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Exactly like a Stingray

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VOLTA: SCIENCE AND CULTURE IN THE AGE OF ENLIGHTENMENT by Giuliano Pancaldi. Princeton, 381 pp., £22.95, June 2003, 0 691 09685 6

IT IS WELL ENOUGH KNOWN that Napoleon's victory over the Austrian army at Marengo on 14 June 1800 had a major effect on the history of the menu. The surprising haste of the engagement left the French commissariat far behind its commander, whose hunger had to be satisfied with what his cook had to hand: a scrawny chicken butchered with a sabre, some eggs, tomatoes, oil, garlic and a few crayfish. Such is the legend of the origin of chicken Marengo. Less well known is the effect of the same battle on physics. In the scientific story, as in the culinary one, longterm outcomes were unpremeditated. Napoleon's triumph restored French control over Lombardy, from where his armies had been expelled the previous year, allowed Pavia University to reopen, and restored that university's greatest physicist, Alessandro Volta, to citizenship of the French-dominated Cisalpine Republic.

Just three months earlier, Volta had written down the instructions for making a new device he had concocted, capable of providing a seemingly inexhaustible, if weak, electrical flow from a pile of silver and zinc discs, each pair separated by moistened card. The effect of Marengo was to make Volta's invention, published a few weeks after the battle, a French one: it gained him a gold medal from the Institut de France and entry into the Bonapartist pantheon. The word ‘pile’ became the standard name for the device, at least within the suddenly enlarged French domains. In Britain, where Volta first sent news of his work, the pile was more pugnaciously baptised a `battery'. Volta himself thought of it as an artificial electric fish. The ironies, contingencies and oddities of this story provide the main theme of Giuliano Pancaldi’s book.

In 1800, Pancaldi writes, `the battery had only limited useful applications,’ yet it ‘paved the way for technological developments that would modify an entire civilisation’. He takes this as a paradigm of the way the endeavours of enlightened artisans, natural philosophers and experimenters didn't turn out as they expected. From it he concludes that the 18th-century enterprise of Enlightenment scarcely planned, and was often taken off guard by, the effects its works ultimately had on public life and industry. So, according to Pancaldi, it is wrong to attribute to the Enlightenment the monolithic and visionary rationalism which both disciples and critics have found in its stern deliverances. Rather, Volta's career illuminates a diverse European world whose purposes were often contingent, improvised and unpredictable. Volta did not set out to bottle a universal source of light and power with his newfangled recipe, though this does not mean that his electrical enlightenment was sundered from social change, practical engineering and lucrative trade.

The tale of the artificial electric fish is utterly different from some recent hagiographical accounts of enlightened enquiry. Unlike Dava Sobel's popular caricature of the clockmaker John Harrison, for example, Pancaldi's carefully characterised Volta was not a solitary persecuted genius hunting the solution to the great scientific problem of his time. Other equally ludicrous fables of the progress of science and technology tell us that the key to understanding the past of the natural sciences is to trace tbc royal road of abstract mathematics and disinterested theory. Volta's work as an experimental philosopher, machine maker and ambitious citizen of the world shows the poverty of this picture. Responding with agility to the exigencies of local and international colleagues and competitors, he navigated his way through the stormy world of late 18th-century European society, offering his patrons and correspondents startling blueprints for new machines and novel pictures of nature's capacities. These were then debated and revised, in a pattern of what Pancaldi calls `competitive imitation'. Volta is to be understood alongside many similar figures of the late Enlightenment, a maker and victim of fashion and markets, an ambitious, often frustrated entrepreneur seeking his place in the unstable society of the fading old regime. The electric battery presents a neat way of probing this world and a sign of its vagaries. It is no mean feat of Pancaldi's to have recovered so much rich material from an unpromising pile of damp metal discs.

Volta's career, most of it spent working for the Austrian Empire's northern Italian institutions, was dominated by problems of long-range orchestration, full of tours abroad and contests at home, obsessed with getting his instruments to behave, then persuading others to admire his virtuosity in manipulating them. He was born into a family almost entirely devoted to churchmanship, his father a former Jesuit, three paternal uncles and all his brothers in holy orders, his two sisters nuns. As was common for members of his patrician class, he was sent to the local Jesuit college in Como, but then rapidly strayed into the paths of enlightened philosophy and poetics. The promised land of Milton's epics and Coalbrookdale's engines became peculiarly appealing for this extreme Anglophile. Pancaldi quotes extensively from Volta's strangely physiological eulogy of England's polity, 'the Kingdom of Vulcan', at the dire end of its American war in 1782: 'Those who know it can tell from its appearance and internal motions that the body is healthy, sturdy, well fed, rich of juice and blood, so that you can still draw a lot from it without enfeebling it too much.' Some never forgave Volta his decisive switch from Jesuit principles to those of the northern Enlightenment. In an incendiary letter regrettably omitted by Pancaldi, his Jesuit teacher judged the errant scholar 'the darkest soul in hell', predicting a future of dishonour, idleness and vice.

Only a little of this infernal vision came true. Before he was 30 the Habsburg government made Volta head of the Como public schools and the following year chair in experimental physics there. The Austrian authorities then permitted him to go on successively more ambitious tours of philosophical Europe. The lessons he learned from visits to transalpine cabinets, colleges and salons, to Voltaire and to the Lunar Men of Birmingham and the Black Country, bore fruit. He became a celebrated physics professor at the prestigious, if troubled, Pavia Universiry, and its rector from I785. Evidently, these journeys and triumphs were accompanied by more fun-loving enterprises. With a mix of precision and ambition worthy of Leporello, he counted no fewer than 112 whores during a visit to Paris. The German experimenter and epigrammatist Georg Lichtenberg 'realised Volta understood a lot about the electricity of girls'. Plans for Volta's secret marriage to an opera singer in 1789 were frustrated by a stern memo from the Austrian government. One of his closest friends recalled that he was the sort of man who attends Mass in the morning and brothels at night. A distinguished French eulogist of Volta's science was rather less impressed by his addiction to word-play and clumsy jokes, which were 'far from being as irreproachable as his experiments'.

These seemingly irreproachable experiments long fascinated and occasionally frustrated Volta's many audiences. His key problem was to ensure that what he could so ingeniously conjure up with his own experimental hardware in Como and Pavia would reliably happen elsewhere in Europe. Theory-dominated stories of the sciences tend to underplay, if not ignore, such problems of replication and credibility. In Lombardy, there was local resentment of, and challenge to, Volta's reputation. The brilliant naturalist Lazzaro Spallanzani had early been a colleague and friend. But in the 178os, relations between the two collapsed, apparently in the wake of the illicit removal of specimens from Spallanzani's fine museum. A pseudonymous pamphlet appeared, attacking Volta as 'almost useless for his students', offering them mere 'child's games in physics'. The aura of infantile entertainment was hard to shake off from electrical shows. Much worse was to follow when the republican French arrived as an army of occupation. Volta compromised with the new regime, then fled from Pavia to escape riots against his allegedly traitorous conduct. His relations with the republicans were not straightforward. In 1797, one Jacobin demagogue in Milan even demanded the professor's head.

More generally, as Pancaldi expertly documents, neither Milanese society nor Pavian colleges ever made it easy for Volta to fulfil his ambitions as a natural philosopher of international standing. He moaned to the government about the lack of local artisans who could build and fix the devices of wood, metal, wax and glass with which he investigated electrical sparks and explosive gases. Intellectuals in Milan set up a 'patriotic society' to cultivate relations between urban patricians and workmen, but one English visitor, more familiar with the instrument shops and studios of industrialising Britain, waspishly noted that there was in the society 'not one close-cropped wig or a dirty pair of breeches to give authority to their proceedings'. Volta had to turn elsewhere for help, both to his own devices and to the increasingly receptive patrons he found in Paris, London and other capitals of the Republic of Letters. The rival claims of teaching, cash, administration, travel and research sapped Volta's energy and ate up his time. 'The professorial chair has been fatal to you,' a Swiss friend remarked: 'It has sent your genius to sleep, it has halted your discoveries.'

This was far too pessimistic. Genial discoveries flowed from Pavia. The production of workable instruments which still lacked completely convincing theoretical explanations - the electric battery for example - came to characterise what Pancaldi calls 'the new 19th-century figure of the scientist'. This is a fascinating inversion of several received pictures of the sciences' modern origin. It was the limitations on the scope of shared theory and of a disciplinary community which helped forge recognisable sciences. Volta certainly did not initially wish to pursue this path. Rather, he shared with his eminent contemporaries and immediate predecessors the overweening desire to find grand schemes that embraced the basic principles of the cosmos.

Electrical phenomena offered I8th-century natural philosophers a seductive candidate for the basis of such a scheme. Finding electricity at work over their heads in lightning strikes and within their own brains and nerves, devising crowd-pleasing shows of sparks and shocks, seeking cures for ills ranging from earthquakes to toothache with powerful electrical devices, these savants became ever more convinced that in the laws of electricity were concealed the principles directing Creation. Volta's onetime patron Bonaparte was sure that ‘man is the product’ of electrical fluids, and that ‘the brain pumps these fluids and gives life, and that after death they return to the ether’. This was, as Pancaldi points out, ‘a broad, vague, but compelling naturalistic worldview’. Volta tried to join in, but with little success. Encountering criticism of, and resistance to, his own ambitious stories about the forces which produced electrical sparks and shocks, he learned a kind of instrumental modesty. The lesson proved invaluable.

Readers of Volta's works who were unwilling to accept his strange idea that all electricity came from attractive forces acting suddenly through empty space nevertheless enthused about the machines he built. Equipped with such instruments as Volta's ‘electrophorus’ and ‘condensatore’, other experimenters found they could manipulate glass, metal and resin to produce indefinitely large quantities of electricity and accumulate the weakly transient charges they sought in the thunderous skies and in tremulous animals. Here was where electricity became decidedly fishy. Many savants reckoned the electrical fluid might be responsible for nervous action - a substance manufactured in the brain and a clue to a visionary new sort of medicine that would restore health through judicious electrical shocks. For these naturalists, stingrays and eels were therefore particularly fascinating. In the somewhat carnivalesque anatomy workrooms of London and Bologna, stingrays were cut up to find the origin of their shocks. Several reckoned the shocks were electrical, but others pointed out that no one had ever managed to draw sparks from a stingray.

Volta's machines, correspondents and publicity helped him solve such puzzles. It was hard to collect and measure the electricity animals generated. But he had designed devices to make weak electricity detectable, and invented a workable language to describe what was going on, distinguishing between capacity - the amount of electricity a body could hold without it leaking away into space-and tension: the strength of the electricity's tendency to escape. Some bodies could hold a lot of electricity at low tension, so no sparks would appear even though strong shocks might be felt. Another problem, even more tantalising, was how such shoks could be controlled by the animal. Stingrays, their eyes narrowing just before they struck their victim, seemed to be able to decide when to deliver the shock. Here was a great Enlightenment puzzle, the wilful interaction between mind and matter. Volta meditated on the working of his electrical machines, decided they showed that bodies could be electrified just by contact between heterogeneous substances, and urged a compelling story of the interactions between will, nerve and electricity. When, in 1799, he learned that experimenters in London had drawn in analogy between electrical condensers and the strange fish, he threw himself into a few months of hard work to build a device that behaved exactly like a stingray. If it had nothing from the animal creation in its make-up, this would show that the electricity in such animals was just the same as that made by machines. It would be composed solely of metal and card, electrified purely by contact, and capable of producing inexhaustible amounts of electricity. By early 1800, he had a machine of pairs of different metals which could do just what the fish could. It has been reconstructed in unprecedented detaíl here by Pancaldi, so we now know why Volta called his new device an ‘artificial electric organ’.

Volta's blueprints were portable, as were his batteries. Once out of Pavia, they could be used for many different purposes and given many different meanings. Just as its name varied from place to place, so did its significance. In London, where Volta first sent his reports, experimenters keen on animal chemistry and natural history spotted the decomposition of the water trapped between the metal discs, a crucial phenomenon on which Volta at first stayed silent. The battery could tear what was thought to be an element apart into its gaseous components. In the learned clubs of Jena, where fascination with self-experimentation and the transcendent properties of the human senses ruled the roost, experimenters applied the battery to their own eyes, ears and genitals in search of life's true cause. Readers would soon learn of Victor Franken stein's similarly extraordinary use of nature's powers to vivify flesh. Electrical experiments became masochistic artworks in Romantic science. Parisian experts fitted the pile into their own stories of physical contact and rational analysis. Pancaldi derives an interesting moral from this plethora of interpretation and debate. The electric pile was reproducible elsewhere precisely because of the distinction between its easy manufacture and its complex meanings. Even Volta could scarcely come up with a single account of how and why it worked. Ultimately, his model fish was turned into commercial bottles of electrochemical energy.

Pancaldi pursues this salutary story of widespread dissensus and permanent reinterpretation well into the 20th century. On the centenary of Volta's death, the Italy of Mussolini and Marconi took the chance to celebrate one of its greatest dead heroes. Como's Fascist senator helped lead the triumph. Puccini composed a march and called it ‘The Electric Shock’. Volta was dressed up as an ancient Roman, and his familiar column of metal discs was represented as an ornately secured bundle, a fasces. Pancaldi, as painstaking as his subject, even tells us of the seating plan adopted by the scientists and notables at the Volta festival, their table shaped in a letter M in honour of the Duce's name. Someone blundered. Mussolini decided not to endorse the event, while at the dinner eminent physicists such

as Niels Bohr and Max Planck ended up sitting with scientifically undistinguished local worthies. The battery and its inventor thus faded into a misty litany of generalities about science, nation and progress. As this impressive book makes clear, it is impossible to understand the career and significance of the electric battery solely by celebrating the achievement of its inventor and the process of its invention. The battery may start with Volta but cannot end with him. Meaning stays in the hands of future users. Our own culture has recently found new fascination in stories of solitary men discovering how to make timepieces and maps, dyestuffs and bombs. Pancaldi's work stands apart from this alluring genre, for it wishes to teach us less of tragically persecuted heroes and more of the lengthy and subtle negotiations which helped make some of the most important engines of modernity.