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.

Essential exam notes

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 the stimulus. *Hydrotropism* is a response to water concentration. *Chemotropism* is a response to chemicals (e.g. pH, salt, nutrients, toxins). *Thigmotropism* is a response to touch. *Gravitropism* (or *geotropism*) is a response to gravity.

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)

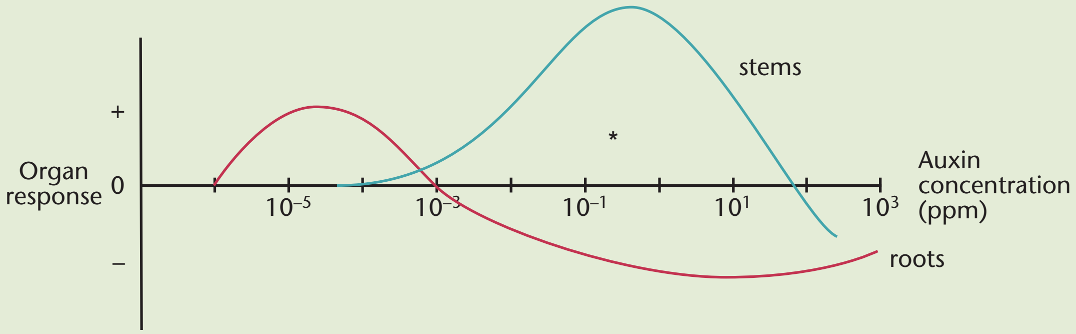
A downwards response to gravity is a +ve response because that is towards the origin of the gravitational pull. Production of IAA in root tips and shoot tips (meristems – tissues with actively dividing cells).

IAA is transported 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. A biological clock is also needed because, like the Sun, the position of stars in the night sky changes as the Earth rotates.
- **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

Question One: Orientation responses of some invertebrates

Some animals display innate behaviours.

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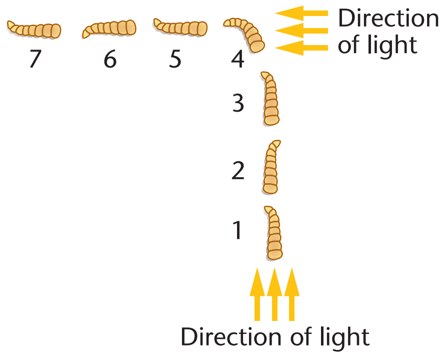
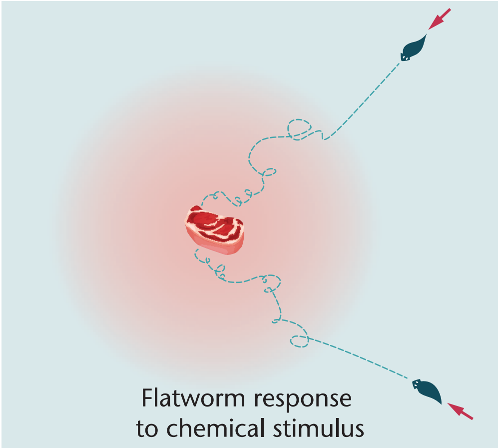
As green bottle fly maggots (*Phaenicia sericata*) crawl, they turn their heads, comparing the light intensity from each side. They always turn towards the darker side, taking them away from light.



A piece of meat in water causes a chemical gradient. Flatworms, such as *Planaria torva*, move along a straight path until they detect an increase in chemical concentration. The flatworms increase their rate of turning in the area until they touch the meat and start feeding.



Compare these responses, the adaptive advantages gained for the animals that display them, and how these animals come to have them.

In your answer:

- identify the full term given for both responses, and define these terms
- using the information above, justify the types of orientation you have described, and explain how they operate in both the maggots and the flatworm
- compare the adaptive advantages these animals gain by displaying these behaviours.

Achievement Standard 91605

Demonstrate understanding of evolutionary processes leading to speciation

BIOLOGY

3.5

Externally assessed 4 credits

Essential exam notes

Describe patterns of evolution

Darwin's theory of evolution by natural selection

- All species have potential for exponential growth, creating a 'struggle for survival'.
- Organisms (that reproduce sexually) exhibit variation – some advantageous, others disadvantageous.
- Those with favourable phenotypes are more likely to survive and reproduce (selected for), others selected against, i.e. 'survival of the fittest'.
- Each generation will be better adapted (microevolution).
- Accumulated changes explain origin of new species and whole new groups (macroevolution).

Post-Darwin developments that improve our understanding of the theory

Mendelian genetics explains inheritance of characteristics.

- Independent assortment, crossing-over during meiosis and random fertilisation of gametes increase number of phenotypic variations.
- Concept of 'gene pool' helps us understand action of natural selection. Evolution is 'succession of changes in gene frequencies within a gene pool'.
- DNA structure and nature of mutations have shown origin of all variations.
- Biochemical evidence (similarities and differences in DNA and proteins) parallels other evidence for evolution.
- 'Survival of the fittest' does not always imply strongest or biggest. 'Fitness' is a function of organism's adaptations (structural, physiological, behavioural) and describes individual's chances of survival and successful reproduction.

Evidence for evolution

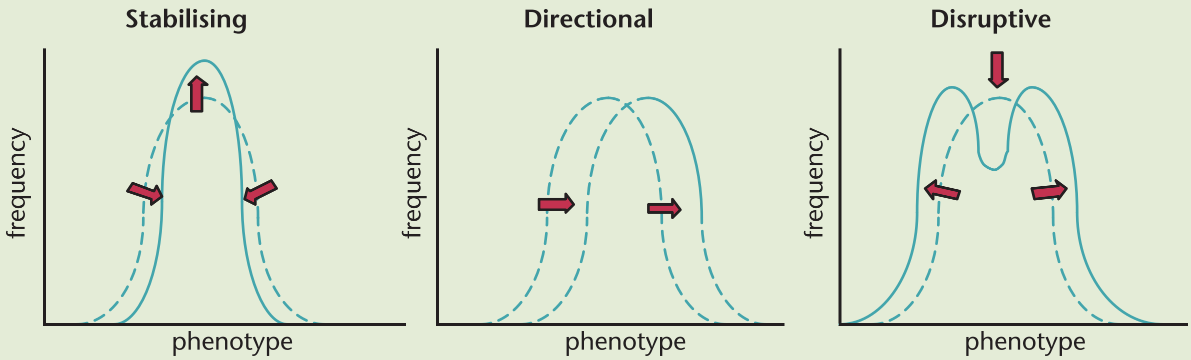
Evidence for evolution includes the following.

- Palaeontology – fossils that are ancestral or related to present-day species.
- Structural evidence – comparative anatomy of present and fossil species; **homologous** organs (same origin, different functions); **analogous** organs (different origin, same function); **vestigial** organs (reduced size due to loss of function).
- Biochemical and biotechnological evidence – DNA (and protein) similarities and differences can be used to determine the relatedness of organisms.
- Embryological evidence – ontogeny (embryological development) resembles phylogeny (evolutionary development).
- Selective breeding/artificial selection mimics natural selection. In selective breeding, individuals that breed and contribute genetically to the next generation are selected on their 'usefulness' to humans rather than their ability to survive in natural situations.
- Biogeographical evidence, geographical origins and distribution.
- Modern examples of microevolution. Evolution on a small scale, e.g. industrial melanism of peppered moths, antibiotic resistance of bacteria, chemical resistance (fungicides, herbicides, insecticides) of many pests.

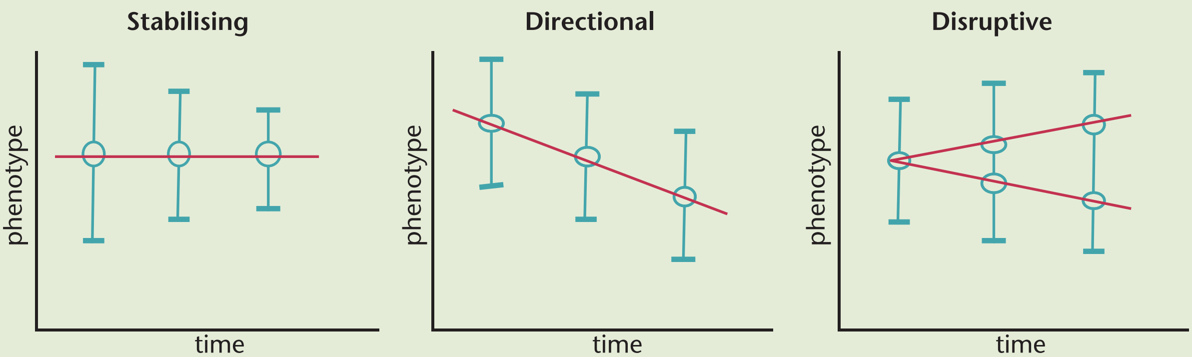
Natural selection

Effect of natural selection on genes is indirect (acts directly on an organism's phenotype, not its genotype) – results in unequal reproductive success of different phenotypes (unequal contribution to the gene pool of the next generation).

- **Stabilising** – selection for those individuals with average phenotypes and against those with extreme phenotypes; population tends to become more uniform.
- **Directional** – selection for one end of phenotypic range at expense of the other; population tends to change in that direction.
- **Disruptive** – selection against average and for extremes; population tends to become bimodal for that phenotypic characteristic.



Key:
- - - - - before natural selection
——— after natural selection
➡ arrows show effect of natural selection on gene pool
——— shows how the mean (or modal) changes (in graphs below)



Speciation

Species concept – a species is a group of organisms capable of **successfully reproducing** (producing fertile offspring) **in nature** ('organisms that share the same gene pool'); 'genetic barriers' keep species distinct.

Groups within a species

Demes – local populations with limited gene flow with other demes. Phenotypic variations reflect local environmental factors (i.e. local natural selection pressures).

Clines – geographical gradient in phenotypic characteristics of individuals of same species. Altitudinal or latitudinal clines are common in plants.

Limitations of species concept:

- **Ring species** – a cline where two extremes are geographically close. Interbreeding is possible between neighbouring demes (i.e. implies same species), not possible between extremes (i.e. implies different species).
- **Sequential** species – species separated by time rather than space. Species are distinguished on anatomical differences, not ability to successfully reproduce.
- **Geographical separation** – species interbreed successfully in captivity (e.g. interbreeding between different dog (*Canis*) species, interbreeding between many New Zealand native plants when grown together in gardens).
- **Asexual species** – interbreeding criterion is difficult to apply, e.g. many protozoa.

Species life cycle – all species are temporary, i.e. a stage in evolutionary process.

- Origin/emergence; new habitat/niche available or new adaptations evolve.
- Increase in range and population size allows increased diversity.
- Demes develop, each responding to local environmental factors.
- Decline of demes due to extinction (inability of members to adapt or compete) or replacement by next (better adapted) species in evolutionary sequence.

Speciation – any process that promotes divergence leading to new species.

- **Allopatric** (different origin) – speciation occurs in different geographic areas (gene flow prevented by islands, glaciers, etc.). Isolated populations subject to differing natural selection pressures. Accumulated differences in two gene pools result in reproductive isolation persisting even if two populations (now two species) become sympatric.
- **Sympatric** (same origin) – speciation occurs in same geographic area. Gene flow prevented by mechanism that is not geographic (i.e. behavioural, ecological, etc.). Albatross species share same geographic range but habitually return to their island of birth to reproduce – thus populations are isolated behaviourally. If a plant carried a mutation that changed its flowering period so it did not cross-pollinate with plants of the same species, it would become isolated reproductively.
- **Sudden** or **instantaneous speciation** by **polyploidy** – special case of sympatric speciation (a new species arising in one generation). Polyploids possess three or more sets of homologous chromosomes (3n, 4n, etc.). Rare in most animal groups, common origin of new species in plants. Polyploids show increased vigour, pest and disease resistance and can cope with extreme environments (especially low temperatures).

  Autopolyploidy – all sets of chromosomes are from same ancestral species, i.e. new species has 1 parental species.

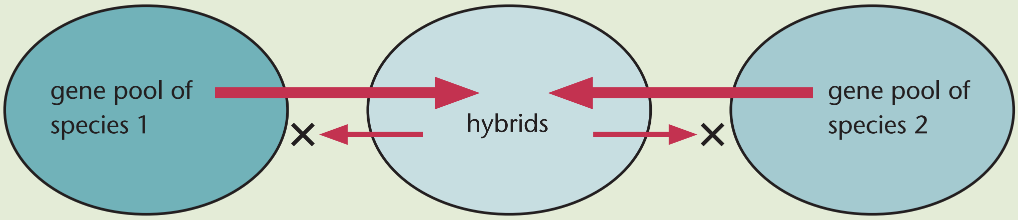
  Allopolyploidy – sets of chromosomes originate from 2 (or more) ancestral species, i.e. new species arose from an otherwise sterile hybrid.

  Amphiploidy – doubling of chromosome number that occurs at first mitosis after fertilisation. Sterile (2n) hybrid between two species becomes a fertile (4n) allopolyploid.

Reproductive isolating mechanisms

Any factor that prevents successful reproduction between 2 species, i.e. prevents gene flow between 2 gene pools.

- **Geographic** – e.g. oceans, deserts, offshore islands, glaciers, mountain ranges, etc., that isolate gene pools.
- **Temporal** (timing of activity / reproduction) – e.g. nocturnal vs diurnal species, species with different breeding seasons.
- **Ecological** (habitat) – closely related species occupy different niches within same geographical area.
- **Ethological** (behavioural) – mating calls, displays, pheromones, etc., that are very species specific and serve as species recognition signals and mate attraction.
- **Structural** (anatomical) – e.g. insect lock-and-key sex organs prevent mating with other species; plants – flower shape determines which pollinators gain entry.
- **Gamete incompatibility** – biochemical differences prevent zygote being formed, sperm/pollen does not respond to chemicals produced by egg.
- **Hybrid inviability** – chromosomal incompatibility leads to developmental problems and low survivorship of hybrids.
- **Hybrid sterility** – hybrid individual is viable and reaches maturity but is sterile. Common in the horse family (e.g. horse × donkey → sterile mule).
- **Hybrid breakdown** – F1 hybrids are fertile but F2 individuals are not.



Hybrids contain genes from both gene pools, but because of hybrid sterility or breakdown, complete flow from one gene pool to the other is not possible and the two gene pools remain separate.

Patterns of evolution

Gradualism – evolutionary change that occurs at relatively slow, steady rate. Includes transitional forms that have accumulated adaptive characteristics.

Punctuated equilibrium – Short periods of rapid change interspersed with (longer) periods of relatively slow change (stasis).

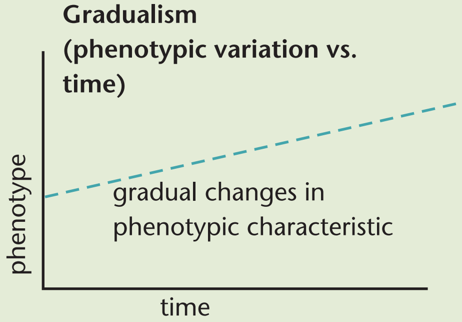
During periods of rapid change, transitional forms are less likely to become fossilised because they change rapidly and the time available for fossils to form is reduced.

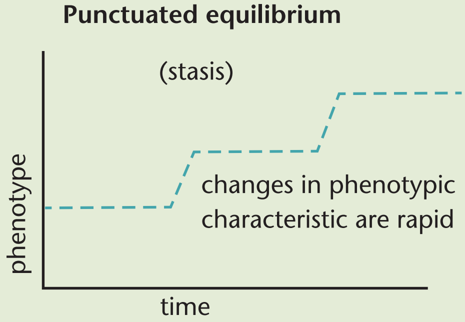
Reasons for rapid change include:

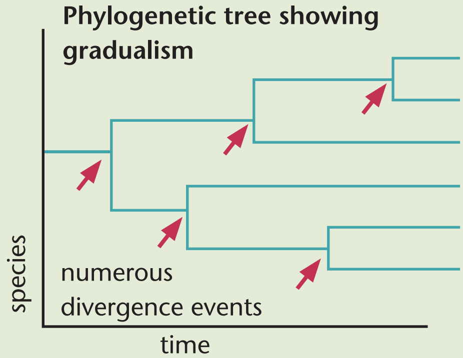
- invasion of new habitat with niches available
- sudden environmental change allows one group to diverge rapidly
- evolution of a new characteristic with a distinct advantage that allows one group to out-compete and thus replace another.

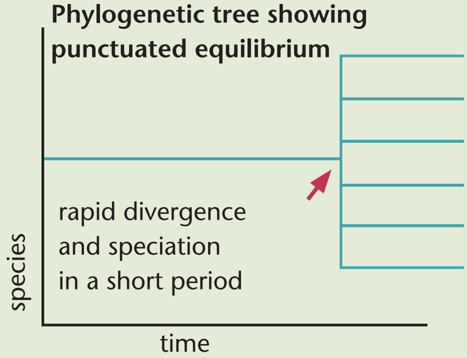
During stasis the gene pool is in 'equilibrium' with environmental selection pressures – thus little evolutionary change occurs.

Diagrammatic comparisons of gradualism and punctuated equilibrium: what to look for in questions









Convergent evolution – species with similar niches tend to evolve similar adaptations despite having different ancestors, e.g. shark (fish), ichthyosaur (reptile), dolphin (mammal), and penguin (bird) – all fast-swimming predators with streamlined bodies and fins/flippers for propulsion and manoeuvrability.

Ecological equivalents – species with different origins developed similar adaptations because they occupy similar niches in different geographic areas.

Analogous organs – organs have same basic structure and function but evolved independently from different ancestral organs in unrelated species, e.g. wings of bats, birds and insects all have large surfaces and associated musculature for flight.

Parallel evolution – similar features evolve in related or unrelated species because both have been subject to similar selection pressures (similar to convergent evolution), e.g. changes to Surface Area : Volume (SA/vol) ratio (body proportions) and furriness of mammal species during ice ages.

Divergent evolution – occurs when two or more related groups evolve different adaptations because they occupy different niches.

Adaptive radiation – divergence of number of species from common ancestor. Each occupies a different niche and evolved different adaptations. When discussing adaptive radiation, the following should be covered:

- Description of ancestor, likely niche, appearance and adaptations, when it existed, possible migrations.
- Description of new habitats into which ancestor or its descendants spread.
- Explanation of how new natural selections pressures in different habitats affected each isolated species and the adaptations each evolved.
- Discussion of relevant reproductive isolating mechanisms that operate to keep gene pools separate.

Homologous organs – found in related species, evolved from common ancestral organ, adapted (diverged) to different functions, but retain common structure, e.g. pentadactyl (5-fingered) limbs of mammals derived from ancestral mammalian limb, including bat wing, whale flipper, human arm.

Sequential evolution – occurs when species changes sufficiently over time, also called linear, serial or vertical evolution, e.g. three *Homo* species (*H. habilis*, *H. erectus* and *H. sapiens*).

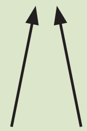
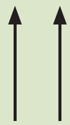
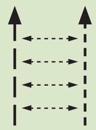
Co-evolution – describes the reciprocal evolutionary effect that two interacting species can have on each other. Each species acts as a natural selective influence on the other.

Examples

- Pollinators and flowering plants – in extreme cases, a species of plant can be pollinated by only one specific species of insect. (This can make both species vulnerable to extinction, because if one diminishes so must the other.)
- Predator species evolve better 'prey-catching' strategies as prey evolve better 'detection-and-escape' strategies.

  Note that many New Zealand native animals are vulnerable to introduced predators because of the the lack of opportunity for coevolution (evolution of effective defences and strategies).
- Swan plants evolve toxins to deter herbivores, monarch butterfly caterillars have evolved mechanisms to detoxify the plant and thus have little competition for this food source.

Diagrammatic comparisons of patterns of evolution: what to look for in questions

Convergent evolution	Parallel evolution	Divergent evolution	Sequential evolution	Co-evolution
				
• unrelated ancestors • become more similar as they become adapted to similar conditions or have similar adaptations	• unrelated ancestors • evolve in the same way for the same reason	• common ancestor • species become more dissimilar as they become adapted to different niches	• common ancestor • species separated by time, one evolves into the next	• unrelated ancestors that have a close relationship • each species has an evolutionary effect on the other

Chance changes in gene frequencies

Genetic drift – chance changes in gene frequencies (that occur in small populations). Some genes become more or less common because individuals that carry them produce more offspring as a result of chance rather than adaptive advantage.

Founder effect – occurs when small number of individuals establishes new population. Gene pool will reflect genotypes of founder individuals. Genetic variation is reduced, but otherwise rare genes may be common simply because they were carried by 'founders'.

Bottleneck effect – when a population becomes small and then expands, new gene pool will reflect genotypes of individuals at the bottleneck; important consideration for endangered species.

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

3.3 Orientation responses

Question One: Orientation responses of some invertebrates

p. 4

1st bullet point – identification, terminology and definition of responses

Green bottle fly maggots

Aspects of the response to be noted and used in the terminology:

- response is directional (away from light), i.e. *negative*
- response is to light intensity, i.e. *photo-*
- response involves movement of the whole organism, i.e. *taxis*
- maggot senses light using a single sense organ; light intensity is compared by turning their heads from side to side, i.e. *klinotaxis*.

Terminology: Negative phototaxis or negative photoklinotaxis.

Definition: Response to light when an organism moves away from the light (towards lower light intensity) which is sensed by a single, light-sensitive organ.

Flatworm

Aspects of the response to be noted and used in the terminology:

- response is directional (towards the chemical trail of the meat), i.e. *positive*
- response is to the concentration of chemicals diffusing from the meat, i.e. *chemo-*
- response involved two aspects of movement.

The two aspects of movement involved:

- movement of the whole organism, i.e. *taxis*
- increased rate of turning – *klinokinesis* or *kinetic response* (non-directional movement of the whole in response to the intensity, rather than direction of the stimulus).

Terminology: There are two separate responses operating at the same time:

- positive chemotaxis
- chemoklinokinesis.

Definition:

- movement of the whole organism towards an area of greater chemical concentration (up a concentration gradient)
- increased rate of turning in response to greater chemical concentration (or the intensity of a chemical stimulus).

(**A** – terms for green bottle fly maggots behaviour identified and defined; **M** – aspects of the green bottle fly maggot's behaviour identified and used to explain term; **A** – terms for flatworm behaviour identified and defined; **M** – aspects of the flatworm's behaviour identified and used to explain term)

2nd bullet point – justification of the types of responses described

This has been covered in the answer to the **1st bullet point**. Each part of each term has been justified.

Explanation of how these responses operate in both organisms

Green bottle fly maggots

Head turning indicates that the maggot has a single light-sensing organ.

This organ can sense light intensity but not its direction. Direction of light is determined by comparing light intensity when the head is turned to one side and then the other.

This means that light intensity from one side must be 'remembered' and compared with light intensity from the other side a moment later when the head has been turned.

The maggot alters the direction of its movement away from the bright side and towards the dim side.

Flatworm

There are chemical-sensitive organs (chemoreceptors) on both sides of its head. Stimuli from both organs can be compared concurrently (i.e. at the same time). As a result, the flatworm can determine the origin of the chemical, i.e. by moving in the direction of the more intense side.

The animal has two responses:

- directional, towards the higher chemical concentration
- increased rate of turning in more highly concentrated areas.

(**A** – relevant aspects of green bottle fly maggot's behaviour described; **M** – explanation of green bottle fly maggot's behaviour explained; **A** – relevant aspects of flatworm's behaviour described; **M** – explanation of green bottle fly maggot's behaviour explained)

3rd bullet point – adaptive advantages gained by both animals

The responses of both animals have an adaptive advantage, i.e. they increase the survival and (reproductive) chances of these animals.

Green bottle fly maggots

The maggots avoid light and find dark areas. This has the following advantages of:

- predators are less likely to see the maggots
- lighted areas are generally also exposed to heat and wind which may cause dehydration
- dark areas are more likely to be found in the maggots' food; adults lay eggs near dead or dying organic (animal) matter; maggots seek entry points to such material, these entry points are in dark crevasses.

Flatworm

Flatworms also feed on decaying animal material. Following the chemical trail has the following advantages:

- flatworms will find food
- the turning movement increases the chance of finding food as the flatworm can cover a wider area (a straight line may miss the meat source).

Comparisons (= similarities):

- both are directional responses where the whole animal moves; the direction of the movement is related to the direction of the environmental stimulus – i.e. both are **taxes**
- behaviour is **innate**.

> The words *innate behaviours* are stated at the very beginning of the question. You should always assume that information given in the resource material is there for a reason. Often this reason is to assist you in answering the question, i.e. information given in the resource material gives hints.

Innate behaviour is genetically determined.

It is therefore predetermined and inflexible; the animal will under certain circumstances behave in a predictable way that is not dependent on any learning process (unlike learned behaviour which is the result of experiences).

Because innate behaviour is genetically based it will be subject to natural selection – i.e. those individuals that behave in a way that has adaptive advantages will (benefit from those advantages and) be more likely to survive and reproduce. In this way, the alleles responsible for this behaviour will become more common in the gene pool.

(**A** – adaptive advantage described; **M** – adaptive advantage in green bottle fly maggots explained; **M** – adaptive advantage in flatworms explained; **M** – taxes comparison discussed; **E** – innate behaviour explained and discussed)

Question Two: Orientation in bean seedlings p.6

Response of the shoot during germination and growth during germination

Shoot is negatively gravitropic (geotropic), i.e. it grows upwards irrespective of its orientation when it emerges from the seed.

After emergence, the shoot is:

- negatively gravitropic, continuing to grow upwards; *and*
- positively phototropic, growing towards light.

(**A** – orientation responses described)

Role of auxin during shoot growth

Cells in the apical meristem divide (new cells are produced). As a result, the stem grows in length. As new cells are produced, those below the meristem elongate by absorbing water (by osmosis).

Osmotic pressure causes the cells to enlarge, stretching the cell wall in the process.

The cell wall at this stage is still plastic and capable of stretching. Auxin increases this plasticity or elasticity of the cell walls, so cells subject to higher levels of auxin will elongate more than those subject to lower auxin levels.

This means that if auxin accumulates on one side of the stem in the zone of elongation, cells on the opposite side will not elongate as much. Shoots will bend away from the side with the highest auxin concentration.

> Auxin is a water-soluble plant hormone.
>
> IAA (indole-3-acetic acid) is the naturally occurring auxin, but there are many synthetic auxins. These are used as herbicides, to promote root growth in cuttings, and as defoliants.
>
> IAA has many other roles in plants – including growth of secondary tissues, apical dominance and inhibition of senescence and leaf fall.

(**A** – role of auxin described; **M** – effect of auxin in stem growth explained)

Auxin and the effects of gravity and light on shoot growth to maturity

Auxin is produced in the meristem (a group of actively dividing cells in the stem tip (bud)).

Auxin is transported from the meristem in two ways:

- in a polar direction – i.e. away from the stem tip (meristem) down the stem
- laterally, across the stem.

Lateral movement is influenced by gravity and light.

- *Gravity* – amyloplasts (starch-containing granules) are denser than cytoplasm and tend to accumulate by gravity on one side of a cell. As auxin accumulates on the 'lower' sides of the cells of stems, these elongate more on one side and the stem bends upwards.
- *Light* – auxin is transported away from light towards the darker side of the stem, where it accumulates. As auxin

Answers