AQA GCSE Biology | 8461

SPECIFICATION POINT 4.6.1.6

Genetic inheritance

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**24**
Available paper years	**2008–2025**

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.

4.6.1.6 Genetic inheritance

Answer 01 · Mark scheme

June 2008 | BLY2H | Original Q2 | Legacy

question	answers	extra information	mark
2(a)	cell membranes		1
2(b)(i)	two recessive / cystic fibrosis / faulty / diseased / the allele(s) / genes from Bob **and** Carol / both parents / the parents	two can be implied by second marking point ignore chromosomes if no other marks awarded 'Carol is a carrier' gains **1** mark	1 1
2(b)(ii)	(inherited) dominant / normal allele / gene from Carol / mother	ignore references to recessive allele / gene from father / Bob if no other marks awarded he has <u>just</u> / <u>only</u> one recessive allele gains **1** mark	1 1
2(c)(i)	reduce number of people with cystic fibrosis (in population) **or** reduce health-care costs **or** expensive to have baby with cystic fibrosis	accept to allow decision / emotional argument qualified eg allows abortion **or** allows people to make choices about termination **or** help to prepare financially / emotionally etc	1

Question 2 continued on next page…

4.6.1.6 Genetic inheritance

COMPONENT NUMBER: BLY2H

COMPONENT NAME: Additional Science / Biology

STATUS: Final

DATE: June 2008

Question 2 continued…

question	answers	extra information	mark
2(c)(ii)	any **one** from: • possible damage / risk to embryo / fetus / baby • screening / it is expensive • (may) have to make ethical / moral / religious decisions • right to life	 allow possible harm / risk to mother ignore not natural / playing God / unethical / immoral / religious unqualified	1
Total			**7**

4.6.1.6 Genetic inheritance

Answer 01 · Mark scheme

June 2008 | BLY2H | Original Q2 | Legacy

COMPONENT NUMBER: BLY2H

COMPONENT NAME: Additional Science / Biology

STATUS: Final

DATE: June 2008

4.6.1.6 Genetic inheritance

Answer 02 · Mark scheme

question	answers	extra information	mark
6(a)	1 in 4 / $^{1}/_{4}$ / 1: 3 / 25% / 0.25	do **not** accept 3:1 / 1:4 / 2:6	1
6(b)	**either** from C **and** D any **three** from: • C **and** D have disorder • I/J don't have disorder • C **and** D have dominant **and** recessive alleles • recessive alleles from C **and** D passed to I/J **or** I/J have two recessive alleles **or** from A **and** B • A is homozygous recessive / rr, **and** B is heterozygous / Rr can be shown in words or symbols • offspring can be rr **or** Rr described	accept synonyms for dominant / recessive eg. Normal / faulty accept genetic diagram if clearly referring to correct individuals or genotypes on family tree allow 'gene' for 'allele' ignore 'C & D are carriers' NB if allele was recessive then all offspring of C **and** D would have the disorder = **3** marks assume response refers to A+B unless contradicted allow any symbol allow without key	3
6(c)(i)	(embryos) checked for inherited / genetic disorders / conditions	accept diseases for disorders	1

Question 6 continued on next page…

COMPONENT NUMBER: BLY2H

COMPONENT NAME: Additional Science / Biology

STATUS: Final

DATE: January 2009

Question 6 continued…

question	answers	extra information	mark
6(c)(ii)	any **three** from: • C/D have disorder / have dominant allele • chance of embryo / foetus / child having disorder **or** may pass on alleles for disorder to their offspring • C/D might want to decide on termination **or** prepare for child with disorder • G **and** H don't have disorder / both homozygous recessive / have no dominant alleles (for this disorder) • so offspring (of G **and** H) cannot / don't have disorder	accept disease / condition accept 'gene' for 'allele' ignore reference to 'carriers'	3
Total			**8**

4.6.1.6 Genetic inheritance

Answer 03 · 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…

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**

4.6.1.6 Genetic inheritance

Answer 04 · Mark scheme

January 2010 | BLY2H | Original Q5 | Legacy

Question 5

question	answers	extra information	mark
5(a)	both parents **Aa**	accept other upper and lower case letters without key **or** symbols with a key allow shown as gametes in punnet square	1
	aa in offspring correctly derived from parents / **aa** correctly derived from the parents given	ignore other offspring / gametes for this mark parents do not have to be correct	1
	offspring **aa** identified as having cystic fibrosis	may be the only offspring shown **or** circled / highlighted / described	1
5(b)(i)	any **one** from: • sure / greater chance of healthy / non-cystic fibrosis egg / embryo / child • greater chance of fertilisation	accept converse if clear eg if you (only) took one it might have cystic fibrosis / might not be fertilised accept some may have the allele reference to suitable embryo is insufficient	1

Question 5 continues on the next page

BLY2H

Question 5 continued

question	answers	extra information	mark
5(b)(ii)	**advantages** any **two** from • greater / certain chance of having child / embryo without cystic fibrosis / healthy • child with cystic fibrosis difficult / expensive to bring up • cystic fibrosis (gene / allele) not passed on through generations **disadvantages** any **two** from: • operation dangers eg infection • ethical or religious issues linked to killing embryos • (high) cost • possible damage to embryo (during testing for cystic fibrosis / during operation) **plus** **conclusion** a statement that implies a valued, qualified judgement eg it is right because the risk of infection is small **or** eg it is wrong because embryos are killed	**to gain 3 marks both advantages <u>and</u> disadvantages must be given** ignore references to abortion unless qualified by later screening ignore risk unqualified accept wrong / cruel to kill embryos accept right to life **Note:** the conclusion mark cannot be given unless a reasonable attempt to give both an advantage and a disadvantage has (already) been made do **not** award the mark if the conclusion only states that advantages outweigh disadvantages	max 3 1
Total			**8**

4.6.1.6 Genetic inheritance

Answer 04 · Mark scheme

January 2010 | BLY2H | Original Q5 | Legacy

BLY2H

4.6.1.6 Genetic inheritance

Answer 05 · Mark scheme

January 2011 | BLY2H | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)	half / 50% sperm have X (chromosome) **or** half / 50% sperm have Y (chromosome) all eggs have X (chromosome)	penalise incorrect use of gene / allele once only annotated genetic diagram could gain **2 marks**	1 1
4(b)	screening	ignore selection	1
4(c)	any **three** from: advantages:**(max 2**) • (girl / children / women) don't / less likely to get / inherit (breast) cancer / this / the disease • future generations get less cancer **or** less likely to have the allele • less expensive (for NHS) than treating cancer disadvantages:**(max 2)** • (wrong / immoral to) reject / kill embryos • possible harm to embryo (that is implanted) / miscarriage • possible harm to mother (due to operational procedure) argued conclusion	max **2** if only advantages **or** only disadvantages discussed do **not** accept reference to allele alone for this point ignore wrong / immoral / religious argument unqualified ignore reference to termination allow reference to needing hormone treatment must refer to **both** advantages and disadvantages and must be at end of answer	3 1
Total			**7**

4.6.1.6 Genetic inheritance

Answer 05 · Mark scheme

January 2011 | BLY2H | Original Q4 | Legacy

BLY2H

4.6.1.6 Genetic inheritance

Answer 06 · Mark scheme

January 2011 | BLY2H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)	cystic fibrosis (allele / gene) recessive carrier has only one cystic fibrosis allele / gene	allow an annotated genetic diagram accept carrier is heterozygous accept any symbol with key or accept conventional use of symbols penalise use of chromosome once only	1 1
6(b)	any **one** from: • Huntington's (allele / gene) dominant • (to have Huntington's) need only one Huntington's allele / gene		1
Total			**3**

4.6.1.6 Genetic inheritance

Answer 06 · Mark scheme

January 2011 | BLY2H | Original Q6 | Legacy

BLY2H

4.6.1.6 Genetic inheritance

Answer 07 · Mark scheme

June 2011 | BLY2H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)	Aa	allow dominant **and** recessive allow heterozygous	1
6(b)(i)	gametes A, a **and** A, a correctly derived offspring from cross identification of round **and** wrinkled offspring	max **1** if gametes are incorrect (eg in punnet square) allow ecf from their gametes for this mark the phenotype of each different offspring genotype must be indicated	1 1 1
6(b)(ii)	(due to) chance **or** expected ratio is only a probability	accept the idea of small numbers not representative ignore anomaly / random / coincidence do **not** accept error	1
6(c)	any **one** idea from: • genes / chromosomes / alleles / DNA not discovered / known about • published in obscure journal / few scientists read his work	do **not** accept religious theme (ie confusion with Darwin's difficulties with the church)	1
Total			**6**

4.6.1.6 Genetic inheritance

Answer 07 · Mark scheme

June 2011 | BLY2H | Original Q6 | Legacy

BLY2H

4.6.1.6 Genetic inheritance

Answer 08 · Mark scheme

June 2012 | BL2HP | Original Q7 | Legacy

Question 7

question	answers	extra information	mark
7(a)(i)	(alternative) forms / types of a / the same gene		1
7(a)(ii)	only expressed if 2 copies inherited **or** not expressed if other allele present	allow over ruled / over powered by the other allele	1
7(b)(i)	**Nn**	ignore heterozygous	1
7(b)(ii)	genetic diagram including:	accept alternative symbols, if defined	
	gametes: **N** and **n** from both parents	accept alternative symbols if correct for answer to (b)(i)	1
	correct derivation of offspring genotypes: **NN Nn Nn nn**	allow if correct for candidate's parental genotypes / gametes	1
	identification of **nn** as having cystic fibrosis		1

Question 7 continues on the next page . . .

BL2HP

Question 7 continued

question	answers	extra information	mark
7(c)	**Argued evaluation** any **four** from: • PGD higher financial cost • PGD occurs before pregnancy / implantation • PGD does not involve abortion so less trauma / less pain / ethical comparison • PGD higher incidence of false positive / use of numbers so higher risk of destroying healthy embryo • PGD no chance of miscarriage whereas CVS does **or** PGD less chance of miscarriage	accept CVS only costs £600 accept detected at earlier stage so less unethical / less trauma accept PGD has (surplus) embryos so some destroyed / unethical	4
Total			**10**

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

4.6.1.6 Genetic inheritance

Answer 09 · Mark scheme

Question 6

question	answers	extra information	mark
6(a)(i)	allele expressed even when other allele present **or** expressed if just one copy of allele is present **or** expressed if heterozygous	if present other allele not expressed	1
6(a)(ii)	2 affected parents have unaffected child **or 1** and **2** → **5** / **6** **or** if recessive all of **1** and **2**'s children would have CADASIL		1
6(a)(iii)	heterozygous – has unaffected children **or** because if homozygous all children would have CADASIL		1
6(b)	genetic diagram including: correct gametes: **D** and **d** **and** **d** (and **d**) derivation of offspring genotypes: **Dd** **Dd** **dd** **dd** identification of **Dd** as CADASIL **or dd** as unaffected correct probability: 0.5 / ½ / 1 in 2 / 50 % / 1 : 1	accept alternative symbols, if defined ignore 7 / 8 or male / female allow just **Dd** **dd** if ½-diagram allow ecf if correct for student's gametes allow ecf if correct for student's gametes	1 1 1 1
6(c)(i)	stem cells can differentiate **or** are undifferentiated / unspecialised can form blood vessel cells / brain cells **or** stem cells can divide		1 1

Question 6 continues on the next page . . .

BL2HP

Question 6 continued . . .

question	answers	extra information	mark
6(c)(ii)	ethical argument – eg no risk of damage to embryo **or** adult can give consent for removal of cells **or** adult can re-grow skin **or** if from a relative then less chance of rejection **or** if from self then no chance of rejection **or** skin cells more accessible	more ethical qualified ignore religion unqualified	1
Total			**10**

4.6.1.6 Genetic inheritance

Answer 09 · Mark scheme

January 2013 | BL2HP | Original Q6 | Legacy

BL2HP

4.6.1.6 Genetic inheritance

Answer 10 · 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: Parental gametes: **H** and **h** from both parents	accept alternative symbols, if defined	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**

4.6.1.6 Genetic inheritance

Answer 11 · Mark scheme June 2014 | BL2HP | Original Q6 | Legacy

6(a)(i)	one form of a / one gene	do **not** allow 'a type of gene' allow a mutation of a gene	1	AO1 2.7.2c,e , 2.7.3a
6(a)(ii)	not expressed if dominant / other allele is present / if heterozygous **or** only expressed if dominant allele not present / or no other allele present	allow need two copies to be expressed / not expressed if only one copy / only expressed if homozygous	1	AO1 2.7.2c,e , 2.7.3a
6(b)(i)	two parents without PKU produce a child with PKU / **6** and **7** → **10**	allow 'it skips a generation'	1	AO3 2.7, 2.7.3a
6(b)(ii)	genetic diagram including: Parental gametes: 6: **N** and **n** **and** 7: **N** and **n** derivation of offspring genotypes: **NN Nn Nn nn** identification: **NN** and **Nn** as non-PKU **OR nn** as PKU correct probability only: 0.25 / ¼ / 1 in 4 / 25% / 1 : 3	accept alternative symbols if defined allow genotypes correctly derived from 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 / AO3 2.7, 2.7.3a
6(c)(i)	mitosis	correct spelling only	1	AO1 2.7.1a,c ,d
6(c)(ii)	8		1	AO2 2.7.1c,i, 2.7.3a, 2.7.3d
6(c)(iii)	DNA	allow deoxyribonucleic acid do **not** allow RNA / ribonucleic acid	1	AO1 2.7.2g, 2.7.3a, 2.7.3d

4.6.1.6 Genetic inheritance

Answer 11 · Mark scheme

June 2014 | BL2HP | Original Q6 | Legacy

Question	Answers	Extra information	Mark	AO / spec ref.
6(d)(i)	may lead to damage to embryo / may destroy embryos / embryo cannot give consent	allow avoid abortion allow emotive terms – eg murder religious argument must be qualified allow ref to miscarriage allow idea of avoiding prejudice against disabled people allow idea of not producing designer babies	1	AO3 2.7, 2.7.3a
6(d)(ii)	any **one** from: • prevent having child with the disorder / prevent future suffering / reduce incidence of the disease • embryo cells could be used in stem cell treatment	ignore ref to having a healthy child ignore ref to selection of gender allow ref to long term cost of treating a child (with a disorder) allow ref to time for parents to become prepared	1	AO3 2.7, 2.7.3a
Total			**12**	

4.6.1.6 Genetic inheritance

Answer 11 · Mark scheme

June 2014 | BL2HP | Original Q6 | Legacy

Question	Answers	Extra information	Mark	AO / spec ref.

4.6.1.6 Genetic inheritance

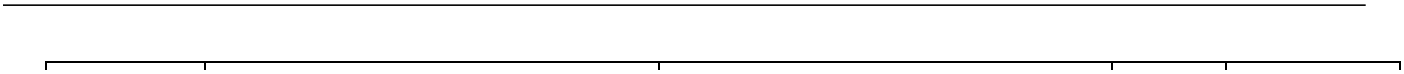
Answer 12 · Mark scheme June 2015 | BL2HP | Original Q3 | Legacy

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**	

4.6.1.6 Genetic inheritance

Answer 12 · Mark scheme

June 2015 | BL2HP | Original Q3 | Legacy



4.6.1.6 Genetic inheritance

Answer 13 · Mark scheme

June 2015 | BL2HP | Original Q8 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
8(a)(i)	3.15 : 1	accept 3.147:1 **or** 3.1 : 1 **or** 3 : 1 do **not** accept 3.14 : 1 Ignore 705:224	1	AO2 2.7
8(a)(ii)	any **two** from: • fertilisation is random **or** ref. to chance combinations (of alleles / genes / chromosomes) • more likely to get theoretical ratios **or** see (correct) pattern **or** get valid results if large number • anomalies have limited effect / anomalies can be identified	 allow ref. to more representative / reliable do **not** allow more accurate **or** precise ignore fair / repeatable accept example of an anomaly	2	AO3 2.7, 2.7.2a
8(b)(i)	in sequence: Homozygous Homozygous Heterozygous	All 3 correct = 2 marks 2 correct = 1 mark 1 or 0 correct = 0 marks	2	AO3 2.7
8(b)(ii)	genetic diagram including: Parental genotypes: **Nn** and **Nn** **or** Gametes: **N** and **n** + **N** and **n** <u>derivation</u> of offspring genotypes: **NN Nn Nn nn** identification: **NN** and **Nn** as purple **and nn** as white	 allow other characters / symbols only if clearly defined allow genotypes correctly derived from candidate's P gametes allow correct identification of candidate's offspring genotypes but only if some F_2 are purple and some are white	 1 1 1	AO2 2.7

4.6.1.6 Genetic inheritance

Answer 13 · Mark scheme

June 2015 | BL2HP | Original Q8 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
8(c)	any **two** from: • did not know about chromosomes / genes / DNA **or** did not know chromosomes occurred in pairs • had pre-conceived theories • Mendel's (mathematical) approach was novel concept • Mendel was not part of academic establishment • work published in obscure journal / work lost for many years • peas gave unusual results cf other species • Mendel's results were not corroborated until later / 1900	 ignore genetics eg blending of inherited characters ignore religious ideas unless qualified allow his work was not understood or no other scientist had similar ideas allow he was not considered to be a scientist / not well known / he was only a monk allow he only worked on pea plants	2	AO1 2.7
Total			**10**	

4.6.1.6 Genetic inheritance

Answer 14 · Mark scheme

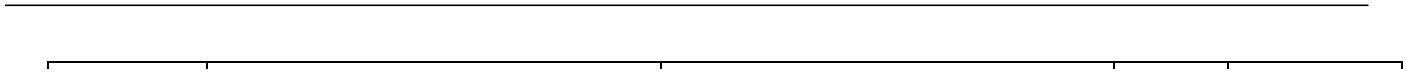
June 2016 | BL2HP | Original Q6 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
6(a)(i)	man has (inherited) polydactyly (PD) allele (from mother) man has (inherited) other / normal / recessive allele from father because father does not have PD allele **or** if father had it father would have had PD **or** father only has normal allele **or** father is homozygous recessive	allow gene for allele	1 1 1	AO1/2/3 2.7, 2.7.2a/c/d 2.7.3a/b
6(a)(ii)	0.5 / ½ / 1 in 2 / 1:1 / 50%	do not allow 1:2 or 50/50 allow 50:50	1	AO3 2.7, 2.7.2a/c/d 2.7.3a/b
6(b)	parental phenotypes: both brown parental genotypes: both **Bb** gametes: **B** **b** and **B** **b** offspring genotypes: **BB** **(2)Bb** **bb** offspring phenotypes correctly assigned to genotypes: **BB** & **Bb** = brown **bb** = red	allow only on gametes answer line allow ecf from genotypes allow ecf from gametes do not penalise confusion of 'phenotypes' & 'genotypes' here	1 1 1 1 1	AO1/2/3 2.7, 2.7.2a/c/e
Total			**9**	

4.6.1.6 Genetic inheritance

Answer 14 · Mark scheme

June 2016 | BL2HP | Original Q6 | Legacy



4.6.1.6 Genetic inheritance

Answer 15 · Mark scheme

June 2017 | BL2HP | Original Q6 | Legacy

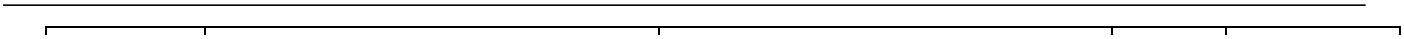
Question	Answers	Extra information	Mark	AO / Spec. Ref.
6(a)(i)	46 **or** 23 pairs		1	AO1 2.7.2b
6(a)(ii)	(alternative / different) form(s) of a gene / of the same gene		1	AO1 2.7.2c
6(a)(iii)	only expressed if the dominant (allele) is not present / if the other (allele) is not present **or** only expressed 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

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**	

4.6.1.6 Genetic inheritance

Answer 15 · Mark scheme

June 2017 | BL2HP | Original Q6 | Legacy



4.6.1.6 Genetic inheritance

Answer 16 · 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

Answer 16 · Mark scheme

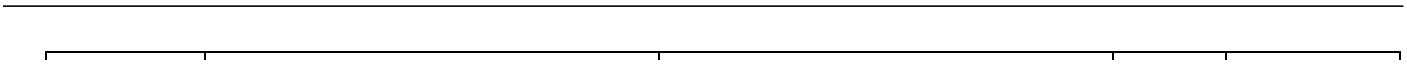
June 2018 | 8461/2H | Original Q8

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**	

4.6.1.6 Genetic inheritance

Answer 16 · Mark scheme

June 2018 | 8461/2H | Original Q8



4.6.1.6 Genetic inheritance

Answer 17 · Mark scheme

June 2019 | 8461/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	same kingdom + phylum + class + order **or** same order **or** they have the top four groups the same	allow both Poales	1	AO3 4.6.4
05.2	**Rr / rR**	do **not** accept **RR** or **rr** ignore heterozygous do not accept homozygous	1	AO3 4.6.1.6 4.6.3.3
05.3	C^WC^W		1	AO3 4.6.1.6
05.4	parental genotypes / gametes correct for both parents: $C^R C^W$ $C^R C^W$ / C^R and C^W genotypes of offspring correctly derived in a Punnett square: C^RC^R C^RC^W C^WC^W correct identification of phenotypes from their cross: C^RC^R = red C^RC^W = pink C^WC^W = white	allow **R** and **W** throughout allow own symbols if defined allow correctly derived genotypes from incorrect gametes allow colours correctly identified from different offspring, only if pink and other colour(s) are given	1 1 1	AO2 4.6.1.6
05.5	answer correctly derived from Question **05.4** to match stated phenotypes	allow 50(%) if no offspring given in Question **05.4** allow to match genotypes if no phenotypes given	1	AO2 4.6.1.6

4.6.1.6 Genetic inheritance

Answer 17 · Mark scheme

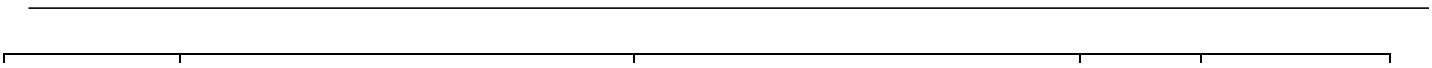
June 2019 | 8461/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	*(several groups)* so many / several plants can be produced	allow each (group) will give a new plant	1	AO1 4.1.2.3 4.6.1.3 4.6.2.5
	(nutrients) for making protein / amino acids **or** for making chlorophyll **or for providing** energy **or for respiration**	allow other examples do **not** accept making energy ignore for growth	1	
	(add hormones) so differentiation occurs **or** so roots / shoots develop	allow for the formation of different tissues / organs / named allow to stimulate cell division	1	
	(sterile conditions) to prevent growth / entry of microorganisms / named type **or** prevent decay / disease	ignore to kill microorganisms ignore contamination unqualified	1	
	(temperature = 20 ^{o}C) so optimum / good growth	allow reference to enzymes working well ignore enzymes not denatured ignore reference to pathogens / microorganisms	1	
05.7	(all new plants have been) produced by asexual reproduction / mitosis **or** produced without (fusion of) gametes	ignore produced from one parent	1	AO2 4.1 4.1.2.2 4.6.1.1 4.6.2.5
	(so) all are genetically identical / clones **or** all are C^RC^W **/** heterozygous	allow all are the same genotype / alleles / genes / DNA	1	
Total			14	

4.6.1.6 Genetic inheritance

Answer 17 · Mark scheme

June 2019 | 8461/2H | Original Q5



4.6.1.6 Genetic inheritance

Answer 18 · 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

Answer 18 · Mark scheme

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

4.6.1.6 Genetic inheritance

Answer 18 · 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**	

4.6.1.6 Genetic inheritance

Answer 18 · Mark scheme

November 2020 | 8461/2H | Original Q5

4.6.1.6 Genetic inheritance

Answer 19 · 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

4.6.1.6 Genetic inheritance

Answer 19 · Mark scheme

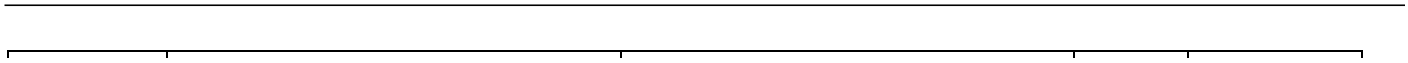
November 2021 | 8461/2H | Original Q8

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**	

4.6.1.6 Genetic inheritance

Answer 19 · Mark scheme

November 2021 | 8461/2H | Original Q8



Answer 20 · Mark scheme

June 2022 | 8461/2H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	parents without MSUD have a child with MSUD	allow 1 and 2 (without MSUD) have child 5 (with MSUD) **or** 7 and 8 (without MSUD) have child 12 (with MSUD) ignore MSUD skips a generation	1	AO3 4.6.1.6 4.6.1.7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	gametes correct: **N + n** and **N + n**		1	AO2
	correct derivation of offspring genotypes: **NN Nn Nn nn**	allow correct for gametes stated	1	AO2
	correct phenotype for each genotype	allow correct for offspring genotypes ignore carrier	1	AO2
	correct probability: 0.25 / ¼ / 25% / 1 in 4	allow correct answer only allow 1:3 do **not** accept 1 in 3 / 1:4	1	AO3 4.6.1.6 4.6.1.7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	liver		1	AO2 4.5.3.3

Answer 20 · Mark scheme

June 2022 | 8461/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4		allow **P** for toxic substance throughout		AO2 4.2.2.1 4.1.3.1 4.6.1.5 4.6.1.6
	(no enzyme 2 made **so**) cannot break down the toxic substance	allow (no enzyme 2 made **so**) cannot change toxic substance into harmless products	1	
	the toxic substance is still made (from the amino acids)	allow toxic substance builds up over time ignore concentration of toxic substance is high(er)	1	
	toxic substance diffuses / moves (from cells) into the blood	ignore incorrect name of organ	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	the toxic substance passes through filter in kidney **or** **P** passes through filter in kidney		1	AO1 4.5.3.3
	(some / all) not reabsorbed	allow (some / all) not absorbed **back** into the blood **or** (some / all) not taken **back** into the blood ignore (some / all) not absorbed into the blood **or** (some / all) not taken into the blood	1	

4.6.1.6 Genetic inheritance

Answer 20 · Mark scheme

June 2022 | 8461/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	proteins contain amino acids **or** proteins are made of amino acids	allow proteins are broken down into amino acids	1	AO1
	must keep (certain) amino acids in low amount	allow (so) (certain) amino acids do not build up allow (so) less of (certain) amino acids are produced	1	AO2
	(so) toxic substance **or P** does not build up in the body **and** cause damage to cells / tissues / organs		1	AO2 4.6.1.5 4.6.1.7 4.4.2.3

Total Question 5		**14**

Answer 21 · Mark scheme

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

Answer 21 · 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

4.6.1.6 Genetic inheritance

Answer 21 · 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

4.6.1.6 Genetic inheritance

Answer 21 · 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**

4.6.1.6 Genetic inheritance

Answer 22 · 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
	$\frac{39\,000}{5572} = 6.99…$	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

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

Answer 23 · 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	

Answer 23 · Mark scheme

June 2024 | 8461/2H | Original Q6

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

Answer 24 · 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

Answer 24 · Mark scheme

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	

4.6.1.6 Genetic inheritance

Answer 24 · 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**

4.6.1.6 Genetic inheritance

Answer 18 · 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 18 · 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.

Answer 19 · 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.

Answer 20 · Examiner comments June 2022 | 8461/2H | Original Q5

Question 5

The topic of this question was the inheritance of a human disease and the specific effects of this condition on the body.

05.1 Evidence from the pedigree diagram given in **Figure 4** that maple syrup urine disease (MSUD) was a recessive condition was provided by the fact that unaffected parents could produce a child with MSUD. Incorrect answers related to one of the parents having the condition but none of her children having it, or to the low frequency of MSUD in this family. Fewer than half of the students gave a correct answer.

05.2 Three-quarters of students were able to draw a correct Punnett square diagram to show that heterozygous parents had a 25 percent chance of producing a child with MSUD.

Answer 20 · Examiner comments June 2022 | 8461/2H | Original Q5

However, fewer than half of these gained all 4 marks, mainly because they did not follow the instruction in the question to *identify the phenotype of each offspring genotype*.

Questions **05.3** to **05.6** were based on **Figure 5** which gave a metabolic pathway showing the breakdown of some types of amino acids and included the production and breakdown of a toxic substance, **P**.

05.3 The majority of students incorrectly selected the *kidney* as the organ in which the reactions were most likely to occur, with the correct answer, the *liver*, in second place.

05.4 Given that MSUD was caused by an inability to make the enzyme that broke down substance **P** into harmless products, students had to explain why the blood of a person with MSUD would contain a high concentration of substance **P**. Around three-quarters of students understood that substance **P** would not be broken down but only around 1 in 100 could fully explain that therefore the concentraton of **P** would build up in the cells that made it *and* that **P** would then move from the cells into the blood. Some thought, incorrectly, that **P** could not be excreted by the kidney and would therefore build up in the blood – although the subsequent question would have given evidence against this idea.

05.5 Some details of how the kidneys function were required to answer this question about why substance **P** would be found in the urine, namely that it would be filtered out of the blood by the kidneys and not reabsorbed. Despite urine being mentioned in the question, a surprisingly large proportion failed to mention the kidneys in their answers. Filtration was a better-understood concept than reabsorption. Fewer than one-third of students scored any marks for this question.

05.6 Since toxic substance **P** was derived from certain amino acids, the majority of students understood that a person with MSUD should have a low-protein diet because proteins were made of amino acids. However, fewer than one third of these could go on to explain that amino acids would need to be kept in small amounts to avoid a build-up of **P** which would harm the body cells / tissues / organs.

Answer 21 · 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.

4.6.1.6 Genetic inheritance

Answer 21 · 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.

4.6.1.6 Genetic inheritance

Answer 22 · 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

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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.

4.6.1.6 Genetic inheritance

Answer 23 · 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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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.