FACULTY OF SCIENCE

SCHOOL OF BIOTECHNOLOGY AND
BIOMOLECULAR SCIENCES

BIOC2201

PRINCIPLES OF MOLECULAR BIOLOGY

- ADVANCED -

Course Manual

Term 3, 2020

UNIVERSITY OF NEW SOUTH WALES

SCHOOL OF BIOTECHNOLOGY AND BIOMOLECULAR SCIENCES

COURSE MANUAL

BIOC2201 Principles of Molecular Biology - Course Outline

1. Information about the Course

Course Code	BIOC2201
Course Name	Principles of Molecular Biology
Academic Unit	School of Biotechnology and Biomolecular Sciences
Level of Course	Level 2
Units of Credit	6 UOC
Term(s) Offered	Term 3
Assumed Knowledge, Prerequisites or Co-requisites	BABS1201 and CHEM1011 or CHEM1031 or CHEM1051 and CHEM1021 or CHEM1041 or CHEM1061
Hours per Week	6 HPW
Number of Weeks	10 weeks

Course Assessment

Task	**% of total mark**
Final Online Theory Examination	39%
Final Online Practical Examination	20%
Online Term Test	25%
Online Quizzes (4x)	16%
TOTAL	**100%**

Course Structure

Summary of Course Structure (for details see 'Course Schedule')				
Component	**HPW**	**Time**	**Day/Weeks**	**Location**
LECTURES				
Online Lectures	3-4		Weeks 1-10	Online
Introductory Q+A	1	1 - 2 pm	Monday, Week 1	Online Teams
Weekly Q+A	1	2 – 3 pm	Friday, Weeks 1-10	Online Teams
Final Q+A	1	1 - 2 pm	Monday, Week 11	Online Teams
Small Group Online Discussion sessions with Facilitator	1			
Option 1	1	11 am – 12 noon	Wednesday	Online Teams
Option 2	1	3 pm - 4 pm	Wednesday	Online Teams
Option 3	1	11 am – 12 noon	Thursday	Online Teams
Option 4	1	3 pm - 4 pm	Thursday	Online Teams
Online Quiz	0.25	5 pm	Friday, Weeks 2, 4, 7 and 10	Online Moodle
Online Term Test	0.75	5 pm	Friday, Week 8	Online Moodle

2. Course Schedule

Week #	Week beginning	Online Lectures (asynchronous)	Live Q+A session (optional)	Online Quiz Fri 17:00	Online Labs – Videos of Lab experiments	Small Group Online Discussion session with Facilitator (every week)	Main Topic for Small Group Online Discussion session with Facilitator
1	14 Sept	Introductory lecture (VM), 4x Nucleic Acids (VM)	Mon 13:00 (VM) Fri 14:00 (VM)	-	Nucleic Acid Analysis I	Wed 11:00 - 12:00 OR Wed 15:00 - 16:00 OR Thu 11:00 - 12:00 OR Thu 15:00 - 16:00	Laboratory Work
2	21 Sept	2x DNA Replication (AG), PCR (VM),	Fri 14:00 (VM)	Nucleic Acids (4%)	Nucleic Acid Analysis II	Wed 11:00 - 12:00 OR Wed 15:00 - 16:00 OR Thu 11:00 - 12:00 OR Thu 15:00 - 16:00	Lecture/Theory Tutorial
3	28 Sept	Transcription (AG), 2x Translation (AG)	Fri 14:00 (VM)	-	Nucleic Acid Analysis III Computer Exercises I	Wed 11:00 - 12:00 OR Wed 15:00 - 16:00 OR Thu 11:00 - 12:00 OR Thu 15:00 - 16:00	Laboratory Work
4	5 Oct	Protein Structure (VM), 2x Practical Revision (VM)	Fri 14:00 (AG)	DNA Replication, Transcription, Translation (4%)	Induction of Beta-galactosidase	Wed 11:00 - 12:00 OR Wed 15:00 - 16:00 OR Thu 11:00 - 12:00 OR Thu 15:00 - 16:00	Lecture/Theory Tutorial
5	12 Oct	4x Gene Expression (VM)	Fri 14:00 (VM)	-	Mitochondrial PCR I & DNA Cloning I	Wed 11:00 - 12:00 OR Wed 15:00 - 16:00 OR Thu 11:00 - 12:00 OR Thu 15:00 - 16:00	Laboratory Work
6	19 Oct	Non-teaching week	-	-	-	-	
7	26 Oct	3x Recombinant DNA Techniques (VM)	Fri 14:00 (VM)	Protein Structure, Gene Expression, PCR (4%)	Mitochondrial PCR II & DNA Cloning II	Wed 11:00 - 12:00 OR Wed 15:00 - 16:00 OR Thu 11:00 - 12:00 OR Thu 15:00 - 16:00	Lecture/Theory Tutorial
8	2 Nov	3x Recombinant DNA Techniques (VM)	Fri 14:00 (VM)	**Online Term Test** (25%)	DNA Cloning III Next-gen Melanoma Computer Exercises II	Wed 11:00 - 12:00 OR Wed 15:00 - 16:00 OR Thu 11:00 - 12:00 OR Thu 15:00 - 16:00	Lecture/Theory Tutorial
9	9 Nov	Stem Cells (VM), 2x Guest lectures (MC, MW)	Fri 14:00 (VM)	-	Mitochondrial PCR III & DNA Cloning IV	Wed 11:00 - 12:00 OR Wed 15:00 - 16:00 OR Thu 11:00 - 12:00 OR Thu 15:00 - 16:00	Laboratory Work
10	16 Nov	2x Practical Revision (VM)	Fri 14:00 (VM)	Recombinant DNA Techniques, Stem Cells (4%)	-	Wed 11:00 - 12:00 OR Wed 15:00 - 16:00 OR Thu 11:00 - 12:00 OR Thu 15:00 - 16:00	Lecture/Theory Tutorial
11	23 Nov	-	Mon 13:00 (VM)	-	-	-	

3. Staff Involved in the Course

Staff	Role	Name	Contact Details	Consultation Times
Course Convenor		**Vincent Murray**	v.murray@unsw.edu.au	By weekly Q+A, online appointment by Teams
Additional Teaching Staff	Lecturers	Anne Galea Marc Wilkins	a.galea@unsw.edu.au m.wilkins@unsw.edu.au	By appointment
	Facilitators	See Moodle for demonstrator lists	Moodle Discussion Boards	By appointment
	Technical & Laboratory Staff	Tammy Tang	sihui.tang@unsw.edu.au	By appointment

4. Course Details

Course Description	BIOC2201 provides an introduction to modern molecular biology and covers the molecular mechanisms of gene expression and fundamental aspects of recombinant DNA technology. The major topics covered include: the structure, function and properties of DNA and RNA; the replication and transcription of DNA; protein synthesis (translation); regulation of gene expression; molecular biological techniques (DNA cloning, hybridisation analysis, DNA sequencing, the polymerase chain reaction (PCR), and microarrays); bioinformatics; applications of molecular biology; biotechnology; and recent advances in molecular biology. The online practical component of this course has been designed to complement lecture material and introduce students to current experimental techniques in molecular biology.
Course Aims	• This course aims to introduce students to core concepts in modern molecular biology, focusing on the detailed mechanisms underlying the process of gene expression and current recombinant DNA techniques and their applications. • This course also aims to introduce students to current laboratory techniques in molecular biology via online experiments designed to reinforce and consolidate the concepts presented in lectures.
Student Learning Outcomes	By the end of this course, you will be able to: • Describe the structure, function and properties of nucleic acids (DNA and RNA). • Explain the processes of DNA replication, transcription and translation, including the principle steps and enzymes involved. • Describe and compare the mechanisms for regulating gene expression in bacteria and eukaryotes. • Describe and list applications of molecular biological techniques, including DNA cloning, DNA sequencing, the polymerase chain reaction (PCR) and microarrays. • List and describe applications of molecular biological techniques in biotechnology. • Provide a broad definition of bioinformatics and its applications. • Understand via online teaching the correct procedures for working safely and effectively in a modern molecular biology laboratory. • Observe online a range of practical techniques in molecular biology that are commonly employed in the isolation, purification, manipulation and analysis of nucleic acids.

Graduate Attributes Developed in this Course

Science Graduate Attributes	**Select the level of FOCUS** *0 = NO FOCUS* *1 = MINIMAL* *2 = MINOR* *3 = MAJOR*	**Activities / Assessment**
Research, inquiry and analytical thinking abilities	3	Guided online laboratory practicals; understand independent and collaborative experimental work; analysis of experimental results; inquiry into molecular biological concepts and theories; bioinformatics lecture to introduce students to modern techniques in handling large biological data sets.
Capability and motivation for intellectual development	3	Small group online discussions aimed at establishing the fundamental language and themes in molecular biology and developing effective scientific communication skills; conceptual tests and an exam question writing challenge designed to evaluate and hone applied thinking.
Ethical, social and professional understanding	2	Lecture component addresses ethical and social issues relevant to the field of molecular biology; lectures and tutorials feature current research strategies and findings in molecular biology and related clinical and/or medical fields.

Communication	3	Revision lectures aimed at developing effective scientific writing and communication skills through the analysis of model exam answers; small group tutorials that provide personalised feedback on scientific communication proficiencies in exam responses.
Teamwork, collaborative and management skills	3	Group discussions facilitated via Moodle; collaborative online laboratory experiments and integration of data/results; exam question writing challenge to facilitate collaborative study strategies for mid-term exams.
Information literacy	3	Opportunities for self-directed learning embedded into lecture material promote development of information literacy skills

Course Topics and Additional Class Information

Main Lecture Topics	• The structure and properties of nucleic acids (Lecturer: Vincent Murray) • DNA replication (Lecturer: Anne Galea) • DNA transcription and translation (Lecturer: Anne Galea) • Protein structure (Lecturer: Vincent Murray) • Control of gene expression (Lecturer: Vincent Murray) • Recombinant DNA techniques (Lecturer: Vincent Murray) • Biotechnology (Lecturer: Vincent Murray) • Stem cells (Lecturer: Vincent Murray) • Bioinformatics (Lecturer: Marc Wilkins)
Online Practical Program **Small Group Online Discussion session with Facilitator**	Students will be enrolled in one of the following times: • Wednesday 11 am – 12 noon • Wednesday 3 pm – 4 pm • Thursday 11 am – 12 noon • Thursday 3 pm – 4 pm Final facilitator groups will be announced before the beginning of Week 1. A list will be displayed on the BIOC2201 Moodle site. Online classes will begin in Week 1 of session. The Small Group Online Discussion session with Facilitator covering the Laboratory Work are run in Weeks 1, 3, 5, and 9 of session. BIOC2201 online laboratory classes will be scheduled as outlined below. BIOC2201 Online Laboratory Class Schedule: • Week 1 – Nucleic Acid Analysis I: Human DNA extraction and Sexing PCR set-up • Week 2 – Nucleic Acid Analysis II: PCR analysis and restriction enzyme digests • Week 3 – Nucleic Acid Analysis III: RNA processing and agarose gel electrophoresis; Computer Exercise I • Week 4 – Induction of β-galactosidase in *E. coli*

	• Week 5 – Mitochondrial PCR I and DNA Cloning I: Ligation of vector and insert • Week 6 – No class • Week 7 – Mitochondrial PCR II and DNA Cloning II: Transformation • Week 8 – DNA Cloning III: Blue/white selection, plasmid isolation and R.E. digest. Virtual Lab – Next-generation sequencing of Melanoma Computer Exercise II • Week 9 – Mitochondrial PCR III and DNA Cloning IV: R.E. digest analysis • Week 10 – No class
Review Lectures	Practical 'Review Lectures' are scheduled for designated BIOC2201 lecture slots throughout the session. During these classes, previous practical laboratory material will be revised. This will provide students with the opportunity to revise practical laboratory material and reflect upon their own level of comprehension of the material presented in the online practical classes.
Small Group Online Discussion session with Facilitator **- Lecture/ Theory Tutorial**	Small group online Tutorials. The Small Group Online Discussion session with Facilitator covering the Lectures/Theory are run in Weeks 2, 4, 7, 8 and 10 of session. The online Discussion session is designed to help each student achieve a better understanding of the lecture topics presented. The scheduled Discussion group topics are as follows: • **Week 2**: The structure and function of nucleic acids • **Week 4**: DNA replication, transcription and translation • **Week 7**: Protein structure, gene expression and PCR • **Week 8**: Preparation for Online Term Test • **Week 10**: Recombinant DNA techniques and stem cells These tutorials are designed to help students prepare for the online tests that will be conducted on Fridays at 5pm in Weeks 2, 4, 7 and 10. Each test is worth 4% of the overall assessment marks in BIOC2201, with the total of four online tests contributing 16% to the final assessment in the course.
Term Test	A Term Test will be held in Week 8 of session at 5pm on Friday. This test is worth 25% of the overall assessment in BIOC2201 and will be held online. The test will cover lecture material from Weeks 1-5 of session. More test details will be released prior to Week 7.
Optional Q&A Session Lectures	'Optional Review Question and Answer Sessions' will be conducted during various time-slots throughout the session. These sessions provide students with an opportunity to ask lecturers questions pertaining to the current lecture series and will assist with preparations for the tutorials, term test and final exams. Attendance at these sessions is non-compulsory.

5. Additional Resources and Support

Text Books	**Recommended Texts:** • *Fundamentals of Biochemistry* (5th Edition, 2016),by Voet, D., Voet, J.G. and Pratt, C.W., Wiley. p. https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9781118918401 p. https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9781118918432 e. https://unswbookshop.vitalsource.com/products/-v9781119228103 **OR** • *Biochemistry* (9th Edition, 2019), by Berg, J.M., Tymoczko, J.L. and Stryer, L., Freeman. p. https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9781319114657 e. https://unswbookshop.vitalsource.com/products/-v9781319248062 • **Additional Molecular Biology Reference Text:** • *Molecular Biology of the Cell,* by Alberts, B. *et al.*, (6th Edition, 2014), Garland Science. p. https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9780815344643 e. https://unswbookshop.vitalsource.com/products/-v9781317563754
Laboratory Manual	The BIOC2201 Laboratory Manual can be downloaded via the BIOC2201 Moodle site.
Required and Additional Readings	Details of recommended readings and reference materials will be provided by individual lecturers during lectures and online via Moodle.
Recommended Internet Sites	Details of recommended internet sites will be provided by individual lecturers during lectures and online via Moodle.
Societies	ASBMB – Australian Society for Biochemistry and Molecular Biology www.asbmb.org.au

6. Required Equipment, Training and Enabling Skills

Enabling Skills Training Required to Complete this Course	ELISE

7. Course Evaluation and Development

Student feedback is gathered periodically by various means. Such feedback is considered carefully with a view to acting on it constructively wherever possible.

8. Administration Matters

Expectations of Students	**PRACTICALS AND TUTORIALS:** **1. A pass in BIOC2201 is conditional upon a satisfactory performance in the practical program.** A satisfactory performance means that: (i) you have attended **ALL** of the Small Group Online Discussion sessions with the Facilitator, (ii) you have achieved an overall pass mark in the practical examination, and (iii) you have kept an accurate and up-to-date laboratory manual, including the recording of all data and calculations required on the "Results" or "Questions" sheets at the end of each practical. Because you will need your practical folder to study for the practical examination, which is to be held in the examination period, we will not be collecting manuals at the end of the session. It will be your responsibility to make certain you have entered the **correct information** for each of the practical experiments (that is, that all of the "Results" and "Questions" sheets are completed correctly). **2. The Small Group Online Discussion sessions with the Facilitator** are very important elements of the curriculum and are **COMPULSORY** components of the course work for BIOC2201. Attendance will be recorded for these online sessions. The computer exercises are examinable, either through the practical examination, theory examination, or both. **3. Practical examination:** This examination will be carried out by the UNSW Examinations Branch and will be scheduled by them in the Term 3 November/December examination period. **See the UNSW examination timetable for the date and location.** The exam will be entirely written and will involve some calculations based on typical experimental data and a series of questions to test your understanding of the experimental concepts and techniques covered in the practical component of the course. **NOTE: Those students who do not achieve a pass in the practical examination will be required to supply their lab manual for checking. If this cannot be achieved before the final assessment review meeting, then final marks will be WITHELD (WD) until the completed lab manual is presented.** **LECTURES:** The lecturer who presents the lectures will set the examination questions and will also be responsible for marking the relevant examinations/tests. Each lecturer will take you through the intricacies of the various topics in molecular biology in a way that you may find difficult to reproduce by simply reading through the syllabus, lecture hand-outs and the prescribed texts.
General Enquiries	All general administrative enquiries can be directed to Julna Zhao, Student Advisor, School of Biotechnology and Biomolecular Sciences, Faculty of Science. Email - j.zhao@unsw.edu.au

Student Absences and Assessment Procedures	**Missed Small Group Online Discussion session with Facilitator:** If you miss a Small Group Online Discussion session with your Facilitator due to illness or some other unavoidable circumstance that can be verified via professional documentation, you must inform your Facilitator and provide them with a copy of your professional documentation (e.g. medical certificate) so that they can make a note of your legitimate absence in their roll book. Do not apply online; do not email the course coordinator to say that you are ill; do not send a copy of your professional documentation to the course coordinator. You will need to catch up on missed work by speaking to your Facilitator or class colleagues. **Missed Tutorial Tests and/or the Term Test:** If you miss an Online Quiz or the Term Test due to illness or some other unavoidable circumstance that can be verified via professional documentation, you **MUST** apply for Special Consideration according to the UNSW Special Consideration and Further Assessment Policy outlined on the following page. There will be **NO** alternative times provided to sit the Online Quizzes or the Term Test. **Depending on their overall performance at the end of the course, students with compliant applications for Special Consideration will either receive an average mark for their missed test or will be invited to sit further assessment on the supplementary exam dates (see below). However, such outcomes will NOT be determined until the end of the final examination period, so please DO NOT ask your course coordinators about this matter prior to this time.** **Missed Final Exams:** If you miss a final exam due to illness or some other unavoidable circumstance that can be verified via professional documentation, you must apply for Special Consideration according to the UNSW Special Consideration and Further Assessment Policy outlined on the following page. The same advice applies to students who sit the final exams but believe that their performance was negatively affected by illness or some other circumstance(s) that can be documented by professional means. All applications for Special Consideration for the final exams will be reviewed after the final examination period. Students with compliant applications will be sent an offer to sit one or more supplementary exams via their UNSW student e-mail account after the final examination period. **Technical issues during an online exam:** If you experience a technical issue during an online exam that prevents you from completing an online exam, you should follow the following instructions: Take screenshots of as many of the following as possible: Error messages, Screen not loading, Timestamped speed tests, Power outage maps, Messages or information from your internet provider regarding the issues experienced, All screenshots must include the date and time the issue occurred. Submit a Special Consideration application (when possible) at the conclusion of your assessment and upload your screenshots.

SPECIAL CONSIDERATION AND FURTHER ASSESSMENT TERM 3 2020

Special Consideration

Students who believe that their performance, either during the session or in the end of session exams, may have been affected by illness or other circumstances may apply for special consideration. Applications can be made for online quizzes, online exams, final examinations, and for absences (longer than a week) from compulsory classes.

You must submit the application prior to the start of the relevant exam, or before a piece of assessment is due, except where illness or misadventure prevent you from doing so. If you become unwell on the day of the exam or fall sick during an exam, you must provide evidence dated within 24 hours of the exam, with your application. This also applies to online exams

UNSW has a fit to sit/submit rule which means that if you sit an exam or submit a piece of assessment, you are declaring yourself fit to do so.

You must obtain and attach Third Party documentation before submitting the application. Failure to do so may result in the application being rejected.

Further information on special consideration can also be found at https://student.unsw.edu.au/specialconsideration.

HOW TO APPLY FOR SPECIAL CONSIDERATION

See the "How to apply" section at
https://student.unsw.edu.au/specialconsideration.

Students will be contacted via *their official university email* as to the outcome of their application.

SUPPLEMENTARY EXAMINATIONS:

The University does not give deferred examinations. However, further assessment exams may be given to those students who were absent from the final exams through illness or misadventure and received Special Consideration approval. Final supplementary exam will be run by The Exam Office and in supplementary exam period. Term supplementary exams will be held during the supplementary exam period.

For Term 3 2020, Supplementary Exams will be scheduled between
Monday 11 Jan – Friday 15 Jan 2021

It is the responsibility of all students to regularly consult their official student email accounts and myUNSW in order to ascertain whether or not they have been granted further assessment. Failure to sit for the appropriate exam may result in an overall failure for the course. Further assessment will NOT be offered on any alternative dates.

Equity and Diversity	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 Convenor prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equity and Diversity Unit (9385 4734 or http://www.studentequity.unsw.edu.au/). Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

UNSW Academic Honesty and Plagiarism

See https://student.unsw.edu.au/plagiarism

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 main repository for resources for staff and students on plagiarism and academic honesty.
http://www.lc.unsw.edu.au/

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 that 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

LECTURE SUMMARIES

NUCLEOTIDES, NUCLEIC ACIDS & THE PROPERTIES OF DNA AND RNA

(Vincent Murray - 4 lectures)

1. Structure of purine and pyrimidine nucleotides and their phosphorylated derivatives; polymeric nucleotides: DNA, the repository of genetic information and RNA, the mediator of its expression.
2. The three major classes of cellular RNA - messenger RNA, ribosomal RNA and transfer RNA; hybridization of DNA and RNA; RNA secondary structure; outline of the role of RNA in protein synthesis.
3. Polynucleotides - nature and properties of the phosphodiester linkage; single and double stranded structures; forces which stabilize the double-stranded DNA structure; nucleases: enzymes which degrade polynucleotides.
4. Properties of DNA - size range of naturally occurring DNA molecules; effect of temperature, DNA Hybridisation, shear forces, acid, alkali; the condensation of long DNA molecules *in vivo* (via formation of nucleosomes, 30nm fibres, solenoids etc) into chromatin structure.
5. Properties and uses of restriction enzymes.
6. The basic principles of molecular cloning.

DNA REPLICATION, TRANSCRIPTION AND TRANSLATION

(Anne Galea - 6 lectures)

1. Replication of DNA - events at the replicating fork; enzymes involved in the synthesis of DNA; the fidelity of DNA replication: the proof-reading mechanism; DNA repair - an introduction.
2. Transcription; DNA-dependent RNA polymerase - mechanism of RNA synthesis; comparison with DNA synthesis; primary transcription products and post-transcriptional modifications.
3. Messenger RNA; template characteristics; comparison of prokaryotic and eukaryotic mRNAs; post-transcriptional modification, "capping"; poly-A tail; splicing.
4. Ribosomes; localisation and isolation; differences between prokaryotic and eukaryotic ribosomes; composition; subunit functions; polysomes.
5. Genetic Code; features - universality; reading; degeneracy.
6. Transfer RNA; general structure; structure-function; aminoacylation; isoaccepting tRNAs.
7. Initiation, elongation and termination of polypeptides; "factors"; role of GTP.
8. Antibiotics as translational inhibitors: streptomycin, tetracycline, chloramphenicol, erythromycin.

PROTEIN STRUCTURE

(Vincent Murray - 1 lecture)

1. Revision of general protein structure - amino acid structure; side-chain properties of the 20 amino acids; peptide bond structure and formation; the 4 levels of protein structure hierarchy (primary, secondary, tertiary and quaternary) and the bonds/forces involved at each level.
2. DNA-binding motifs in proteins - zinc fingers; leucine zippers; helix-turn-helix.
3. DNA-protein and protein-protein interactions - in transcription, translation and control of gene expression; molecular models.

GENE EXPRESSION - Control of Protein Synthesis

(Vincent Murray - 4 lectures)

1. Introduction, terminology, induction (derepression), repression, constitutive proteins and enzymes, co-ordinate control, regulatory genes, structural genes, operon, promoter site, operator site etc.
2. Operator models of transcriptional control mechanisms. Discussion of the basis of control of gene expression is by the specific interactions between proteins and regions of the DNA and that these interactions can be controlled by small molecules.
3. Lactose (lac) operon - general features. Evidence - genetic and biochemical
   Catabolite repression - role of cAMP
4. Tryptophan Operon - co-repressor requirement
5. Eukaryotic gene expression - comparison with prokaryotes
   Transcription factors, upstream regulatory sequences (URS), Enhancers, silencers etc.
6. Characteristic protein domains involved in protein-nucleic acid interactions; Zinc finger, helix-turn-helix, leucine zipper, etc.
7. Translational control
8. Microarrays
9. RNAi and its applications

INTRODUCTION TO RECOMBINANT DNA TECHNIQUES

(Vincent Murray - 6 lectures)

Recombinant DNA techniques enable the identification and isolation of genes and the determination of their detailed structure. In eukaryotes, one gene may constitute only one millionth of the total genome and molecular cloning techniques are used to amplify a segment of a genome containing the gene of interest.

In this series of lectures, the basic principles involved in recombinant DNA technology will be outlined together with applications of the study of gene structure and function in humans.

1. Review of the properties and uses of restriction enzymes.
2. Review of the basic principles of molecular cloning.
3. Cloning vectors, with the emphasis on those with *E. coli* as the host.
4. Brief overview of other vector/host systems.
5. Hybridisation procedures: Southern and Northern blotting.
6. Construction of genomic libraries and the methods for their screening.
7. The conversion of mRNA into cDNA and the uses of cDNA libraries. Advantages and disadvantages as compared to genomic libraries.
8. The polymerase chain reaction (PCR) and its applications.
9. DNA sequencing.
10. Next Generation sequencing. High throughput screening.

BIOTECHNOLOGY AND STEM CELLS

(Vincent Murray - 1 lecture)

Genetically modified organisms, biotechnology, stem cells, induced pluripotent stem cells - "re-programming" of adult somatic cell to pluripotent stem cells by transcription factors.

BIOINFORMATICS

(Marc Wilkins - 1 lecture)

Cellular systems are incredibly complex. They carry genetic information in their genome sequences and use this to build every nuance of living organisms. To help us understand this complexity, the field of bioinformatics has emerged. This assists us with the storage, analysis and interpretation of biological data - particularly that in the fields of biochemistry and molecular biology, genomics and proteomics. This lecture will provide a brief introduction to bioinformatics, and will illustrate the connection between DNA sequence, gene and protein expression, protein structures and function. It will give some insights into how this is helping us model and thus understand complete cellular systems.

STUDY GUIDE

NUCLEOTIDES, NUCLEIC ACIDS AND GENE STRUCTURE

1. What is the repeating unit of DNA?
2. Which are the purine bases? Which are the pyrimidine bases?
3. Which bases are different between DNA and RNA?
4. What is the point of attachment of a purine with a sugar in a nucleotide?
5. What is the point of attachment of a pyrimidine with a sugar in a nucleotide?
6. What is a phosphodiester bond? What is the acid that reacts to form a phosphodiester bond?
7. What is meant by 'polarity'?
8. What is meant by the term 'antiparallel'?
9. What are the forces which stabilize the DNA double helix?
10. DNA and RNA are both highly negatively charged. Which groups carry this charge?
11. Write out shorthand representations for the following containing a guanine base(s): deoxynucleoside, 5'-nucleotide, 5'-nucleoside triphosphate, 5'-deoxynucleoside triphosphate, dinucleotide with a 5'-hydroxyl and a 3'-phosphate.
12. Compare the effect of alkali on DNA and RNA and why is it different?
13. Define the terms endonuclease and exonuclease.
14. Which chemical groups are responsible for the strong absorption of UV light by nucleic acids?
15. What do the terms 'GC content' and 'T_m' mean as applied to DNA?
16. How does T_m vary with GC content?
17. What are the main components of chromatin?
18. What is the nucleosome?

19. "It has not escaped our attention that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material" - Watson & Crick (1953) Nature 171, 737-738. What was the pairing and how does it suggest a replication mechanism?

20. What are the two major steps in gene expression?

21. What are the three main classes of RNA?

22. What type of enzyme are restriction enzymes?

23. Write down some possible DNA sequences that may be recognised by a restriction enzyme.

24. Products of restriction enzyme digestion of DNA can have cohesive or blunt ends. What does this mean?

25. Assuming a random arrangement of bases in DNA, how often is it expected that the following restriction enzymes will cleave DNA: (a) with a 4 base recognition sequence and (b) with a 6 base recognition sequence?

26. Describe the process of cloning a DNA fragment using a restriction enzyme.

REPLICATION, TRANSCRIPTION AND TRANSLATION

1. What are the requirements of DNA polymerase for activity?

2. Why is DNA replication said to be semi-conservative?

3. Explain what is meant by saying that DNA replication is discontinuous.

4. Which strand is the leading strand and which is the lagging strand when DNA replicates?

5. What enzyme activities are possessed by DNA polymerase I?

6. What is the role of primase in DNA replication?

7. What are the requirements of RNA polymerase for activity?

8. Is the mRNA copied from the coding or non-coding strand of DNA?

9. Given that eukaryotic DNA polymerases replicate DNA more slowly than their prokaryotic counterparts and that eukaryotic cells typically contain 1000 times as much DNA as a bacterial cell, how do eukaryotic cells manage to replicate their DNA in a reasonable time?

10. Compare the mechanisms of action of DNA and RNA polymerases.

11. Why is tRNA called an adaptor molecule?

12. Where in a tRNA molecule does the amino acid attach to form aminoacyl-tRNA?

13. Where in a tRNA molecule is the anticodon and what is its function?

14. How are the amino acids activated for protein synthesis?

15. Are there differences in initiation of protein synthesis between prokaryotes and eukaryotes?

16. What are the different types of protein "factors" required for protein synthesis?

17. What steps in protein synthesis require the input of energy?

18. There are three "steps" in elongation of a growing peptide chain (per one amino acid addition). What are they?

19. What are the characteristic differences between prokaryotic and eukaryotic messenger RNAs?

20. Do these differences reveal anything of the possible control mechanisms for protein synthesis?

21. What are the post-transcriptional modifications to eukaryotic messenger RNA?

22. What is the process of "splicing" of eukaryotic pre-messenger RNA?

23. What is the code contained within the messenger RNA?

24. Is this code universal? That is, is it the same for lower to higher organisms?

PROTEIN STRUCTURE

1. Can you recognise the hydrophilic and non-polar amino acids and their R-group types?

2. Can you recognise the basic and acidic amino acids amongst the 20 amino acids?

3. What is the relationship between amino acid sequence and protein tertiary structure?

4. Describe the major factors that stabilise an alpha helix.

5. Describe the major factors that stabilise a beta-sheet.

6. What covalent bonds are involved in the maintenance of tertiary structure?

7. What type of amino acids contribute to hydrophobic interactions in a protein molecule and where are they found in a protein molecule?

8. What type of amino acids contribute to hydrogen bonding interactions in a protein molecule and where are they found in a protein molecule?

9. What type of amino acids contribute to ionic bond interactions in a protein molecule and where are they found in a protein molecule?

10. What type of amino acids contribute to disulphide bonds in a protein molecule and where are they found in a protein molecule?

11. Describe the major energetic contributions to protein stability.

12. Describe the different types of interactions that can occur between proteins and DNA.

13. Name three common motifs that occur in eukaryotic DNA-binding proteins and describe their basic structures.
14. What are the characteristics of zinc finger domains?
15. One type of protein-protein interaction occurs via a leucine 'zipper', describe the features of such an interaction.

GENE EXPRESSION

1. What does transcriptional control of protein synthesis involve?
2. What is an operon?
3. What is the proposed mechanism of control of protein synthesis for genes in an operon?
4. Describe the features of the *Lac* operon
5. What is meant by positive and negative control in relation to transcriptional control?
6. What is catabolite repression?
7. Why is the *lac* repressor a negative effector whereas the cAMP activator protein is a positive effector?
8. What is the proposed mechanism for catabolite repression?
9. What is inducer exclusion?
10. How does glucose inhibit the production of cAMP?
11. What are the essential features of the tryptophan operon?
12. Using the *trp* operon as an example, what is attenuation of transcription?
13. How does the proposed mechanism of attenuation involve levels of aminoacyl transfer RNA?
14. What are the general features of a eukaryotic promoter?
15. What is a TATA box?
16. How is it thought that the binding of RNA polymerase II is controlled?
17. What is an enhancer?
18. What are microarrays and what information can be obtained from a microarray?
19. What is RNAi and how can it be used?
20. What is microRNA?

INTRODUCTION TO RECOMBINANT DNA TECHNIQUES

1. What is meant by the term 'genome'?

2. What are the approximate sizes of the *E. coli* and human genomes?

3. What is a vector?

4. What is an insert?

5. What are the desirable properties of a cloning vector?

6. Describe some of the features of the pUC vectors.

7. What is meant by the term "insertional inactivation"? How is this used to select clones versus re-ligated vector?

8. Describe the process of cloning a DNA fragment.

9. What is the role of DNA ligase? What are the requirements in regard to the ends of the DNA being ligated?

10. How can purified DNA molecules (e.g. plasmids) be introduced into bacterial cells?

11. Describe the situations where lambda phage constructs are used as vectors.

12. Describe the process of hybridisation using a radioactively labelled DNA fragment as the probe.

13. What is a genomic library and what is the most important property of such a library?

14. How can hybridisation be used to select a clone containing a gene of interest?

15. What is cDNA and how is it prepared?

16. Why is a cDNA library less complex than a genomic library? How is such a library prepared?

17. What is the difference between a cDNA library and a genomic library?

18. How can cDNA clones be used?

19. Some cDNA clones can be used to express the encoded protein products; what characteristics are required to allow this to occur?

20. What is the principle of Sanger's manual method of DNA sequencing?
21. What is automated DNA sequencing?
22. Describe the process of Illumina short read DNA sequencing.
23. What is RNA-seq?
24. What is exome-seq?
25. Describe the process of DNA amplification using the polymerase chain reaction.
26. How do you calculate the size of a PCR product?

BIOINFORMATICS

1. What is bioinformatics?
2. What is bioinformatics useful for? Provide general and specific examples.

STEM CELLS

1. What is the definition of a “stem” cell?
2. What are embryonic stem cells?
3. What are somatic (also called adult) stem cells?
4. What are the therapeutic uses of stem cells?
5. What are Induced pluripotent stem cells?
6. How are transcription factors used in the generation of Induced pluripotent stem cells?
7. Name the transcription factors used in the generation of Induced pluripotent stem cells.