

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE 01 MAR 2013		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE APS at 125: a look back at the founding of the American Physiological Society				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Ryan K. L.,				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) United States Army Institute of Surgical Research, JBSA Fort Sam Houston, TX				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 6	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

APS at 125: a look back at the founding of the American Physiological Society

Kathy L. Ryan

United States Army Institute of Surgical Research, Fort Sam Houston, Texas

Submitted 20 October 2012; accepted in final form 27 December 2012

Ryan KL. APS at 125: a look back at the founding of the American Physiological Society. *Adv Physiol Educ* 37: 10–14, 2013; doi:10.1152/advan.00143.2012.—Early efforts in physiological research in the United States were produced by lone investigators working in laboratories funded by their own medical practices. In Europe, however, Claude Bernard and Carl Ludwig produced a new model of scientific research laboratories funded by the state that sought to develop the pursuit of biomedical research as an occupation. American physicians such as Henry Pickering Bowditch and S. Weir Mitchell were exposed to this new “research ethic” during their international studies and brought this new perspective home to America. Along with H. Newell Martin, these men began training professional physiologists who would assume new research positions in academic institutions. In 1887, Bowditch, Mitchell, and H. Newell Martin proposed the formation of a new society for these professional physiologists, the American Physiological Society (APS). Seventeen of the original twenty-eight members met on December 30, 1887, in New York City, NY, to establish APS. From these humble beginnings, APS evolved to become a force for change in American biomedical science.

history; biomedical science; research ethic; American Physiological Society

IN 1887, a small group of men met in a recently established laboratory to organize a biomedical society to promote a new vision of science in America. The founders of the American Physiological Society (APS) were a new type of physician-scientist, one for whom scientific evidence was the basis for medical practice rather than simply the existing practices passed on from previous generations of physicians. While this idea seems evident today, APS emerged from the conflict between these two cultures. The purpose of this historical perspective is to reacquaint APS membership with the founding of APS and the dynamic men who provided the impetus for the development of our society.

Pre-APS American Physiology

Before 1870, American physiological research was, with a few exceptions, essentially nonexistent, because there was no institutional framework within which research could be supported. That is, what research that was accomplished was primarily performed by lone individuals who often were not associated with a university. At the time, there were >400 medical schools in the United States (U.S.) (20) compared with 166 accredited medical schools in the U.S. today (1, 4). The majority of these schools were for profit, proprietary schools

run by practicing clinicians, with students paying these part-time lecturers directly; any physician who so desired could establish a school, hire practicing physicians to give lectures on a part-time basis, and thereby subsidize his income. Because there were no accreditation systems in place, there were no or few prerequisites, no set curriculum across schools, and no exit standards. Indeed, these were professional schools with the goal of transmitting knowledge to students who would, with sometimes very little education actually obtained, begin to practice medicine (9). Even in the few medical schools associated with universities, the research ethic, i.e., the belief that faculty members have an obligation to expand medical knowledge through research, was not a commonly held value (12).

What physiological pursuits occurred during this pre-APS period? Experimental physiology was performed by some medical students at a few U.S. medical schools, particularly the University of Pennsylvania. Between 1800 and 1821, 322 theses were published from candidates for MD degrees, with at least 42 of these including original research (5). Robley Dunglison (1789–1869), an English physician, came to the University of Virginia in 1824 at the request of Thomas Jefferson and served as Mr. Jefferson’s personal physician. While he was the first full-time medical professor in the U.S., he taught a broad range of subjects as the Chair of the Department of Physiology, Pathology, and *Materia Medica*. Although Dunglison has been considered by some the “Father of American Physiology” on the basis of his production of a classic medical textbook (*Human Physiology* in 1832), he did not perform research (20). At about the same time (1822), the Army physician William Beaumont (1785–1853) had the opportunity to begin treatment of a wounded French-Canadian trapper named Alexis St. Martin (1794–1880), who had received a gunshot wound to his abdomen. Because the wound healed with an open fistula to the stomach, Beaumont was able to perform a series of classic experiments over the next 11 yr that laid the foundation for subsequent understandings of the gastric juices and digestive function (18). In 1833, Beaumont published his results in the well-received book *Experiments and Observations on the Gastric Juice and the Physiology of Digestion* (7), which was republished the subsequent year in Scotland and translated into other languages. These experiments and St. Martin’s care were funded from Beaumont’s pay as a military physician, and his research results were some of the only American results widely known to those in Europe in this period (5). Subsequently, John Call Dalton, Jr. (1825–1889), became the first full-time professor of physiology in the U.S. in 1855 at the College of Physicians and Surgeons in New York City, NY. Dalton assumed this teaching position after first attending Claude Bernard’s lectures in Paris, France; as Dalton was a bachelor with no family, he could support himself on the relatively small faculty salary without concurrently practicing medicine. While

Address for reprint requests and other correspondence: K. L. Ryan, Regulatory Compliance Div., United States Army Institute of Surgical Research, 3698 Chambers Pass, Fort Sam Houston, TX 78234-6315 (e-mail: Kathy.ryan@amedd.army.mil).

he introduced vivisection into the medical curriculum and established a small laboratory, he performed his self-funded research as a lone investigator and did not take students into his laboratory (9, 12). Finally, Silas Weir Mitchell (1829–1914; Fig. 1A), who also attended Bernard's lectures in Paris as a young man, established a small research laboratory at his home, performing toxicology studies on the effects of snake venom while at the same time supporting his family through his active medical practice. To secure more time for research, Mitchell applied for academic chairs in physiology at the

University of Pennsylvania in 1863 and Jefferson Medical College in 1868, but he failed in both attempts. During the Civil War, Mitchell became the lead Union physician dealing with neurological wounds and their treatment and is now known as the "Father of American Neurology" for these and subsequent efforts. In addition to his amazingly prolific production of medical papers (>250 papers), Mitchell also was a popular novelist and poet, producing 17 novels as well as a variety of children's books. Despite his inability to secure a chair in physiology, he eventually became a Trustee at the University of Pennsylvania (1875), played a profound role in the rise of the research ethic within academic institutions, and became a founding member of APS (12). Inherent in the preceding discussion is that all of these men supported their research from their own financial coffers as there was no organized effort or consistent source of funding to support their studies. In a very real sense, these men were amateurs as they did not earn their living from the pursuit of science (12).

European Advances

While American physiological research was not well supported or institutionalized and therefore struggled before 1870, a revolution in research was occurring in Europe. In 1852, Claude Bernard (1813–1878) had taken over Francois Magendie's laboratory in Paris (8). Although the French model consisted of laboratories closely tied to hospitals rather than universities, there was some level of government sponsorship of the research enterprise, although the level of funding was such to result in "haphazard" laboratories and equipment (9). Most importantly, Bernard established and promulgated the concept of using experiments to derive physiological knowledge; while a student in Paris, Dalton once answered a question by saying "I think it must be so," to which Bernard replied "Think! Why think when you can experiment?" (19). Somewhat thereafter in 1865, Carl Ludwig (1816–1895) established his Institute of Physiology in Leipzig, Germany. In the German model, laboratories were closely associated with universities rather than hospitals and government sponsorship was meaningful, allowing Ludwig to provide excellent laboratories and to develop new laboratory equipment. Most importantly, full-time positions to perform research were available to investigators for the first time, allowing the development of new knowledge as an occupational pursuit (12, 13). Investigators from throughout the world flocked to the laboratories of both Bernard and Ludwig, and the influence of especially Ludwig on young American investigators was instrumental to the further development of American physiology as an occupation (9). It should be noted that physiology was also flourishing in England at the time, with laboratories established by William Sharpey at the University College of London in 1836 and Michael Foster in Cambridge in 1870 (14).

Models of Physiological Pursuit Transplanted to America

As a student, the American Henry Pickering Bowditch (1840–1911; Fig. 1B) was much influenced by his study abroad (10). The scion of a prestigious family of scientists and merchants, Bowditch received his MD degree in 1868 from Harvard University and then pursued training in Europe. Although he heard lectures from Bernard in Paris, he was dismayed by the state of these laboratories and quickly transferred

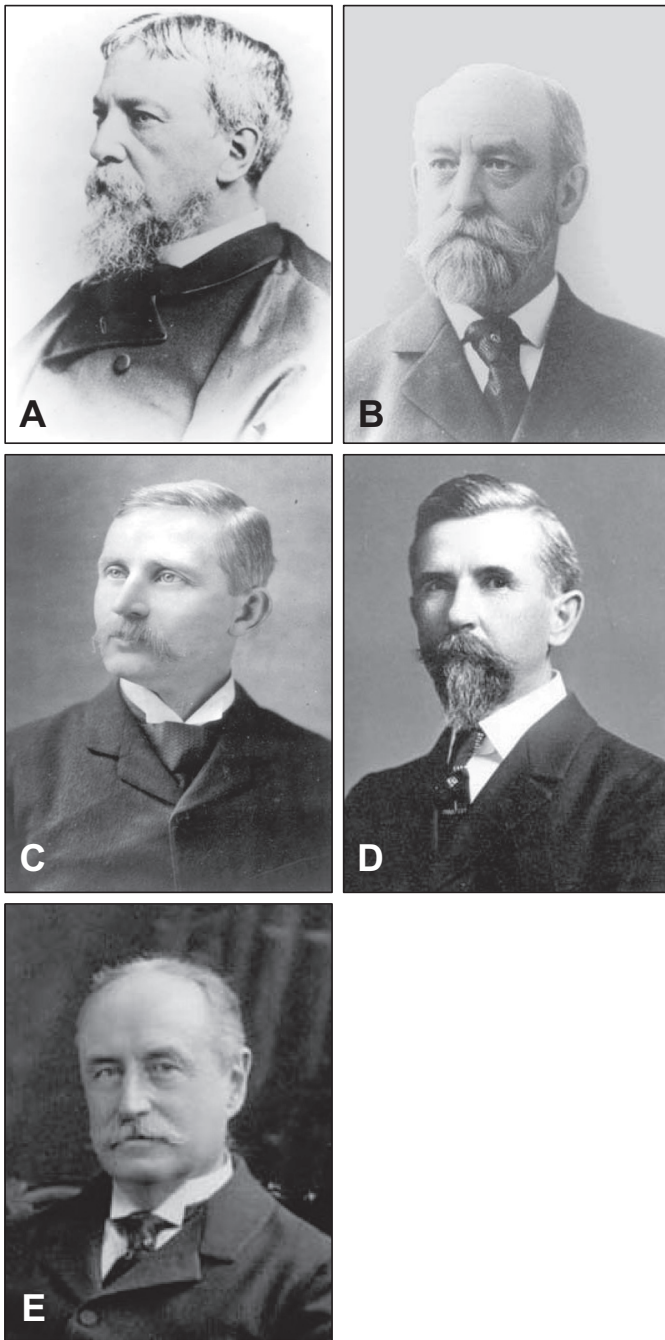


Fig. 1. Founders of the American Physiological Society. A: S. Weir Mitchell. B: Henry Pickering Bowditch. C: Henry Newell Martin. D: Russell H. Chittenden. E: John Green Curtis. [Used with permission from the American Physiological Society.]

to Ludwig's laboratory. During his time with Ludwig, Bowditch characterized the "all or none" contraction of heart muscle as well as defined *treppe* in skeletal muscle. Because of his family's affluence, Bowditch was able to stay in Europe until he was offered the position of Assistant Professor of Physiology at Harvard University in 1871. Upon his acceptance of this position, Bowditch's father provided the financial means for him to buy the finest German laboratory equipment so that he might set up a full research laboratory at Harvard University. Upon his return, he established the first experimental laboratory in the U.S. that accepted students, and he trained many of the first American physiologists (including Walter B. Cannon). In 1883, Bowditch became the Dean of the Medical School at Harvard University, where he had a profound impact on the reformation of medical education by his promotion of the research ethic, setting of a 4-yr medical curriculum, insistence on laboratory teaching in addition to didactic lectures, and defense of animal experimentation. Additionally, Bowditch played a prominent role in the founding of APS and served as its first president (12).

Bowditch, however, was not alone in promoting American physiology, as a number of other students of the European masters were also establishing outposts of research. Perhaps the most important of these was Henry Newell Martin (1848–1896; Fig. 1C), the Irish-born student of Michael Foster who received the first DSc degree in Physiology awarded from Cambridge University in 1873 (15). After serving as an assistant to Thomas Huxley, England's premier biologist, Martin was offered a position as the Chair of Biology at Johns Hopkins University in 1876 at the age of 28. At the time, there was no medical school at Johns Hopkins University, and so physiology was treated as a branch of the biological sciences. Because of this, subsequent students of Martin's received PhD degrees rather than the MD degrees that Bowditch's Harvard University students received. A brilliant experimentalist, Martin is best known for his method of isolating the mammalian heart, allowing for experiments that defined inherent characteristics of the heart. His work on defining the effect of temperature on heart rate resulted in his recognition as the Croonian Lecturer of the Royal Society in 1883 (12). Additionally, he was an exceptional teacher, and, like Bowditch, his students later became influential physiologists at a number of universities (12, 15). Through Martin's influence, the Department of Biology of Johns Hopkins University established a program of fellowships for graduate students, an innovation that has been replicated in most graduate schools (12). Although he was a talented teacher and investigator, Martin fought personal demons after the death of his wife; in 1893, he resigned from Johns Hopkins University because of health problems brought on by alcoholism, and he returned to England, where he died at the age of 48 (11).

Thus, American physiology had made great strides by 1887, in parallel with the development of new university models that supported the professionalization of the scientific endeavor. That is, the rise of philanthropy after the Civil War and the development of endowments to universities provided funding that allowed, for the first time in America, the pursuit of science as an occupation rather than an avocation (17). In addition to Dalton, Mitchell, Bowditch, and Martin, Russell Henry Chittenden (1856–1943; Fig. 1D) had established an active laboratory in physiological chemistry at Yale University

in 1882 after receiving his PhD degree 2 yr before (16). At the University of Michigan, Henry Sewall (1855–1936) had also set up a research laboratory in 1882; Sewall was the first student awarded a doctorate from Martin's department at Johns Hopkins University (12). In New York, John Green Curtis (1844–1913; Fig. 1E) had served as a Surgeon at Bellevue Hospital and adjunct professor of physiology at the College of Physicians and Surgeons since 1870, but by 1883, he was a full-time Professor of Physiology at the College of Physicians and Surgeons (16). A new breed of professional physiologist was emerging, along with the evolution of both universities and medical schools.

Toward a Society

By 1887, there was a growing feeling among American physiologists that they would benefit from a new organization that would enable and facilitate the growth of the discipline. American physiologists were certainly aware of the existence of The Physiological Society, which had been founded in 1876 in England. Nineteen physiologists, led by John Burdon Sanderson and Michael Foster, founded the organization as a dinner society that bonded together "for mutual benefit and protection" from the very powerful and influential antivivisectionist movement; it was not until 1880 that scientific meetings were held. By 1878, The Physiological Society founded the *Journal of Physiology*, in which several American physiologists published their work (12).

Many factors played a role in the decision to start a new society to serve the need of American physiologists. First, just as in England, there were ongoing battles with the antivivisection movement; the American antivivisection movement became very active in the 1880s and threatened programs in experimental physiology, and it was felt that a unified organization would be better able to defend against this threat. Second, during the Civil War and the following years, there was a rise in the establishment of societies of varying ilks, both professional and social cause related. In 1863, the National Academy of Sciences was formed, followed by the American Chemical Society in 1876 and the Society of Naturalists of the Eastern United States (later renamed the American Society of Naturalists) in 1883, in which both Martin and Bowditch were active. Other societies for medical specialties were established, and "society fever" was in the air. Third, the rise of the professional scientist created a desire for a credentialing organization that would separate the full-time physiologist from the "amateur" physiologist, most often a practicing physician teaching physiology for a few hours at a proprietary medical school. It should be noted that the rise of the professional scientists was not universally appreciated, creating a rift with those physicians trained and practicing within the confines of the existing educational system. Indeed, the final impetus for the development of APS was a dispute within the American Medical Association (AMA), of which many of the APS founders were active members (12).

In 1887, the AMA was to host the International Medical Congress in the U.S. A number of prominent physiologists (including Dalton, Mitchell, Bowditch, Martin, and Curtis) were members of the original planning committee for the Congress and saw it as a venue in which American physiologists and other basic scientists could present their work. How-

ever, politics intervened; many members of the original committee were leaders in the new field of scientific medicine, creating resentment over the composition of the committee among more clinically oriented members of the AMA. When the original committee was replaced by one composed primarily of practitioners, the physiologists mentioned above resigned and refused to participate in any capacity. However, these men continued to press for experimental physiologists to be represented at medical meetings, as they continued to promote the rise of scientifically based medicine. To participate in the 1888 Congress of American Physicians and Surgeons, experimental physiologists had to form a society of their own, as participation was limited to members of societies selected by the executive committee of the Congress. Hence, Mitchell proposed to Bowditch the formation of a society for physiologists, and a letter was sent from Bowditch's laboratory on November 10, 1887, inviting interested individuals to participate in this new society. The signatories to the letter were Mitchell, Martin, and Bowditch, and there were 25 positive responses (2, 12).

The Founding of APS

Because many of the invitees were members of the Society of Naturalists, it was thought most convenient to hold the organizational meeting in New York just after the naturalists' meeting. John Green Curtis hosted the convocation at his new physiological laboratory at the College of Physicians and Surgeons on December 30, 1887. Seventeen of the original twenty-eight founding members attended, and Bowditch and Martin were elected as the first President and Secretary, respectively, of APS. The stated goal of the new society was "to promote the advance of Physiology and to facilitate personal intercourse between American Physiologists." Unlike The Physiological Society of England, this society was to be founded as a professional society first and foremost, rather than beginning as a social activity. Eligibility for membership was restricted to residents of North America who had "conducted and published an original research in Physiology or Histology (including Pathology and experimental Therapeutics and experimental research and Hygiene), or who has promoted and encouraged Physiological research." By establishing this rule, the founders clearly drew a line between the professional physiologist and the clinician who lectured on physiology for a few hours each week (12). Indeed, APS became the first American scientific society to require publication of original research as a prerequisite for membership (2). This rule was used extensively in the early years to exclude those without a sincere commitment to research, resulting in a fairly slow growth within its first years [by 1899, there were only 73 members (12)]. However, the organization was fully established in time to participate in the 1888 Congress of American Physicians and Surgeons in Washington, DC, and the APS's first scientific meeting was held in conjunction with the Congress (2).

Table 1 shows the founding members of APS. Of the original 28 members, 5 members had trained with Bowditch at Harvard University and 10 members were trained by or associated with Martin at Johns Hopkins University. Interestingly, 79% of the founding members had studied abroad, with most of these receiving their European training in Germany (9). Fully 17 of the 28 members held a MD degree, with 9 members

Table 1. *Founding members of the American Physiological Society*

12	Degree	Affiliation
Henry G. Beyer	MD, PhD	United States Navy
Henry P. Bowditch	MD	Harvard University
Henry C. Chapman	MD	Jefferson Medical College
Russell H. Chittenden	PhD	Yale University
John G. Curtis	MD	College of Physicians and Surgeons
John C. Dalton, Jr.	MD	College of Physicians and Surgeons
Henry H. Donaldson	PhD	Johns Hopkins University
Frederick W. Ellis	MD	Private practice
George L. Goodale	MD	Harvard University
G. Stanley Hall	PhD	Johns Hopkins University
Hobart A. Hare	MD	University of Pennsylvania
William H. Howell	PhD	Johns Hopkins University
Joseph Jastrow	PhD	Johns Hopkins University
Warren P. Lombard	MD	College of Physicians and Surgeons
H. Newell Martin	DSc	Johns Hopkins University
T. Wesley Mills	MD	McGill University
Charles S. Minot	ScD	Harvard University
S. Weir Mitchell	MD	Private practice
William Osler	MD	Johns Hopkins University
Isaac Ott	MD	Private practice
Edward T. Reichert	MD	University of Pennsylvania
William T. Sedgwick	PhD	Massachusetts Institute of Technology
Henry Sewall	PhD	University of Michigan
Robert M. Smith	MD	University of Pennsylvania
Victor C. Vaughan	MD, PhD	University of Michigan
Joseph W. Warren	MD	Harvard University
William H. Welch	MD	Johns Hopkins University
Horatio C. Wood, Jr.	MD	University of Pennsylvania

Affiliations listed are those in 1887, at the founding of the American Physiological Society. Information is from Refs. 12 and 16.

holding a PhD or DSc degree and 2 members holding both degrees (16). In addition to many of the leading lights in physiology of the time, luminaries in the fields of medicine (e.g., Osler), anatomy and embryology (Minot), and bacteriology (Welch) were counted among the original membership. Of course, all of the founding members were male, as science at the time was not open to women; APS accepted the neuro-physiologist Ida Henrietta Hyde, an Associate Professor of Physiology at the University of Kansas, as its first female member in 1902 (21). American physiologists continued to publish in the *Journal of Physiology*, but, by the late 1890s, it became clear that a new journal was needed to meet the greater needs of the increasing numbers of investigators. In 1898, the first issue of the *American Journal of Physiology* was published, with William Townsend Porter (1862–1949) not only acting as the managing editor but also as the legal owner of the journal with full financial responsibility. Porter was able to fund the journal costs because, in 1901, he had founded Harvard Apparatus to provide inexpensive and reliable laboratory equipment (6). Porter is remembered as the "greatest benefactor" of APS because of his establishment of the journal at his own expense as well as his donation of proceeds from his company to APS (3).

Reflections

The founding of APS presents a watershed moment in the history of biomedical science in the U.S. As the interests of the members diverged, a number of new societies were "spun off" from APS, including the American Society of Biological

Chemists in 1906 (with APS founder Russell Chittenden as the first President), the American Society for Pharmacology and Experimental Therapeutics (1908), the Biophysical Society (1956), and the Society for Neuroscience (1969) (12). In 1912, the Federation of American Societies for Experimental Biology (FASEB) was formed, with APS, the American Society of Biological Chemists, and the American Society for Pharmacology and Experimental Therapeutics as founding members (12). FASEB has become an unequaled force for biomedical science, through which its member societies exert political influence, actively work to improve funding opportunities for science and act to improve science education in this country.

On the occasion of our 125th anniversary, I wonder if the founders of APS would recognize the society that they had the foresight to begin. Could they ever have imagined that their small society would grow to over 11,000 members, with members coming from both the U.S. and other countries? And that 25% of these members would be women (M. Frank, personal communication)? Could they fathom that the organization that they founded would have an operating budget of more than \$18,000,000? Would they recognize the *American Journal of Physiology*, which has been divided into seven sections and has been joined by another seven publications from APS? And on a grander scale, would our founders recognize the industry of scientific research that has been developed from their efforts to bring the research ethic into academic medicine? After all, isn't "evidence-based medicine" the idea that they promulgated 125 yr ago?

ACKNOWLEDGMENTS

The author sincerely thanks Dr. Charles M. Tipton for the invitation to present this work at the "American Physiological Society: 125 Years of Progress" symposium at Experimental Biology 2012 in San Diego, CA.

DISCLAIMER

The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

Author contributions: K.L.R. conception and design of research; K.L.R. prepared figures; K.L.R. drafted manuscript; K.L.R. edited and revised manuscript; K.L.R. approved final version of manuscript.

REFERENCES

1. **American Association of Colleges of Osteopathic Medicine.** *U.S. Colleges of Osteopathic Medicine* (online). <http://www.aacom.org/about/colleges/Pages/default.aspx> [5 July 2012].
2. **Appel TA.** Biological and medical societies and the founding of the American Physiological Society. In: *Physiology in the American Context, 1850–1940*, edited by Geison GL. Baltimore, MD: Am. Physiol. Soc., 1987.
3. **Appel TA.** First quarter century: 1887–1912. In: *History of the American Physiological Society: the First Century, 1887–1987*. Bethesda, MD: Am. Physiol. Soc., 1987.
4. **Association of American Medical Colleges.** *Medical Schools* (online). <https://www.aamc.org/about/medicalschoools/> [5 July 2012].
5. **Atwater EC.** "Squeezing Mother Nature": experimental physiology in the United States before 1870. *Bull Hist Med* 52: 313–335, 1978.
6. **Barger AC.** The meteoric rise and fall of William Townsend Porter, one of Carl J. Wiggers' "Old Guard". *Physiologist* 25: 407–413, 1982.
7. **Beaumont W.** *Experiments and Observations on the Gastric Juice and the Physiology of Digestion*. Plattsburgh, NY: F. P. Allen, 1833.
8. **Bendiner E.** Claude Bernard: Theater's loss was physiology's gain. *Hosp Pract* 14: 130–131 and 134–140, 1979.
9. **Frank RG Jr.** American physiologists in German laboratories, 1865–1914. In: *Physiology in the American Context, 1850–1940*, edited by Geison GL. Baltimore, MD: Am. Physiol. Soc., 1987.
10. **Fye WB.** Why a physiologist? The case of Henry P. Bowditch. *Bull Hist Med* 56: 19–29, 1982.
11. **Fye WBH.** Newell Martin—a remarkable career destroyed by neurasthenia and alcoholism. *J Hist Med Allied Sci* 40: 133–166, 1985.
12. **Fye WB.** *The Development of American Physiology: Scientific Medicine in the Nineteenth Century*. Baltimore, MD: Johns Hopkins Univ. Press, 1987.
13. **Fye WB.** The origin of the full-time faculty system: implications for clinical research. *JAMA* 265: 1555–1562, 1991.
14. **Geison GL.** *Michael Foster and the Cambridge School of Physiology*. Princeton, NJ: Princeton Univ. Press, 1978.
15. **Harvey AM.** Fountainhead of American physiology: H. Newell Martin and his pupil, William Henry Howell. *Johns Hopkins Med J* 136: 38–46, 1975.
16. **Howell WH.** The American Physiological Society during its first twenty-five years. In: *History of the American Physiological Society Semicentennial, 1887–1937*. Baltimore, MD: Am. Physiol. Soc., 1938.
17. **Lucier P.** The professional and the scientist in nineteenth-century America. *Isis* 100: 699–732, 2009.
18. **Meek WJ.** The beginnings of American physiology. *Ann Med Hist* 10: 111–125, 1928.
19. **Mitchell SW.** Biographical memoir of John Call Dalton. *Biogr Mem Natl Acad Sci* 3: 179–185, 1895.
20. **Reed CI.** The expansion of medical education and evolution of physiology in America. *Physiologist* 4: 44–50, 1961.
21. **Tucker GS.** Ida Henrietta Hyde: the first woman member of the society. *Physiologist* 24: 1–9, 1981.