Types of Variation

A Level

Organisms within a population are not identical - they display variation. There are two main types of variation: discontinuous and continuous.

Part A   Definitions

Discontinuous variation is variation [   ]. Traits that display discontinuous variation are usually controlled by [   ] genes.

Continuous variation is variation [   ]. Traits that display discontinuous variation are usually controlled by [   ] genes.

Items:

| many | along a range | one or a few | across discrete categories |

Part B   Discontinuous variation examples

Which of the following traits display discontinuous variation in humans?

☐ height

☐ sex

☐ skin colour

☐ blood type

☐ weight

☐ foot length

Which of the following traits display continuous variation in humans?

- [ ] height

- [ ] sex

- [ ] skin colour

- [ ] blood type

- [ ] weight

- [ ] foot length

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Variation: Causes and Heritability

A Level

Part A   Parent and offspring

Which of the following **could** lead to phenotypic variation between a human parent and their offspring?

☐ their genomes

☐ time spent in sunlight

☐ their diets

Part B   Bacterial clones

Which of the following **could** lead to phenotypic variation between two clones in a bacterial population?

☐ their genomes

☐ nutrient availability

☐ exposure to toxins

Part C   Heritable variation

Which of the following phenotypes may be inherited by a person's offspring?

- [ ] XY genotype
- [ ] green eyes
- [ ] a broken bone
- [ ] A+ blood group
- [ ] tattoos
- [ ] body fat percentage of 30%

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Gameboard:
STEM SMART Biology Week 21

Seedling Variation

A gardener wants to plant some new plants in their garden. They plant seeds from the same parent plant in separate pots. After a few weeks, the gardener notices some variation among the seedlings. The gardener measures the heights of 20 of the seedlings (to the nearest cm). The results are shown in **Figure 1**.
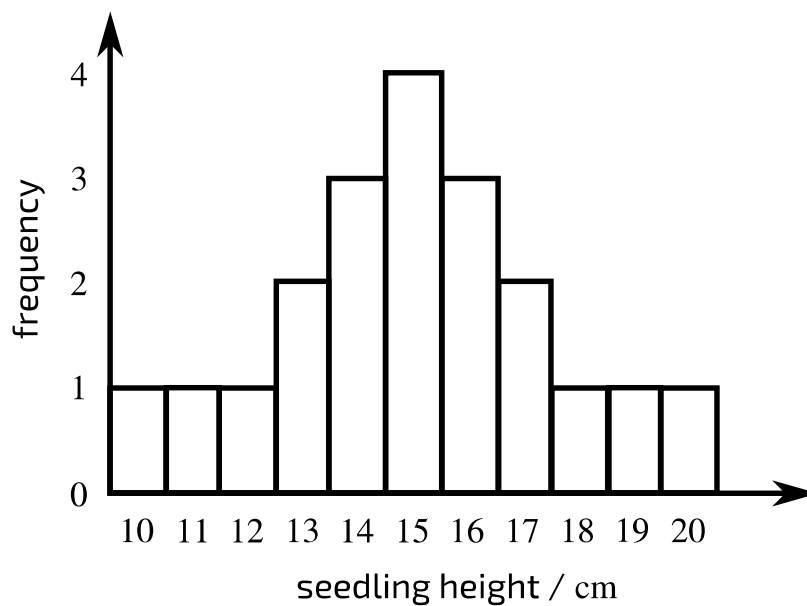
Figure 1: Frequency histogram of seedling height.

Part A   Seedling statements

Which of the following statements about the seedling height are correct? Select all that apply.

- [ ] the variation could be partly due to epigenetic differences
- [ ] the variation could be partly due to environmental differences
- [ ] seedling height is most likely controlled by many genes
- [ ] this is continuous variation
- [ ] this is discontinuous variation
- [ ] seedling height is most likely controlled by one gene

Part B   Mean seedling height

Calculate the mean seedling height.

Part C   Standard deviation

Calculate an unbiased estimate of standard deviation in seedling height. Give your answer to 3 decimal places.

The formula is given below.

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

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Gameboard:
STEM SMART Biology Week 21

Populations and Allele Combinations

A Level

Four populations of the same diploid species each have the same gene (gene A) in the same position on a chromosome.

Each population has a different number of alleles for gene A as shown in the table.

Population	Number of alleles for gene A
P	3
Q	4
R	5
S	6

Each genotype produces a discrete phenotype. Assume that in the heterozygous state, the genotype is the same whether an allele is inherited from the mother or the father.

Part A   Type of variation

What type of variation is this?

Part B   Population P

How many homozygous genotypes are theoretically possible in population P?

How many heterozygous genotypes are theoretically possible in population P?

Part C   Population Q

How many homozygous genotypes are theoretically possible in population Q?

How many heterozygous genotypes are theoretically possible in population Q?

Part D   Population R

How many homozygous genotypes are theoretically possible in population R?

How many heterozygous genotypes are theoretically possible in population R?

Part E   Population S

How many homozygous genotypes are theoretically possible in population S?

How many heterozygous genotypes are theoretically possible in population S?

Part F n alleles

In a population with n alleles, how many **total** genotypes are theoretically possible?

The following symbols may be useful: n

Gameboard:
STEM SMART Biology Week 21

Squirrel Fur Colour

A Level

There are two main colour morphs of grey squirrels (*Sciurus carolinensis*): grey-brown and black. The black colour morph is a result of a mutation in the pigment receptor gene *MC1R*.

A student wants to know if the proportion of grey-brown vs black squirrels differs between two cities. The student collects data on numbers of each colour morph observed in the two cities, in order to carry out a chi-squared test. The results are shown in the table below.

	Grey-brown	Black
City A	370	230
City B	350	50

Part A   Type of variation

What type of variation is this?

Part B   Expected values

In order to carry out a chi-squared test, the student must calculate the expected values. This is based on the null hypothesis: the proportion of grey-brown vs black squirrels is independent of city (i.e. the proportion does not significantly differ between cities).

What would be the expected number of grey-brown squirrels in City A?

What would be the expected number of black squirrels in City A?

What would be the expected number of grey-brown squirrels in City B?

What would be the expected number of black squirrels in City B?

Part C   Chi-squared statistic (χ^2)

Calculate the chi-squared statistic, using the formula below.

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Give your answer to 3 d.p.

Part D   Statistical significance

Using the significance table in the hint below, find the appropriate critical value of chi-squared at the 5% level of significance.

Give your answer to 3 d.p.

Is there evidence to suggest that squirrel type and city are **not** independent? (i.e. does the proportion of grey-brown squirrels vs black squirrels differ significantly between the two cities?)

○ yes

○ no

Gameboard:
STEM SMART Biology Week 21

Goldfish Size

A student wants to know if goldfish kept in an indoor tank are smaller than goldfish kept in an outdoor pond. The student measures the lengths of 10 goldfish in a tank and 10 goldfish in a pond, in order to carry out a two-sample t-test. 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 variation

What type of variation is this?

Part B   Means

Calculate the mean goldfish length in the tank sample ($\bar{x}_1$)

Calculate the mean goldfish length in the pond sample ($\bar{x}_2$)

Part C   Variance

Calculate an unbiased estimate of variance in goldfish length using the tank sample data. Give your answer to 3 decimal places.

The formula is given below.

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

Calculate an unbiased estimate of variance in goldfish length using the pond sample data. Give your answer to 3 decimal places.

The formula is given below.

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

Part D t-test calculation

Calculate the test statistic for this t-test, using the formula below and your answers in the previous parts. Give your answer to 3 decimal places.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Part E   *t*-test conclusion

Using the significance table in the hint below, find the appropriate critical value at the 5% level of significance.

Give your answer to 3 d.p.

Are goldfish kept in an indoor tank significantly smaller than goldfish kept in an outdoor pond?

◯ yes

◯ no

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