Seahorses and the surprising story of Convergent Evolution

By Neil Garrick-Maidment Hon.FBNA
Executive Director and Founder of The Seahorse Trust

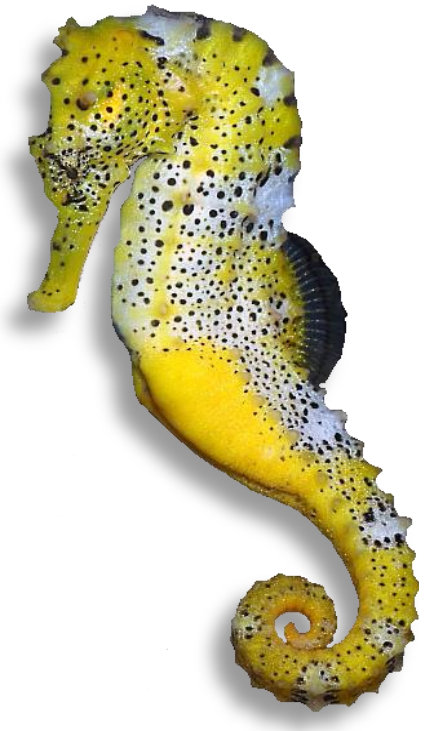
Seahorses appear to be made from many parts of other creatures to form a perfectly formed and highly efficient predator and enigmatic species. In this article we look at what makes seahorses so special and how nature has moulded some of the best parts of other species into one, in one of the finest examples of convergent evolution in the natural world.

What is convergent evolution?

Convergent evolution is when unrelated species independently evolve similar traits or features, like wings, tails or streamlined bodies, because they adapt to similar environments or ecological niches, not because they inherited them from a recent common ancestor.
This process creates analogous structures, which have similar functions but different underlying origins, seen in examples like bats (mammals), pelicans (birds), and dragonflies (insects) all developing flight, or dolphins and whales (mammals) and bass and mackerel (fish) developing tails to swim in the sea.

An expanded deep-dive into nature's most unexpected parallels

Seahorses are some of the most unusual and spectacular animals on Earth. They swim upright, have armoured bodies, grasp with their tails, can change colour, can see in almost pitch black, see in full colour, UV and infrared, and even have true male pregnancies. Beyond their oddities, seahorses are a treasure trove of **convergent evolution**.



When you look closely, seahorses echo features found in cheetahs, monkeys, chameleons, armadillos, kangaroos and even horses, amongst others. These similarities are not signs of shared ancestry but of nature repeatedly stumbling upon the same solutions to similar problems, through **convergent evolution.**

Facial Markings: Seahorses and Cheetahs

Visual adaptations shaped by the need to survive.

Cheetahs are famous for their dark tear-marks, which reduce sun glare and help them focus on prey, it also 'hides' the eyes from prey that could cause them damage by targeting the eye to disable the Cheetah. Seahorses, especially the

Short Snouted Seahorse (***Hippocampus hippocampus***) though living underwater and not chasing gazelles, are highly evolved and stealthy predators, which have independently evolved **contrasting facial patterns**, like the cheetah's tear drop, that serve comparable purposes.
By hiding the seahorses' eyes, the dark patch of the Short Snouted Seahorse, not only fools the prey that there is not a seahorse there, but it also breaks up the outline of the head, alongside other features such as colour and fleshy appendages, making it look like part of the environment it lives in.

Like the Cheetah as it focuses on its prey, the seahorse moves with such stealth, a movement that is almost imperceptible until the last moment. At the right point, the cheetah and seahorse both have a burst of speed, and they catch their prey unawares.

In a successful hunt the cheetah will catch its prey by the throat and strangle it, however, the seahorse sucks its prey in, almost liquidising it before it is swallowed, as the seahorse unlike the cheetah does not have teeth and so has to evolve a mechanism to be able to break up its food.

At this point convergent evolution is no longer, as the Cheetah can swallow large chunks of food into its stomach, which it then digests over a day or so. Whereas the seahorse does not have a true stomach. Instead, it has a digestive tract. The mashed up food enters the tract and as it passes through, it is slowly digested until it exits the seahorse's body through the anus.

Cheetah with its distinct Tear drop Facial markings

Short Snouted Seahorse with its dark eye patch

For a species that is highly evolved, the digestive system of the seahorses leaves a lot of questions as to why it is so inefficient; to the point that sometimes food is only partially digested or not even digested, and the author has even seen hard shelled crustacea (shrimp) come out of the seahorse and swim away. Nature still has some way to go on that one!

When watching a seahorse eat, you will see the body is moved from side to side, in a swaying motion by the currents and movement of the sea, this helps to push and manoeuvre the food

down through the digestive tract. Another clever evolutionary adaption to help the seahorse survive in its aquatic world.

How these markings help seahorses:

- **Camouflage enhancement:** Along with other measures, the eye stripes, spots on the head and eyes, and facial blotches break up the outline of the head (and body), making them harder for predators to spot. It is part of the overall camouflage of the seahorse, which involves colour change and physical body change. By growing and absorbing 'spines' (cirri) on its body to look weedlike, and slow and stealthy movements that make the seahorse look still, allows the seahorse to 'disappear'.
- **Communication:** During courtship, facial markings become more pronounced as seahorses brighten or darken their skin, in fact, the whole body is used for communication, by posture, or when the seahorse is courting. The dark line around the body, the colours on the fins and the overall colour of the body, change to 'show off' the seahorse, just like a peacock to a potential mate.
- **Visual clarity:** While possibly not reducing glare in the same way as cheetahs, the eye stripe causes contrast by reducing glare, may help seahorses distinguish shapes in cluttered marine environments by reducing glare.

  Interestingly, seahorses can see in a variety of different spectrums, depending on what type of habitat they evolved to be in, so seahorses living in seagrass have a green tint to the eyes, whereas seahorses living in coral have a blue tint. By having differing tints this allows them to see objects against the background more clearly.

  As they go into deeper water, one of the first colours that cannot be seen is red, so they occupy a world of greys and blacks. Having tints to the eye spectrum and being able to see in almost pitch black allows the seahorses to distinguish its prey or predators. Some seahorses and close relatives like the Ruby Seadragon ***(Phyllopteryx dewysea***) tend to be red in colour, which in turn makes them almost invisible in the darker areas of the seas where they live, which is quite often at depth.

  Often when there is a dark patch around an animals eye, it is there to reduce glare from all directions (a bit like sunglasses) and with seahorses the light comes from above and so, combined with the eye spine in Short Snouted Seahorses this could serve the same function of protecting the eye from glare, especially as the seahorse can see in the darkest of marine environments. Indeed, the seahorse has an extremely complex eye set up, seeing in exceptionally low light level, in full colour and the latest research suggesting in the UV and possibly infrared as well.

This is convergent evolution in action: two quite different animals using facial contrast to navigate visually complex worlds.

Prehensile Tails: Seahorses and Monkeys

Grasping the world in two completely different habitats

New World monkeys evolved **prehensile tails** to navigate the canopy, gripping branches as they move. Seahorses evolved the same ability—for different, but similar reasons.

Why seahorses need prehensile tails:

Seahorse tails are extraordinarily complex and incredibly flexible and they use them to:

- **Anchoring:** Seahorses are poor swimmers, but they still navigate a 3D world, of seagrass, corals, and other objects. They swim short distances before they anchor to the next object, seemingly without their brains thinking about it, in the same way spider monkeys use their tail like a fifth limb with no thought. Watching a seahorse swim along, the tail is constantly seeking its next holdfast, and this often surprises the seahorse, when it is brought up short as the tail grips and the seahorse suddenly comes to a stop. Their tails let them cling to seagrass, coral, or mangrove roots, so currents do not sweep them away. They can hold onto the tiniest object, even by the tip of the tail, which is very dexterous, and it takes a strong current or the object breaking away to wash the seahorse away.
- **Hunting:** By anchoring themselves, they can ambush tiny crustaceans drifting by. Reaching out and stretching the tail and neck, gives the seahorse an extended reach, coupled with excellent eyesight, and a powerful suck; very few items of prey get away.
- **Protection:** Staying attached to objects, reduces the risk of drifting into open water where predators lurk, it also allows them to blend in with the background, especially when they can sit still, very upright for extended periods of time and not move.

Picture by Kim Maidment

Short Snouted Seahorse, hiding perfectly camouflaged against algae. Its colour pattern matches the colour of the algae and its upright posture, allows it to blend into the background.

Seahorses can hang onto the thinnest of items, such as a seagrass blade.

Their tails are marvels of engineering made up of a hundred or so interlocking bony plates, they are flexible yet crush-resistant. Engineers study them for designing robotic arms and similar, very flexible structures.

Colour Change: Seahorses and Chameleons

Masters of camouflage and communication

Cuttlefish and Chameleons are iconic for their colour-changing abilities, seahorses evolved a similar skill.

Seahorses change colour to:

- **Blend into their surroundings:** Essential for avoiding predators and ambushing prey.
- **Communicate:** Courtship involves synchronized colour changes between mates.
- **Signal stress or aggression:** Sudden darkening can indicate threat or discomfort.

Both seahorses and chameleons use specialized skin cells—chromatophores—to shift pigments. The mechanisms differ, but the outcome is strikingly similar: **dynamic camouflage**.

There are two main reasons seahorses change colour, one for camouflage the other for emotion.

Camouflage

When selecting a colour for camouflage, the seahorse has evolved to be certain colours for certain environments. For instance, Spiny Seahorses (***Hippocampus guttulatus***) are an olive-green colour to resemble and match the seagrass, so they can 'vanish' to any potential predators or from their prey.

The Shiho Seahorse (***Hippocampus sindonis***) is bright red but because it lives at depth (over forty metres in some cases) it cannot be seen because red is the first colour to 'disappear' at depth, making the seahorse look black or dark grey. As it lives amongst bright red sponges, which also lose their colour at depth, it means that the seahorse is almost invisible against the sponges.

However, because the seahorse has excellent eyesight, it can still hunt. As well as great eyesight, they also have an advanced olfactory system, meaning they can 'smell' prey in the water.

Spiny Seahorse (***Hippocampus guttulatus***) blending into the seaweed

Emotion

Emotional colour change in seahorses can be caused by stress, where they normally turn black, an indicator of stress. Or for courtship where a range of colours can be displayed. During courtship where males attract females, or are competing with other males for females, means, that the colour changes from its usual base colour to be much lighter.

In some species like the Three Spot Seahorse (***Hippocampus trimaculatus***) they can change colour from black to white in seconds.

This emotional colour change happens for minutes, unlike the base colour, which takes much longer to develop into the colour the seahorse thinks makes it blend into the background. When the emotional trigger is finished, they revert back to their base colour very quickly.

On the fins the colour is in bands with yellow and black being a common colour. The outer edge of the whole body has a black line around it, emphasising the seahorses elegant, classic shape.

By fluttering the dorsal fin at speed (35 to 70 beats per second), it ripples from top to bottom and the bands of colour are accentuated as they show off their prowess very much like a male peacock.

The Spiny Seahorses above are going through a courtship dance. The male at the back is lighter in colour and notice the dark thin line, outlining the body, the face has gone dark and on the dorsal fins the bands of colour (yellow and black). The dorsal fin is held erect like a Peacocks tail, to show off the male's prowess.

Additional seahorse traits with convergent parallels

Armour Plating — like armadillos, pangolins, and tortoises

Seahorses lack scales like other fish, Instead, their bodies are made up of **bony plates** arranged in rings, covered with skin, with a coating of mucous, like an eel.

The triangular plates are held together by strong ligaments and sadly are the thing left when a seahorse dies on the beach and decays, leaving behind the exoskeleton.

Triangular interlocking plates

The exoskeleton also means that they can be dried out in a shape and sold to the curio and medicine trades, where in excess of 150 million are sold each year (**source; Kealan Doyle 2012**).

This is a practise that could make seahorses extinct within the next 25 to 35 years.

Seahorse skeleton

The exoskeleton:

- Protects against predators.
- Prevents crushing and is resistant to strong tidal currents.
- Gives them a rigid, angular shape.
- Makes the seahorse very flexible.

It is a defensive strategy shared with armadillos, pangolins, tortoises and even some insects —another example of convergent evolution arriving at the same solution in wildly different lineages.

Vertical Posture — like meerkats, prairie dogs, or kangaroos

Most fish swim horizontally. Seahorses swim upright, a rare posture in the marine world as it is not very streamlined. But Seahorses do not need to be streamlined as they are stealthy hunters that lie in wait for their prey. The upright posture gives them an almost mystical look, like a horse swimming under the sea; added to this, they have a head shaped like a horse, they truly are Poseidon's' little 'horses of the sea.'

This upright posture also allows them to be able to see into the distance in the same way meerkats, prairie dogs and kangaroos do when they are stood on their back legs.

Strangely for a fish, seahorses have evolved a true neck, this happened because of, and in parallel with the evolution of its prehensile tail. Prior to this they were straight and horizontal like modern day pipefish, seadragons and most species of fish.

As they evolved a more prehensile tail, to grip onto things, this meant that the head was pointing upwards, not an advantageous position to avoid being eaten, as they could not see predators coming, there were multiple blind spots in their vision. They slowly evolved a true neck - the evolutionary appearance of this can be seen in some pipefish species like the Alligator Pipefish ***Syngnathoides biaculeatus*** or Schultz's Pipefish ***Corythoichthys Schultz*** (below) that have started to form a neck, which allowed the head to face downwards, giving a horse like appearance. This allows the eyes to have an almost 360 degree vision; they can look forwards and backwards at the same time, an excellent feature to keep an eye out for predators or prey. The neck is crucial to a vertical life style and when hunting it can be straightened, along with the prehensile tail, to give a greater reach. Seahorses are one of the few fish in the natural world that have a true neck.

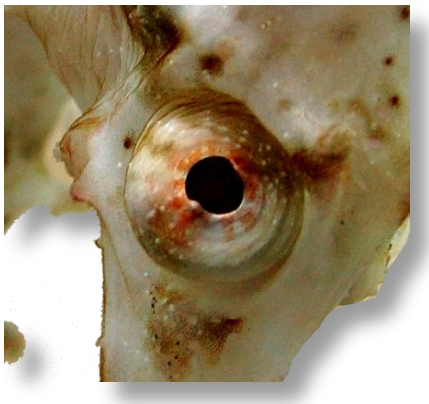
Schultz's Pipefish ***Corythoichthys Schultz*** showing the evolution of the neck, which in the Schulz's Pipefish allows them to raise their bodies higher from the seabed, keeping the body flat. This gives them the advantage of being able to see further distances, than if the head was flat on the seabed.

Why vertical posture evolved:

- Mimics the shape of seagrass blades, sponges or seafans.
- Helps them remain hidden among vertical structures.
- Allows them to pivot and scan for prey with minimal movement.
- Gives them an almost 360 degree vision.

This parallels the upright stance of meerkats, prairie dogs, or kangaroos, which use vertical posture to blend into tall grasses or scan for danger, but at the same time they can watch out for food to eat.

Independent Eye Movement — like chameleons



Seahorse eyes are remarkable in their design and function, seeing in full colour and in the lowest of light levels, they can distinguish prey in the most complex of environments.

Seahorses can move each eye independently, scanning different directions at once, a trait they share with Chameleons. The independence of the eyes give a 360-degree view, allowing them to scan for food and predators. It is especially useful when they are hunting prey in sand. The seahorse stretches forward with one side of the body angled to the sand, as it spots food just below the sand, and one eye focuses and turns towards the prey in the sand, the other eye is watching out for predators from all around. They move forward almost in slow motion, creeping up on the prey and start to turn the head, side on to the sand, the eye constantly looking at the prey. At the last moment, the snout, and head flicks forward and the hapless prey is hoovered up from the seabed, and the seahorse goes back up into an upright position, both eyes on the lookout for the next morsel of food.

Interestingly all seahorses have small dots and lines on the eye and body which makes the eye difficult to see. However, it also allows researchers to identify individual seahorses because the patterns act like fingerprints.

Benefits:

- 360-degree awareness.
- Can see forwards and backwards at the same time.
- Able to see in exceptionally low light levels.
- Can see in full colour and black and white.
- Ability to track prey while watching for predators.
- Efficient hunting without revealing movement.

This is a remarkable case of convergent evolution with chameleons, which use the same strategy for similar reasons. Like chameleons, the seahorse can also direct both eyes to look forward when it is concentrating ahead of itself.

Suction Feeding — like pipefish

Seahorses feed by flicking their head forward at great speed and sucking prey into their long snouts. The mouth, which is at the end of the snout has a bony structure that allows it to open fully when the snout is at full stretch, a bit like a snake. This in turn allows it to take in prey that seems impossibly large to eat. This combined with an incredibly powerful suck means that potentially hard bodied prey like shrimp and small crabs can be dispatched with ease. As seahorses do not have teeth, they need to demolish their prey to be able to swallow it.

As the head is stretched forward and the seahorse is ready to eat the prey, a trigger like arrangement goes off under the snout (circled in red below). This is a bit like opening a paper bag at speed, which creates a sudden intake of water through it. This combined with the large siphons, similar to cuttlefish, which are at the top of the sealed gill, suck the unwitting prey into the snout and down into the digestive tract. When a seahorse has just eaten you often see particles of food being expelled through the siphons giving the appearance of smoke, billowing from them. You can see how the ancient dragon legends came about!

This feeding method:

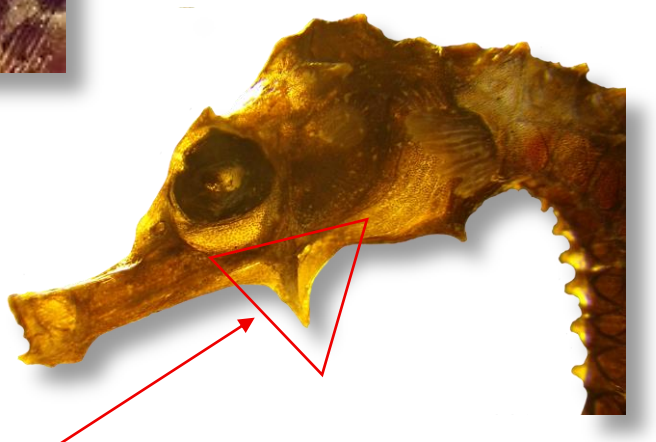
- Creates a powerful vacuum.
- The expanding mouth allows for larger prey to be eaten.
- Allows them to catch tiny, fast-moving prey.
- Allows them to reach food in crevices and holes.
- Requires almost no body movement, preserving camouflage.

Pipefish use similar suction-based feeding strategies.

This picture illustrates how wide the mouth of the seahorse can open. The mouth is situated at the end of the snout and through a clever arrangement of the bones in the snout, not only can the mouth open fully but the underside of the snout also expands out like a concertina along its length, allowing large prey items to be sucked in.

The siphons are located at the top of the head behind and above the eyes. They are the outlets of the gills, which unlike other fish are sealed.

In the picture to the left, you can see the 2 siphon holes either side of the head ridge



The trigger is located under the snout and in this picture on the right it is fully extended downwards.

The trigger is attached to flaps of skin (forming the triangle) that when the trigger is flicked open, fill with water. This in turn, in combination with the siphons creates a jet of water through the gills, creating a powerful suck, that can pull in the prey form up to 2 centimetres away.

Male Pregnancy — a unique trait with distant echoes

True male pregnancy is unique to seahorses; however, the **brood pouch** has parallels with:

- Marsupial pouches
- Frog species that carry eggs on their backs, or in their mouths, like the Darwins Frog
- Certain insects that protect eggs in specialized structures

Seahorses tend to pair for seasons rather than for life as was originally thought, but even pairing for a brief time helps in producing as many fry (babies) as possible, as it reduces the time needed to find a new partner each time.

Each day the pair do a reinforcement, pair bonding dance to ensure they remain together during the season. If the male has given birth over the previous 24 to 48 hours, the dance takes on a more urgent aspect to it.

After the beautiful and elaborate courtship display. As they both rise in the water column they face each other and then the female puts her ovipositor into the male's brood pouch and in seconds transfers her eggs to him. The number of eggs depend on the species but can vary from 1,500 in Big Bellied Seahorses (***Hippocampus abdominalis***) down to fifteen in dwarf seahorses like Barbigants Seahorse (***Hippocampus barbiganti***).

As the eggs enter the males brood pouch, he self-fertilises them and you will see him, wiggle from side to side as the eggs get embedded into the lining of the brood pouch. Although the eggs have remnant yolk sacs like other fish species, being embedded into the placenta-like lining of the pouch means they receive, nutrition, blood, and oxygen directly from the male, A very mammalian like pregnancy. They even produce a hormone called lactose, which produces milk in humans.

After a gestation ranging from 15 to 28 days, depending on the species the male 'unlocks' the entrance to the brood pouch allowing seawater in, this equalises the fluid inside of the pouch with the sea; the fry are about to be released into. At the same time, the fully formed seahorse fry (babies) come loose from the placenta, and you will see the male starting to have contractions, which can last up to 12 hours. As he gets close to giving birth, he will start to move his tail forward and upwards, pumping the pouch. With a final push the male pumps his pouch and the fry are expelled in a cloud of fry. At this point they are completely independent of the parents and go off to spend a few weeks in the plankton layer, before settling on the seabed among algae, corals, and other types of habitat.

By giving birth in such a flurry, this gives some of the fry a chance to survive as it confuses potential predators, which want to eat the perfectly formed seahorse fry. It is thought that only 3 to 5 in a thousand fry survive to maturity, however the seahorses prodigious breeding each month and the sheer quantity of fry born ensure that the species does survive.

Once born the fry are fully their own, being very precocious they are fully formed and look just like miniature seahorses. From the moment of birth, they are eating machines and will consume up to 3,000 particles of plankton every 24 hours. For the first week or two they are in the plankton layer free swimming, where they are heavily predated upon and this is one of the reasons why seahorses produce so many fry. The large numbers of fry born are nature's

way of ensuring some of the next generation continue. As they increase in size they settle on algae, coral, and other objects where they are more camouflaged and have a greater chance of survival.

8mm fry of a Spiny Seahorse
By Francis Apesteguy

Interestingly no matter the size of the adult, the fry tend to be similar in size when they are born, from 5 to 8 millimetres from the top of the head (coronet) to the end of the tail. They can do this by smaller seahorses having less fry, whereas larger seahorses have a lot of fry. It is interesting to see such a variation throughout seahorses, showing that each type of seahorses has adapted to its own ecological niche.

The big question is why do the males have the fry and not the females? It is quite simple. It takes a huge amount of energy to rear the young internally and also to produce a large number of eggs to pass over, so if the roles can be divided between the males and females as happens in small monkeys like Marmosets and Tamarins (not quite convergent evolution but similar shared parental care), then this means they can produce more fry and ultimately more will survive. It also means the adults are not exhausted in fulfilling the entire task on their own and so the fitness of the adults remains at a peak, which in turn allows them to be able to produce more fry.

While not a perfect example of convergent evolution, it shows how many species independently evolve **specialized parental care systems**.

Seahorses have taken the sharing of the role of producing young to the ultimate level and although not strictly a convergent evolutionary trait it does show a similarity with kangaroos and other marsupials that nurture their young in a pouch.

.

Males giving birth:

- Share the role between the male and female.
- This allows more fry to survive.
- Is the only true male pregnancy in the animal kingdom.
- He is still a male because he has testes and produces sperm.

The seahorse shares pouch brooding with kangaroos and other marsupials, and the placenta lined pouch with mammals, Convergent evolution at its ultimate peak.

Why are seahorses a convergence evolutionary hotspot

It is not exactly known why seahorses are a **convergence hotspot**, however they are at a pinnacle of evolution; it is difficult to imagine how much further they can evolve.

Seahorses as we know them, have been around for over 13 to 25 million years unchanged and the adaptions they have evolved, are perfect for the variety of habitats and ecosystems they live in.

They have mastered colour change, specialised their feeding technique, adapted to strong and changing currents, evolved a highly unique way of breeding, have a rigid body to protect themselves and can move between salt water and freshwater for periods of time. They are the ultimate masters of their environment.

Seahorses live in environments full of:

- Predators.
- Strong currents.
- Dense vegetation.
- Tiny, fast prey.

These pressures push evolution toward:

- Camouflage.
- Stability.
- Precision hunting.
- Protection.

Because these challenges also exist in forests, savannas, and deserts, seahorses end up sharing similar traits with animals from completely different worlds. They take the best nature can offer and put it into one very neat package.

Final Thoughts: What Seahorses Teach Us About Evolution

Seahorses are living mosaics of evolutionary innovation. They show that:

- Evolution is not linear—it is opportunistic.
- Similar problems often lead to similar solutions.
- Unrelated species can look or behave alike for entirely varied reasons.

By studying seahorses, scientists gain insight into biomechanics, camouflage, robotics, and the deep patterns that shape life on Earth.

They truly are masters of their own universe.