die of starvation in three to four weeks. Supply them, however, with predigested humus or with fungus-digested cellulose, and they can get on all right. But the crucial test is yet to come. Put them back with other termites of their own kind containing protozoa, they rapidly become re-infected, are then once more able to cope even with pure cellulose, and can live on that indefinitely. There seems, then, no question whatever that the protozoa split up the cellulose for them, and that, in the course of ages, they have become absolutely dependent on these secret sharers for their essential food. The flagellates, for their part, cannot live for more than ten days apart from their termites, and then only in a special blood-serum medium to which finely powdered ligno-cellulose is added. They have never been known to form protective cysts, and, so far as is known, they do not occur anywhere else in Nature. The exact method by which they are transferred from termite to termite is not fully understood—though probably they pass in the semi-fluid substance from the anus of the workers.

The association between these partners is undoubtedly of very long standing—it must have taken many ages to evolve the exact adjustment between them and the extraordinary specialisation that we find. But complete and successful the partnership undoubtedly is. Many minor details have yet to be worked out. We do not yet know in what form the broken-up cellulose is handed on to the insect. A great deal of glycogen (animal starch) is always found in the bodies of the trichonymphids, though none occurs in the intestinal cells of the termite. Even when the diet has been pure cellulose for as much as three months, the protozoa still contain glycogen. The suggestion is that they split the cellulose into the sugar glucose, which they then build up into glycogen. How they hand over the excess to their partners we do not know, or whether, as seems possible, their own bodies are sacrificed in the process. Nor do we know yet how the termite gets the nitrogen necessary for the formation of protein when it is fed on pure cellulose. Possibly the bodies of the junior partners afford the immediate supply: but whence have *they* got their nitrogen? Have they the power of fixing free nitrogen, as certain bacteria have? Or do the termites themselves perform this un-animal-like feat? Do not let us forget, however, that along with the flagellates in the termite's gut there are also myriads of other micro-organisms—spirochætes, bacilli, and what not. It may be that these are, in their degree, essential partners in the process.

Obituary.

SIR JOHN ISAAC THORNYCROFT, F.R.S.

SIR JOHN ISAAC THORNYCROFT, whose death on June 28 we much regret to announce, was born on Feb. 1, 1843, at Rome. He was eldest son of Thomas Thornycroft, a sculptor, who had married Mary, the daughter of John Francis, who had taught him his art. Sir William Hamo Thornycroft, the sculptor, was another son of Thomas Thornycroft. Educated first at private schools, Sir John Thornycroft became a student of the University of Glasgow, and there came under the influence of Rankine and Kelvin. After gaining some experience in shops in the north of England, in 1866, the same year that Sir Alfred Yarrow started at Poplar, he began boat building at Chiswick, and soon became known for his success with steam-boat machinery. The little *Miranda*, built in 1871, was only 45½ feet long, but created considerable stir by steaming at 16¼ knots.

It was the adoption of the spar torpedo, and then the automobile torpedo for naval warfare, that opened a new field to Thornycroft, and in 1873 he constructed his first torpedo-boat for the Norwegian government. In 1877 he built H.M.S. *Lightning* for the Royal Navy. He was probably the first to use a locomotive boiler in a boat, and when this type of boiler proved troublesome, he invented a water-tube boiler. He early employed forced draught in his boats, and was a pioneer in the construction of fast-running, lightly constructed steam engines. His first vessel fitted with a water-tube boiler was the mission boat *Peace*, for use on the Congo. In the two torpedo-boats for the British Navy, Nos. 99 and 100, he introduced the flat stern and the double rudders which became a conspicuous feature of his designs. The history of the torpedo-boat destroyer begins with the *Havock* and *Hornet*, ordered by the Admiralty from Yarrow, and the *Daring* and the *Decoy*, ordered from Thornycroft. The *Hornet*, with Yarrow boilers, attained a speed of 27·3 knots, and was the fastest craft afloat. She was soon beaten, however, by Thornycroft's *Daring*, which attained a speed of 27·9 knots. Both these records were surpassed by the Russian *Sokol*, built by Yarrow in 1895, and by the *Forban*, built by Normand the same year, which did 31 knots. Reciprocating engines were used in this type of craft up to 1906, and Thornycroft built and engined many of the so-called thirty-knotters. On the adoption of the Parsons' steam turbine he was given the contract for some of the coastal destroyers, and in 1907 built and engined the ocean-going destroyer H.M.S. *Tartar*, which with oil fuel and triple screws driven by turbine attained a speed of 35·6 knots.

Thornycroft had been joined by the late John Donaldson in 1872, and later on by the late S. W. Barnaby, while for many years Mr. C. H. Wingfield was the chief mechanical engineer of the firm. Motor building had been added to the firm's activities in 1896, and after Donaldson's death in 1899 the concern was turned into a company. In 1906 the work having outgrown the capacity of the premises at Chiswick, a site was secured at Woolston, near Southampton, and it was there that all the later destroyers were built. During the War the firm built and engined twenty-nine torpedo-boat destroyers and flotilla leaders, with a total tennage of 37,210 tons and 957,000 horsepower, besides some submarines and other vessels. Mention should also be made of the remarkable coastal motor boats which were used with success off the Belgian coast and in the attack of Cronstadt.

A frequent contributor to the *Transactions of the Institution of Naval Architects* and other technical societies, Sir John Thornycroft was elected a fellow of the Royal Society in 1893, and in 1902 received the honour of knighthood. For some years past he has resided at Bembridge, in the Isle of Wight, engaged in the study of the problems in naval architecture to which he has made so many notable contributions. He married in 1870, and had two sons and five daughters. His eldest son, Sir John Edward Thornycroft, the present managing director of the firm, was knighted in 1918.

A DISTINGUISHED naval architect has favoured us with the following appreciation of Sir John Isaac Thornycroft:

Sir John got most of his early technical training from his father, who was a keen amateur engineer with a sound knowledge of mechanical principles. Sir John spent some time at South Kensington and was a contemporary there of Sir Philip Watts. Unlike some of his famous contemporaries, he did not serve an ordinary apprenticeship. He was at the University of Glasgow in the engineering class under Prof. Rankine, and took the natural philosophy class under Lord Kelvin. The class of naval architecture and marine engineering was not then founded, but Prof. Rankine's lectures included much that was the foundation of the science of marine engineering, and young Thornycroft no doubt owed a great deal of his scientific knowledge to the lectures of Prof. Rankine.

Like his co-worker in the development of small high-speed vessels, Sir Alfred Yarrow, Thornycroft began to make high-speed vessels when scarcely out of his teens. He produced the *Miranda*, which attracted the attention of the Admiralty; he built for the Norwegian Government in 1873 a 14-knot boat. Other governments ordered vessels of 18 knots, and the British Government ordered from him in 1878 the first torpedo-boat built for the Navy, the *Lightning*, of 80 ft. length and 18 knots speed. He built this vessel in a small yard on the Thames at Chiswick, and there built many other torpedo-boats, and ultimately the *Speedy* in 1893, which was almost too large for the capacity of the works. Later, the development of the torpedo-boat destroyer, which gradually grew to be too large for the scope of the Chiswick works, caused the acquisition of the present Thornycroft yard at Southampton early in this century, where the traditions of the firm are maintained and where the latest destroyer for the British Navy still holds the high record which has been continuously maintained since Sir John I. Thornycroft first created it in his almost boyhood days.

Thornycroft's early work was associated with the locomotive boiler in ships, but the pressure for higher speed led him to develop the Thornycroft water-tube boiler, which is to-day the steam producer in all the destroyers built by his firm. He devoted himself also to high speed in smaller vessels, and developed the form of small high-speed vessel known as the 'hydroplane,' which by a series of two or more inclined planes in the form of the bottom of the vessel forces her out of the water, and so reduces the resistance and increases the speed. This principle was of great value in the War, and was applied by Thornycrofts in the building of 40-knot coastal motor boats which carried torpedoes and attacked successfully larger ships which their speed enabled them to evade.

Sir John I. Thornycroft had for many years given up the commercial management of the Thornycroft business, and had left it to his son, Sir John E. Thornycroft, devoting himself to the technical and scientific side of ship design and research. He will be remembered as one of the three pioneers in light high-speed vessels and machinery of the last half of the nineteenth century; of the other two, Normand has passed away, but Yarrow is with us still. Sir John I. Thornycroft himself appeared less in the public eye than the other two, preferring the rôle of the scientific worker to that of the commercial man, but his work for his time did not suffer thereby. He was taking a keen interest in engineering and scientific matters to the end.

PROF. LAUNCELOT HARRISON.

THROUGH the untimely and unexpected death of Prof. Launcelot Harrison on Feb. 20 last, at the early age of forty-eight years, Australian zoology has lost one of its most distinguished exponents, and the University of Sydney a brilliant and stimulating teacher, who had made his influence felt both inside and outside the university walls.

Harrison was born at Wellington, N.S.W., in 1880, and was educated at the King's School, Paramatta. Taking up a business career, it was not until 1911 that he found it possible to enter the University of Sydney as a science student. He was already imbued with that profound love of natural history which had been fostered by years of active membership of the Field Naturalist Club and remained with him to the end. After a distinguished undergraduate career, he took the B.Sc. degree in 1913 with first class honours and the University medal in zoology. In the following year he was awarded the John Coutts and the 1851 Exhibition Scholarships and proceeded to Cambridge, where he gained a research exhibition at Emmanuel College and the B.A. degree by research in 1916. In the same year he was selected as advisory entomologist to the Mesopotamian Expeditionary Force with the rank of lieutenant and later of captain, a position he was thoroughly well qualified to fill through his work in Prof. Nuttall's laboratory and by his own investigations on ectoparasitic insects. He did splendid work in the field, but unfortunately he himself fell a victim to both typhus and malaria, and he never fully recovered from their effects.