THE UNIVERSITY OF NEW SOUTH WALES

FACULTY OF MEDICINE

SCHOOL OF MEDICAL SCIENCES

DEPARTMENT OF PHARMACOLOGY

PHAR 3101

Drug Discovery, Design and Development

COURSE OUTLINE

SESSION 2, 2014

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PHAR3101 Course Information

Drug Discovery, Design and Development (PHAR3101) is a 3rd year Science Course worth Six Units of Credit (6 UOC). The course is usually undertaken as part of a major in Pharmacology for the Bachelor of Science or Bachelor of Medical Sciences or as part of the Bachelor of Medicinal Chemistry. The course will build on the information you have gained in Pharmacology (PHAR2011, PHAR3102 & PHAR3251) and Physiology (PHSL2101 & PHSL2201).

OBJECTIVES OF THE COURSE

This course will explore the process of drug development, from target identification to final drug registration. It will present drug development as a process involving target selection, lead discovery using computer-based methods and combinatorial chemistry/high-throughput screening. Safety evaluation, bioavailability, clinical trials, and the essentials of patent law will also be discussed. Along the way you will learn about molecular recognition, computer-aided drug design, and toxicology as applied to the development of new medicines

COURSE CO-ORDINATOR and LECTURERS:

Course Coordinator:
A/Prof. Renate Griffith
Wallace Wurth Building, level 3E ph: 9385 1912

Students wishing to see the course coordinator outside scheduled lecture, tutorial, or practical times should make an appointment *via* email.

Lecturers in this course:

Dr Trudie Binder	w.binder@unsw.edu.au
Dr Orin Chisholm	o.chisholm@unsw.edu.au
Dr Angela Finch	a.finch@unsw.edu.au
A/Prof. Renate Griffith	r.griffith@unsw.edu.au
Prof. Peter Gunning	p.gunning@unsw.edu.au
Dr Greg Smith	g.smith@unsw.edu.au
A/Prof. Laurence Wakelin	l.wakelin@unsw.edu.au

COURSE STRUCTURE and TEACHING STRATEGIES

Learning activities occur on the following days and times:

- Lectures: Monday 1-2 pm, **weeks 1-9, 11-13**; Thursday 12-1 pm, **weeks 1-12**
- Tutorials: Thursday 9-10 am or* 10-11am; **weeks 3-5, 6 (TEST), 7-12**
- Practicals: Tuesday 1-4 pm; **weeks 2-9, 11+12**
- *: Once enrolled in one of the two sessions, students cannot change.

Students are expected to attend all scheduled activities for their full duration (2 hours of lectures per week and up to 4 hours of practical and tutorial sessions per week). Students are reminded that UNSW recommends that a 6 units-of-credit course should involve about 125-150 hours of study and learning activities. The formal learning activities are approximately 60 hours throughout the semester and students are expected (and strongly recommended) to do at least the same number of hours of additional study.

Lectures will provide you with the concepts and theory essential for understanding the processes involved in drug development. To assist in the development of research and analytical skills practical classes and tutorials will be held. These classes and tutorials allow students to engage in a more interactive form of learning than is possible in the lectures. The skills you will learn in practical classes are relevant to your development as professional scientists.

APPROACH TO LEARNING AND TEACHING

The learning and teaching philosophy underpinning this course is centred on student learning and aims to create an environment which interests, challenges, and enthuses students. The teaching is designed to be relevant and engaging in order to prepare students for future careers.

Although the primary source of information for this course is the material covered in lectures, tutorials, and practical classes, effective learning can be enhanced through self-directed use of other resources such as textbooks and Web based sources. Your practical classes will be directly related to the lectures and **it is essential and required to prepare for practical classes before attendance *via* the pre-lab modules**. It is up to you to ensure you perform well in each part of the course: preparing for classes; completing assignments; studying for exams and seeking assistance to clarify your understanding.

STUDENT LEARNING OUTCOMES

PHAR3101 will develop those attributes that the Faculty of Science has identified as important for a Science Graduate to attain. These include skills, qualities, understanding and attitudes that promote lifelong learning that students should acquire during their university experience.

Graduate Attributes

A. Research, inquiry and analytical thinking abilities
B. The capability and motivation for intellectual development
C. Ethical, social and professional understanding
D. Effective communication
E. Teamwork, collaborative and management skills
F. Information Literacy – the skills to locate, evaluate and use relevant information.

On completion of this course students should:

1. be able to describe the process of drug discovery and development
2. be able to discuss the challenges faced in each step of the drug discovery process
3. have gained a basic knowledge of computational methods used in drug discovery
4. be able to organise information into a clear report
5. be able to demonstrate their ability to work in teams and communicate scientific information effectively

ASSESSMENT PROCEDURES

- Progress exam (45 min duration): short and long answer questions **10%**
- Practical assessment (1 report) **10%**
- Formative assessment **5%**
- Group assignment (10% for each individual's report) and synopsis (5%) **15%**
- End of session examination (2 hours duration): short and long answer q. **60%**
  (50% on lectures and tutorials, 10% on practicals)

The *practicals and tutorials* are provided to support lecture material and practise analytical skills. The practical classes and tutorials help you to develop graduate attributes A, C, D & E. During the practical course you will be required to submit a written report covering three of the practical sessions. The report itself should be in the form of a scientific communication comprising aims, results and discussion (see pages 17 to 20 for instructions). Reports must be as concise as possible, and are limited to a maximum of 2000 words of writing (excluding tables, figures and computer traces). **The report will be due Monday, 22 Sept (week 9), at 10 am**. Written assessment tasks must be accompanied by a signed plagiarism form and

must be submitted at the BABS.SOMS.BEES (B.S.B.) Student Office, G27 Biosciences Building. The report also has to be submitted electronically *via* Moodle, through Turnitin. A penalty will apply for late submissions (10% per day). Material covered in the Practical Classes will be examined.

Students will work in teams to research the drug discovery process of a given drug. They will submit an *individual written report* and a *group synopsis* on their findings by Monday, October 20 (week 12). This assessment task will allow you to develop your research, information literacy, communication and time management skills, as well as allowing you to demonstrate your ability to work in a team and collaborate successfully (Graduate attributes A, D, E &F). The marking criteria and instructions are on pages 21 to 26. Written assessment tasks must be accompanied by a signed plagiarism form and must be submitted at the BABS.SOMS.BEES (B.S.B.) Student Office, G27 Biosciences Building. They also have to be submitted electronically *via* Moodle, through Turnitin. A penalty will apply for late submissions (10% per day).

The *progress examination* will be held during the tutorial sessions in week 6, on the 4th of September. This exam will give you feedback on how you are succeeding in the course. **The *progress examination* and *end of session examination* will test not only your knowledge of the process of drug design and development but also your ability to apply the knowledge you have acquired from multiple lectures, practicals and tutorials to drug development scenarios. The examination will be in the format of short and long answer questions. The questions will be based on the material covered in the lectures, practical classes and tutorials. Material covered prior to the progress exam may be again examined in the final exam.** The examinations will address graduate attributes A and B. The end of session examination will be held during the official examination period.

The goal of *formative assessment* is to provide ongoing feedback that you can use to improve your learning. Formative assessment tasks help students identify their strengths and weaknesses and therefore the areas they should focus on.
Pre-tutorial questions and instructions will be posted on Moodle a week before scheduled tutorial sessions. Students will need to print these and attempt to answer them. They need to be shown to the tutor at the beginning of the tutorial, and credit will be given if students have attempted to answer the questions. Feedback will be provided during the tutorial session.

TEXTBOOK AND READING LIST

Recommended Primary Texts:

- Drug Discovery and Development; Technology in Transition. HP Rang. Elsevier Ltd 1st edition 2006.
- Pharmacology in Drug Discovery. T. P. Kenakin. Elsevier, 1st Edition 2012.
- An introduction to medicinal chemistry. G. L. Patrick. 5th Edition Oxford UK, Oxford University Press, 2013.

These textbooks will be available at the UNSW bookshop.

Additional reading suitable as Secondary Resources:

- Textbook of Drug Design. Krogsgaard-Larsen, Liljefors and Madsen (Editors), Taylor and Francis, London UK, 2002.
- Drug Discovery Handbook S.C. Gad (Editor) Wiley-Interscience Hoboken USA, 2005.

These textbooks are available from the UNSW library.

Other Resources:
The following electronic journals are accessible *via* the UNSW library.

- Nature Reviews: Drug Discovery.
- Drug discovery and development
- Drug discovery today.
- Science online special "Drug discovery" http://www.sciencemag.org/sciext/drugdisc/

Links to additional articles of interest will be placed on the course pages on Moodle.

COURSE EVALUATION AND DEVELOPMENT

Each year feedback is sought from students about the courses offered in the Department of Pharmacology and continual improvements are made based on this feedback. The Course and Teaching Evaluation and Improvement [CATEI] Process of UNSW is the way in which student feedback is evaluated and significant changes to the course will be communicated to subsequent cohorts of students. A staff-student liaison group will also be set up and students will be invited to become class representatives to seek feedback from their colleagues and meet with academic staff to discuss any issues that arise. Several improvements to PHAR3101 have been made based on feedback given in 2006 to 2013. These changes include: a new textbook, increased tutorial support and changes to lecture and practical content. Two new practicals were introduced in 2010. The lecture content was revised in 2012. Pre-lab modules and pre-tutorial questions have been introduced for 2014.

GENERAL INFORMATION

The Department of Pharmacology is part of the School of Medical Sciences and is within the Faculty of Medicine. Most academics are located in the Wallace Wurth building on level 3 East. General inquiries can be made at the BABS.SOMS.BEES (B.S.B.) Student Office, located on the Ground Floor of the Biosciences building (G27). Office hours are 9.00 am - 5:00 pm.

Professor Margaret Morris is Head of Department and appointments may be made through her administrative assistant (Ph: 9385 2804) or *via* email (m.morris@unsw.edu.au).

The School of Medical Sciences conducts an Honours program. The Honours program is coordinated by Dr Andrew Moorhouse, a.moorhouse@unsw.edu.au (ph: 9385 2575). Any students considering an Honours year should discuss the requirements with the coordinator. Outstanding students may be considered for scholarships offered by the University and School and these are offered annually.

Postgraduate research degrees
The Department of Pharmacology offers students the opportunity to enter into the following graduate programs:

Doctorate (***Ph.D)***: In Pharmacology. For further information contact the co-ordinator Dr Pascal Carrive (p.carrive@unsw.edu.au).

Course Work Masters: Masters in Drug Development. For more information contact Dr Orin Chisholm (o.chisholm@unsw.edu.au)

Research Masters: In Pharmacology. For more information contact the post-graduate co-ordinator Dr Pascal Carrive (p.carrive@unsw.edu.au)

Vacation Scholarships: The School of Medical Sciences supports several summer vacation scholarships each year to enable good students to undertake short research projects within the department. For further details contact the School Teaching Administrator.

The School Teaching Administrator
Ms Carmen Robinson is able to provide additional information on any courses offered by the School.
BABS.SOMS.BEES (B.S.B.) Student Office, G27 Biosciences Building.
Ph: 9385 2464. Email: Carmen.Robinson@unsw.edu.au

OFFICIAL COMMUNICATION BY EMAIL

All students in the course PHAR3101 are advised that email is now 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) and, if you do not wish to use the University email system, you MUST arrange for your official mail to be forwarded to your chosen address. The University recommends that you check your mail 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 IT at UNSW (http://www.it.unsw.edu.au/students/index.html).
When contacting a lecturer with a query, it is essential that the following information is provided as a minimum: student name, student number, course number, course name.

ATTENDANCE REQUIREMENTS

Attendance at practical classes is compulsory, and must be recorded in the class roll ON THE DAY OF THE CLASS. Arrival more than 15 minutes after the start of the class will be recorded as non-attendance. 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 1 practical class during the session** may result in ineligibility to pass the course.

The University acknowledges that students are involved in many extra-curricular activities throughout their studies. The School of Medical Sciences is generally supportive of students' activities but must be confident that these do not significantly impact on attendance at scheduled teaching activities or completion of assessment requirements.

BEHAVIOUR IN PRACTICAL CLASSES

The practical class is an opportunity for students to develop graduate attribute C by behaving in an ethical, socially responsible and professional manner within the practical class.

- Punctual arrival is expected.
- Turn off mobile phones before entering the class.
- A lab coat must be worn to most practical classes (see pre-lab modules and practical notes).
- Enclosed shoes are compulsory for all practicals.

Information on relevant Occupational Health and Safety policies and expectations will be provided in the practical notes and the pre-lab modules, as outlined at http://www.ohs.unsw.edu.au/.

Students must take due care with biological and hazardous material and make sure all equipment is left clean and functional. Those who don't adhere to these basic laboratory rules will be marked absent.

PRACTICAL CLASSES

The experimental procedure for each practical is given in separate practical notes. Students are required to familiarise themselves with the experimental procedure before attending each class.

NOTE: Pre-lab modules will be provided on Moodle for practicals in 2014. These must be completed at least 1 hour prior to attending each practical class.
Students who do not successfully complete the module will not be allowed to start the experiment until they have done so in class.

In the interests of safety, special attention should be paid to any precautionary measures recommended in the notes. If any accidents or incidents occur they should be reported immediately to the demonstrator in charge of the class who will record the incident and recommend what further action is required.

Animal Experimentation
The procedures used in the laboratory classes involving the use of animals have been approved by Animal Care and Ethics Committee (registration number ACEC 13/76B). All experiments undertaken in the Department of Pharmacology adhere to the NHMRC code of conduct for animal experimentation.

WWW TEACHING RESOURCES

The Department of Pharmacology has chosen to use the University's central Moodle service to provide teaching materials for all of its courses.

- Moodle can be accessed directly from the UNSW homepage.
- Log in using your zPass (zStudentNo. and password).
- After logging on to Moodle, look for the course PHAR3101. You should have access to it if you are properly enrolled.

You can make use of 'echo' recordings taken of the lectures that are available on Moodle. Lecture notes will also be made available on Moodle before each lecture. It is recommended that students print these out and bring them to the lecture, so they can annotate them and make their additional own notes during the lecture.

HANDWRITING

Students whose writing is difficult to read will disadvantage themselves in their written assessment. Make every effort to write clearly and legibly. Do not use your own abbreviations.

STUDENT RIGHTS AND RESPONSIBILITIES

https://my.unsw.edu.au/student/resources/Policies.html#StudentResponsibilities&Conduct

APPEAL PROCEDURES

Details can be found at MyUNSW *via* the Student Central link.

https://my.unsw.edu.au/student/academiclife/assessment/Results.html

https://my.unsw.edu.au/student/academiclife/assessment/finalisation_results.html

GRIEVANCE RESOLUTION OFFICER

In case you have any problems or grievance about the course, you should try to resolve it with the Course Coordinator (A/Prof. Renate Griffith ph: 9385 1912) or the Head of Department (Prof Margaret Morris ph: 9385 1560). If the grievance cannot be resolved in this way, you should contact the School of Medical Sciences Grievance Officer, Dr P.Pandey (9385 2483, P.Pandey@unsw.edu.au).

STUDENT SUPPORT SERVICES

Those 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 coordinator prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Student Equity and Disabilities Unit. 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.

Student Equity and Disabilities Unit, Ground Floor of the Goodsell Building
Tel: +61 2 9385 4734/5434
Email:seadu@unsw.edu.au
Website: www.studentequity.unsw.edu.au

MISSED EXAMS

If you unavoidably miss the final exam, **you must inform the course coordinator and you must lodge a special consideration request**, supported by a medical certificate or other documentation to Student Central (see web address below) within **3 DAYS**.

Your request for consideration will be assessed and a deferred exam may be granted. You cannot assume you will be granted supplementary assessment.

It is intended that supplementary exams for the School of Medical Sciences in Semester 2, 2014, will be held Monday 8th, Tuesday 9th and Wednesday 10th December.

Normally, if you miss an exam (without valid 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 sufficiently early to start on time.
(refer to https://my.unsw.edu.au/student/atoz/SpecialConsideration.html for further details).

MISSED PRACTICAL CLASSES, PROGRESS EXAM, ASSESSMENT DEADLINES

Students who miss practical classes, the progress exam, or the deadline for an assessment item due to illness or for other reasons must submit a copy of medical certificates or other acceptable documentation to the course coordinator (r.griffith@unsw.edu.au). **Certificates should be lodged no more than 3 days after an absence.**

SPECIAL CONSIDERATION

If you believe that your performance in a course, either during session or in an examination, has been adversely affected by sickness or for any other reason, you should consider asking for special consideration in the determination of your results. Such requests should be made as soon as practicable after the problem occurs. **Applications made more than three days after an examination in a course will only be considered in truly exceptional circumstances**.
When submitting a request for special consideration you should provide all possible supporting evidence (eg medical certificates) together with your registration number and enrolment details. Consideration requests must be lodged electronically through the website above. In exceptional circumstances further assessment may be given**. If you believe you might be eligible for further assessment on these grounds, you should put in a request as soon as possible.**

REPEATING STUDENTS

Practical class exemptions may be granted to repeat students but students **must** check with the course co-ordinator whether they have exemption **prior** to their first practical class.

PLAGIARISM

The School of Medical Sciences will not tolerate plagiarism in submitted written work. The University regards this as academic misconduct. Evidence of plagiarism in submitted assignments, etc. will be thoroughly investigated and may be penalised by the award of a score of zero for the assessable work. Evidence of plagiarism may result in a record being made in the Central Plagiarism Register and the Faculty Students Ethics Officer being notified.

What is Plagiarism?
Plagiarism is the presentation of the thoughts or work of another as one's own.* Examples include:

- direct duplication of the thoughts or work of another, including by copying material, 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, web site, Internet, other electronic resource, or another person's assignment without appropriate acknowledgement;
- paraphrasing another person's work with very minor changes keeping the meaning, form and/or progression of ideas of the original;
- 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 a tutor; and
- claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed.†
- For the purposes of this policy, submitting an assessment item that has already been submitted for academic credit elsewhere may be considered plagiarism.
- Knowingly permitting your work to be copied by another student may also be considered to be plagiarism.
- Note that an assessment item produced in oral, not written, form, or involving live presentation, may similarly contain plagiarised material.
- The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does *not* amount to plagiarism.
- The Learning Centre website is the main repository for resources for staff and students on plagiarism and academic honesty. These resources can be located *via*: www.lc.unsw.edu.au/plagiarism

The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- correct referencing practices;
- paraphrasing, summarising, essay writing, and time management;
- appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

Individual assistance is available on request from The Learning Centre.
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.

* Based on a document proposed to the University of Newcastle by the St James Ethics Centre. Used with kind permission from the University of Newcastle

† Adapted with kind permission from the University of Melbourne.

Drug Discovery, Design and Development
LECTURE and PRACTICAL OUTLINES

The course timetable is appended at the end of these outlines (p. 15) and can also be found on Moodle.

The course is divided into 6 main themes covering the drug development process from bench to bedside.

1. Introduction to Drug Design and Development
2. Drug targets
3. Lead Identification and Modification
4. Computer-Aided Drug Design
5. Drug Delivery
6. Pre-clinical and Clinical Testing

1. Introduction to Drug Design and Development

Drug Discovery as a Process

This lecture stresses the important realisation that drug discovery is a lengthy, expensive, and complicated process, that requires the collaboration of a large number of research scientists with skills ranging from computational and structural chemistry, through synthetic organic chemistry, molecular cell biology, genomics, proteomics, physiology, pharmacology, toxicology, and clinical biochemistry, amongst others.

Drug Target Validation

Validation of a drug target involves the demonstration that successful 'targeting' will indeed produce the desired outcomes. Experimental approaches to validation increasingly use genetic manipulation of the target to identify the functional consequences of compromising the target. In this interactive lecture validation approaches will be presented with practical examples of both strengths and weaknesses intrinsic to current approaches.

Target Identification and Validation

In this lecture the role of genomics and bioinformatics in target selection and drug design and development will be explored. The use of genetic approaches to identify target candidates such as the mapping of disease loci, genomics and proteomics will be covered. Also covered will be the role of bioinformatics in the analysis of nucleic acid sequence, protein sequence and structure, expression databases and functional pathway data contained in databases.

Target Validation and Drug Validation Practicals

Practical 1: Target Validation will use siRNA to test the role of a specific tropomyosin to regulate cancer cell growth. Each student team will get to fix and stain cells treated with various siRNAs to estimate impact on cell colony forming capacity. The students will count cell colonies by eye in a 6 chamber plate.
Practical 2: Drug Validation will use the same methodology to generate a dose response curve for cell colony formation after exposure to a lead compound. Members of each team will also evaluate the impact of the drug on the intracellular target by viewing on their computer screen cell images displaying different parts of the cell cytoarchitecture. Students will count cells which have intact actin filaments and intact microtubules.

2. Drug targets

Targets: Membrane Proteins

This lecture will explore the advantages and disadvantages of membrane proteins as drug targets. The qualities that make a good drug targets include: contribution to a biological pathway involved in the pathophysiology of a disease, functionally and structurally information about the target and that the target is “druggable”. Membrane proteins such as receptors, ion channels and transporters are key regulators of cellular function. Membrane proteins account for up to two thirds of known drug targets, demonstrating they are “drugable”. However, membrane receptors pose an increased challenge due to the difficulty in obtaining pure, correctly-folded protein in sufficient quantity for functional or structural assays.

Targets: DNA

DNA, messenger RNA, and ribosomal RNA are important molecular targets for cancer, viral, and microbial chemotherapy. Drugs that bind to these targets inhibit DNA replication, the transcription of mRNA, and its translation into proteins. In this lecture we will focus on how structure-based approaches have been applied to the rational design of DNA groove binding agents that recognise specific nucleotide sequences, and how this provides the opportunity for the development of gene-specific inhibitors of transcription – a holy grail of many molecular pharmacologists.

Targets: RNA

In the “Targets: DNA” lecture we focussed on DNA-binding agents that specifically inhibit the transcription of designated genes, here, in the “Targets: RNA” lecture we will consider the development of agents that selectively block mRNA so as to inhibit gene expression at the level of translation. We will discuss three different approaches: (1) the development of anti-sense oligonucleotides, (2) the design of ribozymes that selectively cleave designated mRNAs, and (3) the use of small inhibitory RNAs, known as siRNAs, in post-transcriptional gene silencing.

Targets: Enzymes

Many cellular process involved in disease are mediated or controlled by the specific action of enzymes. A number of disease processes can therefore be reduced or eliminated by manipulating the activity of specific enzymes. This lecture will briefly outline how selected enzymes are identified as drug targets and then validated. Examples of how several drugs exert their therapeutic effects by interacting with these enzymes will also be given.

3. Lead Identification and Modification

Biological Assays: Lead Identification and High-throughput Screening

Before computational drug discovery was introduced drugs were discovered by chance in a trial- and error-manner. The introduction of new technologies, such as high throughput screening (HTS) can experimentally test hundreds of thousands of compounds a day, which have resulted in a more successful identification of promising drug candidates or reduced drug development costs. The outline of the lectures:

- Lead identification: the new technologies eg. genomics, combinatorial chemistry and HTS used to search new compounds
- Lead optimization: HTS used for validation runs; laboratory biological assays for testing binding properties, activities and selectivity of new compounds.

Lead Identification and Screening Practical: Radioligand Binding

Radioligand binding experiments are easy to perform, and provide useful data in many fields, including drug screening for lead compound identification. Through the analysis of the raw

binding data obtained from COS-7 cell line expressing the human β_2 adrenoceptor, students will gain an understanding of the concepts of kinetic, saturation and competition binding, and will learn to apply various data analytical methods for addressing different binding parameters, eg. the dissociation constant (K_D) and maximum binding capacity (B_{max}) of a radioligand; IC_{50} and inhibitory constants (K_I) of competitors.

Lead Modification Practical: Structure Activity Relationships

This practical will explore the relationship between the structure of a compound and its activity. Using the contraction/relaxation of guinea-pig trachea as the screening assay, drug discovery teams (groups of 3-4 students) will test a lead compound and several compounds based on the lead compound to determine their biological activity.
In the class the following week the data generated will be analysed and the effect of the substituents and stereochemistry of the compounds on activity will be examined.

Sources of active compounds

The decade of the 1990s has seen a revolution in medicinal chemistry, with the introduction of combinatorial methods of general organic synthesis. These approaches make it possible to generate tens of thousands of compounds in a few days, in a form suitable for evaluation in high-throughput biological assays. However, other sources of active compounds will also be discussed in the lecture, in particular natural products and their identification. A recent new approach to the identification of novel hit compounds, which involves screening of mixtures of very small molecules (fragments), typically by using NMR spectroscopy or X-ray crystallography, will be introduced.

4. Computer-Aided Drug Design

Molecular Modelling

Computer-aided drug design methods are widely used today in academic and industrial environments. This lecture will explain the basics on how the structures of molecules can be entered into a computer and manipulated *in silico*. This includes methods for geometry optimisation, molecular dynamics simulation, and conformational searching.

Ligand-based Drug Design

To improve the properties of a potential drug, structure activity relationships are established to identify structural moieties that contribute to the binding and activity of a compound. Computational methods will be discussed in this lecture which can be used to model and predict these properties, and to screen databases for new leads. These methods include quantitative structure-activity relationship (QSAR) and pharmacophore determination. A pharmacophore defines the structural features and geometry of a drug that impart biological activity.

Structure Determination

A fundamental requirement of rational drug design is knowledge of the 3-dimensional structure of the receptor, generally a protein, sometimes a nucleic acid, occasionally a protein-nucleic acid complex. In this lecture we will explore the experimental methods available for determining these structures, focussing on X-ray crystallography, NMR spectroscopy, and mass spectrometry.

Structure-based Drug Design

Where the detailed three-dimensional structure of the protein target is available, so called structure-based computer-aided drug design methods can be utilised to identify and modify lead compounds. If the protein structure is not available, then computer models, based on structures of similar proteins, can be prepared and are suitable for structure-based drug

design. This lecture will introduce structure-based drug design and protein modelling methods.

Molecular Modelling Practical

This practical will learn how to use molecular visualisation software to explore the structure and properties of small, drug-like molecules, including conformational models and superimpositions.

Molecular Modelling Practical: Visualisation

Students will use the same molecular visualisation software to examine protein structures, protein/ligand interactions, and DNA/ligand interactions pertinent to structure-based drug design.

5. Drug Delivery

Bioavailability

Pharmacokinetics is the study of what the body does to a drug once it is within the body. A clinically important outcome of the body's treatment of a drug is how much drug is finally available in the body to bind to its intended therapeutic target (bioavailability). A brief outline will be given in this lecture on how ADME processes (Absorption, Distribution, Metabolism and Excretion) impact on a drug's bioavailability.

Pro-drugs and Drug Delivery

An inactive derivative of a known active drug may be called a prodrug and requires transformation within the body in order to release the active drug. Prodrugs can provide improved physiochemical properties such as solubility and enhanced delivery characteristics and / or therapeutic effect. This lecture outlines barriers to drug action, pro-drugs as drug delivery systems, and the application of pharmacokinetics and pharmacodynamics in drug delivery.

6. Pre-Clinical and Clinical testing

Pre-clinical Toxicology: *In Vitro*

From this lecture students will understand:

- the role of *in vitro* toxicity tests in establishing the safety of new drugs
- *in vitro* toxicity tests required by the world's regulatory bodies; tests for genotoxicity, cytotoxicity and others as required by chemical class
- the theory and methodology underlying various *in vitro* toxicology tests
- the role of Good Laboratory Practice in performing these tests

Pre-clinical Toxicology: *In Vivo*

From this lecture students will understand:

- the role of *in vivo* toxicity tests in establishing the safety of new drugs
- *in vivo* toxicity tests required by the world's regulatory bodies; genotoxicity, acute and short-term toxicity tests, tests for carcinogenic potential, Q-T prolongation and others as required by chemical class.
- the theory and methodology underlying various *in vivo* toxicology tests
- the ethics of *in vivo* toxicity testing and the potential for replacement by *in vitro* models

Pre-clinical Toxicology Practical: Ames Test

Chemicals which damage or mutate DNA and chromosomes are called mutagens. Damage to genetic material may lead to unregulated, cancerous growth of cells and tissues; indeed 80% of known carcinogens (cancer-causing chemicals) are also mutagens. Therefore one of

the early, key tests performed on new chemicals or pharmaceuticals is a test for mutagenicity. The standard *in vitro* test for mutagenicity is known as the Ames test, named for its' inventor Professor Bruce Ames. It is a bacterial reverse mutation assay. In this practical specifically developed, mutant strains of *Salmonella typhimurium* are used, which are unable to synthesize the essential amino acid histidine. Thus the *S. typhimurium* strains will only grow in medium including histidine as an added supplement. Mutagenic chemicals damage the bacterial DNA, causing the strains to revert (reverse-mutate) to the 'wild-type' state in which growth is independent of histidine. In the practical the *S. typhimurium* strain TA98 will be grown in culture with a growth-limiting concentration of histidine. Various test chemicals will be added to the cultures to assess their mutagenic potential. The number of bacterial colonies which form on the culture plates indicates the growth rate; the greater the number of colonies, the greater the mutagenic potential of the chemical.

Clinical Trials

The regulation of therapeutic products and the phases (I-IV) of clinical trial that a drug must pass through before registration will be covered in this lecture.

Clinical Trial Design

This lecture will cover clinical trial design. The components of clinical trial design to be discussed will be: aims, design, controls and placebo, blinds, randomisation procedures, sample size, statistics, endpoints and ethics (ethics will be covered later in the course).

Ethics of Human and Animal Experimentation

Testing of drugs in animals and humans is under strict regulation to limit any harm and distress to the research subjects. In this lecture we will discuss the ethical conduct of biomedical research, including the policies governing biomedical and animal research in Australia. The role of institutional human ethic committees and what constitutes informed consent will be discussed. The general principles for the care and use of animals for scientific purposes and the 3 R's, replacement, reduction and refinement will be covered and the role of institutional animal ethics committees will be covered.

Intellectual Property

The basic principles underlying the protection of intellectual property will be discussed, focussing on the legal issues relevant to the patenting of pharmaceutical agents. We will discuss the types of patents available and what can be protected, the notions of disclosure, prior art, innovation, challenges, and what needs to be included in a patent application.

Commercial Considerations in Drug Development

The lecture will cover commercial considerations in drug development from target discovery, indication selection and lead identification, through safety assessments, clinical trials and marketing. It will look at what drives decisions (Go/No-Go), time-scales, program planning issues and the interactive perspectives of different groups in small through to large pharma companies.

Wk	Start. Mon	Lecture 1 Mon 1-2pm WW LG02	Practical Tue 1-4 WW116 or 115	Tutorial-2 time slots Mat 311; Thu 9-10; 10-11	Lecture 2 Thu 12-1 WWLG02
1	28/7	Introduction & course overview/ Drug discovery as a process R. Griffith			Drug target validation P. Gunning
2	4/8	Target identification and validation R. Griffith	Target Validation P. Gunning (116)		Targets – membrane proteins A. Finch
3	11/8	Targets – DNA L. Wakelin	Drug Validation P. Gunning (116)	Membrane proteins as targets A. Finch	Targets – RNA L. Wakelin
4	18/8	Targets – enzymes R. Griffith	Assessment in DDDD R. Griffith (116)	Nucleic acids and enzymes as targets R. Griffith	Biological assays: lead identification A. Finch
5	25/8	Biological assays: high-throughput screening A. Finch	Lead identification and screening: radioligand binding (116) A. Finch	Lead identification & screening A. Finch	Sources of active compounds R. Griffith
6	1/9*	Molecular Modelling R. Griffith	Lead modification: SAR A. Finch (115 & 116)	**Test** **R.Griffith**	Ligand-based drug design R. Griffith
7	8/9	Structure determination R. Griffith	Lead modification: data analysis A. Finch (115)	SAR A.Finch	Structure-based drug design R. Griffith
8	15/9	Bioavailability R. Griffith	Molecular Modelling R. Griffith (115)	Feedback from test R. Griffith	Pro-drugs and drug delivery T. Binder
9	22/9*	Pre-clinical toxicology – *in vitro* G. Smith	Visualisation: Drug - Target R. Griffith (115)	Computer-aided drug design R. Griffith	Pre-clinical toxicology – *in vivo* G. Smith
	29/9	**Mid-semester break**	**Mid-semester break**	**Mid-semester break**	**Mid-semester break**
10	6/10	**Public holiday**		Pre-clinical toxicology G. Smith	Clinical trials G. Smith
11	13/10	Clinical trial design G. Smith	Preclinical toxicology: Ames test 1 G.Smith (116)	Clinical trial design G. Smith	Ethics of human and animal experimentation G. Smith
12	20/10*	Intellectual property L. Wakelin	Preclinical toxicology: Ames test 2 G.Smith (116)	Drug discovery as a process/exam preparation R. Griffith	Commercial considerations O. Chisholm
13	27/10	The industry experience in Australia Guest lecturer			

***Lab report due 10 am, Monday, week 9. Assignment and group synopsis due 10 am, Monday, week 12.**

Laboratory Report

You are to prepare a manuscript on behalf of the Somsceuticals Respiratory Disease Division using the data you have collected on the SOMS compounds during the practicals in weeks 5-7, and following the instructions below.

- Word limit 2000±200 words (excluding references, tables, figures and figure legends).
- The report should be referenced using in-text referencing in the style of British Journal of Pharmacology.
- Written assessment tasks must be accompanied by a signed plagiarism form and must be submitted at the BABS.SOMS.BEES (B.S.B.) Student Office, G27 Biosciences Building. Electronic submission *via* Moodle is also required.
- The manuscript is to be submitted to the "journal editor" (B.S.B office) by 10 am, 22nd of September 2014. A 10% penalty (per working day) will apply for late submissions.

The manuscript needs to contain the following sections:

1. Title, Authors & Addresses
2. Introduction
3. Methods
4. Results
5. Discussion and conclusions
6. List of references
7. Tables
8. Figures and Legends

Title, Authors and Addresses

The title should contain no more than 150 characters (including spaces) and should not consist of more than one sentence. It must clearly indicate the subject matter of the paper. Titles should indicate broadly what the paper is about. Following the title the name (and student number) and address (Respiratory Disease Division, Somsceuticals, NSW, Australia) of the author should be given.

Introduction

The introduction should give a short and clear account of the background of the drug target and the rationale of the investigation. The final sentence should summarise the broad conclusions of the paper. Do not include a summary of the methods or results in the introduction. *TIP: you need to reference the prior work by Somsceuticals in regards to SOMS1-9 as (unpublished data), for example the synthesis of the compounds.*

Methods

Briefly describe the experiments in a few sentences for each method with reference to the practical manual *e.g.* ...as previously described (PHAR3101, 2014).

Results

The results section includes:

i. A written description in paragraph format of the experimental results. When results are reported, the mean results with standard errors, and the number of observations, and statistical significance should be given. Conclusions or interpretation of results should not be presented.
ii. A graph and figure legend of the competition binding data (<u>do not</u> include the saturation binding, temperature or time course graphs)
iii. A graph and figure legend of the mean % maximum isopertenolol response data
iv. A graph molecular property *vs* either $\log K_i$ or $\log EC_{50}$
v. A table of the K_i and affinity relative to SOMS-1 values for each compound
vi. A table of Mean Log EC_{50} ± SE, mean EC_{50}, Δ and relative potency for each compound
vii. A table of Molecular Properties data (*ie* miLogP, MW, nrotb, TPSA)
viii. A table of π data for each R group

ix. A figure showing the structures being investigated (this is important so your reader can understand what you are talking about when you are comparing the different "R" groups.)

Tables: Each table should have a brief descriptive title. Each column should have a heading and the units of measurement should be given in parentheses in the heading. Use either scientific notation or general number format not both in a given column. Limit numbers to 2 decimal places. Tables should be self-explanatory, with necessary descriptions of each heading provided underneath the table.

Figures and Legends

Figure legends should explain the figures in sufficient detail that, whenever possible, they can be understood without reference to the text. A very brief description of the experimental method, including "n's" and statistical measurements should be included. Do not summarise your results in the figure legend.

Discussion and Conclusions

The purpose of the discussion is to present a brief interpretation of the results with reference to other scientific studies. Repeating the results should be avoided. The main conclusions should be conveyed in a final paragraph with a clear statement of how the study advances knowledge and understanding in the field.

Your discussion should address the following issues

1. What relationship if any exists between each of the functional groups and the potency, affinity and efficacy of each compound? *TIP: to do this you need to compare compounds that only differ at one R group.*
2. Do any of the molecular properties of the compounds relate to their potency, efficacy or affinity?
3. Is there a relationship between π of specific functional groups and potency, efficacy and affinity of the compounds?
4. How do your findings compare to other research on β_2-adrenoceptor ligands? Can our knowledge of the molecular pharmacology of the β_2-adrenoceptor explain your results?
5. Do the compounds have suitable lead-like or drug like qualities?
6. Have you identified a suitable drug candidate for further development?

Citations

In the text, references to other work should take the form: (Bolton and Kitamura, 1983) or 'Bolton and Kitamura (1983) showed that…'

References

The reference list at the end of the manuscript must be arranged alphabetically according to the surname of the first author. When the surnames of first authors are identical, the alphabetical order of the surnames of subsequent authors takes precedence over the year of publication. The authors' names are followed by the year of publication in brackets. If more than one paper by the same authors in one year is cited, a, b, c, etc. are placed after the year of publication, both in the text and in the list of references. All authors should be quoted for papers with up to six authors; for papers with more than six authors, the first six should be quoted followed by *et al*. For example:

Journal Reference

Connor M, Kitchen I (2006). Has the sun set on κ3-opioid receptors? Br J Pharmacol 147: 349–350.

Book Reference

McGrath, JC, Daly CJ (2005). Imaging adrenergic receptors and their function: the use of fluorescent ligands and receptors to visualize adrenergic rceptors. In: Perez DM (ed). *The Adrenergic Receptors, in the 21st Century.* Humana Press: New Jersey, pp 65–72.

Formatting and Technical Instructions

Times New Roman font, size 12, with 1.5 line-spacing throughout the manuscript. Margins at top and bottom and both sides should be 3 cm. *The text should **not** be in two columns*.

PRACTICAL REPORT: MARKING CRITERIA

	Exemplary (>8.5)	**Very Good** (8.4-7.5)	**Good** (7.4-6.5)	**Satisfactory** (6.4-5.0)	**Unacceptable** (<5.0)
Title and Formatting _____ **x 0.5**	Title clearly indicates the subject matter of the paper. Name and student number and departmental address given. Times roman, 12 font, 1.5 line-spacing, Margins 3 cm. Word count 2000 ± 200.	Title indicates the subject matter of the paper. Name and student number and departmental address given. Minor errors in formatting. Word count 2000 ± 200.	Title indicates the subject matter of the paper. Name and student number and departmental address given. Errors in formatting. Word count 2000 ± 200.	Title does not indicate the subject matter of the paper. Name and student number and departmental address given. Errors in formatting. Word count > 2200.	Title, author's name and/or address not given. Formatting requirements not followed. Word count >2200 or<1800.
Introduction _____ **x 2**	Concise and clear account of the scientific background and the rationale of the experiment. Final sentence summarises the broad conclusions of the paper.	Clear account of the scientific background and the rationale of the experiment. Minor omissions or errors. Final sentence summarises the broad conclusions of the paper.	A good introduction of the scientific background and the rationale of the experiment. A few factual error or omissions. Final sentence summarises the broad conclusions of the paper.	Some introduction to the scientific background and the rationale of the experiment. More detail needed. Improved summary of the major finding needed.	Lacking detail of the rationale of the experiment and scientific background. Summary of the major finding not given.
Methods _____ **x 1**	Appropriate detail and referencing of methods used.	Sufficient detail and referencing of methods used. Minor details missing.	Insufficient detail and referencing of methods used. Minor errors.	Methods given but not referenced. Lacks details and has errors.	Methods not written in paragraph style.
Results _____ **x 1**	Excellent description of the experimental results. No conclusions or interpretation of results presented. Data analysis was performed correctly.	Good description of the experimental results. No conclusions or interpretation of results presented. Minor errors in data analysis.	Good description of the experimental results. Lacks some required detail. No conclusions or interpretation of results presented. A few errors or omissions in data analysis.	Description of the experimental results lacks required detail. Some conclusions or interpretation of results presented. Some errors or omissions in data analysis .	No description of results. Results not written in paragraph style. Errors in data analysis. Some data analysis not presented.
Tables, Figures & Legends _____ **x 1**	Graph axes labelled and units of measurement given. Legends explain the figures in sufficient detail that they can be understood without reference to the text. Tables self-explanatory, with necessary descriptions provided in footnotes underneath the table	Graph axes labelled and units of measurement given. Legends explain the figures in sufficient detail that they can be understood without reference to the text. Tables self-explanatory, with footnotes underneath the table. A few minor errors in data presentation	Graph axes labelled and units of measurement given. Not all legends explain the figures in sufficient detail that they can be understood without reference to the text. Most tables self-explanatory, with footnotes underneath the table. Some minor errors in data presentation.	Most graph axes labelled and units of measurement given. Not all legends explain the figures in sufficient detail that they can be understood without reference to the text. Most tables are self-explanatory. Some significant errors in data presentation	Results poorly presented or missing. Graph axes not labelled and units of measurement absent. Legends do not explain the figures in sufficient detail that they can be understood without reference to the text. Tables are not self-explanatory.
Discussion & Conclusion _____ **x 2.5**	Discussion is clear and succinct. Extensive interpretation of the results with reference to previous scientific studies. No re-statement of the results. Main conclusions conveyed in a final paragraph.	Good interpretation of the results, greater reference to previous scientific studies needed. Some re-statement of the results. Main conclusions conveyed in a final paragraph.	Some interpretation of the results, greater reference to previous scientific studies needed. Minor errors in interpretation of the results Some re-statement of the results. Conclusions conveyed in a final paragraph.	Some interpretation of the results, greater reference to previous scientific studies needed. Errors in interpretation of the results Some re-statement of the results. Some conclusions conveyed in a final paragraph.	No interpretation of the results with reference to previous scientific studies given. Results presented. Main conclusions not conveyed in a final paragraph.
Referencing _____ **x 1**	In-text citations and reference list follow BJP conventions. Relevant information selected. A wide range of references used.	In-text citations and reference list follow BJP conventions. Relevant information selected. A wider range of references needed.	In-text citations and reference list follow BJP conventions, with minor errors. Relevant information selected. A wider range of references needed.	In-text citations and/or reference do not follow BJP conventions. Relevant information selected. A wider range of references needed.	BJP conventions not followed. Non-peer reviewed sources used. Information in introduction and discussion not referenced. Wider range of references needed.

Writing Conventions **_____ x 1** **TOTAL /100**	Excellent sentence structure, correct grammar and word usage. Sentences and paragraphs well connected. Appropriate written expression- using discipline specific vocabulary and formal not oral language. Has been proof read.	Good sentence structure, correct grammar and word usage. Sentences and paragraphs well connected. Appropriate written expression- using discipline specific vocabulary and formal not oral language. Proof reading needed to eliminate minor errors.	Good sentence structure, correct grammar and word usage. Sentences and paragraphs not always well connected. Appropriate written expression- better use of discipline specific vocabulary and formal not oral language needed. Proof reading needed to eliminate minor errors.	Poor sentence structure, grammar and word usage. Sentences and paragraphs not well connected. Appropriate written expression- better use of discipline specific vocabulary and formal not oral language needed. Proof reading needed to eliminate errors.	Use of paragraphs and improved sentence structure needed. The report is difficult to read due to poor grammar and word usage. No evidence of proof reading.

Group Assignment

Each group will research the drug design and development process of a given drug and present the information in the form of four individual reports (1000 words each) and a group synopsis (500 words).

The group will (usually) consist of four members. Each member will research one stage of the drug design and development process. These stages are: (A) Target Selection, (B) Lead Discovery, (C) Preclinical Development and (D) Clinical Trials.

Individual report

- The group as a whole needs to decide which person will research each of the four stages of drug design.
- Each team member will write an individual report on their stage of the drug design and development process.
- The word limit is 1000 words, excluding tables, figures legends and references.
- The report should be referenced using in-text referencing in the style of the British Journal of Pharmacology.
- Written assessment tasks must be accompanied by a signed plagiarism form and must be submitted at the BABS.SOMS.BEES (B.S.B.) Student Office, G27 Biosciences Building. An electronic version must also be submitted *via* Moodle through Turnitin.
- The report must be accompanied by the signed Group Evaluation form (p. 26).
- The report is to be submitted by 10 am on the 20th of October, 2014. A penalty will apply for late submissions.

Synopsis

- The group will produce a written synopsis of the drug design and development process of their drug, covering the journey that the drug took from bench to bedside.
- The word limit is 500 words, excluding tables, figures legends and references.
- The synopsis should be referenced using in-text referencing in the style of the British Journal of Pharmacology.
- Written assessment tasks must be accompanied by a signed plagiarism form (signed by all group members) and must be submitted at the BABS.SOMS.BEES (B.S.B.) Student Office, G27 Biosciences Building. An electronic version must also be submitted *via* Moodle through Turnitin.
- The synopsis is to be submitted by 10 am on the 20th of October, 2014. A penalty will apply for late submissions.

Assessment

- The report and synopsis will be worth 15% of your total grade, 10% for the report and 5% for the synopsis.
- The report and the synopsis will be assessed by one of the members of the PHAR3101 lecturing staff (see attached forms).
- You will also give an assessment of how your group has worked and how the group work aspect could be improved (see form on p. 26). **Important: this assessment will not be used to modulate the marks given to each individual for the group synopsis.**

  You will receive a mark depending on the effort you have made to honestly reflect on how your group worked together and on your role in the group.

STAGES OF DRUG DESIGN AND DEVELOPMENT PROCESS

A. Target Selection:
In "Target selection" you should cover the information that the drug design and development team needed to know to start the process *i.e.* the disease they want to treat, what is the patho-physiological basis of it, why was the target chosen (are there other possible targets), what is known about the target (*i.e.* structure, signalling pathways etc), what physiological processes is the target involved in.

B. Lead discovery:
Lead discovery is the next step in the process and includes topics such as lead discovery, lead modification, rational drug design (*i.e.* pharmacophores and QSAR) and screening assays. To research this stage you will need to search for information on the compounds that lead to the final development of your drug of interest.

C. Pre-clinical development:
Pre-clinical development includes a comprehensive account of *in vitro* and *in vivo* studies conducted on your drug. These will include studies in animal models of disease states. Your research should cover how the studies were done, what the drug was compared to *i.e.* placebo or current treatment and the results of these studies. This stage of development also includes toxicology studies and non-human pharmacokinetics and metabolism studies

D. Clinical trials:
The journey from bench to bedside of your drug will end with clinical trials. It may be difficult to find any information on phase 1 and 2 trials as they are often not published. However you may find information on the pharmacokinetics of the drug (this information is generated in phase 1 and sometimes phase 2 trials). This section should summarise what trials were done, what were they comparing (*i.e.* drug *vs.* placebo or drug *vs.* current treatment), the types of patients recruited (*i.e*. the diseases they had, sometimes the one drug is trialled in the treatment of a few different conditions/syndromes etc.), and what were the outcomes (*i.e.* was the drug 10 times better, the same but with fewer side effects etc.), what side effects were reported in the trials. Make sure you only include trials prior to the registration of the drug; often more trials are done post registration for other indications.

INDIVIDUAL REPORT MARKING CRITERIA PHAR3101 S2 2014

Student name/number:_____

Group number & Drug:_____

Stage of the drug design and development process:

(A) Target Selection ☐

(B) Lead Discovery ☐

(C) Preclinical development ☐

(D) Clinical trials ☐

SECTION	COMPONENT PARTS	COMMENTS
Content & structure		
Introduction		
The introduction gives an overview of the whole Stage	**Orientation to topic**. ▪The topic and why it is of interest? **Clearly stated purpose.** ▪ What is the overall purpose of the paper.. **Outline-preview** ▪ How is the report going to be organised? **/5**	
Body of Essay		
Background information	**Clearly introduce**- the pharmacological issues, methods and procedures that related to this stage of the drug design and development process and how it relates to the overall development process. **/30**	
Evaluation of the issues identified from the sources	**Critical evaluation** of the key issues identified and supported by your chosen sources. ▪A balanced and logical presentation that explores the steps taken, challenges faced and outcomes achieved to progress your drug through this phase of the drug design and development process. **/30**	
End of Essay		
Conclusion	**Re-state key findings** and how they relate to the overall drug design and development process. **/10**	

INDIVIDUAL REPORT MARKING CRITERIA PHAR3101 S2 2014

Student name/number:_____

Group number & Drug:_____

Stage of the drug design and development process:

(A) Target Selection ☐

(B) Lead Discovery ☐

(C) Preclinical development ☐

(D) Clinical trials ☐

SECTION	COMPONENT PARTS	COMMENTS
Writing Conventions		
	Overall readability- ▪Sentence structure-correct grammar and word usage. ▪Sentences and paragraphs well connected. ▪Discipline specific – appropriate vocabulary-use of formal not oral language. ▪Has been proof read **/7**	
	Support –sources-evidence BJP **–** ▪**In-text citations and reference list follow conventions.** ▪**Relevant information selected.** **/10**	
Formatting		
	Title page: Course name & number, Topic, student names and numbers, date. **Assignment Presentation:** ▪Neat, margins, 1.5 spacing, 12 point font. Simple staple. Page numbering **/2**	
	Word Limit- ▪1000 words (1000/ stage 4000 total) **/1**	

Additional comments:

Please see over the page

Content & Structure:	/75
Writing Conventions & Formatting:	/20
Assessment of group work	/5
Total:	**/100**

SYNOPSIS MARKING CRITERIA PHAR3101 S2 2014

Group number & Drug:_____

SECTION	COMPONENT PARTS	COMMENTS
Content & structure		
	Orientation to topic. ▪The topic and why it is of interest? **Clearly stated purpose.** ▪ What is the overall purpose of the paper. **Outline-preview** ▪ How is the report going to be organised? **/5**	
	Clearly introduce- the pharmacological issues, methods and procedures that related to the drug design and development process. **/35**	
	Critical evaluation of the key issues identified and supported by your chosen sources. ▪A balanced and logical presentation that explores the steps taken, challenges faced and outcomes achieved to progress your drug through the drug design and development process. **/40**	
Writing conventions & formatting		
	As for the individual assignment (see page 20) (Word limit is 500) **/20**	

Additional comments:

Content & Structure: /80

Writing Conventions & Formatting: /20

Total: /100

Group Evaluation Form

Group number/drug name _____

Instructions: Use the criteria below to evaluate how your group worked together. Because each group member has different strengths and weaknesses, the scores you assign and the comments you make will differ. At the bottom of this sheet, write down any comments you wish to make, such as how the group work could be improved, and sign the form.
This form has to be submitted with your individual report.

Criterion	Group Members			
	A	B	C	myself
Regularly attends meetings				
Is prepared at meetings				
Meets deadlines				
Contributes good ideas				
Effort given to research				
Submits high-quality work				
Listens to other members				
Gives constructive feedback				
Responds to constructive feedback				
Overall assessment of contribution				
Total (/100)				