Name	Date started	Target end date

GCE A LEVEL — BIOLOGY UNIT 4 QUESTION PACK

1075 (Legacy BY5) · New spec Unit 4 Topic 7 · A2 unit, first sat 2017, 90 marks, 2h paper

REVISE
.wales

BIOLOGY — UNIT 4 · HARDY-WEINBERG, SPECIATION & EVOLUTION

4.4 Variation and evolution — the Hardy–Weinberg principle, natural selection, isolating mechanisms and speciation

The Hardy–Weinberg equation as a null model for allele-frequency stability, the conditions under which it fails (selection, drift, mutation, gene flow, non-random mating), reproductive isolating mechanisms, allopatric and sympatric speciation, and worked case studies in canine breeds, Darwin's finches and copper-tolerant Agrostis.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~1 h 6 min

Derived from the legacy BY5 papers' pace of ~1.6 min/mark, padded for long-prose answers (41 marks over 4 questions).

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC BY5 papers (2008 modular spec, 2011–2017) that maps onto new-spec A2 Unit 4 Topic 7 (4.4).

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working — quality of written communication will affect marks. A calculator is allowed. Diagrams included in answers must be fully annotated.

For Examiner's use only

Q	Source	Max	Mark
1	BY5 Jun 11 Q4	10	
2	BY5 Jun 12 Q4	6	
3	BY5 Jun 15 Q5	11	
4	BY5 Jun 17 Q7	14	
Total		**41**	

Hardy-Weinberg, Speciation & Evolution — what the new spec asks

WJEC GCE A Level Biology (from 2015) · Unit 4: Variation, Inheritance & Options · Topic 4.4.

Hardy–Weinberg

- $p + q = 1$ for two alleles at a locus.
- $p^2 + 2pq + q^2 = 1$ for genotype frequencies.
- Assumes large population, random mating, no selection / drift / mutation / migration.

Natural selection

- Variation + heritability + differential survival → adaptation.
- Stabilising, directional, disruptive selection patterns.
- Sickle-cell allele maintained in malarial regions by heterozygote advantage.

Genetic drift

- Random change in allele frequency, strongest in small populations.
- Founder effect — new population from few individuals.
- Bottleneck — sudden reduction reshuffles frequencies.

Reproductive isolation

- Pre-zygotic: ecological, temporal, behavioural, mechanical, gametic.
- Post-zygotic: inviability, sterility (e.g. mule), F_2 breakdown.
- Once gene flow stops, populations diverge.

Speciation

- Allopatric — geographic separation drives divergence.
- Sympatric — reproductive barriers arise within one area.
- Adaptive radiation — one ancestor → many specialised species (Darwin's finches).

Evidence for evolution

- Fossil record showing transitional forms.
- Comparative anatomy (homologous, analogous structures).
- Molecular — DNA / protein similarity across species.

Crib sheet »

Hardy-Weinberg, Speciation & Evolution in one page

Quick-reference notes — revisit before each question.

Hardy–Weinberg

$p+q = 1$; $p^2+2pq+q^2 = 1$.

Predicts allele freq in stable populations.

Deviation ⇒ selection / drift / migration / mutation / non-random mating.

Natural selection

Variation + heritability + differential reproduction → adaptation.

Stabilising, directional, disruptive.

Sickle-cell

Heterozygote advantage — partial malaria resistance.

Maintained allele in malarial regions despite homozygote disadvantage.

Genetic drift

Random allele-frequency change in small populations.

Founder effect — new population from few founders.

Bottleneck — sudden drop reshuffles frequencies.

Pre-zygotic isolation

Geographic, ecological, temporal, behavioural, mechanical, gametic.

Stops mating or successful fertilisation.

Post-zygotic isolation

Hybrid inviability, sterility (mule), or F_2 breakdown.

Confirms reproductive isolation when pre-zygotic incomplete.

Allopatric speciation

Geographic separation cuts gene flow.

Selection / drift diverge populations.

Reproductive isolation arises ⇒ new species.

Sympatric

Diverge within same region.

Polyploidy, ecological / behavioural niche shift.

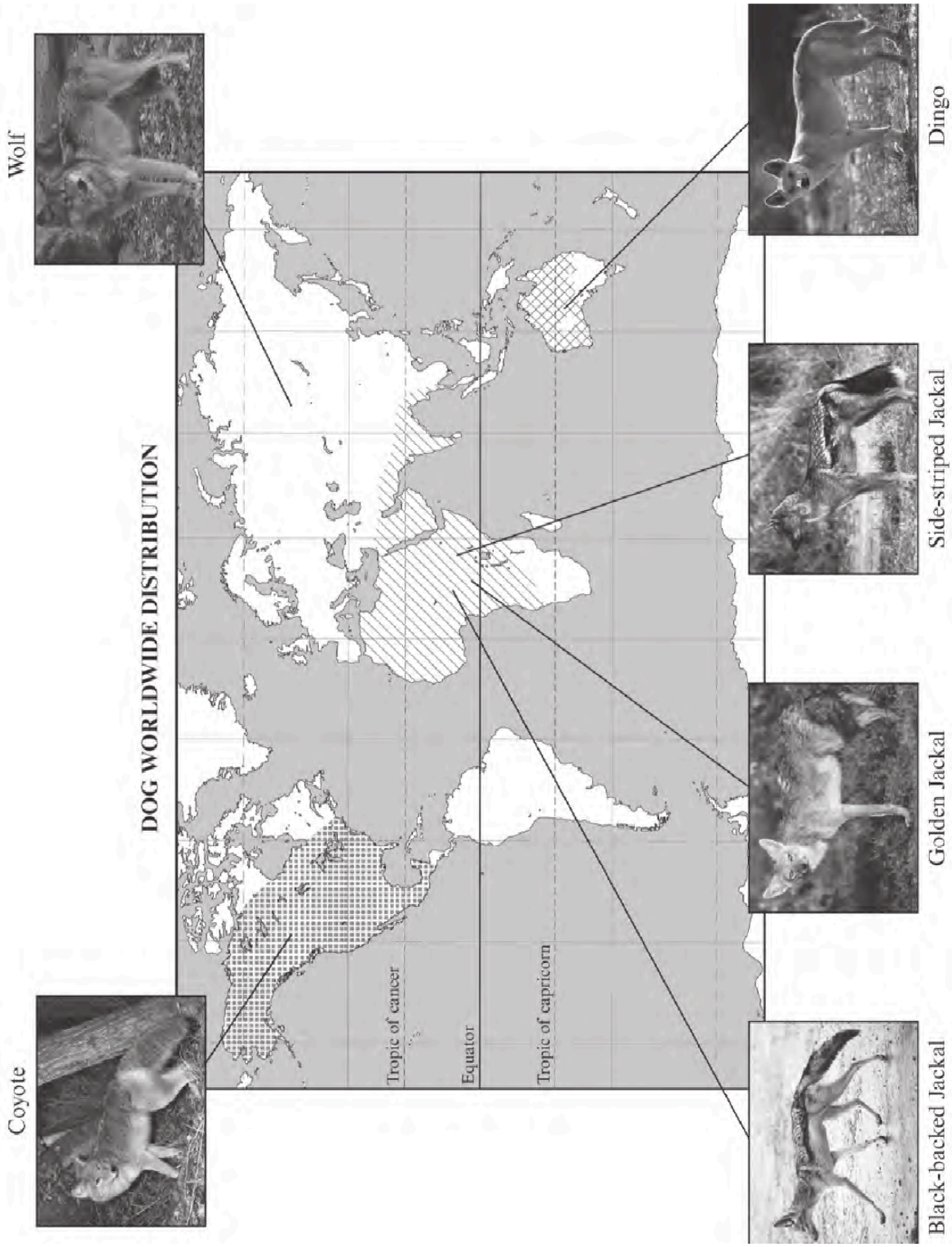
Adaptive radiation

One ancestor → many specialised species.

Darwin's finches in Galapagos.

Often follows colonisation of empty niches.

4. The map shows the world distribution of different members of the canine (dog) family and the grid following shows if mating between different members of the canine family results in fertile offspring.



Examiner only

	dog	wolf	dingo	coyote	golden jackal	black-backed jackal	side-striped jackal
dog	✓	✓	✓	✓	✓	×	×
wolf	✓	✓	✓	✓	✓	×	×
dingo	✓	✓	✓	✓	✓	×	×
coyote	✓	✓	✓	✓	✓	×	×
golden jackal	✓	✓	✓	✓	✓	×	×
black-backed jackal	×	×	×	×	×	✓	×
side-striped jackal	×	×	×	×	×	×	✓

Key:
Fertile offspring = ✓
Infertile offspring = ×

(a) Using the data, state which members of the canine family are the same species as the dog. Give a reason for your answer. [2]

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(b) Suggest **two** *other* pieces of evidence which would confirm that they were members of the same species. [2]

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Examiner only

(c) (i) Use the map to suggest which species are likely to have been produced by sympatric speciation. [1]

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(ii) Suggest a possible isolating mechanism. [1]

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(d) The chromosome number of the dog is 2n 78 and the European Red Fox is 2n 38. Rare cases of mating between dogs and foxes have been recorded (resulting in an animal called a dox) but the offspring are all sterile. Give reasons for this sterility. [4]

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(Total 10 marks)

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Examiner only

4. The evolution of a new species over a long period of time begins when some sort of **isolating mechanism** (1) separates a population into two or more subgroups. Natural selection acting on the subgroups ensures that the individual most suited to the conditions survive or breed more successfully, that is, **survival of the fittest** (2). If the conditions facing the two subgroups are different they will gradually show **divergence** (3) from the ancestral form and from each other. Evidence for the evolutionary relationship of organisms can be derived directly from their **fossil record** (4) and from their **classification** (5).

The following statements could be used to illustrate **one or more** of the numbered terms. After each statement, write in the appropriate **number** or **numbers**.

(a) The pentadactyl limb is a characteristic of extinct and present day mammals. [1]

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(b) A wide range of bacteria are now resistant to penicillin. [1]

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(c) Over 500 species of plants have been recorded on the Galapagos islands and 180 of these are not found anywhere else in the world. [1]

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(d) Two species of pine trees are found in Monterey Bay, California. *Pinus radiata* produces pollen in February and *P. attenuata* produces pollen in April. [1]

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(e) A particular plant-feeding bug, arrives on a suitable host and lives there for several weeks and produces a large number of offspring. [1]

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(f) The cichlid fish are a family recognised by their curious jaw formation.
In Lake Victoria there are about 450 different species. [1]

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(Total 6 marks)

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Examiner only

5. Finches that inhabit the Galapagos Islands (which include the islands of Genovesa and Champion) have become known as Darwin's Finches. They provide useful evidence to support a gene pool model of speciation.

(a) Define the term 'gene pool'. [1]

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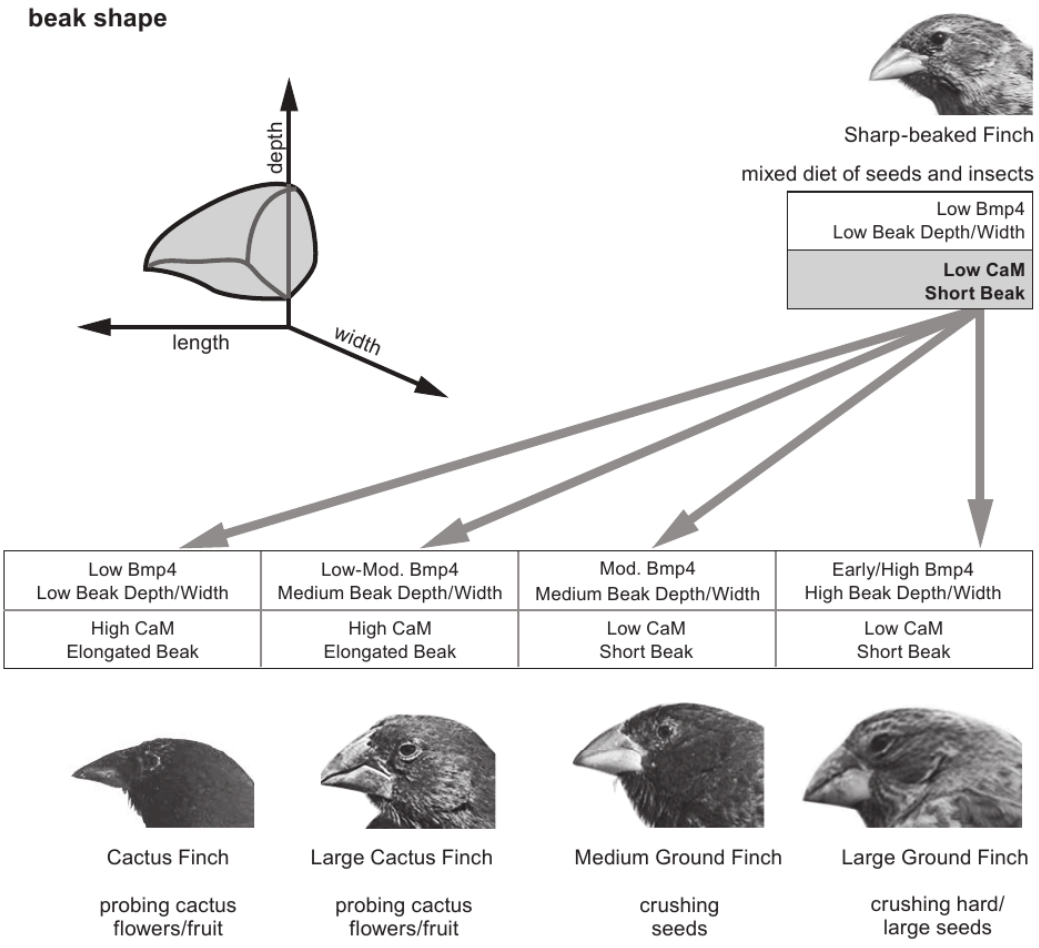
(b) There is a strong correlation between the size of finches' beaks and the size of the seeds the beak is able to crack. Recent research has shown that two proteins are involved in controlling beak size:

Bone promoting molecule 4 (Bmp4) and calmodulin (CaM)

The diagrams below show links between the two molecules, beak shape and food source.



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(i) Describe the link between beak shape and food source. [1]

(ii) Describe the link between CaM and beak shape. [1]

(c) One theory for the evolution of the different species of Darwin's Finches is that a small population of Sharp-beaked Finch *(Geospiza dificilis)* was blown onto one of the islands from mainland South America. Over many generations they became adapted to feed on the different food sources available.

(i) Give **one** reason why, in the early generations of the island colony, the frequencies of the alleles responsible for producing Bmp4 and CaM might have differed from their frequency in the mainland population. [1]

(ii) Explain how, in subsequent generations, the frequency of the allele responsible for producing CaM would have increased on an island where the main food source was cactus flowers. [4]

Examiner only

(d) The Large Cactus Finch *(Geospiza conirostris)* from the island Genovesa has a beak that closely resembles that of the Cactus Finch *(Geospiza scandens)* from the island Champion.

(i) State why these two finches are considered to be separate species. [1]

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(ii) Explain why they evolved into separate species. [2]

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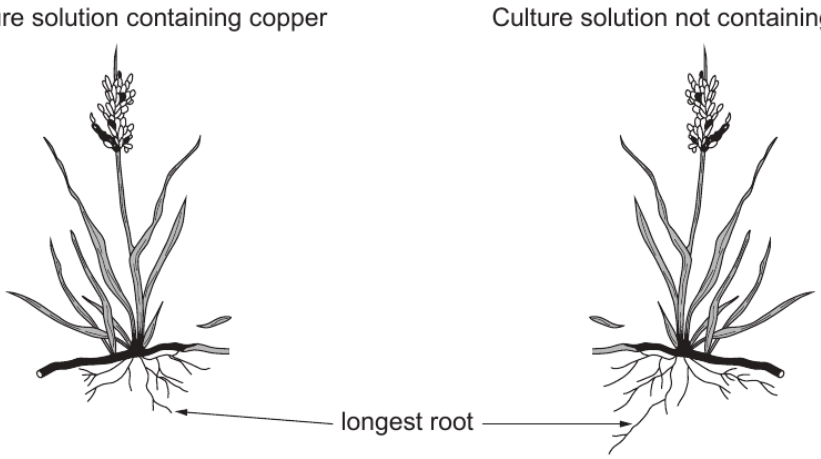
Examiner only

7. Common Bent grass, *Agrostis tenuis*, is known to be able to grow in soils contaminated with copper.
In one study, scientists measured the ability of the grass to tolerate copper by growing samples in culture solutions which did or did not contain copper and measuring the length of the longest root, as shown below.



The table below shows the results of measuring the roots of samples of grass. The figures each represent the mean values of measuring ten plants.

Culture solution	Mean length of longest root / mm			
	Replicate 1	Replicate 2	Replicate 3	mean
With copper	76	83	78	79
Without copper	390	407	424	407

(a) The scientists calculated a tolerance index as follows:

$$\text{Tolerance index} = \frac{\textit{mean length of longest root with copper}}{\textit{mean length of longest root without copper}} \times 100, \text{ rounded to one decimal place}$$

Calculate the tolerance index for the *Agrostis* plants. [2]

tolerance index = ... %

Examiner only

Plants were collected from four survey sites around Parys Mountain, the site of a disused copper mine, and from one site on Aber Mountain, where there had never been copper mining. The scientists also measured the copper concentration in the soil from which the plants were removed. The results of the tolerance tests and the soil analyses are shown in the table below:

Survey site	Soil copper content /mg kg^{-1}	Tolerance Index /%
Aber Mountain site	0.7	5
Parys Mountain site 1	1.1	19
Parys Mountain site 2	9.0	27
Parys Mountain site 3	13.0	51
Parys Mountain site 4	23.5	69

(b) (i) Describe the relationship between soil copper content and tolerance index. [1]

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(ii) What conclusion can be drawn by comparing the results from Aber Mountain with those from Parys Mountain? [1]

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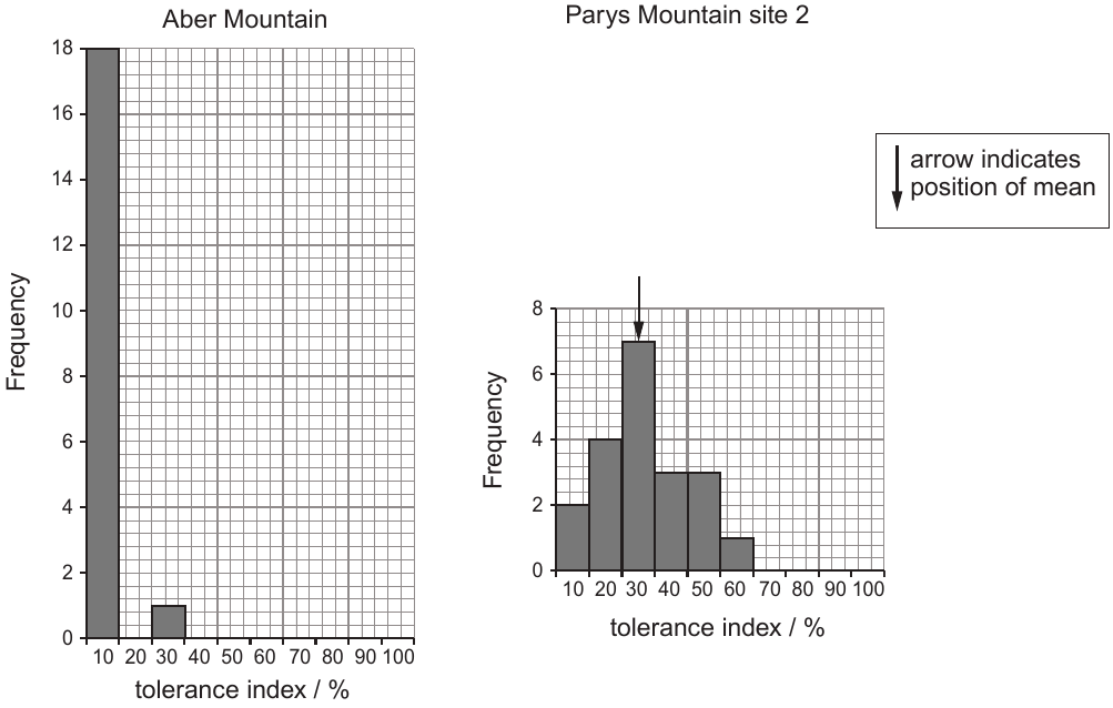
Examiner only

Frequency histograms were used to show the distribution of copper tolerance in the populations of *Agrostis tenuis* in the different survey sites, some of the results are shown below:



(c) (i) State the type of variation shown at each site and with reference to the data shown, explain your answer. [4]

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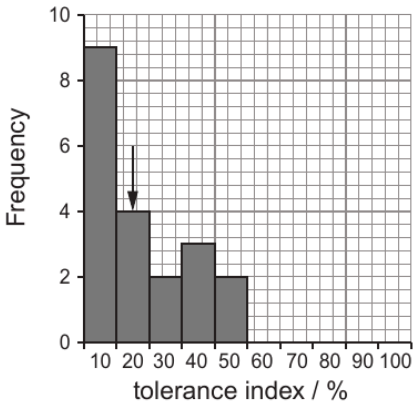
Examiner only

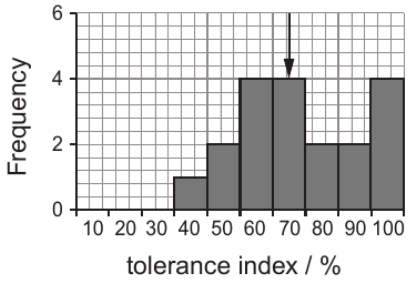
The effect of increasing concentrations of copper on the tolerance of *Agrostis* may be seen by comparing the frequency histograms from sites on Parys Mountain with different soil copper concentrations.

Parys Mountain Site 1 – Soil copper
1.1 mg kg^{-1}



arrow indicates position of mean

Parys Mountain Site 4 – Soil copper
23.5 mg kg^{-1}



(ii) What effect has increasing soil copper concentration had on the position of mean tolerance index in the distribution? [1]

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(iii) Explain how natural selection could have acted on the gene pool of the *Agrostis* population over many generations to bring about the changes to the distribution of the tolerance index. [5]

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END OF QUESTION PACK

4 questions · 41 marks · ~1 h 6 min
Source: WJEC BY5 (2008 modular spec, 2011–2017)
Curated for WJEC Biology 2015 spec A2 Unit 4 — Topic 7 (4.4)