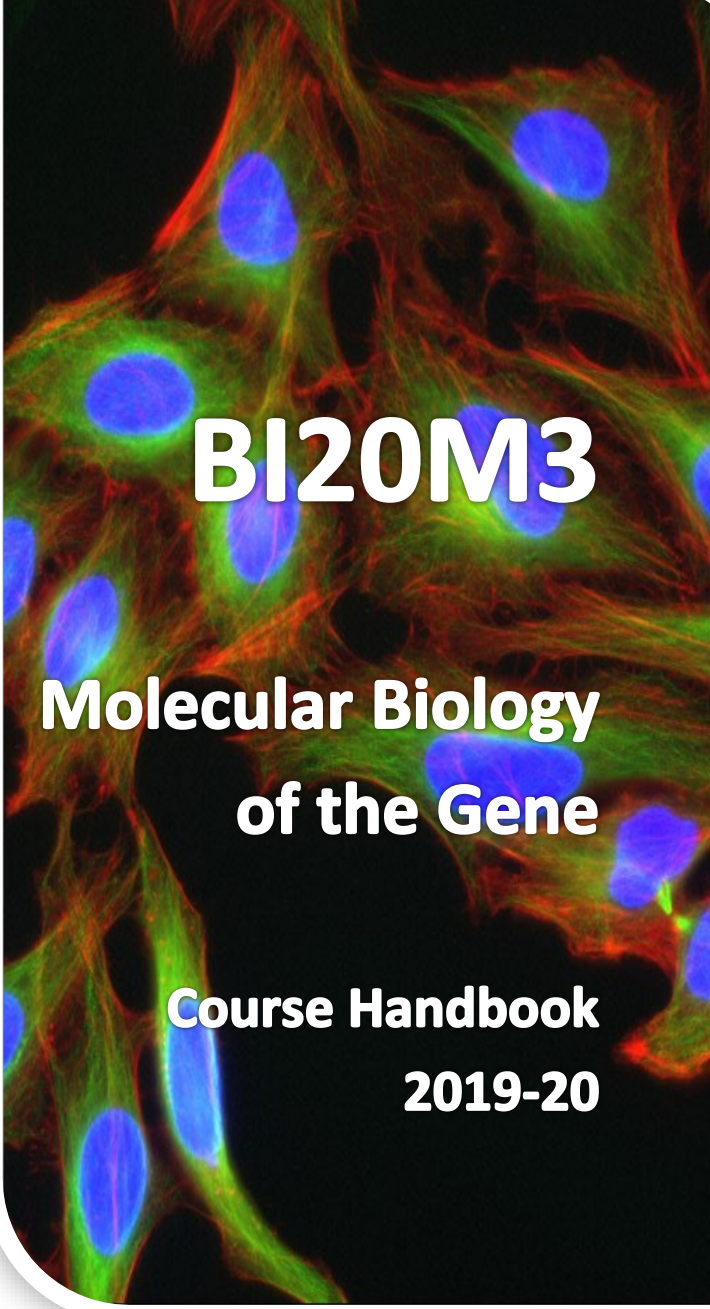
School Of Medicine, Medical Sciences & Nutrition



BI20M3

Molecular Biology of the Gene

Course Handbook

2019-20

UNIVERSITY OF ABERDEEN

Contents

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

With the sequencing of the human genome an understanding of how the one-dimensional information of the genome results in a healthy 4-dimensional human has never been closer. Understanding these processes will lead to a better understanding of how they can go wrong, producing malformation and disease. This course introduces critical aspects of this process and the first of four modules describes what DNA is, how it replicates and how it is packaged into the genomes of bacteria and higher organisms. This first module will also describe how we can manipulate DNA to explore its secrets. The second module will explore the processes that control the expression of genes in both bacteria and higher organisms. This critical aspect of gene function controls where, when and the extent to which genes are turned on; this is the key to multi-cellular complexity and environmental response. The third module will describe the properties of amino acids, peptides and proteins, which contribute to the structure and function of our bodies. This module will also describe how we can analyse the structure and function of proteins. The fourth and final module will be devoted to the study of genes in families and populations. This final module will also discuss how genes can go wrong and lead to disease.

Course Aims & Learning Outcomes

The aims of the course are to enable students:

- To establish an understanding of the structures and functions of nucleic acids and to examine their importance in packaging, replicating and maintaining genetic information;
- To understand the main principles of protein biochemistry, structure and function;
- To understand the basic mechanisms that controls the expression of genes at the levels of transcription and translation in both prokaryotes and eukaryotes
- To understand the principles of how genetic processes can go wrong as a result of mutation and genome rearrangements, thus leading to disease.

The subject-specific learning outcomes are such that, at the end of the course, students should be able:

- To compare and contrast the structure of genomes in eukaryotes and prokaryotes and how they are replicated and packaged;
- To describe the molecular mechanisms involved in gene transcription and translation with specific examples;
- To appreciate the role of protein chemistry and structure in function;
- To describe how genetic mechanisms can go wrong to produce malformation and disease.

Practical skills advanced comprise:

- Ability to follow set protocols and develop competence in measuring volumes and calculating concentration; and the ability to obtain, record, collate and analyse information in the laboratory.

Numerical and Communication skills are encouraged by opportunities:

- To analyse laboratory-acquired information and approach some tutorial problems; and produce written laboratory reports and verbally address topics during tutorials.

Interpersonal and Teamwork skills are encouraged by opportunities:

- To work productively with others in the laboratory; and recognise and respect the views and opinions of others during tutorials.

Self-Management skills are needed in:

- Balancing the various demands of this and other courses you are studying.
- Achieving learning outcomes through a series of lectures, tutorials and practical classes. These three elements complement each other.

The function of the **lectures** is to enable information to be transmitted to a large group. Lectures provide an indication of the quality and quantity of knowledge and understanding expected to be gained by the end of the course. In the majority of cases attendance at lectures is directly linked to exam success. Lectures serve to introduce the student to the information required to pass the exam in a measured and easily digestible format. Attendance at lectures will be recorded by provision of QR codes at the beginning of each lecture. Failure to attend 25% or more of lectures, without good reason, will result in the student being reported to Registry as being “at risk” (C6).

Practical classes enable the class to use a few of the techniques mentioned in the lectures, and to gain experience in the acquisition, recording, evaluation, interpretation and presentation of experimental results. Subject-specific, intellectual and written communication skills are assessed in the written degree examination and in practical reports. Practical and numerical skills are assessed in practical reports. Communication, interpersonal and teamwork skills are encouraged in practicals; these are not formally assessed. Both practical sessions are compulsory, and each practical report will contribute 10% of final mark.

The continuous assessment sessions that follow each of the course modules provide the opportunity for students to engage with the lecture material in a staged and structured manner. These two 1-hour assessments can be attempted by the students over a period of a week after the finish of the relevant block of lectures. **Please use a computer hardwired to**

the University Network to reduce the chance of technical glitches. Each assessment will contribute 10% of final marks.

Learning to understand is an active process and we encourage you to check and organise (in ways best suited to your learning style) material presented in each set of lectures by referring you to the set text.

Course Teaching Staff

Course Co-ordinator(s):
Dr Alasdair Mackenzie (**alasdair.mackenzie@abdn.ac.uk**)

Other Staff:
Prof Iain McEwan **(iain.mcewan@abdn.ac.uk)**
Dr John Barrow (**j.barrow@abdn.ac.uk**)
Prof Martin Collinson (**m.collinson@abdn.ac.uk**)
Dr Alexander Lorenz (**a.lorenz@abdn.ac.uk**)

Assessments & Examinations

Assessment in BI20M3 consists of:

- Two one-hour in-course tests to be carried out after the second and fourth teaching module (20% of final mark).
- Two one-hour on-line tests based on the outcome of the practicals (20% of final mark);
- A 2 hour multiple choice exam (60% of final mark).

Computer based continuous tests ~ online computer based tests will be available online for one week after the last lectures on modules 2 and 4. These tests will not be invigilated and only one hour will be allowed to complete the test once the session is started by the students so it is advisable that the students know their lecture material before the start of the test to make best use of their time. It is also advisable that students have a calculator available as many questions may include simple calculations. Only three attempts will be allowed so it is advisable to prepare well before the test. These tests will contribute 20% of the student's final marks.

Each practical will be followed by an on-line test that will be used to assess the knowledge of the student on the material presented in each practical. In the case of the practical test only one attempt will be permitted. Extra attempts will only be given in the event of a medical emergency during the test or proof of a University based technical glitch.

We would advise that ALL on-line tests be undertaken on a University computer hardwired to the University network. Please do not depend on non-hardwired (Bluetooth etc) University

or home-based servers which have proven to be very unreliable in the past. For further enquiries, please contact the course co-ordinator Dr Mackenzie or Dr Sara Preston

The Examination paper in December will take the form of a series of 100 multiple choice questions to be answered over a two-hour period. All questions carry equal marks. The Course Co-ordinator will give more information about material examined in the different sections of the paper at the end of the course.

Re-sit Examination papers follow the same format as those used in the first diet of examination. For re-sit candidates, marks for Practical Reports and Continuous Assessments still count for a resit examination in the same academic year. Re-sit candidates may be invited to attend an Oral Examination, according to the criteria and arrangements set out in Section (d) above.

Examination results will be posted on the student portals as soon as they are available (approx. 3 weeks), after the examination.

Class Representatives

We 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. You will be informed when the elections for class representative will take place.

What will it involve?

It will involve speaking to your fellow students about the course you represent. This can include any comments that they may have. 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.

Training

Training for class representatives will 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 Medical Sciences Office (based in the Polwarth Building, 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)
- Adviser of studies
- 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 a course has been completed and students are no longer on campus (i.e. work from second semester during the summer vacation), coursework will be kept until the end of Freshers' Week, during the new academic year. After that point, unclaimed student work will be securely destroyed.

Course Reading List

For students intending to study Biochemistry and or Molecular Biology as a final degree option the following is advised. Also note that this is the textbook for the BI25M7 Energy for Life course that runs next term –

> Lehninger Principles of Biochemistry by D.L. Nelson & M.M. Cox (2005) Fifth Edition or later, Worth Publishers Inc., New York. ISBN 0-7167-4339-6.
>
> Or
>
> Biochemistry by T.A. Brown (2017) 1st edition, Scion Publishing Limited, Oxford UK. ISBN 978-1-907-904-28-8.

For Dr Collinson's Lectures;

> Recommended texts include Human Molecular Genetics by Strachan and Read (3rd edition) and Emery's Elements of Medical Genetics (any edition).

Students who are studying other degrees may prefer the following instead:

> Instant Notes in Molecular Biology by Turner, P.C., McLennan, A.G., Bates A.D. & White M.R.M. (2000) Second Edition, Bios, Oxford. ISBN 185996152.

Lecture Synopsis

Lecture 1
Title: **Introduction to BI20M3 course**
Lecturer: **Dr. Alasdair MacKenzie**
Content: A welcome and introduction to the course. This lecture will include a summary of course requirements and student responsibilities.

Module 1; Nucleic Acids

This module will provide an overview of nucleic acid biochemistry with emphasis on the dynamic structure of DNA and the way in which it is replicated and packaged into chromosomes. The basic principles of modern recombinant DNA technologies will also be introduced.

Lectures **1 and 2**
Title: **Chemistry and structure of DNA and RNA**
Lecturer: **Dr. John Barrow**
Content: The genetic code is held within a complex biological polymer, DNA. Moreover, to convert this genetic information into molecules that do work (proteins), a second nucleic acid, RNA, is needed. This lecture describes the structure of DNA and RNA, how their structures were elucidated and the relationship between structure and function in nucleic acids. The concept of chemical instabilities within DNA giving rise to mutations is also introduced.

Lecture 3
Title: **Chromosome structure**
Lecturer: **Dr. John Barrow**
Content: Chromosomes must not only contain genes but must also encode sequences that regulate gene transcription and the replication and segregation of chromosomes. Thus, these huge DNA molecules, especially when considered in relation to the size of a cell, must be packaged into a more compact form. This is a particular problem for eukaryotes with their multiple very large chromosomes. DNA supercoiling is essential to compact DNA but is not sufficient on its own. Histones and other proteins bound to the DNA are needed to pack the DNA into highly ordered structures. The same principles apply to the compaction of prokaryotic chromosomes, but these nucleoprotein structures are less ordered in prokaryotes.

Lecture 4

Title: **DNA replication**

Lecturer: **Dr. John Barrow**

Content: The complex structure of DNA requires complex systems to replicate it. This lecture will describe the fundamental rules of DNA replication and experiments which helped to uncover these rules. The basic reaction of DNA replication will be described followed by a detailed description of how this reaction is catalysed in *E. coli*. The essential requirements of accuracy and processivity will be related to the structure and function of the *E. coli* replication machinery.

Lecture 5

Title: **DNA repair and genome evolution**

Lecturer: **Dr. John Barrow**

Content: The consequences of the chemical instability of DNA (mentioned in the first two lectures) will be described in relation to the generation of mutations. How cells try and minimise the chances of alterations in the genetic code occurring will be described. No biological process is 100% accurate and some of these changes to the DNA sequence arise as a result of errors made by DNA polymerases. How these errors are corrected by mismatch repair will be discussed. Other changes to the genetic code arising from non-enzymatic transformations (DNA damage) must also be minimised and the many repair options that exist to deal with the different types of DNA damage will be described. The effects of DNA damage on DNA replication and genome evolution will also be introduced.

Lectures **6 and 7**

Title: **DNA technologies**

Lecturer: **Dr. John Barrow**

Content: The late 20th century explosion in molecular biological techniques has facilitated major leaps in our understanding of fundamental biological processes. It has also allowed the genetic engineering of organisms. This lecture will describe the basic techniques of DNA cloning. It will also describe how the chemical properties of DNA can be exploited to analyse recombinant DNA molecules by hybridisation, by DNA sequencing, and by the polymerase chain reaction. The use of DNA microarrays to analyse not just single genes but whole genomes will also be discussed.

Lecture 8

Title: **Genome alterations – genetically modified organisms**

Lecturer: **Dr. John Barrow**

Content: The technologies of molecular biology discussed in lectures six and seven can be exploited to alter the genomes of a wide range of organisms. This lecture will describe how recombination can be harnessed to introduce stretches of engineered DNA into the genomes of bacteria, plants and animals.

Module 2; Gene expression and regulation

One of the most important questions within modern biology centres on how one- dimensional information held within the DNA is turned into healthy living 3-dimensional organisms that are able to interact with their environments. This module will describe how this information is decoded by transcription and translation to form proteins and how organisms control these processes to ensure that the correct proteins are produced in the correct cells at the correct times and in the correct amounts. Textbook references, *Lehninger Principles of Biochemistry (4th ed)*, Chapter 26, 27 and 28. **This module will be followed by a one hour on-line assessment available on MyAberdeen covering the contents of modules 1 and 2.**

Lecture 1

Title: **Transcription in prokaryotes**
Lecturer: **Dr. Alasdair MacKenzie**
Content: The first lecture in this series will deal with basal transcription in prokaryotes and will describe how the RNA polymerase enzyme "transcribes" the genetic information in DNA to the messenger RNA that will encode a protein. We will also describe how rates of prokaryotic transcription are controlled using specific examples of metabolic enzymes whose activity is controlled at the level of transcription (e.g. β-galactosidase).

Key words: Transcription, mRNA, tRNA, rRNA, DNA-directed RNA polymerase, σ-factor, Template strand, termination, Operator, Operon, *lac* operon

Lecture 2
Title: **Transcription in Eukaryotes**
Lecturer: **Dr. Alasdair MacKenzie**
Content: This lecture will describe the major differences between prokaryotic and eukaryotic transcription. Although the basic principles are the same, eukaryotic transcription is a much more complex process than prokaryotic transcription and allows for the greater degrees of control required to produce complex multicellular organisms. This lecture will introduce basic concepts in eukaryotic transcription such as the assembly of the basal transcriptional machinery to form the preinitiation complex (PIC).

Key words: RNA polymerase II, TATA binding protein, Pre-initiation complex (PIC), Initiator sequence, promoter sequence, Transcription factors. Initiation complex, elongation, termination

Lectures **3 and 4**
Title: **Gene regulation in Eukaryotes**
Lecturer: **Dr. Alasdair MacKenzie**
Content: In order for complex processes such as embryonic development and human health to occur the activity of a large number of genes within the genome must be coordinated with an enormous degree of precision. This precision is controlled by a class of DNA binding proteins called DNA-binding transactivators that, when activated by the cellular machinery, displace histones to bind DNA sequences called enhancers to form enhancesome complexes. Enhancesome complexes may form at some distance from the gene being activated and it is now known that they interact with the pre-

initiation complex through long distance looping of intervening DNA. This lecture will introduce these processes many of which have only recently been discovered.

Key Words: Enhancer, promoter, DNA-binding transactivators, Histones, co-activators, TFIID.

Lecture 5
Title: **RNA processing**
Lecturer: **Dr. Alasdair MacKenzie**
Content: This lecture will introduce the concepts of post transcriptional processing of eukaryotic mRNA and will describe how the primary transcript is spliced, "capped" and "tailed" before being transported from the nucleus to the cytoplasm to take part in the next stage of gene expression; translation.

Key words: Intron, Exon, 5' cap, Poly(A) tail, Splicing, alternative splicing

Lecture 6
Title: **The genetic code**
Lecturer: **Dr Alasdair MacKenzie**
Content: This set of lectures deals with the way in which genetic information carried in the structure of DNA is translated into the structure of proteins encoded by DNA. Three bases read in sequence along a DNA template form a 'triplet' code-word. Sequences of triplets are transcribed into sequences of complementary three-base 'codons' in messenger RNA (mRNA). Codon sequences are translated into sequences of amino-acid residues in polypeptides. Each of the twenty coded amino-acids has at least one codon. The genetic code (that is, which 3-base code-words specify which amino-acids) was solved using synthetic RNA molecules as mRNAs in a test-tube protein-synthesising system. The code turns out to be degenerate (several amino-acids are specified by more than one code-word), non-overlapping (individual code-words are discrete), comma-less (individual code-words are not separated by non-coding bases) and near-universal (with few exceptions, the same code-words are assigned to the same amino-acids throughout nature). Code-words that are similar to one another tend to be assigned to the same amino-acid or to amino-acids with similar structures. This non-random assignment and degeneracy in general minimise deleterious effects of mutation.

Key Words: Translation, Messenger RNA (mRNA), Central Dogma of Molecular Biology, Genetic Code, Triplet, Codon, Degeneracy, Non-overlapping, comma-less, near-universal nature of code, Frame-shift mutation, Point (single-base) mutation, Silent mutation, Conservative mutation, Open reading frame, Overlapping genes

Lecture 7
Title: **Transcription**
Lecturer: **Dr Alasdair MacKenzie**
Content: The genetic code contained within the mRNA must be "translated" into proteins. This lecture will describe the fascinating choreography of the ribosome subunits, tRNA, mRNA and Amino-acyl tRNA synthetases required for the production of a complete polypeptide.

Key Words: Transfer RNA (tRNA), Adaptor function, Clover-leaf structure, Anticodon, Amino-acyl tRNA synthetase, Wobble hypothesis, Proof-reading during translation.

Lecture 8

Title: **Post transcriptional modification and degradation.**

Lecturer: **Dr Alasdair MacKenzie.**

Content: Once translated many proteins in eukaryotes need to be further altered by a number of processes that include proteolytic cleavage, the formation of disulfide bonds, glycosylation and phosphorylation. Collectively these processes are called post-translational modifications and they are essential for the normal functioning of most human proteins. In eukaryotes any of these processes occur in a part of the cell called the endoplasmic reticulum (ER). Once translated and modified proteins are then sorted and distributed by another cellular structure called the Golgi apparatus. Another critical aspect of protein metabolism is protein degradation where proteins are "tagged" for destruction. This avoids the build-up of excessive un-needed protein in the cell.

Key words: Post-translational modification, disulfide bonds, glycosylation, phosphorylation endoplasmic reticulum, Golgi apparatus, protein degradation.

Module 3; **Proteins**

This module will provide a comprehensive introduction to protein biochemistry, building on the basic chemistry of amino acids and peptides. The properties of proteins will be described, using a number of specific examples. The final lectures in the module will consider the methods used to study proteins. These provide the information that underlies our current understanding of protein structure and function**.**

Lecture 1

Title: **Amino acid biochemistry; amino acids as buffers; amino acid diversity**

Lecturer: **Prof Iain McEwan**

Content: Proteins fulfil a diversity of functions, for example as enzymes, as structural elements of cells and tissues, as carriers of gases and nutrients, as contractile elements in muscle, as antibodies, and as hormones. All this diversity comes from relatively simple building-blocks, L-amino-acid residues. Amino-acids act as zwitterions and may therefore be used as buffers for biological studies. Buffering ability is an important property of proteins, the charge of which alters as the pH changes. The pH at which a particular protein has no net charge is called its isoelectric point.

Keywords: Amino acid, buffering

Lecture 2

Title: **Protein structure**

Lecturer: **Prof Iain McEwan**

Content: Four levels of structure in a protein molecule may be distinguished. The primary structure is the sequence of amino-acid residues, which is always written with the N-terminus on the left and the C-terminus on the right. The terms secondary and tertiary structure describe features of the three-dimensional folding of the polypeptide chain; they determine the final shape of the molecule and the juxtaposition of individual amino-acid residues within the folded structure. Secondary structural features such as the α-helix and the β-sheet occur in varying proportions in different proteins. Tertiary structure relies on a number of different types of force, including hydrogen bonds, ionic bonds, hydrophobic interactions and disulphide bonds. Quaternary structure describes the aggregation of

several polypeptide chains, with specific interactions between the polypeptide sub-units (also called monomers); the sub-units are held together mainly by hydrophobic interactions.

Keywords: three-dimensional structure, α-helix, β-sheet

Lectures **3 and 4**

Title: **Globular proteins (1 and 2)**
Lecturer: **Prof Iain McEwan**
Content: Different types of protein structure are required for different functions. All proteins fall into two broad classes: globular and fibrous proteins. Globular proteins include insulin, which is important in glucose homeostasis, and immunoglobulins, which are one of the body's responses to infection. Other globular proteins include myoglobin, which acts as an oxygen carrier and contains a haem prosthetic group. Haemoglobin is a member of the same family but is more complex in its structure. It contains four subunits, held together by hydrophobic forces. It shows co-operative binding of oxygen and allosteric regulation by carbon dioxide and protons. The mode of action of transcription factor proteins is reliant on their modular structure. We will examine how transcription factors can generally be divided into 2 components; a DNA binding domain and an RNA polymerase activation domain. This lecture will describe the different DNA binding domains or "motifs" and how these allow DNA binding. In addition, the modes of action of various activation domains will be described.

Keywords: globular protein, insulin, immunoglobulin, myoglobin, haemoglobin, transcription factors

Lecture 5
Title: **Fibrous proteins – keratin, elastin and collagen**
Lecturer: **Prof Iain McEwan**
Content: In contrast to most enzymes, circulating and intracellular proteins, which are globular, fibrous proteins have structural roles. An example is keratin, which is made up of α-helices. Collagens contain an unusual triple helix that is quite distinct from the α-helix. These helices form only when there are repeat structures in the polymer, in which glycine occurs at every third monomer position. Collagen is also rich in proline and lysine residues, both of which may be hydroxylated; this is an example of a post-translational modification. Elastin achieves the necessary flexibility by means of unique cross-links between lysine residues.

Keywords: fibrous protein, α-keratin, collagen, elastin

Lecture 6
Title: **Membrane protein, transmembrane proteins**
Lecturer: **Prof Iain McEwan**
Content: Membranes represent a barrier but also contain important activities, reflecting their protein components. The structures of important membrane proteins will be explained, with emphasis on how an α-helix can form the transmembrane part of a protein. Proteins are a major component of cells and are present in all cellular compartments.

Key words: Membrane, phospholipid, GPI-anchor, hydrophobic, hydrophilic, cell-cell interactions, membrane fusion, membrane transport, receptors

Lecture 7
Title: **How we study proteins (1)**
Lecturer: **Prof Iain McEwan**
Content: Proteins are analysed by techniques like electrophoresis, which can give information on size and charge. The important technique of SDS-PAGE will be described in detail, as will the analysis of data to allow us to estimate the molecular mass of proteins and their component chains.

Keywords: Electrophoresis, SDS-PAGE

Lecture 8
Title: **How we study proteins (2)**
Lecturer: **Prof Iain McEwan**
Content: Proteins may be identified by determining their amino-acid composition and, especially, their N-terminal sequence. Many analyses of proteins require them to be cut into smaller pieces by specific proteases.

Keywords: amino-acid composition, amino-acid sequence, proteases

Lecture 9
Title: **How we study proteins (3)**
Lecturer: **Prof Iain McEwan**
Content: The specificity of antibodies is used to provide fast and sensitive assays in many different applications. Among these are enzyme-linked immunosorbent assays (ELISA) and immunoblotting (or western blotting).

Keywords: antibodies, enzyme-linked immunosorbent assay (ELISA), immunoblotting.

Module 4; Genetic disease

This module will explain how genomes can be compromised by mutation and chromosomal rearrangements leading to disorders such as Downs syndrome, cystic fibrosis, fragile-X syndrome and cancer. Recommended text *Human Molecular Genetics* by Strachan and Read (3rd edition) and Emery's Elements of medical genetics (any edition). **This module will be followed by a one hour on-line assessment available on MyAberdeen covering the contents of modules 3 and 4.**

Lecture 1

Title: **Genetic disease**

Lecturer: **Prof Martin Collinson**

Content: This first lecture will revise and extend 1st year lectures on genetic inheritance. The autosomal recessive condition, cystic fibrosis, is carried by around 1 in 25 of the Caucasian population. The gene for the condition, the CFTR gene, produces a protein which forms a chloride iron channel. Mutations within the gene can have different effects on the production of the protein and on its function within the cell. The spectrum of different mutations that give rise to the disease will be described.

Keywords: Mendelian, inheritance, Cystic fibrosis, autosomal, recessive, mutation, ion channel

Lecture 2

Title: **Cancer and autosomal dominant inheritance**

Lecturer: **Prof Martin Collinson**

Content: Cancer affects 1 in 3 individuals in their lifetime but only a very small percentage of them are associated with the genetic predisposition. Most cancer is multifactorial but there are several types that show autosomal dominant inheritance. In this lecture we will consider one of these, colorectal cancer, which can be associated with several genetic conditions for which the genes and their mutations have been identified. As a result of this individuals found to be predisposed may be offered appropriate screening to decrease their risk.

Keywords: Cancer, autosomal, dominant, multifactorial

Lecture 3

Title: **Genome rearrangements and disease**

Lecturer: **Prof Martin Collinson**

Content: Triplet repeat diseases – Huntington's disease, fragile X mental retardation, myotonic dystrophy and others – are caused by expansions of unstable trinucleotide sequences such as $(CTG)_n$. Mechanisms of DNA instability and triplet repeat expansion will be described. We will also look at chromosomal deletions and translocations, their effects on gene expression, and their importance in genetic disease and cancer. X-linked and autosomal dominant patterns of inheritance will be revised.

Keywords: Huntington, myotonic dystrophy, fragile X, trinucleotide repeat, DNA instability, deletion, translocation, cancer

Lecture 4

Title: **Genetic diagnosis and gene therapy**

Lecturer: **Prof Martin Collinson**

Content: The implications of genetics research for prenatal diagnosis, predictive testing and surveillance will be discussed and put in context. Methods for diagnosis based on DNA testing of samples obtained by amniocentesis and chorionic villus sampling will be described. The role of the genetic counsellor and other professionals, and the ethical and practical issues that arise, will be discussed. Recent advances in gene therapy will also be covered. Mitochondrial and Y-linked inheritance will be mentioned.

Keywords: Diagnosis, prenatal, gene therapy, genetic counselling

Lecture 5 **Genes, Nutrition, and the Environment**

Content: The action of genes can be modified by pharmacological and nutritional factors. This lecture explores why piglets born to vitamin A-deficient mothers have no eyes and goes on to explain the role

of retinoids derived from the diet in embryonic development, through a direct control of gene expression.

Keywords: Vitamin A, retinoic acid, control of gene expression.

Lecture 6

Title: **The Human genome and genome projects**

Lecturer: **Prof Martin Collinson**

Content: Humans and other species, such as experimental animals and agriculturally important animals and plants, are having their genomes sequenced. This lecture gives an overview of technology – the factory-scale application of molecular genetics with computers and automation; the basic dideoxy sequencing method and its automation; top-down and bottom-up strategies, and contigs. We will look at web-based databases of genome project information, and how these can help scientists quickly find genome information. The power of sequencing technology has opened up ancient genomes, and we will explore how hybridisation with Neanderthals affected modern humans.

Keywords: Genome, human, homologue, DNA sequence, contig

Practical Lab Work

See BI20M3 practical manuals which are available on line and will be made available at each practical. It is strongly advised that students take time to familiarise themselves with the practical content prior to the start of class.

Practical reports are to be completed by the end of the practical and retained by the student to act as a reference for answering a series of on-line questions that will be available for week after the final practical. You will be given one hour to complete 40 questions relating to the practical. These assessments will comprise 10% of your final mark for each practical.

University Policies

Students are asked to make themselves familiar with the information on key institutional policies which been made available within MyAberdeen (**https://abdn.blackboard.com/bbcswebdav/institution/Policies**). 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 indicate how seriously the University takes your feedback.

These institutional policies should be read in conjunction with this programme and/or course handbook, in which School and College specific policies are detailed. Further information can be found on the **University's Infohub webpage** or by visiting the Infohub.

The information included in the institutional area for 2019/20 includes the following:

- Absence
- Appeals & Complaints
- Student Discipline
- Class Certificates
- MyAberdeen
- Originality Checking
- Feedback
- Communication
- Graduate Attributes
- The Co-Curriculum

Medical Sciences Common Grading Scale

Grade	Grade Point	Category	Honours Class	Description
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			
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
F2	4			
F3	3			
G1	2	Clear Fail/ Abysmal	-	• Token or no submission
G2	1			
G3	0			

Course Timetable BI20M3: 2019-2020

Date	Time	Place	Subject	Session	Staff
Week 7					
Mon 9 Sep	09:00-10:00	ZG18 Zoo LT	Introduction to the course	Lecture	AM
	12:00-13:00	Regent LT	1. Chemistry and Structure of DNA and RNA 1.	Lecture	JB
Tue 10 Sep					
Wed 11 Sep					
Thu 12 Sep					
Fri 13 Sep	16:00-17:00	Regent LT	2. Chemistry and Structure of DNA and RNA 2.	Lecture	JB
Week 8					
Mon 16 Sep	09:00-10:00	ZG18 Zoo LT	3. Chromosome Structure	Lecture	JB
	12:00-13:00	Regent LT	4. DNA replication	Lecture	JB
Tue 17 Sep					
Wed 18 Sep					
Thu 19 Sep					
Fri 20 Sep	16:00-17:00	Regent LT	DNA technologies 1	Lecture	JB
Week 9					
Mon 23 Sep	09:00-10:00	ZG18 Zoo LT	DNA technologies 2	Lecture	JB
	12:00-13:00	Regent LT	Genetically modified organisms	Lecture	JB
Tue 24 Sep					
Wed 25 Sep					
Thu 26 Sep					
Fri 27 Sep	16:00-17:00	Regent LT	Transcription 1	Lecture	AM
Week 10					
Mon 30 Sep	09:00-10:00	ZG18 Zoo LT	Transcription 2	Lecture	AM
	12:00-13:00	Regent LT	Gene Regulation 1	Lecture	AM
Tue 1 Oct					
Wed 2 Oct					
Thu 3 Oct					
Fri 4 Oct	16:00-17:00	Regent LT	Gene Regulation 2	Lecture	AM
Week 11					
Mon 7 Oct	09:00-10:00	ZG18 Zoo LT	RNA processing and the genetic code	Lecture	AM
	12:00-13:00	Regent LT	Translation	Lecture	AM
Tue 8 Oct					
Wed 9 Oct					
Thu 10 Oct					
Fri 11 Oct	16:00-17:00	Regent LT	Translation and the ribosome	Lecture	AM
Week 12					
Mon 14 Oct	09:00-10:00	ZG18 Zoo LT	Post translational processing	Lecture	AM
	12:00-13:00	Regent LT	Transcription 3	Lecture	AM
Tue 15 Oct					
Wed 16 Oct					
Thu 17 Oct					
Fri 18 Oct	16:00-17:00	Regent LT	Transcription 4	Lecture	AM
Week 13					

Mon 21 Oct	09:00-10:00	ZG18 Zoo LT	Protein Structure 1	Lecture	IM
	12:00-13:00	Regent LT	Protein Structure 2	Lecture	IM
Tue 22 Oct					
Wed 23 Oct					
Thu 24 Oct					
Fri 25 Oct	16:00-17:00	Regent LT	Protein Structure 3	Lecture	IM
Week 14					
Mon 28 Oct	09:00-10:00	ZG18 Zoo LT	4. Globular Proteins (2)	Lecture	IM
	12:00-13:00	Regent LT	5. Fibrous Proteins	Lecture	IM
Tue 29 Oct	15:00-18:00	ZB13/14/11	Restriction analysis of plasmid DNA	Practical	AL +AM
Wed 30 Oct					
Thu 31 Oct	09:00-12:00	ZB13/14/06	Restriction analysis of plasmid DNA	Practical	AL+AM
Fri 1 Nov	16:00-17:00	Regent LT	6. Transmembrane Proteins	Lecture	IM
Week 15					
Mon 4 Nov	09:00-10:00	ZG18 Zoo LT	7. How we study proteins (1)	Lecture	IM
	12:00-13:00	Regent LT	8. How we study proteins (2)	Lecture	IM
Tue 5 Nov					
Wed 6 Nov					
Thu 7 Nov					
Fri 8 Nov	16:00-17:00	Regent LT	9. How we study proteins (3)	Lecture	IM
Week 16					
Mon 11 Nov	09:00-10:00	ZG18 Zoo LT	1.Genetic Disease and autosomal recessive inheritance	Lecture	MC
	12:00-13:00	Regent LT	2.Cancer and autosomal dominant inheritance	Lecture	MC
Tue 12 Nov	15:00-18:00	ZB13/14/11	Protein Practical	Practical	JB+AM
Wed 13 Nov					
Thu 14 Nov	09:00-12:00	ZB13/14/06	Protein Practical	Practical	JB+AM
Fri 15 Nov	16:00-17:00	Regent LT	3. Genome rearrangements and disease	Lecture	MC
Week 17					
Mon 18 Nov	09:00-10:00	ZG18 Zoo LT	4. Genetic Diagnosis and Gene Therapy	Lecture	MC
	12:00-13:00	Regent LT	5.Genes, nutrition, and the environment	Lecture	MC
Tue 19 Nov					
Wed 20 Nov					
Thu 21 Nov					
Fri 22 Nov	16:00-17:00	Regent LT	6. Genome projects	Lecture	MC

Staff

Alasdair MacKenzie (Course co-ordinator)	AM
Martin Collinson	MC
Iain McEwan	IM
John Barrow	JB
Alexander Lorenz	AL