Selecting Statistical Tests

A Level

Knowing which statistical test to use for a given dataset is an important skill to learn.

In each of the examples below, you will need to identify which statistical test to use, and the reason why this is the most appropriate test to use.

Part A Fly phenotypes

A researcher carried out a genetic cross between two flies. Both flies were heterozygous for a particular gene in which one allele is dominant to the other. The researcher counted the number of offspring with each phenotype (dominant, recessive). The numbers were different to those the researcher predicted using a Punnett square. They want to know whether this difference is significant, or simply the result of chance.

Which statistical test should they use, and why? Select one test and one reason.

- [ ] chi-squared test
- [ ] Spearman's rank correlation coefficient
- [ ] Student's unpaired t-test
- [ ] reason: this test is used to determine whether a continuous variable (number of offspring) shows a significant difference between two categories of a categorical variable (phenotype)
- [ ] reason: this test is used to compare observed frequencies to expected frequencies of a categorical variable (phenotype) and determine whether there is a significant difference
- [ ] reason: this test is used to determine whether there is a significant correlation between two continuous variables (number of offspring and phenotype)

Part B Plant growth rates

A researcher wants to investigate whether there is a difference in growth rate between two closely related plant species. They plant 20 seeds of each species in individual pots and record the growth rate of each seedling.

Which statistical test should they use, and why? Select one test and one reason.

- [ ] chi-squared test
- [ ] Spearman's rank correlation coefficient
- [ ] Student's unpaired t-test
- [ ] reason: this test is used to compare observed frequencies to expected frequencies of a categorical variable (**growth rate**) and determine whether there is a significant difference
- [ ] reason: this test is used to compare observed frequencies to expected frequencies of a categorical variable (**species**) and determine whether there is a significant difference
- [ ] reason: this test is used to determine whether a continuous variable (**growth rate**) shows a significant difference between two categories of a categorical variable (**species**)
- [ ] reason: this test is used to determine whether a continuous variable (**species**) shows a significant difference between two categories of a categorical variable (**growth rate**)
- [ ] reason: this test is used to determine whether there is a significant correlation between two continuous variables (growth rate and species)

Part C White blood cells

A researcher wants to investigate whether white blood cell count (number of white blood cells per μl) changes with age. The researcher selects 100 adults of various ages and takes a blood sample from each one to measure their white blood cell count.

Which statistical test should they use, and why? Select one test and one reason.

- [ ] chi-squared test
- [ ] Spearman's rank correlation coefficient
- [ ] Student's unpaired t-test
- [ ] reason: this test is used to compare observed frequencies to expected frequencies of a categorical variable (**white blood cell count**) and determine whether there is a significant difference
- [ ] reason: this test is used to compare observed frequencies to expected frequencies of a categorical variable (**age**) and determine whether there is a significant difference
- [ ] reason: this test is used to determine whether there is a significant correlation between two continuous variables (white blood cell count and age)
- [ ] reason: this test is used to determine whether a continuous variable (**white blood cell count**) shows a significant difference between two categories of a categorical variable (**age**)
- [ ] reason: this test is used to determine whether a continuous variable (**age**) shows a significant difference between two categories of a categorical variable (**white blood cell count**)

Part D Deer antlers

A researcher wants to investigate whether, in male deer, longer antlers are associated with having more offspring. The researcher measures the antler length of each male deer in a population, and records how many offspring each male deer has during that breeding season. This number can range from 0 to 30.

Which statistical test should they use, and why? Select one test and one reason.

- [ ] chi-squared test
- [ ] Spearman's rank correlation coefficient
- [ ] Student's unpaired t-test
- [ ] reason: this test is used to determine whether a continuous variable (**number of offspring**) shows a significant difference between two categories of a categorical variable (**antler length**)
- [ ] reason: this test is used to determine whether a continuous variable (**antler length**) shows a significant difference between two categories of a categorical variable (**number of offspring**)
- [ ] reason: this test is used to determine whether there is a significant correlation between two continuous variables (antler length and number of offspring)
- [ ] reason: this test is used to compare observed frequencies to expected frequencies of a categorical variable (**antler length**) and determine whether there is a significant difference
- [ ] reason: this test is used to compare observed frequencies to expected frequencies of a categorical variable (**number of offspring**) and determine whether there is a significant difference

Part E Mouse fur

A particular gene, involved in mouse fur colour, has two alleles. These alleles show codominance, and so each of the three genotypes produce a unique phenotype. A researcher wants to investigate whether, in a particular mouse population, this gene follows the Hardy-Weinberg principle. This principle states that, if p represents the proportion of one allele in a population, and q represents the proportion of the other allele in the population, the proportions of the three genotypes will be p^2, $2pq$, and q^2. The researcher counts the number of mice with each phenotype and compares these numbers to those predicted by the Hardy-Weinberg principle.

Which statistical test should they use, and why? Select one test and one reason.

- [ ] chi-squared test
- [ ] Spearman's rank correlation coefficient
- [ ] Student's unpaired t-test
- [ ] reason: this test is used to determine whether a continuous variable (number of mice) shows a significant difference between two categories of a categorical variable (fur colour)
- [ ] reason: this test is used to determine whether there is a significant correlation between two continuous variables (fur colour and number of mice)
- [ ] reason: this test is used to compare observed frequencies to expected frequencies of a categorical variable (fur colour) and determine whether there is a significant difference

Part F Gene expression

A researcher wants to investigate whether there is a difference in gene expression level (of a particular gene) between healthy cells and cancer cells. They measure the number of RNA molecules produced by this gene in 7 healthy tissue samples and in 7 cancerous tissue samples.

Which statistical test should they use, and why? Select one test and one reason.

- [ ] chi-squared test
- [ ] Spearman's rank correlation coefficient
- [ ] Student's unpaired t-test
- [ ] reason: this test is used to compare observed frequencies to expected frequencies of a categorical variable (**number of RNA molecules**) and determine whether there is a significant difference
- [ ] reason: this test is used to compare observed frequencies to expected frequencies of a categorical variable (**tissue type**) and determine whether there is a significant difference
- [ ] reason: this test is used to determine whether there is a significant correlation between two continuous variables (number of RNA molecules and tissue type)
- [ ] reason: this test is used to determine whether a continuous variable (**number of RNA molecules**) shows a significant difference between two categories of a categorical variable (**tissue type**)
- [ ] reason: this test is used to determine whether a continuous variable (**tissue type**) shows a significant difference between two categories of a categorical variable (**number of RNA molecules**)

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Nervous Systems Revision

A Level

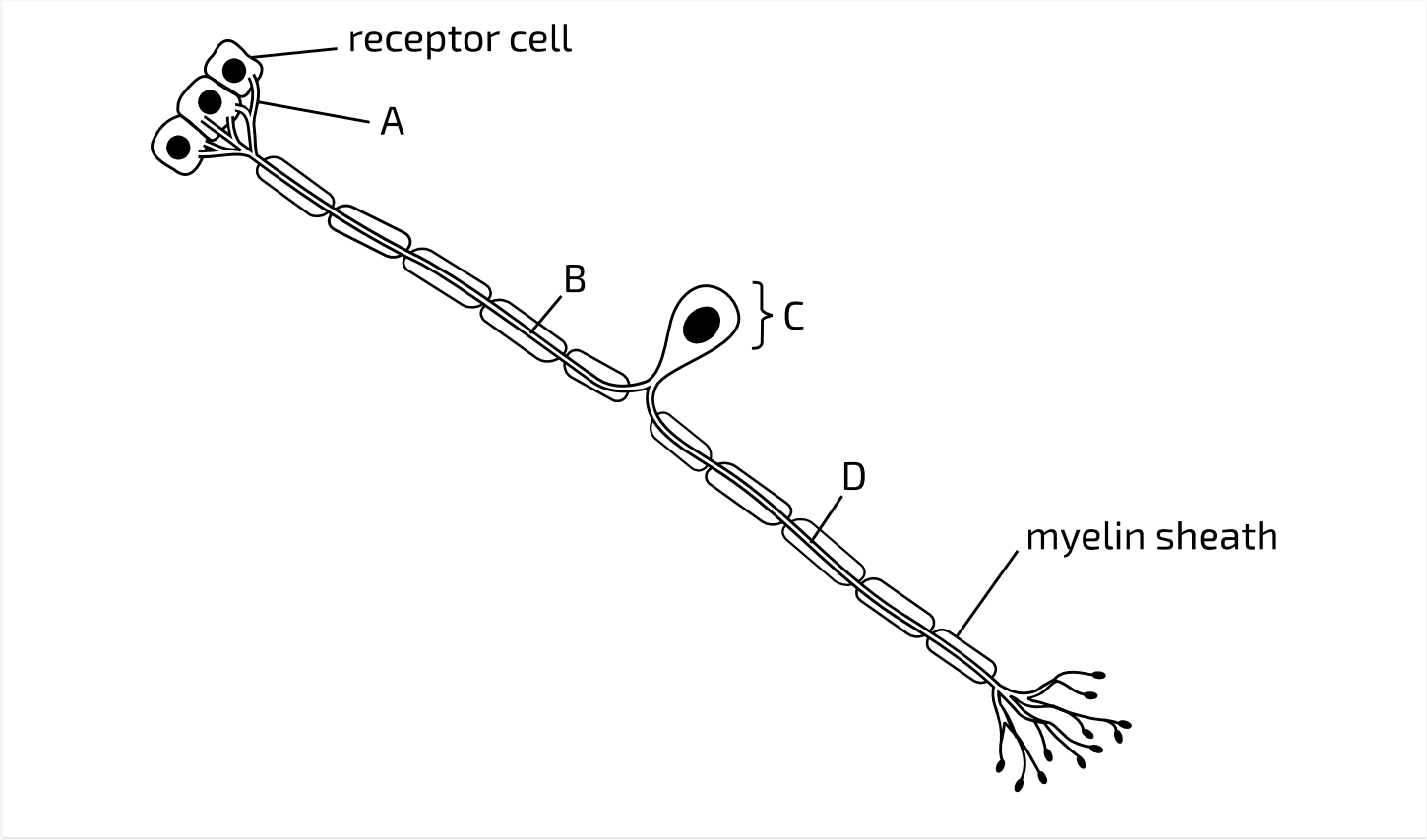

Figure 1: Diagram of a sensory neurone.

Part A Label the diagram

What is the name of part A in **Figure 1**?

What is the name of part B in **Figure 1**?

What is the name of part C in **Figure 1**?

What is the name of part D in **Figure 1**?

Part B Name the gaps

What is the name for the gaps in the myelin sheath?

Part C Signal propagation

In which direction(s) would an action potential be propagated in **Figure 1**? Select all that apply.

- [ ] From A to B
- [ ] From B to A
- [ ] From B to D
- [ ] From C to B
- [ ] From D to B

Part D Action potential

Drag the items below into the correct order on the right to show how an action potential occurs.

Available items

- Voltage-gated K^+ channels open and voltage-gated Na^+ channels close
- This region of the membrane becomes **hyperpolarised**
- Voltage-gated K^+ channels close and this region of the membrane returns to resting membrane potential
- K^+ ions move **out of** the cell and **repolarise** this region of the membrane
- Na^+ channels open
- Na^+ ions move **into** the cell and **depolarise** this region of the membrane (also causing Na^+ channels further along to open, triggering an action potential at that point)

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Gameboard:
STEM SMART Biology Week 47 - Revision - Organ Systems

Sensory Neurone Stimulation

A Level

Figure 1 shows a sensory neurone that receives input from three sensory receptor cells.

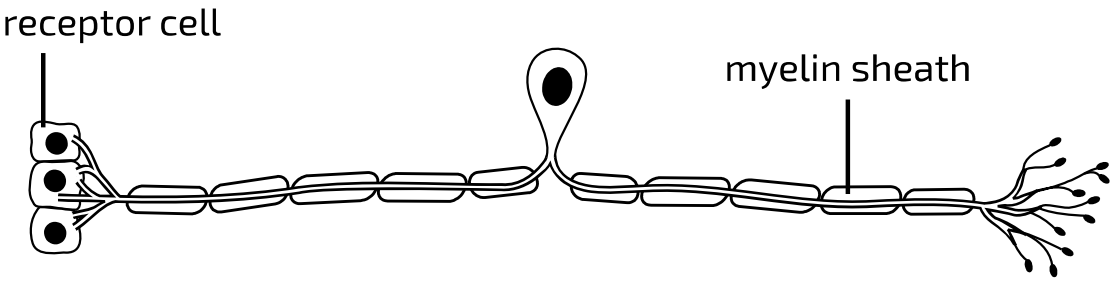

Figure 1: Diagram of a sensory neurone.

Part A Myelin sheath

Which of the following statements explain how the myelin sheath increases the speed of conduction of nerve impulses? Select all that apply.

- [ ] myelin acts as a conductor, allowing ion movement across the axon membrane
- [ ] myelin acts as an insulator, preventing ion movement across the axon membrane
- [ ] myelin acts as a neurotransmitter, transmitting the nerve impulse from one neurone to another
- [ ] ions can only move across the membrane at gaps in the myelin sheath, meaning nerve impulses "jump" from one gap to the next
- [ ] ions can only move across the membrane where there is myelin, meaning nerve impulses "jump" from one myelin bundle to the next

Part B Stimuli & action potentials

Figure 2 shows the changes in the membrane potential of a sensory neurone when the receptor cells are stimulated, as well as the strength of each stimulus.

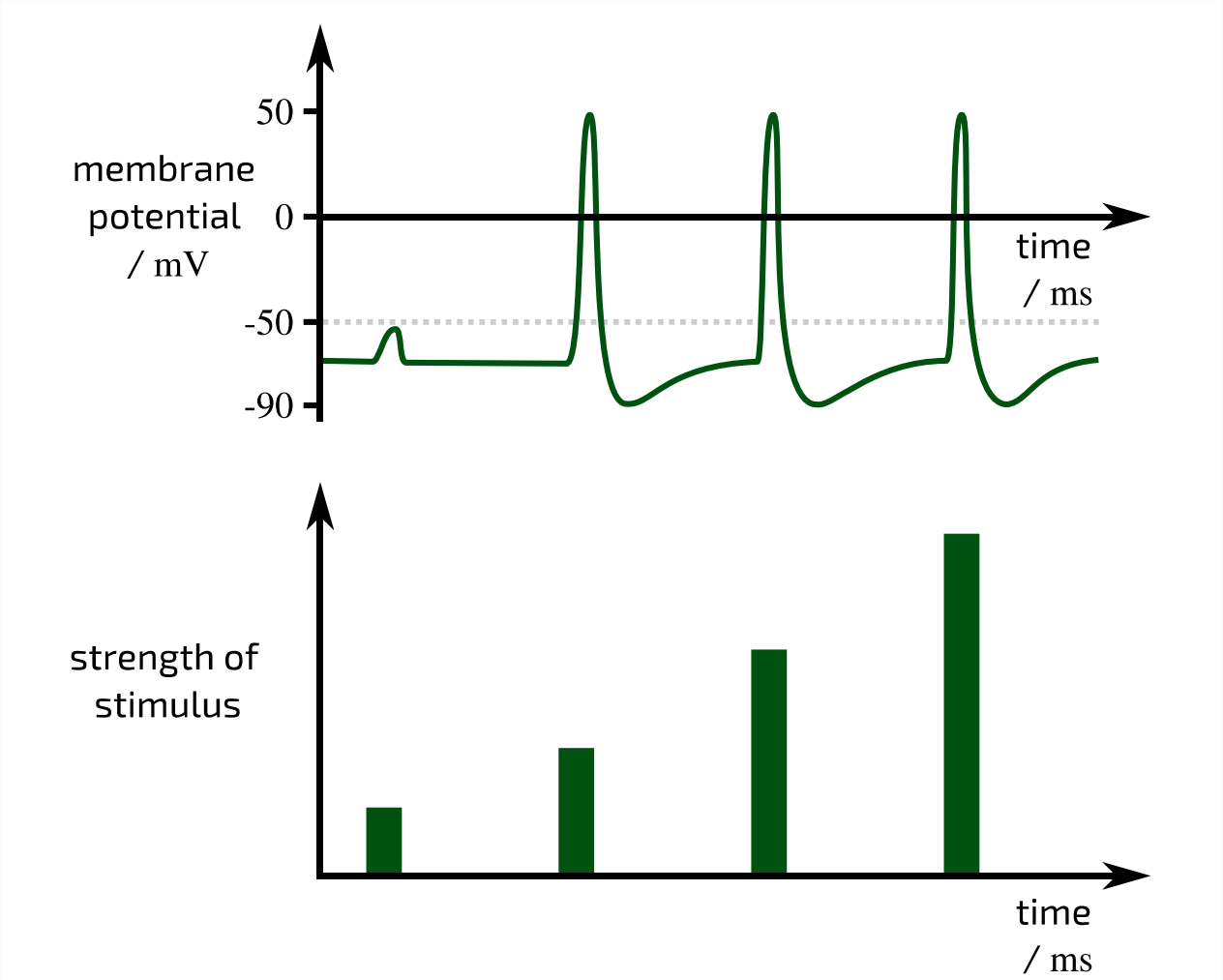

Figure 2: Changes in sensory neurone membrane potential over time in response to stimuli of different strengths being applied to sensory receptor cells.

Which of the following statements explain the relationship between the strength of the stimulus and the resulting action potential? Select all that apply.

- [ ] there is a directly proportional relationship between the strength of the stimulus and the strength of the action potential
- [ ] the action potentials produced by the neurone cause the strength of the stimulus to increase over time
- [ ] if the stimulus is **not** strong enough to increase the membrane potential above a certain threshold ($-50\,\mathrm{mV}$), then only a **weak** action potential is produced
- [ ] if the stimulus is **not** strong enough to increase the membrane potential above a certain threshold ($-50\,\mathrm{mV}$), then **no** action potential is produced
- [ ] if the stimulus is strong enough to increase the membrane potential above a certain threshold ($-50\,\mathrm{mV}$), then an action potential is produced
- [ ] if the stimulus is strong enough to increase the membrane potential above a certain threshold ($-50\,\mathrm{mV}$), then the resting membrane potential becomes positive rather than negative

Adapted with permission from CIE A Level Biology, June 2016, Paper 4, Question 8

Gameboard:

STEM SMART Biology Week 47 - Revision - Organ Systems

Muscular Systems Revision

A Level

Part A Neuromuscular junction

Drag the items below into the correct order on the right to show how a motor neurone triggers muscle contraction at a neuromuscular junction.

Available items

- voltage-gated Ca^{2+} channels in the membrane of the sarcoplasmic reticulum open and Ca^{2+} ions move out into the sarcoplasm
- Ca^{2+} ions in the sarcoplasm allow myosin to bind to (and pull) actin in the sarcomeres, causing muscle contraction
- neurotransmitters are released into the synaptic cleft and bind to Na^{+} channels on the sarcolemma
- voltage-gated Ca^{2+} channels in the membrane of the axon terminal open and Ca^{2+} ions move in
- vesicles containing neurotransmitters fuse with the axon terminal membrane
- Na^{+} channels on the sarcolemma open and Na^{+} ions move in to the sarcoplasm

Part B Muscle contraction

Which of the following statements about muscle contraction are correct? Select all that apply.

- [ ] ATP binds to actin, allowing it to bind to myosin and enabling muscle contraction
- [ ] thick filaments (myosin) pull thin filaments (actin) **out** towards the **edges** of each sarcomere
- [ ] muscle contraction is triggered by the release of Na^{+} ions from the sarcoplasmic reticulum
- [ ] thick filaments (myosin) pull thin filaments (actin) **in** towards the **centre** of each sarcomere
- [ ] Ca^{2+} ions are required to free up myosin-binding sites on the thin filaments (actin)
- [ ] ATP binds to myosin heads, causing them to detach them from actin and enabling further muscle contraction

Part C Energy expenditure

Muscle cells primarily use glycogen to provide the energy they need. Glycogen is broken down into glucose, which is used in respiration to produce ATP.

An individual ("individual A") undergoes $45\ \mathrm{minutes}$ of high-intensity exercise. During this exercise, their muscles break down, on average, $2\ \mathrm{g}$ of stored glycogen per minute.

How many molecules of ATP did individual A's muscles produce during this period of exercise?

Assume that:

- an average molecule of glycogen is composed of $30\,000$ glucose molecules
- each molecule of glucose produces 30 ATP molecules during aerobic respiration
- all of the glucose molecules that are produced are aerobically respired
- the muscles are only using stored glycogen to produce ATP

Give your answer to 1 significant figure.

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Digestive and Excretory Systems Revision

A Level

Part A Insulin & glucagon

Fill in the table below to show the differences between insulin and glucagon.

	Insulin	Glucagon
Released from...		
Released in response to...		
Glycogen is...		

Items:

α cells | β cells | high glucose blood levels | low glucose blood levels | produced from glucose | broken down into glucose

Part B ADH

Which of the following statements about antidiuretic hormone (ADH) are correct? Select all that apply.

- [ ] It is released into the bloodstream from the adrenal glands
- [ ] It is released into the bloodstream from the posterior pituitary gland
- [ ] It is released in response to an **increase** in blood water potential
- [ ] It is released in response to a **decrease** in blood water potential
- [ ] It causes an **increase** in water reabsorption by the cells lining the collecting ducts of the nephrons
- [ ] It causes a **decrease** in water reabsorption by the cells lining the collecting ducts of the nephrons
- [ ] An increase in ADH causes **more** urine to be produced (and causes the urine to be more dilute)
- [ ] An increase in ADH causes **less** urine to be produced (and causes the urine to be more concentrated)

Part C Ultrafiltration part 1

The table below shows the concentration of some of the components of blood, glomerular filtrate and urine.

Component	Blood $(\mathrm{g}/100\mathrm{cm}^3)$	Glomerular filtrate $(\mathrm{g}/100\mathrm{cm}^3)$	Urine $(\mathrm{g}/100\mathrm{cm}^3)$
Glucose	0.10	0.10	0.00
Urea	0.03	0.03	1.80
Amino acids	0.05	0.05	0.00
Large proteins	8.00	0.00	0.00
Inorganic ions (total)	0.90	0.90	variable, up to 3.60

Which of the following statements explain the changes in fluid composition shown in the table above?

- [ ] all of the urea and inorganic ions are reabsorbed in the proximal convoluted tubules
- [ ] large molecules cannot be filtered out of the blood, whereas small molecules and ions can be
- [ ] all of the glucose and amino acids are reabsorbed in the proximal convoluted tubules
- [ ] water is reabsorbed in the collecting ducts
- [ ] glucose and amino acids do not pass from the glomerulus to the Bowman's capsule
- [ ] urea and inorganic ions cannot be reabsorbed in the nephrons

Part D Ultrafiltration part 2

The table below shows the concentration of some of the components of blood, glomerular filtrate and urine.

Component	Blood ($\mathrm{g}/100\mathrm{cm}^3$)	Glomerular filtrate ($\mathrm{g}/100\mathrm{cm}^3$)	Urine ($\mathrm{g}/100\mathrm{cm}^3$)
Glucose	0.10	0.10	0.00
Urea	0.03	0.03	1.80
Amino acids	0.05	0.05	0.00
Large proteins	8.00	0.00	0.00
Inorganic ions (total)	0.90	0.90	variable, up to 3.60

Calculate the percentage increase in urea concentration from the blood to the urine. Give your answer to the nearest percent.

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STEM SMART Biology Week 47 - Revision - Organ Systems

Immune Systems Revision

A Level

Part A Cell type & response type

What type of cell secretes antibodies?

Antibodies are released as part of an adaptive immune response. What is the name given to this particular type of adaptive immune response that involves the release of antibodies?

Part B Variable region

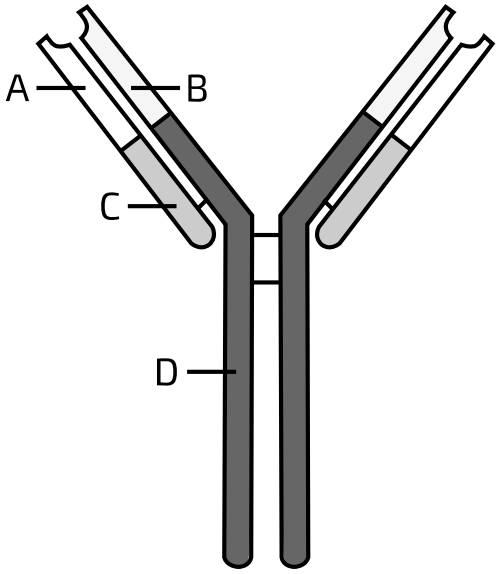

Figure 1: Antibody structure. Four parts of the left side of the antibody are labelled (A-D).

Which letter(s) in **Figure 1** represent(s) the **variable region**?

- [ ] A
- [ ] B
- [ ] C
- [ ] D

Part C Secondary immune response

Why are secondary immune responses faster than primary immune responses? Select all that apply.

- [ ] during a primary immune response, specific memory B cells are produced which continue to circulate in the blood for many years
- [ ] memory B cells can produce and secrete antibodies into the bloodstream faster than naïve B cells
- [ ] the existing antibodies replicate themselves to produce more antibodies
- [ ] activation of immune cells (by binding to antigens) occurs more quickly
- [ ] the antibodies produced in the primary immune response continue to circulate in the blood for many years
- [ ] memory B cells divide and differentiate into plasma cells (effector B cells) more quickly than naïve B cells do

Part D Cell-mediated immune response

Antibodies inactivate and tag pathogens that are found outside of cells (e.g. in the bloodstream). What is the name of the cell type that destroys pathogens that are inside the body's cells by killing those infected cells?

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Gameboard:
STEM SMART Biology Week 47 - Revision - Organ Systems

Animal Cells, Tissues, and Organs

A Level

Name the cell/tissue/organ that is described in each of the following statements.

Part A Blood vessel A

The blood vessel that transports deoxygenated blood from the heart.

Part B Cell B

The cell that ingests and digests cell debris and bacteria in the lungs.

Part C Cell C

The cell that secretes antibodies.

Part D Cell D

The epithelial cell that secretes mucus in the trachea.

Part E **Tissue E**

The tissue that prevents the collapse of the trachea during inhalation.

Part F **Organ F**

The accessory organ of digestion that regulates blood glucose levels.

Adapted with permission from CIE AS Level Biology, June 2012, Paper 2, Question 1