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Neuroscience without borders: preserving the history of neuroscience

INTRODUCTION

Over the last 50 years, neuroscience has enjoyed a spectacular development, with many discoveries greatly expanding our knowledge of brain function. Despite this progress, there has been a disregard for preserving the history of these discoveries. In many European countries, historic objects, instruments, and archives are neglected, while libraries and museums specifically focusing on neuroscience have been closed or drastically cut back. To reverse this trend, the Federation of European Neuroscience Societies (FENS) has organized a number of projects, including (a) the History of Neuroscience online projects, (b) the European Brain Museum Project (EBM), (c) the History online library, (d) the FENS meeting History Corner, (e) history lectures in historic venues, and (f) a series of history seminars in various European venues. These projects aim to stimulate research in, and increase awareness of, the history of European neuroscience. Our seminars have attracted large audiences of students, researchers, and the general public, who have supported our initiatives for the preservation of the history of neuroscience for future generations and for the promotion of interest in the history of neuroscience. It is therefore urgent to develop new methods for preserving our history, not only in Europe but also in the rest of the world, and to increase greatly teaching and research in this important aspect of our scientific and cultural legacy.

Many universities have degree programmes in neuroscience, but few of these programmes teach the history of neuroscience. This seems inconsistent with the fact that all scientific research necessarily builds on historical facts in the process of an experimental investigation, each scientific paper having its own history (Ceccarelli, 2002; Fleck, 1935). Indeed, a typical research paper begins with an introduction discussing scientific issues with reference to historical developments in the field. Experimental methods, both those explicitly referenced in the paper and those tacitly passed on, also have their own history. Furthermore, hypothesis-making and theory-testing depend on previous theories and previously observed

phenomena. The discussion sections of papers frame the

necessarily in explicit terms, and the impact of a discovery can only be understood in relation to contemporary theories, methods and dogmas. Journal editors know that one of the most common criticisms in reviewing papers is inadequate or faulty citation of previous work. Finally, the reference section of a paper is itself historical in nature, pointing to the published documents most relevant to the research being reported. The historical data contained in scientific papers tend to be ultra-contemporary, but sometimes references to 19th century or older discoveries and theories are relevant. It is not unusual that novel experimental strategies address past theoretical problems in a wide cultural perspective, including the discussion of past theories.

It seems therefore obvious that neuroscientists should have a knowledge of the history of their own discipline. Nevertheless, a rigorous history of neuroscience is seldom considered necessary for neuroscience research and too many neuroscientists consider, at most, history as a secondary hobby. However, the perspective of the history of the present time gives neuroscientists special responsibilities towards their discipline, their institutions and the next generation of neuroscientists in preserving their scientific legacies.

In order to preserve the lore and artefacts of past neuroscientific research and to stimulate interest by neuroscientists in the history of their field, the history committee (HC) of FENS has promoted several activities in the history of neuroscience. Six different FENS-HC activities have been initiated since 2010:

THE EUROPEAN HISTORY OF NEUROSCIENCE ONLINE PROJECTS

The annual competition for online history project grants has led to a virtual digital platform, making available autobiographies, photographs, videos, and other electronic materials relating to the work of renowned European neuroscientists. These materials are found on the FENS website (<http://www.fens.org/Outreach/History/>) and now include 25 projects, including biographical presentations on Cajal, Betz, and Golgi,

THE EUROPEAN BRAIN MUSEUM (EBM) PROJECT

This project is the creation of a network of European museums or institutions which preserve brain science archives. The aim of this project was to develop an online database displayed as a map of Europe in order to list, promote, and protect archives of brain sciences. The online project was developed by Richard Brown and is available on the FENS website (<http://www.fens.org/Outreach/History/EBM/>). The first EBM Project Meeting was held at the ICM (Institut du Cerveau et de la Moelle Épineuse) in the Hôpital Pitié Salpêtrière in Paris, France on 23 May 2017. The purpose of this meeting was to gain information on European brain museums, libraries and archives in order to expand and update the information on the website. This will be done in 2018. The meeting was organized by Laura Bossi-Régnier (France), Richard Brown (Canada) and Lorenzo Lorusso (FENS). Participants included Juan Lerma Gomez (FENS); Yves Agid (ICM), Jean-Gael Barbara (FENS); as well as Tasia Asakawa (IBRO-International Brain Research Organization); Didier Leys (EAN-European Academy of Neurology) and representatives from Croatia (Zeljka Krsnik); Ireland (Richard Roche); Italy (Fiorenzo Conti); Russia (Cecilia Msekela); Spain (Fernando De Castro); Switzerland (Enikö Kövari); The Netherlands (Manon Parry); and the United Kingdom, representing Oxford University (Richard Brown). There was also a roundtable on the neuroscience collections and archives in France which was chaired by Laura Bossi-Régnier with the participation of Frédérique Andry-Cazin (Pierre and Marie Curie University, Sorbonne, Paris), Jean-Gaël Barbara (FENS), Jocelyne Caboche (Société des Neurosciences, France), Guillaume Delaunay (Charcot's library, Pierre and Marie Curie University, Paris), and Dominique Ferriot (past-president French ICOM Committee and past director of the Musée des Arts et Métiers, Paris). Finally, Gordon M. Shepherd (Department of Neuroscience, Yale School of Medicine, USA) gave a short presentation on the importance of neuroscience history initiatives, via Skype. At the end of the meeting, Guillaume Delaunay gave the participants a tour of Charcot's library, where we had a group photo (Figure 1).

THE FENS HISTORY ONLINE LIBRARY

This resource is available on the FENS website (<http://www.fens.org/Outreach/History/Online-Library/>) and contains

THE FENS MEETING HISTORY CORNER

The History Corner displays an exhibition of posters on the European History of Neuroscience at FENS Meetings. This is not only the perfect place to learn about eminent neuroscientists and major neuroscience archives but also provides a location to discover the new activities organized by the History Committee, such as the EBM Project.

FENS HISTORY LECTURES IN HISTORIC VENUES

At each FENS meeting, the History committee organizes a series of lectures on the history of neuroscience and these lectures are held in historic venues. In Copenhagen in 2016, the history lectures were held in the 1787 lecture theatre of the Medical Museum at the University of Copenhagen. Following the lectures, there was a tour of the museum. This type of event makes the history of neuroscience come alive in venues listed on the European Brain Museum Tour. In 2018, the history lectures were held at the Medizinhistorisches Museum Berlin.

EUROPEAN HISTORY OF NEUROSCIENCE SEMINARS

The history committee of FENS supports a travelling series of history lectures given in various European venues. These seminars aim to promote local knowledge about the history of neuroscience. They are organized in collaboration with neuroscience institutes and national neuroscience societies throughout Europe. This initiative began in 2015 with the purpose of stimulating interest in the history of neuroscience among professors, researchers, students, and the general public. These seminars stimulate awareness of the neuroscience collections and the historical context of neuroscience (archives, museums, libraries) owned by European biomedical and academic institutions. In planning these seminars, special attention is given to attracting students and young researchers. Since 2015, Paris and Milan have institutionalized the seminar in December. A list of the forthcoming seminars is given on the FENS website (<http://www.fens.org/Outreach/History/History-Seminars/>).

At the end of each seminar, questionnaires were distributed to determine the interest in the FENS-HC activities in the history of neuroscience. This questionnaire had five multiple choice questions and two open-ended questions

and was given out at the European History Seminars in five cities: Milan, Paris, Oxford, Venice, and London over the last 2 years [Table 1]. Our analysis is based on 130 questionnaires from 534 audience members. The majority of the responses from the participants were positive. The consensus of the audiences was that the history of neuroscience as a discipline is not often considered in the neuroscience course curricula for doctoral students. The respondents appreciated the initiative encouraging the preservation and promotion of the history of neuroscience, and the majority of the participants (124/130 = 95.4%) rated the seminars as excellent or good. These high ratings showed that the topics were of interest to the faculty, researchers, students, and the general public who attended. Most of the participants (115/120 = 88.5%) believed that the concepts learned would be useful in their professional and cultural activities. As the seminars were also open to an audience that had no specific biomedical education, the questionnaire results indicated a desire from the public to learn more about the history and treatment of neurological diseases and the discoveries in basic neuroscience.

The majority of the audience (83/130 = 63.8%), which included nonexperts and students as well as researchers, had no prior knowledge of the topics covered. For students, medical school curricula provide little information on the history of medicine and virtually no history of neuroscience. The various seminars attracted slightly different audiences depending on their location, timing, or occurrence as satellites to scientific meetings. For example, FENS satellite meetings attracted more neuroscientists, whereas events in museums attracted more of the general public. Although the survey showed that the participants had little knowledge of the history of neuroscience, they believed that these events were useful for their research and general education. They also felt that the study of the history of neuroscience was important for knowledge of the natural history of diseases of the nervous system, from the first descriptions to subsequent research and modern scientific advances, and would aid clinical practice in the prevention, diagnosis, and treatment of diseases. They could use this knowledge for the training and professional development of doctoral students and young researchers, either to outline



FIGURE 1 The first meeting on European Brain Museum held in Paris on 23 May 2017. From left to right (standing in the front row) Zeljka Krsnik (Curator, Brain collection, Croatian Institute for Brain Research, University of Zagreb School of Medicine, Croatia), Richard Brown (Department of Psychology & Neuroscience, Dalhousie University, Halifax, Nova Scotia, Canada), Didier Leys (Secretary General, EAN), Lorenzo Lorusso (A.S.S.T-Lecco, Merate and Chair of the FENS History Committee), Cecilia Msekela (St Petersburg Pavlov State Medical University, Russia), Manon Parry (Department of History, University of Amsterdam, The Netherlands), Laura Bossi-Régnier (SPHERE, UMR 7219, Paris Diderot University, Paris, France), Juan Lerma Gomez (Director of the Instituto de Neurociencias de Alicante - FENS Secretary General), Fiorenzo Conti (Università Politecnica delle Marche, Ancona, Italy), Enikő Kövari (Curator, Geneva Brain Collection Switzerland, Department of Mental Health and Psychiatry, University of Geneva, Switzerland), Jocelyne Caboche (Société des Neurosciences, France), Frédérique Andry-Cazin (Pierre and Marie Curie University, Sorbonne, Paris France), (standing in the second row) Richard Roche (Maynooth University, Ireland), Jean-Gael Barbara (Sorbonne University, Paris - Member of the FENS History Committee), Fernando De Castro (CSIC Staff Scientist, Hospital Nacional de Paraplégicos, Spain), (kneeling) Tasia Asakawa (Director, Development and Communications, IBRO) and Guillaume Delaunay (Charcot's Library)

TABLE 1 List of speakers, numbers of participants, and numbers (percentage) of questionnaires returned after each of the European History of Neuroscience Seminars

Place	Conference title and speakers (alphabetic order)	Number of participants	Questionnaires collected
Milan	Carlo Besta and the Italian Neurosciences Development www.istituto-besta.it/biblioteca scientifica Avanzini Giuliano, Cornelio Ferdinando, Franchini Antonia Francesca, Lorusso Lorenzo, Mantegazza Renato, Mazzarello Paolo, Porro Alessandro, Riva Michele, Simonetti Fabio, Sironi Vittorio, Zanarotti Tiranini Elisabetta	44	30 (68%)
Oxford	History of understanding of the cerebral cortex www.history.medsci.ox.ac.uk Ackermann Silke, Blakemore Colin, Brown Richard, Corsi Pietro, Lorusso Lorenzo, Molnár Zoltán, Piccolino Marco, Shepherd Gordon M, Young Damion	58	8 (14%)
Venice	Neuroscience contribution to the Veneto Region http://www.scuolagrandesanmarco.it Bentivoglio Marina, Dini Frank Lloyd, Maggioni Ferdinando, Martini Stefano, Padovan Giordano, Paladin Francesco, Po' Mario, Porro Alessandro, Vanzan Marchini Nelli-Elena, Zago Stefano, Zanchin Giorgio	8	5 (62.5%)
Paris	From the history of neuroscience to neuropsychiatry of the future www.icm-institute.org/fr Agid Yves, Barbara Jean-Gaël, Bossi-Règnier Laura, Chérici Céline, Clarac François, Cohen Laurent, Debru Claude, Dubois Bruno, Dupont Jean-Calude, Fagot-Largeault Anne, Fardeau Michel, Fossati Philippe, Gaillard Raphaël, Ganascia Jean-Gabriel, Goetz Christopher, Jouvent Roland, Imbert Michel, Olié Jean-Pierre, Poirier Jacques, Walusinski Olivier	194	23 (12%)
London	Neuroscience, past present future https://www.bna.org.uk Aggleton John, Coles Alasdais, Grant Seth, Hardy John, Lagnado John, Lightman Stafford, Maguire Eleanor, Malucci Giovanna, Matthews Paul, Rose Steven, Tracey Irene, Wade Nick, Whittington Miles	230	64 (27.8%)
Total		534	130 (24%)

the evolution of a specific pathology, or to show how modern ideas about neurological disorders developed over time in different laboratories. The data from these questionnaires demonstrated that these history seminars are useful for stimulating and increasing interest in the history of neuroscience for health professionals, and can be part of a Continuing Medical Education (CME) programme.

THE 100TH ANNIVERSARY OF THE RUSSIAN PAVLOV PHYSIOLOGICAL SOCIETY

In April 2017, members of the FENS-HC were invited to Saint Petersburg, Russia to participate in the Scientific

Forum devoted to the 100th anniversary of the Russian Pavlov Physiological Society. Lectures on the history of neuroscience were given over 2 days in the Maxim Gorky House of Scientists (17 April) and the Pavlov Institute of Physiology of the Russian Academy of Science (18 April). The meeting was organized by Ludmila Filaretova (Director of Pavlov Physiological Institute); Aleksandr Nozdrachev (Head of St. Petersburg chapter of Physiological Society); Pavel Balaban (Vice-President of Russian Physiological Society); Svyatoslav Medvedev (Director of the Institute of Human Brain); and G.A. Sofronov (Director of the Institute of Experimental Medicine). On the first day, the meeting was chaired by Mikhail Ostrovskyy (President of the Russian Pavlov Physiological Society) and Lorenzo Lorusso (Chairman of FENS History Committee).

Lectures were given by Mikhail Ostrovskyy (The 100th anniversary of the Russian Pavlov Physiological Society); Lorenzo Lorusso (FENS greetings for an important historic centenary); Zoltán Molnár (Cortical knowledge from English and Russian neuroscientists); Boleslav Lichterman (Neurosurgery as applied physiology); Willem Hendrik Gispen (The ancient roots for Neuroscience); and Alexander Nozdrachev (The House of Scientists as a world club of scientific. Intelligentsia). This was followed by a tour of the House of Scientists.

On the second day, presentations were given by Ludmila Filaretova (The scientific heritage of Ivan Pavlov and the development of the Institute); Richard Brown (Pavlov in America: The influence of Pavlov on Lashley and Hebb); Marco Piccolino and Luigi Cervetto (A. L. Byzov, and the Russian contribution to vision research); Yuri Shelepin (Aim, Decision Making and Neural Technologies); Svyatoslav Medvedev (Pilgrimage of the light spot. Brain basis of the highest functions); Evgeny Nikolsky and Konstantin Petrov (Butyrylcholinesterase in cholinergic synapse: physiology, pharmacology and toxicology); and Tatiana Chernigovskaya (Brain and Mind: From Behavioral Physiology to Neurocognitive Technology). During this session, we had a tour of the Pavlov museum rooms in the Institute of Physiology, and after the session ended we had a tour of Pavlov's apartment museum, with tea in Pavlov's dining room. On the third day of the meeting, we had a tour of the State University of Saint Petersburg, where Pavlov studied, and a tour of Pavlov's research station at Koltushi. During this visit we learned about the history of Russian physiology from both lectures and museum visits (Brown et al., 2017).

This paper has summarized a number of the initiatives of the FENS-HC since 2010. These include the history presentations at FENS meetings, the European Brain Museum Project, the History grants programme, and the series of history seminars given at various European locations. The responses of the attendees at the first cycle of the European History of Neuroscience seminars have provided a number of points for discussion.

THE PLACE OF HISTORY IN THE STUDY OF NEUROSCIENCE

Neuroscientists work pragmatically, using models and theories that are consistent with their data, without worrying about the philosophical and historical underpinnings of their research. However, at some point theoretical models cease to be able to explain observed phenomena or to produce new testable theories (Fleck, 1935; Kuhn, 1962; Maienschein, Laubichler, & Loettgers, 2008). A significant aspect of the importance of the history of science for neuroscientists, and especially those involved in research to develop new medical

therapies, concerns the emergence (or re-emergence) of alternative medical treatments which are not based on scientific research but founded on unsupported theories, unverified observations or nonreplicable experiments. Controversies about the importance of scientific research for the therapeutic approach to medicine date at least from the second half of the 17th century when, against his opponents in Bologna and elsewhere in Italy and Europe, Marcello Malpighi promoted the importance of anatomy, physiology, chemistry, and other experimental disciplines for medical practice (Piccolino, 1999; Piccolino & Bresadola, 2013) (Figure 2).

This controversy re-emerged in Germany and France, in the 18th and 19th centuries, with, on one side, the various forms of alternative and unconventional medicine inspired by theosophy and the romantic principles of the *Naturphilosophie*, and, on the other, the experimental achievements and theoretical elaborations of experimental scientists of the calibre of Hermann von Helmholtz, Emil du Bois Reymond, Rudolf Ludwig Karl Virchow, Claude Bernard, and the French school of Jean-Martin Charcot (Barbara, 2009). A modern neuroscientist with a historical perspective could face the challenge of new forms of alternative (and often non-scientific) medical practices flourishing in medicine today on a



FIGURE 2 Anatomist and wax modeller Anna Morandi Manzolini' self portrait (1714-1774). She was able to combine neuroscience and art with creation of wax neuro-anatomical models. The picture shows Anna Morandi dissecting a brain. Morandi used the wax models in an educational proposal for teaching anatomy at the University of Bologna. Copyright by Museo di Palazzo Poggi, SMA-Sistema Museale di Ateneo, Alma Mater Studiorum Università di Bologna, Italy

more rational basis. Fact-deniers, charlatans and medical quacks are not just a part of history, they are still with us (Porter, 2003; Wootton, 2007). Since we started writing this paper, a series of “catastrophic” geopolitical and sociological events have made even more clear that the modern world is losing confidence in science and its gnoseological and ethical values. Against this, a knowledge of the history of science in general, and of neuroscience in particular, can provide neuroscientists with intellectual tools for defeating the flourishing antiscientific attitudes of our times, and for supporting the value and importance of their discipline, against the dangerous proliferation of fake news by special interest groups in society.

HISTORICAL STUDY INTEGRATES THE DIVERSE SUB- DISCIPLINES OF NEUROSCIENCE

A second way that the history of neuroscience can aid neuroscience research is in its interdisciplinary nature (Barbara, 2016). Many publications in the history of neuroscience note the importance of interdisciplinary collaborations from the 19th century (Berlucchi, 1999) to the neuroscientific advances of the 1950s and 1960s (Shepherd, 2010) and the present day (Amigó & Small, 2017; Derry, Schunn, & Gernsbacher, 2005). Neuroscience research involves partnerships between universities and industry, and benefits from knowledge of fields outside of neuroscience. Individual scientists have given their perspectives on large-scale collaborations vs. single-lab, hypothesis-driven science (Fairhall et al., 2016). Neuroscience involves a variety of disciplines including neuroanatomy, neurochemistry, neurophysiology, neuropharmacology, neurology, psychiatry, molecular biology, biochemistry, physics, cell biology, developmental biology, evolution, physics, chemistry, engineering, computer science, ethology, psychology, and neuroeconomics (Amigó & Small, 2017). While the term “neurologia – neurology” originates from Thomas Willis (*Cerebri Anatome*, 1664), the term “neuroscience” itself was coined by Francis O. Schmitt in the 1960s in order to embrace in a single word the variety of disciplines converging on the study of brain functions (Shepherd, 2010). From a historical perspective, interdisciplinarity in neuroscience started with the first integration of anatomy and physiology advocated by the French physician Xavier Bichat at the beginning of the 19th century (Barbara, 2016; Shoja, Tubbs, Loukas, Shokouhi, & Ardalan, 2008). Such interdisciplinarity is both necessary and fruitful. However, with it comes the risk of mixing disciplinary assumptions about neural processes without a strong grounding in the bases for these assumptions. A critical historical stance can help neuroscientists engaged in interdisciplinary research confront these issues.

THE IMPORTANCE OF HISTORY IN THE TRAINING OF NEUROSCIENTISTS

It is also important for scientists to adopt a critical historical stance in training students. Falk and Falk (Falk & Falk, 2007, p.44) argued that the training of scientists presents a paradox: on the one hand critical thinking and the rejection of dogma are key scientific values, but on the other hand, scientists “adopt unawares those doctrines (and implicit assumptions) that had been established by the dominant scientific zeitgeist”. These authors suggest that a good knowledge of the history of science is one way that scientists can understand and navigate this paradox. The teaching of clinical disciplines such as psychiatry can also benefit from an interdisciplinary neuroscience curriculum (Gopalan, Azzam, Travis, Schlesinger, & Lewis, 2014). Preserving key experimental records, histological sections, experimental instruments can help us to understand what evidence was available for our previous generations of scientists and it is our responsibility that these are archived before they disappear.

Historians of science should make, and neuroscientists should read, engaging, critical, rigorous histories of the study of the brain and the nervous system to overcome this gap in historical knowledge. Historians of science of an older era emphasized that scientists had an almost moral duty to learn the history of science so that they could position their pursuit of knowledge in relation to the rest of society (Grainger, 1956). This is still an important reason to study the history of neuroscience. In many cases, scientists investigating the brain let societal biases affect their work (Cooter, 2014). To combat these biases, the history of neuroscience was considered important for the scientific community by 93% of the attendees of our seminars. Likewise, scientific theories influence broader societal ideas about the brain. The rise of neuroscience as a discipline has precipitated a “neuroculture”, a distinct sociocultural entity that looks to neurology to explain political, economic, and normative human behaviour (Casper, 2014; Frazzetto & Anker, 2009; Garcia-Lopez, 2012). A confirmation of the importance of neuroscience in society was demonstrated by the high percentage (75%) of the attendees who had some prior knowledge of the topics covered, suggesting an interest in historical knowledge of neuroscience. The attendees appreciated this historical approach to neuroscience and the time dedicated to it (76% of attendees).

Although there are many neuroscience training programmes in Europe and the rest of the world, very few of these teach the history of neuroscience. The history of neuroscience can be approached through a variety of textbooks and monographs, such as those of Neuburger (Neuburger, 1897), Brazier (Brazier, 1984), Clarke and Dewhurst (Clarke & Dewhurst, 1972), Finger (Finger, 1994), Gross

(Gross, 1998), Mazzarello (Mazzarello, 1999), Glickstein (Glickstein, 2014), and Shepherd (Shepherd, 2010) and by books on special topics such as the discovery of electricity and its importance in neuroscience (Finger & Piccolino, 2011; Piccolino & Bresadola, 2013); the neuron doctrine (Shepherd, 2016) and the history of illustrations of the brain (Clarke & O'Malley, 1968). Modern English translations of classic books in other languages are also available (Brodman, 1909; Ramon y Cajal, 1909-1911). There are also autobiographical approaches to the history of neuroscience such as the series on the history of neuroscience in autobiography edited by Larry Squire (Squire, 1996-2014), plus autobiographies of individual neuroscientists, such as Ramón y Cajal (Ramón y Cajal, 1923) and Eric Kandel (Kandel, 2006). In addition, there are biographies of many neuroscientists, including Galen, Galvani, Golgi, Helmholtz, and Pavlov. Finger's book, *Minds behind the brain: A history of the pioneers and their discoveries*, contains short biographical vignettes on many neuroscientists (Finger, 2000). Neurobiographies provide a social history of neuroscience, give inspiration to young scientists, and bridge the gap between neuroscience and the humanities (Soderqvist, 2002). Swanson has produced a monumental work which traces the history of every term used to describe the parts of the brain and how these terms have evolved since the time of Hippocrates (Swanson, 2015). Neuroscientists can also find historical articles in PubMed (with the search term "neuroscience historical article") and through the International Society for the History of Neuroscience (ISHN) (<http://www.ishn.org>). In order to rectify the lack of training in the history of neuroscience in Europe, FENS has developed a history of neuroscience programme with a number of

initiatives described above (<http://www.fens.org/Outreach/History/>). These initiatives are devoted to the promotion and appreciation of the contribution of Europeans to the history of neuroscience. Eventually, they should embrace the rise of neuroscience in European countries that have historically been outside of the mainstream of this research field (such as those of Eastern Europe) and throughout the rest of the world.

PRESERVING THE HISTORY OF NEUROSCIENCE

History is the study of the traces of the past, or, as we have discussed above, the memories of the past. Thus, libraries (Ottlet, 1934), archives (Jimerson, 2003; Steedman, 1998), and museums (Rivera-Orraca, 2009) are all repositories of the memories of the history of neuroscience. However, many of these repositories have selective memories; some select only certain items, and others have political or personal preferences for what is collected (Figure 3).

Some archives have online indexes and others do not. Some archives no longer have archivists. But the greatest problem is that many neuroscientists do not leave their records or equipment to any library, archive, or museum. A related problem is that these institutions tend to "get rid" of items they no longer deem interesting. Old books and papers, just the kinds of things a historian looks for, which have not been taken out of the library for years, get discarded, and thus are no longer available to anyone. Archival materials sit in boxes without being indexed, and museums reject equipment as they have no space to house it. In a visit to the University of



FIGURE 3 Museum Vrolik, the University of Amsterdam's anatomical and embryological museum began as private collection of Gerardus Vrolik (1755-1859) and his son Willem Vrolik (1801-1863). The collection has been purchased by a group of Dutch citizens and offered to the municipality of Amsterdam, to be placed at the Athenaeum Illustre which became later University of Amsterdam. The picture shows the collection of skulls. Copyright by Museum Vrolik, University of Amsterdam, The Netherlands

Cambridge made about 20 years ago for the purpose of writing a history of electrophysiology, one of us (Piccolino) had difficulty in being shown the instruments used by Hodgkin and Huxley for their landmark experiments on the squid axon as they were hidden in a dusty closet in a remote part of the building. The Musée Dupuytren in Paris is now closed and the brains studied by Broca and labelled by him are now in a basement storage room in the Sorbonne, together with the collection of Dejerine's anatomical preparations and memorabilia. On the positive side, the histological preparations and clinical cases that were studied by Sherrington and Le Gros Clark are now electronically archived and available for the general public (<https://history.medsci.ox.ac.uk/slides/>) (Molnár & Brown, 2010).

As it is, most museums exhibit only a small fraction of their holdings; the majority of the collections are in storage and may become lost, damaged, or forgotten. There is also the risk that precious materials may be sold to antiquarians and private collectors, thus disappearing from the reach of scholars and the public. In these ways, much of the history of neuroscience is vanishing, and present traces of the past are being lost. These include books, diaries, published papers, unpublished manuscripts, reprints, original data, lab books, and laboratory equipment, and the expertise and instruction manuals on how to use this equipment, together with the experimental protocols, laboratory skills and the people, both scientists and technicians, who did the work: they retire and then die. How should we save the history of neuroscience and what should be saved?

Understandably, university, library, and archive administrators come and go, and the preservation of historic items is left to chance. Sometimes, the most important historic relics, such as the first traces of recordings, the actual histological sections that were used for the key observations, the first bottles that contained an isolated molecule, or dedicated books and letters, are bequeathed to the next generation of researchers where they are kept in offices or homes and often end up in attics or basements. Very few researchers appreciate the value of these items for the history of neuroscience. We all agree that not everything has to be preserved and not everything has the same relevance. There is no space for it all. However, the most important items, properly displayed, can educate, inspire, and enrich our scientific environment. In spite of the importance of maintaining these traces of our cultural legacy, many European scientific museums are closed or in a state of disrepair. In France, this is the case for institutions such as the Bibliothèque Charcot, the Musée Dupuytren, the Musée de l'Assistance publique-Hôpitaux de Paris, and the Musée des Hospices Civils de Lyon. France's largest anatomical museum, the Musée Delman-Orfila-Rouvière, is closed and part of its collections was transferred to Montpellier in 2011.

We need to restore these institutions for historical, cultural, and scientific reasons: "Historical study is not the study

of the past but the study of the present traces of the past; if men have said, thought, done or suffered anything of which nothing any longer exists, those things are as though they had never been." (Elton, 1967, p.8).

If some of the documents are digitally scanned, or instruments 3D scanned, they are preserved for future generations, and if displayed on accessible and searchable website, this heritage is open for all to use (e.g., <https://history.medsci.ox.ac.uk>). Digital archiving can open up the history of neuroscience research on a global stage if there is sufficient interest and financial support. The University of Oxford owns a number of historically important slides, including collections from Sir Charles Sherrington and Sir Wilfrid Le Gros Clark. The Sherrington collection contains examples of a lifetime of work in understanding the central nervous system, including slides related to original breakthroughs such as cortical localization in the brain (Molnár & Brown, 2010). The Le Gros Clark collection holds brain sections which may be linked to his topological mapping of the main sensory areas of the cerebral cortex and the nuclei of the thalamus. There is also a superb collection of clinical neurological cases with detailed case histories that are currently used for neuroanatomy teaching on computer-assisted learning programmes at the University of Oxford (Chang & Molnár, 2015). These collections are being digitized and made available online as part of a project funded by the Wellcome Trust and FENS and developed at the Oxford History of Medicine website, which focuses on the history of neuroscience [<https://history.medsci.ox.ac.uk/>]. The slides are being made available through "slide", a system for displaying high-resolution, zoomable, digital microscope slides which includes information relating to the slides and their authors. It is important that key aspects of this history are integrated in our current teaching, and students have access to the slides, letters, original manuscripts (Grainger, 1956). The Internet must be used as a powerful tool for saving these materials. Many classic books are now available online, and many journals have now been digitized and are available online, as are some archives. Unfortunately, although many other institutions throughout Europe possess similarly valuable items, no comparable effort has been made to preserve them and make them accessible to scholars and the public.

NEUROSCIENCE WITHOUT BORDERS

The Society for Neuroscience (SfN) has a history website (<https://www.sfn.org/about/history-of-sfn>), as do IBRO and FENS. But what else can be done? Why not develop a virtual museum of neuroscience, including libraries and archives? Why not develop a digital "History of Neuroscience

Museum” (Dempsey, 2000; Kirchhoff, Schweibenz, & Sieglerschmidt, 2009). Europe should have an International Museum of Neuroscience based on networking the neuroscientific institutions in every part of Europe to preserve and explain the scientific and cultural events in the development of neuroscience in each European country. Linking these small individual resources into a larger international network would encourage preservation of the most important historic items, documents, and instruments. It would save the heritage of European neuroscience. The history committees and interested parties of FENS, IBRO, EAN, and SfN plan to promote the creation of a network of archives, libraries and museums with the title of “Neuroscience Without Borders”. This agency will collect information about the historical items in museums, libraries, and archives throughout the world, and will be a tool for researchers, students, and for the public to preserve and commemorate European and international neuroscience for future generations (Cooter, 2014).

The “Neuroscience Without Borders” initiative will contain not only neuroscience materials generated by Europeans but also by thousands of scientists who have come to Europe for training, and by other Europeans who have trained in foreign laboratories before coming back to Europe, and by collaborations with laboratories around the world. Like all scholarly endeavours, neuroscience is international; it knows no borders, geographical, political, racial, or ethnic. Our museums and libraries must therefore collect materials wherever and by whomever generated, and then work with our counterparts around the world to find the most appropriate homes for the objects themselves, and making them digitally available to all.

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CONFLICT OF INTEREST

The authors declare no competing financial interests.

AUTHOR’S CONTRIBUTION

LL, REB, SM, AG, J-GB; ZM, MP, GMS drafted the paper; LL, REB, SM, AG, J-GB, ZM, MP, LBR, GMS analysed data; LL, REB, J-GB, ZM, MP, LBR, LS, GMS, PM, and BE revised the paper.

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