AQA GCSE Biology | 8461

SPECIFICATION POINT 4.1.2.1

Chromosomes

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**56**
Available paper years	**2007–2025**

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

4.1.2.1 Chromosomes

Answer 01 · Mark scheme March 2007 | BLY1B | Original Q1 | Legacy

One	**A**	black skin	**4**
	B	small ears	**2**
	C	thick fur	**3**
	D	white fur	**1**

Answer 02 · Mark scheme March 2007 | BLY1B | Original Q6 | Legacy

Six	**A**	A cloned human could have an identical twin 30 years younger than	**4**
	B	Many cloned animals have died early in their lives.	**3**
	C	The first scientist to clone a human will be famous.	**2**
	D	The techniques needed to clone humans could be used to produce human	**1**

	A	**B**	**C**	**D**

Answer 03 · Mark scheme June 2007 | BLY1B | Original Q5 | Legacy

Five	**1**	**1**	**4**	**3**

Answer 04 · Mark scheme June 2007 | BLY1B | Original Q6 | Legacy

Six	**1**	**2**	**1**	*****

Answer 05 · Mark scheme November 2007 | BLY1B | Original Q6 | Legacy

Six	**1**	**2**	**4**	**2**

4.1.2.1 Chromosomes

Answer 06 · Mark scheme

Question 8

	answers	extra information	mark
(a)(i)	chromosomes	allow DNA ignore nucleus	1
(a)(ii)	enzymes		1
(b)	asexual reproduction / no gametes / no fusion / only one parent cells all contain same genetic information / same genes (as parent) / same DNA	ignore clones	1 1
(c)	can spray crop with herbicide – only weeds killed	crop survives herbicide insufficient	1
(d)	any **one** from: • fears / lack of knowledge about effects of GM food on health • crop plants may pass on gene to wild plants • encourages use of herbicides	allow 'think that GM food is bad for health' ignore not natural **or** against religion	1
total			6

4.1.2.1 Chromosomes

Answer 07 · Mark scheme March 2008 | BLY1BP | Original Q4 | Legacy

Four	**3**	**2**	**4**	**3**

Answer 08 · Mark scheme March 2008 | BLY1BP | Original Q7 | Legacy

Seven	**1**	**2**	**1**	**1**

Answer 09 · Mark scheme June 2008 | BLY1BP | Original Q2 | Legacy

Two	**A**	mutation	**3**	
	B	natural selection	**1**	
	C	extinction	**4**	
	D	variation	**2**	
	A		**B**	**C**	**D**

Answer 10 · Mark scheme June 2008 | BLY1BP | Original Q7 | Legacy

Seven	**1**	**3**	**3**	**2**

4.1.2.1 Chromosomes

Answer 11 · Mark scheme June 2008 | BLY2H | Original Q4 | Legacy

question	answers	extra information	mark
4(a)	any **two** from: • to combine / use amino acids • in specific / particular / correct / right order • to manufacture protein / enzymes / hormones	do **not** allow to make amino acids allow examples of proteins / enzymes / hormones	2
4(b)(i)	(man) B any **three** from: • child gets DNA / bars / lines from mother and father / parents • (child has) mother's 25 / 28 / 30 / 31 **or** child gets 17 / 19 / 22 / 24 from mother • (child has) man B's 10 / 12 / 13 / 14 **or** child gets 18 / 20 / 21 / 23 from B • no bars / DNA / lines from man A correspond to child	no mark for this **but** max **2** marks if A given ignore genes / chromosomes Man B Child Mother 17 — 25 10 — 18 19 — 28 12 — 20 13 — 21 22 — 30 14 — 23 24 — 31 contradictions disqualify 2nd and / or 3rd marking points ignore genes / chromosomes	3
4(b)(ii)	any **two** from: • gametes / eggs / sperm • contain only half of (mother's / father's) DNA / chromosomes / genes / genetic information • due to meiosis		2
Total			**7**

4.1.2.1 Chromosomes

Answer 11 · Mark scheme June 2008 | BLY2H | Original Q4 | Legacy

COMPONENT NUMBER: BLY2H

COMPONENT NAME: Additional Science / Biology

STATUS: Final

DATE: June 2008

Answer 12 · Mark scheme November 2008 | BLY1BP | Original Q6 | Legacy

Six	**3**	**4**	**2**	**3**

Answer 13 · Mark scheme March 2009 | BLY1BP | Original Q1 | Legacy

One	**A**	cell	**4**
	B	nucleus	**1**
	C	chromosome	**2**
	D	gene	**3**

Answer 14 · Mark scheme March 2009 | BLY1BP | Original Q7 | Legacy

Seven	**3**	**2**	**4**	**4**

Answer 15 · Mark scheme March 2009 | BLY1BP | Original Q9 | Legacy

Nine	**1**	**3**	**2**	**3**

4.1.2.1 Chromosomes

Answer 16 · Mark scheme

June 2009 | BLY1BP | Original Q4 | Legacy

Four	**2**	**2**	**1**	**3**

4.1.2.1 Chromosomes

Answer 17 · Mark scheme

June 2009 | BLY1H | Original Q7 | Legacy

Question 7

question	answers	extra information	mark
7(a)	any **three** from • FSH <u>used / given / injected</u> • LH <u>used / given / injected</u> • FSH causes eggs to mature • LH stimulates egg release	if oestrogen **or** progesterone <u>used</u> = max 2 if both oestrogen **and** progesterone <u>used</u> = max 1 ignore <u>effects</u> of oestrogen and progesterone	3

Question 7 continues on next page…

4.1.2.1 Chromosomes

Answer 17 · Mark scheme

June 2009 | BLY1H | Original Q7 | Legacy

BLY1H

Question 7 Continued

question	answers	extra information	mark
7(b)	max **two** pros for IVM / it from: • cheaper • less hormones used • ovarian hyperstimulation **or** the syndrome less likely • IVM treatment shorter	allow max **two** cons for IVF allow 'it's safer for the mother' ignore 'more risks' unqualified	2
	con for IVM • small risk of abnormal sex chromosomes / birth defects / baby cancer	allow max **one** pro for IVF allow 'more risk to baby' ignore 'more risks' unqualified	1
	evaluation eg IVM better because less risk to mother outweighs small risk to baby **or** IVF better because no risk to baby and a small risk to mother	must include an appreciation that there are two sides to the argument	1
Total			**7**

4.1.2.1 Chromosomes

Answer 18 · Mark scheme

June 2009 | BLY2H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)	(genotype / gametes from **T** / mother) h and h (accept h)	eg may be in punnett square	1
	(genotype / gametes from **U** / father) H and h	allow own upper and lower case symbols or allow any symbol correctly used with key	1
	offspring genotypes: correctly derived from correct gametes		1
	chance = 50% / ½ / 0 .5 / 1 : 1 / 1 out of 2	do **not** accept 1 : 2 allow irrespective of working	1
6(b)(i)	(cells from) embryo tested for particular allele / gene / (named) genetic condition / the disease / gender	ignore x-rays / ultra sound	1
6(b)(ii)	any **one** from: • possible harm to embryo **or** mother • sensible reference to abortion • hard to make moral / ethical decisions	ignore moral / ethical unqualified ignore not natural / playing God references to other ideas eg designer babies must be well argued	1
6(c)(i)	(cystic fibrosis is) recessive (allele / gene)	allow not dominant	1
	need two alleles / genes **or** need one allele / gene from each parent **or** both parents must have cystic fibrosis allele / gene		1

Question 6 continues on the next page…

4.1.2.1 Chromosomes

Answer 18 · Mark scheme

BLY2H

Question 6 Continued

question	answers	extra information	mark
6(c)(ii)	any **three** from: • osmosis / diffusion • more concentrated solution outside cells / in mucus • water moves from dilute to more concentrated solution • partially permeable membrane (of cell)	do **not** accept reference to movement of ions / solution by osmosis / diffusion assume concentration is concentration of solute unless they tell us otherwise allow correct references to movement of water in relation to concentration gradient	3
6(c)(iii)	ribosomes		1
Total			**12**

4.1.2.1 Chromosomes

Answer 19 · Mark scheme

June 2010 | BLY1BP | Original Q4 | Legacy

No matching mark scheme was available in the supplied archive for this question.

Answer 20 · Mark scheme

June 2010 | BLY1BP | Original Q6 | Legacy

No matching mark scheme was available in the supplied archive for this question.

4.1.2.1 Chromosomes

Answer 21 · Mark scheme

June 2019 | BLY2H | Original Q7 | Legacy

Question 7

question	answers	extra information	mark
7(a)	any **one** from • chromosomes in pairs • inherited one of each pair from each parent • one of each pair in egg **and** one of each pair in sperm • so sex cells / gametes can have half the number	allow need to pair during cell division / meiosis	1
7(b)	any **two** from: • <u>code</u> • combination / sequence of amino acids • forming specific / particular proteins / examples	If **no other mark** gained allow reference to controlling characteristics / appearance for **1** mark	2
7(c)(i)	C		1
7(c)(ii)	30		1
7(d)(i)	for growth / repair / replacement / asexual reproduction	do **not** accept incorrect qualification, eg growth *of* cells **or** repair of cells they equals cells therefore do not accept they grow etc	1
7(d)(ii)	44 **or** 22 pairs		1
Total			**7**

4.1.2.1 Chromosomes

Answer 22 · Mark scheme

March 2011 | BLY1BP | Original Q4 | Legacy

Four	3	4	3	2

Answer 23 · Mark scheme

June 2011 | BLY1BP | Original Q4 | Legacy

Four	2	4	3	4

Answer 24 · Mark scheme

November 2011 | BLY1BP | Original Q4 | Legacy

Four	4	3	2	1

4.1.2.1 Chromosomes

Answer 25 · Mark scheme

January 2012 | BL1HP | Original Q5 | Legacy

Question 5

question	answers	extra information	mark
5(a)	mutation	correct spelling only ignore other adjectives eg random / spontaneous	1
5(b)		ignore references to X / Y chromosomes	
	idea of mutant gene / new form / this allows hatching (of males)		1
	(individual with advantage) (more) survive / (more) live / (more) don't die	allow immunity rather than resistance throughout	1
	(so survivors) breed / reproduce		1
	mutation / gene passed (from survivors) to offspring / next generation	allow resistance / characteristic for gene 'gene passed on' is insufficient	1
Total			5

4.1.2.1 Chromosomes

Answer 25 · Mark scheme

January 2012 | BL1HP | Original Q5 | Legacy

COMPONENT NUMBER: BL1HP

4.1.2.1 Chromosomes

Answer 26 · Mark scheme

June 2012 | BL1HP | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6 (a)	(jellyfish) gene(s) cut out		1
	ref to enzymes (at any stage)		1
	(gene) transferred to zebra fish at early stage of development / embryo / egg	ignore removal of zebra fish genes	1
6 (b)	any **two** from: • could transfer gene to other (fish) species • effects on food chains • effects on zebra fish themselves, eg may out compete non GM zebra fish	ignore unethical / religious / unnatural accept effects on other species / humans who eat them	2
Total			**5**

4.1.2.1 Chromosomes

Answer 26 · Mark scheme

June 2012 | BL1HP | Original Q6 | Legacy

BL1HP

4.1.2.1 Chromosomes

Answer 27 · Mark scheme

January 2013 | BL2HP | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)(i)	meiosis	allow mieosis	1
4(a)(ii)	testis / testes	allow testicle	1
4(b)(i)	23		1
4(b)(ii)	fuses / joins with cell D / with egg cell **or** used in fertilisation prevents doubling of chromosome number / restores original no. / 46 / diploid no. / normal no. / full no.	allow fuse with another cell accept 23 from each parent / from each gamete	1 1
Total			**5**

4.1.2.1 Chromosomes

Answer 27 · Mark scheme

January 2013 | BL2HP | Original Q4 | Legacy

BL2HP

4.1.2.1 Chromosomes

Answer 28 · Mark scheme

June 2013 | BL2HP | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)	changes code /sequences of bases **or** sequence of amino acids is different		1
	the enzyme has different / wrong shape / structure	allow the active site is changed	1
	so substrate will not fit into enzyme / will not join to enzyme		1
6(b)(i)	46	allow 23 pairs	1
6(b)(ii)	also inherited (from mother) normal chromosome 15 / normal allele / normal gene / boy is heterozygous / **Hh**	allow the boy is a carrier	1
	(allele for) this disorder is recessive **or** the normal allele would give a working enzyme	ignore converse	1
6(b)(iii)	genetic diagram including:	accept alternative symbols, if defined	
	Parental gametes: **H** and **h** from both parents		1
	derivation of offspring genotypes: **HH Hh Hh hh**	allow alternative if correct for student's parental genotypes / gametes	1
	identification of **hh** (having the disorder) if 1 in 4		1
Total			**9**

4.1.2.1 Chromosomes

Answer 29 · Mark scheme

June 2013 | BL2HP | Original Q8 | Legacy

Question 8

question	answers	extra information	mark
8(a)(i)	DNA replication / copies of genetic material were made	'it' = a chromosome allow chromosomes replicate / duplicate / are copied ignore chromosomes divide / split / double	1
8(a)(ii)	one copy of each (chromosome / chromatid / strand) to each offspring cell	ignore ref. to gametes and fertilisation	1
	each offspring cell receives a complete set of / the same genetic material	allow 'so offspring (cells) are identical'	1
8(b)(i)	meiosis	allow mieosis as the only alternative spelling	1
8(b)(ii)	Species A = 4 **and** Species B = 8		1
8(b)(iii)	sum of A + B from (b)(ii) e.g. 12		1

Question 8 continues on the next page...

4.1.2.1 Chromosomes

Question 8 continued...

question	answers	extra information	mark
8(c)(i)	similarities between chromosomes **or** similarities between flowers described	 e.g. shape of petals / pattern on petals / colour / stamens	1
	can breed / can <u>sexually</u> reproduce	allow can reproduce with each other / they can produce offspring	1
8(c)(ii)	any **two** from: • offspring contain 3 copies of each gene / of each chromosome / odd number of each of the chromosomes • some chromosomes unable to pair (in meiosis) • (viable) gametes not formed / some gametes with extra / too many genes / chromosomes **or** some gametes with missing genes / chromosomes		2
Total			**10**

UMS Conversion Calculator: www.aqa.org.uk/umsconversion

4.1.2.1 Chromosomes

Answer 30 · Mark scheme June 2014 | BL1HP | Original Q8 | Legacy

8(a)	any **three** from: • (gene) cut out • (gene / cut out) from (bacterial) chromosome / DNA • ref to enzymes (at any point) • (gene spliced) into maize chromosome / DNA • (gene added) at an early stage of development	accept (gene / cut out) from (bacterial) plasmid	3	AO1 1.7.2d, e
8(b)	any **four** from: • justification based on comparison of the relative merits of at least one advantage and one disadvantage Advantages: • less effort for farmer **or** less likely to harm farmer • (pesticide) always there **or** doesn't wash away • less insects to eat crop / maize **or** carry disease • so greater crop production / yield Disadvantages: • (toxin) kills other insects • so (some) crops don't get pollinated / (sexually) reproduce • possible harm when eaten by humans / animals • damage to food chains • gene may spread to other species	max **3** marks if only advantages or disadvantages given ignore ref to cost allow examples eg no need to spray allow pesticide doesn't contaminate water courses ignore ref to cost allow maize not pollinated allow may have unpleasant taste allow reduced biodiversity	4	AO3 1.7.2e, f
Total			**7**	

4.1.2.1 Chromosomes

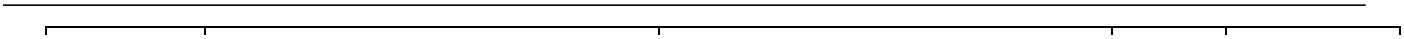
Answer 31 · Mark scheme June 2015 | BL1HP | Original Q8 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
8(a)	part of a chromosome controls a characteristic	allow piece of DNA allow parts of chromosomes allow controls characteristics allow codes for (**or** controls production of) protein / enzyme ignore examples of characteristics	1 1	AO1 1.7.1b/c
8(b)	(iPS method) *similarities* • (both) use of skin / body cell • (both) ref to (formation of) embryo • (both) transfer (embryo) into womb / uterus • (both) use surrogate mothers *differences* • (iPS) uses sexual reproduction • (iPS) surrogate mother is different species • (iPS) no nucleus transfer / removal • (iPS) offspring genetically different from parent • (iPS) no electric shock	max **3** similarities or differences allow converse if clearly referring to adult cell cloning allow ref to egg **and** sperm **or** gamete**s or** fertilisation allow not a clone	4	AO1 / AO3 1.7.2a/c
8(c)	any **one** from: • idea of retaining biodiversity • may be (economically) useful (in the future) • idea of maintaining food chain / ecosystem		1	AO3 1.7
Total			**7**	

4.1.2.1 Chromosomes

Answer 31 · Mark scheme

June 2015 | BL1HP | Original Q8 | Legacy



4.1.2.1 Chromosomes

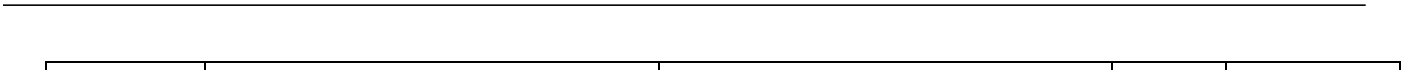
Answer 32 · Mark scheme June 2015 | BL2HP | Original Q3 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
3(a)(i)	in the chromosome(s) in the nucleus	ignore genes / alleles allow nuclei allow mitochondria	1 1	AO1 2.7.2f, 2.7.1b
3(a)(ii)	the DNA / chromosomes / genes are replicated / copied / multiplied / doubled / duplicated	allow DNA is cloned ignore same DNA / chromosomes / genes if unqualified	1	AO1 2.7.1a,c,n
3(b)(i)	1 / one		1	AO2 2.7.2c,e, 2.7.3a,c
3(b)(ii)	2 / two		1	AO2 2.7.2c,d, 2.7.3a,b
3(c)	**B**		1	AO3 2.7.2i
Total			**6**	

4.1.2.1 Chromosomes

Answer 32 · Mark scheme

June 2015 | BL2HP | Original Q3 | Legacy



4.1.2.1 Chromosomes

Answer 33 · Mark scheme

June 2016 | BL1HP | Original Q6 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
6(a)	0.67(%)	allow $0.\dot{6}$ or 0.7 allow **1** mark for evidence of $(2 \times 10^6) \div (3 \times 10^8)$ **or** allow **1** mark for 0.0067 or 0.6	2	AO2 1.1.2
6(b)(i)	idea that food chains start with plants / producers idea that these make food (for other organisms in the chain)	allow food chains do not start with animals **or** larvae are consumers allow idea that plants / producers photosynthesise **or** plants / producers get energy from the sun allow mosquito larvae do not make food / photosynthesise **or** mosquito larvae do not get energy from the sun	1 1	AO1 1.5.1a

4.1.2.1 Chromosomes

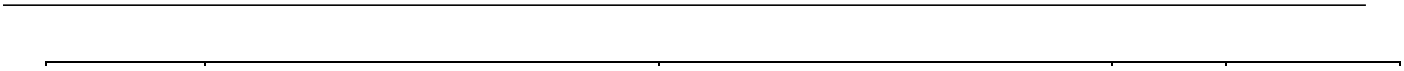
Answer 33 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
6(b)(ii)	any **four** from: • reasoned argument for **or** against release *advantages:* • fewer mosquitos biting **or** spreading malaria • fewer people get / die from malaria • lower medical costs (for those infected **or** for treatment) **or** less healthcare needed • better economically for developing / tropical countries. *disadvantages:* • fewer crops reproduce • poorer crop yield • possible starvation (of people) • high cost of GM production / mosquito release • less food for bats / birds **or** bats / birds die • gene could 'escape' into other wildlife / species	 must refer to at least one advantage and one disadvantage. max **3** marks for either only advantages **or** only disadvantages allow people won't get / die from malaria allow fewer crops pollinated allow disruption to food chain / ecosystem **or** reduction of biodiversity ignore into plants	4	AO3 1.7.2f
6(b)(iii)	any **three** from: • gene from bacteria cut out • ref to enzymes (anywhere in process) • (gene) transferred to chromosome of mosquito • at an early stage of development	 allow allele for gene allow at any point in process, ie in cutting or in splicing allow DNA for chromosome allow egg / embryo	3	AO1 1.7.2d/e
Total			**11**	

4.1.2.1 Chromosomes

Answer 33 · Mark scheme

June 2016 | BL1HP | Original Q6 | Legacy



4.1.2.1 Chromosomes

Answer 34 · Mark scheme June 2016 | BL2HP | Original Q5 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
5(a)	testis / testes	allow testicle(s)	1	AO1 2.7.1f
5(b)(i)	**B** = 13.2 **C** = 6.6 **E** = 3.3	all 3 correct = 2 marks 2 or 1 correct = 1 mark If no marks awarded allow ecf for C **and** E based on answer to B ie C = ½ B **and** E = ½ C for one mark	2	AO2 2.7.1e/h
5(b)(ii)	6.6	allow twice answer for cell **E** in 5bi	1	AO2 2.7.1e/h/i
5(b)(iii)	mitosis	correct spelling only	1	AO1 2.7.1a/d/i
5(c)(i)	any **two** from: • cells that are able to divide • undifferentiated cells / not specialised • can become other types of cells / tissues **or** become specialised /differentiated	allow pluripotent	2	AO1 2.7.1k/l
5(c)(ii)	4-day embryo is a (potential) human life **or** destroying/damaging (potential) human life	allow cord would have been discarded anyway ignore reference to miscarriage allow cannot give consent	1	AO3 2.7
5(c)(iii)	perfect tissue match **or** hard to find suitable donors	allow same/matching antigens allow no danger of rejection allow no need to take immunosuppressant drugs (for life) ignore genetically identical **or** same DNA	1	AO2 2.7.1c

4.1.2.1 Chromosomes

Answer 34 · Mark scheme

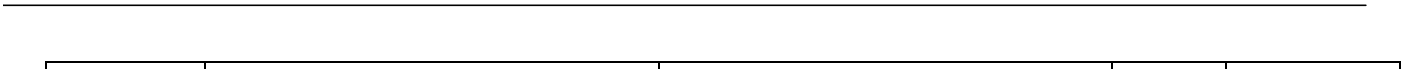
June 2016 | BL2HP | Original Q5 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
5(c)(iv)	stem cells have same faulty gene / allele / DNA / chromosomes	allow genetically identical ignore cells have the same genetic disorder	1	AO2 2.7.1c
Total			10	

4.1.2.1 Chromosomes

Answer 34 · Mark scheme

June 2016 | BL2HP | Original Q5 | Legacy



4.1.2.1 Chromosomes

Answer 35 · Mark scheme June 2017 | BL1HP | Original Q7 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
7(a)	idea that sexual reproduction results in genetic variation	allow converse if clearly referring to asexual reproduction allow reference to natural selection / evolution (if conditions change)	1	AO1 1.7.2a
7(b)(i)	any **four** from: • nucleus taken from egg (cell) (of female) **A or** cytoplasm (and membrane) discarded • nucleus removed / discarded from egg (cell) (from female) **B or** only cytoplasm (and membrane) kept • nucleus from **A** inserted into (enucleated / empty cell / cytoplasm from) egg (cell) (of female) **B** • fertilised / fertilisation (of 'hybrid' cell) • electric shock (after fertilisation) **or** grown into embryo	accept throughout: female **A** = person with faulty mitochondria female **B** = person without faulty mitochondria allow egg and sperm fuse allow cell division / mitosis	4	AO1/3 1.7.2a/c
7(b)(ii)	idea of cytoplasm / mitochondria of 'hybrid' / fertilised cell / embryo comes from cell / female / B with 'normal' mitochondria **OR** only the nucleus is used from A (1) the nucleus does not contain mitochondria **or** these faulty genes (1)		1 1	AO2 1.7.2c

4.1.2.1 Chromosomes

Answer 35 · Mark scheme

7(b)(iii)	any **one** from: • idea that child has unknown parentage **or** 3 parents • against religious beliefs / teachings • could cause (more) prejudice (against people with perceived imperfection)	ignore ref to unethical / immoral ignore ref to being against religion / God's will unqualified	1	AO3 1.7
Total			**8**	

4.1.2.1 Chromosomes

Answer 35 · Mark scheme

June 2017 | BL1HP | Original Q7 | Legacy

4.1.2.1 Chromosomes

Answer 36 · Mark scheme

June 2017 | BL2HP | Original Q6 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
6(a)(i)	46 **or** 23 pairs		1	AO1 2.7.2b
6(a)(ii)	(alternative / different) form(s) of a gene / of the same gene		1	AO1 2.7.2c
6(a)(iii)	only expressed if the dominant (allele) is not present / if the other (allele) is not present **or** only expressed if 2 (recessive alleles) are present	allow won't be expressed if the dominant allele is present	1	AO1 2.7.2e
6(b)(i)	having 2 different alleles	do **not** allow 2 different genes ignore carrier	1	AO1 2.7
6(b)(ii)	genetic diagram including: correct gametes **or** parental genotypes **N** and **n** and **N** and **n** **or** **Nn** and **Nn** offspring genotypes correctly derived: **NN** **Nn** **Nn** **nn** identification of **nn** as AKU correct probability only: 0.25 / ¼ / 1 in 4 / 25% / 1 : 3	allow alternative symbols if defined do **not** allow if alternative symbols used and not defined allow genotypes correct for student's parental gametes allow correct identification of student's offspring genotypes do **not** allow 3 : 1 / 1 : 4 do **not** allow if extra incorrect probabilities given	1 1 1 1	AO2/3 2.7 2.7.3a

4.1.2.1 Chromosomes

Answer 36 · Mark scheme

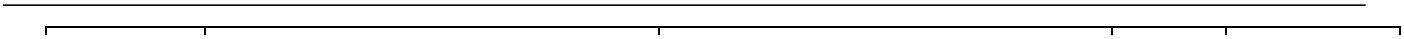
June 2017 | BL2HP | Original Q6 | Legacy

6(c)(i)	mitosis	correct spelling only	1	AO1 2.7.1a/d
6(c)(ii)	4		1	AO2 2.7.1a,d
6(d)(i)	any **one** from: • may lead to damage to embryo **or** may destroy embryos • embryo cannot give consent • ref to possible miscarriage (of implanted embryo) • idea of avoiding prejudice against disabled people • idea of not producing designer babies	allow emotive terms e.g. murder allow disposal of embryos allow embryos used in research ignore religion unqualified	1	AO3 2.7 2.7.3d
6(d)(ii)	any **one** from: • prevent having child with the disorder **or** reduce incidence of the disease / inherited / genetic diseases **or** prevent future suffering of child from the disease • embryo cells could be used in stem cell treatment • can have another child without need for IVF • provides embryos for research • ref to avoiding long term cost of treating a child (with a disorder) **or** avoid parental stress	ignore ref to having a healthy child ignore ref to selection of gender allow reference to parents being prepared in advance	1	AO3 2.7 2.7.3d
Total			**12**	

4.1.2.1 Chromosomes

Answer 36 · Mark scheme

June 2017 | BL2HP | Original Q6 | Legacy



4.1.2.1 Chromosomes

Answer 37 · Mark scheme

June 2018 | 8461/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	DNA / deoxyribo(se)nucleic acid		1	AO1 4.1.2.1
06.2	controls the movement of substances in / out of cell	ignore allows substances in / out of cell	1	AO1 4.1.1.2
06.3	**Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.		5–6	AO2 4.2.2.1 4.2.2.2 4.4.2.1
	Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.		3–4	
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.		1–2	
	No relevant content		0	
	Indicative content fewer (digestive) enzymes enter small intestine • (so) enzymes break down / digest less food • (therefore) less absorption of nutrients • (so) less glucose can enter the blood(stream) • (so) less (glucose) available for respiration • (less absorption of nutrients so) fewer amino acids can enter the blood(stream) • (so) less protein is made (for growth) ignore ref to bile less oxygen enters blood(stream) / reaches cells / organs / tissues (ignore body / lungs) • (so) less (oxygen) available for (aerobic) respiration • (so) less energy released / available (for growth) do **not** accept energy produced for **level 3**, reference to both enzymes and oxygen is required			

4.1.2.1 Chromosomes

Answer 37 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	put ages in (ascending / descending / chronological) order		1	AO2 4.2.2.5
	find middle value	allow a way of achieving this ie $\frac{(n+1)}{2}$ where n is the number of people	1	AO1 4.2.2.5
06.5	most common in young people **or** (more) don't live to an old age	allow causes of this	1	AO3 4.2.2.5
06.6		an answer of 10 584 scores **2** marks		AO2 4.2.2.5
	$0.98 \times 10\,800$	allow $\frac{98}{100} \times 10\,800$	1	
	10 584	allow $10\,800 - (0.02 \times 10\,800)$ or equivalent	1	
06.7	take stem cells from patient (bone marrow / skin)		1	AO2 4.1.2.3
	remove / change / fix the faulty / CF gene		1	
	create embryo using these stem cells	allow idea of transferring nucleus from stem cells into enucleated egg / ovum	1	
	remove stem cells (from embryo) and stimulate / allow them to divide / differentiate into lung (cells)	if no other marks awarded allow **1** mark for therapeutic cloning	1	

4.1.2.1 Chromosomes

Answer 37 · Mark scheme

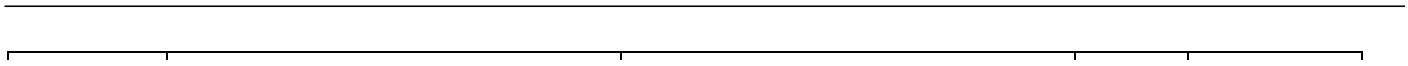
June 2018 | 8461/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.8	idea of ethical / religious concerns about use of embryos such as loss of (potential) human life	allow idea that embryo cannot give consent ignore idea of against human rights of embryo unqualified ignore religious / ethical reasons unqualified	1	AO3 4.1.2.3
Total			18	

4.1.2.1 Chromosomes

Answer 37 · Mark scheme

June 2018 | 8461/1H | Original Q6



4.1.2.1 Chromosomes

Answer 38 · Mark scheme

June 2018 | 8461/2H | Original Q5

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO / Spec. Ref.</th></tr>
<tr><td>05.1</td><td>
<table>
<tr><th></th><th colspan="3">statement is true for</th></tr>
<tr><th></th><th>mitosis only</th><th>meiosis only</th><th>both mitosis and meiosis</th></tr>
<tr><td>all cells produced are genetically identical</td><td>✓</td><td></td><td></td></tr>
<tr><td>in humans, at the end of cell division each cell contains 23 chromosomes</td><td></td><td>✓</td><td></td></tr>
<tr><td>involves DNA replication</td><td></td><td></td><td>✓</td></tr>
</table>
3 correct = 2 marks
2 correct = 1 mark
0 or 1 correct = 0 marks
</td><td></td><td>2</td><td>AO1
4.1.2.2
4.6.1.2</td></tr>
<tr><td>05.2</td><td>any two from:

• many offspring produced
• takes less time
• (more) energy efficient
• genetically identical offspring
• successful traits propagated / maintained / passed on (due to offspring being genetically identical)
• no transfer of gametes or seed dispersal
• not wasteful of flowers / pollen / seeds
• colonisation of local area</td><td>ignore references to one parent only

allow asexual is faster

allow offspring are clones

allow no vulnerable embryo stage
allow no need for animals

must imply local area</td><td>2</td><td>AO3
4.6.1.1
4.6.1.3</td></tr>
</table>

4.1.2.1 Chromosomes

Answer 38 · Mark scheme

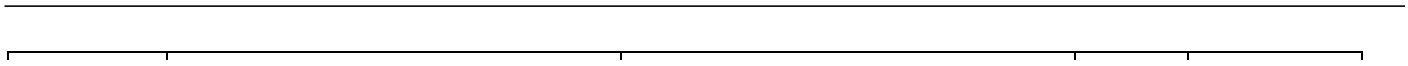
June 2018 | 8461/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3		allow bluebell example described (**max 3** if not bluebell)		
	genetic variation (in offspring)		1	AO1
	(so) better adapted survive	allow reference to natural selection or survival of the fittest	1	AO1
	(and) colonise new areas by seed dispersal **or** can escape adverse event in original area (by living in new area)	must imply new area	1	AO3
	many offspring **so** higher probability some will survive		1	AO3 4.6.1.1 4.6.2.1 4.6.1.3 4.7.1.1
Total			**8**	

4.1.2.1 Chromosomes

Answer 38 · Mark scheme

June 2018 | 8461/2H | Original Q5



4.1.2.1 Chromosomes

Answer 39 · Mark scheme June 2018 | 8461/2H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	3.7		1	AO2 4.7.2.1
08.2	2		1	AO1 4.6.1.6
08.3	(different combinations of alleles cause) many / 22 values **or** in-between values **or** large range of values **or** there are not only two values	allow continuous variation allow there are not only 3 values if 3 is given in question **08.2**	1	AO3 4.6.1.6 4.6.2.1
08.4	different protein made active site changed so substrate does not fit / bind	allow change in shape (of enzyme) or change in 3-D structure ignore denature allow description of substrate allow cannot form E-S complex ignore lock and key description	1 1 1	AO1 4.2.2.1 4.6.1.5
08.5	produces (some) offspring with high-fat milk **or** not all offspring have low-fat milk	ignore reference to alleles	1	AO3 4.6.1.6
08.6	takes less time (to obtain results) **or** more offspring at the same time	allow other sensible suggestion – eg allows screening **or** allow cow 7 to continue to produce eggs **or** avoid injury to cow 7 during mating or giving birth	1	AO3 4.5.3.6

4.1.2.1 Chromosomes

Answer 39 · Mark scheme

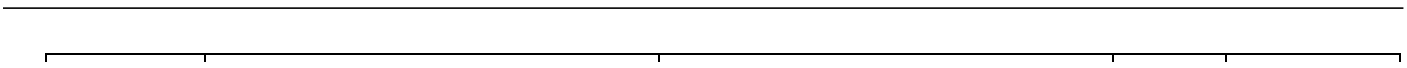
June 2018 | 8461/2H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.7		**max 3** marks if own symbols used with no key **max 3** marks if alternative diagram to Punnett square used		AO2 4.6.1.6
	male gametes correct: d (and d)		1	
	female gametes correct: D and d	allow **1** mark if gametes are correct but gender not identified	1	
	correct derivation of offspring genotypes from given gametes	allow 2 × 2 **or** 2 × 1 derivation	1	
	Dd identified as low-fat **and** dd identified as high-fat in offspring	if DD offspring are produced, must also identify as low-fat	1	
08.8	find female with low(est) fat in milk **and** high(est) milk yield	allow choose from 7, 9, 12, 13 which has the highest yield	1	AO3 4.6.2.3
	find male whose female offspring have high(est) milk yield **and** low(est) fat in milk **or**	allow choose from 16 or 18 whose female offspring has the highest yield	1	AO3 4.6.2.3
	find female with lowest fat in milk **or** cow 13 (1) **or** find male whose female offspring have high(est) milk yield (1)	allow female with high(est) milk yield allow male whose female offspring have lowest fat in milk / male 16		
	cross the best (for both features) female with the best male		1	AO2 4.6.2.3
	select best offspring (for both features) from each generation and repeat for several generations		1	AO2 4.6.2.3
Total			**16**	

4.1.2.1 Chromosomes

Answer 39 · Mark scheme

June 2018 | 8461/2H | Original Q8



4.1.2.1 Chromosomes

Answer 40 · Mark scheme

June 2019 | 8461/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	any **one** from: • (chemical which) catalyses / speeds up reactions in living organisms • (chemical which) catalyses / speeds up biological reactions	allow biological catalyst allow reduces activation energy (of reactions) in living organisms	1	4.2.2.1 AO1
	idea of specificity **or** (is a) protein	allow made of amino acids	1	
08.2	salivary gland	ignore mouth ignore liver	1	4.2.2.1 AO1
	small intestine	allow duodenum / ileum ignore intestine unqualified do **not** accept large intestine	1	

4.1.2.1 Chromosomes

Answer 40 · Mark scheme

June 2019 | 8461/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3	reduced / no enzyme production / release (from pancreas)	allow named example of enzymes ignore reference to hormones	1	4.2.2.1 4.4.2.3 4.4.2.1 AO2
	food is not broken down fully **or** food is not digested fully	allow no food is broken down / digested allow example	1	
	plus any **one** of the following routes for max **2** marks:	mark as pairs		
	less glucose / sugar absorbed **or** less glucose / sugar passes into the blood(stream)		1	
	(so) less glucose available for respiration so more (body / stored) fat used up in metabolism / respiration **or** fewer amino acids absorbed **or** fewer amino acids pass into the blood(stream) (1) (so) fewer amino acids are available for making new protein for repair / replacement (1) **or** fewer fatty acids absorbed **or** fewer fatty acids pass into the blood(stream) (1) (so) fewer fatty acids available so less fat is stored in the body (1) **or** chemotherapy / radiotherapy causes nausea / loss of appetite (1) (so) less intake of food (1)	ignore glycerol ignore glycerol	1	

4.1.2.1 Chromosomes

Answer 40 · Mark scheme

June 2019 | 8461/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4	(cancer) cells cannot divide **or** (cancer) cells are destroyed / killed	do **not** accept reference to the drug killing (cancer) cells	1	4.2.2.7 AO3
	(so) tumour doesn't grow / get bigger **or** tumour less likely to spread **or** tumour less likely to form secondary tumours	allow cancer cells less likely to spread / metastasise	1	
	(because) enzymes **A** and **B** are not working / active / effective / present **or** (because) enzymes **A** and **B** are inhibited	allow reference to both enzymes ignore enzymes unqualified	1	
08.5	(functional) enzyme **B** would still be made / present	allow enzyme **B** is not inhibited	1	4.2.2.7 AO3
	(therefore cancer) cells would still divide uncontrollably **or** (therefore cancer) cells would not be destroyed **or** (therefore) the tumour will (continue to) grow / get bigger / spread **or** the tumour will form secondary tumours		1	
08.6	any **two** from: • to avoid the patients thinking they feel better with the drug **or** to take into account a psychological effect • as a control / comparison • to avoid bias(ed results)	ignore to make it more valid unqualified ignore to provide an independent variable	2	4.3.1.9 AO2
08.7	testing on volunteers with the disease		1	4.3.1.9 AO1

4.1.2.1 Chromosomes

Answer 40 · Mark scheme

June 2019 | 8461/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.8	monoclonal antibody is attached to radioactive substance / toxin / drug / chemical monoclonal antibody will (only) attach to / target (antigen on) cancer cells / tumour (so) radioactive substance / toxin / drug / chemical will (bind to cancer cells and) stop them growing / dividing	allow radioactive substance / toxin / drug / chemical will kill / destroy the cancer cells **OR** monoclonal antibody interrupts the cell cycle **or** monoclonal antibody aids immune response (1) monoclonal antibody will (only) target cancer cells / tumour (1) (so) action of monoclonal antibody stops cancer cells growing / dividing **or** (so) action of monoclonal antibodies helps immune system kill / destroy cancer cells (1)	1 1 1	4.3.2.2 AO1 AO1 AO1
Total			**19**	

4.1.2.1 Chromosomes

Answer 41 · Mark scheme

June 2019 | 8461/2H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	**Level 2:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.		3–4	AO1 AO2
	Level 1: The method would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.		1–2	
	No relevant content		0	
	Indicative content • use of quadrat • (quadrat) of given area / dimensions – eg 0.25 m^2 or 1 m × 1 m • quadrats are placed randomly • method of obtaining randomness – eg random coordinates from a calculator **or** throw over shoulder **or** throw with eyes closed • suitable number of quadrats (10 or more **or** a large number) • count number of plants (in each quadrat) • calculation of mean per quadrat or per unit area • determination of area of field (length × width) • population = mean per m^2 × area of field			4.7.2.1
07.2	more bacteria so more divisions / reproduction (per unit time)		1	AO2 4.1.1.6
07.3	any **three** from: • add (more) sugar • add (more) amino acids / protein • add (more) oxygen • increase temperature • remove toxins / waste **or** maintain pH • stir the culture	if neither point given, allow add (more) nutrients allow in range 26 °C to 40 °C allow maintain optimum temperature if no other mark awarded allow **1** mark for add more food	3	AO3 4.1.1.6 4.4.2.3 4.7.2.3 4.7.4.3 4.7.5.4

4.1.2.1 Chromosomes

Answer 41 · Mark scheme

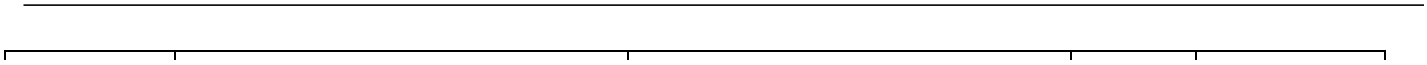
June 2019 | 8461/2H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4		an answer in the range of 2.9 to 3.4 scores **4** marks an answer in the range of 2.08 to 3.77 scores **3** marks		AO2 4.1.1.6 4.6.2.4
	tangent drawn to the curve at 12 hours	do **not** accept if there is an incorrect tangent at 7 hours	1	
	calculation of rate at 7 hours $\frac{\Delta y}{\Delta x}$	allow an answer that correctly rounds to a value in range 10.0 to 11.7	1	
	calculation of rate at 12 hours $\frac{\Delta y}{\Delta x}$	allow an answer that correctly rounds to a value in range 3.1 to 4.8	1	
	3.3	allow in range 2.9 to 3.4 if both rates are in the correct ranges	1	
07.5	can use the glyphosate / weed killer to kill weeds but not kill / affect crop	allow **only** kills weeds	1	AO1 4.6.2.4 4.7.1.3 4.7.5.4
	(so) less competition for light / water / minerals / ions	allow less competition for nutrients ignore food / carbon dioxide / space	1	AO2
	(so) crops have high(er) yield	allow crops grow better / well	1	AO1
Total			**15**	

4.1.2.1 Chromosomes

Answer 41 · Mark scheme

June 2019 | 8461/2H | Original Q7



4.1.2.1 Chromosomes

Answer 42 · Mark scheme

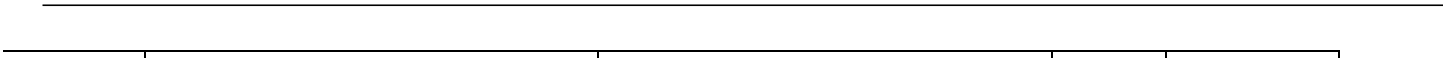
November 2020 | 8461/2H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	many (joined) nucleotides **or** monomers	allow (long) molecule / chain made of repeating units	1	AO1 4.6.1.4 4.6.1.5
04.2	phosphate	ignore phosphorus	1	AO1 4.6.1.5
	(phosphate attached to a) sugar	allow deoxyribose / pentose	1	
		allow **2** marks if position of sugar / phosphate / base is incorrect		
	(which has 1 of 4) base(s) (attached to sugar)		1	
	(bases) are A, C, G **and** T	allow bases are adenine, cytosine, guanine **and** thymine do **not** accept thiamine / adenosine allow description of a pair of nucleotides	1	
04.3		an incorrect answer for one step does not prevent allocation of marks for subsequent steps		AO2 4.6.1.4 4.6.1.5
	$0.34 \times 12\,000\,000\,000$		1	
	$4\,080\,000\,000$		1	
	$\frac{4\,080\,000\,000}{1\,000\,000\,000}$	allow conversion from nm to m at any point in the calculation	1	
	4.08 (m)		1	
	2.04 (m) (divided by 2 due to base pairs)	allow division by 2 at any point in the calculation	1	
04.4	(non-coding parts) can switch genes on / off		1	AO1 4.6.1.5
Total			**11**	

4.1.2.1 Chromosomes

Answer 42 · Mark scheme

November 2020 | 8461/2H | Original Q4



4.1.2.1 Chromosomes

Answer 43 · Mark scheme

November 2020 | 8461/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	any **three** from: • mitosis produces two (daughter) cells but meiosis produces four (daughter) cells • one cell division in mitosis but two cell divisions in meiosis • mitosis produces cells with two of each chromosome, but meiosis produces cells with one of each chromosome • mitosis produces genetically identical cells, but meiosis produced genetically different cells	answers must be comparative allow mitosis produces diploid cells but meiosis produces haploid cells allow mitosis maintains the number of chromosomes **or** mass of DNA **or** mass of genetic material but meiosis halves the number / mass allow mitosis produces cells with 23 pairs **or** 46 chromosomes but meiosis produces cells with 23 chromosomes allow other correct differences between the processes of mitosis and meiosis	3	AO1 4.6.1.1 4.6.1.2 4.1.2.2

4.1.2.1 Chromosomes

Answer 43 · Mark scheme

November 2020 | 8461/2H | Original Q5

05.2	any **one** from: • DNA doubles / copies / replicates (once) • increase in the number of mitochondria / ribosomes / sub-cellular structures	allow chromosomes **or** genetic material **or** genetic information double / replicate / are copied ignore mitochondria / ribosomes are copied / duplicated allow chromosomes / chromatids pulled to side (of cell) allow other correct similarities between the processes of mitosis and meiosis	1	AO1 4.6.1.1 4.6.1.2 4.1.2.2
05.3	Dd / dD has **D** because has Dupuytren's **and** has **d** because child / person 6 is homozygous recessive **or** does not have Dupuytren's **or** is **dd**	allow heterozygous allow has **D** because has Dupuytren's **and** person 1 and person 2 both passed **d** to child / person 6 allow has **D** because has Dupuytren's **and** cannot be homozygous / **DD** or all the children would have Dupuytren's	1 1	AO3 4.6.1.6 4.6.1.7
05.4	male / person 7 gametes correct: **D** and **d** female / person 8 gametes correct: **d** and **d** correct derivation of offspring genotypes: **Dd Dd dd dd** offspring with Dupuytren's identified probability correct from the correct identification given	allow **1** mark for both sets of gametes correct if parents not identified allow correct derivation of offspring genotypes from incorrect gametes allow correct for genotypes stated in mp3 allow probability correct from offspring genotypes if identification not given	1 1 1 1 1	4.6.1.6 4.6.1.7 AO2 AO2 AO2 AO2 AO3

4.1.2.1 Chromosomes

Answer 43 · Mark scheme

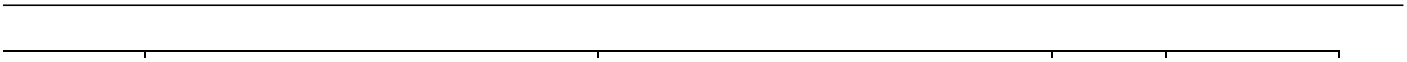
November 2020 | 8461/2H | Original Q5

05.5	female(s) / person(s) 3 / 11 / 12 have Dupuytren's	allow some females have Dupuytren's	1	AO3 4.6.1.6 4.6.1.7 4.6.1.8
	females don't have Y chromosome **or** Dupuytren's is passed from fathers / 1 / 7 to daughters / 3 / 12, (so is not on the Y chromosome)	allow only males have Y chromosomes allow females are XX allow Dupuytren's is passed from mothers / 11 to children / 15, (so is not on the Y chromosome)	1	
Total			**13**	

4.1.2.1 Chromosomes

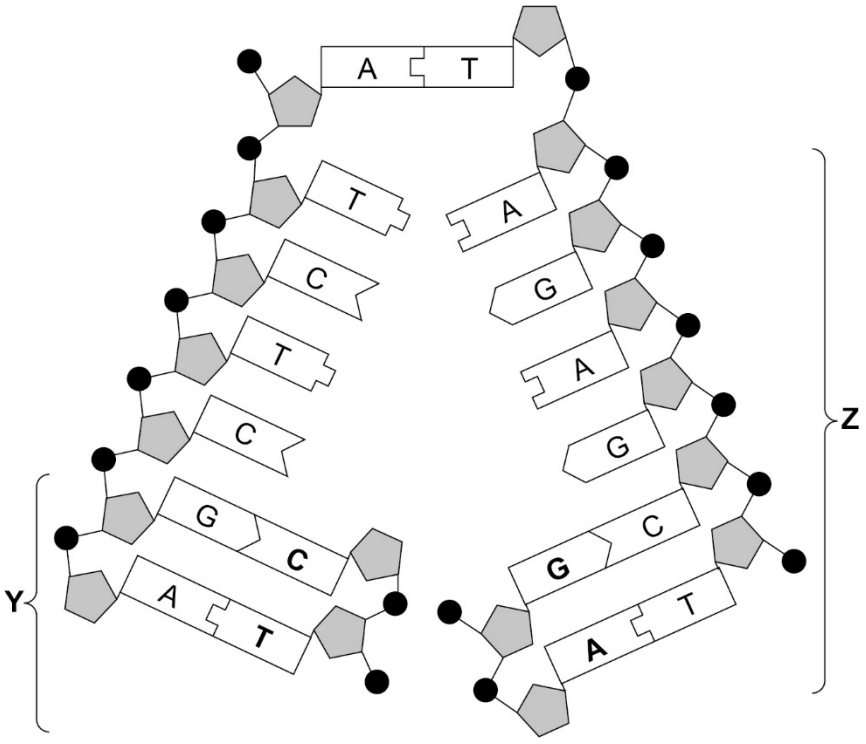
Answer 43 · Mark scheme

November 2020 | 8461/2H | Original Q5



4.1.2.1 Chromosomes

Answer 44 · Mark scheme November 2021 | 8461/2H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	chromosome(s)	allow chromatid(s) / gene(s) / allele(s)	1	AO1 4.6.1.4
01.2	sugar	allow deoxyribose allow pentose do **not** accept ribose	1	AO1 4.6.1.5
01.3	base(s)	allow nitrogenous base(s) allow adenine **and** cytosine **and** guanine **and** thymine	1	AO1 4.6.1.5
01.4	 all four required for the mark		1	AO3 4.6.1.5

4.1.2.1 Chromosomes

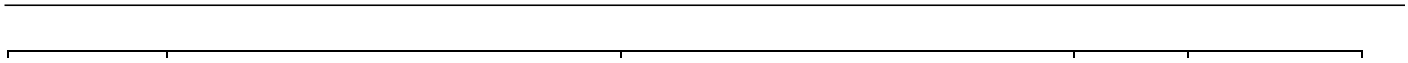
Answer 44 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	replication		1	AO3 4.6.1.5 4.1.2.2
01.6	protein	allow polypeptide	1	AO1 4.6.1.4
01.7	3×10^{-12} grams		1	AO2 4.6.1.2
01.8	meiosis		1	AO1 4.6.1.2
Total			**8**	

4.1.2.1 Chromosomes

Answer 44 · Mark scheme

November 2021 | 8461/2H | Original Q1



4.1.2.1 Chromosomes

Answer 45 · Mark scheme November 2021 | 8461/2H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	mutation means less oxygen for (aerobic) respiration	allow haemoglobin **or** red blood cell carries oxygen for (aerobic) respiration do **not** accept no oxygen for respiration	1	AO2 4.6 4.6.1.5 4.2.2.3
08.2	4 ÷ 17 0.235(29...)	allow 4:13 allow 0.24 **or** 24% allow ratio 1 : 3.25	1 1	AO2 4.6.1.5 4.2.2.3
08.3	father / **8**'s gametes correct: $H^A + H^A$ mother / **9**'s gametes correct: $H^A + H^S$	allow **1** mark for both sets of gametes if parents not identified	1 1	AO2 AO2
	correct derivation of offspring genotypes: H^AH^A H^AH^A H^AH^S H^AH^S	allow correctly derived offspring genotypes from incorrect parental gametes	1	AO2
	correct phenotype for each derived genotype		1	AO2
	0.25 / ¼ / 25% / 1 in 4 / 1:3	allow **only** a probability consistent with student's derivations	1	AO3 4.6.1.6 4.6.1.7 4.6.1.8

4.1.2.1 Chromosomes

Answer 45 · Mark scheme

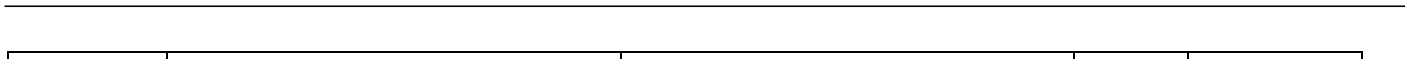
November 2021 | 8461/2H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4	any **three** from: *points for:* • H^AH^S do not get malaria • H^AH^S survive sickle cell anaemia *points against:* • H^AH^A may die from malaria • H^SH^S may become (severely) ill with sickle cell anaemia • Judgement: if parents H^AH^S then some offspring survive both malaria and sickle cell anaemia **or** if parents H^AH^S then some offspring may become (severely) ill with malaria and some become (severely) ill with sickle cell anaemia	to gain full marks both point(s) for and point(s) against must be given	3	AO3 4.6.2.1
Total			**11**	

4.1.2.1 Chromosomes

Answer 45 · Mark scheme

November 2021 | 8461/2H | Original Q8



4.1.2.1 Chromosomes

Answer 46 · Mark scheme

November 2021 | 8461/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	Classification group Kingdom Phylum Class Order Family Genus Species	all 4 correct = **2** marks 2 or 3 correct = **1** mark 0 or 1 correct = **0** marks	2	AO1 4.6.4
09.2	Geospiza fortis	ignore underlining or attempted italics or upper and lower case letters	1	AO2 4.6.4
09.3	offspring have similar beak depths to parents	ignore same beak depths ignore positive correlation / described	1	AO3 4.6.2.1
09.4	parents of a given beak depth produce offspring with several beak depths	allow spread of results for a given parental beak depth about line of best fit allow range of phenotypes for a given parental beak depth	1	AO3 4.6.1.6

4.1.2.1 Chromosomes

Answer 46 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5	colonisers of Isabela have a range of beak depths	allow colonisers of Daphne have a range of beak depths	1	AO2
	due to different combinations of alleles of several genes **or** due to different alleles of one gene **or** due to mutation		1	AO1
	large range of (sizes / species of) seeds / food (on Isabela) **or** large(r) seeds (on Isabela)	allow small range of (sizes / species of) seeds / food on Daphne **or** allow small(er) seeds on Daphne	1	AO2
	more competition for seeds / food (on Isabela)	allow less competition for seeds / food on Daphne ignore competition unqualified	1	AO2
	birds with larger beaks get enough food to (survive and) reproduce (on Isabela)	allow birds with smaller / medium beak sizes get enough food to (survive and) reproduce on Daphne	1	AO2
	(survivors) pass on (beneficial) alleles to offspring	allow pass on genes / mutation ignore pass on chromosomes / characteristics	1	AO1 4.6.2.1 4.6.2.2 4.7.1.1 4.7.1.3

4.1.2.1 Chromosomes

Answer 46 · Mark scheme

November 2021 | 8461/2H | Original Q9

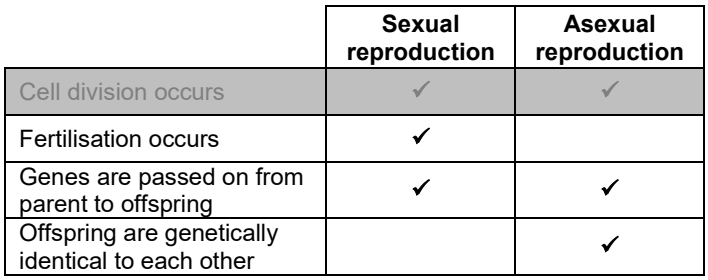
Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.6	Isabela is a large island with more species of plants **or** Isabela is a large island with more variety in seed / food sizes **or** Isabela is a large island with more plants / seeds / food less competition for seeds / food **or** enough seeds / food for both bird species		1 1	AO3 4.7.1.1 4.7.1.3
Total			**13**	

4.1.2.1 Chromosomes

Answer 47 · Mark scheme

June 2022 | 8461/2H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1			2	AO1 4.6.1.1

	Sexual reproduction	Asexual reproduction
Cell division occurs	✓	✓
Fertilisation occurs	✓	
Genes are passed on from parent to offspring	✓	✓
Offspring are genetically identical to each other		✓

allow **1** mark for 1 or 2 correct rows
ignore 'x' in blank boxes

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	pollen (grain)	allow nucleus in pollen (grain)	1	AO1 4.6.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	between 3 and 4 hours		1	AO2 4.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	5 hours 6 hours		1 1	AO2 4.6.1.2

4.1.2.1 Chromosomes

Answer 47 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	2		1	AO2 4.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.6	4		1	AO2 4.6.1.2

Total Question 1		**8**

4.1.2.1 Chromosomes

Answer 48 · Mark scheme

June 2023 | 8461/2H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	any **one** from: • variation of a named / described (desirable) characteristic • not all susceptible to the same disease / pathogen • maintain / increase gene pool	allow eg different flavour / colour allow different customer preferences	1	AO2 4.6.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	any **one** from: • they have the same named /(desirable) characteristic(s) • they grow at the same rate • they ready to harvest at same time	allow eg all high yield **or** all disease-resistant **or** same (desirable) flavour	1	AO2 4.6.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	(a group of) cells are grown (into a new organism)	ignore clones	1	AO1 4.6.2.5

4.1.2.1 Chromosomes

Answer 48 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	any **one** from: different • water • minerals / ions • light • herbivores • disease • plant density • soil pH	 allow rain allow named example ignore nutrients ignore sun unqualified allow named example allow named example allow different temperature allow different environmental conditions	1	AO2 4.6.2.1 4.7.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	male gametes = **X** + **Y** female gametes = **X** + **X** offspring genotypes correctly derived from gametes	if neither mark awarded, allow **1** mark for male = **X** + **X and** female = **X** + **Y** allow correct for chromosome assignment in mp1 & mp2	1 1 1	AO1 AO1 AO2 4.6.1.8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.6	any **one** from: • half are XX and half are XY • equal probability of X or Y sperm fertilising an egg • (the Punnett square shows) 50% (chance of) male / female		1	AO2 4.6.1.8

4.1.2.1 Chromosomes

Answer 48 · Mark scheme

June 2023 | 8461/2H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.7	any **two** from: • temperature • type / amount of food • light • whether chickens are kept indoors or outdoors • amount of movement / space (allowed) • time of year	 allow (volume / amount of) water allow same stocking density allow same number of each type ignore same number unqualified allow mass at start allow age of chicken(s) allow same medication **or** all healthy	2	AO2 4.6.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.8	any **one** from: • (more) valid / representative **or** reduce the effect of anomalies • (more) accurate mean	 allow can calculate a valid mean allow (more) accurate results allow (more) reliable mean / results	1	AO2 4.6.2.3

4.1.2.1 Chromosomes

Answer 48 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.9	breed best of **A** and **B** (together)	allow cross / mate best of **A** and **B**	1	AO2
	select offspring with highest egg numbers **and** heaviest / fastest growing	allow select the best offspring for both desired characteristics	1	AO1
	breed (these) offspring together		1	AO1
	repeat over many / several generations	do **not** accept reference to repeated breeding of the original parents	1	AO1 4.6.2.3

Total Question 3	**15**

4.1.2.1 Chromosomes

Answer 49 · Mark scheme

June 2023 | 8461/2H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec Ref.
07.1	as volume of follicles rises oestrogen concentration (in blood) rises (for 7 / 8 days)	allow (positive) correlation between oestrogen concentration and volume of follicles (for 7 / 8 days) **or** oestrogen concentration is in proportion to follicle volume (for 7 / 8 days) do **not** accept an increase of oestrogen concentration causes an increase of follicle volume	1	AO3 4.5.3.4 4.5.3.6

Question	Answers	Extra information	Mark	AO / Spec Ref.
07.2	(volume of one follicle) $= \frac{4}{3} \times 3.14 \times 11^3$	allow $= \frac{4}{3} \times \pi \times 11^3$	1	AO2
	= 5572.(4533)	allow 5575(.279…)	1	AO2
	(total volume of follicles) = 39 000 (mm^3)		1	AO3
	$\frac{39\,000}{5572} = 6.99\ldots$	allow use of an incorrect volume (from Figure 12) and / or an incorrectly calculated volume of one follicle	1	AO2
	7	do **not** accept 7.0	1	AO2 4.5.3.6

4.1.2.1 Chromosomes

Answer 49 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec Ref.
07.3	(lack of FSH causes) lack of oestrogen (production)	allow lack of FSH causes lack of follicle development / growth / maturation	1	AO2 4.5.3.4
	breast development is dependent on oestrogen (from follicles)	allow (female) secondary sexual characteristics are dependent on oestrogen (from follicles)	1	

Question	Answers	Extra information	Mark	AO / Spec Ref.
07.4	gametes correct: **H + h and H + h**		1	AO2 4.6.1.6 4.6.1.7
	correct derivation of offspring genotypes: **HH Hh Hh hh**	allow correct for gametes stated in mp1	1	
	correct phenotype for each genotype	allow correct for genotypes stated in mp2 do **not** accept if no **hh** offspring	1	

Question	Answers	Extra information	Mark	AO / Spec Ref.
07.5		allow annotated genetic diagram for all marks		AO3 4.6.1.6
	mother (has **hh** so) passes on **h**		1	
	father (has **Hh** so) passes on **H** or **h** with equal probability		1	
	(so) child will be **Hh** / hetero-zygous with 0.5 probability and produces FSH		1	

Total Question 7	14

4.1.2.1 Chromosomes

Answer 50 · Mark scheme

June 2023 | 8461/2H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.1	(A) → E → D → C → B → (F)	must be in this order	1	AO3 4.6.1.2 4.1.2.2

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.2	(start) 16	allow 8 pairs	1	AO3
	(end) 8	the answer must be half the value of the number at the start	1	AO2 4.6.1.2

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.3	(meiosis) forms gametes	allow (meiosis) forms sex cells allow (meiosis) forms eggs **and** sperm	1	AO1 4.6.1.2
	(two gametes) fuse / fertilise		1	
	(so) keeps chromosome number constant (from generation to generation) **or** (so) prevents doubling / increase in chromosome number (in each generation) **or** (so) gives normal / correct chromosome number (for embryo / new cell)	allow gives correct chromosome number (for offspring)	1	

4.1.2.1 Chromosomes

Answer 50 · Mark scheme

June 2023 | 8461/2H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.4	random chromosome from each pair (of chromosomes) moves to one end of the cell **or** goes into each new cell **or** gamete	ignore half the chromosomes ignore half the DNA allow other processes for creating variation ignore mutation	1 1	AO1 4.6.1.2

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.5	base(s)	allow organic / nitrogenous base(s) ignore adenine / cytosine / guanine / thymine	1	AO1 4.6.1.5

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.6	12 / twelve	allow 6 pairs **or** six pairs	1	AO3 4.6.1.5

Total Question 8	**10**

4.1.2.1 Chromosomes

Answer 51 · Mark scheme

June 2024 | 8461/1H | Original Q2

Question 2

Question	Answers	Extra information	Mark	AO / Spec Ref.
02.1	nucleus	allow chromosome ignore in the DNA	1	AO1 4.1.1.2 4.1.2.1

Question	Answers	Extra information	Mark	AO / Spec Ref.
02.2	**A**, **D** and **E**		1	AO1 4.2.2.1 4.2.2.2

4.1.2.1 Chromosomes

Answer 51 · Mark scheme

Question	Answers	Mark	AO / Spec Ref.
02.3	**Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO2
	Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	AO2
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	AO1
	No relevant content	0	4.2.2.1 4.4.2.1 4.4.2.3
	Indicative content: **Difficulty digesting food** • less / no lipase • (so) less / no fat broken down o into fatty acids o into glycerol • less / no carbohydrase / amylase • (so) less / no carbohydrate / starch broken down o into glucose / sugar • less / no protease • (so) less / no protein broken down o into amino acids **Difficulty gaining body mass** • less / no absorption o of small / soluble molecules o of fatty acids o of glycerol o of glucose / sugar o of amino acids • fewer molecules **or** fewer amino acids available for building protein / muscle / cells / tissues • less fat stored • less respiration • less energy • (so less energy) for building new molecules / cells / tissues For **Level 3** details of difficulty digesting food **and** difficulty gaining body mass are needed.		

4.1.2.1 Chromosomes

Answer 51 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec Ref.
02.4	large surface / area	allow large surface / area to volume (ratio)	1	AO1 4.1.3.1 4.2.2.2
	(large) capillary network **or** good / efficient blood supply	allow many capillaries	1	
	walls are thin **or** walls are one cell thick	ignore references to membranes ignore alveoli are thin ignore alveoli are one cell thick do **not** accept thin cell walls ignore references to alveoli being moist ignore steep concentration gradient	1	

4.1.2.1 Chromosomes

Answer 51 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec Ref.
02.5	less (aerobic) respiration	allow (more) anaerobic respiration	1	AO2 4.4.2.1 4.4.2.2
	(so) less energy (released)	do **not** accept less energy produced / made / created	1	4.4.2.3
	(results in) less muscle contraction **or** (results in) reduced metabolism **or** (results in) increased breathing rate / depth **or** (results in) increased heart rate	allow relevant named metabolic processes allow (results in) person getting out of breath	1	
	OR (more) anaerobic respiration (1) (so) lactic acid produced (1)			
	(results in) muscle fatigue **or** (results in) less muscle contraction **or** (results in) increased breathing rate / depth **or** (results in) increased heart rate (1)	allow muscle ache / cramp / tiredness / pain allow (results in) person getting out of breath		

Total Question 2	14

4.1.2.1 Chromosomes

Answer 52 · Mark scheme

June 2024 | 8461/1H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.1	any **one** from: • (cell **or** sub-cellular structures) grows • increase in (number of) sub-cellular structures • increase in (number of) mitochondria • increase in (number of) ribosomes	do **not** accept nucleus ignore increase in cell parts / components allow increase in respiration allow increase in protein (synthesis) do **not** accept changes that occur as the cell divides	1	AO1 4.1.2.2

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.2	(cell) membrane		1	AO1 4.1.2.2 4.1.1.2

4.1.2.1 Chromosomes

Answer 52 · Mark scheme

June 2024 | 8461/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.3		allow use of π button on calculator for 3.14 allow use of $\frac{22}{7}$ for 3.14		AO2 4.1.1.5
	substitution length = $\frac{24\ 500\ 000}{3.14 \times 125^2}$		1	
	(length =) 499.363 (nm)	allow 499 (nm)	1	
	recall of equation magnification = $\frac{\text{image size}}{\text{real size}}$		1	
	correct conversion of mm to nm **or** nm to mm (4 mm = 4 000 000 nm)	allow conversion at any point	1	
	$\frac{4\ 000\ 000}{499.363}$	allow use of correctly rounded calculated value for length	1	
	×8010	allow ×8010.205 do **not** accept if unit given allow an answer consistent with an incorrectly rounded / calculated value for length	1	

4.1.2.1 Chromosomes

Answer 52 · Mark scheme

June 2024 | 8461/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.4	chromosomes cannot be pulled (by the fibres) to each end of the cell	ignore chromosomes cannot be separated unqualified	1	AO3 4.1.2.2
	(so) nucleus cannot divide	allow **two** (genetically identical) cells cannot be formed ignore cytokinesis ignore the cell cannot divide	1	

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.5	tumour cannot grow / proliferate / spread	allow stops secondary tumours forming allow stops metastasis ignore stops uncontrolled cell division do **not** accept the cancer / tumour cannot become malignant	1	AO2 4.1.2.2 4.2.2.7

Question	Answers	Extra information	Mark	AO / Spec Ref.
08.6	testing the drugs on live tissues in a laboratory		1	AO1 4.3.1.9

Total Question 8	**12**

4.1.2.1 Chromosomes

Answer 53 · Mark scheme

June 2024 | 8461/2H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec Ref.
06.1	(an allele) that is always expressed **or** (an allele) that is expressed even when the other / recessive allele is present **or** (an allele) that is expressed in the heterozygote **or** (an allele) that is expressed when only one copy is present	allow always shows in the phenotype ignore stronger	1	AO1 4.6.1.6

Question	Answers	Extra information	Mark	AO / Spec Ref.
06.2		allow an annotated genetic diagram for up to **2** marks		AO3 4.6.1.6 4.6.1.7
	(person **1**) has polydactyly so must have **D**	allow (person **1**) has polydactyly so must have a dominant allele	1	
	has offspring / (person) **5** who does not have polydactyly so must have **d** from person **1** **or** person **5** does not have polydactyly so must be **dd** and must inherit **d** from person **1**		1	

4.1.2.1 Chromosomes

Answer 53 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec Ref.
06.3	Female / **6**'s gametes correct **D + d** Male / **7**'s gametes correct **d + d**	allow **1** mark for both sets of gametes if parents not identified	1 1	AO2 4.6.1.6 4.6.1.7
	correct derivation of offspring genotypes: **Dd Dd dd dd**	derivation must be consistent with parental gametes	1	
	Dd correctly identified as polydactyly in **only** half of offspring	mp4 only awarded if mp3 is correct	1	

Question	Answers	Extra information	Mark	AO / Spec Ref.
06.4	CF allele is recessive	allow CF is recessive	1	AO1
	to have CF, must have 2 CF alleles		1	AO2
	chance of having one CF allele is $\frac{1}{50}$	ignore chance of having one CF allele is one in 50	1	AO2
	(chance of having two CF alleles is) $\frac{1}{50} \times \frac{1}{50} = \frac{1}{2500}$	ignore 50 × 50 = 2500	1	AO2 4.6.1.6 4.6.1.7

Total Question 6	11

4.1.2.1 Chromosomes

Answer 54 · Mark scheme

June 2025 | 8461/2H | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	ADH **or** antidiuretic hormone	allow other correct pituitary hormone eg FSH / LH / TSH ignore functions of hormones	1	AO1 4.5.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	any **one** from: • (it would) be digested to amino acids • (it would) be digested by protease • (it would) be digested (by enzymes) in the stomach • (it would) be digested (by enzymes) in the small intestine • (it would) be digested so (hGH is) not absorbed	allow 'broken down' for digested throughout	1	AO2 4.2.2.1 4.5.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	isolate (hGH) gene from human DNA / chromosome	allow cut (hGH) gene from human DNA / chromosome	1	AO1 4.6.2.4
	join (hGH) gene to (cut) <u>plasmid</u>		1	
	put plasmid (containing gene) into bacteria		1	
	enzyme used at a suitable stage: to cut (hGH) gene from human DNA **or** to insert / join (hGH) gene to plasmid	allow reference to named enzyme used in genetic engineering allow to insert / join (hGH) gene to bacterial DNA	1	

4.1.2.1 Chromosomes

Answer 54 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	any **two** from: • (hGH) easier to isolate / purify / extract • made in larger quantities • no / less chance of immune reaction • no / less chance of passing on disease / pathogens (from animals to humans) **or** no / less chance of infection (of humans) • no / less chance of containing antibiotics / urea / drugs • it is the specific human hormone so may be more effective (in human body)	allow converse if clearly referring to GH ignore reference to speed of production allow no / less chance of rejection ignore reference to side effects allow named (animal) disease eg BSE allow animal GH may not be the correct shape ignore ethical / religious reasons ignore reference to cost	2	AO3 4.6.2.4

Total Question 4	8

4.1.2.1 Chromosomes

Answer 55 · Mark scheme

June 2025 | 8461/2H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	cell division **1**		1	AO2 4.1.2.2 4.6.1.1 4.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	**A** and **C**		1	AO2 4.1.2.2 4.6.1.1 4.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	23 **or** twenty three	do **not** accept 23 pairs	1	AO2 4.6.1.2 4.6.1.8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	5 / five **or** 6 / six	ignore reference to letters	1	AO2 4.6.1.2 4.6.1.8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	(only) mitosis	do **not** accept meiosis / meitosis / metosis	1	AO1
	(so) **all** cells receive a copy of every allele / gene	allow (so) **all** cells receive a copy of every chromosome **or** (so) **all** cells receive a copy of all the DNA **or** (so) **all** cells receive a full set of chromosomes	1	AO2 4.6.1.1 4.1.2.2 4.6.1.3

4.1.2.1 Chromosomes

Answer 55 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.6	gametes are produced by meiosis (so) offspring have unique / different / random combinations of alleles / genes / chromosomes from each parent / gamete	 allow (so) gametes fuse creating unique / different / random combinations of alleles / genes / chromosomes in offspring	1 1	AO1 AO2 4.6.1.1 4.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.7	any **two** from: • faster than sexual • many offspring produced to colonise local area **or** many offspring produced to out-compete other species • genetically identical offspring so well adapted to current conditions / environment • only one parent needed so no need for pollinators / bees • offspring receive water **and** sugars / minerals / ions / salts from parent • less energy / materials required as no need to produce gametes / flowers / seeds / fruits		2	AO1 4.6.1.1 4.6.1.3

4.1.2.1 Chromosomes

Answer 55 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.8	any **two** from: • new combinations of alleles gives genetic variation **or** genetic variation gives selective advantage • seeds dispersed to new / wider area so less vulnerable to habitat loss **or** seeds dispersed to new / wider area so not competing with (parent / offspring) plants for space / water / minerals • larger number of offspring produced so will increase the population quickly	allow genetic variation provides the opportunity for evolution allow genetic variation enables species to adapt to new / changed environments allow larger number of offspring produced will improve survival of the species	2	AO1 4.6.1.1 4.6.1.3 4.6.2.2 4.6.3.1

Total Question 6	12

4.1.2.1 Chromosomes

Answer 56 · Mark scheme

June 2025 | 8461/2H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	*genotype* **HH**	allow homozygous dominant	1	AO3
	reason all offspring have (at least one) **H** **or** female **A** gives **H** to every offspring **or** none of the offspring are white so female **A** does not have a **h**	MP2 is dependent on MP1	1	AO2 4.6.1.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.2	gametes correct for both parents: **H** + **h**		1	AO2
	correct derivation of offspring genotypes: **HH** + **Hh** + **Hh** + **hh**	allow correct derivation from incorrect gametes	1	AO2
	correct phenotype for each genotype: **HH** + **Hh** = Himalayan **and hh** = white	allow correct phenotypes for stated genotypes	1	AO2
	probability correct for offspring genotypes, eg 0.25 / ¼ / 25% / 1 in 4	allow 1:3 do **not** accept 1 in 3 / 1:4 / 3:1 do **not** accept 0 / 100%	1	AO3 4.6.1.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3	gives different set of 3 bases	allow gives a different triplet ignore codon	1	AO1
	codes for a different amino acid		1	AO1
	(which) alters shape of the (enzyme's) active site	allow the (enzyme's) active site is no longer complementary (to tyrosine / substrate)	1	AO2
	(so) tyrosine / substrate no longer fits	allow cannot form enzyme-substrate complexes	1	AO2 4.6.1.5 4.2.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4	temperature inside mother's body is greater than 35 °C **or** temperature inside nest is greater than 35 °C	allow mother's body temperature is 39 °C	1	AO2
	(so) tyrosinase / enzyme does not work	allow tyrosinase / enzyme is inactive do **not** accept tyrosinase / enzyme is denatured	1	AO3 4.2.2.1 4.6.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.5	outside environment is cooler	allow outside environment is less than 35 °C	1	AO2 4.5.2.4
	rabbit loses heat from ears / nose / feet / extremities **or** temperature of ears / nose / feet / extremities drops (more than rest of body)		1	
	(so) tyrosinase is (more) active		1	

4.1.2.1 Chromosomes

Answer 56 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.6	stops (UV / ionising) radiation causing mutation (in skin cells) (which can) lead to (skin) cancer	allow UV / ionising radiation can cause mutation (in skin cells) allow description of cancer eg tumours **or** uncontrolled cell division	1 1	AO2 4.2.2.6 4.2.2.7 4.6.1.5

Total Question 8	**17**

4.1.2.1 Chromosomes

Answer 37 · Examiner comments June 2018 | 8461/1H | Original Q6

Question 6 (standard, standard / high & high demand)

Following updated research information and communications with parents of children with cystic fibrosis, we have decided to withdraw the question on this topic from this paper.

It has been decided not to provide a replacement question as it would not be possible to determine accurately how a replacement question would have performed if it had been part of the original paper taken in 2018.

The following statistics may help you to make effective use of the remainder of the paper:

Mean mark (maximum mark)	
06.1	0.47 (1)
06.2	0.65 (1)
06.3	2.27 (6)
06.4	1.27 (2)
06.5	0.69 (1)
06.6	1.33 (2)
06.7	0.56 (4)
06.8	0.42 (1)
Question 6	7.66 (18)

Answer 42 · Examiner comments November 2020 | 8461/2H | Original Q4

Question 4 (standard, standard/high & high demand)

This question was about DNA. **04.3** is a five-step calculation, which differentiated very well between students. Most were able to multiply the number of nucleotides in the cell (given as 1.2×10^{10}) by the length of one pair of nucleotides (given as 0.34 nm) – although some divided these. The main errors came from attempts to convert nanometres to metres (as required by the question) and in not realising that the answer had to be divided by 2 as the nucleotides came in pairs. Many students wrote out long strings of zeros in their calculations and consequently made transfer errors from one line to the next in their calculation; others did not know how many nanometres there are in a metre and used factors of a thousand or a million to interconvert the units (this being covered by the 'Working Scientifically' section of the Specification, part 4, WS4.4 and 4.5). An eighth of students scored all 5 marks, although nearly 60% scored 3 marks and above. It was also evident that some students had little concept of the sizes of molecules and cells and, although the correct answer was 2.04 m of DNA per cell, the most extreme was 1.76×10^{17} m.

4.1.2.1 Chromosomes

Answer 43 · Examiner comments

November 2020 | 8461/2H | Original Q5

Question 5 (standard/high & high demand)

This question was about cell division and genetics. In **05.1** many students confused the two types of cell division, mitosis and meiosis: 1 in 10 students were able to give 3 correct differences between the two. Some described only one type of division rather than giving the comparison demanded by the question; others fell short of giving sufficient detail – eg describing the daughter cells as 'identical / non-identical' rather than being *genetically* identical / non-identical'; many included irrelevant points about where in the body the cell division occurred (the question asked for differences in the 'processes'). Two common misunderstandings were that meiosis occurred 'in gametes' and that meiosis required two parents whereas mitosis required only one.

For **05.3** explanations of how students derived the genotype of person1 were frequently insufficient. Since this person had the condition Dupuytren's, he must have had either one or two of the dominant alleles. The fact that he had an unaffected child (person 6), showed he must also have had the recessive allele – hence his genotype was Dd or heterozygous. Most students mentioned only the children as evidence and did not relate person 1's genotype to his phenotype.

Students had to draw a Punnett square diagram in **05.4** to find the probability that persons 7 and 8 in could produce another child with Dupuytren's. Since persons 7 and 8 had *different* phenotypes, it was surprising how many students assigned the *same* genotype to each of them (usually both being Dd). Other common errors were not identifying which parent was which (ie gametes D and d from person 7, and only d gametes from person 8) and not assigning phenotypes to the offspring genotypes.

Answer 43 · Examiner comments

November 2020 | 8461/2H | Original Q5

In **05.5** explanations of the evidence in the pedigree diagram that the D allele is *not* on the Y chromosome, it was evident that many students did not know that males are XY and females XX as many thought the female had a Y chromosome. Those that did know this were able to point out that some females had Dupuytren's despite not having a Y chromosome, or that the condition can be passed from fathers to their daughters, or that an affected mother and unaffected father can have an affected son. Many students insisted, erroneously, that the allele must have been on the X chromosome.

4.1.2.1 Chromosomes

Answer 44 · Examiner comments November 2021 | 8461/2H | Original Q1

Question 1 (standard demand)

This question was about DNA and its replication. Answers to most parts of this question were satisfactory, with most students knowing that DNA was found in chromosomes, recognising the term replication with respect to a diagram showing this process, being able to assign symbols for bases on the same diagram, and knowing that meiosis was the type of cell division used in sperm production.

The names of specific parts of the DNA molecule (sugar and base) and the substance coded for by a gene (protein) were less well known – but success here might have been limited by the fact that the questions were open rather than being multiple choice.

More than half of the students were able to deal with numbers in standard form, showing understanding that a sperm cell has half the usual amount of DNA and that half of 6×10^{-12} is 3×10^{-12}.

One-fifth of the students did not attempt **01.4**. This was probably due to there being no answer lines, and the answer having to be written on the diagram (Figure 2).

Answer 45 · Examiner comments November 2021 | 8461/2H | Original Q8

Question 8 (standard/high & high demand)

This question was about the inheritance of sickle cell anaemia and its effects. Answers to **08.1** were generally insufficient. Many students knew that a mutation in the haemoglobin gene could result in less oxygen being transported around the body (although some stated this would 'affect' the amount of oxygen), but hardly any went on to explain that this would mean a lower level of respiration.

Calculations in **08.2** were weak. Some students did not count the number of normal and sickled cells in Figure 13. Many did not understand the difference between the ratio 4:13 and the fraction $\frac{4}{13}$. Many did not go on to convert the correct fraction $\frac{4}{17}$ to a decimal (0.24) or to a percentage (24%). Some students, having worked out a percentage, did not include the % symbol in their answer, thus giving an incorrect proportion of '24'. Thus few students scored both marks.

08.3 was a construction of a Punnett square to determine the probability that certain parents from the family pedigree diagram would produce a child with sickle cell trait, followed by multiplication by ½ to find the probability that this child would be female. A very small proportion of students was completely successful. Errors included assigning the same genotype to parents who had different phenotypes, not stating which gametes came from which parent, not identifying the phenotypes of the offspring genotypes and not dividing the probability from the Punnett square by 2 to allow for the biological sex specified in the question. A few students showed the offspring as being haploid even though each was derived from two haploid gametes.

In **08.4**, students had difficulty in applying information from various other parts of question 8 to evaluate the scientist's statement about the advantage of having the H^S allele in countries where malaria occurs. Around 96% of studebts did not discuss the effects of sickle cell anaemia and malaria on people of different stated genotype and thus scored no marks.

4.1.2.1 Chromosomes

Answer 46 · Examiner comments

November 2021 | 8461/2H | Original Q9

Question 9 (standard, standard/high & high demand)

This question was about Galapagos Island finches. In **09.1**, one-quarter of students were able to give the names of all four of the taxa missing from the table. Once again, probably because there were no answer lines and answers had to be written in the table, a quarter of students did not attempt this question.

In **09.2**, fewer than one-third of students were able to select *Geospiza fortis* from the table as the binomial name of the medium ground finch. It was evident that many did not know that the binomial name consisted of genus + species, while some did not appreciate that binomial indicated a two-word answer: 'fortis' being a common response.

Very few students scored the mark in **09.3**. Most described a 'positive correlation' in the results or stated that the beak depths of the offspring were 'proportional to' those of the parents but did not mention that the offspring beak sizes were approximately the same as those of the corresponding parents. Around one in seven students scored a mark.

Just over 1% of students gave a creditworthy answer to **09.4**. Common incorrect answers were that there was 'a range' of beak depths in the offspring, not stating that this was so for each parental value. There were also vague references to 'anomalies' and 'outliers' and some gave numerical values that were beyond the scales on the graph.

09.5 also proved to be very difficult and it was evident that many students did not understand the question, assuming that it was about speciation which it was not. Better answers attempted to relate beak size to the sizes of seeds produced by plants on the two islands and whether or not there was competition from the second species. Mutations were correctly mentioned quite often as a cause of variation in beak size but this concept then had to be applied to selection on the basis of availability of suitable foods (seeds). The highest mark scored was 4 out of 6, with few gaining half-marks. More than half the students scored no marks at all.

A third of students scored any marks in **09.6**, mainly for stating that competition for food might be reduced on the larger island. However, most did not relate this to the potentially greater abundance or greater variety of plants and seeds on the larger island and many did not qualify the concept of competition with it being for food, despite the relationship between beak size and seed size having been given in the stem before **09.5**.

4.1.2.1 Chromosomes

Answer 46 · Examiner comments

November 2021 | 8461/2H | Original Q9

Concluding Remarks

Overall, this November's paper was broadly comparable in demand to last year's, but this year's students appeared to be weaker on average and so found a number of questions more difficult.

Areas of the Specification about which knowledge was acceptable were:

- 4.6.1.5 DNA structure
- 4.7.4.1 Trophic levels.

Particular areas of the Specification about which knowledge seemed limited were:

- 4.5.2.4 Control of body temperature
- 4.5.3.4 Hormones in human reproduction
- 4.6.1.6 Genetic inheritance
- 4.6.4 Classification of living organisms
- 4.7.1.2 and 4.7.1.3 Abiotic factors and biotic factors
- 4.7.2.2 and 4.7.2.3 How materials are cycled and decomposition .

Students struggled to apply knowledge and understanding of Specification sections:

- 4.6.1.6, 4.6.2.1 and 4.6.3.1 Genetic inheritance, variation and evolution
- 4.7.5.3 Sustainable fisheries.

This year, as in previous years, certain general problems have been perpetuated, such as:

- not paying sufficient attention to information given in the introductory stem to a question
- needless repetition of information given in the stem of the question
- imprecise use of technical vocabulary
- not giving a comparative answer to a comparative question
- not necessarily paying attention to both sides of an argument in an evaluation question
- poor layout of working in mathematical problems, struggling with the interconversion of units and lack of consideration regarding whether the answer obtained is reasonable
- failing to answer a question where there were no answer lines, but where the answer needing to be inserted into a table or diagram.

4.1.2.1 Chromosomes

Answer 46 · Examiner comments

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

4.1.2.1 Chromosomes

Answer 47 · Examiner comments June 2022 | 8461/2H | Original Q1

Question 1

This was the first of three questions common to both the Foundation and Higher Tier papers. The topic was reproduction and meiosis.

01.1 Three-quarters of students correctly selected whether each of the three statements applied to sexual and/or asexual reproduction. The most common error was not knowing that in *both* types of reproduction genes are passed from parents to offspring.

01.2 Almost the same proportion knew that pollen is the male gamete formed in flowering plants. Incorrect answers included 'anther', 'stamen, 'stem', 'stigma', 'sperm' and even 'testis'.

01.3 -01.6 Interpretation of the graph in **Figure 4**, which showed changing amounts of DNA in a cell before, during and after meiosis, was good in questions **01.3** and **01.4** where, respectively, the correct period of DNA synthesis and the correct times of cell divisions were selected. However, only half the students chose the correct values for the amount of DNA expected in a sperm cell and in an embryo in **01.5** and **01.6**.

Answer 48 · Examiner comments June 2023 | 8461/2H | Original Q3

Question 3

This was the third of the three questions common to both the Foundation and Higher Tier papers. The topic was reproduction and selective breeding.

4.1.2.1 Chromosomes

Answer 48 · Examiner comments June 2023 | 8461/2H | Original Q3

03.1 The advantage given by most for growing genetically-different tomatoes was that some might be less susceptible to disease. Almost two-thirds of students gave a suitable answer.

03.2 Deciding on an advantage for growing genetically-identical tomatoes proved more problematic and only one third could suggest a feature such as all growing at the same rate or all having the same named desirable feature such as high yield, disease resistance or flavour.

03.3 Very few students could successfully describe what is meant by tissue culture. Use of 'tissue' as the starting material was deemed inadequate and required amplification in terms of cells being grown. Fewer than 1 in 5 gave an appropriate answer.

03.4 More than two-thirds of students were able to suggest why genetically-identical tomatoes growing in a garden might not all attain the same height – for example, due to variations in light intensity, ions, water or temperature in different areas of the garden.

03.5 This question was about sex determination in dogs. Students had to use the symbols X and Y to complete a blank Punnett square. Most knew that the male dog would produce gametes containing either an X or a Y chromosome, and that all the female gametes would contain an X chromosome, and over three-quarters were successful in the completion of the Punnett square.

03.6 The explanation of why a litter of six puppies might be expected to consist of three males and three females was straightforward for most: either in terms of the expected 1:1 ratio of males and females or the inheritance of a Y chromosome by only half of the offspring (as demonstrated in a correct answer to the previous question).

03.7 This question was about the breeding of chickens for meat production and egg production. Given the results of an investigation in Figure 5 which showed that chicken variety A had high egg production while variety B grew more quickly, students had to suggest two control variables for the investigation. Many answers were rather vague – such as the same 'living conditions' / 'environment'. More specific conditions, such as temperature, lighting, amount or type of food, all being kept indoors or all outdoors, were required. The most common correct answer related to the chickens' food. While most students could suggest at least one suitable control variable, fewer than half could give two.

03.8 The data in the investigation had come from 500 chickens of each variety and students had to give a reason why such a large number had been used. Acceptable answers included the idea this would be more representative, or would give a more valid mean, or would reduce the effects of any anomalies (and not that it would 'eliminate' anomalies). Three-quarters of students were successful.

03.9 In this question, students had to describe how selective breeding of the two chicken varieties might produce a new variety of chicken that was good for both meat production and egg production. Many answers lacked precision: thus it was not often evident that only the best from varieties A and B would be mated and that the best (for both qualities) from the offspring would then be selected and mated, and that this would be continued over several generations. Often, it was impossible to tell from students' answers which generation of chickens was being used: the original parents, the first generation offspring or subsequent generations of offspring. The term 'repeat' was often used in an ambiguous context. Thus only 1 in 20 students scored all 4 marks, and only a third gained half-marks.

4.1.2.1 Chromosomes

Answer 49 · Examiner comments

June 2023 | 8461/2H | Original Q7

Question 7

This question was about an inherited condition resulting in underproduction of the hormone FSH in one woman.

07.1 Given the graph in Figure 12 which showed changes in the concentrations of FSH and oestrogen in the woman's blood and in the number of follicles in her ovaries following 7 days of FSH injections, students had to look for evidence that the follicles were the source of oestrogen. A little over one-third appreciated the correlation between the rising follicle volume and oestrogen concentration lines on the graph. Many related the oestrogen production just to the increase in FSH.

07.2 This question was a 5-mark calculation of the number of follicles present in the woman's ovaries on the 11th day after the start of FSH injections. The question gave the mean diameter of a follicle as 22 mm and Figure 12 showed that, on the 11th day, the total volume of the follicles was 39 000 mm^3.

Despite being given the formula for the volume of a follicle, a considerable number of students squared rather than cubing the radius. Some used the diameter in the calculation instead of the radius. Either of these mistakes prevented them from being awarded the first 2 marks which were for calculating the volume of one follicle, but it was still possible to gain the remaining points. Many students used the 'π' button on their calculator rather than the

4.1.2.1 Chromosomes

Answer 49 · Examiner comments

figure of 3.14 which was given to them but this was accepted within the mark scheme. Many students calculated the volume of one follicle but got no further.
Readings of the total volume of follicles from the graph were often accurate enough to be rewarded but some students read from the incorrect y-axis, from the wrong place on the volume curve or from the FSH curve.

Wrong figures for follicle volumes could be used in the final steps of the calculation as long as the answer given was correct for the figures used. Many students were able to access the last two marking points for dividing their misread total volume by their miscalculated volume of one follicle and then rounding to a whole number, as instructed in the question. Just under half the students scored full marks in this calculation.

07.3 Here students were required to explain the link between lack of FSH in the woman's blood and the lack of breast development. Some students suggested a direct link but better ones knew that FSH would normally have stimulated oestrogen secretion and that the latter was the cause of breast development.

07.4 Given that the woman had inherited a faulty gene for FSH production from each of her parents, and that each parent was able to produce FSH, most students could work out that each parent was heterozygous and were therefore able to construct an appropriate Punnett square diagram to show these parents could have a child who could not produce FSH. Despite the instruction to 'identify the phenotype of each offspring genotype', many simply omitted this or gave inadequate identifications – eg just the woman's phenotype, or describing the different genotypes as being homozygous, heterozygous or carriers, none of which is a phenotype.

07.5 The most successful answers, without any prompting in the question, included another Punnett square to show that the probability of the homozygous recessive woman and the heterozygous man producing a child able to produce FSH was 0.5. This necessitated identifying the woman's gametes as all having the recessive allele while half of the man's gametes would have the recessive and half the dominant allele, and identifying that half the potential offspring would be heterozygous and hence able to make FSH. Almost half the students made some headway with this, but only 1 in 6 gained full marks.

4.1.2.1 Chromosomes

Answer 50 · Examiner comments — June 2023 | 8461/2H | Original Q8

Question 8

This question was about meiosis and DNA structure.

08.1 Given the identity of the first and last diagrams in Figure 13, two-thirds of students were able to put the remaining four in the correct sequence to show the process of meiosis.

08.2 However, in this question, the vast majority did not follow the instruction to give the number of chromosomes per cell in Figure 13 but decided to use human chromosome numbers. Thus, the most common answer for the number of chromosomes at the start of meiosis was 46 and, at the end, 23. Various other numbers were given and, as long as the end number was half the starting number, 1 mark out of 2 was scored. Only 3 percent gave the correct values of 16 and 8 from Figure 13.

08.3 Fewer than a quarter of students were able to give a 3-mark answer explaining why it was necessary for the number of chromosomes at the end of meiosis to be different from that at the start. Many made just two points – either for meiosis producing gametes which could

Answer 50 · Examiner comments — June 2023 | 8461/2H | Original Q8

fuse at fertilisation or for stating that fertilisation would restore the correct chromosome number. Some students simply described the process of meiosis, while others gave a comparison of meiosis and mitosis, both of which were not relevant to the question.

08.4 Most students found it very difficult to describe how meiosis produces cells that are genetically different and so scored no marks. Some described how random fertilisation causes genetic differences which was not relevant. Very few students could describe that one chromosome from each **pair** of chromosomes would separate **randomly** to opposite ends of the cell or into each of the gametes.

08.5 Nearly three-quarters of students knew that the four substances labelled A, C, G or T in Figure 14 were bases. Common errors included ‘amino acids’, ‘proteins’ and ‘nucleotides’.

08.6 Two-thirds evidently knew the meaning of the term nucleotide and successfully counted twelve of them in the portion of DNA shown in Figure 14.

4.1.2.1 Chromosomes

Answer 51 · Examiner comments

June 2024 | 8461/1H | Original Q2

Question 2 (standard demand)

02.1 Most of the students who gained this mark (93%), identified 'nucleus', with many also suggesting 'chromosome'. 'DNA' formed part of the response for a significant proportion of students, but this was often associated with either of the two acceptable answers, so credit could be awarded. Very few students gave alternative components of a cell.

02.2 98% of students identified organs A, D and E as being the lungs, small intestine and pancreas.

02.3 This extended response question provided students with the opportunity to express their knowledge of the enzymes produced by the pancreas and how the products of digestion are used within the body. However, as this question was phrased in the context of a person with cystic fibrosis, marks could only be gained by students who described the details they had revised not occurring. Thus, those who only described what normally goes on in the body without any indication that in this context, these processes would not occur or would be reduced, could not gain credit. Students went about describing their answers in two ways: either giving the details they knew, followed by a statement that these processes would not happen or happen less, or by describing each step in terms of reduction (eg 'less amylase is produced so less starch is digested into glucose').

Lower-attaining students often got no further than repeating the details they had been given; 'less of each enzyme, so less digestion occurs', was a common response by many students, although they often repeated this in multiple ways to fill up the available space. It was also noticeable that lower-attaining students got no further than repeating the information in second bullet point from the question and did not attempt to respond to the command word of the question, 'explain'.

Although knowledge of the enzymes and their actions was generally good, the impact their lack would have on the body's ability to gain mass was less well understood. Few students referred to respiration, energy or the reasons why amino acids are needed by the body or cells. However, many did describe the reduction of absorption, often including the products of digestion in this story, and so could gain access to Level 3 as they had answered both parts of the question. Many students' answers lacked precision, describing the lack of absorption of starch, fat or protein, rather than of the products of the digestion of these large molecules, whilst others went on the describe the egestion of non-digested molecules; neither of which idea was creditworthy.

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4.1.2.1 Chromosomes

Answer 51 · Examiner comments

Those who only gave an answer to one side of the question (almost always the difficulty digesting food), however detailed this was, could not score higher than a mark in Level 2. Hence, students should be reminded, once they have completed their responses to questions such as this, to re-read the question, to ensure they have answered all parts of it.

Less than one third of students scored full marks in this question, with 13% scoring zero.

02.4 This question was generally well answered with nearly 50% of students gaining at least two marks. Despite the command word, 'describe', many students also added explanatory detail, often regarding diffusion in some way, but as the question did not ask for explanations, these were ignored. A 'large surface area' and a 'good blood supply' were frequently given. However, having 'thin walls' or having 'walls only one cell thick' was often poorly expressed, with answers implying that the alveoli themselves were thin or that they have a thin membrane; neither of which are correct. A few students drifted into an insecure knowledge of plant cell structure, describing the presence of 'thin cell walls', which was also not creditworthy.

It is a long-held and often repeated misconception that the alveoli being moist aids gas exchange. This is not correct and did not gain credit, although if included in an answer with three creditworthy points, was ignored.

02.5 Students could tackle this question in either of two routes: the reduction in (aerobic) respiration and its consequences or the occurrence of anaerobic respiration and its consequences. For many students, their responses contained elements of both routes, in which case the description which gave the higher mark was credited.

It should be noted that a reduction of oxygen supply will not stop (aerobic) respiration occurring altogether, so students who described this idea could not gain credit for this first point, although they might still have scored full marks for descriptions involving anaerobic respiration. In describing either route, 'tiredness' and 'fatigue' were common suggestions, however, without further qualification in terms of 'muscle' in the anaerobic respiration route, could not gain credit. Lower-attaining students gave descriptions which contradict the principle of conservation of energy, suggesting that energy is produced, rather than being transferred or released. Others suggest that energy is used *for* respiration, rather than being released by respiration.

27% of students scored full marks in this question, 35% scored two marks, and 22% one mark.

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4.1.2.1 Chromosomes

Answer 52 · Examiner comments

Question 8 (standard, standard/high demand and high demand)

08.1 59% of students achieved the mark in this question, with most stating that the cell grows in size or increases its number of organelles. The increase in number was expressed in many different ways (replication, duplication, multiplication, etc.), all of which were creditworthy.

The most common incorrect answers contained descriptions of what happens during mitosis, such as the chromosomes being pulled to either end of the cell, or of the cell membrane and cytoplasm dividing.

08.2 78% of students answered this question correctly. The most common incorrect answers seen were cell wall and nucleus/nuclear membrane.

08.3 There were many ways in which students achieved a variety of marks in this question. 34% of students achieved 6 marks, and 33% achieved 5 marks, with the conversion from nm to mm being the difference between them. The conversion method was not well understood, with both divisions and multiplications with a large range of factors of 10 seen. Some students began by trying to convert the volume given in the question, which often led to further mistakes later on. Many students were able to substitute the numbers from the question into the equation given and calculate an answer, thus gaining two marks if they went no further (13% of students). Answers using any representation of *pi* (3.1, π or $^{22}/_{7}$) were accepted and seen, despite students being told to use 3.14 in the question.

Students could gain credit for quoting the magnification equation or for showing its use without writing it out in words. However, just quoting the triangular representation of the equation was not creditworthy. A significant minority of students gave the equation upside down and so were not awarded marking point 3 and, if they used it in that incorrect form, were not able to access marking point 5 or marking point 6, either.

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4.1.2.1 Chromosomes

Answer 52 · Examiner comments June 2024 | 8461/1H | Original Q8

08.4 47% of students scored no marks in this question, with 11% scoring full marks and 40% scoring one mark. A simple description of what normally happens during mitosis was not creditworthy, yet was seen regularly. Of the two marking points, marking point 1 was achieved more commonly than marking point 2. Where the mark for marking point 1 was not achieved, the most common errors included: a simple description of chromosomes not being pulled apart with no destination described; vague references to the edges/sides of the cell; or an implication that chromosomes were unable to move (unaided), rather than be moved. Attempts at marking point 2 were often too vague to be creditworthy, with a large number of answers just repeating that the cell couldn't divide, as was given in the question stem.

08.5 16% of students gained credit in this question and, as in question 08.4, a reference to what would be unable to happen in the situation described was required. Many students gave a simple statement linking cancer to uncontrolled cell division and those that went on to say that this could not happen often just paraphrased what had been written in the question, which was not creditworthy. Those that did score the mark mainly mentioned the prevention of the tumour growing, with a minority stating that secondary tumours would be stopped from forming. References to individual cancer cells rather than tumours were seen frequently and were not creditworthy. Some answers referred to preventing the formation of tumours rather than stopping the spread of tumours that were already there and thus did not answer the question.

08.6 83% of students answered this question correctly.

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4.1.2.1 Chromosomes

Answer 52 · Examiner comments

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

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4.1.2.1 Chromosomes

Answer 53 · Examiner comments

June 2024 | 8461/2H | Original Q6

Question 6 (standard, standard/high and high demand)

06.1 Almost 45% of students were able to give a creditworthy answer having clearly learned a suitable definition, although the term 'expressed' was used less frequently by students than other synonyms. Numerous students remain confused between a gene and an allele. References to 'stronger/overpowering' alleles or suggesting they were 'always inherited passed on' did not gain credit.

06.2 Students were asked to explain how the inheritance chart provided shows that person 1 is heterozygous. Many students found it difficult to articulate their responses, with only 30% of students gaining 1 or both marks. Many students did not answer the question directly, but instead explained why the parent could not be a genotype other than heterozygous, rather than showing that they are heterozygous and did have polydactyly. Some students showed a clear understanding of the inheritance of the condition, while many students only gave incomplete answers that involved only part of each marking point.

06.3 55% of students gained all four marks by drawing and fully annotating a Punnett square to explain how the doctor determined a probability of 0.5. The 25% of students that scored three marks commonly did so for either not fully annotating their Punnett square identifying the genotypes of person 6 and 7 explicitly, or they did not identify which offspring were polydactyly. A minority of students did not gain marks by choosing to not use the letters 'D' and 'd' for their alleles, but instead chose a different letter without providing a key.

06.4 Many students correctly identified CF as a recessive condition or allele for marking point 1, and many went on to get marking point 2 also by stating that two copies of the allele are needed. Students that used the biological term 'homozygous recessive' in their explanation were awarded both marking points.

Very few students were awarded marking point 3 without marking point 4. There was clear confusion again here between the terms 'allele' and 'gene', despite the information in the question stem. A number of students gained marking points 3 and 4 with no reference to marking point 1 or 2. 15% of students scored the full four marks available in this question.

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Answer 54 · Examiner comments

June 2025 | 8461/2H | Original Q4

Question 4 (Standard/high demand)

04.1
Almost all students attempted this question, with just over 80% of gaining the mark. ADH and FSH were the most common creditworthy answers seen. Common incorrect answers, although seen relatively rarely, included adrenaline, thyroxine, and progesterone.

04.2
Only a third of students gained credit in this question. Whilst many students were able to begin their answer to this question, a number did not give sufficient detail at this level of demand to gain the mark. Stronger responses often covered several marking points in one succinct sentence e.g. 'The hGH would be digested by protease into amino acids within the stomach and so would not be absorbed into the blood', whilst those that were less successful did not refer to either what would break down the hGH, or where this breakdown would occur.
A significant proportion of students cited the stomach acid as breaking down the protein, with many going on to refer to denaturation of enzymes. A number also referred incorrectly to the hGH 'dissolving', rather than being digested.
Some students misunderstood the question and wrote about the hormone taking longer to get into the blood stream if taken orally, rather than focussing on the hormone being digested as a protein. Other less successful responses correctly recognised that the hormone would be digested but implied that the products of this digestion would work in the same way as the undigested hormone when later absorbed into the bloodstream. The idea of lack of absorption because the hormone was 'too big' was also seen relatively frequently.

04.3
This question differentiated well, with the full range of marks awarded. While a quarter of students scored no marks, a third of students were able to gain 3 or 4 marks. High level responses often went beyond the scope of the specification, using terminology such as recombinant DNA, restriction enzymes / endonucleases and DNA ligase in the correct contexts. 'Sticky ends' also featured frequently with some good descriptions of how these were used within the process. Some students confused 'ligase' with 'lipase' which meant that they were unable to earn credit for mark point 4.
A very small minority of students answered the question in relation to production of insulin rather than hGH, but a number of responses detailed parts of the process of adult cell cloning, rather than genetic engineering.
Some students found explaining the process of genetic engineering difficult and used only the information provided in the question. Reference to plasmids as vectors for mark point 3 and the sweeping statement 'using enzymes and plasmids' were not creditworthy without further qualification as this information was given to them in the question.
Less successful responses often confused the role of the hormone and the enzymes in the process, with the enzyme occasionally being inserted into the plasmid, or the hGH hormone itself (rather than the gene) being cut out, or placed into the plasmid/bacteria.

04.4
50% of students scored no marks on this question. Students are reminded that when answering 'compare' style questions they should make it absolutely clear to what they are referring when writing in the converse and to be mindful when using the word 'it'. In the

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context of this question, 'it' referred to the hormone produced by genetic engineering as this was the subject of the question and therefore, an answer of 'it might spread infection' is incorrect. There was a significant number of responses where marks could not be awarded due to this lack of clarity.

Bullet points 2, 3 and 4 were the most commonly awarded, although for bullet point 4, a lack of qualification relating to the disease being passed on or spreading to humans (rather than the disease just being present in urine) meant this bullet point could not be awarded.

A number of uncreditworthy responses referred to the difficulties in physically collecting the urine from the animal, as well as ideas that the recombinant hormone is simply 'cheaper', 'easier', 'safer' or 'quicker'. A significant proportion of students described recombinant production in purely hygienic terms (e.g. 'cleaner' or 'more sanitary') without recognising it is easier to purify.

Only a very small number of students were able to access bullet point 6, often due to a lack of precision with their wording; many students did state that it was a 'specific human hormone' but often neglected to go on to relate this to effectiveness.

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Question 6 (Standard, Standard/high and High demand)

06.1
Over 70% of students identified the correct cell division that represented mitosis.

06.2
Over half of students identified cells A and C as being genetically identical.

06.3
Just over 85% of students gained the marking point here, knowing that cell J had 23 chromosomes. The most common incorrect response was '23 *pairs*'.

06.4
Students appeared to struggle with the high demand of this question, with only around 15% of students gaining the mark. Knowledge of the *stages* of meiosis is not required for this specification – as such the exact point that the reduction in chromosome numbers happens is not needed, hence, it was reasonable for students to give an answer of 5 or 6 depending on their interpretation.
The most common correct answer was '6', and there was a range of incorrect responses, with '4' being the most common. Some responses gave a list of letters without a number which did not answer the question.

06.5
Students struggled to clearly explain why offspring produced using runners are genetically identical. While many students correctly identified mitosis as being involved for mark point 1, simply stating that offspring were 'clones' was not sufficient without mentioning mitosis. 30% of students gained 1 mark – overwhelmingly for mark point 1. Mark point 2 was rarely awarded due to ineffective articulation at this level of demand. Even answers containing pertinent details often struggled to fully meet the mark scheme requirements. Additionally, many students focused on describing asexual reproduction, with answers such as 'only one parent is required' or 'no gamete fusion,' rather than explaining **why** the offspring were genetically identical. Some described mitosis as producing two genetically identical cells, but this was insufficient to explain why the whole plant was genetically identical.
Despite detailed attempts by most students, only 1% of students gained both available marks.

06.6
Only 10% of students managed to gain any marks in this question. Again, features of sexual reproduction were given, with little additional detail explaining why the offspring produced using flowers, fruits and seeds are not genetical identical. To earn mark point 1, students needed to explicitly link meiosis with the production of gametes, a connection rarely seen in responses that typically mentioned one without the other. Mark point 2 proved highly demanding due to its strict detail requirements. Many good attempts were seen but

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unfortunately lacked the precision needed at this level of demand. A very common error was the suggestion that meiosis actually produced the flowers, fruits and seeds which is incorrect.

06.7

One fifth of students were able to describe at least one advantage of asexual reproduction to the survival of the strawberry plants. For bullet point 1, a direct comparison to sexual reproduction had to be made, but many responses did not use this comparative language. However, if awarded bullet point 1 was by far the most common correct response seen.
For bullet points 2 through to 6, a clear link to a survival advantage was required. Many responses stated that 'less energy was needed', or 'only one parent needed' but then did not link it to the appropriate survival advantage and as such could not be awarded credit.

06.8

This question was set at very high demand with only a quarter of students gaining at least 1 mark. Bullet point 1 was the most common advantage of sexual reproduction given – articulated in many ways to match the variety of options on the mark scheme. Responses such as, 'genetic variation will decrease the chance of a disease killing all the plants' was most commonly awarded – which equated to 'genetic variation gives selective advantage' gaining one mark. Several good answers were seen but sadly students had only referred to 'variation' and not 'genetic variation' and so could not be credited. In addition, some responses correctly stated that 'seed dispersal would lead to less competition' but then didn't qualify this with any of the required examples from the mark scheme and as such were not credited.

Question 8 (Standard/high and High demand)

08.1

A third of students gained both available marks for this question. Many students were able to correctly identify HH as the genotype. The alternative correct response of 'homozygous dominant' was also used by some students. A significant number gave incorrect answers of H, Hh and hh, whilst a few simply wrote heterozygous or homozygous. It was also clear that a significant number of students did not know what 'genotype' meant and wrote answers such as black or Himalayan. Some students used different letters to the required HH and did not include a key to indicate what their letters represented, so could receive no credit.
Some students were able to write very clear explanations for their selection of the HH genotype that matched one the three alternatives on the mark scheme. Some students wrote answers that successfully explained their answer of HH using a reverse logic.

08.2

A pleasing 40% of students were able to successfully draw a fully annotated Punnett square diagram and use it to give the probability of offspring being white – achieving full marks.
Many students were able to use the correct gametes for both parents, gaining mark point 1.
Students demonstrated good skills in deriving offspring genotypes in their Punnett squares even when their selected parental genotypes were incorrect and so gained mark point 2.
The commonest error for this question was the omission to clearly identify the phenotypes for each of the given offspring genotypes for mark point 3. The terms 'homozygous' and 'heterozygous' were used frequently to describe each phenotype, so did not gain credit.
Many students were able to give the correct probability from their Punnett square for mark point 4 to be awarded. Those students who chose incorrect parental genotypes of Hh and hh often subsequently gave 50% as their probability from correctly derived offspring, so could gain credit. A small number of students who ended up with HH, HH, Hh and Hh as their four offspring genotypes thought that the Hh genotypes were white.

08.3

Only 1% of students achieved full marks for this question, with 60% gaining no marks or not attempting the question. Many had an idea of how protein synthesis works but there was much confusion evident, for example amino acids coding for a gene or a protein, rather than the base triplet coding for an amino acid. The first mark point was not achieved by the vast

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majority of students, with some referencing codons or bases but few referred to a triplet or 3 bases. Many students then incorrectly stated that 'a different amino acid or protein was *made*', rather than 'a different amino acid was coded for'.
The final two marking points were most commonly seen among the 15% of students that scored 2 marks in this question. Several students were familiar with and could explain the idea of the active site changing shape and the consequences of that change in that the substrate would no longer fit to it.

08.4
Nearly 60% of students could give a partial explanation as to why the fur was white in the first four weeks of life – gaining at least 1 mark. Responses needed to specifically refer to either the temperature of the nest or the mother's body temperature – rather than the body temperature of the young rabbit.
Many students were able to explain the idea of the tyrosinase/enzyme not working above 35 °C, but a significant number went on to state that the enzyme was denatured which therefore precluded them from the second marking point.

08.5
Three quarters of students were able to score at least 1 mark in this question, with less than 5% of those gaining all 3 available marks. Some students correctly mentioned the outside environment being colder, but many referred to the young rabbit's body temperature falling, rather than just its extremities. A considerable number of students incorrectly stated that the body temperature of the young rabbits was between 15°C and 25°C. Correct ideas for mark point 2 were rarely awarded.
Many students were able to correctly state that the tyrosinase was now active for mark point 3. Some students showed confusion between tyrosine and tyrosinase here – missing out on mark point 3 if they did so.

08.6
Over 70% of students gained at least one mark for their partial explanation of the advantage of producing melanin when exposed to bright sunlight. Most students were able to correctly explain that UV radiation causes skin cancer (or just cancer) with the vast majority achieving this mark point. The idea of UV radiation causes mutation or DNA damage (which then led to cancer) was much less commonly seen.