

School of Medical Sciences

# NEUR3121

## Molecular and Cellular Neuroscience

COURSE OUTLINE

TERM1, 2021

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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 [medicallsciences.med.unsw.edu.au](http://medicallsciences.med.unsw.edu.au)

## COURSE INFORMATION

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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.

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 to understand function. Hence, this provides a strong foundation to the study of many areas in neuroscience. All course materials and information are available online on the course Moodle site (learning management system).

### **Summary of course structure**

The course is delivered via online learning topics (a mixture of pre-recorded lectures and online learning modules), tutorials to consolidate your understanding and apply it to problem solving, and practical classes to gain experience in the dynamic processes of neuroscience. 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 hrs of study and learning activities. The formal learning activities for this course are 63 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 87 hours. Students are strongly recommended to allocate at least eight hours per week for these assessment tasks and additional study.

## COURSE CONVENOR AND TEACHING STAFF

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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](mailto:t.lewis@unsw.edu.au))  
School of Medical Sciences, Wallace Wurth Building, room 302. Tel: 9065 9730

Course co-convenor: AProf. Kate Poole ([k.poole@unsw.edu.au](mailto:k.poole@unsw.edu.au))  
School of Medical Sciences, Lowy Building.

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](mailto:t.lewis@unsw.edu.au))  
Senior Lecturer, School of Medical Sciences, Department of Physiology

AProf. Kate Poole ([k.poole@unsw.edu.au](mailto:k.poole@unsw.edu.au))  
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AProf. Andrew Moorhouse ([a.moorhouse@unsw.edu.au](mailto:a.moorhouse@unsw.edu.au))  
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Dr. Matt Perry ([m.d.perry@unsw.edu.au](mailto:m.d.perry@unsw.edu.au))  
Senior Staff Scientist and Senior Lecturer, Victor Chang Cardiac Research Institute and School of Medical Sciences

Dr. Angela Finch ([angela.finch@unsw.edu.au](mailto:angela.finch@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**

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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'.

### **Course 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 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.

### **Links to the program learning outcomes in science**

The Faculty of Science established the programme learning outcomes that students should achieve 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 including the ability to construct new concepts or create new understanding through the process of enquiry, critical analysis, problem solving and research*
  - 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 enquiry.
2. *Capability and motivation for intellectual development; including capacity for creativity, critical evaluation, entrepreneurship and demonstrating a commitment to their own learning, motivated by curiosity and an appreciation of the value of learning.*
  - The laboratory classes 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 and critical evaluation is also provided with the open-ended nature of the collaborative project on Ion Channels and Disease.

3. *Ethical, social and professional understanding including the ability to critically reflect upon broad ethical principles and codes of conduct in order to behave consistently with a personal respect and commitment to ethical practice and social responsibility, multicultural, cultural and personal diversity.*
  - 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 including the ability to recognise opportunities and contribute positively to collaborative scientific research, and to demonstrate a capacity for self-management, teamwork, leadership and decision making based on open-mindedness, objectivity and reasoned analysis in order to achieve common goals and further the learning of themselves and others.*
  - 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 timeline 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 and appropriate communication in both professional (intra and inter disciplinary) and social (local and international) contexts.*
  - 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 including the ability to make appropriate and effective use of information and information technology relevant to their discipline.*
  - Your ability to assess the strengths and weaknesses of 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.

## RATIONALE AND STRATEGIES UNDERPINNING THE COURSE

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### **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. Online learning activities are a mixture of pre-recorded presentations (lectures) and interactive learning activities. These provide the core knowledge 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 core course knowledge. 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 insight to experimental techniques in real systems.

**The laboratory classes** are provided to support the core course knowledge and to practice applying analytical skills to biological problems. The material covered in the practical classes will be assessed in the progress exam and by the weekly “concept quizzes.” The “concept quizzes” will assess your understanding and application of the key concepts that are explored in the practical classes and related online activities. The key concepts are listed on the Moodle page for each activity. The quiz for each week 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. Student 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 team agreement, a scoping report 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 and reflection on the development of one aspect of their teamwork skills and a peer assessment on the teamwork skills of the other team members. 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 identifying relevant information from appropriate sources, with proper references for all sources; analysis and interpretation of experimental data; integration of information (not just summarising the individual components); and effective communication that demonstrates understanding. The assessment rubric is provided at the end of this course outline and on Moodle.

**There will be a progress exam (1 hour)**, comprised of short answer questions, multiple choice and/or short calculations (a UNSW approved calculator will be required). The questions will be based on the material covered in the online activities, the concept quizzes, the practical classes and the tutorials. This will assess your understanding and application of the concepts developed in the course. The exam will be held during the scheduled practical class. Please see the course schedule for the specific date.

**The end of session exam (2 hours)** 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 previous exam papers 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 exam	20%
End of session exam	40%

### **Examination period**

The final exam period for Term 1, 2021 is Fri 30 April to Thursday 13 May 2021.

The supplementary exam period for Term 1, 2021 is Mon 24 May to Fri 28 May 2021.

## RESOURCES

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See also [Learning Resources](#)

### **Prescribed Textbook**

Blaustein, M.P., Kao, J.P.Y. and Matteson, D.R. (2019). Cellular physiology and neurophysiology, 3rd edition, Philadelphia, PA: Elsevier/Mosby. ISBN 9780323596190  
[Copies are held in the UNSW library]

Alternatively:

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 and available as an online text]

### **Recommended textbooks**

Matthews G.G. (2004). Cellular Physiology of Nerve and Muscle. 4<sup>th</sup> edition. Wiley-Blackwell. ISBN 978-1-4051-0330-5  
[Two copies are held in the UNSW library, call number 573.836/1 and available as an online text]

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.  
[Copies held in the UNSW library, call number MBQ 612.8/229]

Aidley DJ (1998). The Physiology of Excitable Cells. 4<sup>th</sup> edition. Cambridge University Press, Cambridge, UK. ISBN 978-0521574218.  
[Copies held in the UNSW library, call number MB 573.8/2 and available as an online text]

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 Kandel, Siegelbaum S and Hudspeth, AJ (2013). Principles of Neural Science, 5<sup>th</sup> edition. New York: McGraw-Hill. ISBN 9780071390118.  
[An advanced textbook for extended reading. Copies held in the UNSW library, call number MBQ 612.8/204]

### **Moodle**

All the learning resources for this course will be provided on Moodle. This will include specific reading lists for topics, 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

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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. You may want to revise this learning activity to refresh your research skills, to enhance your ability to complete the collaborative project in this course.

## COURSE EVALUATION AND DEVELOPMENT

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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 2020 and the overall results were very positive, with responding students indicating satisfaction with the overall quality of the course and the quality of the online learning activities. Comments from students identified some areas where improvements could be made. As a result, the following adjustments to the course have been made:

1. What was previously face-to-face lectures are now presented as online learning topics, either as new pre-recorded lectures, or online learning activities.

2. The weekly podcast was introduced when the course went online last year and was well received. We will continue with the podcast this year.
3. The course content has been redesigned to incorporate the flexibility week and refocus the key concepts covered in the course.

## **STUDENT REPRESENTATIVES**

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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**

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See also [Advice for Students](#).

### ***Attendance Requirements***

For details on Class Attendance and Absence see [Advice for Students](#) and the guidance 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 progress exam held during the scheduled practical class.

### ***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 (ie. before 11:59 pm). Where relevant, you must complete the online declaration of originality before submitting the work.

### ***Equitable learning services***

The UNSW [Equitable Learning Services](#) is a free and confidential service that provides practical support to students living with a disability or a health / mental health concern. After registering with the Service, the advisors will then meet with you to create an individualised support plan for your studies.

### ***Special consideration***

Special consideration is the process for assessing the impact of short-term events beyond your control (exceptional circumstances), on your performance in a specific assessment task. You can find more detail about the special consideration process at: <https://student.unsw.edu.au/special-consideration>

## **GENERAL INFORMATION**

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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](mailto:c.herbert@unsw.edu.au)) or the Neuroscience honours co-ordinator (Dr Natasha Kumar, [natasha.kumar@unsw.edu.au](mailto: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 COURSE TOPICS**

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### ***Conventions and terminology of electrical activity in neurons [T. Lewis]***

This introduces the key electrical terms of voltage, charge, capacitance, conductance and resistance, which are needed to describe the electrical activity of neurons. The correct units and the range of the expected magnitude for each of these terms measured in excitable tissues is indicated. Ohm's Law is introduced, illustrating how it links current through ion channels (ion fluxes) and membrane potential responses. The conventions used when measuring membrane potentials, and the measurement of inward and outward current movements are defined. Finally it describes the relationship between single channel and macroscopic conductance.

### ***Equilibrium potentials and Nernst equation [T. Lewis]***

This topic 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.

### ***Membrane potentials and GHK equation [T. Lewis]***

This topic discusses the Goldman-Hodgkin-Katz equation to illustrate the role of selective ion permeabilities and salt diffusion gradients in generating membrane potentials across 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.

### ***Action Potential Mechanisms – classical biophysics [A. Moorhouse]***

This topic 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.

### ***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 topic 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, an overview of the voltage gated ion channel superfamily will be provided. 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.

### ***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 topic 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, we 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.

### ***Mechanisms of ion permeation [A. Moorhouse]***

Selective permeation of ions across the cell membrane is critical for neuronal function. This topic 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. It will then describe how the structure of the KcsA K<sup>+</sup> channel pore (resolved in 1998) allows this channel to select for K<sup>+</sup> ions over Na<sup>+</sup> ions while still allowing a fast rate of K<sup>+</sup> permeation. Some of the techniques used to determine the molecular basis of ion selectivity of glycine receptor channels will also be described.

### ***Propagation of electrical signals in axons and dendrites [T. Lewis]***

This topic provides a description of the physical basis for the passive spread of electrical signals in 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.

### ***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 topic 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.

### ***Transient receptor potential channels [G. Housley]***

Each of the members of the Transient Receptor Potential (TRP) channel family are introduced. The common structural features are examined and examples of the physiological roles these ion channels play in the nervous system is introduced. The best understood member of this family is the TRP C channel, and so the activation and regulation of this particular channel is explored further. An example of TRP C function in the cochlear is described. This topic leads into metabotropic receptor signalling, as TRP channel function is often regulated by metabotropic receptors.

### ***Mechanosensitive channels [K. Poole]***

This topic 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 topic will focus on the PIEZO proteins and their unique structure, drawing from newly published research.

### ***GPCR structure – function [A. Finch]***

This topic 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.

### ***Synaptic structure [T. Lewis]***

This topic introduces the basic structure and function of a synapse, composed of a presynaptic terminal and post-synaptic neuron. It looks at the function of the proteins associated with the pre-synaptic terminal that promote clustering, priming, and triggered release of synaptic vesicles. Other proteins span the synaptic cleft (cell adhesion molecules) to help form synapses and orient the pre- and post-synaptic membranes. On the post-synaptic side, proteins assemble to form a scaffold under the membrane to cluster ligand gated ion channels and form the post-synaptic density.

### ***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.

### ***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 ionotropic signalling in terms of temporal regulation of ion channel function will also be discussed.

### ***Pre-synaptic modulation [T. Lewis]***

This topic 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.

### ***Post-synaptic integration [T. Lewis]***

This topic looks at the events on the post-synaptic membrane that can alter the synaptic response. 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.

### ***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.

### ***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? 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. We will discuss 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.

**COURSE SCHEDULE T1, 2020**

		<b>LEARNING TOPICS</b>	<b>TUTORIALS</b>	<b>PRACTICAL CLASSES</b>	
<b>Wk</b>	<b>Week Starting</b>	<b>Online</b>	<b>A: Wed 2-4 pm, Matt 101 B, C: Wed 4-6 pm, online</b>	<b>Wallace Wurth G06/07 Tuesday 12-2 pm</b>	<b>Wallace Wurth 120 Tuesday 12-2 pm</b>
1	15 Feb	Conventions and terminology of neuroscience Equilibrium potentials and Nernst equation [TL]	Teamwork skills [TL]	<b>A:</b> Recording membrane Potentials (simulation)	<b>B:</b> Artificial membrane
2	22 Feb	Membrane potentials and GHK equation [TL] Action Potential Mechanisms – Classical Biophysics [AM]	Team agreement and scoping report. [TL, KP]	<b>B:</b> Recording membrane potentials (simulation)	<b>A:</b> Artificial membrane
3	1 Mar	Voltage-gated ion channel families [MP] Mechanisms of voltage-dependent gating [MP]	Membrane potentials [TL]	<b>A:</b> Voltage clamping a patch (simulation)	<b>B:</b> Collaborative project
4	8 Mar	Mechanisms of ion permeation [AM] Propagation of electrical signals in axons and dendrites [TL]	Analysis of voltage-gated currents. [MP, TL]	<b>B:</b> Voltage clamping a patch (simulation)	<b>A:</b> Collaborative project
5	15 Mar	Ligand-gated ion channel families [TL] Transient receptor potential (TRP) channel family [GH]	Propagation of electrical signals [TL, KP]	<i>Progress Exam</i>	<i>Progress Exam</i>
6	22 Mar	FLEXIBILITY WEEK		Optional: Research laboratory visits.	Optional: Research laboratory visits.
7	29 Mar	Mechanosensitive channels [KP] GPCR structure – function [AF]	Mechanosensitive channels. [KP, TL]	<b>A:</b> Chattering ion channels (simulation)	<b>B:</b> Compound action potential from the toad sciatic nerve.
8	5 Apr	Synaptic structure [TL] Cell-cell communication [KP]	Cell-cell communication [KP, TL]	<b>B:</b> Chattering ion channels (simulation)	<b>A:</b> Compound action potential from the toad sciatic nerve.
9	12 Apr	Metabotropic receptor signalling [AF] Synaptic modulation [TL] Synaptic integration [TL]	GPCRs and metabotropic signalling [AF, TL]	<b>A:</b> Synaptic transmission and propagation (simulation)	
10	19 Apr	Synaptic plasticity [TL] Touch and pain transduction [KP]	Synaptic plasticity [TL]	<b>B:</b> Synaptic transmission and propagation (simulation)	

## 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 before submitting the work.

Task	Knowledge & abilities assessed	Assessment criteria / format	% of total mark	Date of Submission	Feedback		
					WHO	WHEN	HOW
Weekly concept quizzes (6 quizzes, 2.5% each)	<ul style="list-style-type: none"> <li>The key concepts identified in the weekly practical classes and the associated learning topics</li> </ul>	<ul style="list-style-type: none"> <li>Multiple choice questions or calculations</li> <li>Assessing understanding and ability to apply concepts</li> </ul>	15%	Before end of Monday of following week	Dr Lewis	Immediately	Moodle
Collaborative project: Team agreement	<ul style="list-style-type: none"> <li>Management and planning skills</li> </ul>	<ul style="list-style-type: none"> <li>Formative; feedback provided with respect to the elements of good teamwork</li> </ul>	0%	26 Feb 2021	Dr Lewis	5 Mar 2021	Moodle
Collaborative project: Scoping report	<ul style="list-style-type: none"> <li>Information literacy</li> <li>Research, inquiry and critical evaluation of information</li> </ul>	<ul style="list-style-type: none"> <li>Formative; feedback provided according to the relevant criteria in the assessment rubric for the project (see below).</li> </ul>	0%	5 Mar 2021	Dr Lewis, AProf Moorhouse	12 Mar 2021	Moodle
Collaborative project: Final report	<ul style="list-style-type: none"> <li>Logical presentation of ideas</li> <li>Research, inquiry and information literacy</li> <li>Critical evaluation of the literature; integration of information; understanding of the experimental results</li> <li>Demonstrated understanding of the molecular mechanism likely to cause the disease</li> </ul>	<ul style="list-style-type: none"> <li>Assessed according to the relevant criteria in the assessment rubric for the project (see below).</li> </ul>	15%	9 Apr 2021	Dr Lewis, AProf Moorhouse	23 Apr 2021	Moodle

Task	Knowledge & abilities assessed	Assessment criteria / format	% of total mark	Date of Submission	Feedback		
					WHO	WHEN	HOW
Collaborative project: Teamwork	<ul style="list-style-type: none"> <li>Evaluate the teamwork, collaborative and management skills of the team</li> <li>Self-assess your contributions to the team</li> <li>Self-assess and reflect on your development of one specific teamwork skill</li> </ul>	<ul style="list-style-type: none"> <li>Understanding of teamwork skills</li> <li>Reflective practice</li> <li>Professional understanding</li> </ul>	10%	16 Apr 2021	Dr Lewis, AProf Moorhouse	23 Apr 2021	Moodle
Progress Exam	<ul style="list-style-type: none"> <li>Material from learning activities in weeks 1 to 4, inclusive.</li> </ul>	<ul style="list-style-type: none"> <li>A mixture of multiple choice and short answer style questions assessing knowledge, understanding and ability to apply concepts</li> </ul>	20%	16 Mar 2021	Dr Lewis	23 Mar 2021	Moodle
Final Exam	<ul style="list-style-type: none"> <li>Demonstrate understanding of the learning outcomes from the course activities.</li> <li>Ability to apply knowledge and understanding to solve problems in molecular and cellular neuroscience.</li> </ul>	<ul style="list-style-type: none"> <li>A mixture of multiple choice and short answer style questions assessing knowledge, understanding and ability to apply concepts</li> </ul>	40%	Official exam period (30 Apr -13 May 2021)			

**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							
<b>Use of appropriate vocabulary</b>	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.
<b>Content organization</b>	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.
<b>Experimental evidence</b>	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.
<b>Integration of information</b>	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.
<b>Abstract</b>	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)
<b>CRITICAL EVALUATION</b>							
<b>Understanding of literature</b>	How well is the literature selected and the results explained?	15	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.
<b>Demonstration of conclusions</b>	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.
<b>INFORMATION LITERACY</b>							
<b>Referencing</b>	Are all publications / concepts / experimental evidence appropriately referenced? Sufficient references?	15	The 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.
<b>Reference list and citations</b>	Is the in-text citations and reference list presented in the correct format?	5	The reference list and in-text citations are all done in the correct format with no errors.	The reference list and in-text citations are done in the correct format with few errors.	The reference list and in-text citations are mostly in the correct format with some errors.	The reference list and in-text citations are partly done in the correct format with many errors.	Citations are incorrectly formatted. The reference list is incorrect, incomplete or absent.