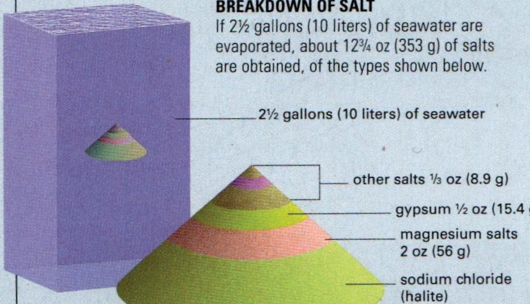
THE CHEMISTRY OF SEAWATER

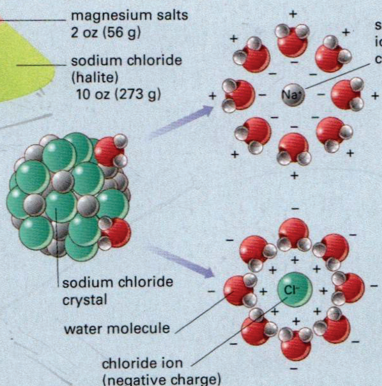
THE OCEANS CONTAIN MILLIONS OF DISSOLVED chemical substances. Most of these are present in exceedingly small concentrations. Those present in significant concentrations include sea salt, which is not a single substance but a mixture of charged particles called ions. Other constituents include gases such as oxygen and carbon dioxide. One reason the oceans contain so many dissolved substances is that water is an excellent solvent.

THE SALTY SEA

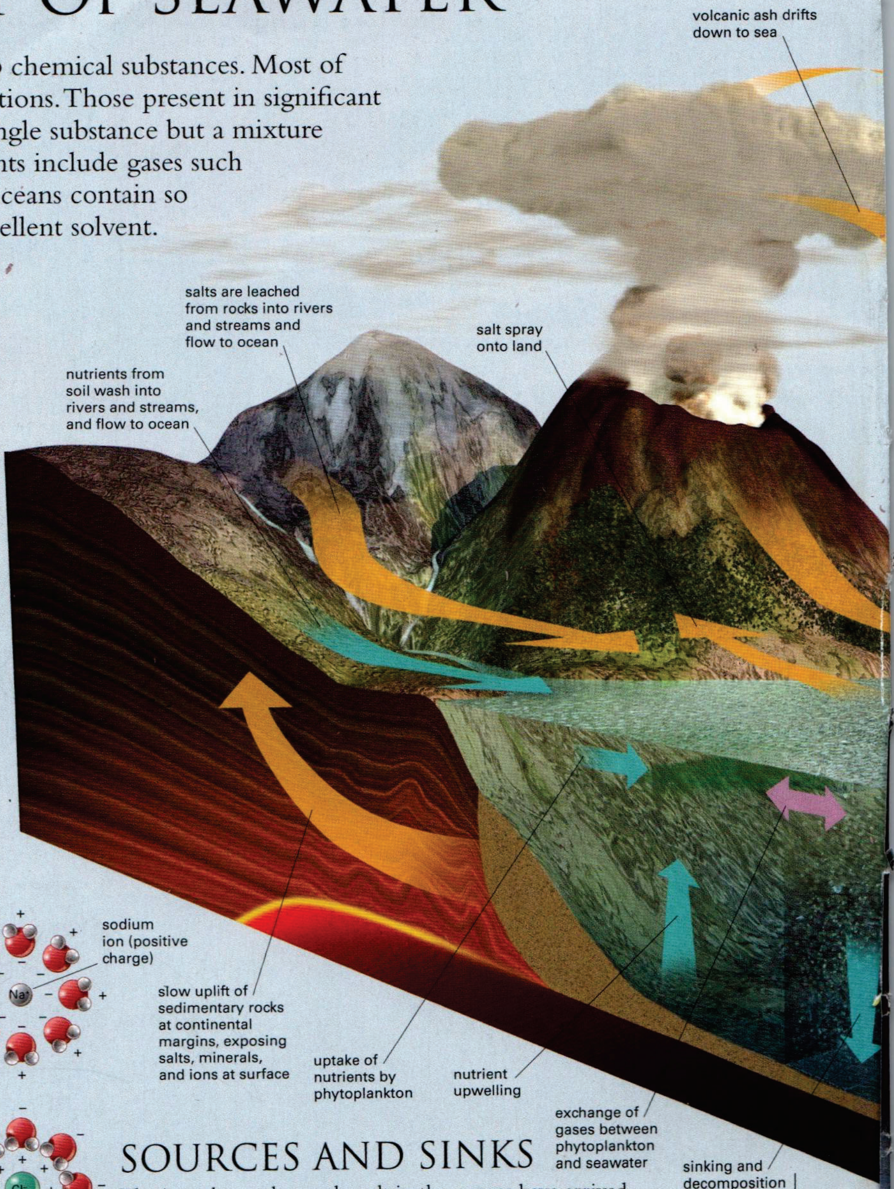
The salt in the oceans exists in the form of charged particles, called ions, some positively charged and some negatively charged. The most common of these are sodium and chloride ions, the components of ordinary table salt (sodium chloride). Together they make up about 85 percent by mass of all the salt in the sea. Nearly all the rest is made up of the next four most common ions, which are sulfate, magnesium, calcium, and potassium. All these ions, together with several others present in smaller quantities, exist throughout the oceans in fixed proportions. Each is distributed extremely uniformly—this is in contrast to some other dissolved substances in seawater, which are unevenly distributed.



BREAKDOWN OF SALT
If 2½ gallons (10 liters) of seawater are evaporated, about 12¾ oz (353 g) of salts are obtained, of the types shown below.



WATER AS A SOLVENT
The charge imbalance on its molecules makes water a good solvent. When dissolving and holding sodium chloride in solution, the positive ends of the molecules face the chloride ions and the negative ends face the sodium ions.



SOURCES AND SINKS

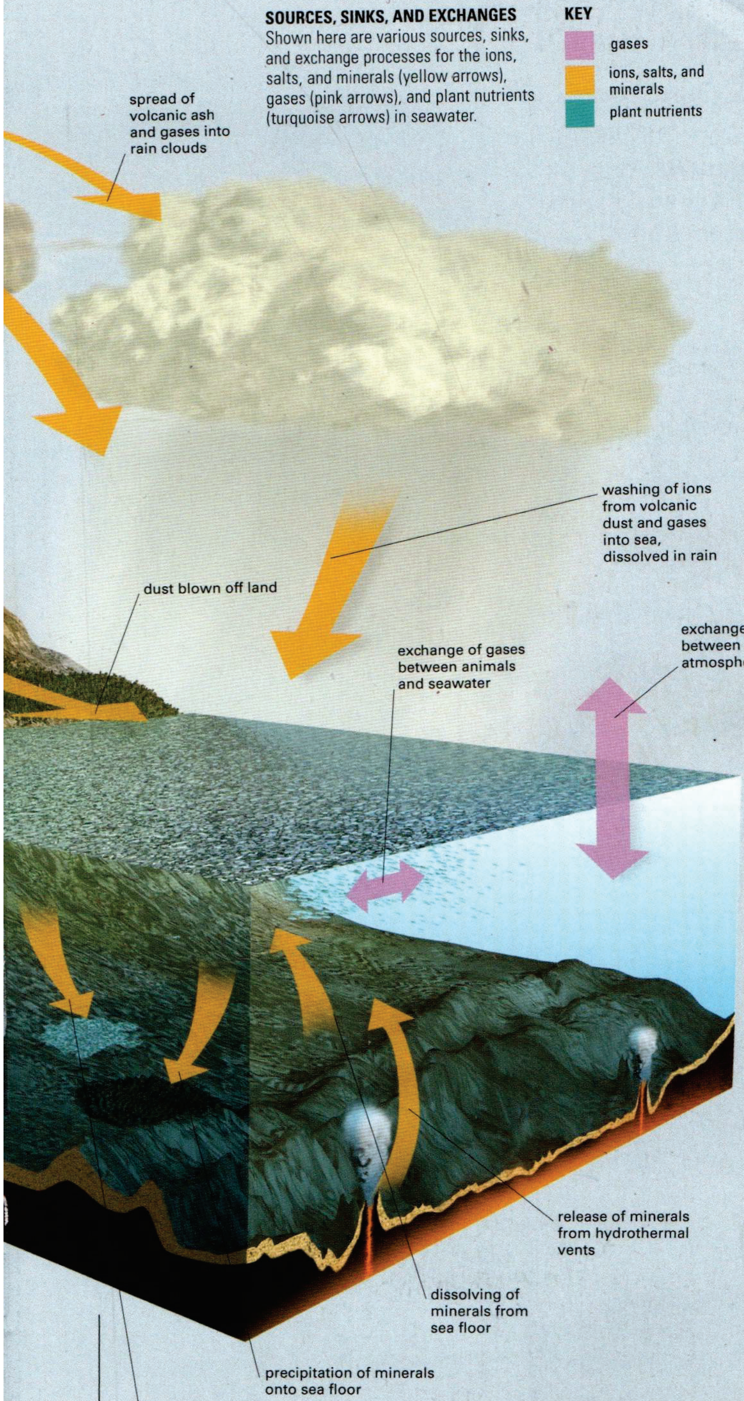
The ions that make up the salt in the oceans have arrived there through various processes. Some were dissolved out of rocks on land by the action of rainwater and carried to the sea in rivers. Others entered the sea in the emanations of hydrothermal vents (see p.188), in dust blown off the land, or came from volcanic ash. There are also "sinks" for every type of ion—processes that remove them from seawater. These range from salt spray onto land to the precipitation of various ions onto the seafloor as mineral deposits. Each type of ion has a characteristic residence time. This is the time that an ion remains in seawater before it is removed. The common ions in seawater have long residence times, ranging from a few hundred years to hundreds of millions of years.

RIVER DISCHARGE
River discharge is a mechanism by which ions of sea salt and nutrients enter the oceans. Here, the Noosa River empties into the sea on the coast of Queensland, Australia.

PEOPLE

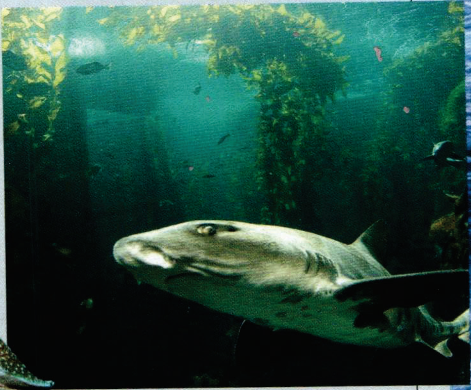
ALEXANDER MARCET

The Swiss chemist and doctor Alexander Marcet (1770–1822) carried out some of the earliest research in marine chemistry. He is best known for his discovery, in 1819, that all the main chemical ions in seawater (such as sodium, chloride, and magnesium ions) are present in exactly the same proportions throughout the world's oceans. The unchanging ratio between the ions holds true regardless of any variations in the salinity of water and is known today as the principle of constant proportions.



GASES IN SEAWATER

The main gases dissolved in seawater are nitrogen (N), oxygen (O_2), and carbon dioxide (CO_2). The levels of O_2 and CO_2 vary in response to the activities of photosynthesizing organisms (phytoplankton) and animals. The level of O_2 is generally highest near the surface, where the gas is absorbed from the air and also produced by photosynthesizers. Its concentration drops to a minimum at about 3,300 ft (1,000 m), where oxygen is consumed by bacterial oxidation of dead organic matter and by animals feeding on this matter. Deeper down, the O_2 level increases again. CO_2 levels are highest at depth and lowest at the surface, where the gas is taken up by photosynthesizers faster than it is produced by respiration.



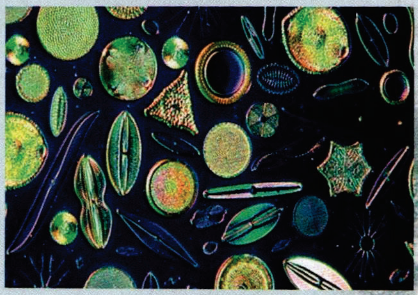
CARBON SINK
Many marine animals, such as nautiluses (below), use carbonate (a compound of carbon and oxygen) in seawater to make their shells. After they die, the shells may form sediments and eventually rocks.

OXYGEN PRODUCER AND CONSUMER
Oxygen levels in the upper ocean depend on the balance between its production by photosynthesizing organisms, such as kelp, and its consumption by animals, such as fish.

NUTRIENTS

Numerous substances present in small amounts in seawater are essential for marine organisms to grow. At the base of the oceanic food chain are phytoplankton—microscopic floating life-forms that obtain energy by photosynthesis. Phytoplankton need substances such as nitrates, iron, and phosphates in order to grow and multiply. If the supply of these nutrients dries up, their growth stops; conversely, blooms (rapid growth phases) occur if it increases. Although the sea receives some input of nutrients from sources such as rivers, the main supply comes from a continuous cycle within the ocean. As organisms die, they sink to the ocean floor, where their tissues decompose and release nutrients. Upwelling of seawater from the ocean floor (see p.60) recharges the surface waters with vital substances, where they are taken up by the phytoplankton, refueling the chain.

PLANKTON BLOOM
This satellite image of the Skagerrak (a strait linking the North and Baltic seas) shows a bloom of phytoplankton, visible as a turquoise discoloration in the water.



SILICEOUS DIATOMS
These tiny forms of planktonic organisms have cell walls made of silicate. They can only grow if there are sufficient amounts of silica present in the water.