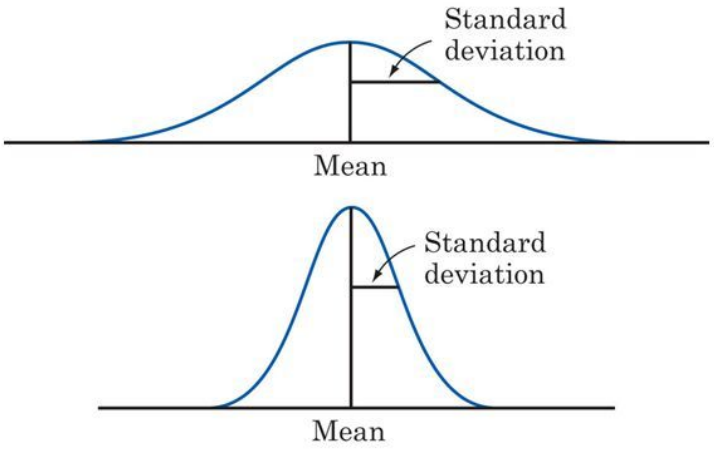
What is **Standard Deviation**?
The spread of data around the mean

Interpreting Standard Deviation
A small standard deviation means that the values in a statistical data set are close to the mean of the data set, on average.

A large standard deviation means that the values in the data set are farther away from the mean, on average.



The figure on the top has a larger SD than the figure below.

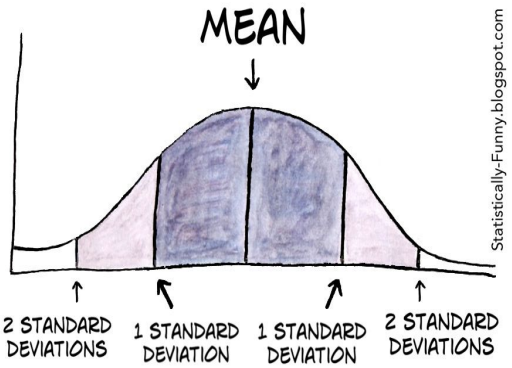
The lower the SD, the more reliable the data.

Formula

$$S = \sqrt{\frac{\Sigma(X - \overline{X})^2}{N}}$$

where S = the standard deviation of a sample,
Σ means "sum of,"
X = each value in the data set,
$\overline{X}$ = mean of all values in the data set,
N = number of values in the data set.

What the results mean



SDI value	Interpretation
0.0	Perfect comparison with consensus group
≤ 1.25	Acceptable
1.25 - 1.49	Acceptable to marginal performance. Some investigation of the test system may be required.
1.5 - 1.99	Marginal performance. Investigation of the test system is recommended.
≥ 2.0	Unacceptable performance. Remedial action usually required.

Lower the SD, the more reliable the data.

In a normal distribution curve (bell curve):
95% of your data points fall within 2 SD of the mean

Standard Error

Allows us to plot error bars on graphs

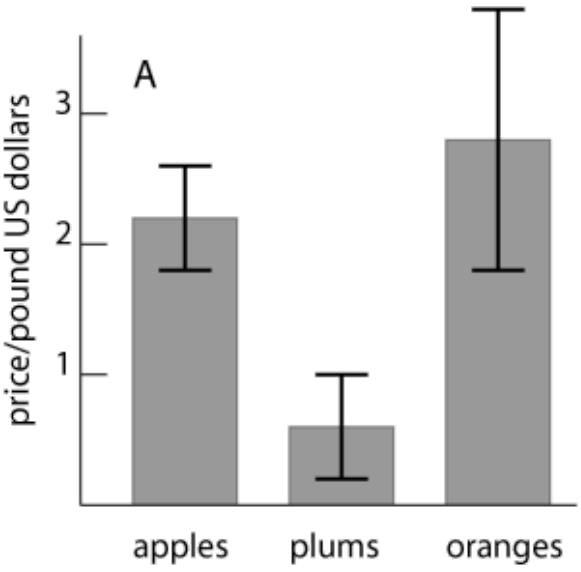
Formula

$$SE = \frac{\sigma}{\sqrt{n}}$$

← Standard deviation

← Number of samples

Interpreting Standard Error



If SE bars overlap (apples and oranges), then there is a greater than 5% probability that results are due to change - therefore data is not significant, i.e. *we can't be certain that apples cost less than oranges*

If SE bars do not overlap (plums and oranges), there is a less than 5% probability that the results are due to chance - therefore data is significant.

We can say for certain that plums cost less than oranges.

When do we use standard error and standard deviation?

For two means on the same sample
E.g. heart rate at rest and exercise on the same group of people

CALCULATIONS

A student measured the heart rate of a group of 5 women at rest, and then after 20 minutes of exercise. Her results are shown below. Calculate standard deviation and standard error. What does the data tell you about the results?

Sample	Rest (x)	x- x’	$(x-x')^2$
1			
2			
3			
4			
5			
Mean			

$$S = \sqrt{\frac{\Sigma(X - \overline{X})^2}{N}}$$

where S = the standard deviation of a sample,
Σ means "sum of,"
X = each value in the data set,
$\overline{X}$ = mean of all values in the data set,
N = number of values in the data set.

Sum of $(x-x')^2$ =

N = 5

Calculate S.D.

Calculate S.E.

Calculate range of S.E.

Sample	Exercise (x)	x- x’	$(x-x')^2$
1			
2			
3			
4			
5			
Mean			

$$S = \sqrt{\frac{\Sigma(X - \overline{X})^2}{N}}$$

where S = the standard deviation of a sample,
Σ means "sum of,"
X = each value in the data set,
$\overline{X}$ = mean of all values in the data set,
N = number of values in the data set.

Sum of $(x-x')^2$ =

N = 5

Calculate S.D.

Calculate S.E.

Calculate Range of S.E.

Is S.D. within ± 2? Is the data reliable?

Do S.E. values overlap? Are the differences significant?

Exam questions

1. Oestrogen is a substance produced by the enzyme aromatase. In females, the main source of oestrogen is the ovaries but aromatase is produced by many other organs in the body, including the lungs. Oestrogen can stimulate the development of some lung tumours. In these tumours, binding of oestrogen to cell-surface receptors stimulates cell division.

Scientists investigated whether two drugs could prevent lung tumours in female mice. First, they removed the ovaries from these mice. They then injected the mice with a tumour-causing chemical found in tobacco twice a day for 4 weeks. The mice were then randomly allocated to one of four groups. Each group contained 10 mice.

- Group Q was given a placebo. This placebo did not contain either drug.
- Group R was given the drug anastrozole. This inhibits the enzyme aromatase.
- Group S was given the drug fulvestrant. This binds to oestrogen receptors.
- Group T was given both anastrozole and fulvestrant.

The mice were given these drugs each week during weeks 5–15 of the investigation.

(a) The scientists removed the ovaries from the mice for the investigation. They gave the mice injections of the substrate of aromatase each day. Explain why these steps were necessary (2)

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(b) The scientists predicted that fulvestrant would be more effective when given with anastrozole than when given alone. Use the information provided to suggest why they predicted this. (2)

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At week 15, the lungs of the mice were removed and examined. The scientists then determined the number of tumours present and the mean tumour area for each group.

Figure 9 and Figure 10 show the scientists' results.

Figure 9

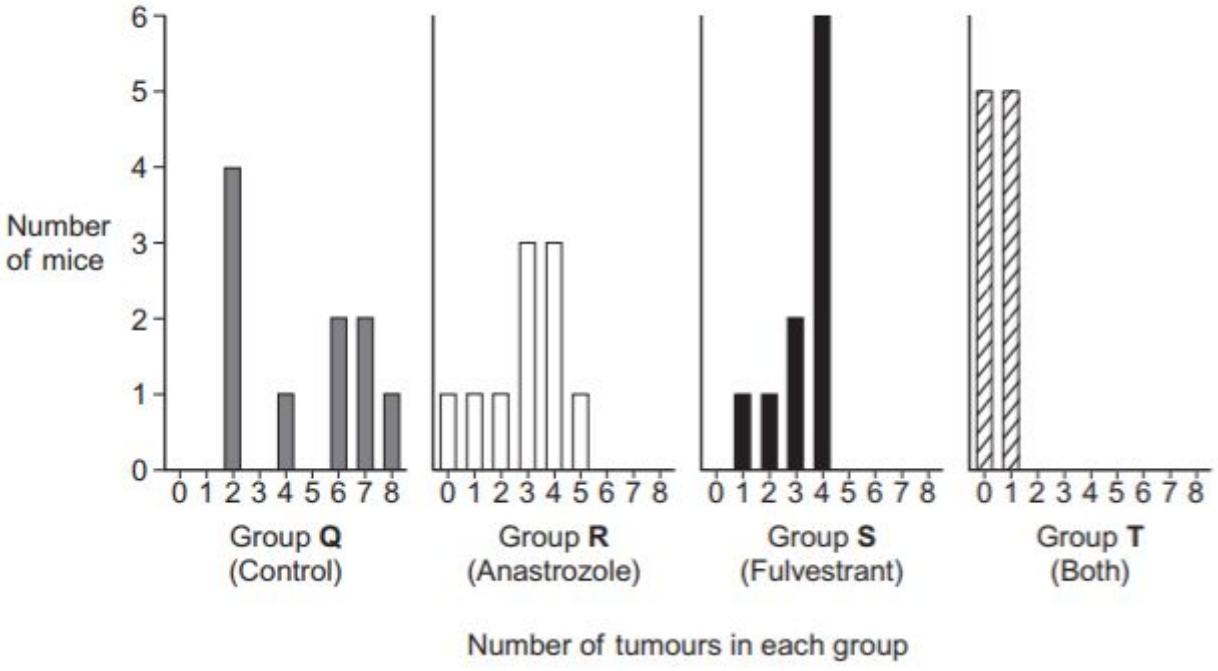
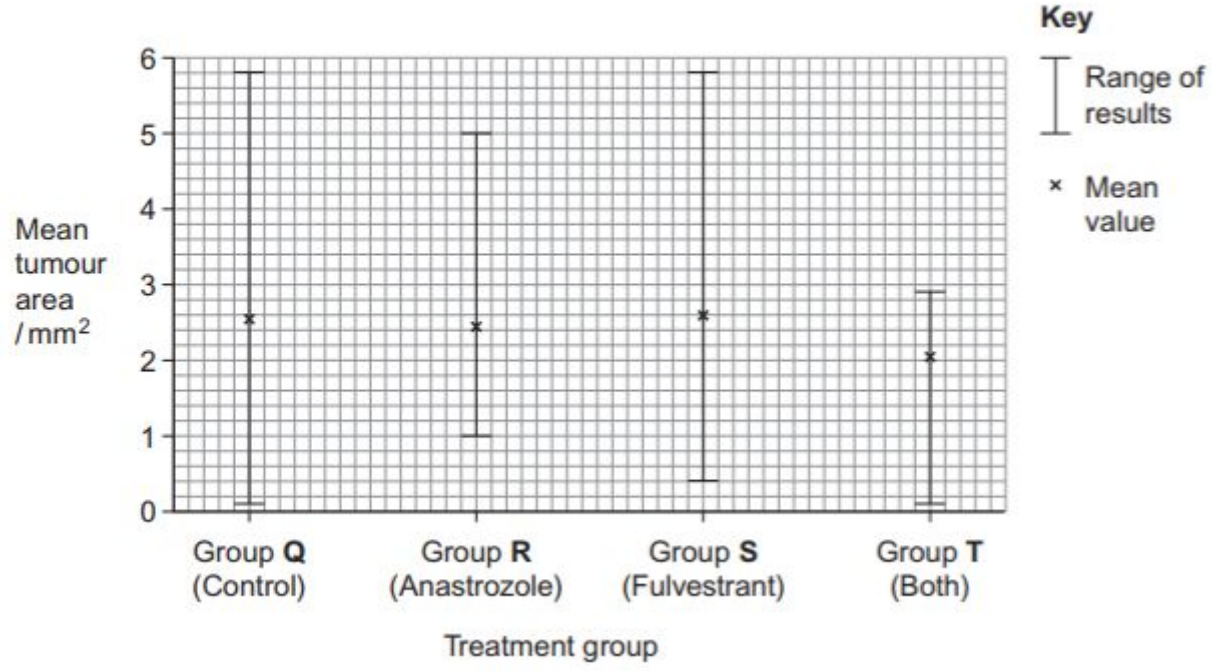


Figure 10



(c) The scientists concluded that both drugs should be used together to reduce the risk of lung cancer in women exposed to tobacco products. Do you agree? Explain your answer. (5)

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(d) The scientists used tumour area as an indicator of tumour size. Explain why tumour area may not be the best indicator of tumour size and suggest a more reliable measurement. (2)

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(e) The scientists repeated the investigation but this time they did not give the drugs until week 9. Suggest why they gave the drugs at week 9, rather than at week 5. (2)

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(f) Another group of scientists is currently using these drugs in human trials. However, the control group is not being given a placebo. Suggest why a placebo is not being given and what is being given to this group instead. (2)

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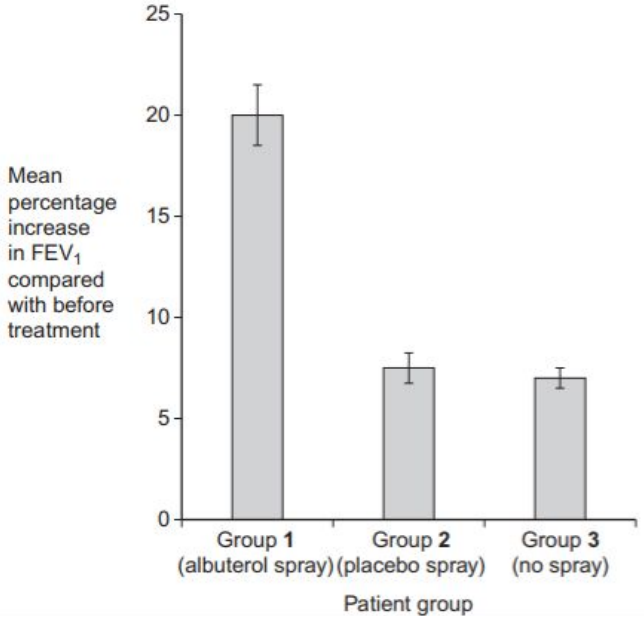
2. The 'placebo effect' describes the improvement in patients' symptoms due to psychological effects. Scientists investigated the placebo effect in patients with asthma.

Scientists measured the forced expiratory volume (FEV1) of each patient at regular intervals. The forced expiratory volume (FEV1) is the volume of air forced out of the lungs in the first second when breathing out.

The scientists recorded each patient's FEV1 before treatment started and after 60 days of treatment. They then calculated the mean increase in FEV1 for each group. Their results are shown in the graph. The bars show the standard deviation.



(a) What do the standard deviation bars suggest about the difference in the mean increase in FEV1 between Group 1 and the other groups? Explain your answer. (2)

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(b) What do the data suggest about the 'placebo effect' in this investigation? Explain your answer. (2)

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(c) On each occasion that a patient's FEV1 was measured, a doctor repeated the measurement several times. Explain why. (2)

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