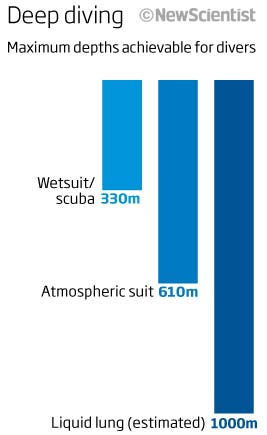
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**Divers could breathe deep with liquid-filled lungs**



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*Inhaling oxygen-rich liquid would allow divers to explore deeper into the ocean than ever before, and even eliminate decompression sickness*

YOU step into your diving suit and pull a helmet over your head. The helmet immediately starts to fill with liquid, but you don’t panic, you simply begin breathing in the fluid as you would air.

No, this is not a scene from the movie *The Abyss* (pictured), but the brainchild of inventor Arnold Lande, a retired heart and lung surgeon formerly based at the University of Texas Medical School at Houston.

While some researchers work on ways to keep divers under for longer [(see “How to spin seawater into air”)](https://www.newscientist.com/article/mg20827865-900-divers-could-breathe-deep-with-liquid-filled-lungs/#bx278659B1), Lande has designed a liquid breathing system that he claims will allow people to dive to great depths without the risk of decompression sickness, otherwise known as the bends. It is caused when inert gases like nitrogen and helium in the air mixture divers breathe dissolve into their blood, particularly under the terrific pressures of the deep ocean. If a diver resurfaces too quickly, these gases can bubble into body tissues like the bubbles that form as a soda bottle is uncapped, causing terrible joint pain, seizures and paralysis.

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Breathing an oxygen-carrying liquid would dispense with the need for inert gases like nitrogen, says Lande, and so [eliminate the threat of the bends](https://www.newscientist.com/article/mg18925331-300-breathing-in-oceans-full-of-air).

The idea to use liquid breathing for deep diving was first investigated in the 1960s. Alveoli in the lungs can exchange oxygen from a fluid if the gas is mobile enough in solution. But the human body isn’t up to the task of heaving a liquid in and out fast enough to inhale sufficient oxygen and exhale enough carbon dioxide, so the idea was dropped.

In a paper presented last month at the first International Conference on Applied Bionics and Biomechanics in Venice, Italy, [Lande proposed a way around this problem](http://www.icabb-iss.org/). He has designed a system in which the diver breathes in an oxygen-carrying liquid called perfluorocarbon, contained in a diving helmet.

To help their lungs push the liquid in and out, the diver would wear a cuirass ventilation device fitted around their chest. These devices, named after the armour worn by medieval soldiers, wrap around the upper body and are attached to a pump that exerts or removes pressure on the chest to help the lungs inhale and exhale. “This would provide the assistance to the diver’s breathing that he needs while he is working hard, having to pull a liquid into his lungs and expel it again,” says Lande.

Gaseous oxygen would be bubbled into the liquid in the helmet to keep it topped up. The helmet would not help with the removal of CO2, though. The system gets rid of this gas directly from the blood through an artificial gill fitted to the suit, in the form of a gas-permeable membrane. A catheter inserted into the femoral vein in the groin takes the blood out of the body to be filtered through the membrane. Heart and lung machines use a similar system, called a membrane oxygenator. For divers, the CO2 would be absorbed by a material such as soda lime, and the treated blood would re-enter the body.

Could divers tolerate breathing in a liquid? The powerful human gag reflex would normally cause them to cough it straight back up. But Lande says that can be overcome with training and, if necessary, a drug to dull the sensation of liquid pouring down the windpipe. “Once they were breathing the liquid in, I don’t think they would have much of a problem with it,” he says. “The alternative is putting a tube down their throat, which carries the risk of infection.”

“Once they were breathing the liquid in, divers would not have much of a problem with it”

To keep the diving suit topped up with power and oxygen, Lande envisions a small propeller-driven, torpedo-like auxiliary vehicle that the diver would take along with them, to carry the necessary battery pack and oxygen tanks.

The idea is perfectly feasible and has been demonstrated extensively in other mammals, says [Thomas Shaffer](http://www.bio.udel.edu/people/thomas-shaffer.php) of the Nemours/Alfred I. duPont Hospital for Children in Wilmington, Delaware, who has investigated liquid ventilation since the 1970s. “A number of us put a perfluorochemical into animals’ lungs and sent them to very great depths – over 300 metres – and then decompressed them in less than 1 second,” he says. “Normally that would mean instant death for a mammal, but with the perfluorochemical, it wasn’t a problem.”

There have long been unconfirmed rumours that the US navy experimented with liquid breathing for divers in the 1980s, says Shaffer, who in 1989 was running trials using liquid ventilation to treat premature babies and adults in respiratory distress. While undertaking these trials, he worked with a doctor who claimed to have previously been a Navy Seal involved in these experiments. “His story seemed credible, but he refused to talk publicly about it,” says Shaffer.

According to this source, the technology worked, but some divers developed stress fractures of the ribs from the huge effort required to breathe liquid without the help of any assistive device.

Another, far more serious, danger would be from divers panicking and vomiting into their breathing liquid, says Shaffer. “If you were to get sick in the fluid and aspirate it, you would have a lot of problems.”

This could be overcome by putting a one-way valve in the system that would prevent any unwanted fluids from entering the lungs. If successful, this technology could allow divers to go as deep as 1000 metres below the surface to respond to deep-sea disasters [(see graph)](https://d1o50x50snmhul.cloudfront.net/wp-content/uploads/2010/11/27865901.jpg). Though the blowout of the Deepwater Horizon oil rig in the Gulf of Mexico occurred at a depth of 1500 metres – too deep for the system to be effective – it could be useful for similar emergencies. Indeed, Shaffer himself was approached by a member of the Russian navy and asked for advice when the Kursk nuclear-powered submarine sank in 2000, but there was not enough time to put a device together to allow divers go down to the wreck, he says.

**How to spin seawater into air**

Israeli inventor Alan Bodner [has developed a prototype device](http://www.likeafish.biz/) to extract air from seawater by lowering its pressure. This causes any gas dissolved in the water to bubble out – just like opening a carbonated drinks bottle. The air can then be captured and pumped into an underwater habitat or used by a diver.

Bodner first unveiled the concept back in 2005 but has now developed a proof-of-concept model. The battery-powered system, about the size of a briefcase, can process 200 litres of seawater per minute. The device uses a centrifugal pump to lower the water pressure, and the air bubbling out is then sucked up by a vacuum pump and piped into a container.

When combined with gas exhaled by a diver, this would be enough to provide them with the litre of oxygen per minute that they need, says Bodner. The system could be attached to a torpedo-style auxiliary rig which a diver could take into the depths with them.

To remove carbon dioxide from exhaled air, Bodner is now developing a system in which the stale air is “scrubbed” of CO2 by mixing it with seawater. The air is pumped into a mixing chamber and seawater is then sprayed in. The droplets cling to and exchange gases with the air molecules, reducing the CO2 in the air, which is then separated from the water and re-circulated back into the breathing apparatus. “This method, combined with my system that can supply oxygen from the water, provides a complete solution for breathing underwater,” says Bodner.