A Correction to the Record of Early Electrophysiology Research on the 250 th Anniversary of a Historic Expedition to Île de Ré

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Abstract: Two successive editions of the Cell Physiology Source Book (ed. N. Sperelakis, Academic Press 2001, 2011). have confused the work of two pioneers of electric fish research, John Walsh MP FRS and Dr Hugh Williamson of Philadelphia. The confusion arises from a misattribution to Walsh of a 1775 paper communicated to the Royal Society of London by Walsh on Williamson's behalf. This note attempts to set the record straight on the eve of the 250th anniversary of Walsh's historic expedition to La Rochelle in the summer of 1772 where he demonstrated the electrogenicity of the marine Torpedo Ray.

Keywords: electrogenesis; electrophysiology; animal electricity

Abstract

The 250th anniversary of the first definitive demonstration of the electrogenicity of the marine Torpedo Ray at Île de Ré by John Walsh provides an opportunity to correct a significant error in the historical record. Successive editions of the Cell Physiology Source Book (ed. N. Sperelakis, Academic Press 2001, 2011) have confused the work of two pioneers of electric fish research, Williamson of Philadelphia and Walsh of London, by mis-attributing to Walsh the authorship of a 1775 paper communicated by him to the Royal Society on Williamson's behalf. This error and subsequent dismissive comments underestimate the importance of the influential research undertaken by Walsh and his associates, Franklin, Hunter, and Cavendish.

A correction to the historical record appears timely with the approach of the 250th anniversary of the historic fishing expedition to La Rochelle and Île de Ré undertaken by John Walsh in the summer of 1772 (Piccolino 2003; Finger and Piccolino 2011). Walsh's experiments, designed with the assistance of Benjamin Franklin, confirmed the electrogenicity of the Torpedo Ray. More importantly perhaps, they led to anatomist John Hunter's well-known dissections of its electric organs "liberally supplied with nerves" (Hunter 1773, 487) and later, of the electric "eel" *Gymnotus electricus* (Hunter 1775). In addition, Walsh's experiments encouraged eminent natural philosopher Henry Cavendish to construct a physical model of the Torpedo and its electric organs which validated their electrical character and function (Schaffer 2004). This work foreshadowed Volta's capacitance law and led indirectly to his invention of an "*organe électrique artificiel*", the Voltaic Pile (Piccolino and Bresadola 2002).

In hindsight Walsh's expedition and the subsequent investigations of his better-known associates (Hunter and Cavendish) can be seen to have had far-reaching consequences through the later work of Luigi Galvani in physiology and Alessandro Volta in electrotechnology. It is desirable therefore to avoid confusion between Walsh's influential Torpedo investigations in France in 1772 and Williamson's work with "electric eels" in Pennsylvania reported in 1775 and mistakenly attributed to Walsh. In fact, the crucial

observations made by Walsh and his party clearly bear the imprint of Benjamin Franklin himself in their elegance and simplicity and would be regarded today as conclusive evidence of electrogenicity, some 250 years later. In his 1772 letter to Franklin, Walsh enthused (1773, 462): "the effect of the Torpedo appears to be absolutely electrical". He based this opinion on the crucial observation that transmission of the Torpedo's shock required a closed electrically conducting path between the upper and lower surfaces of the fish. No shocks were experienced when the current path was interrupted with an insulating link. This key experiment was the crucial element in a suite of careful and systematic procedures witnessed by the academicians of La Rochelle, starting with the simple observation of the similarity between the shock from the Torpedo and that from a lightly charged Leyden Jar (Finger and Piccolino 2011).

Two leading lights of English Enlightenment science, Hunter and Cavendish, added their considerable weight (Hunter 1773; Cavendish 1776) to Walsh's work. Franklin's communication of Walsh's letter (Walsh 1773) gained his protégé the award of the Royal Society's coveted Copley Gold Medal for 1774 and the imprimatur of its president, Sir John Pringle.

Following Walsh's success with the torpedo ray, Williamson (1775, 94) wrote to Walsh describing his own experiments on *Gymnotus electricus* (now *Electrophorus*): "*As the electrical eel has lately engaged the public attention, and yours in particular, I have taken the liberty of sending you some experiments which I made on that fish:…*". Walsh duly communicated them to the Society. Benjamin Franklin had done the same two years earlier with correspondence from Walsh himself, detailing his (Walsh's) successful experiments on *Torpedo nobiliana* at La Rochelle (Walsh 1773).

Several generations of physiology research students will have read the chapters entitled *Electrocytes of Electric Fish* in the 3rd and 4th editions of the Cell Physiology Sourcebook (ed. N. Sperelakis 2001, 2011). There they will have learnt that in 1775, John Walsh "conducted numerous experiments [on electric eels] one of which involved 10 people holding hands in a circle….." (Gotter, Kaetzel, and Dedman 2001,1025; 2011, 855).

Unfortunately, the authors have mistakenly attributed to Walsh, experiments described by Hugh Williamson in his 1775 paper which he (Williamson) carried out in Philadelphia shortly before the outbreak of the Revolutionary War. (Finger and Piccolino 2011). The paper by Williamson (1775), mistakenly attributed to Walsh by Gotter, Kaetzel, and Dedman (2001, 1038; 2011, 869), and incorrectly referenced in the bibliographies to Chapters 60 (3rd ed.) and 48 (4th ed.) of the Source Book was certainly communicated by Walsh to the Society on Williamson's behalf but Walsh is clearly not the author.

The mis-attribution is accompanied by the statement (Gotter, Kaetzel, and Dedman 2001, 1025; 2011, 869), "*Although these experiments were likely to be very convincing to Walsh and his associates, others doubted the electrical nature of the discharge."* Perhaps this would be a reasonable conclusion to draw if the work of "*Walsh and his associates*" had indeed been described in Williamson's paper. However, as indicated earlier, it was not.

Walsh himself was disappointed in not being able to raise a visible spark from the torpedo ray at La Rochelle, *son et lumière* displays then being popularly demanded as evidence of the presence of the "electric fluid". Encouraged by Williamson's work on freshwater "eels",

Walsh imported several specimens from Surinam in 1775 with a view to demonstrating the generation of a spark discharge. Four years after his French expedition he succeeded. He demonstrated the formation of a visible spark from the higher voltage *Electrophorus* in his private aquarium in Mayfair to Fellows of the Royal Society (Piccolino and Bresadola 2002; Finger and Piccolino 2011).

Unfortunately Walsh did not formally publish this achievement for reasons that have remained unclear. However, he wrote of his success to French colleague Jean-Baptiste Le Roy who reported the production of *l'étincelle électrique*, confirmed by Royal Society President Sir John Pringle, in *Observations sur la Physique* (1776). Le Roy's report of Walsh's crowning achievement, the generation of a visible spark discharge, capped his earlier Torpedo demonstrations and vanquished the remaining electric fish sceptics. It subsequently became known to researchers of animal electricity in continental Europe, notably Galvani and Volta.

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