UNIVERSITY OF CAMBRIDGE
Department of Pharmacology

MECHANISMS OF DRUG ACTION (MODA)

COURSE INFORMATION

2022-23

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Contents

SECTION 1 – General Course Information

Aims of the Course

The Mechanisms of Drug Action course aims to provide an understanding of the basic mechanisms of drug action at the levels of both drug-receptor interactions and the effects on body systems. Attention is focused not only on the current use of drugs, but also on a framework for evaluating future therapies.

Teaching Objectives

By the end of the MODA course students should have:

- Attained a core knowledge in basic pharmacology, and so laid a secure foundation in the principles of drug action to support future courses in medicine and veterinary medicine which they will carry with them into their professional careers.
- Developed their experimental and data analysis skills through a range of experiments carried out in the practical laboratories and attendance at demonstrations and supervisions. (See later for "impact of covid on practical delivery").

Learning Outcomes

At the end of the course each student is expected to be able to:

- Demonstrate a broad knowledge of modern pharmacology, from the molecular basis of receptors, to the effects of drugs on whole body systems;
- Identify the major classes of drug receptors and sites of drug action within the body;
- Identify typical examples of drugs which are used to restore physiological functions in the cardiovascular, renal, respiratory, digestive, peripheral nervous and central nervous systems;
- Demonstrate an understanding of the use of drugs to control inflammation and immune responses or to kill invading organisms or malignant cells;
- Apply the basic principles that govern the absorption, distribution and elimination of drugs to predict the time course of drug concentrations in the body and consider the implications of these principles for the therapeutic use of drugs;
- Recognise the fundamental methods used in pharmacological research.

Student Feedback

Feedback from students is received via course student representatives (named on the MoDA Moodle main page) in an end of term meeting between the reps and the course organiser. The collated feedback is furthered overviewed through a Course Review Committee which meets at the end of each term. The Review Committee is set up at the beginning of the academic year comprising veterinary and medical students and representative members of the teaching staff. The Committee meets at the end of each term to discuss all aspects of the course. Furthermore, anyone who would like to make an official suggestion or complaint, is welcome to do so by writing/e-mail directly to the Course Organiser Dr Paul Miller *via* e-mail: pm676@cam.ac.uk. If you prefer you may ask your Director of Studies to forward the message without mentioning your name.

Student Feedback Surveys are sent out as announcements on the Moodle website at the end of each lecture series, we would appreciate you taking the time to complete these short surveys.

To demonstrate how we take feedback seriously, here are some of the changes that have taken place in recent years where student feedback either initiated a change, or supported a change suggested by teaching staff:

Changed for 2022/23:

• In response to student feedback to make practicals more accessible and to learn more from them we are pleased to be offering pre and post-practical quizzes.

• Added to the Moodle "Exam Information and Resources" page, clearer information on the exam assessment, including an example exam paper with answers.

Changed for 2021/22:
In response to student feedback regarding disappointment at missing practical classes in the 2020/21 year, we have prioritised a return to in-person teaching of practical classes (See later for "impact of covid on practical delivery").

In response to very positive student feedback for online lectures, and in particular regarding the more interactive pharmacokinetics component, we have decided to make pharmacokinetics an online only taught lecture series moving forward, as part of a blended learning initiative.

Also regarding the pharmacokinetics lecture series, a separate seminar historically given in the laboratory has now been integrated within the lecture series to enhance the blended learning experience.

Due to Covid upheaval there was no implementable student feedback. The course underwent fundamental restructuring in its delivery as an all online format.

Changed for 2019/20:
Following the highly positive student feedback of Clinical Case Studies introduced for Michaelmas and Lent Terms in 2018/19, a third Clinical Case Study has been brought in for Easter Term, the topic of which will be related to inflammation and thus act as a revision exercise of material covered at the end of Lent Term.

Following feedback regarding how practical paper questions are marked, we have placed on the Moodle a handwritten, marked answer to both a pharmacokinetics and ligand binding question – it is important to note that Examiners retain the right to exercise discretion in how individual questions and parts of questions should be marked, but the model answers provide a good overview how questions are marked.

Changed for 2018/19:
Clinical Case Studies, although a preclinical course, MoDA covers numerous clinical conditions. To reinforce the importance of preclinical concepts from the MoDA course, we have organised two Clinical Case Study sessions (separate sessions for Medics and Vets), more information can be found in the description of the Course Outline.

Practical paper format, for several years, the practical paper (Paper 2) consisted of 2 out of 3 possible questions (ligand binding, pharmacokinetics and trace analysis). It was fed back to us that this made exam preparation difficult and thus to ease student anxiety about not knowing which questions will come up, whilst still enabling an examination of multiple data analysis skills, we have moved to a format where there will be 1 ligand binding question and 1 pharmacokinetic question, both of which will contain a short amount of data analysis, i.e. looking at tables/graphs and interpreting the data. This has occurred in previous years anyway, for example, 2016 and 2018 ligand binding questions, and the 2014 and 2018 pharmacokinetic questions.

Students with disabilities

The Department has facilities for wheel chair access, including a lift and toilet. Any student with disabilities may contact the Course Organizer who will direct you to the officer appointed to deal with problems encountered by disabled students.

Safety

Apart from usual safety measures such as fire procedures, there are also specific safety issues arising as part of the practical work. **These are identified in the handbook practical section**, in the introduction at the beginning of each practical and within the teaching application.

Student Complaints

The Student Complaints Procedure (the Procedure) allows a student to express dissatisfaction about the standard of service provided by the University. You can find all the information at
http://www.studentcomplaints.admin.cam.ac.uk/student complaints

Useful Websites

Information which you may find useful, including this Course Book, can be found on Moodle and the Department's web site:
https://www.vle.cam.ac.uk http://www.phar.cam.ac.uk

and on the relevant sites maintained by the Faculty of Biology:
https://www.biology.cam.ac.uk/undergrads/MedST/Current
https://www.biology.cam.ac.uk/undergrads/VetST/Current

Frequently Asked Questions

Why does Paper 1 look different before 2016/17?
In response to student feedback and to align the MoDA examination format with examinations in the Clinical Schools, we moved to a single-best answer format exam with no negative marking in 2016/17 to replace the true/false (negatively marked) format exam. (Exams from pre-2016/17 may still form useful revision tools.)

Why so many drugs?
The MoDA course covers and extensive body of material, from fundamental pharmacological concepts, through to pharmacotherapy for a wide range of conditions. Consequently, there will always be a large number of drugs, especillay as more drugs become available and personalized medicine becomes more prominent. Moreover, there is regular contact between pre-clinical and clinical academics to ensure that appropriate drugs are covered.

Why are we lectured about drugs not in clinical use?
This is a mechanisms of drug action course, not clinical therapeutics. Certain non-clinical drugs are covered due to their importance in understanding how different organ systems work and/or their importance in development of drugs from useful experimental tools through to clinical therapeutics. In addition, you may encounter drugs that are used clinically outside of the NHS to demonstrate different mechanisms of drug action.

Why no drug list?
Feedback from students resulted in us no longer issuing a drug list at the same time as the Paper 1 examination format changed. The new examination format focuses far more on understanding how drugs work, rather than the need for rote learning of drugs. You may encounter *rogue* drug lists from students/supervisors, be wary of these because course content, and thus drugs covered, changes year-on-year. Note however, that lecture handouts may provide a list of drugs or drugs glossary, as a helpful reference tool.

Do Vets need to learn "medic" drugs / do Medics need to learn "vet" drugs covered in combined lectures?
Yes. The mechanisms of drug action are important, rather than drug names/uses per se. Material covered in Vet Only / Medic Only lectures will only be examined in Vet Only / Medic Only questions in Papers 1 and 3.

Should I learn drugs mentioned on old exam questions that were not covered on this year's course?
No. Course content is regularly updated in response to course reviews, student feedback and input from clinical academics. Therefore, drugs mentioned in lectures and examined 5 years ago will not necessarily be the same as in this year's course, i.e. if you see a drug on a 2014 exam paper that you have not heard of from this year's lectures then do not panic, you will only be examined on what you have been taught this year.

Do we get provided with answers to questions that form part of the practical classes?
Yes. For each practical a PDF version of the practical that includes answers will be uploaded onto Moodle

once all students have completed it.

What is the point of the practical paper?
The written practical paper (Paper 2) provides students with a chance to demonstrate their data handling and interpretation skills, which underpins the use of drugs in the clinic. A recent External Examiner for the 2nd MB / 2nd Vet MB Examinations commented in their report, "*These questions are well constructed, and tested in large part the numerical skills of the students, along with their ability to think about drug action. I applaud the focus on numeracy with medical and veterinary students*." In addition, from a different report, "*I would particularly highlight the following as outstanding aspects of the MODA course at Cambridge. The numeracy and data interpretation content of the course and exam (practical paper)*"

Why are parts of the course split?
Many principals of mechanisms of drug action are common to a variety of species and there are certain related conditions that occur in both humans and non- human animals, and hence may lectures are combined. However, the Medic Only / Vet Only lectures, alongside the Clinical Case Studies, provide an opportunity for lecturers to focus on subject matter more specific to Medicine / Veterinary Medicine.

Why should I bother giving feedback?
We highly value your feedback and, as you can see from the description of Course Feedback, many elements of how the course is run and examined have changed following student feedback. Therefore, please make every effort to provide feedback (both good and bad) via the online surveys that we send out and to your course representatives (names provided on the main MoDA Moodle page) or the course organiser.

Course outline

The course consists of 3 lectures and 1 seminar or practical component in most weeks. The majority of Lectures are combined for Medicine and Veterinary Medicine students, and are delivered in the large Chemistry Main Lecture Theatre (entrance opposite the Scott Polar Research Institute), but in Michaelmas Term some lectures are in the Babbage Lecture Theatre (on the New Museums Site). Lectures for the Veterinary Medicine students only will be delivered mainly in the Biffen Lecture Theatre (Department of Genetics). Practical classes take place in the Department of Pharmacology Teaching Laboratories, Level 1. From 2018/19 we have introduced three Clinical Cases Studies, one each for medics and vets per term, to further develop clinical aspects of the material covered in the main lecture series. Clinical Case Studies will not be examinable by single best answer questions, but information from these case studies will be useful for writing high quality essays in Paper 3."

MoDA Lecture List 2022-23

Lectures will also be recorded*. The department will try to make them available on Moodle as soon as possible after the live lecture but be aware that there may be some delay.
*Note: although rare, there is occasional risk that a technical fault causes a lecture to not be recorded and so it cannot be uploaded.

Michaelmas Term

Date	Time	Topic	Lecture theatre	Lecturer
Tuesday 11th Oct	12.00	Drug interactions with receptors and ion channels	Chemistry	Prof G. R. Ladds
Wednesday 12th Oct	9.00		Babbage	
Thursday 13th Oct	12.00		Chemistry	
Monday 17th Oct	14.00	Ligand binding SEMINAR (Groups B, E, G, H)	Cockcroft	Prof G. R. Ladds

Tuesday 18th Oct	12.00		Chemistry	
Wednesday 19th Oct	9.00		Babbage	
Thursday 20th Oct	12.00	Pharmacology of Peripheral neural transmission	Chemistry	Dr T. Rahman
Friday 21st Oct	14.00	Ligand binding SEMINAR (Groups A, C, D, F)	Babbage	Prof G. R. Ladds
Tuesday 25th Oct	12.00		Chemistry	
Wednesday 26th Oct	9.00		Babbage	
Thursday 27th Oct	12.00		Chemistry	
Tuesday 1st Nov	12.00		Chemistry	
Thursday 3rd Nov	12.00	Cardiovascular and renal pharmacology	Chemistry	Prof R. Henderson
Tuesday 8th Nov	12.00		Chemistry	
Thursday 10th Nov	12.00		Chemistry	
Tuesday 15th Nov	12.00		Chemistry	
Wednesday 16th Nov	9.00		Babbage	
Thursday 17th Nov	12.00		Chemistry	
MEDICS Tuesday 22nd Nov	12.00	Human Aspects of Cardiovascular and Renal Pharmacology	Chemistry	Prof R. Henderson
Thursday 24th Nov	12.00		Chemistry	
Tuesday 29th Nov	12.00		Chemistry	
MEDICS Wednesday 30th Nov	9.00	Medic Clinical Case Study	Babbage	Prof I. Wilkinson
MEDICS Thursday 1st Dec	12.00	Human Aspects of Cardiovascular and Renal Pharmacology	Chemistry	Prof R. Henderson
VETS Tuesday 22nd Nov	12.00	Anthelmintics	Biffen	Prof J. S. Gibson
VETS Thursday 24th Nov	12.00	Vet Clinical Case Study	Biffen	Dr B. Skelly
VETS Thursday 24th Nov	13.30	Anthelmintics	Biffen	Prof J. S. Gibson
VETS Wednesday 30th Nov	14.00	Ectoparasite drugs	Biffen	Prof A. Williams
VACATION				

Lent Term

Date	Time	Topic	Lecture theatre	Lecturer
Thursday 19th Jan	12.00	Pharmacokinetics, drug metabolism and general anesthetics	Chemistry	Dr M. T. Harper
Tuesday 24th Jan	12.00		Chemistry	
Thursday 26th Jan	12.00		Virtual	
Tuesday 31st Jan	12.00		Virtual	
Thursday 2nd Feb	12.00		Chemistry	
VETS Friday 3rd Feb	10.00-12.00	Vet clinical case study	Anatomy	Prof A. Williams

Tuesday 7th Feb	12.00	Chemotherapy	Chemistry	Prof H. W. Van Veen
MEDICS Tuesday 7th Feb	15.00	Medic clinical case study	Babbage	Dr E. Hodson
Thursday 9th Feb	12.00	Chemotherapy	Chemistry	Prof H. W. Van Veen
Tuesday 14th Feb	12.00		Chemistry	
Thursday 16th Feb	12.00		Chemistry	
Friday 17th Feb	12.00		Chemistry	
Tuesday 21st Feb	12.00		Chemistry	
Thursday 23rd Feb	12.00	Pharmacology of inflammation and immunosuppression	Chemistry	Prof E. Smith
Tuesday 28th Feb	12.00		Chemistry	
Thursday 2nd Mar	12.00		Chemistry	
Monday 6th Mar	15.00		Chemistry	
Tuesday 7th Mar	12.00		Chemistry	
Thursday 9th Mar	12.00		Chemistry	
VACATION				

Easter Term

Date	Time	Topic	Lecture theatre	Lecturer
MEDICS Monday 1st May	12.00	Neuropharmacology	Chemistry	Dr D. C. Bulmer
MEDICS Tuesday 2nd May	12.00		Chemistry	
MEDICS Wednesday 3rd May	12.00		Chemistry	
MEDICS Thursday 4th May	16.00		Chemistry	
MEDICS Friday 5th May	9.00	Medic Clinical Case Study	Babbage	Dr M. Huang
MEDICS Friday 5th May	12.00	Neuropharmacology	Chemistry	
VETS Monday 1st May	10.00	Aspects of Veterinary Pharmacology	Biffen	Prof A. Williams
VETS Tuesday 2nd May	10.00	Aspects of Veterinary Pharmacology	Biffen	Prof A. Williams
VETS Wednesday 3rd May	10.00	Veterinary Neuropharmacology	Biffen	Dr C. Adami
VETS Friday 5th May	9.00	Veterinary Neuropharmacology	Biffen	Dr C. Adami
VETS Friday 5th May	10.00	Vet clinical case study	Biffen	Prof A. Williams

It should be noted that the lecture timetable is printed ahead of the actual course. You are strongly advised to consult the **Moodle website** https://www.vle.cam.ac.uk for up- to-date timetable information, as well as the central timetable: https://www.biology.cam.ac.uk/undergrads/MedST/Current/Timetables

Moodle announcements will be sent out by email to alert students of any essential MedST/VetST IB MODA

course information (e.g., timetable changes etc.). Teaching materials associated with the course will be placed in the Resources section on Moodle at the relevant time, but there may not be email notification.

Lecture Capture

Recordings of lectures will be uploaded onto the Mechanisms of Drug Action website within a reasonable time if the lecturer, usually within 48 hours, has consented to the recording. Please note The General Board's Education Committee (GBEC) Expectation to record lectures statement and Expectation to record lectures 22 - 23 policy.

SYNOPSIS OF LECTURES

The following paragraphs outline the individual lecture courses. It should be noted that revision of certain courses, arising from developments in the field, may result in changes to some of the details.

Drug-Receptor Interactions – Prof G Ladds

- What is a drug? Action via specific receptors. Relation between binding and response. Forces involved in drug-receptor interaction. Affinity. Efficacy. Agonists. Antagonists. Structure-activity relations (receptor identification). Competitive antagonism. Quantitative methods for assessing antagonist binding from dose-ratios required to produce a given level of effect.
- Radioligand binding. Specific and non-specific binding. Displacement.
- Reversible *versus* irreversible antagonists. Spare receptors, partial agonists. Cooperativity (Hill plot). Functional or "physiological" antagonism.
- Ligand gated ion channels. Families of channels gated by acetylcholine, γ-amino butyric acid (GABA), glycine or 5-HT.
- G-protein coupled receptors. Basic structure. Pertussis toxin, cholera toxin. Activation and inhibition of adenylyl cyclase. Modulation of ion channels. Activation of phospholipase C. Diacylglycerol, IP_3, protein kinase C.
- Receptor desensitization and down-regulation.
- Ligand-regulated transmembrane kinases. Insulin, epidermal growth factor, platelet derived growth factor.
- Intracellular receptors that modulate gene expression. Glucocorticoids, mineralocorticoids, oestrogens, progestogens.
- Family of voltage-gated ion channels: sodium, calcium and potassium.
- Introduction to the concept of agonist bias.

Peripheral Nervous System – Dr T Rahman

- Somatic efferent, enteric, and autonomic nervous systems. Parasympathetic and sympathetic. Ganglionic transmission, blockers.
- Transmitter processing at a cholinergic synapse. Sites for drug action. Classification of muscarinic receptors, agonists, antagonists, effectors.
- Adrenergic transmission. Pre- and post-junctional sites for drug action. Uptake. Metabolism and inhibitors. False transmitters. Neurone blocking drugs (including guanethidine). Sympathomimetic amines. Adrenergic receptor classification.
- Receptor regulation. Uncoupling, sequestration, degradation. Homologous and heterologous desensitisation
- Non-adrenergic, non-cholinergic (NANC) transmission. Purinergic transmission.
- Endothelium-derived relaxing factor. Nitric oxide as a neurotransmitter.

Cardiovascular and renal pharmacology – Prof R Henderson

- Function of ion channels in the cardiovascular system
- The cardiac action potential, including electrophysiology of pacemaker, Purkinje, atrial and ventricular cells

- Autonomic control of the heart
- Modes of actions of some antidysrhythmic drugs
- Drugs used for fibrinolysis and to inhibit clot formation
- Modes of action of drugs used to control blood pressure and to treat congestive heart failure and the mechanisms of action of drugs used for its treatment
- Autoregulation in the kidney
- The renin-angiotensin-aldosterone system
- Uses and mechanisms of action of loop, thiazide and potassium-sparing diuretics and carbonic anhydrase inhibitors (as diuretics)

Human Aspects of Cardiovascular and Renal Pharmacology (for Medicine students only) – Prof R Henderson

- Hypertension and antihypertensive drugs
- Angina and the mechanisms of action of drugs used for its treatment
- Drugs used to reduce blood lipid levels
- Aetiology of dysrhythmias, especially associated with myocardial infarction, and modes of actions of appropriate antidysrhythmic drugs

Anthelminthics (for Veterinary students only) – Prof J Gibson

- Helminth biology and general features of anthelmintics
- Energy metabolism (cellular integrity) as a target for anthelmintics, e.g. benzimidazoles, salicylanilides and praziquantel and cysteine proteases
- Neuromuscular co-ordination as a target for anthelmintics, e.g. praziquantel, anticholinesterases, imidazothiazoles, tetrahydropyrimidines, piperazine, avermectins, and cyclooctadepsipeptides and aminoacetonitrile derivatives

Ectoparasite Drugs (for Veterinary students only) – Prof A Williams

- Ectoparasite diversity (insects: fleas, lice; arachnids: mites, ticks) and biology
- General features of insecticides and acaracides including safety and environmental considerations
- Insect/arachnid nervous system as a target for ectoparasiticides, e.g. pyrethroids, carbamates, neonicotinoids, phenylpyrazoles
- Properties and role of Insect Growth Regulators

Pharmacokinetics, drug metabolism and general anaesthetics – Dr M Harper

- Processes involved in the absorption, distribution, metabolism and excretion of drugs from the body.
- The advantages and disadvantages of different routes of administration and the effects of changes in the rate of absorption on the time course of drug action.
- Factors affecting drug absorption and passage of drugs across cell membranes and capillaries.
- Binding of drugs to plasma proteins and effects on rates of distribution and elimination.
- Mechanisms involved in metabolism of drugs: phase I oxidation and phase II conjugation.
- Drug-drug interactions that affect drug metabolism; cytochrome P-450 and its inhibition and induction.
- Renal and biliary excretion of drugs.
- Zero (saturating) and first-order rates of elimination.
- Single and multi-compartment models.
- Calculating pharmacokinetic parameters from experimental data: half-life, clearance, volume of distribution and bioavailability.
- Achieving sustained therapy through multiple doses and constant infusion.
- Predicting the time course of drug action in response to single doses, multiple doses and constant infusions.

- Mechanisms of action of general anaesthetics.
- Factors affecting induction, recovery and potency of intravenous anaesthetics and gaseous and volatile anaesthetics.

Chemotherapy – Prof H van Veen

- Principles of chemotherapy. Antibiotics: initial concepts
- Modes of action of antibiotics. Antibiotics that act on cell wall biosynthesis, protein biosynthesis, DNA replication & repair & expression. Antibiotics that act as antimetabolites. Membrane as a target of antibiotics.
- Antiprotozoal drugs. Drugs affecting cellular integrity and biosynthesis of essential cofactors and macromolecules.
- Antiviral drugs. Anti-influenza, anti-herpes virus, anti-HIV agents
- Anticancer drugs. Cellular targets of anticancer drugs. Inhibitors of DNA replication and gene expression. Anticancer agents that bind noncovalently to DNA. Antimetabolites. Inhibitors of chromatin function. Hormone therapy.
- Mechanisms of drug resistance. Intrinsic and acquired drug resistance. Biochemical mechanisms of bacterial drug resistance. Multiple drug resistance versus multidrug resistance. Resistance mechanisms to antifungal, antiviral, antiprotozoal and anticancer drugs.
- Strategies in development and use of drugs. Identification of new drug targets. Specific inhibitors of drug resistance mechanisms. Development of new classes of antibiotics. New inhibitors against drug resistance in anticancer treatment. Combination therapy. Extending antibiotic lifespan.

Inflammation – Prof E Smith

- The inflammatory response
- Histamine and anti-histamines
- Peptide and lipid mediators of inflammation
- 5-Hydroxytryptamine and migraine
- Corticosteroids and non-steroidal anti-inflammatory agents
- Asthma and chronic obstructive pulmonary disorder
- Autoimmune conditions
- Immunosuppression and biologics

Neuropharmacology (for Medicine students only) – Dr Bulmer

- The major neurotransmitter systems in the CNS, including glutamate, GABA, dopamine, 5-HT, noradrenaline and acetylcholine.
- The roles of specific neurotransmitters in disease conditions, particularly anxiety, epilepsy, depression, Parkinson's disease, schizophrenia and sleep disorders; current theories of the mechanisms of action of drugs used to treat these conditions.
- Mechanism of action of new drugs that may become available in the near future for the treatment of less well understood disorders such as cerebral ischaemia (stroke) and Alzheimer's disease.

Aspects of Veterinary Pharmacology (for Veterinary students only) – Prof A Williams

- *Lecture 1: Pharmacology of Common Poisonings in Companion Animal Practice.* This lecture covers common poisonings in dogs and cats, including the mechanisms of action of some of the most commonly-reported poisoning cases in dogs (and cats) in UK.
- *Lecture 2: Haemostasis & Thrombosis.* This lecture examines the mechanisms of action of drugs on haemostasis and thrombosis, which may include drugs like NSAIDs, rodenticide anti-coagulants, chocolate, and paracetamol.

Veterinary neuropharmacology (for Veterinary students only) – Dr C Adami

- Lecture 1. Mechanisms of sedation and anaesthesia in animals

- How neurological pathways and neurotransmission are affected by sedative and anaesthetic drugs. This will include the neurotransmitters GABA, noradrenaline, serotonin, histamine, glutamate and glycine
- Lecture 2a. Pharmacological basis of treatment of behavioural disturbances in companion animals.
- Causes of behavioural disturbances (relating back to NAB lectures on behaviour) and groups of drugs used to break behaviour patterns in conjunction with behaviour modification training will be considered. In particular the mechanisms of action of pheromones, anxiolytics, tranquillizers and antidepressants will be examined.
- Lecture 2b. Basis of epilepsy and its treatment.
- Description of forms of epilepsy, causes and mechanisms of action of drugs used in the treatment of this group of conditions will be considered e.g. $GABA_A$ receptor modulators, voltage-gated sodium channel blockers, voltage-gated calcium channel blockers and NMDA receptor blockers.

Clinical case studies (sometimes referred to as linkers)

As the name suggests these are provided to give some extra clinical context and relevance to the lecture material by looking at relevant human or animal case studies.

Lecture Handouts

Since 2019 the Department of Pharmacology has gone paperless and lecture handouts are only available online on the **Moodle website**

https://www.vle.cam.ac.uk.

However, where a student has a Student Support Document that outlines the need for hardcopies of handouts, please contact the Chief Teaching Technician Sergio Tomey (st474@cam.ac.uk). We ask these students for their understanding that due to current working conditions (i.e. many staff working remotely) it might take longer than usual to get hardcopies out to you (by University Mail Service to your college). Should you have a specific learning difficulty and require printed handouts please seek assistance from your college (e.g. personal tutor, DoS).

Practicals

Practicals are held on Mondays or Fridays from 2 to 5 pm. The practical classes are an **integral component** of the course and attendance is a requirement for professional qualification. An attendance and engagement register is kept. You are reminded that you should not schedule anything else to clash with these practical classes and take into consideration travelling time when organising evening supervisions.

How to get the best out of the practical course.

The practicals in this course have been developed with two objectives in mind; they are intended to teach basic pharmacology in a more interactive manner than that in lectures, and they provide an introduction to the experimental basis of the subject as relevant to medical and veterinary practice. How much you get out of the practical course will depend primarily on the amount of effort you are prepared to put into it. Introductory material and a preparatory quiz will be made available on Moodle a week in advance of each practical. You should ensure that you engage with this material in advance of coming to the practical.

Members of the academic staff supervise the practical class and are aided by demonstrators and technical assistants. Whilst in the teaching classroom, take advantage of the presence of the demonstrators to make sure that you fully understand the principles that are being illustrated. If subsequently you discover a point that you find obscure, ask. At the end of each practical session, you will be asked to discuss your results with a demonstrator before being successfully registered as having completed the class. When all groups have finished the practical class, debrief material and a consolidatory quiz will become available on Moodle.

In many college supervisions the practical work forms the basis for points of discussion. Please use the

practicals and college supervisions associated with the material within the practicals, for your benefit.

In the Michaelmas and Lent term, a ligand binding seminar (see lecture timetable not practical timetable) and pharmacokinetics seminar (integrated within the online only pharmacokinetics lecture series) are provided, dedicated to review and practice the types of questions that will be included in the Written Practical Paper: (i) quantitative receptor pharmacology (ligand binding) and (ii) pharmacokinetics. Students are advised to gain further experience by self-practice and/or in college supervisions. For this purpose, previous exam questions are available on the **Moodle website** https://www.vle.cam.ac.uk on the MoDA page under the Exam Information & Resources tab. Please note, before 2018/19, there was the possibility of quantitative receptor pharmacology, pharmacokinetics or trace analysis questions (students were examined on 2 out of these 3 options), but **trace analysis questions will no longer be used**. Instead, interpretation of experimental data will become part of the quantitative receptor pharmacology and pharmacokinetics questions.

Examinations

The entire course is examinable and will be examined online using Inspera platform. The format of the MODA examination is governed by an official Form and Conduct Notice issued by the Faculty of Biology http://www.biology.cam.ac.uk/exams.

Section I (MoDA I) is a multiple choice-style paper that lasts 90 minutes. Each question is compulsory, although some questions may have medic-specific and vet-specific versions. Section I covers the whole course in a Single Best Answer (SBA) format. Each question in Section I carries the same mark (with no negative marking).

Section II (MoDA 2) is a two-hour data handling examination. It consists of two questions and assesses ability in data handling, numerical manipulation, and logical reasoning. Questions may be drawn from any part of the course and will include questions on quantification of receptor-ligand interactions and pharmacokinetics. Each question carries the same mark. As mentioned previously, prior to 2018/19 there was the possibility of quantitative receptor pharmacology, pharmacokinetics or trace analysis questions (students were examined on 2 out of these 3 options), but trace analysis questions will no longer be used.

Section III (MoDA 3) is a two-hour essay paper. There is a separate medic-specific and vet-specific version of this paper. Candidates are provided with a choice of 8 essay questions and are required to answer three. Each question in Section III carries the same mark.

Note that Clinical Case Studies (sometimes referred to as "linkers") are not directly examinable. However, they do contain knowledge that can be used, where relevant, to supplement answers in the MODA2 and/or MODA3 papers.

It is the responsibility of candidates to assure themselves that they are aware of any changes to the Form and Conduct Notice and the version current at any time can be accessed via the URL of the Faculty:
https://www.biology.cam.ac.uk/exams/MedVetSTexams/form-conduct

The 2nd MB qualification will be determined by performance in Sections I (75%) and II (25%) only. For Tripos, sections are weighted as follows: Section I (30%), Section 2 (20%) and Section III (50%).

Calculators need to be brought to all sections of the exam, including Section I. Rulers (30 cm) are strongly advised to be brought to the Section II exam.

It is a very good idea to gain experience at answering exam questions by working through past papers. Copies of the past papers should be available in College libraries, as should papers for Pharmacology in Part IB of the Medical Sciences Tripos in earlier years which will provide further material for practice relevant to Sections II and III. Past papers are also available on:
Moodle website https://www.vle.cam.ac.uk

For your convenience past Section I, II and III papers are available on the Moodle website.

Marking and classing criteria for the **Section III** (written essay) are described in a document prepared by the Faculty Board, available at https://www.biology.cam.ac.uk/exams/MedVetSTexams

Plagiarism and Academic Misconduct: Student responsibilities

Plagiarism is "using someone else's ideas, words, data, or other material produced by them without acknowledgement". Should the exams be online and open book you must not copy chunks of text from source material unless it is fully acknowledged. The university possesses powerful software to detect plagiarism. It is the student's responsibility to be aware of the university policy on plagiarism and academic misconduct. See: https://www.plagiarism.admin.cam.ac.uk/what-plagiarism/students- responsibilities

Examination Reviews

The University has robust policies in place to ensure that examination results are accurate. However, there may be circumstances where something unusual happens during the examination and you want it taken into account. The University has procedures in place to deal with this possibility.

Students are strongly urged to seek advice from their College Tutor (or relevant departmental staff). Students can also receive free independent advice regarding any University procedure from the Students' Unions' Advice Service
at www.studentadvice.cam.ac.uk.

You have all the information of the process at
http://www.studentcomplaints.admin.cam.ac.uk/examination-reviews

Examination skills and formative assessment

Your main source of advice and assessment of progress is of course your College supervisor. He/she normally sets written work for each supervision. This may consist of essays or data-handling problems, and is often based on past exam questions.

Information on examination skills, prepared by the Faculty of Biology, is available at:
https://www.biology.cam.ac.uk/exams/MedVetSTexams

Transferable skills

All undergraduates are expected by the University to graduate with a number of transferable skills. Many aspects of the Pharmacology course are relevant to general skill acquisition. These include:

Intellectual developed in practical classes, lectures and supervisions.
Communication written and oral skills are acquired in practical classes and essay work.
Organizational managing workload and revision.
Inter-personal group work is carried out in the practical classes and in supervisions.
Numeracy practical work and the practical examination.
Computer literacy computer-aided learning.
See also http://www.transkills.admin.cam.ac.uk/skills-portal

Supervisions

Supervision for Medicine and Veterinary Medicine students is normally in groups of two, three or four, but if Colleges wish to be innovative in the way they organise teaching, e.g. a mixture of smaller/larger group sizes, or having extra presentations, they are free to do so. Supervisions for courses not mentioned below do not require supervisions, but Colleges can run these on an ad hoc basis if necessary. Recommended adequate level of provision of supervision, by term (M/L/E) is as follows: 8/8/4. It must be emphasised that

these are guidelines. Workload hours are likely to vary across individuals according to private study preferences, and may be higher over the examination revision period.

Further learning resources

References

There are two textbooks recommended for most of the course: *Rang and Dale's Pharmacology 9th Edition*. Ed., Flower, Henderson, Loke, MacEwan and Rand (2019) Churchill Livingstone Elsevier.

Basic and Clinical Pharmacology 12th Ed. , B.C. Katzung, (2015) McGraw-Hill. Individual lecturers may give you supplementary reading lists and your College supervisors may also make recommendations.

Library and photocopying facilities

In your College library you should be able to find a copy of each recommended textbook. The University Library catalogue (accessible via the Web) is also available should you wish to find specific articles.

Extra-departmental resources

Language learning is offered to all undergraduates. For information see:
http://www.langcen.cam.ac.uk/lc/index.html

Managed desktop machines and MCS (Managed Cluster Service)

Most of the MCS rooms are available to all staff and students of the University; some rooms are local to particular Departments or Colleges, and most are available for general use only when not required for group teaching. Many other Colleges and some Departments also provide access to MCS rooms facilities from College or Departmental computer rooms. You cannot connect to the MCS from places other than the rooms listed (e.g. from dial-up services or other remote systems), except to transfer files to and from your MCS filespace.

Queries about the MODA Course

Queries with respect to the MODA Course can be directed to any teaching officer in the Department of Pharmacology. Alternatively, you may wish to contact the Course Organiser, Dr Paul Miller *via* e-mail: pm676@cam.ac.uk.

Help regarding supervisions

Any queries regarding supervisions in Pharmacology should be directed to your College Director of Studies in the first instance. He or she may consult the Departmental officer responsible for liaison between the Department and Colleges in cases of difficulty (Dr Paul Miller *via* e-mail: pm676@cam.ac.uk).

SECTION 2 – Practical Course Information

Introduction

The practicals and demonstrations in this course have been prepared with these objectives in mind.

1. They are intended to teach basic pharmacology in a less formal manner than required in lectures.
2. They provide an introduction to the experimental basis of the subject.
3. Animals used for educational purposes are not being used to discover, prove or develop new ideas or techniques, but rather to demonstrate principles and facts that are already well-known. The Department of Pharmacology supports The 3Rs tenet (Replacement, Reduction and Refinement) that guides scientists on the ethical use of animals in science.
    - **Replacement** refers to methods which avoid or replace the use of animals in an area where animals would otherwise have been used
    - **Reduction** refers to any strategy that will result in fewer animals being used

- **Refinement** refers to the modification of husbandry or experimental procedures to minimize pain and distress

4. The 3Rs concept originated from the scientific community and is a widely accepted cornerstone of policies on animal-based science around the world. When no replacement teaching alternative is available, justification is required to use animals. The level and type of training of the students are important factors.
5. All experiments conducted on animals are done in accordance with the Animals (Scientific Procedures) Act 1986 Amendment Regulations 2012, which is overseen by the Home Office.

For more information on the use of animals in scientific research, students are recommended to visit http://www.understandinganimalresearch.org.uk/.

How much you get out of the practical course will depend primarily on the amount of effort you are prepared to put into it. Your time and effort will be much better spent if you read through the description of the experiment or demonstration before arriving at a class. For in attendance laboratory practicals, take advantage of the presence of the demonstrators (identified by their blue lab coats) to make sure that you fully understand the principles that are being illustrated. If subsequently you discover a point you find obscure, ask.

Introductory material and a preparatory quiz will be made available on Moodle a week in advance of each practical. You should ensure that you engage with this material in advance of coming to the practical. When all groups have finished the practical class, debrief material and a consolidatory quiz will become available on Moodle.

In person practicals

All practicals this year will be delivered in person in the teaching classroom. For Michaelmas term there will be three practicals; Dose Ratios (formerly known as Affinity Constant), Transmurally stimulated ileum and the Langendorff/SimHeart practical. The second part of this Langendorff/SimHeart practical requires the use of the simulator SimHeart. You will need to install the simulator software on your computer **before** initiating the online practical.

For both Windows and Mac instructions on how to do this see **APPENDIX C**.

We **strongly recommend** to install SimHeart a few days in advance to make sure it works properly on your computer before the practical. Should you have any issue, please contact Sergio Tomey (st474@cam.ac.uk).

In Lent term there will be one practical (Extended Investigation of Unknown Drugs).

Practical allocation

You will be assigned to a group automatically at the beginning of the course. Groups are named A, C, E and G (for Friday) and B, D, F and H (for Monday). The lists with your name and group will be available in Moodle and will remain fixed for all practicals (in person and online) – so please remember your group! **The practical timetable** (further below) **indicates the day and practical your group must attend**. A reminder will be made in Moodle before the start of each practical.

Lt

Most of the practical sessions are carried out in Lt, the web-based application we use in the teaching laboratory and for the online practicals.

Before the day of your first allocated practical, you will receive an invitation to access Lt. You will need to **create a password** using your university email. This password will be needed to access future practicals in the lab and also online (Langendorff) so, please, make sure you remember your Lt details.

See Appendix B for more information about Lt and on how to login to Lt individually (online practical) and as a group (in the lab).

Should you have any issue accessing Lt Online on the day of the practical, please, contact Sergio Tomey (st474@cam.ac.uk).

MoDA practicals timetable 2022-2023

Pharm = Pharmacology teaching lab (ground floor, Department of Pharmacology)

Dates	Location	Sets	Group	Title
7th Oct	Pharm	D8,T1,T2	A	Dose ratios
10th Oct	Pharm	D7,D15,D16	B	Dose ratios
14th Oct	Pharm	D10,T3,T4	C	Dose ratios
17th Oct	Pharm	D1,D2,D9	D	Dose ratios
21st Oct	Pharm	D3,D4,D11A	E	Dose ratios
24th Oct	Pharm	D5,D6,D11B	F	Dose ratios
28th Oct	Pharm	D13,D14,D12A	G	Dose ratios
31st Oct	Pharm	D17,D18,D12B	H	Dose ratios
4th Nov	Pharm	D8,T1,T2	A	Transmurally stimulated ileum
	Pharm	D10,T3,T4	C	SimHeart virtual lab. Langendorff isolated perfused heart demonstration
		D3,D4,D11A	E	NO PRACTICAL THIS WEEK
		D13,D14,D12A	G	NO PRACTICAL THIS WEEK
7th Nov	Pharm	D7,D15,D16	B	Transmurally stimulated ileum
	Pharm	D1,D2,D9	D	SimHeart virtual lab. Langendorff isolated perfused heart demonstration
		D5,D6,D11B	F	NO PRACTICAL THIS WEEK
		D17,D18,D12B	H	NO PRACTICAL THIS WEEK
11th Nov	Pharm	D3,D4,D11A	E	Transmurally stimulated ileum
	Pharm	D13,D14,D12A	G	SimHeart virtual lab. Langendorff isolated perfused heart demonstration
		D8,T1,T2	A	NO PRACTICAL THIS WEEK
		D10,T3,T4	C	NO PRACTICAL THIS WEEK
14th Nov	Pharm	D5,D6,D11B	F	Transmurally stimulated ileum
	Online	D17,D18,D12B	H	SimHeart virtual lab. Langendorff isolated perfused heart demonstration
		D7,D15,D16	B	NO PRACTICAL THIS WEEK
		D1,D2,D9	D	NO PRACTICAL THIS WEEK
18th Nov	Pharm	D10,T3,T4	C	Transmurally stimulated ileum
	Online	D8,T1,T2	A	SimHeart virtual lab. Langendorff isolated perfused heart demonstration
		D3,D4,D11A	E	NO PRACTICAL THIS WEEK
		D13,D14,D12A	G	NO PRACTICAL THIS WEEK
21st Nov	Pharm	D1,D2,D9	D	Transmurally stimulated ileum
	Pharm	D7,D15,D16	B	SimHeart virtual lab. Langendorff isolated perfused heart demonstration
		D5,D6,D11B	F	NO PRACTICAL THIS WEEK
		D17,D18,D12B	H	NO PRACTICAL THIS WEEK
25th Nov	Pharm	D13,D14,D12A	G	Transmurally stimulated ileum
	Pharm	D3,D4,D11A	E	SimHeart virtual lab. Langendorff isolated perfused heart demonstration
		D8,T1,T2	A	NO PRACTICAL THIS WEEK

		D10,T3,T4	C	NO PRACTICAL THIS WEEK
28th Nov	Pharm	D17,D18,D12B	H	Transmurally stimulated ileum
	Pharm	D5,D6,D11B	F	SimHeart virtual lab. Langendorff isolated perfused heart demonstration
		D7,D15,D16	B	NO PRACTICAL THIS WEEK
		D1,D2,D9	D	NO PRACTICAL THIS WEEK
3rd Feb	Pharm	D8,T1,T2	A	Extended Investigation of Unknown Drugs
6th Feb	Pharm	D7,D15,D16	B	Extended Investigation of Unknown Drugs
10th Feb	Pharm	D10,T3,T4	C	Extended Investigation of Unknown Drugs
13th Feb	Pharm	D1,D2,D9	D	Extended Investigation of Unknown Drugs
17th Feb	Pharm	D3,D4,D11A	E	Extended Investigation of Unknown Drugs
20th Feb	Pharm	D5,D6,D11B	F	Extended Investigation of Unknown Drugs
24th Feb	Pharm	D13,D14,D12A	G	Extended Investigation of Unknown Drugs
27th Feb	Pharm	D17,D18,D12B	H	Extended Investigation of Unknown Drugs

Attendance

To qualify for your professional exams you are **required** to attend practicals. The Department is obliged to sign an undertaking to the appropriate professional bodies certifying each individual student's attendance and the courses are designed in consultation with these bodies.

A register is therefore kept and a demonstrator or member of staff will sign you in; demonstrators and staff can be identified by their blue lab coats. Do not leave a practical class without making sure you are on the register. If you attend, but do not participate in the practical class it is at the discretion of the member of staff taking the register not to sign you in. ANY absence from classes is treated seriously. If you cannot attend, please arrange for either a medical certificate or a letter from your Director of Studies to be sent to the Department. Details of how to organise practical swaps for reasons of necessity (i.e. attending medical appointments etc) will be posted on the Moodle site at the beginning of term.

General points on procedures in the laboratory

1. An introductory talk will be given in the laboratory at the commencement of each class. Please arrive on time.

2. You should not schedule any other commitments prior to about 5.15pm.

3. The sensitivity of tissues to agonists can vary widely from preparation to preparation. Ten-fold variations are common. Where particular doses are quoted they should be regarded as a guide to the likely dose range required rather than as a certain prediction.

4. You are required to comply with all rules and procedures which are laid down to ensure safety in the laboratory. These include the requirement that you wear shoes adequate to protect your feet against broken glass. **You should wear a lab coat** in all the practicals to protect your clothes against spillage. Any special safety equipment supplied to you should be used (e.g. gloves, aprons, safety glasses, etc.).

Please visit the Stay Safe Cambridge University page for more information:
https://www.cam.ac.uk/coronavirus/stay-safe-cambridge-uni/report-symptoms-and- get-a-test)
If you have any questions or concerns do not hesitate to speak to a demonstrator.

If you have queries or comments about this practical course, please contact the Course Organiser, Dr Paul Miller *via* e-mail pm676@cam.ac.uk

Appendices

These appendices should help you to use the equipment you are supplied with, as always, if in doubt see a demonstrator.

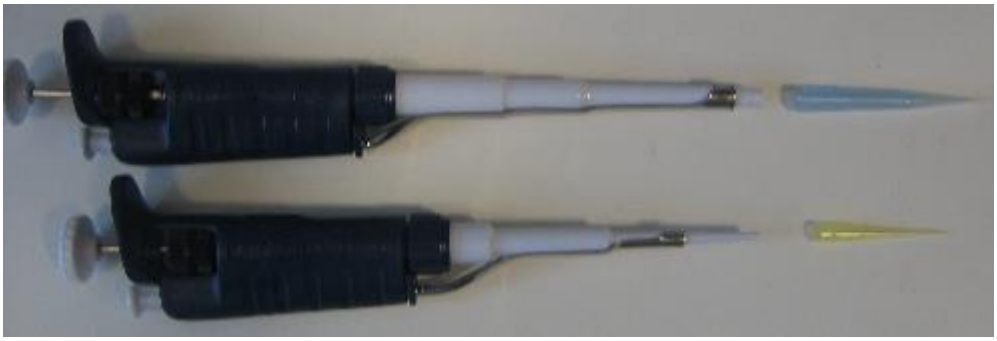
Contents:

Appendix A (non-COVID)

Instructions on the use of the Gilson Pipette

Gilson Pipettes are an accurate way of measuring small volumes and are simple to use after a little practise.

They should always be used with the appropriate tip (see below) and are colour- coded to make this easy. Those with a blue circle on the top (1000 µl) use blue tips, those with a yellow circle on the top of the plunger (20 and 200 µl) use yellow tips.



Before fitting the tip adjust the reading on the side to reflect the amount you want to pipette by twisting the black nut or white head in the appropriate direction. The numbers are read from the top towards the tip and reflect different values depending on the size of pipette being used.

A 20 µl pipette will have two numbers in black corresponding to tens and units and a third in red for decimal points (e.g. 1-0-0 = 10.0 µl).

A 200 µl pipette will have three numbers in black corresponding to hundreds, tens and units (e.g. 1-0-0 = 100 µl)

A 1000 µl pipette will have 1 number in red corresponding to thousands and two numbers in black corresponding to hundreds and tens (e.g. 1-0-0 = 1000 µl)

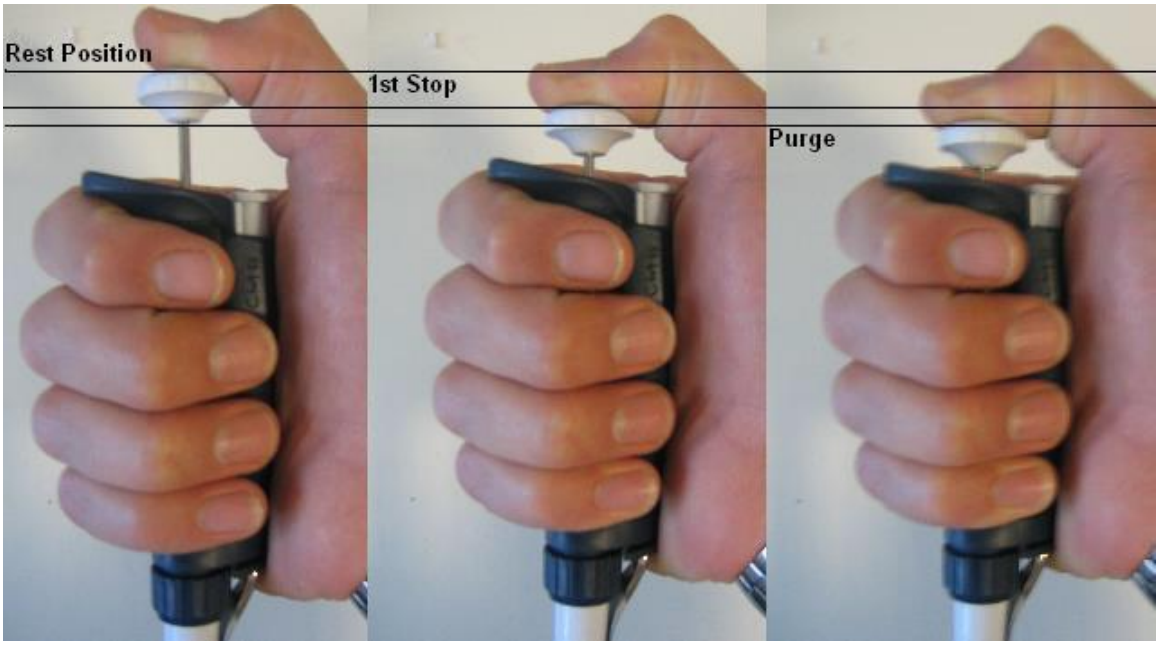
They should never be used above their maximum stated volumes and the most appropriate pipette for the volume required should be used to ensure accuracy.

After setting the volume and fitting the tip there are five easy steps to using them:

1. Preparation: Hold the instrument in a vertical position and depress the plunger smoothly to the first stop (see below).
2. Aspiration: Immerse the pipette tip in the liquid and allow the plunger to slowly move back up to the rest position. Wait one second to make sure all the liquid has entered the tip.
3. Distribution: Place the pipette tip at an angle (10-45^{o}) against the inside wall of the receiving vessel.

Depress the plunger to the first stop position.

4. Wait one second then depress the plunger to the second stop. This “blow-out” stroke removes any remaining sample from the tip. Keeping plunger depressed remove the pipette by sliding the tip up the sidewall of the vessel.
5. Finally allow the plunger to return to the rest position and, using the second white button, expel the used tip into an appropriate receptacle.



Appendix B

Lt

You will use Lt when carrying practicals both remotely and in the lab.

Instructions on how to login to Lt in the teaching laboratory

You will be working in groups of two students in the lab. You should access the application as group by following these simple steps:

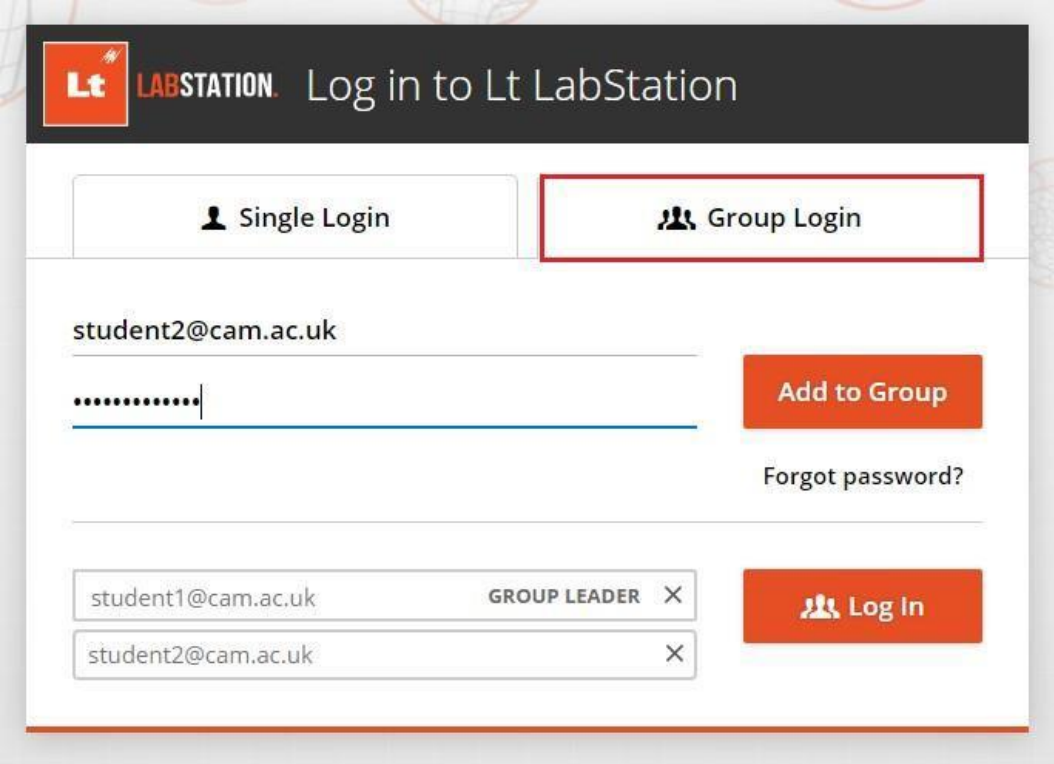
1. Click on the “Group Login” tag if hasn’t been done already. See screenshot below.

2. Enter your university email and password, which you would have previously created after receiving the Lt Invitation at the start of Michaelmas term.

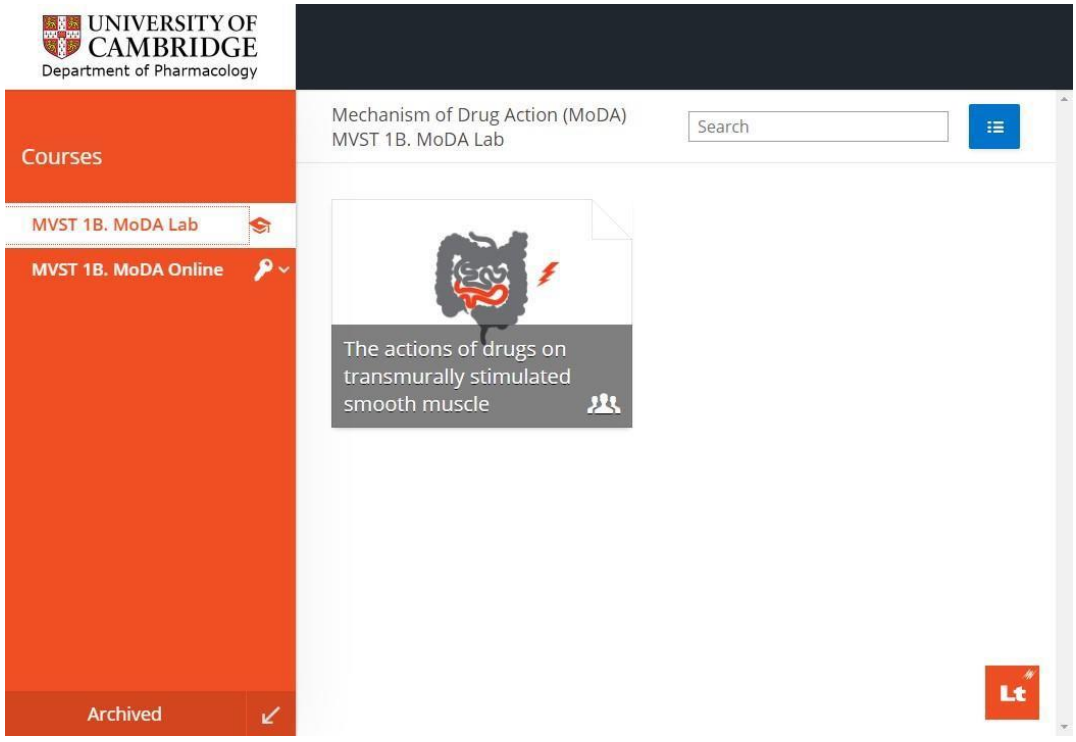
3. Click on the “Add to Group” button after entering your email and password.

The first student to login will appear as Group Leader.

4. Repeat the same steps described above for the second student. Then click on the “Log In” button once all members of the group have been added.



Select the MVST IB MoDA Lab course and click on the practical available. See screenshot below.



Instructions on how to login to Lt from home or college

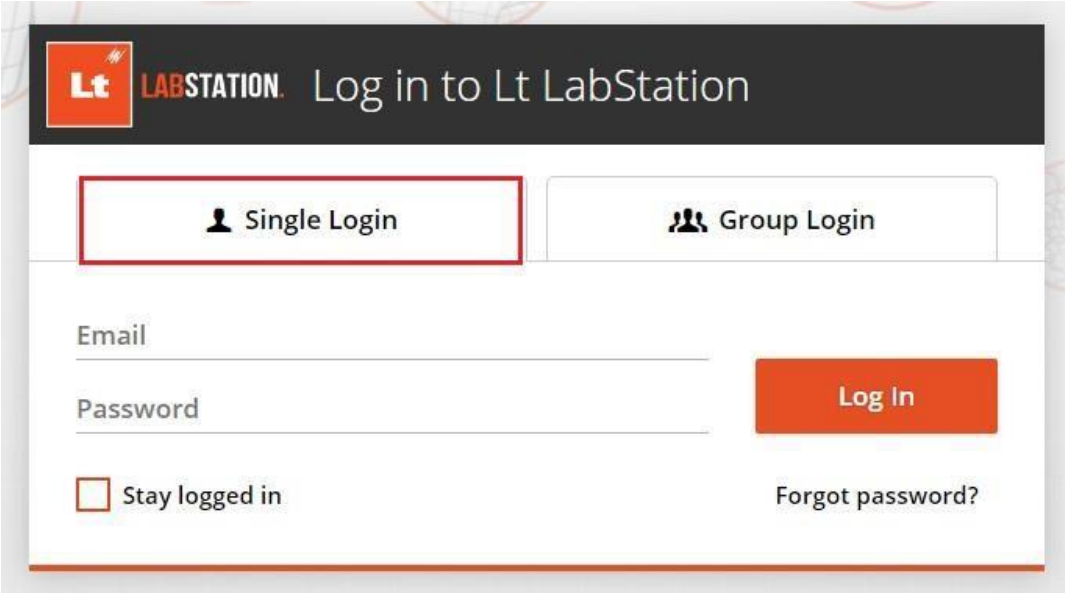
You will normally work individually if you need to attend a practical online. In this case, please follow these steps:

1. Click on the link you will be provided with.

2. Click on the “Single Login” tag. See screenshot below.

3. Enter your university email and password, which you would have previously created after receiving the Lt Invitation at the start of Michaelmas term.

4. Click on the “Log In” button.

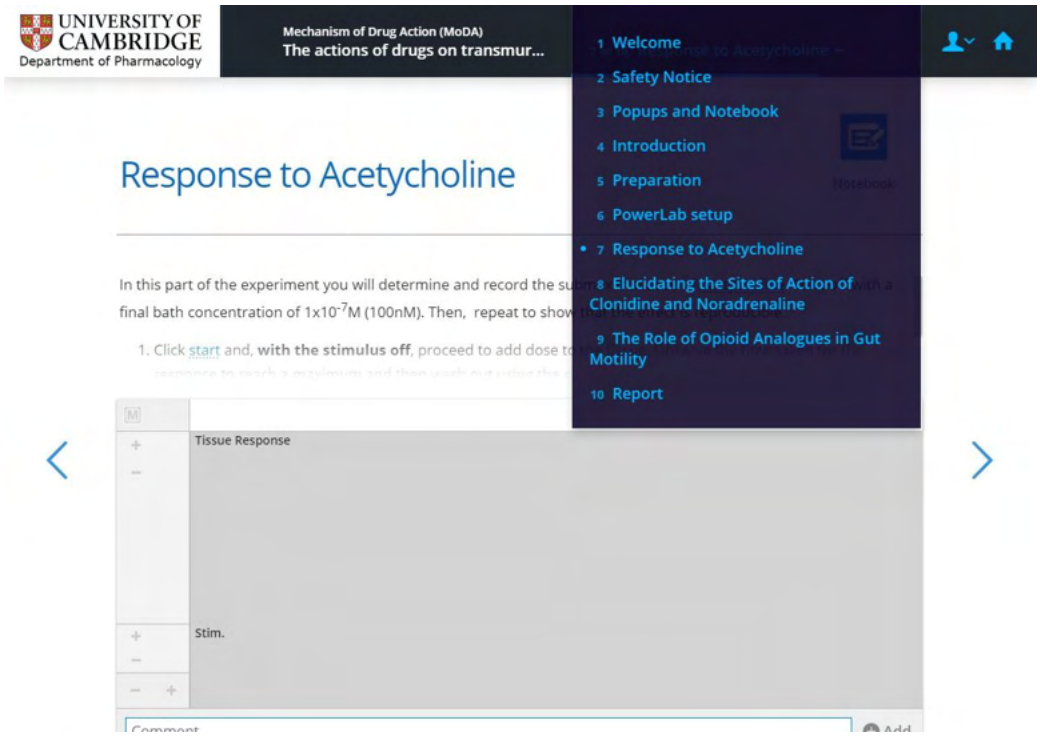


Instructions and introductory videos are provided with each practical to guide you through the virtual practical session.

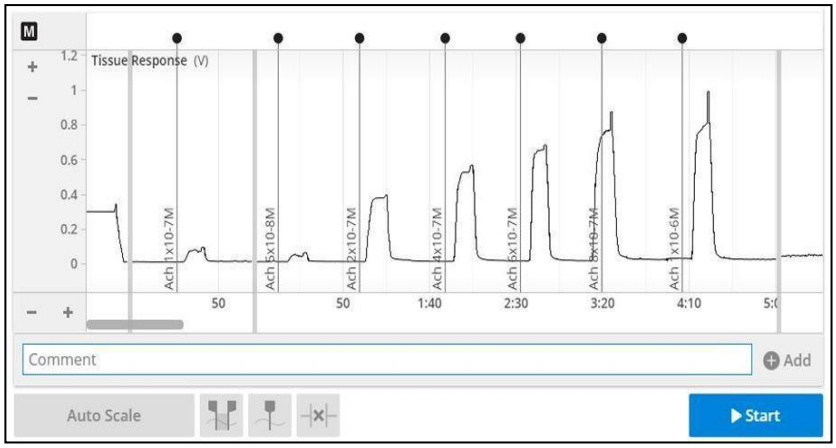
You will have the best experience when using Google Chrome, we recommend this browser wherever possible. If Google Chrome is not installed on your computer, you can download it from the official website:
https://www.google.co.uk/intl/en_uk/chrome/

Instructions on how to login to Lt in the teaching laboratory

Experiments are divided into separate pages which should be followed sequentially using the arrow symbols at both sides of the screen (see below, circled in red). To jump straight to a particular page, use the drop down menu (at the top of the page) and select the desired page from the list (see below).

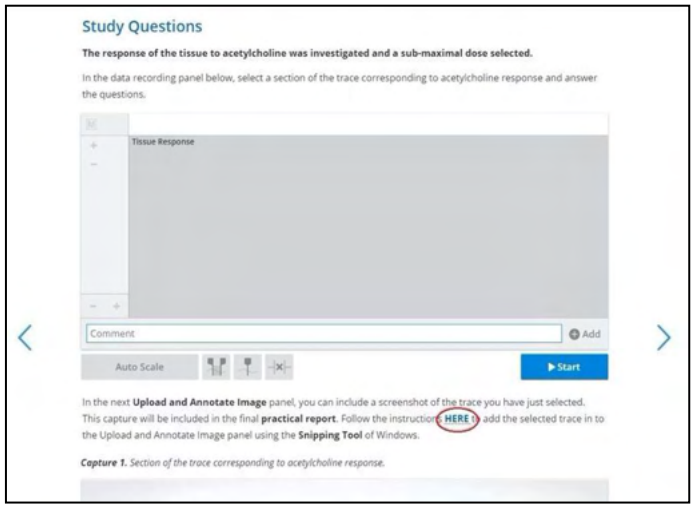


Full instructions are provided at each stage of the experiment to assist you in carrying out the required procedures. Some extra information or instruction can be accessed by clicking on words highlighted in blue, as for a normal hyperlink, which will bring up pop-up pages. Data are recorded and analysed using the data recording panel (see below).



Data can be collected (Start), analysed (Stop), and rescaled (Auto Scale), or scrolled through using the various buttons on the data recording panel (see above). Instructions and videos on how to do this are in the program itself. Moving the cursor across the trace displays values at the selected point. Use the comments box (see above) to record experimental notes on the trace; click in the box, enter text and press [ENTER] or click “Add” to insert the comment on the trace. Pausing the trace using the Stop button on the bottom right will allow comments to be selected and edited. Clicking on the trace, while paused, where a comment needs to be inserted and entering it is usual will insert it at the selected point. Sometimes data are required to be entered in a table. This functions as a normal spreadsheet and data can be directly entered/edited, unless the column is shaded in which case the data in that column is protected. Data displayed in “Value” panels can be dragged directly into a cell in a table.

Throughout the practical, you will find questions that relate to the experiment/page completed. To answer some of these questions you have to select sections of the trace by using the Snipping Tool of Windows. Instructions on how to use the Snipping Tool are available in the Study Questions section (see below). This also includes a demonstration video.

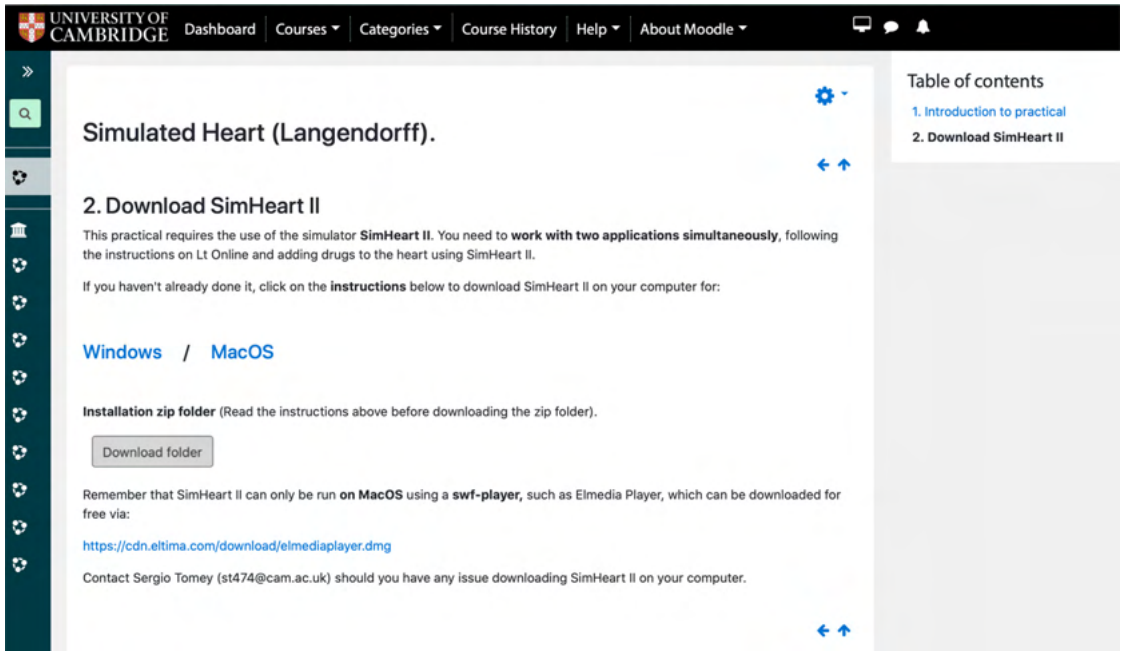


Appendix C

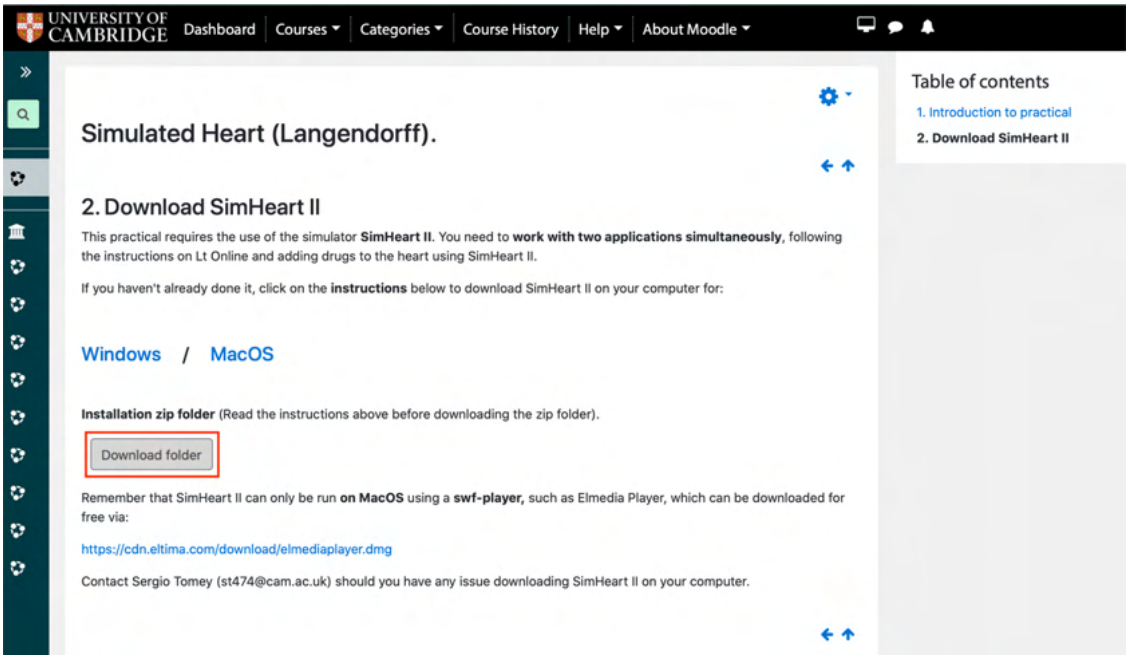
Download information for SimHeart II simulator for practical: "Langendorff isolated perfused heart Online"

(Download Links and Installation Information for **Windows**)

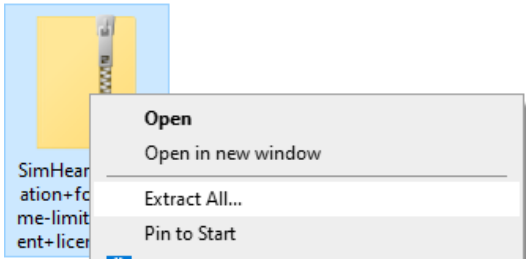
1. Log in to your **Moodle course**.
2. Follow **Practicals** > **Simulated Heart** (Langendorff) > **Download SimHeart II**.



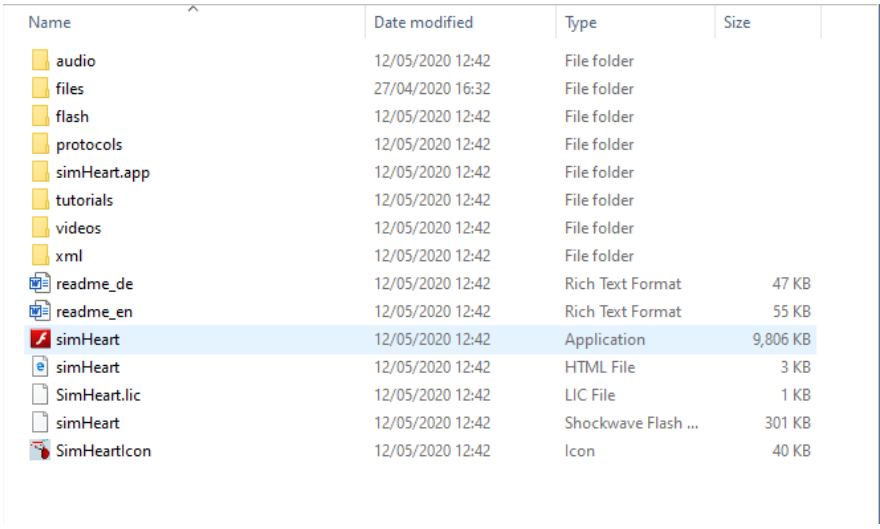
3. Download the installation **.zip folder** by clicking on "Download folder"..



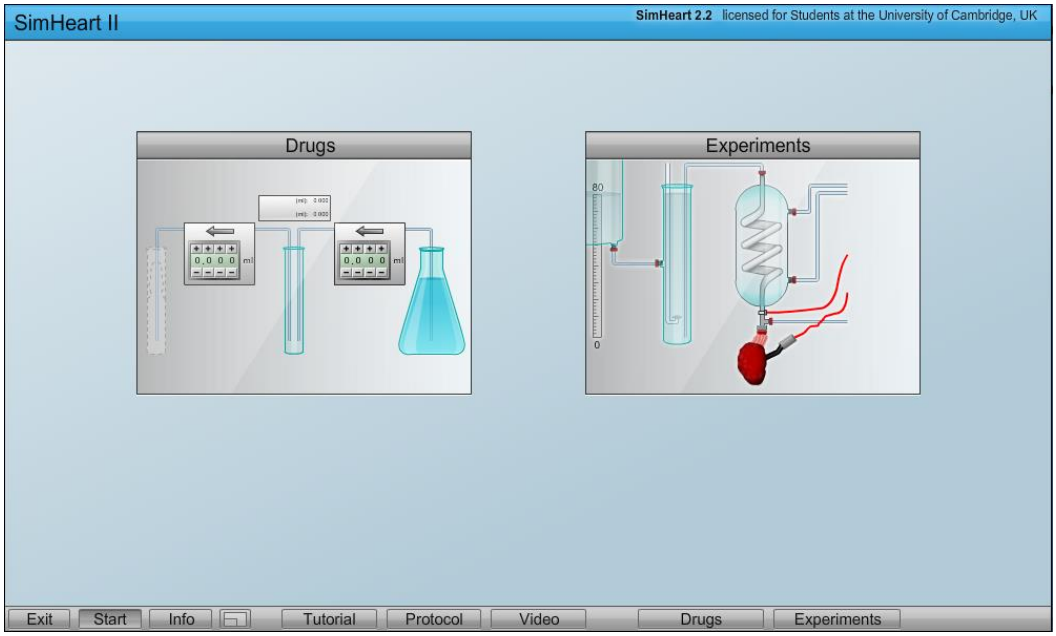
4. Save and **unzip** (Extract All) the .zip folder you have downloaded.



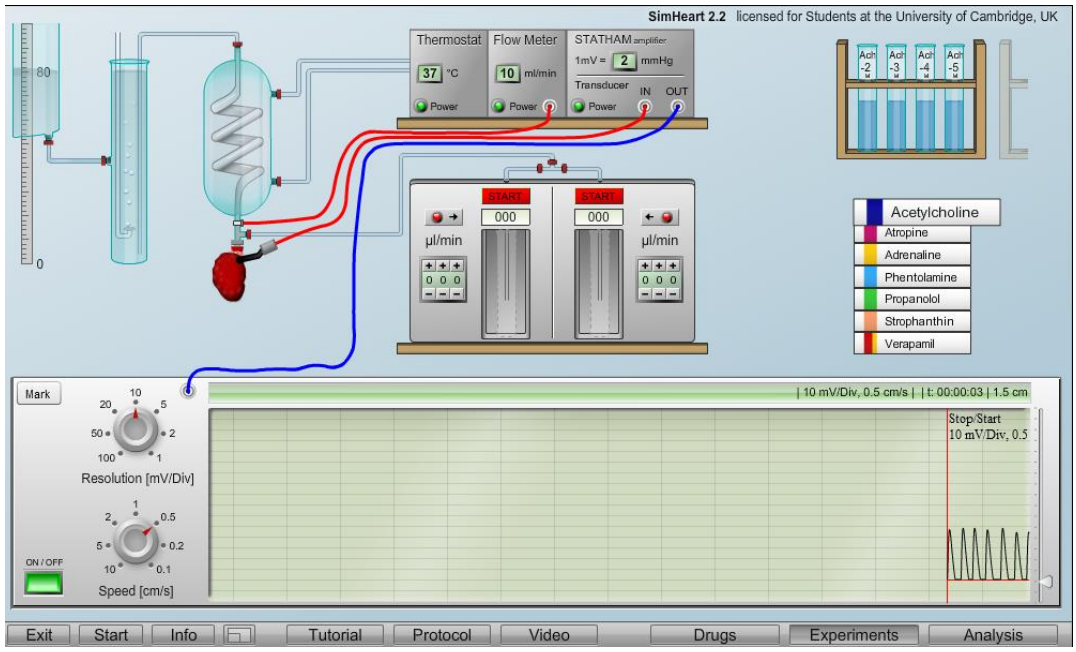
5. Open the folder you have generated and start the simulator via the **SimHeart.exe** file.



6. The simulators should be opened as below.

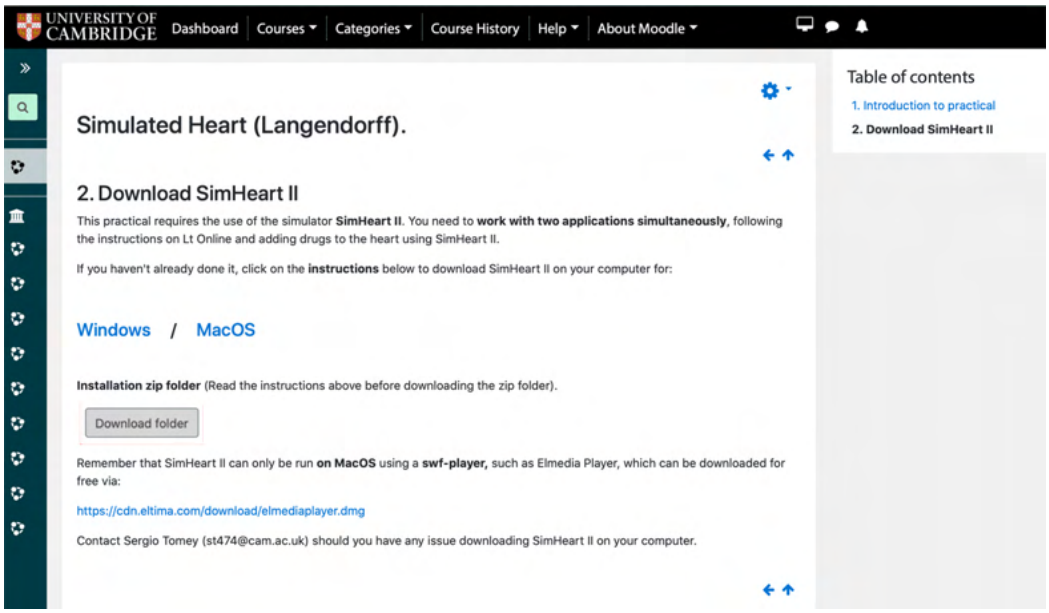


7. Click on the Experiments box to **start the simulation**, which will appear as follow.



(Download Links and Installation Information for **MacOS**)

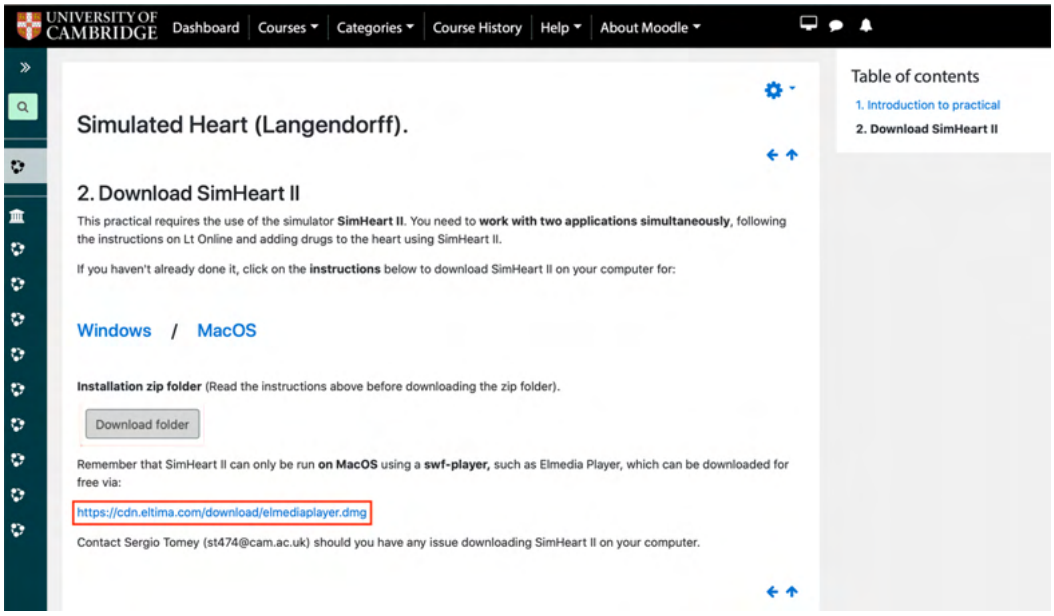
1. Log in to your **Moodle course**.
2. Follow **Practicals** > **Simulated Heart** (Langendorff) > **Download SimHeart II**.



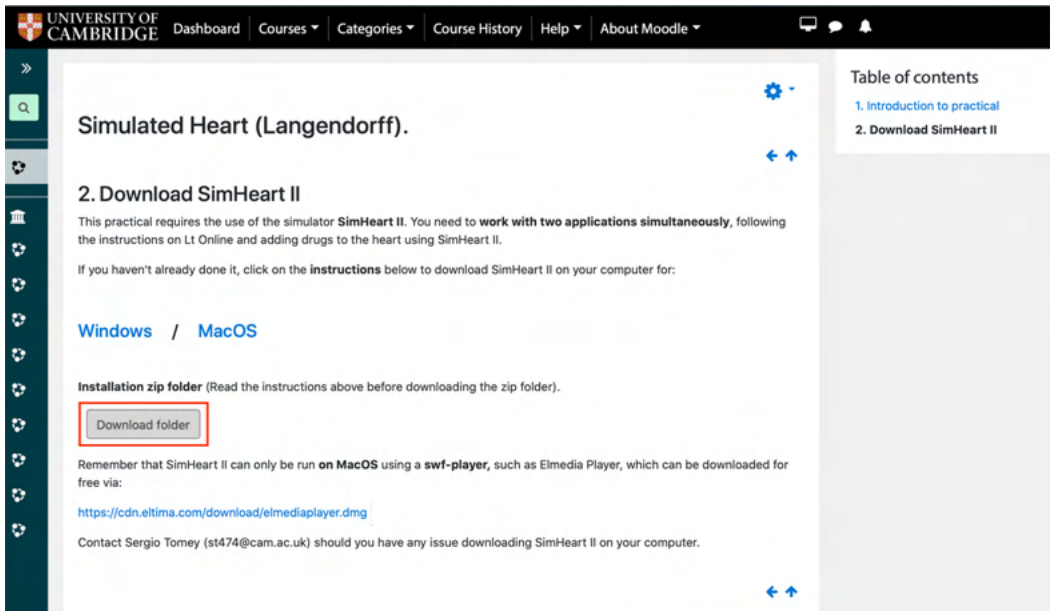
3. SimHeart II can only be run on MacOS using a **swf-player,** such as Elmedia Player, which can be downloaded for free via:

https://cdn.eltima.com/download/elmediaplayer.dmg

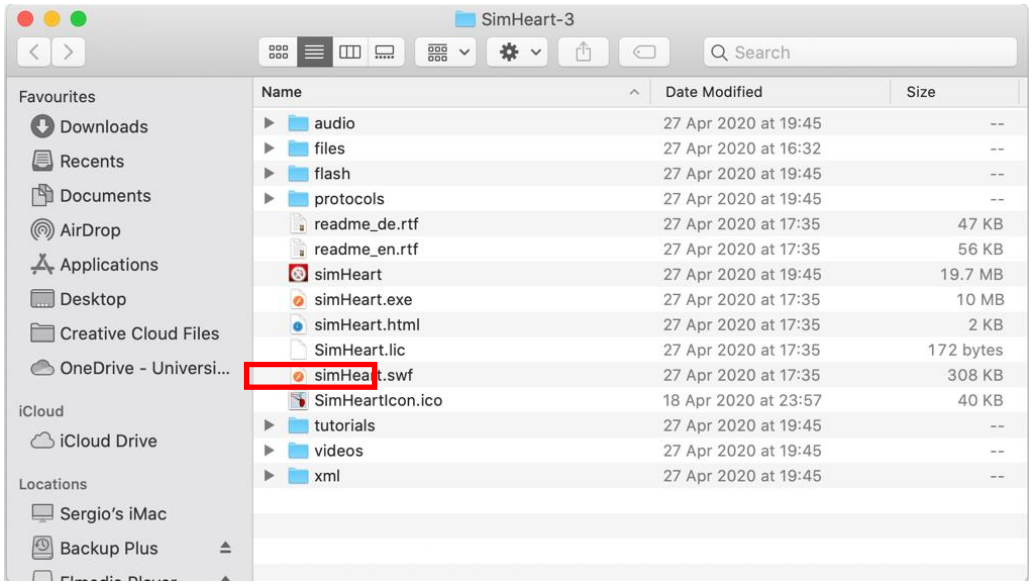
You can also find this link in the Simulated Heart (Langendorff) page on Moodle.



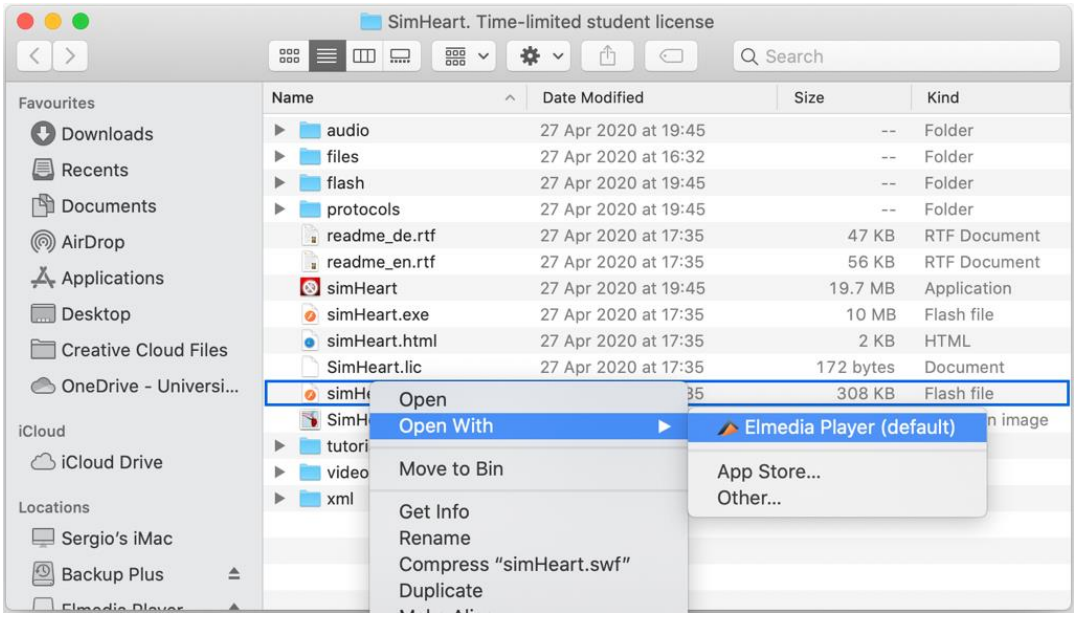
4. After downloading the swf-player (Elmedia Player), download the installation **.zip folder** by clicking on “Download folder”.



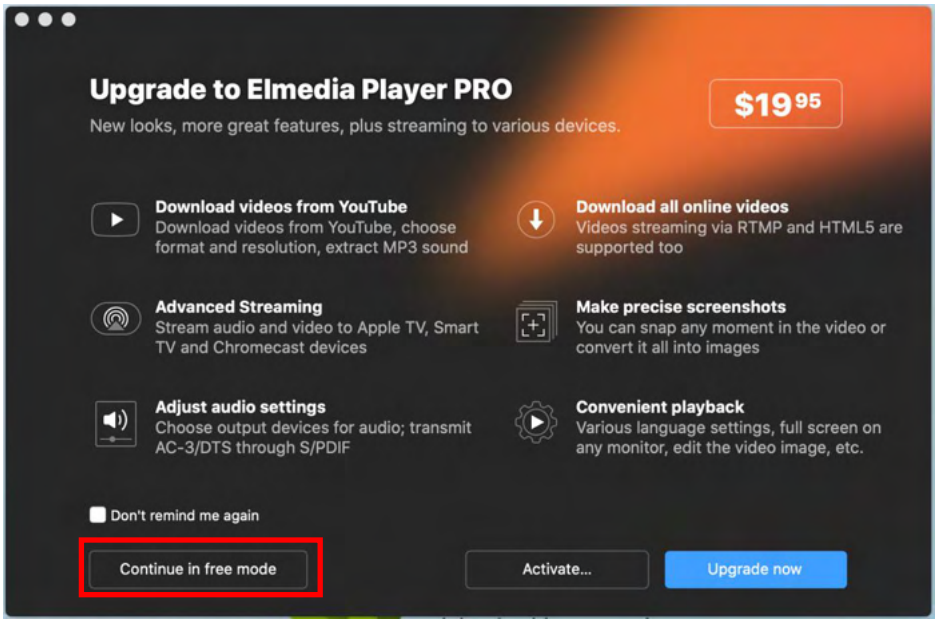
5. Open the .zip folder you have downloaded. Under “protocols” you will find the **SimHeart.swf** file.



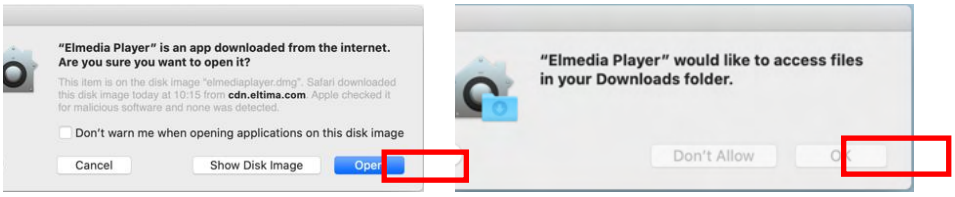
6. To **open the simulator**, right mouse or double click on the SimHeart.swf file, select "Open With" and click on Elmedia Player.



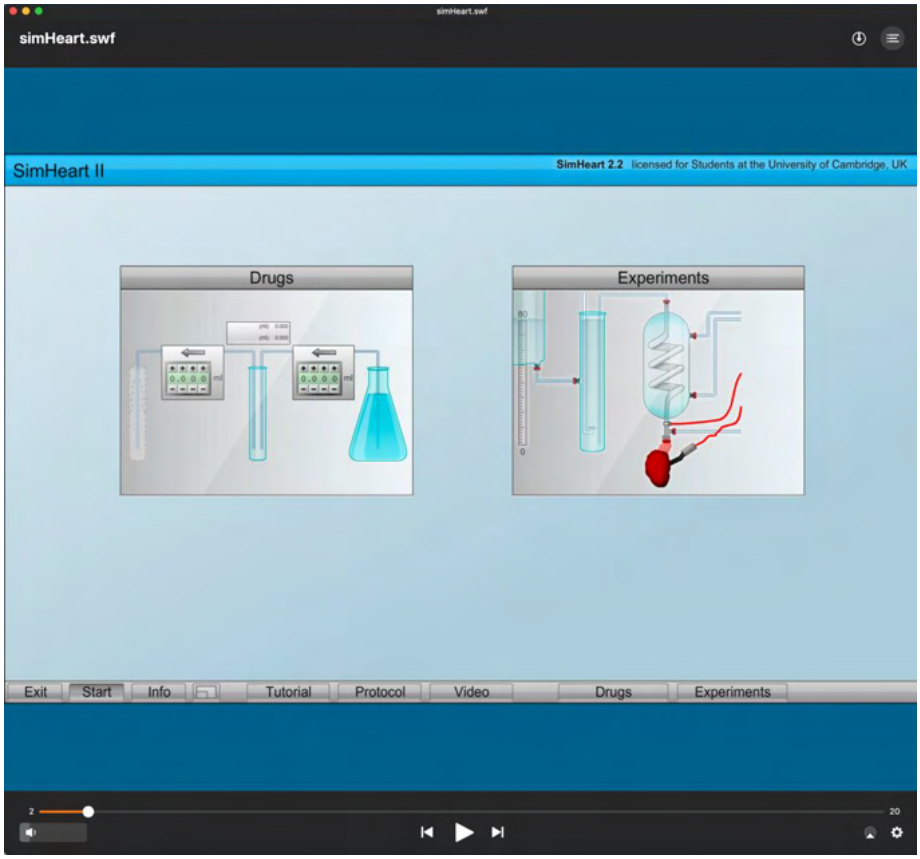
7. You will find the following window. Click on **"Continue in free mode"**.



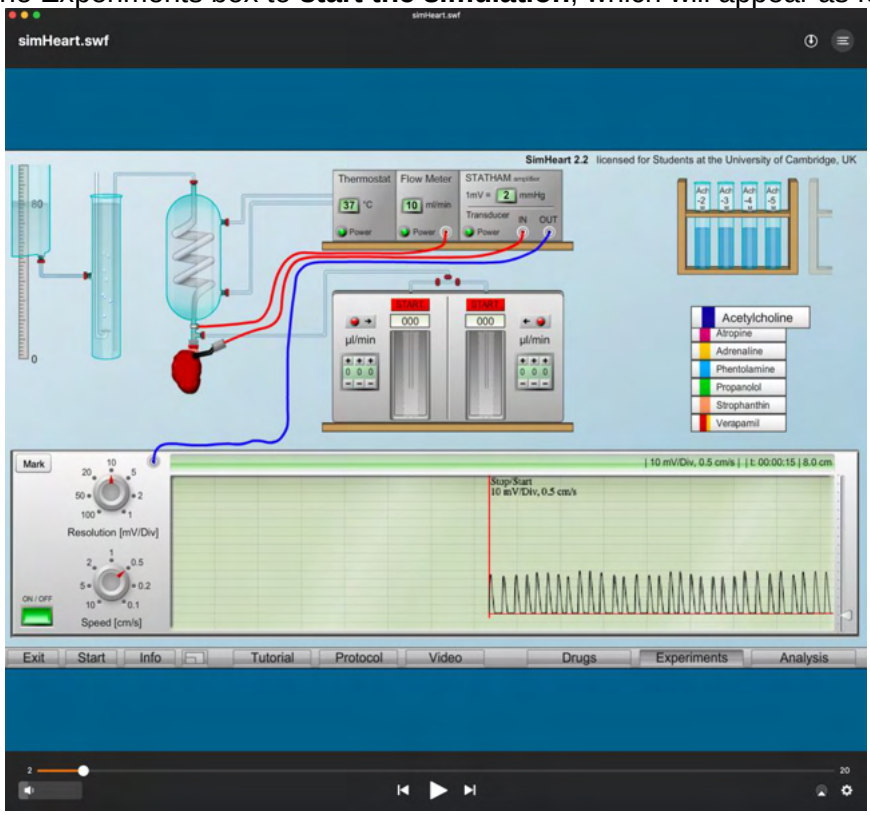
8. You may also find the following windows. Click on **"open"** and **"OK"** respectively.



9. The simulators should be opened as below.



10. Click on the Experiments box to **start the simulation**, which will appear as follow.



IMPORTANT: To play SWF files on Macs with a Silicon M1 Chip follow the instructions in the link below:

https://wiki.eltima.com/knowledge-base/elmedia-player-mac/play-swf-on-mac-with-m1.html

Or use the HTML5 version of SimHeart II (works with all devices!)

Alternatively, you can use the **HTML5 version of SimHeart**, which also works with **tablets and iPads**. Please, note **Internet connection is needed** to use the HTML5 version of the simulator.

https://www.virtual-physiology.com/licensedprogram/?program=SimHeart

Clicking on the link above will open a window with an input field where you shall **add the string below**, which you just need to copy and paste.

FAED970FEBEF06C396FA18C20A060E3B07BEFD0904B59EAC989524413A400F0C0AC0C7EAFE5B7835F9A47BFD11AFF606BB150AF39BD12F04CDF7FB02A8BB477B2E09301F1638E2EDE5BDDF8C6B4F0771514BC8C9CDC3

Contact Sergio Tomey (st474@cam.ac.uk) should you have any issue downloading SimHeart II on your computer.