes and oxidative damage in light-induced photoreceptor injury.

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