LIVING DOWN DEEP

THE DEEP-SEA ENVIRONMENT APPEARS INHOSPITABLE—cold, dark, and with little food. However, it is remarkably stable: temperatures remain between 35 and 39°F (2 and 4°C) year-round, salinity is constant, and the perpetual darkness is overcome by novel communication methods (see pp.228–29). Although deep-sea pressures are immense, most marine animals are unaffected, since they have no air spaces, while animals living below about 5,000 ft (1,500 m) show subtle adaptations. Species diversity of large animals decreases with depth, but there is a huge diversity of small organisms living within deep-sea sediments.

DEEP-SEA ADAPTATIONS
Anglerfish have a lightweight skeleton and muscles for neutral buoyancy. This specimen's muscles have been "cleared" to show the bone, which is stained red.

PRESSURE PROBLEMS

Deep-ocean animals experience huge pressures, but problems arise only in gas-filled organs such as the lungs of diving mammals and the swim bladders of fish. Sperm whales, Weddell seals, and elephant seals all dive to depths where their lungs are compressed, but their flexible rib cages allow this. While underwater, they use oxygen stored in blood and muscles. Deep-sea fish can cover a large vertical range because pressure changes at depth are proportionately less, per foot, than near the surface, so the pressure or size of their swim bladders does not change radically. In oceanic trenches, the pressure is so great that it affects the operation of biological molecules, such as proteins. Pressure-loving bacteria in this habitat have specialized proteins—they cannot grow or reproduce when brought to the surface.

SPERM WHALE
Sperm whales can dive to at least 3,300 ft (1,000 m), where the pressure is 100 times greater than at the surface.

OCEAN LIFE

FINDING FOOD

The major problem of deep-sea living is finding enough food. With the exception of communities based around hydrothermal vents and cold seeps (see pp.188–89), animals living in the deep ocean and on the deep-ocean floor are ultimately reliant on food production in the sunlit layer, thousands of feet above. In the depths, it is too dark for plant plankton to live and to provide food. Sometimes, large mammal or fish carcasses reach the sea bed, but most food arrives as tiny food fragments, slowly sinking from above. Much is eaten before it reaches the sea floor, but much is also added in the form of skins, shed from mid-water crustaceans and salps. Bacteria grow on such material, helping it to clump together and so fall more rapidly.

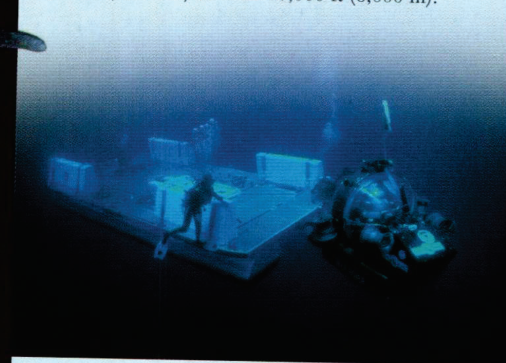
MIDWATER FEEDER
The fangtooth lives at midwater depths of about 1,600–6,500 ft (500–2,000 m). Food is scarce, so its large mouth and sharp teeth help it to catch all available prey.

SEABED CONSUMER
Sea cucumbers vacuum up organic remains from the sea floor. At high latitudes, more food rains down in spring, following surface phytoplankton blooms; these rains may trigger sea cucumbers to reproduce.

DISCOVERY

OBSERVING DEEP-SEA LIFE

Before the advent of modern research submersibles, few biologists had the opportunity to see deep-sea animals alive and in the wild. Dredged and netted specimens are often damaged, and little can be learned from them about the animal's way of life. Modern submersibles have an excellent field of view, are equipped with sophisticated cameras and collecting equipment, and can operate to depths of 3,300 ft (1,000 m) or even 20,000 ft (6,000 m).



A WINDOW ON DEEP-SEA LIFE
Deep Rover is a two-person submersible capable of diving to 3,300 ft (1,000 m), launched from a semi-submersible platform. The occupants can see all the way around through the acrylic hull.

SCAVENGING GIANTS

Many deep-sea animals are smaller than their relatives in shallow water. This is an evolutionary response to the difficulties of finding food in the deep ocean. However, some scavengers survive by growing much larger than their shallow-water counterparts. For example, amphipod and isopod crustaceans that measure only about ½ in (1 cm) long are common in shallow water, where they scavenge on rotting seaweed and other debris. Carrion in the deep sea is sparse, but it comes in big, tough lumps such as whale carcasses. Some deep-sea amphipods grow to a length of 4–6 in (10–15 cm), more than ten times larger than shallow-water species, and so are able to tackle such a bonanza. In the low temperature of the deep ocean, these animals move and grow slowly and reproduce infrequently, but live much longer than their shallow-water counterparts. Sea urchins, hydroids, seapens, and other animals also have giant deep-sea forms. Similar giants are found in cold Antarctic waters.

DEEP-SEA GIANT
The widespread deep-sea scavenger amphipod *Eurythenes* grows to over 3 in (8 cm).

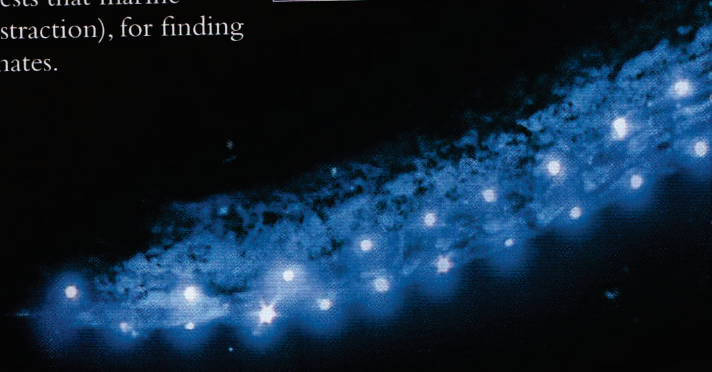
STAYING ALOFT

Huge areas of the deep-sea floor are covered in soft sediments many yards thick, called oozes (see p.181). Seabed animals need ways of staying above these sediments so that they can feed and breathe effectively. Many sedentary filter-feeding animals, such as sea lilies, sea pens, and some sponges, have long stalks, enabling them to keep their feeding structures above the sediment. Some sea cucumbers have developed stiltlike tube feet that help them walk over the sediment surface, instead of having to plow through it. Similarly, the tripodfish props itself up on its fin tips. One species of sea cucumber, *Paelopatides grisea,* has an unusually flattened shape that allows it to lift itself off the sea bed with slow undulations of its body.

SEA LILIES ANCHORED IN THE OOZE
To catch food, sea lilies reach up into the current on stalks up to 60cm (2ft) high. The stalk extends deep into the sediment to provide an anchor.

BIOLUMINESCENCE

BIOLUMINESCENCE IS A COLD LIGHT produced by living organisms. On land, only a few nocturnal animals, such as fireflies, produce light, but in the ocean, thousands of species do so. Deep-water fish and squid use bioluminescence extensively, but there are many other light producers, such as species of bacteria, dinoflagellates, sea pens, jellyfish, mollusks, crustaceans, and echinoderms. Evidence suggests that marine organisms use bioluminescence for defense (as camouflage or distraction), for finding and luring prey, and for recognizing and signaling to potential mates.

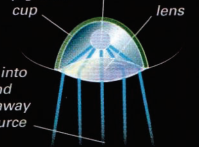


USING LIGHT TO COMMUNICATE
Many bioluminescent marine organisms use their light in communication. This bristlemouth fish can signal to its own kind with its specific photophore pattern.

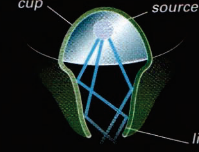
LIGHT PRODUCTION

Bioluminescence is produced by a chemical reaction in special cells known as photocytes, usually contained within light organs called photophores. A light-producing compound called luciferin is oxidized with the help of an enzyme called luciferase, releasing energy in the form of a cold light. Most bioluminescent light is blue-green, but some animals can produce green, yellow, or, more rarely, red light.

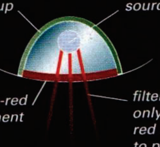
A range of light-producing structures is found in different animals. The hydroid *Obelia* has single photocytes scattered in its tissues, while certain fish and squid have complex photophores with lenses and filters. Some animals, including flashlight and eyelight fish, some anglerfish, ponyfish, and some squid, adopt a different strategy. They culture symbiotic, bioluminescent bacteria in special organs. The bacteria produce their light and are, in return, fed nutrients by their host and given a safe place in which to live.



LENS

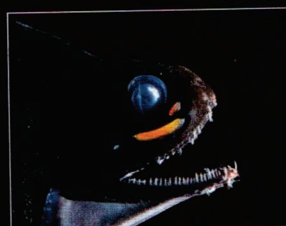


LIGHT PIPE



COLOR FILTER

PHOTOPHORE TYPES
Photophores often feature a pigment cup and a lens that directs the light into a parallel beam. With a light pipe, light can be channeled from the photophore, which might be buried in the animal's body. Color filters in front of the light source fine-tune the color of the emitted light.

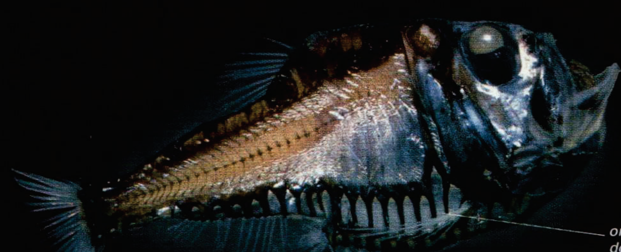


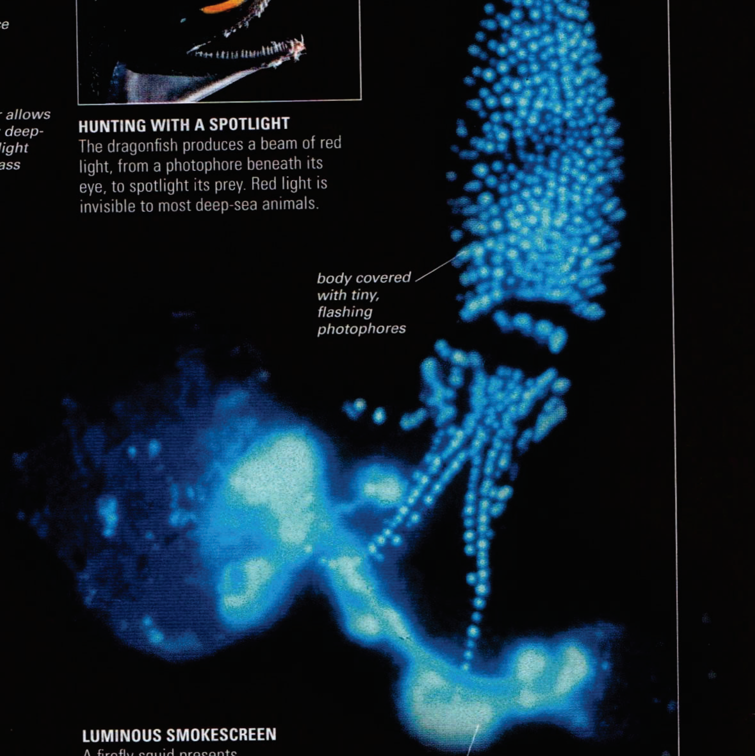
HUNTING WITH A SPOTLIGHT
The dragonfish produces a beam of red light, from a photophore beneath its eye, to spotlight its prey. Red light is invisible to most deep-sea animals.

LIGHT DISGUISE

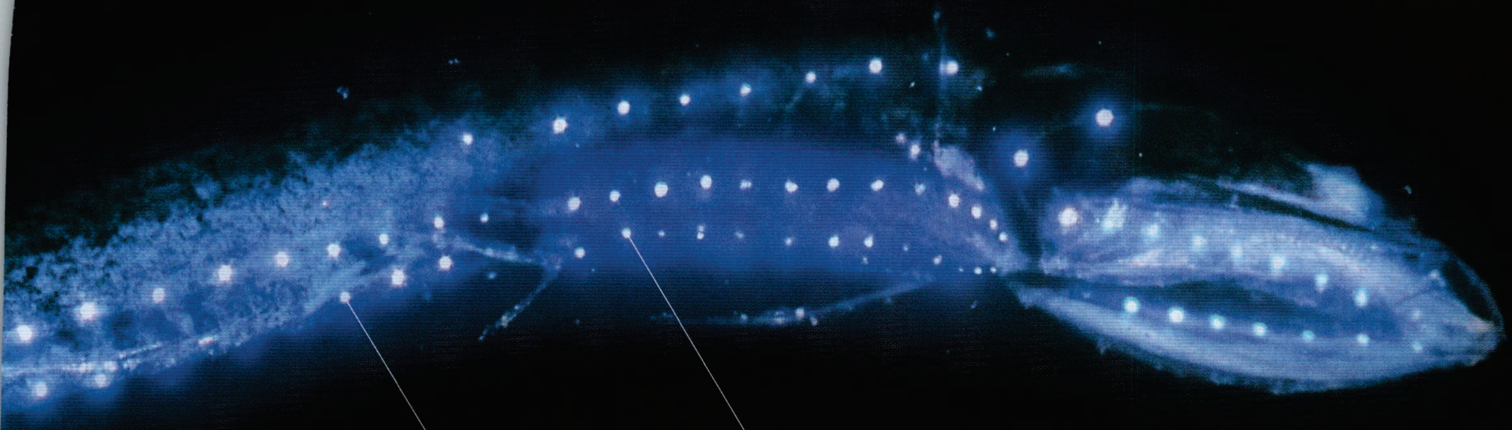
Animals using bioluminescence to attract prey, or to signal to each other, risk alerting their own predators to their presence. However, lights can also be used for camouflage. Hatchetfish live at depths where some surface light is still dimly visible. To keep their silhouette from being seen from below, they manipulate the light they emit from photophores along their belly, to mimic the intensity and direction of the light coming from above. Bioluminescence is also used to confuse potential predators. Flashlight fish turn their cheek lights on and off. Some squid, shrimp, and worms eject luminous secretions or break off luminous body parts that act as decoys, while they escape.

MANIPULATING LIGHT
The silvery, vertical flanks of hatchetfish reflect downwelling light, and their photophores shine downward, camouflaging their silhouette from below.





LUMINOUS SMOKESCREEN
A firefly squid presents a predator with a myriad of confusing pinprick lights emitted from its body. It can also secrete a cloud of luminous particles into the water to act as a smokescreen, allowing it to escape.



LUMINOUS LURE
Fish are attracted to the luminous lure of deep-sea anglerfish and are quickly snapped up. Most anglerfish are brown or black so that they do not light themselves up.

PREDATORS

In the unlit regions of the deep ocean, many hunters try to attract prey, rather than go in search of it. After all, hunting by sight and chasing prey is difficult where the only available light is from bioluminescence. An obvious way of attracting prey is to use a luminous lure, and anglerfish are especially good at this. Anglerfish in the genus *Linophryne* have a head lure, like a fishing rod, lit by luminous bacteria, and a chin barbel with tiny photophores that produce their own light. Midwater fish often have thin skeletons and weak muscles to improve their buoyancy, so luring prey is an energy-efficient way for them to hunt. *Stauroteuthis syrtensis,* an unusual deep-sea octopus with glowing suckers, sets a deadly trap. Its eight tentacles are connected into a web, and its modified suckers, which have lost the ability to grasp, are bioluminescent. Although this species has never been seen hunting, its prey (which are primarily copepods) is probably lured toward the raised, light-emitting arms, and then enfolded and eaten.

GLOWING JELLYFISH
The mauve stinger glows with bioluminescence when it is disturbed by waves, and can also produce a luminous mucus if it is touched.

PHOSPHORESCENCE

On a still, warm night, especially in the tropics, moving boats leave a glittering trail of light in their wake and divers can create swirling pinpricks of light by simply moving around. This phenomenon is caused by bioluminescent plankton, mostly dinoflagellates. Their light is often informally called phophorescence, because it is emitted when they are disturbed, but decays after a few seconds.

Biological phosphorescence is thought to be an anti-predation device. When dinoflagellates are attacked by planktonic copepods, they flash. This alerts nearby shrimp and fish to the copepods' presence, and the copepods themselves may then become prey. Some dinoflagellates, such as *Gonyaulax polyedra,* only produce light at night, so they do not waste energy on light production when it cannot be seen.

Deep-sea jellyfish may use a similar anti-predator strategy. The jellyfish light up only when disturbed by vibrations, which indicate an approaching predator. Often, a series of erratic flashes travels over the entire body surface. Such lights may serve to distract the predator.

BIOLUMINESCENT PLANKTON
Dinoflagellates are tiny, single-celled organisms that emit bright flashes of light when disturbed. In large numbers, they produce "phosphorescent" seas.