



School of Medical Sciences

NEUR3121

Molecular and Cellular Neuroscience

COURSE OUTLINE

SEMESTER 1, 2017

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Please read this outline in conjunction with the following pages on the [School of Medical Sciences website](#):

- [Advice for Students](#)
- [Learning Resources](#)

Or select the "STUDENTS" tab at medicalsciences.med.unsw.edu.au

COURSE INFORMATION

Molecular and Cellular Neuroscience (NEUR3121) is a stage three course worth six units of credit (6 UOC) administered by the School of Medical Sciences. It is delivered across 12 teaching weeks in session 1, with six contact hours per week. NEUR3121 can be undertaken upon successful completion of Physiology 1A (PHSL2101 / 2121 / 2501). The course can contribute to a study plan in Physiology, Neuroscience and/or Pharmacology for the Bachelor of Science or Bachelor of Medical Sciences.

In 2017, Molecular and Cellular Neuroscience (NEUR3121) will commence in the week beginning 27 February.

The content of the course provides an understanding of the way excitable neuronal cells function and communicate with each other, by considering the biophysical principles and mathematical equations that describe these principles. This is then expanded to consider how neuronal function may be manipulated in the experimental situation and altered in disease. Hence, this provides a strong foundation to the study of many areas in neuroscience. This course is a useful forerunner to Neurophysiology (PHPH3131). Students will also find that this course complements Molecular Pharmacology (PHAR3102).

Summary of course structure

Lectures are scheduled for Monday 12-1 pm (Matthews D) and Wednesday 11-12 pm (Wallace Wurth LG03). Practical classes are Thursday 11 am - 2 pm in Wallace Wurth G06/07. There are two tutorial groups, both on Friday: 2-3 pm and 3-4 pm, in Wallace Wurth LG03. The full schedule of activities is provided at the end of this course outline. Students are expected to attend all rostered activities for their full duration. Students are reminded that UNSW recommends that a six units-of-credit course should involve about 150-180 hrs of study and learning activities. The formal learning activities for this course are 72 hours throughout the semester. The completion of the concept quizzes and collaborative project assessment tasks, plus additional self-directed study will make up the balance of at least 78 hours. Students are strongly recommended to allocate at least six hours per week for these assessment tasks and additional study.

COURSE CONVENOR AND TEACHING STAFF

The Department of Physiology is located in the School of Medical Sciences (SoMS), Wallace Wurth building (C27), Faculty of Medicine. General inquiries can be made at the SoMS Administration, located on level 2 of the Wallace Wurth building (office hours are 9:00 am – 5:00 pm).

Course convenor: Dr. Trevor Lewis (t.lewis@unsw.edu.au)
School of Medical Sciences, Wallace Wurth Building, room 302. Tel: 9385 1102

Course co-convenor: Dr. Kate Poole (k.poole@unsw.edu.au)
School of Medical Sciences, Wallace Wurth Building, room 316. Tel: 9385 1764

Email is the best method for communicating with the course convenors or for arranging a consultation.

Teaching Staff (Lecturers / Tutors)

Note: Communication with the teaching staff is most appropriate via email.

Dr. Trevor Lewis (t.lewis@unsw.edu.au)
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Prof. Gary Housley is the Head of Department and appointments may be made through the administrative assistant in SoMS administration offices, room 255.

COURSE DETAILS

This course provides an integrative approach to understanding cellular neuroscience, including current research and techniques. It begins with an understanding of cell membranes, the biophysical principles and the mathematical equations that describe the movement of ions. It then builds a repertoire of the key molecules that underlie the processes of signalling in neural cells. These are then combined to understand the behaviour of neural cell signalling and how these may be manipulated experimentally to understand the function in the normal and disease state.

Given the variety of molecules involved in neural signalling and the continued accumulation of scientific knowledge in this field, students will be introduced to some key online database tools that provide links between genes, the gene product and functional information that is relevant to cellular neuroscience. The ability to use such online databases and search the scientific literature is a key element of this course. The course also aims to develop skills in analytical thinking and problem solving in the context of signalling in neurons. This requires an understanding of the fundamental properties of excitable membranes. Communication is also a key element, as this course aims to develop skills in expressing reasoning and integration of information, rather than just conveying an 'answer'.

Student learning outcomes

At the completion of this course, it is expected that you will have achieved the following outcomes:

1. Able to describe how the properties of ion channels, transporters and receptors contribute to electrical and chemical signalling in neurons.
2. Able to predict what will happen to an excitable cell with a change in electrochemical gradient or synaptic input by applying your understanding of basic biophysical properties, and concepts of neuronal signalling.
3. Able to apply your understanding of molecular and cellular neuroscience to a particular disease state, through critical reading of the scientific literature and integrating information from a variety of different sources.
4. Able to express your understanding of concepts through clear, concise and accurate scientific language.

Graduate attributes developed in this course

The Faculty of Science has compiled a list of graduate attributes that students should develop during the program of study for a degree. These provide a context for the UNSW graduate attributes. This course will contribute to:

1. *Research, inquiry and analytical thinking abilities*
 - Your competence with the discipline specific knowledge presented in the course is assessed by the two progress tests during the session and the end of course exam. Your competence is developed through the supporting tutorials, to assist in formulating and explaining the reasoning for a solution to a problem, and applying your understanding to new situations.
 - Your ability to build upon the core knowledge of the course by creating an understanding of a particular disease state and the molecular mechanism for the disease is specifically assessed in the collaborative project on Ion Channels and Disease. This project provides the opportunity to demonstrate your competence in critical analysis, research and inquiry.
2. *Capability and motivation for intellectual development*
 - The laboratory classes particularly support intellectual development in the concepts of molecular and cellular neuroscience. The activities have an open ended structure that provides an

opportunity for creative, curiosity driven learning. The understanding of the concepts is assessed by 'concept quizzes'.

- Further opportunity for intellectual development is also provided with the open ended nature of the collaborative project on Ion Channels and Disease.

3. *Ethical, Social and Professional Understanding*

- Working within a team requires mutual respect, commitment and ethical practice. There is an opportunity to develop some of these attributes further and to critically reflect upon your performance in these attributes with the collaborative project on Ion Channels and Disease.
- You are assessed on your reflection of how the team worked together and the ability to achieve a common goal.

4. *Teamwork, collaborative and management skills.*

- The collaborative project on Ion Channels and Disease requires strong collaborative effort to achieve the common goal. This is assisted by encouraging teams to establish agreed work practices and commitments. This will provide an opportunity to develop teamwork, collaborative and management skills individually, and to learn from the skills of others in the team. In particular, how the team manages the time line of the project, how decisions are made, the reasoned analysis for the structure and composition of the final report and recognition that all team members have different strengths to contribute. This is assessed by a reflection upon how the team worked together and how effective the collaborative and management skills were in achieving the common goal.

5. *Communication*

- You will have the opportunity to develop your written communication skills as part of the team project on Ion Channels and Disease. You will write a review style report, aimed at a broad scientific audience and an informative summary aimed at a more general audience.

6. *Information literacy*

- Your ability to search the scientific literature to find appropriate information, and to collate information from online databases relevant to molecular and cellular neuroscience, will form the basis for the collaborative project. While these skills are not formally assessed, the ability to make appropriate and effective use of these skills will contribute to your success in achieving the goals of the collaborative project.

Major topics

Topic areas include: how electrical signals are generated across cell membranes; the function, properties and structure of ion channels, receptors and transporters; how individual nerve cells function; how cells communicate with each other in the brain, including synaptic transmission and receptor-mediated signalling; how alterations in function can lead to disease states; modern experimental techniques in cellular physiology; application of molecular biology techniques to manipulate and explore the function of molecules in the nervous system.

RATIONALE AND STRATEGIES UNDERPINNING THE COURSE

Teaching strategies

The learning activities used in the course are varied and aim to create an active learning environment that interests, challenges and inspires students. Lectures provide knowledge of the core material and insights into techniques and recent research. The course material is presented by several lecturers, each with expertise in the field. Tutorials are designed to develop student expertise in using simple mathematical and biophysical principles to solve biological problems and develop analytical skills. The tutorials will provide opportunities for expressing your reasoning or thinking and will support your understanding of the course material presented in the lectures. Practical classes are a combination of computer modelling / simulation of neuronal signalling, that allow testing ideas that cannot easily be done by other means, and classes with biological materials that provide some insight to experimental techniques in real systems.

The laboratory classes are provided to support the lecture material and to practice applying analytical skills to biological problems. The material covered in the practical classes will be assessed in the progress exams and by the 'concept quizzes'. The 'concept quizzes' will assess your understanding and application of the key concepts that are explored in the practical classes. The key concepts for each practical class are listed in the course handbook entry and provided on Moodle. The quiz for each class will be available online via Moodle for a limited time. In most cases it will be possible to complete the quiz at the end of the practical class, however for those classes that take up the entire allocated time, the quiz will need to be completed in your own time. The deadline by which the quizzes need to be completed will be provided on Moodle.

The collaborative assignment will require students to work in teams of four students, researching the properties of a gene product. The gene product is an ion channel and there are one or more diseases that are associated with mutations in the gene. Teams will use online databases to identify characteristics of the gene and the ion channel for which it codes. A literature search will be required to identify the function of the channel and how this is altered in the disease state. The team will produce a scoping report, a summary of normal function and a final report, all of which are submitted online. The final report must include a statement on the contribution of each team member. Each member will also provide an individual reflection on how they have worked together as a team. The final report is a review style article aimed at a general scientific audience, providing information on the function of the ion channel and the effect of the mutation on the ion channel to cause the disease state. The assessment will be based on the ability of the team to identify relevant information from appropriate sources and provide proper references for all sources; the team needs to be able to analyse the variety of information collected and communicate this in a manner that demonstrates an integration of the material, not just summarising the individual components. They need to identify the likely molecular mechanism for how the mutation in the ion channel is able to cause the disease state.

There will be three progress exams throughout the course, each 20 minutes in duration. These exams will be comprised of short answer questions, multiple choice and/or short calculations. The questions will be based on the material covered in the lectures, the concept quizzes from the practical classes and the tutorials. This will assess your understanding and application of the concepts developed in the course. The exams will be held at the start of the scheduled practical class sessions. Please see the course schedule for the specific dates.

The end of session exam will be comprised of short answer questions that will include some mathematical calculations and a UNSW approved calculator will be required. The short answer questions will be based on the material covered in the lectures and tutorials. Material covered in the progress exams may be again examined in the final exam. The lecturer who provided the question will mark the short answers. Students are advised to use the list of previous exam questions provided to self-evaluate their progress during the course, although questions from year to year may vary as the content of the course is developed.

Assessment allocation to final mark:

Concept quizzes	15%
Collaborative project	25%
Progress exams	30%
End of session exam	30%

RESOURCES

See also [Learning Resources](#)

Prescribed Textbook

Blaustein, M.P., Kao, J.P.Y. and Matteson, D.R. (2011). Cellular physiology and neurophysiology, 2nd edition, Philadelphia, PA: Elsevier/Mosby. ISBN 978-0-323-05709-7
[Copies are held in the UNSW library]

Recommended textbooks

Matthews G.G. (2004). Cellular Physiology of Nerve and Muscle. 4th edition. Wiley-Blackwell. ISBN 978-1-4051-0330-5

[Two copies are held in the UNSW library, call number 573.836/1]

Byrne JH and Roberts JL (2004). From Molecules to Networks: An Introduction to Cellular and Molecular Neuroscience. Elsevier Academic Press, San Diego, USA. ISBN 978-0121486605.

[UNSW library call number MBQ 612.8/229. Copies are also available from the UNSW Bookshop.]

Aidley DJ (1998). The Physiology of Excitable Cells. 4th edition. Cambridge University Press, Cambridge, UK. ISBN 978-0521574218.

[Copies held in the UNSW library, call number MB 573.8/2]

Aidley DJ and Stanfield PR (1996). Ion Channels: Molecules in Action, Cambridge University Press, Cambridge, UK. ISBN 978-0521498821.

[Copies held in the UNSW library, call number MB 571.64/4]

Kandel ER, Schwartz JH and Jessell TM (2000). Principles of Neural Science, 4th edition. New York : McGraw-Hill. ISBN 0838577016.

[An advanced textbook for extended reading. Copies held in the UNSW library, call number MBQ 612.8/204]

Moodle

All of the resources for this course will be provided on Moodle. This will include: specific reading lists for different lectures, lecture notes (when provided by the lecturer), a list of online resources, learning activities for the tutorials, notes for the laboratory classes, the course timetable and outline, and various supplementary articles. Announcements will be made via Moodle and it is the students' responsibility to regularly check this site.

REQUIRED EQUIPMENT, TRAINING AND ENABLING SKILLS

Students will be expected to provide a personal laboratory coat and safety glasses for those laboratory classes where they are required.

All students will have completed ELISE in their first year of study at UNSW. The ELISE Plus online tutorial provided by UNSW Library is designed to help you learn more about searching for information and self-directed learning. You may find this provides enabling skills that will enhance your ability to complete the collaborative project in this course.

COURSE EVALUATION AND DEVELOPMENT

NEUR3121 Molecular and Cellular Neuroscience has been developed as part of a broader process to provide a study plan for students wishing to follow a neuroscience path. Student feedback is gathered periodically by various means to assist in the continuing development of this course. Such feedback is obtained from the Course and Teaching Evaluation and Improvement (CATEI) survey and the direct feedback from student representatives. Student feedback is always welcome and is considered carefully with a view to acting on it constructively wherever possible.

A CATEI survey was conducted in 2016 and the overall results were very positive, with 98% of students indicating satisfaction with the overall quality of the course. Comments from students identified some areas where improvements could be made. As a result, the following adjustments to the course have been made:

1. A broader background to the terminology, conventions and basic biophysical properties has been included, along with some revision of basic biochemistry at the relevant points.
2. Additional formative tasks have been provided to assist with understanding of biophysical concepts.
3. The practical classes have been divided into smaller tasks, which will be summarised and discussed in class at the end of each task. This is intended to assist with understanding the key concepts.

STUDENT REPRESENTATIVES

Students enrolled in the course will be invited to elect two student representatives who will meet with the course conveners on two occasions during the session, in a student feedback forum. The representatives need to seek feedback from their colleagues on the content, delivery and relevance of the course and any other issues that arise. The information gathered from this process will be used to inform any future improvements to the course.

ADMINISTRATIVE MATTERS

See also [Advice for Students](#).

Attendance Requirements

For details on the Policy on Class Attendance and Absence see [Advice for Students](#) and the [Policy on Class Attendance and Absence](#).

Guidelines on extra-curricular activities affecting attendance can be found on the School of Medical sciences Website under Special Consideration.

Attendance at laboratory classes is compulsory and must be recorded in the class roll on the day of the class. It is your responsibility to ensure that the demonstrator records your attendance and no discussions will be entered into after the completion of the class. Satisfactory completion of the work set for each class is essential. It should be noted that non-attendance for other than documented medical or other serious reasons, or unsatisfactory performance, for more than one class per course may result in an additional practical assessment exam or in ineligibility to pass the course.

Attendance at all examinations is required, including the three progress exams held during the scheduled practical classes.

Assignment submissions

All assessment tasks that require submission of work will be completed as an online submission via Moodle and are due before the end of the day on which it is due (ie. before 11:59 pm). Where relevant, you must complete the online declaration of originality (equivalent of the submission coversheet in a hard copy submission) before submitting the work.

GENERAL INFORMATION

The Department of Physiology is part of the School of Medical Sciences and is within the Faculty of Medicine. It is located in the Wallace Wurth building. General inquiries can be made at the BABS-SOMS-BEES (B.S.B.) Student Office, located on the Ground Floor Room G27, of the Biosciences Building. Office hours are 9.00 am - 5:00pm

Honours

The School of Medical Sciences offers an honours program, along with a cross-Faculty honours program in Neuroscience. Any students considering an honours year should become familiar with the requirements for the [SoMS Honours](#) and [Neuroscience Honours](#) programs, both of which are available from the SoMS web site. Students should consider which research area(s) is/are of interest and then directly approach the relevant academic(s) or researcher(s). Outstanding students may be considered for honours scholarships offered annually by the School. Further information can be obtained from the SoMS website, the honours program co-ordinator (Dr Greg Smith g.smith@unsw.edu.au) or the Neuroscience honours co-ordinator (Dr John Power, john.power@unsw.edu.au).

Postgraduate Research Degrees

The Department of Physiology offers students the opportunity to enter into a Doctorate (PhD) in Physiology. Further information about this and other postgraduate degrees is available on the 'Students' menu item of the SoMS website.

SUMMARY OF LECTURES

1. Course overview and assessment [T. Lewis]

This lecture will provide you with all of the essential information you require for this course. It will cover the structure and scope of the course, the assessment tasks, teaching rationale and expectations. It is also an opportunity for you to ask any questions you may have.

2. Equilibrium and Gibbs-Donnan potentials [P. Barry]

This lecture starts with the expression for electrochemical potential, the energy of a mole of ions in solution, and how it can be used to derive the Nernst equation, the foundational equation for understanding electrophysiology. The Nernst equation gives the potential at which a distribution of a particular permeant ion would be in equilibrium across a membrane.

The lecture then describes the three conditions for Gibbs-Donnan equilibrium: (1) Gibbs-Donnan equilibrium itself; (2) macroscopic electroneutrality and (3) osmotic equilibrium, and its applications in physiology.

3. Conventions and terminology of neuroscience [A. Moorhouse]

This lecture explains the conventions that are used when describing the electrical activity of neurons, including the relationship between ionic currents and the membrane potentials in neurons. A part of this is knowing and understanding the terminology and language that is used in neuroscience. This lecture provides an essential foundation for subsequent lectures and for reading the literature as part of the collaborative project.

4. Membrane potentials and GHK [P. Barry]

This lecture initially uses the Planck equation to illustrate the role of selective ion permeabilities with two or more permeant ions and salt diffusion gradients in generating membrane potentials across thick membranes. It then discusses the use of the Goldman-Hodgkin-Katz equation to apply these principles to thin biological membranes (6 to 10 nm thick). It also discusses the issue of using activities or concentrations with these equations and any contribution of active transport to membrane potentials. In addition, the concept of unstirred-layers and their relevance to solute and water transport across membranes is briefly introduced. The tutorial and practical class (ArtMem and MemPot) on membrane potentials addresses this material.

5. Electrophysiological techniques [A. Moorhouse]

This lecture will introduce students to different electrophysiological techniques to study electrical and chemical signalling in the brain. The lecture will describe how action potentials, synaptic potentials and ion channel activity can be measured and quantified. It is important to understand the techniques used to elucidate the cellular and molecular study of neuronal function, and it is also hoped this lecture will assist students in their collaborative project and other coursework.

6. Voltage-gated ion channel families [M. Perry]

A basic knowledge of voltage gated ion channels is essential for understanding the physiology of neuronal and other excitable cells. This lecture will give a historical perspective of the key discoveries during the last 50 years that led to our current understanding of voltage gated ion channels, starting with the work of Hodgkin and Huxley in squid axons. After briefly outlining the concept of voltage dependent gating, this lecture will provide an overview of the voltage gated ion channel superfamily. We will discuss how drugs and toxins can be used to differentiate between different types of voltage gated channels, and then examine common and distinct structural features of different channel families and their nomenclature.

7. Mechanisms of voltage-dependent gating [M. Perry]

Electrical signalling in nerve and muscle cells is dependent on the intricately timed opening and closing (gating) of several different types of voltage-gated ion channels. This lecture will outline the basic principles of voltage-dependent gating, first by describing how ion channels sense a change in membrane voltage and then by discussing the molecular and structural basis by which the voltage sensor triggers the opening and closing of channels. Finally the lecture will outline some of the kinetic differences that allow ion channels of different types to open and close at precise time points during the electrical signalling of excitable cells.

8. Mechanisms of ion permeation [A. Moorhouse]

Selective permeation of ions across the cell membrane is critical for neuronal function. This lecture will initially consider some of the basic biophysical principles that determine ion selectivity, focusing on the contribution of properties of both the ions themselves and of the ion channel pores. The lecture will then describe how the structure of the KcSA K⁺ channel pore (resolved in 1998) allows this channel to select for K⁺ ions over Na⁺ ions while still allowing a fast rate of K⁺ permeation. Some of the techniques used to determine the molecular basis of ion selectivity of glycine receptor channels will also be described.

9. Electrotonic properties of axons and dendrites [P. Barry]

This lecture provides a description of the physical basis for the passive electrical properties of axons and dendrites. It describes the time-course for the change in membrane potential in response to a square pulse injection of current. The length constant and the time constant are introduced and used to describe the

conduction of electrical signals along axons and dendrites. The tutorial on electrotonic potentials addresses material from this lecture, as does the practical class on the Voltage Responses to Membrane Currents (MemCable).

10. Action potential generation in axons [A. Moorhouse]

This lecture builds upon your understanding of the action potential from Physiology 1A. It will describe the ionic currents that underlie the action potential and the voltage and time-dependent nature of these currents. It will introduce and define the terms: activation, inactivation, driving force for current flow, and conductance. The Hodgkin-Huxley equations provide a biophysical description of these currents and provide a means for explaining and understanding how the action potential 'works'. Some of the classical experiments of Hodgkin and Huxley will be described.

11. Ligand-gated ion channel families [T. Lewis]

Ligand-gated ion channels are the key ion channels that underlie the process of chemical neurotransmission in the nervous system. This lecture will provide a revision on the different ligand-gated ion channel families and introduce the structural information that is available on each of these families. This includes the molecular topology and quaternary structure of the receptors. The function of these channels is made possible because the ligand binding site is integral to the ion channel. The specificity of the ligand, the specificity of the ion selectivity and the specific arrangement of subunits provides the means for the different functions of the channels.

12. Ligand recognition and signal transduction [T. Lewis]

One of the key questions in the field of ligand-gated ion channels is how the binding of the ligand is able to cause the channel to open. The channel protein appears to work like a miniature machine and there are some good hypotheses as to how the channel protein changes conformation to open the pore. This process is called 'signal transduction'. We will explore the likely events that underlie this process in the nAChR and the evidence that supports the hypothesis. Single channel recordings are an important source of evidence to test the hypothesis.

13. Transient receptor potential channels [G. Housley]

This lecture will introduce the members of the Transient Receptor Potential (TRP) channel family and the different stimuli to which they respond. The common structural features will be examined and examples of the physiological roles these ion channels play in the nervous system will be presented. The best understood member of this family is the TRP C channel, and so the activation and regulation of the channel function will be explored further. This lecture leads in to the lecture on metabotropic receptor signalling, as TRP channel function is often regulated by metabotropic receptors.

14. GPCR structure – function [A. Finch]

This lecture will introduce the members of the G-protein coupled receptor (GPCR) superfamily. The structural features conserved across the superfamily and those that differ between families A, B, C and F will be examined. Our current understanding of the molecular basis for Family A GPCR activation, derived from mutagenesis, biophysical and crystal structure data will be discussed.

15. Metabotropic receptor signalling [A. Finch]

Signalling through G-protein coupled receptors (GPCRs) and receptor enzymes (for example receptor tyrosine kinases) leads to the generation of intracellular signalling molecules. These "second messengers" can act on ion channels and modulate their function. This is termed metabotropic signalling. The focus of this lecture will be the second messengers produced by GPCRs and receptor enzymes and how they modulate channel function. The differences between metabotropic and ionotropic signalling in terms of temporal regulation of ion channel function will also be discussed.

16. Cell-cell communication [T. Lewis]

Communication between cells in the nervous system primarily occurs via electrical or chemical synapses. The differences in these two mechanisms will be explored, in terms of the directionality, the time lag of the response and the mechanism. Chemical synaptic transmission will be further explored to describe the steps involved in the process, from synaptic vesicle release to activation of the post-synaptic ligand-gated ion channels. Further, we will see how ionotropic receptors (ligand-gated ion channels) are responsible for the fast synaptic transmission, while metabotropic receptors (GPCRs) are responsible for slow synaptic transmission.

17. Synaptic transmission – synaptic modulation [J. Power]

This lecture builds upon your understanding of chemical neurotransmission to explore the mechanisms by which the process can be modulated at the pre-synaptic terminal, to either increase or decrease the post-synaptic response. The terms synaptic depression, facilitation and post-tetanic potentiation will be introduced and defined. The role of the availability of synaptic vesicles for release and the concentration of calcium in the pre-synaptic terminal to trigger release to modulate the synaptic response will be investigated.

18. The Postsynaptic Architecture - From Structure to Function [T. Fath]

The lecture provides an overview on the structural and functional organisation of the postsynaptic scaffold. The major neurotransmitters at excitatory synapses are discussed in the context of their integration in the protein scaffold that underlies the postsynaptic membrane. The major components of the postsynaptic scaffold and the complex interactions between these components are explained. A major focus is the conceptual idea of the postsynaptic scaffold as a dynamic anchoring framework for the attachment of a broad range of regulatory proteins that control synaptic function including kinases, phosphatases and actin cytoskeleton-regulating proteins. This introduction to the structural nature of the postsynapse forms the basis for understanding the molecular events that occur during long term potentiation (LTP) and long term depression (LTD) which are fundamental for processes of learning and memory in the central nervous system. The history and current advances in the study of LTP and LTD are described using the hippocampus as an example.

19. Synaptic transmission – postsynaptic integration [J. Power]

Following on from the lecture on pre-synaptic modulation, this lecture now looks at the events on the post-synaptic membrane that can alter the synaptic response. These are key to the mechanisms by which information can be 'processed' by the nervous system. The post-synaptic response depends upon the ligand-gated ion channel that is present on the post-synaptic membrane and will determine the time-course of the response. A neuron may receive many different synaptic inputs and these are able to sum together, to produce either a larger or a smaller post-synaptic response. The mechanisms of spatial, non-linear and temporal summation will be explored. Ion gradients across the cell membrane can change during development so this will also change the post-synaptic response of ionotropic receptors.

20. Receptor response shapes post-synaptic signalling [T. Lewis]

This lecture explores the factors that determine the shape and time course of the post-synaptic current. Two key contributors considered are the mechanism for clearance of the neurotransmitter from the synaptic cleft and the kinetic response of the post-synaptic ligand-gated ion channels. Three examples are explored: the nicotinic acetylcholine receptors at the muscle endplate, excitatory glutamate receptors, and inhibitory glycine and GABA receptors at central synapses.

21. Mechanosensitive channels [K. Poole]

This lecture will discuss an exciting class of newly identified ion channels that are gated in response to mechanical stimuli. We will address the question of how we can experimentally determine if a channel is gated by mechanical stimuli and the different proposed models for how this gating occurs. The lecture will focus on the PIEZO proteins and their unique structure, drawing from newly published research.

22. Touch and Pain Transduction [K. Poole]

How do we sense the difference between mechanical pain and gentle touch? In this lecture we will discuss the variations in mechanotransduction in our sensory neurons and build on knowledge gained from earlier stages of the course to address this question. The lecture will outline the differences between touch receptive neurons and pain sensitive neurons, discuss what we know about the molecules that mediate the initial force sensing event in these cells and ask how we might manipulate the transduction process to block certain forms of pain.

23. Synaptic Failure in Disease [T.Fath]

This lecture builds on the material provided in the previous lecture discussing the postsynaptic scaffold. The lecture focuses on the role of the actin cytoskeleton at the postsynapse. Current concepts of cytoskeletal stability and dynamics at the postsynapse are elaborated on. Research tools that are used to study the biology of cytoskeletal dynamics at the synapse are introduced. The second part of this lecture discusses the synaptic dysfunction in disease in response to cytotoxic stimuli such protein aggregates and their soluble precursors on the example of Alzheimer's disease pathology.

24. Targeting receptor function with transgenic mice [G. Housley]

This lecture explores how ion channel or receptor function can be investigated by using conditional knockout or transgenic mouse models. These systems provide a physiological context to understanding the ion channel or receptor function that cannot be achieved with cell based expression systems. To illustrate the approach, examples of knock-out and knock-in transgenic mouse models will be presented. The outcome is to provide a means of understanding how the function of the individual ion channel or receptor is able to influence or determine the physiological function of the cells or tissues where it is expressed *in vivo*.

COURSE SCHEDULE S1, 2017

		LECTURES		PRACTICAL CLASSES	TUTORIALS: WW LG03
Week	Week Starting	Matthews D Monday 12-1 pm	Wallace Wurth LG03 Wednesday 11 am -12 pm	Wallace Wurth G06/07 Thursday 11 am - 2 pm	Group A: Friday 2-3 pm Group B: Friday 3-4 pm
1	27 Feb	1. Course overview and assessment. [TL]	2. Equilibrium potentials and Gibbs-Donnan [PB]	Introduction to Neurons in Action. Teamwork and team building. [TL, 2 tutors]	Teamwork and team building [TL]
2	6 Mar	3. Conventions and terminology of neuroscience [AM]	4. Membrane potentials and GHK [PB]	Membrane Potentials (MemPot, ArtMem). [TL, 2 tutors]	Membrane potentials [PB, TL]
3	13 Mar	5. Electrophysiological techniques [AM]	6. Voltage-gated ion channel families [MP]	NIA: The Na action potential [TL, 2 tutors] Collaborative Project: scoping report	Collaborative Project: normal function [TL]
4	20 Mar	7. Mechanisms of voltage-dependent gating [MP]	8. Mechanisms of ion permeation [AM]	<i>Progress Test 1</i> Collaborative Project: interpreting scientific papers [TL, 2 tutors]	Analysis of voltage-gated currents [TL, MP]
5	27 Mar	9. Electrotonic properties of axons and dendrites [PB]	10. Action potential generation in axons [AM]	NIA: Voltage clamping a patch [TL, 2 tutors]. Collaborative Project.	Electrotonic potentials [TL, tutor]
6	3 Apr	11. Ligand-gated ion channel families [TL]	12. Ligand recognition and signal transduction [TL]	Voltage responses to membrane currents (MemCable). [TL, JP, 2 tutors]	Analysis of ligand-gated currents [TL, tutor]
7	10 Apr	13. Transient receptor potential channels [GH]	14. GPCR structure – function [AF]	<i>Progress Test 2</i> NIA: Chattering ion channels [TL, 2 tutors]	GOOD FRIDAY (no class)
Mid-Semester Recess					
8	24 Apr	Research Week – working on the collaborative project			
9	1 May	15. Metabotropic receptor signalling [AF]	16. Cell-cell communication [TL]	Compound action potential from the toad sciatic nerve. [TL, KP, 2 tutors]	GPCRs [AF, TL]
10	8 May	17. Synaptic transmission – synaptic modulation [JP]	18. The Postsynaptic Architecture - From Structure to Function [TF]	Research Laboratory Visits [TL, JP, 2 tutors]	Postsynaptic architecture [TF, TL]
11	15 May	19. Synaptic transmission – postsynaptic integration [JP]	20. Receptor response shapes post-synaptic signalling [TL]	<i>Progress Test 3</i> NIA: The neuromuscular junction [JP, 2 tutors]	Neuronal integration [JP, TL]
12	22 May	21. Mechanosensitive channels [KP]	22. Touch and pain transduction [KP]	NEURON: Synaptic Integration [JP, 2 tutors]	Mechanosensitive channels [KP, TL]
13	29 May	23. Synaptic Failure in Disease [TF]	24. Targeting receptor function with transgenic mice [GH]	NIA and NEURON: Postsynaptic inhibition [JP, 2 tutors]	Exam Revision

ASSESSMENT TASKS AND FEEDBACK

Note: All assessment tasks that require submission of work will be completed as an online submission via Moodle and are due before the end of the day on which it is due (ie. before 11:59 pm). Where relevant, you must complete the online declaration of originality (equivalent of the submission coversheet in a hard copy submission) before submitting the work.

Task	Knowledge & abilities assessed	Assessment Criteria	% of total mark	Date of Submission	Feedback		
					WHO	WHEN	HOW
Team agreement	<ul style="list-style-type: none"> • Management and planning skills 	<ul style="list-style-type: none"> • Formative; feedback provided with respect to the elements of good teamwork 	0%	10 Mar 2017	Dr Lewis	17 Mar 2017	Moodle
Concept quiz 1	<ul style="list-style-type: none"> • Equilibrium potential • Nernst equation • The Goldman-Hodgkin-Katz equation • Relative permeability 	<ul style="list-style-type: none"> • Understanding and application of the concepts relating to membrane potentials 	1.6%	9 to 12 Mar 2017	Online	Immediately	Moodle
Concept quiz 2	<ul style="list-style-type: none"> • The effect of the driving force upon the current • Conductance • Temperature dependence of the action potential • Refractory period 	<ul style="list-style-type: none"> • Understanding and application of the concepts relating to the sodium action potential 	1.6%	16 to 19 Mar 2017	Online	Immediately	Moodle
Collaborative project: Scoping report	<ul style="list-style-type: none"> • Information literacy • Research, inquiry and critical evaluation of information 	<ul style="list-style-type: none"> • Formative; feedback provided according to the relevant criteria in the assessment rubric for the project. 	0%	19 Mar 2017	Dr Lewis	24 Mar 2017	Moodle
Progress test 1	<ul style="list-style-type: none"> • Material from lectures 1 to lecture 8, and related material from the laboratory classes of weeks 1 to 4. 	<ul style="list-style-type: none"> • Short answer style questions assessing knowledge, understanding and ability to apply concepts 	10%	23 Mar 2017	Dr Lewis	30 Mar 2017	Moodle
Collaborative project: Individual blog on teamwork	<ul style="list-style-type: none"> • Reflective practice • Reflection and analysis of how the team completed the team agreement and the scoping report 	<ul style="list-style-type: none"> • feedback provided along the criteria that will be used for the final teamwork summary 	0%	26 Mar 2017	Dr Lewis	2 Apr 2017	Moodle

Task	Knowledge & abilities assessed	Assessment Criteria	% of total mark	Date of Submission	Feedback		
					WHO	WHEN	HOW
Concept quiz 3	<ul style="list-style-type: none"> • Reversal potential • Activation of the sodium and potassium conductance • Inactivation of the sodium conductance • Temperature dependence of conductance 	<ul style="list-style-type: none"> • Understanding and application of the concepts relating to voltage-clamping a patch 	1.6%	30 Mar to 2 Apr 2017	Online	Immediately	Moodle
Collaborative project: Normal function report	<ul style="list-style-type: none"> • Understanding of normal function of the ion channel or transporter • Critical evaluation of relevant scientific literature • Integration of information from multiple sources 	<ul style="list-style-type: none"> • Not formally assessed; feedback only 	0%	2 Apr 2017	Dr Lewis	10 Apr 2017	Moodle
Concept quiz 4	<ul style="list-style-type: none"> • Membrane time constant • Membrane space constant • Specific membrane resistance • Specific membrane capacitance 	<ul style="list-style-type: none"> • Understanding and application of the concepts relating to voltage responses to membrane currents 	1.6%	6 to 9 Apr 2017	Online	Immediately	Moodle
Collaborative project: Individual blog on teamwork	<ul style="list-style-type: none"> • Reflective practice • Reflection and analysis of how the team completed the normal function report 	<ul style="list-style-type: none"> • feedback provided along the criteria that will be used for the final teamwork summary 	0%	9 Apr 2017	Dr Lewis	16 Apr 2017	Moodle
Progress test 2	<ul style="list-style-type: none"> • Material from lectures 9 to lecture 16, and related material from the laboratory classes of weeks 5 to 9. 	<ul style="list-style-type: none"> • Short answer style questions assessing knowledge, understanding and ability to apply concepts 	10%	13 Apr 2017	Dr Lewis	20 Apr 2017	Moodle
Concept quiz 5	<ul style="list-style-type: none"> • The voltage-dependence of channel opening is probabilistic • The whole-cell current is an ensemble of the current from individual ion channels 	<ul style="list-style-type: none"> • Understanding and application of the concepts relating to 'chattering' ion channels 	1.6%	13 to 16 Apr 2017	Online	Immediately	Moodle
Concept quiz 6	<ul style="list-style-type: none"> • Conduction velocity • Refractory period 	<ul style="list-style-type: none"> • Understanding and application of the concepts relating to the compound action potential 	1.6%	4 to 7 May 2017	Online	Immediately	Moodle

Task	Knowledge & abilities assessed	Assessment Criteria	% of total mark	Date of Submission	Feedback		
					WHO	WHEN	HOW
Collaborative project: Final report	<ul style="list-style-type: none"> • Logical presentation of ideas • Research, inquiry and information literacy • Critical evaluation of the literature; integration of information; understanding of the experimental results • Demonstrated understanding of the molecular mechanism likely to cause the disease 	<ul style="list-style-type: none"> • See marking rubric in this course outline document 	20%	14 May 2017	Dr Lewis, Dr Power	1 June 2017	Moodle
Progress test 3	<ul style="list-style-type: none"> • Material from lectures 9 to lecture 16, and related material from the laboratory classes of weeks 5 to 9. 	<ul style="list-style-type: none"> • Short answer style questions assessing knowledge, understanding and ability to apply concepts 	10%	18 May 2017	Dr Lewis	25 May 2017	Moodle
Concept quiz 7	<ul style="list-style-type: none"> • Reversal potential • The relationships between the synaptic conductance, the synaptic current, and the synaptic potential. 	<ul style="list-style-type: none"> • Understanding and application of the concepts relating to the neuromuscular junction 	1.6%	18 to 21 May 2017	Online	Immediately	Moodle
Collaborative project: Teamwork summary (blog)	<ul style="list-style-type: none"> • Evaluate and analyse the teamwork, collaborative and management skills of the team • Self-assess and reflect upon your own contributions to the teamwork 	<ul style="list-style-type: none"> • Understanding of teamwork skills • Reflective practice • Professional understanding 	5%	21 May 2017	Dr Lewis	1 Jun 2017	Moodle
Concept quiz 8	<ul style="list-style-type: none"> • Dendritic filtering • Spatial and temporal synaptic summation • NMDA receptor as a detector of coincident pre and post synaptic activity 	<ul style="list-style-type: none"> • Understanding and application of the concepts relating to synaptic integration 	1.6%	25 to 28 May 2017	Online	Immediately	Moodle
Concept quiz 9	<ul style="list-style-type: none"> • Shunting Inhibition • Disinhibition 	<ul style="list-style-type: none"> • Understanding and application of the concepts relating to postsynaptic inhibition 	1.6%	1 to 4 Jun 2016	Online	Immediately	Moodle

ASSESSMENT RUBRIC FOR FINAL REPORT: COLLABORATIVE PROJECT

CRITERIA	Description	%	Exceptional (5)	Very Good (4)	Good (3)	Needs further development (2)	Significant deficiencies (1)
COMMUNICATION / PRESENTATION OF IDEAS							
Use of appropriate vocabulary	How well is the vocabulary and terminology of the topic incorporated into the report?	5	Appropriate terms and vocabulary associated with the topic matter are used correctly and all are defined correctly.	Appropriate terms and vocabulary are used, but some of the terms are used incorrectly or are not defined.	Appropriate terms and vocabulary are used occasionally, and used correctly. Some may not have been defined.	Appropriate terms and vocabulary have been used, but they are not topic specific, or not defined or not all used correctly.	Very few appropriate terms or vocabulary are used in the report and they are not used correctly.
Content organization	How well the content is organized and is there a logical development of the concepts and explanations?	15	The concepts and explanations are very well-organized--the information presented is very easy to follow and has a clear, logical structure.	The concepts and explanations are organized, the information can be followed, and there is a logical structure in most of the report.	The concepts and explanations are somewhat organized. Some of the information can be followed. There is some connection between the sections of the report.	Some concepts and explanations are present, but are not organized. There is a slight connection between the sections of the report.	Few concepts or explanations are presented. There's no clear, logical structure or connection between sections of the report.
Experimental evidence	How well are the key experiments selected to describe the ion channel function in normal tissue and in the disease state?	10	The report presents good experimental evidence. The examples and evidence are well chosen and strongly describe the main ideas.	The report presents sufficient experimental evidence. The examples and evidence adequately describe the main ideas.	The report presents some experimental evidence. The examples and evidence is incomplete in describing the main ideas.	The report presents little experimental evidence. The examples and evidence are poor and do not sufficiently describe the main ideas.	The report has little or no experimental evidence. There is little or no description of the main ideas.
Integration of information	How well is information from different sources brought together for discussion?	10	Where available, multiple sources of evidence are discussed concomitantly.	Where available, multiple sources of evidence are linked in discussion.	Where available, more than one source of evidence is discussed in a sequential fashion.	Limited evidence restricts the discussion to isolated concepts with little linking.	Limited evidence from few sources, with an unstructured discussion.
Abstract	How well does the abstract summarise the main ideas of the report?	5	The abstract provides a clear and succinct summary of the main ideas.	The abstract provides a summary of the main ideas, with logical structure and mostly clear explanation.	The abstract summarizes the main ideas, with some structure and inclusion of unnecessary words / information that hinders clarity.	The abstract somewhat summarizes the main ideas, with little structure or clarity.	The abstract does not provide a summary of the topic or main ideas.
CRITICAL EVALUATION							
Understanding of literature	How well is the literature selected	15	All the literature consulted is relevant	Majority of the literature consulted is relevant	Some relevant and appropriate literature is	Some relevant and appropriate literature is	Some relevant and appropriate literature is

CRITERIA	Description	%	Exceptional (5)	Very Good (4)	Good (3)	Needs further development (2)	Significant deficiencies (1)
Demonstration of conclusions	and the results explained?		and appropriate. The concepts / experimental evidence from the literature are expertly explained.	and appropriate. The concepts / experimental evidence from the literature are correctly explained.	consulted. The concepts / experimental evidence are mostly explained correctly.	consulted. The concepts / experimental evidence are only partly correct.	consulted. The concepts / experimental evidence are poorly explained.
	How well are the scientific links made between the experimental evidence and the conclusions reached?	15	Clear logic and explanation links experimental evidence to conclusions.	Explanation of experimental evidence links to conclusions.	Logic or explanation requires some additional details to link experimental evidence to conclusions.	Insufficient logic or explanation to link experimental evidence to conclusions.	No logic or explanation to link experimental evidence to conclusions.
INFORMATION LITERACY							
Referencing	Are all publications / concepts / experimental evidence appropriately referenced?	15	All information / concepts / experimental evidence from published works or the work of others is correctly referenced.	Some deficiencies in the choice of reference or in providing a reference for the information / concepts / experimental evidence from work of others.	Poorly chosen references or inappropriate references or insufficient references for the information / concepts / experimental evidence presented.	Significant lack of appropriate or sufficient references for the information / concepts / experimental evidence presented.	Inadequately referencing of the information / concepts / experimental evidence from work of others, to the extent that it constitutes plagiarism.
Bibliography and citations	Is the in-text citations and bibliography presented in the correct format? Sufficient references?	5	Done in the correct format with no errors. Includes more than 5 major references (e.g. science journal articles; but no more than 3 are internet sites. Periodicals available on-line are not considered internet sites)	Done in the correct format with few errors. Includes 5 major references (e.g. science journal articles; but no more than 2/5 are internet sites. Periodicals available on-line are not considered internet sites)	Done in the correct format with some errors. Includes 4 or more major references (e.g. science journal articles; but no more than 2/5 are internet sites. Periodicals available on-line are not considered internet sites)	Done in the correct format with many errors. Insufficient appropriate references (e.g. science journal articles; but no more than 2/5 are internet sites. Periodicals available on-line are not considered internet sites)	Citations are few or absent or incorrectly formatted. The bibliography is incorrect, absent or the only sites are internet sites.
Online databases	Have online databases been successfully consulted to obtain a description of the gene and gene product?	5	All key information from scoping report is included. The databases are correctly cited.	Some key information from scoping report is missing, OR some errors in citing the databases.	Most information from scoping report is included and some errors in citing the databases.	Little information from scoping report is included. The databases are incorrectly cited or missing from the bibliography.	Key information is missing and there is no evidence of databases being consulted.