Australasian course in advanced NEUROSCIENCE

Australasian Neuroscience Society

ACAN 2021

Australasian Course in Advanced Neuroscience

ONLINE COURSE PROGRAM

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Instructions for STUDENTS

NOTE: *Students should join all sessions each day. Logging on at least 5 minutes before the lecture starts is strongly encouraged.*

Student introductions

On day 1 (11th October) we will all introduce ourselves. Please prepare a short 3 minute 'elevator' pitch that says who you are, where you are from and what you are doing scientifically. It is important to stick to time as we will have 14 students to get through. No slides required.

Speaker introduction and lecture chairing

Each student will have a speaker/lecture allocated that they will need to introduce and chair. This is a great opportunity to get to know the speaker establish contact with them. The introduction should be about 3 minutes and give good insight into the speaker's scientific career. As the Chair you will also be expected to lead discussion and field questions. We want this to be as interactive as possible on zoom, so this will be an important role for the character of the course. ***Chair allocations are marked in the program.***

Wrap up discussion

On the final session (22nd October) we will hold a general discussion led by the ACAN Directors. Students are expected to be able to pitch ideas on future trends of neuroscience, based on the concepts acquired during the course. Students should be naturally participative at this point.

WEEK 1 | FUNDAMENTALS OF ELECTROPHYSIOLOGY

The Excitable Cell and Synaptic Transmission

Monday 11 OCTOBER

08:45 – 09:00 Course Introduction

Alan Finkel | *ACAN Founder*

SESSION 1 *Chair:* ACAN Directors

09:00 – 10:15 Student Introductions (~3 min/student)

Noorya Ahmed (ANU)
Khaing Phyu Aung (ANU)
Elissa Belluccini (Sydney)
Abdulhameed Bosakhar (RMIT)
Razvan Gamanut (Monash)
Madeline Di Natale (Melbourne)
Jacqueline Heighway (Florey)
Heidi McAlpine (Melbourne)
Elise Pepin (UNSW)
Michael Perkinson (Otago)
Sushmitha Raja (Western Sydney)
Mitchell Ringuet (Melbourne)
Joscelin Smith (Auckland)
Felix Thomas (ANU)

10:15 – 10:30 Break

SESSION 2 *Chair:* Christopher Reid

10:30 – 11:45 The Golden Rules of Electrophysiology

John Bekkers | *The Eccles Institute of Neuroscience* (ACT)

WEEK 1 | FUNDAMENTALS OF ELECTROPHYSIOLOGY

The Excitable Cell and Synaptic Transmission

Tuesday 12 OCTOBER

SESSION 1 — *Chair:* Jacquie Heighway

09:00 – 10:15 — Voltage Gated Channels & Excitability
Bill Connelly | *University of Tasmania* (TAS)

10:15 – 10:30 — Break

SESSION 2 — *Chair:* Karl Iremonger

10:30 – 11:45 — The Electrical Structure of Neurons
Greg Stuart | *The Eccles Institute of Neuroscience* (ACT)

Wednesday 13 OCTOBER

SESSION 1 — *Chair:* Felix Thomas

09:00 – 10:15 — Dendritic Integration
Stephen Williams | *Queensland Brain Institute* (QLD)

10:15 – 10:30 — Break

SESSION 2 — *Chair:* Razvan Gamanut

10:30 – 11:45 — Neural Coding and Information Theory
Ehsan Arabzadeh | *The Eccles Institute of Neuroscience* (ACT)

WEEK 1 | FUNDAMENTALS OF ELECTROPHYSIOLOGY

The Excitable Cell and Synaptic Transmission

Thursday 14 OCTOBER

SESSION 1 — *Chair:* Heidi McAlpine

09:00 – 10:15 — *In Vivo* Patch Clamp
Saba Gharaei | *The Eccles Institute of Neuroscience* (ACT)

10:15 – 10:30 — Break

SESSION 2 — *Chair:* Khaing Phyu Aung

10:30 – 11:45 — Physiology of the Synapse
Wendy Imlach | *Monash University* (VIC)

Friday 15 OCTOBER

SESSION 1 — *Chair:* Madeleine Di Natale

09:00 – 10:15 — Dynamics of Neurotransmitter Release
Sarah Gordon | *The Florey Institute of Neuroscience* (VIC)

10:15 – 10:30 — Break

SESSION 2 — *Chair:* Mitchell Ringuet

10:30 – 11:45 — Long Term Synaptic Plasticity
Cliff Abraham | *University of Otago* (NZ)

11:45 – 13:00 — Lunch Break

SPECIAL SESSION

13:00 – 14:00 — The Squid and its Giant Nerve
Ian Forster | *The Florey Institute of Neuroscience* (VIC)

WEEK 2 | NEURONAL NETWORKS & SYSTEMS

Monday 18 OCTOBER

SESSION 1 — *Chair:* Lucy Palmer

09:00 – 10:15 — Imaging the Brain
Jack Waters | *Allen Institute of Brain Science* (USA)

10:15 – 10:30 — Break

SESSION 2 — *Chair:* Sushmitha Raja

10:45 – 12:00 — Calcium Imaging
Juliette Cheyne | *University of Auckland* (NZ)

Tuesday 19 OCTOBER

SESSION 1 — *Chair:* Joscelin Smith

09:00 – 10:15 — Imaging in Zebrafish
Ethan Scott | *Queensland Brain Institute* (QLD)

10:15 – 10:30 — Break

SESSION 2 — *Chair:* Alexandra Belluccini

10:30 – 11:45 — Advanced Imaging Techniques
Fred Meunier | *Queensland Brain Institute* (QLD)

WEEK 2 | NEURONAL NETWORKS & SYSTEMS

Wednesday 20 OCTOBER

SESSION 1 — *Chair:* Abdulhameed Bosakhar

09:00 – 10:15 — Evolution & Development of Pallium/Subpallium
Rodrigo Suárez | *Queensland Brain Institute* (QLD)

10:15 – 10:30 — Break

SESSION 2 — *Chair:* Élise Pépin

10:45 – 12:00 — Studying Neural Systems *in vivo*
Lizzie Manning | *University of Newcastle (NSW)*

Thursday 21 OCTOBER

SESSION 1 — *Chair:* Noorya Ahmed

09:00 – 10:15 — Neuromodulation in Subcortical Systems and Learning
Miriam Matamales | *UNSW Sydney* (NSW)

10:15 – 10:30 — Break

SESSION 2 — *Chair:* Michael Perkinson

10:30 – 11:45 — Fibre Photometry and the Study of Learning
Philip Jean-Richard Dit Bressel | *UNSW Sydney* (NSW)

Friday 22 OCTOBER

SESSION 1 — *Chair:* Simon Fisher

09:00 – 13:00 — Neural Imaging with Miniaturized Microscopes in Freely Behaving Animals
Daniel Aharoni | *University of California Los Angeles* (USA)

13:00 – 14:00 — Lunch Break

SPECIAL SESSION

14:00 – 15:00 — Course Wrap Up Discussion & Farewell
ACAN Directors

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Ehsan Arabzadeh (ANU)

John Bekkers (ANU)

Juliette Cheyne (Auckland)

Bill Connelly (UTAS)

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Lizzie Manning (Newcastle)

Fred Meunier (UQ)

Ethan Scott (UQ)

Greg Stuart (ANU)

Rodrigo Suarez (UQ)

Jack Waters (Allen)

Stephen Williams (UQ)

STUDENTS

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STUDENT BIOSKETCHES

Noorya AHMED

My name is Noorya Ahmed, and I am currently a third year PhD student under the supervision of Dr Nathalie Dehorter at the Eccles Institute of Neuroscience at ANU. I did my honours research project with Dr Dehorter describing the connectivity of cholinergic interneurons within the striatal circuit, and how this is under the control of genetic regulation. This research was done via immunohistochemistry and confocal microscopy. My current PhD project builds on this and focusses on the role of genetic/molecular regulation on the functional connectivity of the striatal circuit through development. To investigate this, I use cre-lox dependent knockout mice to remove a key regulator of cell activity and cell development (the transcription factor Er81), and explore resulting alterations using whole cell patch clamping to perform single cell and simultaneous paired recordings from striatal interneurons. I also plan to perform in-vitro calcium imaging to investigate network activity during key developmental stages in my knockout conditions, and am excited to learn more about this technique during ACAN. I'm looking forward to the program and to learning more about the wide range of techniques to be presented.

Khaing Phyu AUNG

I am a third year PhD student from John Bekkers' group, JCSMR, ANU. Before I came to Australia I worked as a medical doctor and lecturer at a medical university in Myanmar. I learned about electrophysiology during my study for my Masters degree and was intrigued by it. Hence, I decided to focus my PhD on cellular neurophysiology in order to learn the approaches I will need for my future research career. My long-term goal is to work on diseases such as epilepsy, Alzheimer's or Parkinson's. I hope to find information that will alleviate suffering. When I started my PhD I had no previous experience with neurophysiology. I have since learned basic patch clamping methods, including whole-cell and nucleated outside-out patch recordings. I am currently using these approaches to study the intrinsic electrical properties of inhibitory interneurons in piriform cortex, focusing on an unusual type of spiny interneuron, the horizontal cell, that is only found in the piriform. My future plans for my PhD are to study the synapses made and received by horizontal cells, and also to use RNA labelling techniques to explore ion channel expression in these cells. I look forward to learning as much as possible at ACAN and making many new friends.

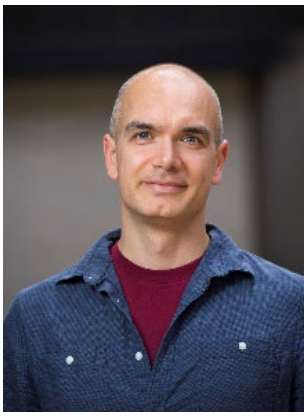
Elissa Alexandra BELLUCINI

Hi there, my name is Elissa. I am in my second year of my PhD at the University of Sydney, under the supervision of Dr Dario Protti and Professor Paul Martin. In my project I am using iterative reconstruction to generate receptive field maps of ganglion cells in the mouse retina. We perform in-vitro whole-cell patch clamp experiments to collect subthreshold and spike responses, while presenting a flashing bar stimulus. Responses undergo principal component analysis, and the resulting spatial weights are fed into the iterative reconstruction algorithm to generate receptive field maps. The broad aim of my project is to produce receptive field maps for ganglion cells with both linear and non-linear properties. I also capture images of recorded cells on a confocal microscope, and analyse the correspondence between receptive field strength and dendritic morphology.

Abdulhameed BOSAKHAR

I am currently a PhD student in the Neurodevelopment in Health and Disease research program (School of Health and Biomedical Sciences, RMIT University) and am supervised by A/Prof Mary Tolcos, Prof David Walker and Dr Sebastian Quezada. My PhD project involves discovering the mechanisms that drive cortical folding (or gyrification) by comparing the brain of gyrencephalic species such as the fetal sheep and postnatal ferret, with the lissencephalic spiny mouse. Cortical folding is a feature of the primate and human brain and is believed to underlie higher-order behaviours however little is known about how the brain acquires its folds. My project will focus on the role of the subplate, a transient cellular compartment in the brain that appears before the onset of cortical folding and almost disappears once folding is complete. During brain development, the subplate provides growth factors and guiding cues to newly born neurons and axons emerging from the subcortical regions, guiding them into the overlying cortical plate. Therefore, could changes in the subplate layer and cells be indicative of the position of folds? In my PhD I will characterise the morphological and functional differences between two cortical layer neurons - the subplate and the cortical plate - located beneath sulci vs gyri as they develop (i.e., before, during and after the completion of cortical folding). I will use techniques such as histology, immunohistochemistry and Golgi staining to assess morphology, as well as whole cell patch-clamping, multi-electrode arrays and calcium imaging to assess function.

Razvan GAMANUT



I did my PhD in neuroanatomy in the team of Dr Henry Kennedy and Dr Kenneth Knoblauch at Stem-cell and Brain Research Institute (Inserm U1208, Lyon, France), and then a two-year postdoc in the same team. During this period, I conducted research in collaboration with Prof Andreas Burkhalter (Washington University School of Medicine in St. Louis, MO, USA), with whom we investigated the connectome of the mouse cortex at mesoscale level, using injections of retrograde tracers. I also developed computational skills to analyse and compare the connectomes of rodents and primates and to deal with large volumes of data through the development of neuroinformatics pipelines. Since October 2019 I am working as an Early Career Research Fellow at Monash University in the group led by Prof Marcello Rosa. In the current project I aim to characterise, at cellular and circuit levels, how the claustrum interacts with different networks of the cerebral cortex. So far I have investigated the projections of the claustrum to the cerebral cortex using injections of retrograde tracers. At ACAN, I am excited to explore the techniques taught, in order to further use them in studying the dynamics of claustro-cortical circuits.

Madeleine DI NATALE

Integrated Control of Gastric Function- The Virtual Stomach

Madeleine Di Natale, first year PhD student. Supervisors - Professor John Furness and Dr Martin Stebbing, Digestive Physiology and Nutrition laboratory, Department of Anatomy and Physiology, MDHS at Melbourne University.

My project will contribute to building The Virtual Stomach, this model will provide a realistic, testable model of the mechanisms of generation and control of gastric movements that will aid in developing neuromodulation treatments for debilitating digestive disorders and conditions. Highly coordinated intrinsic gastric control and communications between the CNS and periphery are necessary for optimal digestive efficiency. Dysfunction of neuronal innervation, specifically the stomach musculature, is of interest for this project. To determine the extent of functional innervation of intrinsic motor neurons, the electrophysiology technique of intracellular recordings from smooth muscle cells (SMCs) will be obtained, recording electrical events from the SMCs at specific distances away from stimulating electrodes, this data collection has been underway for 6 months. To selectively record the responses to inhibitory nerve stimulation, the actions of excitatory neurons will be blocked pharmacologically and vice versa. The convergence of motor neuron inputs to the smooth muscle will be investigated structurally through retrograde tracing and investigation of vagal inputs to enteric neurons through super-resolution microscopy.

Jacqueline HEIGHWAY

Supervisors: Steve Petrou, Chris Reid, Snezana Maljevic, Géza Berecki. My PhD topic is investigating the impact of loss-of-function mutations in SCN2A, a voltage-gated sodium channel gene expressed in the brain. Mutations in this gene cause a suite of neurodevelopmental disorders, and the two I have focused on during my PhD are autism spectrum disorder and developmental and epileptic encephalopathy. I assess the functional consequences of a mutation in transfected CHO cells and also in patient-derived stem cell differentiated neurons using patch clamp electrophysiology. I am now also learning to combine this technique with calcium imaging as a way to study the back-propagating action potential, which is thought to be driven by the SCN2A channel.

Heidi McALPINE

Dr. Heidi McAlpine is a SET 3 Neurosurgery Trainee who completed her BSc(hons), MBBS and DipSurgAnat at the University of Melbourne. She plans to forge a career as a surgeon/scientist and is currently taking a break from neurosurgery training to undertake a PhD at the Florey Institute of Neuroscience and Mental Health under the supervision of A/Prof Lucy Palmer and Professor Kate Drummond. Heidi was awarded the Warren Haynes Fellowship from the Neuroscience Foundation and the Melbourne University Research Training Program Scholarship to undertake her research, which will further characterise the newly discovered neuronal-glioma synapse using in-vitro patch clamping of ex-vivo human tumour. Glioma are primary brain tumours; cancers, embedded within a complex electrical network. The interactions between neurons and glioma cells are more complex than previously recognised. In addition to known autocrine and paracrine interactions, in vivo rodent xenograft models and preliminary in vitro models suggest that bona fide synapses exist between neurons and gliomas that may have implications for growth and survival of glioma cells. Patch-clamp single-cell electrophysiological recordings using freshly explanted human peritumoural tissue are performed to examine the functional connectivity between neurons and glioma. We assess both the spontaneous electrical activity of glioma cells, as well as that in response to external stimulation, or the activity of adjacent neurons. This interaction is further characterised pharmacologically. Activity of neurogliomal synapses will be correlated with pathological and clinical information. Defining the neurogliomal synapse and characterising its electrophysiological and pharmacological properties has the potential to revolutionise our understanding of these tumours, their growth and provide new therapeutic targets.

Élise PÉPIN

Supervisors: Vincent Laurent and Bernard Balleine.

Experimental methods: rodent stereotaxic surgery (mostly rats), In vivo optogenetics (rats), rodent instrumental conditioning, confocal/spinning disk microscopy.

Current project: Optimal decision-making requires the capacity to extract predictive information from environmental events to guide future actions. This capacity is commonly studied in the laboratory through outcome-specific Pavlovian Instrumental Transfer (PIT), during which a stimulus predicting a particular outcome guides choice towards actions earning that same outcome. Over several years, Balleine and colleagues have been investigating the core neural systems and cellular circuits that regulate the PIT effect. They have highlighted the critical role played by one brain region in the expression of PIT: the nucleus accumbens shell (NAc-S). They have proposed that the NAc-S integrates information about the Pavlovian and instrumental contingencies that are necessary to mediate the PIT effect. Yet, the upstream structures providing the NAc-S with such information remain elusive. My PhD research will use precise optogenetic manipulations in freely moving rats to investigate the roles played by NAc-S inputs originating from the basolateral amygdala, the paraventricular thalamus and the infralimbic cortex during a PIT test. The general objective of my research is to describe the neural circuitry that allows the NAc-S to mediate the influence of Pavlovian predictive learning on choice between actions, which represents a central component of decision-making processes and allows us to adapt to our environment.

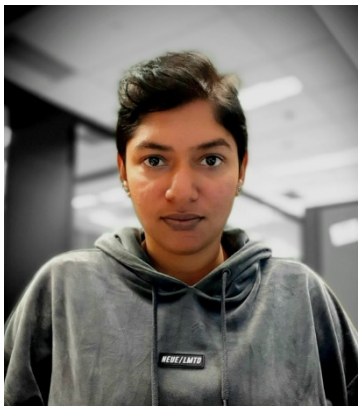
Michael PERKINSON

Supervisors – Professor Colin Brow, Dr Karl Iremonger and Dr Joon Kim.

Current project – Oxytocin neurons bursts are necessary for normal parturition and successful lactation. Oxytocin neuron bursts were first recorded in the 1970's but haven't been recorded for 30 – 40 years due to technical and ethical difficulties. Furthermore, most recordings were made under anaesthetics, which abolishes associated behaviours. Hence, not much is known about how oxytocin neuron bursts are generated and how they are coordinated across the oxytocin neuron population. My PhD currently aims to use fibre photometry to determine the neuronal and hormonal inputs to oxytocin neurons that are necessary for milk-ejection in mice. Specifically, I needed to characterise a mouse model that allows specific and functional transduction of GCaMP6s in oxytocin neurons of the paraventricular nucleus, which I have almost fully completed. I have recorded oxytocin neuron bursts for the first time in freely behaving mice and I am in the process of charactering "normal oxytocin neuron bursts during lactation". Now I plan to use pharmacological interventions to investigate hormonal inputs that are involved in the generation of oxytocin neuron bursts. My PhD has also generated fibre photometry data that can be matched to behaviours from virgin and lactating mice that may provide insight into the normal role of oxytocin neuron activity in freely behaving mice.

Experimental methods used – Immunohistochemistry, on-cell in vitro electrophysiology, fibre photometry, behaviour analysis associated with neuronal activity and image analysis.

Sushmitha RAJA



I am currently in my third year of PhD in the School of Medicine, Western Sydney University, working on the 'Influence of melanopsin phototransduction on retinal physiology' under the supervision of Dr. Morven Cameron, Professor John Morley, and Dr. Dario Protti. I have completed my Master of Science in interdisciplinary research from University Paris Descartes, France, and a Bachelor of Technology in Genetic Engineering from SRM University, India. I also have over 5 years of experience working as a research assistant/engineer in both industry and academia. In my current project, I use dark-adapted dual-eye mouse Electroretinogram (ERG) to study intra-retinal signalling in-vivo, upon melanopsin phototransduction using chemogenetics tools (AAV2-Gq-DREADDs), with and without pharmacological blockades and use immunohistochemistry to study the DREADDs expression and activation profiles of neurons in the retina. I have also characterised different factors that affect the dual-eye mouse ERG including physical factors such as electrode positioning and type on ERG as well as the effects of different anesthetics (presented in ARVO 2021). For the next part of my project, I aim to characterize the expression of Gq-DREADDs in the retina in-vitro to better understand the proportion and the population subtypes of ipRGCs targeted by AAV transfection by studying their electrophysiological responses to DREADDs activation in the dark and study their morphology and stratification using confocal microscopy and dendritic tracing using Neurolucida.

Mitchell Ty RINGUET

Supervisors: John Furness (Florey), Sebastian Furness (MIPS), Stuart McDougall (Florey)

Project: The physiological relevance of DRD2/GHSR1a receptors in the control of defecation

Experimental methods: Patch clamp electrophysiology, retrograde tracing, calcium imaging, RNAscope and IHC

I completed a Masters of Biomedical Science with Dr. Jason Ivanusic (Anatomy & Neuroscience), graduating 2014. I then worked as an RA with Professor John Furness (Anatomy & Neuroscience) for 3 years (2015-2017). In 2018 I moved to QLD where I worked as an RA with Dr. Victor Anggono at Queensland Brian Institute, UQ investigating the role of Copine-6 in AMPAR trafficking. I started my PhD with John in September 2019 and have been investigating the role of DRD2/ GHSR1a receptors in controlling efferent outflow to the distal colon.

Joscelin SMITH

Joscelin Smith is a PhD candidate at the University of Auckland, in Associate Professor Johanna Montgomery's neuro-cardiac group. Her research is focussed on understanding the intra-cardiac nervous system. She is specifically interested in the cellular and molecular mechanisms that change synapse strength in these neurons. She is investigating how the Ganglionated Plexi (which are groups of neurons that cluster on the surface of the heart) change in Atrial Fibrillation, a common type of cardiac arrythmia. She uses a rat model of Atrial Fibrillation and performs whole-cell patch clamp electrophysiology and calcium imaging on these neurons.

Felix THOMAS

My name is Felix Suresh Kevin Thomas and am currently in my second year of PhD. I am under the guidance of Prof. Greg Stuart in the Eccles Institute of Neuroscience at the Australian National University (ANU). Before I joined the PhD program, I did my bachelor in biomedicine and master's in neuroscience. For my master's degree, I studied how reproductive-related neurons modulate social defeat stress using immunocytochemistry and biochemistry techniques. My current research focus on understanding how different superficial superior colliculus (sSC) cells receive and integrate retinal input. To address this, I use in-vitro whole-cell patch clamp recordings, intravitreal adeno-associated virus (AAV)-opsin injections, optogenetic stimulation of retinal input, and microscopy studies to visualise the morphology of sSC. For my immediate future plan, I plan to study how these retinal input affects innate behaviours specific to the sSC neurons. Hence, I will be keen to learn behavioural techniques during the ACAN program. Additionally, I also plan to study in-vivo recordings in sSC neurons if the time permits. I am looking forward to the program in hopes of learning new techniques as well as making new friends.

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