



## **Instructions:**

1. Navigate to the lesson on Standard Deviation [AQA](#) | [OCR](#) | [Edexcel](#)
2. Choose a traffic light colour for how confident you currently feel about answering exam questions on standard deviation.
3. If you chose **RED**
  - watch the lesson video and write notes before starting this question pack
4. If you chose **AMBER** > Do the quiz
  - if your score is less than 50% > watch the lesson video and write notes
  - if your score is more than 50% > start this question pack
5. If you chose **GREEN** > start this question pack

## **How to use this question pack:**

- You do not need to do all the questions
- If you get stuck remember to check the standard deviation video lesson
- Spend 10 minutes on standard deviation graph questions
- Spend 10 minutes on standard deviation table questions
- Try the extension question
- Mark your answers
- Review the trends and repeats between the mark scheme answers
- Summarise the things you've learned on your revision notes
- Update your traffic light on the standard deviation lesson to reflect how confident you feel now
- Leave a comment telling me the things you've learned and feedback on the exercise
- For more questions check out the Statistics Skills Revision Pack [AQA](#) | [OCR](#) | [Edexcel](#) and/or finish the rest of the questions in this pack

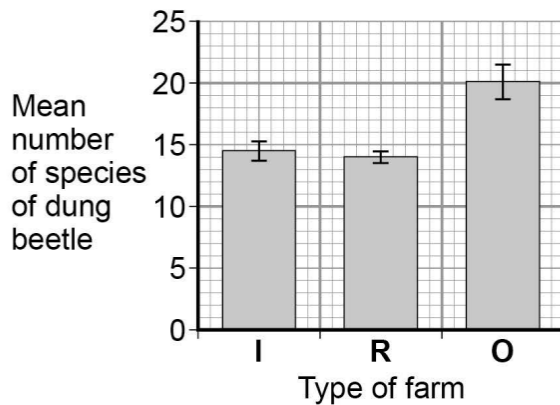


**0 4**

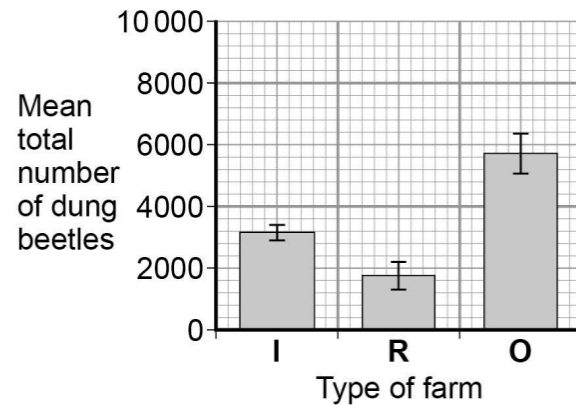
Scientists investigated the effect of different types of animal farming on the diversity and number of dung beetles. They determined the number of dung beetle species and their total number on intensive (I), rough grazing (R) and organic (O) farms.

Figure 4 and Figure 5 show some of their results.

**Figure 4**



**Figure 5**



Key: I Standard deviation

**0 4 . 3**

Explain what the standard deviations suggest about the difference in mean total number of dung beetles between the different types of farm.

**[2 marks]**

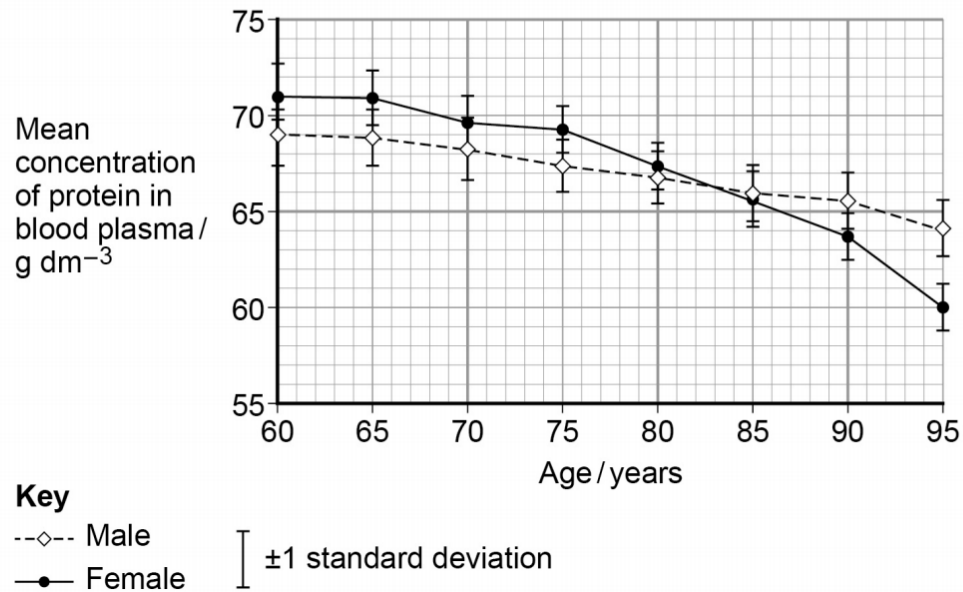


0 4

Scientists investigated how the concentration of protein in blood plasma changes in people between the ages of 60 and 95.

**Figure 4** shows the scientists' results. The bars show  $\pm 1$  standard deviation.

**Figure 4**



0 4 . 3

What can you conclude from **Figure 4** about the effect of ageing on the mean concentration of protein in the blood plasma in males and females?

**[2 marks]**



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.

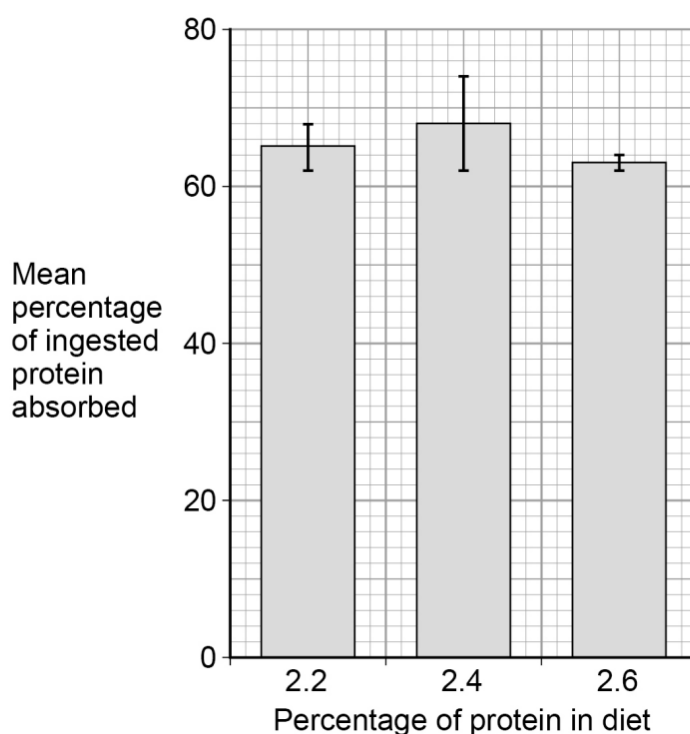
The scientists measured the mean mass of protein fed to the rabbits that was absorbed, which they then expressed as a percentage value.

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

The error bars show  $\pm 2$  standard deviations.

$\pm 2$  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?

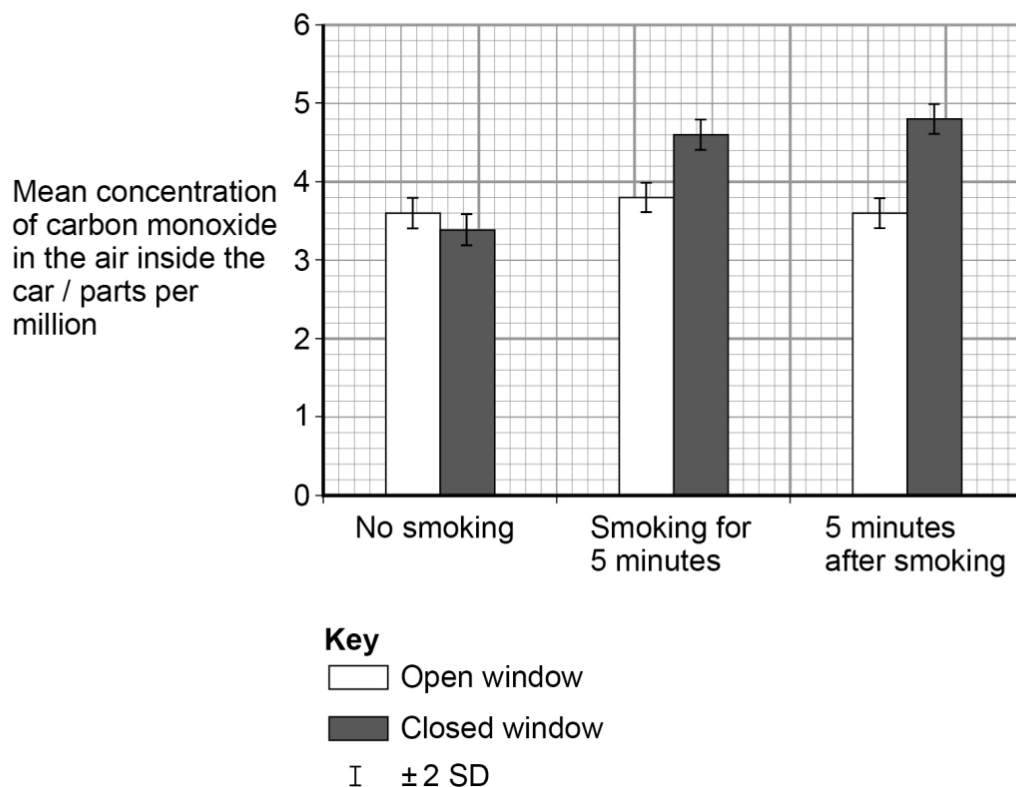
**[3 marks]**



Carbon monoxide is a poisonous gas that is present in cigarette smoke. This carbon monoxide can be absorbed into the blood where it binds with haemoglobin.

Scientists investigated the concentration of carbon monoxide in cars in which people were smoking or not smoking. They measured the concentration with the car windows open and closed. **Figure 7** shows the scientists' results as they presented them. A value of  $\pm 2$  standard deviations from the mean includes over 95% of the data.

**Figure 7**



09.3

In England, in October 2015, a law was introduced making it illegal to smoke in a car carrying someone who is under the age of 18.

Following the introduction of the law, a politician stated:

'It is dangerous to smoke when a child is in the car. Higher levels of deadly toxins can build up, even on short journeys, and children breathe faster than adults, meaning they inhale more of the deadly toxins.'

Use the information provided **and** the data in **Figure 7** to evaluate the politician's statements.

**[4 marks]**



**26** The protease enzyme bromelain can be extracted from pineapples. A student investigated the effect of changing the concentration of the enzyme and measured the time taken to break down the protein gelatine.

(b) The data from the student's experiment is shown in Table 26.

Concentration of bromelain (%)	Rate of protein digestion ( $s^{-1}$ )	Standard deviation
0.010	0.0037	0.00014
0.025	0.0090	0.00034
0.050	0.0155	0.00260
0.075	0.0184	0.00371
0.100	0.0198	0.00340

(ii) Explain what the standard deviation shows in Table 26.

[2]

**2** A student investigated the effect of caffeine on human heart rate.

Three males of the same age were given cups of coffee containing caffeine. Their heart rates were measured 10 minutes after drinking the coffee.

Two hours later they were given cups of coffee with no caffeine and after 10 minutes their heart rates were measured.

The results are shown in the table.

Male	Heart rate / beats $min^{-1}$	
	Coffee containing caffeine	Coffee with no caffeine
1	75	72
2	78	71
3	70	70
Mean $\pm$ sd	74 $\pm$ 4	71 $\pm$ 1

(a) The student concluded that caffeine increases human heart rate.

Analyse the data to explain why these results may not support the conclusion.

(3)



6 Anabolic steroids and testosterone have been used as performance-enhancing drugs by some athletes. These drugs can increase muscle mass and strength.

(a) An investigation was carried out to assess the effect of doses of testosterone on muscle size.

A group of men was randomised into four groups: A, B, C and D. Groups A and B were given a placebo. Groups C and D were both given doses of testosterone. Groups A and C had no exercise training. Groups B and D were given exercise training.

The cross-sectional area of the triceps muscle of each individual was measured at the start of the investigation and after 10 weeks.

The results are shown in the table.

Muscle	Mean cross-sectional area of muscle / mm <sup>2</sup> ± SD			
	Group A Placebo without exercise	Group B Placebo with exercise	Group C Testosterone without exercise	Group D Testosterone with exercise
Triceps – at the start	3621 ± 213	4052 ± 262	3579 ± 260	3483 ± 217
Triceps after 10 weeks	3539 ± 226	4109 ± 230	4003 ± 229	3984 ± 239

(i) Deduce the effect of testosterone on the size of the triceps muscle.

(2)



**0 5 . 3** **Table 1** shows how the scientists published their results. They calculated mean values and two times the standard deviation (SD) of the mean.

Two standard deviations above and below the mean includes 95.4% of the data.

**Table 1**

Group of animals	Mean number of animals per m <sup>2</sup> ( $\pm 2 \times \text{SD}$ )		Mean number of species per m <sup>2</sup> ( $\pm 2 \times \text{SD}$ )	
	Soil under wheat crop	Soil under grassy strips	Soil under wheat crop	Soil under grassy strips
Beetles	41.2 ( $\pm 6.4$ )	80.1 ( $\pm 10.1$ )	10.0 ( $\pm 1.6$ )	17.3 ( $\pm 1.0$ )
Centipedes	18.4 ( $\pm 3.6$ )	13.5 ( $\pm 1.0$ )	1.8 ( $\pm 0.3$ )	2.1 ( $\pm 0.2$ )
Earthworms	244.5 ( $\pm 27.1$ )	281.2 ( $\pm 39.4$ )	3.8 ( $\pm 0.3$ )	5.1 ( $\pm 0.2$ )
Millipedes	38.4 ( $\pm 12.2$ )	36.2 ( $\pm 2.9$ )	3.5 ( $\pm 0.3$ )	3.2 ( $\pm 0.2$ )
Woodlice	0.0	73.9 ( $\pm 8.5$ )	0.0	2.8 ( $\pm 0.2$ )

**0 5 . 4** A summary of this research was published in a farming magazine. The journalist concluded that creating grassy strips around fields had little effect on the diversity of soil animals.

Do you agree with this conclusion?

Use evidence from **Table 1** to justify your answer.

**[4 marks]**





Cell walls make up much of the fibre that people eat.

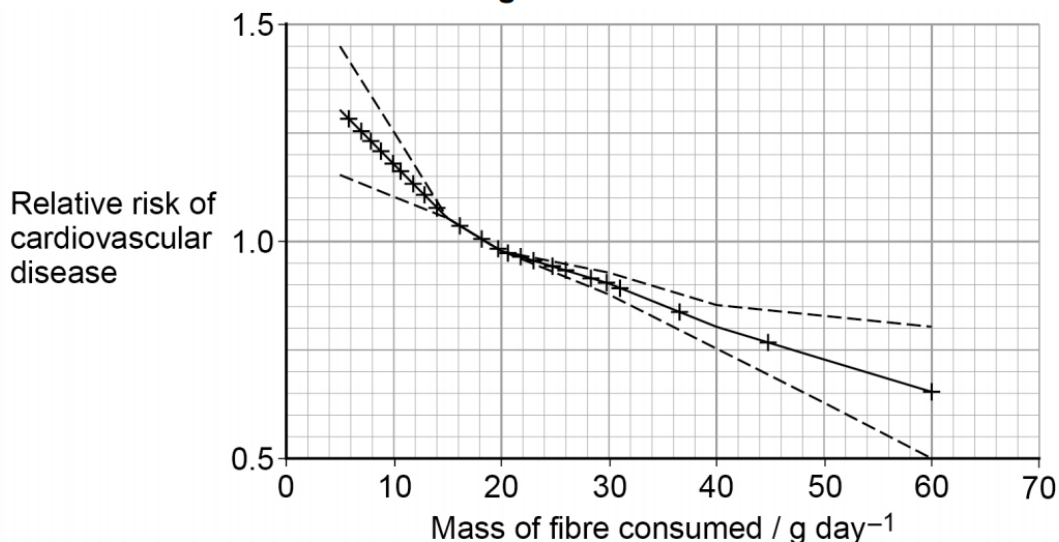
Scientists investigated the relationship between the mass of fibre people ate each day and their risk of cardiovascular disease (CVD).

They gathered data from a large sample of people and used this to calculate a relative risk.

- A relative risk of 1 means there is no difference in risk between the sample and the whole population.
- A relative risk of  $< 1$  means CVD is less likely to occur in the sample than in the whole population.
- A relative risk of  $> 1$  means CVD is more likely to occur in the sample than in the whole population.

Their results are shown in **Figure 3**. A value of  $\pm 2$  standard deviations from the mean includes over 95% of the data.

**Figure 3**



**Key**

— Mean relative risk

--- Line of best fit showing  $\pm 2$  standard deviations from the mean

Each '+' plotted point represents 1000 people

**0 2 . 2** A student concluded from **Figure 3** that eating an extra 10 g of fibre per day would significantly lower his risk of cardiovascular disease.

outside the  
box

Evaluate his conclusion.

**[4 marks]**

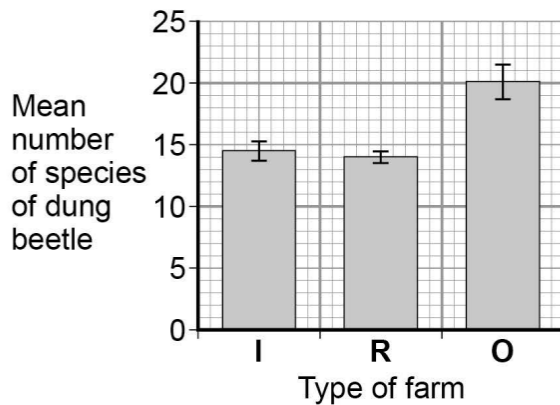


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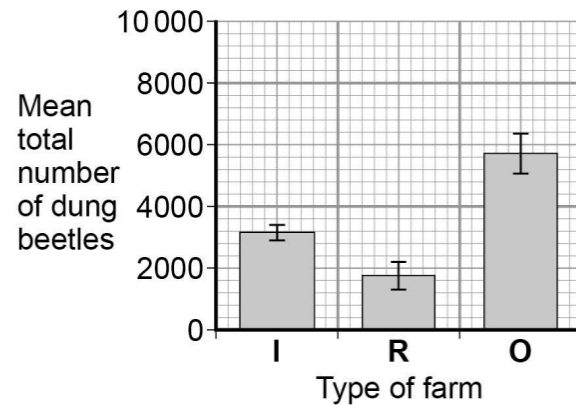
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**Figure 4**



**Figure 5**



**Key:** I Standard deviation

**0 4 . 3**

Explain what the standard deviations suggest about the difference in mean total number of dung beetles between the different types of farm.

**[2 marks]**

1. No overlap in standard deviations;
2. (Difference in mean total) significant/is not due to chance/is real;

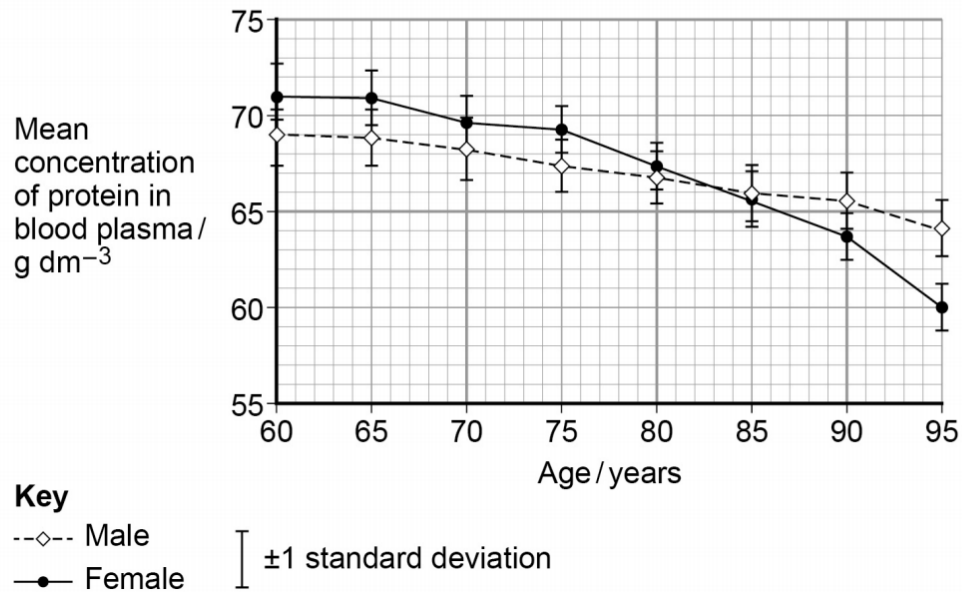


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Scientists investigated how the concentration of protein in blood plasma changes in people between the ages of 60 and 95.

**Figure 4** shows the scientists' results. The bars show  $\pm 1$  standard deviation.

**Figure 4**



0 4 . 3

What can you conclude from **Figure 4** about the effect of ageing on the mean concentration of protein in the blood plasma in males and females?

**[2 marks]**

1. Protein content decreases with age and decreases more in females;
  2. Difference (between sexes) only significant at 95 years because SDs do not overlap;
- OR
- Differences not significant because 2 x SD would overlap;



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.

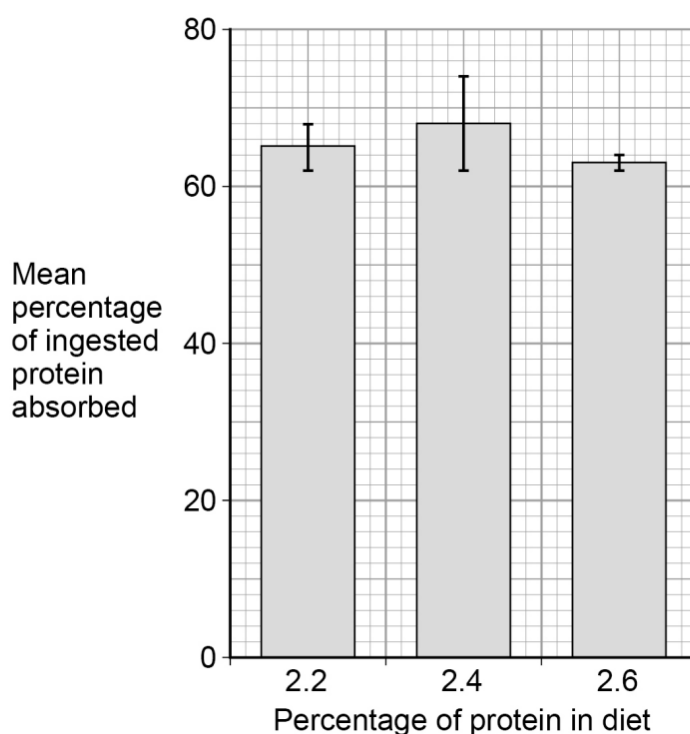
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**Figure 1**



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]**

1. No significant difference (in protein absorption);
2. (because  $\pm 2$ ) SDs overlap;
3. (So mean) percentage absorbed not affected by percentage in diet;
4. Amount of protein (in diet) is not a limiting factor

**OR**

Something else is limiting factor eg amount of protease;

5. (But) small range of protein in diet

**OR**

(Should) Investigate wider range;

Ignore reference to 'significance' unless qualified, eg 'difference'

2. Accept error bar for SD



09.3

In England, in October 2015, a law was introduced making it illegal to smoke in a car carrying someone who is under the age of 18.

Following the introduction of the law, a politician stated:

'It is dangerous to smoke when a child is in the car. Higher levels of deadly toxins can build up, even on short journeys, and children breathe faster than adults, meaning they inhale more of the deadly toxins.'

Use the information provided **and** the data in **Figure 7** to evaluate the politician's statements.

**[4 marks]**

For

1. Significantly higher concentrations of CO (compared with no smoking) with closed window (as no overlap in 2 x SD);

2. Any increase in CO could be dangerous;

OR

CO causes less oxygen to be carried / provided (which could be deadly in children);

3. (significantly) higher levels after (just) 5 minutes (with closed windows supporting short journey statement);

Against

4. No idea if (roughly) 5ppm is 'deadly';

5. No significant difference with open window (as 2 x SD overlaps);

6. No data on child breathing rates;

OR

Idea that children breathe faster but have smaller lung volume, so overall volume of CO inhaled could be similar;

1. Accept higher concentrations of CO with closed window are not due to chance
1. and 3. Idea of higher is required, not just difference
5. Accept difference with open window could be due to chance



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(ii) Explain what the standard deviation shows in Table 26.

- 1 (SD) shows spread (of data) around the mean ✓
- 2 all , data / concentrations , have small SD ✓
- 3 (so) little variation in repeats / high repeatability ✓
- 4 as concentration increases the SD increases (in first 4 concentrations) ✓
- 5 (so) as concentration increases repeatability decreases ✓

**IGNORE** reliability / accuracy  
**IGNORE** ref to 'results'

[2]

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(a) The student concluded that caffeine increases human heart rate.

Analyse the data to explain why these results may not support the conclusion.

(3)

An explanation that makes reference to the following:

- male 3 had same heart rate in both conditions so suggests no effect (1)
- standard deviations overlap so difference may be chance (1)
- caffeine concentration unknown / sample size small so may be unrepresentative (1)



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(i) Deduce the effect of testosterone on the size of the triceps muscle.

(2)

An answer that makes reference to two of the following:

1. increase in cross sectional area with testosterone (and not with placebo) (1)
2. greatest increase with testosterone and exercise (1)
3. significant difference for { testosterone plus exercise / group D } as the SDs (for start and after 10 weeks) do not overlap (1)





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Do you agree with this conclusion?

Use evidence from **Table 1** to justify your answer.

**[4 marks]**

Principle:

1. Overlap of  $2 \times \text{SD}$  shows probability of differences (in means) being due to chance is greater than 0.95;

Agree:

2. No difference in number of earthworms and millipedes (per m<sup>2</sup>);

3. No difference in number of species of centipedes or millipedes;

Disagree:

4. More beetles and woodlice in grassy strips;

5. More species of beetles, earthworms, woodlice in grassy strips;





0 2 . 2

A student concluded from **Figure 3** that eating an extra 10 g of fibre per day would significantly lower his risk of cardiovascular disease.

outside the  
box

Evaluate his conclusion.

[4 marks]

1. Negative correlation (between fibre eaten per day and risk of cardiovascular disease);
2. Original/current fibre intake (of student) not known;
3. (Idea of) significance linked to (2x) standard deviation overlap (at 10 g day<sup>-1</sup> change);

4. If current intake between 5 and 30 (g day<sup>-1</sup>) then (eating 10g more results in a significant) decrease in risk

**OR**

If current intake between 30 and 50 (g day<sup>-1</sup>) then (eating 10g more results in) no significant decrease in risk;

5. Correlation does not mean causation

**OR**

Another named factor may be involved;

6. Little evidence/data for higher mass of fibre per day;

7. Large (2x) standard deviation at high/low mass of fibre makes (mean) less precise

**OR**

Large (2x) standard deviation at high/low amounts of fibre means there is a greater uncertainty;

8. No statistical test (to show if differences are significant);

1. Accept positive correlation with reduced risk

2. Accept 'it depends on original/current fibre intake'.

3. This is for the correct concept, ignore stated values.

3. Ignore reference to probability and chance.

4. Accept stated values between 5 and 30 for (significant) decrease in risk.

4. Accept stated values between 30 and 50 for no significant decrease in risk.

4. Ignore stated values less than 5 or more than 50.

5. Examples of named factors - smoking, exercise, age, sex, genes, other aspects of diet.

7. For 'precise' accept reliable or description of precise/reliable.