Domenico Cotugno (1736–1822)

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Domenico Cotugno (1736–1822) was born in Ruvo di Puglia (Bari, Italy) into a family of humble means. In 1753, he began his medical studies at the University of Naples. He received his doctorate in philosophy and physics in 1755 and subsequently became an assistant at the Ospedale degli Incurabili (Neapolitan Hospital for Incurables). In 1761, he became professor of surgery at the same hospital. For 30 years, he was also professor of anatomy at the

Naples School of Medicine and director of the Hospital for Incurables. Cotugno devoted most of his life to these two institutions. In fact, when he died of a cerebral embolism in 1822, the Hospital for Incurables inherited 100,000 ducats.

In the early 19th century, his reputation as a physician was such that, as the saying went, “no one in Naples could die without a passport from Cotugno”. Throughout the period of political upheaval in the Kingdom of Naples, caused by the revolution of 1799 and the simultaneous rise and fall of the Parthenope Republic, Cotugno’s dedication to medicine was unwavering. He was also an outstanding example of the physician-humanist [3, 4] and created a large library of books on art, architecture, numismatics and antiquities. Cotugno’s scientific work is not only a striking example of the Italian culture of his time but is also part of the scientific tradition that started with Hippocrates and the school of Salerno and continued in the Neapolitan school of the 17th century and in the Experimentalists of the early 18th century.

Cotugno was 25 years old when, in 1761, he published the first description of the course of a nervous filament originating from the second trigeminal branch; later, it was termed the “naso-palatine nerve” by the famous scientist Scarpa [4, 7]. Cotugno also correctly described the role of this nerve in sneezing. In the same year, following the work of Duverney and Valsalva and anticipating that of von Helmholtz, he provided the first detailed description of the anatomy of the inner ear in his dissertation *De aquaeductibus auris humanae internae* [1]. He described the vestibule, semicircular canals and cochlea of the osseous labyrinth of the internal ear and identified the nerve that innervates the semicircular canals as well as the nerve that reaches the cochlea. In disagreement with Valsalva, he rightly claimed that the auditory receptive surface was on the membranous lamina of the cochlea, that this lamina

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became wider as it ascended the cochlea, and that it was made of a large number of cords. Through his experimental observations of fresh rather than dried labyrinths, Cotugno demonstrated that the inner ear is filled with fluid, not with air as was generally held (the Aristotelian dogma of *aer ingenitus*), and that the perilymphatic space communicated with the subarachnoid space at the base of the brain. Cotugno acknowledged Valsalva's and Morgagni's knowledge of perilymph, but he was unaware that Johann Pyl had discovered a second fluid in the inner ear (i.e. endolymph) in 1742.

On the basis of his very accurate description of the basilar membrane of the cochlea, Cotugno formulated the fundamentals of the theory of resonance, which represented the death knell for the theory of resilient, implanted air. This theory had persisted into the 18th century partly because it was believed that liquids could not transmit sound vibrations. Nevertheless, it was Hauksbee (1709) [5] who demonstrated that sound waves propagate in air as well as in water and Cotugno was probably aware of this new discovery. Cotugno's new theory of hearing held that the stapes set the labyrinthine fluid into vibration, which in turn stimulated the membrane fibres:

“When a sound is generated, as in the case of the human voice, we may observe that, among all the strings of the tambourine, only one vibrates in unison with the sound. Thus, within the cochlea, which is our tambourine, for every sound there is a corresponding and appropriate string that, by vibrating in unison, permits the soul to discriminate sounds. This probably explains why the cochlea does not exceed the length of two turns and a half, because in that area there may be an area long enough to get all the possible strings responding in unison to the sounds we hear.” (*De aquaeductibus auris humanae internae anatomica dissertatio*, Cap.XCII, 1761) [1].

Thus, Cotugno was able to deduce that each cochlear nerve fibre has its own “characteristic frequency”, an idea that still holds today. Although Helmholtz did not quote Cotugno's results in his theory of resonance [8], most subsequent handbooks on auditory theories cite the resonance theory as the Cotugno-Helmholtz theory.

In 1764, Cotugno published *Remarks on nervous ischialgia* [2], which represented a true turning point in research

on the cause of this disorder, classified by Hippocrates as a humoral disease. He considered two types of ischialgia, arthritic and nervous; the latter was distinguishable in posterior and anterior ischialgia. The posterior ischialgia is located along the sciatic nerve at the hip and it may reach the distal portion of the limb to the malleolus; the anterior ischialgia follows the crural nerve on the anterior surface of the hip. In this context, Cotugno's etio-pathogenetic interpretation of ischialgia is relevant. He hypothesised that some acrid fluid might penetrate the sheaths of the ischiatic nerve. Indeed, according to this hypothesis, ischialgia is oedema of the nerve, an explanation preserving some aspects of the Hippocrates' description, but rightly shifting the location of trouble to the nervous sheaths.

In close agreement with this description, Cotugno demonstrated the presence of a humour bathing the cerebrum and spinal cord in the vertebral canal between the arachnoid and pia mater. This continuously renewed spinal fluid transudes from the small arteries and is re-absorbed by the small veins (“The vertebral space around the spinal cord is filled with fluid, just similar to the fluid around the brain and the cerebellum”. *De ischiade nervosa*, 1764). Because of this discovery, the cerebrospinal fluid was termed *Liquor Cotunni* [2, 4, 6].

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