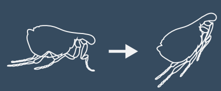
HUMAN SKIN

Returns to original shape after being deformed

HUMAN SKIN

Elastin is responsible for the elasticity in many tissues and organs that make up the human body, including the skin, lungs and in blood vessels. Elastin gives the skin a rubber-like property, enabling it to return to its original shape after being pinched, poked, stretched and contracted.

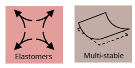
FLEA LEGS



Stored energy catapults the flea

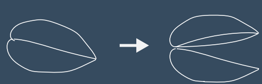
FLEA LEGS

Resilin is an elastomer found in many insects including fleas. It has high extensibility and offers a very efficient means of storing energy. The resin pad in the legs of fleas is squeezed as the legs move, causing energy to be stored like a spring. When all of that stored energy is released, the flea is catapulted into the air in under 1 millisecond.



Morphino

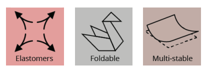
MOLLUSC HINGE



Opens and closes shell for swimming

MOLLUSC HINGE

The hinge ligament of molluscs is made from abductin, that opposes the adductor muscles, causing rapid opening and closing of the shell. Molluscs can open and close their valves about four times per second, enabling them to swim away from slow moving predators such as starfish.



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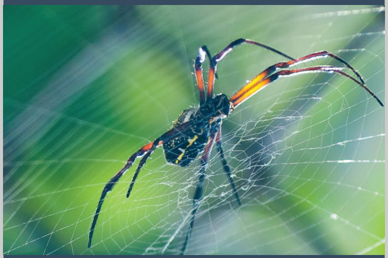
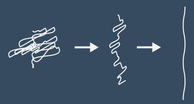
SPIDER SILK

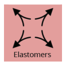


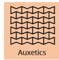


Stretches to support spider and capture prey

SPIDER SILK

Spider silk is one of the strongest materials known to man, yet some silks can stretch up to 5x their original length before breaking. Spiders use their silk for creating webs, wrapping prey, protecting offspring and as a roping line to quickly evade predators. When exposed to water, dragline silk undergoes super-contraction, shrinking by up to 50% in length.

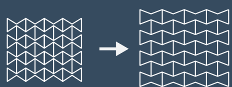




Morphino

COW UDDER

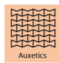
Cow Udder NATURE



Get's fatter when it is stretched

COW UDDER

The skin covering cow udders has auxetic properties. It behaves like a knitted fabric and can exhibit negative Poisson's ratios (i.e. the material gets fatter when it is stretched) with very little force. This happens when the internal volume of the cow teat changes, i.e. when it is full of milk and is being suckled or milked.



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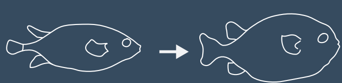
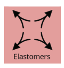
PORCUPINEFISH



Inflates body to scare off predators

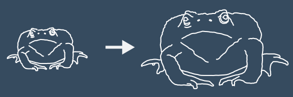
PORCUPINEFISH

When the Porcupinefish feels threatened, it inflates its body up to three times its original volume by swallowing water. When inflated, the collagen structure in the skin becomes stiff, providing a rigid structure to support the spines and to defend off potential predators.



Morphino

FEMALE CANE TOAD



Inflates body to prevent grasping

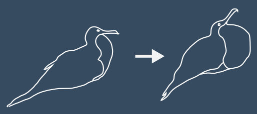
FEMALE CANE TOAD

The female cane toad inflates is body to thwart successful takeovers from rival males. By increasing its body size, the male toad is prevented from grasping the female around the back and attempting a forced mating.

Inflatable

Morphino

FRIGATEBIRD



Inflates pouch as a display of courtship

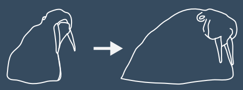
FRIGATEBIRD

When the Frigatebird wants to mate, it inflates a bright red gular pouch under its head as a display of courtship. This also enables the male birds to give a variety of calls such as drumming, reeling and purring in order to attract female mates.

Inflatable

Morphino

WALRUS



Streches and returns to its original shape
Inflates neck to float in water

WALRUS

When a walrus is ready to sleep, it inflates its neck by directing air into chambers in its throat called pharyngeal pouches. These pouches act as a natural pillow/floatation device and help keep its head above water.

Inflatable

Morphino

LADYBIRD WINGS

Folds wings to store and unfolds to fly

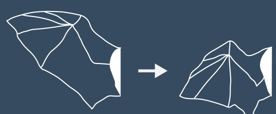
LADYBIRD WINGS

Ladybirds and other beetles have the ability to fold and unfold their wings in a fraction of a second transforming them from a walking insect to a flying one. The wings have an origami-style crease pattern that enables folding, and the veins have a curved shape that enables the hind wing to be rigid when extended but also stable when bent and folded for storage.

Foldable

Morphino

BAT WINGS



Folding and extending bat wings

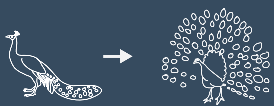
BAT WINGS

The folding and extension of the wings of bats during flight is made possible by a highly anisotropic membrane containing tiny muscles that control the membrane tension. The wing is manoeuvred skeletally through a series of flexible bones with independently controllable joints. This enables the bats to have a high degree of control of their wing during flight.

Foldable Anisotropic

Morphino

PEACOCK TRAIN



Feathers are fanned in a visual display

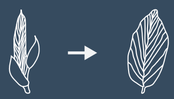
PEACOCK TRAIN

The male Indian Peafowl, or peacock, is predominantly blue with with a long train made up of elongated upper-tail covert feathers which bear colourful eyespots. These stiff feathers are unfolded and raised into a fan and quivered in a display during courtship.

Foldable

Morphino

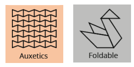
HORNBEAM LEAF



Leaf to unfurl as it emerges

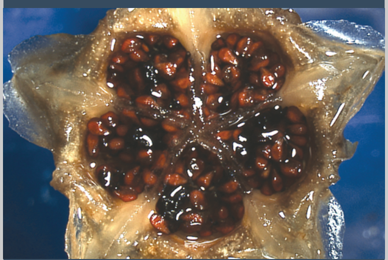
HORNBEAM LEAF

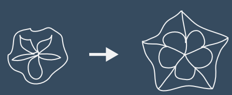
The hornbeam leaf has a regular, corrugated Miura-ori folding pattern than enables it to unfold as it emerges from the bud. The pattern allows extension in two perpendicular directions at the same time. The greater the angle of corrugation, the more compactly the leaf can be stored but the longer it takes to unfold.



Morphino

ICE PLANT





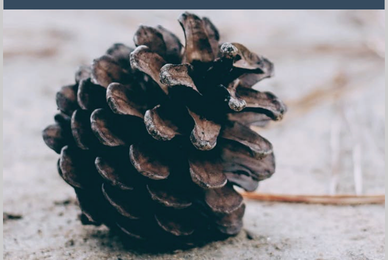
Fold and unfold to prevent seed dispersal

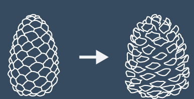
ICE PLANT

The seed capsule valves of the desert ice plant, Delosperma nakurense, fold and unfold through water-actuation in order to prevent premature seed dispersion. This is enabled by anisotropic swelling deformations (directional-dependent shape-change) that is transferred to larger-scale movements through the plant's hierarchical organisation.

Morphino

PINE CONE

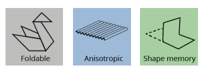




Open when dried and closed when wet

PINE CONE

Pine cones open when dried and close when wetted, i.e. as a result of changes in the humidity of the environment, to prevent premature dispersion of seeds. The stiff inner fibrous cells and humidity-responsive outer amorphous cells gives rise to anisotropic movement of the pine cone due to different temperature responses of the cell layers.



Morphino

TREE BRANCHES

Remain stiff, yet flex and bend in the wind

TREE BRANCHES

Wood is a natural material that is inherently anisotropic (i.e. different internal structure in different directions). By controlling the direction of the fibres that make up the branches, the tree and its branches are able to remain stiff and upright, yet flex and bend in the wind.

Morphino

THREE-BANDED ARMADILLO

Rolls itself into a ball when threatened

THREE-BANDED ARMADILLO

The three-banded armadillo is one of the very few species of armadil-lo that rolls itself into a ball when threatened. It's outer shell is made up of bony scales which act as an impenetrable armour. This armadillo also has another defense mechanism; it leaves a small gap in its rolled up shape, enabling the shell to slam shut when a predator tries to reach inside.

Morphino

GOLDEN WHEEL SPIDER

Rolls away from predators

GOLDEN WHEEL SPIDER

These spiders begin running, after which they flip their body sideways, curl their legs into semicircles and rotate down smooth sand dunes at speeds of 0.5 - 1.5 metres per second. This wheeling movement enables the spiders to escape predatory wasps by blurring their outline.

Morphino

MOTHER-OF-PEARL MOTH CATERPILLAR

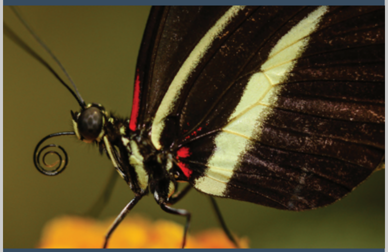
Coils into a ball and uses impulses to roll

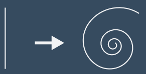
MOTHER-OF-PEARL MOTH CATERPILLAR

The larvae of the mother-of-pearl moth lacks the protective hairs of normal caterpillars. Instead, it can coil itself into a ball within 60ms and freewheel itself backwards away from danger using a series of impulses.

Morphino

BUTTERFLY PROBOSCIS

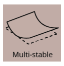




Butterflies coil there proboscis for storage

BUTTERFLY PROBOSCIS

The proboscis of butterflies and moths is stored in a spiralled coil underneath the head of the insect. For feeding, the insect uncoils the proboscis, just like a carpenters measuring tape, and draws nectar through the tube. The proboscis is then coiled again for storage.



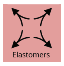
Morphino

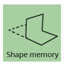
SEA CUCUMBER

Body changes from flexible to stiff armour

SEA CUCUMBER

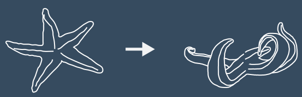
Sea cucumbers can rapidly and reversibly change the stiffness of their connective tissues. This enables its body to be flexible enough to move and squeeze through narrow cracks for protection or for reproduction, and then become stiff enough to withstand large forces from surge currents, to bury themselves into the seabed, or when they are bitten or pulled by predators.





Morphino

STARFISH



Stiffness of arms change for movement

STARFISH

Starfish have hydrostatic skeletons; i.e. skeletons that are flexible and supported by fluid pressure. The fluid is incompressible and the muscles act against this fluid to exert a force. Using this mechanism, the starfish are able to change the stiffness of their arms to flex for movement and stiffen for prizing open a clam for feeding.

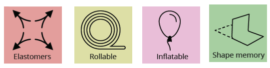
Morphino

OCTOPUS ARMS

Can stretch, bend, twist and apply force

OCTOPUS ARMS

An octopus arm can stretch more than twice its original length, twist and curl, enabling it to reach into small crevasses to forage for and capture food. It is a muscular hydrostat made up of a very similar structure to that of the human tongue.



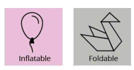
Morphino

CUTTLEFISH SKIN

Changes texture of it's skin for camouflage

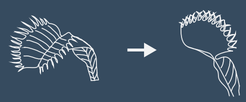
CUTTLEFISH SKIN

Cuttlefish have the ability to not only change their colour, but also change the texture of their skin, in order to camouflage themselves and disguise their true outline. Similar to the octopus arm, the papillae (skin folds) on its body are muscular hydrostats and the cuttlefish can control their shape and degree of expression.



Morphino

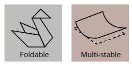
VENUS FLYTRAP



Snaps shut to capture prey

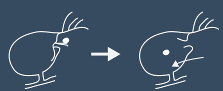
VENUS FLYTRAP

The Venus flytrap exhibits one of the fastest movements in plants. When the hairs on its lobes are triggered, the trap snaps shut in approximately 100ms. This rapid closure is actively controlled by the plant and is a result of snap-buckling instability.



Morphino

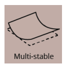
BLADDERWORT



Door opens, the inflow of water sucks the insect

BLADDERWORT

Bladderwort plants have underwater stems with small, carnivorous bladders attached. The bladders are hollow with a trap door that remains closed. The lack of water in the bladder causes a region of low pressure. When a small insect triggers the bristles that protrude from the trap door, the door suddenly opens inwards and a rapid inflow of water sucks the insect inside.



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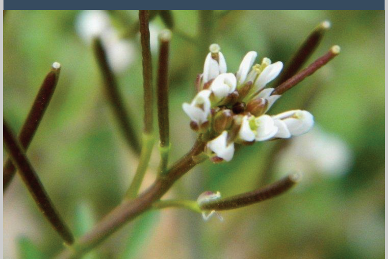
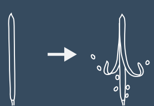
BITTERCRESS SILIQUES

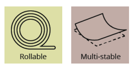




Catapult seeds, up to 5 meters in height.

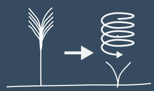
BITTERCRESS SILIQUES

Bittercress siliques use a ballistic seed dispersal mechanism to catapult their seeds into the air, up to 5 meters in height. A change in shape and thickness of the wall of causes the siliquae valves to rapidly coil outwards forcing the fruit to expell the seeds out into the atmosphere in only a few milliseconds.



Morphino

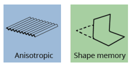
WHEAT AWNS



Seeds bury themselves by twisting and untwisting

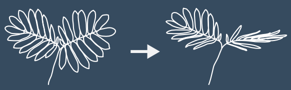
WHEAT AWNS

The dispersal unit of wild wheat has two pronounced awns that are able to propel the seeds into the ground, increasing their chance of survival. During the day when it is dry, the two awns bend outwards and during the night when it is damp, they bend towards each other; the resulting drill-like movement pushes the seed into the ground.



Morphino

SENSITIVE PLANT



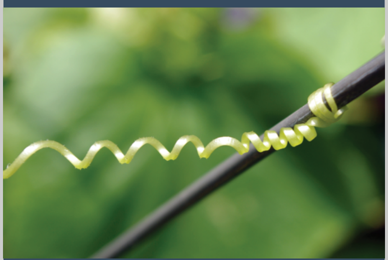
Leaves rapidly fold for protection.

SENSITIVE PLANT

When touched, the leaves of the Sensitive Mimosa rapidly fold and the stem drops. It is theorised that by folding, the plant appears smaller, deterring plant-eating species. The plant also exhibits this behaviour at night, when exposed to excessive heat and rain, to protect itself. Folding takes between 4-5s, whilst unfolding can take anywhere up to 10 mins.

Morphino

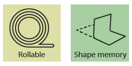
CUCUMBER TENDRIL



Elongates and then coils to reach sunlight

CUCUMBER TENDRIL

A cucumber tendril begins as a straight stem which elongates until it finds something to attach to. The tendril then coils and winds at each end in opposite directions, joined by a 'perversion' at the centre. This forms a helical spring which is soft when pulled gently and stiff when pulled strongly, enabling the plant to lift itself up and reach sunlight.



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