International Biology Olympiad e.V.

Time Allowed: 3HRS

PERSONAL DATA	
First / Given Name *	
Middle Name	
Last/Family Name/ Common Name *	
Preferred Name on badge	
Phone *	
Email *	
Alternate email	
Job description *	
Name of School/Institute/University/Other *	
Gender *	
Date of birth *	
Passport Number	

Cells

1 Which of these structures contains RNA but not DNA?

A nucleus

B mitochondrion

C chloroplast

D ribosome

Your answer

2 Which of the following is a function of the Golgi apparatus?

A to aid endocytosis

B to make proteins from amino acids

C to synthsise ATP

D to make secretory products

Your answer

3 What is the name given to the structures which penetrate the walls of adjacent plant cells?

A middle lamellae

B plasmodesmata

C pits

D channels

Your answer

4 Cells in culture will absorb amino acids from the surrounding culture medium. If radioactively labelled glycine is provided in the culture medium, in which organelle will radioactivity be found first?

A ribosomes

B nucleus

C lysosomes

D Golgi apparatus

Your answer

5 What resolution can be achieved with a light microscope?

A 20 μm

B 2 μm

C 0.2 μm

D 0.02 μm

Your answer

6 Which of the following cell structures does not have an envelope?

A lysosome

B nucleus

C mitochondrion

D chloroplast

Your answer

7 Intestinal epithelial cells have observable “brush borders” seen on the cells.

What are they?

A cilia

B flagella

C microvilli

D villi

Your answer

8 What are centrioles involved in?

A lysosome formation

B intracellular digestion

C ribosome formation

D cell division

Your answer

9 Which one of the following is responsible for the destruction of damaged organelles?

A Golgi apparatus

B cytoskeleton

C smooth ER

D lysosome

Your answer

10 Which of the following is concerned with the synthesis and transport of lipids and steroids in the cell?

A rough ER

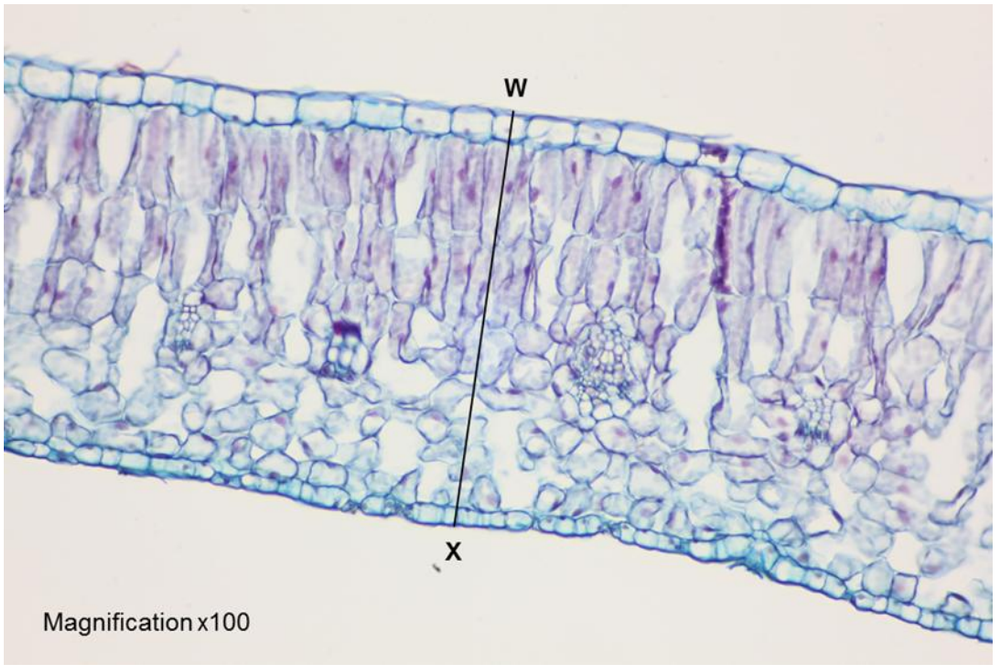
B smooth ER

C Golgi apparatus

D lysosome

Your answer

Question 11 and question 12 use the following photomicrograph:



11 The photomicrograph shows a transverse section of the lamina of a beech tree leaf taken at low power.

What is the actual width of the leaf measured from point **W** – **X**?

A 1.7 mm

B 0.6 µm

C 16.7 µm

D 600 µm

Your answer

12 The beech leaf slide was prepared using two stains.

Which two macromolecules have been stained?

A cellulose and starch

B lignin and nucleic acid

C cellulose and nucleic acid

D starch and lignin

Your answer

13 When mitochondria are extracted from cells, they are usually kept in a 0.25 mol dm^{-3} sucrose solution.
What is the purpose of the sucrose solution?

A it is used as a solvent

B it maintains a constant pH by acting as a buffer

C it acts as a source of food for respiration

D it prevents the mitochondria from changing structure

Your answer

14 A prokaryotic cell can be distinguished from a eukaryotic cell.
Which of the options, **A** – **D**, would only be found in a eukaryotic cell?

A a nucleus

B a cell surface membrane

C ribosomes

D DNA

Your answer

15 Which one of the following has the lowest surface area to volume ratio?

A a virus

B a phagocyte

C a red blood cell

D a bacterium

Your answer

16 Which one of these organelles always contains DNA?

A ribosome

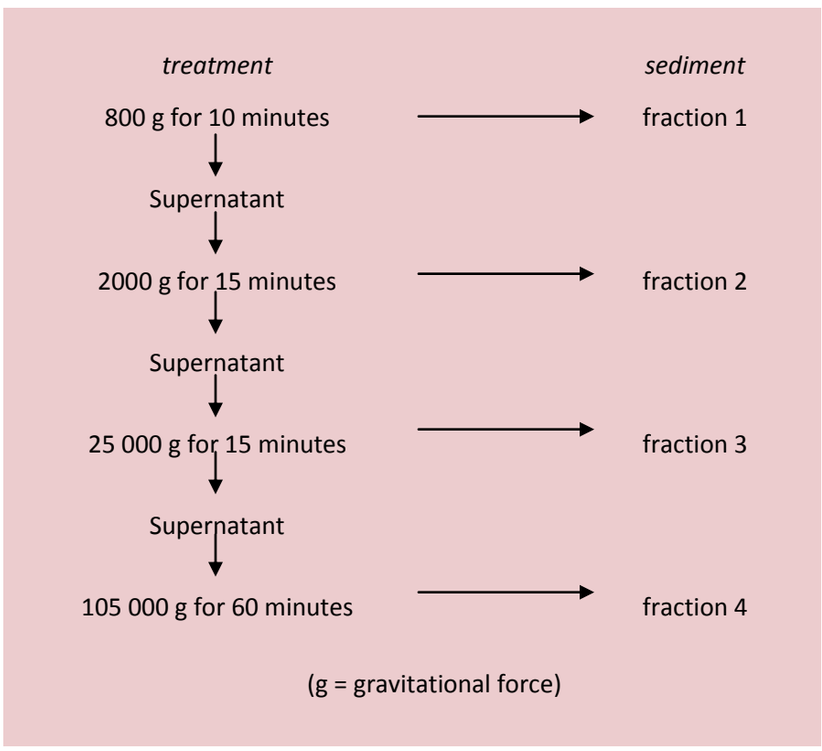
B Golgi body

C mitochondrion

D lysosome

Your answer

17 Some fresh rat liver was homogenised and the suspension subjected to differential centrifugation. The procedure used is shown in the diagram below.



Which row, **A – D**, represents the order in which the organelles were removed from the suspension?

	Fraction 1	Fraction 2	Fraction 3	Fraction 4
A	mitochondria	lysosomes	nuclei	ribosomes
B	mitochondria	nuclei	lysosomes	ribosomes
C	nuclei	mitochondria	lysosomes	ribosomes
D	nuclei	ribosomes	mitochondria	lysosomes

Your answer

18 Some organelles are bounded by a single membrane whilst others have two membranes. Which of the options, **A – D**, is correct?

	Single membrane		Two membranes	
A	tonoplast	lysosome	nucleus	chloroplast
B	chloroplast	lysosome	nucleus	tonoplast
C	nucleus	chloroplast	lysosome	tonoplast
D	tonoplast	chloroplast	nucleus	lysosome

Your answer

19 Which of the following would be found in an animal cell undergoing mitosis but **not** in a plant cell undergoing mitosis?

A chromosome

B centriole

C spindle

D chromatid

Your answer

20 Which of the following is absent from prokaryotic cells?

A plasmids

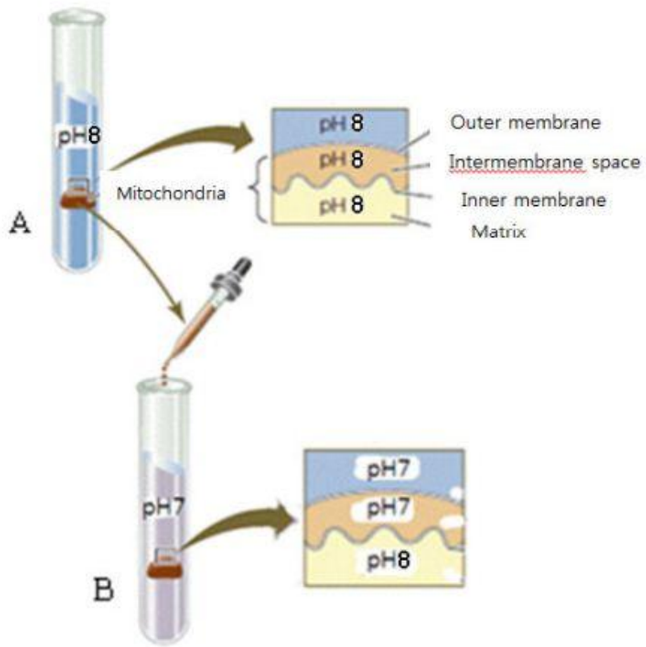
B cell wall

C rough endoplasmic reticulum

D ribosomes

Your answer

21. An experiment was performed to study the relation between H+ concentration and ATP synthesis in mitochondria. Mitochondria were isolated from the cell and placed into a pH 8 media (test tube A), then immediately transferred into a pH 7 media (test tube B). Later, ATP synthesis was verified in test tube B.



Indicate if each of the following statements is true or false.

1. In tube B, ATP was synthesized in the matrix-facing side of the inner mitochondrial membrane.
2. In tube B, ATP was synthesized without the help of electron transport system.
3. If mitochondria in tube A was transferred into a pH 9 media, ATP synthesis will occur in the intermembrane space of mitochondria.
4. If mitochondria remains in tube A but glucose is added, there will be ATP synthesis

Indicate if each of the following statements about posttranslational modification of eukaryotic proteins is true or false.

A. Disulfide bond formation on a protein occur in the endoplasmic reticulum.
B. Glycoproteins may be found in viruses that infect human.
C. Oligosaccharide group addition to a protein may occur in both Golgi apparatus and endoplasmic reticulum.
D. Palmitoylation of a protein can change its intracellular localization .

Genetics and evolution

1 An automated DNA sequencing machine mixes template DNA with four other components. These are:

chain terminating nucleotides labelled with coloured dyes

normal DNA nucleotides

primer sequences

*Taq*polymerase.

Which line of the table shows the functions of these components in the sequencing machine?

	chain-terminating nucleotides	**normal nucleotides**	**primer DNA**	***Taq*polymerase**
A	stop replication	base-pair to template DNA	base-pairs to template DNA	joins nucleotides by phosphodiester bonds
B	stop replication	base-pair to primer DNA	base-pairs to chain-terminating nucleotides	joins bases by ester bonds
C	stop transcription	base-pair to template DNA	base-pairs to primer DNA	joins nucleotides by ester bonds
D	stop transcription	base-pair to primer DNA	base-pairs to normal nucleotides	joins bases by phosphodiester bonds

Your answer ☐

2 Which of the following is an example of post-translational control of gene expression?

A A non-functional protein produced from edited mRNA

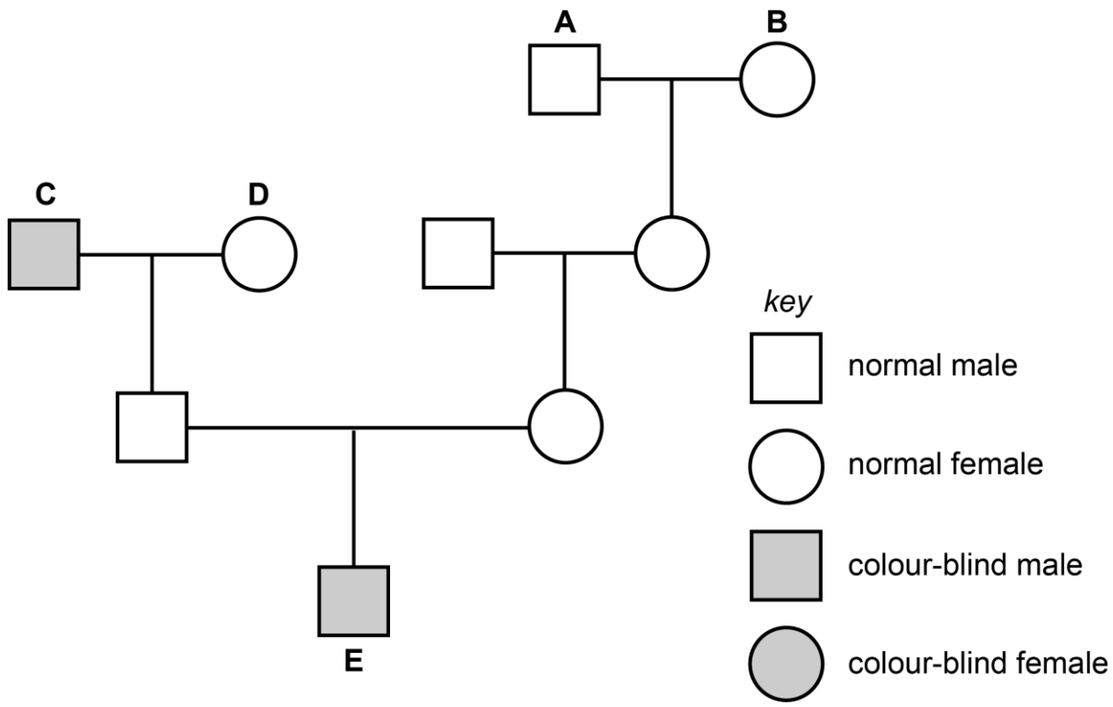
B β-galactosidase activity in *Escherichia coli* exposed to lactose

C Liver cells beginning glycogenolysis in response to glucagon.

D A Hox gene product acting as a transcription factor for many other genes.

Your answer ☐

3 The diagram shows the pedigree of a family carrying the sex-linked allele for red-green colour blindness.



From which labelled member of his family did **E**inherit the allele for colour-blindness?

Your answer

4 The deer in a captive population vary in colour. 53 deer are brown and 14 are white. The coat colour of deer is determined by the gene **R/r**, where the dominant allele **R** codes for brown and the recessive allele **r** codes for white.

Calculate the frequency of the allele **R** in the population using the Hardy-Weinberg principle.

$p + q = 1$

$p^2 + 2pq + q^2 = 1$

A 0.21

B 0.46

C 0.54

D 0.79

Your answer

5 Fur colour in cats is partly controlled by a gene on the X chromosome. The gene has two alleles, one coding for black fur and one coding for ginger fur. The two alleles are codominant, so a heterozygous cat has patches of black and patches of ginger fur, a pattern called tortoiseshell.

When a black female cat was mated with a ginger male, the F1 generation consisted of black males and tortoiseshell females.

What phenotypic ratio would be expected in the F2 generation?

A 1 black female : 1 tortoiseshell female : 2 black males

B 1 black female : 1 ginger female : 2 black males

A 1 black female : 1 tortoiseshell female : 2 black males

C 1 black female : 1 ginger female : 1 black male : 1 ginger male

D 1 black female : 1 tortoiseshell female : 1 black male : 1 ginger male

Your answer

6 Two men who are identical twins marry two women who are also identical twins. Each couple has a daughter. The daughters are more genetically similar than is usual for first cousins.

Which statement describes the degree of genetic similarity between the daughters?

A They are genetically different from each other due to independent assortment in meiosis.

B They are genetically different from each other due to random mutation.

C They are genetically identical because random mutation is rare.

D They are genetically identical because they share the same parental gene pool.

Your answer

7 Skin colour in onions is controlled by two pairs of alleles, **S/s** and **R/r**, located on separate autosomes.

The allele **S** is dominant and must be present to allow development of pigment in the onion skin. Onions with genotype **ss** have white skin.

The allele **R** is dominant and gives a red colour. The allele **r** is recessive and gives a yellow colour.

What is the ratio of phenotypes in the offspring of a cross between plants of genotypes **SsRR** and **ssrr**?

A all red

B 1 red : 1 white

C 1 red : 1 yellow

D 1 white : 2 red : 1 yellow

Your answer

8 An interbreeding population of finches became geographically separated, forming two isolated groups, **S** and **T**. The two groups experienced different selection pressures for many years. Much later, some finches from group **S** were introduced to the habitat of **T**.

What observation determines whether the **S** finches are now a different species to **T**finches?

A Their DNA sequence percentage similarity is less than 100%.

B They differ in the shape of their beaks.

C They fail to produce fertile F_1 hybrids.

A Their DNA sequence percentage similarity is less than 100%.

D They have been separate for 3000000 years.

Your answer

9 A series of three codominant alleles, I^A, I^B and I^O, control whether red blood cells display antigens A, B, both or none of these on their cell surface membranes.

The four children of two parents each have a different ABO blood group.

What were the blood groups of the parents?

A A and B

B A and O

C A and AB

D AB and O

Your answer

10 In a population of birds, the frequencies of genotypes for gene **H/h** differed significantly from the frequencies expected according to the Hardy-Weinberg principle.

Which reason could explain this deviation?

A There was no mating at random with respect to **H/h**.

B There was no mutation at the **H/h** gene locus.

C There was no migration into or out of the population.

D Natural selection did not favour either **H** or **h** at the expense of the other allele.

Your answer

12 Which treatment is an example of somatic gene therapy?

A growing a replacement organ from a person's stem cells

B injecting a functional dominant allele into the liquid in the eye to correct a retinal disease

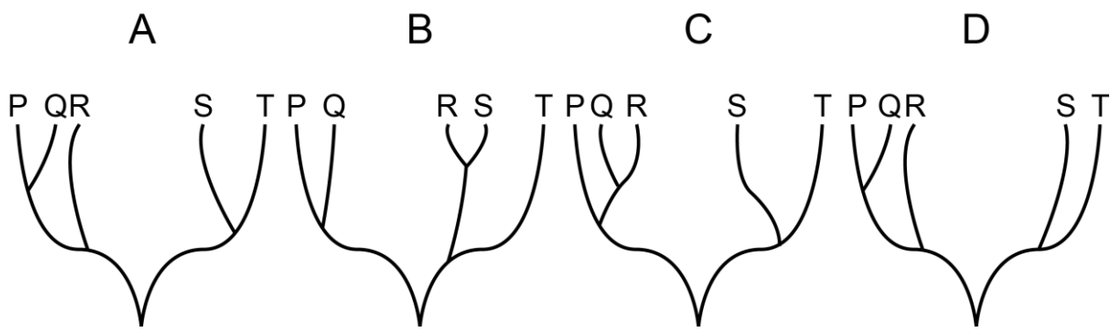
C introducing an extra allele for a growth hormone into sheep embryos

D joining a sperm cell, mother's nucleus and an enucleated donor oocyte to make a healthy baby

Your answer

12 The primary structure of the enzyme cytochrome c oxidase 1 was sequenced for five species, **P**, **Q**, **R**, **S** and **T**. The table shows the number of amino acid differences between each pair of species.

	number of amino acid differences				
	P	**Q**	**R**	**S**	**T**
P	0				
Q	7	0			
R	8	3	0		
S	20	19	18	0	
T	22	17	21	10	0



Your answer

13 The diagrams represent a pair of chromosomes during prophase I of meiosis. **Q** and **q** are alleles of one gene, and **R** and **r** are alleles of another gene.

Which diagrams show situations where allele **Q** will segregate from allele **q** at anaphase I?

Diagram 1:

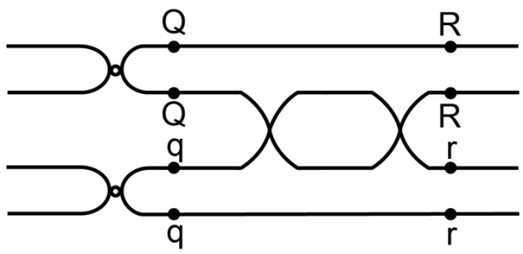


Diagram 2:

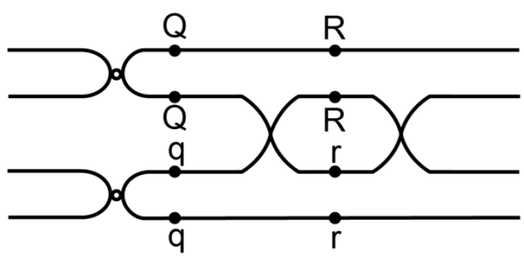
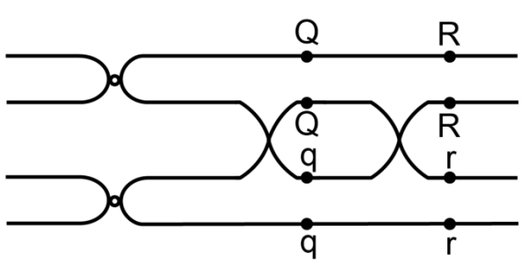


Diagram 3:



A 1, 2 and 3

B Only 1 and 2

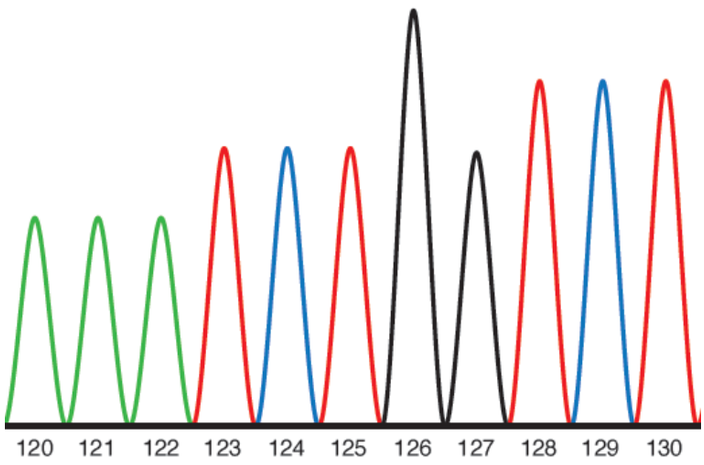
C Only 2 and 3

D Only 1

Your answer

14 Automated sequencing uses fluorescent dyes to identify different bases in a section of DNA, as shown in the table. The diagram shows sample results for bases 120 – 130 of a certain gene.

dye colour	base
black	guanine
blue	cytosine
green	adenine
red	thymine



Which of the following statements are true?

Statement 1: The order of bases in the sequence is **AAATCTGGTTT**.

Statement 2: The base order in mRNA transcribed from this sequence is **UUUAGACCAGA**.

Statement 3: A substitution mutation affecting a base pair somewhere in this sequence could potentially affect any one of five amino acids in the resulting protein.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer

15 Construction of a new road system splits a population of a rare snail species into three sub-populations, **J**, **K** and **L**. Each of these populations is reproductively isolated.

The table shows the sizes of the three populations immediately after the building of the road and again ten years later. DNA analysis was used to find:

p the relative frequency of the dominant allele of a gene

q the relative frequency of the recessive allele of this gene.

The three areas of habitat remained the same as each other over the ten years.

	immediately after road building			after 10 years		
	population size	***p***	***q***	**population size**	***p***	***q***
J	1000	0.50	0.50	1000	0.52	0.48
K	100	0.49	0.51	100	0.63	0.37
L	10	0.40	0.60	10	0.20	0.80

Which statements are supported by this data?

Statement 1: Natural selection is occurring in populations **K** and **L.**

Statement 2: The Founder Effect is strongest in population **L**.

Statement 3: The observed allele frequency changes result from genetic drift.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer

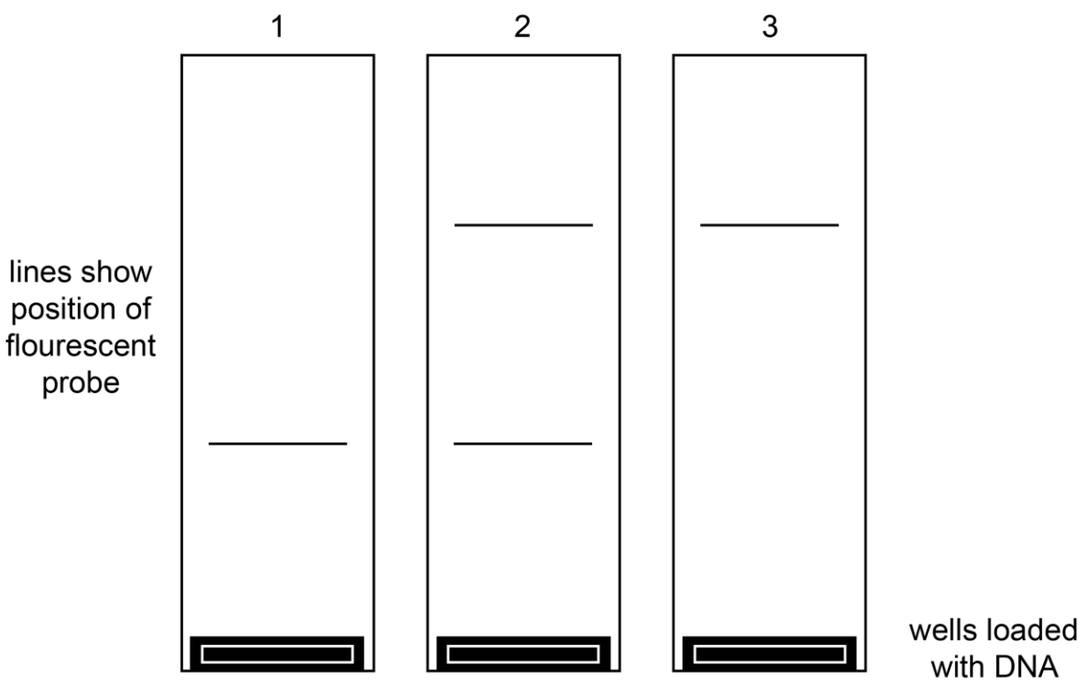
16 The *β-globin* gene codes for a polypeptide in haemoglobin. An individual with the disease sickle cell anaemia has two copies of a recessive allele of this gene. A genetic test can distinguish between the normal and sickle cell alleles.

A restriction digest of normal DNA gives a 7.6 kbpfragment that contains the normal*β-globin*allele.

The same restriction digest gives a 13 kbpfragment if the sickle cell allele is present instead of the normal *β-globin*allele.

After restriction digestion, the fragments are separated by electrophoresis. Afluorescent DNA probe is used to show the location of the fragments on the gel.

The diagram shows results for three individuals.



Which individual(s) suffer from sickle cell anaemia?

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer

17 Genetic engineering to give bacteria the ability to produce human insulin involves these steps.

J Using reverse transcriptase to make cDNAof the insulin gene.

K Incubating a plasmid with a restriction enzyme.

L Extracting mRNA from human pancreatic cells.

M Adding the recombinant vector to bacteria in calcium chloride solution.

N Incubatingthe prepared gene with the cut plasmid.

Which line of the table shows these steps in the correct order?

	step 1	step 2	step 3	step 4	step 5
A	**J**	**L**	**N**	**M**	**K**
B	**L**	**J**	**M**	**N**	**K**
C	**J**	**L**	**M**	**N**	**M**
D	**L**	**J**	**K**	**N**	**M**

Your answer

18 The polymerase chain reaction (PCR) is a laboratory technique used to amplify DNA.

Which statements correctly describe aspects of this process?

Statement 1: When the temperature is at 55^{o}C single-stranded DNA anneals to primers.

Statement 2: DNA copy number increases with each thermal cycle on a logarithmic scale.

Statement 3: The enzyme *Taq* polymerase is used because it catalyses transcription in a bacterium that lives in hot water.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer

19 Gene editing is a new technique for altering plant and animal genomes. The enzyme Cas 9 nuclease cuts DNA at a site identified by the binding of a guide RNA sequence. This allows the addition, alteration or removal of sections of DNA.

Gene editing differs from the traditional process of genetic engineering.

When comparing gene editing and the traditional process of genetic engineering, which statements are true?

Statement 1: Only one of these processes adds foreign DNA.

Statement 2: Only one of these processes knocks out a gene.

Statement 3: Both these processes alter the plant or animal's phenotype.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

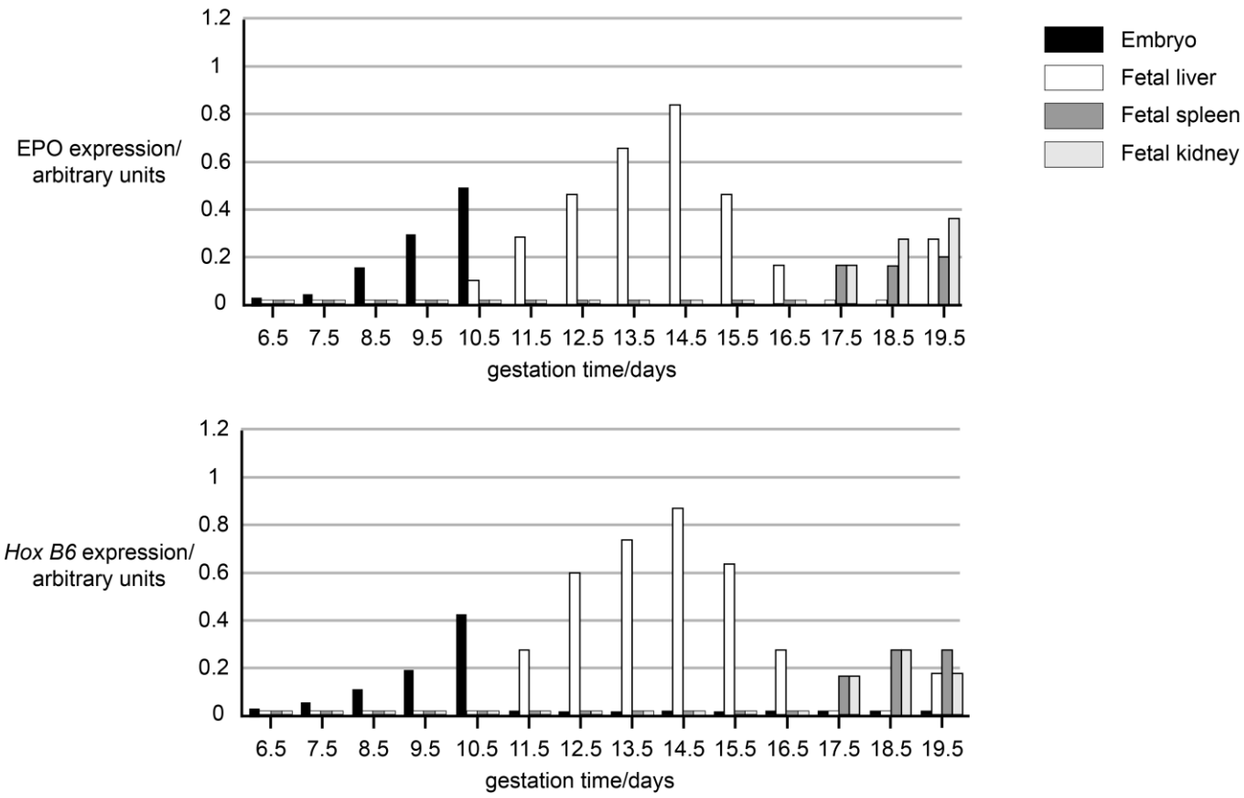
D Only 1

Your answer

20 The diagrams show changes in the expression of two genes, *EPO*and*Hox B6*, in developing mouse embryos.

EPO codes for a protein that triggers stem cells to develop into red blood cells.

Hox B6 is a homeobox gene.



Which conclusions are consistent with the data?

Statement 1: The site of red blood cell production moves from the liver to the spleen and kidney.

Statement 2: Between 6.5 and 19.5 days, most red blood cell production occurs in the liver.

Statement 3: *Hox B6* switches on *EPO*.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Ecology (Circle Correct Answer)

1. A hawk, mouse, snake, grasshopper, and grass form a simple food chain. Which of these organisms is a producer?
   A. Mouse
   B. Hawk
   C. Grass
   D. Grasshopper

2. The sun is necessary to life in all ecosystems on Earth. What does the sun provide that all organisms depend upon to sustain life?
   A. Warm weather
   B. A natural time of day system
   C. Heat and light for living things
   D. Dry weather

3. There is a population of deer living in an area. The deer have thrived for several years. The deer have a successful breeding season and many new deer are now living in the area. The deer population soon decreases. What most likely caused the reduction in the number of deer in the area?
   A. There was not enough space for the deer to rest each day.
   B. The animals died because of a previous disease.
   C. There was not enough food for all the deer.
   D. There was not enough air for that number of deer.

4. An ecosystem includes a beaver population. What would happen to the beaver population if their wetland is destroyed to allow for the building of a shopping center?
   A. The beaver would move.
   B. The beaver would adapt to living in a dry ecosystem.
   C. The beaver would learn to eat new foods.
   D. The beaver would die out because they are adapted to an aquatic habitat.

5. Which is the correct flow of energy in an ocean food chain?
   A. Sun, krill, plankton, whale
   B. Sun, plankton, krill, penguin, whale
   C. Plankton, krill, whale, penguin
   D. Plankton, sun, whale, penguin

6. A biome is a type of
   A. Grassland
   B. Wetland
   C. Population
   D. Ecosystem

7. An unusually large amount of berries gives a specific species of birds plenty to eat. Which of the following would most likely happen due to the increase in berries?
   A. The birds will produce fewer young.
   B. The birds will overeat and die.

C. The bird’s predators will have more birds to feed on.

D. The birds will leave the ecosystem.

8. Which of the following is a true statement about the flow of energy between plants and animals?

A. Insects receive very little of the sun’s energy from their food.

B. Animals and insects get energy directly from the sun.

C. Plants use very little energy from the sun.

D. A tiger receives less of the sun’s energy in its food than a caterpillar does.