Life's Not All Jetting Around! (p. 427)

The closest most of us will come to a jellyfish is a deflated lump on a beach, or a brightly illuminated school in an aquarium's tank. But diving with the oldest swimmers on the planet made Sean Colin and Jack Costello realise that jellyfish propulsion is deceptively complex, and can even determine the jellyfish's diet.

Fishing on the West Coast of the USA, Colin and Costello collected six species, ranging in size and shape from tiny domed bells to larger flatter species. All of the jellies that they collected fell into the hydrozoa class, which make up the largest group of jellyfish in the sea. They transported them back to a lab tank and began to video the creature's gently pulsating movements, correlating each propulsive stroke with the accompanying bell deformations. They soon realised that although some of the smaller jellies were moving by expelling a jet of water out of their bells, the larger jellies had opted for a gentler mode of transport. Watching the spiralling vortices in the jellyfish's wake, they saw that the larger hydrozoa were rippling their bell walls, effectively 'rowing' themselves through the water.

Looking at the animal's morphology, Colin and Costello saw that the swimming style was a direct result of the animal's build. The larger jellyfish bells were too wide to produce a high-pressure jet, but their gentler rippling gait gave them an efficiency that allowed them to swim almost constantly, while the energetic jet swimmers only swam in short intense bursts. This was a surprise, because everyone thought that all jellies had opted for jetting around. Colin explains that even though the jellyfish has an extremely simple body plan, they have cleverly figured out a way to use the surrounding fluid to their advantage. They hit on the 'rowing solution' early in evolution; they just do it in an unconventional way.

Another reason for some jellies choosing to row rather than jetting around, is that their pulse frequency is naturally limited. Colin explains that the jellyfish bell is lined with a single layer of muscle that contracts to thrust the animal forward. The bell only returns to its original shape because of its intrinsic elastic properties, naturally limiting the rate at which the bell can pulse to propel the animal through the water. This makes rowing a more efficient option for larger jellyfish.

Jellyfish hunt blindly, catching whatever particles bump up against their stinging tentacles. The larger jellyfish pulse around sieving the water that passes through their tentacles to trap nutritious particles. While watching the wakes that the different swimmers produced, Colin and Costello realised that the swimming style was probably affecting the fish's diet too. The gentle rowing movement produced currents that washed nutritious zooplankton through the jellyfish tentacles. So larger jellies only dine on the slowest zooplankton that are brought to them by their privately generated wake.

Unlike the larger animals, whose tentacles spread out behind them, the smaller jellies' tentacles trail behind in a bundle. Colin and Costello realised that these little medusae could not use their swimming motions to circulate water over the tentacles for feeding. They also saw that small jellies can't keep up the pace for long. Their bursts of speed force them to rest for almost 90 % of the time. So instead of cruising and sampling the waters, the smaller members of the jet-set have to wait with their tentacles out to ambush whatever drifts their way. Their jet-propelled life style has selected their diet too.

Not Flying, Shallow Diving (p. 371)

Although some diving birds look as if they're flying underwater, they're actually doing the complete opposite. Flying has more to do with overcoming gravity, making a heavier frame a big disadvantage. But a lighter build can increase a diver's buoyancy to a point where it becomes difficult to submerge. So how do diving birds stop themselves from bobbing back up to the surface? Christoffer Johansson set out see how one species overcomes the problem. By digitally analysing the swimming stroke and underwater acceleration patterns of diving Atlantic puffins, he realised that the bird's wing beat is crucial for overcoming the effects of buoyancy and keeping the birds submerged.

Some diving birds are propelled by paddle power, while others use their wings. The majority of thrust is produced by water flowing over the wing surface, but if the wings are too cumbersome to flap at speed, then any advantages from having a large lift surface area will be undone by the bird's inability to move them fast enough through the water. Atlantic Puffins overcome this to some extent by swimming with their wings tucked back. But Johansson wondered what other tricks they use to keep themselves submerged, so he took a trip to the shores of Iceland at the start of the puffin-hunting season.

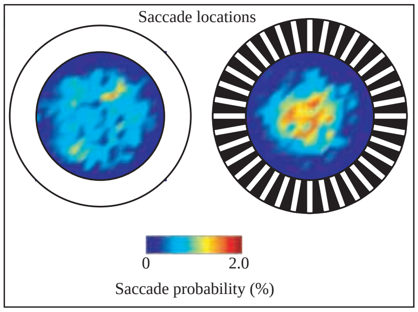
Smoked puffin is a staple of the Icelandic diet. During the hunting season, hunters trap the birds in bag nets, so Johansson had a supply of willing puffins that were happy to avoid the hunter's cooking pot and dive for the cameras. Rather than taking the puffins to the lab, Johansson took his lab to the puffins. But he had to race against time with less than three weeks to build his lab on an Icelandic beach, and film the diving birds.

He filmed six birds, tracking them with two cameras so he could accurately follow their movements in three dimensions. Unlike other diving species, the puffins needed little encouragement, diving spontaneously whenever Johansson approached the tank. Back in Sweden, he analysed the bird's wing movements and diving trajectories by digitising the films and tracking the movement of six points on the bird's bodies.

Johansson admits that he hasn't found the tell-tail stream of air bubbles that sometimes trail from a diving bird's wing during a force-producing upstroke. The active upstroke only became apparent when he scrutinised the bird's acceleration pattern while it swam. The birds accelerated during the down stroke and also during the upstroke, which meant that the upward movement of the wing was actively contributing to the bird's propulsive force.

Although the puffins are not as well adapted to diving as penguins, Johansson believes that the puffin's wing stroke is perfectly adequate for the bird's needs, and shouldn't be thought of as a transition towards the penguin stroke. He explains that the folded back wings also help to reduce the drag forces on the diving bird, which also increases their forward thrust.

But Johansson knows that this is just the beginning, he'd like to go deeper, to see how the depth affects the diver's buoyancy, especially if he can keep working with birds that are as cooperative as the Atlantic puffins.



Fly's Eye View (p. 327)

Encouraging a trapped fly out of an open window can be a frustrating exercise, as it ricochets in almost every direction except the way out. Lance Tammero's goal is to explain how the tiny insect controls its erratic flight. Working with Michael Dickinson in Berkeley, Tammero has decoded Drosophila's flight strategy and used it to reconstruct a fly's view of the world to identify the visual cues that determine the path a fly follows.

A fly's trajectory is far from smooth. Tammero wondered how the visual environment influences the fly's choice of direction, but first he needed to know if the flight path is a random mixture of twists and turns or whether the fly strings together a series of discrete navigational units? Tammero released flies into a circular flight arena. The wall of the first arena was covered in a randomly arranged black and white check pattern. This pattern could be removed leaving undecorated walls, where the upper and lower wall rims were the only remaining visual features. He filmed each individual's flight path, illuminating the arenas with infrared radiation, which wouldn't distract the flies.

Tammero filmed almost 50 insects in both arenas to collect enough flight information before painstakingly analysing each three-dimensional trajectory. He realised that every fly linked short straight flights with rapid turns, called 'saccades', but the visual environment significantly influenced the way the flight units were combined. In the first arena, the flies avoided the decorated walls, limiting their flight to the centre of the arena and making frequent 90 ° turns. Flies that flew freely in a featureless environment flew faster over a wider area and didn't turn as frequently.

Knowing that the visual environment affected the insect's flight path, Tammero reconstructed the fly's view, for both eyes, paying special attention to the 0.5 seconds before the fly switched direction, and used it to determine which visual features influenced the fly's choice. As the fly approached the patterned arena walls, both eyes saw very different views of the world. Tammero's simulation found that the image in the eye closest to the wall was expanded relative to the view from the other eye. As the fly continued to move, he saw features moving differently in both eyes, triggering the fly's saccade response.

Tammero explains that the fly integrates a variety of inputs from at least two navigation systems during a flight sequence. The haltere system contributes information about the fly's orientation in space to keep the fly on the straight and narrow, in much the same way as a gyroscope in a jet. As the fly approaches a wall, the visual 'image expansion' system begins to override the mechanosensory haltere control, signaling the fly to turn almost instantaneously. Tammero believes that the flies limited ability to process visual information has driven the insect to come up with this simple strategy to explore their environment.

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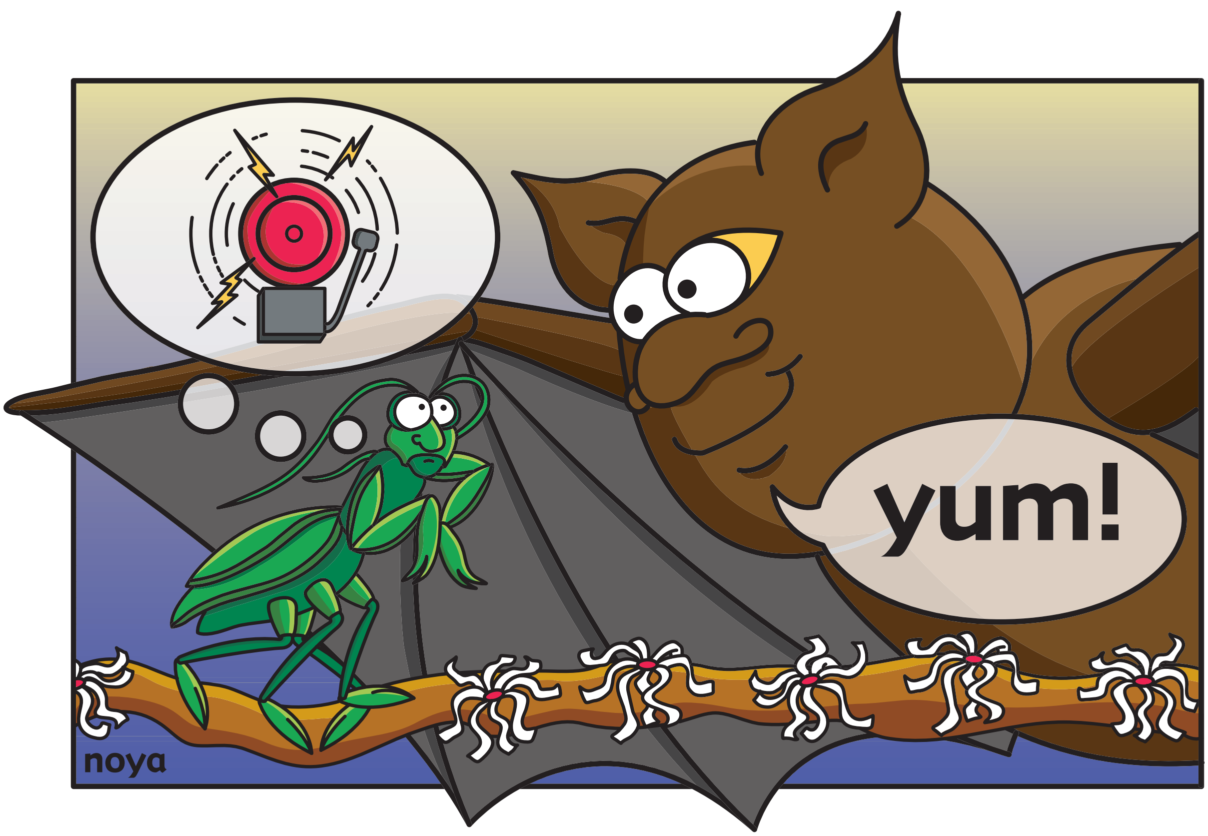

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