

The Cell

Question Paper

Level	Pre U
Subject	Biology
Exam Board	Cambridge International Examinations
Topic	The Cell
Booklet	Question Paper

Time Allowed: 51 minutes

Score: /42

Percentage: /100

- 1 The resolving power of a microscope depends on the wavelength used by the system. Table 1.1 shows the wavelengths and resolving powers of three types of microscope.

Table 1.1

type of microscope	wavelength / μm	resolving power / μm
light microscope	0.8	0.4
ultra-violet microscope	0.2	0.1
electron microscope	0.005	0.0025

Table 1.2 gives details of three biological structures that are investigated using microscopes. The ticks (\checkmark) and crosses (\times) indicate whether or not each structure can be clearly seen with each microscope.

Table 1.2

	<i>Escherichia coli</i> bacterium, length 2 μm	ribosome, diameter 25 nm	plasma membrane, thickness 10 nm
light microscope	\checkmark	\times	\times
ultra-violet microscope			
electron microscope	\checkmark	\checkmark	\checkmark

Which row correctly completes Table 1.2 to show which structures can be clearly seen with an **ultra-violet** microscope?

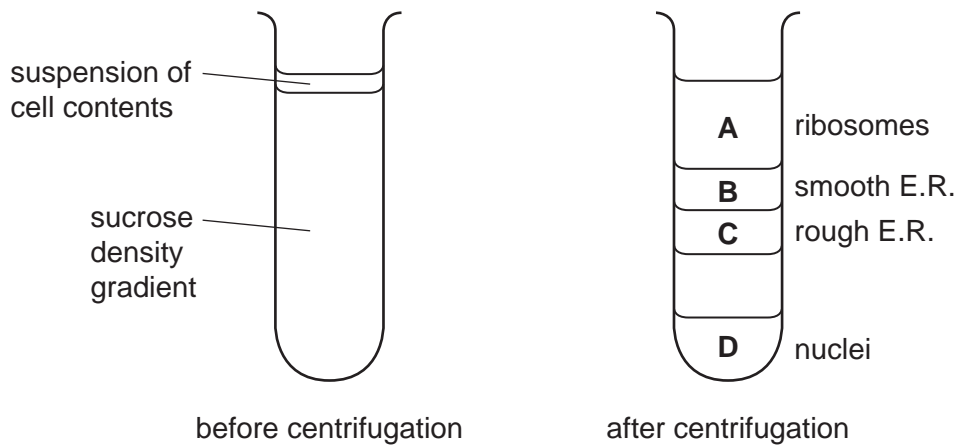
	<i>Escherichia coli</i> bacterium, length 2 μm	ribosome, diameter 25 nm	plasma membrane, thickness 10 nm
A	\checkmark	\checkmark	\checkmark
B	\checkmark	\checkmark	\times
C	\checkmark	\times	\times
D	\times	\times	\times

answer [1]

- 2 Sometimes scientists need to isolate organelles. This can be achieved by taking a number of cells and breaking their cell surface membranes to release the contents of the cells into a buffer solution.

In zonal centrifugation, the suspension of cell contents is placed on top of a sucrose density gradient. The tube is then placed in a centrifuge and spun at high speed. The heavier particles will move towards the bottom of the tube faster than lighter particles, as shown below.

If a sample of intact prokaryotes had been added to a suspension of eukaryotic cell contents, where would you expect them to be found?



answer [1]

- 3 Membranes are important features of many eukaryotic cell structures.

How many statements are correct?

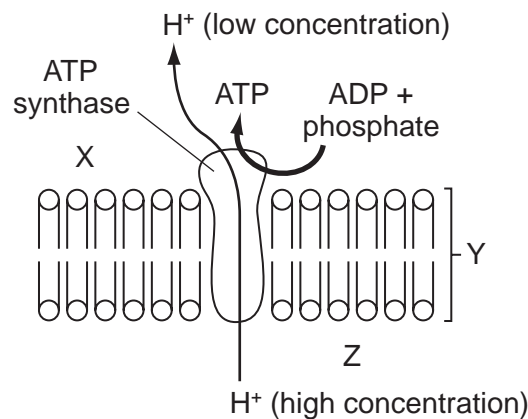
- 1 Cell structures bound by a double membrane include mitochondria, nuclei and chloroplasts.
- 2 Cell structures bound by a single membrane include Golgi apparatus, centrioles and ribosomes.
- 3 Cell structures bound by a single membrane include lysosomes, nucleoli and RER.
- 4 Cell structures bound by a single membrane include proteasomes, SER and cilia.

- A none
- B one
- C two
- D three

answer[1]

- 4 Which statement correctly describes a role of histone proteins?
- A All eukaryotic genes are transcribed continuously because they are not packaged by histones.
 - B DNA must be selectively released from its histone packaging before transcription can occur in bacteria.
 - C Histones package prokaryote chromatin into the nucleosomes that form the bulk of the chromosome.
 - D The organisation of DNA by histones in eukaryotes allows some gene control sequences to be thousands of base pairs away from the gene concerned.

- 5 The diagram shows a membrane in a cell.



Which would be true of the diagram?

- A X is the thylakoid space, Y is the thylakoid membrane and the diagram shows ATP synthesis in a chloroplast.
- B X is the stroma, Y is the thylakoid membrane and the diagram shows ATP synthesis in a mitochondrion.
- C Y is the thylakoid membrane, Z is the cytosol (cytoplasm) and the diagram shows ATP synthesis in a chloroplast.
- D Z is the intermembranous space, X is the matrix and the diagram shows ATP synthesis in a mitochondrion.

- 6 A new fossil unicellular organism was discovered in rocks 150 million years old. Scientists studied the cell structure of several samples under the electron microscope.

Which features suggest it was a eukaryote and not a prokaryote?

- 1 The nucleus was enclosed by a nuclear envelope with nuclear pores and contained two nucleoli.
- 2 The cisternae of rough endoplasmic reticulum were covered with ribosomes.
- 3 Oval organelles 1-2 μm long, in which the inner membrane was folded.
- 4 The cell wall was an extracellular structure, oval in shape.

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

- 7 Which cell organelle is able to produce ribosomes?

- 1 endoplasmic reticulum
- 2 mitochondrion
- 3 chloroplast
- 4 lysosome
- 5 Golgi apparatus

A 2 and 3 only

B 1, 2 a

C 3 and 5 only

D 2 and 4 only

- 8 Which cell organelle shows prokaryotic cell structure and has been proposed as providing evidence of endosymbiosis?

A Golgi apparatus

B mitochondrion

C nucleolus

D ribosome

9 The diagram represents a length of DNA from a prokaryote that includes a structural gene.

Parts of the length of DNA are labelled W, X and Y. They have different functions in the control of transcription of the structural gene.

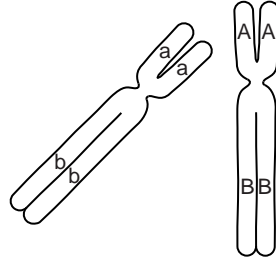


What identifies the functions of parts W, X and Y?

	W	X	Y
A	operator	regulator	regulator
B	promoter	regulator	operator
C	regulator	promoter	operator
D	promoter	operator	promoter

answer [1]

- 10 The diagram shows two homologous chromosomes in early prophase I of meiosis in an animal cell. Two genes, **A/a** and **B/b**, whose loci occur on the homologous chromosomes are also shown.



Which row of diagrams is a possible representation of these chromosomes as they progress from anaphase I to prophase II?

	anaphase I	prophase II
A		
B		
C		
D		

11 At which stage in the cell cycle will a lack of availability of extracellular growth factors result in cells entering the G₀ phase?

A M

B G₁

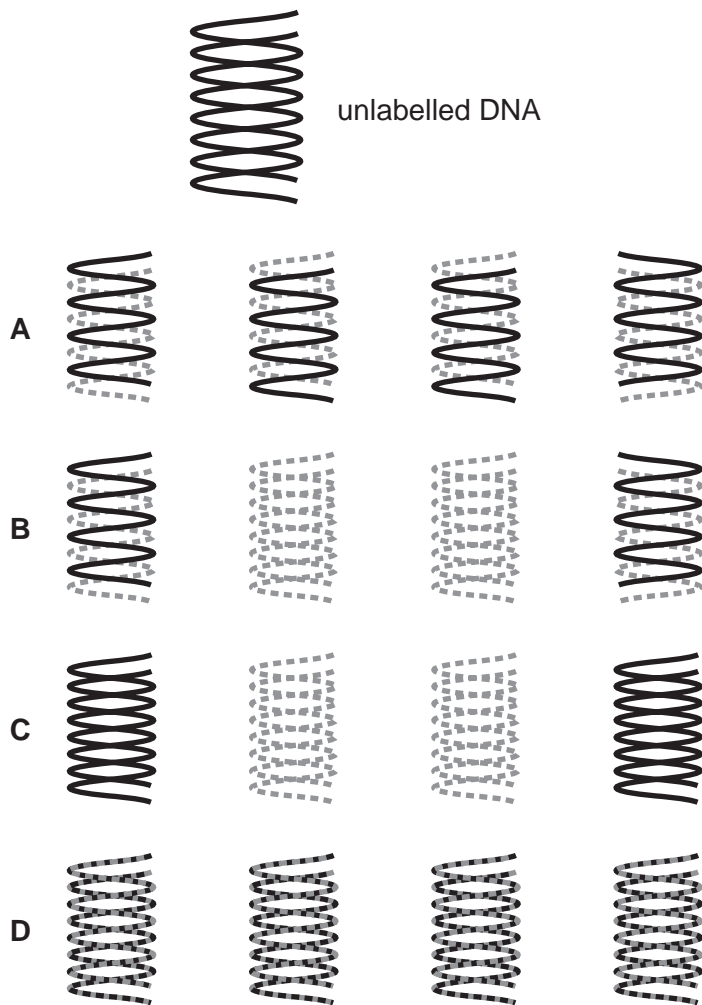
C G₂

D S

12 The sets of diagrams show four possible outcomes when an unlabelled molecule of DNA is allowed to replicate twice in the presence of ¹⁵N-labelled nucleotides.

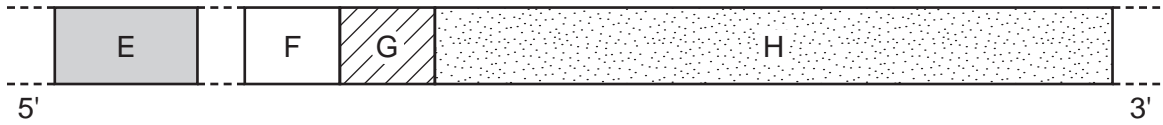
Labelled sections of DNA are represented by dotted lines.

Which set of diagrams correctly shows the result of DNA replication?



- 13 The diagram represents a length of DNA which forms a structure called an operon.

Parts of the operon are labelled E, F, G and H. They have different functions.



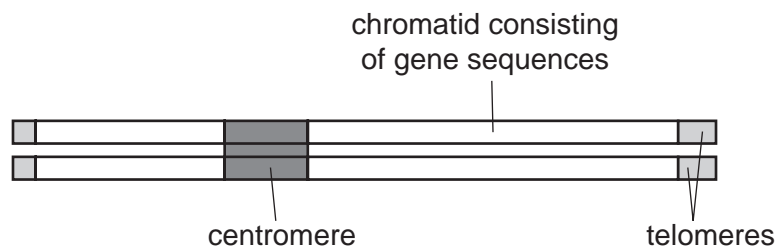
What identifies the functions of parts E, F, G and H?

	E	F	G	H
A	operator	structural gene(s)	regulator/repressor	promoter
B	promoter	regulator/repressor	structural gene(s)	operator
C	regulator/repressor	promoter	operator	structural gene(s)
D	structural gene(s)	operator	promoter	regulator/repressor

- 14 In order to replicate, the ends of a eukaryotic chromosome contain a special sequence of DNA called a telomere. Human telomeres consist of repeating TTAGGG sequences which extend from the ends of the chromosomal DNA.

When cells undergo mitotic division, some of these repeating sequences are lost. This results in a shortening of the telomeric DNA.

The diagram shows a eukaryotic chromosome.



What is a consequence of the loss of repeating DNA sequences from the telomeres?

- A The cell will begin the synthesis of different proteins.
- B The cell will begin to differentiate as a result of the altered DNA.
- C The number of mitotic divisions the cell can make will be limited.
- D The production of mRNA will be reduced.

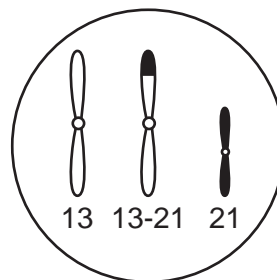
- 15 Possession of white or coloured feathers in poultry is controlled by two genes, P/p and Q/q. The phenotypes of offspring that are expected from mating two birds, each of which is heterozygous at both loci, are shown in the Punnett square.

gametes	PQ	Pq	pQ	pq
PQ	white feathers	white feathers	white feathers	white feathers
Pq	white feathers	white feathers	white feathers	white feathers
pQ	white feathers	white feathers	coloured feathers	coloured feathers
pq	white feathers	white feathers	coloured feathers	white feathers

What best explains the proportion of white to coloured feathers in the Punnett square?

- A dominant epistasis in which the epistatic allele is P
 B dominant epistasis in which the epistatic allele is Q
 C recessive epistasis in which the epistatic allele is p
 D recessive epistasis in which the epistatic allele is q
- 16 Down's syndrome can be caused by a trisomy of chromosome 21, but can also result from translocation of chromosome 21 onto chromosome 13, forming a single chromosome 13-21.

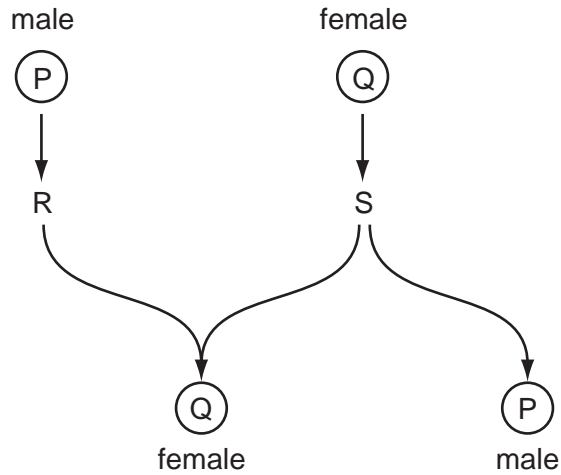
The diagram shows chromosomes 13 and 21 in the nucleus of a diploid (2n) testis cell from a phenotypically normal male carrier of a 13-21 translocation. This cell has a chromosome number of 45.



Which is **not** a likely outcome of fertilisation of normal oocytes by sperm from this male?

	chromosomes in sperm	embryo
A	13 and 21	2n = 46 normal phenotype
B	13-21	2n = 45 normal phenotype
C	13-21 and 21	2n = 46 Down's syndrome
D	13-21 and 21	2n = 47 Down's syndrome

- 17 Sex determination in some insects such as bees and wasps is not controlled by sex chromosomes.



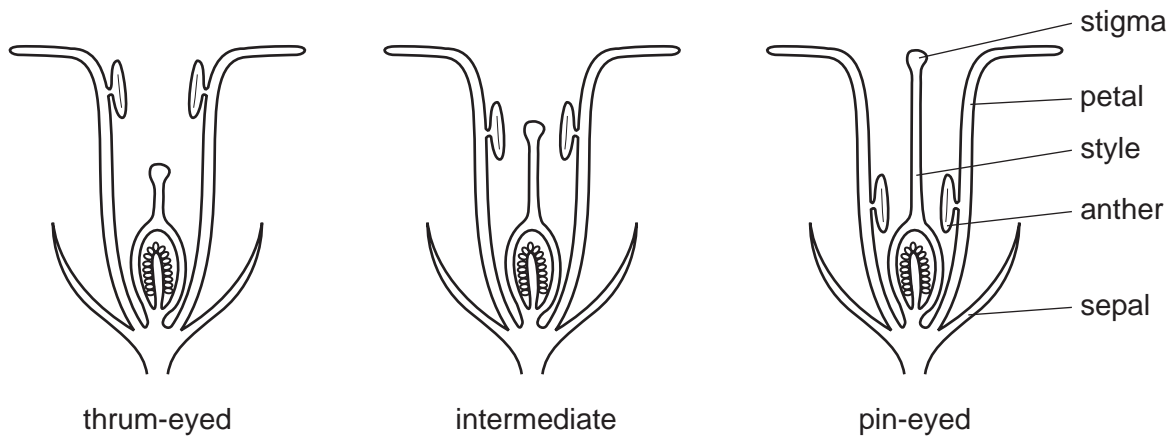
Using the diagram, which row in the table shows how sex is determined in these insects?

	P	Q	R	S
A	n	n	mitosis	mitosis
B	n	2n	mitosis	meiosis
C	2n	n	meiosis	meiosis
D	2n	2n	meiosis	mitosis

- 18 The primrose, *Primula vulgaris*, is a small herbaceous, yellow-flowered plant which is common in cooler areas of the Northern hemisphere including alpine and Arctic areas.

The flowers of the primrose have different flower shapes (polymorphic), which are adaptations for pollination. 'Thrum-eyed' primroses have a short style. 'Pin-eyed' primroses have much longer styles. Some populations of primrose consist almost entirely of plants with intermediate flowers. These populations are common where there are fewer winged insects.

The diagrams show polymorphic flowers of primroses.



Which statements are correct?

- 1 Cross-pollination will be favoured between pin-eyed and thrum-eyed primroses.
- 2 Primroses with pin-eyed flowers are likely to show more genetic diversity than primroses with intermediate flowers.
- 3 Primroses with intermediate flowers are likely to be more able to adapt to changing environmental conditions than pin-eyed and thrum-eyed primroses.
- 4 Self-pollination is more likely to occur in primroses with intermediate flowers.

- A** 1 and 2 only
B 1, 2
C 1, 2 a
D 3 and 4 only

19 Which description of telomeres and telomerase reverse transcriptase (TERT) is correct?

	telomeres	telomerase reverse transcriptase (TERT)
A	present in eukaryotes	uses RNA as a template to make single-stranded DNA
B	present in eukaryotes	inhibits the loss of telomeres from DNA during semi-conservative replication
C	present in prokaryotes	inhibits the loss of telomeres from DNA during semi-conservative replication
D	present in prokaryotes	uses RNA as a template to make single-stranded DNA

answer [1]

20 The enzyme phosphofructokinase is involved in the phosphorylation of hexose phosphate sugars during glycolysis. It is involved in the control of the rate of glycolysis, and thus respiration, by end-product inhibition.

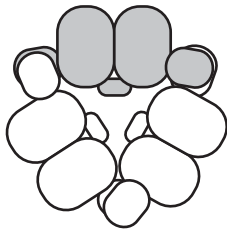
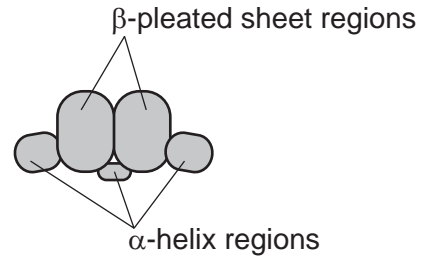
Deduce which of the following is a description of this enzyme.

	shape of binding site(s)	substrate	products
A	no allosteric site, active site complementary to ATP and hexose	hexose	hexose phosphate
B	allosteric site complementary to glucose, active site complementary to hexose phosphate	hexose phosphate	hexose phosphate
C	allosteric site complementary to ATP, active site complementary to ATP and hexose phosphate	hexose phosphate	hexose bisphosphate
D	no allosteric site, active site complementary to hexose bisphosphate	hexose bisphosphate	two triose phosphate

answer [1]

21 Approximately half of the total protein in a pea seed consists of the storage protein vicilin.

- Each molecule of vicilin is made up of three identical polypeptides.
- Each polypeptide is made up of two β -pleated sheet regions with linking α -helix regions, folded into the shape shown to the right.
- This allows the three polypeptides to pack together into a compact, flat storage molecule, as shown below.

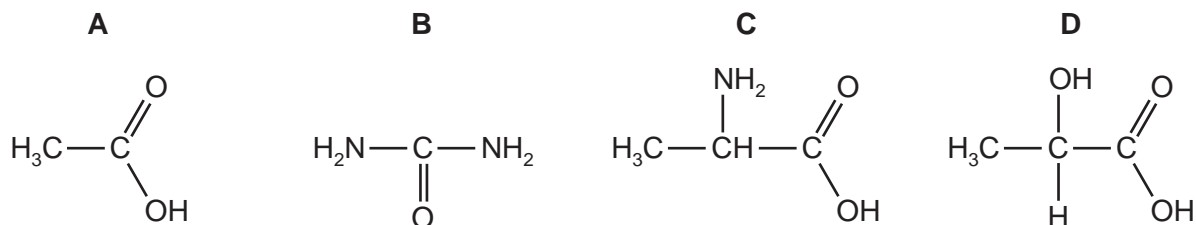


Which row correctly describes the structure of vicilin?

	primary structure	secondary structure	tertiary structure	quaternary structure
A	amino acid sequence of one polypeptide	α -helix and β -pleated sheet regions of each polypeptide	association of three polypeptides	folding of each polypeptide
B	amino acid sequence of one polypeptide	α -helix and β -pleated sheet regions of each polypeptide	folding of each polypeptide	association of three polypeptides
C	association of three polypeptides	amino acid sequence of one polypeptide	α -helix and β -pleated sheet regions of each polypeptide	folding of each polypeptide
D	association of three polypeptides	amino acid sequence of one polypeptide	folding of each polypeptide	α -helix and β -pleated sheet regions of each polypeptide

answer [1]

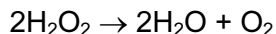
- 22 Which molecule, produced by the Miller-Urey experiments, is an essential component of enzymes that are necessary for life?



- 23 When a competitive inhibitor is introduced into an enzyme reaction, how will the V_{\max} and K_m be affected?

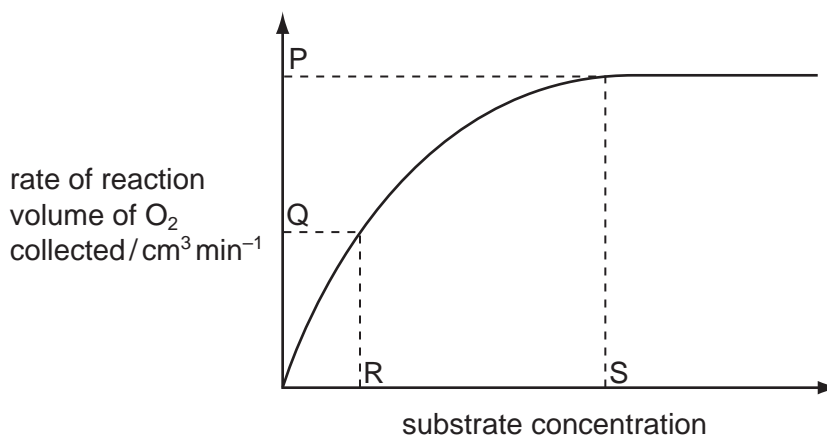
	V_{\max}	K_m
A	decrease	increase
B	decrease	no change
C	increase	decrease
D	no change	increase

- 24 Liver tissue produces an enzyme called catalase which breaks down hydrogen peroxide into water and oxygen.



The rate of this reaction can be determined by measuring the volume of oxygen produced in a given length of time.

Students added small cubes of fresh liver tissue to a range of hydrogen peroxide solutions and measured the volumes of oxygen produced. Their data were used to produce the graph showing how changing the concentration of hydrogen peroxide affected the rate of oxygen production.



Which statements are correct?

- 1 At P, the rate of reaction is limited by the concentration of enzyme.
- 2 At Q, all of the enzyme active sites are occupied by substrate molecules.
- 3 At Q, the rate of reaction is limited by the concentration of the substrate.
- 4 R represents K_m where the reaction rate = $V_{\max}/2$.
- 5 At S, all of the enzyme active sites are occupied by substrate molecules.

- A** 1, 3, 4 and 5 only
B 1, 4 and 5 only
C 2 and 3 only
D 2 and 5 only

- 25 A symbiont may be defined as a species in which individuals live in a long-term, intimate and beneficial relationship with hosts of a different species. As the name suggests, endosymbionts live within their hosts.

Which statement provides the strongest evidence that mitochondria and chloroplasts in eukaryotes originated as prokaryotic endosymbionts?

- A Proteins encoded by the nucleus are exported to these organelles.
- B Their inner membrane has a different structure from other intracellular membranes.
- C They are surrounded by a double membrane.
- D They contain their own DNA and have 70S, rather than 80S, ribosomes.

answer [1]

- 26 Two areas of molecular biology that have received considerable attention in evolutionary studies are the genetic code and cytochrome C. Cytochrome C is an essential component of all respiratory electron transport chains.

Which statements lend evidence to the ideas that

- all living organisms are related
- there is a single, rather than a multiple, origin of life?

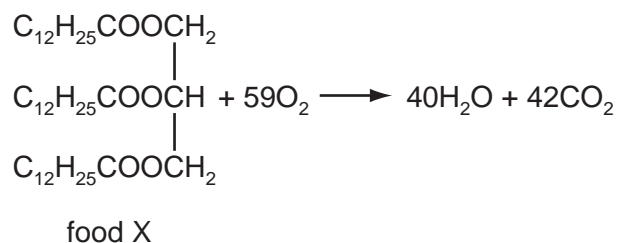
- 1 The almost universal nature of the genetic code is a result of evolutionary convergence from multiple lineages.
- 2 The sequence of amino acids in cytochrome C is similar in organisms that are from similar environments or with similar metabolic demands.
- 3 The majority of organisms have the same, or similar, amino acid sequences for cytochrome C.
- 4 When transferred into a very dissimilar organism, a gene coding for cytochrome C will lead to the expression of a protein that will function in the other organism.

- A 1 and 2 only
- B 2 and 3 only
- C 3 and 4 only
- D 1, 3

answer [1]

- 27 The type of food being respired by an organism can be determined by calculating the RQ (respiratory quotient).

The equation shows the respiration of a food, X.



What is the RQ for food X, and which type of food is being respired?

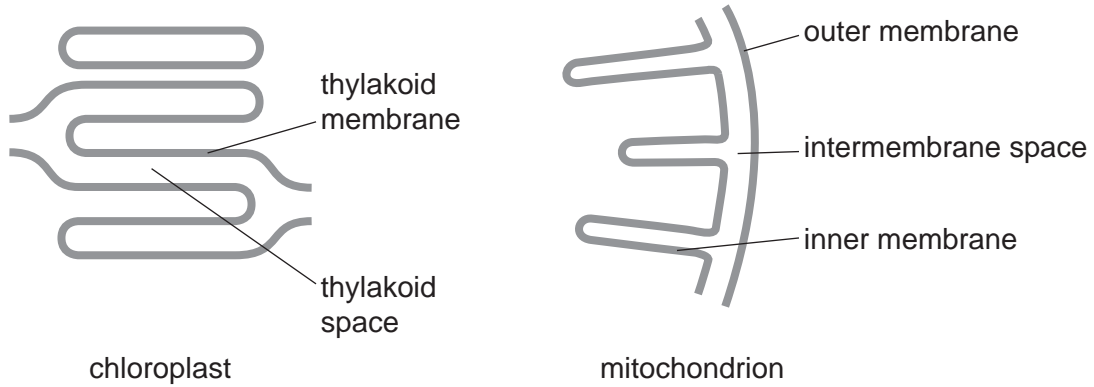
	RQ	type of food being respired
A	0.68	protein
B	0.71	triglyceride
C	1.40	triglyceride
D	7.10	carbohydrate

- 28 What are the products of glycolysis?

- 1 pyruvate
- 2 reduced FAD
- 3 reduced NAD
- 4 reduced NADP

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

29 The diagram shows part of a chloroplast and part of a mitochondrion.



Where does electron transport take place and where does the highest concentration of protons occur in these two organelles?

	electron transport		highest concentration of protons	
	chloroplast	mitochondrion	chloroplast	mitochondrion
A	thylakoid membrane	inner membrane	thylakoid space	intermembrane space
B	thylakoid membrane	outer membrane	thylakoid space	inner membrane
C	thylakoid space	outer membrane	thylakoid membrane	intermembrane space
D	thylakoid space	inner membrane	thylakoid membrane	inner membrane

30 During substrate-level phosphorylation, ATP is synthesised from ADP and inorganic phosphate.

What is the immediate source of energy for this reaction?

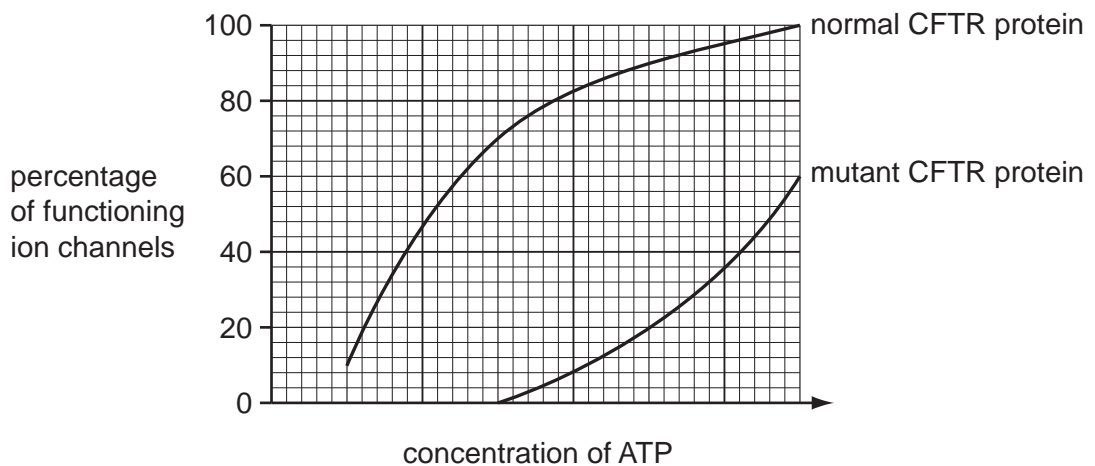
- A** chemical bond energy released during the light-independent stage of photosynthesis
- B** chemical bond energy released during glycolysis and the Krebs cycle
- C** kinetic energy of protons diffusing through mitochondrial membranes into the mitochondrial matrix
- D** kinetic energy of protons diffusing through thylakoid membranes in chloroplasts

31 What is involved in the first step of glycolysis?

- 1 hexose sugars
- 2 hydrolysis of ATP
- 3 mitochondrial matrix enzymes
- 4 reduction of NAD

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

32 One of the many recessive mutations of the *CFTR* gene changes one amino acid in the region of the CFTR protein that binds ATP. The graph shows the effect of different concentrations of ATP on normal and mutant CFTR proteins.



Which correctly describes individuals who are homozygous for this mutation?

- 1 Their CFTR protein cannot bind ATP and cannot act as an ion channel.
- 2 Their CFTR protein binds ATP less readily than normal CFTR protein.
- 3 They produce CFTR protein that must bind ATP to function as an ion channel.
- 4 They produce a mixture of normal and mutant CFTR protein, both of which can act as an ion channel.

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

answer [1]

- 33 The table shows the results of a series of crosses in a species of small mammal.

coat colour phenotype		
male parent	female parent	offspring
dark grey	light grey	dark grey, light grey, albino
light grey	albino	light grey, white with black patches
dark grey	white with black patches	dark grey, light grey
light grey	dark grey	dark grey, light grey, white with black patches

What explains the inheritance of the range of phenotypes shown by these crosses?

- A one gene with a pair of co-dominant alleles
 - B one gene with multiple alleles
 - C sex linkage of the allele for grey coat colour
 - D two genes, each with a dominant and recessive allele
- 34 In the fruit fly, *Drosophila melanogaster*, four genes whose recessive alleles code for black body (B/b), curved wings (C/c), purple eyes (P/p) and vestigial wings (V/v) are linked on chromosome 2.

The table shows some distances apart of the gene loci, as determined by breeding experiments.

gene loci	distance between loci/map units
B/b and P/p	6.0
B/b and V/v	18.5
P/p and V/v	12.5
P/p and C/c	21.0
V/v and C/c	8.5

What is the correct sequence of the loci on chromosome 2?

- A B/b P/p V/v C/c
- B C/c V/v B/b P/p
- C P/p V/v C/c B/b
- D V/v B/b P/p C/c

35 Which statements about the genetic code are correct?

- 1 The genetic code has redundancy and is degenerate.
- 2 There is only one codon for the amino acid methionine.
- 3 Codons act as 'stop' and 'start' signals during transcription and translation.
- 4 Prokaryotes generally use the same genetic code as eukaryotes.
- 5 mRNA codons have the same nucleotide sequence as DNA triplet codes.

A 1, 2 and 3 **B** 1, 2 and 4 **C** 1, 3 and 5 **D** 2, 4 and 5

36 Before the settlement of California in the 1800s, the elk population was very large. By about 1900 there were only a few dozen elk left.

Owing to protection, there are now about 3000 elk living in a small number of isolated herds.

Unfortunately, some of the elk in all the herds have difficulty grazing due to a shortened lower jaw.

Which statements best explain this?

- 1 The early settlers only hunted elk that could graze.
- 2 There was a mutation affecting jaw size in one of the herds.
- 3 There is random mating within each herd.
- 4 The current elk population demonstrates a founder effect.
- 5 There was directional selection favouring short jaws.

A 1, 2 and 4 only **B** 2, 3 and 5 only **C** 2 and 5 only **D** 3 and 4 only

- 37 Ribonuclease is an enzyme that digests RNA. The first five amino acids of the functioning molecule of ribonuclease are:

lys – glu – thr – ala – ala

The mRNA of the gene coding for ribonuclease, for the first 15 nucleotides, has the following sequence.

AUGAAGGAAACUGCU

A genetic code, showing mRNA codons, is shown below.

first position	second position				third position
	U	C	A	G	
U	phe phe leu leu	ser ser ser ser	tyr tyr STOP STOP	cys cys STOP trp	U C A G
C	leu leu leu leu	pro pro pro pro	his his gln gln	arg arg arg arg	U C A G
A	ile ile ile met	thr thr thr thr	asn asn lys lys	ser ser arg arg	U C A G
G	val val val val	ala ala ala ala	asp asp glu glu	gly gly gly gly	U C A G

Which event occurs to explain the information given above?

- A** The first amino acid on the polypeptide chain is removed in post-translational modification.
- B** The first codon is removed from the mRNA transcript in post-transcriptional modification.
- C** The mRNA binds to the rRNA in the second codon position.
- D** There is no tRNA with an anticodon complementary to the first codon.

38 Small samples from crime scenes can be genetically profiled (DNA fingerprinted).

Which is a possible combination of crime scene sample and methods for a successful genetic profiling process?

	crime scene sample	PCR	ethidium bromide and X-rays
A	red blood cells	✓	✓
B	saliva	✗	✓
C	semen	✓	✗
D	skin cells	✓	✓

key

✓ = used

✗ = not used

answer [1]

39 Marker genes are often inserted into genetically engineered crop plant cells, along with desired genes. Bacterial antibiotic resistance genes are sometimes used as marker genes. These may include short DNA repeats to make them unstable so that they are quite quickly eliminated by the genetically engineered crop plant cells.

Which is **not** a reason why elimination of such marker genes is favoured?

- A** It is theoretically possible for the antibiotic resistance marker gene in human food to pass to bacteria in the human gut.
- B** It is difficult to carry out repeated transformations using the same antibiotic.
- C** The antibiotics may affect the growth and differentiation of the fields of crop plants.
- D** There are a few such antibiotic resistance marker genes available.

40 What are the similarities between traditional plant breeding and genetic engineering?

- 1 increases chance of mutation
- 2 involves selection of genetic traits
- 3 must involve closely related species
- 4 transfers genes

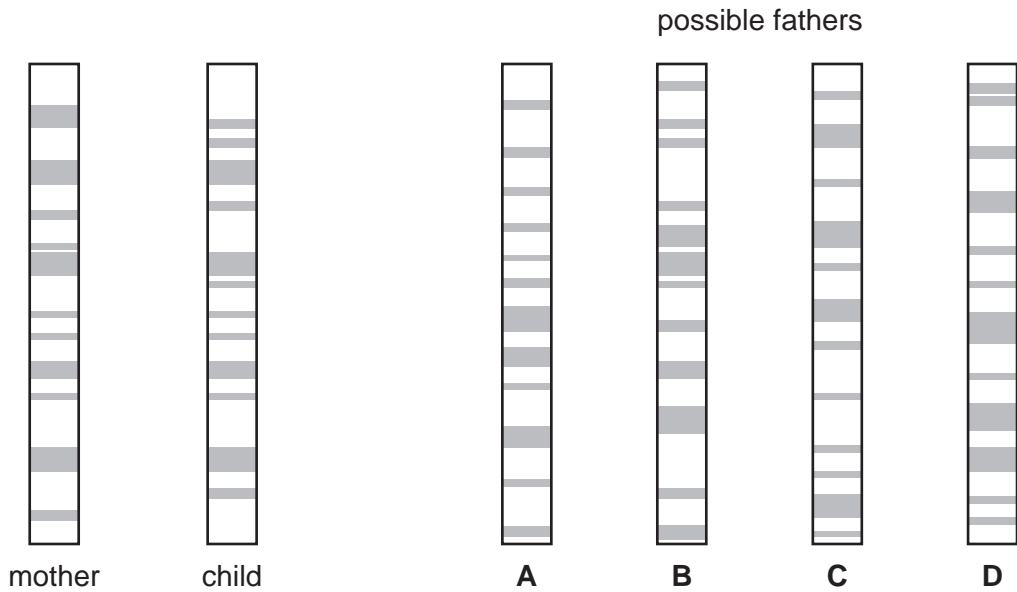
A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

41 Genetic profiling can be used to determine the paternity of a child.

DNA from the mother and the child is cut into fragments, separated by electrophoresis and made visual using a stain.

The diagram shows the genetic profiles of a mother and child, and four possible fathers.

Who is the father?



- 42 Human immunodeficiency virus (HIV) is a retrovirus. After infecting a host cell, viral DNA is produced which is incorporated into the DNA of the host cell. The modified host genome now codes for the production of new HIV particles.

Which could be used as a potential treatment to slow down the spread of HIV?

- 1 inhibitors of restriction endonucleases
- 2 inhibitors of reverse transcriptase
- 3 restriction endonucleases
- 4 reverse transcriptase

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