PROVISIONAL

DELIVERY GUIDE

Topic: You and your genes

June 2015

GCSE (9–1)
Twenty First Century Biology B

GCSE REFORM

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This resource is an exemplar of the types of materials that will be provided to assist in the teaching of the new qualifications being developed for first teaching in 2016. It can be used to teach existing qualifications but may be updated in the future to reflect changes in the new qualifications. Please check the OCR website for updates and additional resources being released. We would welcome your feedback so please get in touch.

CONTENTS

Introduction

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- Content: A clear outline of the content covered by the delivery guide;
- Thinking Conceptually: Expert guidance on the key concepts involved, common difficulties students may have, approaches to teaching that can help students understand these concepts and how this topic links conceptually to other areas of the subject;
- Thinking Contextually: A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resourcesfeedback@ocr.org.uk.

KEY

Click to view associated resources within this document.

Click to view external resources.

Curriculum Content B1.1 What is the genome and what does it do?

B1.1 What is the genome, and how does it affect the way an organism develops and functions?

Students will be required to:

1. explain how the nucleus and genetic material of eukaryotic cells (plants and animals) and the genetic material, including plasmids, of prokaryotic (e.g. bacteria) cells are related to cell functions
2. describe the genome as the entire genetic material of an organism
3. describe DNA as a polymer made up of nucleotides, forming two strands in a double helix
4. explain the terms chromosome, gene, allele, variant, genotype and phenotype
5. describe simply how the genome and its interaction with the environment influence the development of the phenotype of an organism, including the idea that most characteristics depend on instructions in the genome and are modified by the interaction of the organism with its environment
6. explain the importance of amino acids in the synthesis of proteins, including the genome as instructions for the polymerisation of amino acids to make proteins
7. describe DNA as a polymer made from four different nucleotides, each nucleotide consisting of a common sugar and phosphate group with one of four different bases attached to the sugar
8. explain simply how the sequence of bases in DNA codes for the proteins made in protein synthesis, including the idea that each set of three nucleotides is the code for an amino acid
9. recall a simple description of protein synthesis, in which:
    - a copy of a gene is made from messenger RNA (mRNA)
    - the mRNA travels to a ribosome from the cytoplasm
    - the ribosome joins amino acids in an order determined by the mRNA
10. recall that genetic variants can arise from mutations
11. describe how genetic variants in coding DNA may influence phenotype by altering the activity of a protein
12. describe how genetic variants in non-coding DNA may influence phenotype by altering how genes are expressed.

Thinking Conceptually B1.1 What is the genome and what does it do?

Approaches to teaching the content

This chapter can be quite difficult for students to understand as the majority of the concepts are not visible; therefore using models to help explain some of these e.g. the letters ATCG for the genetic code goes some way to address this (IaS3). Images and video clips, possibly even role play, to show certain concepts such as protein synthesis in a continuous 3D process also help students to visualise these processes and therefore lead to a better understanding.

Practical tasks involving students looking at pre-prepared plant and animal cells down the microscope and extracting DNA from onions is a good way of making the jump between a computer generated image of a cell and DNA to 'real-life'.

This section has a large number of key terms that students will find difficult to remember or understand therefore it is important to build in numerous short, fun activities (odd-one-out, taboo, 'hot-seating', Pictionary, dominoes, bingo) into lessons to revisit these terms throughout the unit. This will not only help students to remember and understand these terms, but will inform teachers of any areas to focus on if necessary.

Thinking conceptually - Activity 6 provides an opportunity for learners to develop a conceptual understanding of DNA by constructing a model to use previously learned information on the DNA structure. It also provides a vehicle for learners to self-evaluate their models against an exemplar model. They can also peer-evaluate.

Activity 7 in this section allows an opportunity to overcome common misconceptions held regarding DNA and protein synthesis and the idea that mutations are always harmful.

In Activity 8, a quiz approach to reinforcing key terminology and provide assessment for learning opportunities that will identify level of understanding.

Thinking Conceptually B1.1 What is the genome and what does it do?

Common misconceptions or difficulties students may have

1. Genetic terms are often confused. Students particularly struggle with the difference between a chromosome, gene and allele. They often use the terms gene and allele interchangeably. Being consistent when using these terms when teaching will hopefully help students with their understanding in addition to revisiting key terminology on a regular basis with quick quizzes and games etc.
2. Mutations are always harmful. This is a common misconception. This can be addressed by the teacher particularly when covering substitution mutations where the change in genome may not even change the amino acid sequence, a 'silent' mutation. (Learner activity 4, DNA - The genetic code and mutations). Examples of advantageous mutations e.g. resistance to malaria, pesticide resistance in insects, melanistic variants in peppered moths.
3. Different types of cell (skin, muscle) in a body contain different DNA. Linked with this is another misconception that each cell only contains the genetic information for that cells function. A starter recapping how zygotes are formed and how that one cell divides into two (with the same DNA), then four etc. can be referred to address this issue.
4. Another misconception is that once synthesised on the ribosome, proteins remain in their folded state. Learners often believe that after a protein is released from the ribosomes, there are no further modifications that occur. We are not synthesising enzymes when we are in translation; we are using chains of amino acids to then go on and make proteins. Review the purpose and functions of proteins. Explain to learners that they are still able to undergo changes after being released from the ribosomes.

Conceptual links to other areas of the specification - useful ways to approach this topic to set students up for topics later in the course

Learners will be able to prepare slides to cover the B8.2, PAG Microscopy, histology and microbiology. They will also be identifying the functions of sub-cellular organelles in B4.2. They should have a simple understanding of the double helix model of DNA. The understanding of the way in which biological molecules such as DNA is made and behaves is fundamental to many topics and learners will need this when meiosis and mitosis are covered in B4.3.

In Module B6.3 'How does our understanding of biology help us classify the diversity of organisms on Earth?' an understanding is required of how DNA helps with classifying living organisms.

Approaches to teaching the content

The topic lends itself to a wide range of practical activities both real and virtual. It is vital that learners are provided with practical opportunities to develop appropriate microscopy skills. Learners should have the opportunity to gain skills that will be used again in a number of areas of the specification. As skills are an important aspect of this section, there are some activities that could be set up to be used over a period of time in order to continue to develop skills (e.g. Activity 9).

There are many activities that can be used as starters or plenaries (such as Activity 12) and these mini-activities can support engagement and assessment for learning. This is particularly important in a topic that can be seen as challenging, both in terms of practical and mathematical skills required in using light microscopes and interpretation of microscopic images. The use of Venn diagrams in Activity 10 can support an understanding of the similarities and differences between plant and animal cells and could be used in assessment situations.

Interactive software (such as Activity 11) can provide a useful vehicle to reinforce learning of cell sub-structures. Learners have a 3D visual representation of the substructures to support their learning and also it helps them to locate the size and positioning within the cell.

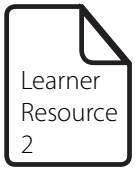
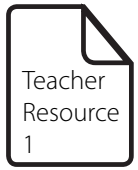
Activity 13 is a starter activity that allows for a quick check on prior learning. Provide learners with mini-whiteboards for them to write the answer to questions that have quick one word/number/answers. There are many activities that can be used as starters or plenaries (such as 'bingo' seen in Activity 14) and these mini-activities can support both engagement and assessment for learning.

Interactive online software (such as found in Activity 10) can provide an opportunity to reinforce learning of difficult concepts that are hard to visualise. Learners have the facility to manipulate structures in 3D that are not normally able to be seen moving in 2-D representation. This can only serve to increase their awareness and understanding of the mechanisms involved.

Activities B1.1 What is the genome and what does it do?

Activities	Resources
Activity 1 **Plant and animal cells under the microscope** To introduce the topic, students could draw, label and annotate a plant and an animal cell on a white board using their knowledge from KS3. Students can then look at a selection of pre-prepared plant and animal cells down microscope and choose one or two cells to draw. As a class discuss what organelles they saw in the majority of cells they looked at and explain that they will be looking at the nucleus and its contents in more detail over the rest of the topic.	
Activity 2 **Extracting DNA from onions cells** *(National Centre for Biotechnology Education)* http://www.ncbe.reading.ac.uk/ncbe/protocols/pracbiotech/PDF/onion.pdf This resource gives the instructions on how to carry out a practical to extract DNA from onions cells. The practical consists of numerous stages. The pictorial instructions on the second page can be projected onto the white board or handed out to students. The teacher will have to decide based on timings and ability of the group whether to let the students carry out the entire practical, whether to have the first part done for them before the lesson or whether to use individual students to take part in different parts of the practical as a demonstration. Once students have extracted the DNA, the teacher can explain that the genome is the entire genetic material of an organism.	Click here
Activity 3 **Structure of DNA - Map from Memory** This activity is a fun way to introduce the structure of DNA and nucleotides to students of all abilities. The teacher must photocopy the Map from Memory resource onto A3 paper before the lesson. • Students work in groups of 3. • Teacher has the 'Map from memory' on the table in front of him/her. • 1 student from each group comes to the front to look at the 'map' for 10 seconds. • The student returns to their group and draws what they can remember onto a blank A3 sheet. • Allow 5 minutes in total. Each group can send one student to see the 'map' as many times as they wish HOWEVER • When finished, teacher gives a mark out of 20 for each group for accuracy - DEDUCT 1 mark for each visit to see the 'map' after the initial viewing. After the activity, the 'Map' can be projected onto the white board and the teacher can use it to explain the key points. You may also want to get students to write any questions they have on pieces of paper and put them into a 'question box' at the end of the lesson. These can then be discussed at the beginning of the next lesson.	Learner Resource 1

Activities B1.1 What is the genome and what does it do?

Activities	Resources
Activity 4 **Cracking the genetic code** https://www.youtube.com/watch?v=i2tHaxT-ClQ As an introduction to DNA triplets coding for amino acids, this 3 minute video clip from the Royal Institutions Christmas Lectures covers the key points required in a clear way. **DNA Cracking the code** *(TES Teaching Resources)* https://www.tes.co.uk/teaching-resource/DNA-Cracking-the-Code-6327146 Lower ability students can complete this worksheet using the triplets and amino acid sequences to colour the hair for three boys correctly. **DNA - The genetic code and mutations** *(Learner Resource 2 and Teacher Resource 1)* Students sitting the higher paper can complete this worksheet to convert DNA triplets into complementary mRNA ones and amino acid sequences into a secret message. The worksheet then goes on to do the same for strands of DNA that have had different types of mutation occur. This section once completed makes a good starting point for a class discussion about mutations, what types there are and what consequences they can have ie can produce genetic variants (some with advantageous phenotypes and others with detrimental phenotypes). **Ribosome Race** *(TES Teaching Resources)* https://www.tes.co.uk/teaching-resource/Ribosome-Race-11009567 As a starter to the next lesson teachers can print out the table of triplets and amino acids from slide one of the PowerPoint for students and project the base sequence and questions on slide 2 onto the white board for students to complete as bellwork to show their understanding of the previous lessons content. This activity of using letters to model the genetic code covers part of IaS3 where 'Models are in science to help explain ideas.'	 

Activities B1.1 What is the genome and what does it do?

Activities	Resources
Activity 5 **Protein Synthesis** B1.1.8 and B1.1.9 are for students sitting the higher paper. Students need to know a general overview of how mRNA takes information from the DNA in the nucleus to the cytoplasm and joins amino acids together. They do not however need to know the details of transcription or translation. This can be taught in a couple of ways: Students can use modelling clay, pipe cleaners, string etc. to model each stage of protein synthesis. Students then use digital cameras (or their phones) to take photos of each stage. These can be put together in any format (PowerPoint, poster etc.) to be used by each group to present how proteins are synthesised to the rest of the class. Depending on the group, students can do their own research using text books selected by the teacher, or the teacher can make it easier by putting the stages up on the white board. or Students can complete the flowchart worksheet by cutting and sticking the stages in the correct order on the left side of the flowchart and drawing an image of each stage on the right side of the flowchart.	Learner Resource 3 Teacher Resource 2
Activity 6 **Making 3D models of the structure of DNA** *(CSIRO)* A good model can be found at: http://www.csiro.au/en/Education/DIY-science/Biology/DNA-model Provide learners with materials to build a model of DNA. Learners follow instructions and apply the principles previously learnt of the structure of DNA to complete the model. Learners can self-evaluate their models against an exemplar model. They could then work in pairs and swap models to peer-evaluate.	

Activities B1.1 What is the genome and what does it do?

Activities	Resources
Activity 7 **Baking the cake! DNA making proteins.** *(Genes Are Us and TES Teaching Resources)* The analogy of a recipe is used to explain the idea of DNA coding for proteins, just as a recipe tells you how to make a cake or gingerbread man. If there is a mistake in the recipe (DNA), it might mean that the cake (protein) will not be made properly. Variations in the genetic code can result in a disorder, for example Connor (in the film from Genes Are Us website at http://www.genesareus.org/filmlibrary/connorsstory) has Duchenne Muscular Dystrophy. However, it is important to point out that not all changes are harmful, for example differences in DNA sequence determine which colour eyes and hair a person has. Your body can read DNA to give it instructions. It is similar to the way you would read a recipe to help you bake a cake. DNA provides the information to tell your body how to make different proteins. The diagram cut-and-stick (or draw lines to match) worksheet at: https://www.tes.co.uk/teaching-resource/btec-chromosomes-genes-dna-6208737 can be used to reinforce the 'recipe book' model for the genome.	
Activity 8 **Revising terminology related to DNA structure** *(Biology Corner)* www.biologycorner.com/worksheets/DNA_crossword.html Learners complete a crossword to review all the relevant terminology and meanings related to DNA structure. This provides a quick way to assess learners' recall and understanding of keywords for the many unfamiliar words covered in this topic area.	
Activity 9 **MICRODOT Kit** *(TIMSTAR)* http://www.timstar.co.uk/mi94128-microdot-kit.html This kit is designed to help students improve their skills and confidence in using microscopes, before moving on to mounted specimens/thin sections or live organisms. It consist of various images printed onto acetate slides. These can be placed under the microscope and provide a reliable, uniform image to focus on. There are a number of structures ranging from a single letter (e) to printed line images of a bacterium, fungus, protist and a virus. The kit also allows measurements to be taken and size of objects determined.	

Activities B1.1 What is the genome and what does it do?

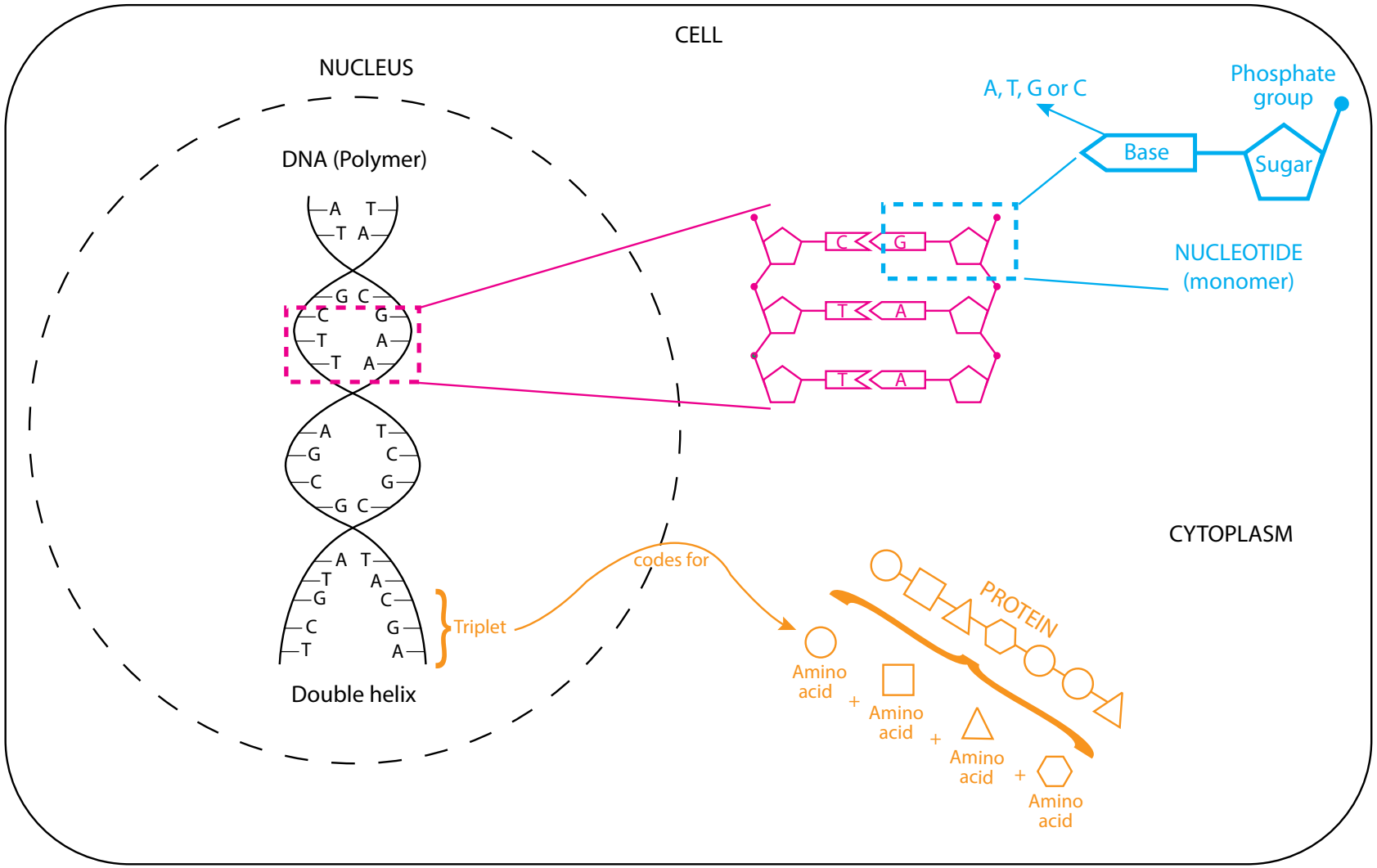
Activities	Resources
Activity 10 **Plant and animal cells** *(TES Teaching Resources)* http://www.tes.co.uk/ResourceDetail.aspx?storyCode=6330798& This PowerPoint provides a suggested approach to delivering activities that encourage learning of the components and functions of plant and animal cells. It has assessment for learning activities that includes interactive diagram labelling, Venn diagram construction for overlap of plant/animal cell structures, true/false statements and extended writing.	
Activity 11 **Inside a cell** *(University of Utah Health Sciences- Genetic Science Learning Center)* http://learn.genetics.utah.edu/content/cells/insideacell/ This interactive software allows learners to track across a 3D diagram of an animal cell and focus in and click on the sub-cellular structures which then magnifies and animates the chosen structure providing information on its function. It also allows the student to click and convert the image to a plant cell to see the additional features that a plant cell contains.	
Activity 12 **Cell Structure: Rap/Poem Memory Aid** *(TES Teaching Resources)* http://www.tes.co.uk/teaching-resource/Cell-Structure-Rap-Poem-Memory-Aid-3011184/ This is a Rap/Poem covering the main sub-structures of animal and plant cells. It could be used as a starter to recap prior learning or to provide a memory aid. An extension activity could be for students to consider writing their own rap memory aid.	
Activity 13 **Reviewing DNA structure** As a starter activity use mini-white boards to review the structure of DNA. Get learners to write answers to the questions to gauge level of prior learning. Example questions include: • What are the four nucleotide bases of DNA? • What are the complementary base pairs? • What does a section of DNA (a gene) code for? Show learners a video clip of transcription of DNA, for example some teachers might like to show their classes this video at: https://www.youtube.com/watch?v=2zAGAmTkZNY	

Activities B1.1 What is the genome and what does it do?

Activities	Resources
Activity 14 **How DNA codes for protein synthesis** *(Biology Corner and TES Teaching Resources)* Describe how sequences of 3 bases code for individual amino acids and that these 3 base sequences are called codons. Learners could play 'Codon Bingo' to help understand the link between the DNA codon and the amino acid it codes for. www.biologycorner.com/worksheets/codon-bingo.html The emphasis here needs to be on the order of nucleotide bases coding for the order of amino acids in proteins. Each set of three nucleotides is the code for an amino acid. Specific details of translation and transcription are not required, but the following activities support an understanding of the order of nucleotide bases coding for the order of amino acids in proteins. Learners can then write out a DNA chain of bases say 21 bases long. Ask learners to 'translate' the coded sequence into a chain of amino acids using the chart provided. If interactive white boards are available there is a Smart® Board notebook file that has a model of transcription, the DNA molecule can be pulled apart and students can drag in mRNA by complimentary base pairing to make an mRNA chain. Translation is also modelled, the mRNA chain is there and learners drag in tRNA carrying amino acids to form the protein chain. This can be found at: https://www.tes.co.uk/teaching-resource/Transcription-and-translation-6064468/. An alternative web based activity can be found at: learn.genetics.utah.edu/content/molecules/transcribe/	

Learner Resource 1 Map from memory

See page 10



Learner Resource 2 DNA – The genetic code and mutations

1. Copy the strand of DNA below to make a complementary strand of mRNA.

AGAACATAACTCTTGACGCTTATCTATAGCATTCCCGCTCTCCGATGCACT

See page 11

Answer:

2. Use the table to look up which amino acid each mRNA triplet codes for.

		SECOND BASE									
		U		C		A		G			
FIRST BASE	U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys	U	THIRD BASE
		UUC		UCC		UAC		UGC		C	
		UUA	Leu	UCA		UAA	Stop	UGA	Stop	A	
		UUG		UCG		UAG		UGG	Trp	G	
	C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg	U	
		CUC		CCC		CAC		CGC		C	
		CUA		CCA		CAA	Gla	CGA		A	
		CUG		CCG		CAG		CGG		G	
	A	AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser	U	
		AUC		ACC		AAC		AGC		C	
		AUA		ACA		AAA	Lys	AGA	Arg	A	
		AUG	Met	ACG		AAG		AGG		G	
	G	GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly	U	
		GUC		GCC		GAC		GGC		C	
		GUA		GCA		GAA	Glu	GGA		A	
		GUG		GCG		GAG		GGG		G	

Answer:

3. Use the single letter codes for each amino acid to work out the message from the amino acid sequence you got in Question 2.

Amino Acid	AA single letter code
Ala	A
Cys	C
Asp	D
Glu	E
Phe	F
Gly	G
His	H
Ile	I
Lys	K
Leu	L
Met	M
Asn	N
Pro	P
Gln	Q
Arg	R
Ser	S
Thr	T
Val	V
Trp	W
Tyr	Y

Answer:

Learner Resource 2 DNA – The genetic code and mutations

Sometimes mistakes can happen when DNA is being copied, changing the order and sequence of bases.
These are mutations, and these can create genetic variants.

DELETION:

The following strand of DNA was copied from the one above, but had a nucleotide deleted.

Transcribe the DNA strand into it’s complementary mRNA, then work out the sequence of amino acids.

AGAACATAACTCTTGACGCTATCTATAGCATTCCCGCTCTCCGATGCACT

Answer:

Compare the amino acid sequence with the original sequence. What has happened? How might this affect the protein made?

Answer:

INSERTION:

The following strand of DNA was also copied from the original strand, but an extra nucleotide was added. Transcribe the DNA strand into its complementary mRNA, then work out the sequence of amino acids.

AGAACATAACTCTTGACGCTTATCTATAGCAGTTCCCGCTCTCCGATGCACT

Answer:

SUBSTITUTION:

The following two strands of DNA have been copied from the original, but one nucleotide in each strand has been replaced by a different nucleotide. Transcribe the DNA strands into their complementary mRNA, then work out the sequence of amino acids.

AGAACTTAACTCTTGACGCTATCTATAGCATTCCCGCTCTCCGATGCACT

AGAACGTAACTCTTGACGCTATCTATAGCATTCCCGCTCTCCGATGCACT

Answer:

What has happened to the sequence of amino acids? How may this affect the protein made?

Answer:

Teacher Resource 1 DNA – The genetic code and mutations – Answers

1. Copy the strand of DNA below to make a complementary strand of mRNA.

See page 11

AGAACATAACTCTTGACGCTTATCTATAGCATTCCCGCTCTCCGATGCACT

Answer: UCU/UGU/AUU/GAG/AAC/UGC/GAA/UAG/AUA/UCG/UAA/GGG/CGA/GAG/GCU/ACG/UGA

2. Use the table to look up which amino acid each mRNA triplet codes for.

		SECOND BASE									
		U		C		A		G			
FIRST BASE	U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys	U	THIRD BASE
		UUC		UCC		UAC		UGC		C	
		UUA	Leu	UCA		UAA	Stop	UGA	Stop	A	
		UUG		UCG		UAG		UGG	Trp	G	
	C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg	U	
		CUC		CCC		CAC		CGC		C	
		CUA		CCA		CAA	Gla	CGA		A	
		CUG		CCG		CAG		CGG		G	
	A	AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser	U	
		AUC		ACC		AAC		AGC		C	
		AUA		ACA		AAA	Lys	AGA	Arg	A	
		AUG	Met	ACG		AAG		AGG		G	
	G	GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly	U	
		GUC		GCC		GAC		GGC		C	
		GUA		GCA		GAA	Glu	GGA		A	
		GUG		GCG		GAG		GGG		G	

Answer: Ser-Cys-Ile-Glu-Asn-Cys-Glu-stop-Ile-Ser-stop-Gly-Arg-Glu-Ala-Thr-stop

Teacher Resource 1 DNA – The genetic code and mutations – Answers

3. Use the single letter codes for each amino acid to work out the message from the amino acid sequence you got in Q2.

Amino Acid	AA single letter code
Ala	A
Cys	C
Asp	D
Glu	E
Phe	F
Gly	G
His	H
Ile	I
Lys	K
Leu	L
Met	M
Asn	N
Pro	P
Gln	Q
Arg	R
Ser	S
Thr	T
Val	V
Trp	W
Tyr	Y

Answer: SCIENCE IS GREAT

Teacher Resource 1 DNA – The genetic code and mutations – Answers

Sometimes mistakes can happen when DNA is being copied, changing the order and sequence of bases.
These are mutations, and these can create genetic variants.

DELETION:

The following strand of DNA was copied from the one above, but had a nucleotide deleted.

Transcribe the DNA strand into it's complementary mRNA, then work out the sequence of amino acids.

AGAACATAACTCTTGACGCTATCTATAGCATTCCCGCTCTCCGATGCACT

Answer: UCU/UGU/AUU/GAG/AAC/UGC/GAU/AGA/UAU/CGU/AAG/GGC/GAG/AGG/CUA/CGU

Ser-Cys-Ile-Glu-Asn-Cys-Asp-Arg-Tyr-Arg-Lys-Gly-Glu-Arg-Leu-Arg

SCIENCDRYRKGERLR

Compare the amino acid sequence with the original sequence. What has happened? How might this affect the protein made?

Answer: All of the amino acids after Cys are different to the original. This would therefore make a different protein to the one it should have. This protein may function differently or not function at all.

INSERTION:

The following strand of DNA was also copied from the original strand, but an extra nucleotide was added. Transcribe the DNA strand into its complementary mRNA, then work out the sequence of amino acids.

AGAACATAACTCTTGACGCTTATCTATAGCAGTTCCCGCTCTCCGATGCACT

Answer: UCU/UGU/AUU/GAG/AAC/UGC/GAA/UAG/AUA/UCG/UCA/AGG/GCG/AGA/GGC/UAC/GUG

Ser-Cys-Ile-Glu-Asn-Cys-Glu-stop-Ile-Ser-Ser-Arg-Ala-Arg-Gly-Tyr-Val

SCIENCE ISSRARGYV

Teacher Resource 1 DNA – The genetic code and mutations – Answers

SUBSTITUTION:

The following two strands of DNA have been copied from the original, but one nucleotide in each strand has been replaced by a different nucleotide. Transcribe the DNA strands into their complementary mRNA, then work out the sequence of amino acids.

AGAACTTAACTCTTGACGCTATCTATAGCATTCCCGCTCTCCGATGCACT

Answer: UCU/UGA/AUU/GAG/AAC/UGC/GAA/UAG/AUA/UCG/UAA/GGG/CGA/GAG/GCU/ACG/UGA

Ser-Stop-Ile-Glu-Asn-Cys-Glu-stop-Ile-Ser-stop-Gly-Arg-Glu-Ala-Thr

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AGAACGTAACTCTTGACGCTATCTATAGCATTCCCGCTCTCCGATGCACT

Answer: UCU/UGC/AUU/GAG/AAC/UGC/GAA/UAG/AUA/UCG/UAA/GGG/CGA/GAG/GCU/ACG/UGA

Ser-Cys-Ile-Glu-Asn-Cys-Glu-stop-Ile-Ser-stop-Gly-Arg-Glu-Ala-Thr

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What has happened to the sequence of amino acids? How may this affect the protein made?

Answer: The first substitution has changed just one amino acid in the chain, the rest are still the same. This may or may not affect the protein and its function.
The second substitution has not made any difference to the amino acid sequence as although the second triplet changed, Cys has more than one triplet that codes for it. Therefore, the same protein will be made as coded for in the original DNA.

Learner Resource 3 Protein synthesis

See page 12

Cut out the statements below and stick them in the correct order in the left hand column on the flow chart (following page).

Draw an image in each of the boxes on the right hand side of the flowchart to help you remember what happens at each stage of protein synthesis.

Once the amino acids join, they form a protein.

The DNA molecule unwinds and 'unzips' along its length.

The mRNA passes through the pores in the nuclear membrane into the cytoplasm and attaches to a ribosome.

mRNA makes a copy of the DNA by lining up mRNA nucleotides along one strand of the DNA with their complementary bases together.

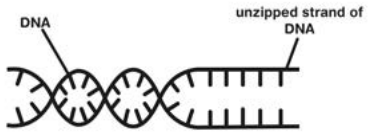
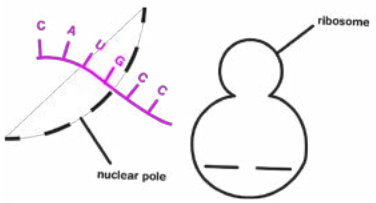
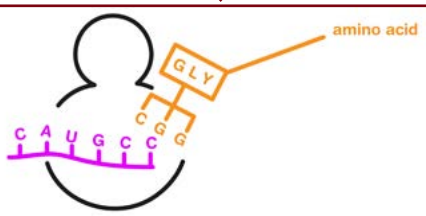
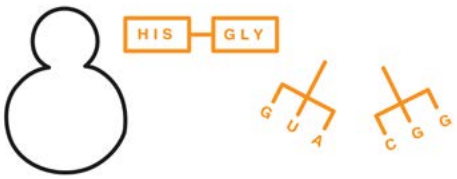
The ribosome joins the amino acids together in the order determined by the sequence of bases.

Each set of 3 nucleotides codes for one amino acid.

Learner Resource 3 Protein synthesis

Teacher Resource 2 Protein synthesis – Answers

See page 12

The DNA molecule unwinds and 'unzips' along its length.	
mRNA makes a copy of the DNA by lining up mRNA nucleotides along one strand of the DNA with their complementary bases together.	
The mRNA passes through the pores in the nuclear membrane into the cytoplasm and attaches to a ribosome.	
Each set of 3 nucleotides codes for one amino acid.	
The ribosome joins the amino acids together in the order determined by the sequence of bases.	
Once the amino acids join, they form a protein.	

Curriculum Content B1.2 How do organisms inherit characteristics?

B1.2 How do organisms inherit characteristics?

1. explain the terms gamete, homozygous, heterozygous, dominant and recessive
2. explain single gene inheritance, including dominant and recessive alleles and use of genetic diagrams
3. predict the results of single gene crosses
4. use direct proportions and simple ratios in genetic crosses
5. use the concept of probability in predicting the outcome of genetic crosses
6. recall that most phenotypic features are the result of multiple genes rather than single gene inheritance
7. describe the development of our understanding of genetics including the work of Mendel and the modern-day use of genome sequencing
8. describe sex determination in humans

Thinking Conceptually B1.2 How do organisms inherit characteristics?

Approaches to teaching the content

This section continues to be quite difficult for students to understand so using models e.g. Punnett squares for single-gene inheritance are helpful (IaS3).

This section also has a large number of key terms that students will find difficult to remember or understand. The concepts involved in genetic crosses can often appear very mathematical and can be challenging for learners. The use of visual interpretations of crosses through interactive resources and cartoon sequences (Activity 1 and 2) can support learners in developing a clear understanding of the concepts involved. Using genetic puzzles, as in Activity 3, can reinforce understanding by asking learners to apply their knowledge and understanding of genetics to explain specific puzzles.

Common misconceptions or difficulties students may have

1. A single gene codes for a single trait and there are only two alleles for each gene. Using Punnett squares to show inheritance can often reinforce this, so teachers must highlight to students that for a lot of characteristics it is a combination of more than one gene that gives rise to the phenotype. Examples to use could be height, eye colour etc. and can be linked back to their KS3 learning of continuous variation exhibiting a range rather than distinct classes.
2. A dominant trait is most likely to be found in a population. Students often believe that a dominant trait is the one that the majority of the population expresses rather than a dominant trait being expressed over a recessive trait in a particular individual. Examples of dominant traits that are rare can be used by the teacher whilst discussing dominant/recessive alleles/traits e.g. Achondroplasia (a type of dwarfism) is shown in less than 1 in 10,000 births and Huntingdons disease affects only 3-7 Europeans per 100,000.
3. The results of a Punnett square crosses are fixed, not probabilities. Students often think of the four 'offspring' in the Punnett square as individuals, rather than probabilities. As a result they believe that a '1 in 4' risk of a couple having a child with a particular genetic disease means one in four of their children will have the disease and if the first child is born with the disease, the next three are much less likely to get it. Teachers must highlight while doing Punnett squares that each child has a 25% chance of having the disease and this is the same for all children the couple have (i.e. refer to probability in each case).

Conceptual links to other areas of the specification - useful ways to approach this topic to set students up for topics later in the course

This sub-section builds on the work on mutations covered in sub-topic B1.1 and Activity 2 provides an opportunity to re-visit and review prior learning. An understanding of how sex is determined and genome sequencing will be useful when topics on meiosis, mitosis and the effect of changes to DNA in cancer formation are covered in B4.3 'How do organisms grow and develop?' Activity 3 and 4 consolidate understanding of genetic crosses and will support learners' ability to apply their understanding to independent sorting events occurring during meiosis.

Thinking Contextually B1.2 How do organisms inherit characteristics?

Approaches to teaching the content

A presentation in Activity 1 (with success criteria to guide students) about Gregor Mendel and his input into our current knowledge about inheritance allows both the concept of how traits are passed on to offspring to be understood by students in addition to understanding the process scientists go through to collect data, use creative thought to explain that data and how these explanations can be modified as more evidence becomes available.

Activities B1.2 How do organisms inherit characteristics?

Activities	Resources
Activity 1 **Harry Potter Genetics PowerPoint presentation** *(TES Teaching Resources)* https://www.tes.co.uk/teaching-resource/BTEC-Applied-Science-Harry-Potter-Genetics-6109054 This PowerPoint presentation is a great starter for introducing inheritance of characteristics, genetic crosses, using simple ratios and using the concept of probability in predicting the outcome of genetic crosses. (B1.2.1, B1.2.2, B1.2.3, B1.2.4 and B1.2.5) Students should then be able to complete any worksheets/exam questions based on genetic crosses after going through some examples of genetic crosses step-by-step with the teacher. The use of genetic diagrams to model and predict outcomes of single gene crosses also covers IaS3.	
Activity 2 **Genetics keyword squares (summary)** This resource is a nice way to summarise the key vocabulary in B1.1 and B1.2. For more able students you may want to delete the definitions so students have to find a keyword in each box and then write their own definitions for each one underneath.	Learner Resource 4 Teacher Resource 3

Activities B1.2 How do organisms inherit characteristics?

Activities	Resources
Activity 3 **Boy or Girl?** *(TES Teaching Resources)* Activity instructions are found at: http://www.tes.co.uk/teaching-resource/Create-a-Kid-6191491/ Show learners pictures of a set of male chromosomes and a set of female chromosomes and ask them to spot the difference. Explain how the sex chromosomes are inherited and that the Y chromosome results in a male. Learners complete diagrams to show the probability of having a male or female offspring. Learners use all the ideas on inheritance to determine the characteristics of a child based on the toss of a coin. The learners are given a list of characteristics which are either dominant or recessive. They flip the coin to determine which allele is inherited.	
Activity 4 **What is heredity?** *(University of Utah)* http://learn.genetics.utah.edu/content/inheritance/ An interactive tour guides learners on the basics of heredity and visually demonstrates how chromosomes and traits are inherited from parents by their children. A pictorial reference to several inherited human traits can be found at http://learn.genetics.utah.edu/content/inheritance/activities. Both variations (dominant and recessive) of each trait are shown, accompanied by brief descriptions, frequencies and other interesting information that can support learning and help overcome common misconceptions.	

Activities B1.2 How do organisms inherit characteristics?

Activities	Resources
Activity 5 **Inheriting traits** https://www.youtube.com/watch?v=GieZ3pk9YVo&feature=player_embedded An excellent cartoon video by the 'Amoeba Sisters' can be used to exemplify the idea of recessive traits and also why these might not just 'disappear' from the population when they are harmful. The section can be found 5 minutes into the video and discusses, as a real life example, sickle cell anaemia and the remarkable difference between having sickle cell anaemia and only being a carrier. The first five minutes of this video clip would also provide a very useful revision activity for work on mutations covered in sub-topic B1.1 as it discusses the types of gene and chromosome mutations and also explain how mutations can occur.	
Activity 6 **Genetic Puzzles** *(TES Teaching Resources)* https://www.tes.co.uk/teaching-resource/genetics-puzzles-6050281 Learners complete genetic puzzles applying their understanding of genetics.	
Activity 7 **Pigeon Breeding: Genetics at work** *(University of Utah)* http://learn.genetics.utah.edu/content/pigeons/probability/ A useful resource (including the interactive software game called 'Pigeonetics' that puts the user's pigeon breeding skills to the test) which allows conceptual thinking to be developed. The resource will need using with great care since bird sex determination involves different sex chromosomes to those in humans and could confuse if used without clear guidance. It should be seen as an opportunity to apply genetic cross skills and practice using a Punnett square, which all can be used to reinforce the idea of independent assortment, probability and sex inheritance using pigeon breeding as the vehicle.	

Activities B1.2 How do organisms inherit characteristics?

Activities	Resources
Activity 8 **The work of Gregor Mendel** Students can make a poster/leaflet/PowerPoint/presentation about Gregor Mendel and how his work developed our understanding of genetics. Success criteria could be based on the following questions the students must answer in their poster/presentation: • Who was Gregor Mendel? (Background information) • What experiments was he famous for? • What were his observations? (give examples of some genetic crosses he carried out and the ratios of characteristics in the offspring he observed). • How did he explain this data? • How did our understanding of genetics change as a result of Mendel's experiments and explanations? • What evidence has become available since that has caused us to accept his explanations/theories? • How has our understanding of genetics developed since? Useful websites: http://www.dnaftb.org/1/ http://en.wikipedia.org/wiki/Gregor_Mendel http://www.biography.com/people/gregor-mendel-39282 http://anthro.palomar.edu/mendel/mendel_1.htm	

Activities B1.2 How do organisms inherit characteristics?

Activities	Resources
Activity 9 **Reebops** **The Nuffield Foundation** http://www.nuffieldfoundation.org/practical-biology/making-reebops-model-meiosis Reebops' are imaginary animals, made out of marshmallows, sweets, pins and cocktail sticks! They have 16 chromosomes (eight pairs) in their body cells. Learners will have a look at the parent Reebops. They will observe their characteristics, such as number of body segments, antennae, etc. Both parents show the same features, except of course one is male and the other is female. Learners carry out a breeding programme, using the same procedures as in a breeding programme with real organisms, and applying the same rules that are found in genetics. This is an excellent, hands-on activity that will allow learners to visualise the impact of single gene inheritance on the phenotype of these imaginary animals.	
Activity 10 **Recipe for traits** University of Utah http://learn.genetics.utah.edu/content/inheritance/activities/ Build your own dog using a 'DNA recipe'! Learners select strips of paper that represent DNA, decode the DNA 'recipe' to reveal their dog's physical traits, and draw it. They will learn that differences in DNA lead to differences in traits. Learners create and decode a 'DNA recipe' for man's best friend to observe how variations in DNA lead to the inheritance of different traits. Strips of paper (representing DNA) are randomly selected and used to assemble a DNA molecule. Learners read the DNA recipe to create a drawing of their pet, and compare it with others in the group to note similarities and differences.	

Learner Resource 4 Genetics keywords

Use the clues provided to find each 'hidden word'. Shade in the boxes to show your answers. Words will twist in all directions, but never cross!

See page 31

O	R	E	S
Y	Z	T	O
G	N	E	M
O	U	S	H

When 2 alleles for a characteristic are different

Answer:

R	E	U	S
O	L	L	E
A	D	A	L
L	G	N	E

Different forms of a gene

Answer:

A	R	E	U
S	B	L	S
R	U	C	N
N	O	A	C

Part of a cell that contains genetic info

Answer:

S	D	H	R
E	C	E	O
M	X	M	T
R	O	S	O

Long threads containing genes, found in the nucleus

Answer:

S	E	A	R
S	I	C	S
Y	V	U	E
T	E	M	R

An allele that produces a characteristic only when there are two of them present

Answer:

M	S	N	B
S	E	L	O
R	F	A	E
A	E	M	U

XX

Answer:

Learner Resource 4 Genetics keywords

G	I	C	E
A	G	T	O
A	E	L	S
M	R	A	R

A male or female reproductive cell

Answer:

E	A	A	G
P	M	R	E
D	Y	T	N
E	S	O	P

The genetic make-up of an organism

Answer:

R	O	E	T
U	D	G	E
S	O	Z	Y
H	M	O	S

When 2 alleles for a characteristic are identical

Answer:

T	Y	E	O
D	R	A	M
U	U	L	P
V	X	C	E

XY

Answer:

R	E	G	L
H	P	B	E
E	Y	O	P
P	N	T	Y

The observable characteristics of an organism

Answer:

L	P	N	I
K	A	M	U
N	O	E	S
T	D	T	O

An allele that produces a characteristic when only one is present

Answer:

Teacher Resource 3 Genetics keywords – Answers

Use the clues provided to find each 'hidden word'. Shade in the boxes to show your answers. Words will twist in all directions, but never cross!

See page 31

O	R	E	S
Y	Z	T	O
G	N	E	M
O	U	S	H

When 2 alleles for a characteristic are different

Answer: HETEROZYGOUS

R	E	U	S
O	L	L	E
A	D	A	L
L	G	N	E

Different forms of a gene

Answer: ALLELE

A	R	E	U
S	B	L	S
R	U	C	N
N	O	A	C

Part of a cell that contains genetic info

Answer: NUCLEUS

S	D	H	R
E	C	E	O
M	X	M	T
R	O	S	O

Long threads containing genes, found in the nucleus

Answer: CHROMOSOMES

S	E	A	R
S	I	C	S
Y	V	U	E
T	E	M	R

An allele that produces a characteristic only when there are two of them present

Answer: RECESSIVE

M	S	N	B
S	E	L	O
R	F	A	E
A	E	M	U

XX

Answer: FEMALE

Teacher Resource 3 Genetics keywords – Answers

G	I	C	E
A	G	T	O
A	E	L	S
M	R	A	R

A male or female reproductive cell

Answer: GAMETE

E	A	A	G
P	M	R	E
D	Y	T	N
E	S	O	P

The genetic make-up of an organism

Answer: GENOTYPE

R	O	E	T
U	D	G	E
S	O	Z	Y
H	M	O	S

When 2 alleles for a characteristic are identical

Answer: HOMOZYGOUS

T	Y	E	O
D	R	A	M
U	U	L	P
V	X	C	E

XY

Answer: MALE

R	E	G	L
H	P	B	E
E	Y	O	P
P	N	T	Y

The observable characteristics of an organism

Answer: PHENOTYPE

L	P	N	I
K	A	M	U
N	O	E	S
T	D	T	O

An allele that produces a characteristic when only one is present

Answer: DOMINANT

Curriculum Content B1.3 How can and should gene technology be used?

B1.3 How can and should gene technology be used?

1. discuss the potential importance for medicine of our increasing understanding of the human genome, including the discovery of genetic variants associated with diseases and the genetic testing of individuals to inform family planning and healthcare
2. describe genetic engineering as a process which involves modifying the genome of an organism to introduce desirable characteristics
3. describe the main steps in the process of genetic engineering including:
    - isolating and replicating the required gene(s)
    - putting the gene(s) into a vector (e.g. a plasmid)
    - using the vector to insert the gene(s) into cells
    - selecting modified cells
4. explain some of the possible benefits and risks, including practical and ethical considerations, of using gene technology in modern agriculture and medicine.

Thinking Conceptually B1.3 How can and should gene technology be used?

Approaches to teaching the content

Much of the learning involved in genetic engineering revolves around an appreciation of the benefits and disadvantages of genetic engineering and a consideration of the impact of these on individual, society and the environment. This involves learners developing skills in analysis and evaluation and this can be done effectively by allowing learners an opportunity to debate and consider moral and ethical issues that are inherent in this sub-topic (Activity 3 can support development of these skills). However, it is still important that learners have a clear understanding of the processes involved in genetic engineering and Activities 1 and 2 will help reinforce the sequencing involved in such a multi-stage process.

Common misconceptions or difficulties students may have

Genetic engineering is often introduced as a topic without a clear reference to the universal genetic code, protein expression or the genetic material shared by all species. Often it is poorly defined, without a clear explanation of all the relevant processes involved. This can lead learners to have many misconceptions about the processes involved in genetic engineering. This unit should be taught after the sub-topic B1.1. 'What is the genome, and how does it affect the way an organism develops and functions?' in order to minimise the chance of learners developing misconceptions.

Conceptual links to other areas of the specification - useful ways to approach this topic to set students up for topics later in the course

Genetic engineering will be an area of discussion in the sub-topic B5.6 'What can happen when organs and control systems stop working?' when comparing type 1 and type 2 diabetes and explaining how they can be treated. Aspects of genetic engineering will have a clear impact on the environment. To this extent, this sub-topic will be important when learners are asked to consider decisions about protecting and conserving biodiversity are affected by ecological, economic, moral and political issues (IaS4) in the B6.4 'Why is biodiversity important, how is it threatened and how can we protect it?'

Thinking Contextually B1.3 How can and should gene technology be used?

Approaches to teaching the content

This section lends itself well to learning new skills, from practical activities involving students using a microscope and drawings skills to debating the morals and ethics and the pros and cons of genetic issues that often come up in the news, namely genetic engineering/modification.

Genetic engineering is an area that can be used to enhance student's debating skills. Students take on the ideas and opinions of various groups for or against genetic engineering and using the websites highlighted in Activity 1 and pros and cons arguments from Activity 2 learn how to evaluate and put together a justified argument for their group, regardless of their own opinion. A class discussion after the debate could focus on whether students would be happy to eat GM foods for example. This will give students a direct link to how genetics affects them directly.

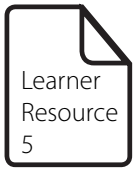
Activities B1.3 How can and should gene technology be used?

Activities	Resources
Activity 1 **What is genetic engineering?** *(TES Teaching Resources)* www.tes.co.uk/teaching-resource/genetic-engineering-the-basics-6090792 An excellent PowerPoint called 'Basic principles in genetic engineering': Show this presentation to learners as an introduction to this sub-topic of work. Take the opportunity to review prior learning of keywords and DNA structure.	
Activity 2 **GM organisms? Is this Frankenstein science!** Another good starter to get students thinking about genetic engineering could simply be a rolling PowerPoint of images of genetically modified organism/products (e.g. fluorescent rabbits, glow fish, insulin, featherless chickens, glow in the dark cats, golden rice) with the question "What question do you want to ask?" **Genetic Engineering/Modification** *(BBC (Big Bang Theory))* http://downloads.bbc.co.uk/schools/teachers/bang/series_3_4/bgtt_teacherspack_lesson_13_genetic_modification.pdf This lesson plan uses clips from 'Bang goes the theory' to introduce genetic modification and the ethics surrounding it. Students complete a worksheet whilst watching the first video clip explaining what genetic modification is using the example of papaya being made resistant to a viral disease. Students then carry out a card sort describing the process and design their own genetically modified organism. The final video and worksheet prompt gets students thinking about the ethical issues surrounding genetic modification.	

Activities B1.3 How can and should gene technology be used?

Activities	Resources
Activity 3 **Classroom debate** Possible motions could include: • GM crops are the way forward for agriculture. • GM crops should be banned. • Modifying genes is 'playing God' and should be stopped. • Research into genetic modification/engineering should continue because of its benefits to the human race. Now that students have learned the process of genetic engineering, its uses and have started looking at some of the issues surrounding the topic. This is a good opportunity for them to research in more detail those issues for and against it. Students will need access to IT or have text books and information available. It is useful for students to spend some time researching the 'argument' they have been given individually at first to prevent some individuals sitting back and letting others do all the work. Once this has been done, students can get into their groups and discuss what they have found, picking out the more important arguments. It is also useful for teachers to explain how the debate will be carried out before students carry out their research. Some methods for carrying out classroom debates can be found on the following websites: http://busyteacher.org/7245-conducting-class-debate-essential-tips.html http://news.bbc.co.uk/cbbcnews/hi/newsid_4450000/newsid_4458000/4458081.stm	

Activities B1.3 How can and should gene technology be used?

Activities	Resources
Activity 4 **Genetic Engineering cut & stick/card sort** *(TES Teaching Resources)* http://www.tes.co.uk/teaching-resource/B1b-Genetic-Engineering-cut-and-amp-stick-card-sort-6087809/ This is a starter/plenary activity that can be used to assess learning. The cards show the sequence for genetically engineering bacteria in order to harvest human insulin.	
Activity 5 **Recombination DNA modelling** *(Biology Corner)* http://www.biologycorner.com/worksheets/DNA_analysis_key.html (then on the page click on original document 'DNA Analysis on Recombination' to load the instructions). Explain to learners they are going to attempt to model the production of some recombinant DNA. Learners can carry out a DNA analysis - Simulating Recombination activity found at the above link. This will allow learners to establish the role of restriction enzymes and DNA ligase to produce a genetically modified plasmid vector that can be put into a bacterium. The discussion questions in the modelling activity can be used as a plenary and also be used to assess learners understanding.	
Activity 6 **Genetic Engineering pros and cons cut and stick** This activity can be used either as a summary/homework for all students or as a starter activity to give lower ability students some ideas from which to form an opinion about genetic engineering if a classroom debate is not suitable. Once students have completed the activity they can write a short paragraph stating their opinion about genetic engineering/ manipulation, using some of the arguments they have grouped to justify their decision.	

Learner Resource 5 Genetic engineering - For or against?

Cut out the statements in the table below and sort then into two groups: arguments for genetic engineering and arguments against it.

See page 45

Scientists exaggerate the benefits of new technology and play down the negatives. We don't know what the long term effects of GM foods is. It could potentially be a dangerous process.	By adding or taking away genes of a plant or animal, modified crops can be produced which may be used to add vitamins and minerals etc to wheat crops grown in third world countries.
Scientists are sensible and new genetic research is monitored, so carrying out mad experiments e.g. cloning humans will not be allowed.	If a new form of life is created, the effect it could have on the rest of nature is currently unknown.
Provided there are controls and proper tests to make sure there are no harmful side-effects of any genetic engineering, nothing can go wrong.	How do we know that safety tests on GM foods are carried out properly? They are expensive and there is a lot of financial pressure to get products on the market as quick as possible.
Some companies making GM foods are so powerful due to massive profits, there is a danger they will put pressure on certain countries governments to allow their products to be grown without proper testing.	GM crops can't be contained. Pollen from modified crops will spread to other plants nearby and hybrids will form e.g. weeds with pesticide resistance.
Parts of your body e.g. skin, bone, livers etc. can be grown after genetic manipulation of the patient's own cells. This reduces chances of rejection and no more long waits for donor organs.	Farmers have been using the idea of genetic manipulation for thousands of years. Modern dairy cows, sheep and plant crops have been selectively and artificially bred. Genetic engineering just makes this process faster and more efficient.
The human population is increasing at a much more rapid rate than food production. Without genetic engineering in the future, the food supply won't be able to keep up.	There are genetic engineering companies cloning deceased pets for their owners. The next step will be human cloning. This needs to stop.
As a result of evolution, pests that are repelled by GM crops producing their own pesticide will eventually evolve into a new strain that will be resistant. The problem hasn't actually gone away then.	Throughout history, there have been new technologies in farming e.g. the invention of the plough 5000 yrs ago and the agrochemical revolution 50 yrs ago. Genetic engineering of plants and animals is just the latest revolution to boost food production.
Crops that have been genetically modified to contain pest resistance reduces the need for farmers to spray harmful chemicals over the countryside.	Modifying genes is 'playing God' and should be stopped.
Genetic engineering can produce bacteria that can 'eat' oil slicks and toxic chemical spills making them harmless.	Sheep and cows can be engineered to produce human growth hormones, antibiotics and blood-clotting chemicals in their milk and vaccines can be grown in genetically engineered potatoes.
Embryonic stem cells that are used to make tissues/organs for patients are a result of 'killing' embryos. An embryo is a potential life.	In the future, inherited diseases such as haemophilia and cystic fibrosis may be cured by replacing defective genes with healthy ones.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