2021 ASSESSMENT RESOURCE

AS
BIOLOGY

Exchange of Substances / Genetics

Version 0.1

Total number of marks: 47

0 3 . 1 Describe the relationship between size and surface area to volume ratio of organisms.

[1 mark]

As size increases, the surface area to volume ratio decreases.

0 3 . 2 A scientist calculated the surface area of a large number of frog eggs. He found that the mean surface area was 9.73 mm^2. Frog eggs are spherical.

The surface area of a sphere is calculated using this equation

$$\text{Surface area} = 4\pi r^2$$

where r is the radius of a sphere

$$\pi = 3.14$$

Use this equation to calculate the mean diameter of a frog egg.

Show your working.

[2 marks]

$SA = 4\pi r^2$

$9.73 = 4\pi r^2$

$r = 0.87994$

diameter $= r \times 2$

$= 0.879 \times 2$

$= 1.76$ mm

Diameter = 1.76 mm

The scientist calculated the ratio of surface area to mass for eggs, tadpoles and frogs. He also determined the mean rate of oxygen uptake by tadpoles and frogs.

His results are shown in **Table 2**.

Table 2

Stage of frog development	Ratio of surface area to mass	Mean rate of oxygen uptake / μmol g^{-1} h^{-1}
Egg	2904 : 1	no information
Tadpole	336 : 1	5.7
Adult	166 : 1	1.3

0 3 . 3 The scientist used units of μmol g^{-1} h^{-1} for the rate of oxygen uptake.

Suggest why he used μmol in these units.

[1 mark]

The mass of oxygen is very small so μmol is the appropriate units to use. Also, it's the standard for measuring oxygen uptake.

0 3 . 4 The scientist decided to use the ratio of surface area to mass, rather than the ratio of surface area to volume. He made this decision for practical reasons.

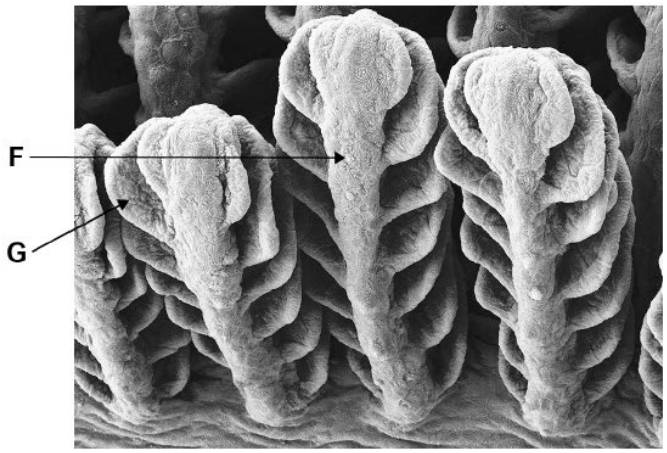
Suggest **one** practical advantage of measuring the masses of frog eggs, tadpoles and adults, compared with measuring their volumes.

[1 mark]

It is easier to measure mass of living organisms rather than volume as their shapes are not perfect (i.e. not spheres /cubes).

0 6 **Figure 4** is an image of a fish gill taken using a scanning electron microscope.

Figure 4



0 6 . 1 Identify structures labelled **F** and **G**.

[1 mark]

F gill filament

G lamallae

0 6 . 2 Describe and explain the advantage of the counter-current principle in gas exchange across a fish gill.

[3 marks]

The counter current exchange system means that water flowing over the gills and blood in the gill filaments flow in opposite directions This maintains a high concentration gradient of oxygen over the entire gill filament which means that oxygen constantly diffuses down its concentration gradient from the water into the blood supply.

0 5 . 1 Describe and explain the mechanism that causes lungs to fill with air.

[3 marks]

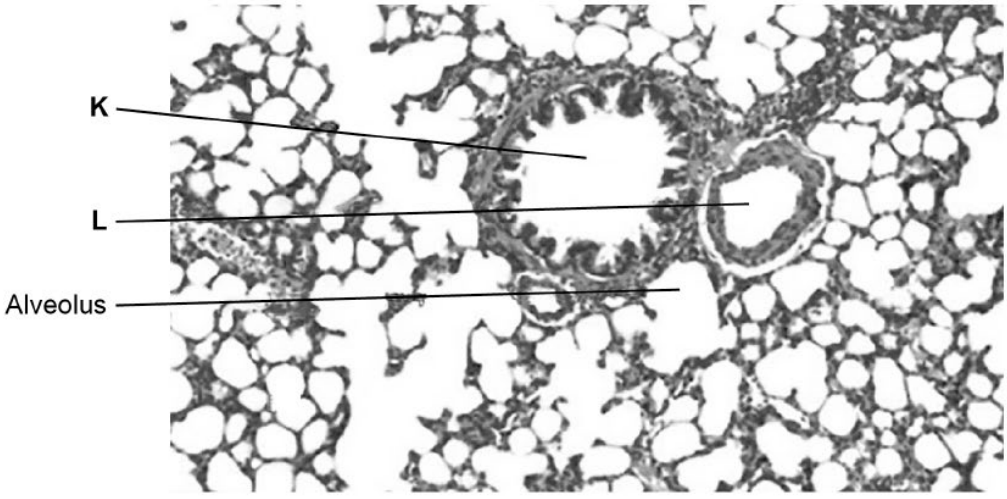
Inhalation is the process by which lungs fill with air. When we breathe in, the rib cage moves upwards and outwards as the volume in the lungs increases. This causes the pressure in the lungs to decrease, so the pressure is now lower than the external pressure. Therefore, air moves into the lungs, down the pressure gradient, as the diaphragm flattens.

A scientist observed sections of lung tissue using an optical microscope.

Figure 5 shows one of these sections.

K is an air-filled tube and **L** is a blood vessel.

Figure 5



0 5 . 2 Identify the structures labelled **K** and **L**.

[1 mark]

K bronchiole

L capillary

0 1 . 1 Describe the role of enzymes in the digestion of proteins in a mammal.

[4 marks]

Enzymes such as protease break down proteins into amino acids. The enzyme has an active site which the substrate fits into to form an enzyme-substrate complex. The enzyme's active site is complementary in shape to the substrate, forming a perfect match.

The substrate is broken down into the products, which are then released. The amino acids are absorbed into the bloodstream from the ileum of the small intestine.

Different types of peptidases are involved in the hydrolysis of proteins, including endopeptidases, exopeptidases and dipeptidases.

Scientists investigated how the diet of rabbits affected their digestion and absorption of protein. The scientists fed rabbits an identical mass of food but varied the percentage of protein in the food.

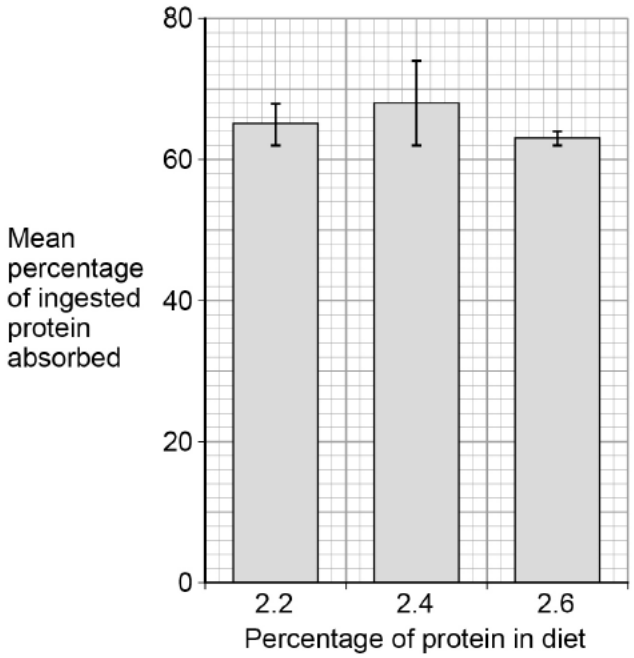
The scientists measured the mean mass of protein fed to the rabbits that was absorbed, which they then expressed as a percentage value.

The scientists' results are shown in **Figure 1**.

The error bars show ± 2 standard deviations.

± 2 standard deviations cover 95% of the data.

Figure 1



0 1 . 2 What can you conclude about the absorption of the products of protein digestion as the percentage of protein increased in the rabbits' food?

[3 marks]

The data in the table suggests that there is no significant difference between the percentages of protein in the diet and mean % of ingested protein absorbed. This is because the error bars of all three protein percentages overlap, suggesting the differences in % of protein absorbed are due to chance / random variation. Therefore we can conclude that increasing the percentage of protein in the diet has no effect on mean percentage of ingested protein absorbed.

0 3 . 1 Explain how an arteriole can reduce the blood flow into capillaries.

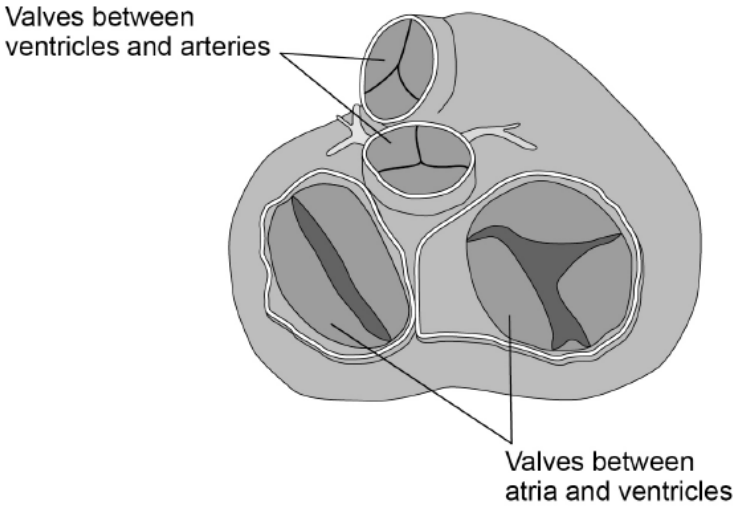
[2 marks]

The lumen of an arteriole is narrower than the lumen of arteries, and the walls are thinner, so as the blood flows from the arteries into the arterioles, blood pressure decreases and blood flow slows. This ensures the capillaries aren't damaged and there's maximum time for absorption and gas exchange.

Figure 1 shows heart valves during one stage of a cardiac cycle.

Ventricles are visible through the open valves.

Figure 1



0 3 . 2 What can you conclude from the appearance of valves in **Figure 1** about heart muscle activity and blood movement between:

1. ventricles and arteries?

[2 marks]

Blood flows more slowly between ventricles and arteries as the gaps between the values are much narrower, so the heart muscle isn't pumping as hard or fast.

2. atria and ventricles?

[2 marks]

The gaps in the values between the ventricles and atria are much wider so blood is flowing much faster and the heart muscle is pumping very hard.

0 3 . 3 Tick (✓) **one** box next to the blood vessel carrying blood at the lowest blood pressure.

[1 mark]

Capillary	✓
Pulmonary vein	
Renal vein	
Vena cava	

0 3 . 4 A scientist measured the heart rate and the volume of blood pumped in a single heart beat (stroke volume) of an athlete before exercise and calculated the cardiac output.

Cardiac output is calculated using this equation.

cardiac output = heart rate × stroke volume

Her results are shown in **Table 1**.

Table 1

Heart rate / beats minute^{-1}	Stroke volume / cm^3	Cardiac output / cm^3 minute^{-1}
62	80	4960

After exercise, the athlete's stroke volume increased by 30% and the cardiac output was 13 832 cm^3 minute^{-1}

Calculate the athlete's heart rate after exercise.

Give the answer to 2 significant figures. Show your working.

[2 marks]

30 % of 80 = 0.3 × 80 = 24

new stroke volume = 104

new cardiac output = 13832

$$\text{heart rate} = \frac{\text{cardiac output}}{\text{stroke volume}}$$

$$= \frac{13832}{104}$$

$$= 133 \text{ cm}^3 \text{ min}^{-1}$$

$$= 130 \text{ cm}^3 \text{ min}^{-1}$$

0 8 . 1 A scientist measured the pressure in a phloem tube in a willow plant stem.
He repeated his measurements to obtain nine readings.

His results are shown in **Table 3**.

Table 3

Phloem pressure / arbitrary units								
7.4	8.0	7.0	8.6	8.2	9.3	7.4	9.1	8.8

The percentage error of the mean phloem pressure in this phloem tube is calculated using this equation.

$$\text{Percentage error} = \frac{\text{uncertainty in measurement}}{\text{mean}} \times 100$$

The uncertainty in measurement is half the range of the measured values.

Calculate the percentage error of the mean phloem pressure in this phloem tube.

Show your working.

[2 marks]

mean = 8.2 range = 9.3 − 7.0 = 2.3

percentage error = $\left(\frac{1.15}{8.2}\right) \times 100 = 14.0243\ldots$

Percentage error 14 %

0 8 . 2 The mass flow hypothesis is used to explain the movement of substances through phloem.

Use your understanding of the mass flow hypothesis to explain how pressure is generated inside this phloem tube.

[3 marks]

Sucrose moves from the source (a photosynthesising leaf or storage organ) into the companion cell of the phloem sieve tube and then is actively transported into the phloem sieve tube using ATP. This increases the solute concentration in the sieve tube and therefore decreases the water potential, causing water to move by osmosis from the surrounding xylem tubes into the sieve tube, down the water potential gradient. This increases the hydrostatic pressure and creates a high hydrostatic pressure at the source. As the solutes move down towards the sink (e.g. the roots), sucrose leaves the phloem sieve tube by diffusion, increasing the water potential and causing water to move out by osmosis. This creates a low hydrostatic pressure at the sink, therefore resulting in a pressure gradient.

0 6 . 1 Describe how mRNA is produced from an exposed template strand of DNA.

Do **not** include DNA helicase or splicing in your answer.

[3 marks]

RNA polymerase moves along the template strand of DNA, adding complementary RNA nucleotides to the template strand. A pairs with U, C pairs with G. Hydrogen bonds form between the bases and DNA ligase catalyses the formation of phosphodiester bonds between adjacent nucleotides.

0 6 . 2 Define the term exon.

[1 mark]

coding part of the gene

Table 3 shows **mRNA** codons for some amino acids.

Table 3

Serine	Proline	Glycine	Threonine	Alanine
UCU	CCU	GGA	ACU	GCA
UCC	CCA	GGG	ACC	GCG

0 6 . 3 **Figure 6** shows the DNA template nucleotide base sequence that determines the sequence of four amino acids.

Figure 6

AGG CGT CCT GGA
UCC GCA GGA CCU

Use information from **Table 3** and **Figure 6** to give the amino acid sequence determined by this sequence of nucleotides.

[1 mark]

serine – alanine – glycine – proline

0 6 . 4 A mutation in the nucleotide sequence shown in **Figure 6** resulted in the following amino acid sequence.

Serine Glycine Glycine Proline

A student concluded that the mutation involved the addition of one nucleotide within the sequence shown in **Figure 6**. Does information in this question support the student's conclusion? Give reasons for your answer.

[2 marks]

The information in figure 6 does not support this conclusion, as the addition of an extra nucleotide would result in a frameshift and affects all following amino acids, but this is not apparent. It seems as though there has been a base substitution from CGT to CCT.

0 8 A scientist investigated birth mass in a population of babies. She determined the birth mass (b) of babies and grouped this information into different ranges of birth mass.

Her results are shown in **Table 4**.

Table 4

Birth mass b / kg	**Range of mass / kg**	**Frequency density**
$0.0 < b \leqslant 2.0$	2.0	5 000
$2.0 < b \leqslant 2.5$	0.5	20 000
$2.5 < b \leqslant 3.0$	0.5	90 000
$3.0 < b \leqslant 3.5$	0.5	260 000
$3.5 < b \leqslant 4.5$	1.0	200 000
$4.5 < b \leqslant 5.5$	1.0	20 000

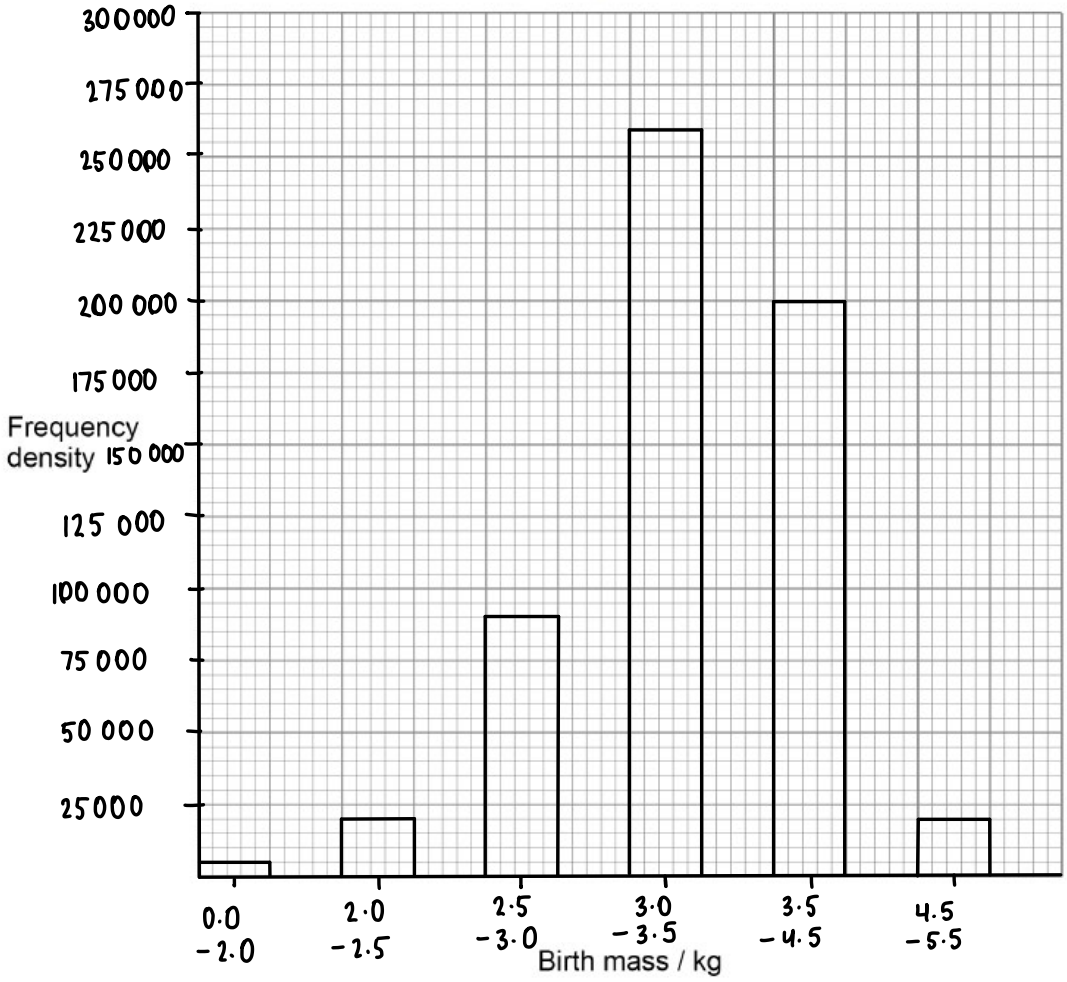
Frequency density is calculated using this equation

$$\text{Frequency density} = \frac{\text{number of babies}}{\text{range of mass}}$$

0 8 . 1 Draw, on **Figure 8**, a **suitable** chart to show the distribution of birth mass for this population of babies.

[4 marks]

Figure 8



0 8 . 2 Babies with birth mass less than 2.5 kg are classified as low birth mass.

Use information in **Table 4** and the equation to calculate the number of babies born with low birth mass in this population.

Show your working.

[2 marks]

number of babies = frequency density x range of mass
= (5000 x 2) + (20,000 x 0.5)
= 10000 + 10000
= 20000

Answer 20,000