Cover image:
Confocal micrograph of fluorescently labelled HeLa cells.
Nuclei are labelled in blue, tubulin in green and actin fibres in red.

Courtesy of:
Kevin Mackenzie
Microscopy and Histology Core Facility
Institute of Medical Sciences
University of Aberdeen
http://www.abdn.ac.uk/ims/microscopy-histology
Course Summary

The “Frontiers of Molecular Medical Sciences” course, SM3001, runs during the first half-session...and it is perhaps one of those marmite experiences; thus, it is essential to check that the assessment format will suit you before selecting this course. There are a number of assessments which will require considerable amounts of time and effort, backed up by your first conducting independent research on the topic – if you apply yourself and don’t try to cut corners, then you are likely to get a (very) good grade for this course; if you think to breeze through doing the bare minimum...well, then maybe a course with a different set of assessments might suit you better (no shame there, I was always far better at sitting exams than anything else – I could barely pass a practical write-up).

So, your first task for this course is some honest self-appraisal – what are you best at – see Page 7 for the assessments for this course?

The modern biologist, if they wish to completely understand and capitalise on a biological process, must not only have exquisite taste in clothing but must also employ a wide range of tools and methodologies drawn from several disciplines. This course is designed to provide students with an understanding of how biological information is obtained and used, drawing on the full range of techniques currently employed in biomedical research. It will provide students with core knowledge facilitating effective study of all fields of modern molecular biology and its subsequent use in the field of medicine. With regard to dress-sense, sorry there is only so much we can do in one term.

The General Aims of the course are to enable students:

- To appreciate how molecular medicine is saving us from COVID-19 and (hopefully) has prevented a compete global meltdown, which would have made the social changes seen in parts of the world following the Black Death pandemic of 1347 to 1348 seem like a half-hearted shuffling of the proverbial deck chairs.
- To obtain a deeper understanding of all the tools that molecular biologists and biomedical scientists had at their disposal when confronted by the greatest medical challenge of our generation...and (hopefully) to be inspired by how they not only rose to the challenge but succeeded beyond our wildest dreams, achieving what we had thought was impossible.
- To establish an understanding of the molecular technologies used by biologists to gain knowledge of molecular cell systems.
- To practise researching, constructing and delivering (as a recorded video) a presentation.
- To practise an essay assessment supported by independent background research. In this unusual approach, you MUST submit an essay for the first assignment – this is the more challenging one and is worth 30% of the final grade.
• However, on receiving your mark, you may choose to also do a second assessment (it is probably easier and will be similar in style to an open-book exam essay). If you do this, then that first essay mark will subsequently only count as 10% and the second for 20%.

• *If you submit the second essay then you have committed to the 10% + 20% format. If you do not submit the second essay then you have committed to 30% for the first essay.*

• Thus, you have choice (choose your own workload) and the opportunity to improve your grade...but you must also take the responsibility for your own decisions...how *Heineken* or just a gimmick? We shall see precious, oh yes, we shall see.

• To establish an appreciation of the advantages and disadvantages of different molecular biological tools, the appropriateness of their application to a given biological problem and how the information from each technique can be integrated.

• To gain an appreciation of the cutting-edge therapies for genetic disorders that are now being introduced to treat disorders with a genetic basis.

• To analyse primary experimental results.

• To establish an understanding of how the targets discovered and studied can then be used in applied research and lead to the development of new medicines.
Course Aims & Learning Outcomes
At the end of the course students should be able to -

• Explain all about COVID-19 to anyone who will listen, be they animal, mineral or vegetable; thus inspiring you to go on to do great deeds and generally save the world from all manner of ills;
• Understand where the disease is going and what the future is likely to hold for further pandemics and what we need to do to avoid this happening again every few years;
• Describe and understand the basis for the cutting-edge technologies currently being introduced into clinical medicine for the treatment of disorders with a genetic basis;
• Describe the basic ‘tools’ and techniques used in molecular biology, such as enzymes, vectors, recombinant DNA methods, gene cloning, PCR etc;
• Describe techniques used for gene mapping to identify the basis of a given mutant phenotype;
• Describe computer techniques used to handle the wealth of nucleic acid and protein sequence data that is becoming available;
• Describe RNA structure, synthesis, degradation, isolation and characterisation techniques;
• Describe techniques that can be used to study (a) sub-cellular localisation of proteins and (b) global patterns of protein expression in different tissues and cell types;
• Describe techniques to analyse gene function. This to include classical genetic analysis, using mutants as a basis for cloning, sequencing and characterising a wild type gene, together with various genetic screening methods;
• Describe methods to obtain function information about a gene from a knowledge of only the gene sequence;
• Describe procedures for expressing foreign genes in appropriate hosts such as bacteria, yeast, insect and mammalian cells (to include transgenic mice in biological research);
• Describe a variety of methods for purifying proteins from tissues or from gene expression systems and also the criteria for selecting particular methods;
• Describe what methods and processes are used to move from these disease-relevant genes and proteins towards new medicines.
Course Teaching Staff

Course Co-ordinator(s):
Dr Iain Greig (i.greig@abdn.ac.uk)

Teaching Staff:
Dr John Barrow (j.barrow@abdn.ac.uk)
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Dr David Stead (d.stead@abdn.ac.uk)
Dr Frank Ward (f.j.ward@abdn.ac.uk)

All staff teaching on this course are based at the Institute of Medical Sciences (IMS).
Assessments & Examinations
Course assessment for SM3001 consists solely of continuous assessment – check that this format matches your strengths.

**CONTINUOUS ASSESSMENT.** This comprises the following assignments -

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<tr>
<td>1. Video recording: presentation on SARS-CoV-2 vaccines</td>
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<tr>
<td>2. Essay question(s)*</td>
<td>30% (or 10% + 20% your choice!)</td>
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<tr>
<td>3. Practical write up</td>
<td>20%</td>
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<tr>
<td>4. CAL protein purification test</td>
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All work will be submitted through MyAberdeen.

The CAL protein purification test is an on-line test that will be available after the practical has taken place on MyAberdeen.

**Essay 1 (Gene Therapy) Summary:** select three diseases with a strong genetic component (i.e. in which a known genetic mutation has led to e.g. a lack of an essential protein, to a poorly functional protein or to the production of a toxic protein responsible for the disease); describe the disease and explain the specific genetic cause of the disease; explain the background to a suitable gene therapy – a technique that could be used for manipulation of the DNA or RNA as to partially or fully correct the error – and describe the actual therapeutic agent which will be used.

This essay counts for 30% if you choose NOT to submit essay 2.

**Essay 2 (Covid) Summary:** for those who choose this option (this choice will only need to be made after receiving grades for the first essay) this will be a current-exam-style (open book) answer on a Covid-related question. It will be marked with the same degree of rigour as current exams (e.g. simple regurgitation of lecture notes will get no better than a 2.2 grade).

Once you submit this essay you are irrevocably COMMITTED to it counting for 20% of your grade and essay 1 for 10%. The choice will be yours to make (expert tip: if you get 18 - 22 for essay 1, don’t bother with essay 2!).
However, you will not see the title for the second essay until after the first essay has been submitted – so, it really would be wise to make a good effort for the first, just in case you then go on to find that the second is not to your taste.

...confused? Well, ask!
Class Representatives
We genuinely value students’ opinions in regard to enhancing the quality of teaching and its delivery; therefore in conjunction with the Students’ Association we support the Class Representative system.

In the School of Medicine, Medical Sciences & Nutrition we operate a system of course representatives, who are elected from within each course. Any student registered within a course that wishes to represent a given group of students can stand for election as a class representative.

What will it involve?
It will involve leading by example: verily, I say unto thee, shalt thou not be first upon the vainglorious field and last from it to depart, ensuring no classmate be left behind? Harken to the clarion call - wilt thou not taketh the initiative and spot problems and opportunities as and when they arise? Nay, shalt thou not fail to meet thine own destiny as thou followeth in the footsteps of giants that hath before thee trodden! Bend thine will and look for the narrow gate that leadeth to the paths of innovation as to make the learning experience of yon classmates more productive and joyous. Fall not into the Slough of Despond that leadeth only to wallowing in...well, you know, like, a bit of a bad time for all (extra point for anyone that can explain to me, preferably in short easily understood terms – that don’t include nominative, accusative, subject or object – the difference between thee and thou...not saying it is a rite of passage for being selected, but it can’t hurt...at least it shows you’ve read this!).

At the basic minimum, this will involve unceasing service, constantly speaking to your fellow students about the course you represent and feeding back issues to the course coordinator with any comments that they may have. Beyond this, you will be expected to set up novel forums to ensure that all students are encouraged to contribute. You will attend a Staff-Student Liaison Committee and you should represent the views and concerns of the students within this meeting. As a representative you will also be able to contribute to the agenda. You will then feedback to the students after this meeting with any actions that are being taken.

Oh, and finally you will have to deliver your COVID-19 vaccine presentation to the class for comment and dissection.

...so, think carefully if this role is for you and that you are not just looking to tick a box on your CV – you will have very large shoes to fill from previous class representatives!

Training
Training for class representatives will apparently be run by the Students Association. Training will take place within each half-session. For more information about the Class representative
system visit www.ausa.org.uk or email the VP Education & Employability vped@abdn.ac.uk. Class representatives are also eligible to undertake the STAR (Students Taking Active Roles) Award with further information about this co-curricular award being available at: www.abdn.ac.uk/careers.
Problems with Coursework

If students have difficulties with any part of the course that they cannot cope with alone they should notify the course coordinator immediately. If the problem relates to the subject matter general advice would be to contact the member of staff who is teaching that part of the course. Students with registered disabilities should contact Mrs Jenna Reynolds (medsci@abdn.ac.uk) in the School Office (based in the IMS, Foresterhill), or Mrs Sheila Jones (s.jones@abdn.ac.uk) in the Old Aberdeen office associated with the teaching laboratories, to ensure that the appropriate facilities have been made available. Otherwise, you are strongly encouraged to contact any of the following as you see appropriate:

- Course student representatives
- Course co-ordinator
- Convenor of the Medical Sciences Staff/Student Liaison Committee (Prof Gordon McEwan)
- Medical Sciences Disabilities Co-ordinator (Dr Derryck Shewan)

All staff are based at Foresterhill and we strongly encourage the use of email or telephone the Medical Sciences Office. You may have a wasted journey travelling to Foresterhill only to find staff unavailable. If you have a cold or are otherwise feeling unwell, then please consider carefully whether it is appropriate to be interacting with fellow life-forms.

Course Reading List

There is no single text that covers the contents of this course and, in this field, textbooks can go out of date fairly quickly. Most general biotechnology texts will provide relevant information. Some additional texts are also detailed below.

There are some special topics for which suitable chapters of an electronically-available textbook will be given. Specifically, Chapter 20 – Genome Defense:

**BOOK**

**Molecular biology**

Clark, David P., author.; Pazdernik, Nanette Jean, author.; McGehee, Michelle R., author. 2019

Available Online ➤
What is Crispr Gene Editing? The Complete WIRED Guide | WIRED
CRISPR 101 | The Simple Guide to Learning CRISPR (synthego.com)
Everything You Need to Know About CRISPR-Cas9 (synthego.com)

Lodish H et al., Molecular Cell Biology (MacMillan, Basingstoke 7th Ed) 2012
ISBN: 1464109818

Alberts et al., Molecular Biology of the Cell (Garland, 6th Ed) 2014
ISBN: 9780815344322

Brown T A, Gene Cloning and DNA analysis: An Introduction (Blackwell, 6th edition) 2010
ISBN: 978-1-4051-8173-0


Turner, McLennan, Bates & Whyte. Molecular Biology (Instant Notes) (Taylor & Francis, 3rd Ed) 2005. ISBN: 0415351677 (This contains very useful notes on techniques and is particularly useful as background reading for the cloning lab).

Notes:

- The University Library has copies of all the books on the list.
- If buying any of these books, make sure you buy the most up to date version. Past editions of these books can substitute to some extent but be aware that as technology advances rapidly, outdated versions may give incomplete information.
Lecture Synopsis

Subject - Gene cloning
No of Lectures - 4
Lecturer - Prof C Munro

These lectures give an account of the techniques employed in the manipulation of DNA and the cloning of specific DNA sequences and complement the Cloning practical. Topics to be covered include -

- Cutting and Joining DNA: restriction endonucleases, ligases, polymerases, gel electrophoresis
- Cloning vectors: plasmids and expression vectors
- Cloning: constructing gene/cDNA libraries
- Selection strategies: DNA homology, antibody screening, functional complementation

Subject - Genomics
No of Lectures – 3
Lecturer – Dr F Grassmann

Genomics is a term that refers to the global analysis of an organism's gene function. The first step involves the large scale application of gene cloning techniques. The aim of these lectures is to give an overview of techniques employed in genome projects; from the generation of the raw DNA sequence to the computational analysis of this sequence. Examples from human, C. elegans and Drosophila genome projects will be used to illustrate key experimental approaches. Topics to be covered will include:

- Genome sequencing strategies: The special problems created by genome projects; generating whole genome physical maps; Clone-by-clone Vs shotgun assembly approaches
- Deciphering the genome: Identifying protein coding genes; the combined use of experimental approaches such as computational gene finding and cDNA projects.
- Assigning function to genes: Using sequence similarity as a tool to provide functional information.

Subject – How molecular medicine is saving us from COVID-19
No of Lectures – 8 (might be more…will feel like more anyway)
Lecturer – Dr I Greig

These lectures are designed to support the 2nd essay and the presentation in which you will describe the development and characteristics of 3 vaccines for the prevention of Covid-19, covering the scientific discoveries and events that came to light during the pandemic. This “scrapbook” will provide both background information on SARS-CoV-2, more detailed information on specific aspects of the disease and the response to it, and will also provide suitable references that contain the required information for the assessments and guide you as to appropriate places to look for additional information. We hope it will also inspire you
and demonstrate quite how much can be achieved by the miracle that is modern molecular medicine.

- Background to the disease
- Local and global events
- Attempts to repurpose existing drugs
- The development of a wide range of differing vaccines against SARS-CoV-2
- The sociopolitical issues associated with the disease
- The future of the disease

**Subject - Gene expression analysis**
**No of Lectures - 4**
**Lecturer - Dr A MacKenzie**

How the one-dimensional information contained within the DNA of the genome is changed into a four-dimensional organism, remains one of the biggest questions in biology. This process starts with transcription. The instructions for where and when a gene is switched on are found in the regulatory regions (enhancers and promoters) that surround the gene and identification of these regions is critical. Once transcription has been initiated selected gene sequences are transcribed into mRNA that is then able to leave the nucleus. How a cell interacts with its environment and assumes a specific identity is reflected by the specific identity, amounts and timing of the expression of mRNA. These lectures explore current methods of identifying the promoter regions of genes and subsequently detecting specific mRNA species.

- Promoter analysis: bioinformatics approaches, reporter gene assays, transgenics
- Quantitative RNA detection Methods: Northern blots, RNase protection Assay, rtPCR Differential display, macroarrays and microarrays
- Qualitative RNA detection Methods: In Situ Hybridisation; Sense and Antisense probes; Radioactive and non-radioactive RNA detection methods

**Subject – Frontiers: Gene therapy, RNA therapeutics and other cutting-edge approaches**
**No of Lectures - 2**
**Lecturer - Dr I Greig**

What treatment can possibly cost $2.1 million? – do we really have drugs that cost over $300,000 per year and have no evidence of efficacy? – what can be done for a bright and bouncy child suddenly struck down by a rare genetic disorder? – can we now use gene editing on humans? – can we paper over mistakes in the genome?

...and, between us, can we work out what on earth is going on with these treatments and techniques?
Subject - Foreign gene expression & protein purification  
**No of Lectures - 6**  
**Lecturer - Dr J Barrow**  
Recombinant DNA technology enables directed transfer and expression of DNA from one species to another. For some time now biologists have been able to harness this technology for the production of both pharmaceutically and scientifically important foreign proteins from a variety of species including man. The aim of these lectures is to explain the principles behind expression of foreign proteins. But in order to study the structure and function of a protein, it is necessary to purify the protein. This is true both for foreign proteins expressed in cells and for proteins derived from their natural source. These lectures will discuss the range of methods available for this purpose and the criteria for selecting particular methods.  

- Why we purify proteins and what influences our choice of methods.  
- The theory and practice behind commonly employed chromatographic methods.  
- The use (and misuse) of protein fusions, such as His tags and maltose binding protein to facilitate protein purification.  

Subject - Antibodies as tools  
**No of Lectures - 2**  
**Lecturer - Dr F Ward**  
Antibodies are incredibly useful both in basic research, as diagnostics, and are increasingly being introduced as sophisticated therapeutics for a range of difficult to treat disorders including cancer.  

- A basic overview of the adaptive immune response that underlies the production of antibodies will be introduced along with the principles of monoclonal antibody technology.  
- Antibodies as research tools or in diagnosis: antibodies can be used in a number of techniques including ELISA, flow cytometry and immunocytochemistry. Even "everyday" tests such as the pregnancy test kit rely on antibody technology.  
- Finally, while at a relatively early stage, antibody therapeutics are gaining market share year-on-year and several are now multi-billion pound blockbuster products. Notable examples of such therapies in cancer and autoimmune disease will be covered in detail.  

Subject – Protein Localisation  
**No of Lectures - 2**  
**Lecturer - Dr B Müller**  
Protein function is usually tightly linked to sub-cellular localisation i.e. growth factor receptors are targeted to the plasma membrane while transcription factors are localised in the nucleus. In some instances the sub-cellular localisation of a protein is subject to regulation i.e. upon activation Glucocorticoid receptors translocate from the cytoplasm to the nucleus where they act as transcription factors and activate gene expression. The aim of these lectures is to
consider methods that can be used to determine the sub-cellular localisation of a specific protein.

- Cell extracts & fractionation techniques: Preparation of whole and fractionated cell extracts, including nuclei, cytosol, mitochondria and membrane fractions.
- Microscopy: use of tags, e.g. GFP; live cell imaging

Subject – Proteomics
No of Lectures - 2
Lecturer - Dr D Stead

Proteomics is a term that refers to the analysis of the proteins expressed by an organism, tissue or cell (the proteome). Because of the high complexity and wide dynamic range within a proteome, large-scale proteomic studies tend to provide information about the more abundant proteins. The aim of these lectures is to provide an overview of the main techniques used in proteomics and the strategies for their application. Topics to be covered will include:

- Protein identification: Peptide mass fingerprinting and tandem mass spectrometry.
- Quantification: 2-D gel electrophoresis and mass spectrometric techniques.
- Post-translational modifications: How they may be detected and characterised.

Subject - Protein:Protein interactions
No of Lectures - 2
Lecturer – Dr L Penny

Proteins often form protein complexes in order to carry out their particular function. The aim of these lectures is to describe different experimental approaches to studying protein: protein interactions, using primary data to illustrate the advantages/disadvantages of each method.

- Yeast two hybrid: basic principle involved and use for identification of previously unknown protein: protein interactions
- Pull-down assays: using affinity purification of GST or His-tagged proteins to pull down interacting partners.
- Co-immunoprecipitation: the use of antibodies to one protein to pull down interacting proteins

Subject - Protein: Nucleic Acid Interactions
No of Lectures - 4
Lecturer - Dr B Müller

A subset of proteins within the cell play a crucial role in controlling gene expression by interacting with DNA or RNA, e.g. transcription or splicing factors, and a number of powerful
techniques are available with which to analyse such protein: nucleic acid interactions. The aim of these lectures is to introduce you to some of these techniques and show you how to analyse the data that these methods can generate.

- Analysis of protein-nucleic acid interactions \textit{in vitro}: EMSA (gel electrophoretic mobility shift assay)
- ChIP: chromatin immunoprecipitation
- Chip-Seq: Genome wide analysis of protein-DNA interaction

**Subject – Target selection**  
**No of Lectures - 1**  
**Lecturer – Dr I Greig**

Only a small proportion of the human genome encodes for proteins which are involved in disease-related processes; only a small proportion of the human genome encodes for proteins which can be modulated by a small molecule drug. The overlap between these – drug targets - is even smaller. So, what makes a good drug target and why can we only modulate some targets and not others?

- What is a drug target?  
- Why are some targets easier than others?  
- What is druggability?

**Subject – High-throughput screening**  
**No of Lectures - 2**  
**Lecturer – Dr I Greig**

Once we have identified and validated a target as being involved in human disease, how do we go about finding molecules which will modulate this target to give us tool compounds and to give us the starting points that can be developed into drugs

- The size of chemical space and the statistical challenges involved in finding a “hit” even in the largest of chemical libraries
- The techniques and assays used to screen millions of compounds against a promising target
- Application of these techniques in the search for new drugs to treat COVID-19
Practical/Lab/Tutorial Work

SUMMARY OF PRACTICALS:

There will be two practicals, a “wet” laboratory Cloning Practical and a computer simulation on Protein Purification. The Cloning Practical involves a continuous experiment which runs over four two-hour sessions. Attendance at all of these sessions is compulsory and is monitored.

1. CLONING PRACTICAL:

This practical will be assessed by a final report

Continuous Assessment:

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Cloning and propagation of restriction fragments in Escherichia coli using the plasmid pBR322.

The main aim of this practical is to teach you some of the basic methods that are central to most gene cloning strategies. A summary of the planned work is shown below and the complete practical manual is available on the course MyAberdeen site; a hard copy of the practical manual will be given out at the first practical session. You are encouraged to read each session’s practical work in advance of the practical so that you can work more effectively.

1. You will use the restriction enzymes EcoRI and BamHI to digest DNA from both phage \( \lambda \) (lambda), to make inserts, and from the vector pBR322.
2. The products of digestion will be analysed using agarose gel electrophoresis.
3. After cleavage, the restriction enzymes will be inactivated by heat treatment; the DNA fragments will be mixed and then ligated together using T4 DNA ligase.
4. The sequence specificity of the ends generated in the two populations of DNA fragments (lambda and pBR322) by BamHI and EcoRI allows only those DNA fragments to be ligated to form circles which have one end terminated by a BamHI cleavage site and the other terminated by an EcoRI cleavage site (see Fig.1). Many of the lambda DNA sequences have such a structure and can therefore combine with BamHI/EcoRI-cut pBR322 to form a mixture of circular recombinant DNA molecules of the type indicated.
5. These circular forms are able effectively to transform competent bacterial cells and propagate within them.
6. Cells that acquire plasmids can be selected on the basis of their resistance to ampicillin, resulting from the presence of the AmpR gene located on fragment 1 of pBR322. Since, on average, cells are unlikely to receive more than one recombinant DNA molecule, DNA plasmids in the mixture are "cloned" in individual cells which are separated by plating on nutrient medium containing ampicillin.

7. Those bacterial colonies containing recombinant plasmids which have a target DNA segment inserted between the EcoRI and BamHI cleavage sites of pBR322 are identified by their sensitivity to tetracycline, since the TetR gene of pBR322 is interrupted and inactivated by insertion of DNA at this position.

8. Finally, you will investigate the structure of the recombinant plasmid DNA’s isolated from three individual transformed clones. Restriction of a recombinant plasmid DNA with EcoRI and BamHI removes the lambda DNA insert from the plasmid, allowing the size of the insert to be determined by agarose gel electrophoresis. Further digests will confirm the identity of the cloned fragments.

2. PROTEIN PURIFICATION COMPUTER AIDED LEARNING PRACTICAL:

The aim of this practical is to enable you to apply your theoretical knowledge of protein structure and properties to explore various scenarios for purifying proteins. The programme allows you to choose the most effective methods from a number of laboratory procedures and gives you “on screen” results of your chosen method. In this manner you can explore different scenarios much more quickly than would be possible in the laboratory.

This practical will be assessed by a test that will be available on MyAberdeen.

Continuous Assessment:

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SM3001 Tutorials

Tutorial work is not assessed but attendance is compulsory and is monitored (details regarding groups will be given out nearer the time the tutorial is to be held). It is essential that you prepare for the tutorials by reading the material provided so that you come to each tutorial prepared to answer the accompanying questions. The material for tutorial 2 is available on the SM3001 course MyAberdeen site.

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<td>Tutorial 1</td>
<td>Making an expression plasmid for growth hormone</td>
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<tr>
<td>Tutorial 2</td>
<td>Analysing primary data from a research paper</td>
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The first tutorial is a theoretical exercise in making a plasmid to allow expression of human growth hormone. This will reinforce the first cloning lectures and, as groups will be split as far as possible into similar intended degrees, this tutorial will allow students to get to know others doing the same degree.

For the second tutorial, you will be provided with a single figure from a research paper. You will have to prepare the presentation of this figure, focusing on the research the methods used and a critical evaluation of the data.
SM3001 Tutorial 1: Making an expression plasmid for growth hormone.

Introduction

Growth hormone is produced by the pituitary gland at the base of the brain and defects in its production or secretion can cause dwarfism. Children who show growth deficiencies can sometimes be treated with injections of growth hormone. Originally, the growth hormone used was extracted and purified from human cadaver pituitary tissue. However, due to worries about transmission of diseases such as CJD (prion disease), the growth hormone is now produced recombinantly from *E. coli* that have been genetically engineered to make the protein.

A typical method of making the expression construct would start with extracting RNA from the pituitary tissue and reverse transcribing it to produce cDNA. This process gives a population of cDNAs, each encoding a single protein expressed in the pituitary. You would then need to “find” the cDNA that encodes growth hormone and insert it into a suitable vector for expression in *E. coli*. You could do this by using specific primers to amplify up the growth hormone cDNA in a PCR reaction.

In this tutorial you will work in groups to devise a strategy to amplify up DNA encoding human growth hormone for subsequent insertion into the expression vector.

Designing the primers

1. First think about how, once you've amplified up your DNA, you would then insert it into the vector. HINT: would restriction sites at the ends of the amplified DNA help?
2. Can you identify in the sequence below the start (ATG) and stop (TAG) sites for translation of the protein? What region of the sequence below would you have to amplify in order to produce growth hormone protein?
3. Can you identify which restriction endonucleases cut at the sequences highlighted below?
4. With this in mind, which restriction sites would be most helpful if you could incorporate them into your amplified sequence? HINT: check out the multiple cloning site (MCS) of the vector you want to put the amplified DNA into (see below).
5. How can you incorporate these restriction sites into your amplified DNA?
6. Design you primers, remembering you need a forward and a reverse primer.

Sequence of growth hormone DNA

1. agcgccccaa ggcccaactc cccgaaccac tcaggtctct gtggacagct cacctagctg
2. caatggctac aggctcccgg acgtccctgc tcctggcttt tggcctgctc tgcctgccct
3. ggcttcaaga gggcagtgcc ttcccaacca ttcccttatc caggcttttt gacaacgcta
4. tgctccggcg ccatcgtcctg cac*cagctg* cacccagacc ctttgacac ctaccaggag tttgaagaag
5. cctatatccc aaaggaacag aagtatctct tcctgcagaa cccccagacc tccctcttgtt
Translation starts at the first ATG and finishes with a TAG stop codon. The hGH protein is 217 amino acids in length. Highlighted in bold, italics in the sequence above are known endonuclease restriction sites.

Sequences recognised by selected restriction endonucleases (the enzyme cut site is denoted by /):

Nrul (tcg/cga), Hind III (a/agctt), Pvu II(cag/ctg), BamH I (g/gatcc), Acc65 I (g/gtacc), Kpn I (ggta/c), EcoR V (gat/atc), Bgl II (a/gatct), Sma I (ccc/ggg), Not I (gc/ggccgc)

Map of expression vector:

The MCS is between 389 and 452
SM3001 Tutorial 2: Analysing primary data from a research paper

Learning outcome: Analyse data from a research paper using examples provided in the tutorial exercise and present to the tutorial group.

In this tutorial you will work in small groups to analyse figure panels from research papers. You are expected to gain an understanding of the questions asked and of the approaches used to answer these questions. You will have an opportunity to discuss your analysis with the rest of the class.

Your need to address and answer the following questions:

- **What is the purpose of the experiment?**  What is the question the authors ask? Why are they interested?
- **What is/are the methods used?** You will need to prepare an explanation of the methods used.
- **What is/are the finding(s)?** Use the figure to explain how the authors arrive at their conclusions.

You should also consider the following questions:

- **Are you convinced by the experiment?** Are essential controls missing?
- **What other experiments could/should be done?** What other experiments could you do to prove the point made?

How can you prepare this?

- Start with the figure and figure legend. Dissect the figure into its different parts. Ask yourself the following questions: What is the role of each part? Does it explain a method? Does it show an experiment/data?
- Identify and research the methods used. Check your lecture notes, the research article (relevant part of methods and results section) and other sources for information. Google it.
- Critically look at each part of the figure, make sure you know what is going on and draw your own conclusions from the data. In case data is shown as measurements only, make sure you know how the numbers are arrived at. Ask yourself whether any controls are missing.
University Policies

Students are asked to make themselves familiar with the information on key education policies, available here. These policies are relevant to all students and will be useful to you throughout your studies. They contain important information and address issues such as what to do if you are absent, how to raise an appeal or a complaint and how the University will calculate your degree outcome.

These University wide education policies should be read in conjunction with this programme and/or course handbook, in which School specific policies are detailed. These policies are effective immediately, for the 2021/22 academic year. Further information can be found on the University’s Infohub webpage or by visiting the Infohub.

The information included in the institutional area for 2021-22 includes the following:

- Absence
- Appeals & Complaints
- Assessment
- Avoiding Plagiarism
- Communication
- Graduate Attributes
- MyAberdeen
- Student Learning Service (SLS)
- Student Monitoring/Class Certificates
- Student Discipline
- The Co-curriculum
# Medical Sciences Common Grading Scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Grade Point</th>
<th>Category</th>
<th>Honours Class</th>
<th>Description</th>
</tr>
</thead>
</table>
| A1    | 22          | Excellent      | First         | • Outstanding ability and critical thought  
• Evidence of extensive reading  
• Superior understanding  
• The best performance that can be expected from a student at this level |
| A2    | 21          |                |               |                                                                                                   |
| A3    | 20          |                |               |                                                                                                   |
| A4    | 19          |                |               |                                                                                                   |
| A5    | 18          |                |               |                                                                                                   |
| B1    | 17          | Very Good      | Upper Second  | • Able to argue logically and organise answers well  
• Shows a thorough grasp of concepts  
• Good use of examples to illustrate points and justify arguments  
• Evidence of reading and wide appreciation of subject |
| B2    | 16          |                | Lower Second  |                                                                                                   |
| B3    | 15          |                |               |                                                                                                   |
| C1    | 14          | Good           | Lower Second  | • Repetition of lecture notes without evidence of further appreciation of subject  
• Lacking illustrative examples and originality  
• Basic level of understanding |
| C2    | 13          |                |               |                                                                                                   |
| C3    | 12          |                |               |                                                                                                   |
| D1    | 11          | Pass           | Third         | • Limited ability to argue logically and organise answers  
• Failure to develop or illustrate points  
• The minimum level of performance required for a student to be awarded a pass |
| D2    | 10          |                |               |                                                                                                   |
| D3    | 9           |                |               |                                                                                                   |
| E1    | 8           | Fail           | Fail          | • Weak presentation  
• Tendency to irrelevance  
• Some attempt at an answer but seriously lacking in content and/or ability to organise thoughts |
| E2    | 7           |                |               |                                                                                                   |
| E3    | 6           |                |               |                                                                                                   |
| F1    | 5           | Clear Fail     | Not used for Honours | • Contains major errors or misconceptions  
• Poor presentation |
<p>| F2    | 4           |                |               |                                                                                                   |
| F3    | 3           |                |               |                                                                                                   |
| G1    | 2           | Clear Fail/Abysmal | -          | • Token or no submission                                                                         |
| G2    | 1           |                |               |                                                                                                   |
| G3    | 0           |                |               |                                                                                                   |</p>
<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Place</th>
<th>Subject</th>
<th>Session</th>
<th>Staff</th>
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<tr>
<td><strong>Week 9</strong></td>
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<tr>
<td>Mon 27 Sep</td>
<td></td>
<td></td>
<td>Course Prologue</td>
<td>Lecture</td>
<td>Dr I Greig</td>
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<td>Gene cloning lectures (1 - 4)</td>
<td>Lecture</td>
<td>Prof C Munro</td>
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<tr>
<td>Fri 1 Oct</td>
<td>10:00-11:00</td>
<td>Polwarth Auditorium</td>
<td>Course introduction</td>
<td>Lecture</td>
<td>Dr I Greig</td>
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<td><strong>Week 10</strong></td>
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<td>09:00-11:00</td>
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<td>Thu 7 Oct</td>
<td>17:00-18:00</td>
<td>Online</td>
<td>Anything worrying you about the course?</td>
<td>Help session</td>
<td>Dr I Greig</td>
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<td>Fri 8 Oct</td>
<td>11:00-13:00</td>
<td>Polwarth 1:039/40</td>
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<td>Wed 20 Oct</td>
<td>11:00-12:00</td>
<td>Polwarth Auditorium</td>
<td>Q&amp;A with Dr Greig – Essay 1</td>
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<td>Mon 18 Oct</td>
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<td>Mon 25 Oct</td>
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<td>Thu 28 Oct</td>
<td>10:00-12:00</td>
<td>Online</td>
<td>Databases for Genomics Research</td>
<td>Tutorial</td>
<td>Dr F Grassmann</td>
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<td>Mon 1 Nov</td>
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<td>Essay 1 Deadline</td>
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<td>Wed 3 Nov</td>
<td>11:00-12:00</td>
<td>Polwarth Auditorium</td>
<td>Q&amp;A with Dr Barrow</td>
<td>Tutorial</td>
<td>Dr J Barrow</td>
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<td>Thu 4 Nov</td>
<td>09:00-11:00</td>
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<td>15:00-17:00</td>
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<td>10:00-11:00</td>
<td>COVID-19 Vaccine Assignment Q&amp;A</td>
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**Week 15**

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<tr>
<td>Mon 8 Nov</td>
<td>Hotel</td>
<td>Online</td>
<td>Protein Localisation (1 - 2)</td>
<td>Lecture</td>
<td>Dr B Müller</td>
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<td>Computer-Aided Protein separation</td>
<td>Lecture</td>
<td>Dr S Dall’Angelo</td>
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<td>Wed 10 Nov</td>
<td>Hotel</td>
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<td>Thu 11 Nov</td>
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<td>Online</td>
<td>Protein separation workshop</td>
<td>Tutorial</td>
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**Week 16**

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<tbody>
<tr>
<td>Mon 15 Nov</td>
<td>Hotel</td>
<td>Online</td>
<td>COVID-19 Vaccines Video Submission</td>
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<td>Mon 15 Nov</td>
<td>Hotel</td>
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<td>Protein: Protein Interactions (1 - 2)</td>
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<td>Dr L Penny</td>
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<td>Wed 17 Nov</td>
<td>Hotel</td>
<td>Online</td>
<td>Where it’s at: Gene therapy, RNA</td>
<td>Lecture</td>
<td>Dr I Greig</td>
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<td></td>
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<td>therapeutics and other frontiers</td>
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<td>Fri 26 Nov</td>
<td>Hotel</td>
<td>Online</td>
<td>Tutorial 2/Group 1</td>
<td>Tutorial</td>
<td>Dr S Miller</td>
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<td>Fri 26 Nov</td>
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<td>Online</td>
<td>Tutorial 2/Group 2</td>
<td>Tutorial</td>
<td>Dr A Mackenzie</td>
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<td>Tutorial 2/Group 3</td>
<td>Tutorial</td>
<td>Dr J Barrow</td>
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<tr>
<td>Fri 26 Nov</td>
<td>Hotel</td>
<td>Online</td>
<td>Protein Separation Quiz Deadline</td>
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**Week 17**

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<td>Mon 22 Nov</td>
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<td>Protein: Nucleic Acid Interaction (1 - 2)</td>
<td>Lecture</td>
<td>Dr B Müller</td>
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<td>Protein: Nucleic Acid Interaction (3 - 4)</td>
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<td>Tutorial</td>
<td>Dr S Miller</td>
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**Week 18**

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<td>Proteomics (1 - 2)</td>
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<td>High throughput screening (1 - 2)</td>
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<tr>
<td>Thu 2 Dec</td>
<td>Hotel</td>
<td>Suttie Centre 012 L. Theatre</td>
<td>Review of presentations and Essay 2 Q&amp;A</td>
<td>Tutorial</td>
<td>Dr I Greig</td>
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<tr>
<td>Fri 3 Dec</td>
<td>Hotel</td>
<td>Suttie Centre 012 L. Theatre</td>
<td>Q&amp;A with Dr Stead</td>
<td>Tutorial</td>
<td>Dr D Stead</td>
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**Week 19**

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<tr>
<td>Mon 6 Dec</td>
<td>Hotel</td>
<td>Pol. Lecture Theatre</td>
<td>Mock Exam: Data Analysis Group 1</td>
<td>Tutorial</td>
<td>Dr I Greig</td>
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<tr>
<td>Thu 9 Dec</td>
<td>Hotel</td>
<td>Pol. Lecture Theatre</td>
<td>Mock Exam: Data Analysis Group 2</td>
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<tr>
<td>Fri 10 Dec</td>
<td>Hotel</td>
<td>Online</td>
<td>Essay 2 (for 10%+20% option) deadline</td>
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