School of Medical Sciences

NEUR3121

Molecular and Cellular Neuroscience

COURSE OUTLINE

TERM1, 2019

CRICOS Provider Code 00098G

CONTENTS

Please read this outline in conjunction with the following pages on the School of Medical Sciences website:

- Advice for Students
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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 10 teaching weeks in term 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 2019, Molecular and Cellular Neuroscience (NEUR3121) will commence in the week beginning 18 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 4-6 pm (Wallace Wurth LG03). Practical classes are Friday 2-4 pm in Wallace Wurth G06/07. There are two tutorial groups, both on Wednesday: 12-2 pm and 2-4 pm, in Matthews 227. 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 (including online material). 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 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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PhD Candidate, School of Medical Sciences, Department of Physiology

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 explain 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 will assess your own skills and the contribution of the rest of the team on how each member of 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. 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 are all opportunities for developing teamwork skills. An important aspect to this process is the recognition that all team members have different strengths to contribute. Everyone will offer an assessment of their own skills and the contribution of the rest of the team and how effective the collaborative and management skills were in achieving the common goal.
5. *Effective 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.
6. *Information literacy*
    - Your ability to assess the strengths and weaknesses or primary scientific papers will be developed as part of the tutorials. In addition, the 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-medicated 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 physiological 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. In addition, tutorials will include discussion of primary research papers to develop student capacity for critical reading of scientific literature and to provide an insight into ongoing research. 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 and related lectures. 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 assessment on the contributions of each team member. 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 can cause the disease state. The assessment rubric is provided at the end of this course outline and on Moodle.

There will be two progress exams throughout the course. 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 tutorial 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	20%
End of session exam	40%

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 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 myExperience 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 myExperience survey was conducted in 2018 and the overall results were very positive, with all responding students indicating satisfaction with the overall quality of the course and the quality of the teaching. 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. Additional practice questions for each topic have been provided.

4. The practical classes have been reformatted to include more demonstrators to assist students and a more efficient use of time.

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 and tutorials 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 two 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 (SoMS) located in the Wallace Wurth building, and is within the Faculty of Medicine. General inquiries regarding courses coordinated by SoMS should be submitted via the UNSW Student Portal Web Forms: http://unsw.to/webforms

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 Cristan Herbert, c.herbert@unsw.edu.au) or the Neuroscience honours co-ordinator (Dr Natasha Kumar, natasha.kumar@unsw.edu.au).

Postgraduate Research Degrees

The Department of Physiology offers students the opportunity to pursue 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. 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 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.

2. 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.

3. 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.

4. 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.

5. 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.

6. 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.

7. Electrotonic properties of axons and dendrites [T. Lewis]
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).

8. 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.

9. 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.

10. 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 can 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.

11. 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.

12. Transient receptor potential channel function [G. Housley]
This lecture will build upon the Transient Receptor Potential (TRP) channel family online activity. 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.

13. 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.

14. Cell-cell communication [K. Poole]
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.

15. Metabotropic receptor signalling [A. Finch]
Signalling through G protein-coupled receptors (GPCRs) and catalytic receptors (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 catalytic receptors and how they modulate channel function. The differences between metabotropic and inotropic signalling in terms of temporal regulation of ion channel function will also be discussed.

16. Synaptic transmission – synaptic modulation [T. Lewis]
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.

17. Synaptic plasticity [T. Lewis]
Synaptic plasticity is the ability of synaptic connections between neurons to increase or decrease in 'strength' due to specific patterns of synaptic activity over time. The changes may also be due to the influence of hormones, development or ageing. This can result in alterations of the pre-synaptic or post-synaptic mechanisms that give rise to the change in synaptic strength. The molecular and synaptic events associated with synaptic plasticity will be explored in several well-established examples and discussed with respect to the probable contribution to the storage of memory and learning.

18. Synaptic transmission – postsynaptic integration [T. Lewis]
Following on from the lectures on synaptic modulation and synaptic plasticity, 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.

19. Touch and Pain Transduction [K. Poole]
How do we sense and distinguish the myriad of stimuli from our environment; for instance, the difference between mechanical pain and gentle touch? In this lecture we will discuss the variations in transduction molecules in our somatosensory 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.

20. 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 can influence or determine the physiological function of the cells or tissues where it is expressed *in vivo*.

ONLINE MATERIAL

There are online activities available on Moodle for each week of the course. These are part of the scheduled course work and form part of the assessable content. Online activities should be completed in the week shown in the course schedule. The online activities are designed to consolidate learning from the previous week (for example where the activity works through example questions) or to prepare you for face-to-face activities in the same week.

The online activities appear in the course schedule below.

COURSE SCHEDULE T1, 2019

		ONLINE	LECTURES		TUTORIALS: Mat 227	PRACTICAL CLASSES
Wk	**Week Starting**		**WW LG03 Monday 4-5 pm**	**WW LG03 Monday 5-6 pm**	**A: Wednesday 12-2 pm B: Wednesday 2-4 pm**	**Wallace Wurth G06/07 Friday 2-4 pm**
1	18 Feb	1. Molecules of neuronal function- introduction to the course	1. Equilibrium potentials and Nernst equation [PB]	2. Membrane potentials and GHK [PB]	Membrane potentials. Teamwork and team building. [TL]	Introduction to Neurons in Action. NIA: The Na action potential.
2	25 Feb	2. Conventions and terminology of neuroscience	3. Electrophysiological techniques [AM]	4. Voltage-gated ion channel families [MP]	Team agreement and scoping report. [TL]	Membrane Potentials.
3	4 Mar	3. Membrane potentials – worked examples	5. Mechanisms of voltage-dependent gating [MP]	6. Mechanisms of ion permeation [AM]	Analysis of voltage-gated currents. [MP, TL] Normal function report.	NIA: Voltage clamping a patch.
4	11 Mar	4. Writing a review paper – interactive module	7. Electrotonic properties of axons and dendrites [TL]	8. Action potential generation in axons [AM]	Electrotonic potentials. [PB, TL]	*Progress Test 1* NIA: Chattering ion channels.
5	18 Mar	5. Electrotonic potentials – worked examples	9. Ligand-gated ion channel families [TL]	10. Ligand recognition and signal transduction [TL]	Analysis of ligand-gated currents. [TL]	Voltage responses to membrane currents.
6	25 Mar	6. Transient receptor potential (TRP) channel family	11. Mechanosensitive channels [KP]	12. Transient receptor potential channel function [GH]	Mechanosensitive channels. [KP, TL]	Compound action potential from the toad sciatic nerve. Research laboratory visits.
7	1 Apr	7. Synaptic transmission – worked examples	13. GPCR structure – function [AF]	14. Cell-cell communication [KP]	Cell-cell communication [KP, TL] Report	Compound action potential from the toad sciatic nerve. Research laboratory visits.
8	8 Apr	8. Synaptic structure	15. Metabotropic receptor signalling [AF]	16. Synaptic transmission – synaptic modulation [TL]	GPCRs and metabotropic signalling [AF]	*Progress Test 2* NIA: The neuromuscular junction.
9	15 Apr	9. Receptor response shapes post-synaptic signalling [TL]	17. Synaptic plasticity [TL]	18. Synaptic transmission – postsynaptic integration [TL]	Synaptic plasticity [TL]	GOOD FRIDAY
10	22 Apr	10. Optogenetics	EASTER MONDAY	EASTER MONDAY	Neuronal integration [TL]	NIA and NEURON: Postsynaptic inhibition.
11	29 Apr		19. Touch and pain transduction [KP]	20. Targeting receptor function with transgenic mice [GH]		

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 / format	% of total mark	Date of Submission	Feedback		
					WHO	WHEN	HOW
Weekly concept quizzes (9 quizzes, 1.6% each)	• The key concepts identified in the weekly practical classes and the associated lecture topics	• Multiple choice questions or calculations • Assessing understanding and ability to apply concepts	15%	Before end of Wednesday of following week	Dr Lewis	Immediately	Moodle
Collaborative project: Team agreement	• Management and planning skills	• Formative; feedback provided with respect to the elements of good teamwork	0%	1 Mar 2019	Dr Lewis	8 Mar 2019	Moodle
Collaborative project: Scoping report	• Information literacy • Research, inquiry and critical evaluation of information	• Formative; feedback provided according to the relevant criteria in the assessment rubric for the project (see below).	0%	1 Mar 2019	Dr Lewis, Dr Poole	8 Mar 2019	Moodle
Collaborative project: Normal function report	• Understanding of normal function of the ion channel or transporter • Critical evaluation of relevant scientific literature • Integration of information from multiple sources	• Assessed according to the relevant criteria in the assessment rubric for the project (see below).	2%	22 Mar 2019	Dr Lewis, Dr Poole	29 Mar 2019	Moodle
Collaborative project: Final report	• 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	• Assessed according to the relevant criteria in the assessment rubric for the project (see below).	18%	16 Apr 2019	Dr Lewis, Dr Power, Dr Poole, AProf Moorhouse	26 Apr 2019	Moodle

Task	Knowledge & abilities assessed	Assessment criteria / format	% of total mark	Date of Submission	Feedback		
					WHO	WHEN	HOW
Collaborative project: Teamwork	• Evaluate and analyse the teamwork, collaborative and management skills of the team • Self-assess and reflect upon your own contributions to the teamwork	• Understanding of teamwork skills • Reflective practice • Professional understanding	5%	20 May 2019	Dr Lewis, Dr Poole	1 Jun 2019	Moodle
Progress test 1	• Material from lectures 1 to lecture 6, the related material from online activities and the laboratory classes of weeks 1 to 3.	• Short answer style questions assessing knowledge, understanding and ability to apply concepts	10%	15 Mar 2019	Dr Lewis	22 Mar 2019	Moodle
Progress test 2	• Material from lectures 7 to lecture 14, the related material from online activities and the laboratory classes of weeks 4 to 7	• Short answer style questions assessing knowledge, understanding and ability to apply concepts	10%	12 Apr 2019	Dr Lewis	19 Apr 2019	Moodle
Final examination	• Demonstrate understanding of the learning outcomes from the course activities. • Ability to apply knowledge and understanding to solve problems in molecular and cellular neuroscience.	• Short answer style questions assessing knowledge, understanding and ability to apply concepts	40%	Official exam period (6-18 May 2019)			

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.

CRITERIA	Description	%	Exceptional (5)	Very Good (4)	Good (3)	Needs further development (2)	Significant deficiencies (1)
CRITICAL EVALUATION							
Understanding of literature	How well is the literature selected and the results explained?	15	All the literature consulted is relevant and appropriate. The concepts / experimental evidence from the literature are expertly explained.	Majority of the literature consulted is relevant and appropriate. The concepts / experimental evidence from the literature are correctly explained.	Some relevant and appropriate literature is consulted. The concepts / experimental evidence are mostly explained correctly.	Some relevant and appropriate literature is consulted. The concepts / experimental evidence are only partly correct.	Some relevant and appropriate literature is consulted. The concepts / experimental evidence are poorly explained.
Demonstration of conclusions	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? Sufficient references?	15	All information / concepts / experimental evidence from published works or the work of others is correctly referenced. Includes more than 5 major references.	Some deficiencies in the choice of reference or in providing a reference for the information / concepts / experimental evidence from work of others. Includes 5 major references.	Poorly chosen references or inappropriate references or insufficient references for the information / concepts / experimental evidence presented. Includes 4 or more major references.	Significant lack of appropriate (e.g. an over-reliance on internet sites) or insufficient 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?	5	The bibliography and in-text citations are all done in the correct format with no errors.	The bibliography and in-text citations are all done in the correct format with few errors.	The bibliography and in-text citations are mostly in the correct format with some errors.	The bibliography and in-text citations are partly done in the correct format with many errors.	Citations are incorrectly formatted. The bibliography is incorrect, incomplete or absent.
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.