

## LIKE A FISH IN WATER

**Bill François** – Fish have many different ways of swimming, in particular small ones swim very differently from big ones. All fish are born in an egg about the same size as a grain of couscous, barely a millimetre across, and that makes for tiny fish that are so small that water will behave very differently from the way it behaves on our scale. That's a law of fluid mechanics: the forces that are exerted on an object placed in water are very different depending on the size of the object. For a large object, like you and me, when we swim, we will move the water in blocks, and therefore we will feel the water as a medium that acts on us like a support, with Archimedes' thrust, and in which we can gain momentum versus water's inertia. For a very small fish of one millimetre, things don't happen like that at all, and the fish is so small that it will to some extent feel the individual shocks of water molecules. They will combine to act like a permanent brake on the fish while it will be unable to move them around in blocks. This makes swimming in water as difficult as swimming in honey for a fish that has just emerged from its egg. So, if they are to swim in the water at small scale, fish must instead swim with an asymmetrical movement like a screwdriver. Consider that an even smaller being, the spermatozoa, has flagellum that turn like a corkscrew so that they screw rather than undulate. That's because if they undulated, they would stand still and therefore we would not have been born. Like fish. The breaded kind.

Now the next thing for the fish is that it will grow. The maximum is set by the sunfish that can in adulthood be eight hundred million times its size when born, so that it goes from the size of a grain of couscous to in excess of two tons. Other fish may only grow to the size of a sardine or an anchovy but even that is already a huge transformation in the physical forces they experience. As the fish grows, it leaves behind those jostling forces and the water seems to the fish to be more and more fluid until it learns gradually to base its swimming on other forces, on drag in particular. Now this is the principle of oars where we use the reaction of the water by which we are surrounded in order to move forward: that's what most fish do when they undulate or else paddle with their fins. As the fish adapts its swimming like this and constantly relearns to swim, its body will totally transform. As it grows up, this fish that began by crawling through the water will become an extremely tapered tuna because it will adapt to swimming with other forces. And the biggest fish like tuna will do even better than swim, they will fly! That means they use lift, which is another force, the same force that makes planes fly, because they are so large and so fast that for them water behaves more like air behaves on our scale. They base their swimming and their movements on inertia and on partial vacua that arise due to the speed of the fluid which creates pressure differences. The tuna does not row or paddle, it is sucked

through the water and flies and it is thanks to this that it is able to swim for two hundred kilometres a day at more than a hundred kilometres per hour which is absolutely incredible when you're in the water. This is a good example of how physics can sculpt the evolution and diversity of living things.

Now there are also behaviours that stem from this such as collective swimming where fish like sardines group together. There may be several billion individuals in a single school and they make decisions all together without there being a vote, arguments or boards of directors. These huge schools of sardines will in turn feed an entire ecosystem of which we ourselves are a part! For example, we admire the Flemish painters of the Renaissance but there would have been no Renaissance if there had not been an immense abundance of herring beds in the North Sea at that time. This allowed states bordering the North Sea to become rich and therefore to be able to concern themselves with painting, to reflect on art, etc. So, the culture of us humans is also linked to these ecosystems and to these physical laws. It's a big whole, and it's one more reason to preserve the ocean and even the smallest fish.

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