FACULTY OF MEDICINE
SCHOOL OF MEDICAL SCIENCES
DEPARTMENT OF PHYSIOLOGY

NEUR3121

MOLECULAR AND CELLULAR NEUROSCIENCE

SESSION 1, 2013

CONTENTS

COURSE INFORMATION

Molecular and Cellular Neuroscience is a stage three course worth six units of credit (6 UOC) and usually undertaken upon successful completion of Physiology 1A (PHSL2101 / 2121). The course can contribute to a major or minor 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 cells function and communicate with each other, how this 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).

COURSE CONVENER AND TEACHING STAFF

Course convener: Dr. Trevor Lewis (t.lewis@unsw.edu.au)
School of Medical Sciences, Wallace Wurth Building, room 302
Tel: 9385 1102
Email is the best method for communicating with the course convenor or for arranging a consultation.

Course co-convener: Dr. John Power (john.power@unsw.edu.au)
School of Medical Sciences, Wallace Wurth Building, room 303
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Teaching Staff (Lecturers / Tutors)

Dr. Trevor Lewis (t.lewis@unsw.edu.au)
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Emeritus Professor, School of Medical Sciences, Department of Physiology

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Prof. Gary Housley (g.housley@unsw.edu.au)
Head of Department, School of Medical Sciences, Department of Physiology

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

OBJECTIVES OF THE COURSE

This course aims to provide students with an integrated approach to understanding cellular neuroscience, including current research and techniques. It looks at the key molecules that underlie the processes of signalling in neural cells, the behaviour of neural cells and how these may be manipulated experimentally to understand function. 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 are key elements of this course. The course also aims to develop skills in analytical thinking and problem solving in the context of electrical signalling in neurons. This requires an understanding of the fundamental electrical 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'.

Approach to Learning and Teaching

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 physical principles to solve biological problems and develop analytical skills. The tutorials will provide opportunities for expressing your reasoning or thinking and will support your understanding of the course material presented in the lectures. Practical classes are a combination of computer modelling / simulation of neuronal signalling, that allow testing ideas that cannot easily be done by other means, and classes with biological materials that provide some insight to experimental techniques in real systems.

Learning outcomes

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 explicitly contribute to:

1. Research, inquiry and analytical thinking abilities
    a. Understanding how the electrical properties of membranes underpin signalling in neurons.
    b. Understanding how different ion channels, transporters and receptors are able to contribute to electrical and chemical signalling in neurons.
    c. Ability to apply basic mathematical and physical properties to biological problems and concepts of neuronal signalling.
    d. Ability to formulate and explain the reasoning for a solution to a problem.
    e. Understand how molecular biology techniques can be applied to manipulate the function of neurons.
2. Effective communication
    a. Ability to formulate and explain the reasoning for a solution to a problem.
    b. Ability to integrate and combine information from a variety of different sources.
    c. Ability to interpret and summarize scientific ideas.
    d. Planning and organising as a member of a team.
3. Information literacy
    a. Ability to use the scientific literature to find appropriate information.
    b. Ability to search and collate information from online databases relevant to molecular and cellular neuroscience.

ASSESSMENT

Practical classes	15%
Group assignment	20%
Progress exams	20%
End of session exam	45%

The practical 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 providing written summaries explaining some of the major concepts from the practical classes. The summaries need to describe the concept, describe how it was demonstrated in the practical class and explain the meaning, mechanism or consequence of the concept. The explanation of concepts will be judged on whether there is clear description of the concept and clear scientific reasoning in the explanation provided. It should be expressed in appropriate scientific language. The first summary task will be a formative assessment, with the feedback provided giving you the opportunity to understand the requirements of the task and to resubmit the summary for marking. Two more summaries will be submitted during the course. Feedback and a mark will be provided, but there is no opportunity for resubmitting these summaries. Topics that are suitable for summaries will be nominated for each practical class. The deadlines for each of the summaries will be provided on Blackboard.

The group assignment will require students to work in groups of four or five students, researching the properties of a gene product, which will be allocated to the group. Each gene product is either an ion channel or transporter and there are one or more diseases that are associated with mutations in the gene. Groups will use online databases to identify characteristics of the gene and the ion channel / transporter

for which it codes. A literature search will be required to identify the function of the channel / transporter and how this is altered in the disease state. The group will produce a progress report and a final report in electronic form. A statement on the contribution of each group member to the report must be included. Each member will also provide a reflection on how they have worked together as a team. Each group will make an oral presentation summarising the work to the class. The assessment will be based on the ability of the group to identify relevant information from appropriate sources and provide proper references for all sources; the group 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. The contribution of each group member to the written report (as indicated by the history of the wiki page) will be considered in the assessment.

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 and practical classes ~~and tutorials~~. The purpose of these progress exams is to provide feedback to students on their understanding and application of the concepts developed in the course. The exams will be held during the scheduled tutorial sessions.

The end of session exam will be comprised of short answer questions that will include some simple calculations. 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 answer questions. 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.

ACADEMIC HONESTY AND PLAGARISM

The School of Medical Sciences will not tolerate plagiarism in submitted written work. The University regards plagiarism as Academic Misconduct (see: https://my.unsw.edu.au/student/atoz/Plagiarism.html).

Evidence of plagiarism in submitted assignments, etc. will be thoroughly investigated and dealt with according to the Student Misconduct Procedure. Academic Misconduct carries penalties. If a student is found guilty of academic misconduct, the penalties include warnings, remedial educative action, being failed in an assignment or excluded from the University for two years.

The following information comes from the UNSW A-Z Student Guide entry on plagiarism.

What is plagiarism?

Plagiarism is using the words or ideas of others and presenting them as your own. Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. The University has adopted an educative approach to plagiarism and has developed a range of resources to support students. UNSW has produced a booklet to assist you with essential information for avoiding plagiarism (pdf).

Details of what plagiarism is can be found on the Learning Centre's Plagiarism & Academic Integrity website and in Appendix A of the Student Misconduct Procedure (pdf).

Examples of plagiarism include:

- Direct duplication of the thoughts or work of another, including by copying work, or knowingly permitting it to be copied. This includes copying materials, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, website, internet, other electronic resource, or another person's assignment, or the student's own assignment from a previous course, without appropriate acknowledgement;
- Quotation without the use of quotation marks;
- Paraphrasing another person's work with very minor change keeping the meaning, form and/or progression of ideas of the original;
- Citing sources which have not been read, without acknowledging the 'secondary' source from which knowledge of them has been obtained;
- Piecing together sections of the work of others into a new whole;
- Presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or tutor;
- Claiming credit for a proportion of work contributed to a group assessment item that is greater than that actually contributed;

- Submitting your own assessment item that has already been submitted for academic credit at UNSW or elsewhere may also be considered plagiarism;
- Using another person's ideas or words in an oral presentation without crediting the source.

The basic principles are that you should not attempt to pass off the work of another person as your own, and it should be possible for a reader to locate information and ideas you have used by going to the original source material. Acknowledgement should be sufficiently accurate to enable the source to be located quickly and easily. If you are unsure whether, or how, to make acknowledgement, consult your lecturer or visit The Learning Centre.

The Learning Centre website is the main repository for resources for staff and students on plagiarism and academic honesty. It can be located at: www.lc.unsw.edu.au/plagiarism

Students are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting, and the proper referencing of sources in preparing all assessment items.

SCHEDULE

Lectures are scheduled for Tuesday 1-2 pm in Wallace Wurth G02 and Wednesday 2-3 pm in Biomed E. Practical classes are Wednesday 9 am to 12 noon in Wallace Wurth G2/G4. Tutorials are Wednesday 3-4 pm in Mathews 312. 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 approximately 75 hours throughout the semester and students are expected (and strongly recommended) to do at least the same number of hours of additional study.

The course timetable is appended at the end of this course outline and can also be found on the course site in Blackboard.

RESOURCES

Prescribed Textbook

Matthews G.G. (2004). Cellular Physiology of Nerve and Muscle. 4th edition. Wiley-Blackwell.
[Two copies are held in the UNSW library, call number 573.836/1, and it is available from the UNSW Bookshop. There is also a copy of the third edition in the UNSW library.]

Recommended textbooks

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]

Other Resources

A number of other resources for this course will be provided on Blackboard. 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, the course timetable and outline, as well as various supplementary articles. Announcements will be made via Blackboard and it is the students' responsibility to regularly check this site.

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.

In the continuing development of this course, consideration is given to the feedback obtained from the Course and Teaching Evaluation and Improvement (CATEI) survey and the direct feedback from student representatives. Student feedback is always welcome and is taken seriously. In response to the course evaluation in 2012, the assessment tasks in the course have been streamlined. The number of practical class summaries submitted has been reduced and the first summary submitted is now a formative task to provide feedback and guidance on completing the task. Additional examples illustrating the marking criteria will also be provided. The number of progress tests has been reduced from four to two and the timing of these tests has been selected to minimize the overlap with assessments in other courses. More details of the depth of information needed for the group project will also be provided.

Students enrolled in the course will be invited to elect two student representatives who will meet with the course convener and teaching staff 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

The Department of Physiology is located in the School of Medical Sciences (SoMS), Wallace Wurth building (C27), Faculty of Medicine. General inquiries can be made at the SoMS reception, located in room 313 on level 3 of the Wallace Wurth building (office hours are 8:30am - 5:00pm).

Prof. Gary Housley is the Head of Department and appointments may be made through the administrative assistant located at the SoMS reception, room 313.

The School Student Advisor is **Ms. Carmen Robinson** and she is able to provide additional information on any courses offered by the School. Ms. Robinson is located in the BABS-SoMS-BEES Students Office, room G27, Biosciences Building. Ms. Robinson may also be contacted either by telephone on 9385 2464 or by email: Carmen.robinson@unsw.edu.au

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, which are available on the honours page of the SoMS web site. Students should consider which research area(s) is/are of interest and then directly approach the relevant academic(s) / 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 Andrew Moorhouse, a.moorhouse@unsw.edu.au) or the Neuroscience honours co-ordinator (Dr John Power, john.power@unsw.edu.au).

Postgraduate Research Degrees

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

Attendance Requirements

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

Computing Facilities

Computer facilities are available to students in the School of Medical Sciences for access to various course-specific teaching programs in Room 106/108 and G2/G4. Swipe card access will be given to all students. Hours of access are 8:30am - 6:00pm. However, priority is given to scheduled classes and meetings.

The use of computing facilities and IT services is governed by the UNSW policies and guidelines that can be found at: https://www.it.unsw.edu.au/students/policies/index.html
All students need to arrange a zPass to be able to login to the computers. This can be arranged at the UNSW Identity Manager: http://idm.unsw.edu.au

Special Consideration

If you believe that your performance in a course, either during session or in an examination, has been adversely affected due to illness or misadventure, you should notify the Registrar and ask for special consideration in the determination of your results. Such requests should be made as soon as practicable after the problem occurs. **Special considerations sought outside the three day time period WILL NOT be accepted except in TRULY exceptional circumstances.**

When submitting a request for special consideration you should provide all possible supporting evidence (e.g. medical certificates) together with your student number and enrolment details. Consideration request forms are available from Student Central in the Chancellery.

Students who miss an assessment must submit an application for consideration to Student Central and must also contact the course convenor immediately. If you miss an assessment and have applied for Special Consideration, this will be taken into account when your final grade is determined. You should note that marks derived from completed assessment tasks may be used as the primary basis for determining an overall mark; for example, by extrapolating from your percentile rank on those tasks. Where appropriate, supplementary examination may be offered, but only when warranted by the circumstances. It is intended that supplementary exams for the School of Medical Sciences in Semester 1, 2013 will be held in the week commencing Monday 8th July, 2013.

Normally, if you miss an exam (without medical reasons) you will be given an absent fail. If you arrive late for an exam no time extension will be granted. It is your responsibility to check timetables and ensure that you arrive with sufficient time.

Please refer to the A-Z Student Guide at myUNSW:
https://my.unsw.edu.au/student/atoz/SpecialConsideration.html
for further details regarding special consideration.

Equity and Diversity

Students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convener prior to, or at the commencement of the course, or with the Equity Officer (Disability) in the Student Equity and Diversity Unit (9385 4734 or www.studentequity.unsw.edu.au). Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

Official Communication by Email

Students are advised that email is the official means by which the School of Medical Sciences at UNSW will communicate with you. All email messages will be sent to your official UNSW email address (e.g., z1234567@student.unsw.edu.au). If you do not wish to use the University email system, you MUST arrange for your official email to be forwarded to your chosen address. The University recommends that you check your email at least every other day. Facilities for checking email are available in the School of Medical Sciences and in the University Library. Further information and assistance is available from the IT Service Centre Assistance Counter, in person on the ground floor of the library annexe (near the post office), by telephone (9385 1333) or via email (ITServiceCentre@unsw.edu.au).

Grievance Officer

If you have any problems or grievance about the course, you should try to resolve it with the course convener. If the grievance cannot be resolved in this way, you should contact the School of Medical Sciences Grievance Officer, Dr Priti Pandey (p.pandey@unsw.edu.au, 9385 2483).

SUMMARY OF LECTURES

1. Welcome. Course overview and information.

An introduction to the course, covering the lecture outline, tutorials and practical classes. An overview of the assessment procedure and the breakdown of the marks will be provided.

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

This lecture starts with the expression for electrochemical potential, the energy of a mole of ions in solution, and how it can be used to derive the Nernst equation, the foundational equation for understanding electrophysiology. The Nernst equation gives the potential at which a distribution of a particular permeant ion would be in equilibrium across a membrane.
The lecture then describes the three conditions for Gibbs-Donnan equilibrium: (1) Gibbs-Donnan equilibrium itself; (2) macroscopic electroneutrality and (3) osmotic equilibrium, and its applications in physiology.

3. 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.

4. 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 group project and other coursework.

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

This lecture provides a description of the physical basis for the passive electrical properties of axons and dendrites. It describes the time-course for the change in membrane potential in response to a square pulse injection of current. The length constant and the time constant are introduced and used to describe the cable properties of the axons or dendrites and action potential propagation.
The tutorial on electrotonic potentials addresses material from this lecture, as does the practical class on the Voltage Responses to Membrane Currents (MemCable).

6. Overview of ion channel, receptor and transporter families [T. Lewis]

This lecture provides a revision (from Physiology 1A) of the role of ion channels, receptors and transporters in neuroscience. It addresses the major families of ion channels and the roles they perform; the types of transporters and the role they perform; and introduces the roles of G-protein coupled receptors. The goal of this lecture is too appreciate the diversity and the differences of the ion channels transporters and receptors, and how this contributes to the specificity of the role they perform.

7. 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.

8. Voltage-gated ion channel families [J. Vandenberg]

- Historical perspective
- Review basic properties of voltage-gated ion channels
- Introduce concept of voltage-dependent gating
- Explain nomenclature of voltage-gated ion channels
- Outline structure of voltage-gated ion channels

9. Mechanisms of voltage-dependent gating [J. Vandenberg]

- principles of gating
- kinetics of gating
- molecular basis of gating
- structural basis of gating

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

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

11. 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.

12. Metabotropic receptor signalling [A. Finch]

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

13. 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.

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

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

15. Transient receptor potential channels [G. Housley]

- Be able to describe the structure and function of the Transient Receptor Potential (TRP) ion channels.
- Be able to provide examples of the physiological roles these ion channels play in the nervous system

16. Cell-cell communication [J. Power]

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

the fast synaptic transmission, while metabotropic receptors (GPCRs) are responsible for slow synaptic transmission.

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

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

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

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

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

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

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

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

21. Recombinant DNA technology and neuroscience [G. Housley]

- Develop an understanding of the elements of gene cloning for expression vectors (for example delivery of the neurotrophin Brain Derived Neurotrophic Factor, BDNF)
- Consider the options for gene delivery into neurons in vitro and in vivo - how can expression of recombinant proteins be achieved in selected regions of the brain.

22. Transgenic and conditional knockout mouse models [G. Housley]

- Develop a step-wise understanding of how to make a knockout mouse.
- Understand the principles of transgenic mouse models, including "knock-in" and conditional knockouts.

23. Synaptic Failure in Disease [T.Fath]

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

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

- To know how receptor function can be investigated by using conditional knockout or transgenic mouse models.
- Exemplars of knock-out and knock-in transgenic mouse models.

CLASS TIMETABLE S1, 2013

Week	Week Starting	Lecture 1 Tuesday 1-2 pm Wallace Wurth LG02	Practical classes Wednesday 9-12 noon Wallace Wurth G2/G4	Lecture 2 Wednesday 2-3 pm Biomed E	Tutorial Wednesday 3-4 pm Matthews 312
1	4 Mar	1. Welcome. Course overview and information.		2. Equilibrium and Gibbs-Donnan potentials [P. Barry]	Tutorial – introduction to group projects
2	11 Mar	3. Membrane potentials and GHK [P. Barry]	Membrane Potentials (MemPot, ArtMem).	4. Electrophysiological techniques [A. Moorhouse]	Tutorial – practical class summaries and group project
3	18 Mar	5. Electrotonic properties of axons and dendrites [P. Barry]	Voltage responses to membrane currents (MemCable).	6. Overview of ion channel, receptor and transporter families [T. Lewis]	Tutorial – membrane potentials
4	25 Mar	7. Mechanisms of ion permeation [A. Moorhouse]	Introduction to Neurons in Action. NIA: The Na action potential	8. Voltage-gated ion channel families [J. Vandenberg]	Tutorial – electrotonic potentials
Mid-session Break					
5	8 Apr	9. Mechanisms of voltage-dependent gating [J. Vandenberg]	NIA: Voltage clamping a patch	10. Action potential generation in axons [A. Moorhouse]	Progress test 1
6	15 Apr	11. GPCR structure – function [A. Finch]	Compound action potential from the toad sciatic nerve	12. Metabotropic receptor signalling [A. Finch]	Tutorial – analysis of voltage-gated currents
7	22Apr	13. Ligand-gated ion channel families [T. Lewis]	NIA: Chattering ion channels	14. Ligand recognition and signal transduction [T. Lewis]	Tutorial – GPCRs
8	29 Apr	15. Transient receptor potential channels [G. Housley]	Patch clamp electrophysiology and data analysis exercise	16. Cell-cell communication [J. Power]	Tutorial – analysis of ligand-gated currents
9	6 May	17. Receptor response shapes post-synaptic signalling [T. Lewis]	NIA: The neuromuscular junction	18. Synaptic transmission – synaptic modulation [J. Power]	Tutorial – molecular biology for neuroscience
10	13 May	19. The Postsynaptic Architecture - From Structure to Function [T. Fath]	NIA: Postsynaptic inhibition	20. Synaptic transmission – postsynaptic integration [J. Power]	Progress test 2
11	20 May	21. Recombinant DNA technology and neuroscience [G. Housley]	NEURON: Synaptic Integration	22. Transgenic and conditional knockout mouse models [G. Housley]	Tutorial – neuronal integration
12	27 May	23. Synaptic Failure in Disease [T.Fath]	Group project presentations.	24. Targeting receptor function with transgenic mice [G. Housley]	Tutorial- Transgenic models
13	3 Jun		Group project presentations.		