2. Adenine (A) and cytosine (C) together make up 50% of the total amount of nitrogenous bases in DNA molecules. Which of the following features of DNA provide the basis to explain this phenomenon?

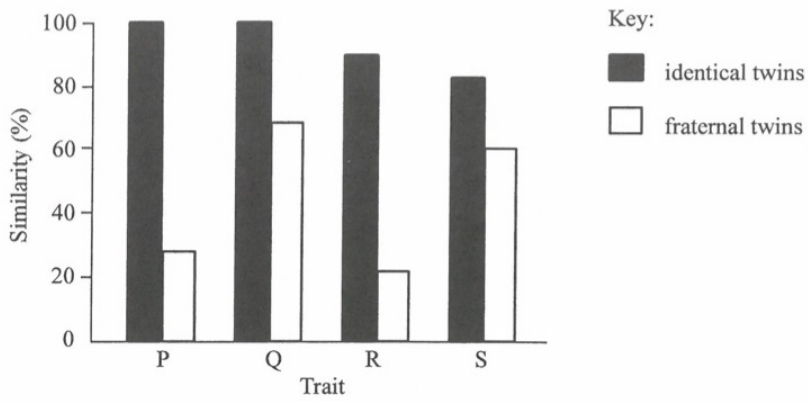
(1) DNA has a helical structure.
(2) DNA is a double-stranded molecule.
(3) The nitrogenous bases are paired complementarily.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

3. In Mendel's experiment, he proposed that a characteristic of the pea plants was controlled by a pair of 'heredity factors'. These factors can be separated in a 'process' before passing to the offspring. According to the current understanding of genetics, what do the 'heredity factors' and the 'process' represent respectively?

	Heredity factors	*Process*
A.	alleles	first meiotic cell division
B.	alleles	second meiotic cell division
C.	chromosomes	first meiotic cell division
D.	chromosomes	second meiotic cell division

6. A large survey about the inheritance of four traits in identical twins and fraternal twins has been conducted. The similarity of these four traits among the individuals in each type of twins are shown in the graph below:



Which trait is most affected by environmental factors?

A. P
B. Q
C. R
D. S

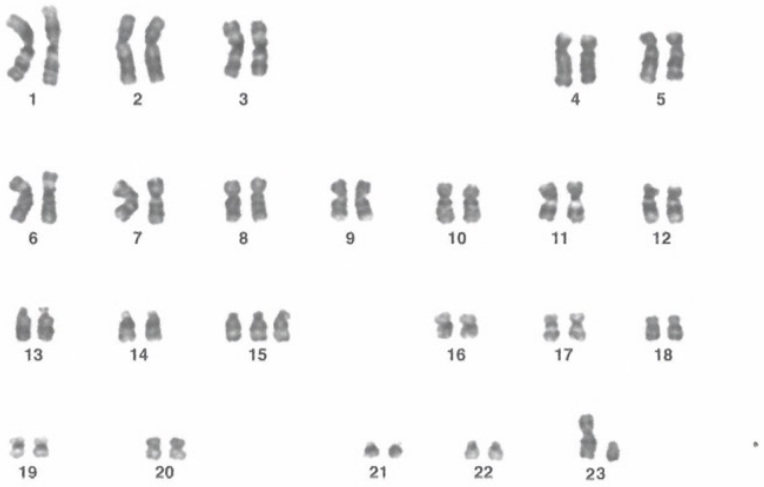
7. The table below shows the comparison among three groups of organisms X, Y and Z:

	X	Y	Z
Cell wall	Present	Present	Absent
Similarity of the amino acid sequence of a protein found in all three organisms (X as a reference)	100%	45%	55%

With reference to the information above, which of the following can be deduced?

A. Both X and Y are prokaryotes.
B. Y is least advanced among the three.
C. X has a closer phylogenetic relationship with Z than Y.
D. Y has a closer phylogenetic relationship with Z than X.

4. The photomicrograph below shows the karyotype of a patient who is suffering from a certain brain disease:



(a) What is the gender of this patient? Describe ***one*** observable feature from the karyotype to support your answer. (2 marks)

(b) (i) Describe the abnormality shown in the karyotype. (1 mark)

(ii) State the type of mutation involved in this abnormality. (1 mark)

(iii) How would this abnormality affect the mRNA level in the brain cells of this patient? (1 mark)

9. Antibiotics have been widely used to treat bacterial infections. They work by killing bacteria or inhibiting their growth. However, some strains of bacteria have developed resistance to antibiotics.

(a) How can antibiotics kill bacteria or inhibit their growth? State ***three*** possible ways. (3 marks)

(b) Bacterium R is a pathogenic bacterium which possesses an antibiotic resistance gene. Its gene product can break down antibiotic X. Scientists have suggested a new approach to fight against bacterium R. This new approach involves the use of a synthetic polynucleotide which binds to the mRNA transcribed from the antibiotic resistance gene. The expression of the gene is then inhibited. By administering this synthetic polynucleotide together with antibiotic X, bacterium R can be killed.

The base sequences of the synthetic polynucleotide and part of the mRNA are shown below:

synthetic polynucleotide: AGT GAC TCG GTC AGC

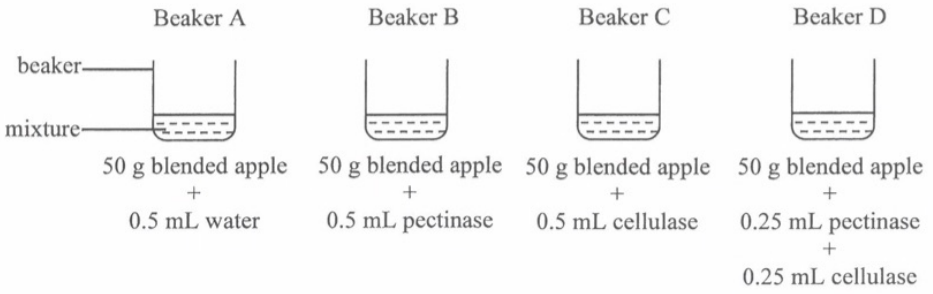
mRNA: ... AUG UCU GUU CCA UCA UCA CUG AGC CAG UCG GCC AUU AAU GCC AAC UAG ...

(i) On the mRNA, underline the base sequence to which the synthetic polynucleotide will bind. (1 mark)

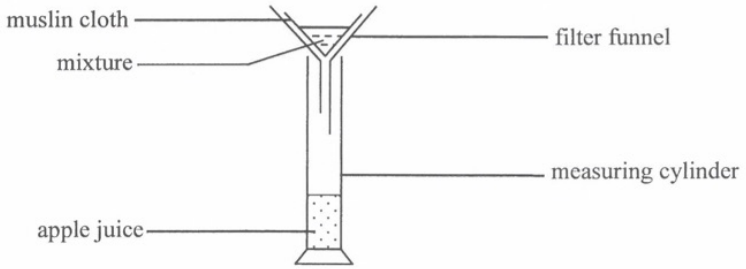
(ii) Explain how the synthetic polynucleotide can inhibit the expression of the antibiotic resistance gene. (3 marks)

(iii) Suggest ***one*** advantage of using synthetic polynucleotides to fight against antibiotic resistant bacteria. (1 mark)

5. Pectinase and cellulase are enzymes that break down the chemical components of plant cell walls. The following experiment investigates the effects of these two enzymes on the production of apple juice:



stir each mixture for 10 minutes and then carry out filtration



The experiment was repeated three times and the results are shown below:

Beaker	Mixture	Volume of apple juice produced (mL)				Cost of enzyme(s) for producing 1 mL apple juice
		Trial 1	Trial 2	Trial 3	Average	
A	0.5 mL water + 50 g blended apple	2.0	1.0	3.0	2.0	---
B	0.5 mL pectinase + 50 g blended apple	33.5	31.0	28.5	31.0	
C	0.5 mL cellulase + 50 g blended apple	4.5	4.0	3.5	4.0	
D	0.25 mL pectinase + 0.25 mL cellulase + 50 g blended apple	34.0	32.0	36.0	34.0	

(a) State the independent variable and dependent variable of this experiment. (2 marks)

(b) Why are three trials better than one trial? (1 mark)

(c) The enzyme solutions used in the experiment were at the same concentration. The prices of 0.5 mL pectinase and 0.5 mL cellulase were $13 and $7 respectively. Complete the above table to show the cost of enzyme(s) for producing 1 mL of apple juice. (2 marks)

(d) Based on the answer in (c), which is the most cost-effective means for producing apple juice? (1 mark)

(e) Explain why the apple juice collected from Beaker D is clearer than that from Beaker A. (1 mark)

DSE M.C. Questions - Basic genetics and Molecular genetics
(sort by difficulty)

Challenging

2012 Q.19 (31%)

The tRNA anticodon for the sequence AGT on the coding strand of DNA is

A. UCA. B. AGU. C. TCA. D. AGT.

2013 Q.11 (35%)

Which of the following statements about codons is correct?

A. A codon may consist of bases A, C, G or T.
B. A codon is a triplet of bases on transfer RNA.
C. Most amino acids are coded by more than one codon.
D. All codons code for amino acids.

2014 Q.11 (31%)

Directions: Questions 10 and 11 refer to the following two crosses of fruit flies. In a fruit flies, male are the heterogametic sex (XY) and the wing shape (normal wing or cut wing) is controlled by a single gene.

	Cross I	***Cross II***
Parents	Normal wing female x Cut wing male	Cut wing female x Normal wing male
F_1	12 normal wing females 11 normal wing males	11 normal wing females 11 cut wing males
F_2	71 normal wing females 34 normal wing males 35 cut wing males	32 normal wing females 33 cut wing females 36 normal wing males 38 cut wing males

From Cross II, we can conclude that

A. the gene for the wing shape is located on the X-chromosome because the cut wing phenotype was passed from the female parent to the F_1 males.
B. the law of independent assortment was demonstrated because new phenotypes, including normal wing females and cut wing males, were found in F_2.
C. the normal wing male parent is heterozygous because four combinations of phenotypes were observed in F_2.
D. the gene for the wing shape is located on an autosome because a ratio 1:1:1:1 was shown in F_2.

Challenging

2014 Q.19 (14%)

Which of the following is ***not*** an application of DNA fingerprinting?

A. Forensic science
B. Screening for genetic diseases
C. Sequencing of the human genome
D. Identification of Chinese medicines

2016 Q.4 (33%)

Which of the following parts of the nucleotide make up the backbone of a polynucleotide strand?

A. sugar and base
B. sugar and phosphate
C. base and phosphate
D. base, sugar and phosphate

2018 Q.12 (39%)

Directions: Questions 12 and 13 refer to the information below. Kathy had two pure-bred cats, one had long white fur while other had short black fur. It is known that fur colour are controlled by two different genes respectively. The two cats gave birth to four kittens which had long black fur.

Which of the following conclusions can be drawn based on the above case?

(1) Long fur is dominant over short fur
(2) The four kittens have the same genotype for fur length and fur colour
(3) The genes controlling fur length and fur colour are located on different chromosomes

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

Average

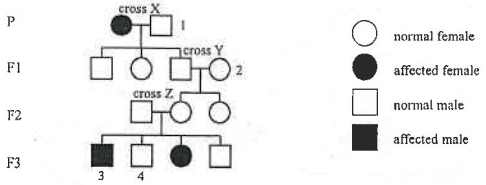
2012 Q.15 (63%)

Identical twins have the same

(1) genotype.
(2) traits involving continuous variations.
(3) traits involving discontinuous variations.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1),(2) and (3)

Directions: Questions 15 to 17 refer to the pedigree below, which shows the inheritance of a certain trait controlled by a pair of alleles located on an autosome (i.e. non-sex chromosome):



2013 Q.15 (47%)

Which cross(es) can be used to deduce which phenotype is dominant?

A. cross Y only B. cross Z only C. crosses X and Y only D. crosses X and Z only

2013 Q.16 (55%)

What are the probable genotypes of individuals 1 and 2?

	Individual 1	***Individual 2***
A.	homozygous	homozygous
B.	homozygous	homozygous or heterozygous
C.	homozygous or heterozygous	homozygous
D.	homozygous or heterozygous	homozygous or heterozygous

2013 Q.17 (71%)

If individual 3 and 4 are twins, which of the following conclusions can be drawn?

A. They are developed from the same fertilized egg.
B. They are developed from different fertilized eggs.
C. They are genetically different for characters displaying continuous variation.
D. They are genetically different for characters displaying discontinuous variation.

Average

2014 Q.10 (50%)

Directions: Questions 10 and 11 refer to the following two crosses of fruit flies. In a fruit flies, male are the heterogametic sex (XY) and the wing shape (normal wing or cut wing) is controlled by a single gene.

	Cross I	*Cross II*
Parents	Normal wing female x Cut wing male	Cut wing female x Normal wing male
F_1	12 normal wing females	11 normal wing females
	11 normal wing males	11 cut wing males
F_2	71 normal wing females	32 normal wing females
	34 normal wing males	33 cut wing females
	35 cut wing males	36 normal wing males
		38 cut wing males

Which of the following observations from Cross I best supports the conclusion that normal wing is the dominant phenotype?

A. All the F_1 individuals are normal wing.
B. The ratio of normal wing individuals to cut wing individuals in F_2 is 3:1.
C. There are more normal wing individuals that cut wing individuals in the F_2.
D. Normal wing males are more or less the same in number as cut wing males in the F_2.

2014 Q.16 (71%)

Which of the following biomolecules are associated with transcription?

(1) DNA
(2) mRNA
(3) amino acid

A. (1) and (2) only B. (1) and (3) only C. (2) and (3) only D. (1), (2) and (3)

2017 Q.9 (53%)

If the base sequence on the coding strand of the DNA is AAC, which of the following combinations correctly shows the mRNA codon and the tRNA anticodon?

	mRNA codon	*tRNA anticodon*
A.	AAC	UUG
B.	AAC	TTG
C.	UUG	AAC
D.	TTG	AAC

Average

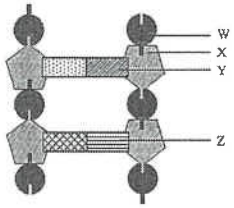
2018 Q.28 (63%)

The DNA model proposed by Watson and Crick leads to the understanding of how

A. Organisms store genetic codes
B. Organisms share a common ancestor
C. Cells produce instructions for protein synthesis
D. Cells can pass genetic information to the next generation

2019 Q.13 (45%)

The diagram below shows a DNA model:



Which of the following combinations shows the most probable identities of molecules W, X, Y and Z?

	W	**X**	**Y**	**Z**
A.	sugar	phosphate	cytosine	thymine
B.	sugar	phosphate	cytosine	guanine
C.	phosphate	sugar	adenine	thymine
D.	phosphate	sugar	adenine	guanine

2019 Q.14 (63%)

In the family, the father is red-green colour blind (a recessive X-linked trait) and is of blood group A, while the mother has normal vision and is of blood group B. Which of the following could be phenotypes of their biological child?

(1) A normal-vision girl with blood group O
(2) a red-green colour blind girl with blood group O
(3) a red-green colour blind boy with blood group AB

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

Easy

2012 Q.18 (78%)
Which of the following descriptions about transcription is correct?

A. tRNA pairs with ribosome to produce amino acids.
B. mRNA pairs with ribosome to produce proteins.
C. Free DNA nucleotides pair with DNA template strand to produce DNA.
D. Free RNA nucleotides pair with DNA template strand to produce mRNA.

2013 Q.4 (81%)
For different DNA nucleotides, the part that varies from one to another is the

A. base.
B. ribose.
C. deoxyribose.
D. phosphate group.

2013 Q.12 (80%)
The DNA of a eukaryotic cell contains 20% adenine (A) bases. What is the percentage of cytosine (C) bases in this DNA?

A. 60%
B. 40%
C. 30%
D. 20%

2013 Q.13 (84%)
A man and his wife are heterozygous for blood type A and B respectively. What is the probability of their son having blood type AB?

A. 0
B. 1/4
C. 1/2
D. 3/4

Easy

2014 Q.12 (80%)
Which of the following combinations of blood groups of parents may produce offspring with blood groups of parents may produce offspring with blood group AB?

(1) A x B
(2) AB x O
(3) AB x AB

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

2014 Q.13 (83%)
The average height of men in a developed country rose by 10 cm between 1890 and 1980. Which of the following is the most probable reason for this observation?

A. Chemical pollution induced mutations leading to the increase in height.
B. Spontaneous mutation resulted in a shift to taller height.
C. The better nutrition supply promoted growth.
D. A taller height had a better chance of survival.

2015 Q.16 (88%)
Variation in skin colour exists among different human races. Which of the following factors plays the major role in determining this variation?

A. exercise
B. nutrition
C. inheritance
D. exposure to sunlight

Easy

2017 Q.8 (79%)

In humans, blood group B is dominant to blood group O. In a family, the father and mother are of blood groups O and B respectively. They have two children who are of blood group B. The father concludes that his wife must be homozygous for blood group B. Is this conclusion correct?

A. No, because there are other blood groups besides blood groups B and O.
B. No, because even if the mother is heterozygous, each child has a 50% chance to be of blood group B.
C. Yes, because the father has no allele for blood group B, all alleles for blood group B must have come from the mother.
D. Yes, because if the mother is heterozygous, one child should be of blood group B and the other should be of blood group O.

2018 Q.13 (77%)

Directions: Questions 12 and 13 refer to the information below. Kathy had two pure-bred cats, one had long white fur while other had short black fur. It is known that fur colour are controlled by two different genes respectively. The two cats gave birth to four kittens which had long black fur.

After the kittens had grown up, they interbred and gave birth to the second filial generation (F2). Among the F2 kittens, there was one with short white fur. Which of the following processes mostly likely contributed to the occurrence of this new phenotype?

(1) Mutation
(2) Random fertilization of gametes
(3) Independent assortment of chromosomes

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

2020 Q.19

19. Which of the following descriptions of the molecular structure of DNA proposed by Watson and Crick is correct?

A. The two chains run in opposite directions.
B. The bases link up the nucleotides to form a chain.
C. The sugar that makes up nucleotides has two types.
D. The phosphate that makes up nucleotides has at least four types.

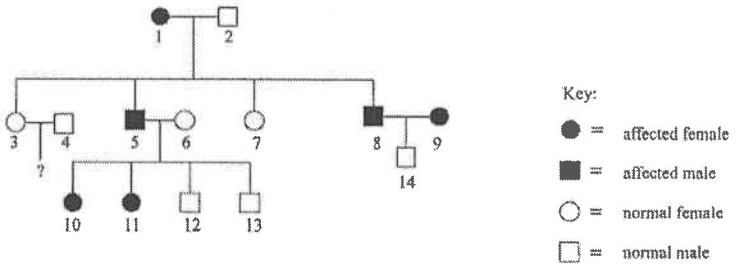
2020 Q.20

20. The amount of DNA in cell P immediately before mitosis is x. After division, there are 4 chromosomes in each daughter cell. Which of the following descriptions is correct?

A. The amount of DNA in the daughter cell is 0.5 x.
B. The amount of DNA in each chromosome is 0.25 x.
C. There are 8 chromosomes in the diploid state of cell P.
D. There are 8 chromosomes in cell P immediately before division.

2020 Q.35

Directions: Questions 35 and 36 refer to the pedigree below, which shows the inheritance of a genetic disorder.



35. Which of the following combinations correctly shows the possible types of inheritance of this disorder?

	Autosomal dominant	*Autosomal recessive*	*X-linked dominant*	*X-linked recessive*
A.	✓		✓	
B.	✓			✓
C.		✓	✓	
D.		✓		✓

2020 Q.36

36. What is the probability of individual 3 and individual 4 giving birth to a normal male?

A. 0
B. 0.25
C. 0.5
D. 1

2020 Q.17

17. 'Transgenic organisms produced by recombinant DNA technology have more potential in terms of evolution than those produced by traditional breeding.'

Which of the following is the best reason for this?

A. Recombinant DNA technology creates new species.
B. Recombinant DNA technology produces new phenotypes.
C. Recombinant DNA technology transfers genes within a species.
D. Recombinant DNA technology transfers genes between different species.

2020 Q.18

Directions: Questions 18 and 19 refer to the following passage about the discovery of DNA structure:

> Many scientists tried to uncover the structure of DNA. In 1952, Franklin took the first X-ray photograph of DNA, which revealed its helical shape. Her colleague, Wilkins, showed some of Franklin's unpublished findings to Watson without her knowledge. Shortly after, Watson and Crick made a crucial advance when they proposed that the DNA molecule was made up of two chains of nucleotides paired to form a double helix. In 1962, Watson, Crick and Wilkins were awarded the Nobel Prize.

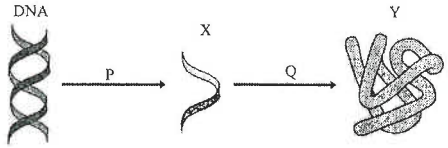
18. Which of the following aspects of the Nature of Science can be exemplified in the above story?

(1) A good scientific experiment must include carefully designed controls.
(2) Scientists are both collaborative and competitive by nature.
(3) Doing science requires imagination and creativity.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

2021 Q1,2,3,11,12,13,14,15,16,17

Directions: Questions 1 to 3 refer to the diagram below, which shows the flow of gene expression within a cell:



1. X represents

A. a transfer RNA.
B. a DNA template.
C. a ribosomal RNA.
D. a messenger RNA.

2. Y could be

(1) an enzyme.
(2) a hormone.
(3) an antibody.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

3. Which of the following combinations correctly states what process P is and where process Q takes place?

	What process P is	*Where process Q takes place*
A.	translation	cytoplasm
B.	translation	nucleus
C.	transcription	cytoplasm
D.	transcription	nucleus

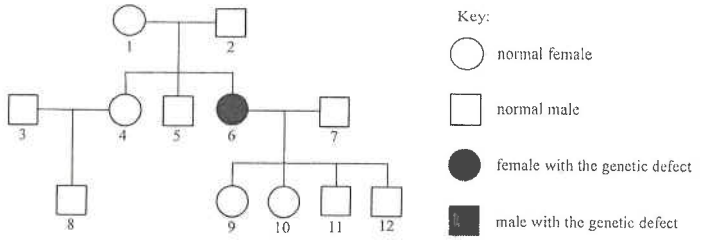
11. The human ABO blood group system is controlled by multiple alleles. Alleles I^A and I^B lead to the presence of antigens A and B on the surface of red blood cells respectively. Allele i leads to the absence of antigens A and B on the surface of red blood cells. How many genotypes are involved in the ABO blood group system?

A. 3
B. 4
C. 6
D. 8

12. A pair of identical twins were adopted by two different families. After the twins grow up, which of the following descriptions about them will most likely apply?

A. They have different shapes of earlobe.
B. They have the same pattern of fingerprint.
C. They have different degrees of short sightedness.
D. They have the same number of freckles on their faces.

Directions: Questions 13 to 15 refer to the pedigree below, which shows the inheritance of a certain genetic defect controlled by a pair of alleles.



13. The phenotype of individual 6 can be explained by the fact that this individual received a defective allele on

A. an autosome from each parent.
B. the Y chromosome from the father.
C. an X chromosome from the mother.
D. an X chromosome from each parent.

14. The offspring of individuals 6 and 7 are normal because each receives a

A. normal allele from the father.
B. normal allele from each parent.
C. defective allele from the father.
D. defective allele from the mother.

15. Which of the following correctly shows the possible genotype(s) of individual 8?

A. heterozygous only
B. homozygous dominant only
C. homozygous recessive only
D. homozygous dominant and heterozygous

16. In the crossing of a red-flowered plant with a white-flowered plant, half of the F1 offspring were red-flowered and the other half were white-flowered. When the F1 white-flowered plants were self-crossed, all the F2 offspring were white-flowered. What can be concluded?

A. The red-flowered parental plant was homozygous.
B. The white-flowered parental plant was heterozygous.
C. White flower is the dominant character in this species of plant.
D. Red flower is the dominant character in this species of plant.

17. Although Mendel proposed that the characteristics of the pea plants were controlled by a pair of 'heredity factors', it was not recognised during his lifetime. His idea was later accepted in the early 20th century because it was supported by

A. the theory of natural selection.
B. the same patterns of inheritance in fruit flies.
C. the behaviours of chromosomes in cell division.
D. the discovery of the double helix structure of DNA.

Answers

Challenging

2012	2013	2014	2016	2018
19 [A]	11 [C]	11 [A]	4 [B]	12 [A]
		19 [C]		

Average

2012	2013	2014	2017	2018	2019
15 [B]	15 [B]	10 [B]	9 [A]	28 [A]	13 [D]
	16 [D]	16 [A]			14 [D]
	17 [B]				

Easy

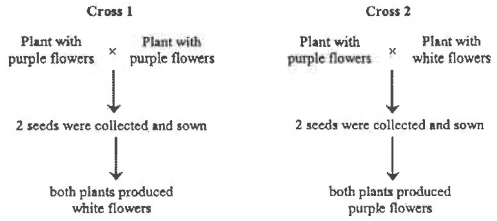
2012	2013	2014	2015	2017	2018
18 [D]	4 [A]	12 [B]	16 [C]	8 [B]	13 [C]
	12 [C]	13 [C]			
	13 [B]				

2020
17[D]
18[C]
19[A]
20[A]
35[A]
36[D]

Past Papers – Basic Genetics

CE- 2003

2. (a) Individuals of a certain type of plant produce either purple or white flowers. The flower colour is controlled by a pair of alleles. A gardener carried out two crosses with this type of plant and the results are shown below:



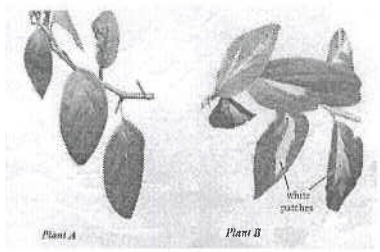
(i) Based on cross 1, deduce the dominant flower colour. Explain your deduction. (5)
(Marks will not be awarded for genetic diagrams.

(ii) Use symbols to show the possible genotypes of the parents in cross 2.
Define the symbols you use. (3)

(iii) If the purple-flower parent in cross 2 was self-pollinated (i.e. the stigma receives pollen grains from the same plant) and a large number of offspring was produced, predict the phenotypes of the offspring and their ratio. (3)

CE- 2004

3. (a) The following pictures show two plants of the same species. Plant A has green leaves. Plant B is a new form recently discovered by a scientist; it has variegated leaves.
The scientist performed an experiment by self-crossing plant A. A large number of offspring were obtained and they all produced green leaves. He then repeated the same procedure with plant B and all the offspring produced variegated leaves.



(i) Assuming that the colour pattern of the leaves is controlled by a pair of alleles, what deductions can be made from the above results regarding the genotypes of plants A and B ? Explain how you arrive at your deductions. (3)
(Marks will not be awarded for genetic diagrams,)

(ii) In order to find out which colour pattern is dominant, the scientist performed another experiment by crossing plant A with plant B. Explain how the results of this cross would enable him to determine the dominant phenotype. (3)

(iii) The white patches on the leaves of plant B might be caused by mineral deficiency instead of genetic changes.
If this is the case, what mineral is likely to be deficient ? What is the function of this mineral in plants ? (2)

CE - 2005

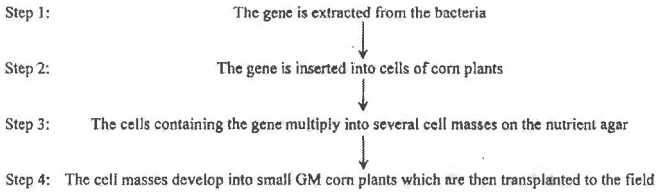
2. Complete the following paragraph with suitable words selected from the list below:

Chromosome	diploid	dominant	embryo	gamete
Haploid	heterozygote	homozygote	meiotic cell division	mitotic cell division
Mutation	protein	recessive		

Genes are the basic units of inheritance. They are carried on the (a)_____ in the nucleus of a cell. A gene may exist in different forms called alleles. When an organism contains two different alleles of the same gene, it is described as a (b)_____ and the allele that expresses itself is said to be (c)_____. During reproduction, some cells in the sex organs undergo (d)_____. During this process, the alleles in these cells separate from each other and every (e)_____ thus formed will possess only one allele for each gene. After fertilization, the zygote formed will contain alleles occurring in pairs and its chromosome number will become (f)_____.

CE- 2006

4. Long ago, scientists discovered that a certain kind of soil bacteria can produce a protein that is toxic to insects. The scientists intended to transfer the gene coding for this protein to crop plants, so as to reduce the damage of crops by insects. In 1995, the US first developed such a genetically modified (GM) corn plant containing this gene. The flowchart below outlines the development of the GM corn plant:



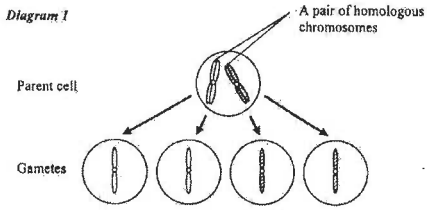
(a) Name the type of cell division that is involved in step 3. State the significance of this type of cell division in the production of the GM corn plants. (2)

(b) Discuss briefly one consequence of cultivating this GM corn plant in the field to the surrounding ecological community. (2)

(c) To improve the quality of food produced, state another character of cultivated plants that scientists would modify besides the insect-resistant character. Give an advantage of this genetic modification. (2)

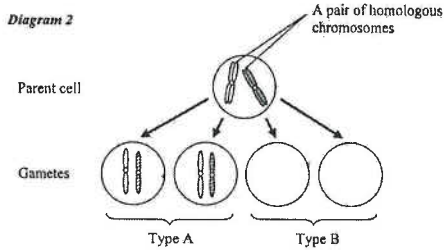
CE - 2006

8. (b) Diagram 1 below shows the result of meiotic cell division in gamete formation in humans: (Note : Only one pair of homologous chromosomes is shown.)



(i) Based on Diagram 1, give two features that are characteristic of meiotic cell division. (2)

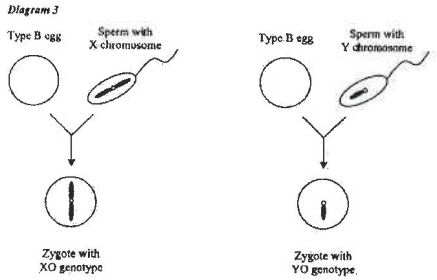
(ii) Sometimes, an abnormality occurs during meiotic cell division in gamete formation in humans. Diagram 2 below shows the abnormality concerning a pair of homologous chromosomes :



(1) Distinguish between type A and type B gametes. (1)

(2) Name a genetic disorder that will develop if a type A egg is fertilized successfully by a normal sperm. (1)

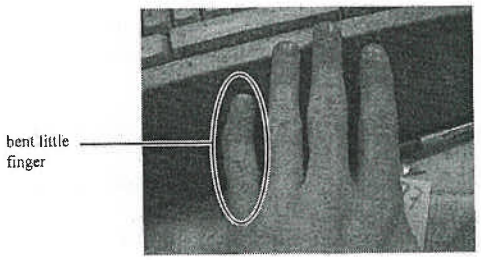
(3) This type of abnormality in cell division may occur in the sex chromosomes. The type B eggs may fertilize with normal sperms to form zygotes with different genotypes as shown in Diagram 3 below:
(Note: Only the sex chromosome is shown.)



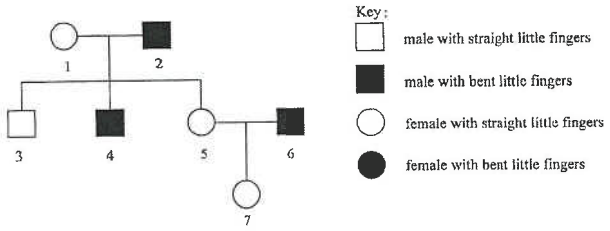
Suggest why zygotes with XO genotype may develop into an individual but not those with YO genotype. (3)

CE - 2007

5. The shape of the human little finger can be straight or bent. The photograph below shows a hand with a bent little finger:



The inheritance of the shape of the little finger is controlled by a pair of alleles. The following pedigree shows the inheritance of this trait in a family:



(a) After studying the pedigree, a student could not determine which little finger shape is dominant. However, he drew the following conclusion.

'Either individual 1 or 2 must be heterozygous.'

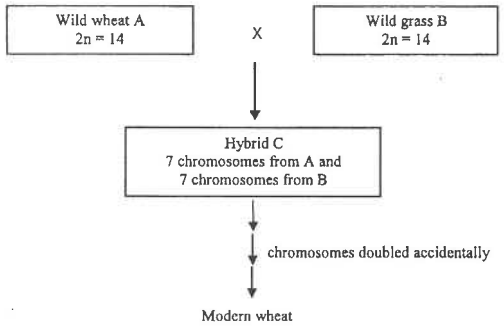
Do you agree with this conclusion? Explain your answer with reference to the role of gametes in inheritance. (3 marks)

(b) Provided that the allele for the bent little fingers is dominant, deduce the possible genotype(s) of individual 4. (4 marks)
(Marks will not be awarded for genetic diagrams.)

(c) Individuals 5 and 6 are going to have another child. What is the probability of their second child having straight little fingers? Illustrate your answer with a genetic diagram. (5 marks)

CE- 2008

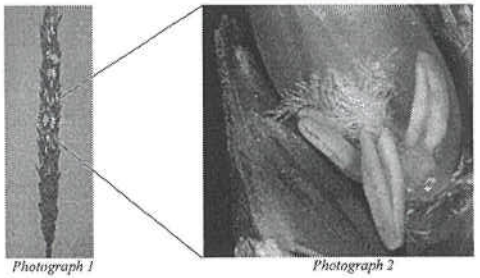
9. (a) A study of the wheat genome reveled that modern wheat is originated from the crosses among wild wheat and wild grasses. Below is one of the crosses.



(i) Hybrid C cannot produce gametes but it can produce offspring asexually. State the type of asexual reproduction employed by hybrid C. (1)

(ii) With reference to the process of meiotic cell division, suggest why hybrid C cannot produce gametes. (2)

(iii) The following photographs show the reproductive structures of wheat.



Photograph 1 *Photograph 2*

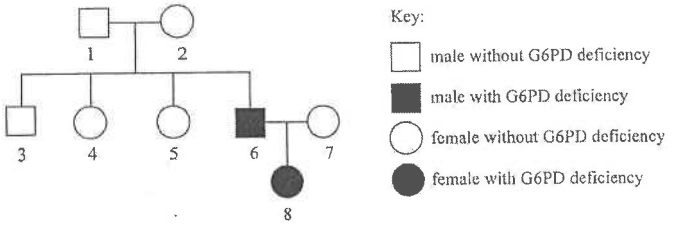
(1) What is the pollinating agent for wheat? Support your answer with two observable features from photograph 2. (3)

(2) A scientist performed a genetic experiment by crossing two different wheat plants. Describe the procedures done in order to ensure cross-pollination, but not self pollination to occur. (3)

CE-2009

3. (a) Glucose-6-phosphate dehydrogenase (G6PD) deficiency is an inherited disorder. People with G6PD deficiency will experience a massive destruction of red blood cells when exposed to certain drugs.

It is known that G6PD deficiency is controlled by a pair of alleles. The pedigree below show the inheritance of this trait in a family:



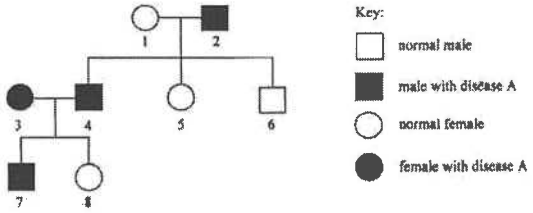
(i) Provided that the allele causing G6PD deficiency is recessive, deduce the possible genotype(s) of individual 7. (4 marks)
(Marks will ***not*** be awarded for genetic diagrams.)

(ii) Individuals 6 and 7 are going to have another child. What is the probability of their second child having G6PD deficiency? (1 mark)

(iii) Is the blood of individual 6 suitable for use in blood transfusion? Justify your answer. (1 mark)

CE - 2010

9. (a) Disease A is a kind of genetic disorder. Its occurrence is controlled by a pair of alleles. The following pedigree shows the inheritance of disease A in a family.



(i) Based on the pedigree above, a student deduced that the allele for disease A is dominant. Explain how he arrived at his answer. (Marks will ***not*** be awarded for genetic diagrams.) (4)

(ii) Individual 8 is going to marry a male heterozygous for disease A. What is the probability of their first child having disease A? (1)

(iii) Using the information in the pedigree for individuals 2, 5 and 6, explain why it is not possible for the allele of disease A to be located on the X chromosome or the Y chromosome. (4)

AL - 2001 2A

3. (a) Contrast the genetic control of ABO blood group and that of red-green colour blindness in humans (5)

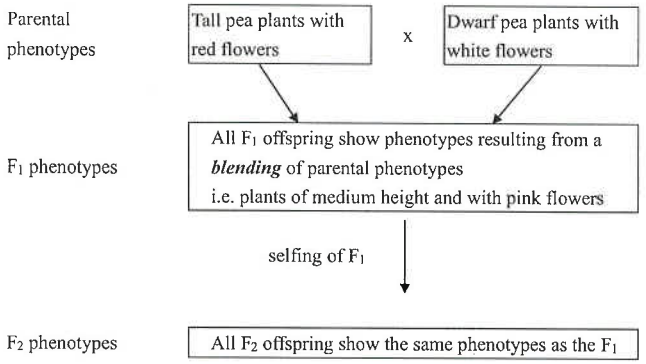
(b) When a man, Tom, of blood group A marries a woman, May, of blood group O, deduce the chances that a child of blood group A would be born to this couple. Use genetic diagram(s) to show your deduction. (7)

AL - 2005 2A

2. The experiments done by Gregor Mendel in the 19th century have led to the replacement of the old concept of heredity, i.e., the Blending Theory, and have given insights to the nature and physical basis of the hereditary materials involved.

In pre-Mendelian times, people observed that children look like both their mother and father. Thus the Blending Theory, which asserted that in inheritance, parental traits were mixed in the offspring, was proposed to explain this observation. However, when the Blending Theory is applied to Mendel's dihybrid experiments, it cannot account for the variations in the offspring.

The following flowchart illustrates the ***hypothetical*** results when the Blending Theory is applied to the inheritance of ***two qualitative traits***:



a. i. With reference to the above flowchart, how do the actual results of Mendel's experiments disprove the Blending Theory? (5)

ii. How do Mendel's laws of inheritance explain the results of his experiments? (4)

b. The ***design*** of Mendel's experiments contributed to his success. Give ***two*** reasons why the ***design*** of his experiments made his findings valid and reliable. (4)

c. In terms of present day knowledge, describe what Mendel's 'hereditary factors' are in diploid organisms and explain the physical basis of the activity of these 'factors' during gamete formation. (4)

AL - 2006 1A

6. A man of blood group A married a woman of blood group B. They have a son and a daughter. The blood group of the son is O.

(a) What is / are the possible blood group(s) of the daughter? Use a genetic diagram to show how you arrive at your answer. (4)
(Use I^A, I^B and i to represent the three alleles that determine the ABO blood groups in humans.)

(b) Explain whether the son can receive blood transfusion from his father. (3)

DSE-2012 1B

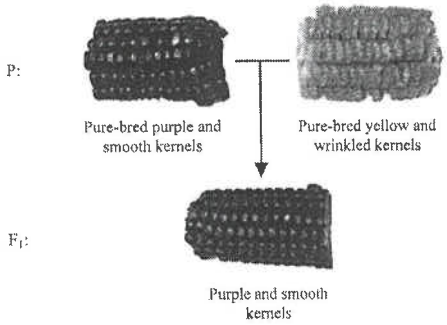
8. The photograph below shows the appearances of some kernels of a corn:

Kernel	Appearance
A	Purple and smooth
B	Purple and wrinkled
C	Yellow and smooth
D	Yellow and wrinkled

The purple colour is produced by a pigmented layer within the kernels. If the layer is not pigmented, the yellow colour of the inner tissue becomes visible. Whether the kernel is smooth or wrinkled is due to the type of food stored inside it. Smooth kernels (starchy corn) store starch while wrinkled kernels (sweet corn) store soluble sugars. The surface of the sweet corns becomes wrinkled when the corn dries up.

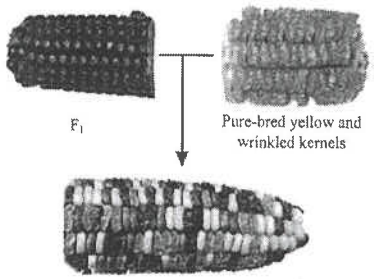
(a) With reference to osmosis, explain why the kernels of sweet corn become wrinkled when they dry up but the kernels of starchy corn remain smooth. (4 marks)

(b) The two traits of the kernels are controlled by genes located on different homologous chromosomes. The following diagram shows the result of a cross between two pure-bred corn plants, one with purple and smooth kernels and the other with yellow and wrinkled kernels:



(i) Based on the results of the cross, deduce which phenotypes are dominant. (3 marks)

3 (ii) The F1 generation produced was crossed with pure-bred corn plants with yellow and wrinkled kernels, as shown below:



Explain the results of the cross using Mendel's law of inheritance. (4 marks)
(Marks will not be awarded for genetic diagrams.)

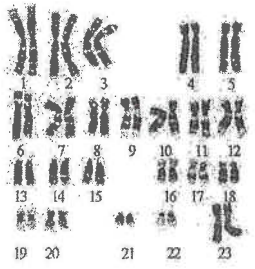
(c) When Mendel proposed how traits are inherited, chromosomes had not yet been discovered. In your opinion, how did Mendel come up with his hypothesis? (3 marks)

DSE - 2013 1B

4. Red-green colour blindness is an X-linked recessive trait in humans. Peter is red-green colour blind while his daughter, Mary, is normal.

(a) Deduce Mary's genotype without using a genetic diagram. (4 marks)

(b) Mary is an expectant mother. The photomicrograph below shows the karyotype of her foetus:

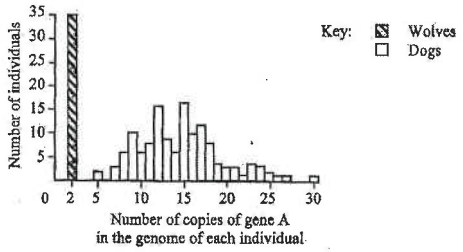


(i) From the photomicrograph, can we deduce whether this foetus will be red-green colour blind or not? Explain your answer. (2 marks)

(ii) Is the foetus a boy or a girl? Explain your answer with reference to the photomicrograph. (3 marks)

DSE - 2014 1B

6. It is generally believed that domestic dogs evolved from ancient wolves. A recent study comparing the genomes of wolves and dogs suggests that genes with key roles in starch digestion were selected during the domestication of wolves into dogs. One of these genes was gene A, which codes for amylase. This gene may exist in many copies in a genome. The following graph shows the number of individuals having different numbers of copies of gene A in 35 wolves and 136 dogs:



(a) Based on the data above and the gene expression processes, explain why the amylase activity in dogs is generally higher than that in wolves. (3 marks)

(b) It is hypothesized that in ancient times, wolves might have been attracted to waste dumps near early human settlements and consumed human food waste. Suggest how the domestication of wolves would have led to the selection of multiple copies of gene A. (5 marks)

DSE – 2015 1B

4. Roger is found to be suitable for donating blood to recipients with blood types different from his own. However, he cannot receive a blood transfusion from his parents. The blood types of his father and mother are A and B respectively.

(a) What is Roger's blood type? (1 mark)

(b) Given that:

I^A represents the allele for producing antigen A on the surface of red blood cells
I^B represents the allele for producing antigen B on the surface of red blood cells
i represents the allele that does not lead to the production of any antigens on the surface of red blood cells

(i) Using the above symbols, state Roger's genotype. (1 mark)

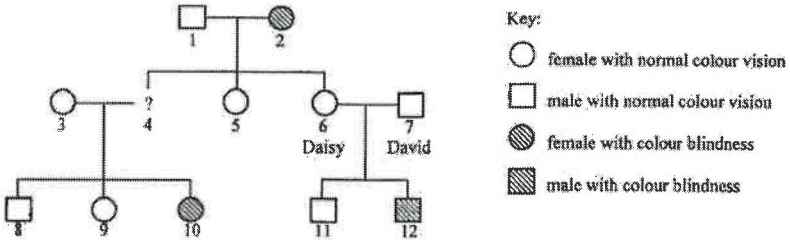
(ii) Using the above symbols, state the genotypes of his parents. (2 marks)

Father:_____ Mother:_____

(c) Explain why Roger cannot receive blood transfusions from his parents. (3 marks)

DSE – 2016 1B

10. Colour blindness is an X-linked recessive genetic disorder. The pedigree below shows the inheritance of colour blindness in a family:



(a) Colour blindness is due to the abnormal development of photoreceptors. State the relevant type of photoreceptors and the location inside the eyeball where these photoreceptors are most abundant. (2 marks)

(b) Given that the dominant allele of colour vision is represented by R while the recessive allele is represented by r, determine all the possible genotypes and phenotypes of the offspring of individuals 1 and 2 using a genetic diagram. (5 marks)
(Note: Punnett square is not accepted)

(c) Draw all possible representation(s) for individual4 with reference to the key of the pedigree. (1 mark)

(d) Daisy (individual 6) has recently given birth to a baby girl. Since one of her sons suffered from colour blindness (individual 12), Daisy worried that their daughter would have colour blindness too. David (individual 7) reassured her by saying that: Don't worry. Our daughter will be fine because I have normal colour vision! Justify David's claim. (5 marks)
(Note: Marks will not be awarded for genetic diagrams.)

HKDSE - 2017 1B

10. a. In 1940, scientist Alfred Sturtevant hypothesised that the ability to roll one's tongue is determined by a single gene. His hypothesis was based on the data below:

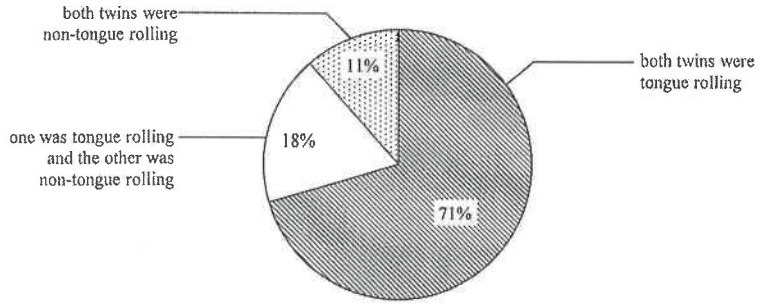
Case	Characters of parents	Tongue rolling offspring	Non-tongue rolling offspring
I	tongue rolling x tongue rolling	28	5
II	tongue rolling x non-tongue rolling	33	22

i. Does the trait of tongue rolling ability show continuous or discontinuous variation? Explain your answer. (2 marks)

ii. Sturtevant concluded that tongue rolling is the dominant phenotype while non-tongue rolling is the recessive phenotype. With reference to the above table, explain how he arrived at this conclusion. (2 marks)

b. In 1965, the offspring of a group of non-tongue rolling parents were studied. It was found that more than 30% of the offspring were tongue rollers. Does this finding support Sturtevant's conclusion in (a)(ii)? Explain your answer. (2 marks)

c. In 1971, another study on identical twins was carried out to further explore the factors influencing the tongue rolling trait. The results are summarized in the chart below:



i. What is the advantage of using identical twins as the subjects for the study?(2 marks)

ii. With reference to the above chart, complete the following table with data that support the conclusion. (2 marks)

Conclusion	Evidence
Genetic factors play a significant role in the determination of the tongue rolling trait	
There are other factors influencing the tongue rolling trait	

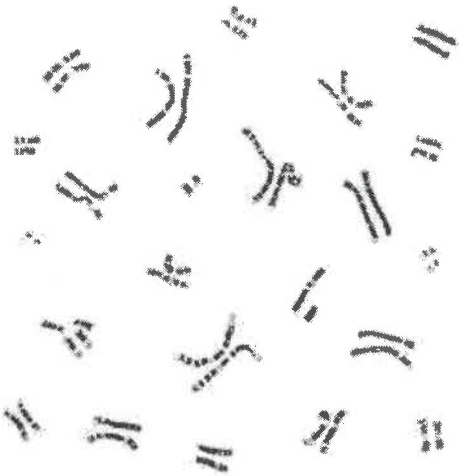
d. i. In the above case regarding the development of knowledge about the inheritance of the tongue rolling trait, which of the following ideas about science is demonstrate? (2 marks)

Ideas about science	Put a '✓' in the appropriate spaces below
Science is a process of ongoing inquiries.	
Science is affected by social and cultural factors.	
Scientists may not arrive at the same conclusions about the same set of data	
Scientific investigations may not require doing experiments in laboratories	

ii. Elaborate on how the development of knowledge about the inheritance of the tongue rolling trait can be used to demonstrate that scientists have to be open-minded. (1 mark)

HKDSE - 2018 1B

5. The photomicrograph below shows the paired homologous chromosomes of a normal boy for karyotyping:



(a) Circle the sex chromosomes on the above photograph.

(b) State the type of cells, somatic cells or gametes, from which the karyotype was obtained. Explain your answer. (2 marks)

(c) It is commonly thought that the sex of offspring is mainly determined by the mother. Explain why this is no/true. (3 marks)

6. Hong Kong Red Cross Blood Transfusion Service keeps stocks of different blood groups to ensure that there is enough blood supply for transfusion in hospitals.

(a) Of all the blood groups, blood group O is in greatest demand in the Accident and Emergency Departments of hospitals. Suggest why the demand for blood group O is the greatest. (3 marks)

(b) The table below shows some recommendations for adult female and male donors:

	Female donors	Male donors
Maximum number of donations in a year	4	5
Interval between donations	No less than 105 days	No less than 75 days

Suggest why there are different recommendations for female and male donors. (3 marks)

9. Although most DNA is stored in the nucleus, mitochondria also have a small amount of their own DNA. The mitochondrial DNA contains some genes coding for enzymes which are essential for oxidative phosphorylation. Mutations of these mitochondrial genes cause Leigh syndrome, which is rare and fatal metabolic disease.

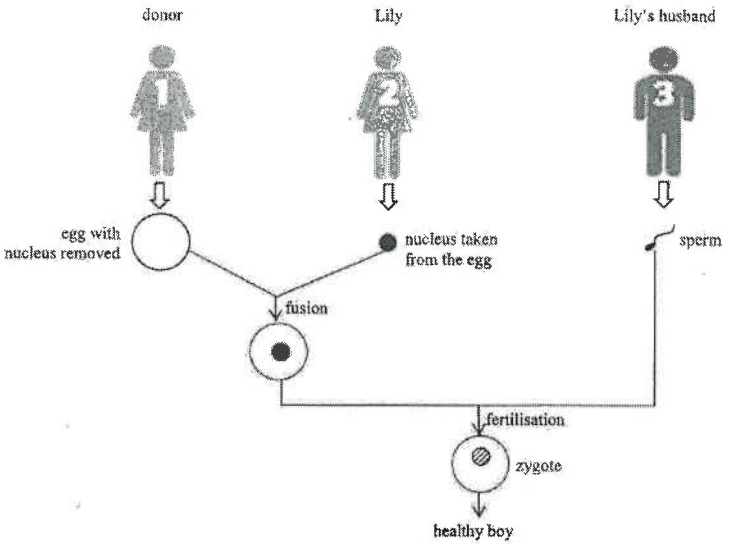
(a) Explain why gene mutations in the mitochondrial DNA can effect oxidative phosphorylation. (4 marks)

(b) What are the major products of oxidative phosphorylation? State their significance. (4 marks)

(c) Lily had two children who died from Leigh syndrome. It was found that her eggs contained mutated mitochondrial genes. Her children suffered from the disease because normally mitochondria in zygotes come from the eggs while sperms do not contribute any.

(i) With regard to the fertilization process and the structure of sperms, suggest why sperms do not contribute any mitochondria to zygotes. (1 mark)

(ii) By using a new method called the 'three-parent baby' technique, Lily gave birth to a healthy boy in 2016. Below are the main steps in the technique:



Identify the source(s) of DNA of the nucleus and mitochondria in the boy's cells. (2 marks)

Nucleus:

Mitochondia:

Past Papers Marking Scheme – Basic Genetics

CE- 2003 Q.2 (a)

(i) The offspring in cross 1 have white flowers, so they must have received at least one allele for white flower from either of the parents 1
Since both parents have purple flowers, each of them must carry at least one allele for purple flower 1
Thus at least one of the parents is heterozygous 1
In the heterozygous condition, only the dominant character is shown 1
Thus purple flower is the dominant character 1

(ii) F represents the allele for purple flower; f represents the allele for white flower 1
(accept other sets of symbols)
The possible genotypes of the purple-flower are FF or Ff 1 or 0
and that of the white-flower parent is ff 1

If gene is used instead of allele in (i) or (ii), deduct 1 mark

(iii) If the genotype of purple-flower parent is FF, all offspring will produce purple flowers 1
If the genotype if Ff, purple-flower offspring and white-flower offspring will be formed 1+
and they would be in the ratio of 3:1 1

CE- 2004 Q.3 (a)

(i) Plant A is homozygous for the green-leaf allele 1
Plant B is homozygous for the variegated-leaf allele 1
because all the offspring of each plant have the same phenotype as the parent 1

(ii) Both plants A and B are homozygous, but of different phenotypes 1
When they are crossed, all their offspring will be heterozygous 1
In heterozygous condition, the phenotype shown by the offspring is the dominant phenotype 1

Effective communication (c) *1*

(iii) Magnesium 1+
For the formation of chlorophyll 1

Or Nitrate 1+
For the formation of chlorophyll / protein 1

CE - 2005 Q.2

(a) chromosome 1
(b) heterozygote 1
(c) dominant 1
(d) meiotic cell division 1
(e) gamete 1
(f) diploid 1

CE - 2006 Q.4

(a) *mitotic cell division 1+
This ensures that all the GM corn plants produced carry the inserted gene / are genetically identical 1
(b) It may kill some other insects / lead to a drop in the insect population 1
thus resulting in the extinction of the species / reduction of biodiversity 1
or It may kill some beneficial insects 1
which may help the pollination of other plants 1
or If the corn grains are dispersed into the natural environment 1
the plants formed will outcompete / displace some other species 1
due to its resistance to insects 1
(c) Ability to fix nitrogen / nitrogen fixation 1
to increase nitrogen content of the food produced 1

CE - 2006 Q.8 (b)

(i) Four daughter cells are formed from a single parent cell,
The two members of a pair of homologous chromosomes are separated; / each goes to a different daughter cell
Each daughter cell contains the haploid number of chromosomes Any two 1,1

(ii) (1) Type A gamete has both members of the homologous pair, while type B gamete has none of that homologous pair 1
(2) *Down / Down's syndrome 1
(3) The X chromosome carries more genes than the Y chromosome 1
Absence of the X chromosome will result in the loss of more genes/alleles 1
that may be essential to the survival of the zygotes and its subsequent development 1

CE- 2007 Q.5

(a) Yes.
To produce offspring with different phenotypes 1
there must be two different combination of gametes 1
therefore, either one of the parents must be heterozygous, producing two types of gametes carrying different alleles 1

OR
The parents are of different phenotypes, hence, one of the parents must be homozygous recessive 1
To produce offspring with different phenotypes 1
the other parent must be heterozygous, producing two types of gametes carrying different alleles 1

(b) Individual 1 possesses straight little fingers, she must be homozygous recessive 1
and pass an allele for straight little fingers to individual 4 1
Individual 4 possesses bent little fingers, she must have at least one allele for bent little fingers 1
Hence, individual 4 is heterozygous 1

(c) Define symbol (S) 1
Let B be the allele for bent little fingers
and b be the allele for straight little fingers

HKDSE – 2017 1B

10. (a) (i)
- discontinuous trait (1)
- because there are distinctive categories with no intermediate categories (1) (2)

(ii)
- in case I, non-rolling offspring appeared even when both parents were tongue rollers (1)
- this shows that the allele for non-tongue rolling was masked in the **parents (1)**
hence, tongue rolling should be the dominant phenotype and non-tongue rolling should be the recessive phenotype

OR
- in case I, non-tongue rolling offspring must have inherited at least one allele for non-tongue rolling from at least one of their roller parents (1)
- however, both parents showed tongue rolling phenotype, i.e. non-tongue rolling phenotype was masked (1)
hence, tongue rolling should be the dominant phenotype and non-tongue rolling should be the recessive phenotype (2)

(b)
- no, it did not support the conclusion (1)
- if non-tongue rolling was the recessive phenotype, all the offspring of the non-tongue rolling parents would be non-tongue rollers (1)

OR

no, it did not support the conclusion (1)
tongue rolling offspring must have inherited at least one allele for tongue rolling from at least one of their non-tongue rolling parents, however, both parents showed non-tongue rolling phenotype, tongue-rolling should be recessive. (1+1)

(c) (i)
- the genetic composition of the identical twins is exactly the same (1)
- they should show the same phenotype / tongue rolling ability (1) if the trait is controlled by genetic factors (2)

(ii)

Conclusion	Evidence
Genetic factor plays a significant role in the determination of the tongue rolling trait.	82% of the identical twins showed same phenotype (1)
There are other factors influencing the tongue rolling trait.	18% of the identical twins showed different phenotypes (1)

(2)

Instructions to markers: (1) candidates must quote numerical data in this part (2) as the first evidence, candidates need to elaborate that two groups were identical twins with the same phenotype.

(d) (i)

Ideas about Science	
Science is a process of ongoing inquiries.	✓
Science is affected by social and cultural factors.	
Scientists having the same set of data may not arrive at the same conclusions.	
Scientific investigation need not necessarily be doing experiments in laboratories.	✓

(2)

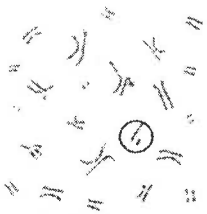
(deduct 1 mark for each mistake)

Instructions to markers:
Total 1 tick in the answer box, 1 correct tick (ONE mark) ; 1 incorrect tick (NO mark);
Total 2 ticks in the answer boxes, 2 correct ticks (TWO marks), 1 correct tick and 1 incorrect tick (ONE mark), 2 incorrect ticks (No mark);
Total 3 ticks, 2 correct ticks and 1 incorrect tick (ONE mark), 1 correct tick and 2 incorrect ticks (NO mark)
Total 4 ticks, NO mark

(ii)
- Scientists who conducted tongue rolling experiments in 1965 or 1971 should have been skeptical and have looked for evidence from different sources / perspectives (1) / have been ready to review / challenge current ideas / knowledge / theories (1)

13 marks

DSE - 2018

5. (a)
-  (1)

(b)
- somatic cells (1)
- because there are 2 sets of chromosomes / 46 chromosomes / 23 pairs of chromosomes (1) (1+1)

(c)
- mother will produce only one type of eggs with an X chromosome (1)
- father will produce two types of sperm cells, one with an X chromosome while another one with a Y chromosome (1)
- the sex of offspring will be determined by which type of sperm cells is involved in the fertilization (1), which is a random process (3)

6 marks

6. (a)
- the blood cells of blood group O contain neither antigen A nor B (1)
- therefore, it can be transfused to patients of any of the ABO blood groups / group O individuals are universal donors (1)
- it will be used for transfusion to other blood groups if there are not enough blood reserve for other blood groups, (1)
- the population of blood group O individuals is the largest of all blood groups in Hong Kong (1) (max. 3)

(b)
- male donors can donate blood more frequently than female donors or vice versa (1) because

Any *two* of the following:
- females have regular loss of blood (1)
- due to menstruation (1)
- compensatory production of blood cells after blood donation is faster in males (1) (3)

6 marks

9. (a)
- gene mutation involves alternation in the nucleotide / base sequence / triplet code in DNA of a single gene (1)
- polypeptide produced from the mutated gene has a different amino acid sequence (1)
- it folds into an enzyme with a different active site shape / 3D conformation (1)
- this enzyme can no longer function in the oxidative phosphorylation (1) / fail to produce a functional enzyme / active site of this enzyme can no longer fit the substrate (4)

(b)
- it regenerates NAD and FAD (1)
- which are important hydrogen carriers in glycolysis / Krebs cycle (1)
- it leads to the formation of ATP (1)
- which is an important energy source to support cellular activities / reactions (1) (4)

(c) (i)
- during fertilization, only the head of the sperm, which contains nucleus, will enter the egg / the middle piece of sperm, which contains mitochondria, will not enter the egg / be left outside the egg (1)
as a result, the sperm does not contribute any mitochondria to zygote (1)

(ii)
- Nucleus: from Lily and Lily's husband (1)
- Mitochondria: mainly from donor (1) (2)

11 marks

AL - 2003 2A

3. Crops that are drought resistant are economically desirable because they can survive well in environments that have a limited water supply, whereas crops that are drought sensitive cannot. Drought-resistant crops can produce a metabolite that can adjust the osmotic potential of the cell sap in the root.

(a) In drought conditions, explain how the root cells of the following plants response osmotically.

(i) drought-sensitive plants (2)

(ii) drought-resistant plants (2)

(b) In the drought-resistant plant, a gene encodes a key enzyme in the biosynthetic pathway of this metabolite. The nucleotide sequences of the drought-sensitive allele S and drought-resistant allele R are :

S : ATAAGCATGACATTA

R : ATAAGCAAGACATTA

(i) What is the nucleotide sequence of the mRNA for S? (2)

(ii) Using the universal codon table below, determine the amino acid sequence encoded by the allele S. (2)

(iii) How is allele R different from S? What difference would this make to the translated product? (3)

Universal codon table

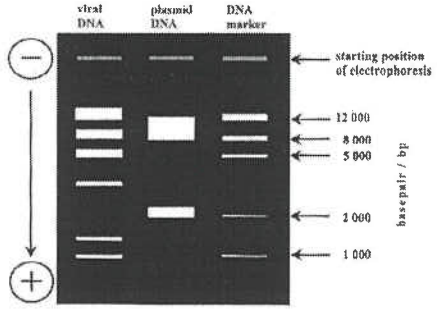
First base in the codon	Second base in the codon				Third base in the codon
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Glu	Arg	A
	Leu	Pro	Glu	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

(U, C, A and G stand for the 4 different bases in nucleotides.)

(The various amino acids are represented by their short forms in the table.)

AL - 2004 1B

11. Three DNA samples were used in the following analysis. These included linear viral DNA, plasmid DNA and DNA marker. The same amount of DNA from each sample was completely cut with a restriction enzyme. This was followed by gel electrophoresis where the DNA fragment moved from the negative to the positive pole. The gel was then stained with a dye so that bands containing DNA fragments could be visualized under ultra-violet light. The DNA marker has a known molecular size in basepair (bp). The marker served as a standard to measure the molecular size of DNA fragments. A photograph of the electrophoresis pattern is shown below:



(N.B. Assume that within the same band, the DNA fragments have homogeneous molecular size and identical nucleotide sequence.)

(a) Based on the pattern shown, determine the number of sites that can be cut by the restriction enzyme in the

(i) plasmid DNA (1)

(ii) linear viral DNA (1)

(b) Based on the pattern shown, the molecular size of the DNA marker is 28 000 bp (found by the sum of the molecular size of its DNA fragments). What is the molecular size of the plasmid DNA? Show your calculation.

(N.B. Assume that the molecular size of an individual DNA fragment is measured by the leading edge of the fragment facing the positive pole.) (1)

(c) According to the pattern shown, explain whether the viral DNA or the plasmid DNA has a larger molecular size. (2)

(d) Suppose the patterns of DNA fragments shown are unique to the virus and the plasmid,

(i) what is the scientific name for these patterns? (1)

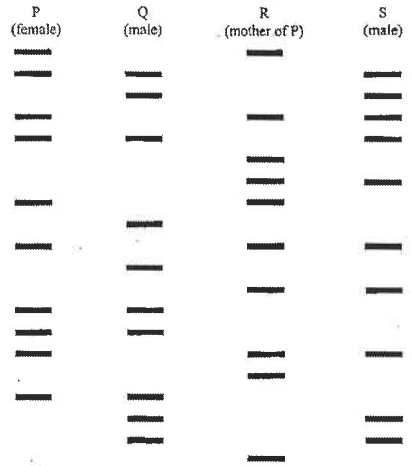
(ii) state *two* applications of these viral and plasmid DNA patterns. (2)

(e) If the same amount of human DNA is completely cut by the above-mentioned restriction enzyme and electrophoresed in the same way, a smear with no discrete DNA bands is obtained. Account for this result. (3)

AL - 2005 1A

8. DNA fingerprinting can be applied in different areas.

(a) One application of DNA fingerprinting is to identify the relationship among members in a family. The result of a DNA fingerprinting test performed on four individuals, P, Q, R and S, is shown below:



Based on the data above, deduce with reasons the most probable relationship of the following persons with P:

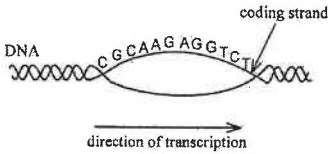
(i) Q (2)
(ii) S (2)

(b) Another application of DNA fingerprinting is to identify the evolutionary relationship among different groups of living organisms. What is the assumption involved in this application of DNA fingerprinting? (1)

AL - 2006 2A

2. DNA controls various metabolic processes in our body through encoding different types of proteins synthesized in the cells.

(a) The diagram below shows the process of transcription of a DNA strand, which encodes part of a polypeptide:



(i) According to the DNA sequence shown, deduce the mRNA produced (1)
(ii) Describe the process by which the mRNA obtained directs the synthesis of the polypeptide part. (5)

(c) In some people, a gene mutation results in the formation of a defective digestive enzyme that may cause a gastrointestinal disease.

(i) One way to treat this disease is by enzyme replacement, i.e. introducing an external source of the digestive enzyme into the patient's gastrointestinal tract. The enzyme used can be produced by recombinant DNA technology. Outline how the enzyme is produced by this technology. (4)
(ii) Gene therapy can be an alternative method for the treatment of this genetic disease. State *two* fundamental differences between the principles of gene therapy and enzyme replacement mentioned in (c)(i). (2)

(d) What potential hazards should scientists consider in the use of gene therapy in treating genetic diseases? (3)

AL - 2008 2A

1. In malaria prevalent areas, such as Africa and the Middle East, sickle-cell trait is quite common. People with sickle-cell trait are mildly anaemic and are heterozygous for the gene encoding the β-chain of haemoglobin. The beginning part of the coding DNA (non-template strand) of the β-chain for both the normal allele [A] and the mutated allele [S] are listed below. The first nucleotide is numbered as 1.

1 24
normal allele [A]: ATG GTG CAC CTG ACT CCT GAG GAG ..... (non-template strand)

1 24
mutated allele [S] ATG GTG CAC CTG ACT CCT GTG GAG ..... (non-template strand)

(a) Using the nucleotide number as a reference, identify the mutation in the [S] allele. (1)

(b) Give the corresponding mRNA sequence for the part of the [S] allele shown above. (2)

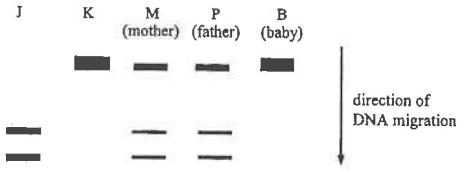
(c) Based on the codon table below, give the amino acid sequence encoded by the mRNA sequence in (b). (2)

First base in the codon	Second base in the codon				Third base in the codon
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

Note: The various amino acids are represented by their short forms in the table.

(d) DNA testing was carried out on a married couple, M and P, their newborn baby B, and two individuals (J and K). In this test, the DNA that codes for the β-chain of each person was subjected to treatment by a restriction enzyme. This enzyme recognises the DNA sequence **CT*N*AG** and cuts the DNA between the C and T nucleotides. The DNA fragment(s) formed were then analysed by gel electrophoresis. The results are shown below:

(Note: *N* = any nucleotide A, T, C or G)



J: reference DNA sample from a person with normal β-chain

K: reference DNA sample from a person with sickle-cell anaemia, i.e. homozygous for the [S] allele

(i) In the gel electrophoresis results above, two DNA bands are observed in the J sample while only one DNA band is present in the K sample. Explain these results by referring to the DNA sequence of the alleles shown on the opposite page. (4)

(ii) From the results of the DNA testing, deduce the genotype of the mother and that of the father. Briefly explain your deduction. (2)

(iii) With the aid of a genetic diagram, find the probability of this married couple having a child with sickle-cell trait. (5)
(Use A and S to represent the two alleles as given in this question.)

(e) It is known that people with sickle-cell trait are more resistant to malaria. Based on this information, explain why the sickle-cell trait is more common in malarial prevalent areas than areas with low incidence of malaria. (4)

AL - 2009 1A

2. Complete the following paragraph with suitable word(s)

Scientists mark use of genetic technology to produce transgenic crops. An example is genetically modified (GM) maize that is resistant to insect pests. This involved the isolation of a bacterial (a) ,which is then introduced into the maize plant via a (b) the GM maize can produce a protein at the (c) inside its cells. This protein is toxic to the insect pests of maize but not humans. However, the production of GM crops has raised concerns in different aspects, such as (d) and (e) (5)

AL - 2009 1A

7. In a bacterial genome, cytosine contributes to 28% of the total number of nitrogenous bases in its double-stranded DNA

(a) What is the percentage of guanine in this DNA? Explain your answer. (2)

(b) Calculate the percentage of adenine in this DNA. (2)

(c) How much uracil can be found in this DNA? (1)

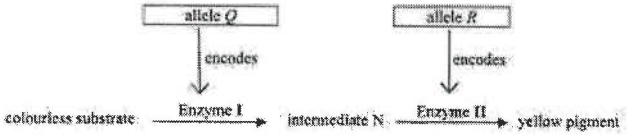
AL - 2010 2A

3. In honeybees, female are developed form fertilised eggs whereas drones (males) are developed from unfertilized eggs. Therefore, females are diploid and drones are haploid. There are two types of female bees: the queen and the workers. However, only the queen can lay eggs.

(a) State the type(s) of the cell division involved in gamete formation in the queen and the drones respectively. (2)

(b) A new queen usually mates with many drones before she settles down for the development of a new colony. Explain the biological significance of mating with many drones. (2)

(c) Honeybees are usually yellow in body colour. Without the yellow pigment, honeybees would appear greyish. Formation of the yellow pigment involves enzymes **I** and **II**. Its biochemical pathway is shown below:



Dominant alleles Q and R encode enzymes **I** and **II** respectively. Their recessive alleles q and r do not lead to the production of functional enzymes. These two genes are not linked.

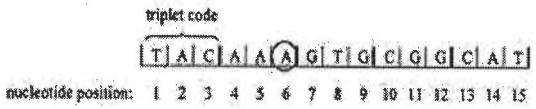
(i) In a cross, a queen of genotypes QqRr was allowed to mate with a drone of genotype qr.

(1) State the body colour of the queen and the drone. (2)

(2) Using the given allele representations, determine the genotypes and phenotypic ratio of worker offspring with the aid of a genetic diagram. (4)
(Note: Assume all the offspring produced are worker bees.)

(3) 15 000 greyish workers were produced form the above cross. If these workers are fed with intermediate N for several days, predict how many would become yellow. Explain your answer. (4)

(ii) Part of the nucleotide sequence of allele Q is shown below:



(1) If the nucleotide at position 6 is deleted in a mutation, how would this affect the production of enzyme **I**? (3)

(2) If the nucleotide at position 6 is replaced by another nucleotide with a different base, a functional enzyme may still be produced. How would you account for this? (3)

HKDSE - 2020 1B

9. The following DNA sequence shows the coding strand of part of a gene found in insect species A:

... ATG GTC GTA TAC GCT ACC CTG TCG ATG CTA GCT AGC ...

(a) Which of the following correctly shows the sequence of the mRNA corresponding to the underlined sequence of this coding strand? Put a '✓' in the appropriate box to indicate your choice. (1 mark)

☐ AUG GUC GUA UAC GCU ACC

☐ UAC CAG CAU AUG CGA UGG

(b) Using the following codon table, write the amino acid sequence of the protein translated from the mRNA in (a). (2 marks)

First base of the codon	Second base of the codon: U	C	A	G	Third base of the codon
U	Phe	Ser	Tyr	Cys	U
					C
	Leu		STOP	STOP	A
				Trp	G
C	Leu	Pro	His	Arg	U
					C
			Gln		A
					G
A	Ile	Thr	Asn	Ser	U
					C
			Lys	Arg	A
	Met				G
G	Val	Ala	Asp	Gly	U
					C
			Glu		A
					G

(c) It was found that the gene has two alleles. The difference between the two alleles in the underlined sequence is highlighted below:

allele1: ... ATG GTC GTA TA**C** GCT ACC ...

allele 2: ... ATG GTC GTA TA**G** GCT ACC ...
(mutated)

(i) What kind of mutation is this? (1 mark)

(ii) With reference to the codon table, describe how this mutation affects the protein translated from this gene. (3 marks)

(iii) Individuals from insect species A exist in two forms, green bodied and brown bodied. Individuals with a green body have only allele 1. Some of those with a brown body have both allele 1 and allele 2 while others have only allele 2.
If the body colour of insect species A was only caused by the mutation of this gene, which allele (1 or 2) would be recessive? Explain your answer. (3 marks)
(Note: Marks will not be awarded for genetic diagrams.)

HKDSE - 2021 1B

6. Pathogen X is a pathogen that infects humans. Research has discovered an antigen Y present on the surface of pathogen X. Using recombinant DNA technology, antigen Y can be produced and serves as a vaccine to induce immunity against pathogen X.

(c) Refer to the codon table below, answer the questions that follow:

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

(i) The starting sequence of the coding strand of the gene which encodes antigen Y is shown below:

ATG GCC ATA AAT TGC TGT ... ...

Referring to the codon table, write the corresponding amino acid sequence of the coding strand shown above. (2 marks)

(ii) Over the years, mutation has occurred in the gene encoding antigen Y in different strains of pathogen X. The variations in the starting sequence of this gene are shown below:

original strain: ATG GCC ATA AAT TGC TGT ... ...
strain P: ATG GCC ATA AAT TGC TGC ... ...
strain Q: ATG GCC ATA AAT TGA TGT ... ...
strain R: ATG GCT ATA AAC TGC TGT ... ...

One of these strains has the ability to infect people who have been injected with the vaccine containing antigen Y. With reference to the codon table, which strain (P, Q or R) will that be? Explain your answer. (4 marks)

10. In humans, breast milk provides not only nutrients but also protective effects to infants. Recently, scientists discovered a new constituent of breast milk: short RNA fragments enclosed in vesicles. Scientists have very diverse views about the roles of these short RNA fragments. The following are two of the hypotheses:

Hypothesis 1: the short RNA fragments serve as food particles
Hypothesis 2: the short RNA fragments regulate gene expression in infants

(a) To test Hypothesis 1, scientists performed an experiment of *in vitro* digestion of breast milk. The method is shown below:

Method of *in vitro* digestion with 20 mL of fresh breast milk

Step 1	Addition of hydrochloric acid solution
Step 2	Addition of enzyme mixture 1
Step 3	Incubation at 37°C for 20 minutes
Step 4	Addition of sodium hydrogen carbonate solution
Step 5	Addition of enzyme mixture 2
Step 6	Incubation at 37°C for 30 minutes
Step 7	Incubation at 85°C for 3 minutes
Step 8	Measurement of the level of short RNA fragments and nucleotides

(iii) After the *in vitro* digestion, the level of short RNA fragments in the reaction mixture was similar to that of fresh breast milk and no nucleotides were detected. Explain why the results disprove Hypothesis 1. (2 marks)

(b) Scientists will ask scientific questions when designing experiments to test Hypothesis 2. Suggest *one* example of these scientific questions. (1 mark)

6. Pathogen X is a pathogen that infects humans. Research has discovered an antigen Y present on the surface of pathogen X. Using recombinant DNA technology, antigen Y can be produced and serves as a vaccine to induce immunity against pathogen X.

(b) Other than the use of recombinant DNA technology, suggest another way to produce a vaccine. (1 mark)

Past Papers Marking Scheme – Molecular and Applied Genetics

AL - 2003 2A

3. (a) (i) • root cells have a higher water potential than soil water (1), water leaves the root cells by osmosis (1) — 2

(ii) • synthesis of the metabolite lowers the water potential (1) / lowers the solute potential of root cells to below that of soil water, cells will not lose water to the environment and survive (1) / cells can still absorb water — 2

(b) (i) mRNA of S : UAU UCG UAC UGU AAU (2) (concept of complementary bases) — 2

(ii) • amino acid sequence of S: Tyr Ser Tyr Cys Asn (2) — 2

(iii) • R has nucleotides AAG instead of ATG (1) in the third triplet of nucleotides (1) — 2

or The 8th base (1) T is replaced by A (1)

• the third amino acid changes from Tyr to Phe (1) / replaced by Phe in the encoded peptide — 1

AL - 2004 1B

11. (a) (i) 2 (1) — 1

(ii) 5 (1) — 1

(b) 8000 bp + 2000 bp = 10000 bp (1) — 1

(c) • viral DNA is larger (1), sum of base pair of all DNA fragments of viral DNA > that of plasmid DNA (1) — 2

(d) (i) • fingerprint (1) — 1

(ii) Any two uses of fingerprint (1 mark for each use): e.g. (accept correct alternatives)

- use in detecting the presence of this virus and plasmid (1)
- use in the identification of this virus and plasmid (1) — max. 2
- use in the study of the relationship between viruses and the relationship between bacteria (1)

(e)

Concept for mark award:	
• human DNA is large in size (1)	max. 3
• the restriction enzyme cuts the DNA into many different DNA fragments (1) / many restriction sites	
• some fragments are close in size (1)	
• cannot be separated effectively ∴ merge as a smear (1)	

(11)

AL - 2005 1A

8. (a) (i) The bands of P either come from R (mother) or from Q (1). Therefore, Q is her father (1). — 2

(ii) S has many bands common to P. The bands of S either come form Q or R (1). Therefore, he is a son of Q and R and a brother of P (1). — 2

(b) The closer the evolutionary relationship of two groups of living organisms, the more common bands they will have in their DNA fingerprinting patterns (1). — 1

(5)

AL - 2006 2A

2. (a) (i) CGCAAGAGGUCU (1) — 1

(ii)

Concept for mark award:	
· fate of mRNA after transcription (1-2)	max. 5
· amino acids carried by tRNA (1)	
· complementary pairing between anticodons of tRNA and codons of mRNA (1)	
· attachment of tRNA to ribosomes (1) in sequence	
· formation of peptide bond (1)	

e.g.

- the mRNA transcribed moves out to the cytoplasm (1) and attaches onto rRNA / the ribosomes (1) — max. 5
- different tRNA molecules carry different amino acids (1)
- aminoacyl-tRNA molecules / amino acid-tRNA complex with anticodons complementary to the codons of the mRNA (1) will attach to the ribosome (1) in sequence and a peptide bond will be formed between adjacent amino acids (1), thus forming the polypeptide

(c) (i)

Concept for mark award:	
· obtaining the gene coding for the enzyme (1)	max. 4
· introducing the gene into cultured cells through a vector (1)	
· expression of the gene forming the enzyme (1)	
· mass production of the enzyme (1)	
· purification of the enzyme (1)	

e.g.

- synthesize the DNA sequence coding for the functional enzyme in bacteria (1) / use restriction enzyme to cut the non-defective gene from the host cell — max. 4
- introduce the DNA / gene into cultured cells through a plasmid (1) / vector
- the gene is expressed in the cultured cells to produce the enzyme (1)
- mass culturing / fermentation of the cultured cells mass produces the enzyme (1)
- enzyme is purified for use (1)

(ii)

Concept for mark award:	
· comparison in terms of	2
> any introduction of the gene into patient's body (1)	
> source of enzyme (1)	

e.g.

Gene therapy	Enzyme replacement	
· foreign gene is introduced into the patient's cells	· no introduction of foreign gene into patient's cells	1
· enzyme is produced by the patient	· enzyme is obtained from an external source	1

(d) Any **three** of the following: (accept correct alternatives) max. 3

- there are potential adverse side effects due to misplacement of target gene (1) / mutation, errors in the process (1), defective or harmful gene products produced (1), absence of normal gene product (1)
- microbes / chemicals used to carry the gene into patient's cells may bring about adverse / unknown effect on human health (1) / the vector may elicit undesirable response in the patient / allergy / inflammation

(20)

AL - 2008 2A

1. (a) Nucleotide number 20 A is changed to T (1)

(b) Concept of mark award:
base sequence being the same as the coding sequence (1) except T replaced by U (1)/ (2 or 0)

AUG GUG CAC CUG ACU CCU GUG GAG

(c) Met Val His Leu Thr Pro Val Glu (2)

(d) (i)
- J has only the A alleles (1)
- the A / normal allele contains a sequence of CTGAG which can be recognized by the restriction enzyme (1); the β-chain gene is thus cut into two DNA fragments (1) of different lengths between C and T within this sequence
- in the S / mutated allele of K, the DNA sequence at the same position is CTGTG (1) / the restriction site is lost / not recognized / the enzyme cannot cut the allele; thus only one band appears on the gel

(ii)
- the genotype of M and P must be AS (1) / heterozygous because they have all the bands of J and K (1)

(iii)

Parent	AS	X	AS		
Gamete	A	S	A	S	1
Offspring	AA	AS	AS	SS	1
Offspring phenotypes	normal	sickle-cell trait		sickle cell anaemia	1,1

The chance for the couple to have a child with sickle-cell trait is 2/4 = ½ 1

(e)

Concept for mark award:
- advantage of sickle-cell trait outweighs disadvantage of being mildly anaemic in malarial prevalent areas (1)
- malarial infection as selection agent (1)
- preferential survival of individuals with sickle-cell trait (1)
- reproduction to pass the S allele to subsequent generations (1), hence a rise in proportion of individuals with sickle-cell trait from one generation to another (1)
- reasons for fewer cases of sickle-cell trait in areas with low incidence of malaria:
  - > no such selection advantage (1)
  - > being mildly anaemic is a disadvantage (1)

max. 4

e.g.
- in malarial prevalent areas, the survival advantage brought by sickle-cell trait against malarial infection outweighs the disadvantages of being mildly anaemic (1)
- malarial infection acts as a selection agent for people with sickle-cell trait (1)
- people with sickle-cell trait are able to survive (1) and reproduce, passing the S allele to the subsequent generations (1)
- the proportion of individuals within a population having the sickle-cell trait increases from one generation to another (1), making the trait more common in the population
- in areas with low incidence of malaria, people with sickle-cell trait would not have such a selection advantage (1), instead being mildly anaemic is a disadvantage (1), thus the trait is less common in these areas

max. 4

AL - 2009 1A

2. a. gene (1)
b. vector / plasmid (1)
c. rough endoplasmic reticulum / ribosome (1)
d & e.
- possible allergic reaction to human through affecting the metabolism of plant (1) / long term effect of GM crops on humans is unknown
- spread of the new gene from the GM crop to the wild species, upsetting the balance of nature (1) / unknown long-term effect on ecosystem

AL - 2009 1A

7. (a) 28% (1)
guanine forms complementary pairs with cytosine in a double-stranded DNA (1), therefore the amount of G is equal to the amount of C. (2)

(b) (100-28x2) / 2 (1)
= 22% (1) (2)

(c) There is no uracil in DNA (1)

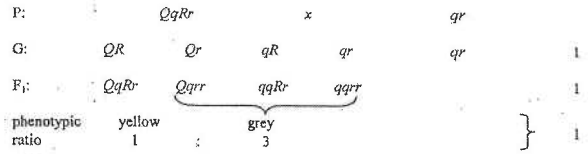
AL - 2010 2A

3 (a) · queen produces gametes by meiotic cell division (1) and mitosis (accept)
· drones produce gametes by mitotic cell division (1) (2)

(b) any ***one*** set of the following:
· this increases the variations of the offspring produced (1) so that some offspring may continue to survive even if there is a sudden environmental change (1) 1,1

(c) (i) (1) queen: yellow (1)
drone: greyish (1) (2)

(2)



Correct presentation of genetic diagram (1) 1

(4)

(3)

Concept for mark award:	
· correct perdition (1)	(4)
· identification of the ratio of offspring with genotype *qqRr* (1)	
· with the ability to produce functional enzyme **II** (1), these offspring can covert intermediate N into yellow pigment (1)	

e.g. · about 5000 (1) (4)
· only 1/3 of the offspring are of the genotype qqRr (1) which is capable of producing functional enzyme **II** (1) for the conversion of intermediate N into yellow pigment (1)

(ii) (1)

Concept for mark award:	
· deleting a nucleotide results in the shift of nucleotide sequence (1), leading to a change in the entire amino acid sequence (1)	(3)
· protein produced is completely different (1)	

e.g. · the loss of a nucleotide shifts the subsequent nucleotide sequence by one nucleotide (1) (3)
· hence the whole chain of amino acids that follows will be completely different (1) from the original one
· no enzyme **I** is produced (1) / a completely different protein is produced

(2)

e.g. · the substitution of a nucleotide only leads to the change of one triplet codon (1) / one codon
· any one set of the following
> the new code formed may be degenerate (1) / may encode for the same amino acid, so there is no change to the original polypeptide / the same polypeptide is formed (1)
> the new code formed encodes another amino acid which is not involved in the formation of active site (1), so the shape/ conformation of the active site remains the same (1)