Heart Rate Medication

Student's t-test (Unpaired Samples)

Subject & topics: Biology | Physiology | Breathing & Circulation **Stage & difficulty:** A Level P3

A pharmaceutical company developed two drugs (drug **A** and drug **B**), both of which were designed to decrease resting heart rate. The company carried out a drug trial to determine whether there is a difference in effectiveness between the two drugs.

They selected 30 participants and randomly assigned 15 participants to group **A** and 15 participants to group **B**. Participants in group **A** took drug **A** for 30 days, and participants in group **B** took drug **B** for 30 days. On the last day of the trial, the resting heart rate of each individual was measured.

- For group **A**, the mean resting heart rate is $70\,\text{bpm}$, and the estimated standard deviation, s, is $6.5\,\text{bpm}$.
- For group **B**, the mean resting heart rate is $67\,\text{bpm}$, and the estimated standard deviation, s, is $6.0\,\text{bpm}$.

Part A

Type of test

The researcher responsible for analysing the data decided to perform Student's t-test on the data.

Why did they decide to perform this type of test?

- Student's t-test is used to determine whether there is a significant correlation between **two continuous variables (resting heart rate and drug type)**.
- Student's t-test is used to investigate whether a **continuous variable (drug type)** shows a significant difference between two categories of a **categorical variable (resting heart rate)**.
- Student's t-test is used to investigate whether a **continuous variable (resting heart rate)** shows a significant difference between two categories of a **categorical variable (drug type)**.
- Student's t-test is used to compare observed frequencies to expected frequencies of a **categorical variable (resting heart rate)** and determine whether there is a significant difference.
- Student's t-test is used to compare observed frequencies to expected frequencies of a **categorical variable (drug type)** and determine whether there is a significant difference.

Part B

Null and alternative hypothesis

Select the correct null hypothesis (H_0) and the correct alternative hypothesis (H_1) below.

- [ ] null hypothesis: the resting heart rate of individuals taking drug **A** is the **same** as the resting heart rate of individuals taking drug **B**
- [ ] null hypothesis: the resting heart rate of individuals taking drug **A** is **different** from the resting heart rate of individuals taking drug **B**
- [ ] alternative hypothesis: the resting heart rate of individuals taking drug **A** is the **same** as the resting heart rate of individuals taking drug **B**
- [ ] alternative hypothesis: the resting heart rate of individuals taking drug **A** is **different** from the resting heart rate of individuals taking drug **B**

Part C

Calculate t

Calculate the t-value using the formula below. Let group A be the group with the larger mean.

$$t = \frac{\bar{x}_A - \bar{x}_B}{\sqrt{\frac{s_A^2}{n_A} + \frac{s_B^2}{n_B}}}$$

Give your answer to 3 dp.

Part D

Critical value of t

Identify the critical value for this t-test at the 5% level of significance.

Part E

t-test conclusion

The magnitude of the calculated t-value is [ ] the critical value.

Therefore, the probability that the difference occurred by chance is [ ] 5%. In other words, the difference between the two samples is [ ].

Therefore we [ ] the null hypothesis (H_0).

There [ ] evidence to suggest that individuals taking drug A have a different resting heart rate from individuals taking drug B.

Items:

greater than | less than | equal to | reject | do not reject | significant | not significant | is | is insufficient

Fish Metabolic Rates

Student's t-test (Unpaired Samples)

Subject & topics: Biology | Evolution | Variation **Stage & difficulty:** A Level P3

A researcher wanted to investigate whether higher water temperatures are associated with increased metabolic rate in a particular fish species.

One group of this species was kept in a tank of $10\,^{\circ}\mathrm{C}$ water, and another group of the same species was kept in a tank of $16\,^{\circ}\mathrm{C}$ water.

10 fish were randomly selected from each group and their metabolic rates were measured using a respirometer. The results are shown in the table below.

Temperature of water $(^{\circ}\mathrm{C})$	**Mean metabolic rate** $(\mathrm{mg\,O_2\,kg^{-1}\,hour^{-1}})$
10	86.0
16	131.6

The estimated standard deviation, s, for both groups was $8.3\ \mathrm{mg\ O_2\ kg^{-1}\ hour^{-1}}$

Part A

Type of test

The researcher decided to perform Student's t-test on the data.

Why did they decide to perform this type of test?

- Student's t-test is used to investigate whether a **continuous variable (temperature)** shows a significant difference between two categories of a **categorical variable (metabolic rate)**.
- Student's t-test is used to compare observed frequencies to expected frequencies of a **categorical variable (metabolic rate)** and determine whether there is a significant difference.
- Student's t-test is used to determine whether there is a significant correlation between **two continuous variables (metabolic rate and temperature)**.
- Student's t-test is used to compare observed frequencies to expected frequencies of a **categorical variable (temperature)** and determine whether there is a significant difference.
- Student's t-test is used to investigate whether a **continuous variable (metabolic rate)** shows a significant difference between two categories of a **categorical variable (temperature)**.

Part B

Null and alternative hypotheses

Select the correct null hypothesis (H_0) and the correct alternative hypothesis (H_1) below.

- [ ] null hypothesis: fish metabolic rate is the **same** at both temperatures
- [ ] null hypothesis: fish metabolic rate is **higher** at higher temperatures
- [ ] null hypothesis: fish metabolic rate is **lower** at higher temperatures
- [ ] alternative hypothesis: fish metabolic rate is the **same** at both temperatures
- [ ] alternative hypothesis: fish metabolic rate is **higher** at higher temperatures
- [ ] alternative hypothesis: fish metabolic rate is **lower** at higher temperatures

Part C

Calculate t

Calculate the t-value using the formula below. Let group A be the group with the larger mean.

$$t = \frac{\bar{x}_A - \bar{x}_B}{\sqrt{\frac{s_A^2}{n_A} + \frac{s_B^2}{n_B}}}$$

Give your answer to 3 dp.

Part D

Critical value of t

Identify the critical value for this t-test at the 5% level of significance.

Part E

t-test conclusion

The calculated t-value is [ ] the critical value.

Therefore, the probability that the difference occurred by chance is [ ] 5%. In other words, the difference between the two samples is [ ].

Therefore we [ ] the null hypothesis (H_0).

There [ ] evidence to suggest that higher water temperatures are associated with increased metabolic rate in this species.

Items:

greater than | less than | equal to | reject | do not reject | significant | not significant | is | is insufficient

Adapted with permission from OCR A Level Biology B June 2017, Practical Skills in Biology, Question 3

Question deck:

STEM SMART Biology Week 44 - Student's t-test

Goldfish Sizes

Student's t-test (Unpaired Samples)

Subject & topics: Biology | Evolution | Variation **Stage & difficulty:** A Level P3

A researcher wanted to investigate whether goldfish kept in an indoor tank are smaller than goldfish kept in an outdoor pond. The researcher measured the lengths of 10 goldfish in a tank and 10 goldfish in a pond. The results are shown in the table below.

	Goldfish lengths (cm)									
Tank	19	14	17	13	15	15	13	16	12	16
Pond	19	15	19	18	21	14	16	22	15	21

Part A

Type of test

The researcher decided to perform Student's t-test on the data.

Why did they decide to perform this type of test?

- Student's t-test is used to investigate whether a **continuous variable (body length)** shows a significant difference between two categories of a **categorical variable (habitat)**.
- Student's t-test is used to determine whether there is a significant correlation between **two continuous variables (body length and habitat)**.
- Student's t-test is used to compare observed frequencies to expected frequencies of a **categorical variable (body length)** and determine whether there is a significant difference.
- Student's t-test is used to investigate whether a **continuous variable (habitat)** shows a significant difference between two categories of a **categorical variable (body length)**.
- Student's t-test is used to compare observed frequencies to expected frequencies of a **categorical variable (body length)** and determine whether there is a significant difference.

Part B

Null and alternative hypothesis

Select the correct null hypothesis (H_0) and the correct alternative hypothesis (H_1) below.

- [ ] null hypothesis: goldfish kept in an indoor tank are the **same length** as goldfish kept in an outdoor pond
- [ ] null hypothesis: goldfish kept in an indoor tank are **longer** than goldfish kept in an outdoor pond
- [ ] null hypothesis: goldfish kept in an indoor tank are **shorter** than goldfish kept in an outdoor pond
- [ ] alternative hypothesis: goldfish kept in an indoor tank are the **same length** as goldfish kept in an outdoor pond
- [ ] alternative hypothesis: goldfish kept in an indoor tank are **longer** than goldfish kept in an outdoor pond
- [ ] alternative hypothesis: goldfish kept in an indoor tank are **shorter** than goldfish kept in an outdoor pond

Part C

Means

Calculate the mean goldfish length, $\bar{x}$, in the tank sample.

Calculate the mean goldfish length, $\bar{x}$, in the pond sample.

Part D

Variances

Estimate the variance, s^2, of length of goldfish kept in the tank using the formula below.

$$s^2 = \frac{\sum(x - \bar{x})^2}{n - 1}$$

Give your answer to 4 dp.

Estimate the variance, s^2, of length of goldfish kept in the pond using the formula below.

$$s^2 = \frac{\sum(x - \bar{x})^2}{n - 1}$$

Give your answer to 4 dp.

Part E

Calculate t

Calculate the t-value using the formula below and your previous answers. Let group A be the group with the larger mean.

$$t = \frac{\bar{x}_A - \bar{x}_B}{\sqrt{\frac{s_A^2}{n_A} + \frac{s_B^2}{n_B}}}$$

Give your answer to 3 dp.

Part F

Critical value of t

Identify the critical value for this t-test at the 5% level of significance.

Part G

t-test conclusion

The calculated t-value is [ ] the critical value.

Therefore, the probability that the difference occurred by chance is [ ] 5%. In other words, the difference between the two samples is [ ].

Therefore we [ ] the null hypothesis (H_0).

There [ ] evidence to suggest that goldfish kept in an indoor tank are smaller than goldfish kept in an outdoor pond.

Items:

greater than | less than | equal to | reject | do not reject | significant | not significant | is | is insufficient

Question deck:

STEM SMART Biology Week 44 - Student's t-test

Comparing Antibiotics

Student's t-test (Unpaired Samples)

Subject & topics: Biology | Maths Skills | Statistical Tests **Stage & difficulty:** A Level P3

A researcher wanted to compare the effectiveness of two antibiotics (antibiotic **A** and antibiotic **B**).

They prepared 10 agar plates and spread the bacteria on each one. On each plate, 5 paper discs that had been soaked in an antibiotic solution were placed in different positions on the plate. For 5 of the plates, all of the discs were soaked in antibiotic **A**. For the other 5 plates, all of the discs were soaked in antibiotic **B**. After allowing the bacteria to grow overnight, the researcher measured the diameter of the zone of inhibition (the clear area in which no bacteria were growing) around each disc. This zone of inhibition is a useful measure of how effective an antibiotic is at preventing bacterial growth. The larger the zone of inhibition, the more effective the antibiotic is.

The researcher's results are summarised below.

- For antibiotic **A**, the mean diameter of the zone of inhibition was $14.8\,\text{mm}$, and the standard deviation, s, was $2.0\,\text{mm}$.
- For antibiotic **B**, the mean diameter of the zone of inhibition was $16.6\,\text{mm}$, and the standard deviation, s, was $2.5\,\text{mm}$.

Part A

Type of test

The researcher decided to perform Student's t-test on the data.

Why did they decide to perform this type of test?

- Student's t-test is used to investigate whether a **continuous variable (antibiotic type)** shows a significant difference between two categories of a **categorical variable (diameter of the zone of inhibition)**.
- Student's t-test is used to compare observed frequencies to expected frequencies of a **categorical variable (diameter of the zone of inhibition)** and determine whether there is a significant difference.
- Student's t-test is used to investigate whether a **continuous variable (diameter of the zone of inhibition)** shows a significant difference between two categories of a **categorical variable (antibiotic type)**.
- Student's t-test is used to compare observed frequencies to expected frequencies of a **categorical variable (antibiotic type)** and determine whether there is a significant difference.
- Student's t-test is used to determine whether there is a significant correlation between **two continuous variables (diameter of the zone of inhibition and antibiotic type)**.

Part B

Null and alternative hypotheses

Select the correct null hypothesis (H_0) and the correct alternative hypothesis (H_1) below.

- [ ] null hypothesis: the diameter of the zone of inhibition is the **same** regardless of which antibiotic is used
- [ ] null hypothesis: the diameter of the zone of inhibition around antibiotic **A** is **different** from the diameter of the zone of inhibition around antibiotic **B**
- [ ] alternative hypothesis: the diameter of the zone of inhibition is the **same** regardless of which antibiotic is used
- [ ] alternative hypothesis: the diameter of the zone of inhibition around antibiotic **A** is **different** from the diameter of the zone of inhibition around antibiotic **B**

Part C

Calculate t

Calculate the t-value using the formula below.

$$t = \frac{\bar{x}_A - \bar{x}_B}{\sqrt{\frac{s_A^2}{n_A} + \frac{s_B^2}{n_B}}}$$

Give your answer to 3 dp.

Part D

Critical value of t

Identify the critical value for this t-test at the 5% level of significance.

Part E

t-test conclusion

The magnitude of the calculated t-value is [ ] that of the critical value.

Therefore, the probability that the difference occurred by chance is [ ] 5%. In other words, the difference between the two samples is [ ].

Therefore we [ ] the null hypothesis (H_0).

There [ ] evidence to suggest that the diameter of the zone of inhibition around antibiotic **A** is different from the diameter of the zone of inhibition around antibiotic **B**.

Items:

greater than | less than | equal to | reject | do not reject | significant | not significant | is | is insufficient

---

Question deck:

STEM SMART Biology Week 44 - Student's t-test

Catalase Comparison

Student's t-test (Unpaired Samples)

Subject & topics: Biology | Maths Skills | Statistical Tests **Stage & difficulty:** A Level P3

A student wanted to investigate whether catalase is more active in the presence of light. They set up 12 test tubes, each containing the same volume and concentration of hydrogen peroxide solution. 6 test tubes were placed in a water bath at $30\,^{\circ}\mathrm{C}$ in a sunlit room, and the other 6 test tubes were placed in a water bath at $30\,^{\circ}\mathrm{C}$ in a dark room. Sections of potato (of equal mass) were added to each test tube, and the volume of oxygen gas released in each test tube was measured using a gas syringe.

The results are shown in the table below.

	Volume of $\mathrm{O_2}$ released (ml)					
Light	29	28	24	26	32	25
Dark	28	22	26	32	24	30

Part A

Means and variances

Calculate the means and variances of the volume of $\mathrm{O_2}$ released in each condition. The formula for calculating variance, s^2, is given below.

$$s^2 = \frac{\sum(x-\bar{x})^2}{n-1}$$

Give inexact answers to 3 dp.

	Mean, $\bar{x}$	**Variance, s^2**
Light		
Dark		

Part B

Null and alternative hypotheses

Select the correct null hypothesis (H_0) and the correct alternative hypothesis (H_1) below.

- [ ] null hypothesis: catalase activity is the **same** in the light as it is in the dark
- [ ] null hypothesis: catalase is **more** active (i.e. more oxygen is released) in the light than in the dark
- [ ] null hypothesis: catalase is **less** active (i.e. less oxygen is released) in the light than in the dark
- [ ] alternative hypothesis: catalase activity is the **same** in the light as it is in the dark
- [ ] alternative hypothesis: catalase is **more** active (i.e. more oxygen is released) in the light than in the dark
- [ ] alternative hypothesis: catalase is **less** active (i.e. less oxygen is released) in the light than in the dark

Part C

Calculate t

Calculate the t-value using the formula below. Let group A be the group with the larger mean.

$$t = \frac{\bar{x}_A - \bar{x}_B}{\sqrt{\frac{s_A^2}{n_A} + \frac{s_B^2}{n_B}}}$$

Give your answer to 3 dp.

Part D

Critical value of t

Identify the critical value for this t-test at the 5% level of significance.

Part E

t-test conclusion

The calculated t-value is [ ] the critical value.

Therefore, the probability that the difference occurred by chance is [ ] 5%. In other words, the difference between the two samples is [ ].

Therefore we [ ] the null hypothesis (H_0).

There [ ] evidence to suggest that catalase is more active in the light than in the dark

Items:

greater than | less than | equal to | reject | do not reject | significant | not significant | is | is insufficient