Accessibility statement

# Genes to Proteins - CHE00021I

« Back to module search

- **Department**: Chemistry
- **Module co-ordinator**: Prof. Tony Wilkinson
- **Credit value**: 20 credits
- **Credit level**: I
- **Academic year of delivery**: 2020-21
  - See module specification for other years: 2018-19 2019-20

## Module summary

This first half of this module covers Gene Regulation and Genetic Engineering with a strong Biological Chemistry perspective. This leads into the second half of the module which concerns Protein Architecture and Action including how proteins are assembled and/or modified to carry out their functions.

## Module will run

| Occurrence | Teaching cycle |
|---|---|
| A | Spring Term 2020-21 to Summer Term 2020-21 |

## Module aims

This module builds on core biological chemistry material taught in Year 2 of the chemistry degree. The first half of the course (for Chemists only) provides a detailed overview of molecular biology – a field which over the last 50 years has transformed biological chemistry. After a brief introduction to genes and genomes, the factors regulating gene expression in bacteria and higher organisms will be explored. The course will consider how genes are translated into proteins and how DNA is replicated with high fidelity. With this foundation the course will go on to describe how genes can be isolated and precisely manipulated – leading to the field of genetic engineering, which is underpinning our understanding of protein function. Methods for tailoring enzyme properties using random and rational approaches will be described with examples.

The second half of the module (for both Chemists and Biochemists) explores advanced aspects of protein science – including protein structure and function, determination of structure and protein engineering. Our appreciation of almost all aspects of biochemistry and molecular biology has been enhanced by the elucidation of atomic resolution structures that reveal the underlying chemical mechanisms responsible for biological function. In addition, our ability to exploit this understanding through the use of genetic approaches to engineer proteins, is leading to the generation of improved proteins for therapeutic and biotechnology applications. Students studying this module will be equipped to go on to further studies in biochemistry/molecular biology related fields of study, as well as having valuable insight into the growing biotechnology sector of industry.

## Module learning outcomes

Students will:

- learn in detail about transcription and translation of genetic information and gain confidence in understanding the way in which (i) transcription is regulated and (ii) genetic decisions are made.
- be expected to appreciate the roles of the macromolecular machines RNA polymerase, DNA polymerase and the ribosome and understand how the information stored within DNA is disseminated.

- explore how knowledge of gene structure and function can be exploited through genetic engineering methods. Students will learn how to design oligonucleotides for PCR, sequencing and mutagenesis.
- explore the engineering of proteins using various techniques – including rational amino acid mutagenesis, random mutagenesis and DNA shuffling experiments and computer aided design. Students will be expected to appreciate, rationalise and sometimes predict how modification of proteins can modify their behaviour and properties.
- engage with a case study based on applications of genetic engineering technology, in order to demonstrate they have come to grips with the key concepts.
- understand the basic principles of how protein structures are determined using the methods of X-ray crystallography, electron microscopy or NMR spectroscopy
- appreciate how protein structure relates to protein mechanism and thus to biological function.
- understand how the relationship between sequence, structure and function can be exploited to model the structure of homologous proteins
- learn about the wide range of functions which can be performed by proteins, such as enzymes, signalling proteins, membrane bound transport proteins and structural proteins. Students will be expected to rationalise and understand the behaviour of different proteins based on their structural features.
- engage with case studies to cement their understanding of the key topics.

# Module content

This module begins by exploring the factors that regulate gene expression in bacteria leading to a consideration of how knowledge of gene control allows us to understand the molecular basis of decision-making by cells. We will then discuss how knowledge of gene control and protein synthesis can be exploited for the expression of foreign (such as human) genes in genetically modified micro-organisms. The module will go on to describe the products of these genes - proteins, the most versatile of all molecules. After a discussion of the main features of protein structure, the course will cover the determination of 3D structure through diffraction, microscopy and NMR methods. After a brief discussion of the patterns that are emerging in protein structure (and how this can be exploited to predict protein structure), the course continues with detailed examples of proteins in action.

**Transcription & Control of Gene Expression: 6 lectures AJW (6) 1×2h unassessed workshop (AJW)**

- Key components of transcriptional regulatory circuits - repressors, activators, promoters, operators.
- Transcription termination and attenuation in gene regulation.
- Gene regulatory mechanisms in bacteriophage lambda.

**Protein Synthesis and DNA Replication: 4 lectures AJW (4)**

- Aminoacyl tRNA Synthetases, tRNA, and the Ribosome.
- Replication Forks, DNA polymerase, and Replication Initiation, *ori* sequences and DnaA.

**Genetic Engineering and Protein Engineering: 8 lectures GJG (8), 1×2h unassessed workshop (AJW)**

- Methods and tools of gene cloning and sequencing of DNA.
- Polymerase chain reaction (PCR).
- Recombinant protein production.
- Tailoring enzyme properties using random and rational approaches.

**Introduction to Protein Architecture and Action: 1 lecture KSW (1)**

**Determining Protein Structure and Stability: 9 lectures KSW (4), MJP (3) AAA (2)**

Techniques of Structure Determination

- Protein Crystallography
- Circular Dichroism Spectroscopy and Protein Folding
- NMR Spectroscopy
- Cryo-Electron Microscopy

**Protein Structure and Diversity: 3 lectures. (REH 3)**

- Essential features of protein structure and the forces involved in protein folding and assembly.
- Relationship between sequence, structure and function - generating models of homologous proteins.

**The function of proteins in biological systems. 5 lectures : REH (2) AAA (3)**

- Proteins as Enzymes - Protein Kinases and Proteins as Switches,
- DNA translocating motors and viruses.

The Proteins component of the course contains 2 Workshops (**KSW** and **KDC**) in which Molecular Graphics will be used. The first will feature **Electron Density Map Fitting** and the second will explore the **Structural Basis of Enzyme Action**

**Assessment:** Workshop assessment: 1 x 3.5 hour Assessed Computational Workshop on Structural Basis of Enzyme Action. Closed examination: students answer two compulsory questions.

# Assessment

| Task | Length | % of module mark |
|---|---|---|
| **24 hour open exam**<br>Genes to Proteins | N/A | 80 |
| **Essay/coursework**<br>Assessed Workshop | 3.5 hours | 20 |

## Special assessment rules

None

## Additional assessment information

Assessed Computational Workshop on Structural Basis of Enzyme Action. This workshop takes the forms of an extended session in which the students are introduced to relevant software and databases as they explore the structure of a specified glycosyl hydrolase. After the workshop, the students have up to a week to complete and hand in a set of questions on the enzyme which can be addressed using the skills they have learnt.

## Reassessment

| Task | Length | % of module mark |
|---|---|---|
| **24 hour open exam**<br>Genes to Proteins | N/A | 80 |
| **Essay/coursework**<br>Assessed Workshop | 3.5 hours | 20 |

# Module feedback

Students will receive feedback on their performance in the workshop assessments. They will receive verbal feedback on their progress in the formative workshops, which support lectures.

The closed examinations held in the Summer term are marked typically within 4 weeks with mark slips (with per-question break-down) being returned to students via supervisors in week 10 of the Summer Term. Outline answers are made available via the Chemistry web pages when the students receive their marks, so that they can assess their own detailed progress/achievement. The examiners reports for each question are made available to the students via the Chemistry web pages.

# Indicative reading

This is provided by the individual lectures in the form of suggested textbooks and review articles listed on hand-out material and as citations on slides.

## Coronavirus (COVID-19): changes to courses

The 2020/21 academic year will start in September. We aim to deliver as much face-to-face teaching as we can, supported by high quality online alternatives where we must.

Find details of the measures we're planning to protect our community.

Course changes for new students