BIOLOGY

Unit 4 – Written examination 2

2008 Trial Examination

SOLUTIONS

SECTION A: Multiple-choice questions (1 mark each)

Question 1

Answer: D

Explanation:

Each replicated strand contains one parental strand and one synthesised strand, so DNA replication is semi-conservative.

Question 2

Answer: C

Explanation:

Only the leading strand is synthesised continuously; the lagging strand is synthesised in fragments.

Question 3

Answer: C

Explanation:

There are two noticeable groups of chromosomes moving towards the pole of the cell, so the cell must be in anaphase. In meiosis, the centromere does not break in the first stage, since the chromosomes are still double-stranded. The cell must be in anaphase I.

Question 4

Answer: A

Explanation:

The diagram indicates that the cell is diploid to start off with, divides twice and each daughter cell is haploid.

Question 5

Answer: C

Explanation:

Frameshift mutations are caused by additions and deletions.

Question 6

Answer: B

Explanation:

The daughter chromatids will end up in different daughter cells. Each chromatid does consist of a single strand, and the centromere does not break until anaphase II. Due to crossing over between homologous chromosomes, the chromatids may not be genetically identical.

Question 7

Answer: C

Explanation:

Process 1 is transcription. Product 1 is mature mRNA, with the introns removed.

Question 8

Answer: B

Explanation:

Process 2 is translation which occurs at the ribosomes in the cytosol.

Question 9

Answer: D

Explanation:

Since one child has type O blood, both parents must be heterozygous. Their children could be type A, type B, type AB or type O, as shown on the punnet square below.

	I^A	i
I^B	I^AI^B	I^Bi
i	I^Ai	ii

Question 10

Answer: A

Explanation:

Although there is a 25% chance of having type B blood, that individual is heterozygous, not homozygous. There is no chance these two parents could produce a child who is homozygous for type B blood.

Question 11

Answer: D

Explanation:

Since the condition is caused by having an extra chromosome, it will be best detected by karyotyping.

Question 12

Answer: A

Explanation:

Although Klinefelter's condition is an example of aneuploidy, it is caused by the chromosomes failing to separate (non-disjunction).

Question 13

Answer: B

Explanation:

Multiple genes are involved, so this is an example of polygenic inheritance.

Question 14

Answer: A

Explanation:

This condition is not dominant, because unaffected parents have an affected child (or children). The males in generations 2 and 3 have the condition because their mothers are carriers.

Question 15

Answer: C

Explanation:

The heterozygous individual has a different phenotype to each parent, indicating neither phenotype is dominant. If this was a case of codominance, all of the offspring would have red and white patches. The heterozygote has a "blended" phenotype, which can only be caused by intermediate inheritance.

Question 16

Answer: D

Explanation:

There are 100 plants, so there will be 200 alleles.

PLANT COLOUR	WHITE ALLELES	RED ALLELES
20 White	40	0
20 Pink	20	20
60 Red	0	120
Total	60	140

The frequency of the C^W allele = $\frac{60}{200}$ = 0.30

The frequency of the C^R allele = $\frac{140}{200}$ = 0.70

Question 17

Answer: B

Explanation:

A plant with brown seeds must be homozygous (ggii). A plant with green seeds could be homozygous for both genes (GGii), but could also be heterozygous for the pigment gene (Ggii). A plant heterozygous for both genes will lack pigment. If a plant is homozygous for the (I) allele, it will lack pigment.

Question 18

Answer: B

Explanation:

For a seed to have colouration it needs to have two copies of the (i) allele. Genotypes that allow for seeds to be coloured are shown in bold in the punnet square below.

GAMETES →	GI	Gi	gI	gi
GI	GGII	GGIi	GgII	GgIi
Gi	GGIi	**GGii**	GgIi	**Ggii**
gI	GgII	GgIi	ggII	ggIi
gi	GgIi	**Ggii**	ggIi	**ggii**

Question 19

Answer: A

Explanation:

The sample available is small, so DNA would have to be amplified to gain sufficient amounts to perform DNA profiling. The method of amplifying DNA uses the polymerase chain reaction (PCR).

Question 20

Answer: A

Explanation:

Genetic drift is the change in allele frequencies in a population caused by chance. Genetic drift is more likely to occur in small populations, due to the greater proportional effect of factors influencing allele frequencies.

Question 21

Answer: C

Explanation:

All of these organisms live in a similar environment (arboreal). Their similarities are due to environmental pressures, rather than genetic similarity.

Question 22

Answer: A

Explanation:

It is generally the hard components or traces of an organism that are fossilised. Soft sections may be preserved as films, not fossils.

Question 23

Answer: D

Explanation:

Mass extinctions, colonising an isolated area and a catastrophic event all open up niches for surviving organisms to fill. An increase in population size would tend to create competition.

Question 24

Answer: D

Explanation:

Species A is found in the top layer and should be the most recent species. A is incorrect because being found in the same area does not mean that the organisms are related. B is incorrect, as species C would have existed after species D. C is incorrect because there is no data to indicate the abundance of any of the species.

Question 25

Answer: B

Explanation:

If the foraman magnum is central, it indicates the organism is bipedal.

SECTION B: Short-answer questions

Question 1

a. The mode is recessive.
Two unaffected individuals, I-1 and I-2, have affected children, II-2 and II-3.

OR

For the condition to be dominant there must be at least one affected individual in each generation. There is no affected individual in generation I.

1 mark

AND

The mode is autosomal.
If the condition is X-linked recessive, then all affected females must have an affected father, as well as an affected (or carrier) mother. For this to be true, individuals I-1 and III-1 must be affected. Since they aren't, it must be autosomal.

1 mark

b. $\frac{1}{4}$

1 mark

The chance of being male is $\frac{1}{2}$, and the chance of being affected is $\frac{1}{2}$, so the chance of being both is $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$.

Phenotypes: Unaffected male (IV-3) x Affected female
Genotypes: Ff x ff

The Punnett square below shows the possible genotypes of their children.

	F	f
f	Ff	ff
f	Ff	ff

c. There is a range of different phenotypes.

1 mark

d. There will be no effect on the protein.

1 mark

AND

The repeat sequence is located in an intron, which is not translated.

1 mark

e. The condition could be diagnosed by performing gel **electrophoresis**.

1 mark

AND

The normal allele is smaller than the mutant allele. On an electrophoresis gel, the mutant allele will stay closer to the wells than the normal allele.

1 mark

Total 8 marks

Question 2

a. Hind III.

1 mark

b. Both of the following

- It produces fragments with sticky ends
- It cuts around the desired gene, rather than through the gene

1 mark for each correct response

c. DNA ligase

Note: DNA must be specified, as RNA ligase is also involved in protein synthesis.

1 mark

d. The antibiotic resistance gene has been inserted to identify the bacteria that have taken up the recombinant plasmid.

Note: The bacteria is grown in agar containing the antibiotic, which acts as a selective agent. Only the bacteria with the recombinant plasmid will grow.

1 mark

e. A codon will always code for the same amino acid.

1 mark

Total 6 marks

Question 3

a. Let G = grey body colour and g = black body colour. Let L = long wings and l = vestigial wings

Phenotypes:	Grey body, long wings	x	Black body, vestigial wings
Genotypes:	GgLl	x	ggll
Gametes:	GL,Gl,gL,gl	x	gl

1 mark

AND

GAMETES →	GL	Gl	gL	gl
gl	GGLl	Ggll	ggLl	Ggll

Note: It isn't necessary to complete 16 squares in circumstances such as this, as one parent is only able to produce one combination of gametes.

1 mark

AND

Genotypic ratio 1GGLl: 1Ggll:1ggLl: 1ggll
Phenotypic ratio 1 Grey body, long wings: 1 grey body, vestigial wings: 1 black body, long wings: 1 black body vestigial wings
Note: It must be specified which is the genotypic ratio, and which is the phenotypic ratio

1 mark

b. There are two phenotypes in the P generation, one in the F_1 generation and four in the F_2 generation.

1 mark

AND

There are two genes – one for body colour and one for wing length. Each gene has two alleles.

1 mark

c. The genes are linked.

1 mark

AND

If the genes are on different chromosomes, the phenotypic ratio will be 1:1:1:1. The data shows there are high numbers of parental type offspring (1339 and 1205) and low numbers of recombinant offspring (151 and 147). This occurs because of crossing over, which occurs between sister chromatids of a homologous pair. Therefore, the genes are linked.

1 mark

d. Meiosis

1 mark
Total 8 marks

Question 4

a. Since the populations of cheetahs were widely distributed, the reason for the mass extinction must reflect this (e.g. a global catastrophe or ice age).

1 mark

b. Any of the following:
- Radio isometric dating (radiometric dating)
- Potassium to argon dating
- Any other reasonable suggestion (NOT carbon-14 OR uranium to lead dating)

1 mark

c. There is a low amount of genetic variation in the population of cheetahs.

1 mark

AND

The lack of rejection indicates there is no variation between the donor and the recipients.

1 mark

d. Sperm samples could be taken from cheetahs taken from the wild. If they have the same abnormalities, then the abnormalities cannot be caused by being in a zoo.

1 mark

e. Natural selection.

1 mark

AND

There was variation for these traits in an ancestral population of cheetahs. A selection pressure, such as a lack of food, occurred, so those animals with these traits were biologically fitter than those who did not have these traits.

1 mark

AND

Those animals that are more biologically fit are more likely to survive long enough to produce offspring. The incidence of these traits will therefore increase in subsequent generations.

1 mark

Total 8 marks

Question 5

a. The order from the top down is: Shark, Goldfish, House cat, Dolphin, Chimpanzee

4 or 5 Correct: 2 marks
2 or 3 correct: 1 mark
0 or 1 correct: 0 marks

b. Convergent evolution.

1 mark

AND

There is a genetic distance of 77 units between the dolphin and the shark.

1 mark

Total 4 marks

Question 6

a. The "Out of Africa" or replacement theory

1 mark

b. If the gene pool was that small, a genetic bottleneck would have occurred.

OR

There would have been excessive inbreeding in the human race.

1 mark

c. Any of the following

- They may not have had offspring
- They may have had only sons
- Their female offspring may have died before producing female offspring
- Any other reasonable suggestion

1 mark

d. Mitochondrial DNA changes at a known rate and can be used as a molecular clock.

1 mark

e. Disprove

1 mark

AND

Mitochondrial Eve existed about 140,000 years ago, whereas the earliest point of divergence for Asian *Homo* species is only 90,000 years ago.

1 mark

f. You would expect to find greater diversity in the modern Asian population.

1 mark

AND

The modern Asian population would be expected to have both Asian and African forms, whereas the African population would only have the African forms.

1 mark

g. Cultural evolution

1 mark

h. Artificial selection.

1 mark

AND

300 years is not sufficient time for evolution to produce a new species. The rate of evolution must have been influenced by human intervention.

1 mark

Total 11 marks

Question 7

a. This is incorrect. Although a normal gene is inserted, the faulty gene is not removed.

1 mark

b. Somatic gene therapy

1 mark

AND

The gene was inserted into "existing body cells".

1 mark

c. Any of the following

- Knowing the gene sequence
- Knowing the target tissue
- Having an appropriate vector

1 mark

d. Somatic gene therapy cannot be used to treat polygenic traits, because you would need to have multiple genes and vectors. It is not known which genes are involved and what their effects are.

1 mark

Total 5 marks

