CANDIDATE NAME: _____ **INDEX NUMBER** _____

CG _____

JC2 PRELIM EXAMINATION 2016

BIOLOGY PAPER 1
Higher 2

Thursday
22 September 2016

Additional materials:
OTAS Sheet

1 hour 15 minutes

READ THESE INSTRUCTIONS FIRST

Write your name and index number in the spaces at the top of this page and on all the work you hand in.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in this paper. Record your choice in **2B pencil** on the OTAS sheet provided.

At the end of examination, submit the question paper and MCQ OTAS sheet separately.

This question paper consists of 28 printed pages excluding this cover page.

Section A [40 marks]

Answer all questions on the OTAS provided.

1. Which of the following best accounts for the difference in structure between amylose which is helical and cellulose which is fibrous?

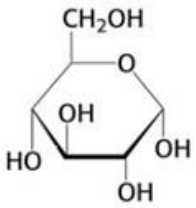
A Presence or absence of 180^{o} rotation of alternate subunits.

B Presence or absence of branching in the macromolecule

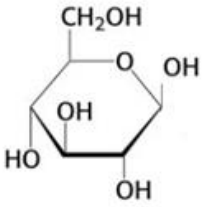
C Subunits are either monosaccharides or amino acids.

D Different tendency of macromolecule to form hydrogen bonds with water.

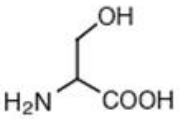
2. Which of the following combination of polymer, monomer and bond formed between monomers is correct?



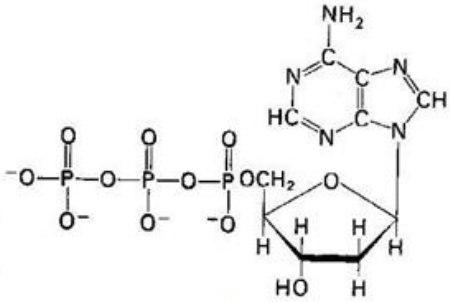
U



X



Y



Z

	starch	*cellulose*	*polypeptide*	*polynucleotide*
A	**X**, β -1,4 glycosidic bond	**U**, α -1,4 glycosidic bond	**Z**, ester linkage	**Y**, disulphide linkage
B	**U**, α -1,4 glycosidic bond	**X**, β -1,4 glycosidic bond	**Y**, peptide bond	**Z**, phosphodiester linkage
C	**Z**, peptide bond	**X**, hydrogen bond	**Z**, ionic bond	**U**, hydrogen bond
D	**X**, ionic bonds	**Y**, peptide bond	**U**, hydrogen bond	**Z**, α -1,6 glycosidic bond

3. Most wild plants contain toxins that deter animals from eating them. A scientist discovered that a toxin produced by a certain plant was also toxic to the same plant if it as applied to the roots of the plant. As the first step on finding out why the plant was not normally killed by its own toxin, he fractionated some plant cells and found that the toxin was in the fraction that contained the largest cell organelle. He also found that the toxin was no longer toxic after it was heated. Which of the following statements are consistent with the scientist's observations?

I. The toxin was stored in the central vacuole.
II. The toxin cannot cross the membrane of the organelle in which it is stored.
III. The toxin was stored in chloroplast.
IV. The toxin is likely to be lipid-soluble.
V. The toxin may be an enzyme.

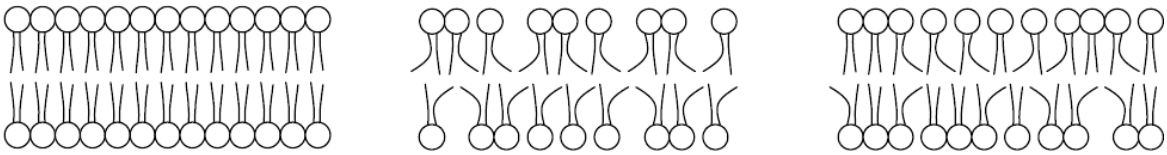
A **I, II** and **V**
B **I, IV** and **V**
C **II, III** and **IV**
D **III, IV** and **V**

4. Which of the following is/are the most likely consequence/(s) for a cell lacking functional lysosomes?

(i) The cell becomes crowded with undegraded wastes.
(ii) The cell dies because its ATP-synthesizing mechanisms are missing.
(iii) The cell dies from a lack of enzymes to catalyze metabolic reactions.
(iv) The cell is unable to reproduce itself.
(v) The cell is unable to grow to a mature size and always remains small.

A **(i)** only
B **(i)** and **(v)**
C **(ii)** and **(iv)**
D **(iii)** and **(iv)**

5. A mutated strain of the bacterium *Escherichia coli* was found to be incapable of incorporating unsaturated phospholipids into its plasma membrane. Which of the following correctly depicts and describes the membrane of such a bacteria?



Type I Type II Type III

A The membrane would appear as Type I and would be more fluid at low temperatures.

B The membrane would appear as Type I and would be less fluid at low temperatures.

C The membrane would appear as Type II and would be more fluid at low temperatures.

D The membrane would appear as Type III and would be no different from normal bacterial membranes.

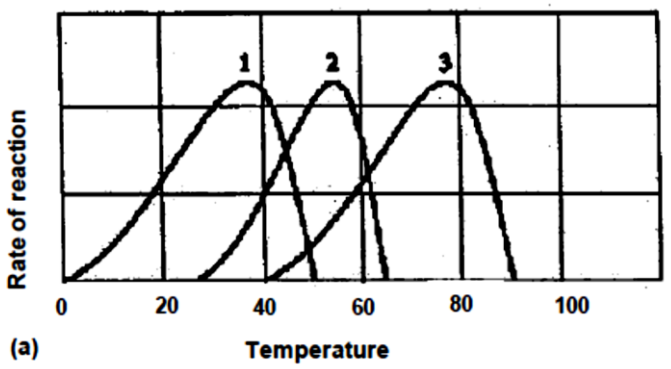
6. When mucus is secreted from a goblet cell in the trachea, these events take place.

(i) addition of carbohydrate to protein
(ii) fusion of the vesicle with the plasma membrane
(iii) secretion of a glycoprotein
(vi) separation of a vesicle from the Golgi apparatus

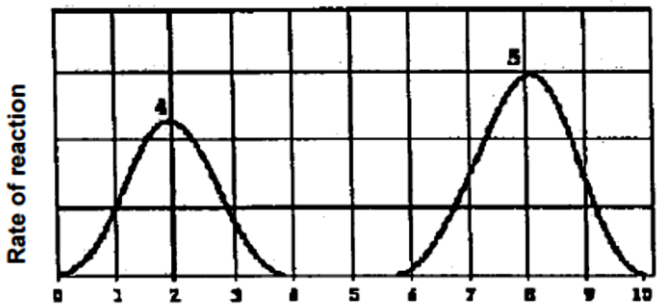
What is the sequence in which these events take place?

A (i), (vi), (ii), (iii)
B (i), (vi), (iii), (ii)
C (vi), (i), (ii), (iii)
D (vi), (i), (iii), (ii)

7. The following graphs show the activities of different enzymes (1-5) under different conditions:



(a)



(b)

Which statement is a correct explanation for the rate of reaction of different enzymes?

A Kinetic energy of enzyme 3 and its substrate is fastest at 75°C.

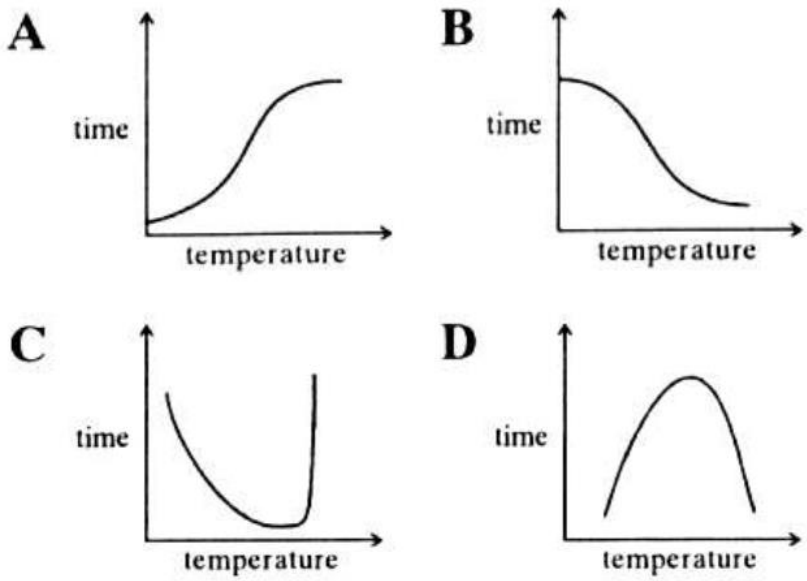
B At pH 2, most of the R groups at the active site of enzyme 4 are all negatively charged.

C At pH 8.1, substrate is bonded to the active site of enzyme 5 by hydrogen bonds only.

D At 60°C, several hydrogen bonds between R groups of enzyme 2 are broken.

8. In an investigation to determine the effect of temperature on the activity of an enzyme, the time taken for all the substrates to disappear from a standard solution was recorded. C

Which graph shows the result of this investigation?



9. Which of the following statements about meiosis is **false**?

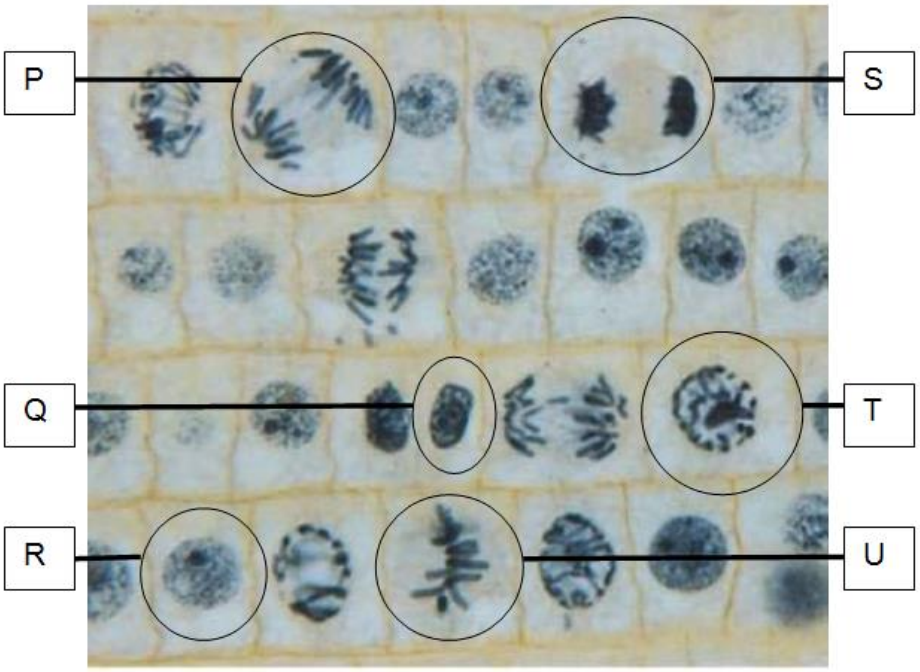
A Sister chromatids are separated at anaphase II

B Homologous chromosomes are separated in anaphase I.

C Cells at the beginning of Meiosis II are haploid

D Homologous chromosomes are paired on the metaphase plate in metaphase I.

10. The photographs below show a section of the onion root tip. The cells are at different stages of mitosis.



Which of the following shows the correct sequence of events that occurs in these cells?

A R, T, U, P, S, Q

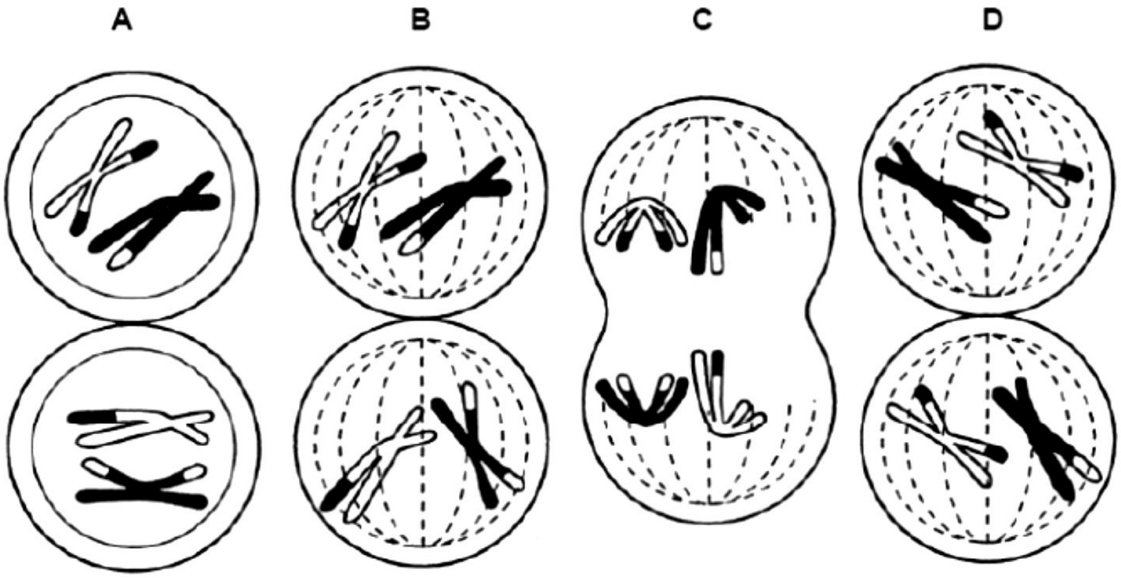
B T, U, P, S, Q, R

C Q, T, P, S, U, R

D T, R, P, S, U, Q

11. The diagram shows anaphase I of meiosis.

Which diagram shows metaphase II as meiosis continues in this cell? B



12. For a double-stranded DNA, which of the following base ratios always equals 1?

I. (A + T) / (G + C)
II. (A + G) / (C + T)
III. C / G
IV. (G + T) / (A + C)
V. A / G

A **I** and **III**

B **I**, **II** and **III**

C **II**, **III** and **IV**

D **III, IV** and **V**

13. The diagram below is a template strand of a DNA molecule.

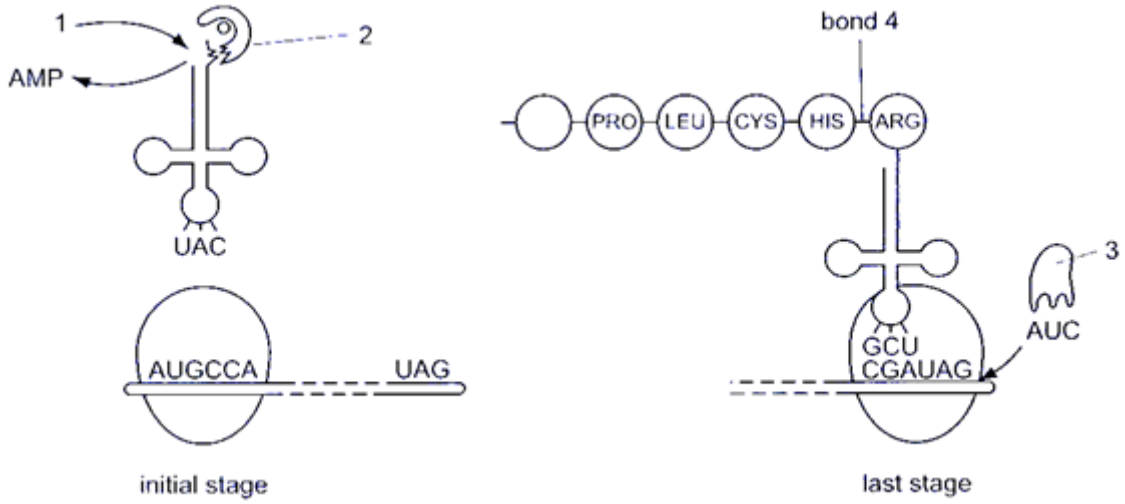
Promoter (18 nucleotides in length)	TAC	DNA sequence of 330 nucleotides	ATC

The number of amino acids in the protein coded by this template strand is

A 110 **B** 111 **C** 112 **D** 118

14. A number of molecules other than tRNA and mRNA are involved during translation.

The diagram shows some of these molecules and nucleotides in the codon and anticodon positions.



Which of the following is correct?

	1	2	3	4
A	ADP	Aminoacyl tRNA synthetase	Amino acid	Hydrogen bond
B	ADP	Amino acid	Translation releasing factor	Hydrogen bond
C	ATP	Aminoacyl tRNA synthetase	Aminoacyl tRNA	Peptide bond
D	ATP	Aminoacyl tRNA synthetase	Translation releasing factor	Peptide bond

15. With reference to a single eukaryotic gene, which of the following molecules contains the fewest number of nucleotides?

A A single strand of the original DNA segment

B A primary RNA transcript made from the original DNA segment

C A single strand of the original DNA segment after a point mutation

D A single strand of the complementary DNA (cDNA) made from the mature mRNA

16. DNA methylation is known to silence genes because it prevents transcription factors from binding. Which of the following best explains this phenomenon?

A DNA methylation modifies the shape of the transcription factor.

B DNA methylation prevents dimerization of DNA binding proteins.

C DNA methylation modifies the shape of the DNA element where the transcription factor binds.

D DNA methylation causes acetylation of histone proteins which causes heterochromatin to be formed.

17. Which of the following statements are true of the end-replication problem of linear DNA?

1. When a linear DNA molecule replicates, a gap is left at the 3' end of each new strand because DNA polymerase can only add nucleotides to a 3' end.
2. Telomerase prevents the end-replication problem from occurring.
3. Repeated rounds of replication produce shorter and shorter DNA molecules.
4. Prokaryotes do not have the end-replication problem.

A 1 and 2
B 1 and 4
C 2 and 3
D 3 and 4

18. Rhabdoviruses infect human cells. The genome of rhabdoviruses consists of a single-stranded RNA molecule whose sequence is complementary to the RNA sequence which functions as a messenger RNA. How is the "+" messenger RNA produced in such cells by rhabdovirus?

A Host cell RNA polymerase activity
B One portion of the infecting RNA is directly translated by host cell ribosomes.
C Reverse transcriptase activity
D The infecting virus particle contains an RNA-dependent RNA polymerase.

19. Some events that take place during generalized transduction are listed below.

I Bacterial host DNA is fragmented
II Bacterial DNA instead of viral DNA may be packaged in a phage capsid
III Recombination between donor DNA and recipient DNA
IV Phage infects a bacterial cell
V Phage DNA and proteins are made
VI Release of progeny virus

Which sequence of events is most accurate in describing generalized transduction?

A **IV, I, III, V,VI, II**

B **IV, I, V, II, VI,III**

C **IV, III, I, V, II,VI**

D **IV, V, I, III, II,VI**

20. A mutation that makes the regulatory gene of an inducible operon non-functional would result in

A continuous transcription of the operon's genes.
B reduced transcription of the operon's gene.
C accumulation of large quantities of a substrate for the catabolic pathway controlled by the operon.
D irreversible binding of the repressor to the promoter.

21. The coat colour of Norwegian cattle is mainly determined by the distribution of two pigments: red and black. Both pigments are the action of the enzyme tyrosinase in cells called melanocytes. A normal level of activity of the enzyme leads to the production of red pigment, whilst a high activity allows only black pigment production. The activity of the enzyme is increased by melanocyte stimulating hormone (MSH), which binds to an MSH receptor.

The receptor is coded for by the **E** locus, which has the three alleles, $\mathbf{E^D}$, $\mathbf{E^A}$ and **e**. $\mathbf{E^D}$ is insensitive to protein A which blocks MSH receptor. $\mathbf{E^A}$ is sensitive to protein A which blocks MSH receptor. No receptor is produced by the recessive allele, **e**.

The dominant allele of a second gene, the **A** locus, codes for a protein which binds to and blocks the MSH receptor coded for by $\mathbf{E^A}$, thus preventing stimulation of tyrosinase activity in a melanocyte.

What would be the coat colours of cattle with the following genotypes?

	eeAa	**E^Aeaa**	**E^DeAa**	**E^AE^AAa**
A	Red	Black	Black	Red
B	Red	Black	Red	Red
C	Black	Red	Red	Black
D	Red	Red	Black	Black

22. Two parents have a son who has blood group A and phenylketonuria. One parent has blood group O and the other has blood group AB. Neither parent has phenylketonuria. What is the probability that the second child of these parents will be a girl with blood group B who does not have phenylketonuria?

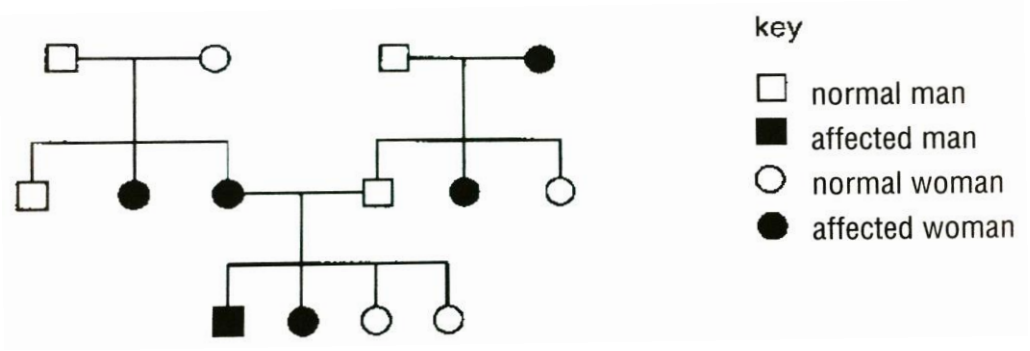
A 1 in 16

B 1 in 8

C 3 in 16

D 3 in 8

23. The family tree shows the inheritance of a skin condition.



What is the genetic basis of the skin condition?

A autosomal dominant

B sex-linked dominant

C autosomal recessive

D sex-linked recessive

24. In the board bean, a pure-breeding variety with green seeds and black hilums (the point of attached of the seed to the pod) was crossed with a pure-breeding variety with yellow seeds and white hilums. All the F_1 plants had yellow seeds and white hilums. When these were allowed to self-fertilise, the plants of the F_2 generation produced the following seeds.

Yellow seeds and white hilums	89
Yellow seeds and black hilums	28
Green seeds and white hilums	25
Green seeds and black hilums	45

A chi-squared (χ^2) test was performed to test the significance of the difference between the observed and expected results.

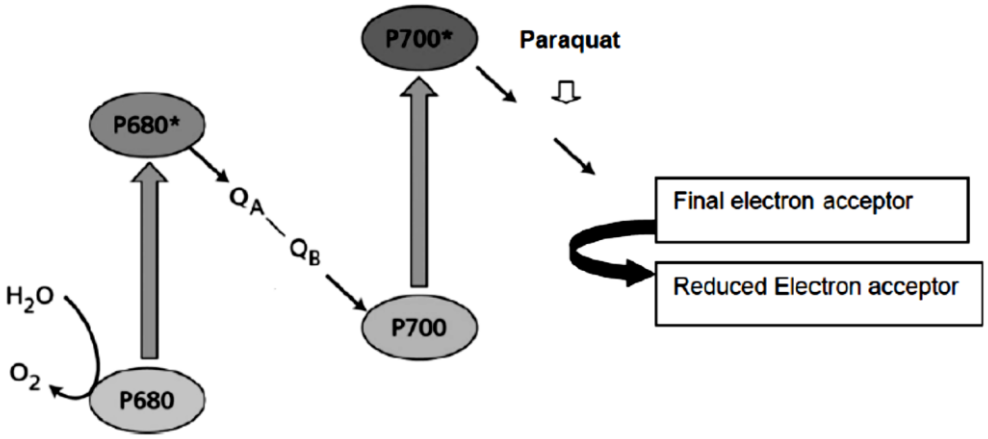
$$\chi^2 = \sum \frac{(O-E)^2}{E} \qquad \nu = c - 1$$

degrees of freedom	*p = 0.5*	*p = 0.1*	*p = 0.05*	*p = 0.01*	*p = 0.001*
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.6	5.99	9.21	13.82
3	2.37	6.25	7.82	11.34	16.27
4	3.36	7.78	9.49	13.28	18.46

Which combination correctly describes the results of the χ^2 test?

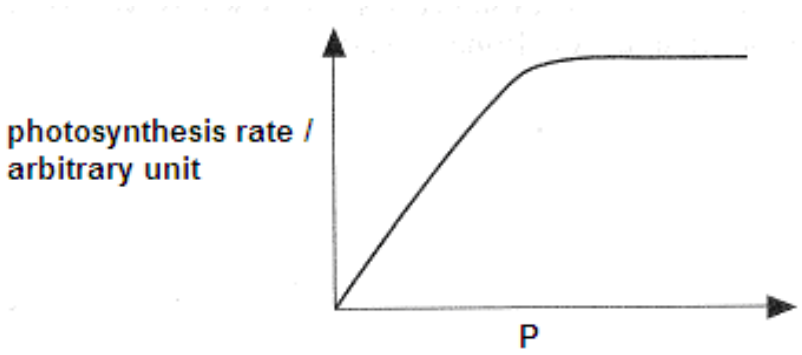
	number of degrees of freedom	*probability*	*these are two pairs of segregating alleles at two loci*
A	3	> 0.05	yes
B	3	< 0.05	no
C	4	> 0.05	yes
D	4	< 0.05	no

25. Paraquat is a poison that disrupts electron transport at the position indicated in the diagram. Paraquat was added to isolated chloroplasts. Which of the following correctly represents the outcomes in the presence of paraquat?



A Both light dependent reactions and Calvin cycle will not be able to proceed.
B Only Calvin cycle can proceed.
C Only light dependent reactions can occur.
D Both light dependent reactions and Calvin cycle can still proceed as per normal.

26. The following graph shows the relationship between the rates of photosynthesis with environmental factor **P**.

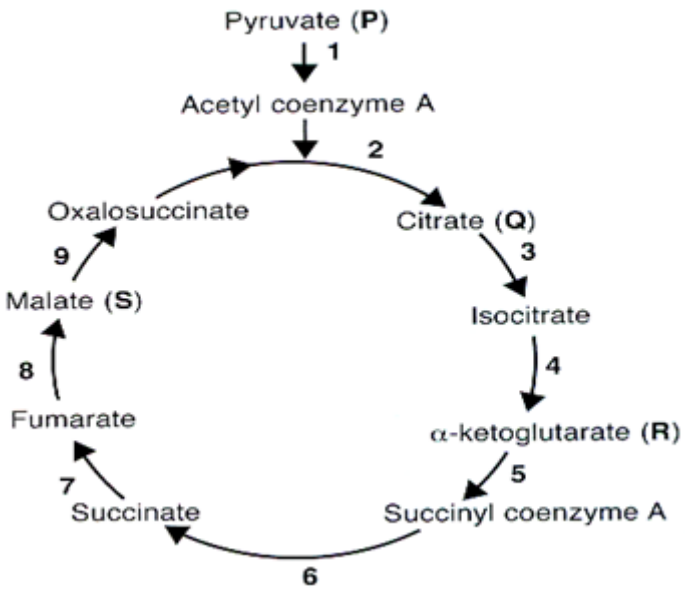


P most probably represents

1. carbon dioxide concentration.
2. oxygen concentration.
3. light intensity.
4. temperature.

A ***1*** and ***2*** **B** ***1*** and ***3*** **C** ***1*** and ***4*** **D** ***1***, ***3*** and ***4***

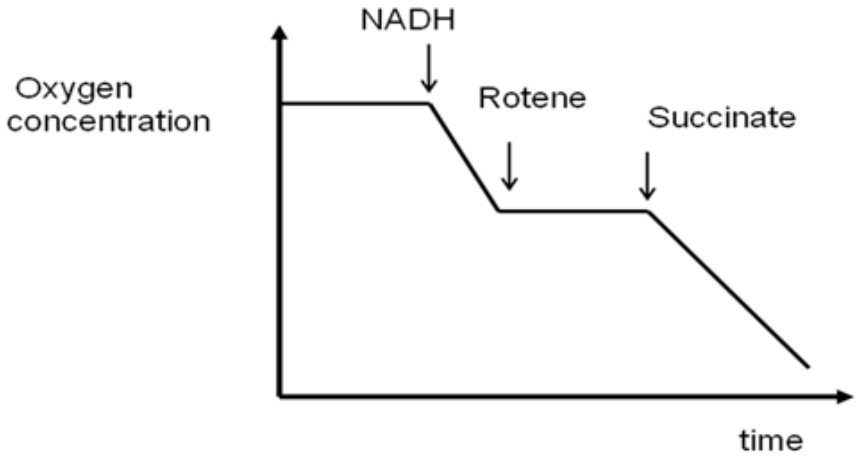
27. The diagram below shows the Krebs Cycle.



At which stages are hydrogen atoms transferred to NAD^+?

A 1, 4, 5 and 7
B 1, 4, 5 and 9
C 2, 4, 5 and 7
D 4, 5, 7 and 9

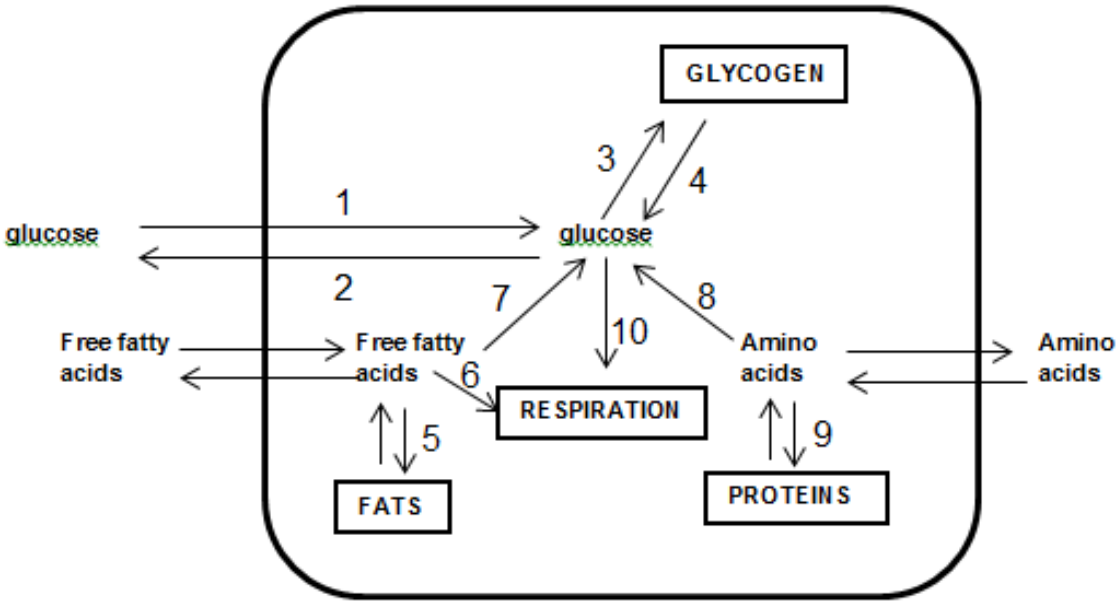
28. A suspension of mitochondria was prepared in a buffer containing ADP and inorganic phosphate (Pi). The oxygen concentration in the buffer was monitored carefully and recorded as shown below. At the times indicated, a specific reagent was added to the buffer. Throughout the experiment, the concentrations of ADP and Pi were in excess.



Which one of the following shows correctly from the highest to the lowest, the rate of ATP production after the addition of the three chemicals?

	Highest ATP production	⟶	***Lowest ATP production***
A	NADH	Succinate	Rotene
B	Succinate	NADH	Rotene
C	Rotene	NADH	Succinate
D	Rotene	Succinate	NADH

29. The diagram below shows some biochemical pathways in a liver cell. During which processes will the hormone glucagon exert an effect?



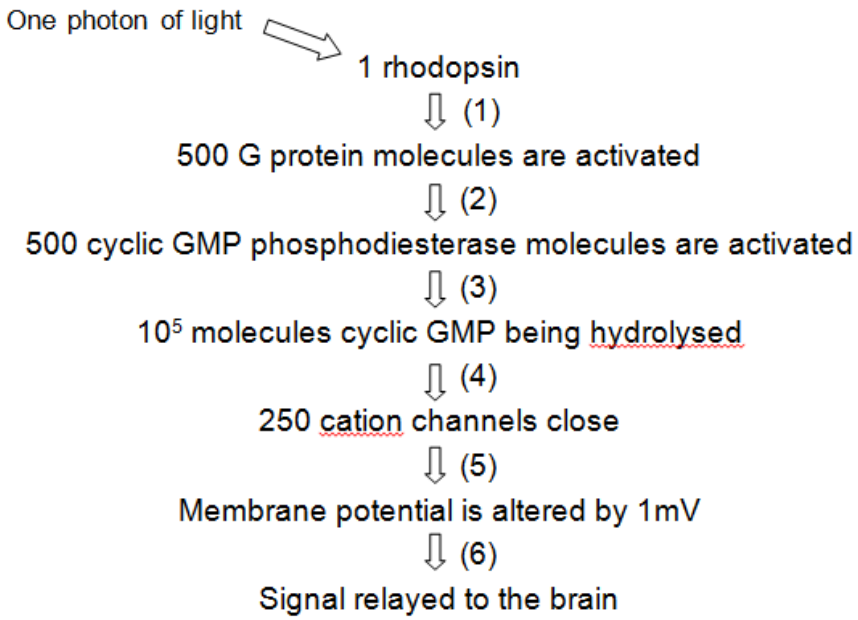
A (1), (3), (5), (9)

B (1), (4), (8), (10)

C (2), (7), (9), (10)

D (4), (6), (7), (8)

30. Rhodopsin, a light sensitive pigment that is present on the rods in the eyes. Rhodopsin is a G protein coupled receptor. The flow chart below shows how the chain of reactions that occur when rhodopsin absorbs a photon of light.



Identify the stages where *amplification* and *cellular responses* have occurred.

	Amplification	***Cellular response***
A	1, 2, 3, 4, 5	6
B	1, 3	1, 2, 3, 4, 5, 6
C	1, 3	5
D	2, 3	5

31. A neurone is undergoing relative refractory period. Which of the following statements is true?

A Membrane potential is less negative than resting potential.

B There is delayed closing of voltage-gated potassium channels.

C It is possible to initiate another action potential if a weaker stimulus is applied.

D It is impossible to initiate another action potential regardless of the stimulus strength.

32. Tetrodotoxin, a puffer fish toxin, blocks voltage-gated sodium channels. Black widow spider's venom causes the voltage-gated calcium channels to be constantly open. Crotoxin binds irreversibly to acetylcholine receptors. What will happen to the transmission of nerve impulses if each toxin is applied?

	Tetrodotoxin	**Black widow spider's venom**	**Crotoxin**
A	block action potentials along axon	reduce transmission of impulse across synapse	increase transmission of impulse across synapse
B	increase transmission of impulse across synapse	reduce transmission of impulse across synapse	block action potentials along axon
C	block action potentials along axon	increase transmission of impulse across synapse	reduce transmission of impulse across synapse
D	reduce transmission of impulse across synapse	block action potentials along axon	increase transmission of impulse across synapse

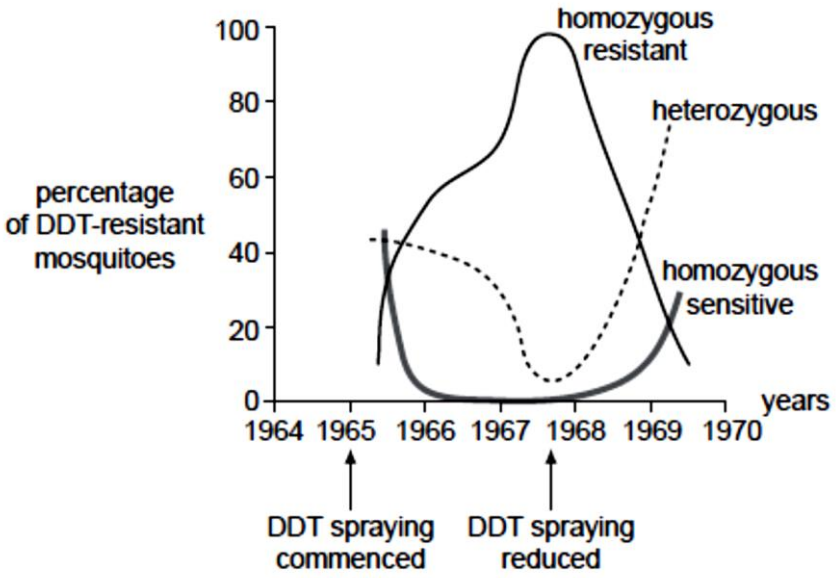
33. Members of two different species possess a similar-looking structure that they use in a similar fashion to perform the same function. Which information would best help distinguish between an explanation based on homology versus one based on convergent evolution?

A The two species live at great distance from each other.
B The two species share many proteins in common, and the nucleotide sequences that code for these proteins are almost identical.
C The sizes of the structures in adult members of both species are similar in size.
D Both species are well adapted to their particular environments.

34. In the mid-1960s, DDT was widely used as an insecticide against mosquitoes. The sensitivity to insecticide in mosquitoes is determined by a single gene that has two alleles.

allele **1** : resistant to DDT
allele **2** : sensitive to DDT

Over several years genotypic frequencies were measured in a population of mosquito larvae. The graph below shows the results.



Analysis of the graph reveals that in the population

A when spraying levels declined, heterozygous advantage occurred.

B there were no alleles for sensitivity present in the population in 1967.

C the number of alleles for resistance was equal to the number for sensitivity in 1966.

D the homozygous resistant genotype was unable to produce offspring at low spraying levels.

35. Which of the following statements is/are true of genetic drift?

(i) Genetic drift requires the presence of variation.

(ii) Genetic drift can results in the loss of beneficial alleles.

(iii) Founders effect and genetic bottleneck drive genetic drift

(iv) Genetic drift occurs in small population only

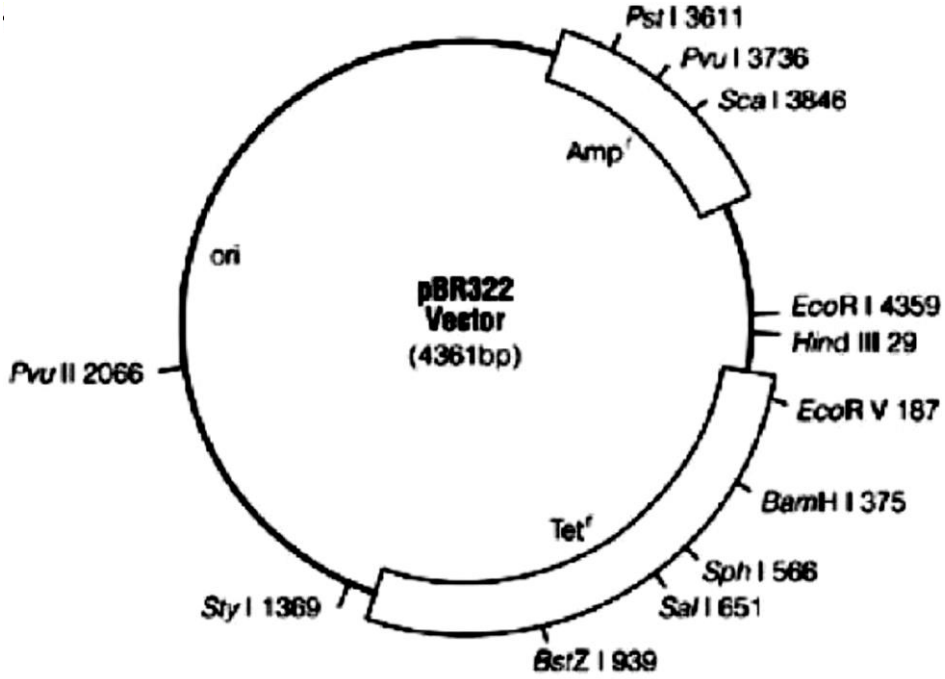
A (i) and (iv) only

B (ii) and (iii) only

C (i), (ii) and (iii) only

D (ii), (iii) and (iv) only

36. pBR322 vector is used to clone a eukaryotic gene which has been digested by the restriction endonuclease BamHI.



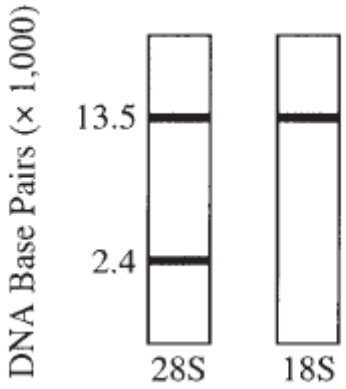
Following transformation, bacterial cells were grown in four different media, as shown below:

I nutrient broth plus ampicillin
II nutrient broth plus tetracycline
III nutrient broth plus ampicillin and tetracycline
IV nutrient broth without antibiotics

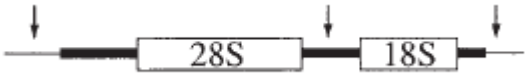
Which of the following media would bacterial cells that contain the recombinant plasmids grow in?

A I and II
B I and III
C I and IV
D IV only

37. The autoradiograms obtained below (after electrophoresis and Southern Blotting) show human DNA digested with a specific restriction enzyme and probed with labeled rRNA. In the autoradiogram on the left, the probe was 28S rRNA; at the right, the probe was 18S rRNA.



If the arrows in the following map show the location of the restriction sites of this restriction enzyme, which map *best* explains the results shown above?

A


B


C


D


38. Which of the following statements are **true** about all stem cells?

I Stem cells can be induced to differentiate by environmental signals.
II Stem cells are easily isolated and propagated
III Stem cells are able to develop into whole organisms if implanted into the womb
IV Stem cells make more stem cells under appropriate conditions.

A I and IV

B II and III

C I, III and IV

D All of the above

39. Non -viral *ex vivo* transfer of a gene encoding coagulation factor VII was performed using fibroblast cells isolated from patients suffering from severe haemophilia A.

What is the sequence of events for the *ex vivo* transfer of the gene encoding coagulation factor VIII?

1 Transfection with plasmids containing the gene encoding coagulation factor VII

2 Implantation of cells into patients

3 Isolation of fibroblasts

4 Selection and cloning of cells expressing coagulation factor VII

A 2, 3, 1, 4

B 3, 1, 4, 2

C 3, 2, 4, 1

D 3, 4, 2, 1

40. Maize varieties are being developed in which the leaves produce proteins that are toxic to insects. The DNA coding for these toxic proteins was inserted into a maize chromosome via a bacterial plasmid. Many people are opposed to this process.

Which objection is **not** biologically valid?

A Beneficial insects may be killed if they eat genetically modified maize.

B Genes for antibiotic resistance are present in plasmids and these genes may be passed to harmful bacteria.

C Hybridisation may transfer the bacterial genes from maize to weeds, giving the weed species new and harmful characteristics.

D Mutations may be caused in cattle or humans that eat the genetically modified maize.

End of Paper

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CANDIDATE NAME: _____ **INDEX NUMBER** _____

CG _____

JC2 PRELIM EXAMINATION 2016

BIOLOGY PAPER 1
Higher 2

Thursday
22 September 2016

Additional materials:
OTAS Sheet

1 hour 15 minutes

READ THESE INSTRUCTIONS FIRST

Write your name and index number in the spaces at the top of this page and on all the work you hand in.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in this paper. Record your choice in **2B pencil** on the OTAS sheet provided.

At the end of examination, submit the question paper and MCQ OTAS sheet separately.

This question paper consists of 28 printed pages excluding this cover page.

Section A [40 marks]

Answer all questions on the OTAS provided.

1. Which of the following best accounts for the difference in structure between amylose which is helical and cellulose which is fibrous?

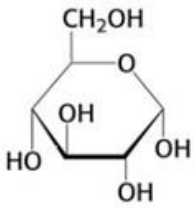
A Presence or absence of 180^{o} rotation of alternate subunits.

B Presence or absence of branching in the macromolecule

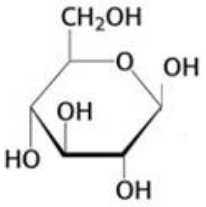
C Subunits are either monosaccharides or amino acids.

D Different tendency of macromolecule to form hydrogen bonds with water.

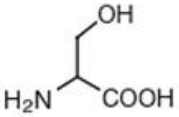
2. Which of the following combination of polymer, monomer and bond formed between monomers is correct?



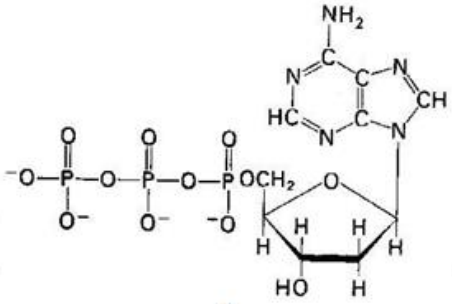
U



X



Y



Z

	starch	*cellulose*	*polypeptide*	*polynucleotide*
A	**X**, β -1,4 glycosidic bond	**U**, α -1,4 glycosidic bond	**Z**, ester linkage	**Y**, disulphide linkage
B	**U**, α -1,4 glycosidic bond	**X**, β -1,4 glycosidic bond	**Y**, peptide bond	**Z**, phosphodiester linkage
C	**Z**, peptide bond	**X**, hydrogen bond	**Z**, ionic bond	**U**, hydrogen bond
D	**X**, ionic bonds	**Y**, peptide bond	**U**, hydrogen bond	**Z**, α -1,6 glycosidic bond

3. Most wild plants contain toxins that deter animals from eating them. A scientist discovered that a toxin produced by a certain plant was also toxic to the same plant if it was applied to the roots of the plant. As the first step on finding out why the plant was not normally killed by its own toxin, he fractionated some plant cells and found that the toxin was in the fraction that contained the largest cell organelle. He also found that the toxin was no longer toxic after it was heated. Which of the following statements are consistent with the scientist's observations?

I. The toxin was stored in the central vacuole.
II. The toxin cannot cross the membrane of the organelle in which it is stored.
III. The toxin was stored in chloroplast.
IV. The toxin is likely to be lipid-soluble.
V. The toxin may be an enzyme.

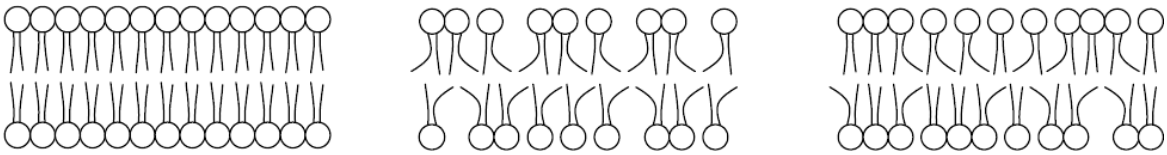
A **I, II** and **V**
B **I, IV** and **V**
C **II, III** and **IV**
D **III, IV** and **V**

4. Which of the following is/are the most likely consequence/(s) for a cell lacking functional lysosomes?

(i) The cell becomes crowded with undegraded wastes.
(ii) The cell dies because its ATP-synthesizing mechanisms are missing.
(iii) The cell dies from a lack of enzymes to catalyze metabolic reactions.
(iv) The cell is unable to reproduce itself.
(v) The cell is unable to grow to a mature size and always remains small.

A **(i)** only
B **(i)** and **(v)**
C **(ii)** and **(iv)**
D **(iii)** and **(iv)**

5. A mutated strain of the bacterium *Escherichia coli* was found to be incapable of incorporating unsaturated phospholipids into its plasma membrane. Which of the following correctly depicts and describes the membrane of such a bacteria?



Type I Type II Type III

A The membrane would appear as Type I and would be more fluid at low temperatures.

B The membrane would appear as Type I and would be less fluid at low temperatures.

C The membrane would appear as Type II and would be more fluid at low temperatures.

D The membrane would appear as Type III and would be no different from normal bacterial membranes.

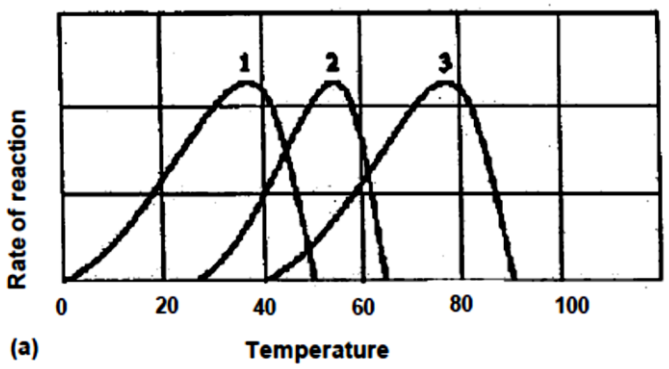
6. When mucus is secreted from a goblet cell in the trachea, these events take place.

(i) addition of carbohydrate to protein
(ii) fusion of the vesicle with the plasma membrane
(iii) secretion of a glycoprotein
(vi) separation of a vesicle from the Golgi apparatus

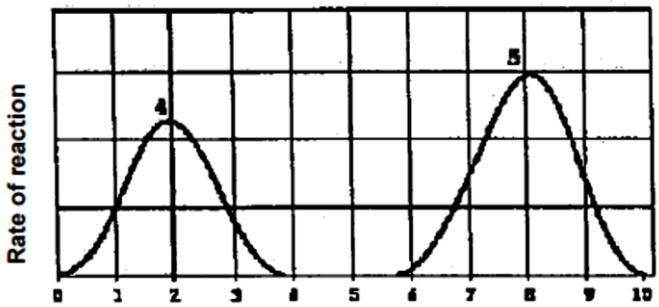
What is the sequence in which these events take place?

A (i), (vi), (ii), (iii)
B (i), (vi), (iii), (ii)
C (vi), (i), (ii), (iii)
D (vi), (i), (iii), (ii)

7. The following graphs show the activities of different enzymes (1-5) under different conditions:



(a)



(b)

Which statement is a correct explanation for the rate of reaction of different enzymes?

A Kinetic energy of enzyme 3 and its substrate is fastest at 75°C.

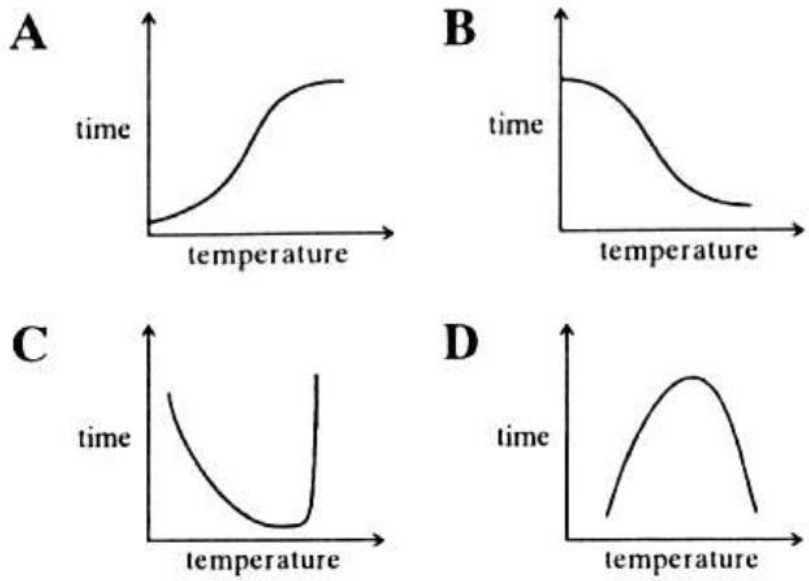
B At pH 2, most of the R groups at the active site of enzyme 4 are all negatively charged.

C At pH 8.1, substrate is bonded to the active site of enzyme 5 by hydrogen bonds only.

D At 60°C, several hydrogen bonds between R groups of enzyme 2 are broken.

8. In an investigation to determine the effect of temperature on the activity of an enzyme, the time taken for all the substrates to disappear from a standard solution was recorded.

Which graph shows the result of this investigation?



9. Which of the following statements about meiosis is **false**?

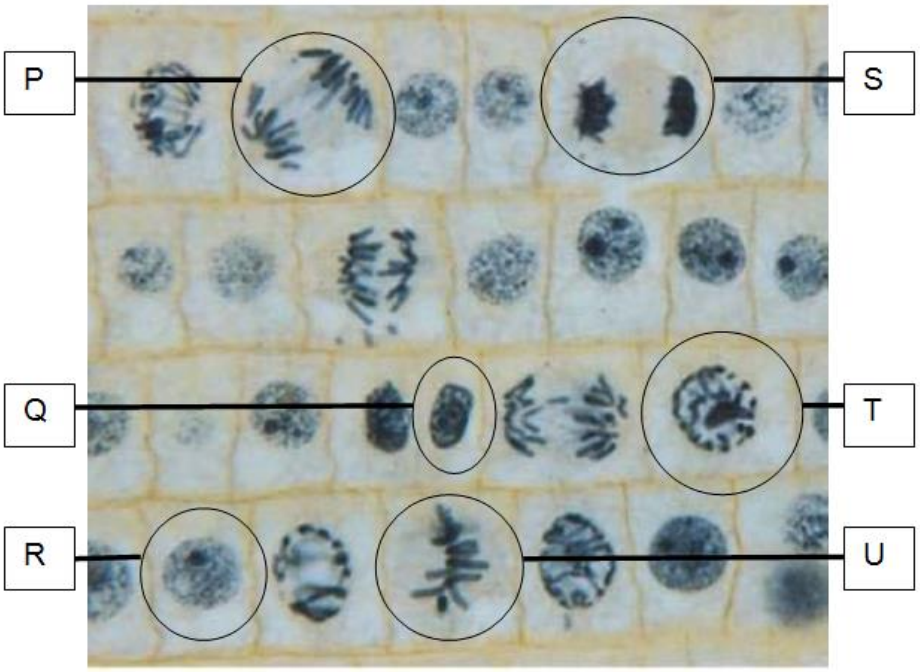
A Sister chromatids are separated at anaphase II

B Homologous chromosomes are separated in anaphase I.

C Cells at the beginning of Meiosis II are haploid

D Homologous chromosomes are paired on the metaphase plate in metaphase I.

10. The photographs below show a section of the onion root tip. The cells are at different stages of mitosis.



Which of the following shows the correct sequence of events that occurs in these cells?

A R, T, U, P, S, Q

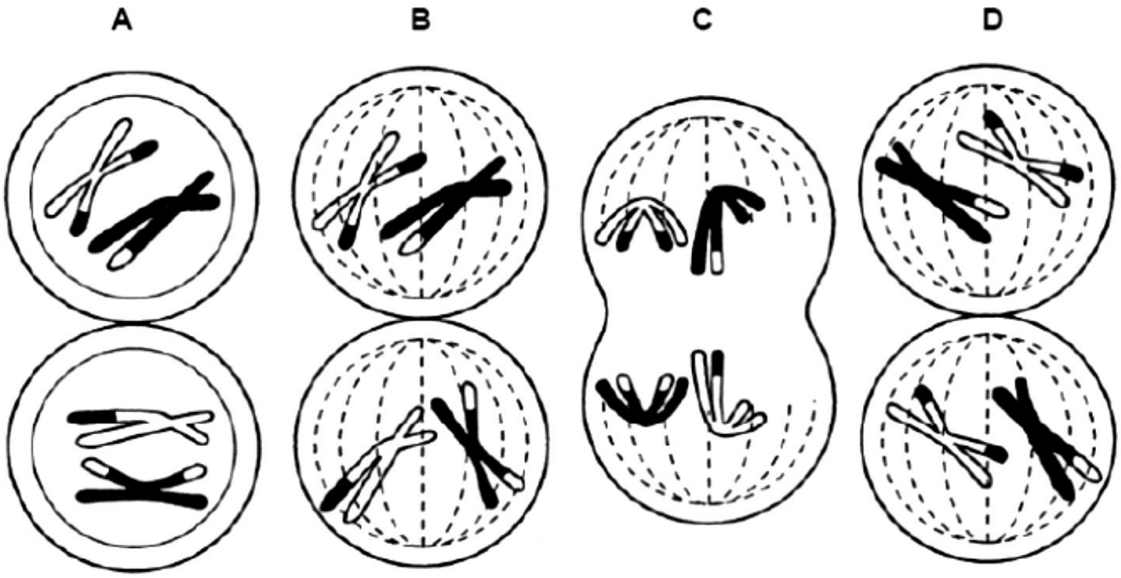
B T, U, P, S, Q, R

C Q, T, P, S, U, R

D T, R, P, S, U, Q

11. The diagram shows anaphase I of meiosis.

Which diagram shows metaphase II as meiosis continues in this cell?



12. For a double-stranded DNA, which of the following base ratios always equals 1?

I. (A + T) / (G + C)
II. (A + G) / (C + T)
III. C / G
IV. (G + T) / (A + C)
V. A / G

A **I** and **III**

B **I**, **II** and **III**

C **II**, **III** and **IV**

D **III, IV** and **V**

13. The diagram below is a template strand of a DNA molecule.

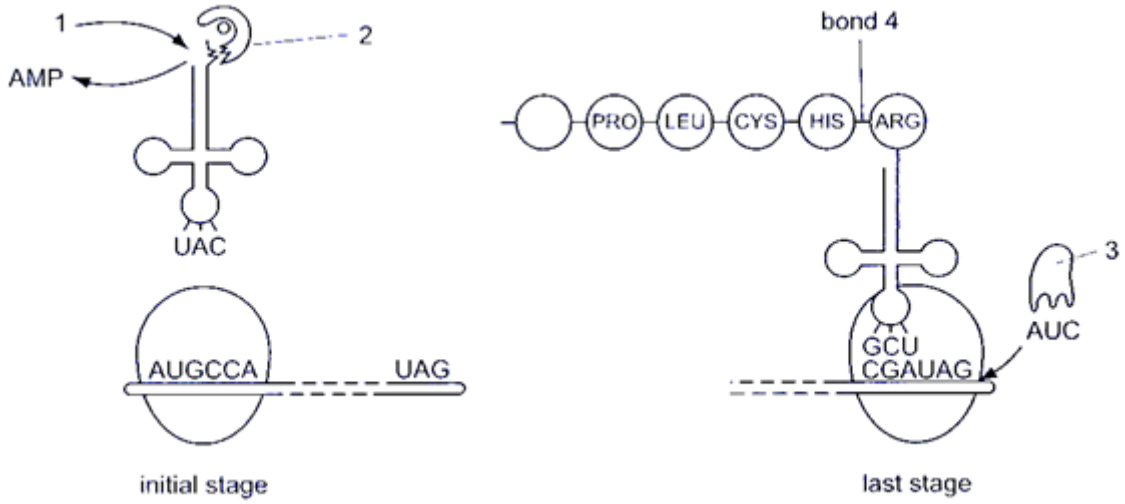
Promoter (18 nucleotides in length)	TAC	DNA sequence of 330 nucleotides	ATC

The number of amino acids in the protein coded by this template strand is

A 110 **B** 111 **C** 112 **D** 118

14. A number of molecules other than tRNA and mRNA are involved during translation.

The diagram shows some of these molecules and nucleotides in the codon and anticodon positions.



Which of the following is correct?

	1	2	3	4
A	ADP	Aminoacyl tRNA synthetase	Amino acid	Hydrogen bond
B	ADP	Amino acid	Translation releasing factor	Hydrogen bond
C	ATP	Aminoacyl tRNA synthetase	Aminoacyl tRNA	Peptide bond
D	ATP	Aminoacyl tRNA synthetase	Translation releasing factor	Peptide bond

15. With reference to a single eukaryotic gene, which of the following molecules contains the fewest number of nucleotides?

A A single strand of the original DNA segment

B A primary RNA transcript made from the original DNA segment

C A single strand of the original DNA segment after a point mutation

D A single strand of the complementary DNA (cDNA) made from the mature mRNA

16. DNA methylation is known to silence genes because it prevents transcription factors from binding. Which of the following best explains this phenomenon?

A DNA methylation modifies the shape of the transcription factor.

B DNA methylation prevents dimerization of DNA binding proteins.

C DNA methylation modifies the shape of the DNA element where the transcription factor binds.

D DNA methylation causes acetylation of histone proteins which causes heterochromatin to be formed.

17. Which of the following statements are true of the end-replication problem of linear DNA?

1. When a linear DNA molecule replicates, a gap is left at the 3' end of each new strand because DNA polymerase can only add nucleotides to a 3' end.
2. Telomerase prevents the end-replication problem from occurring.
3. Repeated rounds of replication produce shorter and shorter DNA molecules.
4. Prokaryotes do not have the end-replication problem.

A 1 and 2
B 1 and 4
C 2 and 3
D 3 and 4

18. Rhabdoviruses infect human cells. The genome of rhabdoviruses consists of a single-stranded RNA molecule whose sequence is complementary to the RNA sequence which functions as a messenger RNA. How is the "+" messenger RNA produced in such cells by rhabdovirus?

A Host cell RNA polymerase activity
B One portion of the infecting RNA is directly translated by host cell ribosomes.
C Reverse transcriptase activity
D The infecting virus particle contains an RNA-dependent RNA polymerase.

19. Some events that take place during generalized transduction are listed below.

I Bacterial host DNA is fragmented
II Bacterial DNA instead of viral DNA may be packaged in a phage capsid
III Recombination between donor DNA and recipient DNA
IV Phage infects a bacterial cell
V Phage DNA and proteins are made
VI Release of progeny virus

Which sequence of events is most accurate in describing generalized transduction?

A **IV, I, III, V,VI, II**

B **IV, I, V, II, VI,III**

C **IV, III, I, V, II,VI**

D **IV, V, I, III, II,VI**

20. A mutation that makes the regulatory gene of an inducible operon non-functional would result in

A continuous transcription of the operon's genes.
B reduced transcription of the operon's gene.
C accumulation of large quantities of a substrate for the catabolic pathway controlled by the operon.
D irreversible binding of the repressor to the promoter.

21. The coat colour of Norwegian cattle is mainly determined by the distribution of two pigments: red and black. Both pigments are made due to the action of the enzyme tyrosinase in cells called melanocytes. A normal level of activity of the enzyme leads to the production of red pigment, whilst a high activity allows only black pigment production. The activity of the enzyme is increased by melanocyte stimulating hormone (MSH), which binds to an MSH receptor.

The receptor is coded for by the **E** locus, which has the three alleles, $\mathbf{E^D}$, $\mathbf{E^A}$ and **e**. $\mathbf{E^D}$ is insensitive to protein A which blocks MSH receptor. $\mathbf{E^A}$ is sensitive to protein A which blocks MSH receptor. No receptor is produced by the recessive allele, **e**.

The dominant allele of a second gene, the **A** locus, codes for a protein which binds to and blocks the MSH receptor coded for by $\mathbf{E^A}$, thus preventing stimulation of tyrosinase activity in a melanocyte.

What would be the coat colours of cattle with the following genotypes?

	eeAa	**E^Aeaa**	**E^DeAa**	**E^AE^AAa**
A	Red	Black	Black	Red
B	Red	Black	Red	Red
C	Black	Red	Red	Black
D	Red	Red	Black	Black

22. Two parents have a son who has blood group A and phenylketonuria. One parent has blood group O and the other has blood group AB. Neither parent has phenylketonuria. What is the probability that the second child of these parents will be a girl with blood group B who does not have phenylketonuria?

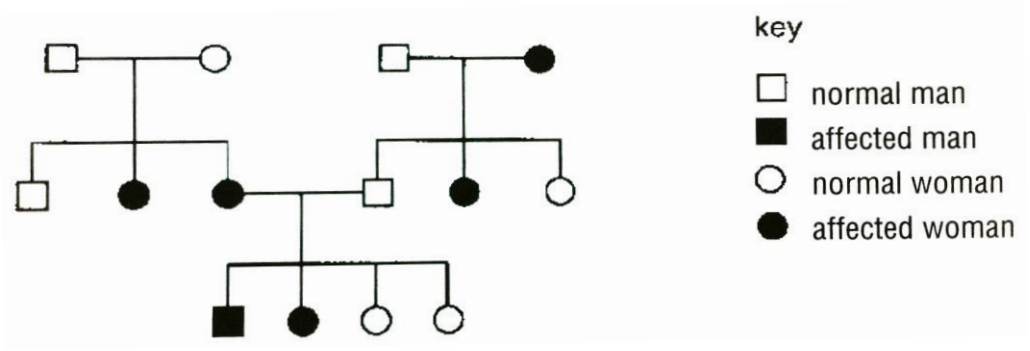
A 1 in 16

B 1 in 8

C 3 in 16

D 3 in 8

23. The family tree shows the inheritance of a skin condition.



What is the genetic basis of the skin condition?

A autosomal dominant

B sex-linked dominant

C autosomal recessive

D sex-linked recessive

24. In the board bean, a pure-breeding variety with green seeds and black hilums (the point of attached of the seed to the pod) was crossed with a pure-breeding variety with yellow seeds and white hilums. All the F_1 plants had yellow seeds and white hilums. When these were allowed to self-fertilise, the plants of the F_2 generation produced the following seeds.

Yellow seeds and white hilums	89
Yellow seeds and black hilums	28
Green seeds and white hilums	25
Green seeds and black hilums	45

A chi-squared (χ^2) test was performed to test the significance of the difference between the observed and expected results.

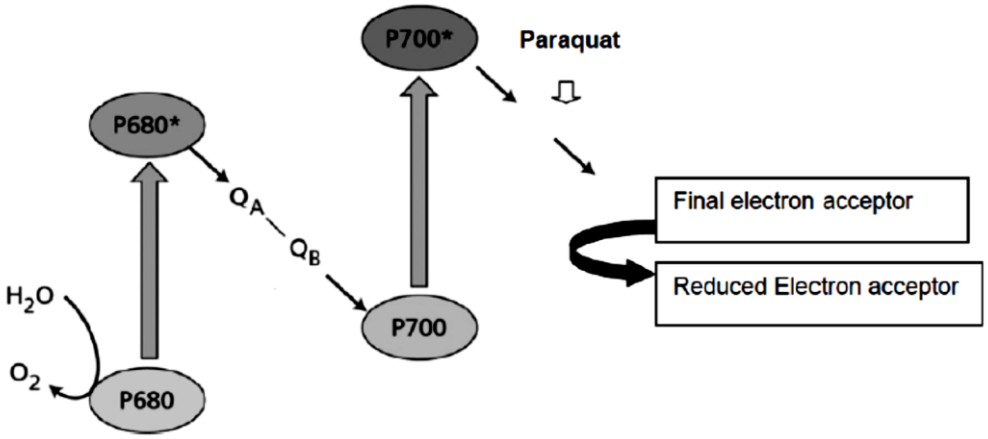
$$\chi^2 = \sum \frac{(O-E)^2}{E} \qquad \nu = c - 1$$

degrees of freedom	*p = 0.5*	*p = 0.1*	*p = 0.05*	*p = 0.01*	*p = 0.001*
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.6	5.99	9.21	13.82
3	2.37	6.25	7.82	11.34	16.27
4	3.36	7.78	9.49	13.28	18.46

Which combination correctly describes the results of the χ^2 test?

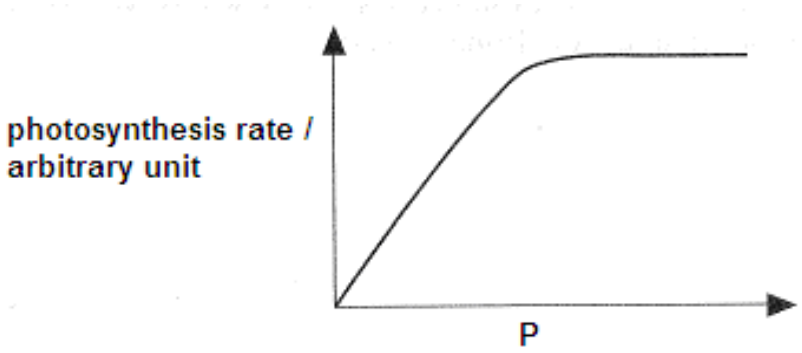
	number of degrees of freedom	*probability*	*these are two pairs of segregating alleles at two loci*
A	3	< 0.05	yes
B	3	< 0.05	no
C	4	> 0.05	yes
D	4	< 0.05	no

25. Paraquat is a poison that disrupts electron transport at the position indicated in the diagram. Paraquat was added to isolated chloroplasts. Which of the following correctly represents the outcomes in the presence of paraquat?



A Both light dependent reactions and Calvin cycle will not be able to proceed.
B Only Calvin cycle can proceed.
C Only light dependent reactions can occur.
D Both light dependent reactions and Calvin cycle can still proceed as per normal.

26. The following graph shows the relationship between the rates of photosynthesis with environmental factor **P**.

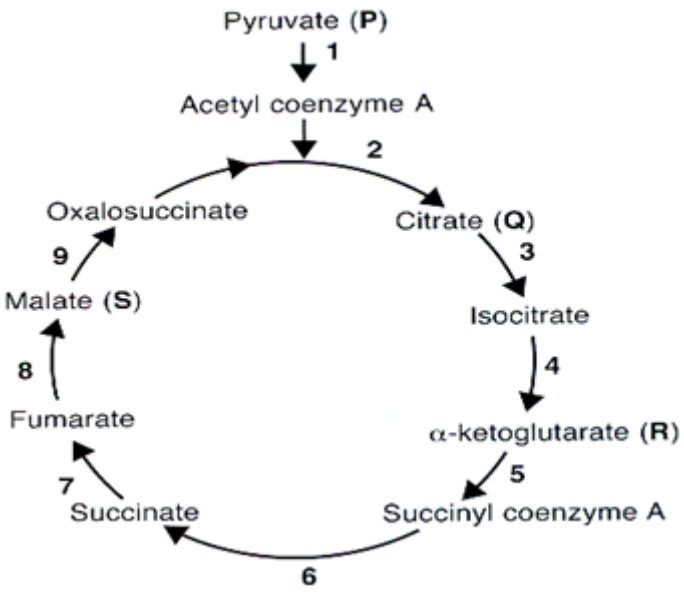


P most probably represents

1. carbon dioxide concentration.
2. oxygen concentration.
3. light intensity.
4. temperature.

A ***1*** and ***2*** **B** ***1*** and ***3*** **C** ***1*** and ***4*** **D** ***1***, ***3*** and ***4***

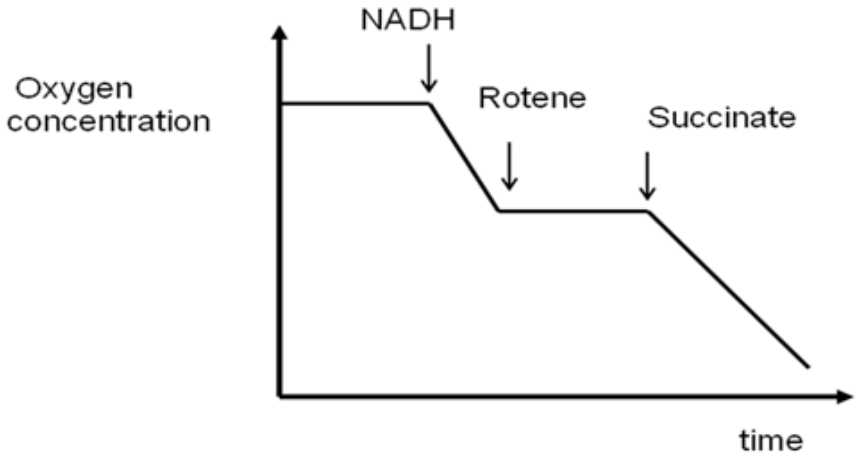
27. The diagram below shows the Krebs Cycle.



At which stages are carbon atoms removed?

A 1, 4 and 7
B 1, 4 and 5
C 2, 4 and 5
D 4, 5 and 8

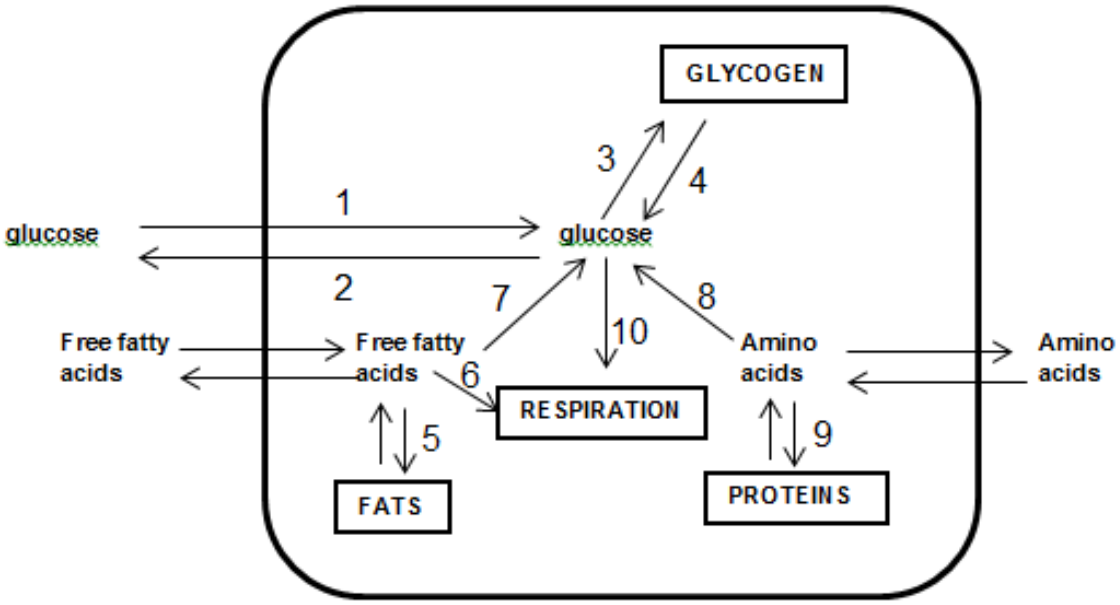
28. A suspension of mitochondria was prepared in a buffer containing ADP and inorganic phosphate (Pi). The oxygen concentration in the buffer was monitored carefully and recorded as shown below. At the times indicated, a specific reagent was added to the buffer. Throughout the experiment, the concentrations of ADP and Pi were in excess.



Which one of the following shows correctly from the highest to the lowest, the rate of ATP production after the addition of the three chemicals?

	Highest rate of ATP production	⟶	***Lowest rate of ATP production***
A	NADH	Succinate	Rotene
B	Succinate	NADH	Rotene
C	Rotene	NADH	Succinate
D	Rotene	Succinate	NADH

29. The diagram below shows some biochemical pathways in a liver cell. During which processes will the hormone glucagon exert an effect?



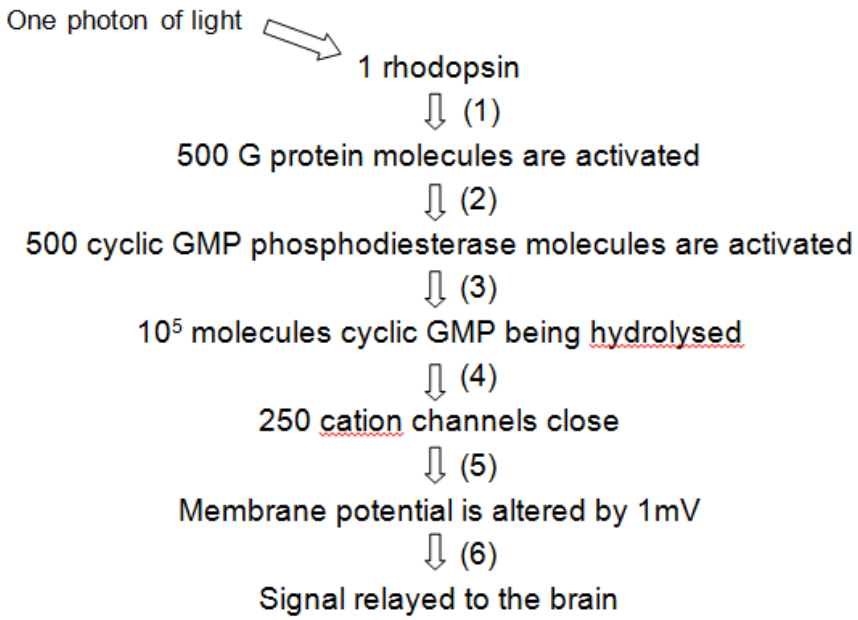
A (1), (3), (5), (9)

B (1), (4), (8), (10)

C (2), (7), (9), (10)

D (4), (6), (7), (8)

30. Rhodopsin, a light sensitive pigment that is present on the rods in the eyes. Rhodopsin is a G protein coupled receptor. The flow chart below shows how the chain of reactions that occur when rhodopsin absorbs a photon of light.



Identify the stages where *amplification* and *cellular responses* have occurred.

	Amplification	***Cellular response***
A	1, 2, 3, 4, 5	6
B	1, 3	1, 2, 3, 4, 5, 6
C	1, 3	5
D	2, 3	5

31. A neurone is undergoing relative refractory period. Which of the following statements is true?

A Membrane potential is less negative than resting potential.

B There is delayed closing of voltage-gated potassium channels.

C It is possible to initiate another action potential if a weaker stimulus is applied.

D It is impossible to initiate another action potential regardless of the stimulus strength.

32. Tetrodotoxin, a puffer fish toxin, blocks voltage-gated sodium channels. Black widow spider's venom causes the voltage-gated calcium channels to be constantly open. Crotoxin binds irreversibly to acetylcholine receptors. What will happen to the transmission of nerve impulses if each toxin is applied?

	Tetrodotoxin	**Black widow spider's venom**	**Crotoxin**
A	block action potentials along axon	reduce transmission of impulse across synapse	increase transmission of impulse across synapse
B	increase transmission of impulse across synapse	reduce transmission of impulse across synapse	block action potentials along axon
C	block action potentials along axon	increase transmission of impulse across synapse	reduce transmission of impulse across synapse
D	reduce transmission of impulse across synapse	block action potentials along axon	increase transmission of impulse across synapse

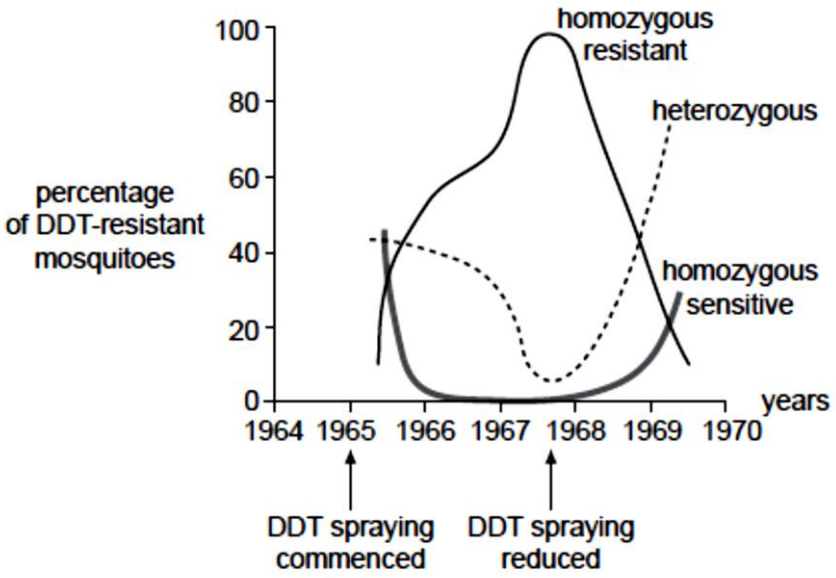
33. Members of two different species possess a similar-looking structure that they use in a similar fashion to perform the same function. Which information would best help distinguish between an explanation based on homology versus one based on convergent evolution?

A The two species live at great distance from each other.
B The two species share many proteins in common, and the nucleotide sequences that code for these proteins are almost identical.
C The sizes of the structures in adult members of both species are similar in size.
D Both species are well adapted to their particular environments.

34. In the mid-1960s, DDT was widely used as an insecticide against mosquitoes. The sensitivity to insecticide in mosquitoes is determined by a single gene that has two alleles.

allele **1** : resistant to DDT
allele **2** : sensitive to DDT

Over several years genotypic frequencies were measured in a population of mosquito larvae. The graph below shows the results.



Analysis of the graph reveals that in the population

A when spraying levels declined, heterozygous advantage occurred.

B there were no alleles for sensitivity present in the population in 1967.

C the number of alleles for resistance was equal to the number for sensitivity in 1966.

D the homozygous resistant genotype was unable to produce offspring at low spraying levels.

35. Which of the following statements is/are true of genetic drift?

(i) Genetic drift requires the presence of variation.

(ii) Genetic drift can result in the loss of beneficial alleles.

(iii) Founder effect and genetic bottleneck drive genetic drift

(iv) Genetic drift occurs in small population only

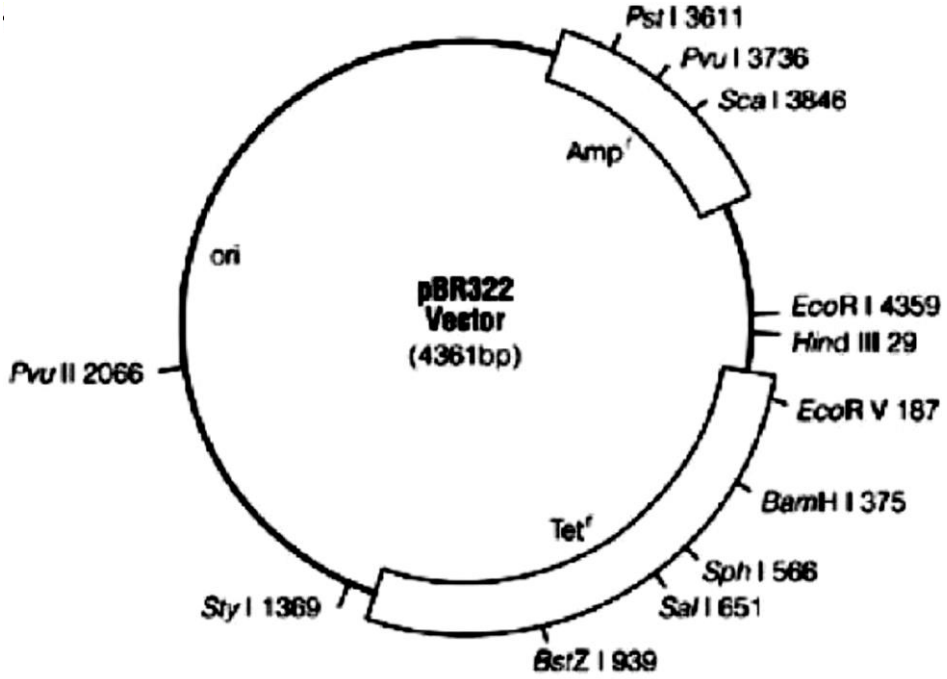
A (i) and (iv) only

B (ii) and (iii) only

C (i), (ii) and (iii) only

D (ii), (iii) and (iv) only

36. pBR322 vector is used to clone a eukaryotic gene which has been digested by the restriction endonuclease BamHI.



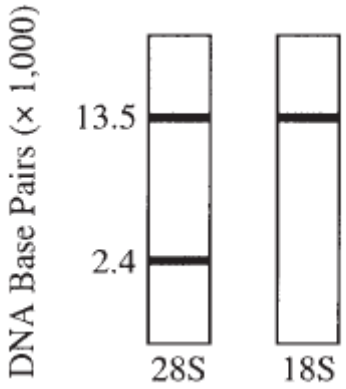
Following transformation, bacterial cells were grown in four different media, as shown below:

I nutrient broth plus ampicillin
II nutrient broth plus tetracycline
III nutrient broth plus ampicillin and tetracycline
IV nutrient broth without antibiotics

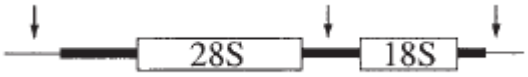
In which media would bacterial cells that contain the recombinant plasmids grow in?

A I and II
B I and III
C I and IV
D IV only

37. The autoradiograms obtained below (after electrophoresis and Southern Blotting) show human DNA digested with a specific restriction enzyme and probed with labeled rRNA. In the autoradiogram on the left, the probe was 28S rRNA; at the right, the probe was 18S rRNA.



If the arrows in the following map show the location of the restriction sites of this restriction enzyme, which map *best* explains the results shown above?

A


B


C


D


38. Which of the following statements are **true** about all stem cells?

I Stem cells can be induced to differentiate by environmental signals.
II Stem cells are easily isolated and propagated
III Stem cells are able to develop into whole organisms if implanted into the womb
IV Stem cells make more stem cells under appropriate conditions.

A I and IV

B II and III

C I, III and IV

D All of the above

39. Non -viral *ex vivo* transfer of a gene encoding coagulation factor VII was performed using fibroblast cells isolated from patients suffering from severe haemophilia A.

What is the sequence of events for the *ex vivo* transfer of the gene encoding coagulation factor VIII?

1 Transfection with plasmids containing the gene encoding coagulation factor VII

2 Implantation of cells into patients

3 Isolation of fibroblasts

4 Selection and cloning of cells expressing coagulation factor VII

A 2, 3, 1, 4

B 3, 1, 4, 2

C 3, 2, 4, 1

D 3, 4, 2, 1

40. Maize varieties are being developed in which the leaves produce proteins that are toxic to insects. The DNA coding for these toxic proteins was inserted into a maize chromosome via a bacterial plasmid. Many people are opposed to this process.

Which objection is **not** biologically valid?

A Beneficial insects may be killed if they eat genetically modified maize.

B Genes for antibiotic resistance are present in plasmids and these genes may be passed to harmful bacteria.

C Hybridisation may transfer the bacterial genes from maize to weeds, giving the weed species new and harmful characteristics.

D Mutations may be caused in cattle or humans that eat the genetically modified maize.

End of Paper

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CANDIDATE NAME (CG) _____ *INDEX NUMBER* _____

JC2 Preliminary Examination 2016

BIOLOGY
Higher 2

Paper 3

19th SEP 2016/ Monday
2 hours

Additional materials:
Answer paper

READ THESE INSTRUCTIONS FIRST

Write your name and index number in the spaces at the top of this page and on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in all the sections.

.

At the end of examination,
1. fasten all your work securely together

FOR EXAMINER'S USE	
1	/14
2	/14
3	/12
	/40
4	/12
5	/20
TOTAL	/72

INFORMATION FOR CANDIDATES
The intended number of marks is given in brackets [ ] at the end of each question or part question.

This question paper consists of 14 printed pages
Answer **all** questions

Question 1

The first ever gene therapy trial was initiated in 1990 by Dr William French Anderson to treat a four year old girl named Ashanthi. Ashanthi was suffering from severe combined immunodeficiency (SCID), a genetic disorder characterised by the absence of functional T-lyymphocytes.

In Ashanthi's case, the disease was caused by the absence of the enzyme adenosine deaminase (ADA-SCID). An alternative form of SCID is known as X-linked SCID.

(a) From your knowledge, contrast between the two forms of SCID mentioned in the paragraph above. [3]

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There were several *ex vivo* methods of gene therapy that were considered in Ashanthi's treatment, detailed in table 1.1. The virus vector used was a modified retrovirus.

Method	Description
A	• Normal ADA allele is introduced into viral vector • Recombinant virus is introduced into T-cells obtained from patient • Genetically modified cells are reintroduced into patient
B	• Normal ADA allele is introduced into viral vector • Recombinant virus is introduced into the cells derived from inner cell mass of blastocyst • Genetically modified cells are reintroduced into patient.
C	• Normal ADA allele is introduced into viral vector • Recombinant virus introduced into hematopoietic stem cells obtained from patient • Genetically modified cells are reintroduced into patient

Table 1.1

(b) With reference to the information presented in Table 1.1,

(i) Suggest one reason why *ex vivo* approach was utilised for gene therapy. [1]

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(ii) State the most preferred method of ex vivo gene therapy for ADA-SCID and justify the preference over the other 2 methods. [3]

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(c) Explain why the retrovirus was an efficient vector in the gene therapy of Ashanthi's condition. [2]

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Apart from diseases that plague human health, the effect of plant diseases on agriculture have also been in the spotlight. One such disease is the ringspot virus that plagues the papaya agricultural industry. Scientists have developed effective circumventive methods to tackle the problem of the ringspot virus through genetically modifying papaya. To do this, viral genes encoding capsid proteins were transferred to the papaya genome. These viral capsid proteins elicit something similar to an "immune response" from the papaya plant. Thus, the genetically modified papaya plants were resistant to infection by the papaya ringspot virus.

Figure 1.2 below depicts the comparative infection of transgenic and non-transgenic papaya in the 1995 field trail in Kapoho, Hawaii.

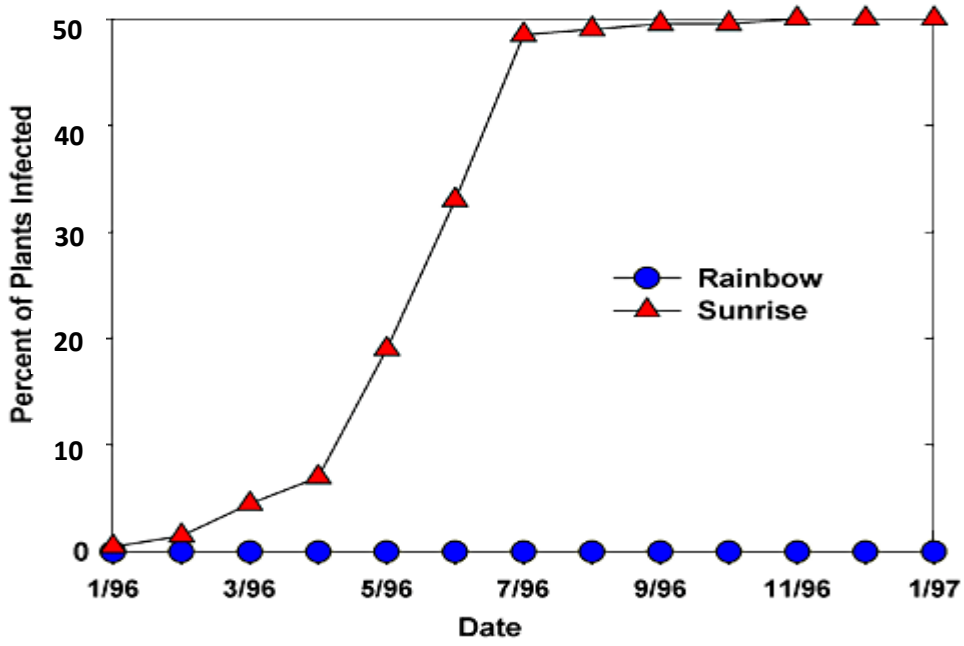

Figure 1.2

(d) With reference to Figure 1.2,

(i) Determine the identities of the transgenic and non-transgenic papaya species. [1]

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(ii) Evaluate and justify thoroughly the efficacy of the genetic intervention. [2]

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It was observed that three years later, the percentage of infected transgenic papaya species increased.

(e) Suggest and explain a possible reason for this phenomenon. [2]

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[Total: 14 marks]

Question 2

The location of the gene locus responsible for disease X was not discovered until 1985. Scientists used restriction fragment length polymorphism to discover the genetic markers associated with the disease. One such marker was a 950bp-long region known as XD15 that had been sequenced prior to 1985.

Samples of DNA were obtained from a family known to have the condition. The XD15 locus was amplified by polymerase chain reaction and mixed with *Pst*I and *Eco*RI in two separate restriction digests. The results of gel electrophoresis followed by southern blot of both restriction digests are shown in Figure. 2.1.

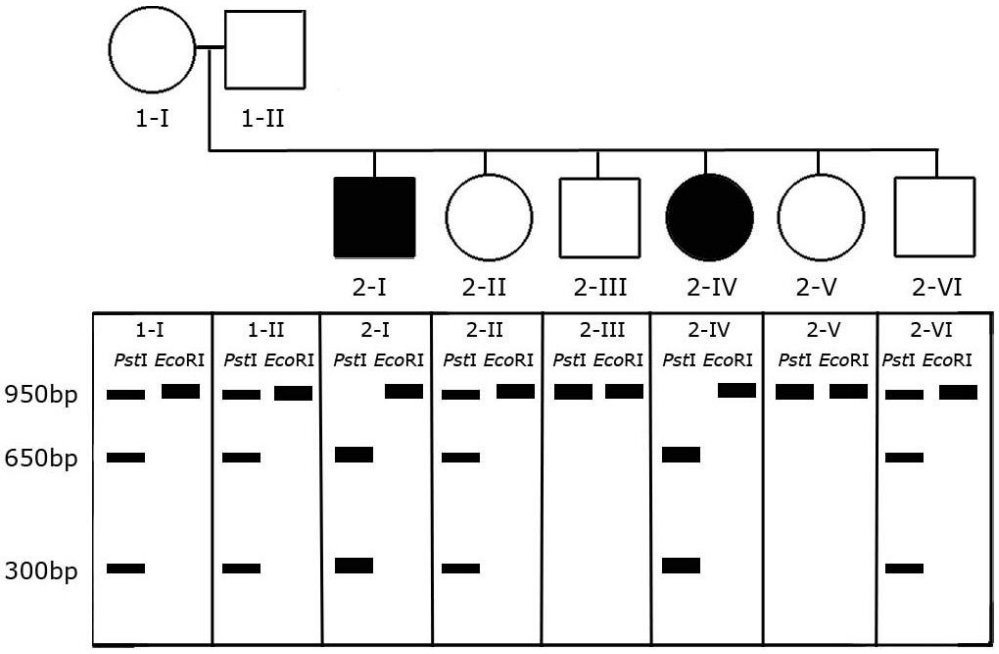

Figure. 2.1

(a) Using the information in Figure. 2.1,

(i) state and explain which restriction enzyme digest should be used to detect the XD15 genetic marker associated with disease X. [3]

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(ii) Draw a restriction map of the XD15 genetic marker that is associated with disease X.

Indicate on the restriction map the position of the radioactively-tagged probe that would enable visualization of the RFLP fragments. [2]

(b) Explain why genetic markers like XD15 can be used to detect the presence of disease-causing alleles. [2]

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The XD15 locus was amplified by polymerase chain reaction prior to gel electrophoresis and southern blot. The DNA sequence of the XD15 locus is shown in Figure. 2.2.

5' - GGATCCATCCCGATCGAAAGCTAGCTAGGATCC - 3'
3' - CCTAGGTAGGGCTAGCTTTCGATCGATCCTAGG - 5'

Figure. 2.2

(c) Design two 7-base long primers for the sequence to be amplified. [2]

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(d) Contrast between the process of PCR and DNA replication that occurs naturally in cells. [3]

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(e) Besides disease detection, RFLP analysis may be used for DNA fingerprinting as well. Explain one difference in the approach employed during RFLP analysis for both processes (disease detection and DNA fingerprinting). [2]

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[Total: 14 marks]

Question 3

(a) Plant growth regulators (PGR) such as auxin, cytokinin and ethylene are naturally produced in plants and are important in determination of the developmental pathway of plant cells.

Synthetic analogues that can be mass produced are frequently used in plant tissue culture instead of the natural PGR.

Table 3.1 summarizes the general characteristics and roles of some natural and synthetic PGR.

Type of PGR	Examples	Role
Auxins	IAA(natural) - unstable to heat & light	Promote cell division and cell growth Root initiation (when auxin:cytokinin is high)
	2,4-D(synthetic) – stable to heat & light	
Cytokinins	2iP(natural) – unstable to heat & light	Promotes cell division Shoot formation (when auxin:cytokinin is low)
	Kinetin(synthetic) - stable to heat & light	
Abscisic acid (ABA)	-	Inhibits cell division Maturation of somatic embryos Abscission (i.e. shedding) of plant leaves Seed dormancy Induces stomatal closure to reduce water loss by transpiration
Ethylene	-	Abscission (i.e. shedding) of leaves and flowers Seed and bud dormancy by growth inhibition Fruit ripening

Table 3.1

Prunus lannesiana is an early-flowering cherry (only in spring) in Japan Izu peninsula. It is commonly known as Sakura or Japanese Cherry. Researchers are keen to propagate *P. lannesiana* from sterilized explants by micropropagation due to the advantages that the technique offers. Hence, a study was made to analyse the concentration of PGR present in the *P. lannesiana* in the four seasons and the results were summarized in Table 3.2.

Conc. of PGR / arbitrary unit \ **Season**	**Spring (Mar-May)**	**Summer (June – Aug)**	**Autumn (Sep-Nov)**	**Winter (Dec – Feb)**
IAA (auxin)	15	20	25	30
2iP (cytokinin)	10	15	10	5
ABA	5	5	12	15
Ethylene	12 – 20	18	16	14

Table 3.2

Table 3.3 illustrates the physiological development of *P. lannesiana* in the various seasons.

Season	**Spring**	**Summer**	**Autumn**	**Winter**
Shoot development	Very Active	Active	Minimal	Nil
Root development	Minimal	Moderate	Active	Very Active
Leaves development	Very Active	Active	Senescence (leaves turning autumn yellow) and abscission	Nil
Flowers development	Short full bloom in early spring, followed by senescence	Nil	Nil	Buds develop but dormant in late winter
Fruit and seed development	Fruit and seed development in late spring	Seed maturation	Seed dormant	Seed dormant

Table 3.3

(i) State one economical limitation of micropropagation. [1]

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(ii) Suggest why synthetic PGR (e.g. 2,4-D and Kinetin) are used instead of natural PGR (e.g. IAA and 2iP) in plant tissue culture. [1]

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(iii) Using the information provided in Table 3.2 and Table 3.3, explain the effect of the change in the auxin:cytokinin ratio from Spring to Winter and vice versa. [4]

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(b) The Salmon Genome Project (SGP) is developed to increase knowledge of the biology of Atlantic salmon and aid agricultural breeding of the fish.

(i) Describe how the SGP serves to increase knowledge of the biology of Atlantic salmon. [2]

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In order to produce transgenic salmon expressing salmon growth hormone, sGH, the coding sequence of sGH gene is isolated from a library and cloned, using *Sac* I, into the plasmid expression vector, pBluescript II SK. The plasmid map is shown in Figure. 3.1.

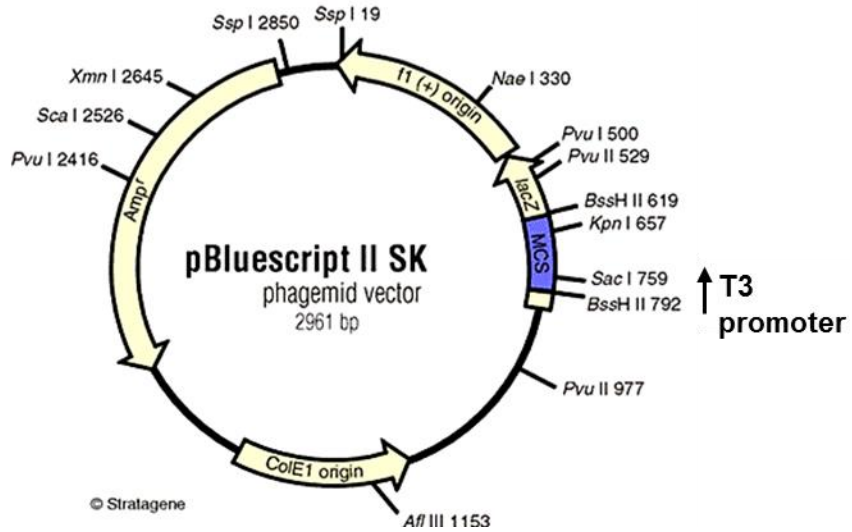

Figure 3.1

(ii) With reference to figure 3.1, describe the features of the multiple cloning site (MCS). [2]

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Subsequent to insertion of sGH gene into pBlueScript II SK, transformation into *E. coli* cells was carried out and some colonies were obtained. The plasmid DNA was extracted, digested with *Sac* I and the restriction fragments were separated in gel electrophoresis.

(iii) It was found that the recombinant plasmid with sGH gene inserted yielded no polypeptide. With reference to Fig. 3.1, state and explain a reason for this. [2]

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[Total: 12 marks]

Planning Question - Write your answers on the separate answer paper provided.

Question 4

Cefazolin is an antibiotic that disrupts the synthesis of bacterial peptidoglycan cell by preventing the formation of peptide bonds. It is bactericidal (kills bacteria) and is effective against gram-positive bacteria.

Streptococcus pneumoniae is a bacterium responsible for conditions like pneumonia and bacterial meningitis. It is a gram-positive bacterium which establishes itself as small white colonies. Discs containing cefazolin can be placed on an agar plate containing *Streptococcus pneumoniae*. If the cefazolin has been effective against *Streptococcus pneumonia,* a clear zone will be seen around the disc as shown in Figure 4.1.

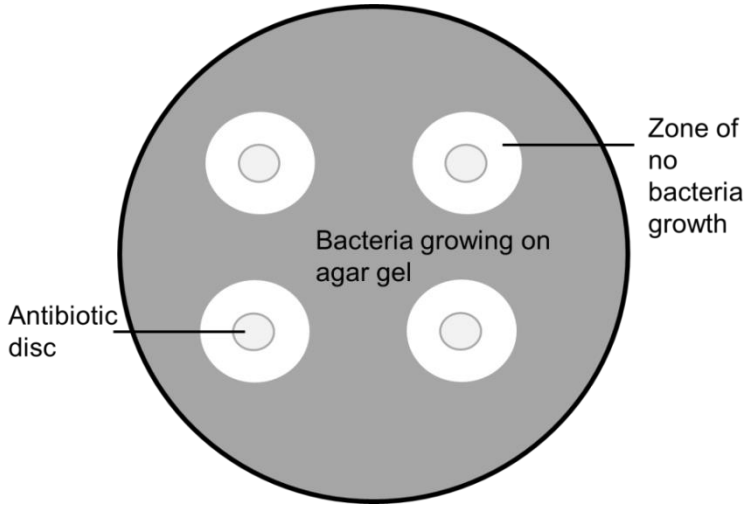


Figure 4.1

You are to plan but not carry out an experiment to investigate the effectiveness of different concentrations of cefazolin on the growth of *Streptococcus pneumoniae*.

Your plan must be based on the assumption that you have been provided with the following equipment and materials:

- Bunsen burner, to enable good aseptic conditions
- Bacterial culture in nutrient broth
- Molten nutrient agar
- Distilled water
- Sterile 90mm Petri dishes
- Sterile loops (to plate bacteria onto nutrient agar)
- $1cm^3$ pipette
- Filter paper discs
- Forceps
- Vernier calipers
- 1% cefazolin solution
- Bactericidal disinfectant for containment of used forceps and pipettes, also to clean work surfaces

Your plan should include:

- a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- an explanation of theory to support your practical procedure
- an explanation of the dependent and independent variables involved
- relevant, clearly labeled diagrams, if necessary
- proposed layout of results tables and graphs with clear headings and labels
- correct use of scientific and technical terms
- safety measures to minimise any risks associated with the proposed experiment

[Total: 12 marks]

Free-response question

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labeled diagrams, where appropriate.
Your answers must be in continuous prose where appropriate.
Your answers must be set out in sections (a), (b), etc as indicated in the question.

Question 5

(a) Discuss the advantages and evolutionary consequences of using plant tissue culture to propagate transgenic plants. [8]

(b) Outline the ethical and social implications of genetically modified organisms. [6]

(c) Explain why gene therapy is opined to have limited success in the treatment of genetic diseases. [6]

CANDIDATE NAME _____ **INDEX NUMBER** _____

CG _____

JC2 Preliminary Examination 2016

H2 BIOLOGY
9648

Paper 2

2 Hours

MARK SCHEME

Date / Day: /

INSTRUCTIONS TO CANDIDATES
Write your name, CG and index number in the spaces at the top of this page and on all separate writing papers used.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.

Section A
Answer **all** questions.
Write your answers in spaces provided on the question paper.

Section B
Answer **only one** question out of two.
Write your answers on the separate answer paper provided.

INFORMATION FOR CANDIDATES
The intended number of marks is given in brackets [ ] at the end of each question or part question.

FOR EXAMINER'S USE	
Section A	
1	**/11**
2	**/**
3	**/**
4	**/13**
5	**/**
6	**/**
7	**/10**
Total	**/80**
Section B	
9 OR 10	**/20**
TOTAL	**/100**

This question paper consists of 23 printed pages and 1 blank pages

SECTION A

Answer **all** questions.

Question 1

Figure 1.1 below depicts the molecular structure of a basic unit of collagen.

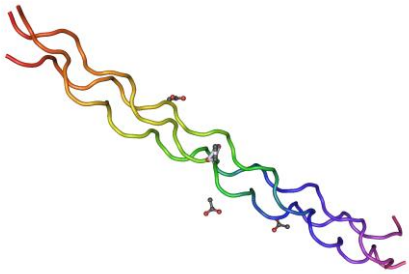


Figure 1.1

(a) State the name given to such a basic unit of collagen. [1]

- Tropocollagen.

(b) Describe how the monomers of this basic unit are joined together to achieve the final molecular configuration as shown in Figure 1.1. [3]

- Monomers are <u>amino acids</u>
- Join together via <u>condensation reaction</u> to form <u>peptide bonds</u> with a loss of water molecules forming a polypeptide
- Three such polypeptides join together via <u>intermolecular hydrogen bonding</u> between NH and CO groups to form tropocollagen

Collagen is normally found in animal connective tissue where its role is as a structural molecule. Figure 1.2 shows an electron micrograph of collagen.

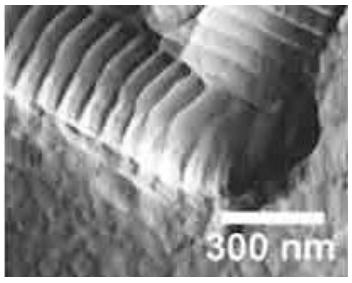


Figure 1.2

(c) Explain the banded appearance of collagen shown in Figure 1.2. [2]

- Due to **staggered arrangement/ longitudinal displacement** of tropocollagen subunits with respect to each other.
- Held by **covalent cross links** between adjacent tropocollagen subunits.

(d) Explain why collagen is able play the role of a structural molecule. [2]

- Large molecular size so insoluble.
- large **number of hydrophobic, non-polar amino acids** that face the outside of the triple helix so insoluble

  (Max 1 for solubility)

- Several tropocollagen molecules are further **covalent cross-linked** with neighbouring tropocollagen molecules running parallel to them to form a collagen fibrils/fibres giving great tensile strength.

Another common structural molecule found in nature is cellulose. Cellulose is the main structural molecule in plants.

(e) Compare the structures of cellulose and collagen. [3]

Similarities:

- Both have intermolecular hydrogen bonding
- Both associate to form fibrous structures.

Differences:

- β-glucose monomer in cellulose vs amino acid monomer in collagen
- β 1,4 Glycosidic bond in cellulose vs peptide bond in collagen.
- Cellulose is a straight chain structure while collagen is helical

[Total: 11 marks]

Question 2

The following Figure 2.1 shows an electron micrograph of several cells.

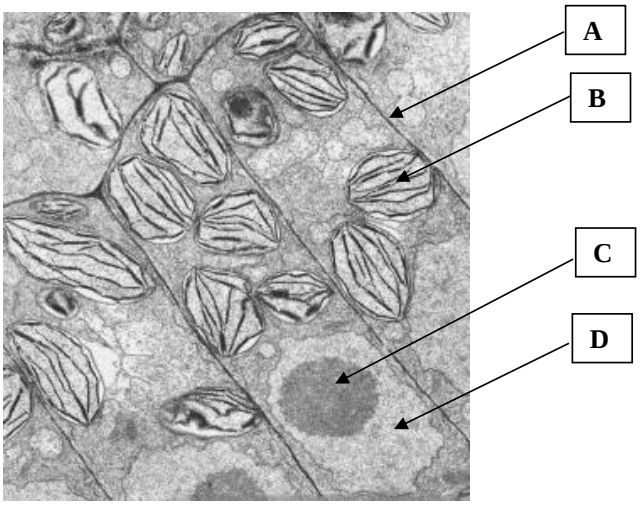


Figure 2.1

(a) Label the organelles **A – D**. [4]

A – Cell Wall

B - Chloroplast

C - Nucleolus

D – Nucleus

(b) Discuss the role of organelle C. [3]

- Contains rRNA genes
- Involved in the **synthesis of ribosomal RNA (rRNA) <u>via transcription</u>,**
- which is a constituent of **ribosomes.**
- **Also involved in the assembly of rRNA and ribosomal proteins** into **large and small subunits**

Max 3

(c) In the nucleoplasm of such cells, genetic material can be found. State the nature of this genetic material and briefly describe how this genetic material is organized. [3]

- Made up of DNA
- Organised into chromosomes
- Condensed around histone octamer and non-histone proteins

Such genetic material can take part in processes such as what is shown in **Figure 2.2**.

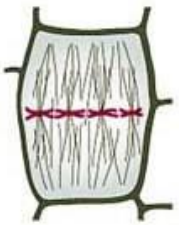


Figure 2.2

(d) With appropriate reasons, precisely identify the process shown in **Figure 2.2**. [3]

- Mitosis Metaphase
- Chromosome lined up at the equator of the cell
- No nuclear envelope visible
- Only one row and not two so not meiosis

Max 3

(e) Suggest the significance of the **next stage** of the above process. [2]

- Next stage is anaphase (no credit for stating this)
- Separates sister chromatids into individual chromosomes
- Allows each replicated chromatid/chromosome to move to the pole of the cell
- Ensures that each daughter cell will have the original chromosome number restored.
- AVP

Max 2

[Total: 15 marks]

Comment [WU1]: Just a suggestion: Can consider this question (from 2015 P2 to up the level a little, although the next question already touches on operon.. :☺

In the nucleoplasm of such cells, genetic material can be found. State 2 ways in which the organization of genes found in these cells differ from that found in bacterium. [2]

Suggest one advantage of this organization in bacterium. [1]

Question 3

A set of abundant nucleoid-associated proteins (NAPs) play key functions in organizing the bacterial chromosome and regulating gene transcription globally. Histone-like nucleoid structuring protein (H-NS) is representative of a family of NAPs that are widespread across bacterial species. They have drawn extensive attention due to their crucial function in gene silencing in bacterial pathogens. Figure 3.1 illustrates how H-NS is able to silence genes of bacterial pathogens. *(Information obtained from Biophysical Journal Oct 2015, 109(7))*

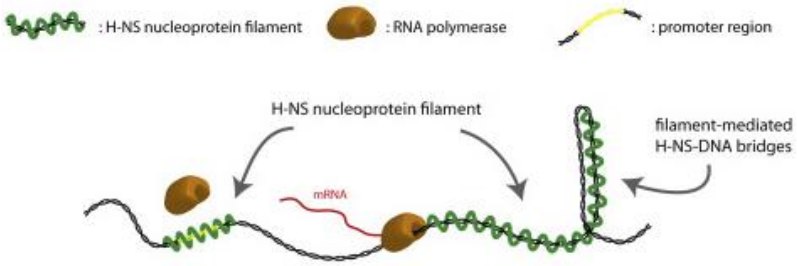


Figure 3.1

(a) State the name of one bacterial pathogen. [1]

- Bacteriophage

(b) Explain the role of RNA polymerase in a bacterial cell. [3]

- Involved in transcription, leading to the production of messenger RNA.
- Messenger RNA acts as a template for translation into proteins at ribosomes.
- Binds to promoter of gene, bringing ribonucleotides together, joining them via phosphodiester bonds

(c) Using the information from Figure 3.1, suggest how H-NS is able to silence genes. [2]

- Inhibits binding of RNA polymerase to the promoter region
- Blocks the movement of RNA polymerase along the gene

The following figure shows regulation of transcription in the trp operon of a bacterial cell.

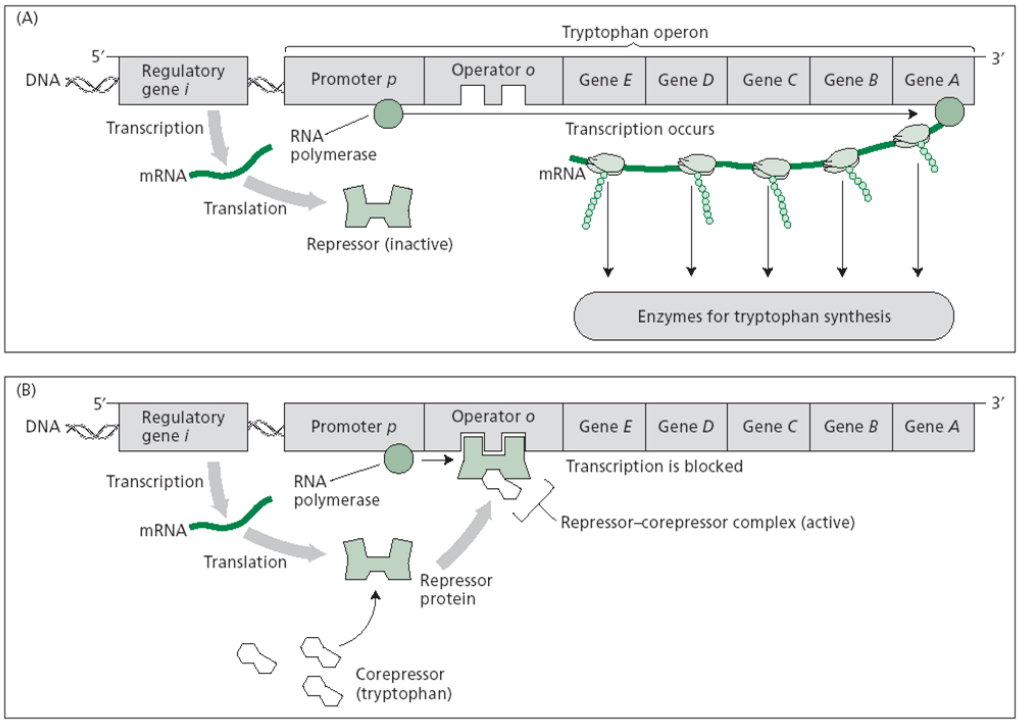


Figure 3.2

(d) Using the information in figure 3.2, describe the process of negative regulation in bacterial operons. [4]

- Involves the use of a repressor molecule
- In the trp operon example, repressor is made in the inactive form, operon default on/transcription occurs.
- In the presence of co-repressor tryptophan, repressor is activated = repressor-corepressor complex.
- repressor-corepressor complex binds to operator, block RNA polymerase and operon is switched off/transcription does not occur.

(e) Suggest why tryptophan is the ideal co-repressor for this operon. [2]

- Enzymes produced by operon result in the synthesis of tryptophan.
- Tryptophan thus inhibits its own production when it is in excess.
- Acts as an end product inhibitor

Max 2

(f) The lac operon is an example of an inducible operon system. Contrast negative regulation of the lac operon with that of the trp operon. [2]

Lac operon	**Trp operon**
Repressor produced in the active form	Repressor produced in the inactive form
Requires allolactose as an inducer	Requires tryptophan as a co-repressor

Question 4

The diagram shows the chromosome from a plant cell in which 2n = 4. The dominant allele **A** of a gene results in red flower and pink spines on the fruit. The recessive allele, **a**, gives yellow flower and green spines. The dominant allele **B** intensifies the colour of the pink spines to red. The plant is heterozygous as shown below:

(a) The plant was selfed. Give the phenotypic ratio of the offspring. Explain your answer. [3]

1. 9 red flower and red spines on the fruit : 3 red flower with pink spines on the fruit : 4 yellow flower with green spines on the fruit;
2. Due to epistasis;
3. Offspring with genotype aa and B/b alleles will have yellow flower and green spines on the fruit as pink is not expressed so the colour cannot be intensify even in the presence of B allele/ recessive alleles a **mask** the dominant allele B;

The plant is also heterozygous for another characteristic, the height of the plant. Allele T = tall is dominant to allele t = dwarf. A cross was made between the tall, red-flowered plant with a dwarf, yellow-flowered plant and produced a large number of offspring. **Table 4.1** shows the results.

Table 4.1

Phenotype	**Number of offspring**
Tall, red-flowered plant	35
Tall, yellow-flowered plant	14
Dwarf, red-flowered plant	16
Dwarf, yellow-flowered plant	33

(b) The ratio of phenotypes expected in a cross such as this is 1:1:1:1. Chi-squared test was performed on these data giving a calculated value of X^2 of 14.64.

Table 4.2: Distribution of X^2

Degrees of freedom	Probability, p				
	0.10	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

(i) Use the calculated value of X^2 and the table of probability provided in **Table 4.2** to find the probability of the results of the cross is due to chance. [1]

1. Probability: $0.001 < p < 0.01$

(ii) State what conclusions may be drawn from the probability found in (b)(i). [2]

1. There is significant difference between expected results and actual results/ Probability of the actual results deviating from the expected results due to chance is low since it is less than 0.05
2. Inheritance pattern does not conform to the 1:1:1:1 ratio

(iii) Explain the difference between the expected and actual results of the test cross. [3]

1. Difference is due to the two genes being linked together
2. Tendency for these two genotypes (AT and at) of the gametes to be produced → more tall, red-flowered plant and dwarf, yellow-flowered plants are produced
3. Due to crossing over during Prophase I of meiosis, new recombinants where A is linked to t and a is linked to T are produced, resulting in tall, yellow-flowered plants and dwarf, red-flowered plants.

(c) Briefly explain how another factor, besides crossing over, can bring about genetic variation in the offspring produced by a sexually reproducing organism (Exclude mutation from your answer). [1]

1. Independent assortment of homologous chromosomes during meiosis 1results in different combination of alleles into the gametes / 2^n possible combinations where n is the number of homologous pairs. (Rej: independent assortment without any sufficient elaboration)

OR

2. random fertilization/ fusion of gametes results in different genotypes/ combination of alleles in the offspring/ results from each gamete having different sets of chromosomes

In another completely different cross involving humans, the following results were obtained.

Phenotypes	Genotypes	Color of skin
Extremely dark	PPQQRR	6
Very dark	PpQQRR	5
Dark	PpQqRR	4
Intermediate	PpQqRr	3
Light	ppQqRr	2
Very light	ppqqRr	1
Extremely light	ppqqrr	0

(d) What is the term used to describe the range of phenotypes in the above example? [1]

1. Continuous Variation (Rej: Polygenic inheritance)

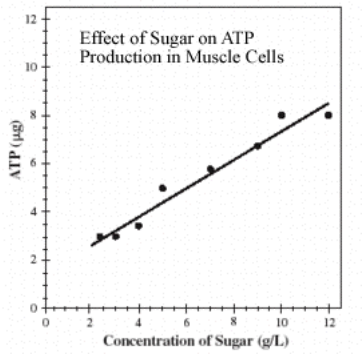
(e) Explain the genetic basis for the range of phenotypes seen. [2]

1. Human skin colour is controlled by **3 pairs/many** of independent genes. (rej: multiple alleles)
2. Cumulative/additive effect on the trait without complete dominance.

[Total: 13 marks]

Question 5

The following figure shows the effect of sugar levels on muscle cells.



(a) Describe and explain the effect of sugar on ATP production in muscle cells. [3]

1. As concentration of sugar increases from 2 to 12g/L ATP production increases from 2.5 to 8.5ug.
2. Sugar (Glucose) used in mitochondria of muscle cells in aerobic respiration/ description of stages of respiration **apart from only glycolysis**
3. Aerobic respiration produces ATP

(b) Suggest and explain what will happen to ATP production if the concentration of sugar continued to increase. [2]

1. It will plateau off
2. Possible limiting factors with example = rate of sugar uptake into muscle cell/ respiratory enzyme conc/ oxygen concentration AVP (Rej: limited number of cells or mitochondria)

The coenzyme cytochrome *c* oxidoreductase, is the third complex in the electron transport chain, playing a critical role in biochemical generation of ATP (oxidative phosphorylation).

(c) Explain how the coenzyme cytochrome c oxidoreductase may aid in the production of ATP in the electron transport chain. [3]

1. Serves as an electron carrier
2. Energy released when passing electrons used to pump/ actively transport H+ into intermembrane space/ create proton gradient
3. H+ then moves down a conc gradient through the stalked particle/ ATP synthase complex to make ATP from ADP and Pi.
4. AVP

(d) Actimycin A is known to inhibit the coenzyme cytochrome c oxidoreductase. Predict the effect actimycin A would have on the aerobic respiratory process. [2]

1. Electrons cannot move down the chain, ATP not made
2. NAD+ and FAD not regenerated
3. hence Krebs cycle and link reaction shut down, aerobic respiration shut down
4. AVP

Rej: inhibit ATP production unless accompanied by valid explanation.

Any 2

[Total: 10 marks]

Question 6

The following Figure 6.1 shows the synaptic knob of a synapse found in the sympathetic ganglion of frogs. Such synapses are unique as they contain receptors to the neurotransmitter noradrenaline (NE) on the pre-synaptic membrane itself. These are known as autoreceptors.

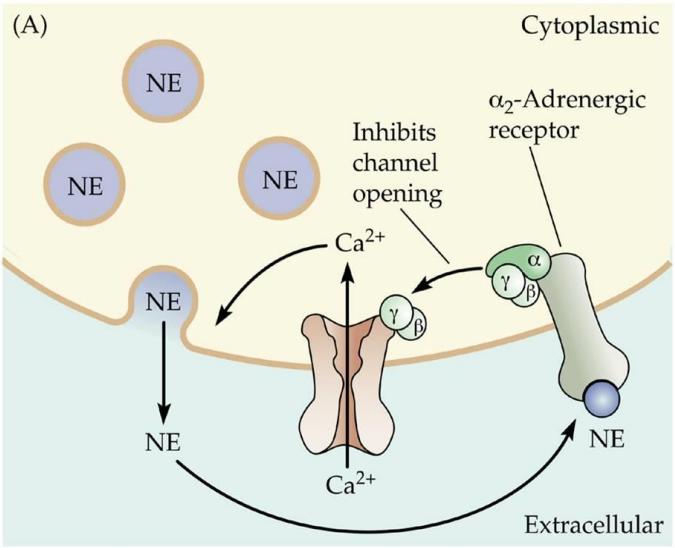


Figure 6.1

(a) State the name given to synapses that use noradrenaline as the neurotransmitter. [1]

- Adrenergic synapse

(b) Using the information given in Figure 6.1, explain how the release of noradrenaline at the pre-synaptic membrane may eventually inhibit the synapse itself. [3]

- Noradrenaline binds to α_2-Adrenegic receptor.
- Leads to the β & ϒ subunits moving to and binding with the Ca^{2+} channel thus inhibiting opening of Ca^{2+} channel, preventing Ca^{2+} influx.
- Prevents fusion of synaptic vesicles with presynaptic membrane.

(c) Suggest the significance of this self-inhibitory effect. [1]

- Rapid self-regulation of neurotransmitter release.
- AVP

(d) Explain one function of synapses. [2]

1. Ensure **one-way transmission of nerve impulses**. As only the presynaptic membrane can release neurotransmitter and only postsynaptic membrane has receptors that trigger an action potential.

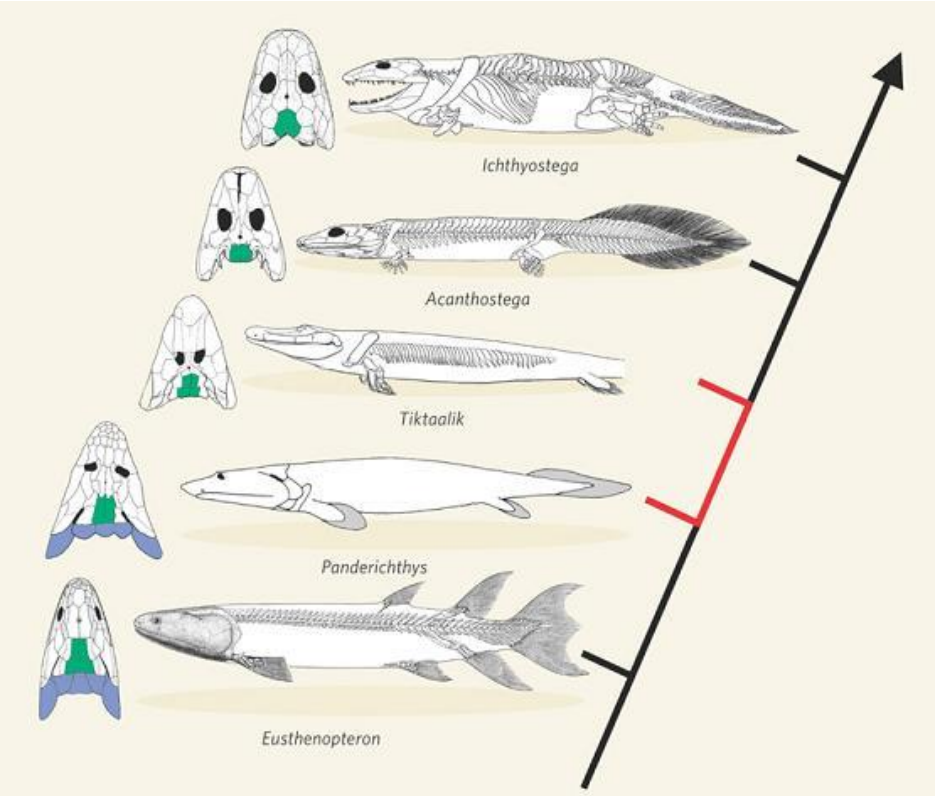
2. The post-synaptic neurone and synapses act as **a junction for the integration of stimuli** from **various sources** to **produce a co-ordinated response**. (Allow for alternative point on inhibition)

3. **Filter out** low-level stimuli that are of no significance, i.e. remove "background noise" from the body's nervous system as all neurotransmitter will have been released but stimuli continues = adaptation

[Total: 7 marks]

Question 7

Figure 7.1 shows a series of fossils. This series depicts how land-based amphibians could have evolved from fishes. Tiktaalik hails from the Late Devonian period, about 360 million years ago, and is both chronologically and morphologically intermediate between two other major fossils in this series, the more fish-like *Panderichthys* and the more tetrapod-like *Acanthostega*.



(a) State the name given to fossils such as *Tiktaalik* that have characteristics from two seemingly diverse groups of organisms. [1]

- Transitional forms

(b) Explain how such fossil records can actually support Darwin's theory of evolution. [4]

- Similarities amongst group of organisms
- Suggests a <u>common ancestor</u>
- Differences amongst group of organisms
- Suggests modification due to <u>natural selection</u>
- Evidence for <u>descent with modification</u>.

In most respects *Tiktaalik's* body is fish-like: it has fins and gill arches, just like a fish. However, its skull and especially its limbs mark it as a tetrapod ancestor. Species such as *Panderichthys* had true fins, similar to those of modern ray-finned fishes, consisting of an array of long, thin, spindly bones unsuitable for bearing weight. On the other side of the gap

is *Acanthostega*, with true limbs – each containing a radius and an ulna, just like our arms, and outfitted with eight true toes.

(c) State the name given to similar structures such as the limbs of *Acanthostega* and *Tiktaalik*.

- Homology / Homologous structures

(d) It was believed that the environment *Tiktaalik* evolved in was filled with swampy, silty lagoons. These dirty, unclear water masses also tended to have algae covering its surface. Using this information, describe how the amphibian-like *Acanthostega* could have evolved from the species *Tiktaalik*. [4]

- Variation existed within the *Tiktaalik* population; some individuals had the beginnings of true limbs.
- Formed two sub-populations, one on land and one in the swamps (those with fins and gill arches)
- These individuals within the swamps were selected against as the silty water and algae made survival more difficult, eg difficulty breathing. OWTTE/ Those on land selected for as easier to breathe/more food options OWTTE
- Alleles for true limbs passed down to next generation.
- No interbreeding/genetic isolation/reproductive isolation existed between the two sub-populations

Stimulus information adapted from:
http://www.patheos.com/blogs/daylightatheism/2006/04/hello-beautiful/ &
https://sciencenotes.wordpress.com/tag/

Section B

Question 8

(a) Explain the eukaryotic processing of pre-mRNA. [6]

1. Capping changes 5' end with the addition of 7-methylguanosine group;
2. Protects mRNA from degradation by 5' exonucleases / confers stability / assists in ribosomal binding;
3. Splicing removes introns and ligates exons to produce a mature mRNA;
4. Alternative splicing may occur, resulting in different combinations mature mRNA from a gene;
5. Addition of poly-A tail to 3' end of mRNA;
6. Allows slower degradation by 3' exonucleases / longer poly(A) tail implies longer half-life of mRNA / facilitates transport of mRNA from nucleus to cytoplasm;

(b) Compare and contrast between prokaryotic and eukaryotic control of gene expression at the translational and post-translation level. [9]

Feature	Eukaryotic	Prokaryotic
Initiation of translation	Initiated by recognition of AUG sites by small ribosomal subunit;	
	First amino acid methionine	First amino acid N-formyl-methionine;
Translational repressors	Translational repressors bind at 5' UTR to prevent translation initiation;	
Stability of mRNA	Eukaryotic mRNA more stable / present in cytoplasm for longer period of time, due to 5' cap and poly A tail	Prokaryotic mRNA has no poly A tail or 5' cap, so less stable / have shorter half-life;
Biochemical Modification	Addition of biochemical groups to proteins → activate protein;	Biochemical modification not as significant due to lack organelles such as ER & GA;
Protein degradation	Unwanted / misfolded proteins can be degraded by proteasomes / lysosomal degradation	Lack lysosomes / proteasomes but possess other mechanism of degrading proteins;
Feedback inhibition	Feedback mechanism present to control gene expression;	

(c) Describe the significance of gene amplification. [5]

1. Definition – selective increase in number of copies of a particular gene without a proportional increase in other genes;
2. Meet the needs of cells resulting in higher level of mRNA and polypeptide synthesis at different development stages of cells;
3. Specific example
4. May cause diseases like cancer due to over-expression of proteins leading to development of malignant tumours ;
5. May confer drug resistance, ref to example of methotrexate;
6. May confer selective advantage which allow organisms to survive in a particular environment;
7. May contribute to evolution of genome, ref to homologous genes;

Question 9

(a) With reference to the three different stages of cell signaling, describe in detail the sequence of events when a glucagon molecule reaches the liver cell. [10]

Signal reception
The hormone, glucagon acts the "first messenger" or a ligand, binding specifically to a G-protein-linked receptor located on the outside surface of the plasma membrane of the target cell.
Forming a hormone receptor complex
activates the G protein → displacement by GTP of GDP
The activated G protein moves to and then activates the enzyme adenylyl cyclase,
Adenylyl cyclase catalyses the formation of cAMP from ATP.

Signal transduction
cAMP acts as a second messenger
moves within the cell to activate enzymes
such as protein kinases.
Protein kinases then activate other enzymes by phosphorylating them.
In a cascade reaction
Signal is amplified

Cellular response
regulate cellular activities in the cytoplasm by increasing the blood glucose level to 90mg glucose/100ml blood
regulate transcription in the nucleus
by synthesis of enzymes or other proteins from genes
eg. activating enzymes required for increasing blood glucose level
such as glycogenolysis – breakdown of glycogen to give glucose,
gluconeogenesis – synthesis of glucose from sources other than carbohydrates, etc

(b) Discuss roles played by proteins in maintaining the potential differences across membranes and in the transmission of nerve impulses along an axon [7]

1. Na+/K+ pump on axon membrane;
2. to maintain membrane potential (potential difference across membranes);
3. via active transport requiring ATP;
4. for every 3 Na+ out, 2 K+ in;
5. to maintain a electrochemical gradient of Na+ and K+ across axon membrane
6. non-gated K and Na ion leakage channels;
7. based on facilitated diffusion controlling movement of Na+ & K+ in and out of axoplasm down electrochemical gradient;
8. there are 20x more K+ leakage channels in the axon membrane than Na+ channels
9. Both Na+/K+ pump and leakage channels are responsible for the resting potential of the nerve cell
10. voltage gated Na+ and K+ ion channels;
11. nec for depolarisation and repolarisation of axon membrane
12. arrival of stimulus or initial depolarisation → opening of Na+ channels,
13. entry of Na+ into axoplasm causing depolarization of membrane
14. A.P. generated when threshold potential exceeded;
15. A.P. transmitted/propagated to adjacent region of axon by closure of Na+ gates so that Na+ must move to region ahead and not out of nerve cell;
16. efflux of K+ out of axoplasm as Na+ channels close & K+ channels open;
17. repolarisation occurs;

(c) Explain how loss of myelination, which happens in the demyelinating disease multiple sclerosis, disrupts signal transmission in the nervous system. [3]

Myelin sheath made of lipids is important in electrical insulation
limiting the APs to the node of Ranviers allowing the A.P to jump from node to node increasing the speed of transmission
Loss of myelination leads to more AP generated → Decreasing/slow speed of transmission

Accept the reverse explanation.

CANDIDATE NAME _____ **INDEX NUMBER** _____

CG _____

JC2 Preliminary Examination 2016

H2 BIOLOGY
9648

Paper 2

2 Hours

Additional materials:
Writing papers

Date / Day: 13th September 2016/Tuesday

INSTRUCTIONS TO CANDIDATES
Write your name, CG and index number in the spaces at the top of this page and on all separate writing papers used.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.

Section A
Answer **all** questions.
Write your answers in spaces provided on the question paper.

Section B
Answer **only one** question out of two.
Write your answers on the separate answer paper provided.

INFORMATION FOR CANDIDATES
The intended number of marks is given in brackets [ ] at the end of each question or part question.

FOR EXAMINER'S USE	
Section A	
1	**/11**
2	**/15**
3	**/14**
4	**/13**
5	**/10**
6	**/7**
7	**/10**
Total	**/80**
Section B	
9 OR 10	**/20**
TOTAL	**/100**

This question paper consists of 18 printed pages

SECTION A

Answer **all** questions.

Question 1

Figure 1.1 below depicts the molecular structure of a basic unit of collagen.

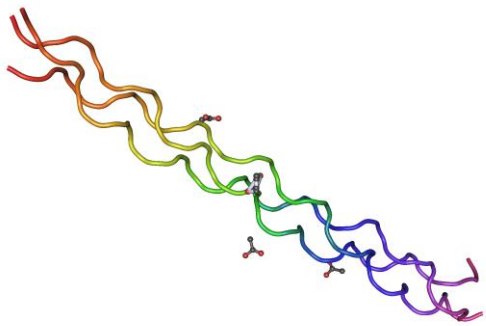


Figure 1.1

(a) State the name given to such a basic unit of collagen. [1]

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(b) Describe how the monomers of this basic unit are joined together to achieve the final molecular configuration as shown in **Figure 1.1**. [3]

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Collagen is normally found in animal connective tissue where its role is as a structural molecule. Figure 1.2 shows an electron micrograph of collagen.

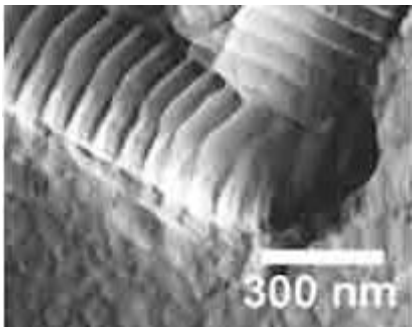

Figure 1.2

(c) Explain the banded appearance of collagen shown in **Figure 1.2**. [2]

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(d) Explain why collagen is able play the role of a structural molecule. [2]

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Another common structural molecule found in nature is cellulose. Cellulose is the main structural molecule in plants.

(e) Compare the structures of cellulose and collagen. [3]

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[Total: 11 marks]

Question 2

The following Figure 2.1 shows an electron micrograph of several cells.

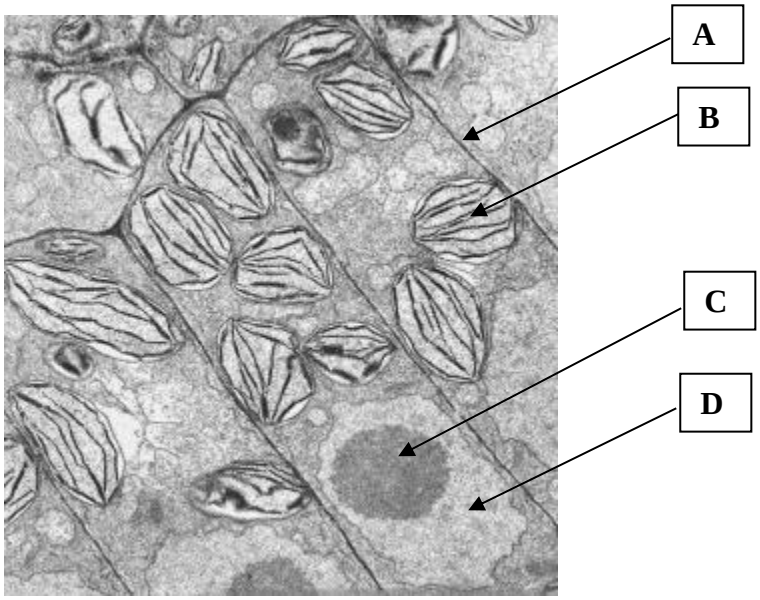

Figure 2.1

(a) Label the organelles **A – D**. [4]

A - ……...

B - ……...

C - ……...

D - ……...

(b) Discuss the role of organelle C. [3]

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(c) In the nucleoplasm of such cells, genetic material can be found. State the nature of this genetic material and briefly describe how this genetic material is organized. [3]

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Such genetic material can take part in processes such as what is shown in **Figure 2.2**.

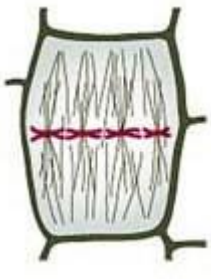

Figure 2.2

(d) With appropriate reasons, precisely identify the process shown in **Figure 2.2**. [3]

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(e) Suggest the significance of the **next stage** of the above process. [2]

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[Total: 15 marks]

Question 3

A set of abundant nucleoid-associated proteins (NAPs) play key functions in organizing the bacterial chromosome and regulating gene transcription globally. Histone-like nucleoid structuring protein (H-NS) is representative of a family of NAPs that are widespread across bacterial species. They have drawn extensive attention due to their crucial function in gene silencing in bacterial pathogens. Figure 3.1 illustrates how H-NS is able to silence genes of bacterial pathogens. *(Information obtained from Biophysical Journal Oct 2015, 109(7))*

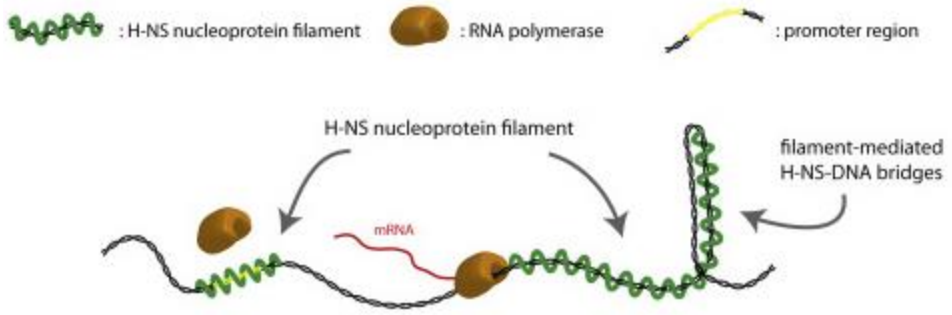

Figure 3.1

(a) State the name of one bacterial pathogen. [1]

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(b) Explain the role of RNA polymerase in a bacterial cell. [3]

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(c) Using the information from **Figure 3.1**, suggest how H-NS is able to silence genes. [2]

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The following figure shows regulation of transcription in the trp operon of a bacterial cell.

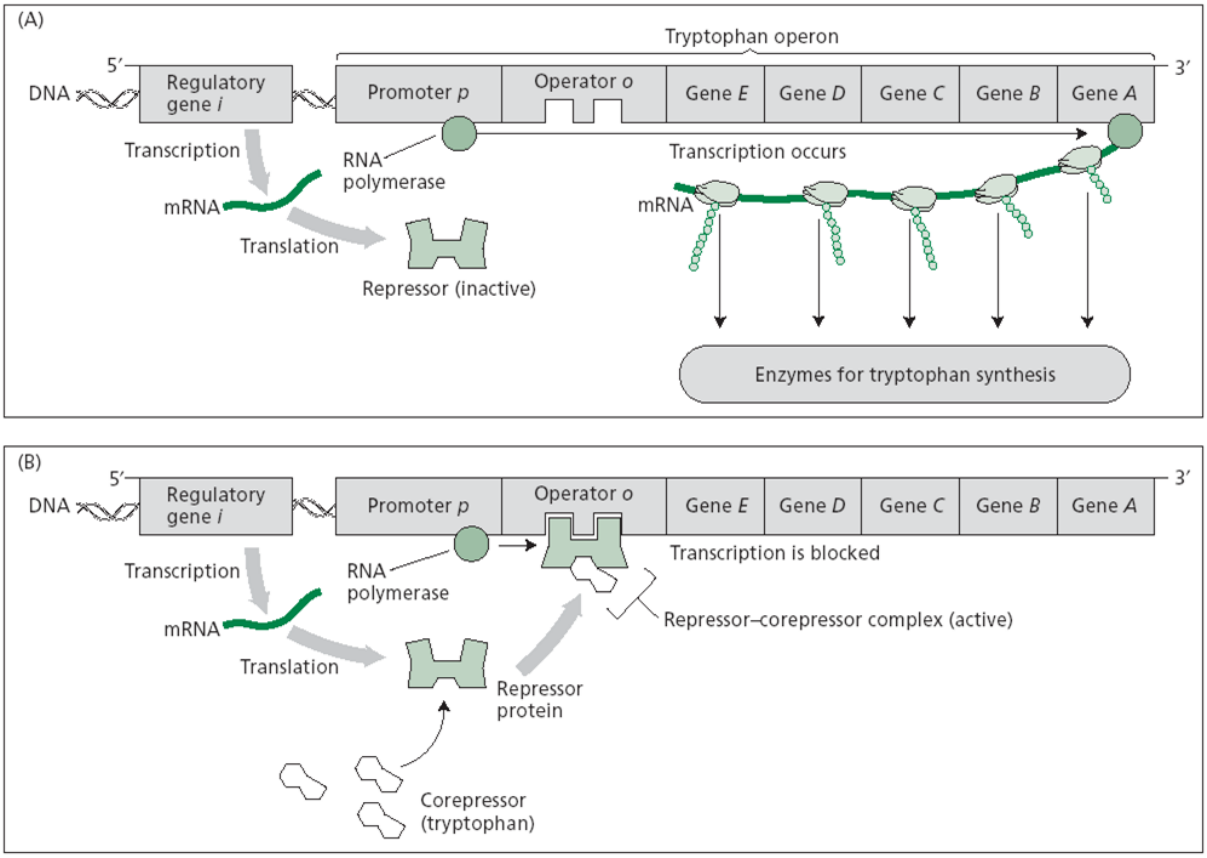

Figure 3.2

(d) Using the information in **figure 3.2**, describe the process of negative regulation in bacterial operons. [4]

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(e) Suggest why tryptophan is the ideal co-repressor for this operon. [2]

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(f) The lac operon is an example of an inducible operon system. Contrast negative regulation of the lac operon with that of the trp operon. [2]

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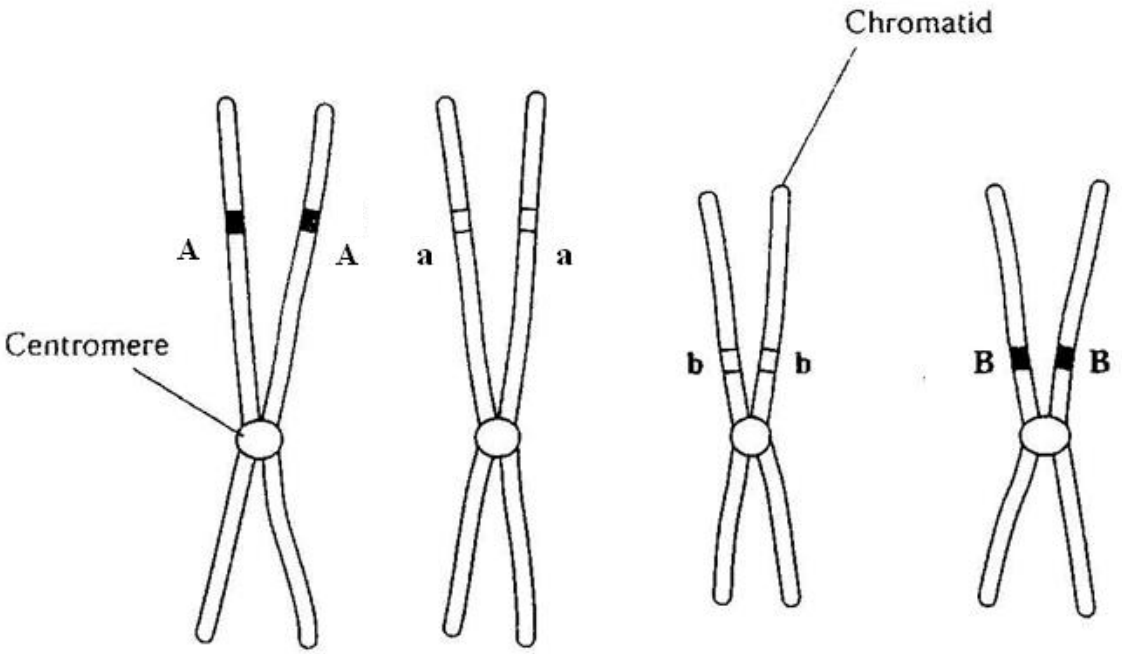
[Total: 14 marks]

Question 4

The diagram shows the chromosome from a plant cell in which 2n = 4. The dominant allele **A** of a gene results in red flower and pink spines on the fruit. The recessive allele, **a**, gives yellow flower and green spines. The dominant allele **B** intensifies the colour of the pink spines to red. The plant is heterozygous as shown below:



(a) The plant was selfed. Give the phenotypic ratio of the offspring. Explain your answer. [3]

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The plant is also heterozygous for another characteristic, the height of the plant. Allele T = tall is dominant to allele t = dwarf. A cross was made between the tall, red-flowered plant with a dwarf, yellow-flowered plant and produced a large number of offspring. **Table 4.1** shows the results.

Table 4.1

Phenotype	**Number of offspring**
Tall, red-flowered plant	35
Tall, yellow-flowered plant	14
Dwarf, red-flowered plant	16
Dwarf, yellow-flowered plant	33

(b) The ratio of phenotypes expected in a cross such as this is 1:1:1:1. Chi-squared test was performed on these data giving a calculated value of X^2 of 14.64.

Table 4.2: Distribution of X^2

Degrees of freedom	Probability, p				
	0.10	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

(i) Use the calculated value of X^2 and the table of probability provided in **Table 4.2** to find the probability of the results of the cross is due to chance. [1]

Probability ……

(ii) State what conclusions may be drawn from the probability found in (b)(i). [2]

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(iii) Explain the difference between the expected and actual results of the test cross. [3]

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(c) Briefly explain how another factor, besides crossing over, can bring about genetic variation in the offspring produced by a sexually reproducing organism (Exclude mutation from your answer). [1]

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In another completely different cross involving humans, the following results were obtained.

Phenotypes	Genotypes	Color of skin
Extremely dark	PPQQRR	6
Very dark	PpQQRR	5
Dark	PpQqRR	4
Intermediate	PpQqRr	3
Light	ppQqRr	2
Very light	ppqqRr	1
Extremely light	ppqqrr	0

(d) What is the term used to describe the range of phenotypes in the above example? [1]

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(e) Explain the genetic basis for the range of phenotypes seen. [2]

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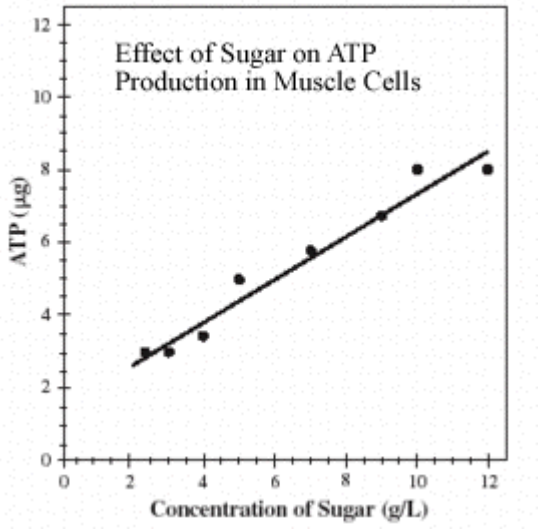
[Total: 13 marks]

Question 5

The following figure shows the effect of sugar levels on muscle cells.



(a) Describe and explain the effect of sugar on ATP production in muscle cells. [3]

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(b) Suggest and explain what will happen to ATP production if the concentration of sugar continued to increase. [2]

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The coenzyme cytochrome *c* oxidoreductase, is the third complex in the electron transport chain, playing a critical role in biochemical generation of ATP (oxidative phosphorylation).

(c) Explain how the coenzyme cytochrome c oxidoreductase may aid in the production of ATP in the electron transport chain. [3]

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(d) Actimycin A is known to inhibit the coenzyme cytochrome c oxidoreductase. Predict the effect actimycin A would have on the aerobic respiratory process. [2]

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[Total: 10 marks]

Question 6

The following Figure 6.1 shows the synaptic knob of a synapse found in the sympathetic ganglion of frogs. Such synapses are unique as they contain receptors to the neurotransmitter noradrenaline (NE) on the pre-synaptic membrane itself. These are known as autoreceptors.

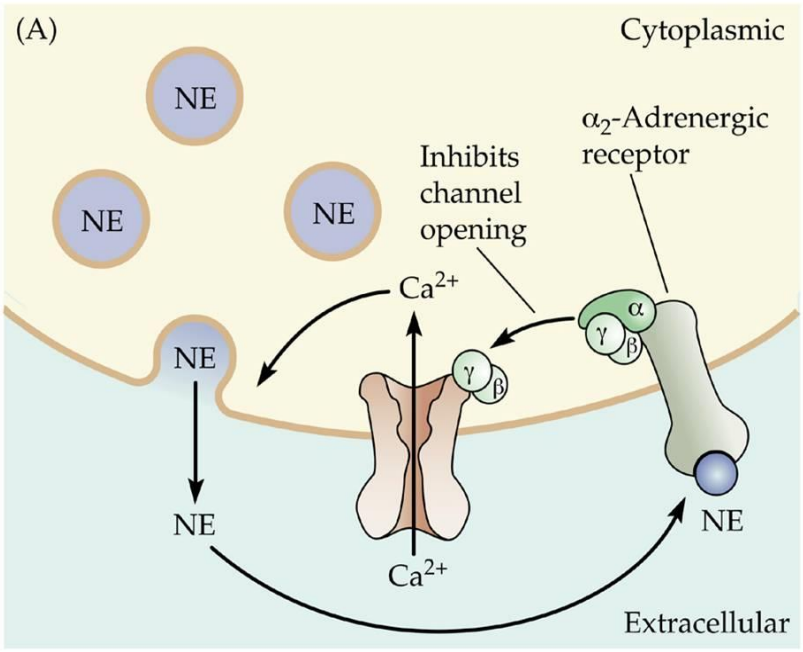

Figure 6.1

(a) State the name given to synapses that use noradrenaline as the neurotransmitter. [1]

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(b) Using the information given in Figure 6.1, explain how the release of noradrenaline at the pre-synaptic membrane may eventually inhibit the synapse itself. [3]

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(c) Suggest the significance of this self-inhibitory effect. [1]

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(d) Describe two functions of synapses. [2]

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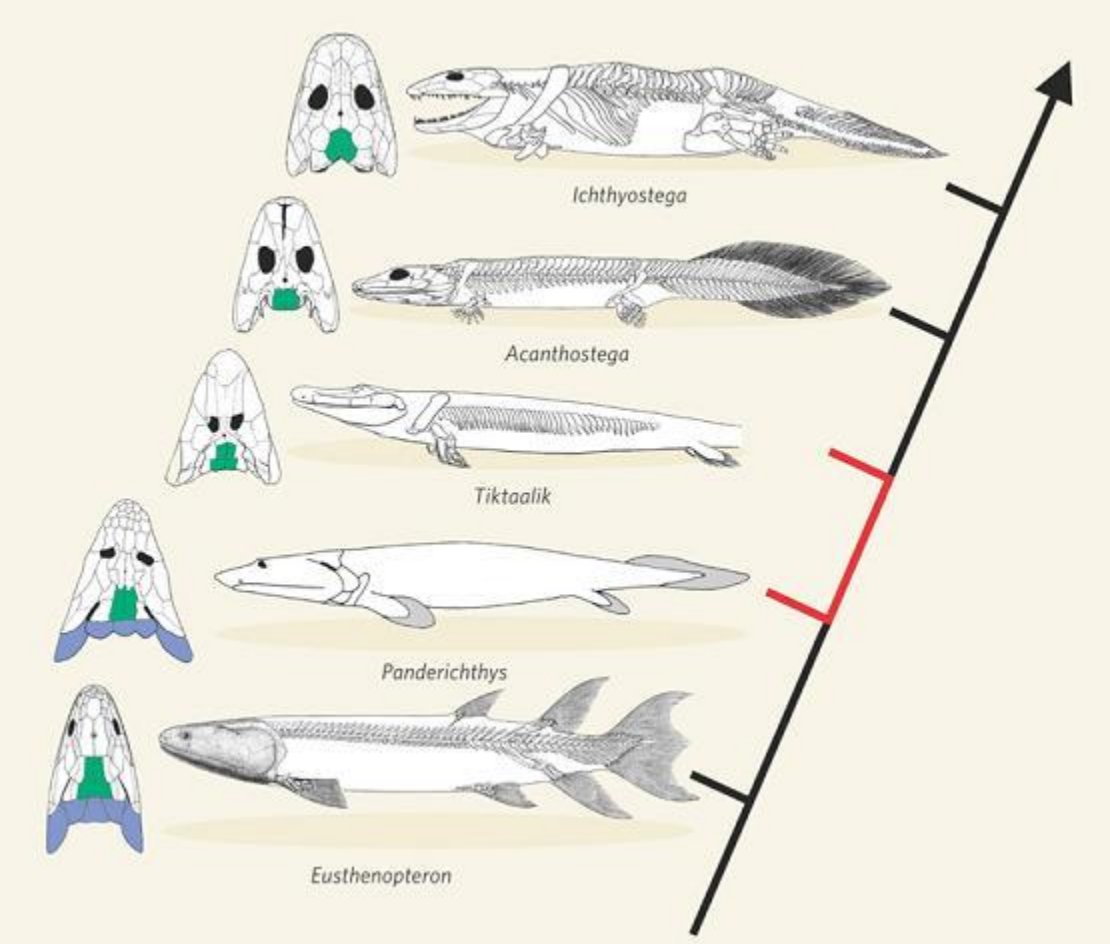
[Total: 7 marks]

Question 7

Figure 7.1 shows a series of fossils. This series depicts how land-based amphibians could have evolved from fishes. Tiktaalik hails from the Late Devonian period, about 360 million years ago, and is both chronologically and morphologically intermediate between two other major fossils in this series, the more fish-like *Panderichthys* and the more tetrapod-like *Acanthostega*.



(a) State the name given to fossils such as *Tiktaalik* that have characteristics from two seemingly diverse groups of organisms. [1]

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(b) Explain how such fossil records can actually support Darwin's theory of evolution. [4]

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In most respects *Tiktaalik's* body is fish-like: it has fins and gill arches, just like a fish. However, its skull and especially its limbs mark it as a tetrapod ancestor. Species such as *Panderichthys* had true fins, similar to those of modern ray-finned fishes, consisting of an array of long, thin, spindly bones unsuitable for bearing weight. On the other side of the gap is *Acanthostega*, with true limbs – each containing a radius and an ulna, just like our arms, and outfitted with eight true toes.

(c) State the name given to similar structures such as the limbs of *Acanthostega* and *Tiktaalik*. [1]

……

(d) It was believed that the environment *Tiktaalik* evolved in was filled with swampy, silty lagoons. These dirty, unclear water masses also tended to have algae covering its surface. Using this information, describe how the amphibian-like *Acanthostega* could have evolved from the species *Tiktaalik*. [4]

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Stimulus information adapted from: http://www.patheos.com/blogs/daylightatheism/2006/04/hello-beautiful/ & https://sciencenotes.wordpress.com/tag/

[Total: 10 marks]

Section B

Answer **one** question

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labeled diagrams, where appropriate.
Your answers must be in continuous prose where appropriate.
Your answers must be set out in sections (a), (b), etc as indicated in the question.

Question 8

(a) Explain the eukaryotic processing of pre-mRNA. [6]

(b) Compare and contrast between prokaryotic and eukaryotic control of gene expression at the translational and post-translation level. [9]

(c) Describe the significance of gene amplification. [5]

Question 9

(a) With reference to the three different stages of cell signaling, describe in detail the sequence of events when a glucagon molecule reaches the liver cell. [10]

(b) Discuss roles played by proteins in maintaining the potential differences across membranes and in the transmission of nerve impulses along an axon. [7]

(c) Explain how loss of myelination, which happens in the demyelinating disease multiple sclerosis, disrupts signal transmission in the nervous system. [3]

CANDIDATE NAME (CG) _____ *INDEX NUMBER* _____

JC2 Preliminary Examination 2016

BIOLOGY
Higher 2

Paper 3

19th SEP 2016/ Monday
2 hours

MARK SCHEME

READ THESE INSTRUCTIONS FIRST

Write your name and index number in the spaces at the top of this page and on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in all the sections.

.

At the end of examination,
1. fasten all your work securely together

FOR EXAMINER'S USE	
1	/14
2	/14
3	/12
	/40
4	/12
5	/20
TOTAL	/72

INFORMATION FOR CANDIDATES
The intended number of marks is given in brackets [ ] at the end of each question or part question.

This question paper consists of 17 printed pages and 1 blank page

Answer **all** questions

Question 1

The first ever gene therapy trial was initiated in 1990 by Dr William French Anderson to treat a four year old girl named Ashanthi. Ashanthi was suffering from severe combined immunodeficiency (SCID), a genetic disorder characterised by the absence of functional T-lyymphocytes.

In Ashanthi's case, the disease was caused by the absence of the enzyme adenosine deaminase (ADA-SCID). An alternative form of SCID is known as X-linked SCID.

(a) From your knowledge, contrast between the two forms of SCID mentioned in the paragraph above. [3]

	X-linked SCID	**ADA-SCID**	
Gene involved	• Gene coding for **interleukin 2 receptor gamma**	• Gene coding for **adenosine deaminase**	1m
Chromosome on which the gene is found	• **X chromosome**	• **Chromosome 20**	1m
Effect of mutation leading to SCID	• Results in production of **defective interleukin receptor**	• Mutation results in non-functional enzyme that is **defective in purine metabolism / cannot break down purines**	1m
	• Leading to **defective signalling pathway** which **prevents proper development** of T-lymphocytes	• Leading to the **accumulation of deoxyadenosine** which is **toxic** to immature lymphoid cell	1m

[max 3]

There were several *ex vivo* methods of gene therapy that were considered in Ashanthi's treatment, detailed in Table 1.1. The virus vector used was a modified retrovirus.

Method	Description
A	• Normal ADA allele is introduced into viral vector • Recombinant virus is introduced into T-cells obtained from patient • Genetically modified cells are reintroduced into patient
B	• Normal ADA allele is introduced into viral vector • Recombinant virus is introduced into the cells derived from inner cell mass of blastocyst • Genetically modified cells are reintroduced into patient.
C	• Normal ADA allele is introduced into viral vector • Recombinant virus introduced into hematopoietic stem cells obtained from patient • Genetically modified cells are reintroduced into patient

Table 1.1

(b) With reference to the information presented in Table 1.1,

(i) Suggest one reason why *ex vivo* approach was utilised for gene therapy. [1]

- Allows specific **identification of target cells** with therapeutic gene (OWTTE).
- Allows **monitoring of gene expression before reintroduction** as success rate is very low.
- Safer because can **monitor for cancer cells** caused by the **random integration of DNA / insertional mutagenesis by retrovirus** which can knock out tumour suppressor genes or activate proto-oncogenes.

[any 1]

(ii) State the most preferred method of ex vivo gene therapy for ADA-SCID and justify the preference over the other 2 methods. [3]

- Method C.
- **Hematopoietic stem cells** are capable of **long term self renewal**, making the treatment **more permanent** as compared to using **differentiated T-cells** in **method A**.
- **Hematopoietic stem cells** are derived from the patient **will not trigger any immune response** when returned to patient, as compared to using **embryonic stem cells** from another source in **method B**.

(c) Explain why the retrovirus was an efficient vector in the gene therapy of Ashanthi's condition. [2]

- It contains surface **glycoproteins** which are **specific** to the cell-surface receptors on T-**lymphocytes**, thus **increasing the efficiency** of gene delivery to the **specific target cell**.
- It contains the enzyme **integrase**, allowing the **integration** of the **normal ADA allele** into the **genome** of the target cell.

Apart from diseases that plague human health, the effect of plant diseases on agriculture have also been in the spotlight. One such disease is the ringspot virus that plagues the papaya agricultural industry. Scientists have developed effective circumventive methods to tackle the problem of the ringspot virus through genetically modifying papaya. To do this, viral genes encoding capsid proteins were transferred to the papaya genome. These viral capsid proteins elicit something similar to an "immune response" from the papaya plant. Thus, the genetically modified papaya plants were resistant to infection by the papaya ringspot virus.

Figure 1.2 below depicts the comparative infection of transgenic and non-transgenic papaya in the 1995 field trail in Kapoho, Hawaii.

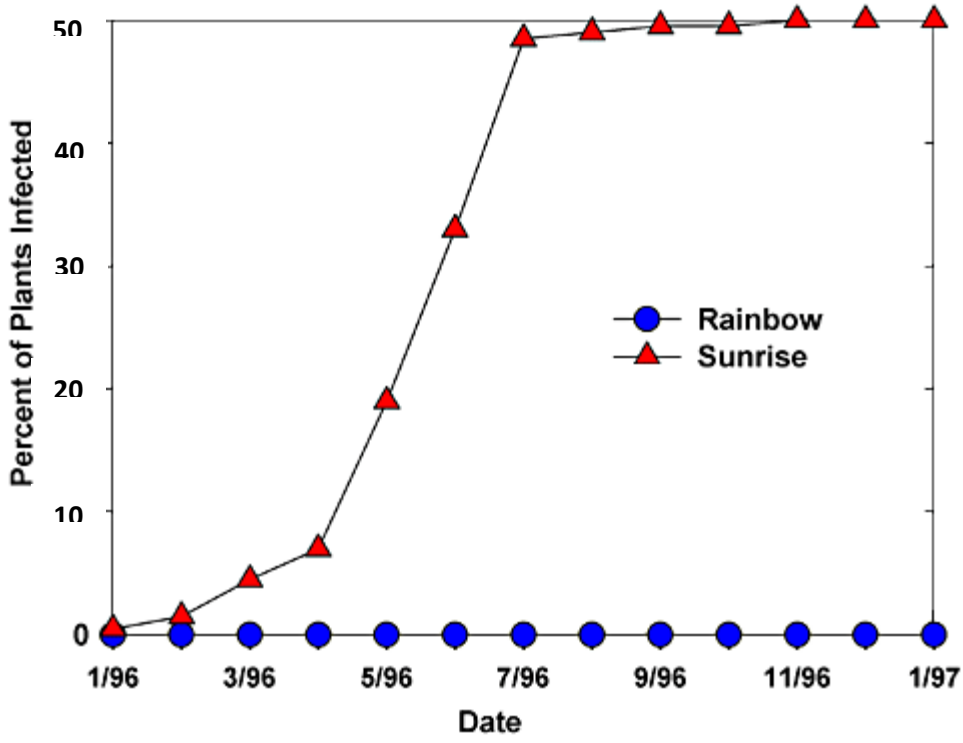


Figure 1.2

(d) With reference to Figure 1.2,

(i) Determine the identities of the transgenic and non-transgenic papaya species. [1]

- Transgenic species: Rainbow + Non-transgenic species: Sunrise.

(ii) Evaluate and justify thoroughly the efficacy of the genetic intervention. [2]

- Highly effective
- Quote values:

The percentage of infected Sunrise papaya species increased to from **0% to 16% by April'96**, followed by a sharp increase from **16% to 98% by July'96** and **reached 100% by Nov'96**, as compared to the percentage of infected Rainbow species which **remained at 0%** throughout the year.

It was observed that three years later, the percentage of infected transgenic papaya species increased.

(e) Suggest and explain a possible reason for this phenomenon. [2]

- **Mutation** in the ringspot virus **genome** had occurred,
- Enables ringspot virus to **make new surface glycoproteins** that GM papaya is no longer resistant to as **immune response is no longer triggered** by infection with the ringspot virus.
- AVP+ explanation

[Total: 14 marks]

Question 2

The location of the gene locus responsible for disease X was not discovered until 1985. Scientists used restriction fragment length polymorphism to discover the genetic markers associated with the disease. One such marker was a 950bp-long region known as XD15 that had been sequenced prior to 1985.

Samples of DNA were obtained from a family known to have the condition. The XD15 locus was amplified by polymerase chain reaction and mixed with *Pst*I and *Eco*RI in two separate restriction digests. The results of gel electrophoresis followed by southern blot of both restriction digests are shown in Fig. 2.1.

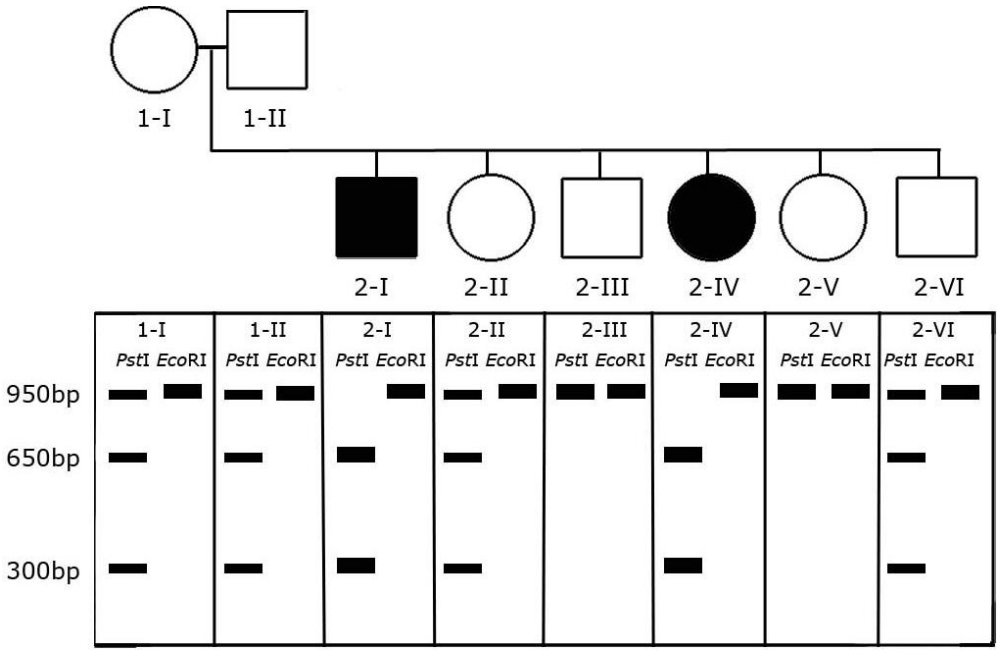


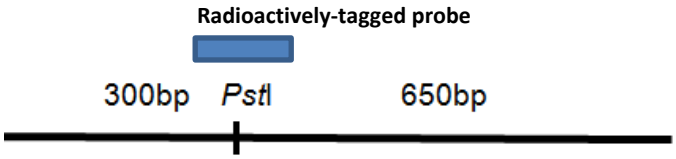
Fig. 2.1

(a) Using the information in Fig. 2.1,

(i) state and explain which restriction enzyme digest should be used to detect the XD15 genetic marker associated with disease X.[3]

- ***Pst*I**
- Digestion with *Pst*I produced **two bands** of **300bp and 650bp** in **affected individuals** but **unaffected individuals** showed either a **single band of 950bp** or **three bands of 950bp, 650bp and 300bp**.
- But after digestion with *Eco*RI, **all individuals** had **single 950bp fragments** and the affected and unaffected individuals are not differentiated.

(ii) draw a restriction map of the XD15 genetic marker that is associated with disease X. Indicate on the restriction map the position of the radioactively-tagged probe that would enable visualization of the RFLP fragments. [2]



- [Size of fragment + labelling of restriction site] -1m
- [Position of probe + label of probe] -1m

(b) Explain why genetic markers like XD15 can be used to detect the presence of disease-causing alleles. [2]

- These genetic markers are easily **identifiable** because they are **highly polymorphic**
- They are **closely/ tightly linked** to the disease-causing alleles on the same chromosome, thus **unlikely that crossing over will occur** /are likely to be **inherited together** as one unit with the disease-causing allele

The XD15 locus was amplified by polymerase chain reaction prior to gel electrophoresis and southern blot. The DNA sequence of the XD15 locus is shown in Fig. 2.2.

5' - GGATCCATCCCGATCGAAAGCTAGCTAGGATCC - 3'
3' - CCTAGGTAGGGCTAGCTTTCGATCGATCCTAGG - 5'

Fig. 2.2

(c) Design two 7-base long primers for the sequence to be amplified. [2]

Primer 1: 5' – GGATCCA – 3'
Primer 2: 3' – TCCTAGG – 5'

- 5' and 3' indicated correctly on both primers- 1m
- Correct sequence of both primers – 1m
- 1m awarded if one of the primer has correct sequence and direction indicated.

(d) Contrast between the process of PCR and DNA replication that occurs naturally in cells. [3]

Basis of comparison)	**Differences**

1. Nature of primers	DNA replication involves RNA primers while PCR requires DNA primers.
2. Location	DNA replication takes place in the nucleus of the cell while PCR is automated/takes place in a thermocycler.
3. Enzymes involved	DNA replication involves DNA polymerase while PCR involves the enzyme *Taq* polymerase.
4. Proof-reading	In DNA replication, the daughter strands are proofread by DNA polymerase I but there is no proofreading of daughter strands in PCR by *Taq* polymerase.
5. Unzipping of template DNA	In PCR, high temperatures are required for denaturing the strands while in DNA replications, the enzyme helicase unwinds the strands.
6. Synthesis of primers	In DNA replication, primase synthesises the RNA primers, but in PCR, the primers are added in/primase is not involved.

[max 3]

(e) Besides disease detection, RFLP analysis may be used for DNA fingerprinting as well. Explain one difference in the approach employed during RFLP analysis for both processes (disease detection and DNA fingerprinting). [2]

	Disease detection	**DNA fingerprinting**
Number of DNA probes used	One probe;	Multiple probes;
➔Reason	Only one loci is analysed in disease detection;	multiple loci are analysed in the creation of a DNA fingerprint;
Location where restriction enzymes cut	Restriction enzymes cut **within** the gene locus	Restriction enzymes cut **outside** the Variable number of tandem repeat (VNTR) loci
➔ Reason	Changes in base sequence changes restriction sites that result in different sized restriction fragments being released when cut with the restriction enzyme.	The DNA polymorphism for this loci arises due to different number of tandem repeats of a particular sequence. Cutting outside the VNTR loci releases fragments of different lengths for each allele. Gel electrophoresis can then separate the different alleles by size.

[max 2: state difference 1m + explanation 1m]

[Total: 14 marks]

Question 3

(a) Plant growth regulators (PGR) such as auxin, cytokinin and ethylene are naturally produced in plants and are important in determination of the developmental pathway of plant cells.

Synthetic analogues that can be mass produced are frequently used in plant tissue culture instead of the natural PGR.

Table 3.1 summarizes the general characteristics and roles of some natural and synthetic PGR.

Type of PGR	Examples	Role
Auxins	IAA(natural) - unstable to heat & light	Promote cell division and cell growth Root initiation (when auxin:cytokinin is high)
	2,4-D(synthetic) – stable to heat & light	
Cytokinins	2iP(natural) – unstable to heat & light	Promotes cell division Shoot formation (when auxin:cytokinin is low)
	Kinetin(synthetic) - stable to heat & light	
Abscisic acid (ABA)	-	Inhibits cell division Maturation of somatic embryos Abscission (i.e. shedding) of plant leaves Seed dormancy Induces stomatal closure to reduce water loss by transpiration
Ethylene	-	Abscission (i.e. shedding) of leaves and flowers Seed and bud dormancy by growth inhibition Fruit ripening

Table 3.1

Prunus lannesiana is an early-flowering cherry (only in spring) in Japan Izu peninsula. It is commonly known as Sakura or Japanese Cherry. Researchers are keen to propagate *P. lannesiana* from sterilized explants by micropropagation due to the advantages that the technique offers. Hence, a study was made to analyse the concentration of PGR present in the *P. lannesiana* in the four seasons and the results were summarized in Table 3.2.

Conc. of PGR / arbitrary unit \ Season	Spring (Mar-May)	Summer (June – Aug)	Autumn (Sep-Nov)	Winter (Dec – Feb)
IAA (auxin)	15	20	25	30
2iP (cytokinin)	10	15	10	5
ABA	5	5	12	15
Ethylene	12 – 20	18	16	14

Table 3.2

Table 3.3 illustrates the physiological development of *P. lannesiana* in the various seasons.

Season	Spring	Summer	Autumn	Winter
Shoot development	Very Active	Active	Minimal	Nil
Root development	Minimal	Moderate	Active	Very Active
Leaves development	Very Active	Active	Senescence (leaves turning autumn yellow) and abscission	Nil
Flowers development	Short full bloom in early spring, followed by senescence	Nil	Nil	Buds develop but dormant in late winter
Fruit and seed development	Fruit and seed development in late spring	Seed maturation	Seed dormant	Seed dormant

Table 3.3

(i) State one economical limitation of micropropagation. [1]

1. Micropropagation **requires sophisticated facilities, sterile laboratory conditions and special nutrient media – high cost to maintain**
2. It also **requires trained personnel** with specialised skills / **technical expertise – high cost to train**;
3. AVP

(ii) Suggest why synthetic PGR (e.g. 2,4-D and Kinetin) are used instead of natural PGR (e.g. IAA and 2iP) in plant tissue culture. [1]

1. **Lower Cost due to mass production**;
2. **More stable to heat** and **light**;

(iii) Using the information provided in Table 3.2 and Table 3.3, explain the effect of the change in the auxin:cytokinin ratio from Spring to Winter and vice versa. [4]

1. When season change from Spring to Winter, the **auxin:cytokinin ratio generally increased from 3:2 in spring to 6:1 in winter / by four fold**;
2. which **promotes root growth in winter** to **improve absorption of nutrients and water** to sustain the survival of plant;
3. When season change from Winter to Spring, the **auxin:cytokinin ratio decreased from 6:1 in winter to 3:2 in spring / by four fold**;
4. which **promotes shoot development in spring**, allowing for **full bloom of *Prunus lannesiana* in spring for pollination / for photosynthesis for maximal growth / for regeneration of leaves for photosynthesis**;

(b) The Salmon Genome Project (SGP) is developed to increase knowledge of the biology of Atlantic salmon and aid agricultural breeding of the fish.

(i) Describe how the SGP serves to increase knowledge of the biology of Atlantic salmon. [2]

1. To **generate the genomic map** of the Atlantic Salmon;

2. To identify, locate and analyse genes and their regulatory sequences;
3. To study patterns of inheritance of these genes;
4. To establish possible evolutionary relationships with other organisms;

In order to produce transgenic salmon expressing salmon growth hormone, sGH, the coding sequence of sGH gene is isolated from a library and cloned, using *Sac* I, into the plasmid expression vector, pBluescript II SK. The plasmid map is shown in **Fig. 3.1**.

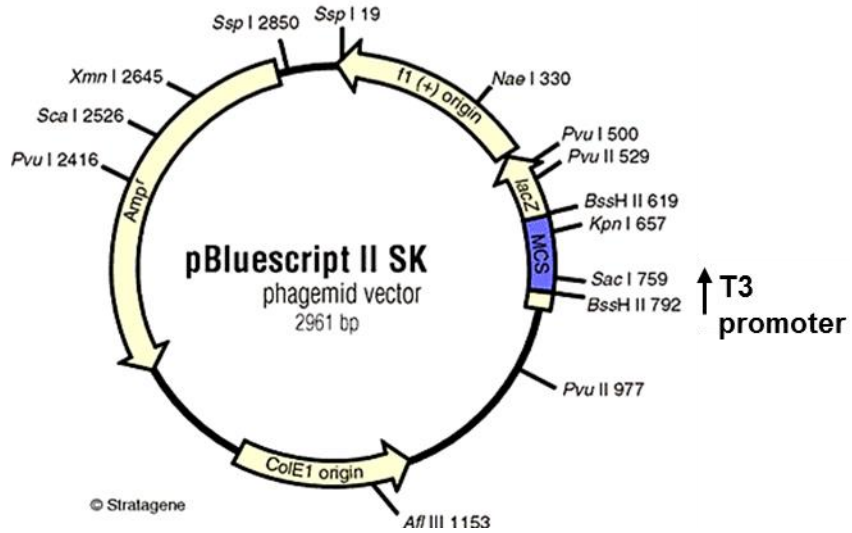


Figure 3.1

(ii) With reference to figure 3.1, describe the features of the multiple cloning site (MCS). [2]

1. Consists of a **variety** of **restriction enzyme sites** / **recognition sites** for **different** restriction enzymes such as *BssH* II, *Sac* I and *Kpn* I;
2. **Found within** the selection marker ***lacZ* gene**;
3. There is only **one / unique recognition site** for **each restriction enzyme** for the insertion of the gene of interest (GOI) into the vector;

Subsequent to insertion of sGH gene into pBlueScript II SK, transformation into *E. coli* cells was carried out and some colonies were obtained. The plasmid DNA was extracted, digested with *Sac* I and the restriction fragments were separated in gel electrophoresis.

(iii) It was found that the recombinant plasmid with sGH gene inserted yielded no polypeptide. With reference to Fig. 3.1, state and explain a reason for this. [2]

Either:
1. Since ***Sac* I restriction site is within / near T3 promoter**, sGH gene inserted may **disrupt the promoter sequence**;
2. This results in **no expression** / transcription & translation of gene & thus **no polypeptide** is produced;

OR:
3. sGH inserted in the **wrong orientation,** hence **sequence of gene is reversed**;

4. So even though a protein is expressed under the control of T3 promoter, the amino acid sequence and hence the **3D conformation of polypeptide** is **different** from original;

[Total: 12 marks]

Question 4

Cefazolin is an antibiotic that disrupts the synthesis of bacterial peptidoglycan cell by preventing the formation of peptide bonds. It is bactericidal (kills bacteria) and is effective against gram-positive bacteria.

Streptococcus pneumoniae is a bacterium responsible for conditions like pneumonia and bacterial meningitis. It is a gram-positive bacterium which establishes itself as small white colonies. Discs containing cefazolin can be placed on an agar plate containing *Streptococcus pneumoniae*. If the cefazolin has been effective against *Streptococcus pneumonia,* a clear zone will be seen around the disc as shown in **Figure 4.1**.

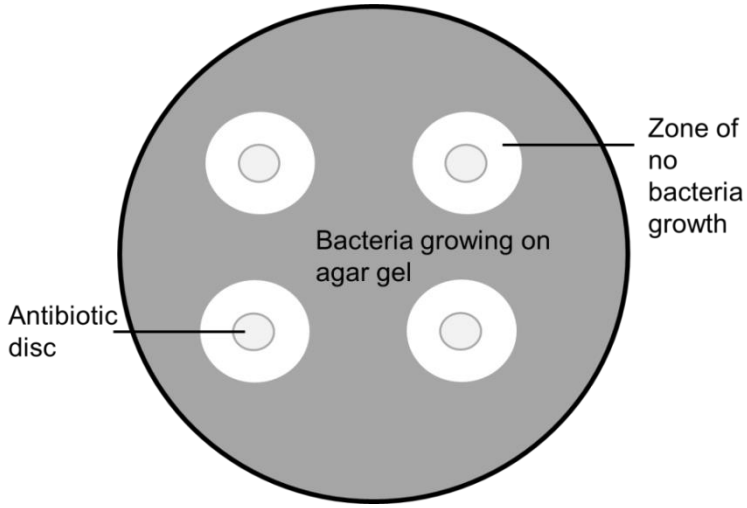


Figure 4.1

You are to plan but not carry out an experiment to investigate the effectiveness of different concentrations of cefazolin on the growth of *Streptococcus pneumoniae*.

Your plan must be based on the assumption that you have been provided with the following equipment and materials:

- Bunsen burner, to enable good aseptic conditions
- Bacterial culture in nutrient broth
- Molten nutrient agar
- Distilled water
- Sterile 90mm Petri dishes
- Sterile loops (to plate bacteria onto nutrient agar)
- $1cm^3$ pipette
- Filter paper discs
- Forceps
- Vernier calipers
- 1% cefazolin solution
- Bactericidal disinfectant for containment of used forceps and pipettes, also to clean work surfaces

- Your plan should include:
- a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- an explanation of theory to support your practical procedure
- an explanation of the dependent and independent variables involved
- relevant, clearly labeled diagrams, if necessary
- proposed layout of results tables and graphs with clear headings and labels
- correct use of scientific and technical terms
- safety measures to minimise any risks associated with the proposed experiment

Total: [12 marks]

Question 4: Planning Answer

<table>
<tr>
<td>Theory</td>
<td>

Cefazolin is an antibiotic that interferes with the synthesis of peptidoglycan in bacterial cell wall by disrupting peptide bond formation.
This greatly weakens the cell wall and causes the bacterium to lyse or burst open, because of osmotic pressure. As a result, this directly kills the bacteria.
cefazolin is placed in the form of antibiotic discs on the agar gel plated with Streptococcus pneumoniae. The size of the clear zone formed after incubation is a measure of the effectiveness of the cefazolin. Increasing concentration of cafazolin will increase the diameter of the clear zone.

</td>
<td>✓ description of scientific reasoning and theory of the method used to measure effectiveness of cefazolin</td>
</tr>
<tr>
<td>Variables</td>
<td>Independent variables: 5 concentrations of cefazolin solution (0.2, 0.4, 0.6, 0.8, 1.0 %) prepared by simple dilution.

Dependent variables: Diameter of clear zone / mm

Controlled variables (any 2):

Concentration and volume of bacterial culture
Concentration and volume of agar used
Size of filter paper disc
Weight of filter paper

</td>
<td>✓ independent, dependent variables and controlled variables</td>
</tr>
<tr>
<td>Procedure</td>
<td>
1. Add 10cm^3 of molten nutrient agar to the petri dish using aseptic technique and leave to set.
2. Prepare cefazolin solutions of 5 different concentrations using simple dilution according to the table below. Label the beakers accordingly.
<table>
<tr><th>Concentration of cefazolin solution / %</th><th>Volume of 1% cefazolin stock solution / cm^3</th><th>Volume of distilled water / cm^3</th><th>Total volume / cm^3</th></tr>
<tr><td>1.0</td><td>10</td><td>0</td><td>10</td></tr>
<tr><td>0.8</td><td>8.0</td><td>2.0</td><td>10</td></tr>
<tr><td>0.6</td><td>6.0</td><td>4.0</td><td>10</td></tr>
<tr><td>0.4</td><td>4.0</td><td>6.0</td><td>10</td></tr>
<tr><td>0.2</td><td>2.0</td><td>8.0</td><td>10</td></tr>
</table>
3. Draw lines on the base of the petri dish so that the base is divided into 6 equal parts. Label the sections 1 to 6.
4. When the gel is cast on the petri dish, use a sterile loop to plate the nutrient broth containing Streptococcus pneumoniae onto the agar gel.
5. Prepare a control disc by soaking a sterile disc in distilled water.
</td>
<td>✓ dilution method

✓ control

✓ method-</td>
</tr>
</table>

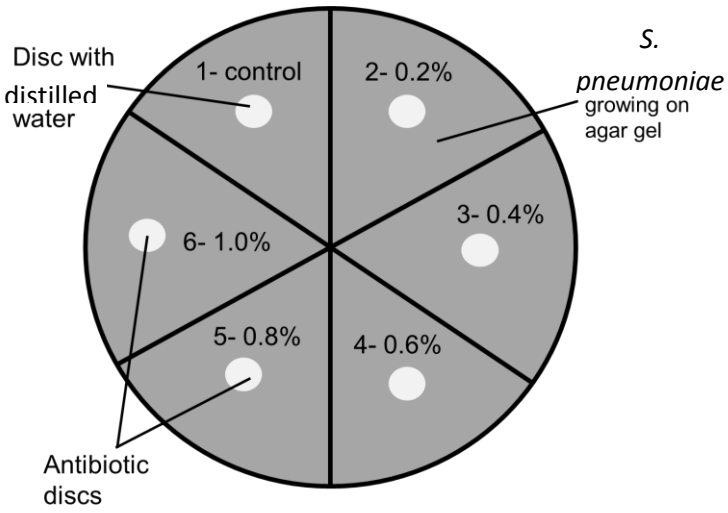
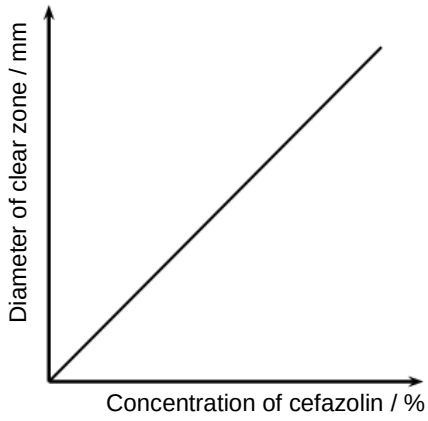
	6. Using the Bunsen burner, flame and cool forceps to sterilize them. 7. Use sterile forceps to place the control disc in the centre of section 1 8. Prepare the 5 cefazolin discs containing 5 different cefazolin concentrations by soaking each of the discs into the 5 different concentrations of cefazolin solutions prepared from simple dilution. 9. Using flamed and cooled forceps place the disc containing the 5 concentrations into the other 5 labeled sections. 10. The setup of the petri dish in the experiment is as shown below:  11. Conduct 3 replicates from steps 1-8 and 2 repeats for all prepared concentration of cefazolin. 12. Seal the petri dish and incubate the petri dish at 30°C for 2 days. 13. Without opening the lid measure the diameter of the clear zone around each disc using vernier calipers. 14. Tabulate the results to show the effect of different cefazolin concentrations on *Streptococcus pneumoniae* growth.	setup ✓ relevant diagram ✓ 3 replicates, 2 repeats ✓ fixed incubation time

	Table showing the effect of different concentration of cefazolin/% on the diameter of clear zone /mm Conc. of cefazolin | Diameter of clear zone /mm: Reading 1, Reading 2, Reading 3, Average 1.0 0.8 0.6 0.4 0.2 0.0 (Control) Average = reading 1 + reading 2 + reading 3 / 3 15. Plot a graph of diameter of clear zone /mm produced against the concentration of cefazolin /%. Graph of diameter of clear zone /mm produced against the concentration of cefazolin /%.  The increase in the diameter of the clear zones should be directly proportional to the concentration of cefazolin.	✓ method to calculate growth of bacteria ✓ appropriate table and graph ✓ expected relationship between [penicillin] and diameter of clear zone
Risk and precaution	To prevent infection or growth of harmful microorganisms: • Cover all cut or broken skin with a waterproof dressing • Wear tightly fitting disposable gloves and clean laboratory coat • Clean the bench surface with bactericidal disinfectant and use a bunsen burner which creates a sterile environment. Students should work as close as possible to the flame. • Swap any spillages with bactericidal disinfectant. • Proper disposal / treatment of contaminated materials or equipment using sterilizer/autoclave	✓ Safety (Any 1)

Question 5

Free-response question

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labeled diagrams, where appropriate.
Your answers must be in continuous prose where appropriate.
Your answers must be set out in sections (a), (b), etc as indicated in the question.

(a) Discuss the advantages and evolutionary consequences of using plant tissue culture to propagate transgenic plants. [8]

(b) Outline the ethical and social implications of genetically modified organisms. [6]

(c) Explain why gene therapy is opined to have limited success in the treatment of genetic diseases. [6]

Question 5

(a) Discuss the advantages and evolutionary consequences of using plant tissue culture to propagate transgenic plants. [8]

Advantages [MAX = 5]:

1. **All** transgenic plants **contain the desired gene** - Using plant tissue culture of a genetically engineered plant cell will give rise to **whole transgenic plants** that are **genetically identical**

2. **Rapid production** - allows **large numbers** of transgenic plants to be grown from just one or a **few stock plants** can be achieved; through asexual means;

3. Plant diseases can be avoided - Production of bacteria or virus-free plants; since only **meristematic tissue** of the transgenic plant is used for propagation OR plant cloning method uses **dilute sodium hypochlorite** for surface sterilization, ensuring bacteria or virus-free plants

4. Transgenic plants can be produced at **any time of the year**/ not subject to seasonal change; thus plants can be produced out of season and people can buy plants at lower prices than usual;

5. **Reliability**; and **quality control** can be achieved - since growing conditions are standardized and optimized

6. Land area needed to grow these transgenic plants through tissue culture is much less; **save space**;

7. Prevents "loss" of transgene due to sexual reproduction / through gamete formation; maintenance of transgene within entire crop;

Evolutionary Consequences [MAX = 3]:

7. Desirable / beneficial genes are quickly passed on to subsequent generations / ensures integrity and **maintenance of genetic composition** as the transgenic plants can propagate rapidly under favourable environment;

8. **Lack of genetic variation** poses a **problem to the survival** of a species / unable to respond to unfavourable changes in selection pressure as a result of changing environment;

9. **Low evolutionary potential** thus no speciation / natural selection cannot occur without variation;

10. Thus there is a **high risk of extinction** of that species as all individuals are genetically

identical, thus equally susceptible to pathogens / succumb to outbreak of epidemics / disease;

11. When transgenic plants are reintroduced into the wild, might cross- pollinate and these might cause production of pesticide/herbicide resistance / generating "**superweeds**" that will disrupt the ecological balance / ecosystem.

Note: Ans must make reference to transgenic plants, not a generic propagation of plants by plant cloning,

(b) Outline the ethical and social implications of genetically modified organisms. [6]

Definition of GMO – 1m

Organism that has acquired one or more genes by **recombinant DNA technology**. The genes may or may not be from the same species.

Ethical concerns (Max 3):

1. Exploitation of animals for food (+ any 1 elaborated point)
   A. **Increased use of growth hormone has harmful effect**s on the health of animals. Eg the use of bovine somatotrophin in dairy cattle increases the risk of mastitis
   B. Concern whether the animals are **biologically capable of withstanding additional stress** of increased production of milk, meat and other products

2. Exploitation of animals for medical research (+ elaboration)
   A. Medical experiments may **cause suffering** in animals and there are **concerns of violations of animals' rights**. (eg. Oncomouse)

3. Religious concerns or dietary restrictions (+ any 1 elaborated point)
   A. Eg. Religious groups are concerned that GM foods might contain genes from animals prohibited by their religion
   B. Eg. Objections to consumption of plants that have been modified to carry animal genes or vice versa by vegetarians.

4. There is concern about the **rights of patenting** a genetically modified animal or plant. (+ elaboration)
   A. Companies have sought to patent the transgenic animals or plants that they have developed, however, people argue that patenting animals is unethical as it **reduces them to the level of objects**.

5. **Labelling of products** on sale to indicate that genetic engineering was involved in their production is **not mandatory** in some countries (+elaboration)
   A. this deprives consumers from making an informed choice based on their religious, medical (allergies), personal (vegetarians) backgrounds.

Social Concerns (max 3)

1. Release (accidental or otherwise) of GM animals into the wild may result in GM animals

outcompeting wild types such that **ecological balance is disrupted**/severe impacts on the food-chain.

2. Introduction of foreign gene(s) may result in production of secondary metabolites that may be **toxic** to animals themselves and/or livestock/humans that consume them.

3. New proteins in GM animals may be potentially **allergenic** to humans that consume them.

4. **Antibiotic resistance genes** may be transferred to bacteria in the gut, increasing the resistance of such bacteria to medicinal antibiotics.

5. E.g., larger transgenic salmon may be preferably selected as mates over smaller wild types, thus **destabilises ecosystem** and hence **threatens biodiversity**;

(c) Explain why gene therapy is opined to have limited success in the treatment of genetic diseases. [6]

1. Short-lived nature
   - Many vectors **do not** allow for the **integration of the normal allele into the target cell genome / the rapidly dividing nature of many cells** (i.e. new cells need to be targeted) prevents the effects of gene therapy from being long-lived and stable**.**
   - As a result, patients have to undergo **multiple rounds of gene therapy**.

2. Immune response
   - The **vector** that is introduced into the tissue might be recognised by the immune system as a **foreign** particle (e.g. due to previous infection) and elicit an **immune response**.
   - As a result, the effectiveness of the therapy is reduced as the vectors are **destroyed**.

3. Viral vector may regain virulence
   - Even though the in the viral vector is modified to be safe/disease-causing viral gene is removed, the viral vector may **regain** or **develop virulence.**
   - This causes **harm** in the patient body.

4. Insertional mutagenesis
   - For some viral vectors (e.g. retrovirus), the **integration of normal allele into host genome** is **random** and may **disrupt host's gene** or regulatory gene sequences/control elements.
   - Disruption of tumour suppressor gene/ conversion of proto-oncogene to oncogene **(one named e.g.)** may cause **cancer**.

5. Multi-gene disorders/disease
   - Many common **diseases** (**one named e.g.** heart disease/high blood pressure/ Alzheimer's disease/diabetes), are caused by the combined effects of **multiple genes**.
   - Gene therapy is not effective as it is **impossible to introduce many normal alleles** into target cells at the same time.

6. Large genes

- There may be a **problem finding a suitable vector** if the **normal allele** that needs to be delivered into the target cells is **large** (e.g. viral vectors can only accept genetic material of a certain size).

7. Non-dividing target cells
   - Some viral vectors may **not be able to infect non-dividing cells** (eg. retrovirus). Hence gene therapy may not be suitable for diseases involving some cell types.
     OR
     If the modified target cell (with the normal functional allele) does not divide and multiply, the introduced gene is lost when the cell dies.

8. Diseases caused by presence of a dominant allele
   - Gene therapy is ineffective when the **mutated defective allele** is **dominant** and the **normal allele is recessive.**
   - The expression of the normal allele will still be **masked** by the dominant defective allele even after being introduced into the target cell genome

9. Problem with controlling the activity of gene expression
   - Modified cells **may not synthesize sufficient** functional **proteins** to bring about an improvement.
   - Due to (**any valid reason**): e.g. not all cells taking up the normal allele / cells not expressing the proteins at the right time (eg. in thalassemia disease) / normal allele not expressed because they are integrated into a heterochromatic region of the host cell genome.

10. AVP

[1 mark for each well-elaborated point]

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