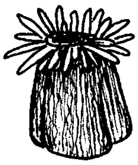
How intertidal animals avoid drying out

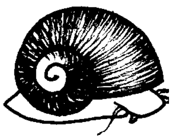
The problem – pre-visit preparation

Nearly all seashore creatures are marine animals that manage to survive for a few hours when the tide is out. They are only active when covered by water – when the tide is in. They are adapted for breathing, moving, sensing, feeding and mating underwater. When the tide goes out they stop doing all of these things if they are stranded out of water.

Question: Why live on the shore then if drying out makes life so difficult? Most can only have half a life – when the tide is in.



Answer: The shore is a place to live for animals that are tough enough or cunning enough to exploit it. If they can survive the physical rigors of the intertidal zone, they may, by living there, escape some other threats such as being eaten by predators that are less desiccation tolerant and are therefore restricted to living lower down on the shore or below the tide.



Some facts about drying out

- Drying is caused by wind and by the sun's heat. Wind is the worst desiccator.

- Drying out can be worse on a rocky shore than on land … because:

  a. Seashores are often windy places. Wind comes uninterrupted off the sea and may have built up over hundreds or thousands of kilometres

  b. There is usually little shade from the sun – no tree cover on most shores. Sometimes cliffs give shade on south facing shores and their rocks often have more obvious algal cover

  c. Unlike soil on land, rocks hold little or no water when the tide falls. (Rocky shores have no 'soil' because the waves wash all loose particles away)

How do animals cope with the stresses of drying out?

Apart from animals that live permanently attached under large stable boulders, all intertidal animals have adaptations for either holding a reservoir of water and/or reducing the loss of water while the tide is out.

a. Physical adaptations:

- Waterproof shells
- Shells have spare space inside for holding water
- Shells have neat fit to rock or tightly closing openings
- Snail shells have smooth shapes that reduce turbulent airflow and thereby lessen water loss

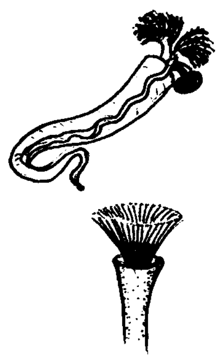
Many fixed animals – oysters, barnacles and tubeworms – have white shells to reflect the sun's rays

b. Behavioural adaptations:

- Mobile animals stop moving when exposed
- They clamp their shells tight against the rock
- Many move to wet, moist or shaded retreats as tide falls
- Fixed animals close their shell openings or plug them tight

Pre-visit investigations and specimen inspections

Teachers should have class sets of common shells such as nerita, topshell, cats eye and limpet (collected from beaches that are not in a marine reserve). Class sets of photographs of oysters, barnacles and tubeworms are also useful to show to a class.



Using shell specimens and or photographs ask students to name and illustrate the physical adaptations of two to five different animals and describe how each adaptation works to reduce water loss. Select common animals that they will be able to see alive when they visit the marine reserve.

Ask them to describe the food and feeding method of each one and to consider if these limit or determine where it has to live or where it has to spend its feeding time. Algae grow best on open rocks where the light is bright. These are therefore the places where grazing snails must feed but they are also often the sites of greatest wind and sun when the tide is out (= the most severe drying conditions).

Site-visit investigations

At the shore have the students identify the same animals and comment on the severity of the drying conditions they are exposed to. Have them observe and note behavioural adaptations for coping with the period when the tide is out. Do they clamp down where they were stranded, move to a damp crevice or, as in the case of some limpets, return to a permanent home site?

Example:

Nerita – Adapted to survive severe drying conditions

Snail: Nerita, *Nerita atramentosa*. Grazer on open rocks near top of shore.

Severity of drying problem? Severe. It inhabits bare smooth rocks and must endure a long exposure time out of water during each low tide, in some sites up to 9 hours.

Nerita's physical adaptations

a. tough waterproof shell

b. base of shell fits very neatly to a smooth rock surface so wind cannot blow around the soft moist body when the shell is clamped down tight

c. Shell is streamlined so that wind slips around the shell smoothly thereby reducing the turbulent eddies which draw water vapour away from the shell/rock junction

d. Internal shell volume is larger than animal volume and is therefore able to hold a reservoir of water while the tide is out

Nerita's behavioural modifications

As the falling tide laps around mobile intertidal animals, leaving them momentarily stranded on wet rock between waves, they have a few minutes to prepare for the low tide period when they will be exposed out of water.

Some of the snails move under ledges or into moist crevices but on sunny days nerita snails often congregate into tight packs. These frequently contain over 20 individuals and may consist of over 100. The water held between the shells supplements the water held inside them.

On a hot sunny day have the children count the number of snails in different packs. As these snails are out of water longer than other grazers lower on the shore they need better water retention and they benefit from the additional stored water which prevents them becoming dehydrated. It also keeps them cool as it evaporates.

NB: *for shell shape related to shore position for three common grazers (nerita, topshell and cats eye) see 'Seashore shells: Grazers and predators', Walsby & Coote. 1994 Auckland Science Advisory Service bulletin.*

Simple classroom experiment

Classroom demonstration of water retention by nerita packs

Materials

- About 20 nerita shells
- A 2-litre bulk ice cream box and lid
- Blue Tac or plasticine
- Small measuring cylinder or graduated test tube

Method

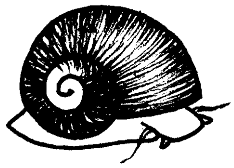
- Cut the rim off the ice cream box lids to make a flat plastic board
- Neatly plug the openings of the shells with Blue Tac so it is very slightly proud of the rim
- Press each shell on to the board so the Blue Tac holds it in position, arranging the shells to form a tight pack
- Place the board in the ice cream carton
- Accurately measure out 10 ml of water and pour it gently over the pack
- Tilt the board slightly to allow water to drain off it. Some water remains held between the shells (due to surface tension).

Pour the water that ran off into the carton back into the measuring tube. The difference in volume from 10 ml equals the volume held around the shells – normally about 2 ml.

It is easy for the students to see the water held between the shells and to appreciate how helpful it would be on a hot windy day to reduce drying stress on the small snails.

Control experiment

Ideally the experiment should be duplicated with the same number of snail shells stuck to the board but with each shell at least a shell length away from other shells. Much less water will be held around the snails if they are not congregated together and this shows the advantage of the packing behaviour for retaining water.



Senior studies

Desiccation demonstrations

Senior students with access to digital top-pan balances can perform a variety of simple informative experiments to demonstrate the rates of water loss from intertidal snails.

Using 2-litre ice cream cartons as temporary aquariums each with a false floor made from a cut down lid it is easy to arrange for a known number of snails to adhere to the plastic floorboard. By lifting the board from the tank the snails are left ‘stranded by the falling tide’ and the rates at which they lose water by evaporation can be measured and plotted on a graph by weighing the board and its attached snails at precise intervals. The boards are tilted and wiped to remove surface water when first lifted from the water.

Examples of possible studies

1. Comparison of water loss rates from three different species: nerita, topshell and cats eye. Nerita, *Nerita atramentosa*, (which lives highest on the shore) has the most perfect fit to a flat surface and the cats eye, *Turbo smaragdus*, (which lives lowest on the shore) has the least perfect fit but may be able to hold more water beneath the shell by capillarity. The topshell, *Melagraphia aethiops* is intermediate in both fit and position on the shore.

To compare water loss by the three species, shells of similar size must be selected for the comparisons to be valid.

2. Comparison of water loss under different conditions.
   This is easily investigated by leaving boards with attached snails
   a) in sun or shade,
   b) in still air
   c) exposed to wind
   e) in shade
   f) in calm conditions
   g) in the wind
   h) in sunny / calm conditions
   i) in sun and wind
   j) in shaded / calm conditions
   k) in shade and wind

At the marine reserve a complementary study of the shore positions of each species allows the water loss / water holding characteristics to be related to the length of tidal exposure. (See also *Platform shore distribution studies* for Goat Island Bay and Long Bay, page 98)