

### EXOSKELETON



This trait requires periodic moulting as the hard shell prevents growth. The growing shell is soft and makes the animal vulnerable to predation whilst this occurs.

B1

### EXOSKELETON



Exoskeletons create a water sealed covering using an impermeable layer of wax which prevents desiccation.

B1

### LARGE SA:V



This cannot be played on a Species with a 'Small SA:V' Trait.

The larger an organism's surface area (SA), in relation to its volume, the more rapidly it loses heat so it is advantageous to be smaller in desert environments. For example, Desert Rats have large, thin ears to increase their surface area.

B1

### SMALL SA:V



This cannot be played on a Species with a 'Large SA:V' Trait.

Larger organisms tend to have a smaller surface area to volume ratio. This helps to retain heat which is advantageous for animals living in cold environments.

B1

### SMALL SA:V



This cannot be played on a Species with a 'Large SA:V' Trait.

The Arctic fox has small ears that have a small surface area to volume ratio to prevent heat loss.

B1

### BURROWING



When this Trait is played, this Species becomes Protected.

Many organisms spend time underground to avoid predation and to be buffered from changes in atmospheric temperature.

B1

### SLOW TWITCH MUSCLE FIBRES



These fibres allow a species to carry heavy loads for longer periods of time. They tend to have large quantities of mitochondria and phosphocreatine to regenerate ATP.

B1

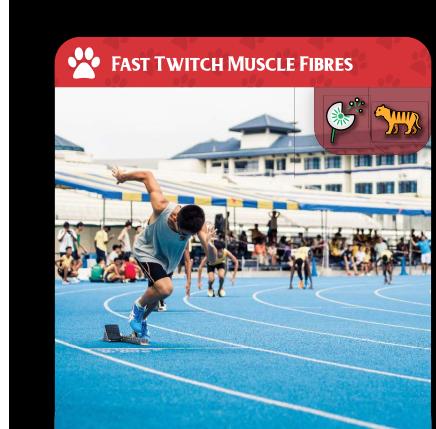
### SLOW TWITCH MUSCLE FIBRES



These fibres produce energy using aerobic respiration, so they have a good blood supply to provide them with the oxygen they need.

B1

### FAST TWITCH MUSCLE FIBRES



Draw 1 card at the beginning of each of your turns for as long as this card is active in your Community.

These fibres allow a species to exert large forces over short periods. They tend to utilise the glycolytic pathway.

B1



Hot blood leaving the core body loses heat to the cold blood returning from the extremity so that when it re-enters the core it does not lower the body temperature.



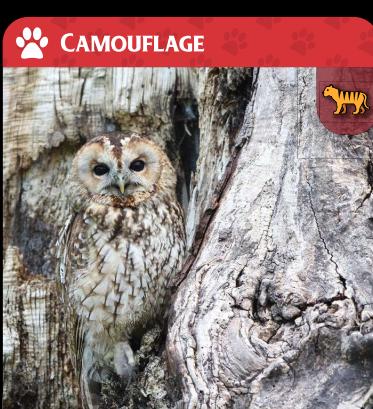
Very few organisms have a high enough density of sweat glands to lose their excess heat through evaporation of sweat. However, dogs and other species use licking and panting to lose heat through evaporation.



Disadvantages of sweating and panting include dehydration, electrolyte imbalance, and an unwanted increase in metabolic rate.



Unirected movement in response to unfavourable conditions. An organism varies the frequency of turns and rate of movement to increase the chances of returning to a favourable environment.



Many species utilise colours to make them less visible to predators or prey. Some species of cephalopod have been shown to 'hold' shells around themselves so they blend in on the ocean bed.



When orcas hunt seals they swim together to form a bow wave. Together they generate enough force to knock seals into the sea where they can trap and kill them.



Leathery or waxy skins can prevent the entry of parasites into many organisms.

B1



This tissue is only present in mammals and can be hydrolysed to produce fatty acids and glycerol which are used to generate energy.

B1



**+** Look through the discard pile. Take the first 3 Trait cards you find and add them to your hand.

Following the theory of natural selection, a random mutation may be beneficial to an individual. This individual is more likely to survive and reproduce, thereby spreading the beneficial mutation through generations.

B1



Affects Animal Species only.

**-** Your opponent chooses 1 of your Vulnerable Species. It loses 2 Trait cards.

**+** If all your Species are Resilient, draw 3 cards.

The predator-prey relationship comprises antagonistic interactions where the predator gains at the expense of the prey.

B1



**-** Choose 1 of your Vulnerable Species. It loses 2 Trait cards.

**+** Draw 1 card for each Resilient Species.

A desert can reach up to 50 degrees Celsius during the day and experience less than 250 mm rainfall per year. Desert species must be adapted to cope with these extremes in order to survive.

B1



**-** Choose 1 of your Vulnerable Species. It loses 2 Trait cards.

**+** Draw 1 card for each Resilient Species.

Desert species must be adapted to scarcity of water and extremes in temperatures. For example, the Saguaro Cactus has an expanding trunk to store water and closes its flowers during the heat of midday.

B1



This card affects your Community again on your next Nature Calls if fewer than half of your Species are Resilient when facing this Event card for the first time.

**-** Each Vulnerable Species loses 2 Trait cards.

**+** Draw 2 cards for each Resilient Species.

A prolonged period of dry weather causes water shortages, which impacts existing communities in the area.

B1



Affects all players.

**-** Each Vulnerable Species loses 1 Trait card.

**+** For each Resilient Species: draw 2 cards and add them to your hand, and choose a random card from 1 opponent's hand for them to discard.

The gradual increase in the overall temperature of the planet caused by the greenhouse effect is of increasing concern amongst scientists. Climate change is a threat to all ecosystems.

B1



Affects all players.

**-** Each Vulnerable Species loses 1 Trait card.

**+** For each Resilient Species: draw 2 cards and add them to your hand, and choose a random card from 1 opponent's hand for them to discard.

Climate change will alter how well adapted individuals are to their local environment. This will reduce species survival and reproduction and disrupt the functioning of ecosystems.

B1

### HERBIVORE INTRODUCED INTO ECOSYSTEM



Affects Plant Species only.

— Your opponent chooses 2 of your Vulnerable Species. Lose 1 Trait card from each.

+ If all your Species are Resilient, draw 3 cards.

*Plants are not as calorific a diet for animals as meat. Therefore, herbivorous animals must eat more plant material to obtain the nutrients they need for survival and reproduction.*

B1

### ICE AGE



Affects all players.

— Each Vulnerable Species loses 1 Trait card.

+ Draw 2 cards for each Resilient Species

*Glacial ice sheets cover huge parts of the planet, resulting in an extremely cold and dry climate. Some well-adapted mammals are able to thrive in this harsh environment but the majority of species would face extinction.*

B1

### INTENSIVE FARMING



Affects Plants only.

— Choose 1 of your Vulnerable Species. It loses 2 Trait cards.

+ Draw 1 card for each Resilient Species.

*Intensive farming techniques such as crop monoculture result in nutrient-poor soils, which has a direct effect on plants.*

B1

### MONSOON



— If more than half of your Species are Vulnerable, choose 1 Vulnerable Species to go extinct.

+ If half or more of your Species are Resilient draw two cards for every opponent.

*Monsoon season includes a period of extremely high precipitation. Some species can flourish during this environmental change, whilst it may be detrimental to others.*

B1

### NATURAL DISASTER



— Each Vulnerable Species loses 2 Trait cards.

+ Draw 1 card for each Resilient Species.

*Floods, earthquakes, tsunamis, volcanic eruptions, cyclones, hurricanes and tornadoes have devastating impacts on surrounding ecosystems.*

B1

### NATURAL DISASTER



— Each Vulnerable Species loses 2 Trait cards.

+ Draw 1 card for each Resilient Species.

*In 2012 Hurricane Sandy caused an unprecedented amount of sewage to leak out into the local water systems having an inevitable impact on the security of those ecosystems.*

B1

### RAINFOREST



+ Search the discard pile and take the first Plant Trait card you find. Place this in your Community as a new Species. If there are no Trait cards in the discard pile, search the deck for the first one you find, and then shuffle the deck.

*Tropical rainforests experience the combination of high temperatures, heavy rains and high humidity which make it the most highly favourable and biodiverse biome.*

B1

### TAIGA



— For each Vulnerable Species, give 2 cards from your hand to the player on your right.

+ Draw 1 card for each Resilient Species.

*These cool, moist 'snow forests' are a large biome made up of coniferous tree species and mossy soils that are poor in nutrients. The average temperature is below freezing.*

B1

### TAIGA



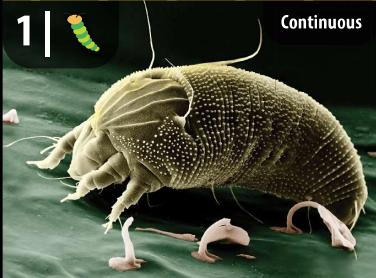
— For each Vulnerable Species, give 2 cards from your hand to the player on your right.

+ Draw 1 card for each Resilient Species.

*Coniferous trees, commonly called evergreens, are adapted to this environment with long thin waxy needles. The wax provides protection from drying out and as the needles are retained through winter they can start photosynthesis as soon as increased daylight hours arrive in the spring.*

B1

### TROPHIC LV. I PARASITE INVASION



Affects Plants only.

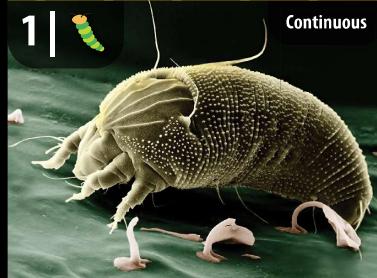
The opponent to your left chooses 1 of your Vulnerable Species. This Species loses 1 Trait card at the end of this turn and your next 2 turns. If the Species becomes Resilient to Parasitism this Event is removed to the Event History.

**+** If all your Species are Resilient, draw 2 cards.

*Phytophthora infestans* is a fungus-like organism which invades and spreads in potato foliage, causing potato blight. The disease has evolved aggressive strains which make it hard to control.

B1

### TROPHIC LV. I PARASITE INVASION



Affects Plants only.

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**+** If all your Species are Resilient, draw 2 cards.

*Virulent pathogens* overcome plant host defences and lead to disease. *Avirulent pathogens* only damage a small part of the plant because the host is able to contain the infection.

B1

### TUNDRA



**-** Lose a Trait card on each Vulnerable Species.

**+** If you have at least 1 Resilient Species, draw 1 card.

Tundra biomes encompass extreme Arctic regions. These conditions reduce species diversity; vegetation is limited to dwarf shrubs, grasses, mosses, and lichens.

B1

### TUNDRA



**-** Lose a Trait card on each Vulnerable Species.

**+** If you have at least 1 Resilient Species, draw 1 card.

Temperatures and precipitation are extremely low, and a permanent layer of ice can be found below the shallow soils.

B1

### FACULTATIVE MUTUALISM

Play in response to an Event that affects your Community. Choose an opponent's Species and one of your Species that is Vulnerable to this Event. For the duration of the Event, treat your chosen Species as if it had the Trait cards of the opponent's Species. That opponent draws 1 card.

If one or both sides of a mutualism can survive without the other, the relationship is facultative. For example, honeybees and angiosperms can survive independently as other pollinators and other sources of nectar are available respectively.

B1

### RESOURCE PARTITIONING

Activate one or both of these effects:  
- Look through the discard pile, choose any 2 Trait cards, and add them to your hand.  
- When 'Intraspecific Competition' or 'Interspecific Competition' is played, negate that card's effect.

When two populations have overlapping niches they experience competition. These populations may specialise to use different parts of the same resource in order to decrease competition.

B1

### RESOURCE PARTITIONING

Activate one or both of these effects:

- Look through the discard pile, choose any 2 Trait cards, and add them to your hand.
- When 'Intraspecific Competition' or 'Interspecific Competition' is played, negate that card's effect.

Anolis lizards live at different altitudes in forests. The ancestral populations have diverged to minimise competition so that species are specialised to each area of the canopy or forest floor.

B1

### OBLIGATE MUTUALISM

Play in response to an Event that affects your Community. Choose two of your Species on the same Trophic Level. For the duration of the Event, treat both Species as if it had the Traits of the other in addition to its own.

One or both of two interacting species cannot survive without the other. This relationship exists between midges and cacao trees: the tree depends on the midge as no other species is able to pollinate it.

B1

### COMMENSALISM

Add the top 3 cards in the discard pile to your hand.

One species benefits whilst the other species is neither positively nor negatively affected. Barnacles gain by growing on the surface of some whales as they are moved to plankton rich areas but they have no tangible effect on the host.

B1

## INTRASPECIFIC COMPETITION

Choose an opponent's Trait card and place it in the discard pile.

As the population of any species increases, the greater demand for finite shared resources results in competition between individuals in the population.

B1

## INTRASPECIFIC COMPETITION

Choose an opponent's Trait card and place it in the discard pile.

Direct or contest competition involves a physical or chemical interaction between individuals.

B1

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Choose an opponent's Trait card and place it in the discard pile.

One species of salamander, *Plethodon glutinosus*, has evolved such that the levels of aggression expressed by individuals is higher in populations where resources are scarcer.

B1

## ANTAGONISM

Choose an opponent's Trait card and add it to one of your Species. If you have no Species, place it in the discard pile.

Host-parasite relationships have antagonistic characteristics. American chestnuts are attacked by chestnut blight which targets the vascular systems of the tree.

B1

## ANTAGONISM

Choose an opponent's Trait card and add it to one of your Species. If you have no Species, place it in the discard pile.

An antagonism is any relationship where one individual loses more than it gains. However there are some antagonisms where both individuals experience greater costs than benefits.

B1

## ANTAGONISM

Choose an opponent's Trait card and add it to one of your Species. If you have no Species, place it in the discard pile.

Any predator-prey relationship will be antagonistic. Lynx and snowshoe hares have often been used as a model system for studying predator-prey cycles.

B1

## DENITRIFICATION

Continuous

Play on an opponent's Community. Their Resource Number is reduced by 2 for as long as this card is active. This card cannot affect Communities that have any Plants that are Resilient to Low Nutrient Availability. If one of these Traits is added this card is removed and placed in the discard pile.

Some soils contain populations of denitrifying bacteria which reduce nitrates and release nitrogen gas. One example is the species *Paracoccus denitrificans*. Denitrifying bacteria tend to occur in anoxic conditions.

B1

## CONTINENTAL DRIFT

Every player gives their hand to the player to their left.

Now part of the more general theory of plate tectonics, continental drift explains how continents have moved relative to one another. These movements have meant that species are exposed to new conditions and resources.

B1

## INTERACTION INHIBITOR

Negate the activation and/or effect of an Interaction card and place it in the discard pile.

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B1

## RECIPROCAL ALTRUISM

Play in response to an Event that affects your Community. Choose 1 Trait card from an opponent's Species and add it to 1 of your Species. That opponent then adds this card to their hand. They cannot activate this card during this turn.

Vampire bats cannot last longer than approximately three days without a blood meal but these are often difficult to find. As a result those that do feed take on more than they need and share it around the colony. This is not selfless as in doing so they secure future meals when others have fed and they have not.

B1

## SCAVENGER

If an opponent's Species goes Extinct, add the Trait cards of their Extinct Species to your hand.

Species with a scavenger lifestyle eat carrion or dead plant matter. Vultures are a common example and often make use of meat left by predators such as lions.

B1

## SCAVENGER

If an opponent's Species goes Extinct, add the Trait cards of their Extinct Species to your hand.

An increasing problem in urban areas is that foxes use refuse sites and bins as a source of food. This is not only a nuisance but also means that some populations may not retain vital knowledge about how to hunt.

B1

## DETritivores

Play in response to an Event that affects your Community. Any Trait cards you lose due to this Event are not put into the discard pile but return to your hand.

A large collection of species survive by consuming dead plant material and recycling it into the ecosystem. They often serve to break up large material, which increases the surface area on which saprophytes feed.

B1

## DETritivores

Play in response to an Event that affects your Community. Any Trait cards you lose due to this Event are not put into the discard pile but return to your hand.

Some detritivores, including butterflies, consume the eggested material from other species. They serve to reduce the waste of energy and fixed carbon.

B1

## EPIDEMIC

Choose an opponent's Trophic Level. Each Species in that Trophic Level that is Vulnerable to Parasitism loses 2 Traits.

The fungus *Hymenoscyphus fraxineus* is predicted to cause a large decrease in ash trees across Europe.

B1

## EPIDEMIC

Choose an opponent's Trophic Level. Each Species in that Trophic Level that is Vulnerable to Parasitism loses 2 Traits.

When epidemics cross continents they are referred to as pandemics. One devastating example was the influenza pandemic in 1918.

B1

## CROSS-BREEDING

Choose any 2 Plant Species in play. Collect the Traits, shuffle them and redistribute to reflect the initial numbers of Traits on each Species.

*Cross-breeding is used to introduce desirable traits into other plant lines. For this reason it has been invaluable throughout human history to increase agricultural output.*

B1

## CROSS-BREEDING

Choose any 2 Plant Species in play. Collect the Traits, shuffle them and redistribute to reflect the initial numbers of Traits on each Species.

*Modern molecular techniques sometimes use plasmids from the bacterium Agrobacterium tumefaciens to introduce desirable genes or alleles into other plant species or strains.*

B1

## INTERSPECIFIC COMPETITION

Choose one of your opponents. Play rock-paper-scissors. The winner draws 3 cards and the loser discards 3 cards.

*Members of different species compete for shared resources and the competition is often asymmetric. This means that one party is significantly fitter than the other and tends to out-compete the other.*

B1

## INTERSPECIFIC COMPETITION

Choose one of your opponents. Play rock-paper-scissors. The winner draws 3 cards and the loser discards 3 cards.

*The decline of red squirrels in the UK parallel to the rise of grey squirrels is a common example of how inter-specific competition can be asymmetric. Grey squirrels out-compete red squirrels for the same resources in their deciduous habitat.*

B1

## MIGRATION

Can only be played on your turn. Choose an opponent's Animal Species and move it to your Community.

*Migrations are any large scale movement of a population. They are frequently, although not exclusively, cyclic and reflect the changing availability of resources across the seasons. This is a classic example of a circannual rhythm.*

B1

## FORAGING

When one of your Trophic Level 2 Species has lost one of their food sources, replace it with 2 Traits from an opponent's Plant Species.

*Foraging is studied as part of ethology and modelled using optimisation models similar to those historically used in economics. These models suggest that there is selection for choices which increase food foraged per unit time.*

B1

## RITUALISATION

Can only be played on your turn. Go through the discard pile and add any 2 Interaction cards of your choice to your hand, apart from 'Ritualisation' or 'Commensalism'.

*This describes the process where existing behaviours are modified to create a system of communication. For example, South African Bush Dogs evolved scent marking behaviour, through ritualisation, as a form of signalling to mark their territories.*

B1

## TERRAFORMING

When an opponent plays an Event on a Community that is not their own, the Event is played on the opponent's Community instead, and they cannot gain any positive effects from it.

*This theoretical process is a form of geoengineering and biological alterations to a planet's surface to increase its ability to support life. It includes a wide range of chemical alterations to the atmosphere and other abiotic parts of the environment.*

B1

## COMPETITIVE EXCLUSION

Can only be played on your turn. Can only be played on an opponent if they have more than 1 Species on the same Trophic Level. Choose an opponent's Species on that Trophic Level. They choose 2 Traits from it to place in the discard pile.

*No two species can occupy exactly the same niche, as resources are limited. One species usually dominates and excludes the other from that niche resulting in resource partitioning, niche divergence or, in some cases, species extinction.*

B1

## ↗ COMPETITIVE EXCLUSION

Can only be played on your turn. Can only be played on an opponent if they have more than 1 Species on the same Trophic Level. Choose an opponent's Species on that Trophic Level. They choose 2 Traits from it to place in the discard pile.

For example, species of Anolis lizard occupy different areas of their tree habitat in order to avoid costly competitive interspecific interactions.

B1

## ↗ WIDE RANGING PREDATOR

Can only be played on your turn. Choose an opponent's Species that is Vulnerable to Predation, remove a Trait card of your choice from it and place it in the discard pile. You must have a Species that is 1 Trophic Level higher than the chosen Species.

Orcas are wide ranging predators, they are known to swim over 100 km a day. A group of killer whales have been tracked from the Antarctic Peninsula to Brazil, this group travelled 9,400 km in 42 days.

B1

## ↗ WIDE RANGING PREDATOR

Can only be played on your turn. Choose an opponent's Species that is Vulnerable to Predation, remove a Trait card of your choice from it and place it in the discard pile. You must have a Species that is 1 Trophic Level higher than the chosen Species.

This is a type of predator who has a large home range that encompasses numerous communities, all of which it affects either positively or negatively. They are usually apex predators.

B1

## ↗ WIDE RANGING PREDATOR

Can only be played on your turn. Choose an opponent's Species that is Vulnerable to Predation, remove a Trait card of your choice from it and place it in the discard pile. You must have a Species that is 1 Trophic Level higher than the chosen Species.

Tigers are wide ranging predators; territories of males can be as large as 100 square km and territories of females are around 20 square km. Individuals have been known to travel distances of approximately 650 km.

B1

## ↗ DOOMSDAY VAULT

Can only be played on your turn. Choose one of your Plant Species. It becomes Protected.

Seed banks like the Doomsday Vault are used to preserve the genetic material of plant species by storing their seeds in below freezing temperatures. This is done to prevent the extinction of plant species around the world.

B1

## ↗ DOOMSDAY VAULT

Can only be played on your turn. Choose one of your Plant Species. It becomes Protected.

Officially called the Svalbard Global Seed Vault, this seed bank is located in Norway and acts as a back-up to all other gene banks. It includes plant seeds from all over the world and has a total capacity of 4.5 million seed samples.

B1

## ↗ PROTECTIVE MUTUALISM

Continuous

Can only be played on your turn. Place this card between 2 Species. Both of these Species are Resilient to Predation. If either Species goes Extinct, remove this card.

One example is seen between sea urchins and crabs. The sea urchins use the crabs to transport them to more nutrient rich feeding grounds, whilst the crab benefits from reduced predation risk from fish.

B1

## ↗ PROTECTIVE MUTUALISM

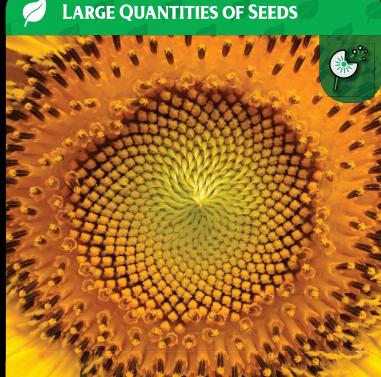
Continuous

Can only be played on your turn. Place this card between 2 Species. Both of these Species are Resilient to Predation. If either Species goes Extinct, remove this card.

This is an interaction between individuals of 2 species in which all participating organisms benefit. It's special as one species gets protection from predation by the other species.

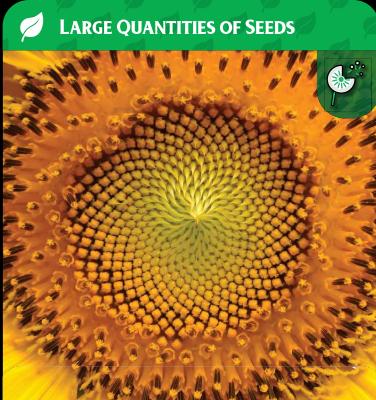
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## LARGE QUANTITIES OF SEEDS



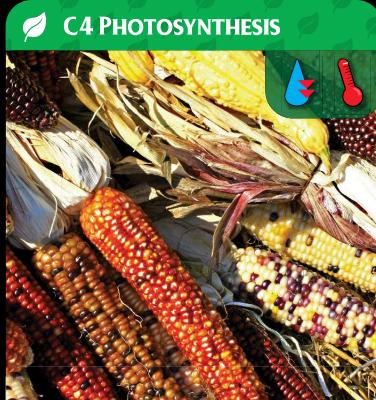
Angiosperm seeds are formed from a double fertilisation forming the diploid embryo and the triploid endosperm. Many seeds have a seed coat which protects the newly formed diploid sporophyte.

B1



Once fertilisation occurs in an Angiosperm or Gymnosperm, the ovule becomes a seed which is subsequently dispersed from the parent plant. Seeds that settle in suitable conditions germinate and develop into new sporophytes.

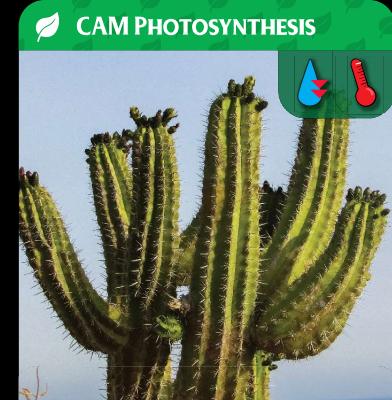
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**Invest 1.** This cannot be played on a Species with a 'CAM Photosynthesis' Trait.

C<sub>4</sub> photosynthesis separates carbon capture and the Calvin cycle spatially, allowing for an increased carbon dioxide concentration around Rubisco, thus reducing the effects of photorespiration.

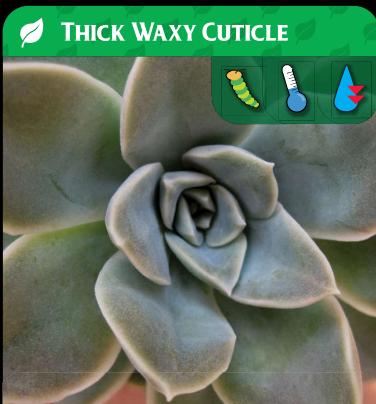
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**Invest 1.** This cannot be played on a Species with a 'C<sub>4</sub> Photosynthesis' Trait.

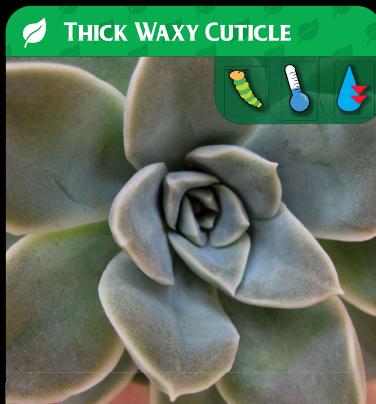
Crassulacean Acid Metabolism (CAM) separates carbon fixation and the Calvin cycle in time, increasing the rate of photorespiration. It needs more ATP molecules than C<sub>3</sub> photosynthesis to form one hexose sugar.

B1



This layer is secreted by the epithelial cells and prevents the loss of water vapour and heat from the leaf.

B1



The cuticle is usually thickest on the adaxial surface of a leaf (that facing upwards or towards the sun) as this is where heat from solar radiation would cause the greatest increase on transpiration rate.

B1



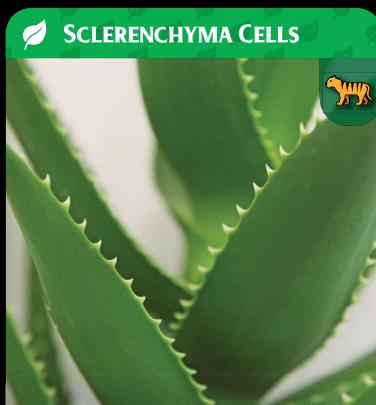
This layer prevents parasites from penetrating the leaves of a plant, therefore protecting the plant from infection.

B1



This has evolved several times. It often uses hairs (which may detect movement) to trap insects, which are digested extracellularly by the secretion of digestive enzymes.

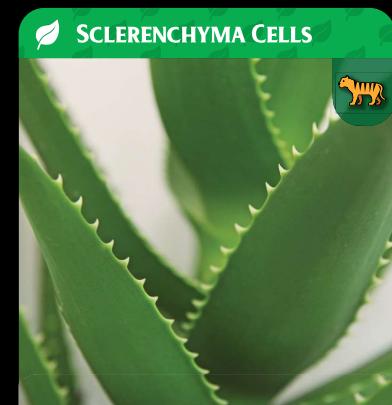
B1



**Invest 1.**

Sclerenchyma cells provide mechanical stiffness and strength to plant tissue but require an investment of fixed carbon in structural tissue.

B1



**Invest 1.**

These cells form inedible tissue which prevents the plant from being eaten by herbivores.

B1

## SCLERENCHYMA CELLS



Invest 1.

These cells are found in stress tolerating species like grasses and increase the leaf biomass of the plant.

B1

## DEEP ROOT SYSTEM



This cannot be played on a Species with a 'Shallow Root System' Trait.

Deep roots provide a plant with a larger rhizosphere (the volume of soil influenced by the presence of the plant root). This can increase the plants access to water (possibly linking into aquifers) and minerals.

B1

## DEEP ROOT SYSTEM



This cannot be played on a Species with a 'Shallow Root System' Trait.

Deep roots anchor the plant preventing it from being moved easily. However, they decrease the relative growth rate of the plant as there is a smaller investment in photosynthetic tissues.

B1

## ALKALOIDS



Invest 1 or play on a Species that is Resilient to Low Nutrient Availability.

This group of chemicals are costly to make as they require nitrogen. Nitrogen is often in limiting supply relative to its use due to it being a macronutrient.

B1

## ALKALOIDS



Invest 1 or play on a Species that is Resilient to Low Nutrient Availability.

Nicotine, morphine and quinine (found in tonic water) are all examples of alkaloids. Alkaloids make plants unpalatable and can affect the nervous system of predators.

B1

## HIGH ROOT HAIR DENSITY



The greater the density of root hair cells, the higher the surface area of the root system, which facilitates more rapid transport of nutrients and water into the plant.

B1

## HIGH ROOT HAIR DENSITY



These are single epidermal cells that project from fully developed roots. Root hairs can make up to 50% of the root surface area depending on the amount of nutrients in the soil.

B1

## CLUSTER ROOTS



Invest 1.

Cluster roots release bursts of citrate which frees phosphate from organic sources in the soil, thereby increasing the bioavailability of phosphate.

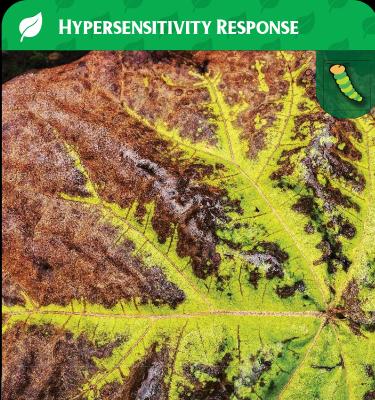
B1

## HYPERSensitivity RESPONSE



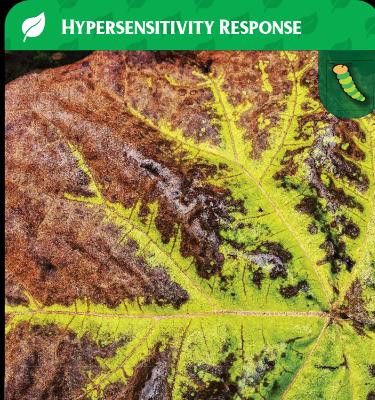
Cells surrounding an infected area produce free radicals. This oxidative stress causes cell death. The dead cells form a barrier to the progress of the infection.

B1



The barrier formed by dead cells from a hypersensitive response slows the spread of necrotrophic pathogens but completely halts the progress of biotrophic pathogens, and so protects the plant from further infection.

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### HYPERSENSITIVITY RESPONSE

This is a form of programmed cell death using the production of reactive oxygen species and triggered by the detection of a pathogen, and occurs in cells surrounding the infection site.

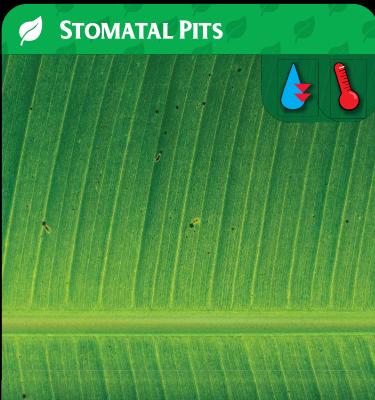
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### TERPENES

These volatile, odorous compounds do not contain nitrogen so they are not overly costly to make. Terpene scents such as mint and lemon peel act to deter many herbivores.

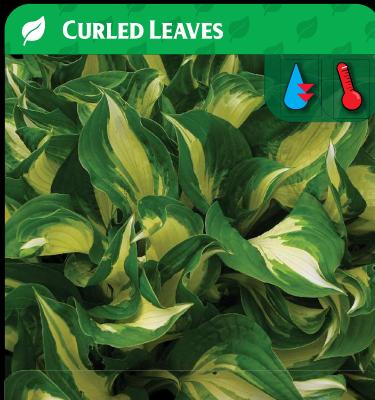
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### STOMATAL PITS

These grooves create a locally increased concentration of water vapour outside the stomata. This decreases the concentration gradient, which decreases the transpiration rate of the plant.

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### CURLED LEAVES

This arrangement of leaves traps water vapour outside the stomata. This decreases the concentration gradient, which decreases the rate of transpiration of the plant.

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### SYSTEMIC ACQUIRED RESISTANCE

As leaves export compounds like sucrose into the phloem, plants cannot gain information about leaf infections via this route. Instead, leaves release volatile chemicals such as methyl salicylic acid, which are detected elsewhere in the plant.

B1



### SYSTEMIC ACQUIRED RESISTANCE

Volatile chemicals released by infected leaves increase the expression of immunity related genes elsewhere in the plant, which prevents the spread of the pathogen beyond the initial leaf infected.

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### PATTERN TRIGGERED IMMUNITY

Pattern recognition receptors (PRRs) are expressed by cell membranes, and bind to pathogen-associated molecular patterns (PAMPs). This allows the plant to distinguish between self and non-self material and activities.

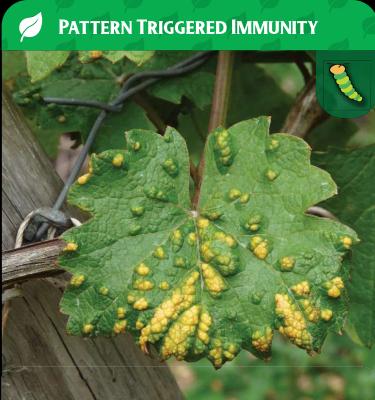
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### PATTERN TRIGGERED IMMUNITY

Pathogen-associated molecular patterns (PAMPs) are used to identify infection. These can be molecules that constitute the pathogen, which are called microbe-associated molecular patterns (MAMPs).

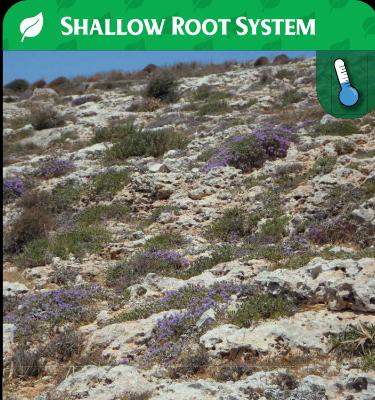
B1



### PATTERN TRIGGERED IMMUNITY

Pathogen-associated molecular patterns (PAMPs) can be molecules derived from the host itself (indicators of damage). These are called damage-associated molecular patterns (DAMPs).

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### SHALLOW ROOT SYSTEM

This cannot be played on a Species with a 'Deep Root System' Trait.

Thin layers of soil are often found in cold environments. Plants in these environments tend not to invest much in their roots.

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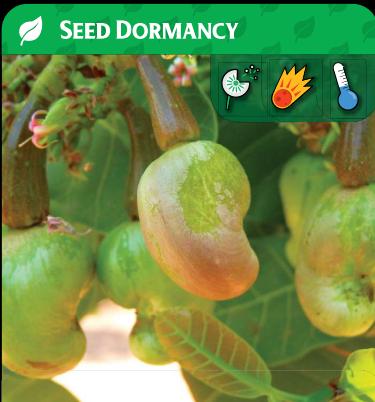


### SHALLOW ROOT SYSTEM

This cannot be played on a Species with a 'Deep Root System' Trait.

Often found in plants in cold environments that have a thin layer of soil, shallow roots allow plants to access available nutrients without much investment in root tissue.

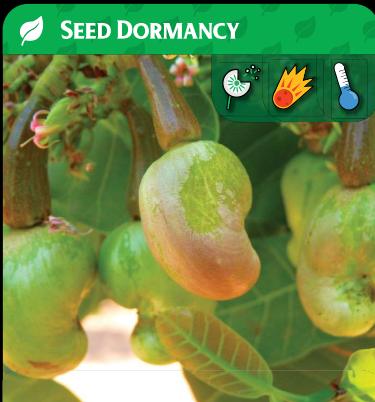
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### SEED DORMANCY

Many seeds must be exposed to a period of cold before they will germinate. This increases the chance that the plant will only start to grow in the spring when warmer weather and higher light intensities favour growth.

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### SEED DORMANCY

Delayed germination allows seeds to be dispersed further away from the mother plant, increasing the chance of reaching an area with fewer competitors and better access to light, nutrients and water.

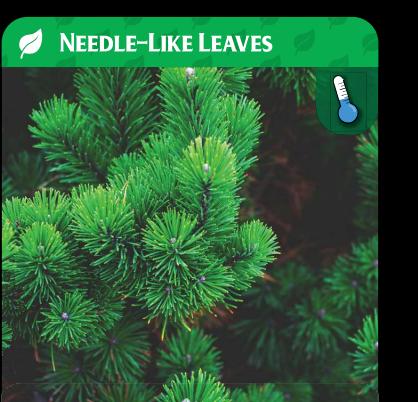
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### SEED DORMANCY

Dormancy allows the seed to be germinated in favourable climatic conditions or when inter/intraspecific competition is low.

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### NEEDLE-LIKE LEAVES

These narrow, needle-like leaves reduce the surface area for heat loss. To maximise photosynthesis these leaves are numerous.

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### NEEDLE-LIKE LEAVES

These needles have a thick outer coating and a thick layer of wax to allow the plant to withstand cold conditions.

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### RUDERAL

Ruderal species are adapted to favourable but frequently disturbed environments. They grow quickly and reproduce often to maximise productivity in between disturbance events.

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## AERENCHYMA



This tissue contains lots of air-filled spaces that facilitate gas exchange between the root and shoot, which is advantageous in waterlogged and hypoxic environments.

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## AERENCHYMA



The air-filled spaces within this tissue lower the resistance in transport systems so gases can be easily exchanged between submerged roots and above water shoots.

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## AERENCHYMA



This tissue type is often found in wetland plants which grow in soils with a low oxygen content (hypoxic) and facilitates easier uptake of oxygen and other gases in such conditions.

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