Fish 'Fiziks'

Why do dead fish float? How do fish that live on the bottom stay there and not float to the surface? How do fish move around in the water? These are all serious questions about fish survival and the ancient science of physics.

What is physics?

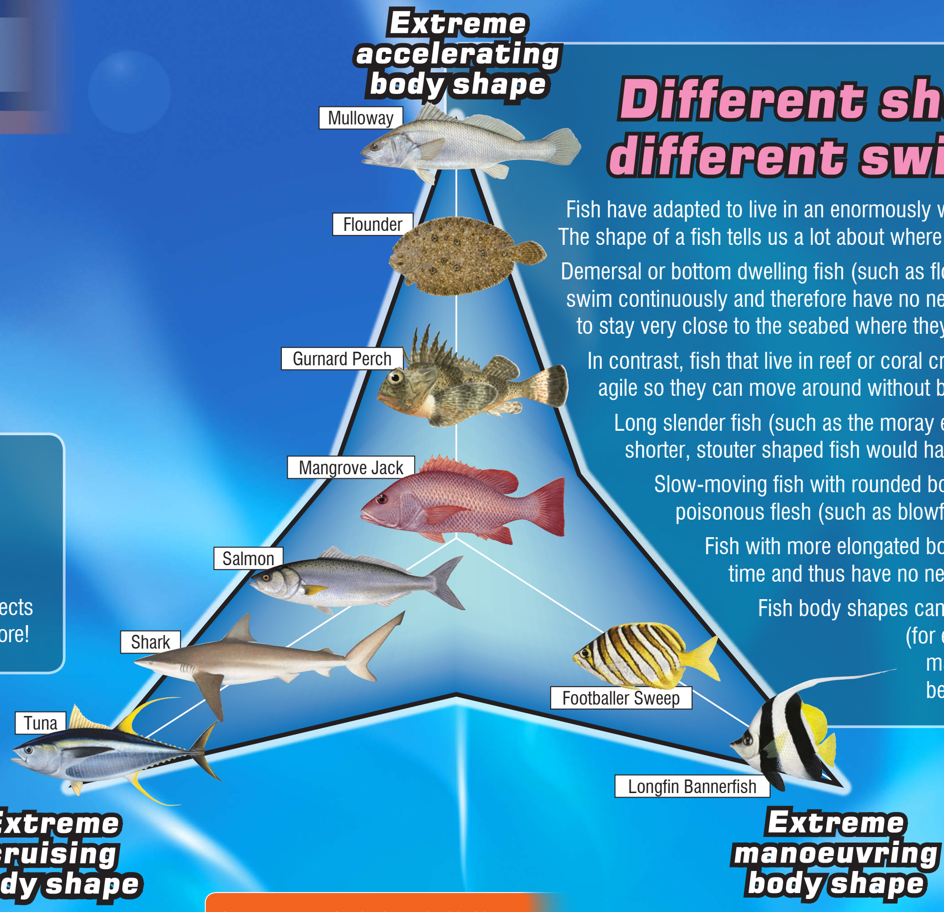
physics /'fiziks/ n. – the science dealing with natural laws and processes, and the states and properties of matter and energy, other than those limited to living matter and chemical changes. *(Macquarie Dictionary)*

That's the definition, but what does it mean? Physics is the branch of science that investigates things like the motion of objects through water, air and on-land; electricity; magnetism; light, heat and gases; the tiny particles that make up atoms – and more!

How does physics affect fish?

Fish live in an environment that is 800 times denser than air, yet some fish can travel through this stuff – water – at speeds of 90 km per hour. Physics can help explain how this actually happens.

The ability of a fish to survive in water depends to a large extent on physics. Physical factors like pressure, density, light and movement have a major impact on a fish being able to move, get food, escape predators and successfully reproduce – in short, to live.



Different shapes different swimmers

Boyle's Law describes the relationship between pressure and volume: For a fixed amount of gas kept at a fixed temperature, pressure and volume are inversely proportional – that is, while one increases the other decreases.

Fish have adapted to live in an enormously wide range of aquatic habitats, and this includes the shape of their body. The shape of a fish tells us a lot about where it lives, how it feeds and, in particular, how it moves through the water.

Demersal or bottom dwelling fish (such as flounder and wobbegong) are generally flat in shape, as they do not swim continuously and therefore have no need to be streamlined. Looking a bit like a pancake means they are able to stay very close to the seabed where they feed.

In contrast, fish that live in reef or coral crevices (for example butterfly fish) have deep, flat bodies that are highly agile so they can move around without bumping into rocks and reefs.

Long slender fish (such as the moray eel and cobbler) are able to hide under rocks and amongst coral, where shorter, stouter shaped fish would have difficulty in going.

Slow-moving fish with rounded bodies are often protected by spines or armor plating, and may also have poisonous flesh (such as blowfish and white-barred boxfish), owing to their lack of manoeuvrability.

Fish with more elongated bodies (such as Australian herring) are able to swim very fast for a long time and thus have no need for any special body protection.

Fish body shapes can be broken up into three distinct groups – 'extreme accelerating' (for example mulloway); 'extreme cruising' (such as tunas); and extreme manoeuvring (such as angelfish). Of course, there is a range of shapes in between these – as shown in the diagram nearby.

As oxygen remains in the swim bladder after a fish dies, and other gases are released during decomposition, dead fish eventually float to the surface.

Under pressure – swim bladders

Fish are slightly denser than water. If they weren't, they would have a hard time trying to swim and would simply float on the surface. However, pressure increases with depth, so fish counteract changes in pressure through an organ called a 'swim bladder'.

Swim bladders are only found in ray-finned fishes (the major group of bony fishes). There are two types of swim bladder in fish. The 'physostome' (pronounced fi-so-stome) is a relatively primitive type, where there is a connection between the swim bladder and the intestine (gut). This allows the fish to swallow air into the intestine, which then fills up the swim bladder. You may have seen herring doing this at the surface.

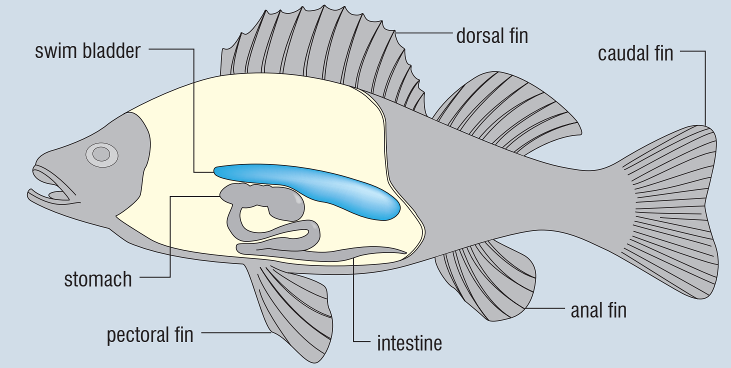
A more advanced type of swim bladder called a 'physoclist' (pronounced fiz-o-klist) is self-contained – it does not have a connection to the intestine. Water passes through the gills, where oxygen is extracted and carried through the bloodstream. Some of that oxygen can be released into the swim bladder via blood vessels attached to the bladder.

The amount of gas in the swim bladder enable fish to control their ability to 'float' and 'sink' in the water column.

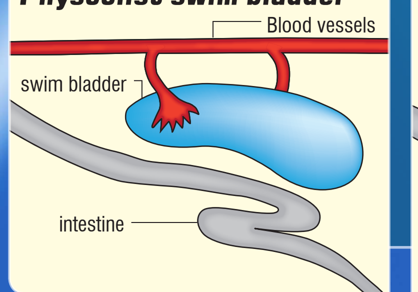
If a fish moves into deeper water, more oxygen is absorbed into the bladder, increasing the volume of gas in the bladder and the fish's buoyancy. If the fish moves into shallower water, then oxygen in the bladder diffuses back into the blood and out the gills, decreasing the fish's buoyancy.

Pelagic (open-water) fish such as tailor have a small swim bladder, as they only have to make small adjustments to their position in the water column. Demersal (bottom-dwelling) fish, such as Western Australian dhufish, have a relatively large swim bladder as they have to cope with large changes in pressure.

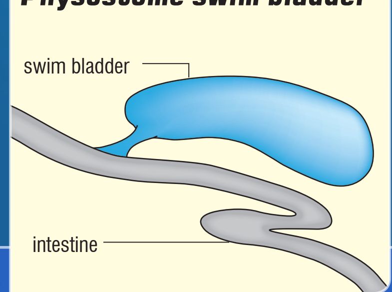
General location of the swim bladder



Physoclist swim bladder



Physostome swim bladder



A bit of leverage

In physics, a 'lever' is a rigid object that is used in conjunction with a pivot point (or 'fulcrum') so as to gain a mechanical advantage – in plain words; you can use a small effort to overcome a greater resistance.

In the case of a fish, its skull acts as the fulcrum, staying relatively still, with its backbone acting like a lever, which moves the fish's body from side-to-side and through the water. The 'effort' or power to propel the fish through the water is provided by its muscle tissue, which makes up about 80% of the entire fish.

Photo: Ross Marriott

Floating sharks

Cartilaginous fish, like sharks and rays, do not have swim bladders to give them buoyancy. This is not so much of a problem for rays and demersal sharks – they mostly rest on the sea floor. However, those sharks that are fast moving, open water feeders need to be able to stay afloat in the water column.

The side or 'pectoral' fins of a shark help them achieve lift in the water, as if they were flying. However, as a shark increases in size, its pectoral fins would need to grow proportionally larger to maintain the same amount of lift to keep it afloat.

To gain the extra buoyancy that it needs, larger sharks have a liver more than twice the size of a smaller shark of the same species. The liver contains oils and hydrocarbons (chemicals similar to those found in petroleum products) that are lighter in weight than the shark and the surrounding water. This gives the shark the extra buoyancy that it needs.

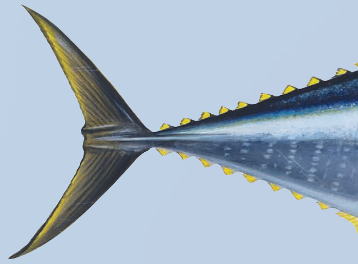
Large sharks, such as the basking shark, can have a liver that makes up 20-25% of its body weight.

It is estimated that a healthy 4 m tiger shark could have as much as 82 L of oil in its liver.

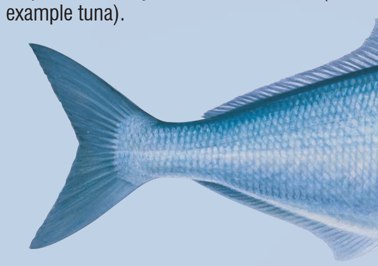
A tail of physics

The tail or 'caudal' fin is connected with the speed and strength of a fish's forward movement and its shape plays an important part.

Continuous tail: Swims at slow speed but highly manoeuvrable, enabling access into crevices and caves (for example cobbler).



Lunate tail: Very fast fish, able to maintain high speeds for long periods of time, but a lack of surface area means they can't stop or turn easily or swim backwards (for example tuna).



Forked tail: Cruising fish that swim continuously at very fast rate (for example tailor and Australian herring). Extra fin surface provides more manoeuvrability than fish with a lunate tail.

Truncate tail: Cruises at intermediate speeds, with increased manoeuvrability due to even larger surface area (for example mangrove jack). Also able to accelerate quickly when needed.

Rounded tail: Swims at intermediate speeds, with greater manoeuvrability, and able to accelerate quickly for short periods (for example Chinaman cod).

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