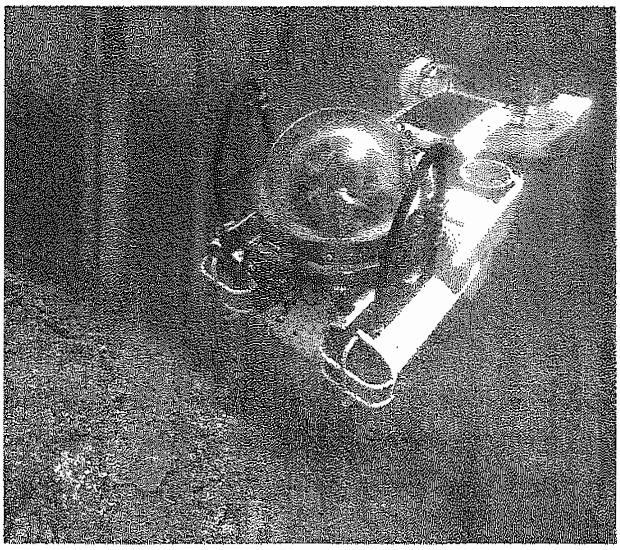
*You should spend about 20 minutes on **Questions 27–40**, which are based on Reading Passage 3 below.*



The Deep Sea

At a time when most think of outer space as the final frontier, we must remember that a great deal of unfinished business remains here on earth. Robots crawl on the surface of Mars, and spacecraft exit our solar system, but most of our own planet has still never been seen by human eyes. It seems ironic that we know more about impact craters on the far side of the moon than about the longest and largest mountain range on earth. It is amazing that human beings crossed a quarter of a million miles of space to visit our nearest celestial neighbor before penetrating just two miles deep into the earth's own waters to explore the Midocean Ridge. And it would be hard to imagine a more significant part of our planet to investigate – a chain of volcanic mountains 42,000 miles long where most of the earth's solid surface was born, and where vast volcanoes continue to create new submarine landscapes.

The figure we so often see quoted – 71% of the earth's surface – understates the oceans' importance. If you consider instead three-dimensional volumes, the land-dwellers' share of the planet shrinks even more toward insignificance: less than 1% of the total. Most of the oceans' enormous volume, lies deep below the familiar surface. The upper sunlit layer, by one estimate, contains only 2 or 3% of the total space available to life. The other 97% of the earth's biosphere lies deep beneath the water's surface, where sunlight never penetrates.

Until recently, it was impossible to study the deep ocean directly. By the sixteenth century, diving bells allowed people to stay underwater for a short time: they could swim to the bell to breathe air trapped underneath it rather than return all the way to the surface. Later, other devices, including pressurized or armored suits, heavy metal helmets, and compressed air supplied through hoses from the surface, allowed at least one diver to reach 500 feet or so.

It was 1930 when a biologist named William Beebe and his engineering colleague Otis Barton sealed themselves into a new kind of diving craft, an invention that finally allowed humans to penetrate beyond the shallow sunlit layer of the sea and the history of deep-sea exploration began. Science then was largely incidental – something that happened along the way. In terms of technical ingenuity and human bravery, this part of the story is every bit as amazing as the history of early aviation. Yet many of these individuals, and the deep-diving vehicles that they built and tested, are not well known.

It was not until the 1970s that deep-diving manned submersibles were able to reach the Midocean Ridge and begin making major contributions to a wide range of scientific questions. A burst of discoveries followed in short order. Several of these profoundly changed whole fields of science, and their implications are still not fully understood. For example, biologists may now be seeing – in the strange communities of microbes and animals that live around deep volcanic vents – clues to the origin of life on earth. No one even knew that these communities existed before explorers began diving to the bottom in submersibles.

Entering the deep, black abyss presents unique challenges for which humans must carefully prepare if they wish to survive. It is an unforgiving environment, both harsh and strangely beautiful, that few who have not experienced it firsthand can fully appreciate. Even the most powerful searchlights penetrate only tens of feet. Suspended particles scatter the light and water itself is far less transparent than air; it absorbs and scatters light. The ocean also swallows other types of electromagnetic radiation, including radio signals. That is why many deep sea vehicles dangle from tethers. Inside those tethers, copper wires or fiber optic strands transmit signals that would dissipate and die if broadcast into open water.

Another challenge is that the temperature near the bottom in very deep water typically hovers just four degrees above freezing, and submersibles rarely have much insulation. Since water absorbs heat more quickly than air, the cold down below seems to penetrate a diving capsule far more quickly than it would penetrate, say, a control van up above, on the deck of the mother ship.

And finally, the abyss clamps down with crushing pressure on anything that enters it. This force is like air pressure on land, except that water is much heavier than air. At sea level on land, we don't even notice 1 atmosphere of pressure, about 15 pounds per square inch, the weight of the earth's blanket of air. In the deepest part of the ocean, nearly seven miles down, it's about 1,200 atmospheres, 18,000 pounds per square inch. A square-inch column of lead would crush down on your body with equal force if it were 3,600 feet tall.

Fish that live in the deep don't feel the pressure, because they are filled with water from their own environment. It has already been compressed by abyssal pressure as much as water can be (which is not much). A diving craft, however, is a hollow chamber, rudely displacing the water around it. That chamber must withstand the full brunt of deep-sea pressure – thousands of pounds per square inch. If seawater with that much pressure behind it ever finds a way to break inside, it explodes through the hole with laserlike intensity.

It was into such a terrifying environment that the first twentieth-century explorers ventured.