Jan Swammerdam, 1637-80

By Prof. F. J. Cole, F.R.S.

JAN SWAMMERDAM was born at Amsterdam on February 12, 1637, and died there on February 17, 1680. He was the son of a prosperous apothecary, Johan Jacobsz Swammerdam, with whom he is frequently confused, and the grandson of J. Theodorus, who assumed the name of Swammerdam, and was born in the Dutch village of Swammerdam or Swadenburgerdam (now Zwammerdam) on the Old Rhine.

The pseudo-learned atmosphere of his father's private collection of rarities, which included minerals, fossils, plants, animals, manufactured and artistic curiosities and coins, the animal section forming about a sixth of the whole, could scarcely have been responsible for the rigorous scientific attitude towards natural knowledge which was characteristic of Swammerdam himself. His father intended him for the Church, but he embarked upon the study of medicine, only to be diverted from it by his passion for entomological research. Finally, however, he completed his medical course and graduated M.D. at Leyden in 1667. In the meantime, he had become friendly with his famous contemporaries Steno and de Graaf, but later his relations with de Graaf were embittered by a controversy on the structure of the genital organs. Also before graduation he had visited France, where he was befriended by Melchisedec Thévenot, and continued his entomological investigations. It was here that he publicly demonstrated the valves of the lymphatic vessels on June 19, 1664 (published 1667), but in this he was anticipated by another Hollander, Frederik Ruysch, who issued a detailed description of the valves in 1665.

On returning home, Swammerdam participated in the foundation of the private Amsterdam "College" of Medicine. This company of enthusiasts printed small volumes of transactions in 1667 and 1673, which are now exceedingly rare, and to which Swammerdam himself contributed. He was thus for the time committed to human anatomy, and experimented with methods of injection, inflation and preservation. He did not, however, invent *solidifying* coloured injection masses, as is generally stated, but he was responsible for the general adoption of the method by anatomists after his time. His first wax injection was carried out in van Horne's house in Leyden in 1666. It was probably in 1671 that he sent to the Royal Society, accompanied by descriptions and figures (published in 1672), his famous preparation of the human female genitalia. Arteries and veins had been injected with yellow and red wax, which acted as a preservative, and the whole was then dried. The Royal Society's collection was handed over to the British Museum in 1781, and this historic specimen was never again seen. Later, Swammerdam applied the injection method to the smaller invertebrates, and he succeeded in filling the blood vessels of a Lepidopterous larva from the heart by means of a capillary glass tube.

After an illness, Swammerdam abandoned human anatomy, and thenceforward devoted himself entirely to comparative anatomy, chiefly of insects. Such a devotion to science absorbed not only all his time and attention, but also was expensive, and his father penalized the neglect of a profitable profession by cutting off supplies. To mollify his angry parent, Swammerdam wasted much valuable time in cataloguing the family museum, and this catalogue, which was published in 1679, shows that the collection was not comparable with many others which existed in Holland at the time.

In 1673 Swammerdam came under the disturbing influence of Anthoinette Bourignon, and henceforward his interest in science began to decline. It flared up from time to time, but the process of extinction had set in. Finally, he convinced himself that the pursuit of learning was vain and even impious, and he died in an atmosphere darkened by the turmoils of an unbalanced mind. Nevertheless, it was during this period of strife that he completed his classic treatises on the honey-bee and the mayfly, working, as the rhetorical Boerhaave tells us, exposed bareheaded to the scorching heat of the sun and "dissolving into sweat under the irresistible ardours of that powerful luminary".

The early death of Swammerdam was not entirely responsible for the fact that the bulk of his work remained unpublished, for to his own indifference were added the apathy and neglect of his successors. The manuscripts passed first into the hands of Thévenot, who designed to publish them, but he died without discharging this important trust. After some vicissitudes, the papers were acquired by G. Duverney, the celebrated Parisian anatomist, who had already undertaken other charges of a similar nature, but lacked the desire to liquidate any of them. Finally, Boerhaave was moved to intervene, and in the subsequent proceedings he played an important and honourable part. He purchased the documents from Duverney, and published them under his own

guarantee as two imposing folio volumes in Dutch and Latin in 1737–38, exactly a century after the birth of their author, but nevertheless not yet out of date! It is painful to reflect that Swammerdam's own collection of preparations shared the common fate of the museums of his period, and, having failed to attract a purchaser, was dispersed. Unlike his great contemporaries, Malpighi and Leeuwenhoek, Swammerdam was not a fellow of the Royal Society; but he corresponded with the Society, the archives of which include some material in his autograph. One genus (1826) and some ten species of insects have been named after him.

The picture which the evidence justifies us in forming of the personality of Swammerdam, is that of a man with an introspective and self-torturing mind which found expression sometimes in pompous and scornful criticism of others, but more often in the superfluous distractions of mysticism and spiritual exaltation. Add to this a consuming energy which produced, in some ten years before the age of forty, one of the most remarkable works in natural history which has ever been written, and also an indifferent physique wasted from time to time by fevers, and the result could only be a life which rapidly burnt itself out. His strength in research lay in observation and experiment. In reflection he was dangerous, and apart from the fact that he was a convinced and uncompromising opponent of spontaneous generation, which was incompatible with his belief in preformation, no important generalization can be associated with his name. No portrait of him is known to exist. That reproduced by Michelet and others is a forgery based on one of the lay figures in Rembrandt's "Anatomy Lesson" of 1632, the model of which could not have been Swammerdam.

The methods employed by Swammerdam in his finer work have been partly disclosed by Boerhaave. He used a simple dissecting microscope of his own design, made by Samuel J. van Musschenbroek, and very delicate dissecting instruments sharpened under the microscope. He was one of the first naturalists after Boyle to appreciate the importance of alcohol as a preservative, and was probably the first to make dissections under water, and to clear up an entomologica preparation by dissolving out the fatty substances. The modern practice of preparing Lepidopterous larvæ for exhibition by pressing out the viscera and inflating and drying the skin was invented by Swammerdam.

In addition to various Parerga to be found in the works of T. Bartholini, sen., Thévenot, van Horne, Blasius, Boccone, Steno, the *Philosophical Transactions* and the works of the Amsterdam "College", Swammerdam published four major works during his lifetime. The first of these, an inaugural dissertation on respiration, was published in 1667 in Latin, and five other Latin editions appeared later. In 1927 the first edition was re-issued in Holland with a Dutch translation. This little treatise has considerable physiological importance. The discovery of the part played by air in respiration may here be recognized in one of its earliest phases, and the mechanism of mammalian respiration is ingeniously demonstrated by means of a pair of bellows containing the wind-pipe and lungs, in which the action of the bellows on the lungs can be observed through a glass window cut in the side. As pointed out by Patterson, this idea was adopted without acknowledgement by Mayow in 1674. In the interests of priority, it should also be recorded that Swammerdam's experiment had been published for thirteen years before Borelli issued the first volume of his "De Motu Animalium".

Swammerdam was among the earliest to test the effects of injecting the vessels of *living* animals, and his discovery that the mammalian lung sinks in water before it has functioned, but floats afterwards, has important medico-legal bearings in cases of suspected infanticide. Significant observations on clinical and chemical thermometers are also to be found in this remarkable thesis, and even topics foreign to its express purpose, such as the hermaphroditism and reciprocal union and fertilization of snails, are not excluded.

Swammerdam's first entomological publication, which later formed a part of the "Biblia Naturæ", was his "General History of Insects". It appeared in 1669 in the Dutch language, and was followed by five other French and Latin editions. A few years later, in 1672, the work on the uterus was issued, and went through eight editions, all of them in Latin. It includes the polemic against de Graaf, but is important from the point of view of anatomical injections and the preformation doctrine.

The treatise on the mayfly was first published in 1675 in Dutch—six years after Malpighi's treatise on *Bombyx*—but only two other editions, in English and French respectively, appear to have been printed. To Anthoinette Bourignon the mayfly was a "little beast which lives for only a single day, and throughout that time endures many miseries". She gave, however, a grudging consent to the printing of the book, but implored Swammerdam to devote himself in the future to the more serious things of eternity. In this expansive and verbose work Swammerdam followed the lead of Servetus, and undertook the dubious task of establishing an ethical system which united the diverse interests of biology and divinity. In spite of the fact that it had a numerous following, amongst whom may be mentioned Lesser in Germany and Kirby and Spence in England, insecto-theology, as it was called, fell an inevitable victim to its own

disruptive elements. The biology of the work, however, greatly diluted as it is, shows us Swammerdam at his best. He appears to have started work on the mayfly as early as 1667. The anatomy of the small nymph is beautifully worked out, and in this respect Swammerdam is clearly superior to Malpighi. In addition, the curious life-history, in which the brevity of the adult stage is contrasted with the exceptionally long larval period, is laid bare for the first time. This work is also included in the "Biblia Naturæ".

The posthumous "Bible [not Book] of Nature" owes its name probably to its sponsor Boerhaave, and the detailed and accurate plates are the work of an artist employed by the author. One of the Ephemera plates, however, is signed "Auctor del". In all, eight editions were published, including German, French and English translations. It is impossible in this brief notice to refer to more than a few of the topics which are investigated in this stupendous work. Its plan, based on selected types, is monographic, comparative and experimental, and it is undoubtedly the foundation of our modern knowledge of the structure, metamorphosis and classification of insects. In addition, there are valuable observations on Crustacea, Mollusca and the life-history and anatomy of the frog in both larval and adult stages. Swammerdam spent some five years on the hive-bee, dealing with the anatomy, life-history and general economy of that much investigated animal, and his account of it is the most trustworthy and comprehensive we have had from any one man. It would, in fact, rank high even if judged by modern standards. In 1668 Swammerdam had already discovered by skilful dissection that an insect larva, pupa and imago may *at one stage* of the life-cycle exist simultaneously one within the other like a nest of boxes, and he had also studied experimentally the conditions which induce and regulate moulting and metamorphosis. His consequent assumption that no new parts are formed, and that the perfect insect is there *all the time*, led him to adopt the Preformation doctrine, the long and evil reign of which lies so heavily on his reputation. Swammerdam severely criticizes Harvey's views on metamorphosis, esteeming him at "little less than nothing", and stating that his work on generation contains almost as many errors as words. Harvey's philosophy of generation may have been, as Vallisneri says, "encrusted with Aristotelian pitch and heavy with rust", but it was the deadly blight of Preformation that stopped the clock.

Swammerdam accidentally stumbled upon the mimetic resemblance of certain Diptera to bees, and he found that some Lepidopterous egg masses might give rise to flies instead of caterpillars, which is the earliest record of egg parasites. He observed also in the case of the frog the first cleavage of the ovum, and noted the cellular structure of later stages. He admits, however, that blood corpuscles had been known for "some years" before he saw them, but does not give the source of his information, which could scarcely have been Leeuwenhoek. He certainly found the oval blood corpuscles of the frog before Leeuwenhoek. His ingenious neuro-muscular preparation (1668) by which he studied the relation of muscle and nerve, and the nature of muscle contraction and the nerve impulse, enabled him to refute the current belief that muscular action was due to a material substance reaching the muscle via the nerves, and in his experiments on the contraction of the heart and muscle he invented a form of plethysmograph. These results alone would entitle him to be regarded as one of the founders of experimental biology. But to the discoveries which are to be found in the "Biblia Naturæ" there is almost no end.

Chemical Exploration of the Stratosphere*

By Prof. F. A. Paneth

OUR prospect of finding differences in the chemical composition of the air is, of course, better the higher the sample is obtained in the stratosphere. An important part of the whole research is therefore the collection of air samples from great altitudes. For this purpose, sending up automatic devices in unmanned balloons is the most efficient method. Aeroplanes cannot attain sufficiently high altitudes; even Squadron Leader F. R. D. Swain in his record flight last September reached only 15 km., and the inconveniences of an airtight suit preclude complicated scientific operations. Balloon ascents in closed gondolas, as introduced by A. Piccard in 1931, give more freedom for observations, and can attain greater heights. A year ago, Capt. Stevens and Capt. Anderson in a stratosphere flight arranged by the National Geographic Society and the U.S. Army Air Corps reached 22 km.; but it cannot be said that the scientific results of the expedition justified the immense costs. The varying conditions of the atmosphere make numerous observations necessary, and only the cheap flights of sounding

* *Continued from p.* 182.