

Continuous and discontinuous variation

Investigate and describe examples of continuous and discontinuous variation

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). Teacher answers start on a new page.

Name

Date

Aim

To collect data to show that height in a sample of pupils shows continuous variation and that seed shape in peas shows discontinuous variation.

Background

Variation is the differences between individuals of the same species. There are two types. In **continuous variation** there is a range of phenotypes between two extremes, for example body length and body mass. In **discontinuous variation** there are a limited number of phenotypes with no intermediates, for example ABO blood groups.

Continuous variation is caused by both genes and the environment. For example, a person with genes for tallness will be shorter if their diet is poor. Discontinuous variation is usually caused by genes only. Seed shape in peas (round or wrinkled) is controlled by a single gene, so every seed falls into one of two clear groups. Ear lobe shape and tongue rolling are often used in class, but they are not clear examples: many ear lobes are in between, and some people can learn to roll their tongue.

To describe variation in a population you must use a sample that is representative and avoids bias. The sample should be large (at least 30 individuals), chosen at random from the same group, for example pupils of the same age. A **random** sample is one where every individual has an equal chance of being chosen, for example by using random numbers to pick names from a register, or by taking pea seeds from a well-mixed bag without looking.

Hypothesis

Height will show continuous variation, with most people near the middle of a range, and pea seed shape will show discontinuous variation, with only two categories (round and wrinkled) and no intermediates.

Equipment

- Class register (or list of names) and a calculator or random number table to choose a random sample of 40 pupils
- Metre rule fixed to a wall (graduated in mm)
- Set square or book to mark the top of the head against the metre rule
- A bag of about 200 dried pea seeds from a cross between round-seeded and wrinkled-seeded plants (from a biological supplier)
- Two Petri dishes or trays and a hand lens
- Results table (and scrap paper for a tally)
- Graph paper
- Sharp pencil and ruler

Risk assessment

Hazard	Risk	Precaution
Standing on chairs or tables to read the rule	Falls	Stand on the floor; use a set square or book on the head and read the rule at eye level.
Sensitivity about height or body features	Pupils may feel embarrassed	Record results by number, not name, and do not comment on an individual's measurements.
Seeds (may be treated with fungicide)	Harm if swallowed	Do not put seeds in the mouth. Wash your hands after handling them.

Method

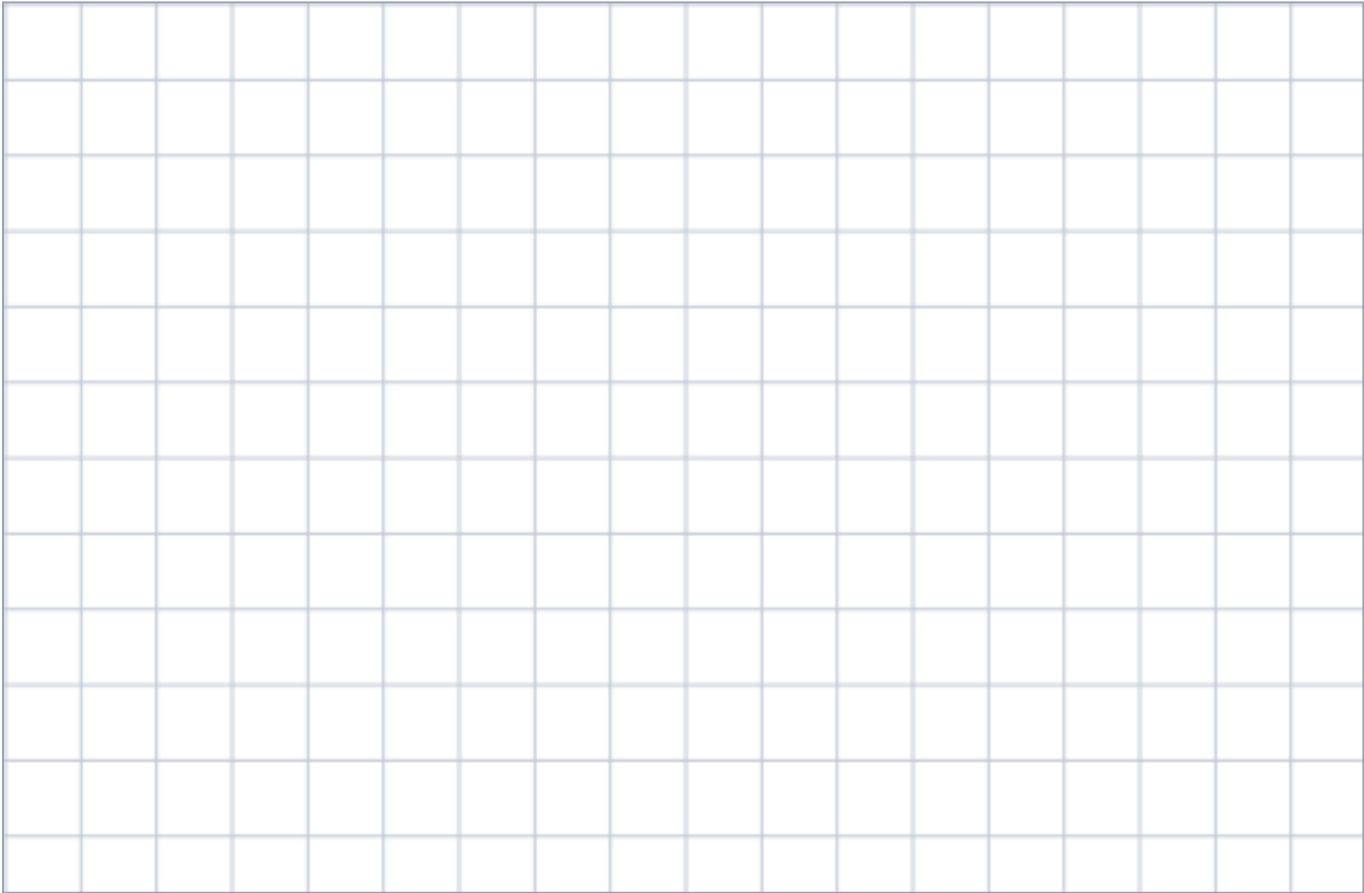
1. Choose a sample of 40 pupils from the same year group by random sampling. Give each pupil on the register a number, then use a random number table or calculator to choose 40 numbers.
2. Fix a metre rule vertically to a wall with the zero at floor level.
3. Ask the first pupil to stand with their back and heels against the wall, without shoes and with their feet flat on the floor.
4. Place a set square (or book) flat on the top of their head, touching the rule, and read the height at eye level to the nearest cm.
5. Record the height in a results table, using a number for each pupil rather than a name.
6. Repeat steps 3 to 5 for all 40 pupils.
7. Shake the bag of pea seeds to mix them. Without looking, take out seeds until you have a sample of 100.
8. Sort the seeds into two dishes: round (smooth) and wrinkled. Use a hand lens if you are not sure.
9. Group the heights into classes of 5 cm (for example 150–154 cm) and count the number of pupils in each class.
10. Count the number of round seeds and the number of wrinkled seeds.
11. Draw a histogram of the heights (bars touching) and a bar chart of the seed shapes (bars not touching).
12. Describe the shape of each graph and state which feature shows continuous variation and which shows discontinuous variation.

Results

Results table: height of 40 pupils and shape of 100 pea seeds		
feature	class	number of individuals
height / cm	150-154	
height / cm	155-159	
height / cm	160-164	
height / cm	165-169	
height / cm	170-174	
height / cm	175-179	
height / cm	180-184	
pea seed shape	round	
pea seed shape	wrinkled	

Graph

Two graphs. (1) Histogram of height: height / cm on the x-axis (classes 150-154 to 180-184, bars touching because height is continuous data) and number of pupils on the y-axis from 0 to 12 (for example 1 cm for 1 pupil). (2) Bar chart of pea seed shape: pea seed shape on the x-axis (round, wrinkled, bars of equal width with gaps between them because the data are in categories) and number of seeds on the y-axis from 0 to 80 (for example 1 cm for 10 seeds).



Exam questions 10 questions · 25 marks

1 State two differences between continuous variation and discontinuous variation. **[2 marks]**

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2 A student measured the height of a sample of pupils. State whether height shows continuous or discontinuous variation. Give a reason for your answer. **[2 marks]**

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3 The student plotted a graph of height and a graph of pea seed shape (round or wrinkled). State the type of graph used for each, and give one reason for the choice for height. **[3 marks]**

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4 In a sample of 160 pea seeds, 118 were round. Calculate the percentage of the seeds that were round. Give your answer to one decimal place. **[2 marks]**

Answer =

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- 5** The table shows the heights of 40 pupils. Use the table to find the number of pupils with a height from 160 cm to 174 cm. **[2 marks]**

Height of 40 pupils	
height / cm	number of pupils
150-154	2
155-159	5
160-164	9
165-169	11
170-174	8
175-179	4
180-184	1

- 6** Height is affected by genes and by the environment. Explain what this means, using one example of an environmental factor. **[3 marks]**

- 7** The student used a sample of 40 pupils. Explain why a sample of at least 30 is better than a sample of five. **[2 marks]**

- 8** The student chose the sample by asking friends to take part. Explain why this could cause bias, and describe a better method of choosing the sample. **[3 marks]**

9 Suggest two ways in which the student could improve the accuracy of the height measurements. **[2 marks]**

10 Describe how you would investigate variation in the length of the leaves of a plant species, such as privet, and show whether it is continuous variation. **[4 marks]**

Teacher answers

Practical skill 16: Continuous and discontinuous variation. The example results are practice data, not real measurements.

Example results

Example results (practice data)		
feature	class	number of individuals
height / cm	150-154	2
height / cm	155-159	5
height / cm	160-164	9
height / cm	165-169	11
height / cm	170-174	8
height / cm	175-179	4
height / cm	180-184	1
pea seed shape	round	74
pea seed shape	wrinkled	26

Conclusion

In the example results the 40 heights are between 150 cm and 184 cm and most pupils are in the middle classes (165-169 cm has the most, 11 pupils), with fewer pupils at the extremes. The histogram is a bell shape and the heights have no gaps, so height shows continuous variation. Height is affected by both genes and the environment, for example diet. Pea seed shape has only two categories: 74 seeds were round and 26 were wrinkled, and no seed was in between. This is discontinuous variation, which is usually caused by genes only. This supports the hypothesis. Because both samples were chosen at random and were large, the results are more likely to be representative.

Errors and improvements

Error	Effect on the results	Improvement
Heights are read to the nearest cm and the set square may not be level, or pupils may stand on tiptoes or slouch (random error)	Some heights are too high or too low, which could move a pupil into the wrong class	Use a set square, ask pupils to stand straight with heels against the wall, and have the same person take every reading at eye level.
A few pea seeds are damaged or only slightly wrinkled, so they are hard to place in a group	Some seeds may be put in the wrong group, so the counts are not accurate	Agree what counts as wrinkled before starting, use a hand lens, and have the same person sort every seed.
The sample is small, or chosen by picking friends rather than at random (bias)	The sample may not represent the whole year group, so conclusions may be wrong	Use a larger sample (for example 100 pupils) chosen by random numbers from a register, and use pupils of the same age.
Pupils of different ages, or of both sexes, mixed in one sample	Part of the variation is caused by age and sex, so the pattern is harder to interpret	Use pupils of the same age, and if comparing sexes, record the sexes separately.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [2]

- continuous variation has a range of phenotypes between two extremes, but discontinuous variation has a limited number of phenotypes / categories (1)
- continuous variation has intermediate phenotypes, but discontinuous variation has none / no intermediates (1)
- continuous variation is caused by genes and environment, but discontinuous variation is usually caused by genes only (1)
- Max 2

2. [2]

- continuous variation (1)
- because there is a range of heights between two extremes / pupils can have any height in the range with no gaps (1)

3. [3]

- height: histogram (1)
- pea seed shape: bar chart (1)
- height is continuous data so the bars touch / there are no gaps in the data (1)

4. [2]

- $118 \div 160 \times 100$ (1)
- 73.8% (1)
- allow 73.75%; correct answer with no working scores 2

5. [2]

- $9 + 11 + 8$ (1)
- 28 (1)
- correct answer with no working scores 2

6. [3]

- genes decide the height a person could reach / determine the potential height (1)
- the environment, for example diet / nutrition / disease, affects how much of this potential is reached (1)
- e.g. a person with genes for tallness will be shorter if their diet is poor (1)

7. [2]

- a larger sample is more likely to be representative of the whole group / population (1)
- the effect of unusual (extreme) individuals is reduced (1)

8. [3]

- friends may be similar (for example in age, sex or height), so the sample may not represent the whole group (1)
- a better method is random sampling, where every pupil has an equal chance of being chosen (1)
- for example by numbering the register and choosing numbers using a random number table / calculator (1)

9. [2]

- ask pupils to stand straight with heels against the wall / without shoes (1)
- use a set square or book on top of the head and read the rule at eye level (1)
- have the same person take all the measurements (1)
- Max 2

10. [4]

- collect a large sample of leaves, for example at least 30 (1)
- choose the leaves at random, for example by using random numbers to pick branches / from plants in the same habitat (1)
- measure the length of each leaf with a ruler to the nearest mm (1)
- group the lengths into classes and count the number in each class (1)
- draw a histogram (1)
- a bell-shaped histogram with no gaps shows continuous variation (1)
- Max 4

Exam tips

- Learn the syllabus examples: body length and body mass show continuous variation; ABO blood groups, and seed shape and seed colour in peas, show discontinuous variation.
- Use the exact phrases: continuous variation is a range of phenotypes between two extremes, and discontinuous variation is a limited number of phenotypes with no intermediates. Continuous variation is caused by genes and the environment; discontinuous variation usually by genes only.
- Histograms are for continuous data and have bars that touch. Bar charts are for categories and have bars of equal width that do not touch.
- Sampling questions: say the sample must be large and random (every individual has an equal chance of being chosen) to avoid bias.
- Label graph axes with the quantity and unit using a slash, for example 'height / cm', and give the y-axis as 'number of pupils'.