UNIVERSITY OF CAMBRIDGE

Institute of Continuing Education

Undergraduate Certificate in Genetics

2022-2023

Course code: 2223CCR211

COURSE GUIDE

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Welcome to the **Undergraduate Certificate in Genetics**, a University of Cambridge award offered by the Institute of Continuing Education (ICE). The Certificate is taught and awarded at FHEQ level 4 (i.e. first-year undergraduate level) and attracts 60 credits. The award is completed in one academic year and each unit (term) is equally weighted. For further information about academic credit please see our website http://www.ice.cam.ac.uk/studying-with-us/information-for-students/faqs/3-credit-faqs

Important information for the 2022-2023Academic Year

The **Undergraduate Certificate 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 Certificate 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 explores key scientific advances and recent changes in our understanding of genetics. You will learn about medical and biotechnological breakthroughs and future possibilities including genome editing. The course explores the mechanisms that create genetic variation and how genes pass from generation to generation.

As well as a broad introduction to the subject, the course aims to promote discussion about the current and future application of the Human Genome Project and genomic data in the medical field. 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.

The course aims to:

1. show what DNA is at the molecular level and how it is read by the cellular machinery, how it is replicated, how it is maintained and mutated, and the implication of such mutations / changes for human health and diseases
2. introduce students to the core concepts of what genes are and how they work, enabling students to appreciate the transfer of genetic information in living cells
3. give insight into how genes are orchestrated and function together as part of the genome, what can go wrong and how they can be manipulated in the laboratory
4. detail key advances in modern genetic techniques and projects such as genome wide association studies and disease-risk prediction, the 100,000 genomes project, gene therapy, and the use of stem cells
5. cover the principles of epigenetic control of gene expression and how this can go wrong in disease
6. explain how genetic material is passed from generation to generation and how this can influence the genetic structure of whole populations
7. discuss the theory of evolution and the genetic evidence that supports it.

Course Aims and Learning Outcomes

Overall the course aims to:

- Explain what DNA is at the molecular level;
- Introduce students to the core concepts of what genes are and how they work, enabling students to appreciate the transfer of genetic information in living cells;
- Explain how mutations can arise and the consequences for cellular functioning;
- Demonstrate how gene function is controlled as part of the genome;
- Detail key advances in modern genetic techniques and projects such as genome wide association studies, gene therapy and the use of stem cells;
- Explain how genetic material is passed from generation to generation and how this can influence the genetic structure of whole populations.

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

- Knowledge of what genes are and how DNA sequence determines protein composition and function
- Knowledge of how genes are arranged within chromosomes
- Knowledge of the mechanisms by which variation is generated
- Knowledge of the inheritance and underlying causes of genetic traits and diseases including the interplay of genes and the environment

Skills and other attributes

- A heightened ability to consider problems in a rigorous scientific manner
- The ability to critically assess scientific papers and writing and place biological studies into the broad field of Genetics
- An understanding of some practical data collection methods, data interpretation and presentation • An ability to use scientific search engines, such as Web of Science, to access online publications
- A heightened ability to discuss scientific ideas in an open forum

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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Contact details of ICE

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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 2023/23 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

DNA, the stuff our genes are made of

Start date	7 - October 2022	**End date**	
Synchronous Sessions	Saturday 15 October 2022 Saturday 29 October 2022 Saturday 12 November 2022 Saturday 26 November 2022		
Delivery	Remote: Zoom-based synchronous and online VLE-based asynchronous teaching	**No of synchronous meetings**	4

Summary

This unit introduces the core concepts of what genes are and how they work. The transfer of information from DNA to living cells and practical concepts underpinning basic laboratory manipulation of DNA are introduced, along with the theory, application and ethical considerations associated with techniques such as genomic sequencing and DNA profiling.

Content

DNA molecules are at the core of life and they determine what we are. The DNA code is inherited from generation to generation and contains instructions for the development and life functions of all known organisms.

This unit examines the structure of DNA, from the initial experiments by Dorothy Hodgkin, Francis Crick and James Watson, to our current understanding of the molecular machines that run our cells. We will consider how genes are co-ordinated and how they determine growth and development in organisms.

Our understanding of how genes work has developed rapidly, partly because DNA is particularly amenable to manipulation in the laboratory. The unit explains how scientists investigate gene activity and determine the molecular mechanisms involved. The discovery and development of DNA profiling (fingerprinting) provides an illustration of an application of widespread significance arising from a programme of pure research.

Provisional unit structure

Topic	Indicative content for synchronous and asynchronous delivery
The flow of genetic information	Consideration of DNA as the universal hereditary material. Landmark papers and the historical context. DNA structure, DNA packaging, DNA replication in eukaryotes and prokaryotes; RNA transcription, post- transcriptional processing and protein translation. An introduction to genes and their organisation.
Manipulation of DNA and basic laboratory techniques	An introduction to the structure and organisation of the cell. Isolation and purification of DNA. Restriction digestion and DNA electrophoresis. The Polymerase Chain Reaction and mutagenesis. DNA fingerprinting and profiling. Engagement with online and virtuallaboratory resources.
High throughput sequencing, genotyping and genetic testing.	Technology, theory and application of high throughput approaches to sequencing, genotyping and genetic testing. Ethical and social considerations relating to DNA testing and genome sequencing

Student assessment

There are two assignments. Assignment 1 (essay) is weighted at 60% of the unit total and the assignment 2 (short answers) is weighted at 40% of the unit total.

Assignment 1: An essay discussing the transfer of information from DNA to the rest of the cell (2,000-2,500 words or equivalent). The precise title is provided through the VLE at the start of the unit.

Assignment 2: Short answer and data handling questions on the practical techniques covered in the unit (equivalent to 1,000-1,500 words). The exact questions are provided through the VLE at the start of the unit.

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)

Syllabus for second unit

Lent term 2023

From genes to genomes

Start date	2 January 2023	**End date**	
Synchronous Sessions	Saturday 14 January 2023 Saturday 28 January 2023 Saturday 11 February 2023 Saturday 25 February 2023		
Delivery	Remote: Zoom-based synchronous and online VLE-based asynchronous teaching	**No of synchronous meetings**	4

Summary

This unit explores some of the many areas of active whole genome research that followed on from the Human Genome Project and led to an unprecedented transformation in our biological understanding of human diseases and medical practices. You explore how genetic variation across the human genome is currently used to study susceptibility to common late-onset diseases. This unit introduces you to the concepts of gene editing and epigenetics.

Content

The unit focuses on the Human Genome Project, the achievements that followed, and its relevance to health and disease. You look at the technology developed and the current methods of researching genome data along with the rapidly growing field of ‘bioinformatics’ and discuss its impact on medical research and modern health care. You look at the emergence of Genome-Wide Association Studies and the identification of new chromosomal regions associated with diseases, exploring how these findings are starting to shed light on defective biological processes and mechanisms at the cellular level.

You will study an introduction to the fundamentals of gene editing, including CRISPR/Cas9, and of epigenetic control and its crucial role in disease. This includes how some genes are activated while others are silenced, and how is this controlled.

Provisional unit structure

Topic	Indicative content for synchronous and asynchronous delivery
The Human Genome Project	The history and the motivation for the Human Genome Project. What lessons have been learnt from it? How is the information used? What are Genome Wide Association Studies and what do they tell us about disease? The wider applications of genome sequencing across organisms.
Genes and Cancer	The connection between genes and cancer and the relevance of the human genome project to this. Consideration of experimental papers and techniques to grow study and genetically modify cancer cells. Introduction to pharmacogenomics. Engagement with online and virtual laboratory resources.
Cancer genomes and bioinformatics	Understanding cancer genomes. An introduction to some of the computational tools that allow exploration of genomic information. The legal aspects of genetics and copywriting of genomes.
Epigenetics	Introduction to the fundamentals of epigenetics and its role in diseases as well as the application of gene editing techniques such as CRISPR/Cas9.

Student assessment

There are two assignments associated with this unit and they are equally weighted:

Assignment 1: An essay discussing how the Human Genome Project has advanced our understanding of human genetics and human disease (1,500 – 2,000 words). The precise title will be provided on the VLE at the start of the unit.

Assignment 2: Short answer questions, provided at the unit outset, requiring application of computational skills introduced to demonstrate the ability to access and extract information from publically accessible genome-related databases (equivalent to 1,500 – 2,000 words).

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 22nd March 2023 by noon (GMT\|*) (*Greenwich Mean Time)

Syllabus for third unit

Easter term 2023

Genetics: past, present and future

Start date	27 March 2023 Saturday 15 April 2023	**End date**	
Synchronous Sessions	Saturday 29 April 2023 Saturday 13 May 2023 Saturday 20 May 2023		
Delivery	Remote: Zoom-based synchronous and online VLE-based asynchronous teaching	**No of synchronous meetings**	4

Summary

In this unit you discuss genetic inheritance and the theory of evolution alongside the science behind the inheritance of specific characteristics. You consider how genes are passed on from generation to generation and investigate the mechanisms of inheritance in families to develop appreciation of the distribution of variation within populations and the interaction between genes and the environment.

This unit discusses and explores the potential applications of genetic manipulation and examines the benefits and dangers of manipulating the human genome.

Content

This unit explains how genetic variation is generated, passed on in families and distributed among populations. You study the diversity of gene frequencies in different populations and the effects of chance, selection and migration on these.

The unit covers the techniques and applications of genetic technologies including how to copy, move and overexpress genes. You will consider the issues linked to the production of genetically modified organisms, genetic diseases, nature versus nurture, and gene therapy.

Provisional unit structure

Topic	Indicative content for synchronous and asynchronous delivery
Genetics and evolution	The connection between evolution and genetics. How genetic variation is generated and distributed in families and populations. The study and application of ancient DNA and the use of genetics to trace human migration.
Genes and the environment	Exploration of the contribution of genes and the environment to the expression of individual phenotypes and characteristics.
Genetic technologies	The study and manipulation of genes in a laboratory setting. Molecular cloning, recombinant gene expression and purification. The application of gene therapy.
Genetic elements	Study of unusual genetic elements such as the Y chromosome and mitochondrial DNA. Insights into the genetic evolution of microbial drug resistance and approaches for combatting antibiotic resistance.

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Student assessment

There are two assignments associated with the unit. Assignment 1 (essay) is weighted at 60% of the unit total and the assignment 2 (experimental techniques) is weighted at 40% of the unit total.

Assignment 1: An essay discussing the interaction between genes and the environment (2000-2,500 words). The precise title will be provided through the VLE at the start of the unit.

Assignment 2: Short answer questions relevant to the genetic manipulation and the creation and study of genetically modified organisms. The precise questions will be placed in the VLE at the start of the unit (1,000-1,500 words or equivalent).

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:
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 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 which are accessible electronically. 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
Brown, Terry	Gene Cloning and DNA Analysis	Wiley Blackwell, 2016
Carey, Nessa	The Epigenetic Revolution	Icon Books Ltd, 2012
Carey, Nessa	Junk DNA: A journey through the dark matter of the genome	Icon Books Ltd, 2015
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
Gupta, PK	Molecular Biology and Genetic Engineering	Global Media, 2007
Krebs, J *et al.,*	Lewin's Genes XII	Jones & Bartlett, 2018
McLennon, A *et al.,*	BIOS Instant Notes in Molecular Biology	Taylor & Francis Group, 2012
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: **DNA, the stuff our genes are made of**	
Saturday 15th October 2022	Between 10:30 and 15:30 BST
Saturday 29th October 2022	Between 10:30 and 15:30 GMT
Saturday 12th November 2022	Between 10:30 and 15:30 GMT
Saturday 26thNovember 2022	Between 10:30 and 15:30 GMT
Lent 2023: **From genes to genomes**	
Saturday 14th January 2023	Between 10:30 and 15:30 GMT
Saturday 28th January 2023	Between 10:30 and 15:30 GMT
Saturday 11th February 2023	Between 10:30 and 15:30 GMT
Saturday 25th February 2023	Between 10:30 and 15:30 GMT
Easter 2023: **Genetics: past, present and future**	
Saturday 15th April 2023	Between 10:30 and 15:30 BST
Saturday 29th April 2023	Between 10:30 and 15:30 BST
Saturday 13th May 2023	Between 10:30 and 15:30 BST
Saturday 20th May 2023	Between 10:30 and 15:30 BST

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