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Some questions may have been altered or removed compared to the version of this paper used during the competition period.

Answers are not provided at this time.

Students are not expected to have memorised all the facts assessed, or be familiar with all the topics presented. Their biological intuition and problem solving is being assessed.

Intermediate Biology Olympiad 2021

Duration: 60 minutes

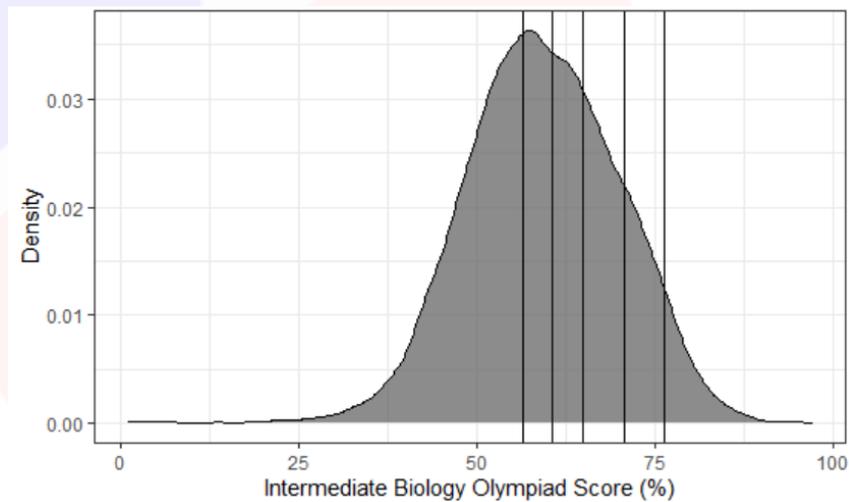
Total marks available: 78

Participation: 8873 students took part from 449 schools.

Grade boundaries:

Medal	Percentage of Students (%)	Mark (%)
Gold	5	76.28
Silver	10	70.66
Bronze	15	64.91
Highly Commended	15	60.50
Commended	15	56.47

Mark Distribution:



Question 1

Part 1 of 7

Which type(s) of molecule are ribosomes made from?

1 mark

Choose as many as appropriate

- a) RNA
- b) DNA
- c) mRNA
- d) tRNA
- e) Proteins
- f) Carbohydrates

Part 2 of 7

Human proteins can be made artificially in bacteria. Which of the following are advantages of using bacteria to make proteins?

2 marks

Choose as many as appropriate

- a) Bacteria are easy to transform
- b) Bacteria always add the same post-translational modifications as human cells
- c) Bacteria are easier to grow than human cells
- d) Bacteria use the same triplet code as human cells
- e) Human genes can usually be transformed into bacteria without modification

Part 3 of 7

Sort the following molecules into the inputs and outputs of **photosynthesis**.



By Des_Callaghan - Own work, CC BY-SA 4.0,
<https://commons.wikimedia.org/w/index.php?curid=35894254>

2 marks

Groups

Input

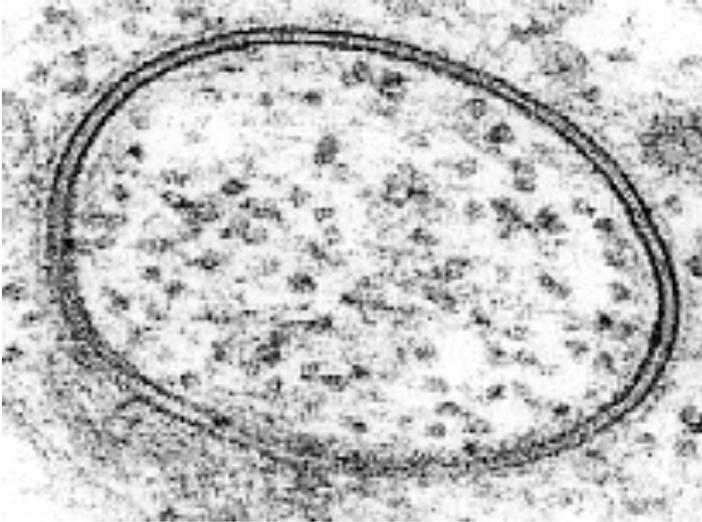
Output

Put into the groups above

- a) Oxygen
- b) Water
- c) Light energy
- d) Sugar
- e) Chemical Energy
- f) Carbon dioxide

Part 4 of 7

Which molecules are able to cross a cell-membrane lipid bilayer?



By Sandraamurray - Own work, Public Domain,
<https://commons.wikimedia.org/w/index.php?curid=5514703>

1 mark

Choose *ONE*

- a) Antibodies
- b) Glucose
- c) Starch
- d) Potassium ions
- e) Steroid hormones

Part 5 of 7

A random mutation changed an alanine codon to a STOP codon within a protein sequence. Which is the most likely outcome?

1 mark

Choose *ONE*

- a) Antibiotic resistance
- b) A new more useful protein
- c) A truncated useless protein
- d) The protein would probably not be affected

Part 6 of 7

Order the vessels blood flows through as it completes a loop from the leg muscles, around the body and back to the muscles. Place these in the correct order with leaving the leg muscle at the top, and reentering again at the bottom.

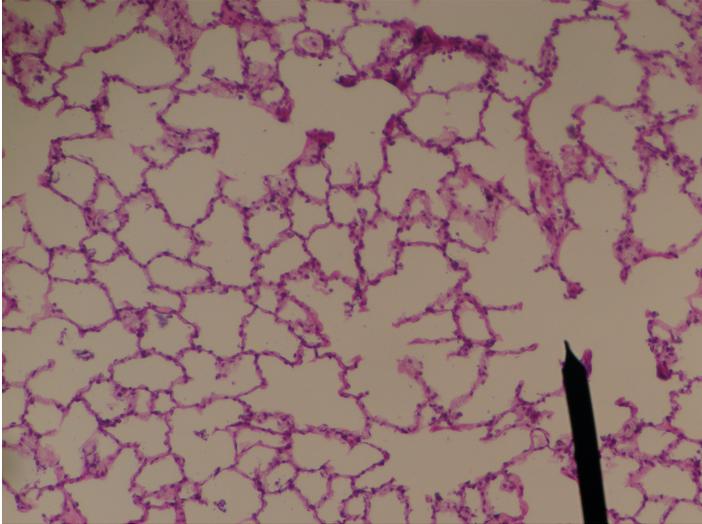
2 marks

Put into the correct order

- a) Vena cava
- b) Left atrium
- c) Aorta
- d) Right atrium
- e) Lungs
- f) Left ventricle
- g) Right ventricle

Part 7 of 7

Which features increase gas exchange within **human** lungs?



By Jpogi - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=46568489>

1 mark

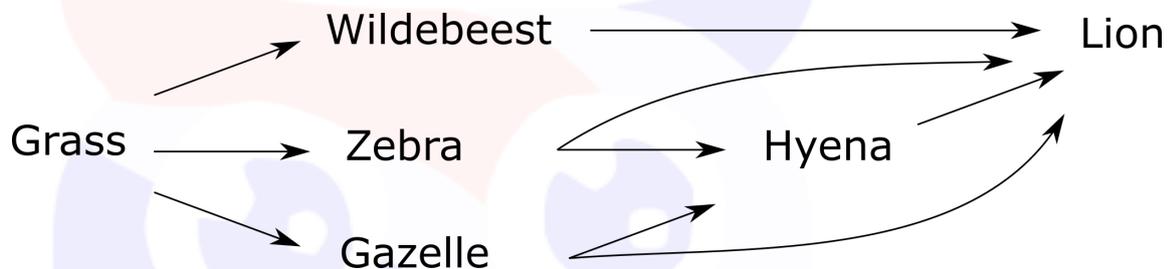
Choose as many as appropriate

- a) Large surface area of alveoli
- b) Large surface area of microvilli
- c) Single cell layer of epithelial cells
- d) Counter-current exchange of gasses

Question 2

Part 1 of 4

Food webs illustrate energy flow within an ecosystem. Below is part of a food web for the African savannah.



A food web from the savannah

Part 2 of 4

Which organism is the primary producer?

1 mark

Choose *ONE*

- a) Grass
- b) Wildebeest
- c) Zebra
- d) Gazelle
- e) Hyena
- f) Lion

Part 3 of 4

Mark all organisms which will probably be **negatively** affected by an increased in zebras.

2 marks

Choose *as many as appropriate*

- a) Grass
- b) Wildebeest
- c) Gazelle
- d) Hyena
- e) Lion

Part 4 of 4

Which trophic level holds the most energy?

1 mark

Choose *ONE*

- a) Grass
- b) Wildebeest/Zebra/Gazelle
- c) Hyena
- d) Lion

Question 3

Part 1 of 3

Cabbage leaves can be placed in coloured water. Uptake of water can be measured by the speed at which the dye is taken up.



Laura Hamilton, Flickr, <https://www.flickr.com/photos/mslaura/4023084459>, CC BY-NC-ND 2.0

Part 2 of 3

Which vessel carries water up the plant stem?

1 mark

Choose *ONE*

- a) Artery
- b) Xylem
- c) Phloem

Part 3 of 3

What would increase the rate of uptake of water?

2 marks

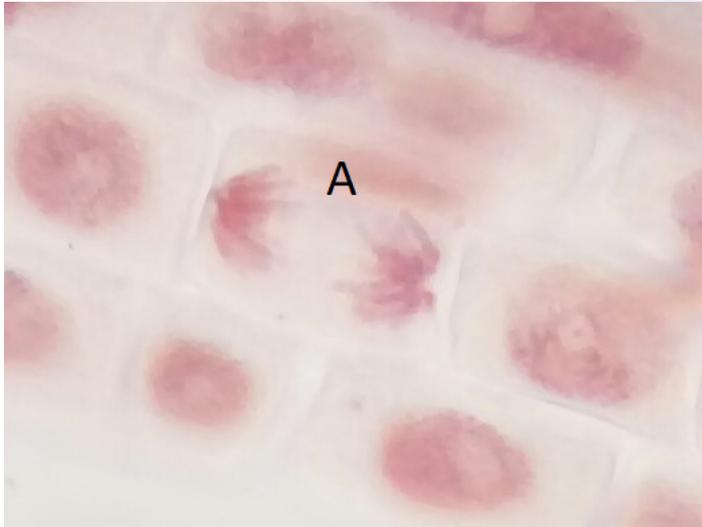
Choose *as many as appropriate*

- a) Moving the plant into a dark room
- b) Increasing the humidity
- c) Increasing the airflow of the room
- d) Increasing the air temperature
- e) Cutting all the leaves in half

Question 4

Part 1 of 3

The image below shows an epidermal onion peel stained for DNA. An onion cell has 8 pairs of chromosomes.



DNA Stained Onion Peel (Credit: Laurararas, Wikimedia, CC4.0)

Part 2 of 3

Which phase of the cell cycle is the cell labelled 'A' in?

1 mark

Choose *ONE*

- a) G1
- b) S
- c) G2
- d) Mitosis
- e) Meiosis

Part 3 of 3

How many chromosomes does the cell marked 'A' have?

2 marks

Write something below

Question 5

Part 1 of 9

Tulips can be pink or white. A plant breeding company wanted to find out if the pink allele was dominant or recessive. A pure breeding pink tulip was crossed with a pure breeding white tulip. The progeny of the cross were all pink.



A pink tulip

Part 2 of 9

Is the pink allele dominant or recessive?

1 mark

Choose ONE

- a) Dominant
- b) Recessive

Part 3 of 9

A population of 1750 tulips is in Hardy-Weinberg equilibrium, and 1253 of them are pink. *The Hardy-Weinberg equilibrium states the allele frequencies of the dominant (*p*) and recessive (*q*) alleles can be calculated as $p + q = 1$. The frequency of dominant homozygotes, heterozygotes and recessive homozygotes can be calculated as $p^2 + 2pq + q^2 = 1$, respectively.*

Part 4 of 9

What is the frequency of the recessive allele in the population? Give your answer to ****two decimal places****.

1 mark

Write something below

Part 5 of 9

What is the frequency of heterozygote tulips in the same population? Give your answer to ****two decimal places****.

2 marks

Write something below

Part 6 of 9

The scientists notice some tulips have ruffled edges. The scientists want to know whether the ruffled allele is dominant or recessive. They sowed the seeds of a ruffled plant which had selfed (fertilised its own seed). 75% of the progeny had ruffled petals and 25% had normal petals.



A tulip with ruffled edges

Part 7 of 9

Is the ruffled allele dominant or recessive?

1 mark

Choose ONE

- a) Dominant
- b) Recessive

Part 8 of 9

Was the parent plant (F₀) homozygous or heterozygous for the ruffled allele?

1 mark

Choose ONE

- a) Homozygous
- b) Heterozygous

Part 9 of 9

The scientists collected the seed from only the progeny ****without**** ruffles which had selfed. What percentage of these seeds (the F₂) had ruffles? Give your answer to the nearest whole number

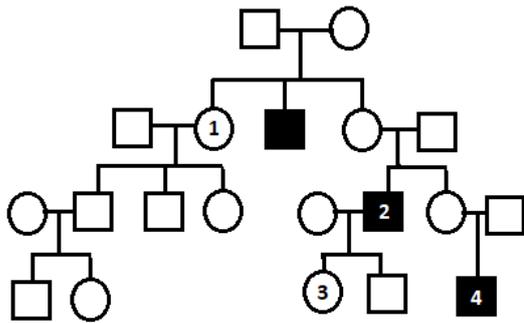
2 marks

Write something below

Question 6

Part 1 of 4

The pedigree below shows the inheritance of colourblindness, a sex-linked condition. * Squares indicate males, and circles females. * An empty shape indicates a normal individual, whereas a filled shape indicates an affected individual.



A disease pedigree

Part 2 of 4

Is individual 1 a carrier of the disease?

1 mark

Choose *ONE*

- a) Yes
- b) No
- c) Unable to tell

Part 3 of 4

Is individual 3 a carrier of the disease?

1 mark

Choose *ONE*

- a) Yes
- b) No
- c) Unable to tell

Part 4 of 4

If individual 3 and 4 have a child, what is the chance it is colourblind? (in percent, %)

2 marks

Write something below

Question 7

Part 1 of 4

Evolution is change in the heritable characteristics of populations over successive generations.

Part 2 of 4

Which of the following evolutionary forces **increase** genetic diversity?

2 marks

Choose as many as appropriate

- a) Natural Selection
- b) Artificial Selection
- c) Immigration
- d) Spontaneous mutation
- e) Horizontal Gene Transfer

Part 3 of 4

An artificial selection pressure was applied to a population of bacteria by the sudden addition of a strong antibiotic. The majority of bacteria die but some survived. What is the most plausible reason for this?

1 mark

Choose ONE

- a) The antibiotic caused a mutation
- b) An antibiotic resistance gene was already in the population
- c) The antibiotic only kills bacteria about 50% of the time
- d) The antibiotic quickly degraded in the environment

Part 4 of 4

A scientist compared the haemoglobin found in a lowland goat species and a mountain-dwelling goat species. How has haemoglobin most likely to have evolved within the mountain goat species?



By Darklich14 - Own work, CC BY 3.0, <https://commons.wikimedia.org/w/index.php?curid=9825969>

1 mark

Choose *ONE*

- a) A greater number of haeme groups
- b) Higher affinity for oxygen
- c) Different functional groups than haeme
- d) ****Decreased**** expression
- e) No functional changes

Question 8

Part 1 of 3

The Svalbard Global Seed Vault contains seeds from hundreds of thousands of plant species buried deep under a mountain on an arctic island. Scientists researching ancient crops with drought resistance lost their collections in the Syrian civil war. They withdrew samples from the Svalbard Vault to revive these species.



By Miksu - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=61440471>

Part 2 of 3

What is the likely consequences of reviving species in this way compared to saving existing populations?

1 mark

Choose ONE

- a) Increased genetic diversity
- b) Increased rate of harmful mutations
- c) Increased fitness
- d) Increased tolerance to environmental pressures
- e) Increased rate of adaptation/evolution

Part 3 of 3

How should seeds be preserved to maintain the genetic health of species (ignore practicalities and the survival of seeds over-time)?

2 marks

Choose as many as appropriate

- a) Take seeds from individuals in a wide variety of areas
- b) Take seeds from a large number of individuals
- c) Revive seeds periodically, grow them, then store only the new seeds
- d) Take seeds from individuals of any shape and size (not just the most typical looking individuals)
- e) Take seeds only from family lines which have been nurtured by people for a very long time

Question 9

Part 1 of 3

The Regent Honeyeater is an Australian bird. Recently, it has become critically endangered with about 300 individuals in an area 10× greater than the UK. Scientists have noticed that as it became rare, male Regent Honeyeaters have started signing the songs of other birds, rather than their own. Female Regent Honeyeaters do not like males which sing the songs of other birds.

Part 2 of 3

What is a likely reason male Regent Honeyeaters are singing different songs?



1 mark

Choose *ONE*

- a) Natural selection (birds singing these songs are fitter)
- b) Sexual selection (birds singing these songs mate more)
- c) Their instinct has changed
- d) The songs they hear and learn when they are young have changed
- e) Hybridisation (other species are mating with Regent Honeyeaters)

Part 3 of 3

What method would ****not**** help Regent Honeyeaters sing their own songs?

1 mark

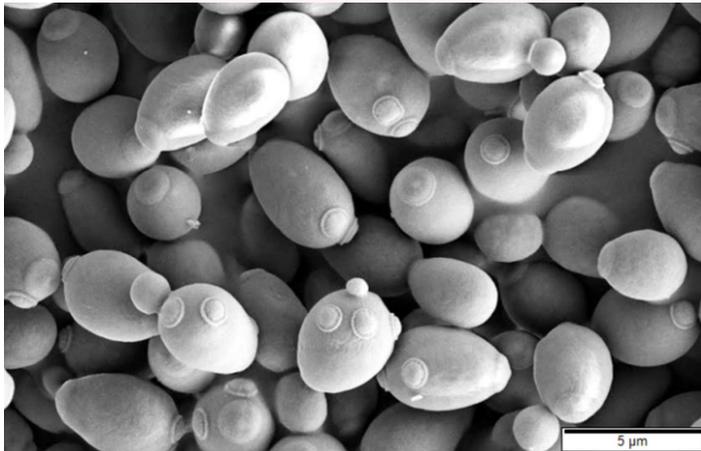
Choose *ONE*

- a) Play recordings of Regent Honeyeater songs on loudspeakers
- b) Keep young Regent Honeyeaters in captivity with singing adults
- c) Keep young Regent Honeyeaters away from other species
- d) Relocate young Regent Honeyeaters to distant areas
- e) When raised in captivity, only release Regent Honeyeaters singing the correct songs

Question 10

Part 1 of 6

Yeast is a model organism used in medical research, as well as an industrial organism used in brewing. Scientists wanted to measure whether a mutant yeast strain was better at fermenting sugar. Mutant and non-mutant cells were put in flasks with solutions containing 200 g/l glucose. They then measured the concentration of glucose in the flasks over time.



By Mogana Das Murtey and Patchamuthu Ramasamy - [1], CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=52254246>

Part 2 of 6

To ensure they are measuring fermentation, the scientists should:

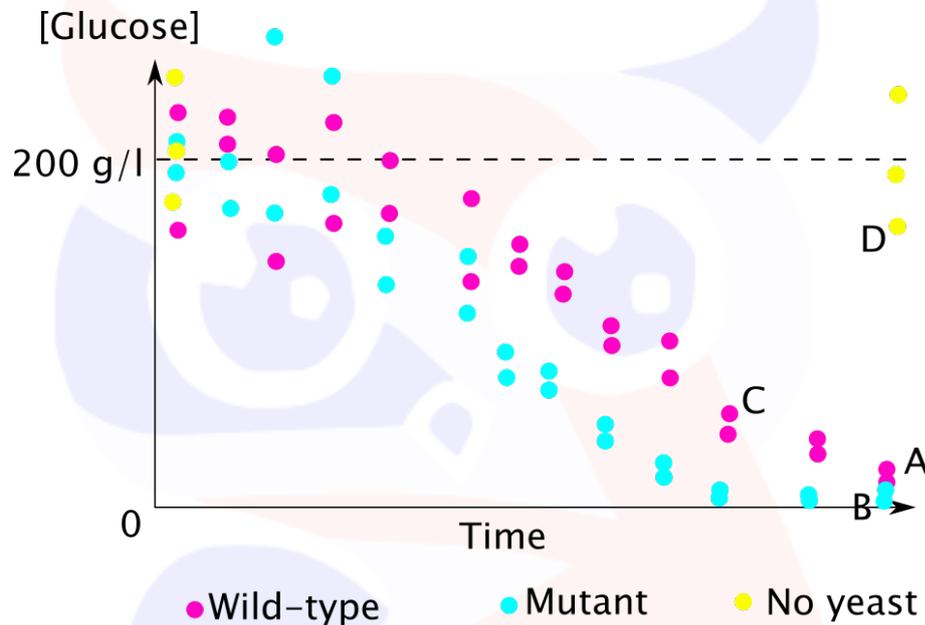
1 mark

Choose *ONE*

- a) Tightly seal the flasks
- b) Bubble oxygen into the flasks
- c) Bubble CO₂ into the flasks
- d) Use solutions containing plenty of fats (lipids)
- e) Use solutions containing plenty of amino-acids (proteins)

Part 3 of 6

The scientists used Benedict's reagent to measure the concentration of glucose in each flask over time. Each dot is a repeated measurement of the same sample.



Growth curves for mutant and wild type yeast

Part 4 of 6

What is revealed by this data?

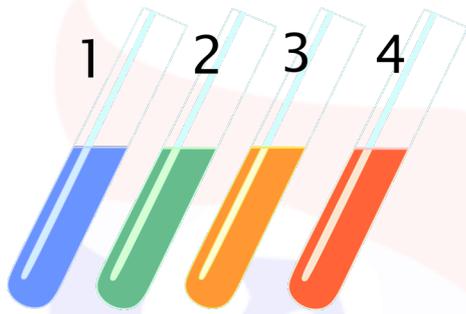
3 marks

Choose as many as appropriate

- The mutant strain is better at fermentation
- Glucose is degraded over time by a non-biological process in this experiment
- Samples from early time-points should be diluted because the measurements are saturated
- It is unclear if the difference between strains is caused by a mutation effecting metabolism or cell-division

Part 5 of 6

Which tube of Benedict's reagent and sample matches which letter on the graph?



2 marks

Groups

Tube 1

Tube 2

Tube 3

Tube 4

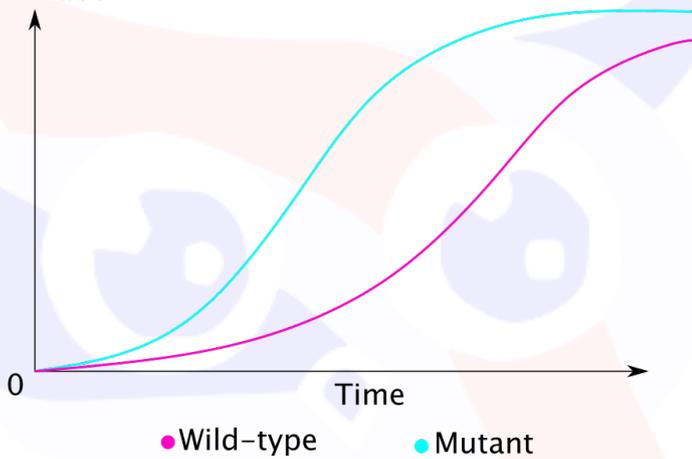
Put into the groups above

- a) Sample C
- b) Sample A
- c) Sample D
- d) Sample B

Part 6 of 6

The scientists measured the rate of fermentation in the same samples with a second method. What label(s) could the Y axis have)?

Unknown label



Unlabelled graph

2 marks

Choose as many as appropriate

- a) Oxygen concentration
- b) pH
- c) CO₂ concentration
- d) Ethanol concentration
- e) Number of cells

Question 11

Part 1 of 5

The *Central Dogma* describes how the genetic code is interpreted to make useful products via a one-directional flow of information through different polymers.

Part 2 of 5

Place the molecules of the dogma in the correct order. Put the beginning material at the top and end with the functional material at the bottom.

1 mark

Put into the correct order

- a) DNA
- b) mRNA
- c) Polypeptide
- d) pre-mRNA
- e) Catalytic and structural biological machines

Part 3 of 5

Sort the following properties into pre-mRNA, mRNA, both or neither:

3 marks

Groups

pre-mRNA

mRNA

Both

Neither

Put into the groups above

- a) Contains adenosine
- b) Contains introns
- c) Contains uracil
- d) Double-stranded molecule
- e) Contains non-coding information
- f) Contains exons

Part 4 of 5

A pre-mRNA molecule has 20% A, 40% U, 10% C, and 30% G. What is the composition of the double-stranded DNA that it was transcribed from?

2 marks

Choose *ONE*

- a) 20% A, 40% U, 10% C, and 30% G
- b) 20% A, 40% T, 10% C, and 30% G
- c) 40% A, 20% T, 30% C, and 10% G
- d) 40% A, 20% U, 30% C, and 10% G
- e) 25% A, 25% U, 25% C, and 25% G
- f) 30% A, 30% T, 20% C, and 20% G

Part 5 of 5

There are exceptions to the dogma, including viruses which encode information from RNA into DNA. Which protein is responsible for this conversion?

1 mark

Choose *ONE*

- a) Protease
- b) Helicase
- c) Topoisomerase
- d) RNA reverse transcriptase
- e) RNase
- f) Transcriptase
- g) RNA polymerase

Question 12

Part 1 of 3

Sort the human defence processes into the correct category.

2 marks

Groups

Innate

Adaptive

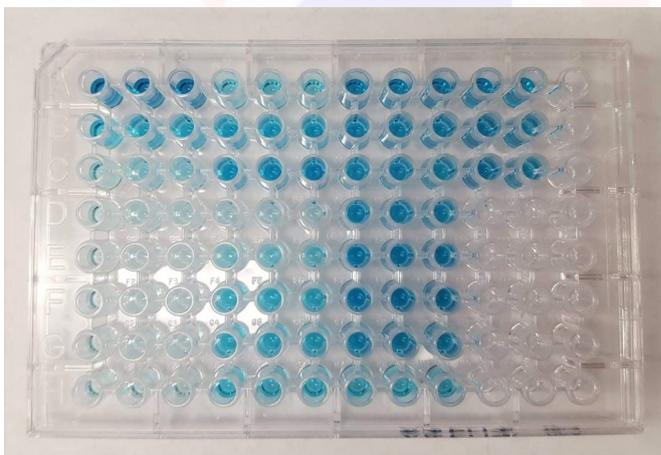
Put into the groups above

- a) Phagocytosis
- b) Antibody production by B cells
- c) Antigen presentation
- d) Physical barriers preventing entry

Part 2 of 3

*This question will assess how easily you understand unfamiliar methods. Note: **different ELISAs work in different ways***

People given COVID-19 vaccines usually make antibodies against the viral spike protein. The levels of anti-spike antibodies can be measured with an ELISA (Enzyme-Linked Immunosorbent Assay): 1. The wells of a plate are coated with spike protein. 2. A blood sample is incubated within the well. 3. The well is washed with soapy water. 4. An artificial anti-spike antibody is incubated in the well. This antibody is linked to an enzyme. 5. The well is washed with soapy water. 6. The enzyme's substrate is added to the well. 7. After some time, the colour of the well is recorded. If present, the enzyme catalyses the conversion of the colourless substrate into a bright blue colour.



An ELISA plate with 96 wells

Part 3 of 3

Mark the following true or false

5 marks

Mark the following as *TRUE* or *FALSE*

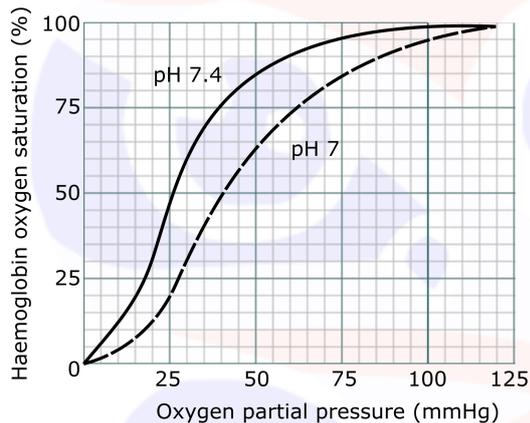
- a) If the patient has more anti-spike antibodies, the well will look more blue
- TRUE FALSE
- b) The scientist should include a control well with water instead of blood to compare the colour levels
- TRUE FALSE
- c) If the scientist forgets the second wash, the well will look blue
- TRUE FALSE
- d) If it is a cold day, the well will look more blue
- TRUE FALSE
- e) This experiment would work better at 100°C
- TRUE FALSE

Question 13

Part 1 of 6

Haemoglobin binds or releases oxygen depending on the partial pressure of oxygen in the tissue.

Partial pressure is a measure of the amount of oxygen in fluids around the haemoglobin, and is usually given in the non-SI unit of pressure, mmHg The Bohr effect of pH on oxygen saturation is shown.



Bohr effect graph

Part 2 of 6

What happens to the saturation of haemoglobin as it moves into a tissue which has the same pH but lower partial pressure of oxygen?

1 mark

Choose ONE

- a) Higher saturation
- b) Lower saturation

Part 3 of 6

What happens to the saturation of haemoglobin as it moves into a tissue which has a lower pH but the same partial pressure of oxygen?

1 mark

Choose ONE

- a) Higher saturation
- b) Lower saturation

Part 4 of 6

Anaerobic respiration produces lactic acid. Does a muscle respiring anaerobically receive more or less oxygen from haemoglobin in the blood than a muscle respiring aerobically?

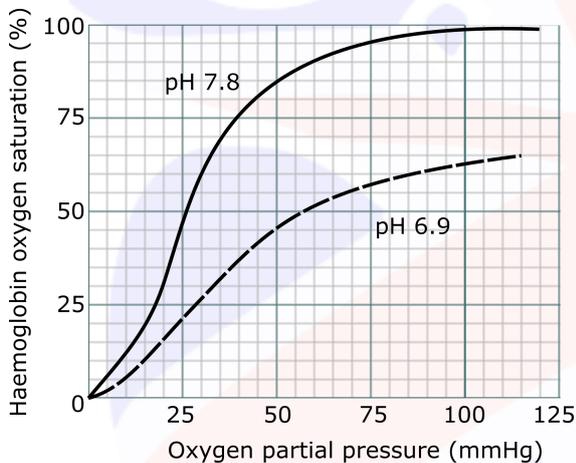
1 mark

Choose *ONE*

- a) More oxygen
- b) Less oxygen

Part 5 of 6

The **Root effect** is analogous to the Bohr effect, but fine tunes haemoglobin within fish. Fish use the Root effect to fill their swim bladders with oxygen gas to control their buoyancy. The Root effect is shown below.



Root effect graph for a rainbow trout

Part 6 of 6

Mark the following as true or false

4 marks

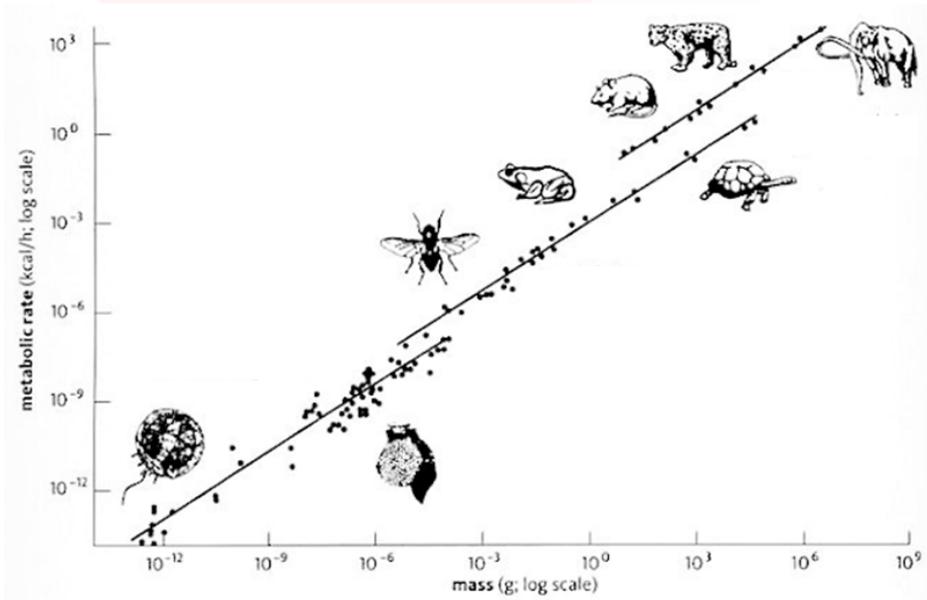
Mark the following as *TRUE* or *FALSE*

- a) Fish haemoglobin responds to pH in an identical way to mammal haemoglobin.
TRUE FALSE
- b) Fish acidify capillaries at the swim bladder to offload oxygen
TRUE FALSE
- c) The Root effect can unload oxygen against a concentration gradient
TRUE FALSE
- d) The Root effect reduces the efficiency of gills at taking up oxygen
TRUE FALSE

Question 14

Part 1 of 8

This question assesses your numerical skills with unfamiliar biology Keiber's law states that the resting metabolic rate of an organism scales to the $\frac{3}{4}$ power of the animal's mass ($\text{mass}^{0.75}$). Thus, a dog having a mass 100 times that of a mouse will consume only about 32 times more energy than the mouse at rest.



Metabolic rate scales to the $\frac{3}{4}$ power of mass (Hemmingen, 1960)

Part 2 of 8

How many times more energy will a cat use at rest compared to a mouse? A cat has a mass 50 times greater than a mouse. Give the nearest **whole number**

2 marks

Write something below

Part 3 of 8

The specific metabolic rate of an animal is their resting metabolic rate divided by their mass.

Part 4 of 8

Which will have a the greatest specific metabolic rate:

1 mark

Choose ONE

- a) Mouse
- b) Cat
- c) Dog
- d) They are all roughly equal

Part 5 of 8

Unlike metabolic rate, heart volume scales 1:1 with the mass of an animal. If a mouse has a heart volume of 0.5 mL, what is the heart volume of a cat? A cat has a mass 50 times greater than a mouse. Give the nearest ****whole number****

2 marks

Write something below

Part 6 of 8

The heart pumps to provide oxygen to tissues, so resting heart rate is proportional to the resting metabolic rate of an animal. Which animal will have the fastest resting heart beat?

1 mark

Choose ONE

- a) Mouse
- b) Cat
- c) Dog
- d) They are all roughly equal

Part 7 of 8

During exercise, metabolic rate increases. Heart rate has a similar maximum speed in all animals. Which animal has the greatest ability to exercise?

1 mark

Choose *ONE*

- a) Mouse
- b) Cat
- c) Dog
- d) They are all roughly equal

Part 8 of 8

Approximately what power of mass do animals' **maximum** metabolic rates scale with? (**mass**) Give a number with **two decimal** places.

1 mark

Write something below
