THE SCHOOL FOR EXCELLENCE (TSFX)

UNIT 4 BIOLOGY 2008

WRITTEN EXAMINATION 2

Reading Time: 15 minutes
Writing Time: 1 hour 30 minutes

QUESTION AND ANSWER BOOK

Structure of Booklet

Section	*Number of Questions*	*Number of Questions to be Answered*	*Number of Marks*	*Suggested Times (min)*
A Multiple Choice Questions	25	25	25	30
B Short Answer Questions	7	7	50	60
			Total 75	**Total 90**

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SECTION A – MULTIPLE-CHOICE QUESTIONS

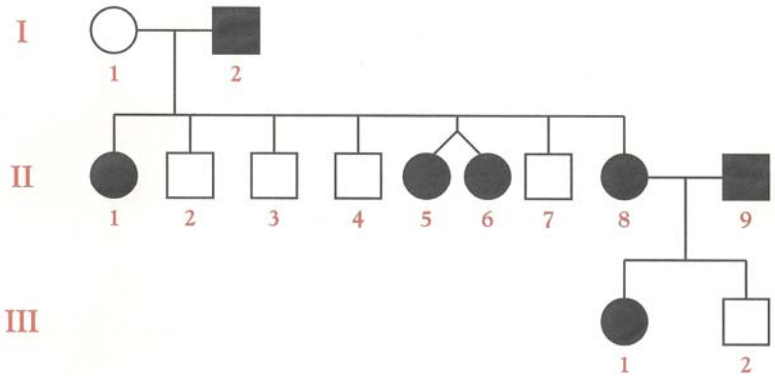
Instructions for Section A

Answer all questions in pencil on the answer sheet for multiple-choice questions. A correct answer scores1, an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

QUESTION 1
Deoxyribonucleic acid (DNA) is composed of nucleotide subunits. Which of the following statements is true regarding DNA nucleotides?

A Covalent bonds exist between deoxyribose sugars and the bases.
B Adenine and thymine are the purine bases.
C Adenine pairs with uracil within the double helix.
D The 3' end of a DNA strand has a free phosphate group.

QUESTION 2
The following pedigree depicts the inheritance of Incontinentia Pigmenti within a family.



Skin lesions are common symptoms of this rare condition, while vascular problems in the retina of the eye can lead to detachment of the retina in early childhood of other unfortunate sufferers.

Incontinentia Pigmenti is most likely:

A an autosomal dominant condition.
B a sex-linked dominant condition.
C an autosomal recessive condition.
D a sex-linked recessive condition.

QUESTION 3
Based on the pedigree above, the chance of individual III-1 possessing a homozygous genotype is:

A 0%
B 50%
C 67%
D 100%

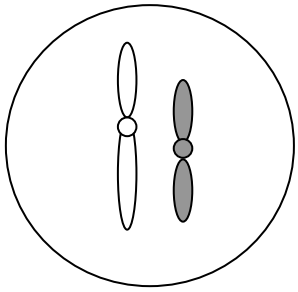
QUESTION 4
In the pedigree above:

A I-2 is the uncle of II-9.
B II-5 and II-6 are fraternal twin girls.
C II-1 is the sister-in-law of II-9.
D III-1 is the grandson of I-1.

QUESTION 5
Complementary base pairing between two RNA molecules takes place during the process of:

A transcription.
B translation.
C reverse transcription.
D DNA replication.

QUESTION 6
Meiosis is a form of nuclear division which contributes greatly to variation within a species. The following diagram represents a cell during meiosis:



The cell could be from an organism with a:

A diploid number of 4 during telophase I.
B haploid number of 4 during telophase I.
C diploid number of 2 during telophase II.
D haploid number of 2 during telophase II.

QUESTION 7
DNA replication:

A requires DNA polymerase to unzip the complementary parent strands of DNA.
B occurs during mitosis and meiosis.
C occurs prior to meiosis.
D cannot take place in prokayotes as they do not possess paired chromosomes.

QUESTION 8
Transcription:

A Requires DNA polymerase to unzip the complementary parent strands of DNA.
B Occurs continuously during the lifetime of a cell.
C Requires helicase to unzip the complementary parent strands of DNA.
D Only occurs during cell division.

QUESTION 9
Apoptosis occurs in most tissues of the vertebrate body. Examples of apoptosis include:

A The destruction of skin cells in a bicycle accident.
B Invading bacteria being engulfed by phagocytes.
C The retention of webbing between the toes on a duck's foot.
D The destruction of most cytotoxic T cells after overcoming an infection.

Use the mRNA Code Dictionary below to answer Question 10:

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

QUESTION 10
In a living cell, which of the following mRNA molecules would code for a short polypeptide: Met – Ala – Tyr – Ile – Ser?

A AUG – GCC – UAU – AUA – AGC – UAA – AGA – GUC – GGC.
B AUG – GGC – UAU – AUA – AGC.
C AUG – GCC – UAU – AUA – AGC – UAC – AGA – GUC – GGC.
D AUG – GGC – UGA – AUA – AGC.

QUESTION 11
Eco RI is a widely used restriction enzyme with the recognition sequence GAATTC.
In producing sticky ends, *Eco* RI cuts:

A Hydrogen bonds only.
B Covalent bonds only.
C Hydrogen and covalent bonds.
D Ionic and hydrogen bonds.

QUESTION 12
Gene technology can involve the insertion of DNA from one species into the genetic material of another.

An example is the insertion of a human insulin gene into the plasmids of bacteria. Instead of inserting a regular human insulin gene into the plasmid, however, human insulin copy DNA (cDNA) may be inserted. For this to occur, reverse transcriptase is originally used to make the cDNA, using insulin mRNA as the template.

The advantage of using cDNA over the normal gene is that:

A Bacterial plasmids are already composed of cDNA, making the DNA easier to insert.
B cDNA only contains exons, making it easier to insert.
C The destruction of human pancreas cells is not required.
D The gene is more likely to be activated by the promoter sequence.

QUESTION 13
Cloning of organisms has been a relatively recent advance in gene technology. Issues readily arise from this procedure, particularly when its purpose is considered not to be in the general interests of the public.

Already a biotechnology company is offering to clone your favourite pet dog for the small sum of $150,000. While the company guarantees a genetic duplicate, can it guarantee an identical personality?

A No, because phenotype is a product of both genotype and environment.
B No, because the company cannot guarantee which genes will turn on in the clone.
C Yes, because identical genotypes will ensure perfect clones.
D Yes, but the younger animal will need to adjust to more modern times.

QUESTION 14
An important issue associated with the cloning of animals is:

A The random insertion of a gene within a recipient's chromosome, possibly resulting in the deactivation of another gene.
B The production of too many toy dog breeds.
C Insurance companies refusing to cover claims involving cloned livestock.
D The use of old donor animals which can result in the premature death of the cloned recipients.

QUESTION 15
Pingelap Atoll is a small island in the Pacific Ocean. In 1775 a typhoon wiped out most of the population, leaving only 20-30 survivors. One of the survivors was the chief, who had many children, and happened to be a carrier of the autosomal recessive condition known as achromatopsia.

Individuals who have this condition suffer from monochromatic vision, i.e. they can only see one colour. Of the 3,000 people living on Pingelap today, 5-10% suffer from achromatopsia, the highest frequency of this condition anywhere in the world.

Achromatopsia on Pingelap Atoll is an example of:

A Natural selection.
B Genetic drift.
C Artificial selection.
D Gene flow.

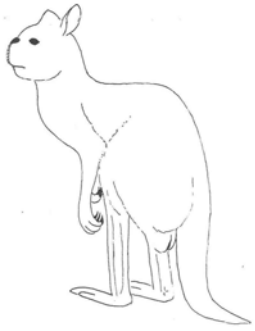
QUESTION 16
An allele coding for a particular body colour in a beetle population is most likely to be eliminated from the population if:

A Gene flow causes it to pass into other populations.
B It codes for the recessive phenotype which is selected against.
C Genetic drift acts against the phenotype.
D It codes for the dominant phenotype which is selected against.

QUESTION 17
Today's wide range of kangaroos evolved from shorter nosed ancestors from thousands of years ago. The shorter nosed ancestors lived in Australia when the continent was once covered by forests, from the east to west coast. As the climate became drier, however, grasslands replaced much of the forest. In response, all of the short-nosed browsing species of kangaroo independently evolved the longer grazing snouts that we recognise today.

The independent evolution of longer grazing snouts from shorter browsing snouts in Australian kangaroos is an example of:

A Convergent evolution.
B Parallel evolution.
C Allopatric speciation.
D Divergent evolution.



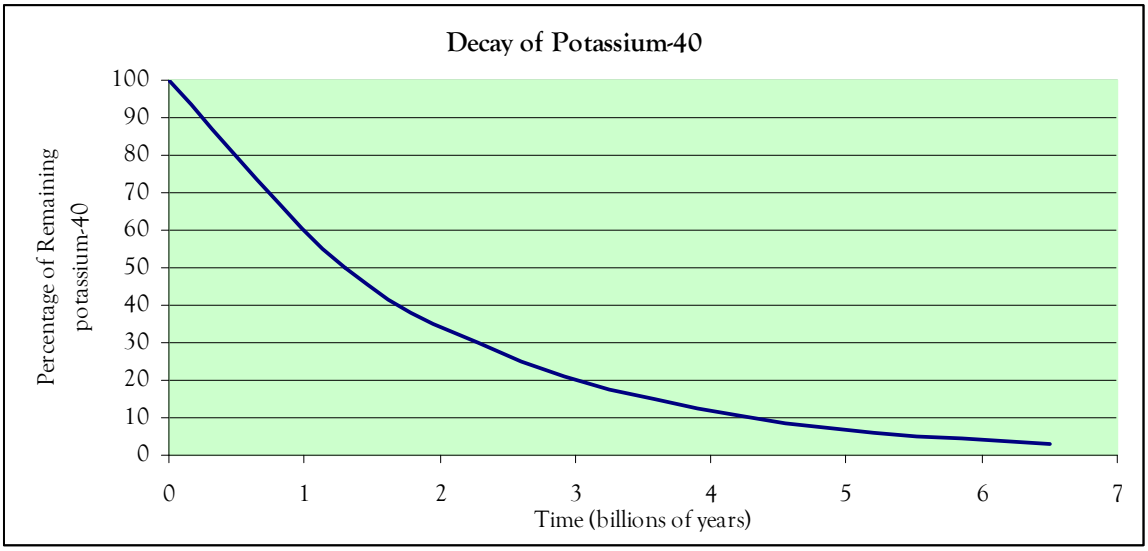
QUESTION 18
Radio-carbon dating has been a valuable technique for dating a wide variety of fossils. The following statement is true for this process:

A It involves a comparison of the levels of ^{14}C and ^{12}C within the fossil.
B It is used to date volcanic rock surrounding dinosaur remains.
C It is only useful for dating fossils up to 50 million years old.
D The nitrogen produced from the breakdown of ^{14}C must be trapped within the fossil.

Use the following information to answer Questions 19 and 20:

Radioisotopes with much longer half-lives than carbon-14 are also used in dating fossils. Potassium-40 is an isotope which can be used to date volcanic rock. It has a half-life of 1,300 million (1.3 billion) years, when it breaks down to argon-40.

The graph below shows the percentage of potassium-40 remaining in rock over a period of billions of years.



QUESTION 19
A rock was found to contain 80% of its original potassium-40. The approximate age of the rock is:

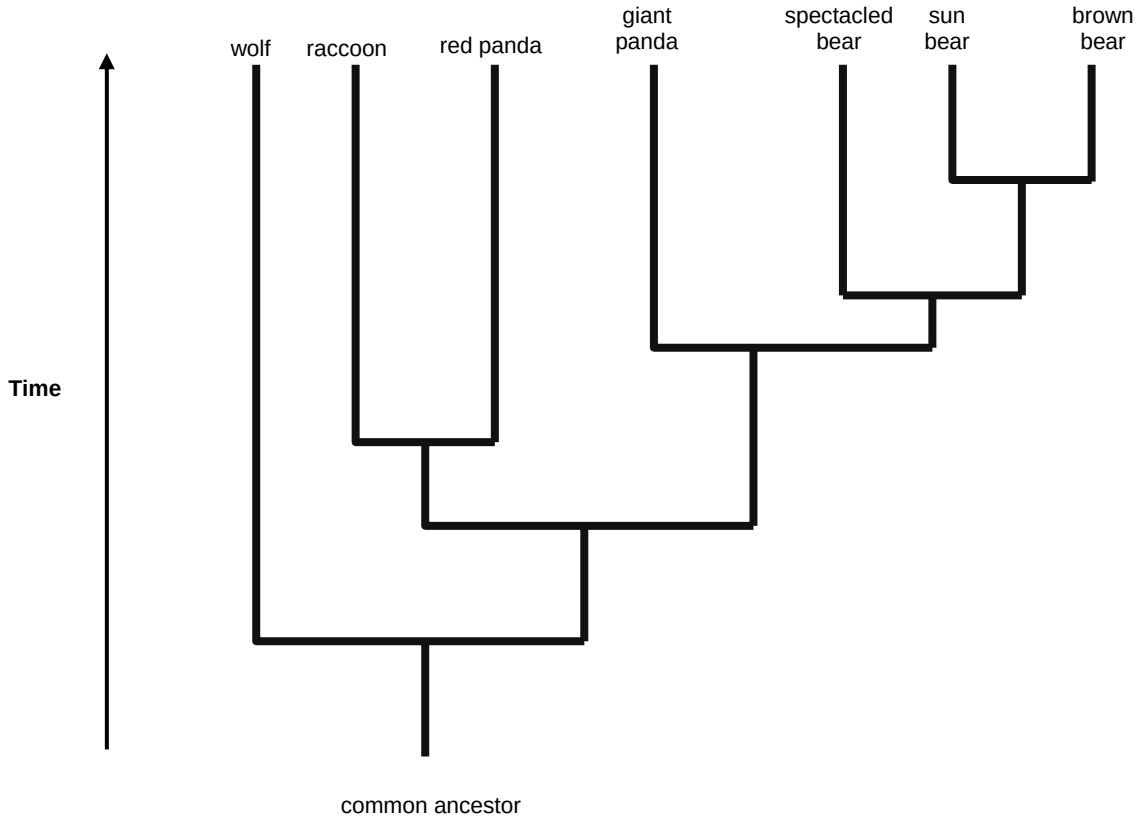
A 50 million years.
B 500 million years.
C 5 billion years.
D impossible to determine from the information given.

QUESTION 20
Any organism that perished within this rock as it formed would be:

A Younger than 5 billion years.
B Older than 5 billion years.
C 5 billion years old.
D Non-existent.

Use the following information to answer Questions 21 and 22.

The phylogenetic tree below depicts the evolutionary relationship between a selection of mammals based on DNA evidence:



QUESTION 21
Using the phylogenetic tree it can be concluded that the species most closely related to the sun bear is the:

A Wolf.
B Brown bear.
C Spectacled bear.
D Spectacled bear and brown bear.

QUESTION 22
It can also be concluded that:

A The most recent common ancestor of wolves and sun bears existed approximately 60 million years ago.
B red pandas are more closely related to raccoons than they are to giant pandas.
C wolves and brown bears have no common ancestors.
D giant pandas are the most closely related group to the spectacled bears.

QUESTION 23
Which of the following groups of primates are thought to have diverged from the ancestors of hominins at the earliest time?

A New World monkeys.
B Old World monkeys.
C Lesser apes.
D Australopithecines.

QUESTION 24
Hominins are thought to have arisen in Africa 6-7 million years ago. Which of the following lists depicts hominins in their most likely order of appearance, from the most ancient to most recent species?

A *Australopithecus afarensis – Homo erectus – Homo habilis – Homo sapiens*.
B *Australopithecus afarensis – Homo habilis – Homo heidelbergensis – Homo sapiens*.
C *Homo habilis – Homo erectus – Sahelanthropus tchadensis – Homo sapiens*.
D *Australopithecus afarensis – Australopithecus africanus – Homo neanderthalensis – Homo habilis*.

QUESTION 25
Hominins are thought to have left Africa on more than one occasion. Current evidence seems to indicate that the first hominins to do so were members of:

A *Homo sapiens* approximately 100,000 years ago.
B *Homo sapiens* approximately 1 million years ago.
C *Homo erectus* approximately 1.8 million years ago.
D *Homo habilis* approximately 2.2 million years ago.

SECTION B: SHORT ANSWER QUESTIONS

Instructions for Section B

Answer this section in pen.
Answer all questions in the spaces provided.

QUESTION 1
Haemoglobin is a large protein found in red blood cells. It is produced in precursor red cells known as erythroblasts in bone marrow. These precursor cells eject their nuclei before entering the circulatory system as red blood cells.

a. Why is the presence of a nucleus necessary for haemoglobin production in a precursor red blood cell?

_____

_____

_____

1 mark

b. Suggest how the production of haemoglobin continues in these cells for a short time after they eject their nuclei.

_____

_____

_____

1 mark

c. Explain why cells, other than erythroblasts, do not produce haemoglobin**.**

_____

_____

_____

_____

2 marks

d. The haemoglobin of sufferers of the hereditary blood disorder sickle cell anaemia differs in only one amino acid in one of the peptide chains from normal haemoglobin. The peptide sequences involving this difference are:

Normal Haemoglobin: threonine – proline – glutamic acid – glutamic acid – lysine
Sickle cell haemoglobin: threonine – proline – valine – glutamic acid – lysine

i. A segment of mRNA in a person with normal haemoglobin had the following sequence:

ACUCCCGAAGAAAAA

Write the DNA base sequence that produced this mRNA:

_____

1 mark

ii. If the anticodons for valine are CAA, CAG, CAU or CAC, write the DNA sequence for a person suffering from sickle cell anaemia.

_____

1 mark

iii. On the basis of this information, what kind of change in the DNA has resulted in sickle cell anaemia?

_____

_____

_____

1 mark

Total 7 marks

QUESTION 2

The data in ***Figure 1*** shows the result of electrophoresis of PCR fragments amplified using probes for the site which has been shown to be altered in Huntington's disease. The male parent, as shown in the pedigree below, first revealed Huntington's disease when he was 40 years old. Of his children six have Huntington's disease, and the age at which the symptoms first began is shown by the number below the band from the PCR fragment.

In Huntington's disease, PCR amplifies a region of the chromosome which has variable number of repeating CAG sequences. Normal individuals can have up to 30 copies of each sequence, but individuals with Huntington's disease have 37 to over a hundred copies

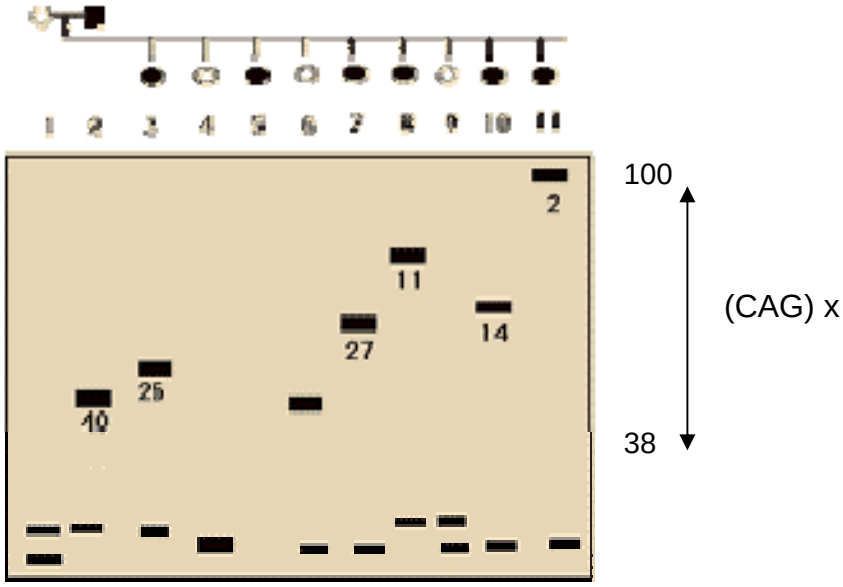


Figure 1

a. Draw an arrow on the right hand side of the diagram to indicate the direction of movement of the DNA fragments.

1 mark

b. The restriction enzyme *Eco* P151 was used to prepare the fragments for the gel electrophoresis above.

i. Consult the table below and state the recognition site for the *Eco*P151 enzyme.

Enzyme	**Recognition Site**
Eco RI	GAATTC
Bam HI	GGATCC
Hael II	GGCC
Eco P151	CAGCAG
Taq I	TCGA

Recognition Site: _____ 1 mark

ii. Place a circle around every recognition site on the DNA sequence below that could be cut by the enzyme *Eco* P151.

AATGGGTACCAGCAGTTAAGGCCTTATGGTAGGGCAGCAGCCCCGGGGTAT

ATGTCGACAGCAGTTAGGTCACACCCCAGCAGAATGGGTACCAG

1 mark

iii. State how many fragments of DNA were created by this action.

Number of Fragments: _____ 1 mark

c. Using the data at the start of the question, state the prognosis and age of onset for child number 6.

_____

_____

_____

1 mark

d. If a person at risk of Huntington's disease has 56 CAG repeats in one of the HD alleles, what would be their prognosis and at what age would the onset of the disease be (use the gel to assist your prediction)?

_____

_____

_____

2 marks

e. Suggest a reason why the allele for Huntington's disease still exists in the human population despite the fact that it is a fatal disease with no known cure?

_____

_____

_____

1 mark

Total 8 marks

QUESTION 3
The ABO gene which controls the ABO blood types is located on chromosome number 9. It has three alleles that determine antigen production.

The pedigree below represents three generations of a family.

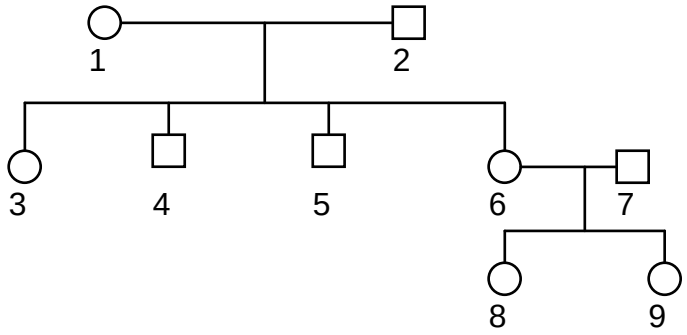


Figure 2

a. What is co-dominance and how does it relate to the ABO gene?

_____

_____

_____

_____

_____

_____

2 marks

b. If individuals 1 and 2 in the first generation belong to Group AB and Group O respectively, what genotypic and phenotypic ratios would you expect in their offspring?

3 marks

c. If individual 9 had blood group O, what are the possible blood groups of her father? Explain.

2 marks

d. Individuals 1 and 2 are also both carriers for the condition of albinism, what is the chance that their children will be both albino and blood group O? Show all working.

2 marks

Total 9 Marks

QUESTION 4

In 2005, scientists in Scotland successfully demonstrated a laser-based technique for introducing foreign genes into mammalian cells called Photoporation cell transfection. The new technique involves the violet laser being focused onto cell membranes for a fraction of a second – this causes the membrane to open up, allowing foreign genes to enter. The cell's internal mechanism causes the membrane of the cell to heal itself thus appearing to suffer no long-lasting damage. After inserting the genes, the team grew the cells, which appeared to remain healthy and multiplied normally. The scientists confirmed the presence of the inserted gene by transfecting some mammalian cells with an antibiotic gene and with a red fluorescent protein. The new technique, which is cheap and powerful, could have important implications for future studies in biomedicine and healthcare.

a. What is transfection?

_____

_____

_____

1 mark

b. Explain why the scientists added an antibiotic gene with a red fluorescent gene**.**

_____

_____

_____

2 marks

c. Describe, with illustrations, an experimental procedure that the scientists may have used to confirm the success of this new technique.

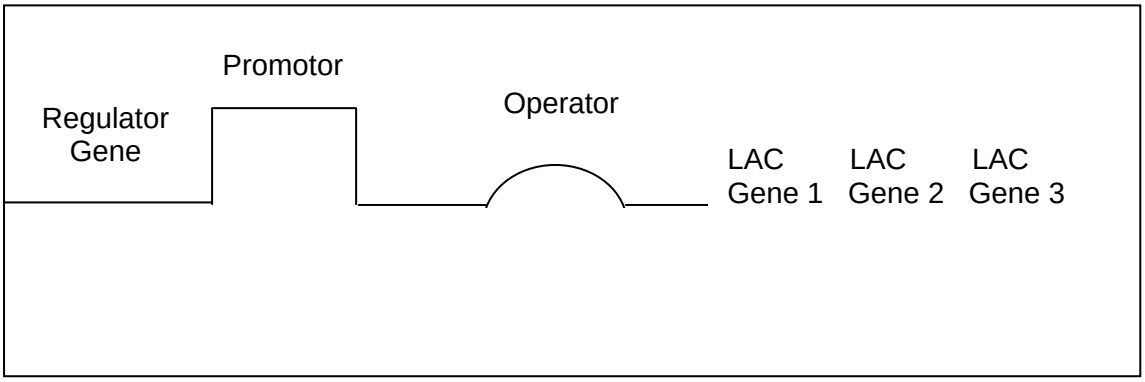
3 marks

Total 6 marks

QUESTION 5

E. coli bacteria can synthesise lactase, the enzyme that breaks down lactose. As they live in the intestinal tract of humans, they are provided with lactose whenever you drink milk. Lactase is only synthesised in the presence of lactose. In the Lac (Lactose) Operon of *E. coli*, there are three structural genes coding for protein needed to metabolise lactose. When lactose is present, a modified lactose molecule called allolactose binds to the repressor, changing its shape and therefore preventing it from now binding to the Operator.

Components of the Lac Operon are represented as follows:



a. What is the function of the:

i. Regulator Gene

_____

_____

1 mark

ii. Promotor

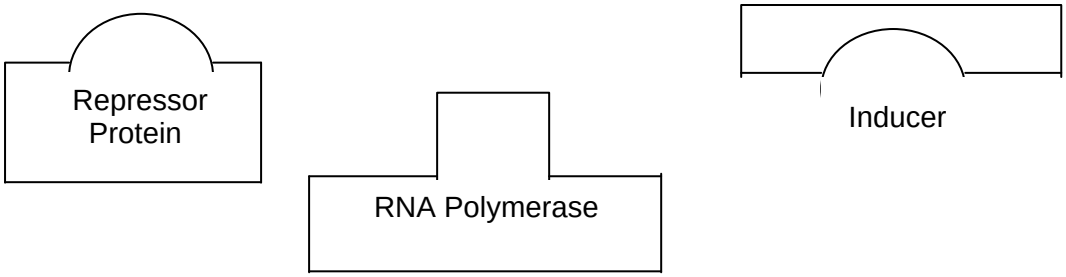
_____

_____

_____

1 mark

b. Use the following symbols representing the repressor, RNA polymerase and Inducer, in the diagram above to show what would occur if there is no lactose present in a growing medium.



2 marks

c. More than 100000 years ago, a gene mutation occurred that resulted in the appearance of a lactose-tolerant phenotype in human populations. At that time, this phenotype was not a selective advantage. What cultural change would have favoured individuals who were lactose tolerant?

_____

_____

_____

_____

1 mark

Total 5 marks

QUESTION 6

Homo floresiensis ("Man of Flores", nicknamed *Hobbit*) is a possible species in the genus *Homo*, remarkable for its small body and brain, and for the possibility that it has survived until relatively recent times. It was named after the Indonesian island of Flores on which its remains were found. One largely complete subfossil skeleton, and a complete jawbone from a second individual dated at 18,000 years old, were discovered in deposits on Flores in 2003. Parts of seven other individuals have been recovered, as well as small stone tools ranging from 94,000 to 13,000 years ago

a. Name a dating technique which could have been used to date either the subfossil skeleton or the stone tools.

_____

1 mark

Figure 4: Skull of *Homo floresiensis* on left compared to *Homo sapiens* on right.

b. *Homo floresiensis* was very small in stature, reaching just over one metre in height, on an island which harboured dwarf elephants and giant rats. Some scientists believe that *Homo floresiensis* was a direct descendant of *Homo erectus.*

i. What criteria do scientists use to classify living organisms into the same species

_____

_____

_____

_____

1 mark

ii. Give one reason why species classification of fossilized remains of the *Homo floresiensis* remains difficult**.**

_____

_____

_____

1 mark

c. Researchers hope to find preserved mitochondrial DNA to compare with samples from specimens of *Homo neanderthalensis* and *Homo sapiens*.

i. What is mitochondrial DNA?

1 mark

ii. Explain how mitochondrial DNA could be used to compare samples with *Homo sapiens*.

2 marks

iii. The specimens were not fossilized, but were described in a *Nature* news article as having "the consistency of wet blotting paper". Once exposed, the bones had to be left to dry before they could be dug up. How likely is it that useful DNA specimens exist in the sample considering their location? Explain.

2 marks

Total 8 marks

QUESTION 7

a. Compared to ancestral forms, modern man exhibits severe body hair reduction. Give an example of how this could be a selective advantage?

1 mark

b. Explain the steps involved in the process of body hair reduction in modern man.

3 marks

c. A scientist claimed to have found evidence showing the time at which humans began wearing clothes. If reduced body hair is a selective advantage, suggest a reason why humans began wearing clothes and continue to do so today.

1 mark

d. Name and describe one selective pressure acting on modern humans in today's world.

2 marks

Total 7 marks

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