Core practical 16b: Investigate the effect of one abiotic factor on the morphology of one species

Objectives

- To investigate the effect of an abiotic factor on the morphology of a species
- To plan an investigation independently

Safety

- Students should complete their own risk assessments before carrying out the investigation. You must check and agree to it before any practical work is undertaken. The points below are general notes for fieldwork only.
- There is a low risk of infection from organisms or from soil and water. Cover any cuts with a plaster and do not eat while working outdoors. Wash your hands using soap after fieldwork.
- There is a possibility of allergic reactions to substances such as pollen, plant sap or insect stings. Ensure students inform you immediately if they feel unwell. Wear gloves if working with nettles.
- Prepare appropriately for the weather.
- If working near water, do not enter water and always work within sight of others. Make sure you know the direction of tide movement and stay well clear of breaking waves.
- Mineral solutions should be provided ready prepared as some constituents are hazardous as a solid.

Specification links

- Practical techniques 5, 8, 11, 12
- CPAC 1a, 2a–2d, 3a–3c, 4a, 4b, 5a, 5b

Procedure

You will plan and carry out an investigation into the effect of one abiotic factor on the morphology (form and structure) of a chosen species. Your teacher will advise you of the options available and provide you with appropriate background information. When you have written a title for your investigation, follow the steps below.

1. Do some background research on your chosen topic. Try to find some high quality sources such as articles in scientific journals. Use your research to help you to form a hypothesis.
2. Write down your hypothesis and null hypothesis.
3. Write a short paragraph to explain why you arrived at your hypothesis, using your researched references to back this up.
4. Write a step-by-step plan for your investigation. If possible, carry out a small pilot study to test your methods before you start. Your plan should include the following:
   - A description of how the different levels of your independent variable will be set. How will you determine different levels of light intensity or wave exposure, for example?
   - A detailed description of how your dependent variable will be measured. How many individuals will you measure? How will you choose your samples without bias? What measurements and calculations will you make? What is the best equipment to use? Will you investigate relative dimensions (see fig A)? Explain your decisions and reference your background reading wherever possible.

5. Think of any variables that should be controlled. Explain why they must be either controlled or measured and taken into account and explain how you will do this. Do not forget to consider biotic factors, particularly competition.
6. Decide which statistical test you will use and explain why. Check what sample size you will need.
7. Write an equipment list and check with your teacher that all items will be available.
8. Carry out a risk assessment.
9. Carry out your investigation and record the results in a table.

Notes on procedure

Core practical 16 is to 'Investigate the effect of one abiotic factor on the distribution or morphology of one species taking into account the safe and ethical use of organisms'. This has been split into two parts. This practical investigates the effect of an abiotic factor on morphology, while Core practical 16a investigates the effect on distribution. Core practical 16b encourages a high level of independent planning and research. This will allow students to cover a wide range of practical skills and meet any or all of the CPAC criteria with a single investigation if necessary. Some examples of suitable topics are given below.

The effect of light intensity on the morphology of plants

Light affects the rate of photosynthesis and hence growth, but differences in light intensity could also change the way a plant grows. Students could choose from a variety of ways to measure leaf size, including linear dimension, leaf area or dry mass. They could also compare other factors, such as stem internode length, petiole length or number of serrations on leaf edges. Suitable species to study include nettles, ivy and brambles.

The effect of height on the shore or wave exposure on the morphology of rocky shore organisms

Many rocky shore species have been shown to vary in shape or size in relation to abiotic factors such as period of immersion, which is linked to height above low water, or water movement, which is linked to the degree of exposure to waves. A wave-exposed section of shore that faces the direction of prevailing wind can be compared with a nearby area that is sheltered by a headland or harbour wall. Height on the shore can be measured using the distance seaward from the top of the seaweed or barnacle zone, or as distance landward from low water mark on that day. Consult online tide tables to find this. Measuring height above chart datum using a cross staff or similar is an even better alternative.

Good titles for investigations include:

- Does the shape of a dog whelk vary between wave-exposed and wave-sheltered shores?

  Waves can dislodge or damage shells and smaller shells present less surface area to the oncoming waves. Dog whelks (*Nucella lapillus*) also have a muscular foot that helps them hold onto the rock. Does the relative size of such structures vary with wave exposure?
- Does the size or growth rate of egg wrack (*Ascophyllum nodosum*) vary with height on the shore?

  Light is absorbed by seawater, so the deeper the water, the less light is available. On the other hand, egg wrack is a marine organism and suffers desiccation stress when out of water for long periods. Egg wrack has large air bladders. One air bladder per year is laid down on the main frond from the second year onwards. This means the length of a particular year's growth can be measured.
- Does the shape of limpets vary with height on the shore?
- Example data for this investigation are provided. The shape of a limpet can be approximated as a cone. Students should suggest a hypothesis stating how the shape of the cone might vary to be better adapted for the reduced water availability and extremes of temperature found on the upper shore. Ideas such as a reduced surface area-to-volume ratio, a reduced circumference (shell edge)-to-volume ratio, and an increased height-to-diameter ratio have been suggested previously. Students could calculate these using cone height and mean diameter, then test their hypothesis using a Students *t*-test.

Mineral ion availability and morphology of seedling growth

This is a laboratory-based alternative to fieldwork that investigates the effect of a lack of one key mineral ion on seedling morphology. Students could choose from a variety of growth parameters, such as mass, root or stem length, and leaf area. They should research the functions of the mineral that will be deficient and use this to plan the measurements they will take. Encourage students to study relative dimensions: for example, is root growth limited more than shoot growth by a lack of phosphate ions?

Germinated barley or mung beans can be grown in the mouth of a test tube, suspended using plastic film or cotton wool, with the growing root in the mineral solution below. Mineral solutions such as Sach's culture medium made up with all key nutrients can be compared to a solution where one key nutrient is omitted. It is usually more effective to make a simple comparison of solutions with and without the mineral and increase the number of replicates than to investigate a range of concentrations. Controlled variables such as other mineral ions, size of seed, temperature and light should all be considered.

The seeds will need to be grown for about 3 weeks and regularly topped up with growth solution to get the best results.

Answers to questions

1. Check the publication type. Is it subject to peer review, as scientific journals should be? Is there any possibility of bias, such as commercial interests? Is it up to date? Check the author(s). Can you tell who wrote the article? If so, are they experts in this topic? Have they published elsewhere? Check to see if the information is backed up by similar statements in other publications. Is the publication widely cited by other authors? If so, make sure it is cited for the right reasons!
2. A hazard is a potential source of harm. A risk refers to the likelihood that a person will be harmed, e.g. high risk or low risk.
3. Reliability: results are reliable if they can be repeated by other scientists to achieve similar results.

   Validity: a measurement is valid if it measures what it is supposed to be measuring. This depends both on the suitability of the method and the equipment. For example, results are unlikely to be valid if variables other than the independent variable have not been controlled.

Sample data

Upper shore		Lower shore	
Mean shell diameter/mm	Mean shell height/mm	Mean shell diameter/mm	Mean shell height/mm
61.0	34.2	44.3	26.7
64.5	30.5	50.0	22.4
40.0	15.7	58.8	30.0
57.0	33.9	46.8	23.0
63.0	34.5	47.5	29.0
55.8	30.2	46.4	19.6
61.0	26.9	50.0	14.0
52.2	34.1	48.4	18.3
58.3	22.7	48.0	26.0
57.1	30.8	35.5	13.0
52.0	25.0	50.0	21.2
55.4	25.8	52.0	19.0
53.9	23.0	53.8	29.0
60.2	31.0	48.6	21.6
56.7	30.3	45.3	20.5
59.0	30.5	44.6	26.0
52.5	25.0	47.9	18.0
62.5	29.0	45.0	18.5
62.4	28.0	43.5	21.8
61.3	26.8	47.6	23.2
60.7	27.0	50.0	21.0
60.0	32.0	39.0	19.6
61.5	32.0	25.4	7.3
64.0	30.0	47.2	19.0

Table A Shell dimensions of limpet (*Patella vulgata*) populations from the lower shore (low desiccation stress) and upper shore (high desiccation stress).

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All the maths you need

- Use ratios, fractions and percentages.
- Use an appropriate number of significant figures.
- Find arithmetic means.
- Construct and interpret frequency tables and diagrams, bar charts and histograms.
- Understand the principles of sampling as applied to scientific data.
- Understand the terms mean, median and mode.
- Select and use a statistical test.
- Understand measures of dispersion, including standard deviation and range.
- Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined.
- Plot two variables from experimental or other data.
- Calculate the circumferences, surface areas and volumes of regular shapes.

Equipment

Write a list of the equipment you will require for your planned investigation.

Diagram

fig A Measuring a single linear dimension rarely describes the morphology of an organism effectively. Shape, or relative dimensions, may also be a more important morphological feature than overall size in some situations. In the diagram, the first two leaves are the same shape but different sizes, while the second and third are the same height but different shapes. Using a height to length ratio would distinguish between the taller and more flattened shapes irrespective of size.

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Analysis of results

1. Draw a graph of your results. This might be a frequency diagram or histogram of class sizes.
2. Carry out an appropriate statistical test. If you are testing for a significant difference between two levels of an independent variable, use a Student's *t*-test. If you are testing for a relationship, using multiple levels of the independent variable, use a test for correlation.
3. Write a short conclusion, explaining your results using biological ideas and backing this up with scientific references. Consider the mechanism by which any differences could arise, such as natural selection or phenotypic plasticity.
4. Evaluate your investigation. Identify and explain any anomalies. Give values for the uncertainty of key measurements. Comment on the reliability and validity of data and any major sources of error.
5. Write a reference list for your sources of information, following good practice for scientific referencing.

Learning tip

- Remember that a difference in means between two treatments or an apparent relationship between variables can occur by chance when we sample populations. A statistical test is required to determine how confident we can be that observed patterns are real.

Questions

1. When researching background information for your project, how can you check that a source of information is reliable?
2. In a risk assessment, what is the difference between a risk and a hazard?
3. Write definitions for the terms 'reliability' and 'validity'.

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If making up mineral ion solutions:

- Potassium nitrate(V) is oxidising and dangerous with some metals and flammable substances.
- Iron(III) chloride is harmful as a solid.
- Sodium nitrate is oxidising and harmful as a solid and dangerous with some metals and flammable materials.
- Calcium nitrate(V)-4-water is oxidising and irritant as a solid.

Equipment per student/group	Notes on equipment
	Students will need to submit a list of required equipment, which will depend on their plans. Equipment for the investigations suggested on the Teacher sheet is listed here.
Field-based investigations	
ruler with millimetre divisions, dial callipers, graph paper, mass balance, tape measure, set squares	Offer these for measuring the dimensions of organisms if required.
quadrat, 20 m tape measure, random number tables	Offer these for selecting a sample of organisms to measure if required.
light meter, thermometer or temperature meter, humidity meter or datalogger	These may be required for measuring environmental variables.
plastic gloves and scissors or cutters	To protect hands when removing and handling leaves if studying nettles
Lab-based investigations	
barley seeds or mung beans	Germinated for 5–7 days
test tubes	
cotton wool or plastic film	
light meter, thermometer or temperature meter	These may be required for measuring environmental variables.
aluminium foil or black plastic	To cover test tubes to prevent algal growth

complete Sach's culture medium dissolved in 1 litre of water 0.25 g calcium sulfate(VI)-2-water 0.25 g calcium phosphate(V)-2-water $CaH_4(PO_4)_2$-water 0.25 g magnesium sulfate(VI)-7-water 0.08 g of sodium chloride 0.70 g potassium nitrate(V) 0.005 g iron(III) chloride-6-water	Students will need a small amount of complete medium for controls. Students will need additional complete medium and additional quantities of any nutrient-deficient medium to top up test tubes regularly.
For Sach's culture medium with mineral deficiencies make changes as below. deficient in calcium: 0.2 g potassium sulfate(VI) replaces calcium sulfate(VI)-2-water and 0.71 g sodium dihydrogenphosphate(V)-2-water replaces calcium phosphate(V) deficient in iron: omit iron(III) chloride-6-water deficient in nitrogen: 0.52 g potassium chloride replaces potassium nitrate(V) deficient in phosphorus: 0.16 g calcium nitrate(V)-4-water replaces calcium phosphate(V) deficient in sulfur: 0.16 g of calcium chloride replaces calcium sulfate(VI) and 0.21 g magnesium chloride-6-water replaces magnesium sulfate(VI) deficient in magnesium: 0.17 g potassium sulfate(VI) replaces magnesium sulfate(VI) deficient in potassium: 0.59 g sodium nitrate(V) replaces potassium nitrate(V)	
rulers with millimetre divisions, dial callipers, graph paper, mass balance	Offer these for measuring the dimensions of plants if required.
Notes	