

Unit 14: Genetics and Genetic Engineering

Delivery guidance

This is an interesting and fascinating area of biology; massive advances have occurred in the last 30 years. Building on basic genetics work studied at level 2, this unit will allow learners to study the basis of life, DNA, cell division and how characteristics are inherited. There will be opportunities to carry out practical work using genetic engineering techniques and to investigate advances and possible future advances in genetic technology. Breeding experiments will allow use of mathematics and statistics to calculate probability and predict ratios of inherited characteristics in generations of fruit flies.

Some learners will be interested in family ancestry and may be involved in researching their family trees. Others may have relatives or know people who have genetic diseases and may be interested in how these are inherited. Many learners are interested in forensic science and DNA fingerprinting. These interests may attract learners to this unit.

You should encourage learners to read and research around the subject of genetics and genetic engineering. Some may have read books by Richard Dawkins, or at least have heard of him. Learners can be encouraged to watch documentaries about genetic engineering and its use in forensic science, food technology, commercial applications for food production and medical applications. While it is important for them to understand and be able to separate fact from fiction, it is also important that they realise this is an exciting area of science where the boundaries are being stretched. You should encourage learners to access journals and popular scientific magazines.

A wide range of delivery methods will be appropriate to allow access to the unit, for example:

- discussions, both as a class and in small groups, relating to advances in genetic technology and its role in the future
- production of photographic/video evidence of investigations carried out
- model making, to show the structure of DNA and protein synthesis
- practical work, to explore the stages of cell division, breeding experiments and genetic engineering techniques
- collaboration of learners to share results from practical work.

Group work is acceptable, but there must be evidence that learners have individually carried out certain practical procedures. This means that observation records will need to be validated by the assessor or other appropriate person.

Approaching the unit

Learners need to undertake practical work, and this needs to be assessed and validated by assessors for this unit. Centres must ensure they comply with all health and safety guidance and regulations. You should encourage learners to risk-assess practical work to help ensure they are aware of the safety issues and follow the relevant procedures and guidelines.

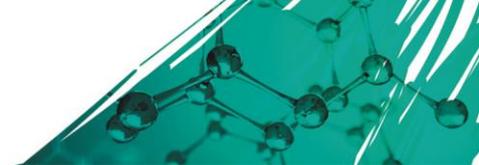
For **learning aim A**, use of simulations and animations of DNA and protein synthesis could give stimulus material to aid recall of knowledge from level 2, and allow learners to extend their understanding of the structure and functions of nucleic acids and protein synthesis. Model-making using paper shapes or sweets (e.g. liquorice allsorts) can be useful to help some learners understand the concept. Secondary source material showing the genetic code will be required. Discussion about how and why changes to bases occur, and the impact on the

proteins created, should evolve from this.

For **learning aim B**, in preparation for assessment, learners will need to have the opportunity to prepare and stain microscope slides for examination. Handling and use of microscopes may need to be revised. You should demonstrate good biological drawing technique. You should give learners opportunities for practice prior to assessment using, for instance, purchased prepared microscope slides of material other than that to be assessed. Photomicrographs, simulations from the internet, and textbooks should be available, in conjunction with purchased slides of mitosis and meiosis, to allow learners to identify the stages of cell division. Kinaesthetic learners may benefit from the opportunity to model the actions of chromosomes during mitosis and meiosis, for example, by using pipe cleaners. Learners can take photos and use them as part of their report explaining and evaluating the behaviour of chromosomes in variation. Learners with appropriate IT knowledge and skills could produce their own animation of cell division.

For **learning aim C**, centre staff will need to be aware of the need to prepare in advance for learners to access live materials to carry out breeding experiments if *Drosophila* are going to be used. Learners should be familiar with monohybrid inheritance from level 2 work, but will need introducing to dihybrid inheritance. Many learners will need support and guidance with the mathematics involved in chi-squared testing in advance of assessment for this learning aim. Carrying out chi-squared tests on data generated by simulations from the internet or from alternative practical work would be preferable to learners just carrying out mathematical processing of secondary source data. For assessment, it will probably be necessary for learners to share results from the investigations they have carried out.

For **learning aim D**, learners may well be familiar with DNA fingerprinting from TV programmes, and some may have extracted DNA as part of their work for level 2. Learners are required to build on these experiences to demonstrate their ability to extract, separate and amplify DNA as part of the pass criteria for this learning aim. Kits are available for a modest cost from educational suppliers. A visit to an institution where commercial or diagnostic testing occurs will allow learners to compare techniques with those that they used. Visiting speakers and reports in popular scientific magazines and journals will keep learners informed about current developments and the potential developments of genetic engineering technologies; they need to carry out evaluation of these to achieve the distinction criterion. Research graduates from local universities or research facilities may be available to discuss their work during a visit to your centre.



Assessment Model

Learning aim	Key content areas	Recommended assessment approach
<p>A Understand the structure and function of nucleic acids in order to describe gene expression and the process of protein synthesis</p>	<p>A1 Nucleic acids A2 The basis of the genetic code A3 Protein synthesis</p>	<p>A portfolio of evidence to include:</p> <ul style="list-style-type: none"> • photographic evidence of DNA models made by learners • a leaflet/report explaining the structure of nucleic acids and how they code for protein synthesis • annotated diagrams of the stages of protein synthesis, how and where the stages occur and analysis of impact of possible errors.
<p>B Explore how the process of cell division in eukaryotic cells contributes to genetic variation</p>	<p>B1 Human chromosome B2 Cell division and its role in variation B3 Practical demonstration of slide preparation of dividing cells</p>	<p>A portfolio of evidence to include:</p> <ul style="list-style-type: none"> • a leaflet on the structure and function of human chromosomes • an observation record of microscope slide preparation of mitosis and meiosis • annotated diagrams identifying the stages in mitosis and meiosis. • a report explaining and evaluating how the behaviour of the chromosomes during meiosis leads to variation.
<p>C Explore the principles of inheritance and their application in predicting genetic traits</p>	<p>C1 Principles of classical genetics C2 Further genetics</p>	<p>A portfolio of evidence to include:</p> <ul style="list-style-type: none"> • an observation record to validate the practical work carried out on <i>Drosophila</i> • statistical analysis of the patterns of inheritance ratios from practical work • genetic diagrams and report using appropriate terminology to predict and describe the results of genetic crosses.

Learning aim	Key content areas	Recommended assessment approach
<p>D Explore basic DNA techniques and the use of genetic engineering technologies</p>	<p>D1 DNA extraction D2 Gel electrophoresis D3 DNA amplification D4 Transformation of cells D5 Uses of genetic engineering</p>	<p>A portfolio of evidence to include:</p> <ul style="list-style-type: none"> • a brief report on practical techniques carried out and their applications in industry and medicine • observation records to validate the practical work • a report on how restriction enzymes and electrophoresis work with an explanation of stem cell therapies and their uses.

Assessment guidance

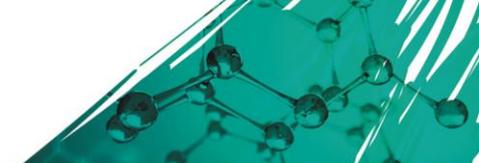
This is an internally assessed unit comprising of a number of practically-assessed learning aims. It is recommended that there are four assignments for the unit, one for each learning aim. A holistic approach to the pass, merit and distinction criteria is required.

Advance planning is essential in the centre to ensure availability of practical equipment prior to work commencing on this unit. Suitable laboratory facilities will need to be available. Specimens and DNA kits will need to be ordered in a timely manner. Learners will require access to microscopes. Health and safety guidance and regulations must be understood by learners and followed at all times.

Learners must provide independent, valid and authentic evidence to meet the assessment criteria. Practical work will need to be validated by the assessor. Observation records on their own are not sufficient; there must always be learner-generated evidence available for standards verification.

The summary of unit content and assessment guidance suggests the use of photographic/video equipment. It is not intended that expensive or state-of-the-art equipment should be available. Many learners will be able to use their own phones and IT equipment to achieve adequate photos/videos.

Any secondary sources used by learners in reports must be referenced, and learners are expected to provide a bibliography.



Getting started

This provides you with a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

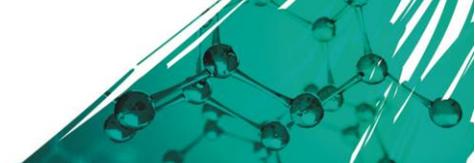
Unit 14: Genetics and Genetic Engineering
<p>Introduction</p> <p>Introduce the unit by discussing genes, what they are, where they are found, and the structure of the DNA that forms them.</p>
Learning aim A – Understand the structure and function of nucleic acids in order to describe the process of protein synthesis
<ul style="list-style-type: none"> • Learners should work in small groups to produce a flipchart sheet that shows their current knowledge and understanding of chromosomes, genes, DNA, types of RNA, genetic code and protein synthesis. • Oversee a class presentation of the group information, with each member of the group feeding back on at least one point discussed. • Learners could create models of nucleic acids in pairs or small groups. Encourage feedback from all groups. You should comment as needed to ensure accuracy and extend knowledge. Individual learners should collaborate to produce a DNA model. • Use of animations/simulations should be made for an assessor-led discussion on the structure and role of the types of RNA and stages in protein synthesis. Learners should understand the use of genetic code in protein synthesis. You could lead a discussion about occurrence and impact of errors that can occur during the stages of protein synthesis. • Learners could carry out research using secondary sources and animations to consolidate their knowledge and understanding of the learning aim content. They can then produce individual portfolios consisting of diagrams and/or photos in a leaflet that explains the structure and function of nucleic acids, protein synthesis and impact of errors associated with the process.
Learning aim B – Explore how the process of cell division in eukaryotic cells contributes to genetic variation
<ul style="list-style-type: none"> • Learners should carry out practical work to practise preparation of microscope slides (not the same slides as those required for assessment) and use of microscopes. Input from yourself about good drawing technique and the opportunity to practise skills will be required. Guidance is available in the specification. • Learners should have the opportunity to use prepared slides with microscopes, Bioviewers (if available), secondary source texts and animations from the internet, to follow and understand the stages in mitosis and meiosis. • Use of chenille sticks/stems will allow learners to model the stages of mitosis and meiosis; this will help consolidate their knowledge and understanding. A discussion about the stages and the impact on variation would be helpful at this point. • Learners should follow instructions to prepare slides of mitosis and meiosis. Observation records are required to validate the level of competency demonstrated by learners. Learners should produce reports containing diagrams to explain the structure and function of chromosomes and an evaluation of their behaviour during cell division and the relevance to variation.

Learning aim C – Explore the principles of inheritance and their application in predicting genetic traits

- You should introduce learners to the techniques involved in breeding *Drosophila* to be able to obtain results for processing. Learners will need to maintain records of their investigations (in logbooks).
- While gestation is occurring, secondary sources and your input can be used to revise learner knowledge of monohybrid inheritance, leading to discussion and extension of knowledge to cover dihybrid inheritance of characteristics. Simulations are available on the internet.
- Learners will need to research and present information to peers on the work of Gregor Mendel and its importance in modern genetics.
- The mathematical abilities of learners will need to be extended to cover chi-squared testing and probability.
- Learners will need to undertake research work into genetic diseases. They will then need to make calculations and predictions of how crosses between non-affected, affected and carriers of these diseases affect the next generation. They should consider a wide range of diseases. Learners could work in pairs to choose a disease (you could have cards with diseases on them for learners to select from) and then feed back to the rest of the class.
- Learners will need to collaborate to share results from the breeding investigations undertaken.
- Assessment requires learners to produce a portfolio of evidence that includes a report on the practical work they carried out with an analysis of their results. Notes produced from research into genetic crosses need to be presented, possibly as a report or leaflet, and must include predictions for monohybrid and dihybrid inheritance and variation.

Learning aim D - Explore basic DNA techniques and the use of genetic engineering technologies

- You could introduce the topic by showing clips of DNA being extracted and amplified (PCR), and electrophoresis of a DNA sample. You should encourage discussion about the science of what is happening and why. Learners will need to practise these techniques and to investigate their uses and possible future uses.
- A visit to a research laboratory/university where these techniques are used would add interest and a vocational context to the work. Alternatively, a visiting speaker would give learners the opportunity to ask questions and explore developments in this exciting field.
- Learners will research the other technologies (indicated in the unit content) and their current and potential uses. This will involve use of textbooks, the internet and access to scientific journals and, possibly, documentaries. Learners should research different technologies and then present their findings to the class.
- Learners will be assessed on their ability to carry out the basic techniques they have practised. Assessors will need to validate the level of performance achieved by each learner in conjunction with learner reports of their own investigations. Using their research notes, the future of genetic engineering technologies and their applications in medicine and commerce must be analysed and evaluated in a report or information leaflet produced by individual learners for assessment.



Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

This unit links to:

- *Unit 1: Principles and Applications of Biology I*
- *Unit 4: Investigative Project Skills*
- *Unit 5: Principles and Applications of Biology II*
- *Unit 13: Biological Molecules and Metabolic Pathways*
- *Unit 15: Diseases and Infections*
- *Unit 19: Microbiology and Microbiological Techniques.*

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC International qualification in Applied Science. Check the Pearson website (<http://qualifications.pearson.com/endorsed-resources>) for more information as titles achieve endorsement.

Textbooks

Annets, F, Foale, S, Hartley, J, Hocking, S, Hudson, L, Kelly, T, Llewellyn, R, Musa, I, and Sorenson, J *BTEC Level 3 National Applied Science Student Book* (Pearson, 2010) ISBN 9781846906800

The chapter on genes and genetic engineering supports the unit content and has activities suitable for learners to access to practice skills and acquire knowledge and understanding prior to assessment.

You could use any current A-level textbook with a section on genetics and genetic engineering for reference.

Journals

New Scientist Scientific American

This technical journal requires high-level reading skills and the ability to use and understand technical terms. Contains articles and the latest news and research into related topics.

Videos

<https://www.youtube.com/watch?v=gG7uCskUOrA>

From DNA to protein. Good summary of transcription and translation, and role of types of RNA.

<https://www.youtube.com/watch?v=pOsAbTi9tHw>

Mitosis rap: Mr W's Cell Division Song. Animations, diagrams and video footage of stages of cell division.

<https://www.youtube.com/watch?v=1p47ndHOUHs> Video lecture about dihybrid crosses.



<https://www.youtube.com/watch?v=QEG8dz7cbnY> <https://www.youtube.com/watch?v=6QYgN-toA1A>

Gel electrophoresis – two instructional videos to prepare and read gel electrophoresis results.

<https://www.youtube.com/watch?v=LxbP82mi02Y>

Onion root tip observations. Opportunity to see stages in root tip mitosis with commentary.

Websites

http://media.hhmi.org/biointeractive/vlabs/bacterial_id/index.html The Virtual Bacterial ID Lab, Howard Hughes Medical Institute.

Simulations and information about genetic engineering techniques and PCR.

<http://www.eurostemcell.org>

This website provides 'independent, expert-reviewed information and road- tested educational resources on stem cells and their impact on society'.

It is a good source of stimulus and information for learners and staff.

Pearson is not responsible for the content of any external internet sites. It is essential for tutors to preview each website before using it in class so as to ensure that the URL is still accurate, relevant and appropriate. We suggest that tutors bookmark useful websites and consider enabling learners to access them through the school/college intranet.