

GRADE 12 LIFE SCIENCES

K-TESTS

DNA, MEIOSIS, GENETICS & GENETIC ENGINEERING

MEMORANDUMS

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DISCLAIMER

Where pertinent, questions that have been inspired by other examiners outside of St. Peter's College have been acknowledged. All other questions come from the author along with credit to Mrs A Greeff.

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To educators: When checking answers with the Memorandum document, please note that differences of opinion between schools and educators may exist, and that this is provided as a hopeful guideline to students to assist where possible.

To students: Please be critical when checking through your answers, especially for higher-order questions. Do not assume your written answers will necessarily be accepted if they deviate from the Memorandum answers provided.

Aim for students: Do not use your textbook or notes to answer the questions. These should be done from what has been memorized and understood. Time management must also be practiced. Critical reflection should focus on:

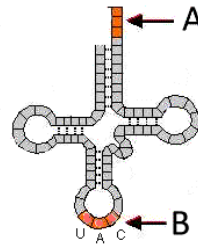
- *What terminology has not been effectively memorized*
- *Why you may not be receiving the full compliment of marks for longer questions*
- *Paying attention to instruction verbs of questions*
- *Linking concepts between different strands*

K-TEST 01 – 60 marks (50 minutes)

QUESTION 1 (Credit: M Marangoni)

Several Multiple Choice questions are provided below. Write down the letter representing the most appropriate answer:

1.1. Consider the following nucleic acid. What is part B? (1)



D Anticodon ✓

This is a tRNA molecule – where A is where amino acid attaches. mRNA has the codon

1.2. A DNA strand contains 24 nucleotides. How many amino acids will this DNA strand code? (1)

B 8 ✓

For every 3 nucleotides, one amino acid is coded for. So $24 / 3 = 8$

1.3. During an investigation, the DNA of an animal cell was analysed in a laboratory and the results are shown in the table below:

Base Composition			
Adenine	X	Y	Z
30,1%	20,0%	29,9%	20,0%

Which of the following is the correct identification of the bases called X, Y and Z? (2)

	X	Y	Z
A	cytosine	thymine	guanine ✓✓

Adenine and Thymine will have (roughly) the same percentages, while Cytosine and Guanine will be the same. (it is ok to have a minor percentage difference)

1.4. You have obtained a sample of DNA, and you transcribe mRNA from this DNA and purify it. You then separate the two strands of DNA and analyse the base composition of each strand and of the mRNA. You obtain the data shown in the table below. Which strand of the DNA is the coding strand, serving as a template for this mRNA synthesis? (2)

	A	G	C	T	U
DNA strand number 1	19.3	26.0	31.0	24.0	0
DNA strand number 2	24.2	30.8	25.7	19.3	0
mRNA	19.3	25.7	30.8	0	24.2

B Strand 2 ✓✓

The coding strand will have the same percentages of complimentary bases as mRNA. So if 24,2 U on mRNA, must be 24,2 complimentary Adenine on coding strand etc. NOT like percentage with like

QUESTION 2

Provide the correct biological term for the following: (6)

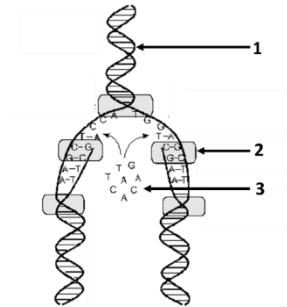
- 2.1. The monomer of proteins **Amino acids ✓**
- 2.2. The monomer of nucleic acids **Nucleotide ✓**
- 2.3. A pair of matching chromosomes in a cell, one from each parent
Homologous (chromosomes) ✓
- 2.4. Inheriting two different versions of a gene **Heterozygous ✓**
- 2.5. Having more than two sets of chromosomes **Polyploidy ✓**
- 2.6. Organisms that have developed due to recombinant DNA technology
Transgenic ✓ (NOTE: not transgene)

Define the following terms: (4)

- 2.7. Gene
A short section of DNA (or nucleotides) that codes for one specific trait / characteristic ✓
- 2.8. Gene pool
The total genetic diversity within a population ✓
OR All the genes present within a population that can present in a genotype
- 2.9. Genome
The complete set of genes present within a cell or individual ✓
- 2.10. Genotype
The two inherited alleles of a gene an individual has inherited ✓

QUESTION 3

Analyse the picture below and answer the questions that follow:



- 3.1. Name the process occurring in this image. Justify your answer with ONE visible feature. (2)

DNA replication ✓

Reason: One double strand becoming two double strands / Thymine is a free floating nucleotide, not uracil (either reason ✓)

- 3.2. Name the enzyme represented by 2. (1)

DNA polymerase ✓ (NOTE: helicase would potentially be accepted for the enzyme above this, but is not a SAGS requirement to know)

- 3.3. Where in the cell is this process occurring? (1)

Nucleus ✓

- 3.4. Describe why this process is important to meiosis. (2)

To have the correct number of chromosomes, DNA must duplicate first before halving ✓ If not, an incomplete set of chromosomal instructions will be present in the gametes ✓

Below is a section of a single strand of DNA:

A T G A C G T C T

3.5. Write down the complimentary mRNA sequence for the above. (3)

U A C ✓ U G C ✓ A G A ✓ (Mark each codon separately)

3.6. In point form, describe the process that creates the mRNA strand in a cell. (5)

Any 5 of the following points: (✓✓✓✓✓)

- **DNA unwinds and unzips**
- **Hydrogen bond between nucleotides are broken**
- **RNA polymerase catalyses new strand formation**
- **Free floating nucleotides join in complimentary fashion**
- **A with U and C with G**
- **New mRNA strand separates from DNA and leaves nucleus**
- **DNA reziaps and recoils**

3.7. Using your mRNA strand from 3.5., provide the amino acid sequence coded for using the mRNA codon table below. (3)

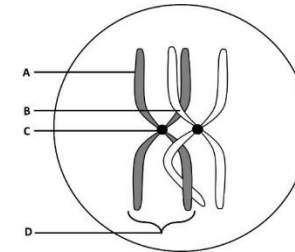
		Second Base of mRNA Codon				
		U	C	A	G	
First Base of mRNA Codon	U	UUU Phe UUC Phe UUA Leu UUG Leu	UCU Ser UCC Ser UCA Ser UCG Ser	UAU Tyr UAC Tyr UAA STOP UAG STOP	UGU Cys UGC Cys UGA STOP UGG Trp	U C A G
	C	CUU Leu CUC Leu CUA Leu CUG Leu	CCU Pro CCC Pro CCA Pro CCG Pro	CAU His CAC His CAA Gln CAG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

Tyr ✓ Cys ✓ Arg ✓

***NOTE: do not use the anti-codons of the given sequence. Take time to check your understanding of this concept**

QUESTION 4 (Credit: C Marangoni)

Analyse the image below of a cell undergoing a phase of meiosis. Use this image, as well as your own knowledge, to answer the question that follow.



4.1. Provide labels for structures A, C and D only. (3)

A – Chromosome / sister chromatid ✓

C – Centromere ✓

D – Homologous chromosomes ✓

***NOTE: Set your answer out appropriately to show label letters. No indication of this = 0 marks!**

4.2. Which phase of meiosis is shown in the diagram? Justify your answer. (2)

Prophase I ✓ (Must have the I for the mark, not just 'prophase')

Reason: Crossing over is visibly occurring ✓

4.3. State the number of chromosomes that are present in this cell. (1)

Two ✓ (Count the number of centromeres present)

4.4. Name ONE organ in animals and ONE organ in plants in which meiosis will occur. (2)

Animal = Testes / Ovaries ✓

Plants = Ovary / Anther ✓

Must specify animal vs plant or no marks

QUESTION 5

Clouded leopards are a particular breed of leopard indigenous to Central America. The spots found on the coat of the clouded leopard can either be dark or normal in colour. The gene for this trait is carried on the X chromosome. Dark spots (r) are recessive and normal spots are dominant (R).

5.1. Explain what is meant by the term 'recessive' (1)

A gene that is masked by the dominant gene / will not be present in the phenotype is heterozygous genotype is present ✓

5.2. State ONE other sex-linked disorder you have studied. (1)

Hemophilia / Colour blindness ✓

**Other examples do exist but these two are directly from SAGS*

5.3. A male clouded leopard with normal spots mated with a female clouded leopard with dark spots. Use a Punnett square to show the possible phenotypic and genotype ratio of their offspring. (6)

Parents: X_rX_r ✓ and X_RY ✓

	X_r	X_r	
X_R	X_RX_r	X_RX_r	
Y	X_rY	X_rY	✓✓ (Punnett correct)

Phenotype ratio: 1 normal spotted female : 1 dark spotted male ✓

Genotype ratio: 1 X_RX_r : 1 X_rY ✓

***NOTE:** Always in lowest common form for ratios

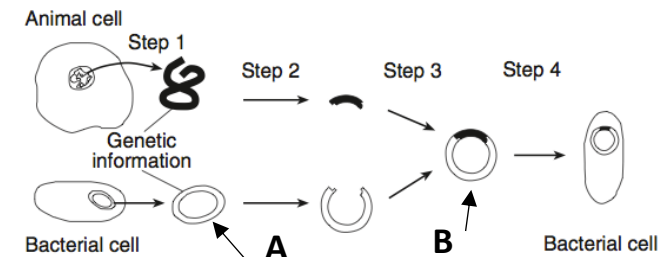
Phenotype MUST have genders as well since sex-linked

Phenotype should preferably not be referred to as 'carrier female' – rather stick to 'normal' or 'affected' only

If completed as an autosomal condition = max 2 /6 marks and only awarded if the Punnett has been completed correctly with continued accuracy

QUESTION 6

The image below illustrates how artificial human insulin is manufactured.



6.1. Name the process occurring in this image. (1)

Recombinant DNA technology ✓

6.2. Identify structure A. (1)

Plasmid ✓

6.3. Describe how step 3 is able to occur so that structure B can be created. (3)

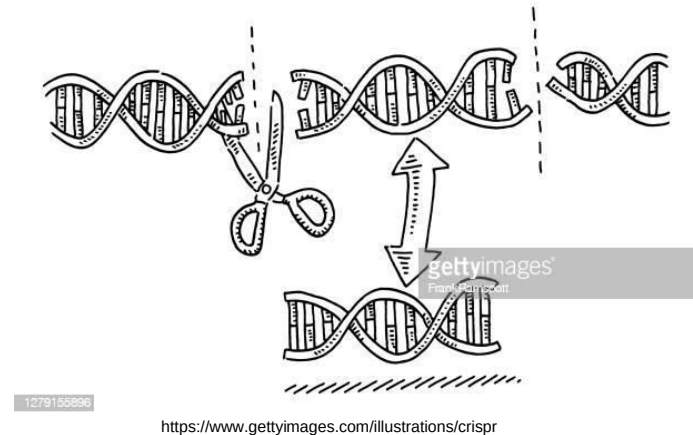
Ligase enzyme ✓ is used to glue together / attach ✓ the extracted gene to the open / cut plasmid ✓

- 6.4. In order for artificial insulin to be made available to the public, it must undergo a number of drug trials. Explain why drug trials are an important part of the medical world. (2)

Any two of the following ✓✓:

- Ensures the efficacy / accuracy of the product
- Ensures the safety of the product / no unforeseen side effects
- Tests on a general population to ensure success in varied population types
- Not straight to humans, must pass first safety trials in lab and animals / minimize risk to humans

- 6.5. Consider the cartoon below. Explain why this is an effective depiction of how CRISPR functions. (4)



Allocation:

Use of cartoon ✓✓

Link to CRISPR ✓✓

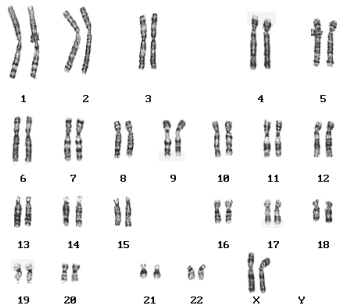
- Scissors are cutting the DNA ✓: CRISPR can remove specific sections of DNA ✓
- The arrow is showing a switching between two sections of DNA (genes) ✓: CRISPR is able to insert desired genes where the undesirable was removed ✓

K-TEST 02 – 60 marks (50 minutes)

QUESTION 1

Several Multiple Choice questions are provided below. Write down the letter representing the most correct answer.

1.1. Below is an image of a karyotype from a sample of foetal cells.



From the above karyotype, we can conclude the following: (1)

B. The foetus is female ✓

A – Normal gonosomes ; C – 22 pairs of autosomes ; D – XX gonosomes

1.2. Concerning humans, which of the following statements is FALSE regarding the number of chromosomes present: (1)

C. Gonosome – n ✓

All others are correct – gonosome only refers to 2 chromosomes, cannot be a compliment of n

1.3. Analyse the picture below of a single cell in a phase of meiosis. A and B represent chromosomes:

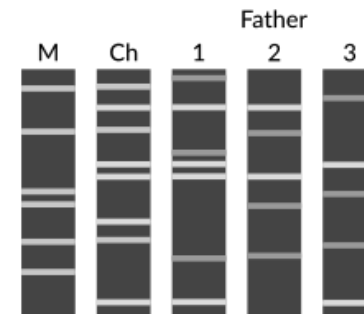


Based on the image, this cell is most likely in which phase of meiosis?

D. **Anaphase II ✓** (1)

Sister chromatids are separating, not homologous ones

1.4. A paternity test was conducted using DNA fingerprinting. There were 3 possible fathers of the child, labelled 1, 2 and 3. A set of DNA was taken from the mother, labelled M. DNA from the child is labelled Ch.



Who is most likely the father of the Child (Ch)? (2)

A. Father 1 ✓✓

Bands in common with the child that are NOT accounted for by the mother

- 1.5. The mass of DNA in a non-dividing liver cell was analysed and found to be 6.60 pg per cell. (pg = picogram; 1pg = 1×10^{-12} g).

Which of the following combinations show the correct average mass of DNA in the listed cells of the same species: (2)

	DNA content (pg per cell)		
	a muscle cell	a mature red blood cell	an ovum
A	3.30	0	3.30
B	6.60	0	3.30 ✓✓
C	6.60	6.6	6.60
D	13.20	6.6	6.60

Muscle is diploid cell, so same amount as liver cell; RBC has no nucleus, so has no genetic material; Ovum is gamete, so half amount

- 1.6. Which bonds must break during DNA replication before complimentary base-pairing can occur? (1)

D Hydrogen bonds between nucleotides ✓

Peptide bonds are between amino acids; nitrogen bonds are incorrect; bond with the phosphates is not broken as this is part of backbone

QUESTION 2

Study the following table which consists of two items (numbered 1 and 2) in the first column and a term in the second column. **Decide which item(s) relate to the term.**

Write down your choice in the space provided in the "answer" column, making use of the following codes: (6)

- A only item 1 relates to the term
 B only item 2 relates to the term
 C both item 1 and 2 relate to the term
 D neither item 1 or 2 relates to the term

Item	Term
1. Insertion 2. Deletion	Frameshift mutation
1. Haploid chromosome number in humans 2. Diploid number of chromosomes in humans	23 chromosomes
1. Inheriting two identical versions of an allele 2. Inheriting two different versions of an allele	Heterozygous
1. Increased chance of genetic mutations 2. Inbreeding	Hybrid vigour
1. Used to extract desired genes from DNA sample 2. Used to duplicate a DNA sample	PCR
1. Only found in the nucleus 2. Only found at the ribosome	mtDNA

ANSWERS: 1 – C ; 2 – A ; 3 – B ; 4 – D ; 5 – B ; 6 – D

QUESTION 3

Analyse the following text. Use this, as well as your own information, to answer the questions that follow:

Recombinant bovine growth hormone (rBGH) is a synthetic (man-made) hormone that is marketed to dairy farmers to increase milk production in cows. It has been used in the United States since it was approved by the Food and Drug Administration (FDA) in 1993, but its use is not permitted in the European Union, Canada, and some other countries. Some rBGH products on the market differ chemically from a cow's natural growth hormone by one amino acid. Both the natural and injected recombinant forms of the hormone stimulate a cow's milk production by increasing levels of another hormone known as insulin-like growth factor (IGF-1). Concerns about possible health effects on humans from milk produced using rBGH have been raised.

Firstly, does drinking milk from rBGH-treated cows increase blood levels of growth hormone or IGF-1 in consumers? If it does, would this be expected to have any health effects in people, including increasing the risk of cancer? Several scientific reviews have not been able to conclusively prove a link between increased IGF-1 levels to increased cancer risk, despite there being some evidence for this. Second, cows treated with rBGH tend to develop more udder infections (mastitis). These cows are given more antibiotics than cows not given rBGH.

Although the use of rBGH is still approved in the United States, demand for the product has decreased in recent years. Many large grocery store chains no longer carry milk from cows treated with rBGH. A United States Department of Agriculture survey of American dairy farms (conducted in 2007) found that less than 1 in 5 cows (17%) were being injected with rBGH.

Adapted from <https://www.cancer.org/cancer/cancer-causes/recombinant-bovine-growth-hormone.html>

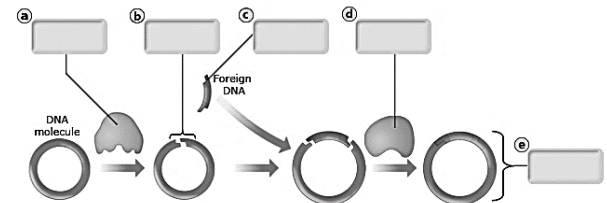
3.1. Based on the information given above, decide whether the following conclusions are SUPPORTED, CONTRADICTED or UNKNOWN. State only your decision of answer, you do not need to give reasons for your decision. (3)

- a) Use of rBGH is in high demand around the world **Contradicted ✓**
- b) Less than 20% of cows in America currently have rBGH injected into them **Supported ✓**
- c) South Africa does not permit the use of rBGH **Unknown ✓**

3.2. The creation of recombinant DNA is important for the creation of rBGH. Explain what is meant by the term 'recombinant DNA'. (1)

DNA that has been artificially formed by combining two organisms DNA OR Using laboratory methods to combine genetic material from several sources ✓

3.3. Below is a visual representation of the process used to create rBGH:



Provide labels for the enzymes (a) and (d) in the image above AND describe the function of each enzyme in relation to the creation of recombinant DNA. (4)

A = restriction enzyme ✓ - used to cut /remove specific genes or open a plasmid ✓

D = ligase ✓ - used to glue or combine different DNA sources into one molecule

- 3.4. The 'DNA molecule' in the above picture can be found in bacterial cells. Provide the term for this circular form of DNA. (1)

Plasmid ✓

- 3.5. Explain why the use of rBGH must be continually given to cows in order for them to produce large amounts of milk. (2)

Any two of the following points ✓✓

Not naturally made in the body / does not stay in the body / effect is temporary / not a change in DNA / is not a permanent solution / if stopped giving to cow, more milk would not be produced

- 3.6. "Some rBGH products on the market differ chemically from a cow's natural growth hormone by one amino acid."

- a) Amino acids are the monomers of proteins. Name the monomer of nucleic acids. **Nucleotide ✓** (1)
- b) Explain what type of mutation would allow for a functional BGH protein to be made with only one amino acid difference. (2)

Substitution mutation ✓

Only one nucleotide is changes which changes only one amino acid / not a frameshift mutation which affects many amino acids ✓

- 3.7. Below is a section of DNA from the gene to create BGH in a cow:

CATTGCAGG

- a) Write down the mRNA sequence for this section of DNA. (1)

G U A A C G U C C ✓ (all or nothing correct)

- b) Briefly describe the process sed to create the mRNA strand. (3)

Any three of the following points ✓✓✓:

- DNA unwinds and unzips + Hydrogen bond between nucleotides are broken**
- RNA polymerase catalyses new strand formation**
- Free floating nucleotides join in complimentary fashion**
- New mRNA strand separates from DNA and leaves nucleus**
- DNA reziips and recoils**

- 3.8. Use the mRNA codon table below to state the three amino acids formed from the mRNA sequence formed. (3)

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

Val ✓ Thr ✓ Ser ✓

***NOTE: do not use the anti-codons of the given sequence. Take time to check your understanding of this concept**

- 3.9. The FDA in the United States approved the commercial use of rBGH, but some other countries did not. Defend the importance of institutions like the FDA in the regulation of clinical trial procedures and the assessment of medications/interventions. (2)

***NOTE: Not an opinion question. Can only argue in favour**

Any two of the following separate points ✓✓:

- **Ensure safety of consumers**
- **Ensure efficacy and accuracy of products**
- **Ensure laws are being adhered to / correct procedure being followed**
- **Ensuring no animal cruelty is occurring**

- 3.10 Milk is a staple food for many people in the world as a rich source of protein. Farmers are therefore forced to try and produce as much milk as possible. Provide TWO ethical arguments in support and TWO ethical arguments against the use of rBGH by farmers. (4)

Ethical point ✓ + explanation ✓ (x 2 for each side of argument)

***NOTE: Must state which is support and against. Or else 0 marks**

Support:

Do no harm – Withholding vital food is likely to lead to death

Beneficence – The greater good of feeding the world is realized

Against:

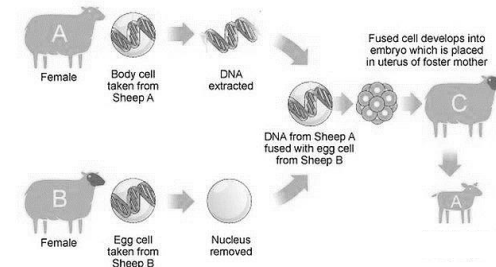
Animal harm – increases diseases in cows

Human harm – unknown side effects of ingesting

(Informed) Consent – Consumers are not given a choice regarding use

QUESTION 4

The image below illustrates a certain type of cloning:



- 4.1. Name the type of cloning depicted above. (1)

Somatic Cell Nuclear Transfer (or SCNT) ✓

- 4.2. To which sheep is Lamb A genetically identical? (1)

Sheep / Female A ✓

- 4.3. Is the cell taken from Sheep A diploid or haploid? Justify your answer. (2)

Diploid ✓

Taken from a body cell / somatic cell ✓

- 4.4. Provide another term for the 'foster mother'. (1)

Surrogate ✓

- 4.5. Provide TWO differences between plant and animal cloning. (2)

Plant more successful than animal / plant is easier than animal / plant does not require surrogate / plant can be large scale

Any TWO acknowledging both sides ✓✓

4.6. "Cloning of human embryos should be legalised"

Provide ONE argument in favour and ONE against this statement.
(2)

***NOTE: Must state which is favour and which is against. Or else 0 marks**

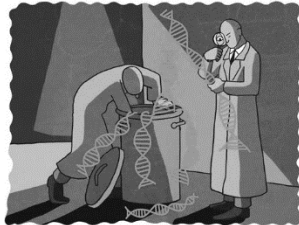
Favour (Any one ✓):

Human cloning can help with disease research / Can help in finding a cure for genetic diseases / Can help to develop healthy organs or tissue for transplant

Against (Any one ✓):

Unknown side effects which are difficult to research / considered murder among many / the embryo is not able to give consent

4.7. Consider the following cartoon:



How does this image link to the goals of the Human Genome project?
(4)

HGP wanted to map the human genome / find out all the genes and their functions ✓

A lot of DNA was considered 'junk DNA' as we did not know its function ✓

Seen by men digging in the trash ✓ and using a magnifying glass to look at DNA fragments ✓

QUESTION 5

In mice, yellow fur colour (T) is dominant over grey fur colour (t). It also happens that all embryos which are homozygous for the dominant factor die before birth.

If a colony of heterozygous mice were interbred to produce 300 young live mice, how many of these living offspring would be likely to have yellow fur and how many would have grey fur? Use a Punnett diagram to substantiate your answer.
(6)

Parents: Tt ✓ x Tt ✓

	T	t	
T	TT	Tt	
t	Tt	tt	✓✓ (Punnett correct)

Therefore 25% of all offspring die due to being homozygous for yellow, so of living, would be 2 yellow : 1 grey ✓

Therefore, 200 yellow, 100 grey ✓

K-TEST 03 – 60 marks (50 minutes)

QUESTION 1

Provide the correct biological term for the following: (5)

1.1. A group of three adjacent nucleotides found on an mRNA molecule
Codon ✓

1.2. The enzyme which catalyses the process of transcription
RNA Polymerase ✓

1.3. The process used to duplicate DNA when making a fingerprint
Polymerase Chain Reaction (PCR) ✓

1.4. A genetic cross involving only one characteristic at a time
Monohybrid ✓

1.5. The sugar found in RNA **Ribose ✓**

For each of the phrases in Column 1, state whether it applies to A only, B only, both A and B or neither in Column 2. Write down A only, B only, A and B or neither. (5)

<u>COLUMN 1</u>	<u>COLUMN 2</u>
Female sex chromosomes of human	A. XX chromosomes B. XY chromosomes
TT	A. Heterozygous B. Homozygous
Chances of having a male offspring in humans	A. 25% B. 75%
Outward appearance of an individual	A. Genotype B. Phenotype
Genes are separated randomly between gametes	A. Mendel B. Law of segregation

ANSWERS:

1 – A only ; 2 – B only ; C – Neither ; D – B only ; E – Both

Choose a description from Column B which best suits the words in Column A.

Write the correct letter next to the appropriate number. (15)

<u>COLUMN A</u>		<u>COLUMN B</u>
1. Gene	A	Banded patterns of DNA
2. Allele	B	An individual with the same alleles for a particular gene
3. Gamete	C	The specific alleles an individual has inherited for a particular gene
4. Somatic cell	D	23 pairs of chromosomes
5. Homozygous	E	The location of a gene on a chromosome
6. Recessive allele	F	Sex-linked disease
7. Genome	G	Small section of DNA which determines a characteristic
8. Haemophilia	H	An individual with different alleles for a gene
9. Locus	I	The different versions of a gene
10. DNA fingerprint	J	An allele which only has an effect when homozygous
11. Genotype	K	An allele which has an effect whether homozygous or heterozygous
12. Heterozygous	L	The outward appearance of an organism
13. Dominant allele	M	23 chromosomes
14. Phenotype	N	The full set of genes found in an individual
15. Mutation	O	Change in genetic make-up of an organism

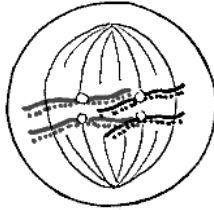
ANSWERS:

1 – G ; 2 – I ; 3 – M ; 4 – D ; 5 – B ; 6 – J ; 7 – N ; 8 – F ; 9 – E ; 10 – A ;

11 – C ; 12 – H ; 13 – K ; 14 – L ; 15 – O

QUESTION 2

The image below shows a cell undergoing a phase of meiosis:



- 2.1. State which phase of meiosis is being depicted in the image. Justify your answer with TWO visible reasons. (3)

Metaphase 1 ✓

Reasons: They are in homologous pairs ✓ / Lined up on the equator of the cell ✓

- 2.2. In order for meiosis to occur effectively, DNA replication needs to occur during Interphase. Using a flow diagram, describe the process of DNA replication. (5)

Heading provided ✓ ("A flow diagram...")

In the form of a flow diagram ✓ (uses arrows, flows down top to bottom of page)

Any three of the following points ✓✓✓:

- **DNA unwinds and unzips / hydrogen bonds break**
- **DNA polymerase catalyses the process**
- **Free floating nucleotides attach in complementary fashion / C with G and A with T**
- **Two new identical strands of DNA created**

- 2.3. Using the above image as a guide, sketch what the next phase of meiosis for this cell would look like. No labels or heading are required. (3)

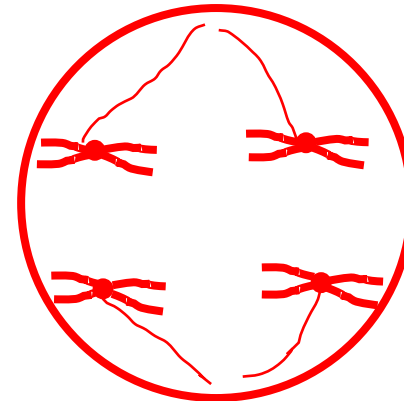
Allocation:

4 chromosomes present in the cell (regardless of position) ✓

Sister chromatids are still attached (regardless of number of chromosomes) ✓

Homologous pairs are separating ✓

***NOTE: Not concerned over dotted and solid line drawing / size of chromosomes, as long as distinguishable**



- 2.4. Based on the cell in the above image, how many chromosomes will be present in the gametes at the end of meiosis? (1)

Two ✓

(Cell started with 4, will end with half)

***NOTE: Do not always assume it is a human cell. Applied based on image given in this case**

QUESTION 3

- 3.1. In the *Drosophila* fruit fly, most flies have smooth edged wings while a few have jagged edged wings, resulting from a recessive allele. A female fly with jagged edged wings was crossed with a male fly with smooth wings. It was found that all their resultant offspring had smooth wings.

Is the mutation for wings a sex-linked disorder or an autosomal disorder? Use a Punnett square to explain your answer fully. Use the letters R and r when answering the following questions to represent the respective alleles: (6)

If autosomal:

Parents: RR (male) x rr (female)

	r	r	
R	Rr	Rr	
R	Rr	Rr	✓✓(Punnett correct)

If sex-linked

Parents: X_rX_r and X_RY

	X_r	X_r	
X_R	X_RX_r	X_RX_r	
Y	X_rY	X_rY	✓✓(Punnett correct)

Therefore, it cannot be sex-linked as this is impossible ✓ / Would have to produce some jagged if sex linked

Used two different Punnetts to prove ✓

- 3.2. A pure bred brown winged butterfly was crossed with a pink winged butterfly. Brown is dominant over pink. The offspring in the F1 generation were allowed to interbreed. Use the letters B and b to answer the following questions.

- a) State the phenotype of the F1 generation. (1)

All brown winged (must be whole phrase) ✓

- b) What is the genotype of the F1 generation? (1)

All Bb ✓ (must be whole phrase)

- c) Use a Punnett square to state the phenotype and genotype ratios of the F2 generation. (6)

Parents: Bb ✓ x Bb ✓

	B	b	
B	BB	Bb	
b	Bb	bb	✓✓(Punnett correct)

Genotype ratio: 1 BB : 2 Bb : 1 bb ✓

Phenotype ratio: 3 Brown wing : 1 pink wing ✓

QUESTION 4

Analyse the following text and answer the questions that follow:

Crown gall disease in plants is caused by a soil bacterium, *Agrobacterium tumefaciens*. The infected plant develops a tumour (referred to as a gall) in its stem. The gall is caused by a plasmid in the bacterium. Galls can grow large and kill the host plant. Using genetic engineering, a modified plasmid can be created by having its tumour-producing gene removed and a 'good gene' introduced in its place. This good gene is introduced into the plant genome by the bacteria 'infecting' the plant with its plasmid. Crown gall disease is then prevented in these 'new plants' along with the 'good gene' being expressed.

[Adapted from John Addy, Erica Larkcom and Ruth Miller]



- 4.1. Describe how the tumour-causing gene is removed from *Agrobacterium tumefaciens*. (2)

Restriction enzymes ✓

Used to cut out the specific section of DNA / gene ✓

- 4.2. Explain why the 'new plants' produced would not be an example of artificial selection. (2)

Artificial selection is still a natural process of breeding / artificial selection is only where human chooses who reproduces ✓

This is an external / direct manipulation of genes ✓

- 4.3. Provide ONE similarity and ONE difference between the process described in the text and gene therapy. (2)

***NOTE: Must state which is similarity and difference. Or no marks**

Similarity (Any one ✓): Use of vectors / desire to introduce favourable genes / both forms of genetic engineering

Difference (Any one ✓): Gene therapy is specific to humans / Gene therapy does not add in traits, just replaces defective ones / Plant transformation is much more successful than gene therapy

- 4.4. Suggest ONE 'good gene' a farmer would want inserted into a plant he is cultivating. (1)

Any one appropriate ✓

Frost resistance / pest resistance / drought resistance / improved nutritional quality / improved yield or size of fruit / improved speed to fruiting / greater amount of fruit produced / able to ripen sooner / longer stalks

NOT: Seedless varieties / other vague answers, must be specific)

- 4.5. What is meant by the term 'genetic engineering'? (2)

The artificial manipulation ✓ modification or recombination of DNA or other nucleic acid molecules to modify an organism ✓

K-TEST 04 – 60 marks (50 minutes)

QUESTION 1

Several Multiple Choice questions are provided below. Write down the letter representing the most correct answer:

1.1. Two individuals are crossed. One is homozygous dominant (TT) and the other is heterozygous. The genotypes of their offspring will be: (2)

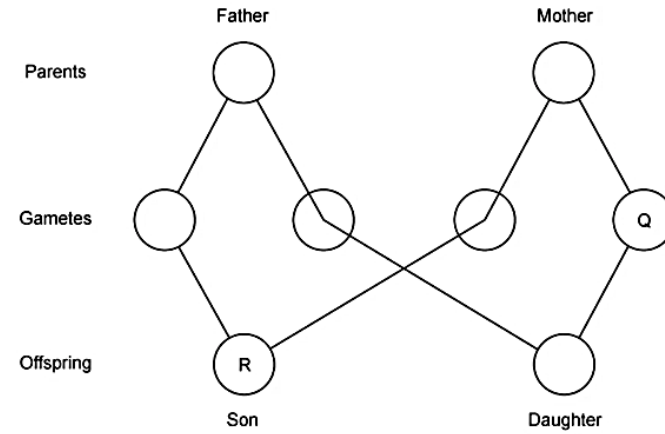
B 50% TT ; 50% Tt ✓✓

1.2. DNA was extracted from one liver cell of a walrus and a human. In what way will these two sets of DNA be different? (1)

D The order of nucleotides present ✓

A – ratio does not change between organisms / B – pentose sugar is constant / C – all organisms have combination of same four nucleotides

1.3. The image below shows how sex can be predicted in offspring.



<https://www.savemyexams.co.uk/revision/gcse-biology-cie-new/17-inheritance/>

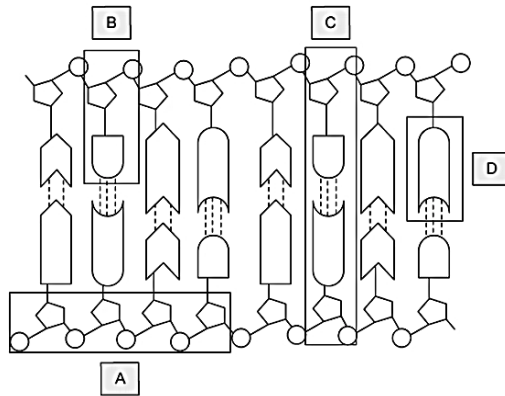
Which of the following correctly states the gonosomes of P and Q? (2)

	Q	R
A	X	XY
B	X	XX
C	Y	XY
D	Y	XX

ANSWER: A ✓✓

Mother can only provide an X ; boys gonosomes are XY

- 1.4. The diagram below shows a DNA molecule. Which letter (A – D) represents one nucleotide? (1)



ANSWER: B ✓

Nucleotide must be one sugar, one phosphate and one nitrogenous base

A = S-P backbone ; C = Two nucleotides ; D = nitrogenous base only

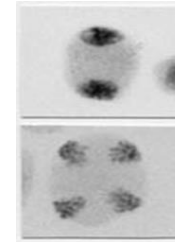
- 1.5. You are provided with a section of DNA that consists of 14 000 base pairs. Which of the following would be the correct inventory of sub-molecules present? (2)

C 28 000 pentose sugars, 28 000 phosphates, and an equal ratio of cytosine to guanine and adenine to thymine ✓✓

Reminder: 14 000 base pairs, meaning two strands of DNA. So each pair has 2 sugars and 2 phosphates

QUESTION 2

Two similar phases of meiosis are shown in the micrograph below:



- 2.1. Identify the phase of meiosis occurring in each of the two cells above. (2)

Top picture = Telophase 1 ✓

Bottom picture = Telophase 2 ✓

- 2.2. Fully describe ONE way in which genetic variation is achieved through the process of meiosis. (4)

Crossing over ✓ - exchange of genes between homologous chromosomes ✓ at random ✓ Creates unique chromosomes that will be inherited ✓

OR Independent / random assortment of chromosomes ✓ each gamete has random chance to inherit one version of a chromosome ✓ no chromosome is the same ✓ creates unique combinations at fertilization ✓

OR Fertilization ✓ meiosis created genetical different gametes ✓ random combination of sex cells ✓ allows for unique genetic combinations ✓

- 2.3. Explain what is meant by the term 'haploid'. (1)

A cell that contains a single set of chromosomes / A cell that contains half the number of chromosomes of a diploid or somatic cell ✓

- 2.4. Down Syndrome is a chromosomal mutation caused by non-disjunction during meiosis. Describe non-disjunction and how this can directly lead to having a child with Down Syndrome specifically. (3)

Non-disjunction – is the incorrect separation of chromosomes during meiosis ✓

Chromosome 21 chromatids do not separate / Chromosome 21 centromere does not split ✓

One gamete then has an extra chromosome 21 ✓

- 2.5. Explain how a karyotype can be used to determine if a person has Down Syndrome. (2)

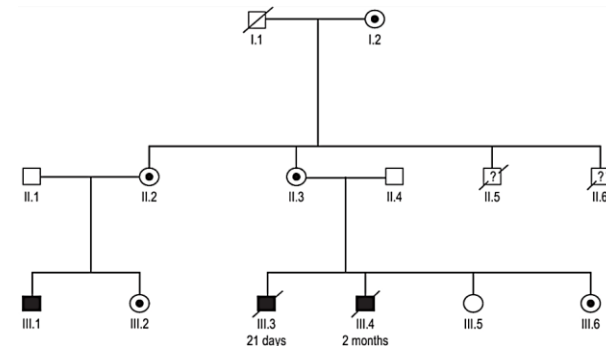
Karyotype is a visual representation of all the chromosomes of an individual ✓

If there is an extra chromosome 21, person has Down Syndrome ✓

QUESTION 3

Barth syndrome is a rare genetic disorder characterised by severe heart problems, underdeveloped muscular structure, growth delay and an extremely low predicted life expectancy. This disorder arises almost exclusively in males and is an X-linked recessive disorder.

Although most males born with this disorder die at a young age, there have been isolated instances of individuals surviving into late adulthood. One such case was investigated in a Spanish journal, *Revista Española de Cardilogía* in 2013. As part of that investigation, the following family pedigree was constructed for Patient A:



In the pedigree, the squares represent males and the circles females. Fully blackened individuals are affected, clear shapes are unaffected individuals, and circles with a dot in the middle indicate carrier females. Shapes with lines drawn through them indicate deceased individuals.

Patient A was found to have two male cousins who died in infancy from Barth syndrome, and two male uncles who also died of suspected 'infectious diseases' at birth.

- 3.1. Explain what is meant by the phrase 'X-linked recessive'. (2)

X-linked – located on the X chromosome ✓

Recessive – the allele that is masked by the dominant and is only expressed homozygously ✓

- 3.2. From the pedigree, identify which individual represents 'Patient A'.
(1)

III.1 ✓

- 3.3. Using the symbols **B** for the normal gene, and **b** for Barth syndrome, identify the genotypes of the following individuals: (2)

a) II.2 $X_B X_b$ ✓

b) II.4 $X_B Y$ ✓

- 3.4. Suggest ONE reason why the genotypes of individuals II.5 and II.6 are unknown. (2)

Died at a young age / never did a genetic test / the genetic test didn't exist at the time (Any one ✓)

- 3.5. Using your knowledge of genetics, explain why Barth Syndrome is almost exclusively found to affect males. (2)

Males only need one allele to be affected ✓

Affected males will generally die before reproducing, not able to pass on their version to a daughter to affect her ✓

- 3.6. Around half the cases of Barth syndrome are caused by a substitution mutation. Provide a sketch to illustrate the concept of a substitution mutation. (2)

Allocation

Sketch shows one nucleotide switching ✓

Completed as a sketch ✓

- 3.7. Individual III.2, Lolita, comes to you (in the role as a genetic counsellor) asking for advice. She knows she is a carrier of the defective gene for Barth Syndrome and wishes to have children. She is married to a man who is not affected by the disorder. Using a Punnett square (and the letters from 3.3), determine the percentage chance that she will have a child with Barth Syndrome and the gender of the child. (6)

Parents: $X_B X_b$ ✓ and $X_B Y$ ✓

	X_B	X_b	
X_B	$X_B X_B$	$X_B X_b$	
Y	$X_B Y$	$X_b Y$	✓✓ (Punnett correct)

25% chance ✓ of a male child affected ✓

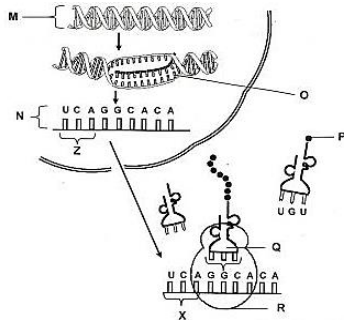
- 3.8. Discuss the importance and impact of genetic counsellors in modern times. (3)

Genetics is becoming more understood and accepted / more people are wanting to conduct genetics tests on newborns / improvements in treating genetic conditions all the time / sensitivity of genetics tests are improving / With greater knowledge inquisition comes greater need for counselling / counsellors can have an impact on a family's decision to keep the child or not, or future children, or even marry

Any three ✓✓✓

QUESTION 4

The diagram below illustrates the process of protein synthesis:



4.1. Provide labels for the following structures: (4)

- a) P **Amino acid ✓**
- b) M **DNA ✓**
- c) R **Ribosome ✓**
- d) Q **tRNA (Transfer RNA) ✓**

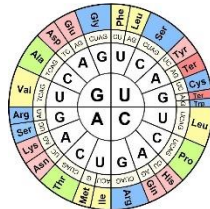
4.2. Name the process occurring at label O. (1)

Transcription ✓

4.3. Write down the complimentary DNA sequence of codon Z. (1)

A G T ✓

4.4. Using the mRNA circle below, state the three amino acids coded for by mRNA strand N. (3)



Ser ✓ Gly ✓ Thr ✓

***NOTE: do not use the anti-codons of the given sequence. Take time to check your understanding of this concept**

4.5. A point mutation occurred at the third base of the last codon of mRNA strand N, whereby adenine was replaced with guanine. How would this have affected the protein created? Explain your answer fully. (3)

No effect / neutral mutation ✓

ACA makes Thr, ACG also makes Thr ✓ So no amino acid difference ✓

4.6. Tabulate TWO differences between the structure of DNA and proteins. (5)

Heading provided ("A table...") AND In table format ✓

Per correct difference ✓✓ (x 2) (Any of the two given below)

DNA	Proteins
Monomer is nucleotides	Monomer is amino acids
Double helix	Many different complex structures
Contains C, H, O, N and P	Contains C, H, O and N
Contains hydrogen bonds	Contains peptide bonds

NOTE: Not looking for functional differences

4.7. The structure of DNA was a relatively recent discovery in general scientific terms. Briefly discuss why it was so important that Watson and Crick cracked the code of the structure of DNA. (3)

Key to understanding inheritance / key to medical research into genetic diseases / essential to understanding evolution and mutation / DNA became integral to criminal investigations / laid foundation for biotechnology and genetic engineering

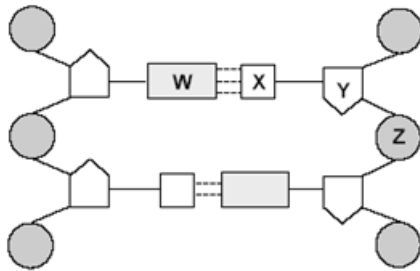
(Any three ✓✓✓)

K-TEST 05 – 60 marks (50 minutes)

QUESTION 1

Several Multiple Choice questions are provided below. Select the letter which represents the most correct answer:

- 1.1. The diagram below represents a DNA molecule. Which part depicts deoxyribose? (1)



C. Y ✓

W and X are nitrogenous bases ; Z is phosphate

- 1.2. The following events occur after DNA is subjected to radiation. The events are listed in no order.

P: Change in protein structure
Q: Change in amino acid sequence
R: Change in cell activities
S: Mutation

What is the correct sequence of events? (1)

B S, Q, P, R ✓

- 1.3. Which statement about a diploid cell is NOT correct? (1)

D. It is one that possesses one complete set of chromosomes. ✓

This describes a haploid cell. All others are correct

- 1.4. In a genetic engineering experiment a piece of double-stranded DNA containing 6000 nucleotides coding for a specific polypeptide is transcribed and translated. What is the total number of amino acids in this polypeptide? (2)

B. 1000 ✓✓

Double stranded DNA, but only half is used to make mRNA (6000 / 2)

Then for every 3 nucleotides you get one amino acid (3000 / 3)

Final answer is 1000 amino acids

QUESTION 2

State the name for the following terms: (4)

2.1. A pair of similar shaped and sized chromosomes present during meiosis **Homologous ✓**

2.2. A body cell containing a diploid number of chromosomes

Somatic cell ✓

2.3. The name given to chromosomes that determine sex

Gonosomes ✓

2.4. The use of biological processes in industry; the use of living organisms or processes to develop products

Biotechnology ✓

Provide definitions for the following terms: (4)

2.5. Transgenic

Organism which has developed due to recombinant DNA technology ✓

2.6. Allele

Two or more alternative forms of a gene ✓

2.7. Monohybrid cross

The breeding of two individuals whose genetic composition is only different for one gene ✓

2.8. Polyploidy

Organisms which contain more than two full sets of chromosomes ✓

QUESTION 3

Analyse the following text and answer the questions that follow:

In 1962 Watson, Crick, and Wilkins jointly received the Nobel Prize in Physiology or Medicine for their determination of the structure of deoxyribonucleic acid (DNA). Wilkins's colleague Franklin was not so honored. The reasons for her exclusion have been debated and are still unclear. There is a Nobel Prize stipulation that states "in no case may a prize amount be divided between more than three persons." The fact she died before the prize was awarded may also have been a factor, although the stipulation against posthumous awards was not instated until 1974.*

**posthumous – after death*

3.1. In what year did Watson and Crick discover the structure of DNA? (1)

1953 ✓

3.2. Briefly describe how Watson and Crick's work lead the understanding of genetic replication. (2)

Helped understand the concept of complimentary base pairing ✓

How to create an exact copy of the strand but still allow more change / mutation ✓

3.3. In the 60's, the process of protein synthesis was also discovered through their work. In the for of a flow diagram, describe the process of translation that occurs in protein synthesis. (6)

Heading provided ("A flow diagram...") ✓

In flow diagram format (use of arrows, flow from top - bottom of page) ✓

Any four of the following points (✓✓✓✓):

- Small section of DNA unwinds and unzips (hydrogen bonds broken)
- RNA polymerase catalyses process
- Free floating nucleotides join in complimentary fashion to the DNA
- Thymine replaced with uracil on mRNA strand
- New mRNA strand detaches from DNA and leaves to cytoplasm
- DNA rezips and recoils

3.4. Do you feel it was justified that Rosalind Franklin did not receive the Nobel Prize for her contributions? Justify your answer with ONE well-explained point. (3)

***NOTE: No correct answer for decision, but first mark is given to that a decision is provided (Yes or No stated) and matches the reasoning**

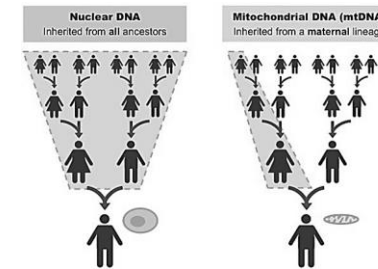
Next two marks go to one well-explained reason ✓✓

Yes – She did not publish her research / she avoided collaboration / only three can be awarded and she had died at the time

No – Her crystallography pictures were the key to the discovery / her research was shown without her permission / prejudice against female scientists was present at the time

QUESTION 4

Consider the following infographic:



4.1. Tabulate THREE differences between nuclear DNA and mitochondrial DNA. (5)

Heading provided ("A table...") ✓

In table format ✓

Per correct difference for both structures ✓✓✓

DNA	mtDNA
Inherited from both parents	Inherited mother only
Found in nucleus	Found in mitochondria
Much longer / many more bases	Shorter, much less bases
Controls variety of metabolic activities	Limited to control activity of mitochondria

Any three of the above

- 4.2. Briefly describe the theory related to how mitochondrial DNA came into existence. (3)

Endosymbiosis ✓

Internal symbiotic relationship of a prokaryote into a eukaryote ✓ which gave rise to mitochondria and chloroplasts ✓

Consider the following case"

Switched babies

June 1 2014 at 10:23 a.m.
By Vivian Attwood.

Durban – The case of two children who were mistakenly switched shortly after birth made headlines this week.

The babies, a boy and a girl, were born on the same day in 2010 at Oliver Tambo Memorial Hospital in Johannesburg. While the hospital has conceded its error, it has given no details of how it occurred. The mistake was detected when one of the mothers had DNA tests done after her ex-husband refused to pay maintenance, claiming he was not the father.

This mother then demanded that her biological child be returned to her. However, the other mother refused. The matter is currently to be considered by the North Gauteng High Court.

[Source: <www.iol.co.za/news/south-africa>]

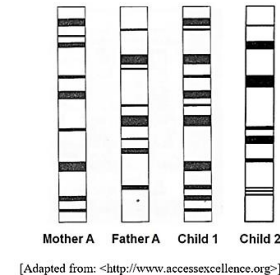
- 4.3. The High Court is expected to make an objective decision. Provide ONE argument FOR and ONE argument AGAINST the returning of the babies to their biological parents. (2)

***NOTE: Must state which is For and which is Against argument. Or no marks**

FOR (Any one ✓) – Biological parents have a right to their child / was not their mistake / children may have genetic conditions they need to hear from their families / money lost preparing for a specific gender of baby

AGAINST (Any one ✓) – Babies and mother have already formed bond / traumatic to the babies which can have emotional scarring / unnecessary financial burden with everything bought already

- 4.4. The diagram below shows the DNA profiles of one set of the parents with their biological child as well as the child they took home from the hospital. Which child is the biological child of Mother A and Father A? Substantiate your answer. (2)



Child 1 ✓

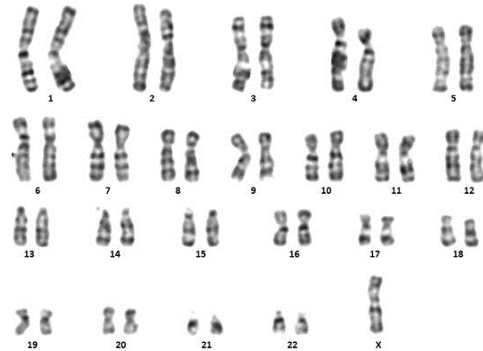
Has bands accounted for by mother and father ✓

- 4.5. State any THREE steps involved in the process of creating a DNA profile. (3)

Any three of the following (✓✓✓)

- Non-coding DNA is used
- Restriction enzymes cut specific sections of variable DNA
- Polymerase Chain Reaction (PCR) duplicated DNA
- DNA separated into bands based on electrophoresis
- Picture taken on film showing DNA bands for comparison

Analyse the following karyotype:



4.6. What is meant by the term 'karyotype'? (2)

A picture / visual representation ✓ of all the chromosomes an individual has inherited ✓

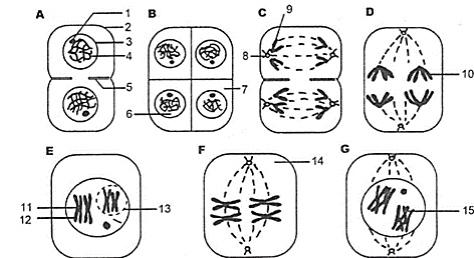
4.7. Identify what is unusual about this karyotype that would indicate this person has a chromosomal disorder. (2)

The individual only has one gonosome / sex chromosome ✓

They should have two gonosomes ✓

QUESTION 5

The diagram below (pictures A – G) shows different phases of meiosis. The slides are not in the correct sequence.



5.1. State ONE visible reason to justify why the above images are indeed showing meiosis occurring. (1)

Four cells are being produced from one / shows homologous pairings of chromosomes / crossing over is occurring (Any one ✓)

5.2. Why does meiosis occur in animals and plants? (2)

To create haploid gametes ✓ needed for sexual reproduction ✓

5.3. Why are chromosomes and their structure significant to the functioning of meiosis? (3)

Chromosomes are made of DNA which controls all life / functioning ✓

Meiosis needs to create cells with the correct number of chromosomes, or else new life will not function ✓

Coiled structure ensures correct and accurate division ✓

5.4. Place the images above in the correct order for meiosis. (2)

E – G – F – D – A – C – B ✓✓ (All or nothing marks)

QUESTION 6

Consider the following:

Researchers at the University of Missouri, led by Praveen Rao, are developing a free, online resource that could help scientists accelerate their discoveries for various human diseases — such as sickle cell disease, cystic fibrosis, and even COVID-19 — by analyzing human genomes three times faster than currently available methods. Since the Human Genome Project (HGP) began in the early 1990s, advances in technology have allowed scientists to develop a more detailed view of the human genome.

<https://www.eurekalert.org/news-releases/937326>

6.1. Describe TWO of the main goals of the Human Genome Project. (4)

Goal ✓ + description ✓ (x2) (Any two of the following)

- Sequence the human genome ✓; find the exact nucleotide sequence of human genome ✓
- Identifying all the genes of HG / mapping the genes ✓; finding the function / locations of all genes in HG ✓
- Creating database of HG ✓; allow for further medical research ✓
- Research into genetic or inherited conditions ✓; linkage maps to track over generations ✓

6.2. Suggest and explain ONE benefit of being able to analyse a human genome 3 times faster. (2)

Suggestion ✓ + explanation ✓

Medical research can be advanced quicker, tracing inherited identification / improve the ability to conduct gene therapy, can locate genes faster / can bring genetic therapy to the masses, becomes cheaper and more accessible

(Any one with explanation)

6.3. What is meant by the term genome? (1)

A full set of genes present within the cell of an organism ✓

6.4. Sickle-cell disease and cystic fibrosis are both autosomal conditions. Name ONE sex-linked genetic disorder you have learnt about. (1)

Red-green colour blindness / Haemophilia ✓

***Other disorders do exist which can be mentioned but these are direct from SAGS**

K-TEST 06 – 60 marks (50 minutes)

QUESTION 1

Study the following table which consists of two items (numbered 1 and 2) in the first column and a term in the second column. **Decide which item(s) relate to the term.**

Write down your choice in the space provided in the "answer" column, making use of the following codes: (5)

- A only item 1 relates to the term
- B only item 2 relates to the term
- C both item 1 and 2 relate to the term
- D neither item 1 or 2 relates to the term

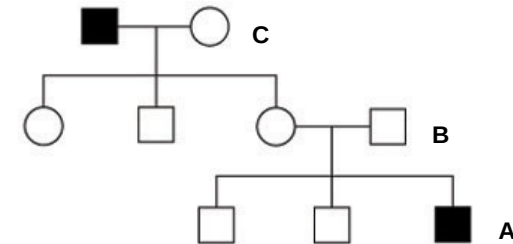
Item	Term
1. All the genes present within a population 2. All the genes present within a cell	Gene pool
1. Sex cell 2. Diploid cell	Gonosome
1. Used when creating a DNA profile 2. Used when creating mRNA	Polymerase
1. Present in mRNA 2. Present in mtDNA	Thymine
1. Homologous chromosomes separated 2. Sister chromatids are separated	Anaphase II

ANSWERS: 1 – B ; 2 – D ; 3 – C ; 4 – B ; 5 – B

QUESTION 2

Even though many strides have been made to reduce the trade in ivory, elephant poaching continues to occur in Africa. Tusks are important structures to elephants, providing both protection from enemies and a means to forage for food. They are not essential for survival though. A growing trend is being seen that more elephants are being born without tusks, essentially inheriting a 'tuskless gene' from their parents. It was found that this 'tuskless gene' was inherited in an autosomal recessive fashion.

Below is an image of a family pedigree tracking one family of elephants in Mozambique. In the image, filled shapes represent individuals who are tuskless and non-filled shapes represent individuals who have tusks. Circles are females, squares are males.



2.1. What is meant by the term 'autosomal recessive'? (2)

Autosomal – found on chromosome 1 – 22 / not found on gonosome ✓

Recessive – Masked by the dominant allele, and only expressed homozygously ✓

2.2. Choose a key to represent a normal individual and a tuskless individual. State and use this chosen key to identify the genotypes of individuals A and B from the pedigree. (4)

***Choose letters with different capital to lowercase letter (Like T, R, B, A)**

KEY: Normal = R ✓; Tuskless = r ✓ (NOTE: Not a genotype to give!)

Individual A = rr ✓ Individual B = Rr ✓

- 2.3. Explain why, based only on the information presented, it is impossible to say with certainty what the genotype of individual C is. (3)

Children of C will all be heterozygous individuals ✓

But since C only gives one allele, cannot tell if she is homozygous or heterozygous for sure ✓

Just because no children were born tuskless cannot be assumed ✓

- 2.4. Elephant A is going to have offspring with a female who has no history of the tuskless gene in her family. Use a Punnett square (and chosen key in 2.2) to show the predicted chance their offspring will be born tuskless. Include in your answer the genotype and phenotype ratios of the potential offspring. (7)

Parents: rr ✓ x RR ✓

	<i>r</i>	<i>r</i>	
<i>R</i>	<i>Rr</i>	<i>Rr</i>	
<i>R</i>	<i>Rr</i>	<i>Rr</i>	✓✓ (Punnett correct)

Genotype ratio: All Rr ✓

Phenotype ratio: All normal / have tusks ✓

Therefore – 0% chance to be tuskless ✓

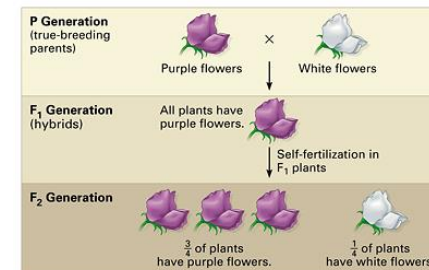
- 2.5. The 'tuskless' gene is caused by a mutation. Explain why this mutation can be described as both a beneficial and a harmful mutation to the elephants. (2)

Beneficial – Less chance of poaching ✓

Harmful – Less protection from enemies / decreased ability to forage for food ✓

QUESTION 3

The image below is one example of the experiments conducted by Mendel using pea plants to understand inheritance.



- 3.1. Describe how the work conducted by Mendel paved the way for modern genetics. (3)

Laid basis for understanding inheritance patterns / provided mathematical foundation of inheritance patterns ✓

Understanding that genes come in pairs and interact in different ways / dominance and recessiveness ✓

Independent assortment or the random chance of being able to inherit / foundation for investigating meiosis procedure ✓

- 3.2. Originally, Mendel's conclusions were not accepted by the scientific community. Suggest ONE reason why this was the case, and provide ONE reason why it was accepted at a later stage. (2)

Rejected – Uneducated masses who did not understand / period of scientific oppression / no corroboration from other scientists / the concept was completely foreign, not easily accepted (Any one ✓)

Later acceptance – More research was conducted / reliable data, was found to be consistent / advances in technology / discovery of nucleic acids (Any one ✓)

- 3.3. State what the genotypes representing the following words:

- a) True-breeding *Homozygous ✓*
b) Hybrids *Heterozygous* (2)

- 3.4. State ONE other type of characteristic of the pea plant that Mendel experimented with. (1)

Plant height / pea colour / pea texture / flower position / pea pod texture / pea pod colour (Any one ✓)

QUESTION 4

Proposition 37 was a California ballot measure rejected in California at the statewide election on November 6, 2012. This initiative would have required labelling of genetically engineered food. It would have disallowed the practice of labelling genetically engineered food with the word "natural".



- 4.1. What is meant by the term 'Genetically Modified Organisms'? (1)

Individuals who genetic composition has been artificially changed ✓

- 4.2. Explain how GMO's are related to artificial selection. (2)

Artificial selection is where a human chooses to breed desired genes naturally ✓

GMO is direct gene manipulation to achieve desired characteristics ✓

- 4.3. Justify whether you feel those in favour of Proposition 37 have a valid scientific argument to force companies into labelling their products as genetically modified. Support your view with TWO valid arguments. (2)

**NOTE: No correct side of argument, no mark allocated to decision for this question but must be stated. Two marks to each reason given ✓✓*

Yes – Have a right to know ingredients / may be unknown side effects / moral objections / taking away from local natural farmers

No – no scientific evidence of harm / ingredients are the same, no different / ingredients are still natural, just placed artificially / will end up being more nutritious / can be cheaper than 'organic'

A

Daffodil

Beta-carotene biosynthesis gene extracted from Daffodil

Gene inserted into normal rice plant

Yield of Golden Rice

Beta-carotene biosynthesis genes facilitate the production of beta-carotene in the rice

The beta-carotene filled rice is consumed

The gut converts beta-carotene to vitamin A

B

- ### Micropropagation ✓

Diagram illustrating the process of transcription elongation. The DNA double helix is shown with the template strand (3' to 5') and the growing mRNA strand (5' to 3'). The mRNA strand is being synthesized by RNA polymerase, which is moving along the DNA template. The growing mRNA strand has a 5' cap (labeled 4) and a 3' end (labeled 5). The template strand has a 3' end (labeled 2) and a 5' end (labeled 3). The growing mRNA strand is labeled "Direction of transcription (downstream)" with an arrow pointing to the right.

- 5.5. Construct a biological drawing to show the full structure of a generic nucleotide (indicated by label 3). (4)

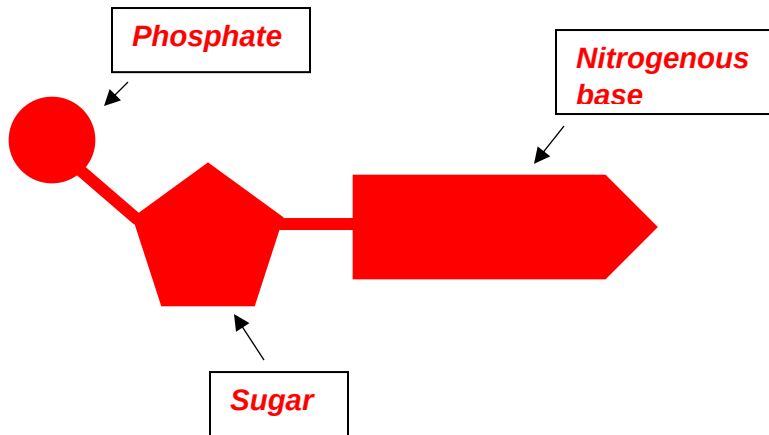
Allocation:

Heading provided ("A biological drawing...") ✓

Correct structure drawn ✓

Appropriate size and proportion of image ✓

Correct labels of nucleotide ✓



**NOTE:*

Size should be at least 1/3 of a page big

Label for sugar being a specific type is not necessary as a generic nucleotide asked

Phosphate cannot be larger than the sugar

Sugar must be a 5-sided shape

Nitrogenous base shape not important

Label lines cannot cross over the actual image

- 5.6. Explain why the order of nucleotides of molecule 4 determines what protein is made. (2)

Protein made depends on the order of amino acids ✓

Order of amino acids determined by codons order on mRNA ✓

- 5.7. Discuss the impact a frameshift mutation would have on the process of protein synthesis. (3)

Frameshift is either an insertion or deletion of a nucleotide ✓

Affects the order of all nucleotides/codons after the mutation ✓

All amino acids are changed and significantly affects protein made / may stop protein synthesis occurring properly ✓

- 5.8. Discuss how knowledge of mutations has increased our knowledge of inheritance patterns. (3)

Mutations cause changes in genes / creates alleles / creates dysfunction in protein made ✓

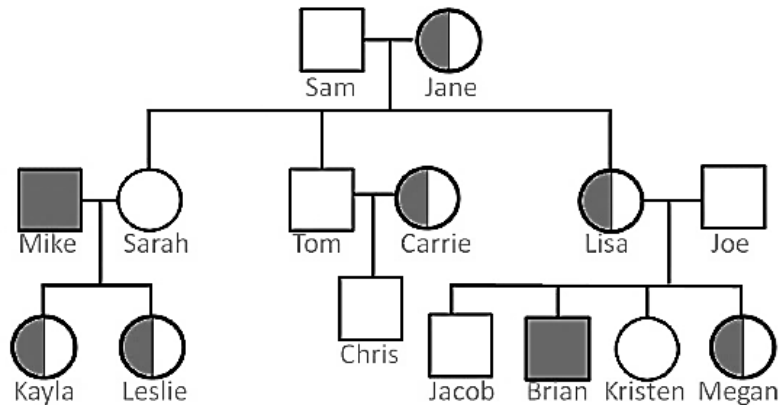
Mutations cause change in phenotype which can be traced through hybrid crosses ✓

Some mutations are not passed on (such as skin cancer) ✓

K-TEST 07 – 60 marks (50 minutes)

QUESTION 1

Analyse the family pedigree below showing the inheritance of red-green colour blindness:



<https://brainly.com/question>

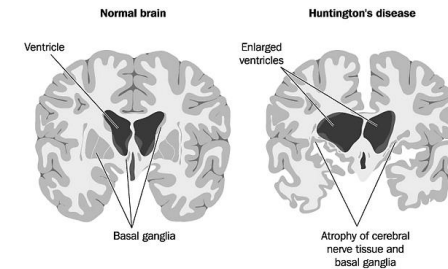
State whether the following are TRUE or FALSE based on the pedigree:

(6)

- 1.1. Chris has red-green colour blindness **False ✓**
- 1.2. Lisa is a carrier of the disorder **True ✓**
- 1.3. Mike's genotype is $X^{R}Y$ **False ✓**
- 1.4. Carrie's genotype is Rr **False ✓ (must be sex-linked)**
- 1.5. Megan inherited the defective gene from her father **False ✓**
- 1.6. The disorder is only affecting males in this family **True ✓**

QUESTION 2

Huntington's disease is a progressive brain disorder that causes uncontrolled movements, emotional problems, and loss of thinking ability. It usually appears in a person's thirties or forties. Many people with Huntington's disease develop involuntary jerking or twitching. Affected individuals may have trouble walking, speaking, and swallowing. Individuals with Huntington's disease usually live 15 to 20 years after symptoms begin. This condition is inherited in an autosomal dominant pattern.



- 2.1. Explain what is meant by the phrase 'autosomal dominant'. (2)

Autosomal – found on chromosome 1 – 22, not sex linked ✓

Dominant – allele which masks the recessive, will be expressed both homozygously and heterozygously ✓

- 2.2. Provide a key to represent the normal (unaffected) condition and for Huntington's disease. (2)

***Choose letters with different capital to lowercase letter (Like T, R, B, A)**

KEY: Normal = b ✓; Huntington's = B ✓ (NOTE: Not a genotype to give!)

***Note the dominant!**

- 2.3. Use a Punnett square to show the probability that the offspring an unaffected individual and a heterozygous individual would have Huntington's disease. Use your key chosen in 2.2.

In your answer you must include the phenotype and genotype ratios.

(7)

Parents: $bb \checkmark \times Bb \checkmark$

	b	b	
B	Bb	Bb	
b	bb	bb	$\checkmark\checkmark$ (Punnett correct)

Genotype ratio: $1 Bb : 1 bb \checkmark$

(Must be lowest common form)

Phenotype ratio: $1 \text{ normal or unaffected} : 1 \text{ Huntington's} \checkmark$

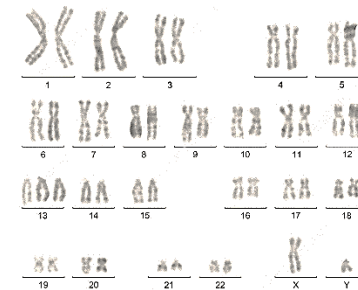
(Must be lowest common form)

Therefore – 50% chance of having Huntington's $\checkmark$

QUESTION 3

Patau Syndrome is a chromosomal condition associated with severe intellectual disability and physical abnormalities in many parts of the body. Individuals with Patau Syndrome often have heart defects, brain or spinal cord abnormalities, very small or poorly developed eyes, extra fingers or toes, an opening in the lip with or without an opening in the roof of the mouth, and weak muscle tone. Due to the presence of several life-threatening medical problems, many infants with Patau Syndrome die within their first days or weeks of life.

The karyotype below shows an individual with Patau Syndrome



- 3.1. Identify the gender of the child from the given karyotype. (1)

Male $\checkmark$

- 3.2. Describe the chromosomal abnormality from the karyotype. (2)

Extra chromosome 13 $\checkmark\checkmark$ / **Trisomy 13** / **3 chromosome 21 instead of 2**

- 3.3. State TWO phenotypic outcomes of Patau Syndrome. (2)

Heart defects / brain and spinal cord abnormalities / poorly developed eyes / extra fingers or toes / opening in the lip / weak muscle tone (Any two $\checkmark\checkmark$)

- 3.4. Describe the process in which an individual would acquire Patau Syndrome. (3)

Chromosomal non-disjunction ✓

Incorrect separation of chromosomes / centromere does not split during meiosis ✓

Gametes end up with an extra chromosome ✓

- 3.5. Although the relationship between age of a mother and incidence of Patau Syndrome has not been established, some chromosomal abnormalities have been linked to the increasing age of a woman. In your opinion, should it be compulsory for pregnant women over the age of 35 to have an amniocentesis performed? Justify your answer with ONE biologically relevant point. (3)

***Note: Either side can be argued – first mark goes to stating decision and matches the argument given ✓**

Next two marks go to one well-explained point ✓✓

Yes – Allows for knowledge and preparation / give the family time to emotionally and financially prepare / knowledge gained is worth more than minor risk

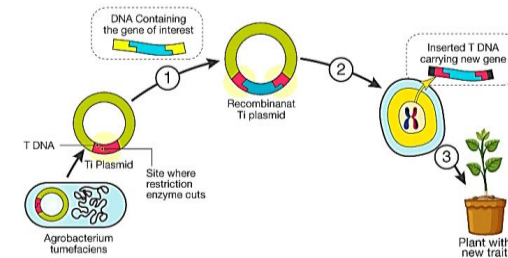
No – Amniocentesis carries risk to mother and child / right to choose medical procedures / some women cant afford the procedure / moral and religious objections to increased abortions

- 3.6. Explain why CRISPR technology could not be used to treat Patau Syndrome. (2)

Patau is a chromosomal disorder (whole chromosome extra) ✓ CRISPR can only delete or edit genes ✓

QUESTION 4

The diagram below shows the process involved in transforming a plant



- 4.1. State the name of the specific process illustrated. (1)

Recombinant DNA technology ✓

- 4.2. Identify and explain any FOUR steps in this biotechnological process. (4)

Any four of the following (✓✓✓✓)

- Plasmid is extracted from bacteria / yeast cell
- Restriction enzymes extract/cut out desired gene
- Restriction enzymes cut open plasmid creating sticky ends
- Ligase enzyme glue/joins gene to open plasmid
- Recombinant DNA reinserted into vector
- Vector placed into plant to transform plant

- 4.3. Suggest ONE reason why plants would need to be transformed. (1)

Increasing poor quality of farmland / increased demand for yield / decreased nutritional qualities / lack of farming knowledge / staple food for survival of a nation / important commodity in commerce (Any one ✓)

- 4.4. Tabulate TWO advantages and TWO disadvantages of GMO organisms. (6)

Heading provided ("A table...") ✓

In table format ✓

Per correct advantage ✓✓ Per correct disadvantage ✓✓

Advantage	Disadvantage
Better quality produce	Unknown side effects from consumption
Easier to grow / access for poorer communities	Takes away from local farmers
Improved health of community	Can become invasive species / food web disruption
Aid in improving the economy	Expensive to research

Any two each of the above

- 4.5. A controversial point regarding GM foods is labelling. Do you feel it should be compulsory to labelled foods that contain GM sources? Justify your answer with ONE well-explained point. (3)

**Note: Either side can be argued – first mark goes to stating decision and matches the argument given ✓*

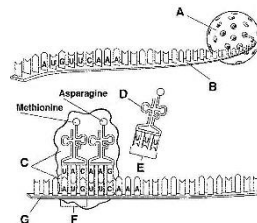
Next two marks go to one well-explained point ✓✓

Yes – Right to know / may have allergies / preference for organic

No – No difference in contents / prejudice towards companies / no scientific evidence they cause harm

QUESTION 5

The image below depicts the process of translation



- 5.1. Provide labels for structures A, B, C and E. (4)

A – Nucleus ✓; B – mRNA ✓; C – Ribosome ✓; E – Anti-codon

- 5.2. What are represented by the words 'methionine' and 'asparagine'? (1)

Amino acids ✓

- 5.3. State the type of bond that will exist between methionine and asparagine. (1)

Peptide bond ✓

- 5.4. Structure D is a specific type of nucleic acid. Name any TWO other forms of nucleic acid. (2)

mRNA / DNA / mitochondrial DNA / ribosomal RNA (Any two ✓✓)

- 5.5. The image shows translation. In flow diagram form, describe the process that happened before translation. (7)

Heading provided ("A flow diagram...") ✓

In flow diagram format (use of arrows, flow from top - bottom of page) ✓

Any 5 of the following points: (✓✓✓✓✓)

- DNA unwinds and unzips
- Hydrogen bond between nucleotides are broken
- RNA polymerase catalyses new strand formation
- Free floating nucleotides join in complimentary fashion
- A with U and C with G
- New mRNA strand separates from DNA and leaves nucleus
- DNA rezip and recoils

K-TEST 08 – 60 marks (50 minutes)

QUESTION 1

Select the term in Column B that matches the phrase in Column A. (10)

COLUMN A	COLUMN B
1. Bonds that hold nucleotides together in a DNA strand	A. Polygenic
2. A complete set of genes contained within the cell of an organism	B. Mutation
3. Continuous characteristics influenced by several alleles	C. Heterozygous
4. An organism that has inherited two of the same version of an allele	D. Karyotype
5. A group of three adjacent nucleotides found on a tRNA strand	E. Nucleotide
6. A permanent change in the nucleotide sequence of DNA	F. Peptide
7. The monomer of proteins	G. Hydrogen
8. A visual representation of all the chromosomes and individual has inherited	H. Amino acids
9. The monomer of nucleic acids	I. Codon
10. The bonds that form between amino acids	J. Genome
	K. Homozygous
	L. Anticodon

ANSWERS:

1 – G ; 2 – J ; 3 – A ; 4 – K ; 5 – L ; 6 – B ; 7 – H ; 8 – D ; 9 – E ; 10 – F

QUESTION 2

Study the following table which consists of two items (numbered 1 and 2) in the first column and a term in the second column. **Decide which item(s) relate to the term.**

Write down your choice in the space provided in the "answer" column, making use of the following codes: (6)

- A** only item 1 relates to the term
B only item 2 relates to the term
C both item 1 and 2 relate to the term
D neither item 1 or 2 relates to the term

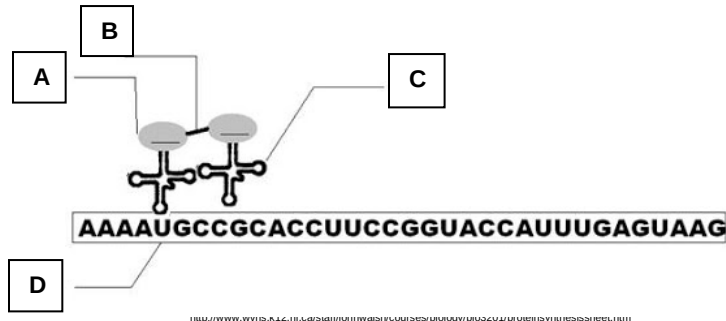
Item	Term
1. Makes use of micropropagation 2. Makes use of vectors	Gene therapy
1. Double-stranded, ring-shaped molecule in the mitochondria 2. Single-stranded, ring-shaped molecule in the mitochondria	mtDNA
1. Is the organism that matures a cloned embryo 2. Provides the nucleus of the organism to be cloned	Donor
1. A haploid cell 2. Produced in the gonads of an individual	Somatic cell
1. Use of living processes 2. Creation of products to benefit society	Biotechnology
1. Guided by nature 2. Creates greater variety in organisms	Artificial selection

ANSWERS:

1 – B ; 2 – A ; 3 – B ; 4 – D ; 5 – C ; 6 – D

QUESTION 3

The picture below represents a particular process occurring during protein synthesis. Analyse the picture to help you answer the questions that follow.



3.1. Identify structures A and C. (2)

A – Amino acid ✓ C – tRNA ✓

***NOTE: Must write link of label letter to answer. Or no marks**

3.2. State the bond represented by B. (1)

Peptide bond ✓

3.3. Where in the cell would the process above take place? (1)

Cytoplasm / at the ribosome ✓

3.4. State the first THREE anti-codons for the section of mRNA shown. (3)

UUU ✓ UAC ✓ GGC ✓

3.5. State and explain TWO reasons why molecule D is mRNA and not DNA. (4)

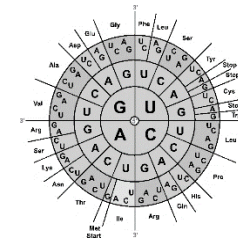
Contains uracil ✓ and not thymine ✓

Is a single strand ✓ not double strand ✓

Translation is occurring ✓ this does not involve DNA ✓

Any two of the above

3.6. Use the mRNA circle below to identify the first two amino acids of the polypeptide shown in the diagram. (2)



Start (or Met) ✓

Pro ✓

***NOTE: AAA does not have an amino acid attached, so does not count**

3.7. A mutation occurs where the first nucleotide of the above mRNA sequence is changed from A to U. State the type of mutation and describe the effect this will have on the protein created. (3)

Substitution ✓

Now codes for a STOP codon ✓

Result: Protein will not be made ✓

- 3.8. Describe ONE difference between the process of DNA replication and DNA transcription. (2)

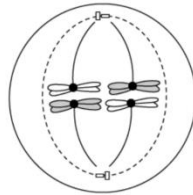
One difference describing both side of difference ✓✓

Replication uses DNA polymerase, transcription uses RNA polymerase / Replication creates a double strand, transcription makes one / replication has A-T complimentary, transcription has A-U complimentary

Any one

QUESTION 4

The image below represents a certain stage of meiosis. Analyse the picture and answer the questions that follow:



- 4.1. State ONE organ in humans where meiosis occurs. (1)

Testes / ovaries ✓

- 4.2. Explain why meiosis is an important process for humans. (2)

Needed to create gametes with half the number of chromosomes ✓

Meiosis creates variety which is important for evolution/adaptation ✓

- 4.3. Identify the phase of meiosis shown in the diagram. Provide a reason for your answer. (2)

Metaphase 1 ✓

Homologous pairs lined up on the equator ✓

- 4.4. Briefly explain what the process of 'crossing over' is and why it is an important process in meiosis. (2)

Exchange of genes between homologous chromosomes ✓

Creates genetic variation important for adaptation ✓

- 4.5. Based on the diagram above, how many chromosomes will be present in this cell's gametes? (1)

Two ✓

- 4.6. Down Syndrome is a disorder that results from abnormal meiosis. A famous reality television show, "Born This Way", airs on the American network A&E. This reality show follows the lives of 7 individuals living with Down Syndrome. Critique the use of reality television shows to raise awareness of this and similar genetic conditions. (2)

**NOTE: A critique argument can be all in favour, all against or one for either side.*

From sections given can be two from either side or one from each ✓✓

Favour critique: normalizes behaviour / educates the viewers / encourages personal research / can raise funding for research for cures

Against critique: Encourages ridicule / tv sensationalizes the life and not accurate representation / may spread misinformation / people research incorrectly

QUESTION 5

Analyse the following text and answer the questions that follow:

Duchenne Muscular Dystrophy (DMD) is a fatal neuromuscular disorder caused by a recessive mutation on the X chromosome. DMD is more common in boys than in girls. It is now known that the DMD gene encodes dystrophin, a huge muscle protein with about 4,000 amino acids that plays an integral role in maintaining the structural integrity of muscle cells. Most DMD patients use a wheelchair by their early teens, with their muscles becoming progressively weaker. Patients usually die from heart or respiratory problems by their twenties or thirties, if not before. Although DMD is named after the French neurologist Duchenne de Boulogne, who first described the disorder in the late 1800s, the cause of this disease remained a medical mystery until the mid-1980s, at which time the DMD gene defect was identified.

5.1. Define the following terms:

a) recessive (1)

Allele masked by recessive, only expressed homozygously ✓

b) gene (1)

A short section of DNA / short sequence of nucleotides which controls the expression of one characteristic ✓

5.2. Explain why DMD is more common in boys than girls. (2)

Males only need one defective gene ✓ Many die before reproducing to create a daughter with two copies to be affected ✓

5.3. Describe ONE way the work of Mendel would have assisted in gaining an understanding of the cause of DMD. (2)

Reason ✓ + extension ✓

Knowledge of dominant vs recessive traits / mathematical probability of inheritance pattern / the concept of carriers

5.4. If **D** represents the dominant allele, and **d** the recessive allele, state the genotypes of the following individuals:

a) Normal male X_DY ✓

b) Carrier female X_DX_d ✓ (2)

5.5. Using the same letters stated in 5.4., use a Punnett square to show the phenotype and genotype ratio of the offspring a normal male and carrier female would produce. (5)

Parents: X_DX_d and X_DY ✓ (Both parents correct)

	X_D	X_d	
X_D	X_DX_D	X_DX_d	
Y	X_DY	X_dY	✓✓ (Punnett correct)

Phenotype ratio: 2 normal female : 1 normal male : 1 affected male ✓

Genotype ratio: 1 X_DX_D : 1 X_DX_d : 1 X_DY : 1 X_dY ✓

**NOTE: Do not refer to carrier females in phenotype ratio. Not truly correct as 'carrier' is not a physical expression*

5.6. Consider the following:

Prenatal tests are common when parents suspect their child has a genetic disease such as DMD. However, some X-linked diseases have no formal test or known causal factor, so some parents only test the sex of the baby. If it is a girl, she will be carried to full term; if it is a boy, it will be aborted due to the high chance of having a deadly disease.

Evaluate the ethics of the above information by providing ONE argument in favour and ONE argument against the use of 'sex testing' for genetic conditions. (2)

*** NOTE: Must state which is favour and against. Or else no marks**

FAVOUR – Right of the parents to decide / save the family emotional turmoil / reduce the financial burden (Any one ✓)

AGAINST – Not confirmed so unnecessary to abort / killing unborn child is unjustified / child can still live a fulfilling life (Any one ✓)

5.7. Besides a thorough knowledge of genetics, suggest ONE other skill a genetic counsellor should be trained in to deal specifically with individuals who have a family history of DMD. (1)

Grief counselling / financial counselling / prognosis of DMD / spiritual counselling (Any one ✓)