Achievement Standard 91603

Demonstrate understanding of the responses of plants and animals to their external environment

BIOLOGY

3.3

Externally assessed 5 credits

To make learning easier, the resource material for this Achievement Standard has been divided into three sections:

- Orientation responses
- Biological timing responses
- Interspecific and intraspecific relationships.

Orientation responses

Tropisms

Growth responses (usually of plants), direction of growth response related to direction of stimulus; +ve (positive) is growth towards, –ve (negative) is growth away from stimulus. Hydrotropism is response to water, chemotropism is response to chemicals (e.g. pH, salt, nutrients, toxins), thigmotropism is response to touch.

Phototropism (response to light)

Shoots show a +ve response. Roots show a zero or –ve response. Early experiments (using cereal coleoptiles) indicated:

- Photoreceptor located in shoot tip. Covered – no response. Pigment involved (cryptochrome) responds to blue light.
- Response occurs lower in the stem, hormone involved (auxin, IAA).

  Hormones are active in very small concentrations, produced in one organ then transported away, have effect in another (target or effector) organ.
- Cells on the darker side show greater elongation than those on the bright side.
- IAA is transported in two directions concurrently
  - away from tip (where it is produced) to the zone of elongation (where it has its effect)
  - laterally (sideways across the stem) to the dark side.

Geotropism (response to gravity)

A downwards response to gravity is a +ve response because that is towards the origin of the gravitational pull.

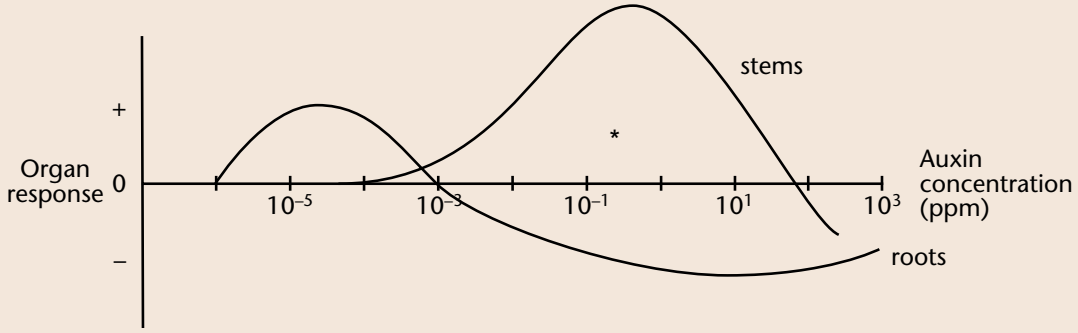
Production of IAA in root tips and shoot tips (meristems – tissues with actively dividing cells).

Transport away from meristems.

Lateral transport (across root or shoot), i.e. IAA accumulates on lower side of the root possibly as the result of starch granules settling in the cells and carrying IAA.

Cell elongation in shoots (bend upwards).

Inhibitory effect in roots (bend downwards).



* This graph shows that at the auxin concentrations found in stems and roots the stem cells elongate more and the stem bends upwards but the root cells are inhibited from elongating and the root bends downwards.

Auxins – IAA is only naturally occurring auxin. Synthetic auxins (MCPA, 24-D, 245-T, agent orange, IBA) are used as rooting hormones for cuttings, and as herbicides and defoliants.

Nastic responses

Responses (of plants) that are non-directional. You should NOT use +ve or –ve in your description because nastic responses are not directional.

Plants respond to intensity of a stimulus. Examples include the following.

- Turgor movements of some leaves (e.g. Mimosa plant) when touched (thigmonasty).
- Venus fly-trap plant capturing an insect in its leaf (thigmonasty).
- Opening and closing of flowers and leaves in response to light intensity (sleep movement) (photonasty).

Taxis

Innate (instinctive or genetically determined) response where an organism (usually an animal, but also aquatic plants, gametes, etc.) moves toward or away from an environmental stimulus, i.e. directional response that involves movement of whole organism. +ve (positive) toward stimulus, –ve (negative) away from stimulus.

- Earthworms move away from light when disturbed: –ve phototaxis.
- Slaters move away when touched: –ve thigmotaxis.
- Male moths follow pheromone trail produced by a female: +ve chemotaxis.
- Moths attracted to a light at night: +ve phototaxis.
- Sperm following chemical trail produced by ovum: +ve chemotaxis.
- Lobsters, slaters, earwigs back into tight spaces: +ve thigmotaxis.

Tropotaxis – animal compares intensity of a stimulus using two (or more) sense organs on either side of its body to determine direction of stimulus.

Klinotaxis – animal determines direction of stimulus by moving a single sense organ and comparing relative intensities.

Kinesis

Non-directional response of an organism. You should NOT use +ve or –ve in your description because kineses are not directional. Rate of activity is dependent on intensity of the stimulus. Examples include the following.

- Rate of movement of slaters depends on light intensity: Photokinesis.
- Slaters increase random movements in low humidity: Hydrokinesis.
- Flatworms increase rates of turning in low-light areas: Photokinesis.

Orthokinesis – organism's response involves rate of movement.

Klinokinesis – organism responds by changing rate of turning as it moves.

Summary of orientation responses

	Growth response – movement of parts of organism	Movement of whole organism, cell, gamete etc.
Directional +ve or –ve	Tropism +ve = towards, –ve = away	Taxis +ve = towards, –ve = away
Response to intensity of stimulus	Nastic movement	Kinesis

Migration

A regular (repeated annually or once in a lifetime) movement of a population of animals between habitats; reproduction usually occurs in one habitat and environmental extremes are avoided in the other habitat. Migrations occur regularly – usually annually, but other periods do occur (e.g. daily migration of plankton up and down the water column). In some species, migration occurs once in a lifetime prior to breeding (e.g. salmon return to fresh water and eels migrate to deep marine trenches).

- Involves a return journey (one-way migration is really dispersal).
- There is a purpose – e.g. breeding in a favourable environment, movement to make use of an available food source, avoidance of climatic extremes (cold, dry, etc.).
- Migration is active (not simply carried along by currents, wind, etc.).
- Usually involves long distances and considerable expenditure of energy.
- Involves significant numbers of animals (usually populations).
- Migration is genetically controlled (instinctive) but initiated by environmental factors (day-length, temperature changes, lack of food/population size).

Homing – ability of an animal to find its way back home (nest, burrow, etc.) over unfamiliar territory. Occurs as a result of unusual events (storms) or movement in search of food, mates, etc.

Navigation – use of environmental cues for orientation. Examples include the following.

- **Sun compass** – sun's position (one point of reference) in the sky changes with time of day – animal needs a biological clock. Birds that have had their biological clock 're-entrained' to a different time fly off in a new direction consistent with their biological clock.

  Bees use sun to navigate. Foraging bees communicate direction, distance and type of new food sources to worker bees by 'round dance' and 'waggle dance', taking changing direction of the sun into account.
- **Star compass** – stars form a complex pattern of points. Young nestling birds imprint (learn) pattern of the stars at an early age.
- **Magnetic compass** – many organisms (e.g. bees, pigeons, whales, some humans) have crystals of magnetite (magnetic Fe_3O_4) present in their sensory systems. Small magnets attached to the head show this sense can be upset.
- **Visual signals/landmarks** – require a period of learning before they can be used.

  Digger wasps perform familiarisation flight before foraging for insect prey.

  Homing pigeons must be trained, by progressively taking them further from home.

  Migrating birds are less likely to become lost on their second migration.

  Sea birds use cloud formations and wave refraction patterns (caused by islands).
- **Scent trails** – ants use these to backtrack home or to allow other ants to follow.

  Salmon use memory of smell (organic esters) of their native stream to return to breed.

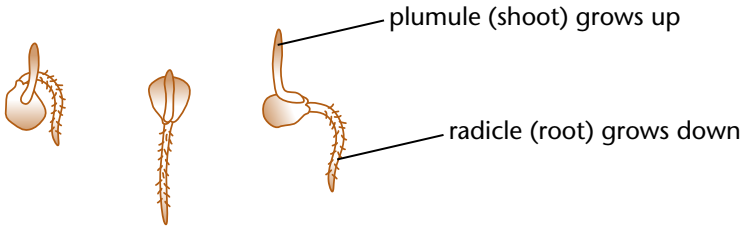
NCEA practice

Questions
Orientation responses

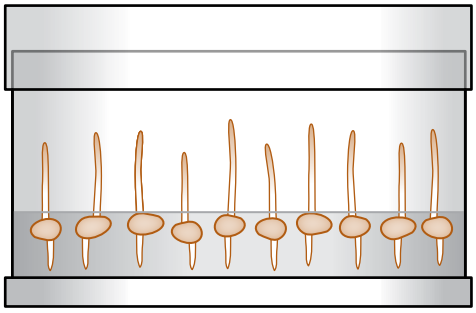
Year 2012
Ans. p. 87

Question One: Microgravity and plant responses

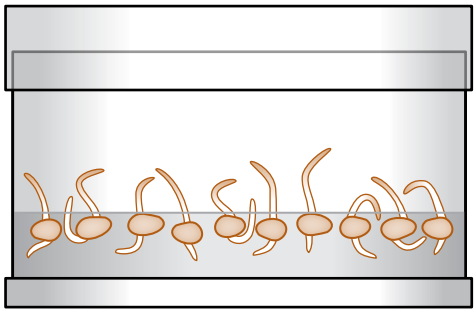
Plant roots and stems demonstrate different responses when grown in constant environmental conditions.



In conditions of microgravity (very weak gravity, such as in orbit), plants can be grown, but may exhibit unusual growth patterns, such as some roots growing up and stems down, less growth, and non-vertical growth, as shown in the following diagram.



On the ground



In microgravity

Analyse the growth responses of roots and shoots in relation to gravity.

In your answer, you should include:

- a description of the responses of the root and the shoot
- the mechanism responsible for the responses
- the adaptive advantage of the responses
- why the plants in microgravity tend not to thrive.

You may use diagrams to assist with your explanations.

Questions: Interspecific and intraspecific relationships

Question One: Pukeko behaviour

Year 2012 Ans. p. 90

Pukeko

Pukeko (*Porphyrio porphyrio*) have an interesting social structure. They live in family groups, where they carry out **cooperative interactions** in their breeding behaviour. They form a **hierarchy**, which is maintained by agonistic displays (such as threats and submission). Only the most dominant individuals breed.

The family groups are very **territorial** towards other such groups.

Analyse the breeding behaviours of the pukeko, and how these result in successful reproductive outcomes. In your answer you should:

- define the terms cooperative interaction, hierarchy, territorial
- explain why these behaviours are carried out
- discuss how the behaviours benefit both the group and each individual member.

Year 2011
Ans. p. 92

Question Two: Waved albatross behaviour

Waved albatrosses (*Phoebastria irrorata*) breed in colonies. Juvenile birds appear to have an in-built navigation behaviour, which helps them when they first fly out to sea. They return to the breeding colony after about two years, but are four to six years of age when they first breed.

Waved albatrosses are an example of a species that undergoes migration.

a. Define the term migration.

b. Birds returning to the colony for the first time already have a set of stereotyped behaviours, but require a period of learning to perfect the series of synchronised performances, such as preening, pointing, calling and bill clacking. The waved albatrosses then form monogamous relationships.

Explain the purpose of these behaviours.

Waved albatross courtship behaviour

Question Eight: Leaving Africa

Year 2010
Ans. p. 108

The earliest evidence of tool making, known as **Oldowan** tool culture, has been associated with *Homo habilis* – approximately 2 to 1.5 million years ago. *Homo erectus* (1.8 million years ago to 300 000 years ago) was the first known species to use **fire** and **Acheulean** stone tools.

a. Explain how Acheulean tools **differ** from Oldowan tools in their **design** and **manufacture**.

b. The table presents fossil data for species belonging to the genus *Homo*.

Hominin species	Estimated existence in millions of years before present (b.p.)	Cranial capacity range	Evidence of use of fire	Fossil excavation sites
H. habilis	2.0–1.5	500–800 cm^3	No	East Africa
H. georgicus	1.8–1.7	600–780 cm^3	No	Europe / Asia (Georgia)
H. erectus and *H. ergaster*	1.7–0.2	800–1 100 cm^3	Yes	Africa and Asia
H. heidelbergensis	0.6–0.25	1 000–1 300 cm^3	Yes	Africa / Asia / Europe

The map shows fossil excavation sites for *H. habilis*, *H. georgicus*, *H. erectus* and *H. ergaster*.

Homo erectus is considered to be the first hominin capable of migrating out of Africa and across Asia, about 1.5 million years ago.

Discuss the reasons why many scientists believe *Homo erectus* was the first hominin equipped to migrate out of Africa.

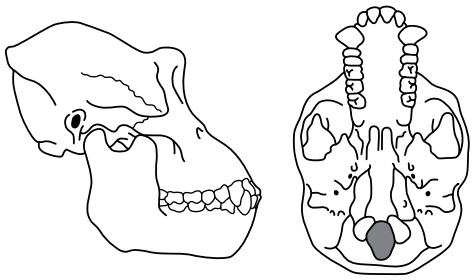
You should consider:

- evidence from the **table of fossil data** and the map
- the **features** of *H. erectus* that enabled it to survive outside Africa
- **evidence** that conflicts with this view.

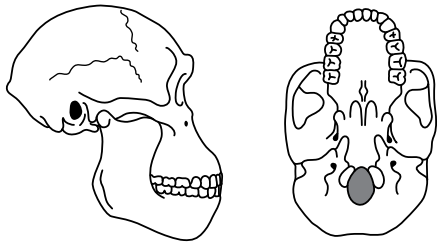
Question Nine: Trends in biological evolution

Year 2010
Ans. p. 109

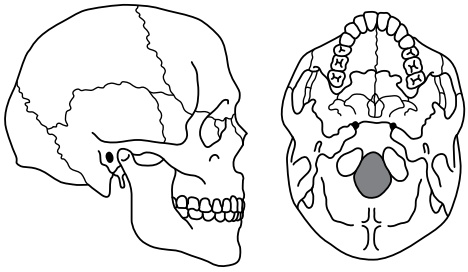
The drawings compare the features of a female gorilla skull with those of *Australopithecus africanus* and *Homo sapiens*.



Female gorilla



Australopithecus africanus

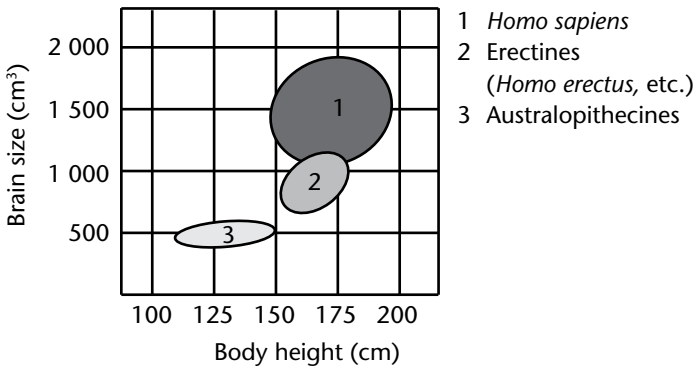


Homo sapiens

a. Use the details of the skull structures to **explain** the mode of locomotion of **each** of the THREE species shown.

b. Endocranial capacity can be correlated with body height in hominins.

Endocranial capacity (brain size) and body height ratio for major groups of the genus *Homo*



Discuss the significance of increase in endocranial capacity compared with body height in hominins. Relate this to what we currently understand about the trend in human biological evolution.

In your answer you should:

- describe and explain the observed relationship
- link this relationship to other developmental trends in the hominins
- discuss the importance of bipedalism in endocranial development in hominins.

You must refer to the information given above.

Question Ten: Cultural evolution

Year 2009
Ans. p. 110

a. At least 27 000 years ago, people living in what is now Austria buried two newborn babies in a grave. The babies were found side-by-side, covered with red ochre, and under the shoulder-blade of a mammoth. More than 30 ivory beads were also found in the grave.

Discuss what this burial **and** the associated evidence suggest about social behaviour **and** abstract thought in stone-age *Homo sapiens*.

Answers and explanations

A – correct answer to a question provides evidence for 'Achievement' grade.

M – correct answer to a question provides evidence for 'Achievement with Merit' grade. A partial answer (description) may provide evidence for an ***A*** grade.

E – correct answer to a question provides evidence for 'Achieved with Excellence' grade. A partial answer (explanation or description) may provide evidence for ***M*** or ***A*** grades respectively.

If a question uses the word 'explain' or 'reason', it is worth 'Merit' at the minimum. A question using the words 'discuss' or 'justify' or 'relate' or 'compare *and* contrast' or 'analyse', indicates 'Excellence'. For a 'Merit'- or 'Excellence'-level question, always try to give a simple definition or explanation first (to gain 'Achievement').

To answer questions it is important to have *learnt* the work and to have good **literacy skills**. Answers must be *clearly expressed* to show depth of knowledge.

- Use biological terminology correctly and with confidence. Spelling words correctly is important for 'Merit' or 'Excellence'.
- Answers *must* be linked to the question. A general or rote-learned answer without reference to context of the resource material will gain a maximum of 'Achieved', but more likely 'Not achieved'. Read resource material carefully and integrate it into your answers to ensure an answer is relevant to the question. Simply rephrasing a question will also not get any credit.
- Attempt all questions – it is generally possible to obtain 'Achieved' even in questions with 'explain/discuss' stems. Failing to attempt all questions may result in not enough questions answered to gain an 'Achieved' grade overall.
- Apply knowledge of content and process to unfamiliar contexts. A question will still be about a point in the Achievement Standard – if you have learnt it, you can answer it!
- For 'Excellence', you will need to apply skills in logical and critical thinking as well as written communication (paragraph-length answers which link ideas and concepts in a coherent manner). Define or describe a term or process before going on to discuss it. Use a concluding sentence to sum up an answer in which the (unfamiliar) resource material is linked to the concept being asked about.

Achievement Standard 91603 (Biology 3.3): Demonstrate understanding of the responses of plants and animals to their external environment

3.4 Orientation responses (page 4)

Question One: Microgravity and plant responses

Part 1 – Description of responses

- shoots – negative (–ve) gravitropism
- roots – positive (+ve) gravitropism

> Gravitropism = geotropism (gravi- refers to gravity, geo refers to the earth and its gravitational pull).
>
> Roots show positive (+ve) gravitropism because they grow towards the source of the environmental stimulus, which in this case is downwards, similarly shoots grow away so show negative (–ve) gravitropism.

(***A*** – both described)

Part 2 – Mechanism responsible for the responses

Shoot

- Shoot tip has a meristem where cells undergo mitosis and new cells are produced.

  The meristem produces IAA (IAA belongs to a class of hormones called auxins).
- Behind the meristem is a zone of cell elongation (and differentiation) where cells elongate (and the cell wall stretches) due to osmotic water absorption.
- IAA is transported in two directions:
  - ✦ polar transport – this is active transport of IAA away from the meristem, to the zone of elongation
  - ✦ lateral transport to the lower side of non-vertical shoots – IAA not actively transported; transport is under the influence of gravity.
- IAA promotes shoot elongation by stimulating cell-wall growth, causing cells on the lower side of a horizontal shoot to elongate more than those near the upper surface. Consequently, the shoot 'bends' upwards.

Root

Root tip has a meristem where cells undergo mitosis and new cells are produced. The meristem (is protected by a root cap which) produces IAA.

Behind the meristem is a zone of cell elongation (and differentiation) where cells elongate (and the cell wall stretches) due to osmotic water absorption.

- IAA is transported in two directions:
  - ✦ polar transport away from the meristem to the zone of elongation