



Faculty of Medicine
School of Medical Sciences

PHAR 3102

Molecular Pharmacology

COURSE OUTLINE

SESSION 1, 2017

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PHAR3102 Course Information

Molecular Pharmacology (PHAR3102) 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 in a Bachelor of Science or Bachelor of Medical Sciences and as part of the Medicinal Chemistry Program. This course builds on the information you have already gained in Introductory Pharmacology and Toxicology (PHAR2011).

OBJECTIVES OF THE COURSE

This course will examine the molecular basis of drug action and explore how cutting-edge biotechnology and biomedical research can advance pharmacological knowledge, increasing our understanding of how drugs work. The following areas will be studied in detail: genetic variability in drug action, protein structure-activity relationships, receptor-ligand interactions, signal transduction, biochemical and molecular aspects of receptors and their signalling mechanisms. Research and analytical skills will be developed in practical classes.

COURSE CO-ORDINATOR and LECTURERS

Course Coordinator:

Dr Angela Finch

Rm 326 Wallace Wurth Building East ph: 9385 1325

Co-coordinator

Dr Lu Liu

Rm 325 Wallace Wurth Building East ph: 9385 8762

Students wishing to see the course coordinators should make an appointment *via* email as our offices are not readily accessible. We will organize to meet you in a convenient location elsewhere in the building.

Lecturers in this course:

Dr Angela Finch

a.finch@unsw.edu.au

Dr Renate Griffith

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Please read this manual/outline in conjunction with the following pages on the [School of Medical Sciences website](#):

- [Advice for Students](#)
- [Learning Resources](#)

(or see "STUDENTS" tab at medicallsciences.med.unsw.edu.au)

COURSE STRUCTURE and TEACHING STRATEGIES

Learning activities occur on the following days and times:

- Lectures: Tuesday 9-10 am and Wednesday 1-2 pm
- Collaborative Learning Session: Wednesday 9-10 am or 2-3 pm*
- Practicals: Thursday 10 am -1 pm or 2-5pm*

* 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 collaborative learning sessions per week). Students are reminded that UNSW recommends that a 6 units-of-credit course should involve about 150 hours of study and learning activities. The formal learning activities are approximately 72 hours throughout the semester and students are expected (and strongly recommended) to do at least the same number of hours of additional study *i.e.* 6 hours per week.

Lectures will provide you with the concepts and theory essential for an understanding of molecular pharmacology. To assist in the development of research and analytical skills practical classes and collaborative learning sessions will be held. These classes 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 professional development.

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 and challenges students. The teaching is designed to be engaging and relevant in order to prepare students for future careers.

Although the primary source of information for this course is the lecture material, 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 to prepare for practical classes before attendance. 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.

TEXTBOOKS AND OTHER RESOURCES

Due to the cutting edge nature of this course and the rapid advances made in the field of Molecular Pharmacology, a single primary text which adequately covers the content of this course has not been identified. Therefore each lecturer will provide you with additional resources to supplement their lecture material. These resources will take the form of text books, journal articles or web-based resources. If available, links to the electronic form of these resources will be put on the course Moodle page.

Three textbooks have been identified that together cover the majority of the course content. These texts are also available as online resources from the UNSW library

“Pharmacology in drug discovery: understanding drug response” by T. P. Kenakin, will be used as a reference text for lectures given in weeks 4, 7-12.

“Molecular Pharmacology: From DNA to Drug Design” by Dickenson, Freeman, Lloyd Mills, Thode, & Sivasubramaniam, will be used as a reference text for lectures in weeks 1, 2, 5-11.

“General and Molecular Pharmacology: Principles of Drug Action” Edited by Francesco Clementi and Guido Fumagalli, will be used as an additional reference text throughout the course.

STUDENT LEARNING OUTCOMES

PHAR3102 will develop those attributes that the Faculty of Science has identified as important for a Science Graduate to attain and the Learning Objectives of the Pharmacology Major.

Science 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.

Pharmacology Major Learning Outcomes

1. Demonstrate an understanding of how drugs/therapeutics are developed, work and are used safely.
2. Critically analyse, interpret and effectively communicate pharmacology data and literature.
3. Design and/or execute experiments or other activities to address pharmacological scenarios.

On completion of this course students should:

- be able to describe the genomic regulation of drug action
- be able to discuss the molecular pharmacology of receptors, channels and enzymes
- apply their knowledge of molecular biology techniques to the design of an experiment to test a molecular pharmacology hypothesis
- be able to accurately record experimental data and draw conclusions from experimental data
- be able to demonstrate their ability to communicate scientific information effectively to a variety of audiences and in a variety of formats.

ASSESSMENT PROCEDURES

- | | |
|---|------------|
| • Progress exam (40 min duration) | 15% |
| • Laboratory notebook | 10% |
| • Collaborative Learning Activities | 20% |
| • End of session examination (2 hours duration) | 55% |
| • Formative Assessment | |

The *practicals* are provided to support lecture material and practise analytical skills. The practical classes and collaborative learning sessions help you to develop graduate attributes A, B, C, D & E. At the completion of the practical course you will be required to submit your laboratory notebook covering all of the practical sessions.

In the collaborative learning sessions, students will work in teams to research a technique used in molecular pharmacology. They will build a *wiki* and facilitate a *learning activity* in the collaborative learning session. They will then apply this knowledge help in the critical analysis and interpretation of data presented in a journal article. This assessment task will allow you to develop your research, information literacy, critical analysis skills, 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, B, D, E & F).

A penalty will apply for late submissions of assessment tasks (10% per day).

The *progress examination* will be held in the lecture slot on Tuesday the 10th of April. 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 molecular pharmacology of receptors, channels and enzymes, and molecular techniques used in pharmacology but also your ability to apply the knowledge you have acquired from multiple lectures, collaborative learning sessions and practicals to molecular pharmacology scenarios. The examinations may be in the format of MCQ, short and long answer questions. The questions will be based on the material covered in the lectures, practical classes and collaborative learning sessions. 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.

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 UNSW [myExperience](#) survey is the way in which student feedback is evaluated and significant changes to the course will be communicated to subsequent cohorts of students. Also, a staff-student liaison group will 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. Based on feedback given in these meetings changes will be implemented during the course and for future years.

Based on the feedback received; in 2009 and 2010: questions were provided to help focus the reading of journal articles for collaborative learning sessions, the proportion of total marks for the final examination was reduced, marks to encourage participation in collaborative learning sessions were given, smaller practical classes and reduction in the length of each experiment to ensure it can be completed within a three hour practical class were implemented; In 2011: the journal club questions are referenced back to the lectures to a greater extent. Dr Finch has worked with Dr Kenakin to develop a textbook that covers some parts of the course; in 2012: formative quizzes have been added to provide more continual feedback and a new textbook will be trialled; in 2013: the practical manual was revised. In 2014: the order of the topics covered in the collaborative learning sessions has been changed to better match with the lecture content; in 2015: the unannounced 'spot quizzes' are now timetabled quizzes additional information is provided for each wiki topic to help focus the wiki to the most relevant information; in 2017: the final exam has been reduced from 60% to 55% and the weighting of the journal club component of the collaborative learning sessions has also been increased.

GENERAL INFORMATION

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

Professor Margaret Morris is Head of Department and appointments to meet with her may be made via email (m.morris@unsw.edu.au).

There is an honours program conducted by the School. The Honours program is coordinated by Dr Greg Smith (g.smith@unsw.edu.au), Ph: 9385 8075. Any students considering an Honours year should discuss the requirements with the coordinator.

Honours Administrator: Vicky Sawatt (v.sawatt@unsw.edu.au) Ph:9385 8195.

Postgraduate degrees

The Department of Pharmacology offers students the opportunity to enter the following graduate programs:

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

Research Masters: In Pharmacology. Contact the post-graduate co-ordinators A/Prof Pascal Carrive (p.carrive@unsw.edu.au) and Dr Nicole Jones (n.jones@unsw.edu.au)

Doctorate (Ph.D): In Pharmacology. Contact the post-graduate co-ordinators A/Prof Pascal Carrive (p.carrive@unsw.edu.au) and Dr Nicole Jones (n.jones@unsw.edu.au)

Enrolment and administrative help

The Student Administration Officers are available to help with problems with enrolment and scheduling, and should be the first point of contact for administrative problems. They can be found in the BSB Student Office, Room G27, Ground floor of the BioSciences Building. ph:9385 2464,

Email: SOMSenquiries@unsw.edu.au

Attendance Requirements

For details on the Policy on Class Attendance and Absence see [Advice for Students](#) and the [Policy on Class Attendance and Absence](#).

Attendance at practical classes is compulsory, and must be recorded in the class roll at the start of each 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 an additional practical assessment exam or ineligibility to pass the course. Students who miss practical classes due to illness or for other reasons must submit a copy of medical certificates or other documentation to the course coordinator.

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.

Students must take due care with biological and hazardous material and make sure all equipment is left clean and functional. 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.

For more details see [Advice for Students-Practical Classes](#)

Special Consideration

Please see [UNSW-Special Consideration](#) and [Student Advice-Special Consideration](#)

The supplementary exams for the School of Medical Sciences in Semester 1, 2017 will be held on the 12th-14th July, 2017. (TO BE CONFIRMED)

If you unavoidably miss the progress exam in PHAR3102, you must lodge an application with UNSW Student Central for special consideration. If your request for consideration is granted an alternative assessment will be organised which may take the form of a supplementary exam or increased weighting of the final exam.

Student Support Services

Details of the available student support services can be found at [Student Advice-Student support services](#).

Appeal Procedures

Details can be found at [Student-Advice-Reviews and Appeals](#)

Academic Integrity and Plagiarism

The School of Medical Sciences will not tolerate plagiarism in submitted written work. The University regards this as academic misconduct and imposes severe penalties. Evidence of plagiarism in submitted assignments, etc. will be thoroughly investigated and may be penalized by the award of a score of zero for the assessable work. Flagrant plagiarism will be directly referred to the Division of the Registrar for disciplinary action under UNSW rules.

The [UNSW Student Code](#) outlines the standard of conduct expected of students with respect to their academic integrity and plagiarism.

More details of what constitutes plagiarism can be found [here](#)

LECTURE and PRACTICAL OUTLINES

The course timetable is appended at the end of these notes

The course is divided into 4 main themes covering the molecular basis of drug action.

- Genomic Regulation of Drug Actions
- Molecular Pharmacology of Receptors, Channels and Enzymes
- Signal Transduction and Modulation
- Receptor Theory

Genomic Regulation of Drug Actions

Pharmacogenetics and Pharmacogenomics

The concept of pharmacogenetics and pharmacogenomics will be covered in these lectures. The types of genetic mutations: single nucleotide polymorphisms; tandem repeat polymorphisms; gene insertion and deletion; gene duplications; alternative splicing and their effects on drug targets will be explored. The influence of genetic background on drug efficacy and the use of pharmacogenomics to individualise therapy will also be covered.

Pharmacogenetics: Practical

In this practical we will investigate the role polymorphisms of cytochrome *P450 2D6* play in inter-individual differences in drug metabolism and their contribution to either a lack of efficacy or adverse side effects of drugs. To identify these polymorphisms, we will be using publicly accessible databases, other computer based techniques and data obtained from PCR.

The Regulation of Gene Transcription

This lecture will briefly discuss the process of gene transcription and go on to examine transcription factors in more detail – including their different structures and roles in biological functions such as development, responses to environmental stimuli (e.g. heat or low oxygen), and gene transcription. A number of examples of therapeutic agents that can act by modulating gene transcription – including hormones acting at nuclear receptors, will be discussed.

Pharmacological Regulation of Gene Expression: Practical

Drug induced changes of gene expression of transcription factors will be examined. Techniques learnt include tissue/cell culture, RNA isolation, RNA quantification, RT-PCR and gel electrophoresis. Primer design will also be introduced.

Molecular Pharmacology of Enzymes, Channels and Receptors

Protein Structure and Receptor-Ligand Interactions

In this lecture we will review the non-covalent interactions underlying the molecular recognition between a protein ('receptor') and a small molecule ('ligand'). We will focus on the relationships between affinity and specificity, enthalpy and entropy and these non-covalent interactions. We will also review the basics of protein structure, including the structure and properties of amino acid side chains and the four levels of protein architecture, primary through to quaternary structure. We will focus on the importance of non-covalent interactions in protein structure.

How Enzymes Work

This lecture will cover general principles of how enzymes work including; catalytic transition state, binding energy and reaction specificity, equilibrium constant and enzyme kinetics (the Michaelis-Menten equation).

Drug Modulation of Enzyme Function

This lecture will cover the basic principles of how drugs modulate enzyme activity including competitive, non-competitive and uncompetitive inhibition. A brief overview of analytical techniques used in enzyme activity characterisation will also be given.

Voltage-gated ion channels

This lecture introduces the families of voltage-gated channels and identifies the key organs where they have an important role (e.g. nervous system, heart, skeletal muscle). The main structural domains of the voltage-gated ion channels with respect to the crystal structures that are available and how they relate to the experimental evidence for function will be discussed. We will relate these structural domains to common drug actions. Introduces the idea of ion channels as 'enzymes' where the product is the conduction of ions across the cells membrane.

Ligand-gated ion channels

This lecture introduces the families of ligand-gated ion channels. The main structural domains with respect to the crystal structures available and how they relate to the experimental evidence for function will be discussed. We will discuss some key actions of ligand-gated ion channels (e.g. neurotransmission), how they are altered by common drug actions, and the kinetic mechanism of the actions.

Catalytic Receptors

This lecture introduces the catalytic receptors, covering the five main types of catalytic receptors. The main structural features of catalytic receptors and how they relate to function of these receptors will be examined. The signalling pathways of each main types of catalytic receptors and how signalling is regulated will also be discussed.

G-Protein Coupled Receptors (GPCRs)

This lecture will provide an introduction to the six G-protein coupled receptors (GPCR) families. It will explore the structural similarities and diversity between these families. Representative members from each family will be examined in more detail. The role of receptor dimerisation and receptor activity modifying proteins (RAMPs) in producing different receptor phenotypes will also be covered.

GPCRs: Role of Structural Motifs in Binding, Activation and Regulation of Signalling

This lecture will take a more detail look at the key structural regions of GPCRs and their role in receptor activation and regulation. The structural regions examined will include the N-terminus, extracellular loops, specific transmembrane helices, the DRY motif, the NPXXY motif, intracellular loops and tails.

Signal Transduction and Modulation

Second Messengers

This lecture will review the types of second messenger molecules. Several examples of second messenger systems, including: the phosphoinositol, Ca^{2+} , cAMP, cGMP and arachidonic acid systems will be covered. The main signal transduction pathways used by GPCRs and catalytic receptors will be introduced in this lecture and the role of second messengers as drug targets will be explored.

Guanine Nucleotide-Binding Proteins (G-proteins)

This lecture will review the members of the G-protein superfamily. It will explore the structural characteristics of this family and the mechanisms of G-protein activation and regulation, including the GTPase and GTP switch. G-protein dependent signalling pathways will be covered. The role of G-proteins in disease will be discussed.

Regulation of GPCR Signalling

Mechanisms by which receptor desensitisation occurs, including internalisation, phosphorylation, binding of β -arrestins, and degradation will be covered. The role of homologous and heterologous in receptor regulation will be explored. Some of the key enzymes involved in modulation of signalling include; second messenger dependant kinases, G-protein receptor kinases, regulators of G protein signaling (RGS) proteins and guanine nucleotide exchange factors (GEFs) that facilitate GDP dissociation, GTPase activating proteins (GAPs) that stimulate GTP hydrolysis and guanine dissociation inhibitors (GDIs). The function and regulation of these enzymes will be covered.

Receptor Internalisation & Alternative Signalling Pathways

Ligand mediated receptor endocytosis and the regulation of this process will be discussed. The role of RAB and ARF proteins and other small GTP-binding proteins that control trafficking and the role of ubiquitylation in the process will be covered. The classification of desensitisation of GPCRs into Class A and Class B and the role of internalisation in non-G-protein mediated receptor signalling will also be discussed.

Receptor Signalling: Practical

This practical will examine the ability of the β_2 adrenergic receptor to activate extracellular signal-regulated kinase (ERK) via G-protein dependent and independent pathways.

Receptor Theory

Advanced Pharmacodynamics

The pharmacological concept of potency, efficacy, pD_2 , pA_2 will be reviewed. The calculation of pD_2 and pA_2 values from concentration-response curves of agonists and antagonists will be covered. Factors affecting pharmacodynamic variability and the role of this variability in drug efficacy and toxicity will be discussed.

Determining Antagonist Potency: Practical

In this computer-aided practical the antagonist potency of mepyramine against histamine-induced contractile responses of guinea-pig ileum will be determined. EC_{50} values will be obtained from concentration-response curves generated by semi-log paper and Prism. The antagonist pA_2 value will be calculated using the Arunklakshana & Schild method.

Constitutively Active Receptors and Inverse Agonists:

The concept of constitutively active receptors will be discussed in this lecture. Examples of wide-type receptors, naturally occurring receptor mutants, receptor variants created by site-directed mutagenesis, showing constitutive activity will be covered. The concept of inverse agonism and its discovery through molecular pharmacology techniques will be discussed. Examples of inverse agonists will be given and their potential as therapeutics will be discussed.

Allosteric Modulators:

This lecture will cover the principles of receptor allosteric modulation. The concepts of allosteric versus orthosteric binding sites will be explored. The allosteric mechanisms in activation of enzymes, ligand-gated channels and receptor will be covered. The role of allosteric sites as novel drug targets will be explored.

Signalling-Bias.

Signalling-bias (also called; ligand-directed signalling, functional selectivity, agonist-directed trafficking, biased agonism, or protean agonism) describes the observation that different ligands acting on the same receptor cause different patterns of response. These observations have led to a change in the concept of the receptor as either off or on but rather existing in a spectrum of conformational states each of which gives rise to a different signalling outcome. This lecture will explore these concepts and the influence they have on drug development.

Receptor Theory

Since the 1920's models have been developed to assist in the understanding of the complex events that occur upon ligand binding to receptor. The first simple model was the two-state model, however with advances in pharmacology (such as molecular pharmacology) this model could no longer explain the results obtained, this led to the development of more complex models; including the Occupational and Operational models of agonist action followed by the Ternary complex model and the Cubic ternary complex model. These lectures will discuss the development of these models and examine specific examples of experimental results which support the receptor states described by these models. The Induction versus Conformational Selection hypotheses of ligand action will also be covered.

New concepts in Pharmacology

In this lecture we will discuss the emerging concepts in receptor pharmacology that are currently being published and debated at scientific meetings, including orphan receptors and drug discovery for these receptors.

TIMETABLE

Wk	starting	Lecture Tues 9-10am Mat D	Lecture Wed 1-2pm WWLG03	Collaborative Learning Wed 9-10am WWLG03 or Wed 2-3pm Morven Brown G6	Practical Thurs 10-1 or 2-5pm Wallace Wurth 120
1	27/2	Pharmacogenetics/genomics I (L Liu)	Pharmacogenetics/genomics II (L Liu)	Introduction to Collaborative Learning Sessions	Molecular Pharmacology Workshop (AF)
2	6/3	Nuclear Receptors/Transcription Factors (N Jones)	Protein Structure & Receptor-Ligand Interactions (R Griffith)	Microarray/ siRNA	Pharmacogenetics (AF)
3	13/3	Enzymes (R Griffith)	Enzyme Modulation (R Griffith)	Journal Club	Pharmacological Regulation of Gene Expression (Part A) (LL)
4	20/3	Channels (T Lewis)	Channels (T Lewis)	Genetically Engineered Animals/ Reporter Gene Assays	Pharmacological Regulation of Gene Expression (Part B) (LL)
5	27/3	Catalytic Receptors (A Finch)	GPCRs: Introduction to Families A, B, C & F (A Finch)	Journal Club	Pharmacological Regulation of Gene Expression (Part C) (LL)
6	3/4	GPCRs: Role of Structural Motifs in Binding, Activation and Regulation of Signalling (A Finch)	Second Messengers (L Liu)	Protein Crystallography/Receptor binding assays	Pharmacological Regulation of Gene Expression (Part D) (LL)
7	10/4	Progress Exam	G-proteins (L Liu)	Journal Club	Receptor Signalling (Part A) (AF)
Mid-Semester Break					
8	24/4	ANZAC DAY	Regulation of GPCR Signalling (L Liu)	Careers in Pharmacology Workshop	Receptor Signalling (Part B) (AF)
9	1/5	Receptor Internalisation & Alternative Signalling Pathways (A Finch)	Allosteric Modulators (A Finch)	Bioluminescence Resonance Energy Transfer/ Confocal Microscopy	Receptor Signalling (Part C) (AF)
10	8/5	Constitutive Active Receptors (L Liu)	Advanced Pharmacodynamics (L Liu)	Journal Club	Receptor Signalling (Part D) (AF)
11	15/5	Signalling Bias (A Finch)	Receptor Theory I (A Finch)	Calcium signalling/ cAMP Assays	Determining Antagonist Potency (LL)
12	22/5	Receptor Theory II (A Finch)	New concepts in Mol. Pharmacology (N. Smith)	Journal Club	Advanced Pharmacodynamics (LL)
13	29/5	Exam Revision			

ASSESSMENT TASKS

Task	Due Date
Collaborative Learning Session Assessment:	
<i>Part 1a:</i> Molecular Techniques Wiki feedback meeting	No later than one week before due date
<i>Part 1b:</i> Molecular Techniques Wiki	9 am the Monday of the week of scheduled presentation
<i>Part 2:</i> Learning Activity	During assigned collaborative learning session
<i>Part 3a:</i> Journal club notes	Prior to the start of each collaborative learning session where assigned
<i>Part 3b:</i> Evidence of Critical Analysis Skills Development	Friday, 2 nd June, 9am
Open-book Quizzes	In practical class in weeks 4, 6, 9 & 12
Progress Exam	Tuesday, 11 th April, 9 am
Laboratory Notebook	Monday 22 nd May, 10am
Final Examination	Official exam period

Formative Assessment

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.

Open Book Quizzes.

Four times in the semester, during a practical class, a 15 minute open-book quiz will be given. This quiz will be a mixture of MCQ and short answer questions. You will be able to use your lecture notes (slides and your handwritten notes) and other notes you have made from textbooks and other additional reading suggested by your lecturers.

Exams

The questions will be based on the material covered in the lectures, practical classes and collaborative learning sessions.

Progress examination (15%) will be held in the lecture slot at **9am on Tuesday the 10th of April**. This exam will give you feedback on how you are succeeding in the course. This examination consists of two parts (A & B):

- Part A consists of 12 multiple choice questions, each worth 2 marks.
- Part B consists of 5 short answer questions, each worth 5 marks Answer ALL of these questions.

Final Examination (55%)

The examination consists of three parts (A, B & C)

- Part A consists of 20 multiple choice questions, each worth 2 marks.
- Part B consists of 6 short answer questions, each worth 10 marks. Answer 4 of these questions. If you answer more than 4 questions, only the first 4 will be marked

- Part C consists of 4 long answer questions, each worth 20 marks. Answer 2 of these questions. If you answer more than 2 questions, only the first 2 will be marked

Material covered prior to the progress exam may be again examined in the final exam

Laboratory Notebook (10%)

You will be required to keep a laboratory notebook for all practical classes in this course. Keeping a laboratory notebook is an important skill for every scientist to develop. Laboratory notebooks are a complete record of all the procedures carried out and data collected for each experiment. Enough detail needs to be recorded so as someone could reproduce your experiment at a later date. A laboratory notebook is a legal document and as such certain conventions and procedures must be followed.

The requirements for laboratory notebooks are given below:

- The lab notebook must be a bound book and not a spiral notebook or loose sheets in a folder
- The first 2 pages should be reserved for a table of contents
- Each page is numbered
- All entries are to be made in blue or black ink.
- Never remove any pages from your laboratory notebook.
- All information should be recorded directly into your notebook. Write down in detail what you do for each step of the experiment and record your results as you obtain them. Graph, films, printouts etc. should be stuck directly into your notebook. Do not record data or calculations on scraps of paper and later copy them into your book. Whilst your laboratory notebook should be legible and as neat as possible it is more important that you record all the information.
- If you make a mistake strike it through with a single line and initial and date the correction. Do not use correction fluid or scribble out the mistake. The mistake should still be readable as sometimes you will realize that the entry was not a mistake after all and will want to be able to read it.
- Do not skip pages in your laboratory notebook (for example to allow space for data that will be collected later) instead make reference such as "continued from page 2" or "continued on page 5". You can start a new a new experiment on a new page however any blank space on the preceding page must have an X put through it.
- Each entry in the laboratory notebook should begin with the date, the title and a brief description of the aims of the experiment.
- At the end of each day your laboratory notebook should be signed and dated by a witness (*i.e.* a demonstrator)

The following information should be recorded in your laboratory notebook for each experiment:

To be completed before you come to class:

1. A brief and informative title.
2. The aims of the experiment.

This section should clearly and concisely describe the purpose of the experiment (two or three sentences maximum) in your own words, explaining what the question is that you

are asking (your hypothesis) and the methods you are using to answer your question. *N.B. This only needs to be done once for multi-week experiments.*

3. Preparation calculations for each practical

To be completed during the class:

4. A concise step by step description of what you actually do when performing the experiment (this should be in point form).

The protocol should contain enough information to allow another researcher to repeat what you've done. If you reference the lab manual, you need to be specific and record which pages you are referring to. Also, if you did the experiment differently to what is written in the lab manual, you need to indicate this. Key information such as centrifuge speeds, temperatures, master mix recipes, incubation times and concentrations, along with notes on major deviations from the manual/protocol needed to be recorded. Extraneous information like telling the reader you were labelling tubes should not be included. It is OK to note what is in each tube and its label, but you don't need to tell us you wrote a label on the tubes.

5. Record any calculations you have done

6. Any observations (e.g. gel has a bubble, not all the sample loaded, current not stable).

7. All data collected with correct units, titles and labelled axes on graphs, and titles and labels for all drawings, films and printouts.

To be completed at the end of the experiment:

8. A summary of your findings and conclusions (two or three sentences maximum, this can be in point form).

How do your findings relate to your original aims/hypothesis? If the results were not as expected, suggest possible reasons for this. How do your findings relate to other studies in the scientific literature? *N.B. This only needs to be done once for multi-week experiments.*

Laboratory Notebooks are due before **10am, Monday 22nd May**. Laboratory notebooks are to be submitted at the BABS.SOMS.BEES (B.S.B.) Student Office, G27 Biosciences Building. You will need to staple or use sticky-tape to attach the Assessment Cover Sheet to the front cover of your book.

Marking Criteria – Laboratory Notebook

Criteria	<i>Excellent</i> >8.5	<i>Very Good</i> 8.4-7.5	<i>Good</i> 7.4-6.5	<i>Needs Improvement</i> 6.4-5.0	<i>Unacceptable</i> <5.0
Organisation _____ /10 x 0.5	Each experiment has a title and date and appears in the table of contents. Errors are neatly struck through, no correction fluid used. All entries in pen. Each page numbered. Each day is initialled.	Each experiment has a title and date and appears in the table of contents. Most errors are neatly struck through. All entries in pen. Each page numbered. Each day is initialled.	All but one experiment has a title and date and appears in the table of contents. Some errors are not neatly struck through. Some entries not in pen. Each page numbered. Each day is initialled.	Not all experiments have a title and date and appear in the table of contents. Not all errors are neatly struck through. Not all entries are in pen or each page numbered. One day not initialled.	Experiments lack a title and date and don't appear in the table of contents. Errors are not neatly struck through. Entries not in pen. Page numbers lacking. More than one day is not initialled.
Safety _____ /10 x 0.5	All safety summaries attached and signed.	8-9 safety summaries attached and signed.	6-7 safety summaries attached and signed.	6-5 safety summaries attached and signed	>50% of safety summaries not attached and/or signed.
Aims _____ /10 x2	The aims of each experiment or the questions to be answered is clearly identified and stated.	The aims of each experiment or the questions to be answered are stated.	The aims of most experiments or the questions to be answered are identified but more detail needed.	The aims of some experiments or the questions to be answered are partially identified, however more details are needed.	The majority of the aims of each experiment or the questions to be answered are not given.
Experimental protocol _____ /10 x2	The protocol for each experiment is succinctly described with all key information included. All calculations are correct.	The protocol for each experiment is described with all key information included. Only minor errors in calculations.	The protocol for each experiment is described however, key information missing in some experiments. A few errors in calculations.	Describes how the experiments were done, but key information missing. Errors in calculations.	Does not accurately describe how the experiments were done. Calculations are incorrect or missing.
Data _____ /10 x2.5	All data collected are presented. The data are clearly labelled. Correct units are given.	All data collected are presented. The data are clearly labelled with minor omissions. Minor errors in units given.	Data collected are presented and clearly labelled but with minor omissions. Errors in units given.	Some data not presented or not labelled. Errors in units.	Most of the data collected not presented. The data are not labelled. Correct units not used.
Conclusions _____ /10 x2.5	Clear and concise conclusions given. Conclusions are valid and supported by appropriate reference(s).	Clear conclusions are given. Conclusions are mostly valid and supported by appropriate reference(s).	Conclusions are given. Minor errors in conclusions. Appropriate references needed.	Conclusions are given for most experiments. Some conclusions are not valid and or not supported by appropriate reference(s).	Conclusions do not accurately describe the results of the experiments or are not presented for the majority of experiments.

Collaborative Learning Session (CLS) (20%)

Overview

Publishing a scientific paper is the primary way that a scientist contributes new knowledge or methods to the scientific community. Collectively, these journal articles chronicle advances in science and technology. Without this foundation of work—whether a seminal contribution or a simple finding—future experiments would have no context and scientific research could not progress. Thus, understanding the literature is vital to understanding scientific research. It is important to realise that it is not uncommon for scientists not to agree with the interpretation and conclusions that the authors of papers make and that it is important to draw our own conclusion about the data. Unfortunately in this digital era there are also less than reputable publishers that don't conduct proper peer review and publish articles that are not scientifically sound, we all need to sharpen our critical analysis skills so we can spot these.

To understand scientific literature, however, it is important to know what tools and techniques scientists use to ask and answer questions. Over the course of the semester, you will explore several molecular biology techniques that are essential to understanding the scientific papers publish in the area of molecular pharmacology. Each student team will design and lead an exploration of a laboratory technique that is found in the papers to be discussed in each “journal club” collaborative learning session.

The learning objectives of the collaborative learning sessions (CLS) are for you to develop the skills and confidence in interpreting and critically evaluating data presented in scientific articles

Part 1: Make a wiki about the technique

To help your classmates prepare for the activity you will design, your group will write a wiki about the technique that contains the following information:

- **How the technique works.** For example, describe the materials needed or provide an annotated diagram of the important steps involved, or the molecular process that occur during each step of the technique.
- **How the technique is used.** Include a description of what type of information this technique provides and what types of questions can be answered using the technique.
- Two **Hypotheses** that could be tested using this technique and two hypotheses that could not be tested using this technique. Include an explanation of why they can or cannot be tested using this technique.
- **Benefits and limitations of the technique.**
- **References.** List any resources that your group used to develop the fact sheet or in-class activity, and highlight other important resources where your classmates can find more information.

The Wiki should not be longer than 1000 words. Each member of the group must write and/or edit a minimum of 100 words. Contributions of less than this will result in a grade of 0/5%. Each member must log onto Moodle themselves; if you use someone else's log-on, or work collaboratively outside Moodle your contribution will not be recognised.

Researching your assigned technique

Places to look for general information:

- Textbooks
- Internet: Beware that not all sites will be accurate! Good information can usually be found at university websites, textbook publishers and scientific company websites (*be aware that they are trying to sell their product so they are putting a positive spin on the information presented*).

Places to look for specific information:

- The library has many books covering molecular biology techniques
- The [Current Protocols](#) series of books are available in the library and electronically via the library catalogue. This series includes: Current Protocols in Molecular Biology, Current Protocols in Pharmacology, Current Protocols in Nucleic Acid Chemistry, Current Protocols in Human Genetics, Current Protocols in Bioinformatics, Current Protocols in Protein Science.
- Scientific literature (*hint: limit your search to reviews or methods journals*)
- Journal Websites such as: [Nature Methods](#), [Molecular Pharmacology](#), [Trends in Pharmaceutical Sciences](#), [Cell](#), [Science Signaling](#),

Part 2: Design and lead an in-class activity

Each team will work together to design and lead an in-class activity that will:

1. Actively engage your classmates in learning about the technique.
2. Help your classmates determine how well they understand the technique.

The entire activity should take no more than 15 minutes. After the activity, plan to spend 5 minutes to tie everything together and answer any questions your classmates might have. Altogether, you will have 20 minutes of collaborative learning session time, so use it wisely.

Some ideas for activities

- **Interpret data from an experiment** that employs the technique. Develop a series of key questions that will encourage discussion about what conclusions can be drawn from those data.
- **Sequence the important steps in the technique.** Diagram each step on a separate sheet of paper. Have groups of students describe what is happening at each step, arrange the diagrams into the correct order, and explain why they ordered the steps in that way.
- **Act out the important steps of the technique.** Provide materials for your classmates to serve as critical molecules, reactions, or other “players” in technique, then have each person describe what their role is, and have the entire class act out the technique. Discuss key points afterwards.
- **Solve a scenario where the technique is done or used incorrectly** (e.g. steps missing or out of order, or incorrect conclusions drawn from an experiment). Have your classmates work together to determine the correct order of the steps, propose more appropriate conclusions (and justify their answers), or answer questions about the scenario.
- **Compare and contrast.** Have classmates compare and contrast your technique with another related technique. Give your classmates a set of scientific questions and have each group decide which technique to use for each and explain their decisions.

Part 3: Critical analysis skills development

Journal Club

A journal article that uses the techniques learnt about the previous week and the questions that will step your thorough interpreting and critically evaluating the data will be posted on Moodle. You need to submit your answers to the questions to your collection prior to the start of the collaborative learning session. In the collaborative learning session as a class we will step through interpreting and critically evaluating the data presented in article assigned for journal club.

Collection of evidence of critical analysis skills development

You will make a collection of evidence to show your critical analysis skills development. This collection of work will show your progress over time. The collection should include your answers to the journal club questions. It could also include how well you did in the critical analysis question on the quizzes and how you have applied the skills you have learnt to other assessment tasks or situations.

Evidence of Critical Analysis Skills Development (10%)

You will submit a statement of evidence of critical analysis skills development. This statement should not exceed 500 words. In your statement you should describe your progress and achievements in regards to the activities we have done in the CLS and how your critical analysis skills have developed. As part of your statement you should identify the best journal club analysis you did. This example of your critical analysis skills will be marked. Below is a list of some prompts to get you started on reflecting on your progress and achievements.

- Has your learning trajectory been linear or were there ups and downs?
- What were the challenges and difficult experiences?
- What, how, when did you learn?
- How have the tasks in the CLS help you achieve the learning outcomes of the course?
- How have you applied what you learnt in CLS to other situations?
- What are your strengths and weaknesses in regards to critical analysis skills?
- What areas of further skill development do you need to work on?

TIMELINE (what is due when):

Draft wiki at least one week before your wiki is due (1%)

Organise a time to meet with the course coordinator that suits the majority of the team. Complete the draft of the wiki at least 24h before the meeting. The coordinator will review your draft of the wiki and a description of your activity (and any accompanying visual aids, worksheets etc.) and feedback and suggestions for improvement will be given in this meeting.

Final wiki on the Monday before you present (4%)

The coordinator will open your wiki for viewing by the whole course at 9am Monday so that your classmates can study it before the collaborative learning session.

Learning activity during collaborative learning session (5%)

- Introduce the activity, give instructions
- Guide classmates in completing the activity
- Wrap-up; tie everything together and answer questions
- Do not give a "lecture" on the topic as the rest of the class will have covered that prior to the class by reading your wiki

What to do on the weeks another team will be presenting:

Study the wiki to familiarise yourself with the technique so that you can participate meaningfully in the planned activity. You should come to class prepared to discuss any of the

information found in the wiki and how the technique is used in the paper for discussion in the next journal club.

Journal Club

You need to submit your answers to the questions to your collection prior to the start of the collaborative learning session. This will form part of your evidence of critical analysis skills development. You should also bring a copy of the paper and your answers to the collaborative learning session.

Collection of evidence of critical analysis skills development

You should work on building this collection throughout the semester. To aid in writing your statement of development you can also use this as a place to record moments that significantly enhanced your learning or challenges you faced.

Evidence of Critical Analysis Skills Development (10%)

Your statement of development is due on **Friday the 2nd June at 9am**. After you have completed the final journal club CLS you will need to go back and look at your collection and select the journal club that shows your best critical analysis and interpretation of the data. You will then write about your progress and achievements in regards to the activities we have done in the CLS and how your critical analysis skills have developed.

Marking Criteria Part 1– Molecular Techniques Wiki

Criteria	Excellent (>8.5)	Very Good (8.4-7.5)	Good (7.4-6.5)	Needs Improvement (6.4-5.0)	Unacceptable (<5.0)
Completeness _____/10 x1.5	The wiki contains all assigned elements and all details necessary to fully explain the technique. Your wiki can stand alone for the readers to use as a comprehensive source of information on the technique.	The wiki contains all assigned elements, but lacks a few minor details. Your wiki provides readers with most of what they should know about the technique but could be more comprehensive.	The wiki contains all assigned elements, but lacks some details. Your wiki provides readers with most of what they should know about the technique but lacks a key detail.	The wiki contains all assigned elements but lacks important details. Your wiki provides a general overview, but readers would need to look elsewhere to fill in the gaps.	One or more assigned elements are missing or incomplete. Your wiki lacks key information needed to give the reader a basic understanding of the technique.
Accuracy _____/10 x1.5	All information included in the wiki is accurate. The reader can confidently rely on the wiki as a source of information about the technique.	The information is accurate except for a few minor errors. The wiki is useful as a resource but may mislead the readers on a few small details.	The information is accurate except for a few minor errors. The wiki is useful as a resource but may mislead the readers with some details.	The information contains several errors. While no significant errors are made, the wiki contains enough errors to detract from its usefulness as a source of information about the technique.	A significant error is made that causes confusion. The reader cannot depend on your work as a reliable source of information about the technique.
Clarity _____/10 x 1.5	The wiki is well written and easy to read. All terms are clearly defined and topics are fully explained. Your writing allows readers to easily understand the meaning of all points presented.	The majority of the wiki is well written and easy to read, but a few minor terms or details are unclear. Your writing allows readers to understand the meaning of all points presented.	The majority of the wiki is well written and easy to read, but some terms or details are unclear. Your writing requires readers to infer your meaning regarding a few details.	Some parts are unclear or poorly written. The lack of clarity in your writing is distracting to readers and causes them to question your meaning, but they can still draw appropriate conclusions with some effort.	Major portions or key details of the wiki are unclear or poorly written. Your writing is unclear enough to cause the reader to misinterpret your meaning, leading to confusion about the technique.
Creativity _____/10 x 1.5	The wiki makes optimal use of visual aids or other creative elements (pictures, drawings, flow charts, figures, etc.) to illustrate key points of the technique. Your creativity greatly enhances your wiki as a learning tool and provides additional means for the reader to gain understanding about the technique beyond what is stated in the text.	The wiki makes use of visual aids or other creative elements to illustrate key points of the technique. Your creativity enhances your wiki as a learning tool and allows the reader to gain greater understanding about the technique.	The wiki includes visual aids or other creative elements to illustrate the technique, but they are not original or inclusive of details specific to the technique. The readers gain something from the aids but may have trouble visualizing or fully understanding parts of the technique.	The wiki includes pictures or diagrams, but they do not contribute to the readers' understanding of the technique.	Visual aids or creative elements are not used. The reader does not gain a full sense of the technique from your information sheet.
First draft _____/10 x 2	The first draft was complete. No coordinator contribution needed to bring wiki up to minimal required standard. Minor corrections needed	The first draft was complete. Minor coordinator contribution needed to bring wiki up to minimal required standard. Some corrections required.	The first draft was complete. Some coordinator contribution needed to bring wiki up to minimal required standard. Significant corrections required.	The first draft was incomplete. Significant coordinator contribution needed to bring wiki up to minimal required standard. Major corrections required.	Large amount of coordinator contribution needed to bring wiki up to minimal required standard. Extensive corrections required.
Evidence of Collaboration Writing Process _____/10 x 1	Revision history indicates substantial team collaboration. Extensive discussion, drafting, editing, and revision were evident throughout the collaboration.	Revision history indicates team collaboration. Discussion, drafting, editing, and revision were evident throughout the collaboration	Revision history shows some evidence of team collaboration. Some evidence of drafting, editing, writing, and revising in the final product.	Revision history indicates little team collaboration. Very little evidence of a drafting, editing, writing, and revision process	The revision history indicates no team collaboration. No evidence of a drafting, editing, writing, and revision process.
Individual contribution to the wiki _____/10 x 1	Contributes extensively to the researching, writing, and editing. Shows appropriate wiki etiquette when editing and respects the work of others	Contributes to the researching, writing, and editing. Shows appropriate wiki etiquette when editing and respects the work of others.	Contributes to the researching, writing or editing. Displays appropriate wiki etiquette most of the time and generally respects the work of others	Provides minimal contribution to the researching, writing and editing. Displays appropriate wiki etiquette some of the time but often fails to respect the work of others	Does not contribute to the researching, writing and editing (<100 words).

Marking Criteria Part 2– Molecular Techniques Learning Activity

Criteria	<i>Excellent</i> (>8.5)	<i>Very Good</i> (8.4-7.5)	<i>Good</i> (7.4-6.5)	<i>Needs Improvement</i> (6.4-5.0)	<i>Unacceptable</i> (<5.0)
Choice of content _____/10 x3	The activity addresses key or difficult aspects of the technique. Your classmates will leave with a deeper understanding or reinforced knowledge of the technique.	The activity addresses an important aspect of the technique. Your classmates will learn about the technique but would benefit more from a more in depth choice of content.	The activity addresses an important aspect of the technique, but not the most important or difficult aspects. Your classmates will learn something about the technique but would benefit more from a different choice of content.	The activity addresses a minor or easily understood aspect of the technique. This will not help further their understanding of the technique beyond what they could easily grasp on their own.	The activity does not address any important details of the technique or its uses. Your classmates will not learn from it.
Knowledge of the technique _____/10 x3	The presenters serve as experts on the technique. The content of the activity is clear and accurate, and the team is able to provide thorough and accurate answers to all reasonable questions raised by the class. Your classmates can depend on you to teach them all they need to know about the technique.	The presenters are knowledgeable about the technique. The content of the activity is clear and accurate. The team is able to accurately answer most reasonable questions raised by the class without assistance. You are able to give your classmates a sound knowledge of the technique.	The presenters have some knowledge of the technique. The content of the activity is clear and mostly accurate. The team is able to answer most reasonable questions raised by the class but requires assistance from the instructor in some cases. You are able to teach your classmates most of what they need to know about the technique.	The presenters know a little more about the technique than their classmates. Some content of the activity is unclear or inaccurate, or the team is only able to answer basic questions raised by their classmates about the technique. Your classmates cannot depend on you to teach them much about the technique.	The presenters do not understand the technique themselves. Much of the content of the activity is inaccurate or vague, or the team cannot answer basic questions about the technique. Your lack of preparation causes confusion for your classmates.
Activity design _____/10 x3	The chosen activity engages all members of the class in learning about the technique. The activity is well-designed, creative, and generates useful discussion. Your classmates will gain something from the activity beyond what they would gain from simply reading the information sheet.	The chosen activity engages all members of the class in learning about the technique and generates good discussion. Your classmates will learn from the activity, but would benefit from a more creative format.	The chosen activity engages most members of the class in learning about the technique and generates some discussion but lacks originality. Your classmates will learn from the activity, but would benefit from a more engaging format or better planned activity	The chosen activity engages the class in learning about the technique but is not well-designed or does not generate useful discussion. Poor planning reduces the effectiveness of the activity in helping your classmates learn about the technique.	The chosen activity does not engage the class in learning about the technique. Your classmates could learn the information just as well by reading the information sheet.
Team participation (team graded as a whole) _____/10 x1	All members of the presenting team work together to lead the activity and make sure it runs smoothly and all members of the team are willing and able to answer questions about the technique. Everyone contributes equally and works as a team.	All members of the presenting team participate in leading the activity and are willing and able to answer questions about the technique, but all do not contribute equally.	All members of the presenting team participate in leading the activity and are able to answer questions about the technique, however, the members of the team work independently rather than as a team.	Some members of the presenting team show little effort to participate in leading the activity or are not prepared to answer questions about the technique.	The presenting team does not work together to lead the activity and answer questions. Some members do not participate, or a lack of preparation and communication leads to confusion.

Marking Criteria Part 3– Evidence of Critical Analysis Skills Development

Criteria	<i>Excellent</i> (>8.5)	<i>Very Good</i> (8.4-7.5)	<i>Good</i> (7.4-6.5)	<i>Needs Improvement</i> (6.4-5.0)	<i>Unacceptable</i> (<5.0)
Choice of content in the collection _____/10 x 2	Collection contains samples of best work; all journal clubs' answers presented; strongly demonstrates a progressive growth with a variety of evidence.	Collection contains samples of work; ≥ 4 journal clubs' answers presented; demonstrates a progressive growth with a variety of evidence.	Collection contains samples of work; >3 journal clubs' answers presented and additional evidence provided; demonstrates a progressive growth.	Collection contains samples of work; >3 journal clubs' answers presented or additional evidence provided; demonstrates some development.	Collection contains limited samples/ examples of work; doesn't demonstrate a progressive growth
Critical analysis Skills (as demonstrated in nominated best work) _____/10 x 3	The work consistently demonstrates clear, accurate, understanding of the data. Shows high level critical analysis skills.	The work demonstrates clear, accurate, understanding of the data. Shows high level critical analysis skills.	The work often demonstrates clear, accurate, understanding of the data. Shows developing critical analysis skills.	The work shows some understanding of the data but often misinterprets data presented in paper. Shows developing critical analysis skills.	Superficially evaluates and misinterprets the data presented in the paper. Shows lack of critical analysis skills.
Statement of development _____/10 x 4	Provides an in-depth insightful analysis of the learning experience; detailed description of analytical skills development trajectory; diverse examples are used throughout to support claims of development	Provides an insightful analysis of the learning experience; describes analytical skills development trajectory; examples are used throughout to support claims of development	Provides an analysis of the learning experience; describes analytical skills development trajectory; Some examples are used to support claims of development	Provides an analysis of the learning experience but is vague and/or unclear; poorly describes analytical skills development trajectory; examples are not used consistently to support claims of development	Provides a description of the learning experience but lacks personal insight; doesn't describe analytical skills development trajectory; no examples provided to show development of skills
Presentation _____/10 x 1	Writing is clear, concise, and well organized with excellent sentence /paragraph structure. Thoughts are expressed in a coherent and logical manner. There are no spelling and grammar errors	Writing is clear and well organized with excellent sentence /paragraph structure. Thoughts are expressed in a coherent and logical manner. There are a few spelling and/or grammar errors	Writing is mostly clear and well organized with good sentence/paragraph structure. Thoughts are expressed in a logical manner. There are a few spelling and/or grammar errors.	Writing is unclear. Thoughts are not expressed in a logical manner. There are many spelling and/or grammar errors	Writing is unclear and disorganized. There are numerous spelling and/or grammar errors.