

DIVING, UNDERWATER. With the oceans comprising more than 70 percent of the Earth's surface, it is no wonder that human beings have been curious about the undersea realm since the beginnings of history. Plato and Aristotle wondered about deep-sea life and speculated about going underwater. Roger Bacon, a 13th-century English friar, wrote about the possibility of submarine operations. Leonardo da Vinci designed a diving helmet of leather. It had spikes to protect the diver from monsters, and a breathing tube stretched from the helmet to the surface with a cork float. (*See also* Deep-Sea Life.)

In 1716 the English astronomer and mathematician Edmund Halley, who discovered Halley's Comet, invented two types of diving bells. One was made of wood and looked like an upside-down wastebasket with eyes. The two "eyes" were not to see out of but to let light in. Air was provided by two 36-gallon (136-liter) barrels that alternated from surface to bottom with cargoes of fresh air, and a flexible tube transferred the air from the barrel to the bell and the diver inside.

Halley's second diving bell was made of lead. It was 8 feet (2.5 meters) in height, 3 feet (1 meter) in diameter at the top, and 5 feet (1.5 meters) at the bottom. There was a seat inside for several divers, and the air-supply system was essentially the same as for the first bell. Halley and four other daring divers reportedly stayed at 10 fathoms (60 feet, or 18 meters) for an hour and a half in the lead bell. Their only problem, he reported, was a pain in the ears "as if a quill had been thrust into them." In those days they did not understand the problems of increased pressure and depth.

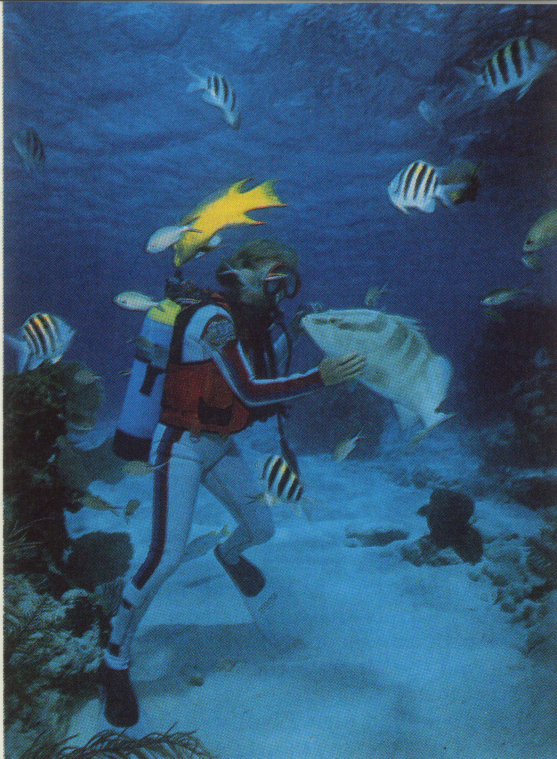
Development of Scuba

Modern exploration of the undersea world had its beginnings in June 1943, when Jacques Cousteau made his first dive with a revolutionary breathing device he had developed with Émile Gagnan, a French engineer. Captain Cousteau, then a French Navy gunnery officer, had not been satisfied with the superficial probing of the ocean surface. It was not enough that humans could stay underwater and look only as long as they could hold their breath.

Gagnan had designed a gas-flow demand regulator for use on automobiles and in hospital operating rooms during World War II. Cousteau thought that the invention could be modified for use underwater. The two tried several concepts and finally came up with a successful model of an open-circuit, compressed air scuba (Self-Contained Underwater Breathing Apparatus). (*See also* Cousteau.)

Not only did Cousteau realize his own dream of "flying" underwater like a fish, but he also enabled many others to peer into the ocean and study its

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Dave Woodward—CLICK/Chicago

A scuba diver explores a shallow portion of the ocean floor while being investigated by curious fishes.

innermost secrets. Today thousands of scuba divers explore reefs in every ocean of the world, studying marine life and exploring shipwrecks. Divers have explored the frigid waters of the North Pole, and they have cruised the steep drop-offs of tropical subsea canyons in the Caribbean.

Learning Process

For most people, learning how to dive is not difficult. The first step is often snorkeling, or so-called free diving. The only equipment required for snorkeling is a face mask and a snorkel. The snorkeler swims along the surface of the water, looking at the underwater scenery through the face mask while breathing through the snorkel. Most snorkelers also wear rubber or plastic fins on their feet to make swimming as effortless as possible. For a closer look at the reef below, the diver holds his breath and dives down. Breathhold diving, as this is called, is a safe, enjoyable pastime as long as the diver guards against excessive hyperventilation, or rapid breathing, on the surface before a dive. This can result in an excessive buildup of carbon dioxide and cause what is called shallow-water blackout.

When a diver decides to explore deeper ocean areas, it is necessary to enroll in a certified scuba training course. Here the diver first learns how to handle the equipment: Along with the mask, fins, and snorkel used in free diving, the scuba diver uses a scuba tank, regulator, pressure and depth gauges, weight-belt, and buoyancy compensator (BC)—essentially an inflatable lifejacket that serves as a safety device and helps a diver to regulate buoyancy underwater.

A diver's early training also includes how to deal with the two major physiological problems associated with diving: air embolism and bends. Both problems are caused by the increase in pressure that occurs as a diver goes deeper. The pressure of the atmosphere at sea level is 14.7 pounds per square inch (1.03 kilograms per square centimeter). This pressure is termed 1 atmosphere. Every foot of sea water contributes 0.445 pounds per square inch (0.3 kilogram per square centimeter) of pressure on the diver. The result is that at 33 feet (10 meters) the pressure doubles. At 66 feet (20 meters) it is again increased by 1 atmosphere.

A diver equalizes for these pressure changes: on the way down, most notably by clearing the ears; on the way up, breathing must be normal—never holding one's breath—because the air in the lungs will expand. Pressure decreases on the way up in the same ratio as the increase on the way down. If a diver takes a deep breath at 33 feet (10 meters), holds it, and rises to the surface, the air in the lungs will expand to twice its original volume and the diver will suffer what is called an air embolism.

Air embolism occurs when the lungs overexpand to the point that air bubbles are forced through the lungs into the circulatory system. The bubbles can become lodged in the heart, the arteries, or the brain. The symptoms of air embolism appear within minutes—even seconds—after surfacing. There can be dizziness, confusion, weakness, blurred vision, convulsions, and even death.

Bends, also known as decompression sickness and caisson disease, also results from differences in underwater pressure. Because of the increased pressure under water, the nitrogen in the compressed air that is breathed is absorbed by the fluids and tissues of the diver's body. If a diver who has been in deep water comes up properly, as pressure is reduced, the nitrogen is released from the fluids and tissues, passes through the veins, is freed in the lungs and is breathed out.

The key to coming up properly is time. The United States Navy developed dive, or decompression, tables to indicate the amount of time it takes for nitrogen to dissolve from the diver's bloodstream. Divers overextending their stay in deep water must make stops on their way back to the surface to allow these nitrogen bubbles to dissolve. If a diver comes up too rapidly, it causes bends: The bubbles can go into the bloodstream and lodge in the brain, lungs, or spinal cord. In minor cases the bubbles can cause itchy skin and stiff joints; in more extreme cases there can be pain, partial or total paralysis, and death.

Most divers learn the time and depths to which they can go without requiring decompression—called no-decompression diving—and stay within those limits. A diver can stay at 30 feet (9 meters) indefinitely, but can stay at 130 feet (40 meters) for only 10 minutes without decompressing on the way up.

Depths greater than 130 feet are not recommended for recreational diving. At about 100 feet (30 meters),

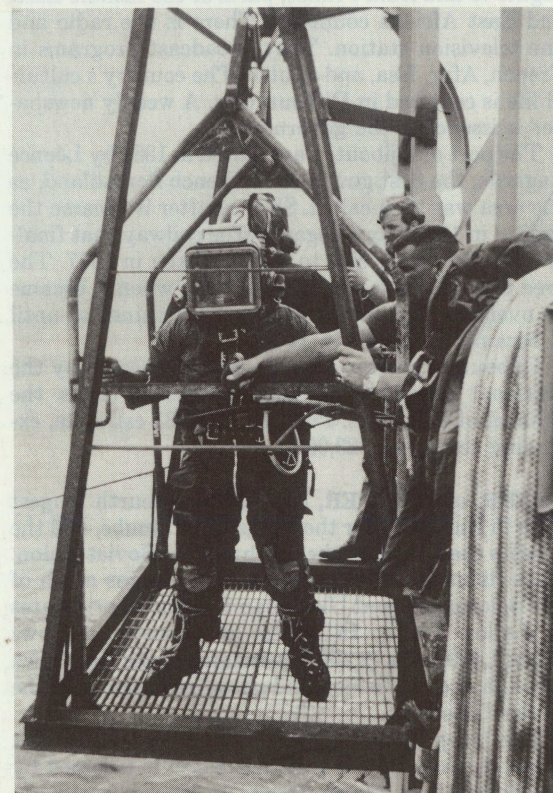
and sometimes shallower, nitrogen affects the diver's nervous system with results similar to intoxication. This is called nitrogen narcosis. It does not happen suddenly but increases by degrees with increasing depth. It is not a permanent or traumatic condition, but it is known to impair judgment seriously. At 130 feet it can be very noticeable, another reason 130 feet has been established as a maximum depth for sport diving.

Commercial Diving

Commercial diving technology has made significant strides in ushering in the age of undersea exploration. Commercial operations have extended into deeper and deeper waters because of the needs of the offshore petroleum industry. After an oil platform is placed offshore, the subsea support structure must be maintained, serviced, and inspected by divers.

Until the 1960s divers went only to depths above 300 feet (90 meters). In these depths diving practices have remained the same. Divers descend from the surface breathing mixed gas, rather than compressed air, to prevent the nitrogen narcosis problem. They wear either hard hats—brass and copper helmets with glass portholes—or band masks—plasticized helmets with built-in faceplates. Both systems are tied to the surface by hoses that supply both breathing gases and communication lines that allow the

A navy diver is readied to be lowered into the water on a platform in a procedure for testing diving equipment.



Courtesy US Navy

diver to talk with the surface support team. The gas mixture is generally a helium-oxygen mixture called heliox, the helium replacing nitrogen. Helium, however, produces a high, squeaky "Donald Duck" voice in the diver, and sometimes communication can be nearly impossible because of it.

Heliox also is often used in submersible chambers, in which divers rest between dives during their underwater work periods. The chambers also serve for decompressing, or being brought back to surface pressure, at the end of a job. The problem with this type of procedure is the length of decompression. A diver working at 900 feet (275 meters) for six hours, for example, must decompress for nine days.

In 1974 a United States diving company, Ocean-eering International, introduced a revolutionary armored diving suit called Jim. It had been developed over many years by a British company and named after Jim Jarratt, who had explored the wreck of the *Lusitania* in the 1930s in a preliminary model of the suit. Jim is a one-person submersible device that is essentially a pressurized suit of armor that lets a diver work at depths of up to 2,000 feet (600 meters) while remaining at surface pressure. Because the diver is never subjected to the pressure of the depths, there is never a need to undergo decompression. The first Jim dives were to 905 feet (275 meters) in the Canadian Arctic, and the diver was able to surface in minutes instead of decompressing for the usual nine days.

This introduced a sort of technological wizardry into the ocean arena, and today the bottom of the sea in busy petroleum locations looks like a subsea Cape Canaveral. Included in this inner-space fleet are the Mantis and Wasp that look like the insects they are named for and take divers to 2,000 feet (600 meters). Wasp, with its yellow body and acrylic dome head, allows a diver to hover mid-water because it has thrusters in the place of feet. In 1982 marine scientists from the University of California at Santa Barbara used the Wasp to explore deep areas off Santa Barbara. Other 1-atmosphere diving systems, including one called Deep Rover, have been developed that allow a diver to go to 3,000 feet (900 meters). Eventually 7,000 feet (2,100 meters) will be a common depth in which divers and scientists can work and study.

How much deeper will human beings want to go? The average depth of the Pacific Ocean is 13,739 feet (4,188 meters), and the average depth of the Atlantic, 12,257 feet (3,736 meters). There is much unexplored territory, and with advanced submersibles humans may eventually see large portions of it.

There is more down there than petroleum. There are manganese nodules loaded with valuable copper, cobalt, and nickel, and many believe there is twice as much gold in the sea as on land. There are long-lost wrecks, as well as uncharted ridges, to be mapped by future explorers. But the ultimate lure for deep diving is the quest for knowledge.

DIVORCE see MARRIAGE.