government of a prohibitive duty on sulphur Muspratt found a substitute in iron pyrites, which was thus introduced as the raw material for the manufacture of sulphuric acid. He was always anxious to employ the best scientific advice available and to try every novelty that promised advantage. He was a close friend of Liebig, whose mineral manures were compounded at his works. He died at Seaforth Hall, near Liverpool, on the 4th of May 1886. After his retirement in 1857 his business was continued in the hands of four of his ten children.

His eldest son, JAMES SHERIDAN MUSPRATT (1821–1871), studied chemistry under Thomas Graham at Glasgow and London and under Liebig at Giessen, and in 1848 founded the Liverpool College of Chemistry, an institution for training chemists, of which he also acted as director. From 1854 to 1860 he was occupied in preparing a dictionary of *Chemistry . . . as applied and relating to the Arts and Manufactures*, which was translated into German and Russian, and he published a translation of Plattner's treatise on the blow-pipe in 1845, and *Outlines of Analysis* in 1849. His original work included a research on the sulphites (1845), and the preparation of toluidine and nitro-aniline in 1845–1846 with A. W. Hofmann.

MUSSCHENBROEK, PIETER VAN (1692–1761), Dutch natural philosopher, was born on the 14th of March 1692 at Leiden, where his father Johann Joosten van Musschenbroek (1660–1707) was a maker of physical apparatus. He studied at the university of his native city, where he was a pupil and friend of W. J. s'G. Gravesande. Graduating in 1715 with a dissertation, *De aëris praesentia in humoribus animalium*, Musschenbroek was appointed professor at Duisburg in 1719. In 1723 he was promoted to the chair of natural philosophy and mathematics at Utrecht. In 1731 he declined an invitation to Copenhagen, and was promoted in consequence to the chair of astronomy at Utrecht in 1732. The attempt of George II. of England in 1737 to attract him to the newly-established university of Göttingen was also unsuccessful. At length, however, the claims of his native city overcame his resolution to remain at Utrecht, and he accepted the mathematical chair at Leiden in 1739, where, declining all offers from abroad, he remained till his death on the 9th of September 1761.

His first important production was *Epitome elementorum physico-mathematicorum* (12mo, Leiden, 1726)—a work which was afterwards gradually altered as it passed through several editions, and which appeared at length (posthumously, ed. by Johann Lulofs, one of his colleagues as Leiden) in 1762, under the title of *Introductio ad philosophiam naturalem*. The *Physicae experimentales et geometricae dissertationes* (1729) threw new light on magnetism, capillary attraction, and the cohesion of bodies. A Latin edition with notes (1731) of the Italian work *Saggi di naturali esperienze fatte nell' Accademia del Cimento* contained among many other investigations a description of a new instrument, the pyrometer, which Musschenbroek had invented, and of several experiments which he had made on the expansion of bodies by heat. Musschenbroek was also the author of *Elementa physica* (8vo, 1729), and his name is associated with the invention of the Leyden jar (*q.v.*).

MUSSEL (O. Eng. *muscle*, Lat. *musculus*, diminutive of *mus*, mouse, applied to small sea fish and mussels), a term applied in England to two families of Lamellibranch Molluscs—the marine *Mytilacea*, of which the edible mussel, *Mytilus edulis*, is the representative; and the fresh-water *Unionidae*, of which the river mussel, *Unio pictorum*, and the swan mussel, *Anodonta cygnea*, are the common British examples. It is not obvious why these fresh-water forms have been associated popularly with the *Mytilacea* under the name mussel, unless it be on account of the frequently very dark colour of their shells. They are somewhat remote from the sea mussels in structure, and have not even a common economic importance.

The sea mussel (*Mytilus edulis*) belongs to the second order of the class *Lamellibranchia* (*q.v.*), namely the Filibranchia, distinguished by the comparatively free condition of the gill-filaments, which, whilst adhering to one another to form gill-plates, are yet not fused to one another by concrescence. It is also remarkable for the small size of its foot and the large development of two glands in the foot—the byssus-forming and the byssus-cementing glands. The byssus is a collection of horny threads by which the sea mussel (like many other Lamellibranch or bivalve molluscs) fixes itself to stones, rocks or submerged wood, but is not a permanent means of attachment, since it can be discarded by the animal, which, after a certain amount of locomotion, again fixes itself by new secretion of byssus from the foot. Such movement is more frequent in young mussels than in the full-grown. *Mytilus* possesses no siphonal tube-like productions of the margin of the mantle-skirt, nor any notching of the same, representative of the siphons which are found in its fresh-water ally, the *Dreissensia polymorpha*.

Mytilus edulis is an exceedingly abundant and widely distributed form. It occurs on both sides of the northern Atlantic and in the Mediterranean basin. It presents varieties of form and colour according to the depth of water and other circumstances of its habitat. Usually it is found on the British coast encrusting rocks exposed at low tides, or on the flat surfaces formed by sandbanks overlying clay, the latter kind of colonies being known locally as "scalps." Under these conditions it forms continuous masses of individuals closely packed together, sometimes extending over many acres of surface and numbering millions. The readiness with which the young *Mytilus* attaches itself to wicker-work is made the means of artificially cultivating and securing these molluscs for the market both in the Bay of Kiel in North Germany and at the mouth of the Somme and other spots on the coast of France.

Natural scalps are subject to extreme vicissitudes: an area of many acres may be destroyed by a local change of current producing a deposit of sand or shingle over the scalp, or by exposure to frost at low tide in winter, or by accumulation of decomposing vegetable matter. The chief localities of natural scalps on the British coast are Morecambe Bay in Lancashire and the flat eastern shores, especially that of the Wash of Lincoln, and similar shallow bays. These scalps are in some cases in the hands of private owners, and the Fisheries Department has made arrangements by which some local authorities, *e.g.* the corporation of Boston, can lease layings to individuals for the purpose of artificial cultivation.

The sea mussel is scarcely inferior in commercial value to the oyster. In 1873 the value of mussels exported from Antwerp alone to Paris to be used as human food was £280,000. In Britain their chief consumption is in the deep-sea line fishery, where they are held to be the most effective of all baits. Twenty-eight boats engaged in haddock-fishing at Eyemouth used between October 1882 and May 1883 920 tons of mussels (about 47,000,000 individuals), costing nearly £1800 to the fishermen, about one-half of which sum was expended on the carriage of the mussels. The quantity of mussels landed on Scottish coasts has decreased in recent years owing to the decline in the line fisheries. In 1896 the quantity was over 243,000 cwts., valued at £14,950; in 1902 it was only 95,663 cwts., valued at £5976. In the statistics for England and Wales mussels are not separately distinguished. Many thousand tons of mussels are wastefully employed as manure by the farmers on lands adjoining scalp-producing coasts, as in Lancashire and Norfolk, three half-pence a bushel being the price quoted in such cases. It is a curious fact, illustrative of the ignorant procedure and arbitrary fashions of fisher-folk, that on the Atlantic seaboard of the United States the sea mussel, *Mytilus edulis*, though common, is not used as bait nor as food. Instead, the soft clam, *Mya arenaria*, a Lamellibranch not used by English or Norwegian fishermen, though abundant on their shores, is employed as bait by the fishermen to the extent of 1¼ million bushels per annum, valued at £120,000. At the mouth of the river Conway in North Wales the sea mussel is crushed in large quantities in order to extract pearls of an inferior quality which are occasionally found in these as in other Lamellibranch molluscs (Gwyn Jeffreys).

Mytilus edulis is considered of fair size for eating when it is 2 in. in length, which size is attained in three years after the spat or young mussel has fixed itself. Under favourable circumstances it will grow much larger than this, specimens being recorded of 9 in. in length. It is very tolerant of fresh water, fattening best, as does the oyster, in water of density 1014 (the density of the water of the North Sea being 1026). Experiments made by removing mussels from salt water to brackish, and finally to quite fresh water show that it is even more tolerant of fresh water than the oyster; of thirty mussels so transferred all were alive after fifteen days. *Mytilus edulis* is occasionally poisonous, owing to conditions not satisfactorily determined.

The fresh-water Mussels, *Anodonta cygnea*, *Unio pictorum*,