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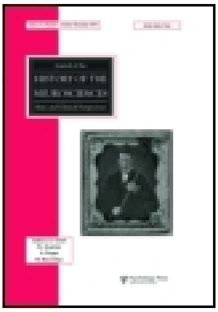

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The Role of *The Gentleman's Magazine* in the Dissemination of Knowledge About Electric Fish in the Eighteenth Century

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Although torpedoes and Malopterurus, a Nile catfish, had been described and even used medically in antiquity, their discharges were poorly understood before the second half of the eighteenth century. It was then that their actions, along with those of certain South American "eels," became firmly associated with electricity. The realization that an animal could produce electricity marked a turning point in the history of neurophysiology, which had long described nerve actions with recourse to animal spirits. By examining The Gentleman's Magazine *during the period when electric fish were becoming electrical, one can begin to appreciate how new discoveries about these unusual creatures captured the imagination of scientists and were filtered down to the literate public.*

Keywords electric fish, electric eel, *Gymnotus electricus*, Electrophorus electricus, torpedo, Nile catfish, *Malopterurus electricus, The Gentleman's Magazine*, Edward Cave, John Walsh, John Hunter, Henry Cavendish, Benjamin Franklin, Jan Ingenhousz, Edward Bancroft, John Pringle, Hugh Williamson, Alexander Garden, Ferchault de Réaumur

Electric Fish Prior to 1750

Depictions of the electric catfish of the Nile *(Malopterurus electricus)* can be found on ancient Egypt tombs, especially those of Dynasty V of the Old Kingdom, some 4,400 years ago (for more on the early history of electric fish, see Kellaway, 1946; Wu, 1984; Moller, 1995; Piccolino, 2003, 2007a; Whitaker, 2002). Little is known, however, about how they were perceived or might have been used by the Ancient Egyptians. In contrast, the Greeks, including Plato and the Aristotelians, described the numbing powers of the torpedo in their works. In addition, Ancient Greek physicians considered the flesh of these rays light and easily digestible and therefore recommended them for patients with digestive problems and wasting diseases.

Scribonius Largus recognized the therapeutic effects of the torpedo's discharges in the first century AD. He recommended them for gout and headache pain (see Scribonius Largus, 1983, Parts XI, CXLII). Other Roman writers expanded the list of disorders helped or cured by applying these miraculous fish.

The Romans also wrote about the torpedo's remarkable ability to "torpify" at a distance. For example, Plutarch (1957, XII, p. 435) wrote: "You know, of course, the property of the torpedo: not only does it paralyse all those who touch it, but even through

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the net creates a heavy numbness in the hands of trawlers." Unlike poisons from stings or bites, these remote actions were poorly understood. Even Galen seemed challenged by the torpedo's powers; although he wrote about some sort of venom and associated its benumbing effects with the sensation of cold, one of the four basic qualities of Greco-Roman antiquity (Debru, 2006).

During the Middle Ages and into the Renaissance, the torpedo's powers were greatly exaggerated, as it continued to be endowed with almost magical or occult properties (Copenhaver, 1991). It was not until the seventeenth century, following Francis Bacon's appeal for more detailed observations and experiments, and Galileo's impact in Italy, that Francesco Redi (1671) conducted a proper dissection of the torpedo and associated its "virtue" with its two hooked falciform muscles (Guerrini, 1999).

Still, the time was not ripe for associating the discharges of these fish with electricity. Rather, the actions of this fish were now viewed as resulting from extremely rapid muscular contractions, feeling somewhat like the benumbing effects of a mechanical blow to one's elbow. This mechanical theory was embraced into the eighteenth century. It was most closely associated with René-Antoine Ferchault de Réaumur (1717), a respected member of the French *Académie Royale des Sciences*, during the first half of the new century.

Early Neurophysiology

Just as there was little understanding of electric fish from antiquity into the mid-1700s, the same can be said about nervous system physiology during this time. Indeed, highly speculative doctrines based on ancient notions still dominated the literature and bedside medicine (Clarke, 1968; Brazier, 1984; Clower, 1998; Piccolino & Bresadola, 2003; Ochs, 2004). Specifically, the idea that animal spirits are somehow conveyed through the nerves provided the basis for almost all physiological thinking. This notion had originated in Greco-Roman times, and it served as a basis for Galen's highly influential writings (Rocca, 2003).

Originally, the nerves were thought to be hollow tubes, but after anatomists began to realize that they are filled with fluid, they were increasingly perceived as fluid-filled conduits that must release some sort of juice that could fill muscles or make them contract by chemical reactions (Bentivoglio, 1996). In England, Thomas Willis (1676–1680), William Croone (1664), and others brought iatrochemistry into the picture during the seventeenth century. With the rise of Newtonian science later in the century, iatromechanical conceptions, based on particles in motion, were also advanced. Indeed, many theorists combined chemical and mechanical ideas.

By this time, however, the experimentalists were revealing difficulties with these fanciful theories of nerve action. Problems began to surface in the second half of the seventeenth century with the work of Jan Swammerdam on frogs and Francis Glisson on humans (Swammerdam, 1758; Glisson, 1677). These experimenters and their followers noted that contracting muscles do not increase in volume, which would have been expected if nerve spirits in an ether or fluid entered the muscles. Further, Giovanni Alphonso Borelli (1685) immersed an animal's limb in water and cut across some "inflated" muscles only to observe that bubbles did not come out. Also leaving scientists wondering how the nerves might really work were experiments in which the nerves failed to swell when tied, and studies showing no spurting of an internal liquid when the nerves were cut transversely.

Recognizing the difficulties with even modified theories of animal spirits, a few philosophers, including Isaac Newton (1730) and David Hartley (1749), loosely speculated that the nerves might transmit their messages by vibrations. Although tense, bowstring-like nerves were not a prerequisite for this alternative theory, Herman Boerhaave (1743) and Albrecht von Haller (1769), two of the leading medical writers of the era, dismissed vibration theories as absurd in part because the nerves seemed so soft and pulpy. Clearly, there was a need for a more attractive alternative at this moment in time.

Electricity Enters the Picture

By the middle of the eighteenth century, electricity was on the minds of many experimental natural philosophers. The modern history of this force began in 1600, when William Gilbert tried to distinguish between electricity and magnetism, coined the term "electricity," and began to investigate it experimentally. Gilbert's (1600) work was followed by the development of machines for producing electricity, first by rubbing a globe of sulfur and then by rubbing glass globes, tubes, and disks (Hackmann, 1978; Heilbron, 1979). With the invention of the Leyden jar (Figure 1) in 1745, static electricity from these machines could be stored and released on demand (Dorsman & Grommelin, 1957).

These technological innovations led to spectacular demonstrations by serious scientists and showmen (Schaffer, 1983, 1993; Bertucci and Pancaldi, 2001; Bertucci, 2007). To cite but three examples: suspended boys were electrified without harm and then shocked those who came close to them; long lines of monks jumped simultaneously into the air when connected to charged Leyden jars; and glasses of brandy were set on fire with "electrified kisses."

Benjamin Franklin, more than anyone else, helped to make electricity a science at midcentury (Cohen, 1990). He came forth with a new theory of electricity based on some bodies having more or less electricity than would characterize the equilibrium condition. Franklin used his theory to explain thunderstorms and even the explosive actions of a discharging Leyden jar, which he maintained involved the neutralization of opposite charges. He further showed that electricity from frictional machines has its qualitative equivalent in lightning, which could be captured in a Leyden jar by using a special kite or a pointed rod. And he coined many electrical terms that are still used today, some being: plus and minus, positive and negative, electrical shock, electrician, charging, discharge, electrical battery, brush, conductor, and condenser. Many of Franklin's achievements

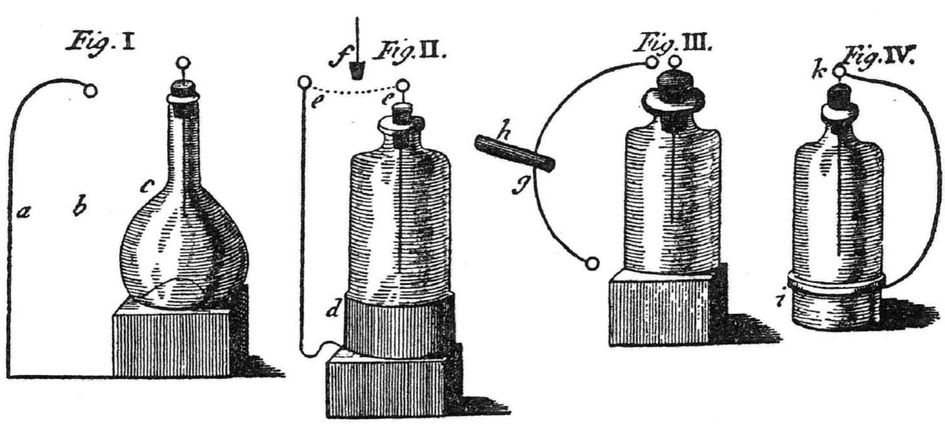


Figure 1. Leyden jars for storing electricity (From Franklin, 1751).

appeared in a pamphlet published in 1751, which he then dutifully updated as he acquired new information.

Electricity became a universal force to many mid-eighteenth-century minds (Ritterbush, 1964). Machines could produce it, it was present in the heavens, it was blamed for earthquakes, it seemed to exist in at least one mineral (tourmaline), and scientists even proposed that the sensitive mimosa plant curled its leaves when touched, because this action released its accumulated electricity (Turner, 1746). Completing this picture, electricity was now starting to be touted as a wonderful new cure for disorders of the nervous system — a contention that Franklin and inquisitive amateurs, along with many trained scientists and physicians, were now putting to the test (Bertucci & Pancaldi, 2001; Finger, 2006, 2007; Bertucci, 2007).

The idea that the nerves might work electrically began to draw attention in this exciting *Zeitgeist.* In its favor, no other agent could travel as fast as it could, which was in accord with the belief that nerve actions are virtually instantaneous. Moreover, it could elicit muscle contractions, even in people with paralyses, and it could dramatically affect the vital processes of the body.

Stephen Hales (1733, pp. 58–59) was one of the first scientists to raise the possibility that the nerves might work electrically. But his statement was little more than a brief conjecture, and he did not develop this idea, which stemmed from some of Newton's thoughts. Within two decades, however, more such statements began to appear, and now with experimenters providing indirect evidence to support this novel contention (e.g., Beccaria, 1753).

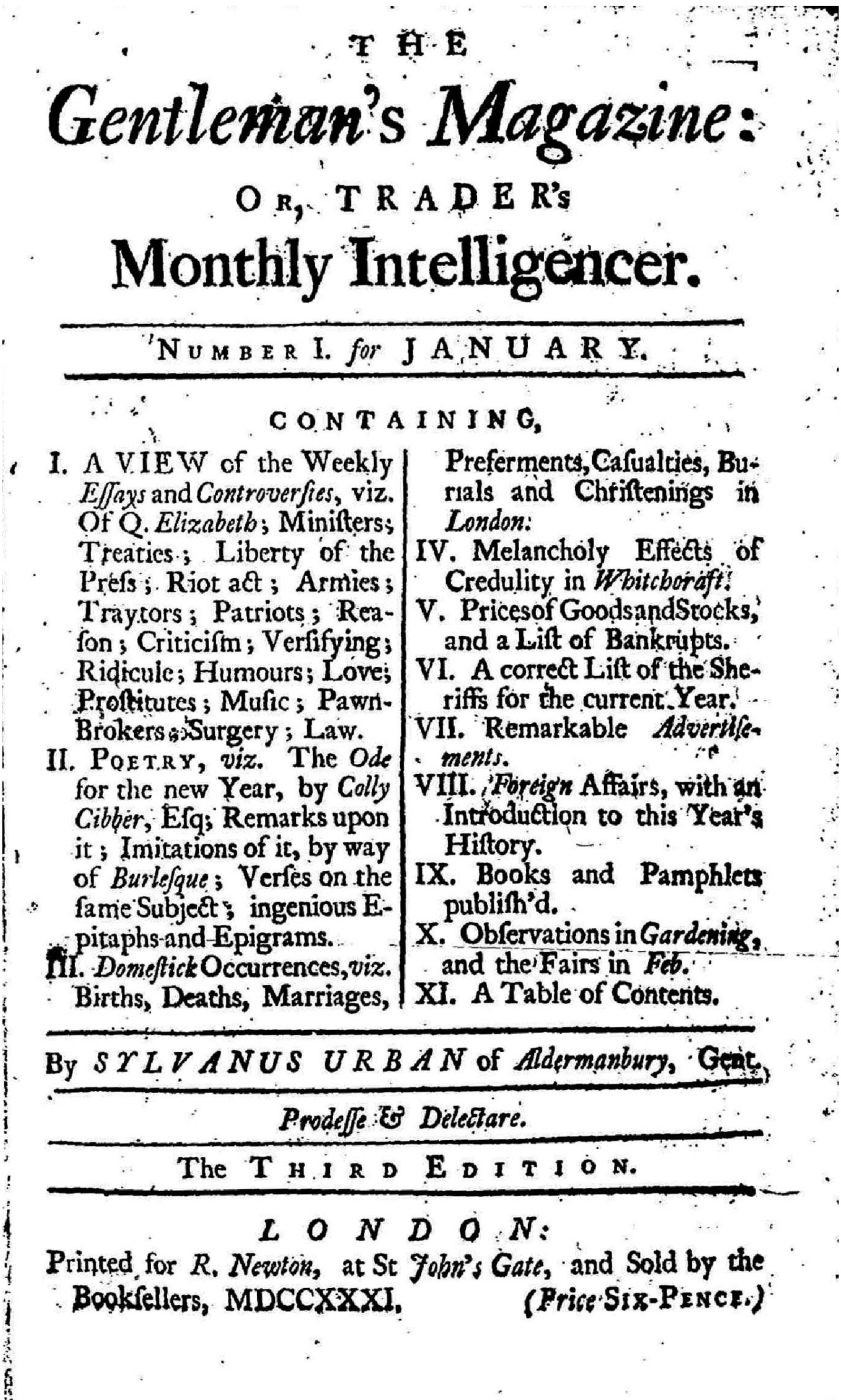
The biggest problem with this fresh way of thinking about the nervous system was that it was hard to envision how the electrical force could be confined to the nerves or to the specific muscles where the nerves ended (Home, 1970). After all, living bodies are moist, and every scientist believed that externally applied electricity must quickly spread from one body part to another. And with electricity running helter skelter throughout the body, there would be physiological chaos and nothing like wonderfully coordinated movements. Albrecht von Haller (1762, 1769) discussed this problem and his writings carried considerable weight at this time.

Thus, the challenge facing those favoring animal electricity was a serious one. The obvious need was to provide hard evidence that would show convincingly that some animals do, in fact, function electrically. If this could be demonstrated with good experiments, attention could then focus on how this might come about and, more importantly, the generality of the phenomenon.

Given this intellectual climate, it is easy to understand why research on "tremble" or "torporific" fish, which have powers and properties that had never been well explained, and which were beginning to be associated with electricity, were drawing so much scientific attention.

The Gentleman's Magazine

Established in 1731, *The Gentleman's Magazine; or Trader's Monthly Intelligencer* (Figure 2) was the first general interest magazine in the modern sense, as well as an extremely successful literary endeavor (Carlson, 1938). Edward ("Ned") Cave, the magazine's founder, was a savvy journalist and shrewd businessman, who fully understood what the literate public in the Age of Enlightenment wanted. After working for a several provincial journals earlier in his career, Cave purchased a printing press at St. John's Gate, London, for his new magazine and other printing jobs (e.g., he would publish Franklin's



THE

Gentleman's Magazine:

OR, TRADER's

Monthly Intelligencer.

NUMBER I. *for* JANUARY.

CONTAINING,

I. A VIEW of the Weekly *Essays* and *Controversies*, viz. Of Q. *Elizabeth*; Ministers; Treaties; Liberty of the Press; Riot act; Armies; Traytors; Patriots; Reason; Criticism; Versifying; Ridicule; Humours; Love; Prostitutes; Music; Pawn-Brokers; Surgery; Law.

II. POETRY, *viz.* The *Ode* for the new Year, by *Colly Cibber*, Esq; Remarks upon it; Imitations of it, by way of *Burlesque*; Verses on the same Subject; ingenious Epitaphs and Epigrams.

III. *Domestick* Occurrences, *viz.* Births, Deaths, Marriages, Preferments, Casualties, Burials and Christenings in *London:*

IV. Melancholy Effects of Credulity in *Whitchcraft*.

V. Prices of Goods and Stocks, and a List of Bankrupts.

VI. A correct List of the Sheriffs for the current Year.

VII. Remarkable *Advertisements*.

VIII. *Foreign* Affairs, with an Introduction to this Year's History.

IX. Books and Pamphlets publish'd.

X. Observations in *Gardening*, and the Fairs in *Feb.*

XI. A Table of Contents.

By *SYLVANUS URBAN* of *Aldermanbury*, Gent.

Prodesse & Delectare.

The THIRD EDITION.

LONDON:

Printed for *R. Newton*, at St *John's Gate*, and Sold by the Booksellers, MDCCXXXI. (*Price* SIX-PENCE.)

Figure 2. The cover page of the first issue of *Gentleman's Magazine*, 1731.

pamphlet on electricity). He simultaneously adopted the pseudonym Sylvanus Urban and began to print the periodical he hoped would appeal to people in rural *(sylva* means woods or forest in Latin) and city (hence Urban) locations in Britain, and ultimately around the world.

The Gentleman's Magazine was extremely successful for many reasons. One was Cave's ability to attract good editorial help and staff writers, such as literary great Samuel Johnson, who wrote various pieces, including a series of medical biographies (McHenry, 1959). Another was the wide range of its contents. Unlike other publications, this monthly periodical included current political news, historical chronicles, poetry, travel logs, science, proposed medical cures, and much more under a single, very economical cover.

At its peak, Cave's magazine had over 10,000 subscribers, with many of those individuals sharing the latest copies with friends, acquaintances, and family. Needless to say, its success led others to try to start their own magazines, while Cave and his editors tried to stay a step ahead of the competition by being flexible with the content, being aggressive in its promotion, and striving to provide readers with the essentials and exciting new material.

Early on, Parliamentary news took up many of the pages of *The Gentleman's Magazine*. By the start of its second decade, theological and political matters rose in importance. By the 1750s, in contrast, medical and scientific developments were very much on the rise. Now the public most wanted information about discoveries that might improve their lives, as exemplified by Franklin's lightning rod and new ways of treating dreaded diseases.

Cave and his editors published many articles on electricity in this context. They were often epitomes or abridged versions of material presented at established scientific societies. Not surprisingly, many of the epitomes were based on articles in the *Philosophical Transactions of the Royal Society of London*, the most respected scientific journal in the English-speaking world. Still, Cave left the door open for anyone to submit an article or a comment on a published article — a democratic policy that some physicians, witnesses, and patients took advantage of when it came to medical electricity (Locke & Finger, 2007). Given Cave's open-door policy, and the very nature of eighteenth-century reports, which were often lacking in detail and devoid of controls, the quality of the articles, as might be expected, tended to vary greatly, although politeness was always the unwritten rule.

Thus, *The Gentleman's Magazine* can provide a unique window for viewing what the literate mid-eighteenth-century public might have been told about the latest breakthroughs in science and medicine (Porter, 1985; Locke & Finger, 2007). With this in mind, we have now examined this periodical to see how it covered torpedo rays, African catfish, and the more recently discovered South American "eels," when scientists were just beginning to discuss the possibility of animal electricity (i.e., prior to Galvani's opus of 1791). As we shall now illustrate, some of the more important reports that led to a shift in thinking about animal electricity were covered, although there were significant omissions in what the lay public encountered over a period spanning almost half a century.

Electric Fish in *The Gentleman's Magazine*

The first article in *The Gentleman's Magazine* mentioning these unusual fish came forth in 1750. In an abstract of "Mr. Anson's Voyage," readers were first told about a dangerous flat fish that wrapped its large fins around divers on an island off the coast of Chile. Although probably a ray, it seems unlikely that this fish was a torpedo, as this term or "tremble fish" was not used, and there was no mention of numbness or pain. In contrast, one encounters the word torpedo in the description of a ray caught further north, off the Mexican coast, later in the article. Moreover, its numbing discharge is described and compared to that from smaller French and Italian torpedoes and South American eels:

> At *Chequetan*, and no where else, they found the Torpedo, which causes a numbness in those who touch it. If this climate be different from those of *Italy* and *France*, where the same fish has been taken notice of by Messrs *Lorenzini* and *Reaumur*, its effects in *America* are much stronger than in *Europe*. Our author avers, that the numbness seizes the whole body; his arm was violently affected by one which he leaned on with his cane for some time, and believes it would have been more so, had not the fish been near expiring. Neither is this numbness so transient as naturalists have supposed; Mr *Walter* had some feeling of it the next day; so that this *American* torpedo is in its effects like that which M. *Reaumur* observed at *Cayenna* but of a very different figure, being [in the present case] like a thornback [a type of ray; *Raja clavata*], and the other [in French Guiana] was like a conger, or an eel. (Anon., 1750, p. 67)

The anonymous author of the aforementioned piece was incorrect in stating that Réaumur (without an accent; it would also be missing from other articles mentioning him) observed eels in Guiana, revealing one of the shortcomings of some of the articles in *The Gentleman's Magazine.* Réaumur worked through many correspondents, one being Jacques François Artur, who sent him a wealth of information about the flora and fauna in French Guiana (Chaïa, 1968). Interestingly, the underlying nature of the torpedo's shock, which Réaumur (1717) thought was mechanical, was not brought up in this article.

In 1763, Réaumur's name came up again in an unusually lengthy article celebrating his contributions to science (Anon., 1763). He died in 1757 and was here praised as "a man of great ingenuity and learning, of the strictest integrity and honour, the warmest benevolence, and the most extensive liberality" (Anon., 1763, p. 116). It is here that readers are provided with a brief statement about his rapid muscular contraction theory of the torpedo's effects.

> M. *Reaumur*, after many experiments made with the Torpedo, or Numb-fish, discovered that its effect was not produced by an emission of torporific particles, as some have supposed, but by the great quickness of a stroke given by this fish to the limb that touches it, by muscles of a most admirable structure, which are adapted to that purpose. (Anon., 1763, p. 112)

The "as some have proposed" was a reference to Stefano Lorenzini and his followers. Late in the previous century, Lorenzini (1678, trans. in 1705) had come forth a mechanical theory of corpuscular emanations—one based on Galileo's atomistic ideas about sensation (see Piccolino, 2007b). In a footnote, the anonymous writer openly questioned whether direct contact with the fish is needed to feel its "stroke," as Réaumur had claimed. If nothing else, the footnote shows that some people were realizing that Réaumur's mechanical theory could not account for an often-witnessed phenomenon with these fish — that their discharges could be felt through wet nets, moistened wood, and metal rods, as first claimed by the ancients.

The next lengthy article on electric fish brings forth and develops the possibility that its discharges are electrical. It is dated 1769 and reviews Edward Bancroft's book, *An Essay on the Natural History of Guiana in South America,* which had just been published in London (Bancroft, 1769). Bancroft's book is made up of a series of letters, and it covers the geography, flora, and fauna of the region, as well as facts about the "Indians" living there. Notably, it includes far more information about the eels encountered in the murky rivers of the region than others had previously provided.

The anonymous book reviewer tells readers:

> The fishes described in this book have also, most of them, been described before, but in the account given of the Torpedo eel, the author refutes the opinion of Reaumur, that the shock of the Torpedo is the effect of a stroke given with great quickness to the limb that touches it, by muscles of a peculiar structure; he takes for granted that the shock of the Torpedo, and the terperfic [*sic.*] eel are produced in the same manner, and, with respect to the eel, he relates the following facts.
>
> If it is caught with a hook and *line*, the person that holds the line feels a shock like that of electricity.
>
> If a person who touches it with a rod, holds the hand of another person, and that person of a third, and so on to a dozen, a violent shock will be felt by all at the same instant.
>
> If a person holds a finger in the water, at the distance of ten feet from the fish, he will receive a violent shock at the moment when the fish is touched by another person.
>
> If the fish is enraged and puts his head above the water, and the hand of a person comes within five or six inches of it, he will feel a shock, nearly the same as if at another time he touched it. (Anon, 1769, p. 146)

Thus, the readers of *The Gentleman's Magazine* were informed that at least one man, a British North American who had spent several years in Guiana as a physician, was thinking that the eel and the torpedo probably release some sort of an electrical discharge. Reflecting the changing times, this possibility is not presented as yet another loose philosophical conjecture. It is a working hypothesis supported by a number of experiments based on the physics of electricity.

Nevertheless, Bancroft was in error if he really believed the eel's painful discharges could travel across several inches of air. In this case there was either a water droplet bridge of some sort between the hand and the fish; the distance was only a fraction of an inch when the shock was actually released; or the subject in the experiment (not necessarily Bancroft or even in his presence) had a vivid imagination.

It is also worth noting that the term "Torpedo eel" was used in this article. Early on, the word "torpedo" became the generic term for all fish with torporific or benumbing powers. Thus, early writers sometimes used this term for the Nile catfish, in addition to the torpedo proper. When the powerful South American eels were discovered, they too were sometimes called torpedoes (e.g., Schilling, 1770a, 1770b). This appellation, as can be imagined, caused considerable confusion, which is why some ancient writers added an adjective when describing the ray (e.g., "sea torpedo"), and why the reviewer of Bancroft's book used the word "torpedo" as an adjective for "eel." Others, however, would not be this specific or would be confused, and the literature would remain somewhat muddled throughout the century (see Anon., 1776).

The experiments of John Walsh are mentioned next. Walsh was intrigued by what Bancroft had written about torpedoes and South American eels probably both being electrical, and Franklin had urged him to do electrical experiments they planned together on torpedoes. Walsh was a member of the Royal Society, and he and Franklin had, in fact, recently supported Bancroft's election into that organization.

Walsh conducted his physiological experiments on small torpedoes caught off the French coast, where they are frequently encountered (Piccolino, 2003, 2007a; Piccolino & Bresadola, 2002, 2003). *The Gentleman's Magazine* presented one of his key findings and his conclusions in 1772, a year before they were published, again with Franklin's urging and help, in the *Philosophical Transactions* (Walsh, 1773).

This information in *The Gentleman's Magazine* was presented as an "Extract of a Letter from the [Mon]Sieur Seignette, Secretary to the Academy at Rochelle" (Seignette, 1772, p. 567). La Rochelle was the birthplace of Réaumur and the town where Walsh conducted most of his research. Pierre-Henry Seignette, the mayor of the town, as well as other members of the town's scientific academy, were often invited to witness and even to participate in his experiments, so as to confirm his findings. This was a matter of even greater importance when "amateurs" were involved, and Walsh, like Franklin when he started his electrical studies in Philadelphia, was an amateur who understood the rules and demands of good science.

The Gentleman's Magazine readership is specifically informed that the members of the Académie de la Rochelle had come together to witness one of Walsh's more impressive experiments, which had just been reported in a French journal:

> The discovery of Mr. Walsh, Member of the English Parliament, and of the Royal Society of London, was mentioned in the Gazette for the month of August last. The experiment, of which I am now to give an account, was tried before the Academy of this city. A live torpedo was placed on a table upon a wet napkin. Round another table stood five of the members of the society singly, not one touching the other. Two brass wires, 13 feet long each, were suspended to the ceiling by silken cords. One of these wires was supported at one end by the napkin on which lay the fish, the other end was immersed in a bowl full of water that stood upon the table on which there were placed four other bowls, all equally filled with water. The first person who stood round the second table put the fore-finger of one hand in the bowl in which the end of the brass wire was immersed, and the fore-finger of his other hand in the second bowl that stood next to it. The second person in like manner put the fore-finger of one hand in the second bowl, and the fore-finger of the other hand in the third bowl, and so on successively till the five communicated by means of the water in the bowls. In the last bowl, one end of the second brass wire was immersed and with the other Mr. Walsh touched the back of the torpedo, when all the five persons whose fingers were in the water felt a shock at the same instant, which differed in nothing from the Leyden experiment, except in the degree of violence. Mr. Walsh, who stood himself distinct from the circle of conduction, felt no commotion. This experiment was several times repeated, and every time with the same success. (Seignette, 1772, p. 567)

The translation continued:

> The action of the torpedo is communicated by the same medium as that of electrical fluid; whatever intercepts the action of the one, will intercept the action of the other. The effects produced by the torpedo resemble in every respect a faint electricity. (Seignette, 1772, p. 567)

In his full report to the Royal Society, Walsh (1773) compared the torpedo to a Leyden jar but emphasized that the fish delivers its shocks deliberately. He also mentioned its special organs, which John Hunter (1773), another member of the organization, described in detail in an accompanying article. Walsh did not, however, triumph in all of his experiments, and he discussed his failures in his lengthier report; although they were not covered in *The Gentleman's Magazine* article. Specifically, even the liveliest of his torpedoes did not attract or repulse certain objects (e.g., pith balls, thin leaves of metal), as would be expected with an electrically charged body. And even more importantly, he was unable to elicit a spark or a sound, thought to be a basic characteristic of an electrical discharge that could be felt. Hence, the ironclad case for animal electricity that Walsh and Franklin had hoped to make when Walsh set off for France was by no means completed.

Following this report, several other papers on electric fish in the *Philosophical Transactions of the Royal Society of London* made it into *The Gentleman's Magazine* as epitomes. Hence, soon after Walsh (1774) informed the Royal Society that gigantic torpedoes had been caught off the English coastline, *The Gentleman's Magazine* covered the discovery (Walsh, 1775). The awarding of the 1774 Copley Medal to Walsh was also noted in the brief article, which in its entirety reads:

> Naturalists have generally considered the torpedo, or electric ray, as an inhabitant only of warmer climates; but, contrary to this received opinion, two of these fish, taken in Torbay, were sent up, in 1773, to London, one of them weighing 53 pounds avoirdupois, which is much larger than any that this writer [Walsh] ever saw or read of in the bay of Biscay, the Mediterranean, &c. Their electrical organs were injected by Mr. John Hunter. Accounts of several others caught on the coast of Cornwall, &c. and some curious particulars relating to them, are subjoined, for which the society have, this year, adjudged to Mr. Walsh their prize medal. (Walsh, 1775, p. 83)

The editors of *The Gentleman's Magazine* were never concerned with esoteric details, which most people could care less about, and even fewer might understand. Their aim was to provide the latest news in a readable and interesting way — the understanding being that those who wanted to know more could always consult the lengthier society reports. This aim to be selective, informative, and yet entertaining, was exemplified by the fate of Henry Cavendish's (1776a) subsequent contribution to the field.

Cavendish attempted to work out the physics of the torpedo discharge, from which he deduced that, because the electricity released from this fish is too widely distributed and lacks sufficient force or spring, a spark should never have been expected. He made extensive calculations and constructed some models of the torpedo using Leyden jars immersed in water, which Walsh experienced and felt replicated his subjective experiences with real torpedoes. Nevertheless, Cavendish's article in the *Philosophical Transactions* was so technical that few readers understood exactly what he did and its importance.

Faced with what to report so as not to put readers asleep, the editors provided a title ("An Account of some Attempts to Imitate the Effects of the Torpedo by Electricity") followed by the author's name and affiliation (By the Hon. Henry Cavendish, F. R. S.) and simply directed their interested readers to the primary source. To quote: "We must refer our electrical readers to the article, as we find in it none of the *utile*, and little of the *dulce*" (Cavendish, 1776b, p. 561).

The same strategy of sending interested readers to the primary source was used if there were questions about the originality, intrinsic value, or newsworthiness of a scientific report. Consequently, although the *Philosophical Transactions* published a four-page letter by Jan Ingenhousz (1775a; Figure 3) on his torpedo experiments at Leghorn, Italy, this article was reduced to a few lines, with readers again being directed to the original report:

> These fish being gently pressed on the side of the head occasioned a shock, or trembling, as well as out of the water as in it, sometimes very weak, at other times very strong, and by giving one shock did not lose the power of giving another, as strong, and sometimes stronger. For other experiments made by this *live machine* we must refer to the article. (Ingenhousz, 1775b, p. 436)

Eels from Guiana, with their decidedly stronger shocks, now made their way back into the magazine, reflecting the fact that some were now being examined outside the jungles of South America (Figure 4). Hugh Williamson (1775a, 1775b), who made his way from Philadelphia to London to tell Walsh and his colleagues about the electrical experiments he had done with an eel that had survived the trip to Philadelphia, had his *Philosophical Transactions* paper summarized in *The Gentleman's Magazine:*

> The *Gymnotus* seems possessed of powers superior to, or rather different from, those of the Torpedo, communicating a painful sensation, like that of an electrical shock, to those who touched it, and killing its prey at a distance. This effect depends entirely on the will of the eel, and is owing to the true electrical fluid, which it discharges from its body. It is a freshwater fish, and was caught in Guiana, W of Surinam. (Williamson, 1775b, p. 437)

An abridgement of Alexander Garden's (1775a) submission to the Royal Society, "An Account of the *Gymnotus Electricus,* or Electrical Eel," appeared right after Williamson's. Garden studied eels that were transported to South Carolina, where he practiced medicine and was involved with natural history (he was one of Linnaeus's American correspondents and sent him hundreds of specimens; the gardenia plant was named after him). This summary reads:

> These experiments were made at Charles-Town, South-Carolina, on five of these fish, taken in Surinam river. The largest was three feet eight inches long, and some, it is said, have been seen upwards of twenty feet, whose stroke, or shock, was instant death. (Garden, 1775b, p. 437)

The editors, who aspired to present spectacular and wondrous "facts," did not pick up on Garden's confusion between a single eel and either a large water snake or a group of eels. Thus, they helped convey the false impression that these eels might be many times longer than they actually are.

Along the same lines, the readers of *The Gentleman's Magazine* were also badly misled 11 years later, when Lieutenant William Paterson reported to the Royal Society that he had discovered a new electric fish (Paterson, 1786a). In this case, nobody seemed to realize that the fish (Figure 5) Paterson caught off Madagascar was only opening and closing its mouth rapidly and vibrating its fins in bursts, so as to produce high-frequency whirring noises and vibrations (Ritterbush, 1964, p. 42). *The Gentleman's Magazine* article even

Figure 3. Jan Ingenhousz, who conducted electrical experiments on torpedoes caught off the coast of Italy in 1775.

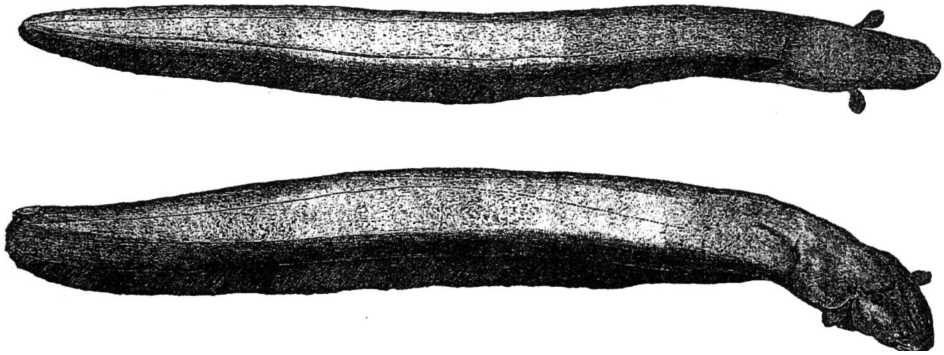


Figure 4. The so-called "electric eel." Known by many names in the eighteenth century, including *Gymnotus electricus* after it was shown to be electrical, this strongly shocking river dweller from northern South America is actually a fish. Its newer scientific name is *Electrophorus electricus* (From Hunter, 1775).

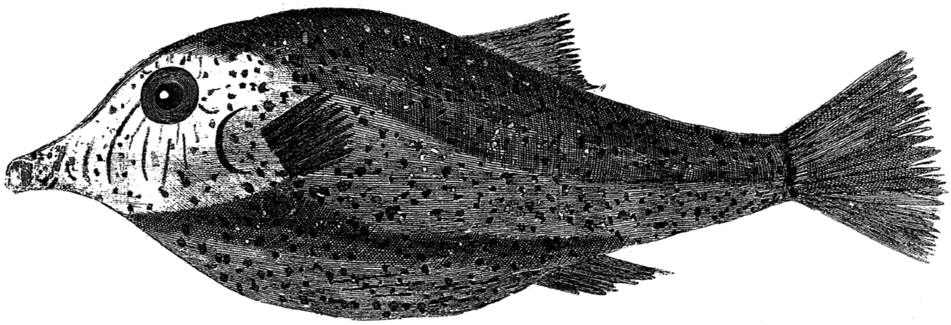


Figure 5. In 1786, Lt. William Paterson told the Royal Society that this odd-looking fish could deliver a "severe electrical shock." His discovery of a new electric fish was dutifully covered in *Gentleman's Magazine.* Paterson, however, was misled by the whirring sounds and vibrations produced by the rapid mouth and body movements of this fish.

included a picture of the mighty seven-inch fish "that gave him a severe electrical shock, which obliged him to quit his hold" (Paterson, 1786b, p. 1007).

Paterson's fish was the only illustration accompanying any of *The Gentleman's Magazine* articles on electric fish in the eighteenth century, and for a long time scientists from around the world continued to describe this strange new electric fish (dubbed *Tetrodon electricus)* in books and articles. It was only much later identified as a harmless toby (Ritterbush, 1964, p. 42).

Errors of Commission and Omission

The editors of *The Gentleman's Magazine* clearly made several errors of commission when dealing with electric fish. Readers were informed that electric eels may grow four times as long as they really are (Garden, 1775b), and they were introduced to a new electric fish that was hardly what it was reported to be (Paterson, 1789b). These errors stemmed from accepting what others had published, especially if the reports came from established scientists or had been reviewed by trusted authorities, such as the men of the Royal Society. Notably, the reports by Garden (1775b) and Paterson (1786b) had been published in *Philosophical Transactions*; although Garden (1775a) himself had wondered whether these eels really grew more than a few feet long, having written in his original report, "I shall be on the watch to procure a more accurate knowledge of, and acquaintance with, this animal" (Garden, 1775a, p. 110).

In addition to these errors of commission, there were some significant errors of omission. Some of these omissions might have been because the editors did not feel that the readership would find the material interesting, because they doubted its credibility, or because they were not in the journals they routinely consulted.

Thus, the editors did not include anything on fish electricity prior to Bancroft's 1769 book on Guiana; although there had been some informative earlier reports. The omissions in this instance most likely stemmed from the fact that the letters and books were not in English, and in rather obscure journals or buried in travel books.

In this context, there is no mention of Michel Adanson's *Histoire Naturelle du Sénégal*, which appeared in 1757 in French, and was even translated into English. Adanson wrote that one river fish (an electric catfish) gave him a shock that . . ."did not appear to me sensibly different from the commotion of the Leyden [jar] experiment that I had tried many times." He even added that it "is similarly communicated by a simple contact, with a . . . rod of iron five or six feet long" (Adanson, 1757, p. 135).

Similarly, two important letters from Guiana had been published in a Dutch scientific journal prior to Bancroft's report. Laurens Storm van's Gravesande, a high-ranking official in the region, sent one of these letters to Jean Nicolas Sébastien Allamand in 1754. Allamand was a codiscoverer (with Van Musschenbroek) of the Leyden jar, and he published this informative letter with commentary two years later (Allamand, 1756). Frans Van der Lott, a surgeon in Guiana, published a second letter in the same Dutch scientific journal six years later, and, setting an example for Bancroft to follow, he described how five people holding hands and completing a circuit with an eel could still feel the shocks (Van der Lott, 1762). Allamand and Van der Lott also mentioned that the shocks were therapeutic, which would have been of considerable interest to the readers of *The Gentleman's Magazine*, who were at this time reading many articles about electrical therapy (Locke & Finger, 2007).

In addition, John Hunter's anatomical studies on the French torpedoes and South American eels also were never mentioned; although his name came up in a single sentence when Walsh's (1775) huge English torpedoes were noted. Hunter, who worked in London, was arguably the most skilled and visible dissector of the second half of the eighteenth century, as well as an ardent collector of unusual animal and body-part specimens. He provided good verbal and exceptional graphic illustrations of the nerves and electric organs of the torpedo (Figure 6) and the electric eel (Hunter, 1773, 1775). His anatomical studies guided Cavendish in his research, and they later provided physicist Alessandro Volta with a model for his pile or battery, which involved columns of paired disks made with different metals separated by moist pasteboard. Able to produce a stream of electricity, which a Leyden jar could not do, Volta (1800) appropriately called his new device an *organe électrique artificiel* when he first described it to the Royal Society.

Walsh's groundbreaking "spark" experiment with the electric eel must be regarded as the most important omission of all. In 1776, Walsh made a thin cut through a wire and observed a small flash of light across the gap when the eel gave a discharge in a darkened room. Williamson (1775a) had earlier done this sort of experiment and felt the shock but had not observed a spark — an important fact not reported in the 1775 summary of his *Philosophical Transactions* paper. More than any other experiment at the time, Walsh's spark demonstration convinced people that animal electricity really exists — at least in some bizarre fish.

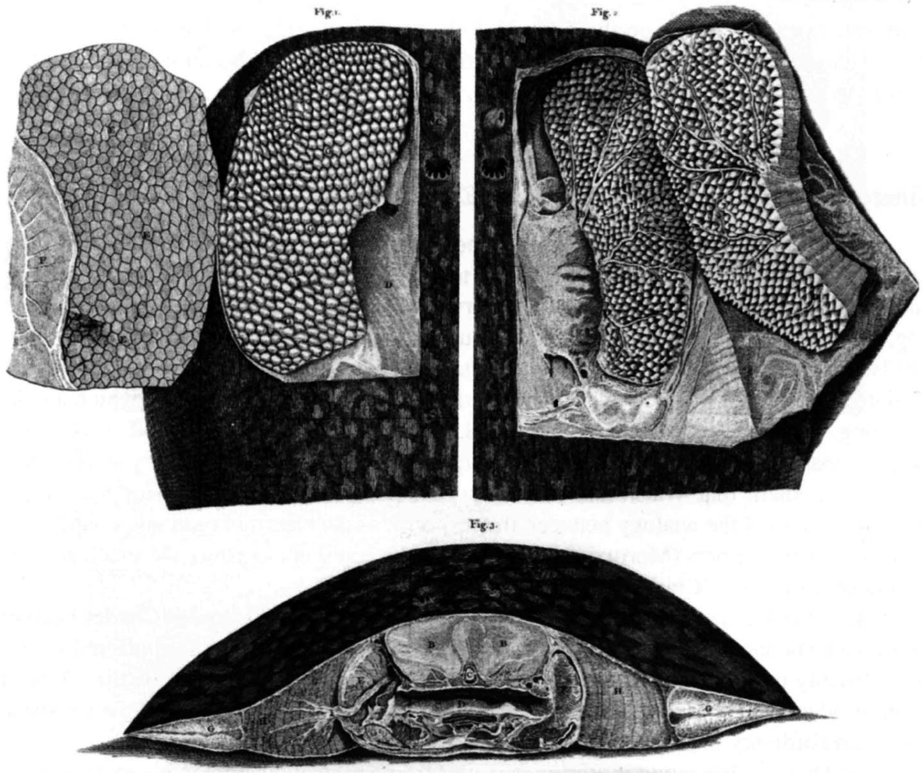


Figure 6. One of John Hunter's (1773) illustrations of the electrical organs of a French torpedo. Hunter received this torpedo from Walsh. Hunter's (1773, 1775) articles on the anatomy of this torpedo and the much more powerful electric eel appeared in the *Philosophical Transactions of the Royal Society.* Although they were extremely important in helping scientists to understand how these fish could make and store electricity, they were not the subject of articles in *Gentleman's Magazine.*

Walsh never published his spark experiment in the *Philosophical Transactions*, or anywhere else for that matter, and this may explain why the editors of *The Gentleman's Magazine* did not cover his triumph. He did, however, send a note to a Parisian friend, Jean-Baptiste Le Roy (1776), who announced it in the authoritative French physics journal, *Observations sur la Physique*, and it was reported in some London newspapers. Further, numerous members of the Royal Society, including John Pringle, Jan Ingenhousz, and Tiberius Cavallo, were present for a demonstration. These "expert witnesses" also helped to spread the word, but again mainly to other scientists (e.g., in a letter from Pringle to Haller, in one from Ingenhousz to Franklin, also dated 1776; and later in a technical book by Cavallo; see Sonntag, 1999, pp. 344–345; Willcox, 1983, p. 7; Cavallo, 1795). Yet unlike Walsh's eels, which saw daylight after the spark experiment, most individuals who depended on *The Gentleman's Magazine* to stay abreast of the latest scientific developments remained in the dark.

Conclusions

Edward Cave's periodical allowed literate people to keep abreast of the latest scientific and medical developments, and by doing so it played an important role during the Enlightenment (Porter, 1985). In addition to covering the nature of electricity, ways of controlling it, and electrical medicine, it featured a number of articles on electric fish when these wondrous creatures were just starting to become electrical. On the pages of Cave's popular periodical, people did, in fact, learn that the discharges from some fish shared many of the same properties as charged Leyden jars. Yet mistakes were made: some by including sensational material that would later be found to be erroneous, and others by not covering truly newsworthy items, such as Walsh's landmark spark experiment in a darkened room.

The coverage in *The Gentleman's Magazine* was obviously selective, and the bias of the editors was always toward verifiable observations and empirical studies, in accordance with Baconian scientific ideals. Consequently, the electric fish articles strongly emphasized experiments and replicable experiences, the building blocks for true knowledge. Other matters were left to the reader's imagination, including how these observations and new discoveries might relate to human physiology and what they might imply about electrical medicine.

In this context, there was nothing in *The Gentleman's Magazine* about what the discovery of animal electricity meant for the theory of animal spirits, which for so long, in one form or another, had dominated human nerve physiology. This might have been deemed suitable material for academicians and erudite city physicians, but not for the great majority of subscribers — inquisitive workingmen and landowners who did not study medicine and would not have had an academic or a scientific society affiliation.

These deeper implications of the electric fish discoveries might not have even entered most reader's minds. But the leading scientists and physicians of the era, who might have dismissed electricity in the past because it seemingly could not be confined to a nerve or muscle, could no longer ignore what these discoveries signified. It would be in this new and exciting *Zeitgeist* that Luigi Galvani (1791) and others would now go on to maintain, albeit amid controversy, that even the human nervous system could be electrical in nature.

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