

## B.4.1 · Adaptation to environment

International Baccalaureate · IB Diploma · Biology · HL

### Scope and prerequisites

This handout covers selected HL/SL topics for the course first assessed in 2025; it is not the whole syllabus.

Prerequisites: transpiration from B.2.3 onwards and natural selection from D.4.1.

The examples are original and fictional: they are not real measurements or real student investigations.

### Adaptation to environment

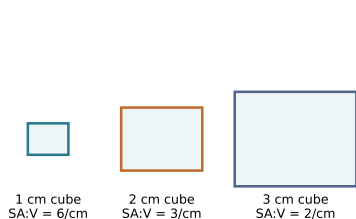
#### ■ What would explain this observation?

- A cactus survives months without rain while a water lily lives with its leaves flat on the water surface. Both are plants, yet their bodies are nearly opposite. Why?

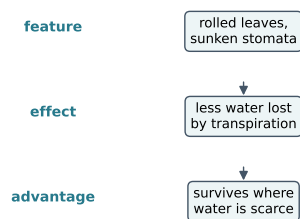
#### ■ Build the model

- An **adaptation** is an inherited feature that improves survival or reproduction in a particular environment. Adaptations are structural (rolled leaves, sunken stomata in a **xerophyte**), physiological (concentrated urine in a desert mammal) or behavioural (a lizard basking to warm up).
- A useful adaptation explanation links feature → effect → advantage: rolled leaves trap moist air, so less water is lost by transpiration, so the plant survives drought. **Surface area to volume ratio** (SA:V) explains many adaptations: a smaller body has a larger SA:V and loses heat or water faster.
- adaptation: An inherited feature improving survival or reproduction in a given environment; xerophyte: A plant adapted to dry conditions; surface area to volume ratio: Surface area divided by volume, controlling exchange rates.

Smaller body → larger surface area per volume



An adaptation links a feature to survival in its environment



*Selection needs heritable variation and an environment that favours some variants*

#### ■ Choose evidence that can test it

- Compare water loss from a xerophyte leaf and a mesophyte leaf under the same warm, dry, moving air: the adaptation model predicts less loss from the xerophyte. Keep leaf size, temperature and humidity constant, or the comparison proves nothing.
- Measure the SA:V of model cubes or of organisms and compare with their habitats; a claim about surface area must come from measured dimensions, not from looking at the picture.

#### ■ Work from known quantities

- Known: cube side  $s = 3$  cm. Surface area =  $6s^2 = 6 \times 9 = 54$  cm<sup>2</sup>; volume =  $s^3 = 27$  cm<sup>3</sup>. SA:V =  $54/27 = 2$  per cm. For a 1 cm cube: SA:V =  $6/1 = 6$  per cm. Tripling the side cut the ratio to one third – larger bodies have less surface per unit volume, so they lose less heat per unit of tissue.

#### Example:

A desert mammal model has body surface 400 cm<sup>2</sup> and volume 2,000 cm<sup>3</sup>. Find its SA:V and compare it with a small desert mouse at 2 per cm, using the same sequence: known quantities → model → relation → substitution → unit and interpretation. (Answer: SA:V =  $400/2,000 = 0.2$  per cm – one tenth of the mouse's, so the larger animal loses proportionally less water and heat through its surface.)

#### ■ Check the conclusion and its limits

- A plausible story about a feature's use is a hypothesis until evidence supports it; some features are side effects of other traits, not adaptations. The cube model assumes a uniform shape – real organisms extend surface where exchange is needed (lungs, gills, root hairs), breaking the simple scaling.

#### Warn:

A desert plant adapts during one hot summer by growing thicker cuticle because it needs to. This claim is false: adaptations are INHERITED features shaped by selection over generations; an individual's one-season response is acclimatization, not adaptation, and need never directs the change.

#### Key:

Adaptation to environment: inherited features link to survival through a feature → effect → advantage chain, testable by controlled comparison. SA:V =  $6/s$  for a cube, and it falls as size rises – exchange surfaces and body plans follow from it.