UNIVERSITY OF CAMBRIDGE

Institute of Continuing Education

Undergraduate Diploma in Genetics

2022-2023

Course code: 2223DCR105

COURSE GUIDE

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Welcome to the **Undergraduate Diploma in Genetics,** a University of Cambridge award offered by the Institute of Continuing Education (ICE). The Diploma is taught and awarded at FHEQ level 5 (i.e. second-year undergraduate level) and attracts 60 credits. The award is completed in one academic year. For further information about academic credit please see our website:
http://www.ice.cam.ac.uk/studying-with-us/information-for-students/qualifications-that-we-offer.

Important information for the 2022-2023 Academic Year

The **Undergraduate Diploma in Genetics** is taught using remote methods. There will be no face-to-face teaching on the course. Teaching is via asynchronous, self-paced approaches facilitated by the course Virtual Learning Environment (VLE) along with scheduled synchronous delivery using remote learning platforms such as Zoom. You are encouraged to attend synchronous sessions to maximise your learning. However, as this may not always be possible we will record these sessions and place them in the VLE.

Examples of asynchronous teaching approaches on the course include, but are not limited to: structured reading within the VLE and through external recommended sources; utilisation of podcasts or videos; engagement with virtual practical and laboratory resources; quizzes and activities in the VLE; pre-recorded lectures and seminars; online discussion forums; and your own self-directed learning. Synchronous teaching may include: delivery of lectures, seminars and their associated discussion; group-based activities; journal clubs; debates; discussions based around pre-reading; and practical demonstrations.

Synchronous teaching takes place during a time window as outlined in each provisional unit structure. Exactly when teaching occurs in this window varies from session to session and is confirmed, via the VLE, in advance of the teaching. This allows the teaching staff to maximise the effectiveness of the synchronous sessions for the material they are covering. For example, it might consist of 4 separate sessions each of 45 minutes in length; or a 30 minute seminar, followed by discussion, group work, group feedback and another seminar.

The majority of the course teaching, both in terms of material and content, occurs through asynchronous approaches via the VLE ahead of and between the synchronous sessions. This material appears progressively over the unit to help guide and structure your learning journey.

Course Overview

The **Undergraduate Diploma in Genetics** focuses on DNA at the core of life - how DNA works and how it informs the structures and functions of living things. The course will provide a detailed overview of the fundamental processes involved in the transfer and interpretation of genetic information, including its application in both research and industrial settings. The course will also introduce the use of, the importance of, and some of the caveats with, model organisms. It will finish with an exploration of the wonderful world of plant and microbial genetics.

Genetics is at the forefront of biological science. The course aims to discuss the successes of the Human Genome Project, the ease with which genomes can be sequenced, and the continual development in gene editing technology. These advances make this an extremely exciting time to be learning about the importance of genetics. Each unit contains one or two specific assignments related to the unit content. These allow you to demonstrate how you have met the course learning outcomes. In addition to summative assignments you will have opportunity to produce work for formative feedback from the teaching team and your fellow learners.

The course is three discrete units. A broad overview of each unit, the dates of synchronous teaching delivery and a course reading and resource list for each of these units is included in this course guide. Throughout the year additional readings and resources are put on the course VLE.

Course Aims and Learning Outcomes

Overall, the course aims:

- To enable students to generate ideas through the analysis of abstract genetic concepts

- To instil students with a broad-range of discipline specific skills with which to analyse and formulate responses to genetic-based problems

- To provide detailed knowledge of the control of gene expression, the use of model organisms, plant and microbial genetics and recombinant DNA technology

- To encourage students to accept responsibility for achieving personal and group objectives

- To provide the ability to access and evaluate genetic-related information from a range of sources

Within the overall aims of the course the following learning outcomes will be delivered through the taught material and assessed via the unit assignments.

Knowledge and understanding

- Explain how the principles of genetics underlie much of the basis of molecular biology, including through the context of plant and microbial genetics
- Explain the principles of gene expression and how it is controlled through the use of detailed examples
- Understand why model organisms are used and the relative advantages, disadvantages and applications of different model systems

- Describe how comparative genetics has contributed to understanding core cellular functions

Skills and other attributes

Intellectual skills:

- Identify, analyse and communicate the principles and concepts underlying our understanding of genetics and any competing perspectives
- To identify patterns and relationships in data through undertaking research of the existing literature
- Collect and synthesis relevant information from a range of authoritative sources to inform solutions for unfamiliar genetics based problems
- Evaluate the results of experimental data in the context of appropriate genetic models and theories

Practical skills:

- To use openly available computational tools and databases to extract and analyse genetic information
- To devise and evaluate appropriate experimental approaches to investigate relevant areas of genetics
- To extract, analyse, evaluate and communicate genetic information

Other transferable skills:

- Interact effectively within a team, giving and receiving information and ideas and modifying responses where appropriate
- Show an awareness of personal responsibility and professional codes
- The capacity for independent thought and judgement
- The development of independent learning, study and time management skills
- The deployment of skills in critical reasoning
- The development of competence in using IT to support one's work
- The ability to reference sources of information to support one's reasoning

Study hours

The award of academic credit is a means of quantifying and recognising learning, and within the UK, one credit notionally represents 10 hours of learning[1]. Each of the units in this course attracts 20 credits so students should expect to need to study for approximately 200 hours in total to complete each unit successfully. However, it is recognised that students study at different paces and use a variety of approaches, so this is a recommendation, rather than a hard-and-fast calculation.

1 'Academic credit in higher education in England – an introduction'. The Quality Assurance Agency for Higher Education, 2009

Teaching staff

A range of academic experts teach on the course. This means you will have access to and involvement with people who have extensive subject knowledge and who are, in many cases, actively involved in research in genetics and its related disciplines. For a list of tutors who teach on the biological science programmes, please see the Biological and life sciences subject page on the Institute's website. (http://www.ice.cam.ac.uk/courses/courses-subject/biological-and-

life-sciences)

Administrative staff

Arts and Sciences Enquiries
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Please refer to the 'information for students' section on ICE's website www.ice.cam.ac.uk/studying-with-us/information-for-students and the 2022/23 Student Handbook for award-bearing courses for further information and guidance relating to all aspects of the course including study skills, assignments, assessment and moderation. The Course Information and Help and Guidance section of the ICE VLE will also contain valuable information specific to your course.

Information correct as at 31.08.2022

Syllabus for first unit

Michaelmas term 2022

The regulation and control of gene expression

Start date	7 October 2022	**End date**	
Synchronous Sessions	Saturday 22 October 2022 Saturday 05 November 2022 Saturday 19 November 2022 Saturday 03 December 2022		
Delivery	Remote: Zoom-based synchronous and online VLE-based asynchronous teaching	**No of synchronous meetings**	4

Summary

This unit aims to develop a detailed understanding of the cellular and molecular mechanisms that facilitate the transfer of information held within DNA into functional molecules. Students will explore and investigate the mechanisms by which these processes are regulated, consider why regulation is important and assess what can happen when regulation goes wrong. The unit will also introduce the importance of recombinant DNA technology by exploring key historical advances alongside modern day approaches.

Content

Proteins, the products of gene expression, dictate cellular phenotype and function. The regulation of gene expression is a critical element in the normal functioning of the cell. Disruption of this process can lead to significant changes in the behaviour and function of a cell and may lead to the development of disease. It is consequently essential to understand how genetic information is expressed and regulated in a controlled manner.

Using examples from both prokaryotic and eukaryotic systems this unit will provide detailed coverage of the biological mechanisms that control gene expression. This will include, but is not limited to: transcriptional and pre-transcriptional regulation, protein translation, epigenetic regulation and small non-coding RNAs. The unit will also address some of the biological impacts - at the level of the individual cell, tissue and organism - of the failure of proper regulation of gene expression.

The importance of understanding how gene expression can be controlled and manipulated has been at the forefront of advances in molecular biology and in the pharmaceutical industry. The unit will use case studies and online practical sessions to explore the historical context and application of recombinant DNA technology and how it continues to drive the advancement of biological and genetic knowledge.

Provisional unit structure

Topic	**Indicative content for synchronous and asynchronous delivery**
Manipulation of DNA	This topic will cover the theory and practice of recombinant DNA technology and its application in the advancement of biological knowledge. Case studies and online practical sessions will demonstrate the fundamental experimental principles and their application.
The flow of genetic information	Using examples from prokaryotic and eukaryotic systems this topic will consider the wide range of mechanisms regulating and controlling gene expression and what happens when these mechanisms go wrong.

Student assessment

The unit requires a commitment to reading and pre-class preparation, including some specific reading between class sessions, along with ongoing engagement with the VLE.

There are two assessment pieces for this unit and each contributes 50% of the credit for this unit.

Assessment 1: Using three specific examples analyse how gene expression is regulated and why this is important.

- This work must be presented as an essay of 2,000 words that contains appropriate figures and referencing.
- Examples may originate from material covered in the course, or may come from your own research.
- The precise title is provided through the VLE.

Assessment 2: Complete a series of short answer questions and problems relating to the material covered in the teaching delivered in the unit.

- The exact questions are provided through the VLE.

Questions about the assignments should be directed to the course director.

All students are expected to upload their assignments into the VLE and these are analysed using the text comparison software Turnitin.

Closing date for the submission of assignments:
Wednesday 4th January 2023 before noon
(GMT)

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Syllabus for second unit

Lent term 2023

Model Organisms

Start date	2 January 2023	**End date**	
Synchronous Sessions	Saturday 21 January 2023 Saturday 04 February 2023 Saturday 18 February 2023 Saturday 04 March 2023		
Delivery	Remote: Zoom-based synchronous and online VLE-based asynchronous teaching	**No of synchronous meetings**	4

Aims

This unit will introduce students to the essential biological and genetic experimental system, the model organism. Students will be able to explore the historical importance and modern day relevance of key model organisms including *Drosophila melanogaster, Caenorhabditis elegans, Mus musculus*, and *Arabidopsis thalania*. The unit will also explore, where relevant, the importance and relevance of bacterial and viral experimental systems.

Content

Genetics, possibly more than any other branch of biology, has made extensive use of model organisms to enhance our functional and molecular understanding of biological systems. Since the early days of Gregor Mendel's observations around the inheritance patterns displayed by the pea plant geneticists have sought to observe and manipulate the genetic makeup of a range of organisms to better understand how they, and more complex organisms, such as humans, work.

Within this unit and using five core experimental systems, students will consider the importance of model organisms to the development of understanding and progress in the area of genetics. Topics of study will include: the historical context; landmark experiments; the relevance of the model system to the wider genetic landscape; caveats specific to each model organism; and the applicability of the model system to genetics in the future.

Provisional unit structure

Topic	Indicative content for synchronous and asynchronous delivery
Mus musculus	The mouse (Mus musculus) as a model organism.
Drosophila Melanogaster	The fruit fly (Drosophila melanogaster) as a model organism.
Arabidopsis thaliana	Plants as model organisms – the use and utility of Arabidopsis thaliana.
Caenorhabditis elegans and Saccharomyces Cerevisiae	Worms and yeasts – using Caenorhabditis elegans and Saccharomyces cerevisiae as model organisms.

Student assessment

The unit requires a commitment to reading and pre-class preparation, including some specific reading between class sessions, along with ongoing engagement with the VLE.

There are two assessment pieces for this unit and each contributes 50% of the credit for this unit.

Assessment 1: Perform a critical analysis of a relevant research paper (1,750 – 2,000 words).

- A selection of relevant research papers that utilise model organisms to advance the understanding of genetics along with a suggested framework to structure the assignment will be provided.
- Students are expected to consider how the paper fits within the published literature, whether its methodology and analysis is sound, whether the data supports the conclusions drawn, and what additional experiments would seem appropriate to consider.

Assessment 2: Complete problem-based learning exercises focused on experimental studies using model organisms (equivalent to 1,750 – 2,000 words).

- Guidance on how to address these sorts of questions, and the opportunity to complete practice questions for formative feedback will be provided through the teaching and the VLE.

Questions about the assignments should be directed to the course director.

All students are expected to upload their assignments into the VLE and these are analyzed using the text comparison software Turnitin.

Closing date for the submission of assignments:
Wednesday 22nd March 2023 by noon (GMT*) (*Greenwich Mean Time)

Syllabus for third unit

Easter term 2023

Plant and Microbial Genetics

Start date	27 March 2023	**End date**	
Synchronous Sessions	Saturday 01 April 2023 Saturday 22 April 2023 Saturday 06 May 2023 Saturday 20 May 2023		
Delivery	Remote: Zoom-based synchronous and online VLE-based asynchronous teaching	**No of synchronous meetings**	4

Aims

This unit will deepen student understanding of genetics through the study of plant and microbial systems with a particular focus on how genetic methods control physiological, metabolic, developmental and cell signalling processes. Students will be able to demonstrate the importance and benefit of comparative genomics. The unit will provide students with a critical awareness of the important role plant and microbial systems have in genetic engineering and how these systems are integral to scientific and societal advancement.

Content

The previous two Units have introduced multiple examples of the importance of understanding how non-mammalian genetics work. In this Unit we will build on this knowledge by providing an in depth understanding of the core concepts of plant and microbial genetics.

The key characteristics of microbial and plant genetics will be considered both in terms of their uniqueness, as well as their similarity, to mammalian systems. This will enable an exploration of the importance of these systems in their own right and their relevance to the improved understanding of other branches of genetics.

Particular consideration will be given to the practical applications of plant and microbial systems along with discussion of how these applications impact on an ethical and a practical level within society.

Provisional unit structure

Topic	Indicative content for synchronous and asynchronous delivery
Microbial genetics	An introduction to microbial genetics; the differences between prokaryotic and eukaryotic genetics; the applications and uses of microbial genetics in understanding complex systems.
Plant genetics	An introduction to plant genetics; similarities, differences, and applicability to mammalian genetics; the application of plant genetics to understanding cellular functionality.
Practical applications	This session will consider some of the practical applications and experimental underpinnings of plant and microbial systems.
Case studies	Using a range of plant and microbial case studies students will be introduced to key issues, technologies, and applications with relevance to, or impacts upon, society. These may include approaches such as genetic modification of crops and the application of CRISPR-based cloning technologies.

Student assessment

The unit requires a commitment to reading and pre-class preparation, including some specific reading between class sessions, along with ongoing engagement with the VLE.

There is a choice of assessment for this unit.

Option 1:

Using specific examples critically assess how the study of plant and microbial genetics has helped our understanding of mammalian biology.

- This work must be presented as an essay of 3,500 – 4,000 words that contains appropriate figures and referencing. Examples may originate from material covered in the course, or may come from your own research.

Option 2:

You must complete both parts of the option 2 assignment, which are equally weighted towards your overall unit mark.

i) The development of CRISPR/Cas9 technology has benefited from our understanding of the microbial genetics system. Explain the trajectory of this development and choose an application where CRISPR has been effectively utilized

- This work must be presented as an essay of 1,750 – 2,000 words that contains appropriate figures and referencing. Examples may originate from material covered in the course, or may come from your own research.

ii) Complete the short answer questions on aspects of plant and microbial genetics provided

in the VLE.

Questions about the assignments should be directed to the course director.

All students are expected to upload their assignments into the VLE and these are analyzed using the text comparison software Turnitin.

Closing date for the submission of assignments:
Friday 9th June 2023 by noon BST* (British Summer Time)

Recommended Readings

Engagement with a wide range of reading material and additional resources will enhance and improve your understanding of the subjects you are studying and help you have a more comprehensive and satisfactory learning experience.

Many genetics and molecular biology texts exist and the majority of these provide excellent introductions to the topics taught in the course. The texts and resources listed below are an indication of the sorts of reading material that will benefit your learning. They are a mix of textbooks and popular science books. Where possible the textbooks are available electronically through the University library and can be accessed using your Raven credentials.

Throughout the course you are given specific readings as part of the teaching. These will be accessible electronically via access provided by the University. Information about, and links to, these appear in the VLE as necessary.

For some texts older editions still contain the relevant information and students are welcome to discuss this, and other reading options, with the Tutors or Course Director. Background reading will greatly increase appreciation of the course.

AUTHOR	**TITLE**	**PUBLISHER**
Arney, Kat	Herding Hemingway's Cats: Understanding how our genes work	Bloomsbury Publishing, 2016
Bonini NM and Berger SL	The sustained impact of model organisms-in genetics and epigenetics	Genetics 205: 1–4. (2017)
Cobb, Matthew	Life's Great Secret: The Race to Crack the Genetic Code	Profile Books, 2015
Fletcher, Hugh *et al.,*	BIOS Instant Notes in Genetics	CRC Press LLC, 2012
Hanage WP	Not so simple after all: Bacteria, their population genetics, and recombination.	Cold Spring Harb Perspect Biol. 2016;8(7) pii:a018069
Hartl DL	Essential Genetics and Genomics	Jones & Bartlett Learning, 2020
Krebs, J *et al.,*	Lewin's Genes XII	Jones & Bartlett, 2018
Lehner B	Genotype to phenotype: lessons from model organisms for human genetics.	Nat. Rev. Genet. 14: 168–178. (2013)
Miglani, Gurbachan S.	Essentials of Molecular Genetics	Alpha Science International, 2015
Mukherjee, Siddhartha	The Gene: An Intimate History	Vintage, 2017

Reich, David	Who we are and how we got here	OUP, 2018
Rutherford, Adam	A brief history of everyone who ever lived	Orion Publishing, 2016
Sapolsky, Robert	Behave: The Biology of Humans at Our Best and Worst	Vintage, 2018

TIMETABLE FOR SYNCHRONOUS TEACHING

Michaelmas 2022: The regulation and control of gene expression	
Saturday 22nd October 2022	Between 10:30 and 15:30 BST
Saturday 5th November 2022	Between 10:30 and 15:30 GMT
Saturday 19th November 2022	Between 10:30 and 15:30 GMT
Saturday 3rd December 2022	Between 10:30 and 15:30 GMT
Lent 2023: Model Organisms	
Saturday 21st January 2023	Between 10:30 and 15:30 GMT
Saturday 4th February 2023	Between 10:30 and 15:30 GMT
Saturday 18th February 2023	Between 10:30 and 15:30 GMT
Saturday 4th March 2023	Between 10:30 and 15:30 GMT
Easter 2023: Plant and Microbial Genetics	
Saturday 1stApril 2023	Between 10:30 and 15:30 BST
Saturday 22ndnd April 2023	Between 10:30 and 15:30 BST
Saturday 6th May 2023	Between 10:30 and 15:30 BST
Saturday 20th May 2023	Between 10:30 and 15:30 BST

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